BROADWATER

RESOURCE REPORT NO. 3

FISH, VEGETATION, AND WILDLIFE

FOR A

PROJECT TO CONSTRUCT AND OPERATE A

LIQUEFIED NATURAL GAS RECEIVING TERMINAL

IN

LONG ISLAND SOUND

LONG ISLAND, NEW YORK

UNITED STATES OF AMERICA

JANUARY 2006

PUBLIC

BW001168

RESOURCE REPORT 3–FISH, VEGETATION, AND WILDLIFE

Minimum Filing Requirement	Location in Environmental Report
• • Classify the fishery type of each surface water body that would be crossed, including fisheries of special concern. (§ 380.12 (e) (1)).• •	Sections 3.2.1 and 3.2.2
• • Describe terrestrial and wetland wildlife and habitats that would be affected by the project. (§ 380.12 (e) (2)).• •	Sections 3.2.1.4 and 3.2.1.5
• • Describe the major vegetative cover types that would be crossed and provide the acreage of each vegetative cover type that would be affected by construction. (§ 380.12 (e) (3)).• •	Section 3.1.1.5
• • Describe the effects of construction and operation procedures on the fishery resources and proposed mitigation measures. (§ 380.12 (e) (4)).• •	Section 3.3
• • Evaluate the potential for short-term, long-term, and permanent impact on the wildlife resources and state-listed endangered or threatened species caused by construction and operation of the project and proposed mitigation measures. (§ 380.12(e)(4)).• •	Section 3.3.4
• • Identify all federally listed or proposed endangered or threatened species that potentially occur in the vicinity of the project and discussion results of consultations with other agencies. (§ 380.12 (e) (5)).• •	Sections 3.2.2.8 and 3.3.4.8, and Appendix F
• • Identify all federally listed essential fish habitat (EFH) that potentially occurs in the vicinity of the project and the results of abbreviated consultations with NMFS, and any resulting EFH assessments. (§380.12(e)(4 & 7)).	Sections 3.2.1.1 and 3.3.1.1, and Appendix A
• • Describe any significant biological resources that would be affected. Describe impact and any mitigation proposed to avoid or minimize that impact. (§ 380.12 (e) (4 & 7)).	Section 3.2.1

Environmental Information Request
October 19, 2005

Request	Location in Environmental Report
1. Quantify the extent, magnitude, and duration of turbidity and sedimentation associated with trenching or dredging activities, and specify the planned and potential methods to avoid and minimize impacts to the water column, benthic habitats, and marine resources due to turbidity and sedimentation. Identify the threshold values that Broadwater used to determine that turbidity and sedimentation would not be significant.	Section 3.3.1.1. *See* also Resource Report 2, Section 2.3.5.
2. Describe the length, depth, width, and shape of the trench and spoil area that was used to generate acreage and sediment volume estimates. Describe the extent, magnitude, and duration of potential impacts to the benthic habitat, water column, and biological resources during natural backfilling of the trench associated with the presence of a trench, changes in specific sediment type within the trench, and thermal impacts. Evaluate methods to minimize potential impacts of the trench and thermal impacts to marine resources during operation, such as active backfilling with excavated spoil material during pipeline installation activities as approved for the Islander East pipeline.	Trench and Spoil Pile dimensions are identified in Resource Report 1, Section 1.5.3.3.1, and on Figures 1-16 and 1-17. Sections 3.3.1.1 and 3.3.4.1.
3. Specify whether Broadwater would use anti-fouling paint on the FSRU and yoke mooring system. If anti-fouling paint is planned, provide information regarding the expected use of anti-fouling paint including structures, frequency, chemical concentrations, potential impacts to marine resources, and measures to minimize potential impacts.	Section 3.3.2.2. *See* also Resource Report 2, Section 2.5.1.2.

Environmental Information Request
October 19, 2005

Request	Location in Environmental Report
4. For hydrostatic testing, specify the volume of water, season, intake and discharge location, any chemical additives (biocides, chlorine, etc.), treatment of the discharge water, and potential impacts to marine resources. Specify the technical threshold values that Broadwater used to conclude that impacts would not be significant, and identify any planned and potential measures to minimize impacts of hydrostatic water intake, treatment, and discharge on the water column and biological resources.	Section 3.3.1.1. *See* also Resource Report 2, Section 2.5.1.1.
5. Quantify the impact of noise and acoustic shock on marine mammals during construction and operation of the Broadwater Project, and provide the technical basis (and literature references) that Broadwater used to conclude that impacts would not be significant. Specify the seasonal schedule of pile-driving activities.	Sections 3.3.1.2, 3.3.2.2, 3.3.4.2, and 3.3.4.6, and Section 1.5.2 of Appendix A. *See* also Resource Report 9.
6. Describe the measures to avoid and minimize potential impacts to sea turtles and marine mammals associated with vessel strikes during construction and operation of the planned Project including impacts associated with the use of support vessels.	Sections 3.3.4.5 and 3.3.4.6
7. Provide ichthyoplankton survey results collected in the vicinity of the planned Project including survey data and summary results by species, lifestage, depth strata, and month/season.	Section 3.2.2.4
8. Describe the habitat function of the planned "mud mat" associated with the yoke mooring system relative to existing substrate conditions. Specify the time necessary for this mud mat to become fully functional as biological habitat.	Section 3.3.1.2.

Request	Location in Environmental Report
9. Specify the individual volumes of ballast and cooling water intake and discharge for the FSRU and each type of LNG carrier. Describe the intake designs and operations including volume, velocity, duration, depth, and screen mesh size for intake structures on both the FSRU and the LNG carriers. Quantify the impact of these water intakes on ichthyoplankton, by season, including EFH species, and commercial and recreational fish and shellfish. Specify the planned and potential measures to minimize possible impacts of water intake on water and biological resources.	Section 3.3.4.4. *See* also the descriptions of water intakes, volumes, and screening in Resource Report 1 and Resource Report 2, Section 2.5.2.2.
• • Describe the ichthyoplankton abundance and diversity at the FSRU site including depth distribution and seasonal occurrence by lifestage. Draft Resource Report 3 does not describe abundance and diversity by depth distribution or seasonal occurrence by lifestage.	Section 3.2.2.4
• • Impacts to ichthyoplankton associated with water intake and discharges from FSRU and LNG carriers including entrainment of ichthyoplankton introduction of non-native species. Draft Resource Report 3 does not specify the ichthyoplankton impacts associated with water intakes or discharges.	Section 3.3.4.4
• • Lighting plans to minimize impacts to birds, marine mammals, and other pertinent resources. Draft Resource Report 3 does not provide a lighting plan and does not identify planned and potential mitigation measures to minimize lighting impacts.	Sections 3.3.1.1, 3.3.1.2, and 3.3.2.2 (general impacts and mitigation measures). Section 3.3.4.3 (Squid); Section 3.3.4.5 (Turtles); and Section 3.3.4.7 (Avian)

Environmental Information Request
October 19, 2005

Request	Location in Environmental Report
• • Impacts to Essential Fish Habitat species and habitat throughout the Project area including direct impacts to EFH resources and indirect impacts to water quality, habitat suitability, and the food web. The EFH Assessment should specify impacts and appropriate mitigation measures to EFH associated with turbidity, sedimentation, bio-fouling, and thermal impacts.	Appendix A
• • Potential impacts to benthic communities and habitats from construction of the pipeline and yoke structure. Draft Resource Report 3 does not specify or quantify impacts of turbidity, sedimentation, or recovery rates for the benthic community directly or indirectly impacted.	Section 3.3.1.1 (general impacts on water quality and sedimentation) Section 3.3.4.1, benthic biological impacts and recovery
• • Impacts to marine resources from increased water turbidity and suspension of sediments during construction of the pipeline and yoke structure. Draft Resource Report 3 does not specify the extent or duration of turbidity.	Section 3.3.1.1. *See* also Resource Report 2, Section 2.3.5.
• • Potential impacts of noise and vibration to marine mammals, fishes, birds, and other marine resources during construction and operation of the pipeline and FSRU. Draft Resource Report 3 does not discuss potential impacts to marine mammals or birds due to noise nor mention potential noise impacts during Project operation.	Sections 3.3.1.2, 3.3.4.2, and 3.3.4.6. *See* also Resource Report 9.
• • Impacts to marine resources due to waste streams or toxic substance spills. Draft Resource Report 3 does not specify impacts to marine resources associated with waste streams or spills.	Section 3.3.2.2. *See* also Resource Report 2.

Environmental Information Request
October 19, 2005

Request	Location in Environmental Report
• • Impacts to threatened and endangered species or their habitat as a result of construction and operation of the proposed project. Draft Resource Report 3 does not identify measures to avoid and minimize potential impacts.	Sections 3.3.1.1 and 3.3.1.2 (general impacts and minimization) Section 3.3.4.2 (potential finfish impacts and minimization) Section 3.3.4.5 (potential sea turtle impacts and minimization) Section 3.3.4.6 (potential marine mammal impacts and minimization)
• • Potential impacts to marine resources associated with the use of anti-fouling paint on project structures. Draft Resource Report 3 does not mention anti-fouling paint.	Section 3.3.2.2. *See* also Resource Report 2, Section 2.5.1.2.

Environmental Information Request
January 18, 2006

Request	Location in Environmental Report
1. As requested in our EIR dated October 19, 2005, address the following issues specifically related to marine resources:	
a. Identify the anticipated peak noise levels during construction and operation of the proposed Project, and provide literature references to support the statement that injury and mortality of marine resources may occur when noise levels reach 180 decibels.	Section 1.4.2
b. Provide the expected velocity of intakes, depth of intakes, and screen mesh size of intakes for a typical LNG carrier.	Section 3.3.2.2

Environmental Information Request
January 18, 2006

Request	Location in Environmental Report
2. Report the ichthyoplankton densities, potential annual entrainment, and standing crop by species and lifestage for the intermediate water depth based on the Polatti ichthyoplankton program. Present results in absolute numbers as well as Age 1 equivalents. Identify any mitigation measures that Broadwater proposes to minimize impacts to ichthyoplankton (FSRU and LNG carrier).	To be submitted as a supplemental filing

Table of Contents

3. FISH, VEGETATION, AND WILDLIFE 3-1
3.1 Introduction 3-1
3.2 Existing Conditions 3-3
3.2.1 Long Island Sound Habitats 3-3
3.2.1.1 Essential Fish Habitat 3-11
3.2.1.2 NYSDOS Significant Coastal Fish and Wildlife Habitat 3-11
3.2.1.3 USFWS Northeast Coastal Areas Study 3-16
3.2.1.4 Wetlands 3-18
3.2.1.5 Vegetation 3-18
3.2.2 Fish and Wildlife Resources 3-18
3.2.2.1 Benthos 3-18
3.2.2.2 Finfish 3-31
3.2.2.3 Shellfish 3-47
3.2.2.4 Plankton 3-51
3.2.2.5 Reptiles 3-58
3.2.2.6 Marine Mammals 3-59
3.2.2.7 Avian Species 3-60
3.2.2.8 Threatened and Endangered Species 3-61
3.2.2.9 Commercially Important Species 3-63
3.3 Potential Impacts and Mitigation 3-64
3.3.1 General Construction Impacts 3-67
3.3.1.1 Pipeline 3-67
3.3.1.2 Tower Structure and FSRU 3-70
3.3.2 General Operational Impacts 3-72
3.3.2.1 Pipeline 3-72
3.3.2.2 FSRU 3-73
3.3.3 Long Island Sound Habitats 3-76
3.3.3.1 Essential Fish Habitat 3-77
3.3.4 Fish and Wildlife Resources 3-79
3.3.4.1 Benthos 3-79
3.3.4.2 Finfish 3-80
3.3.4.3 Shellfish 3-86
3.3.4.4 Plankton 3-88
3.3.4.5 Reptiles 3-92
3.3.4.6 Marine Mammals 3-93
3.3.4.7 Avian Species 3-94
3.3.4.8 Threatened and Endangered Species 3-94
3.3.4.9 Commercially Important Species 3-94
3.4 References 3-95

APPENDIX

A ESSENTIAL FISH HABITAT ASSESSMENT A-1

B BENTHIC VIDEO SURVEY REPORT B-1

C BENTHIC LABORATORY ANALYTICAL RESULTS C-1

D DROP CAMERA VIDEO D-1

E ICHTHYOPLANKTON ENTRAINMENT ESTIMATES AT THE BROADWATER FSRU FACILITY BASED ON DATA COLLECTED DURING THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM E-1

F CORRESPONDENCE F-1

G SEDIMENT DEPOSITION RESULTING FROM CONSTRUCTION OF A NATURAL GAS PIPELINE TRENCH G-1

H NATURAL BACKFILLING OF NATURAL GAS PIPELINE TRENCH H-1

List of Tables

3-1 Species with Identified EFH within the Project Area 3-16

3-2 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005 3-25

3-3 Fish Species Collected during Long Island Trawl Surveys (LISTS) from 1984 to 2003 3-32

3-4 Finfish and Invertebrate Biomass Indices for the Spring Sampling Period, 1992-2003 3-38

3-5 Finfish and Invertebrate Biomass Indices for the Fall Sampling Period, 1992-2003 3-39

3-6 Important Recreational, Commercial, and Forage Species Present in Long Island Sound 3-40

3-7 Species for which EFH has been Designated for Egg and/or Larval Stages in the Vicinity of the Proposed FSRU 3-53

3-8 General Habitat Parameters for Egg and Larval Stages for Species With Designated EFH in the FSRU Project Area 3-54

3-9 Threatened and Endangered Species Potentially Occurring in the Project Area 3-61

3-10 Broadwater Pipeline Installation, Summary of Sediment-Related Impacts 3-67

3-11 Estimated Distance to 190 and 180 Db RMS Level 3-71

3-12 Utilization of the Sound by Fish Species 3-82

List of Figures

3-1 Proposed FSRU Facility Location and Proposed Pipeline Route ... 3-2

3-2 Proposed Broadwater Project Location in Long Island Sound, in Relation to the Central and Western Basins ... 3-4

3-3a Seafloor Elevation Profile Along the Proposed Pipeline Route ... 3-6

3-3b Seafloor Elevation Profile Along the Proposed Pipeline Route ... 3-7

3-3c Seafloor Elevation Profile Along the Proposed Pipeline Route ... 3-8

3-3d Seafloor Elevation Profile Along the Proposed Pipeline Route ... 3-9

3-4 Habitat Types in the Project Area ... 3-10

3-5 Sedimentary Environments ... 3-12

3-6 Essential Fish Habitats in the Project Area ... 3-13

3-7A Significant Habitat Areas in and Around Long Island Sound ... 3-14

3-7B Significant Habitat Areas ... 3-15

3-8 Benthic Community Species Diversity in the Project Area ... 3-20

3-9 Benthic Faunal Assemblages in the Project Area ... 3-21

3-10 Broadwater Benthic Sampling Stations ... 3-23

3-11 Benthic Community Species Diversity in the Project Area; Based on Spring 2005 Field Surveys ... 3-29

3-12 Broadwater Benthic Communities; Based on Spring 2005 Field Surveys ... 3-30

3-13 Aggregate Finfish Catch ... 3-35

3-14 Aggregate Demersal Catch ... 3-36

3-15 Mean Finfish Count in the Project Area ... 3-37

3-16 American Lobster Distribution in Long Island Sound ... 3-50

3-17 Trawling Lanes in the Project Area ... 3-65

3-18 Lobster Pot Densities in the Project Area ... 3-66

List of Acronyms and Abbreviations

bcf	billion cubic feet
bcfd	billion cubic feet per day
CTDEP	Connecticut Department of Environmental Protection
dB	decibel
°C	degrees Celsius
°F	degrees Fahrenheit
EBP	early benthic phase
EFH	essential fish habitat
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FSRU	floating storage and regasification unit
ha	hectare
HDD	horizontal directional drilling
IGTS	Iroquois Gas Transmission System
km	kilometer
LISTS	Long Island Sound Trawl Surveys
LNG	liquefied natural gas
mm	millimeter
MMPA	Marine Mammal Protection Act of 1972
NOAA	National Oceanic and Atmospheric Administration
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
SCFWH	significant coastal fish and wildlife habitat
SCV	submerged combustion vaporizer

SPCC	Spill Prevention, Control, and Countermeasures (SPCC)
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
YMS	yoke mooring system

3. FISH, VEGETATION, AND WILDLIFE

3.1 INTRODUCTION

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and connecting pipeline for the import, storage, regasification, and transportation of natural gas. The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS). The FERC application for the Project requires the submittal of 13 Resource Reports, with each report evaluating Project effects on a particular aspect of the environment.

Resource Report 3 describes the existing conditions relating to fish, vegetation, habitat, and wildlife in the Project area. This Resource Report also discusses the potential impacts on these resources associated with construction and operation of the proposed Project and methods that will be utilized to avoid and minimize impacts.

The proposed Broadwater LNG terminal will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 km) from the shore of Long Island in New York State waters, as shown on Figure 3-1. The LNG terminal facilities facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcfd) and will be capable of delivering a peak day throughput of 1.25 bcfd. The Project will deliver the regasified LNG to the existing interstate natural gas pipeline system via an interconnection to the IGTS pipeline. Onshore facilities are discussed in the Onshore Facilities Resource Reports.

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [m^3] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas) with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 m^3 up to a potential future size of 250,000 m^3 at the frequency of two to three carriers per week.

Source: ESRI StreetMap, 2002.

Figure 3-1
Proposed Broadwater Project
Location in Long Island Sound

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the stationary tower also serves the purpose of securing the FSRU in such a manner to allow it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS), allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [m^2]).

A 30-inch-diameter natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be installed beneath the seafloor from the stationary tower structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. To stabilize and protect the operating components, sections of the pipeline will be covered with engineered back-fill material or spoil removed during the lowering operation. Figure 3-1 presents the proposed pipeline route.

3.2 EXISTING CONDITIONS

3.2.1 Long Island Sound Habitats

Long Island Sound is a northeast-southwest trending basin that is approximately 112 miles (180 km) long and 21 miles (34 km) across at its widest point. It has a total surface area of 1,300 square miles (3,370 km^2) and a volume of approximately 18 trillion gallons. Its 16,000-square-mile (41,500-km^2) drainage basin includes much of New England and Long Island (Institute for Sustainable Energy 2003).

Long Island Sound can be divided into three basins: the eastern, central, and western basins. The eastern basin stretches from the Race to the Mattituck Sill, the central basin from the Mattituck Sill to Stratford Shoal, and the western basin from Stratford Shoal to the Narrows (*see* Figure 3-2). The Project is located in New York waters near the central axis of the Sound. The proposed FSRU will be located in the central basin of the Sound. The proposed pipeline will be located in New York waters from the FSRU to a tie-in with the existing IGTS just south of the Connecticut border. The pipeline will traverse portions of the central and western basins and will cross Stratford Shoal, which divides these basins.

Habitat types and ecological diversity in Long Island Sound are dependent on bathymetry, hydrology, geology and sediments, coastal morphology, and water quality.

The eastern basin of Long Island Sound is the deepest, with depths occasionally exceeding 328 feet (100 meters [m]) in some areas. The eastern basin is influenced by the great exchange of ocean water that occurs with Block Island Sound via the Race. The Mattituck Sill moderates deepwater flow between the eastern and central basin and effectively forms the division between the two. The central basin, the largest and widest

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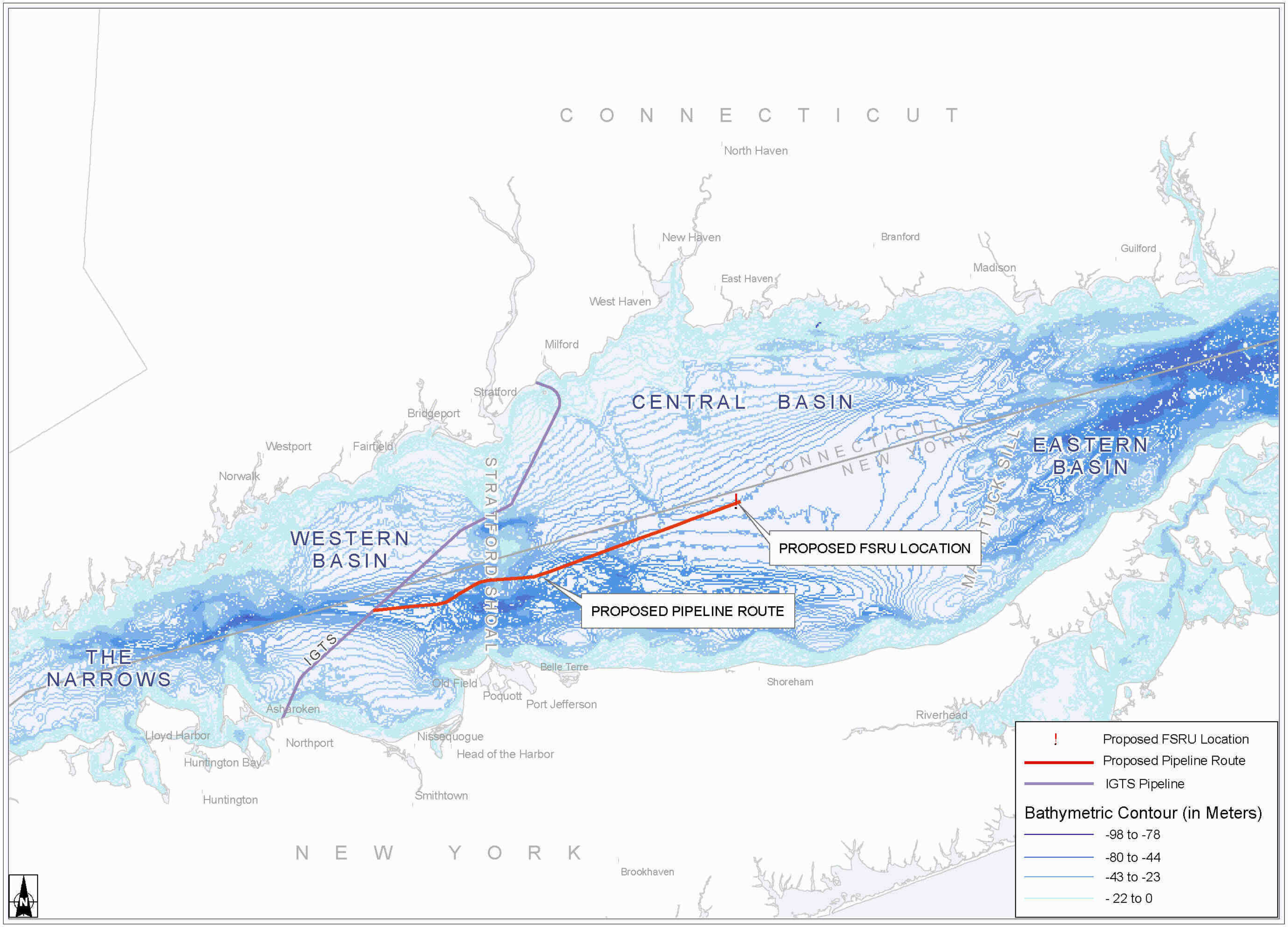


Source: U. S. Geological Survey Open-File Report OFR 00-304, 2000.

Figure 3-2 Proposed Broadwater Project Location in Long Island Sound, in Relation to the Central and Western Basins portion of the Sound, has depths up to 126 feet (38 m) in proximity to the Project area (*see* Figures 3-3a through 3-3d), with depths ranging up to 92 feet (28 meters) toward the eastern end of the Project area. Stratford Shoal limits water circulation between the central and western basins and forms the division between these basins. Water depths at the central portion of the shoal traversed by the Project are as shallow as 55 feet (17 meters), with steep slopes evident to the east and west of the central axis of the shoal. Although the western basin is generally shallower than the eastern and central basins, within the Project area depths ranged from 100 feet to 126 feet (30 to 38 meters) below sea level.

The most prevalent types of sediments in Long Island Sound, by percentage of area, are silt (31%), fine sand (30%), and coarse sand (20%); medium sand, gravelly sand, and gravel make up the remainder (19%). Sediments in the central basin are mapped as large areas of silt and fine sand, with some coarser sediments along the shorelines. Sediments in the western basin are mapped primarily as silt and fine sand; however, significant areas of medium and coarse sand also occur (USGS 2001). The sedimentary environments in the basins are primarily depositional. The sedimentary environment at Stratford Shoal is variable and includes areas of erosion/non-deposition, sorting and reworking, and fine-grained sedimentary deposition. As discussed in Resource Report 7, Soils, the actual conditions identified in the Sound closely approximate the mapped sedimentary environments in the Sound.

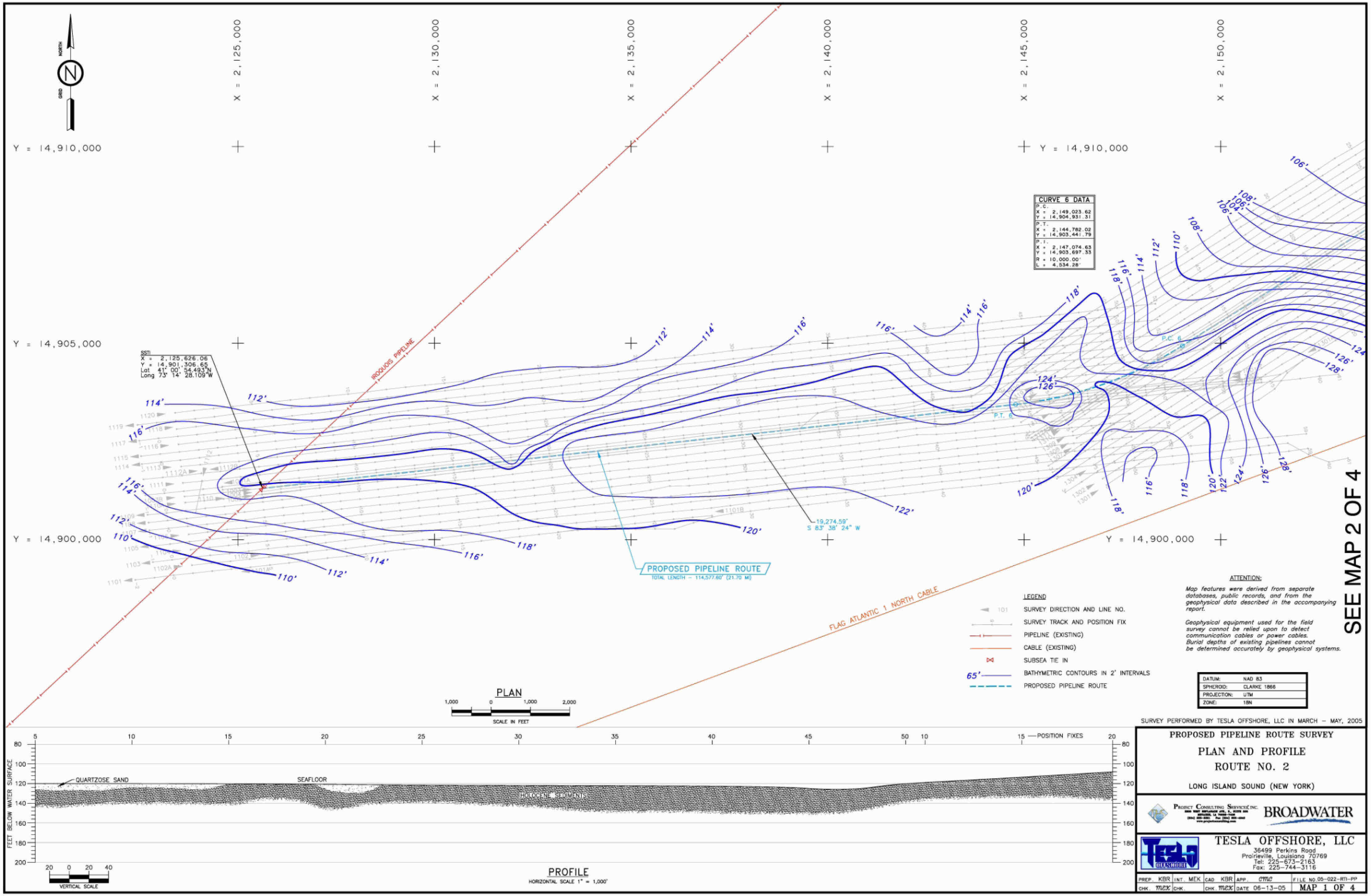
There are numerous finfish habitat types in Long Island Sound. Gottschall et al. (2000) divided the Sound into 14 habitat types for evaluation purposes. The majority of the Project falls within habitat area 2 in the western basin and habitat area 7 in the central basin (*see* Figure 3-4). Each of these areas is characterized by water depths greater than 18 m and a mud bottom (i.e., areas with >50% silt/clay) (Gottschall et al. 2000; Reid et al. 1979). Although Stratford Shoal is not included in the habitat areas devised by Gottschall, based on the review of existing literature and field surveys results, Stratford Shoal is comprised primarily of sand, gravel, and cobble substrates.

FSRU

Based on data collected during the geophysical surveys, the water depth at the proposed FSRU location is approximately 93 feet (28 m) and the area has relatively little topographic relief. The sedimentary environment is fine-grained deposition with bottom sediments dominated by sandy silt, clayey silt, or silt.

Pipeline Route

Based on field surveys, water depths along the proposed pipeline route through the central basin range from 95 to 130 feet (29 to 40 m), while water depths through the western basin range from 115 to 130 feet (35 to 40 m). Sediments along the pipeline route through the central and western basins consist primarily of sandy silt, clayey silt, or silt, and the sedimentary environment is primarily depositional.



NORTH
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X = 2,130,000
X = 2,135,000
X = 2,140,000
X = 2,145,000
X = 2,150,000
Y = 14,910,000
Y = 14,905,000
Y = 14,900,000
CURVE 6 DATA
P.C.
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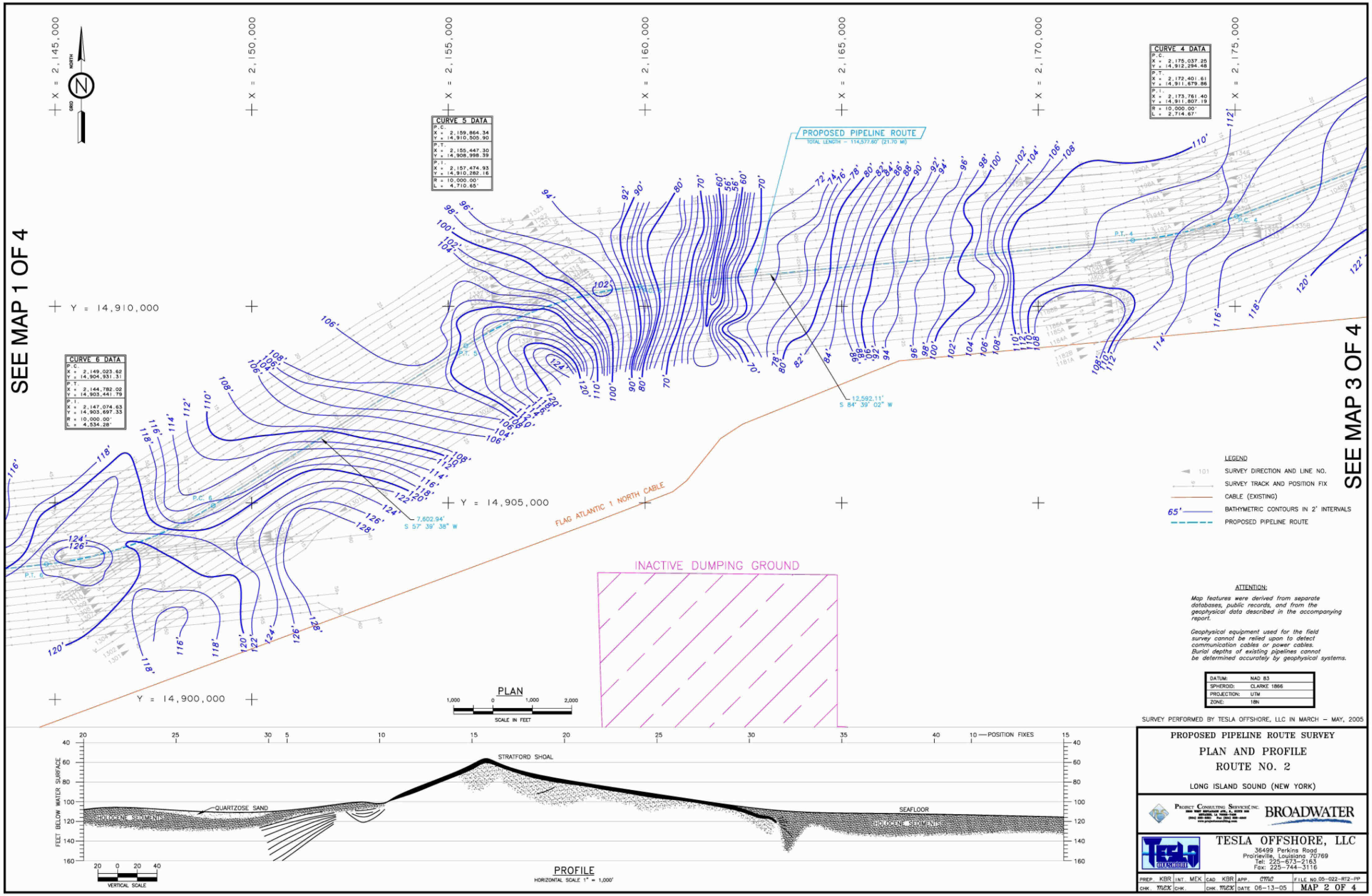
Y = 14,904,931.31
P.T.
X = 2,144,782.02
Y = 14,903,441.79
P.I.
X = 2,147,074.63
Y = 14,903,697.33
R = 10,000.00'
L = 4,534.28'
SSTI
X = 2,125,626.06
Y = 14,901,306.65
Lat 41° 00' 54.493"N
Long 73° 14' 28.109"W
IROQUOIS PIPELINE
FLAG ATLANTIC 1 NORTH CABLE
19,274.59'
S 83° 38' 24" W
PROPOSED PIPELINE ROUTE
TOTAL LENGTH - 114,577.60' (21.70 MI)
P.C. 6
P.T. 6
SEE MAP 2 OF 4
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
PIPELINE (EXISTING)
CABLE (EXISTING)
SUBSEA TIE IN
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
PLAN
SCALE IN FEET
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
FEET BELOW WATER SURFACE
QUARTZOSE SAND
SEAFLOOR
POSITION FIXES
PROFILE
HORIZONTAL SCALE 1" = 1,000'
VERTICAL SCALE
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
PROJECT CONSULTING SERVICES, INC.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR
INT. MEK
CAD KBR
CHK. MEK
DATE 06-13-05
FILE NO. 05-022-RTI-PP
MAP 1 OF 4


SEE MAP 1 OF 4
SEE MAP 3 OF 4
X = 2,145,000
X = 2,150,000
X = 2,155,000
X = 2,160,000
X = 2,165,000
X = 2,170,000
X = 2,175,000
Y = 14,910,000
Y = 14,905,000
Y = 14,900,000
NORTH
GRID
CURVE 5 DATA
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P.T.
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P.I.
X = 2,157,474.93
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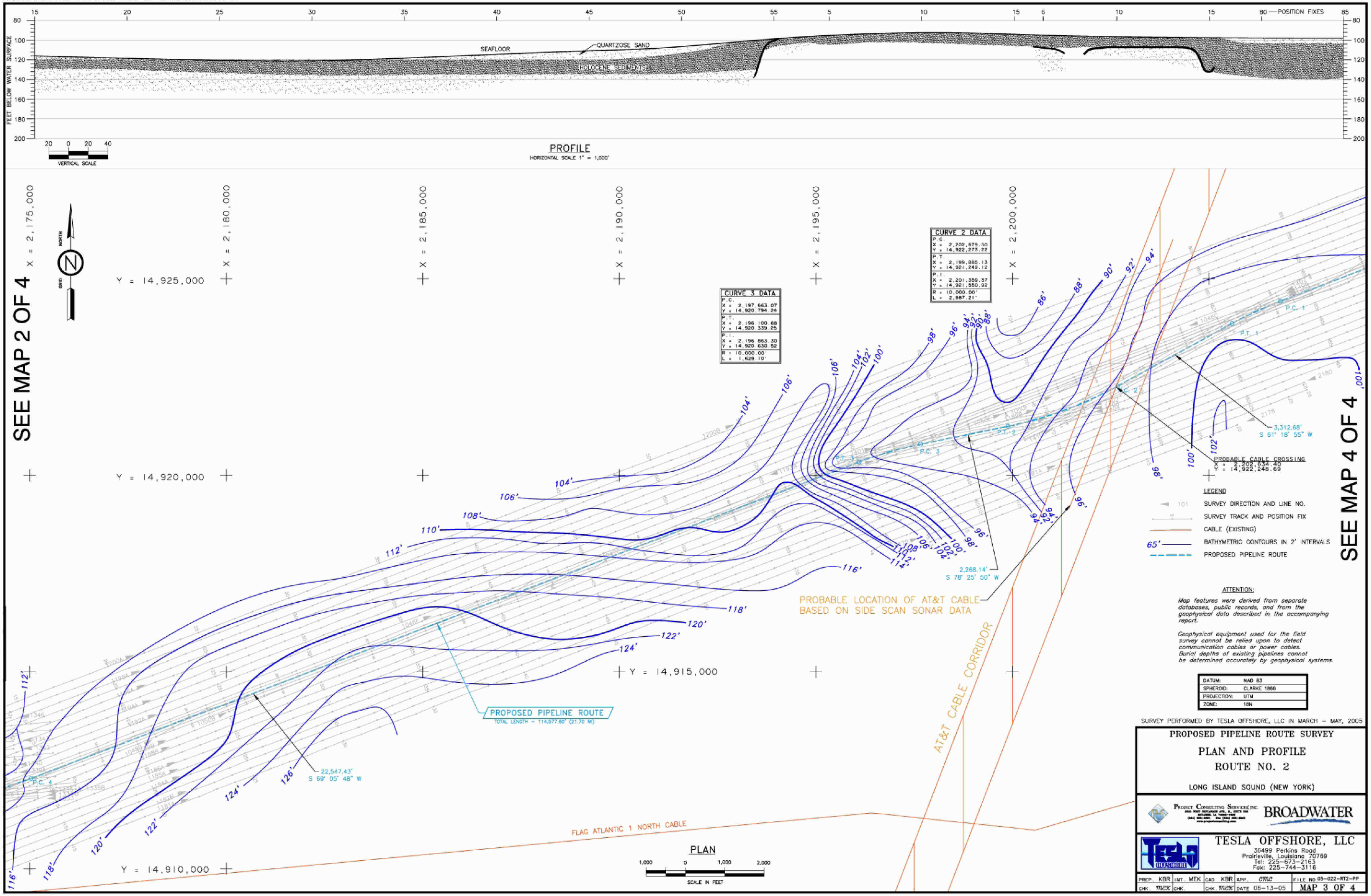
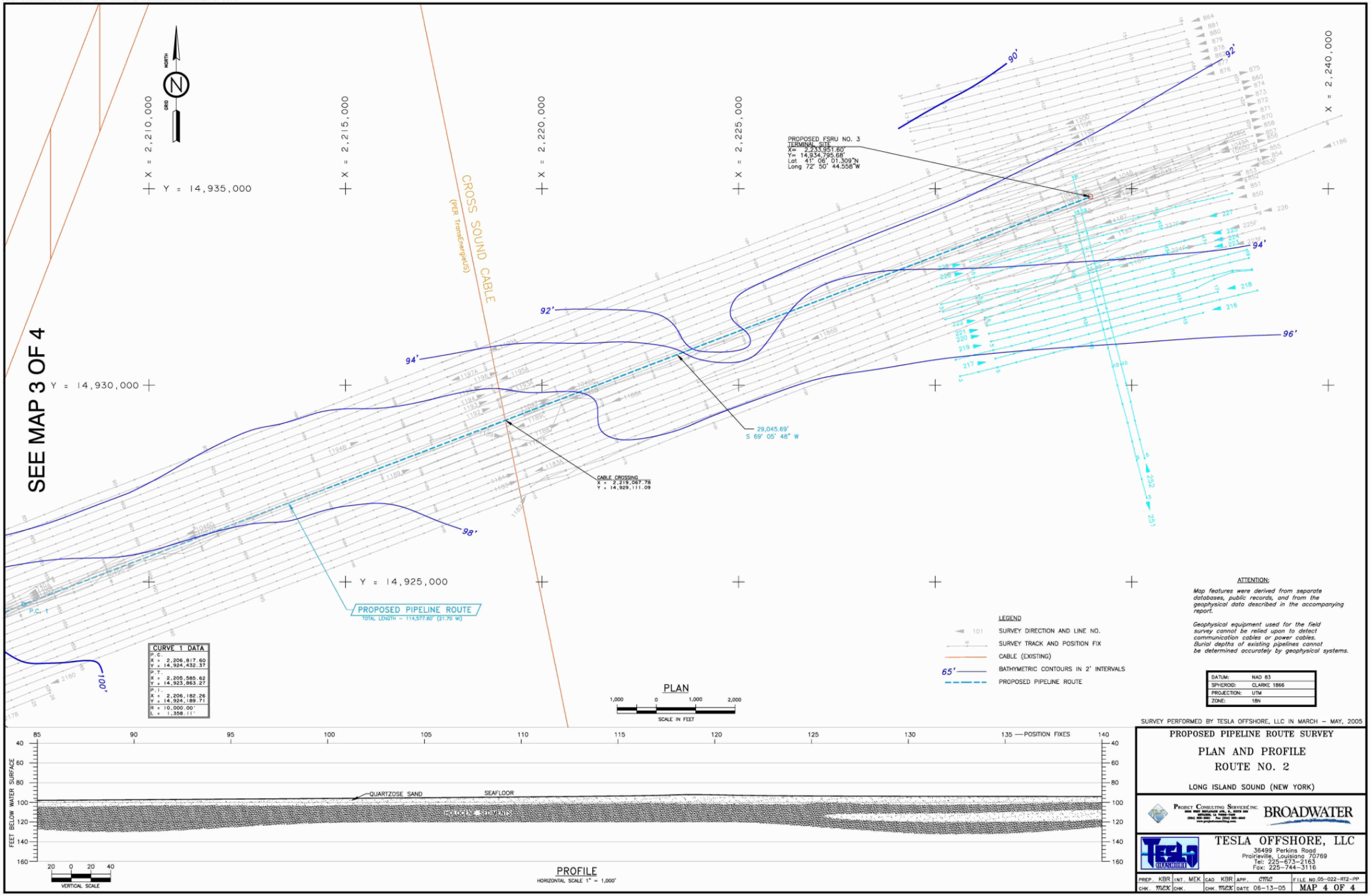
R = 10,000.00'
L = 4,710.65'
CURVE 6 DATA
P.C.
X = 2,149,023.62
Y = 14,904,931.31
P.T.
X = 2,144,782.02
Y = 14,903,441.79
P.I.
X = 2,147,074.63
Y = 14,903,697.33
R = 10,000.00'
L = 4,534.28'
CURVE 4 DATA
P.C.
X = 2,175,037.25
Y = 14,912,294.48
P.T.
X = 2,172,401.61
Y = 14,911,679.86
P.I.
X = 2,173,761.40
Y = 14,911,807.19
R = 10,000.00'
L = 2,714.67'
PROPOSED PIPELINE ROUTE
TOTAL LENGTH = 114,577.60' (21.70 MI)
12,592.11'
S 84° 39' 02" W
7,602.94'
S 57° 39' 38" W
P.C. 6
P.T. 6
P.T. 5
P.T. 4
P.C. 4
FLAG ATLANTIC 1 NORTH CABLE
INACTIVE DUMPING GROUND
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
65' BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
PLAN
1,000 0 1,000 2,000
SCALE IN FEET
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
10 — POSITION FIXES
FEET BELOW WATER SURFACE
STRATFORD SHOAL
QUARTZOSE SAND
HOLOCENE SEDIMENTS
SEAFLOOR
PROFILE
HORIZONTAL SCALE 1" = 1,000'
VERTICAL SCALE
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
Project Consulting Services, Inc.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR INT. MEK CAD KBR APP.
CHK. CHK. DATE 06-13-05
FILE NO. 05-022-RT2-PP
MAP 2 OF 4



POSITION FIXES
FEET BELOW WATER SURFACE
SEAFLOOR
QUARTZOSE SAND
HOLOCENE SEDIMENTS
VERTICAL SCALE
PROFILE
HORIZONTAL SCALE 1" = 1,000'
SEE MAP 2 OF 4
SEE MAP 4 OF 4
NORTH
GRID
X = 2,175,000
X = 2,180,000
X = 2,185,000
X = 2,190,000
X = 2,195,000
X = 2,200,000
Y = 14,925,000
Y = 14,920,000
Y = 14,915,000
Y = 14,910,000
CURVE 3 DATA
P.C.
X = 2,197,663.07
Y = 14,920,794.24
P.T.
X = 2,196,100.68
Y = 14,920,339.25
P.I.
X = 2,196,863.30
Y = 14,920,630.52
R = 10,000.00'
L = 1,629.10'
CURVE 2 DATA
P.C.
X = 2,202,679.50
Y = 14,922,273.22
P.T.
X = 2,199,885.13
Y = 14,921,249.12
P.I.
X = 2,201,359.37
Y = 14,921,550.92
R = 10,000.00'
L = 2,987.21'
3,312.68'
S 61° 18' 55" W
PROBABLE CABLE CROSSING
X = 2,202,634.40
Y = 14,922,248.69
2,268.14'
S 78° 25' 50" W
PROBABLE LOCATION OF AT&T CABLE
BASED ON SIDE SCAN SONAR DATA
AT&T CABLE CORRIDOR
PROPOSED PIPELINE ROUTE
TOTAL LENGTH ~ 114,377.60' (21.70 MI)
22,547.43'
S 69° 05' 48" W
FLAG ATLANTIC 1 NORTH CABLE
PLAN
SCALE IN FEET
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
Project Consulting Services, Inc.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR
INT. MEK
CAD KBR
APP. cmc
FILE NO. 05-022-RT2-PP
CHK. mex
CHK.
CHK. mex
DATE 06-13-05
MAP 3 OF 4


SEE MAP 3 OF 4
NORTH
GRID
X = 2,210,000
X = 2,215,000
X = 2,220,000
X = 2,225,000
X = 2,240,000
Y = 14,935,000
Y = 14,930,000
Y = 14,925,000
CROSS SOUND CABLE
(PER TransEnergieUS)
PROPOSED FSRU NO. 3
TERMINAL SITE
X= 2,233,951.60'
Y= 14,934,795.68'
Lat 41° 06' 01.309"N
Long 72° 50' 44.558"W
29,045.69'
S 69° 05' 48" W
CABLE CROSSING
X = 2,219,067.78
Y = 14,929,111.09
PROPOSED PIPELINE ROUTE
TOTAL LENGTH = 114,577.60' (21.70 M)
P.C. 1
90'
92'
94'
96'
98'
100'
CURVE 1 DATA
P.C.
X = 2,206,817.60
Y = 14,924,432.37
P.T.
X = 2,205,565.62
Y = 14,923,863.27
P.I.
X = 2,206,182.26
Y = 14,924,189.71
R = 10,000.00'
L = 1,358.11'
PLAN
1,000 0 1,000 2,000
SCALE IN FEET
LEGEND
SURVEY DIRECTION AND LINE NO.
SURVEY TRACK AND POSITION FIX
CABLE (EXISTING)
BATHYMETRIC CONTOURS IN 2' INTERVALS
PROPOSED PIPELINE ROUTE
ATTENTION:
Map features were derived from separate databases, public records, and from the geophysical data described in the accompanying report.
Geophysical equipment used for the field survey cannot be relied upon to detect communication cables or power cables. Burial depths of existing pipelines cannot be determined accurately by geophysical systems.
DATUM: NAD 83
SPHEROID: CLARKE 1866
PROJECTION: UTM
ZONE: 18N
SURVEY PERFORMED BY TESLA OFFSHORE, LLC IN MARCH – MAY, 2005
85 90 95 100 105 110 115 120 125 130 135 140
POSITION FIXES
FEET BELOW WATER SURFACE
QUARTZOSE SAND
SEAFLOOR
HOLOCENE SEDIMENTS
20 0 20 40
VERTICAL SCALE
PROFILE
HORIZONTAL SCALE 1" = 1,000'
PROPOSED PIPELINE ROUTE SURVEY
PLAN AND PROFILE
ROUTE NO. 2
LONG ISLAND SOUND (NEW YORK)
Project Consulting Services, Inc.
BROADWATER
TESLA OFFSHORE, LLC
36499 Perkins Road
Prairieville, Louisiana 70769
Tel: 225-673-2163
Fax: 225-744-3116
PREP. KBR INT. MEK CAD KBR APP. CMC FILE NO. 05-022-RT2-PP
CHK. MEK CHK. CHK. MEK DATE 06-13-05 MAP 4 OF 4

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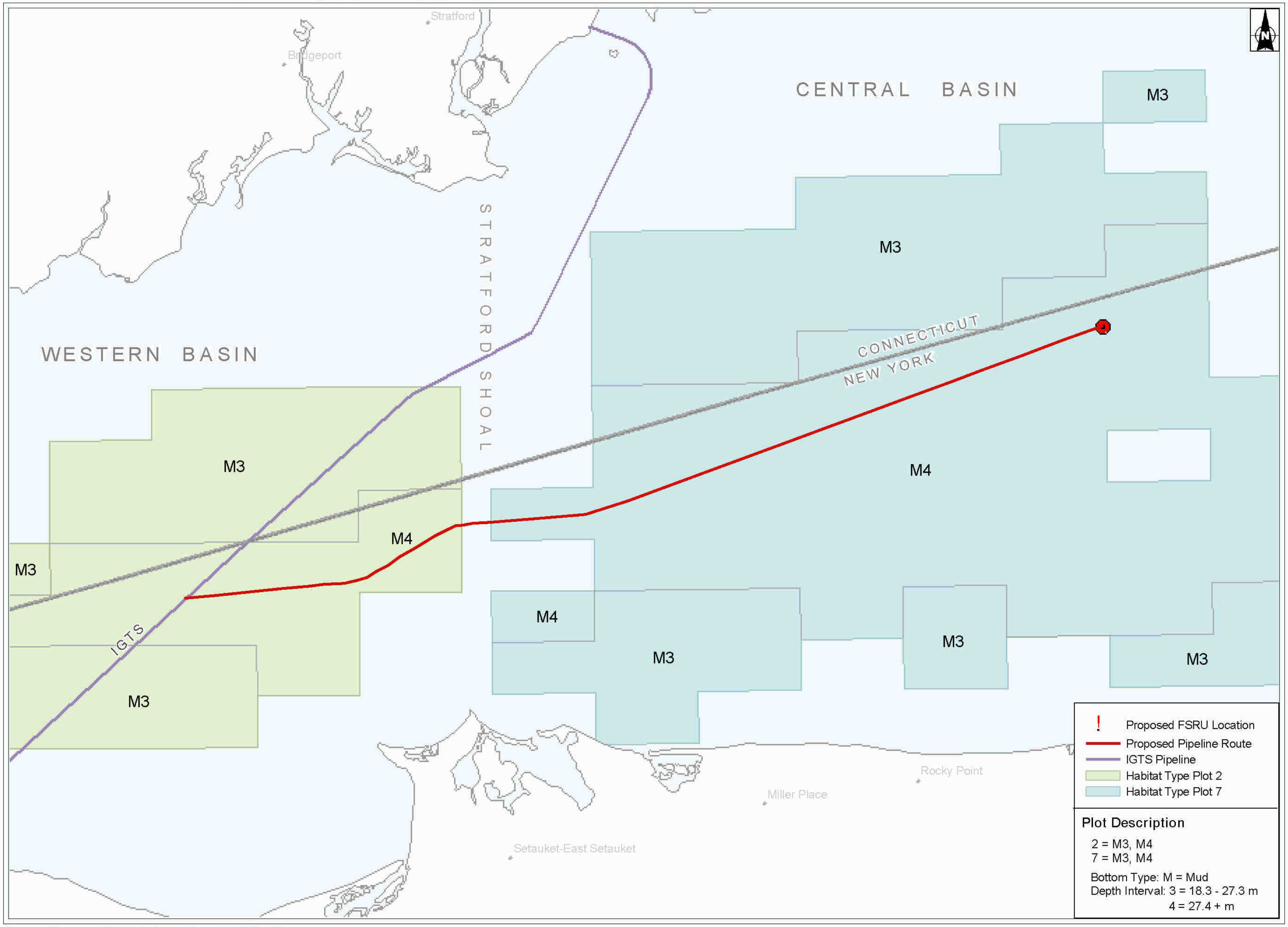
\\BUFSDL4\GIS\Pensacola\LNG\BROADWATER\Maps\MXD\Resource_Reports_Final\RR3\f\Fig3-4_habitat_types.mxd 01/15/06



Source: Figure 4, NOAA Technical Report NMFS 148. Gottschall, et.al., 2000.

Figure 3-4 Habitat Types in the Project Area

BW001191

Water depth along the proposed pipeline route through Stratford Shoal is considerably more variable due to the sharp topographic rise associated with the shoal. Depths across Stratford Shoal range from approximately 55 feet (17 m) toward the central portion of the shoal to 126 feet (38 m) toward the outer edge of the shoal. The pipeline route through Stratford Shoal traverses erosion/non-deposition, and sorting and reworking sediments in the steeper central portion of the shoal, and fine-grained depositional sedimentary environments at the shoal margins. Sands and gravels are predominant in the central portion of the shoal, with silt-clay/sand, and sand-silt-clay sediments more predominant on the margins. Bathymetry and sediments types along the route are indicated on Figures 3-3a through d and 3-5, respectively.

3.2.1.1 Essential Fish Habitat

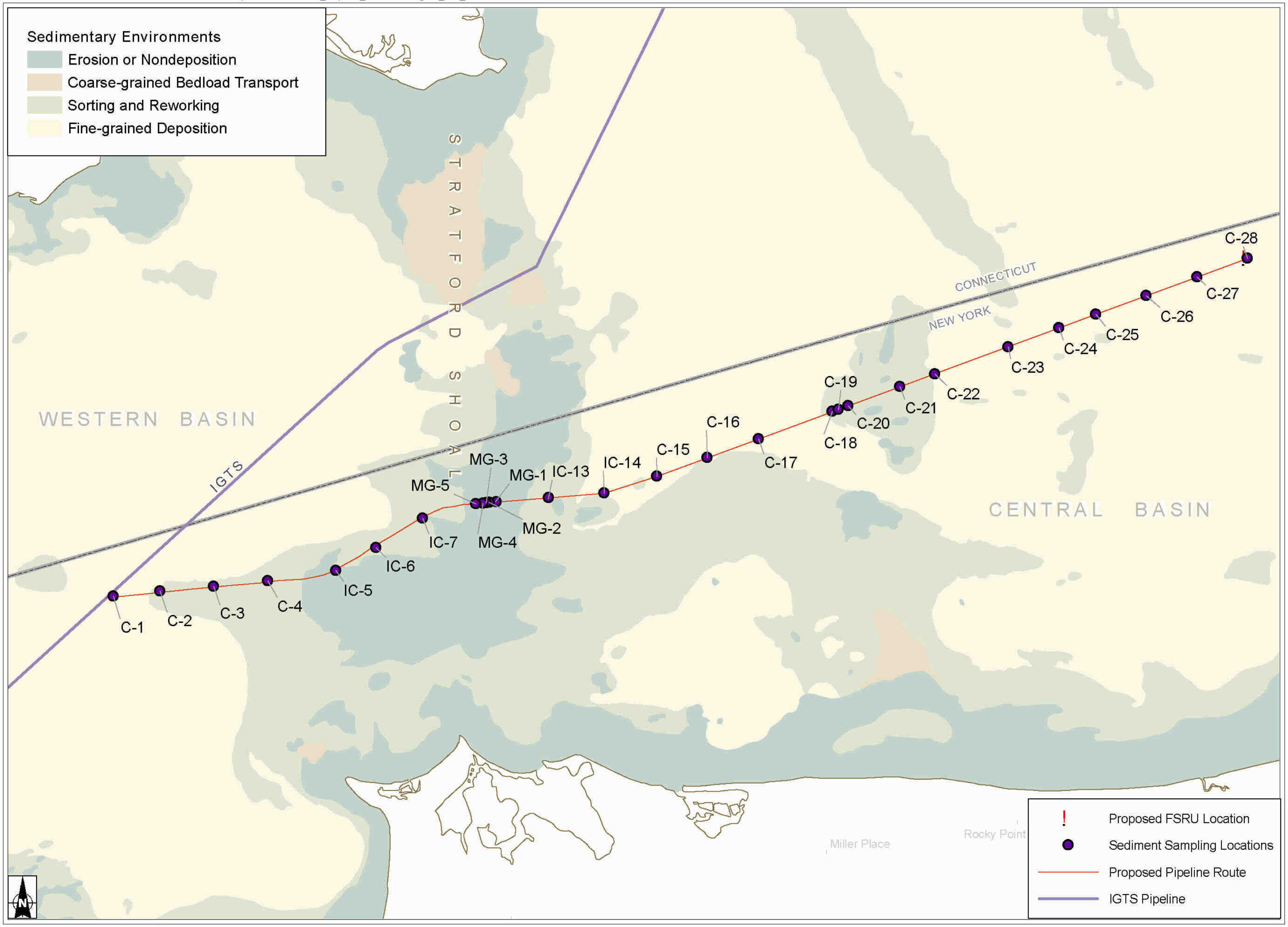
Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act, Essential Fish Habitat (EFH), or "those waters and substrate necessary to fish for spawning, breeding, and feeding or growth to maturity," have been designated in Long Island Sound. The National Oceanic and Atmospheric Administration's fisheries unit (NOAA Fisheries) must be consulted on all proposed activities authorized, funded, or undertaken by a federal agency that may adversely affect EFH. Broadwater is in the process of consulting with NOAA Fisheries to assess potential impacts resulting from the Project.

The proposed FSRU and pipeline route will cross designated EFH for several species in Long Island Sound. A summary of the 10-minute by 10-minute latitude and longitude squares and a summary of those species for which EFH has been designated within or adjacent to the proposed pipeline route are provided on Figure 3-6. Table 3-1 provides a summary of the species and specific life stages for which EFH has been designated in the Project area. A detailed discussion of EFH resources is provided as Appendix A to this report.

3.2.1.2 NYSDOS Significant Coastal Fish and Wildlife Habitat

The New York State Department of State (NYSDOS) designates and maps significant coastal fish and wildlife habitat (SCFWH) areas within the state based on recommendations from the New York State Department of Environmental Conservation (NYSDEC). In addition, regionally important natural areas are identified in the Long Island Sound Coastal Management Plan (NYSDOS 2005). New York State's Coastal Management Program and the Long Island Sound Coastal Management Plan include policies that call for the protection of Long Island Sound ecosystems, including SCFWH areas and regionally important natural areas.

NYSDOS-designated SCFWH areas and regionally important natural areas in the central and western basins of Long Island Sound are depicted in relation to the Project area on Figures 3-7A and 3-7B. The SCFWH area nearest the FSRU, Wading River Marsh, is approximately 9.5 miles (15.3 km) from the Project area. The habitat area nearest the pipeline, Port Jefferson Beaches, is over 3 miles from the Project area. Based on the distances from the proposed Project, no Project-related impacts on significant coastal habitats are anticipated.



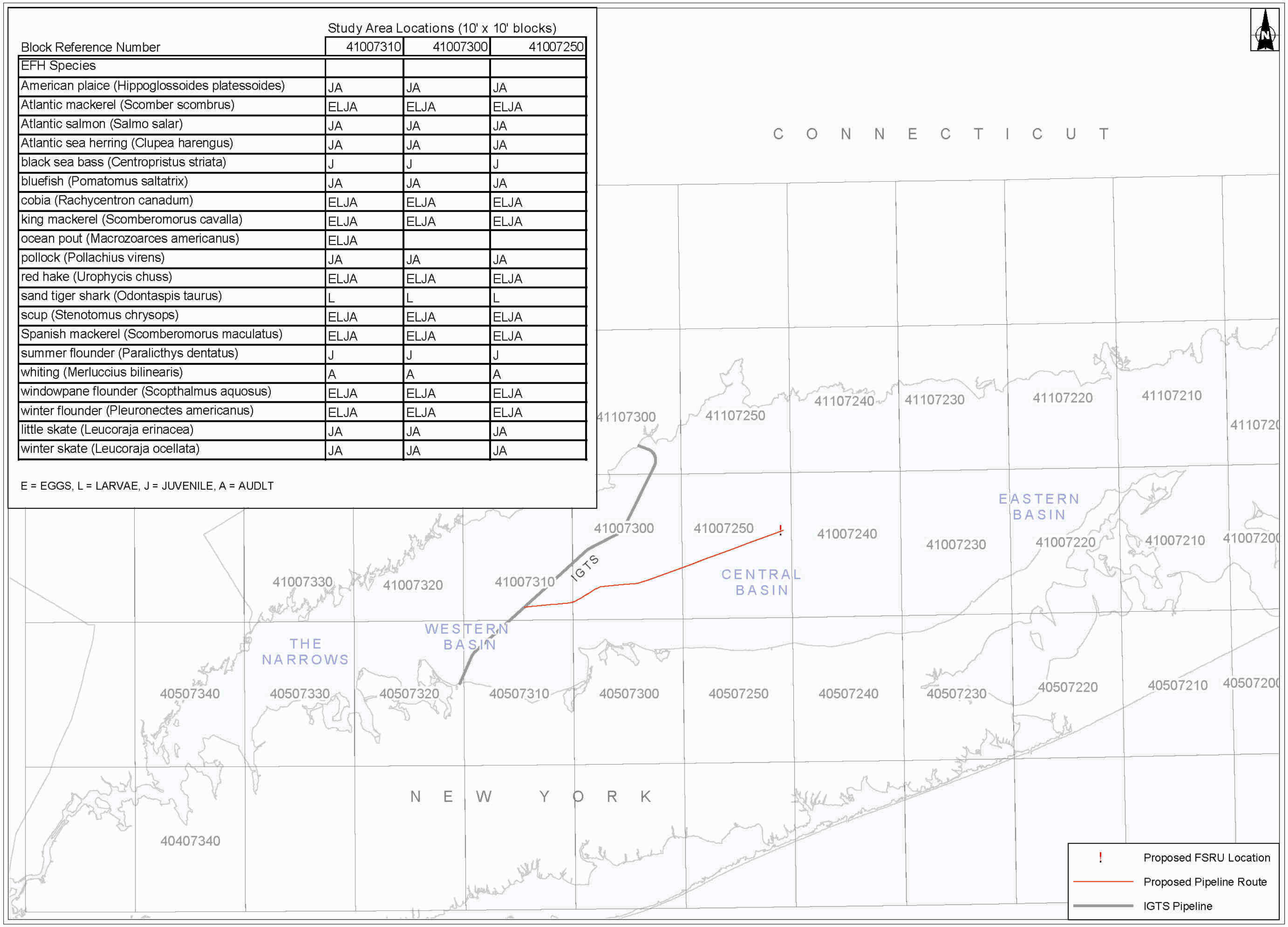
Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000.

0 1 2 4
Miles

Figure 3-5 Sedimentary Environments

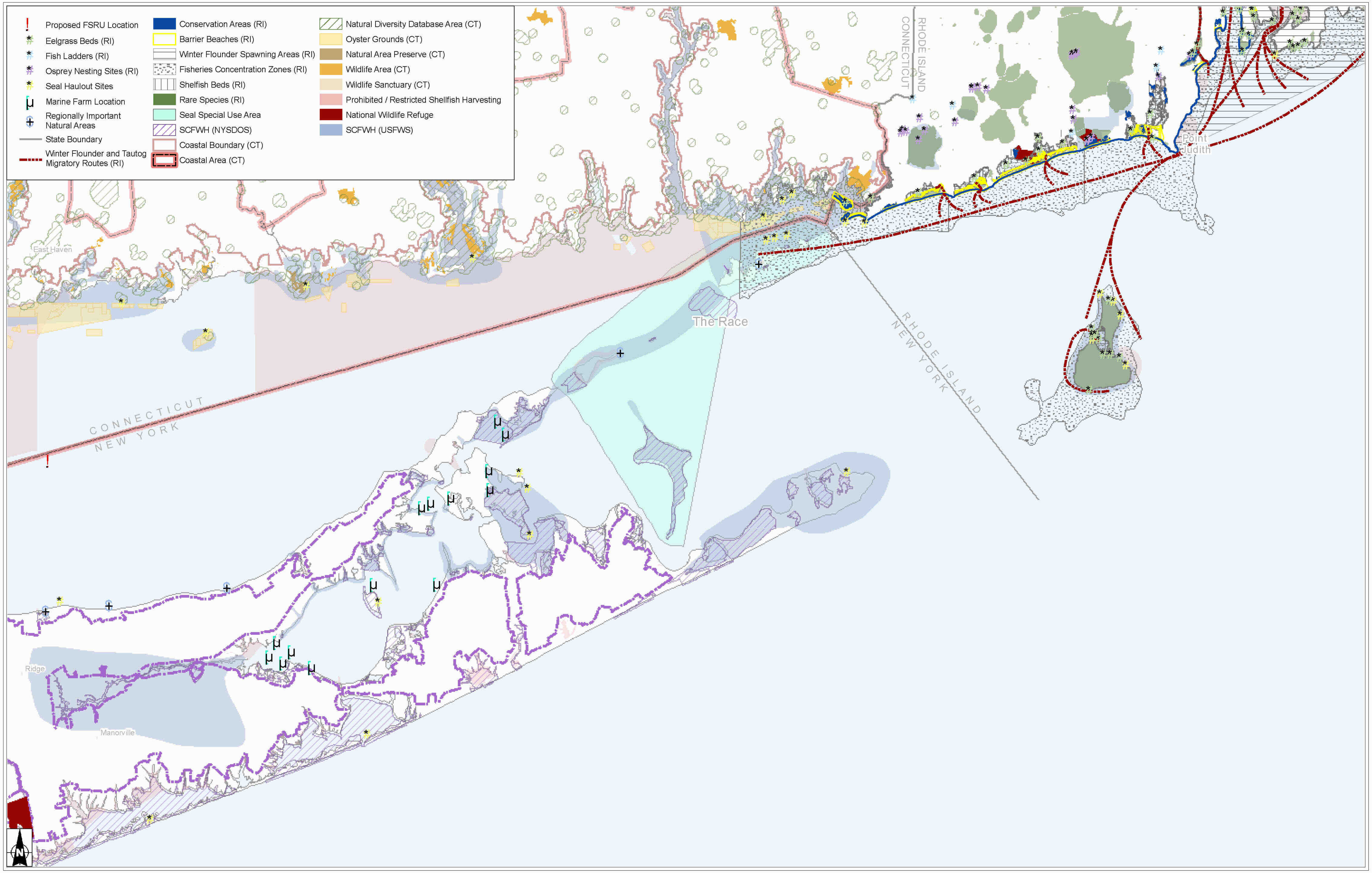
Block Reference Number	Study Area Locations (10' x 10' blocks) 41007310	41007300	41007250
EFH Species			
American plaice (Hippoglossoides platessoides)	JA	JA	JA
Atlantic mackerel (Scomber scombrus)	ELJA	ELJA	ELJA
Atlantic salmon (Salmo salar)	JA	JA	JA
Atlantic sea herring (Clupea harengus)	JA	JA	JA
black sea bass (Centropristus striata)	J	J	J
bluefish (Pomatomus saltatrix)	JA	JA	JA
cobia (Rachycentron canadum)	ELJA	ELJA	ELJA
king mackerel (Scomberomorus cavalla)	ELJA	ELJA	ELJA
ocean pout (Macrozoarces americanus)	ELJA		
pollock (Pollachius virens)	JA	JA	JA
red hake (Urophycis chuss)	ELJA	ELJA	ELJA
sand tiger shark (Odontaspis taurus)	L	L	L
scup (Stenotomus chrysops)	ELJA	ELJA	ELJA
Spanish mackerel (Scomberomorus maculatus)	ELJA	ELJA	ELJA
summer flounder (Paralicthys dentatus)	J	J	J
whiting (Merluccius bilinearis)	A	A	A
windowpane flounder (Scopthalmus aquosus)	ELJA	ELJA	ELJA
winter flounder (Pleuronectes americanus)	ELJA	ELJA	ELJA
little skate (Leucoraja erinacea)	JA	JA	JA
winter skate (Leucoraja ocellata)	JA	JA	JA

E = EGGS, L = LARVAE, J = JUVENILE, A = AUDLT



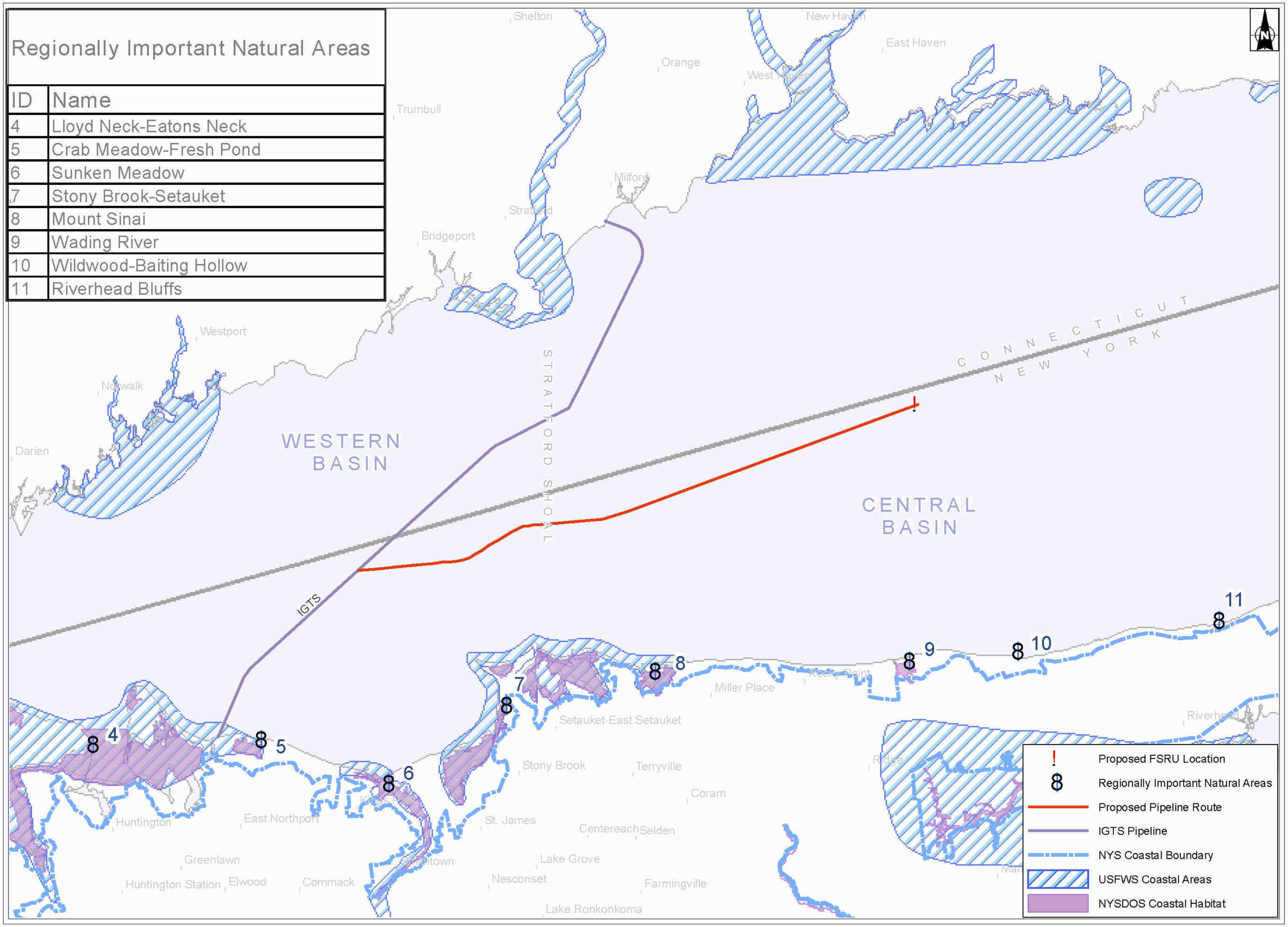
Source: Essential Fish Habitat, NOAA Fisheries, 2005.

Figure 3-6 Essential Fish Habitats in the Project Area



0 2.5 5 10
Miles

Figure 3-7A
Significant Habitat Areas in and Around Long Island Sound



Source: US Fish and Wildlife Service, NYSDOS Coastal Program, Long Island Sound Coastal Management Plan.

0 2.5 5 10
Miles

Figure 3-7B Significant Habitat Areas

Table 3-1 Species with Identified EFH within the Project Area

Species	Egg	Larvae	Juvenile	Adult
American plaice (*Hippoglossoides platessoides*)*			X	X
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X
Atlantic salmon (*Salmo salar*)			X	X
Atlantic sea herring (*Clupea harengus*)			X	X
Black sea bass (*Centropristus striata*)	n/a		X	
Bluefish (*Pomatomus saltatrix*)			X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Little skate (*Leucoraja erinacea*)			X	X
Ocean pout (*Macrozoarces americanus*)	X	X	X	X
Pollock (*Pollachius virens*)			X	X
Red hake (*Urophycis chuss*)	X	X	X	X
Sand tiger shark (*Odontaspis taurus*)		X		
Scup (*Stenotomus chrysops*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Summer flounder (*Paralicthys dentatus*)			X	
Silver hake (*Merluccius bilinearis*)				X
Windowpane flounder (*Scopthalmus aquosus*)	X	X	X	X
Winter flounder (*Pleuronectes americanus*)	X	X	X	X
Winter skate (*Leucoraja ocellata*)			X	X

* While the summaries for EFH square 41007310, 41007300 and 41007250 (listed in the on-line geographic Guide to EFH Designations) identifies these areas as EFH for J and A life stages of American Plaice, no EFH designation for any life stage of this species is indicated for Long Island Sound in the NEFMC EFH Amendment dated October 7, 1998. In addition, this species has not been encountered during LISTS surveys conducted by CTDEP from 1984-2003. Therefore, this species is not discussed in this assessment.

NYSDOS-designated SCFWH areas and regionally important natural areas in the central and eastern basins of Long Island Sound and in Block Island Sound along potential LNG carrier routes are depicted relative to the Project area on Figure 3-7A. Due to the transient nature of the LNG carriers in proximity to significant coastal habitats, no Project-related impacts are anticipated.

3.2.1.3 USFWS Northeast Coastal Areas Study

Long Island Sound is one of 28 Estuaries of National Significance designated by Congress, which have been identified as containing a significant portion of the shoreline of the continental U.S. and are considered to be among the most productive estuaries from a biological perspective. Both the Peconic Bay and New York-New Jersey Harbor also are classified as Estuaries of National Significance. Other recognized estuaries supporting considerable mixed use include Galveston Bay, Texas; Mobile Bay, Alabama; Puget Sound, Washington; and San Francisco Bay, California.

The United States Fish and Wildlife Service (USFWS) received funding in 1990 for a study of the coastal areas of southern New England and Long Island, including Long Island Sound. The study included an inventory of the natural values of the coastal areas and identification of areas in greatest need of protection for fish and wildlife habitat, endangered species habitat, migratory waterfowl values, and the preservation of biological diversity. The study culminated in a report with a brief narrative for regionally significant habitats and habitat complexes in need of protection. The significance of a site or resource was based on its regional importance to federal trust species. The report states, "For example, the presence of a population, regardless of size, of a U.S. Endangered or Threatened species, the occurrence of an exemplary and undisturbed stand of a regionally scarce community type, a large wintering concentration of waterfowl in numbers or densities considerably greater that what is generally encountered in the region, areas with a high diversity of trust species, a highly vulnerable breeding or spawning area of a fish or bird species that has been substantially reduced or qualitatively degraded from historical times, may all be considered "regionally significant" sites or resources in this report"(USFWS 2005).

USFWS-designated SCFWH sites in the central and western Sound are depicted, in relation to the Project area, on Figure 3-7B. Each of the USFWS-designated significant coastal habitat sites within New York State corresponds to a significant coastal fish and wildlife habitat area designated by NYSDOS, and all but one (the North Fork Beach Complex) correspond to regionally important natural areas identified in the Long Island Sound Coastal Management Plan.

The USFWS significant coastal habitat site in New York waters nearest to the FSRU, Port Jefferson-Stony Brook Harbor Complex, is approximately 12.8 miles (20.6 km) from the FSRU. This complex also is closest in proximity to the pipeline, located approximately 3.8 miles (6.1 km) from the pipeline south of Stratford Shoal. The USFWS significant coastal habitat site in Connecticut waters nearest the FSRU is the New Haven Harbor Complex. While this mapped habitat extends out into the Sound, the point nearest to the FSRU is still approximately 8.7 miles (14 km) from the Project area. Based on the distance of these significant coastal habitats from the proposed Project, Project-related impacts on significant coastal habitats throughout Long Island Sound are not anticipated.

USFWS-designated SCFWH sites and regionally important natural areas in the central and eastern basins of Long Island Sound and in Block Island Sound that lie in proximity to potential LNG carrier routes are depicted relative to the Project area on Figure 3-7A. Due to the transient nature of the LNG carriers in proximity to significant coastal habitats, no Project-related impacts are anticipated.

3.2.1.4 Wetlands

Siting the Project in deep water near the middle of the Sound and away from shallow nearshore areas avoids impacts on wetlands.

3.2.1.5 Vegetation

Siting the Project in deep water near the middle of the Sound avoids impacts on vegetation. Based on the water depths in proximity to the Project area and the results of the video survey performed in conjunction with the environmental field sampling effort (*see* Appendix B), no submerged aquatic vegetation is expected to occur in the Project area. Submerged aquatic vegetation is more typically associated with shallow nearshore waters.

3.2.2 Fish and Wildlife Resources

3.2.2.1 Benthos

Marine benthos are those organisms that are attached to or rest on the sediments (epifauna) and those that burrow or bore into the sediments (infauna). Benthos comprise an important portion of the estuarine food webs (Zajac 1996). Commercially important shellfish such as lobster and sea scallops are discussed in Section 3.2.2.3. This section focuses on the deepwater (>16 feet [>5m]) infaunal benthic community.

Long Island Sound is home to a well-developed and mature (high abundance and diversity) invertebrate community. The benthic invertebrate community, in particular, is an important part of the marine environment in the Sound. The benthic community consists of a wide variety of small aquatic invertebrates that burrow into or are in contact with the substrate, such as worms (polychaetes and oligochaetes), crustaceans (shrimp, lobster, and amphipods), and bivalves (clams and mussels). Because they are suspension and deposit feeders, benthic organisms cycle nutrients from the sediment and water column to higher trophic levels (Wildish and Kristmanson 1997).

Life strategies of benthic invertebrates are tightly coupled with sediment characteristics and depth of water. The distribution and abundance of benthic invertebrates are influenced by a wide variety of physical parameters (e.g., type of substrate, water temperature, dissolved oxygen levels, pH, salinity, and hydrodynamics). Benthic organisms can provide information about local environmental conditions because they live and feed on the sediment and have limited mobility. The abundance, diversity, and composition of benthic species, in combination with their relative pollution tolerance, are indicators of habitat quality.

When an area is disturbed, the benthic community is often the first to reestablish, especially if sediment conditions are reestablished or improved relative to previous conditions.

Several historical studies of the benthic community structure in Long Island Sound have been conducted. In 1956 Sanders conducted short-term studies at eight locations in the central Sound that led to concepts about the relationship between infaunal species and their sedimentary environment. Sanders recognized a community type, the *Nephtys incisa - Yoldia limatula - Nucula annulata* community, that was consistent among four of the eight sites he sampled. Each of the four sites was found in the central basin at depths of 13 to 98 feet (4 to 30 m) in sediments of >25% silt-clay content (Sanders 1956).

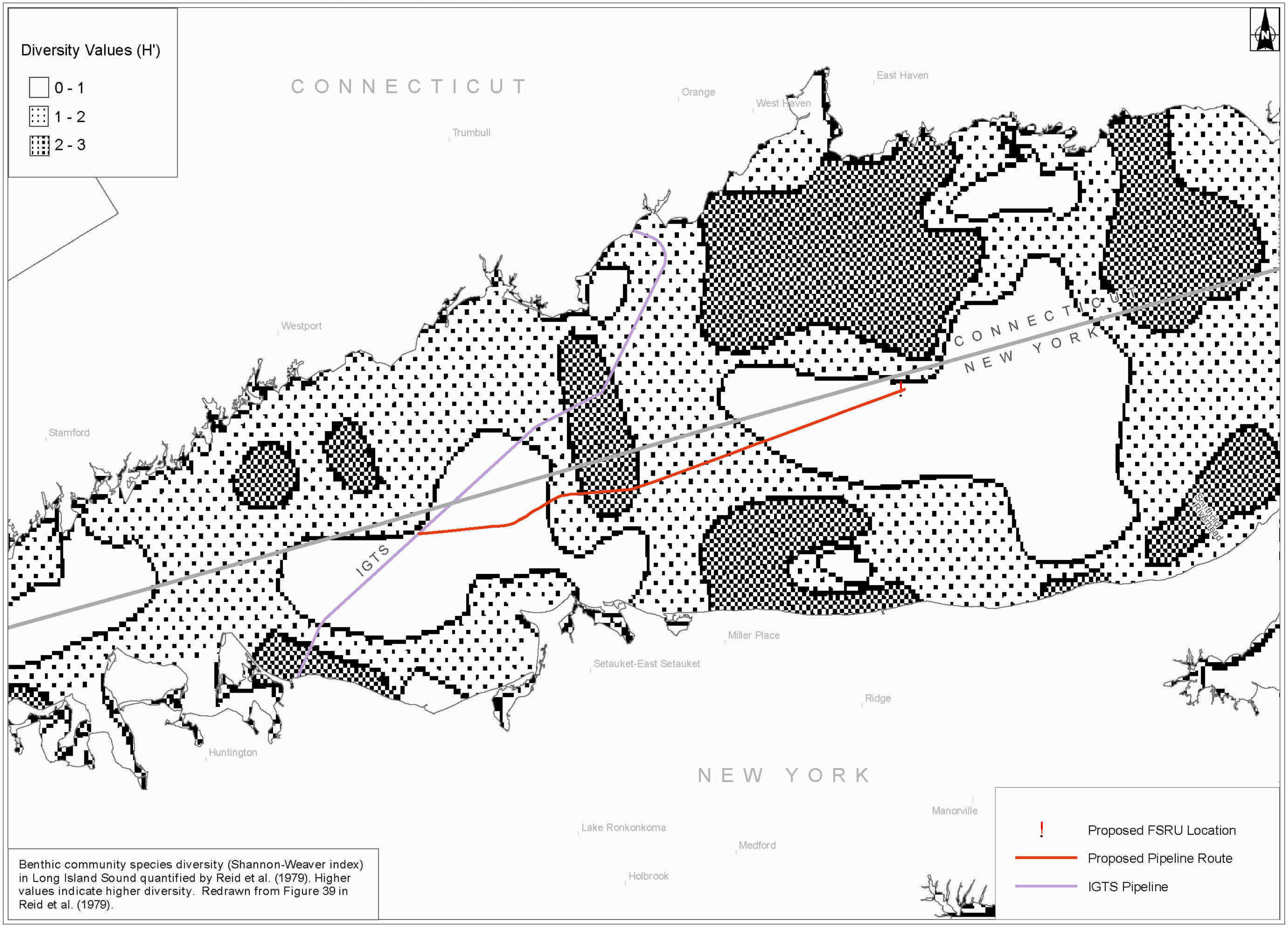
In 1972 Reid et al. conducted the first Sound-wide survey of benthic communities in Long Island Sound, sampling 142 stations located every 1.8 to 3 miles (3 to 5 km) on north-south transects spaced 5.4 miles (8.7 km) apart for the length of the Sound (100 sampling stations in the central and western basins) (Reid et al. 1979). A subset of the stations were resampled in April and September 1973, and 45 of the stations were revisited annually between 1975 and 1978.

Annelids, mollusks, and arthropods accounted for the majority of the 248 species collected. When these taxa were totaled, the relative abundance was annelids 46%, arthropods 33%, and mollusks 21%. The studies also showed that the lowest species diversity was often found at deepwater stations in sediments with a high silt-clay content (*see* Figure 3-8).

Three consistent faunal groups were recognized in the central and western basins of the Sound (*see* Figure 3-9): a muddy, deep-water assemblage distributed throughout much of the central and western basins; a shallow, sandy assemblage along much of the north shore of Long Island; and a transitional shallow-water assemblage in the western portion of the Sound and along the Connecticut shore. While additional benthic communities existed outside of these groupings and these areas, they were not as consistent as the species assemblages described for these areas. A muddy assemblage, consistent with that described by Sanders (1956), was found to occupy the flat seabed in the central and western basins; this assemblage consists of polycheate worms (*Nephtys incisa*, *Mediomastus ambiseta*, and *Polydora cornuta*); clams (*Nucula annulata* and *Yoldia limatula*); and the amphipod *Ampelisca abdita* (Reid et al. 1979).

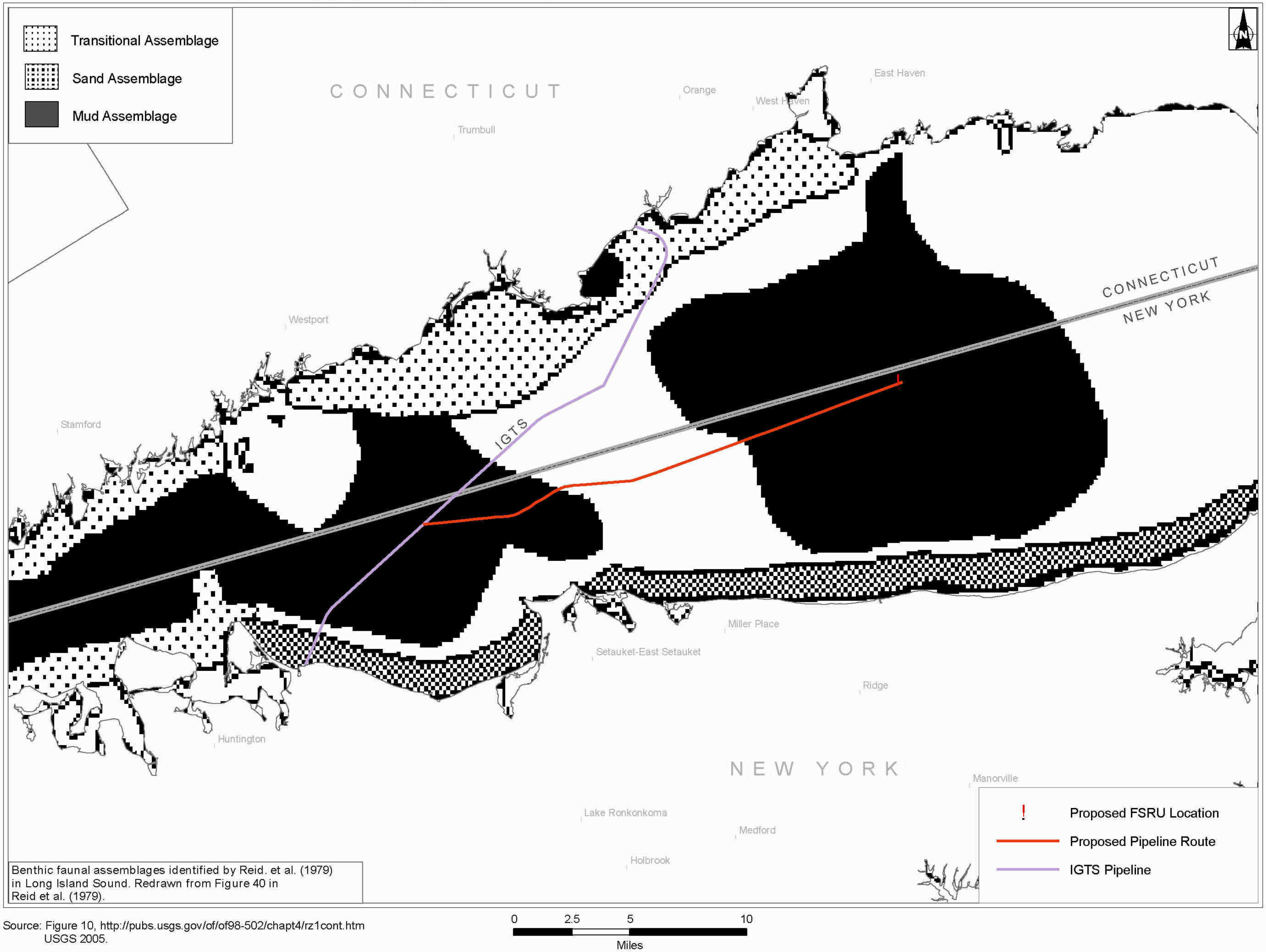
A study conducted by Pellegrino and Hubbard (1983) in Connecticut waters of Long Island Sound confirmed several general trends in community structure that were found previously by Reid et al. (1979). Species richness increased from west to east in the Sound, the mean density of individuals per sample was generally higher in the central and eastern basins of the Sound than in the western basin, and the western and central basins were dominated by the bivalves *Mulinia lateralis* and *Nucula annulata* and the polychaete *Nephtys incisa* (Pellegrino and Hubbard 1983). The inclusion of *Mulinia lateralis* as one of the dominant species is significant because it is considered an opportunistic species (Williams et al. 1986). The dominance of an opportunistic species may indicate recent disturbance or other habitat degradation.

Zajac (1998) and Zajac et al. (2000) reviewed the existing literature and reanalyzed portions of the data to characterize Sound-wide trends in community structure and variability in community structure at different spatial scales. Sound-wide trends are



Source: Figure 9, http://pubs.usgs.gov/of/of98-502/chapt4/rz1cont.htm
USGS 2005.

Figure 3-8 Benthic Community Species Diversity in the Project Area



Source: Figure 10, http://pubs.usgs.gov/of/of98-502/chapt4/rz1cont.htm
USGS 2005.

Figure 3-9 Benthic Faunal Assemblages in the Project Area evident in the general makeup of communities, and there also is a fair degree of local variation in community structure. Consistent groups of species form community types that are recognizable in portions of the Sound such as the central basin.

Based on Zajac's re-analysis of the previously collected data, benthic communities were found to be highly variable and were grouped into more than a dozen assemblages. Assemblages in the central and western basins were found to be similar to those reported in previous studies.

Stations along Stratford Shoal were found to be the most species-rich, with 31 of the possible 35 dominant species present. Species that occurred at moderate to high abundances included *Asabellides occulata*, *Tellina agilis*, *Spiophanes bombyx*, and *lymenella zonalis*. Other sub-clusters near Stratford Shoal were found to be species-rich but dominated by crustaceans, including *Ampelisca abdita*, *Ampelisca vadorum*, and *Corophium acheruscum* (Zajac et al. 2000).

The analysis suggests that spatial variation in community structure is low for large areas of the western and central basins and relatively higher in the Narrows to the west and in the eastern basin, where greater interaction with the Atlantic Ocean occurs. Overall trends in community variation may be related to several habitat characteristics, including sediment grain-size, the geographic location of the habitat, and size of the habitat. General community types appear to be consistent, but longer-term changes may occur in the populations of some of the dominant organisms (Zajac et al. 2000).

McCall (1977, 1978) conducted studies in Long Island Sound between 1972 and 1973 that were designed to address how infaunal communities responded to disturbance, as well as subsequent successional dynamics leading to the reestablishment of the benthic community. McCall (1977) determined that there were three successional groups of species: Group I, those that initially colonized disturbed areas in very high numbers; Group II, those that are typical of intermediary succession following disturbance; and Group III, those that represent the successional endpoint community. Based on McCall's work, the communities sampled during Broadwater's field efforts, which are described in greater detail below, resemble a gradation between secondary and tertiary successional stages. These stages exhibit species that are similar to those noted by McCall as Groups II and III, which typically attain peak abundance during middle to late portions of succession and include bivalves and polycheates. These species represent larger, mobile and deeper-lived organisms (especially Group III). In contrast, the first stage successional community (Group I) typically consists of early colonizers, which are very high in number and opportunistic in nature. They are generally small, live in tubes within upper layers of the sediment, and have rapid colonization life history strategies.

In April and May 2005, a site-specific benthic survey was conducted to verify and refine information on the benthic communities in the Project area. Samples were collected at the proposed location of the FSRU, and at 27 stations along the proposed pipeline route (*see* Figure 3-10). Each location was sampled in triplicate, with one sample centered on the proposed centerline of the pipeline and two additional samples offset by

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Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

0 1 2 4
Miles

Figure 3-10 Broadwater Benthic Sampling Stations

BW001204

approximately 200 feet from the centerline. Appendix C provides the laboratory analysis results for the benthic identification at each sampling location.

In addition to the benthic collection, videos of the bottom were obtained for 23 of the stations, which were analyzed to supplement benthic sampling. To collect videos of the bottom, a drop camera was lowered to the depth for the specific sample location as indicated by the fathometer on the survey vessel. The drop camera was allowed to stabilize in the water column until it remained steady enough to obtain a good image. An onboard monitor was used to ensure that the camera was steady and to make initial observations of the benthic community. Once the image was steady, a slow trawl across the bottom captured the bottom video for that location. The video collected during the field surveys is provided as Appendix D.

Underwater video observations are best used to supplement existing benthic data. Due to the camera movement, shadows, camera magnification, and video quality, it is often difficult to confirm species identification and to determine abundances using only video observations. Results of the benthic characterization based on the video observations are provided below.

In addition to the benthic analyses, sediment and chemical analyses also were conducted at each station. Chemical analysis revealed that sediments were essentially clean, with no stations exceeding established regulatory guidance values. The results of the chemical analysis are discussed in greater detail in Section 2.3.6 of Resource Report 2, Water Use and Quality. Grain-size analysis showed that the sediments were generally consistent with those mapped for the Sound. Sediment results are discussed in greater detail in Resource Report 7, Soils. The majority of the stations were characterized by fine-grained sediments (fine sand, silt, and clay), with few rock mounds (sites MG 1, MG2, and MG3 in the vicinity of Stratford Shoal) and amphipod mats (site C28) in the Project area.

Based on field surveys, soft-sediment communities in the Project area were dominated by several burrowing and tube-dwelling polychaetes, amphipods, tunicates, and anemones. In general, shell hash (*Mercenaria mercenaria*, other clam species, *Crepidula* sp., and *Ensis directis*) varied in abundance within the Project area. Based on video observation, no live individuals of shellfish (hard clams, surf clams, or oysters) were observed, which suggests that a low density of shellfish occur in this area. However, at several locations the video showed evidence of burrows, which are most likely used by lobsters, other invertebrates (e.g., the mud shrimp [*Axius serratus*]), and fish species in the area. The greatest differences in species composition were found when comparing the soft-sediment community (the majority of the proposed Project area) compared to the community inhabiting the rock mounds (sites MG1, MG2, and MG3 across Stratford Shoal). The results of the benthic sampling are summarized in Table 3-2.

Benthic community biodiversity was assessed for each of the sampling locations from the benthic grab data (*see* Table 3-2). Diversity was calculated for each sampling location using the Shannon-Weiner Index. While benthic diversity in the mud assemblages was generally greater than expected based on existing literature, the field data show the

Table 3-2 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	Sample ID		
	C1N	C1C	C1S
Total # of Organisms Identified	125	295	205
Total # of Organisms in Sample	125	295	205
Taxa Richness	15	14	19
Diversity (H_1)	2.13	1.26	2.01
Eveness	1.81	1.10	1.57

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Copepoda *Nephtys* sp.

	C2N	C2C	C2S
Total # of Organisms Identified	108	107	109
Total # of Organisms in Sample	630	510	625
Taxa Richness	11	11	14
Diversity (H_1)	1.11	1.53	1.87
Eveness	1.06	1.47	1.63

Notes: dominant species, when totaled = at least 50% sample

Copepoda Bivalvia (juv.)

	C3N	C3C	C3S
Total # of Organisms Identified	101	111	154
Total # of Organisms in Sample	346	368	856
Taxa Richness	16	12	14
Diversity (H_1)	2.00	1.55	1.68
Eveness	1.66	1.44	1.47

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Cirratulidae

	C4N	C4C	C4S
Total # of Organisms Identified	107	114	107
Total # of Organisms in Sample	402	783	1160
Taxa Richness	13	11	13
Diversity (H_1)	1.86	1.57	1.70
Eveness	1.67	1.50	1.52

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda Cirratulidae

	IC5N	IC5C	IC5S
Total # of Organisms Identified	129	126	138
Total # of Organisms in Sample	698	788	347
Taxa Richness	17	17	18
Diversity (H_1)	2.35	2.53	2.12
Eveness	1.91	2.06	1.69

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Bivalvia (juv.) *Pinnixa* sp. Copepoda

	IC6N	IC6C	IC6S
Total # of Organisms Identified	96	61	115
Total # of Organisms in Sample	330	61	407
Taxa Richness	13	13	13
Diversity (H_1)	1.69	2.02	1.70
Eveness	1.52	1.82	1.52

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda *Nephtys* sp. *Molgula* sp. *Leptocheirus pinguis* Cirratulidae

	IC7N	IC7C	IC7S
Total # of Organisms Identified	62	96	77
Total # of Organisms in Sample	62	96	77
Taxa Richness	13	15	13
Diversity (H_1)	2.04	2.08	1.52
Eveness	1.83	1.77	1.36

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp. *Nephtys* sp. Cirratulidae Copepoda *Molgula* sp. *Haminoea solitaria*

	MG3N	MG3C	MG3S
Total # of Organisms Identified	112	99	95
Total # of Organisms in Sample	700	438	906
Taxa Richness	13	14	15
Diversity (H_1)	1.89	2.01	1.94
Eveness	1.69	1.75	1.65

Notes: dominant species, when totaled = at least 50% sample

Ampelisca sp. *Ampharete arctica*

		MG4C	
Total # of Organisms Identified		103	
Total # of Organisms in Sample		774	
Taxa Richness		18	
Diversity (H_1)		\$2.10	
Eveness		\$1.67	

Notes: dominant species, when totaled = at least 50% sample

Ampelisca sp. *Ampharete arctica*

	MG5N	MG5C	MG5S
Total # of Organisms Identified	100	105	92
Total # of Organisms in Sample	480	767	400
Taxa Richness	13	14	14
Diversity (H_1)	2.06	2.04	2.08
Eveness	1.85	1.78	1.81

Notes: dominant species, when totaled = at least 50% sample

Ampharete arctica Ampeliscidae Aoridae *Astarte undata*

Table 3-2 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	IC13N	IC13C	IC13S
Total # of Organisms Identified	113	134	114
Total # of Organisms in Sample	920	1130	751
Taxa Richness	18	17	12
Diversity (H_1)	2.41	2.42	2.06
Eveness	1.92	1.97	1.91

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Pinnixa* sp., Aoridae, *Ampelisca sp.*, *Nephtys* sp., *Asychis elongata*, *Anadara traversa*

	IC14N	IC14C	IC14S
Total # of Organisms Identified	120	144	182
Total # of Organisms in Sample	120	144	182
Taxa Richness	16	20	15
Diversity (H_1)	2.21	2.24	1.58
Eveness	1.83	1.73	1.34

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), Copepoda, Aoridae

	C15N	C15C	C15S
Total # of Organisms Identified	98	116	105
Total # of Organisms in Sample	211	500	273
Taxa Richness	18	14	14
Diversity (H_1)	2.25	1.66	1.65
Eveness	1.80	1.45	1.44

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Tellina* sp., Copepoda, *Nephtys* sp.

	C16N	C16C	C16S
Total # of Organisms Identified	101	94	95
Total # of Organisms in Sample	240	270	365
Taxa Richness	14	20	15
Diversity (H_1)	2.02	2.39	2.01
Eveness	1.77	1.83	1.71

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), Copepoda, *Pinnixa* sp.

	C17N	C17C	C17S
Total # of Organisms Identified	76	77	73
Total # of Organisms in Sample	76	77	73
Taxa Richness	16	15	15
Diversity (H_1)	2.50	2.33	2.28
Eveness	2.08	1.98	1.94

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Pinnixa* sp., Sabellidae, *Ateocina canaliculata*[2], Copepoda, *Tellina* sp., *Molgula* sp.

	C18N	C18C	C18S
Total # of Organisms Identified	123	112	94
Total # of Organisms in Sample	1386	1220	1400
Taxa Richness	16	18	19
Diversity (H_1)	2.29	2.35	2.50
Eveness	1.90	1.87	1.95

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp., *Nephtys* sp., Copepoda, *Leptocheirus pinguis*, *Ampharete arctica*, *Clymenella* sp., *Asychis elongata*

	C19N	C19C	C19S
Total # of Organisms Identified	92	106	126
Total # of Organisms in Sample	1034	1220	970
Taxa Richness	19	19	17
Diversity (H_1)	2.41	2.58	2.03
Eveness	1.89	2.02	1.65

Notes: dominant species, when totaled = at least 50% sample

Copepoda, *Ampharete arctica*, *Crepidula fornicata*, *Nephtys* sp.

	C20N	C20C	C20S
Total # of Organisms Identified	91	113	150
Total # of Organisms in Sample	483	113	150
Taxa Richness	17	17	18
Diversity (H_1)	2.41	2.28	2.50
Eveness	1.96	1.85	1.99

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp., *Ampharete arctica*, *Crepidula plana*, *Asychis elongata*, *Ampelisca* sp., Aoridae

	C21	C21C	C21S
	108	128	118
Total # of Organisms in Sample	690	1120	674
Taxa Richness	15	16	18
Diversity (H_1)	2.26	2.42	2.42
Eveness	1.92	2.01	1.92

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp., *Ampelisca* sp., *Nephtys* sp., *Ampharete arctica*, Copepoda

	C22N	C22C	C22S
Total # of Organisms Identified	60	62	50
Total # of Organisms in Sample	60	62	50
Taxa Richness	14	13	13
Diversity (H_1)	2.27	2.08	2.25
Eveness	1.98	1.87	2.02

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp., *Molgula* sp., Copepoda, Aoridae, *Asychis elongata*

Table 3-2 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	C23N	C23C	C23S
Total # of Organisms Identified	124	112	157
Total # of Organisms in Sample	481	112	157
Taxa Richness	10	16	20
Diversity (H_1)	1.28	1.81	2.55
Eveness	1.28	1.50	1.96

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda Pyramellidae *Nephtys* sp. *Asychis elongata* Sabellidae *Molgula* sp.

	C24N	C24C	C24S
Total # of Organisms Identified	102	96	113
Total # of Organisms in Sample	102	96	113
Taxa Richness	16	17	21
Diversity (H_1)	2.27	2.33	2.61
Eveness	1.88	1.89	1.98

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp. *Pinnixa* sp. Copepoda *Molgula* sp. Bivalvia (juv.) *Ampelisca* sp.

	C25N	C25C	C25S
Total # of Organisms Identified	100	132	109
Total # of Organisms in Sample	100	132	109
Taxa Richness	21	21	16
Diversity (H_1)	2.60	2.61	2.24
Eveness	1.97	1.98	1.86

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Bivalvia (juv.) *Nephtys* sp. *Asychis elongata* Sabellidae *Ampelisca* sp. *Pinnixa* sp. Copepoda

	C26N	C26C	C26S
Total # of Organisms Identified	195	18	99
Total # of Organisms in Sample	195	18	99
Taxa Richness	15	7	18
Diversity (H_1)	2.14	1.74	2.55
Eveness	1.82	2.06	2.04

Notes: dominant species, when totaled = at least 50% sample

Cirratulidae *Nephtys* sp. *Ampelisca* sp. *Pinnixa* sp. Copepoda Bivalvia (juv.) *Molgula* sp.

	C27N	C27C	C27S
Total # of Organisms Identified	156	138	123
Total # of Organisms in Sample	156	138	123
Taxa Richness	15	19	16
Diversity (H_1)	2.14	2.29	2.05
Eveness	1.82	1.79	1.70

Notes: dominant species, when totaled = at least 50% sample

Cirratulidae *Nephtys* sp. Copepoda

	C28N	C28C	C28S
Total # of Organisms Identified	118	122	197
Total # of Organisms in Sample	118	122	197
Taxa Richness	13	17	13
Diversity (H_1)	1.87	2.44	1.97
Eveness	1.67	1.98	1.77

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Copepoda Cirratulidae *Nephtys* sp. *Ampelisca* sp. Bivalvia (juv.)

diversity to be consistent within a given portion of the Project area. Diversity values (H^1) were expected to be lowest along the floors of the western and central basins (ranging from 0 to 1), moderate within the transitional areas around Stratford Shoal (ranging from 1 to 2), and highest along Stratford Shoal (ranging from 2 to 3) (*see* Figure 3-8). Values calculated from the samples collected revealed moderate diversity west of Stratford Shoal (typically from 1 to 2), and values at and east of Stratford Shoal were generally higher (typically from 2 to 3).

The benthic survey revealed that benthic communities are generally consistent with what would be expected based on depth, substrate, and sedimentary environment in the Project area (*see* Figure 3-11). Four general benthic communities were identified in the Project area: a Deep Basin Mud Community, a Western Transition Community, a Shoal Community, and an Eastern Transition Community (*see* Figure 3-12).

Deep Basin Mud Community

(Stations C-1, -2 , -3, -4, -19, -21, -22, -23, -24, -26, -27, and -28)
A Deep Basin Mud Community was found at stations located at the eastern and western edges of the proposed Project area, along the floor of the western and central basins. Bottom substrates are comprised of fine silt and sand and a patchy distribution of clay. Based on video observations, these 12 analyzed stations were similar with regard to abundance of worm tubes and burrowing anemones, as well as the occasional presence of the tunicate *Molgula* sp. The mud tubes are comprised of mud and mucous. Shrimp, amphipods, and a few solitary hydroids were present at these stations. Burrows were also observed. These burrows are most likely used by lobsters, other invertebrates (e.g., mud shrimp [*Axius serratus*]), and fish species in the area. Shell debris is sparse at these stations. The benthic samples collected at these sites were dominated by polychaetes, amphipods, and juvenile bivalves (*see* Table 3-2). These organisms are typically found in soft sediments.

Western Transition Community

(Stations IC-5, -6, and -7)
The Western Transition Community is located in the western portion of the Project area, along the transition from the western basin floor to Stratford Shoal. The bottom sediment observed in the underwater video is composed of fine-grain silt, which is similar to the existing sediment mapping classifications. Worm tubes and anemones are present. One of the dominant organisms collected in the benthic samples was the pea crab (*Pinnixia* sp). Pea crabs are typically found living on mud bottoms and in tubes of the polychaete worms *Arenicola* and *Chaetopterus variopedatus*, which also were present in benthic samples. These polychaete species are found in soft offshore sediments. The solitary tunicate *Molgula* sp. and the polychaete worm *Nephtys* sp. also were dominant species identified in the benthic samples. Both of these species are found in areas with a mixture of fine-grained sand and silt.

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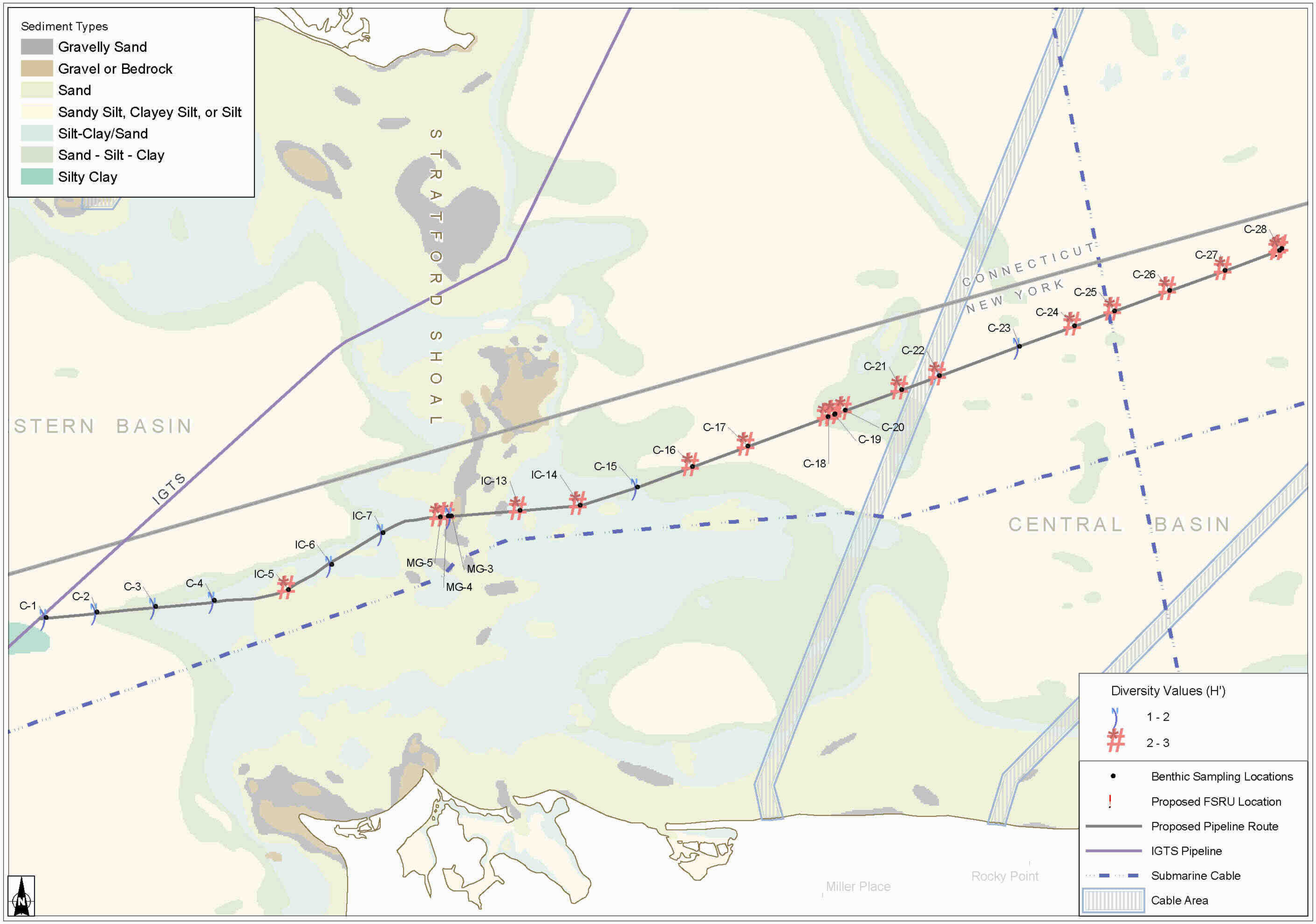
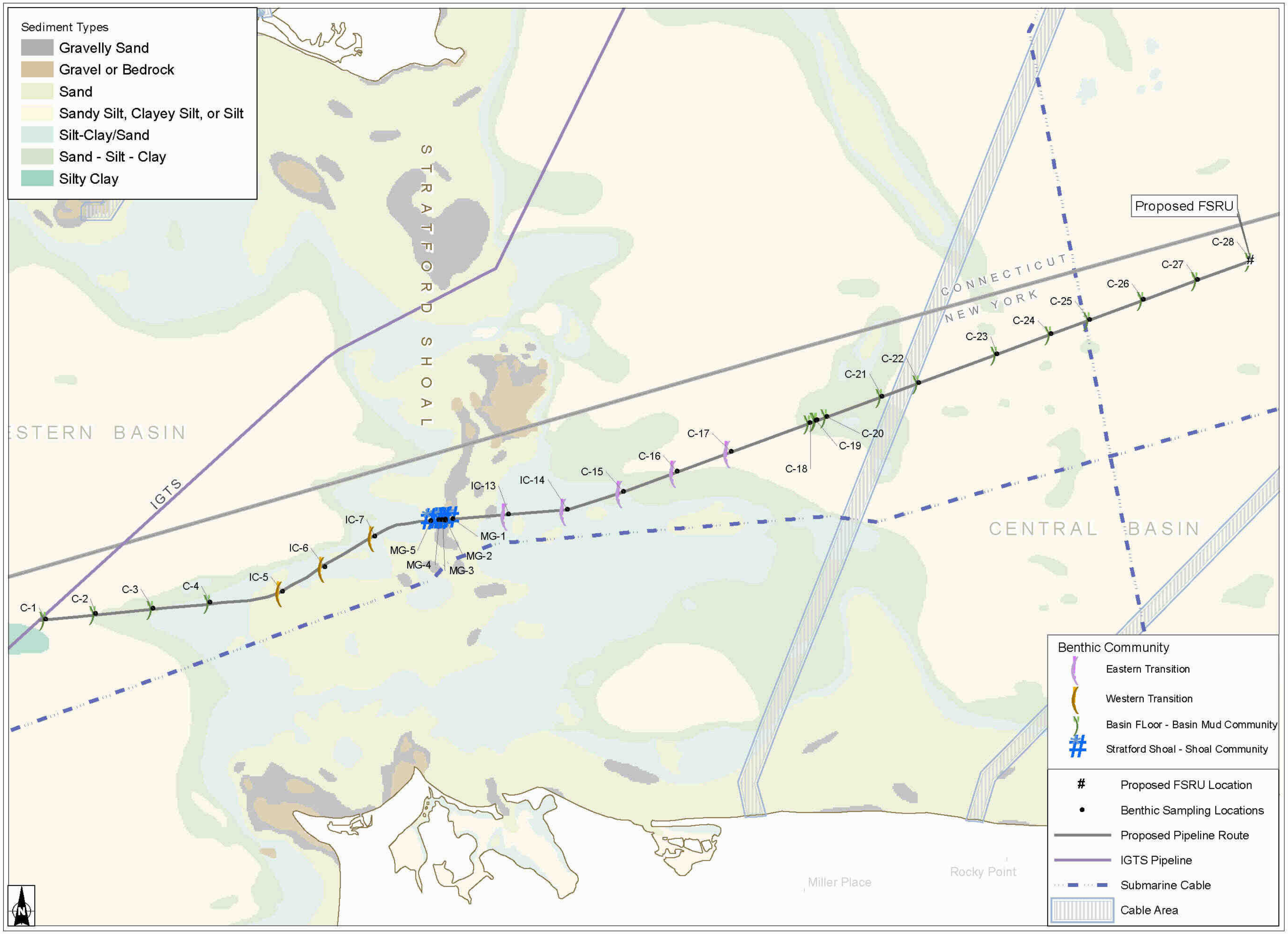


Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000; Broadwater Surveys conducted in April/May 2005.

Figure 3-11 Benthic Community Species Diversity in the Project Area; Based on Spring 2005 Field Surveys



Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

Figure 3-12 Broadwater Benthic Communities; Based on Spring 2005 Field Surveys

Shoal Community

(Stations MG -1, -2 and -3)
The Shoal Community is located at Stratford Shoal. Based on sediment samples collected using a vibracore, the bottom sediments found in this area are classified as gravely sand and cobbles. The benthic community found in the sediment at these sites is diverse and complex. Bivalves are present, and the shell hash is comprised of *Mercenaria mercenaria*, other clam species, *Crepidula* sp., and *Ensis directis*. The bottom sediment is covered by colonies of hydroids and amphipod mats. A spider crab and whelk were observed. Motile organisms at these stations include shrimp and amphipods. The two dominant organisms identified in benthic samples collected at these sites were the amphipod *Ampelisca* sp. and the polychaete *Ampharete artica*. *Ampelisca* sp., which are found on sandy and muddy bottoms, build parchlike tubes and form mats. One common species is *A. abdita*, which construct tubes of fine sand grains approximately 3.5 centimeters in length and 2 to 3 millimeters wide. Most of the tube is below the substrate, with approximately 1 centimeter above the surface.

Eastern Transition Community

(Stations IC-13 and -14, and C-15, -16, and -17)
The Eastern Transition Community is located in the middle of the proposed Project area, along the transition from Stratford Shoal to the central basin floor. Bottom sediments are comprised of silt and sand. Polychaete worm tubes, burrowing anemones, and tunicates are present in the greatest numbers. Colonial hydroids are present on shell debris, and solitary hydroids are scattered throughout each area. The dominant organisms found living in the sediment in this transition community included polychaetes, amphipods, and bivalves. These organisms are found in deep and shallow water and are typical of sand and silt sediment types. The results of the benthic sampling are summarized in Table 3-2.

3.2.2.2 Finfish

Long Island Sound supports diadromous and marine fisheries and is home to finfish species of ecological, commercial, and recreational importance.

Since 1984, the State of Connecticut Department of Environmental Protection (CTDEP) has collected data regarding finfish, lobster, and long-finned squid abundance as part of the Long Island Sound Trawl Surveys (LISTS). Gottschall et al. (2000) summarized the data from the surveys conducted between 1984 and 1994. In addition, CTDEP publishes the results of the ongoing surveys in its Annual Performance Reports.

Ninety-five finfish species have been collected during the LISTS in Long Island Sound between 1984 and 2003 (Gottschall et al. 2004). Most of these species migrate through the area to take advantage of seasonal water temperatures and nursery and spawning grounds, but a few, such as tautog, are resident species that utilize the Sound throughout their life history (Gottschall et al. 2000). Table 3-3 lists all the species collected during the LISTS in Long Island Sound between 1984 and 2003.

Table 3-3 Fish Species Collected during Long Island Trawl Surveys (LISTS) from 1984 to 2003

Common Name	Scientific Name
Anchovy, bay	*Anchoa mitchilli*
Anchovy, striped	*Anchoa hepsetus*
Banded rudderfish	*Seriola zonata*
Bass, striped	*Morone saxatilis*
Bigeye	*Priacanthus arenatus*
Bigeye, short	*Pristigenys alta*
Black sea bass	*Centropristes striata*
Bluefish	*Pomatomus saltatrix*
Bonito, Atlantic	*Sarda sarda*
Butterfish	*Peprilus triacanthus*
Cod, Atlantic	*Gadus morhua*
Cornetfish, red	*Fistularia petimba*
Croaker, Atlantic	*Mircopogonias undulatus*
Cunner	*Tautogolabrus adspersus*
Cusk-eel, fawn	*Lepophidium profundorum*
Cusk-eel, striped	*Ophidion marginatum*
Dogfish, smooth	*Mustelus canis*
Dogfish, spiny	*Squalus acanthius*
Eel, American	*Anguilla rostrata*
Eel, conger	*Conger oceanicus*
Filefish, orange	*Monacanthus hispidus*
Filefish, planehead	*Paralichthys oblongus*
Flounder, fourspot	*Etropus microstomus*
Flounder, smallmouth	*Paralichthys dentatus*
Flounder, summer	*Scophthalmus aquosus*
Flounder, windowpane	*Pleuronectes americanus*
Flounder, winter	*Pleuronectes ferrugineus*
Glasseye, snapper	*Priacanthus cruentatus*
Goatfish, dwarf	*Upeneus parvus*
Goatfish, red	*Mullus auratus*
Goby, naked	*Gobiosoma bosci*
Goosefish	*Lophius americanus*
Grubby	*Myoxocephalus aeneus*
Gunnel, rock	*Pholis gunnellus*
Haddock	*Melanogrammus aeglefinus*
Hake, red	*Urophycis chuss*

Table 3-3 Fish Species Collected during Long Island Trawl Surveys (LISTS) from 1984 to 2003

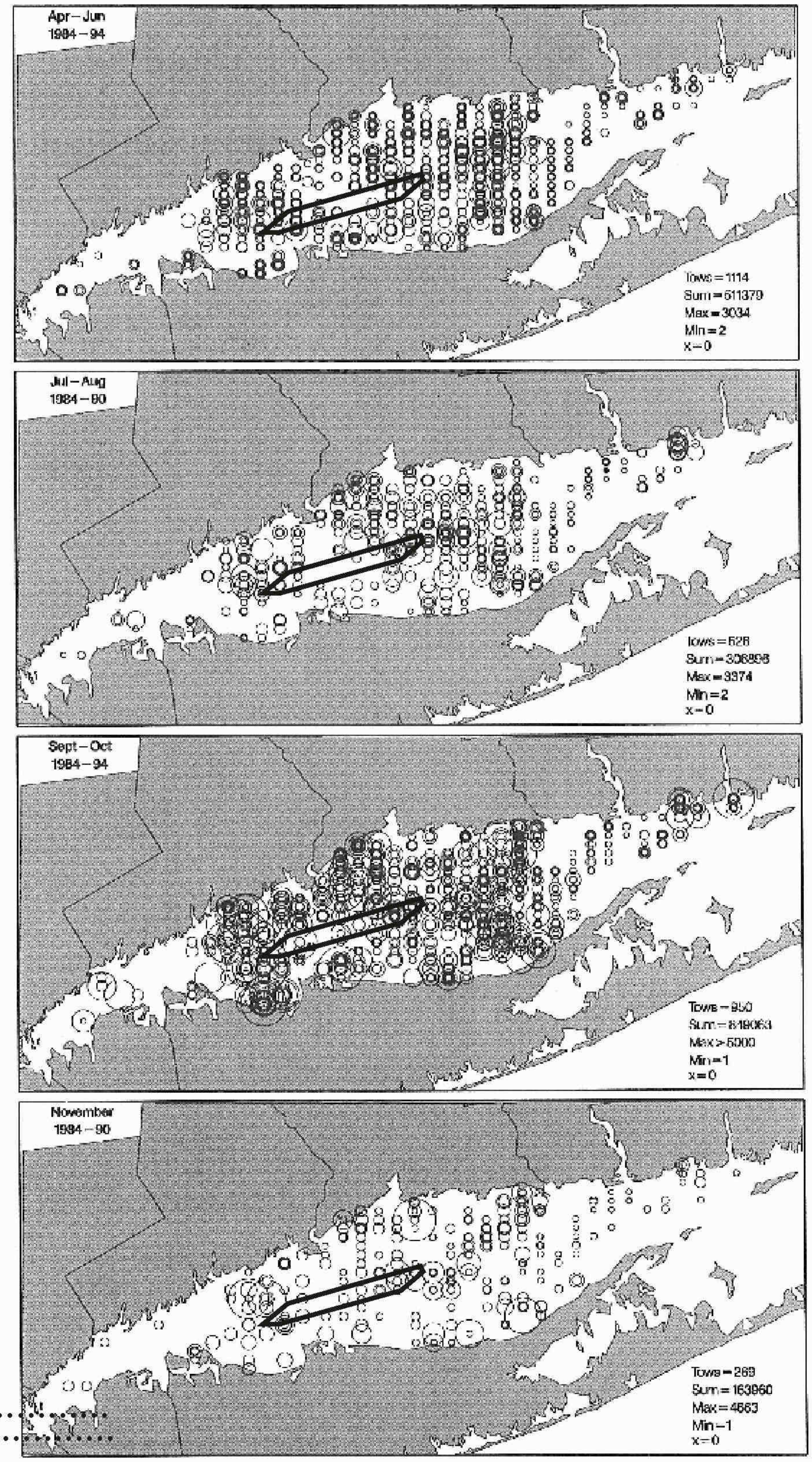
Common Name	Scientific Name
Hake, silver	*Merluccius bilinearis*
Hake, spotted	*Urophycis regia*
Herring, alewife	*Alosa pseudoharengus*
Herring, Atlantic	*Clupea harengus*
Herring, blueback	*Alosa aestivalis*
Herring, round	*Etrumeus teres*
Hogchoker	*Trinectes maculatus*
Jack, crevalle	*Caranx hippos*
Jack, yellow	*Caranx bartholomaei*
Kingfish, northern	*Menticirrhus saxatilis*
Lamprey, sea	*Petromyzon marinus*
Lizardfish, inshore	*Synodus foetens*
Lookdown	*Selene vomer*
Lumpfish	*Cyclopterus lumpus*
Mackerel, Atlantic	*Scomber scombrus*
Mackerel, Spanish	*Scomberomorus maculatus*
Menhaden, Atlantic	*Brevoortia tyrannus*
Moonfish	*Selene setapinnis*
Ocean pout	*Macrozoarces americanus*
Oyster toadfish	*Opsanus tau*
Pipefish, northern	*Syngnathus fuscus*
Pollock	*Pollachius virens*
Pompano, African	*Alectis ciliaris*
Puffer, northern	*Sphoeroides maculatus*
Rockling, fourbeard	*Enchelyopus cimbrius*
Salmon, Atlantic	*Salmo salar*
Sand lance, American	*Ammodytes americanus*
Sandbar (brown) shark	*Carcharhinus plumbeus*
Scad, bigeye	*Selar crumenophthalmus*
Scad, mackerel	*Decapterus macarellus*
Scad, rough	*Trachurus lathami*
Scad, round	*Decapterus punctatus*
Sculpin, longhorn	*Myoxocephalus octodecemspinosus*
Scup	*Stenotomus chrysops*
Sea raven	*Hemitripterus americanus*
Seahorse	*Hippocampus sp.*

Table 3-3 Fish Species Collected during Long Island Trawl Surveys (LISTS) from 1984 to 2003

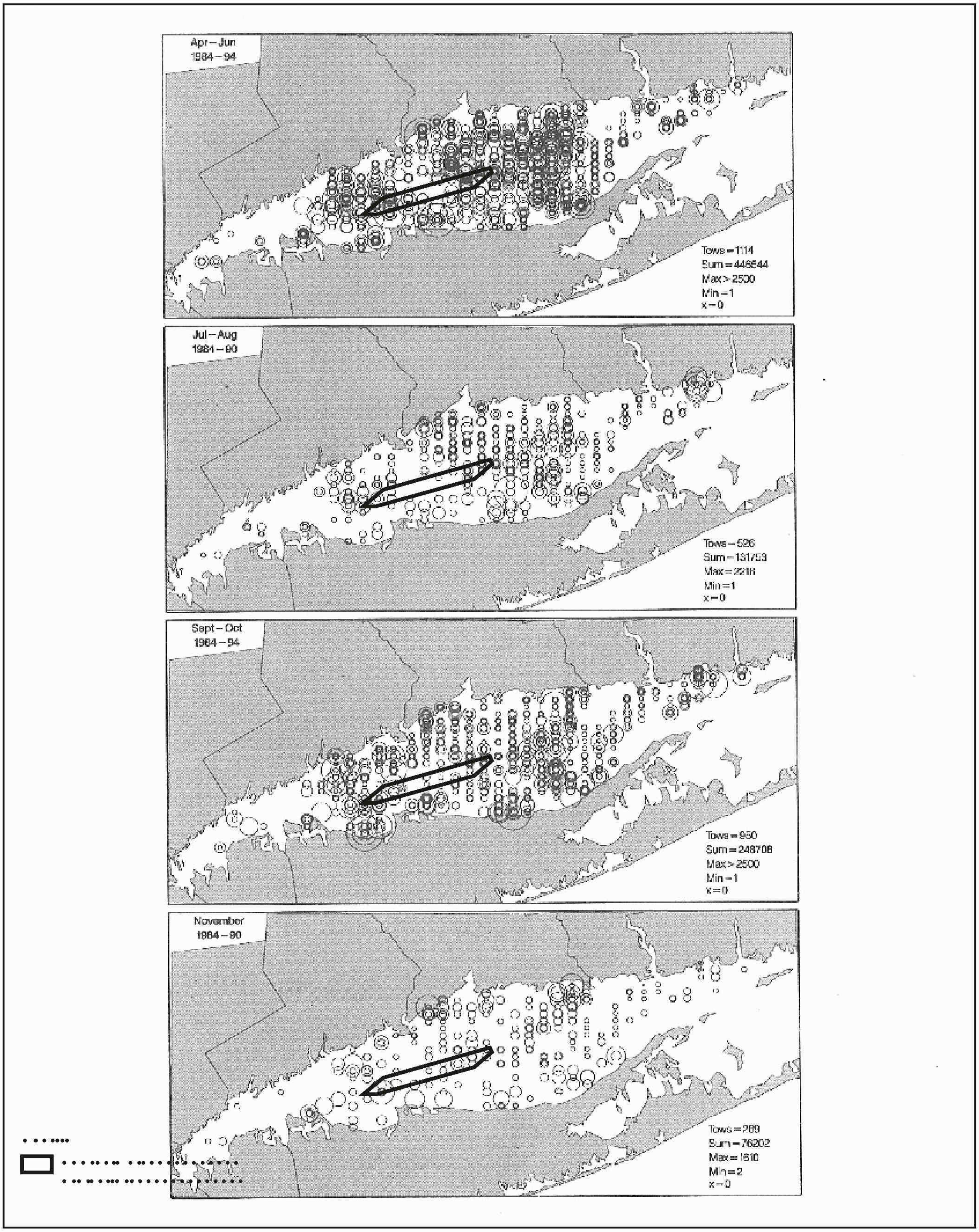
Common Name	Scientific Name
Sea robin, northern	*Prionotus carolinus*
Sea robin, striped	*Prionotus evolans*
Sea snail	*Liparis atlanticus*
sennet, northern	*Sphyraena borealis*
Shad, American	*Alosa sapidissima*
Shad, gizzard	*Dorosoma cepedianum*
Shad, hickory	*Alosa mediocris*
Sharksucker	*Echeneis naucrates*
Skate, barndoor	*Dipturus laevis*
Skate, clearnose	*Raja eglanteria*
Skate, little	*Leucoraja erinacea*
Skate, winter	*Leucoraja ocellata*
Smelt, rainbow	*Osmerus mordax*
Spot	*Leioxtomus xanthurus*
Stingray, roughtail	*Dasyatis centroura*
Sturgeon, Atlantic	*Acipenser oxyrhynchus*
Tautog	*Tautoga onitis*
Tomcod, Atlantic	*Microgadus tomcod*
Triggerfish, gray	*Balistes capriscus*
Weakfish	*Cynoscion regalis*

Based on Gottschall's summary of LISTS surveys, overall use by finfish, American lobster, and long-finned squid is greatest in Long Island Sound between September and October and lowest in winter. Use of Long Island Sound by demersal species is greatest from April through June and lowest in winter. Aggregate catch per tow of finfish species, reported by season for LISTS, are depicted on Figure 3-13, and aggregate catch per tow of demersal species are depicted on Figure 3-14.

Mean finfish count and mean finfish weight for trawls in the Project area, conducted as part of LISTS for 2000, were obtained from CTDEP to assess existing conditions in the Sound. The proposed FSRU location is located at the intersection of four survey squares with mean finfish counts that ranged from 492.3 per tow to 2,879.6 per tow. The mean finfish count along the majority of the proposed pipeline route ranges from 0 per tow to 1,000 per tow. Four of the 16 survey squares traversed by the proposed pipeline route had mean finfish counts between 1,001 and 3,375 per tow. Mean finfish counts for 2000 LISTS in the Project area are depicted on Figure 3-15. Finfish and invertebrate biomass indices for LISTS spring and fall tows conducted between 1992 and 2003 are presented in Tables 3-4 and 3-5, respectively.



Apr – Jun
1984 – 94
Tows = 1114
Sum = 611379
Max = 3034
Min = 2
x = 0
Jul – Aug
1984 – 90
Tows = 526
Sum = 306896
Max = 3374
Min = 2
x = 0
Sept – Oct
1984 – 94
Tows = 950
Sum = 849063
Max > 5000
Min = 1
x = 0
November
1984 – 90
Tows = 269
Sum = 163960
Max = 4663
Min = 1
x = 0



Apr – Jun
1984 – 94
Tows = 1114
Sum = 446544
Max > 2500
Min = 1
x = 0
Jul – Aug
1984 – 90
Tows = 526
Sum = 131753
Max = 2218
Min = 1
x = 0
Sept – Oct
1984 – 94
Tows = 950
Sum = 248706
Max > 2500
Min = 1
x = 0
November
1984 – 90
Tows = 289
Sum = 76202
Max = 1610
Min = 2
x = 0

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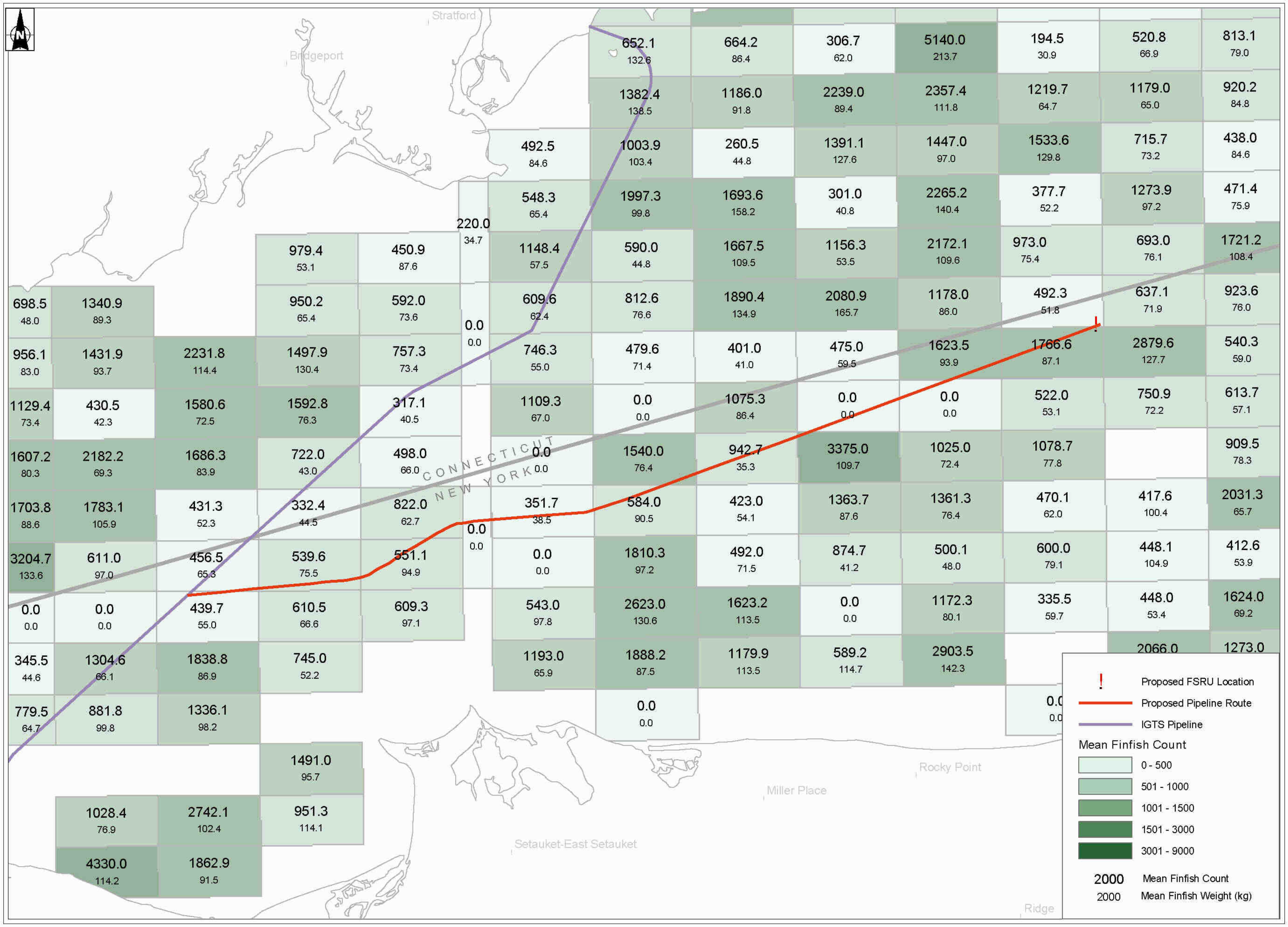
\\BUFSDL4\GIS\Pensacola\LNG\BROADWATER\Maps\MXD\Resource_Reports_Final\RR3\Fig3-7_finfish_count.mxd 01/15/06



Source: Connecticut Department of Environmental Protection, 2004.

0 2.5 5 10
Miles

Figure 3-15 Mean Finfish Count in the Project Area

Table 3-4 **Finfish and invertebrate biomass indices for the spring sampling period, 1992-2003.**
The geometric mean weight (kg) per tow was calculated for 38 finfish and 15 invertebrate species for the spring (April-June) sampling period.

	Spring											
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
alewife	0.06	0.17	0.32	0.15	0.50	0.25	0.20	0.37	0.34	0.15	0.25	0.19
black sea bass	0.01	0.03	0.06	0.03	0.06	0.06	0.02	0.05	0.07	0.17	0.40	0.17
bluefish	0.45	0.08	0.13	0.04	0.10	0.23	0.17	0.35	0.09	0.08	0.36	0.20
butterfish	0.43	0.10	0.31	0.19	0.73	1.27	1.06	0.52	0.69	0.79	1.48	0.64
cunner	0.02	0.04	0.01	0.03	0.02	0.03	0.04	0.04	0.03	0.04	0.05	0.03
dogfish, smooth	1.04	0.44	1.14	0.63	0.83	0.42	0.90	1.05	0.85	0.82	2.31	1.10
dogfish, spiny	0.10	0.02	0.12	0.00	0.00	0.01	0.03	0.02	0.00	0.08	0.06	0.07
flounder, fourspot	2.19	0.75	0.75	1.48	1.37	2.08	1.28	0.96	1.31	1.28	1.35	1.01
flounder, summer	0.35	0.27	0.48	0.16	0.53	0.60	1.15	1.09	1.35	1.21	2.38	2.45
flounder, windowpane	1.96	2.53	2.96	1.60	4.76	4.16	3.21	2.38	1.69	1.97	1.31	1.21
flounder, winter	8.72	7.54	9.44	6.51	14.61	10.63	9.65	6.67	7.46	9.77	6.31	6.64
hake, red	0.78	0.85	0.14	0.66	0.21	0.33	0.94	1.05	0.59	0.45	0.96	0.13
hake, silver	0.20	0.14	0.40	0.36	0.12	0.39	0.48	0.56	0.19	0.54	0.52	0.06
hake, spotted	0.01	0.01	0.00	0.02	0.03	0.09	0.03	0.13	0.27	0.17	0.20	0.13
herring, Atlantic	1.06	2.03	1.09	1.77	0.55	0.88	0.25	0.22	0.42	0.26	0.14	0.19
herring, blueback	0.05	0.02	0.06	0.03	0.04	0.04	0.02	0.00	0.04	0.02	0.01	0.02
hogchoker	0.04	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.03	0.04	0.04	0.04
kingfish, northern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mackerel, Spanish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
menhaden, Atlantic	0.07	0.03	0.03	0.04	0.01	0.01	0.00	0.00	0.02	0.00	0.03	0.01
moonfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ocean pout	0.07	0.09	0.04	0.04	0.04	0.03	0.02	0.02	0.03	0.01	0.03	0.02
rockling, fourbeard	0.13	0.10	0.05	0.10	0.05	0.11	0.08	0.13	0.09	0.12	0.06	0.06
scad, rough	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sculpin, longhorn	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.03	0.01	0.01	0.01
scup	0.48	0.49	0.58	0.65	0.73	0.75	0.75	0.56	4.56	2.85	13.16	2.28
sea raven	0.03	0.00	0.00	0.00	0.01	0.00	0.05	0.03	0.05	0.02	0.03	0.01
searobin, northern	0.26	0.35	0.28	0.27	0.28	0.33	0.17	0.22	0.70	0.51	0.51	0.40
searobin, striped	0.86	0.30	0.51	0.77	0.46	0.40	0.87	1.14	1.99	1.40	2.21	1.21
shad, American	0.29	0.09	0.21	0.10	0.11	0.23	0.13	0.20	0.05	0.01	0.11	0.03
shad, hickory	0.01	0.01	0.01	0.01	0.03	0.02	0.05	0.06	0.05	0.03	0.09	0.05
skate, little	5.89	5.99	8.87	3.38	9.35	6.00	6.27	4.25	3.43	4.47	4.56	4.35
skate, winter	0.37	0.52	0.28	0.21	0.46	0.29	0.46	0.27	0.25	0.21	0.25	0.24
spot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
striped bass	0.31	0.43	0.45	0.49	0.77	1.13	1.15	1.86	1.13	0.93	2.10	1.38
sturgeon, Atlantic	0.05	0.05	0.08	0.03	0.02	0.04	0.13	0.08	0.05	0.03	0.16	0.00
tautog	1.00	0.51	0.51	0.19	0.63	0.42	0.49	0.51	0.59	0.78	1.09	0.61
weakfish	0.11	0.03	0.01	0.05	0.06	0.15	0.20	0.31	0.12	0.11	0.12	0.03
Invertebrates												
crab, blue	0.03	0.02	0.00	0.02	0.00	0.02	0.02	0.03	0.04	0.01	0.04	0.01
crab, flat claw hermit	0.15	0.08	0.18	0.02	0.09	0.04	0.10	0.10	0.07	0.12	0.14	0.32
crab, horseshoe	0.35	0.45	0.60	0.13	0.61	0.33	0.55	0.80	0.74	0.94	0.76	1.33
crab, lady	0.25	0.23	0.16	0.18	0.50	0.50	0.39	0.16	0.13	0.04	0.07	0.01
crab, rock	1.17	0.61	0.64	0.14	0.45	0.32	1.04	0.55	0.25	0.35	0.31	0.36
crab, spider	0.98	1.08	1.22	0.32	0.96	0.52	0.69	0.39	0.35	1.02	1.30	1.85
jellyfish, lion's mane	0.01	0.11	0.01	0.15	0.10	0.08	0.19	0.06	0.06	0.03	0.02	0.23
lobster, American	2.80	2.32	1.53	3.24	2.72	3.02	6.56	4.95	3.90	3.04	2.55	1.48
mussel, blue	0.31	0.01	0.07	0.03	0.03	0.01	0.05	0.03	0.04	0.01	0.17	0.08
northern moon shell	0.05	0.04	0.12	0.03	0.02	0.02	0.04	0.05	0.05	0.08	0.10	0.10
oyster, common	0.04	0.00	0.06	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.00	0.00
shrimp, mantis	0.06	0.13	0.05	0.05	0.04	0.03	0.03	0.07	0.18	0.08	0.04	0.03
squid, long-finned	1.01	0.91	0.67	0.89	0.55	0.99	0.41	0.62	0.51	0.41	0.42	0.42
starfish sp.	0.22	0.13	0.06	0.02	0.03	0.03	0.05	0.04	0.06	0.28	0.24	0.29
whelks	0.16	0.04	0.07	0.01	0.07	0.03	0.06	0.08	0.09	0.13	0.12	0.31

Table 3-5. **Finfish and invertebrate biomass indices for the fall sampling period, 1992-2003.** *The geometric mean weight (kg) per tow was calculated for 38 finfish and 15 invertebrate species for the fall (Sept-Oct) sampling period.*

	Fall											
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
alewife	0.03	0.08	0.10	0.02	0.04	0.22	0.02	0.07	0.02	0.09	0.03	0.09
black sea bass	0.01	0.01	0.01	0.00	0.01	0.01	0.05	0.07	0.07	0.23	0.31	0.08
bluefish	16.39	9.91	9.45	8.09	7.62	6.53	5.06	8.51	8.34	6.11	7.87	8.99
butterfish	6.31	4.12	3.40	10.26	9.30	6.97	13.27	15.43	4.45	7.80	6.56	3.47
cunner	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02
dogfish, smooth	1.20	1.75	0.76	0.85	1.16	1.09	1.32	1.27	2.85	3.02	6.09	6.18
dogfish, spiny	0.03	0.08	0.18	0.00	0.01	0.05	0.10	0.05	0.06	0.24	0.07	0.00
flounder, fourspot	0.14	0.16	0.14	0.08	0.48	0.24	0.19	0.14	0.35	0.17	0.25	0.30
flounder, summer	0.87	0.85	0.47	0.43	1.61	1.84	1.77	2.27	1.77	3.19	4.41	3.27
flounder, windowpane	0.51	0.73	0.42	0.32	2.11	1.30	0.61	0.38	0.45	0.30	0.38	0.43
flounder, winter	0.84	0.99	0.78	0.45	1.56	1.04	0.87	1.37	1.28	0.62	0.55	0.34
hake, red	0.11	0.34	0.19	0.04	0.48	0.18	0.10	0.06	0.32	0.07	0.02	0.19
hake, silver	0.04	0.02	0.28	0.02	0.01	0.06	0.01	0.03	0.01	0.01	0.01	0.02
hake, spotted	0.09	0.30	0.15	0.04	0.37	0.03	0.08	0.17	0.34	0.09	0.19	0.41
herring, Atlantic	0.07	0.01	0.01	0.00	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.03
herring, blueback	0.01	0.01	0.12	0.03	0.01	0.09	0.02	0.01	0.01	0.05	0.01	0.01
hogchoker	0.02	0.03	0.01	0.01	0.04	0.01	0.01	0.04	0.02	0.03	0.05	0.04
kingfish, northern	0.00	0.01	0.00	0.03	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00
mackerel, Spanish	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
menhaden, Atlantic	0.36	0.22	0.36	0.25	0.25	0.24	0.09	0.39	0.22	0.05	0.35	0.25
moonfish	0.02	0.00	0.03	0.03	0.12	0.05	0.13	0.09	0.13	0.04	0.08	0.03
ocean pout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rockling, fourbeard	0.01	0.00	0.01	0.00	0.02	0.01	0.00	0.00	0.02	0.00	0.00	0.00
scad, rough	0.00	0.03	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.01	0.01	0.01
sculpin, longhorn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
scup	4.96	3.72	3.33	4.63	3.68	2.49	4.50	22.72	30.76	11.28	23.69	28.95
sea raven	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
searobin, northern	0.02	0.05	0.06	0.02	0.04	0.02	0.08	0.06	0.08	0.13	0.18	0.11
searobin, striped	0.82	0.54	0.32	0.34	0.81	0.60	1.04	1.37	1.59	1.27	2.12	2.43
shad, American	0.14	0.35	0.39	0.43	0.06	0.16	0.26	0.42	0.14	0.07	0.16	0.17
shad, hickory	0.03	0.02	0.04	0.02	0.05	0.05	0.02	0.07	0.05	0.02	0.02	0.05
skate, little	2.47	4.61	3.47	1.78	5.66	3.81	4.06	2.85	2.92	2.88	3.00	1.96
skate, winter	0.11	0.15	0.21	0.09	0.25	0.10	0.09	0.08	0.01	0.21	0.21	0.00
spot	0.00	0.07	0.03	0.00	0.14	0.01	0.00	0.06	0.13	0.01	0.08	0.00
striped bass	0.09	0.16	0.11	0.15	0.21	0.68	0.38	0.39	0.51	0.48	0.70	0.26
sturgeon, Atlantic	0.21	0.19	0.13	0.10	0.02	0.06	0.04	0.21	0.08	0.23	0.18	0.27
tautog	0.22	0.22	0.15	0.09	0.07	0.14	0.27	0.31	0.30	0.20	0.27	0.43
weakfish	0.47	0.56	1.26	1.27	1.88	1.70	0.94	3.39	3.17	2.41	2.86	1.72
Invertebrates												
crab, blue	0.15	0.17	0.05	0.04	0.04	0.11	0.10	0.17	0.11	0.05	0.10	0.06
crab, flat claw hermit	0.17	0.40	0.15	0.11	0.26	0.16	0.35	0.16	0.17	0.33	0.30	0.13
crab, horseshoe	1.01	1.16	0.55	0.32	1.27	1.32	0.93	1.09	1.31	1.39	1.76	1.67
crab, lady	1:52	1.58	1.52	1.56	3.54	1.84	0.82	0.48	0.60	0.17	0.14	0.10
crab, rock	0.58	0.55	0.18	0.09	0.45	0.32	0.37	0.22	0.19	0.13	0.12	0.04
crab, spider	0.53	1.89	0.46	0.25	0.71	0.42	0.25	0.24	0.21	0.30	0.27	0.47
jellyfish, lion's mane	0.02	0.01	0.03	0.17	0.18	0.50	0.17	0.03	0.22	0.17	0.10	0.01
lobster, American	3.17	4.11	3.58	3.03	3.48	7.22	4.24	4.16	2.65	1.91	1.10	1.28
mussel, blue	0.07	0.06	0.12	0.02	0.00	0.01	0.09	0.00	0.04	0.12	0.11	0.02
northern moon shell	0.03	0.02	0.03	0.01	0.01	0.00	0.02	0.01	0.00	0.04	0.10	0.00
oyster, common	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.03	0.01	0.00	0.00	0.00
shrimp, mantis	0.05	0.08	0.02	0.02	0.13	0.06	0.02	0.09	0.18	0.05	0.06	0.02
squid, long-finned	5.00	7.92	4.71	4.68	5.53	2.20	6.40	6.06	4.05	2.39	1.81	5.88
starfish sp.	0.11	0.08	0.07	0.00	0.01	0.02	0.05	0.02	0.12	0.22	0.09	0.01
whelks	0.28	0.28	0.06	0.08	0.22	0.10	0.27	0.23	0.38	0.52	0.38	0.24

Representative fish species of recreational and commercial importance are listed in Table 3-6, along with important forage species. Species that have recognized value within the Sound, but that are not specifically identified as having EFH (addressed in Appendix A) within the Sound, are discussed below.

Table 3-6 Important Recreational, Commercial, and Forage Species Present in Long Island Sound

Important Commercial Species	Important Recreational Species	Important Forage Species	Other Species
Atlantic mackerel (*Scomber scombrus*) (EFH) (P)	Bluefish (*Pomatomus saltatrix*) (EFH) (P)	Alewife (*Alosa pseudoharengus*) (P)	Hogchoker (Trinectes maculates) (D)
Atlantic sea herring (*Clupea harengus harengus*) (EFH)(P)	Fourspot flounder (*aralichthys blongus*) (D)	American Shad (*Alosa sapidissima*) (P)	Planehead filefish (Paralichthys oblongus)(D)
Bluefish (*Pomatomus saltatrix*) (EFH)	Scup (*Stenotomus chrysops*) (EFH) (D)	Atlantic menhaden (*Brevoortia tyrannus*) (P)	Smooth dogfish (Mustelus canis) (P)
Butterfish (*Peprilus triacanthus*) (P)	Striped bass (*Morone saxatilis*) (P)	Atlantic sea herring (*Clupea harengus harengus*) (EFH) (P)	Spiny dogfish (Squalus acanthius) (P)
Goosefish (*Lophius americanus*)(D)	Summer flounder (*Paralicthys dentatus*) (EFH) (D)	Blueback herring (*Alosa aestivalis*) (P)	Striped sea robin (*Prionotus evolans*)(D)
Red hake (*Urophycis chuss*) (EFH) (D)	Tautog (*Tautoga onitis*) (D)	Butterfish (*Peprilus triacanthus*)(P)	
Scup (*Stenotomus chrysops*) (EFH) (D)	Weakfish (*Cynoscion regalis*) (P)	Hickory shad (Alosa mediocris) (P)	
Silver hake/whiting (*Merluccius bilinearis*) (EFH)(P)	Winter flounder (*Pseudopleuronectes americanus*) (EFH) (D)		
Striped bass (*Morone saxatilis*)(P)			
Summer flounder (*Paralicthys dentatus*) (EFH) (D)			
Winter flounder (*Pseudopleuronectes americanus*) (EFH) (D)			

(P) - Pelagic (D) - Demersal

Demersal Fish

Goosefish (*Lophius americanus*). Goosefish, also known as monkfish, is a benthic species found in coastal waters from New Brunswick, Canada, to northern Florida at depths up to 1,500 feet (457 m). Goosefish inhabit bottoms of sand, mud, and broken shell in waters ranging in temperature from about 32°F to 75°F (0°C to 23°C). They spawn offshore from spring to early fall, depending on the latitude, with spawning as early as March in North Carolina waters and as late as September in the cooler waters of New England. The pelagic eggs are deposited in large gelatinous masses that hatch in continental shelf waters that are 41°F to 65°F (5°C to 18.3°C).

The larvae of the goosefish feed on various small pelagic animals such as copepods, crustacean larvae, and glass worms (*Sagitta*); adults feed on fish, seabirds, and invertebrates (Bigelow and Schroeder 1953).

Goosefish have been a relatively rare species in Long Island Sound, and most have been found in water depths greater than 59 feet (18 m) over mud and transitional sediments in the central basin (Gottschall et al. 2000). Goosefish taken during LISTS were typically juveniles and most were taken in the spring (Gottschall et al. 2000). The rarity of goosefish in the Sound minimizes potential impacts on this species.

Tautog (*Tautoga onitis*). Tautog are territorial fish found on hard-bottom reefs and rocky environments from Nova Scotia to South Carolina, and most commonly from Cape Cod to Chesapeake Bay (Bigelow and Schroeder 1953). South from Cape Cod to New Jersey, tautog can be found up to 12 miles (19 km) offshore in waters up to 79 feet (24 m) deep, and occasionally near the deep Great South Channel between Nantucket Shoals and Georges Bank (Chang 1990). Tautog are typically found in association with cover, frequenting rock piles, boulder-strewn bottoms, bridge and wharf pilings, artificial reefs, and old wrecks.

Tautog feed in the daytime, with peaks periods occurring at dawn and dusk. Their diet consist of a variety of invertebrates such as mussels, clams, crabs, sand dollars, amphipods, shrimp, small lobsters, and barnacles.

Beginning in the spring, adult tautog migrate inshore to spawn, with spawning occurring from late April to early August. Tautog eggs are found in greatest abundance at or near the water surface (Merriman and Sclar 1952; Herman 1963; Stolgitis 1970; Fritzsche 1978; Bourne and Govoni 1988). After a brief larval stage (about 3 weeks), they settle on the bottom in areas with cover and water depths typically less than 3 feet (1 m) (Malchoff, 1993; Sogard et al. 1992). During the larval stage they migrate vertically in the water column, staying near the surface during the day and utilizing deeper waters at night. As they mature, they spend more time in deeper waters (Malchoff 1993; Sogard et al. 1992). Juvenile tautog are typically found in waters from 1 to 30 feet (1 to 9 m) deep, but the main habitat requirement and distribution factor is the availability of cover (Olla et al. 1975; Olla and Studholme 1975). Adult tautog prefer complexly structured coastal habitats and are extremely local (Bigelow and Schroeder 1953).

When water temperatures fall below 52°F (11°C), there is an overall migration of tautog to offshore areas (Cooper 1966), though the migration distances are not necessarily long. Adult tautog have been observed during winter in less than 32 feet (10 m) of water in eastern Long Island Sound (Zawacki and Briggs 1976; Auster 1989). Tautog seek shelter and enter a torpor-like state to hibernate when water temperatures are very low, emerging when temperatures reach 39°F (4.0°C) (Nichols and Breder 1926; Cooper 1966; Briggs 1977; Olla and Studholme 1975).

Based on Gottschall's summary of LISTS from 1984- 1994, tautog were commonly observed in most months and most were adults. Abundance was highest from May through July, declined in August, and increased in October and November (Gottschall et al. 2000). In November, tautog were widely dispersed in the Sound but were most abundant over mud bottoms in depths greater than 29 feet (9 m). From May through October, tautog were generally found over all bottom types in waters less than 59 feet (18 m) deep and were concentrated in areas north of Hempstead, between New Haven and Norwalk, off Eaton's Neck, and off Mattituck (Gottschall et al. 2000). Tuatog abundance during spring surveys in Long Island Sound declined from 2.75 per tow in 1984 to 0.15 per tow in 1995. Tautog abundance has generally increased modestly over the past seven years (1996 to 2002), but decreased slightly in spring 2003 to 0.52 per tow, 37% below average levels. The 2003 fall abundance (0.37 per tow), continued a generally increasing trend since the series low of 0.07 per tow in 1996 (Gottschall et al. 2004). Poletti (*see* Appendix E) demonstrated the presence of tautog eggs in the central portion of the Sound from late April through early August and larvae from early May through late July.

Fourspot Flounder (*Paralichthys oblongus*). Fourspot flounder are found from Georges Bank to southern Florida. They are demersal fish that feed on invertebrates and fish. They spawn in late spring and early summer and again in fall. The eggs are buoyant and the larvae are planktonic.

During LISTS conducted in Long Island Sound from 1984 to 1994, fourspot flounder abundance increased sharply from April to a peak in June, then decreased just as rapidly through August. Abundance remained low through fall then rose slightly in November (Gottschall et al. 2000). While they were found throughout the Sound over all bottom types, fourspot flounder were most abundant in the central and western basins over mud bottoms, and numbers increased with depth during periods of highest abundance (Gottschall et al. 2000).

Review of the 20-year survey series indicates that fourspot flounder abundance gradually increases over a period of years, then rapidly declines, and that the peak abundance has decreased throughout the series (Gottschall et al. 2004). The years 1998 to 2003 appear to mark such a decline, with abundance in spring 2003 being the fourth lowest in the 20-year series (2.78 per tow) (Gottschall et al. 2004). The Poletti data confirmed the presence of fourspot flounder larvae in the central portion of the Sound from early June through August.

Pelagic Fish

Butterfish (*Peprilus triacanthus*). The butterfish is a small, schooling species found from Newfoundland to Florida (Nichols and Breder 1927; Bigelow and Schroeder 1953). They migrate in response to seasonal changes in water temperature, moving northward and inshore in summer to feed and spawn, and southward and offshore in winter to avoid cool waters. Spawning occurs from May to October and peaks in July and August.

Butterfish form loose schools and feed on small fish, squid, and crustaceans. They grow rapidly (most reach sexual maturity at age 1) and are short lived (typically less than 4 years). They are prey for many species, including silver hake, bluefish, swordfish, and long-finned squid. In addition, they are commercially important from Southern New England to Cape Hatteras (NOAA 2005).

Butterfish were the most abundant species taken during LISTS between 1984 and 1994, and they were observed in Long Island Sound from April through November. Relative abundance was low through July, peaked in August and September, and declined through October and November. Abundance was highest over mud and transitional bottoms in depths from 29 to 88 feet (9 to 27 m) but individuals were collected over all bottom types and at all depths. In May, adults comprised 83% of the LISTS catch, in September and October 9%, and in November 27% (Gottschall et al. 2000). While butterfish abundance has generally increased during the course of the surveys, four outstanding years of abundance occurred during the 1990s (301.72 per tow in 1992, 320.06 per tow in 1995, 355.49 per tow in 1998 and 477.91 per tow in 1999); abundance then fell to 125.97 per tow in 2000, rose in 2002 to near the series average (172.75 per tow) and fell to 112.86 per tow in 2003, well below the series average (172.75 per tow) (Gottschall et al. 2004). The Poletti data demonstrated the presence of butterfish eggs in the central portion of the Sound from late May through August and larvae from early June through August.

Striped Bass (*Morone saxatilis*). The striped bass is an anadromous species found along the Atlantic coast from the St. Lawrence estuary to northern Florida. Most striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity (NOAA 2005). Striped bass spawn from mid-February (in the southern part of their range) to late June or July. Spawning occurs at or near the surface in fresh or slightly brackish waters at temperatures ranging from 50° to 73°F (10° to 23°C); peak spawning activity is observed between 59° and 68°F (15° and 20° C). Juvenile striped bass move downriver into higher salinity waters during their first summer or autumn (NOAA 2005).

During the LISTS conducted in Long Island Sound from 1984 to 1994, striped bass were most commonly taken in waters less than 59 feet (18 m) deep along the Connecticut and Long Island shorelines, particularly near the mouths of the Connecticut and Housatonic Rivers. The highest abundance occurred in May and November, and abundance was low in summer (Gottschall et al. 2000). The abundance of striped bass in LISTS for Long Island Sound has been above the series average for the last nine years (1995-2003), with the 2003 spring abundance of 0.87 per tow the fourth highest in the 20-year series (Gottschall et al. 2004).

Weakfish (*Cynoscion regalis*). Weakfish are found from Nova Scotia to Florida and are important to both commercial and recreational fisheries. Fish younger than 4 years old migrate south in the winter and north in the spring, while adults tend to migrate offshore when temperatures decline and return to inshore grounds in the spring when the coastal waters begin to warm (Grosslein and Azarovitz 1982; Mercer 1989).

Spawning takes place along the coast and in estuaries from May to October. Females produce more than 300,000 buoyant, spherical eggs (Mercer 1989), which hatch in approximately 48 hours and take up residence in estuaries from April to August. Weakfish typically live to an age of 9 years (NOAA 2005).

Weakfish feed mainly between dusk and dawn on species such as anchovy, killifish, silversides, young herring, porgies, mysid shrimp, small crabs, worms, and clams (NOAA 2005).

During the LISTS conducted in Long Island Sound from 1984 to 1994, weakfish first appeared in catches in May, increased in abundance slightly through summer when most of the catch were adults, then increased dramatically from August through October, when the young of the year comprised 98% of the catch, and fell again in November (Gottschall et al. 2004).

In the spring, the few adults taken were along the Mattituck Sill and along the coasts of the western basin, with abundance highest over transitional bottoms in depths less than 59 feet (18 m). In the summer, abundance was highest along the north side of the Sound (Gottschall et al. 2000). In the fall, abundance was highest along the south side of the Sound (Gottschall et al. 2000).

The young of the year were widely distributed, from August through October, with the greatest abundance over mud bottoms in the central and western basins along the south side of the Sound. Depths of 29 to 59 feet (9 to 18 m) were favored in September, and in October abundance increased with depth (Gottschall et al. 2000).

The overall number of weakfish caught during fall surveys has steadily decreased from 23,561 fish in 2000 to 5,592 in 2003. While Age 0 weakfish have been very abundant in the last five years (1999- 2003) the abundance of age 1+ fish has fallen since the late 1990s (Gottschall et al. 2004).

The fall abundance provides the best estimate for weakfish in Long Island Sound. Fall abundance for weakfish reached an index record of 63.42 fish per tow in 2000. Abundance dropped to 40.51 and 41.45 per tow in 2001 and 2002, respectively, but still remained dramatically above the series mean of 15.10 per tow. The 2003 fall abundance of 49.46 per tow is second only to the 2000 abundance (Gottschall et al. 2004). The Poletti data demonstrated the presence of weakfish eggs in central Long Island Sound from mid-May through August and larvae from early June through August.

Alewife (*Alosa pseudoharengus*) and Blueback Herring (*Alosa aestivalis*). Alewife and blueback herring are collectively referred to as “river herring.” Both species are anadromous, undertaking upriver spawning migrations during spring and returning to marine waters following spawning. Alewives are found from Labrador to South Carolina, and blueback herring are found from Nova Scotia to Florida. Fisheries for these species are typically mixed in coastal rivers where ranges overlap.

Alewives live up to 10 years and blueback herring live up to 8 years, and each reach sexual maturity at age 4. Alewives spawn in spring when water temperatures are between 61°F and 66°F (16°C and 19°C), and blueback herring spawn when water temperatures are between 70°F and 75°F (21°C and 24°C). Females of both species produce from 60,000 to 300,000 eggs per female.

Adult alewives feed on shrimp and small fish; the young feed on diatoms, copepods, and ostracods. They are preyed upon by just about all larger piscivorous fish. Blueback herring feed on plankton, various small floating animals, small fish fry, and fish eggs. They are prey for species such as weakfish, spiny dogfish, striped bass, and bluefish (NOAA 2005).

During the LISTS conducted in Long Island Sound, alewives exhibited a seasonal inshore/offshore pattern, with the greatest abundance occurring in April, primarily in depths greater than 59 feet (18 m) over mud bottoms. Abundance declined through May and June, remained relatively stable through the summer, and rose again in November to levels similar to those in May (Gottschall et al. 2000). In May, and September through November they were most abundant along the Connecticut shore in depths less than 29 feet (9 m), particularly from the mouth of the Housatonic River to the mouth of the Hammonassett River (Gottschall et al. 2000). In summer they were distributed at all depths and were most abundant near the Mattituck Sill and nearby portions of the central basin (Gottschall et al. 2000). Juveniles comprised 97% to 100% of the catch each month throughout the year. The spring 2003 abundance of alewives was 1.14 per tow, just above the average of 0.96 per tow, which continues the trend of levels slightly above average since 1994 (Gottschall et al. 2004).

Blueback herring were found during every month of the LISTS conducted in Long Island Sound, and most were juveniles. Like alewives, blueback herring are closely associated with the Connecticut shoreline for most of the year (with the exception of summer), where they are commonly found in depths less than 59 feet (18 m). In summer they are more abundant in depths greater than 29 feet (9 m) and are most abundant in depths greater than 59 feet (18 m) in the central basin (Gottschall et al. 2000).

The abundance of blueback herring has been measured in Long Island Sound since 1989. The fall 2003 abundance was 0.10 per tow, the sixth consecutive year below the average of 0.24 per tow (Gottschall et al. 2004).

American Shad (*Alosa sapidissima*). The American shad is an anadromous species that occurs along the Atlantic coast from southern Labrador to northern Florida. They move into rivers to spawn beginning in January (southern rivers) and continuing until July in the northernmost rivers. The life history patterns of American shad depend on their river of origin. In northern rivers, shad return to spawn at age 5, laying 125,000 to 250,000 eggs. Some shad then die but many spawners return to the sea. In southern rivers, spawners produce greater numbers of eggs and then die. American shad migrate north along the coast to Canada after spawning, where they feed during the summer; they then migrate south along the continental shelf for winter. The young of the year remain in fresh to brackish water, where they feed on copepods and insect larvae, before entering the sea in early fall. Adult American shad feed on plankton, small crustaceans, and small fish. Shad are eaten at sea by seals, sharks, bluefin tuna, kingfish, and porpoises. Young shad in freshwater are eaten by bass, American eels, and birds (Virginia Institute of Marine Science 2005).

Almost every major river along the Atlantic seaboard historically supported a spawning population of American shad, but excessive fishing led to historic declines in abundance in the Hudson and Connecticut Rivers, as well as in rivers in Maryland, North Carolina, and Florida. Dam construction has also contributed to this fisheries' decline (NOAA 2005).

Based on review of Gottschall's summary of the LISTS conducted in Long Island Sound, American shad exhibited a seasonal inshore/offshore pattern similar to alewives and blueback herring. American shad are closely associated with the Connecticut shoreline during the spring, fall and November (which for the purposes of these surveys represents winter), where they are commonly found in depths less than 59 feet (18 m), particularly between the Housatonic River and Hammonassett River. In summer they are abundant across the central basin of the Sound and at the Mattituck Sill in depths greater than 29 feet (9 m) (Gottschall et al. 2000).

The fall abundance of American shad has typically fluctuated every two to three years over the course of the survey series. The fall 2003 abundance of 0.75 per tow was the fourth consecutive year below the average of 1.17 per tow (Gottschall et al. 2004).

Atlantic Menhaden (*Brevoortia tyrannus*). Atlantic menhaden are found in coastal and estuarine waters from Nova Scotia to northern Florida. They are found inshore in summer and move southward and into deeper, offshore waters in winter. During fall and early winter, most menhaden migrate south to the North Carolina capes, where they remain until March and early April. They reach sexual maturity at around age 3 and spawn between March and May, and again between September and October.

The larvae use brackish and fresh waters as nursery areas. In fall the young of the year leave the estuary and join the schools in the southward migration. Adults are found in near-surface waters of shallow areas overlying the continental shelf, usually in greatest abundance immediately adjacent to major estuaries. Juveniles also are generally pelagic, with the smallest fish found farthest up river. Menhaden feed on phytoplankton and zooplankton and are prey for striped bass, bluefish, seatrout, tuna, and sharks (Virginia Institute of Marine Science 2005).

During the LISTS conducted in Long Island Sound, Atlantic menhaden generally increased in abundance from April through November, when abundance peaked. Catches from April through August were highest near New Haven Harbor, and from September through October along the Connecticut shore between New Haven Harbor and Norwalk. Catches in November were highest along the Connecticut shore from Milford to Guilford and extended across the Sound along and adjacent to the Mattituck Sill (Gottschall et al. 2000).

Review of the series from 1984 to 1994 revealed that from April to June, the majority of the menhaden caught were adults, and that from September to October, they were primarily juveniles (Gottschall et al. 2000). The fall 2003 abundance of Atlantic menhaden was 0.95 per tow, which is average (Gottschall et al. 2004). The Poletti data demonstrated the presence of Atlantic menhaden in central Long Island Sound from mid-May through late June and larvae from late May through August.

Hickory Shad (*Alosa mediocris*). Hickory shad are found along the Atlantic coast from Maine to Florida. They are anadromous fish that live in coastal ocean waters as adults and swim into tidal freshwater areas to spawn. Hickory shad feed on squid, small fish, fish eggs, and some invertebrates.

Based on review of Gottschall's summary of the LISTS conducted in Long Island Sound, hickory shad were relatively uncommon (averaging 0.01 per tow). Those that were caught suggested seasonal inshore/offshore patterns similar to other forage species. In spring they were caught primarily in depths less than 59 feet (18m), particularly near the Housatonic River (Gottschall et al. 2000). In summer they were more abundant in depths greater than 59 feet (18 m) near New Haven Harbor. In fall they returned to depths less than 59 feet (18 m) and in November they dispersed throughout the Sound (Gottschall et al. 2000). Hickory shad have become more common since 1991, and in 2003 the abundance in both spring and fall was 0.09 per tow (Gottschall et al. 2004).

Other Species

As described in Section 3.1, the majority of the Project is located within the central and western basins of Long Island Sound, with depths greater than 90 feet (27.4 m) over mud bottoms. Based on a review of seasonal distribution maps included in NOAA Technical Report NMFS 148, *The Distribution and Size Composition of Finfish, American Lobster, and Long-Finned Squid in Long Island Sound Based on the Connecticut Fisheries Division Bottom Trawl Survey, 1984-1994* (Gottschall et al. 2000), additional representative fish species likely to utilize the habitat characteristic of the Project area during the winter months include hogchoker (*Trinectes maculates*), planehead filefish (*Paralichthys oblongus*), smooth dogfish (*Mustelus canis*), spiny dogfish (*Squalus acanthius*), and striped sea robin (*Prionotus evolans*).

3.2.2.3 Shellfish

Several species of crustaceans are commonly found in Long Island Sound, including blue crab (*Callinectes sapidus*), lady crab (*Ovalipes ocellatus*), spider crab (*Libinia emarginata*), rock crab (*Cancer irroratus),* red crab (*Geryon quinquedens*), green crab (*Carcinus maenas*), and American lobster (*Homarus americanus*). Blue crab, rock crab, lady crab, and spider crab are substrate generalists that live on sand, rock, or mud. Lobster have complex habitat needs depending on life stage and are discussed in greater detail below.

Horseshoe crab *(Limulus polyphemus)*, an arthropod species, are also commonly found in the Sound. Adult horseshoe crabs spend most of their time in deeper waters feeding mainly on marine worms and shellfish, including razor clams and soft-shelled clams. The identification of individual horseshoe crabs on the video collected during the field surveys confirm their presence in the Project area.

The LISTS reports for Long Island Sound include biomass data for invertebrate species, including horseshoe crab, lady crab, rock crab, and spider crab for the 1992 to 2003 period. Lady crab fall abundance was stable from 1992 to 1995 (approximately 1.5 kilograms [kg] per tow), more than doubled to 3.54 kg per tow in 1996, and fell to the series low in 2003 (0.10 kg per tow) (Gottschall et al. 2004). Spring and fall rock crab abundance have also been in decline. Spider crab spring abundance has been increasing for the last three years, while the fall abundance declined from 1996 to 2002 and rose moderately to average levels in 2003 (Gottschall et al. 2004). Spring and fall horseshoe crab abundance have generally increased since 1996, to the highest spring abundance recorded and the second highest fall abundance recorded (Gottschall et al. 2004).

Several species of mollusks are also found in the shallow nearshore waters of Long Island Sound.

American Lobster (*Homarus americanus*)

Lobster is a commercially important shellfish that occurs throughout Long Island Sound. Lobsters are nocturnal, typically emerging from shelters within the hour following sunset, foraging for 2 hours, and returning to the same or another shelter. Observations suggest that, during these foraging periods, lobsters become familiar with their surroundings, which may allow them to quickly locate shelter when faced with a threat (Karnofsky et al. 1989). The importance of shelters varies based on the life stage of the lobster. While, adolescent lobsters may move up to 984 feet (300 m), younger lobsters may move on a scale of several meters or less.

Life Cycle. Female lobsters carry fertilized eggs for a period of 9 to 12 months before releasing them into the water column. Lobster larvae are typically present in the top 3 feet (1 m) of the water column from May to June, where they molt multiple times over a period of 6 to 8 weeks. Lobster larvae are approximately one-third of an inch long when they hatch from the egg, and they are approximately three-quarters of an inch long when they sink to the bottom and begin benthic life. While pelagic, the larvae feed on a range of planktonic organisms. They then settle to the bottom, preferably on complex substrates that provide shelter (Hudon 1987; Able et al. 1988; Wahle and Steneck 1991).

Once the lobsters settle on the bottom, the early benthic phase (EBP) begins. The EBP is a series of juvenile lobster stages that spans multiple years and includes a shelter-restricted juvenile stage, an emergent juvenile stage, and a vagile juvenile stage. In the beginning of the shelter-restricted juvenile stage, the lobster stays in the shelter 100% of the time, feeding on plankton and benthic items found in or at the shelter entrance. During the emergent juvenile phase, the lobster makes limited forays from the shelter, reducing shelter use to 50% to 80% of the time, and begins to supplement plankton with increased feeding on benthic prey such as polycheates and amphipods (Lawton and Lavalli 1995). Shelter use is reduced to 30% to 50% during the vagile stage, when the juvenile lobster increases foraging excursions and begins to pursue prey.

Lobster are considered adult when they have reached physiological and sexual maturity. In Long Island Sound, lobsters grow at an accelerated rate and sexual maturity occurs at a smaller size (Briggs and Mushacke 1979; Lawton and Lavalli 1995). For the adult lobster, shelter is most important during mating and molting.

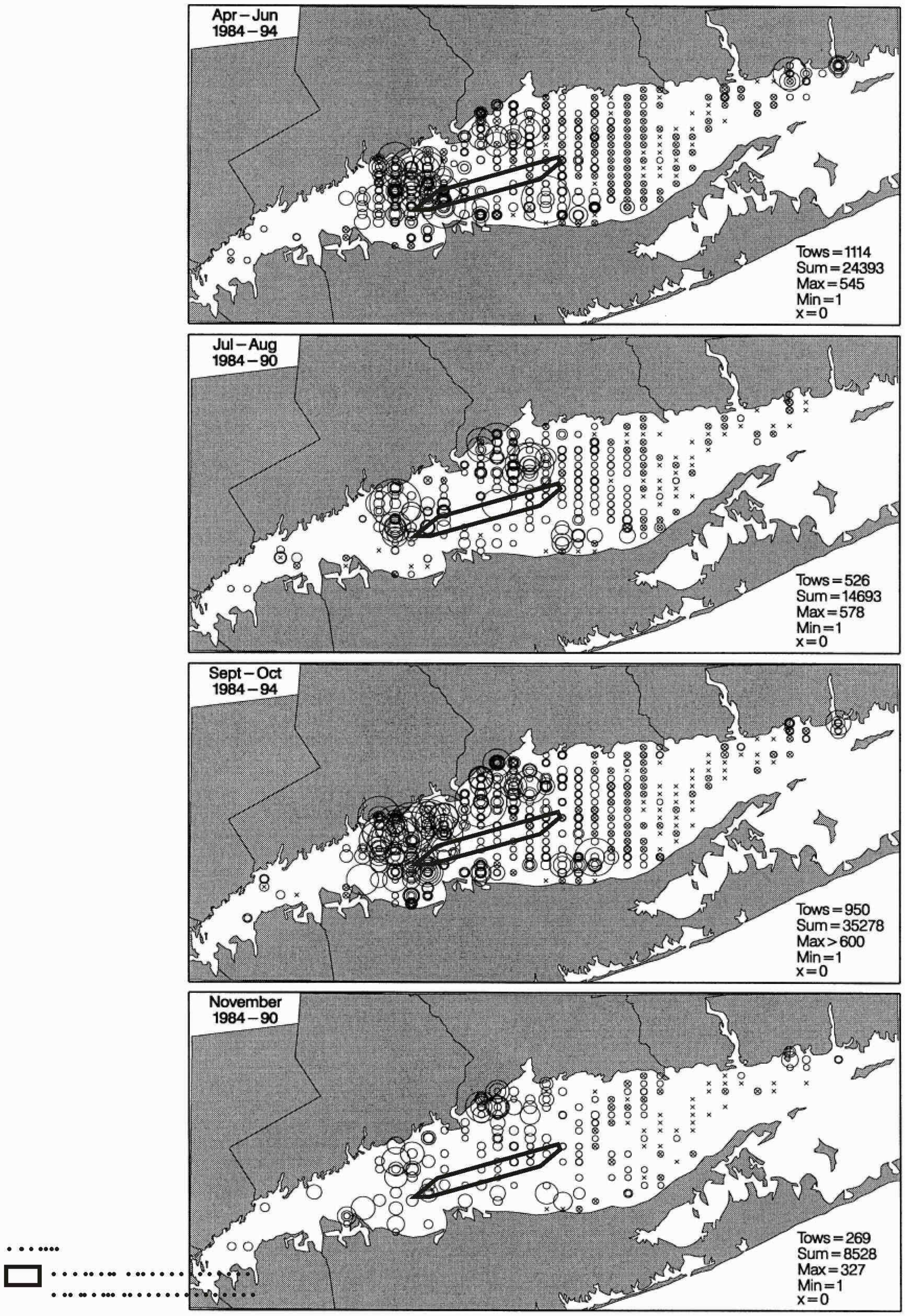
The CTDEP has collected data regarding lobster abundance as part of the LISTS. Lobsters are found throughout Long Island Sound during all seasons, and abundance is highest in areas with a mud bottom. The density of lobster pots and fishing activity in the Project area demonstrates the presence of lobster in the Project area. Unlike lobster populations elsewhere, lobsters in Long Island Sound are not migratory. Based on the LISTS conducted between 1984 and 1994, Gottschall et al. (2000) showed that lobsters concentrated in three particular mud areas: the western Sound, the area between the Housatonic River and New Haven Harbor, and the area north of Shoreham (*see* Figure 3-16). The Project largely avoids these areas. Lobster abundance was below average in the 1980s, rose during the early 1990s, moderated or declined slightly between 1994 and 1996, abruptly rose to a peak in 1997 (19.60 per tow, fall index) and 1998 (18.52 per tow, spring index), and has since declined precipitously (Gottschall et al. 2004). Mass lobster mortality of unknown cause was reported by fishermen in 1998, fall 1999, and sporadically in 2000. While mortality occurred throughout the Sound, most lobster mortality occurred in the western Sound (Gottschall et al. 2004).

The spring 2003 abundance index for lobster fell 38% from 2002 (from 6.31 per tow in 2002 to 3.89 per tow in 2003). This marked the fifth straight year of declining abundance for this species and the second time in 9 years that abundance fell below the series mean of 6.98 per tow.

The fall abundance also dropped for 5 straight years from the peak in 1997 to a series low of 2.68 per tow in 2002. In 2003 the fall index rose by 13% to 3.03 per tow (still 62% below the average of 7.91 per tow), which was the second lowest rank of the 20-year series.

Long-finned Squid (*Loligo pealei*)

Squid are highly mobile, schooling, pelagic macroinvertebrates that prey on small finfish and crustaceans. Their short lifespan (less than one year) combined with their rapid growth and capacity to spawn year-round leads to a seasonally dynamic resource. Individuals hatched in summer generally grow more rapidly than those hatched in winter.



Apr – Jun
1984 – 94
Tows = 1114
Sum = 24393
Max = 545
Min = 1
x = 0
Jul – Aug
1984 – 90
Tows = 526
Sum = 14693
Max = 578
Min = 1
x = 0
Sept – Oct
1984 – 94
Tows = 950
Sum = 35278
Max > 600
Min = 1
x = 0
November
1984 – 90
Tows = 269
Sum = 8528
Max = 327
Min = 1
x = 0

Long-finned squid occur in waters of the continental shelf and slope from Newfoundland to the Gulf of Venezuela and are commercially important from Cape Hatteras to the Georges Bank. North of Cape Hatteras, individuals migrate seasonally, moving offshore during late autumn to overwinter in warmer waters along the edge of the continental shelf, and moving inshore during the spring and early summer (Cargnelli et al. 1999). When nearshore waters warm, squid move inshore to take advantage of nearshore nursery habitats, laying eggs on benthic habitats in late spring and summer. Pelagic larvae live near the surface of inshore waters, and subadults migrate offshore in fall (Hatfield and Cadrin 2002).

The CTDEP collects data regarding long-finned squid abundance as part of the LISTS. Consistent with seasonal migration patterns for this species, long-finned squid were commonly found in the Sound between May and November but were rare in April. The percent of juveniles in the population increases throughout the summer, from approximately 35% between May and June when adults dominate the population, to 98% in September (Gottschall et al. 2000). Populations remain stable through late spring and summer and then peak in September. In late spring, squid concentrate on transitional bottoms at Mattituck Sill and nearby in the central basin. In summer, they spread throughout the Sound but are typically more abundant in the central and western basins (Gottschall et al. 2000). In fall the squid are more abundant at increased depths and most abundant over mud bottoms. Abundance during the fall surveys varies, with lows of 27.40 per tow in 1986, 28.60 per tow in 1987, and 35.49 per tow in 2002, and highs of 159.16 per tow in 1988, 272.11 per tow in 1993, and 202.29 per tow in 1998 (Gottschall et al. 2004).

The spring 2003 abundance index for squid fell to 2.5 per tow in 2003, a 20-year low and the sixth consecutive year below the average abundance of 4.69 per tow. Conversely, the 2003 fall abundance (269.32 per tow) was more than 6 times that of the 2002 fall abundance (35.48 per tow) (Gottschall et al. 2004).

3.2.2.4 Plankton

Plankton, small free-floating or weakly swimming organisms that drift in the water column, play an important role in cycling nutrients and minerals in marine ecosystems. Plankton can be divided into groups that are primarily producers (phytoplankton) or primarily consumers (zooplankton). In Long Island Sound, the seasonal stratification of the water column has a significant effect on the ability of planktonic communities to cycle nutrients. Water column dynamics play a significant role in the distribution of the plankton throughout the course of a year, as discussed below. The water column is well mixed from fall through late spring. As water temperatures in the Sound rise, warmer water near the surface becomes isolated from denser, colder water at depth, thereby preventing the exchange of nutrients. Nutrient exchange sometimes occurs in the summer when storms or increased tidal mixing (caused by new moon phases) temporarily mixes the water column. Consistent nutrient exchange is restored in the fall when surface waters cool and sink (Peterson 1983; Anderson and Taylor 2001).

Phytoplankton

Prior to stratification, when nutrients are readily available from multiple sources, including the seabed, phytoplankton are evenly distributed throughout the water column (Peterson 1983). Blooms (growth levels that exceed the loss to death and grazing) dominated by diatoms occur in late winter (January/February), and blooms dominated by dinoflagellates occur in the early summer (June/July) (Capriulo and Carpenter 1983). Once stratification occurs, the nutrients in the photic zone become depleted, phytoplankton populations decline, and the size distribution of phytoplankton changes. Prior to stratification, up to 90% of the phytoplankton biomass is made up of cells greater than 10 microns in diameter. Once stratification occurs, 98% of the biomass is made up of cells with diameters less than 10 microns (Peterson and Kimmerer 1994). When mixing occurs in the fall, another bloom dominated by diatoms occurs (Capriulo and Carpenter 1983).

Zooplankton

Long Island Sound has a diverse zooplankton community that includes holoplankton (organisms that are planktonic throughout their life cycles) and meroplankton (organisms that have planktonic larval stages). Deevey (1956) found that the highest abundance of zooplankton occurs in late spring and late summer and that larvae of benthic organisms exhibit seasonal patterns, with crustacean larvae abundant in cold months and molluscan and polychaete larvae abundant in warm months (Deevey 1956).

The zooplankton community structure in Long Island Sound is strongly influenced by stratification. Prior to stratification, dominant species include *Acartia hudsonica,* (the most abundant species), *Temora longicornis* (the species with the highest biomass), and *Pseudocalanus* species (Peterson 1985). While present throughout the year, *A. tonsa*, *Oithona similes*, and *Paracalanus crassirostris* dominate in the stratified waters of summer (Peterson 1985).

The zooplankton community structure in Long Island Sound is further influenced by stratification through the use of different portions of the water column by different species. Prior to stratification, copepods have overlapping distribution in the water column (Peterson 1983). Following stratification, zoning is evident, with *A. hudsonica* in the upper 16 feet (5 m) of the water column, *T. longicornis* at depths of 16 to 49 feet (5 to 15 m), and *Pseudocalanus* species at depths from 49 to 66 feet (15 to 50 m) (Peterson 1983; Peterson and Kimmerer 1994).

Ichthyoplankton

NOAA Fisheries is charged with managing fishery resources in Long Island Sound. In an effort to accomplish this, NOAA Fisheries designates Essential Fish Habitat (EFH) for species and life stages. The proposed FSRU area is EFH for the egg and/or larval life stages of Atlantic mackerel, cobia, king mackerel, red hake, sand tiger shark, scup, Spanish mackerel, windowpane flounder, and winter flounder (*see* Table 3-7). While 95 species of finfish were identified in Long Island Sound between 1984 and 2003 (Gottschall et al. 2004), and additional species are assumed to be present in the area, this table presents a listing of species for which EFH is managed for egg and larval stages in the vicinity of the FSRU. Table 3-8 provides a summary of general habitat parameters for egg and larval life stages of species with designated EFH for these life stages in the Project area. A more detailed discussion of EFH is provided in Appendix A.

Table 3-7 Species for which EFH has been Designated for Egg and/or Larval Stages in the Vicinity of the Proposed FSRU

Species	Egg	Larvae
Atlantic mackerel (*Scomber scombrus*)	X	X
Cobia (*Rachycentron canadum*)	X	X
King mackerel (*Scomberomorus cavalla*)	X	X
Red hake (*Urophycis chuss*)	X	X
Sand tiger shark (*Odontaspis taurus*)		X
Scup (*Stenotomus chrysops*)	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X
Windowpane flounder (*Scopthalmus aquosus*)	X	X
Winter flounder (*Pleuronectes americanus*)	X	X

The ichthyoplankton data available for Long Island Sound is very limited. Although NOAA Fisheries maintains extensive ichthyoplankton databases, they are for federal waters only. Because Long Island Sound is comprised entirely of state waters, no defined data collection efforts have been undertaken by NOAA Fisheries. As part of various power relicensing projects throughout the region, some level of ichthyoplankton data was collected, although much of the data has not been publicly released. In addition, Broadwater conducted limited ichthyoplankton surveys in August and October of 2005 to supplement the data that is available (*see* Attachments 1 and 2 of Appendix E).

Broadwater obtained and evaluated data collected by the New York Power Authority's (NYPA) 2002 Poletti Ichthyoplankton Program to estimate ichthyoplankton abundance and distribution in the Project area. This program collected data on the distribution of fish eggs and larvae in Long Island Sound, the East River, the Hudson River, and New York Harbor during March through August 2002. In addition, Broadwater conducted its own ichthyoplankton sampling efforts in August and October 2005. The protocols followed for these surveys are presented as Attachment 3 of Appendix E.

The sampling area for the 2002 Poletti Ichthyoplankton Program extended from Raritan Bay in the west to the Connecticut/Rhode Island border in the east, including all of Long Island Sound, Upper and Lower New York Bays, the East River, and part of the Hudson River. The Poletti data was divided into 10 regions, with the data from Regions 7

Table 3-8 General Habitat Parameters for Egg and Larval Stages for Species With Designated EFH in the FSRU Project Area

Species	Life Stage	EFH Blocks	Temp		Salinity	Depth		Seasonal	IP Habitat Description
			°C	(°F)	(%)	m	(ft)	Occurrence	
Atlantic mackerel (*Scomber scombrus*)	Eggs	41007250, 41007240, 41007300	5-23	(41-73)	(18 - >30)	0 – 15	(0-49)		Pelagic waters
Atlantic mackerel	Larvae	41007250, 41007240, 41007300	6-22	(43-72)	(>30)	10-130	(32-427)		Pelagic waters
Cobia (*Rachycentron canadum*)	Eggs and larvae	41007250, 41007240, 41007300	>20	(>6)	>25				Sandy shoals of capes and offshore bars, high-profile rock bottoms and barrier islands, Ocean-side waters from surf zone to shelf break, but from the Gulf Stream shoreward; high–salinity bays, estuaries, and seagrass habitat
King mackerel (*Scomberomorus cavalla*)	Eggs and larvae	41007250, 41007240, 41007300	>20	(>60)	>30				Sandy shoals of capes and offshore bars, high–profile rock bottoms and barrier islands, ocean–side waters from surf zone to shelf break, but from the Gulf Stream shoreward
Red hake (*Urophycis chuss*)	Eggs	41007250, 41007240, 41007300	<10	(<50)	< 25			May to November, peaks in June and July	Surface waters of the inner continental shelf
Red hake	Larvae	41007250, 41007240, 41007300	<19	(<66)	>0.5	<200	(<656)	May to December, peaks in September and October	Surface waters
Sand tiger shark (*Odontaspis taurus*)	Larvae	41007250, 41007240, 41007300							

Table 3-8 General Habitat Parameters for Egg and Larval Stages for Species With Designated EFH in the FSRU Project Area

Species	Life Stage	EFH Blocks	Temp °C	Temp (°F)	Salinity (%)	Depth m	Depth (ft)	Seasonal Occurrence	IP Habitat Description
Scup (*Stenotomus chrysops*)	Eggs	41007250, 41007240, 41007300	13 – 23	(55-73)	>15	<30	(<98)	May – August	Pelagic waters in estuaries
Scup	Larvae	41007250, 41007240, 41007300	13 – 23	(55-73)	>15	<20	(<66)	May – September	Pelagic waters in estuaries
Spanish mackerel (*Scomberomorus maculatus*)	Eggs and larvae	41007250, 41007240, 41007300	>20	(>60)	>30				Sandy shoals of capes and offshore bars, high–profile rock bottoms and barrier islands, ocean–side waters from surf zone to shelf break, but from the Gulf Stream shoreward
Windowpane flounder (*Scopthalmus aquosus*)	Eggs	41007250, 41007240, 41007300	<20	(<60)		<70	(<230)	February to November, peaks May and October in middle Atlantic	Surface waters
Windowpane flounder	Larvae	41007250, 41007240, 41007300	<20	(<60)		<70	(<230)	February to November, peaks May and October in middle Atlantic	Pelagic waters
Winter flounder (*Pleuronectes americanus*)	Eggs	41007250, 41007240, 41007300	<10	(<50)	10 – 30	<5	(<16)	February to June	Bottom habitats with a substrate of sand, muddy sand, mud, and gravel
Winter flounder	Larvae	41007250, 41007240, 41007300	<15	(<59)	4 – 30	<6	(<20)	March to July	Pelagic and bottom waters

Source: NOAA Fisheries 2005.

through 10 representing Long Island Sound, and Regions 7 through 9 specifically representing the central basin of Long Island Sound.

Sampling for the 2002 Poletti Ichthyoplankton Program was conducted during daylight hours on a biweekly basis from March to July 2002. A Tucker trawl was used to collect a water column plankton tow at a randomly selected depth in the water column (between the surface and 10 feet [3 m] above the bottom), and an epibenthic sled was used to collect near-bottom samples. To assess ichthyoplankton abundance in the vicinity of proposed FSRU facility, Broadwater evaluated sampling results for samples collected in sample Regions 7 through 9 (which represent the central basin of Long Island Sound) using a Tucker trawl in water depths greater than 98 feet (30 m). Samples collected in water greater than 98 feet (30 m) deep were used because they best represented the location of the FSRU facility in water approximately 95 feet (29 m) deep in the central basin of Long Island Sound. Although the mid-depth [20- to 98-foot, 6- to 30-m] sampling strata also represents the FSRU location at the upper end of its depth range, the inclusion of samples from water as shallow as 20 feet in the lab composites for the mid-depth strata was not considered to be as representative of the proposed FSRU location (95 feet [29 m] deep) as data from the deep sampling strata. Only samples collected using the Tucker trawl were used for the Broadwater estimates because they best represented the location of the FSRU facility's water withdrawal from 35 to 45 feet (11 to 14 m) below the surface. For additional details on sample collection procedures and laboratory methods, *see* Appendix E, *Broadwater FSRU 2002 Poletti Ichthyoplankton Program Summary Report*.

Using the Poletti data subset, the species and life stages occurring during each biweekly survey were identified (11 surveys were conducted from March through August 2002), and the mean number of eggs and larvae per 1,000 m^3 of seawater were calculated as an estimate of the density in the vicinity of the proposed FSRU. Mean egg density ranged from approximately 200/1,000m^3 during the last two surveys (July 8 to August 5) to about 5,000/1,000 m^3 during Survey 3 (April 1 to 14) and Survey 7 (May 27 to June 9). Mean larvae density ranged from approximately 100/1,000 m^3 during Survey 1 (March 4 to 17) to >10,000/1,000 m^3 during Survey 8 (June 10 to 23).

Icthyoplankton densities are not expected to be uniform across the March to July period due to the seasonal variation in icthyoplankton density and species composition typical of Mid-Atlantic nearshore and estuarine regions. Based on the Poletti data, egg density had two peaks in 2002, one in April dominated by fourbeard rockling, and a second peak in late May to June with a more diverse assemblage comprising summer spawning species such as tautog, weakfish/scup, Atlantic menhaden, and sea robin. Larval density peaked during July. Prior to July, larval fish density and diversity was low and was comprised primarily of winter/early spring spawning species such as American sand lance, winter flounder, fourbeard rockling, rock gunnel, and grubby. Larval fish diversity and density increased markedly during July when summer spawning species such as Atlantic menhaden, tautog, cunner, scup, sea robin, weakfish, and bay anchovy were present.

Both fish egg and larvae density dropped noticeably after their respective June to July peaks, suggesting that the peak period of ichthyoplankton occurrence was captured by the March to July sampling window of the 2002 Poletti Ichthyoplankton Program. Comparison with other regional ichthyoplankton surveys in Long Island Sound (Wheatland 1956; Pearcy and Richards 1962), Great South Bay, New York (Monteleone 1992), Narragansett Bay (Bourne and Govone 1988; Keller et al. 1999), and Buzzards Bay (Chute and Turner 2001) suggest that abundance and diversity of ichthyoplankton are low in the winter, when few species (with the exception of American sand lance) spawn. Both egg abundance and diversity increase during the early spring, when winter flounder begin to spawn in estuaries and shallow nearshore areas. Egg and larval diversity and density peak during the summer, when many migrant and resident species spawn. Spawning is curtailed in the fall as water temperatures drop.

In addition to assessing the Poletti data, which was collected between March and August, Broadwater conducted ichthyoplankton sampling in the vicinity of the proposed FSRU in August and October 2005 to assess late summer and fall ichthyoplankton densities. A discussion of the results of these sampling efforts is included in this Resource Report, and summary reports for each of these sampling efforts are included as Attachments 1 and 2 of Appendix E.

Eggs from seven taxa and larvae from 13 taxa were collected during day and night sampling conducted on August 23, 2005, in the vicinity of the proposed Broadwater FSRU location. The ichthyoplankton community was dominated by bay anchovy (*Anchoa mitchilli*) eggs and larvae which accounted for approximately 80% of all eggs and larvae collected.

Samples of the ichthyoplankton community in the vicinity of the proposed Broadwater FSRU location were collected during day and night sampling on October 4, 2005. The samples were dominated by bay anchovy and Atlantic menhaden (*Brevoortia tyrannus*). Atlantic menhaden was the only fish egg collected during this sampling, and Atlantic menhaden, bay anchovy, and feather blenny (*Hypsoblennius hentzi*) were the only larvae collected during this sampling.

Ichthyoplankton abundance and diversity in the vicinity of the proposed FSRU location was considerably lower during the October 4, 2005, sampling event than on August 23, 2005, reflecting the seasonality of the ichthyoplankton community in Long Island Sound (*see* Figure 7 in Attachment 2 of Appendix E). In water depths representing the FSRU intake location (mid-depth strata), the average egg density during day and night sampling was 74.7/100 m^3 in August, compared to 5.9/100 m^3 in October; the average larvae density was 639.5/100 m^3 in August, compared to 49.3/100 m^3 in October. In August, eggs from seven taxa and larvae from 13 taxa were collected. Catches were dominated by bay anchovy, which accounted for approximately 80% of all eggs and larvae collected. In October, eggs from one taxa (Atlantic menhaden) and larvae from three taxa were collected. Larval catches were dominated again by bay anchovy, which accounted for 81.5% of all larvae.

The data results from the Poletti and Broadwater sampling efforts are typical of estuarine systems in the Mid-Atlantic Bight. Ichthyoplankton abundance and diversity are low in the winter when few species spawn. Ichthyoplankton abundance and diversity begin to increase in the early spring, reaching a peak during mid-late summer when many species reproduce. Ichthyoplankton abundance and diversity decline in the fall when spawning is curtailed (Able and Fahay 1998).

This dominance of bay anchovy is consistent with other regional studies, including Narragansett Bay (Bourne and Govoni 1988; Keller et al. 1999), Great South Bay, New York (Monteleone 1992), Long Island Sound (Wheatland 1956), the lower Hudson River estuary (Dovel 1981), and the Mystic River estuary (Pearcy and Richards 1962). Young stages of bay anchovy occur in every estuary in the Middle Atlantic Bight (Able and Fahay 1998), and bay anchovy are generally considered to be the most abundant western Atlantic coastal fish (McHugh 1967; Haedrich 1983). Based on available information, bay anchovy eggs can reasonably be expected to occur in Long Island Sound from June to September, and bay anchovy larvae can reasonably be expected to occur from June to November, with peak densities in July and August. Bay anchovy eggs and larvae were likely at or near their seasonal peak density in Long Island Sound during the August 23, 2005, sampling event, and their seasonal decline in abundance during the fall is clearly demonstrated by the reduced density during the October 4, 2005, sampling event (*see* Figure 7 in Attachment 2 of Appendix E).

Atlantic menhaden was the only species collected in greater density in October than in August. Atlantic menhaden spawn at night and during nearly every month in some part of its range (McHugh et al. 1959). There is limited spawning activity during the northward spring migration, limited summer spawning as far north as Cape Cod and the Gulf of Maine, then increased spawning activity during the southward fall migration (Able and Fahay 1998). This pattern is followed by intense spawning in the South Atlantic Bight during winter (Higham and Nicholson 1964).

3.2.2.5 Reptiles

Four species of sea turtle, including Kemp's Ridley (*Lepidochelys kempii*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*), may be found in the waters of Long Island Sound. Each of the four species is federally and state listed as an endangered or threatened species. Sea turtles use shallow-water marine benthic habitats such as seagrass beds for foraging and resting. Each species has a different preferred diet, but as a group they consume plants and animals, including eelgrass, mollusks, crustaceans, tunicates, jellyfish, and fish. While these species breed on beaches from the Carolinas to Mexico, migratory routes show that they utilize Long Island waters in summer (May to November), and the waters off Long Island are thought to be developmental habitat for juvenile turtles (Sadove 2005). Each of these species is covered in detail in Section 3.2.2.8, Threatened and Endangered Species.

Broadwater has requested stranding data from the Riverhead Foundation to identify the species that are most likely to be found in the Project area (*see* Appendix F). To date, no information has been received.

3.2.2.6 Marine Mammals

The Marine Mammal Protection Act of 1972 (MMPA) established a moratorium on the taking of marine mammals in U.S. waters. The definition of a "take" includes the capture, killing, or harassment of an individual. Harassment encompasses a broad category of disturbances that may cause disruption or changes in behavioral patterns. NOAA Fisheries has the authority to enforce the MMPA for cetaceans and some pinnipeds. Multiple marine mammal species have been reported stranded along the shores of Long Island Sound. Species commonly found in the Sound include harbor seals, gray seals, harbor porpoise, and common dolphin. The Riverhead Foundation, an agency that tracks marine mammal strandings in Long Island Sound, reported that 25 cetacean species and numerous pinniped species have been found stranded in Long Island Sound.

Broadwater has requested stranding data from the Riverhead Foundation to identify the species that most likely are to be found in the Project area. To date, no information has been received.

Pinnipeds

Several seal species may be found within the waters of Long Island Sound, and two—the harbor seal and gray seal—are commonly found in the Sound.

Harbor Seals (*Phoca vitulina*). Harbor seals range widely in the coastal areas of the North Pacific and North Atlantic, with worldwide populations estimated to be between 400,000 and 500,000. In the summer they are commonly found in eastern Canada and Maine. In winter they are known to migrate as far south as Long Island Sound. They feed primarily on schooling fish such as menhaden and herring, and on squid, octopus, and crustaceans (Riverhead Foundation 2005). Harbor seal are typically found in Long Island Sound from November to May.

Gray Seals (*Halichoerus grypus*). Gray seals are found only in the waters of the western north Atlantic and are estimated to number 200,000 to 300,000 worldwide. Populations are concentrated in eastern Canada, but can extend southward to eastern Long Island. They feed primarily on schooling fish such as herring, mackerel, flounder, cod, and salmon, and on squid, octopus, crustaceans, and seabirds (Riverhead Foundation 2005). Gray Seal are typically found in Long Island Sound from November to May.

Harp Seals (*Phoca groenlandica*). Harp seals, the most abundant pinniped in the northern hemisphere, are found primarily from Newfoundland to Russia in the pack ice of the north Atlantic, but can be found as far south as Virginia. The worldwide population is estimated to be between 4 and 6 million. They feed primarily on schooling fish such as herring and cod, and on crustaceans (Riverhead Foundation 2005).

Hooded Seals (*Cystophora cristata*). The hooded seal's breeding range is limited to the central and western north Atlantic, and worldwide populations are estimated to be between 250,000 and 300,000. They feed on a variety of schooling fish, squid, shrimp, octopus, and crustaceans (Riverhead Foundation 2005).

Ringed Seals (*Phoca hispida*). Ringed seals are commonly found in the Arctic Ocean, and other large populations occur in Hudson Bay, the Baltic Sea, and the Bering Sea; they are rare in Long Island waters. They feed mainly on polar cod (Riverhead Foundation 2005).

Cetaceans

The common dolphin and harbor porpoise are two cetacean species that are regularly found in Long Island Sound. The Riverhead Foundation indicated that occasional strandings of the pilot whale and minke whale have been reported in the Sound.

Common Dolphin (*Delphinus delphis*). The common dolphin can be found in the offshore waters of nearly all tropical, subtropical, and warm temperate seas. In the Atlantic Ocean, they range from Nova Scotia to Argentina. In the North Atlantic their main prey appears to be cod.

Harbor Porpoise *(Phocoena phocoena).* The harbor porpoise is widely distributed throughout coastal waters in the northern hemisphere. They feed mainly on cephalopods, benthic invertebrates, capelin, hake, cod, and schooling fish such as herring and mackerel (Riverhead Foundation). Harbor porpoises are commonly found in the Sound during winter months. Anecdotal reports of large numbers of harbor porpoises have been reported for Long Island Sound and use of the Sound by this species is likely underestimated (Durham 2005).

3.2.2.7 Avian Species

Long Island Sound is home to many avian species and also is an important wintering area. The Project area is located in deep water (>59 feet [>18m]) in the central portion of the Sound. Bird use in this area is likely dominated by pelagic species, including northern gannet (*Moru bassanus*), Wilson's storm petrel (*Oceanitus oceanicus*), and razorbill (*Alca torda*). Common offshore species that may utilize the area include greater scaup (*Aythya marila*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta deglandi*), long-tailed duck (*Clangula hyemalis*), red-breasted merganser (*Mergus serrator),* red-throated loon (*Gavia stellata*), Common loon (*Gavia immer),* double-crested cormorant (*Phalacrocorax auritus*), great cormorant (*Phalacrocorax carbo*), Common tern (*Sterna hirundo*), and gulls (*Larus* sp.). Species that are less common may be winter or summer visitors, including lesser scaup (*Aythya affinis),* black scoter (*Melanitta nigra),* red-necked grebe (*Podiceps grisegena*), Wilson's storm petrel, merlin (*Falco columbarius*), peregrine falcon (*Falco peregrinus*), roseate tern (*Sterna dougallii*), Forster's tern (*Sterna forsteri*), and razorbill. In addition to these species, the central portion of Long Island Sound may see occasional use by species more typically found in inshore areas, including Canada goose (*Branta Canadensis*), brant (*Branta bernicla*), bufflehead (*Bucephala albeola*), Common goldeneye (*Bucephala clangula*), horned grebe (*Podiceps auritus*), osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), and least tern (*Sterna antillarum*).

3.2.2.8 Threatened and Endangered Species

NOAA Fisheries has the primary responsibility for the conservation, management, and protection of marine species, marine mammals, and threatened and endangered marine species pursuant to the Magnuson Stevens Fisheries Act and the MMPA. On February 24, 2005, Broadwater requested information regarding the presence of endangered or threatened species, species of special concern, and the existence of critical or significant habitats on or in the vicinity of the Project area. Information was requested from USFWS, NOAA Fisheries, and NYSDEC's New York State Natural Heritage Program (*see* Appendix F).

In a letter dated March 17, 2005, USFWS responded that, except for occasional transient individuals, no threatened or endangered species under the jurisdiction of USFWS are known to occur in the Project area. In addition, no habitat designated or proposed as "critical habitat" in accordance with the Endangered Species Act (ESA) occurs in the Project area. The letter indicated that no further ESA coordination or consultation with USFWS is required for this Project. NYSDEC also indicated that only occasional transient individuals are expected to occur in the Project area.

In a letter dated August 16, 2005, NOAA Fisheries responded that four species of federally threatened or endangered sea turtles and three whale species under NOAA's jurisdiction are found seasonally in New York waters. These species are listed in Table 3-9 and discussed below. They also indicated that the leatherback sea turtles and whales are not typically present in Long Island Sound but are present in New York waters outside of the Sound.

Table 3-9 Threatened and Endangered Species Potentially Occurring in the Project Area

	Fed Status	State Status
Mammals		
Finback whale (*Balaenoptera physalus*)	E	E
Humpback whale (*Megaptera novaeangliae*)	E	E
Northern right whale (*Balaena glacialis*)	E	E
Fish		
Shortnose sturgeon (*Acipenser brevirostrum*)	E	E
Reptiles		
Kemp's Ridley turtle (*Lepidochelys kempii*)	E	E
Loggerhead turtle (*Caretta caretta*)	T	T
Green turtle (*Chelonia mydas*)	T	T
Leatherback turtle (*Dermochelys coriacea*)	E	E

E = Endangered T = Threatened

Table 3-9 identifies the species potentially occurring in the Project area, based on a review of federally protected species known to inhabit the North Atlantic. In addition to the species listed below, Broadwater recognizes the presence of other federally and state-protected species that can be found in offshore habitats of Long Island Sound, including the bald eagle and three tern (*Sterna* sp.) species. However, due to the Project's location in the central part of Long Island Sound and the lack of potential direct impacts, these species were not evaluated further.

Finback Whale *(Balaenoptera physalus*). The finback whale is found worldwide in all ocean basins. They may migrate to subtropical waters for mating and calving during the winter months and to the colder areas of the Arctic and Antarctic for feeding during the summer months. While finback whales may be sighted off the coast of Long Island during summer, they are not likely to be found in Long Island Sound (Young 2005; Durham 2005).

Humpback Whale *(Megaptera novaeangliae).* The humpback whale is found worldwide in all ocean basins. Seasonal migrants, they are found primarily in temperate waters in winter (the breeding season), and they are usually found in northern waters with high biological productivity in summer (the feeding season). New England waters are favored summer feeding grounds. While humpback whales may be sighted off the coast of Long Island during summer, they are not likely to be found in Long Island Sound (Young 2005; Durham 2005).

Northern Right Whale *(Balaena glacialis).* The range of most northern right whales in the western North Atlantic extends from calving areas in coastal waters off the southeastern United States in winter to feeding and nursery grounds in New England waters and north to the Bay of Fundy and the Scotian Shelf in summer. Five "high use" areas have been identified by NOAA Fisheries, including coastal Florida and Georgia, the Great South Channel, Massachusetts Bay and Cape Cod Bay, the Bay of Fundy, and the Scotian Shelf. While northern right whales may be sighted off the coast of Long Island during summer, they are not likely to be found in Long Island Sound (Durham 2005) (NOAA 2005).

Shortnose Sturgeon *(Acipenser brevirostrum).* The Shortnose sturgeon is an anadromous fish that spawns in coastal rivers along the east coast of North America from Canada to Florida. It prefers the nearshore marine, estuarine, and riverine habitat of large river systems. Shortnose sturgeon do not appear to make long distance offshore migrations. This species is very rarely found in Long Island Sound.

Threats to this species include habitat alterations from discharges, dredging or disposal of material into rivers, or related development activities involving estuarine/riverine mudflats and marshes (NOAA 2005).

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*). Kemp's Ridley sea turtle is found mainly in coastal areas of the Gulf of Mexico and the northwestern Atlantic Ocean. The major nesting beach for Kemp's Ridleys is a 10-mile stretch on the Gulf Coast of Mexico, near Rancho Nuevo. After hatching in Mexico, many juveniles travel to Long Island waters with the Gulf Stream in summer. The waters off Long Island provide important developmental habitat for juveniles of this species (Sadove 2005). Kemp's

Ridley turtles feed largely on crabs while in Long Island waters, but also eat fish, jellyfish, squid, snails, clams, sea stars, and marine vegetation (Riverhead Foundation). They feed preferentially in nearshore waters where crabs are abundant. In fall Kemp's Ridley turtles leave Long Island waters and migrate south to warmer waters (Sadove 2005).

Threats to this species include disruption of the nesting beach, trawling, floating debris and incidental take associated with dredging (NOAA 2005).

Loggerhead Sea Turtle *(Caretta caretta).* Loggerhead sea turtles inhabit continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters around the globe. The loggerhead turtle's Atlantic range extends from Newfoundland to as far south as Argentina. Primary Atlantic nesting sites are found along the east coast of Florida, with additional sites in Georgia, the Carolinas, and the Gulf Coast of Florida.

Loggerheads are found in Long Island waters beginning in June and in fall move south to warmer waters. They feed on crabs, crustaceans, squid, bivalves, jellyfish, fish, and eelgrass (Riverhead Foundation 2005).

The most significant threats to loggerhead turtle populations are coastal development, commercial fisheries, and pollution (NOAA 2005).

Green Sea Turtle *(Chelonia mydas).* Green sea turtles are found throughout the world. The primary nesting sites in U.S. Atlantic waters are along the east coast of Florida, with additional sites in the U.S. Virgin Islands and Puerto Rico. Green sea turtles are found in Long Island waters in summer. Juveniles feed on squid, bivalves, jellyfish, and crustaceans, while adults feed mainly on submerged aquatic vegetation and algae.

The greatest cause of decline in green turtle populations is commercial harvest for eggs and food. Other threats include the use of turtle parts for leather, jewelry, and curios and incidental catch during commercial shrimp trawling (NOAA 2005).

Leatherback Sea Turtle *(Dermochelys coriacea).* Leatherback sea turtles are found from Cape Sable, Nova Scotia, south to Puerto Rico and the U.S. Virgin Islands. Nesting occurs from February to July from Georgia to the U.S. Virgin Islands. During the summer, leatherbacks tend to be found along the east coast of the U.S. from the Gulf of Maine south to the middle of Florida and are commonly seen in Long Island's offshore waters in late summer. Leatherbacks feed on jellyfish and other gelatinous species (Riverhead Foundation 2005).

Threats to this species while in U.S. waters include incidental take by commercial fisheries and marine pollution (NOAA 2005).

3.2.2.9 Commercially Important Species

The waters of Long Island Sound support a variety of finfish and shellfish, several species of which are recreationally and commercially important. The bulk of the summer commercial fishery consists of scup, butterfish, striped bass, weakfish, summer flounder, and menhaden. Winter flounder and windowpane flounder support the winter trawl fishery in Long Island Sound. Bottom-trawling activities have been identified in the general area of the proposed Project (*see* Figure 3-17, trawl lanes) that could potentially be impacted by the Project. Finfish are discussed in detail in Section 3.2.2.2, and a summary of EFH is presented in Section 3.2.1.1.

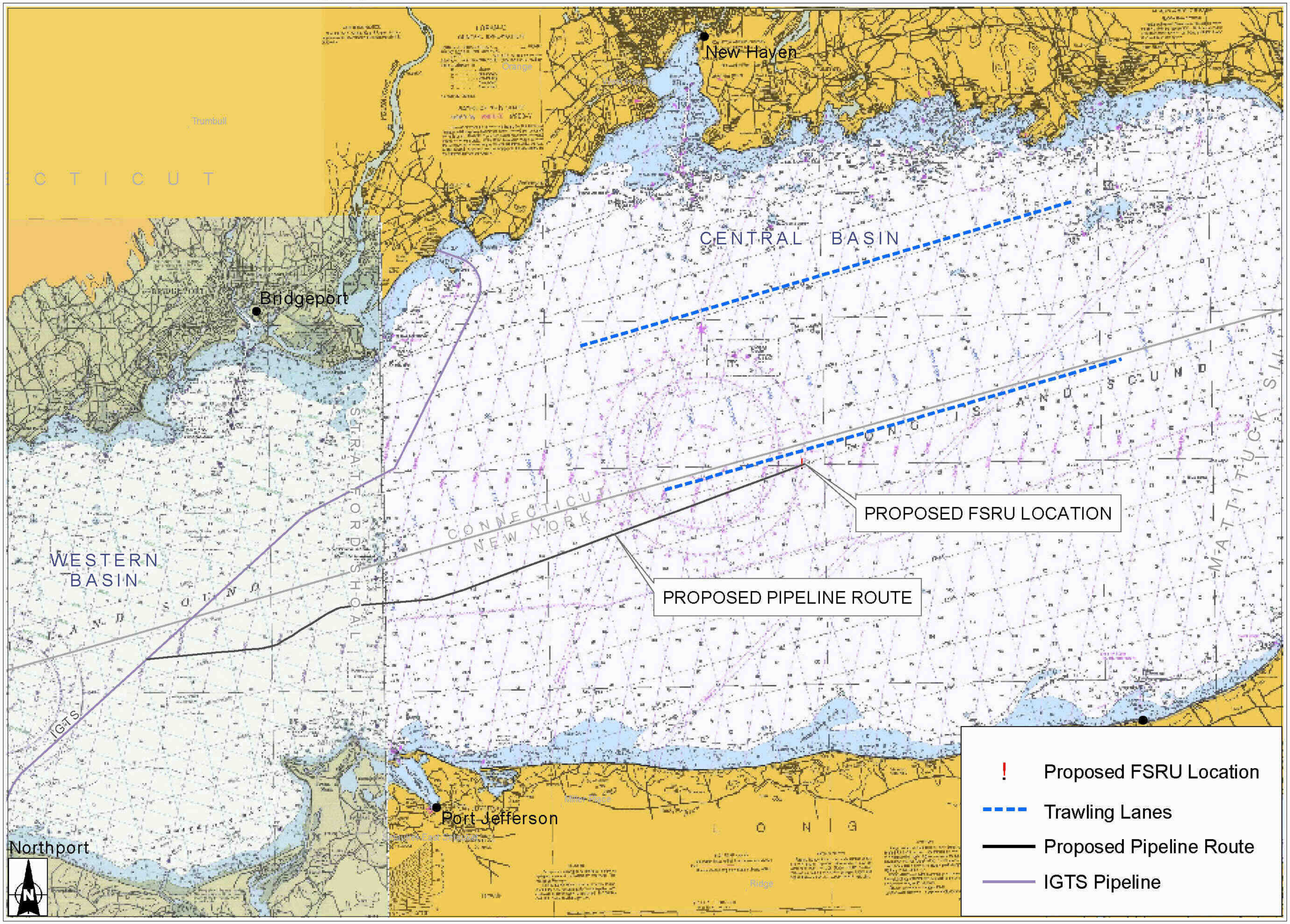
Important shellfish in Long Island Sound include the American lobster (*Homarus americanus*), blue crab (*Callinectes sapidus*), red crab (*Geryon quinquedens*), green crab (*Carcinus maenas*), clams, conches, oysters, and bay scallops. Lobster pot densities in Long Island Sound are depicted on Figure 3-18. As demonstrated on this figure, the entire central portion of the Sound is heavily utilized by lobster fishermen. Geophysical and geotechnical surveys completed by Broadwater during the spring of 2005 confirmed that lobster fishing is prevalent in the Project area. Only in the nearshore area of Connecticut, where shellfishing is more prevalent, and the extreme eastern portion of the Sound, where topography, substrates, and currents are less conducive to lobsters, are lobster pot densities much lower.

Broadwater has undertaken a fishermen's outreach program for the proposed Project area to gain knowledge of commercial and recreational fishing in the area. The majority of the fishermen working in the area target lobster, and many of the lobstermen supplement their fishing efforts with by-catch, other fish caught with fixed gear, and fish caught through trawling. Trawling is restricted to trawl lanes created through cooperative agreements between fishermen. Species reported as collected by the fishermen surveyed include lobster, tautog (blackfish), black sea bass, scup (porgies), conch, squid, summer flounder (fluke), flounder, bluefish, striped bass, and butterfish. Commercial and recreational fishing are covered in greater detail in Resource Report 8.

3.3 POTENTIAL IMPACTS AND MITIGATION

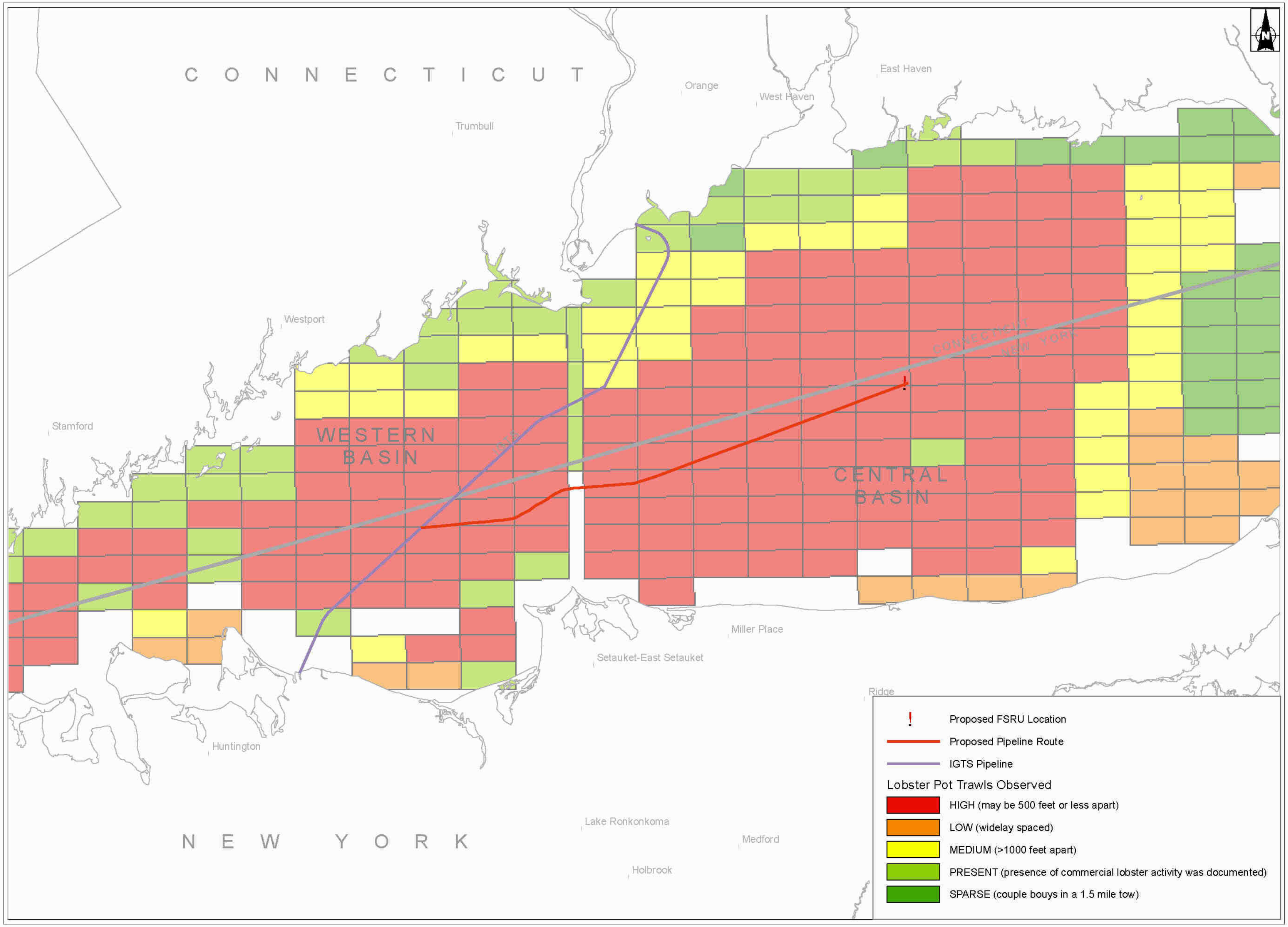
Construction and operation of the proposed facilities have the potential to result in both positive and negative impacts on the marine environment. Impacts during construction are expected to be minor, localized, and short-term, resulting from the installation of the pipeline and FSRU. Installation of the Project will require bottom disturbance, resulting in temporary habitat disturbance.

Both positive and negative impacts have been identified in conjunction with the operation of the Project. Positive impacts will result from the diversification of habitat within the Sound, with the FSRU creating shaded habitat and additional structure in the central portion of the Sound in an area that currently is relatively homogeneous in terms of habitat availability. In addition, the likely USCG designation of a safety and security zone in conjunction with the Project will create a habitat that may be excluded from fishing impacts. Potential impacts on commercial fishing due to establishment of a safety and security zone are discussed in Resource Report 8, Land Use, Recreation, and Aesthetics.



Source: Trawl Lane Locations (Loran Lines 43970 to 43973, 15070 to 15 Miles East, New York and Loran Lines 44010 to 44012, 15080 to 14955, Connecticut) provided by Broadwater Stakeholder Team, 2005,
U. S. Geological Survey Open-File Report OFR 00-304, 2000,
U. S. NOAA Electronic Nautical Charts.

Figure 3-17 Trawling Lanes in the Project Area



Source: Connecticut Department of Environmental Protection, 2004.

0 2.5 5 10
Miles

Figure 3-18 Lobster Pot Densities in the Project Area

BW001247

Impacts on biological resources due to operation of the Project will largely result from water intakes and discharges associated with the daily FSRU operations. While two to three LNG carriers will be offloading cargo on a weekly basis, the overall impact from increased vessel traffic will be negligible given the magnitude of existing commercial traffic in the Sound. Resource Report 8 includes a broader analysis of the existing commercial traffic in the Sound.

Impacts have been minimized by siting the facility in deepwater habitat in the Sound, away from shoreline and nearshore areas that serve as important nesting, feeding, resting, spawning, and nursery areas for many species. Impacts will be further minimized by installing the facilities during winter, when use of the Sound by marine species is reduced, and by utilizing appropriate installation technologies and best management practices.

The following section presents a general discussion of potential Project-related impacts, followed by a more specific discussion of those impacts on a resource-by-resource basis.

3.3.1 General Construction Impacts

3.3.1.1 Pipeline

Construction of the proposed pipeline will result in temporary direct impacts on the seabed as a result of pipeline installation activities. Where technically feasible, Broadwater will use a post-lay subsea plow as the primary means of lowering the pipeline. Alternative construction methods will be used at the IGTS and FSRU tie-ins, the AT&T and CSC cable crossing, and potentially across Stratford Shoal. Because of the presence of existing utilities, the excavations at these locations will be performed using a submersible pump or by divers using hand-jetting or air-lifting equipment. Information regarding the construction methodologies is provided in Resource Report 1, General Project Description. An installation summary, including affected acreages and volumes, is presented in Table 3-10.

Table 3-10 Broadwater Pipeline Installation, Summary of Sediment-Related Impacts

Impact Type	Sediment Volume (cu yards)	Impact (acres)	Comment
Pipeline lowering via plow; 19.7 miles to a depth of 3 feet	304,500	179.1	Impacts include both the trench and associated spoil mounds.
Pipeline lowering via plow; 2 miles with 5 feet of cover	39,500	18.2	In proximity to the FSRU, the pipeline will be lowered to a greater depth to accommodate design considerations.
AT&T cable crossing	3,030	0.4	Impacts include excavations for crossing bridge and pipeline trench transition.
Cross Sound Cable crossing	3,030	0.4	Impacts include excavations for crossing bridge and pipeline trench transition.
FSRU tie-in	1,650	0.2	Includes expansion loop.
Check and isolation valve spool	270	< 0.1	Located approximately 2,000 feet from the FSRU.

Table 3-10 Broadwater Pipeline Installation, Summary of Sediment-Related Impacts

Impact Type	Sediment Volume (cu yards)	Impact (acres)	Comment
IGTS tie-in	2,340	0.3	Includes expansion offset
Anchor footprint	N/A	16	8-point mooring, three anchor sets per mile, and three passes (one lay, and two plow)
Anchor cable sweep	N/A	2,020	8-point mooring, midline buoys on quarter anchors, three anchor sets per mile, and three passes (one lay, and two plow)
Total	354,320	2,234.7	

Installation of the pipeline will directly affect the seabed within the corridor in which the pipeline will be installed and along which anchor placement and cable sweep will occur. In addition to the potential for direct mortality from these construction activities, limited changes in turbidity levels, suspended solids, and sediment deposition in the vicinity of the active construction area are expected from direct disturbance to the seabed. While it is unavoidable that some sediments will become suspended in the water column and dispersed as a result of plowing and dredging activities, the proposed use of the subsea plow for the vast majority of the installation will minimize these impacts. Based on the water quality and sediment modeling results, increases in TSS and resulting sedimentation are predicted to largely fall within the existing variation in ambient TSS levels and sedimentation rates in Long Island Sound. Excessive sedimentation that could adversely impact existing communities would be restricted to the central pipeline corridor, primarily associated with the spoil piles resulting from the subsea plowing. Based on Project-specific modeling to assess potential sedimentation impacts, with the exception of the spoil pile footprints, the maximum increase in sediment deposition would be 0.2 inch (4.99 mm), with most areas falling well below that (*see* Appendix G). The sediment transport and sediment deposition modeling results demonstrate that neither increased sediment in the water column nor increased sediment deposition will result in a significant adverse impact on the water column or on existing ecosystems in Long Island Sound. Detailed water quality/sediment modeling results are presented in Section 2.3.5, and Appendix A of Resource Report 2, Water Use and Quality.

As indicated in Table 3-10, anchor sweep during installation of the pipeline has the potential to impact up to 2,020 acres of the sediment surface. Unlike the area directly affected by pipeline construction, the impacts resulting from anchor sweep will be limited to surficial disturbance. These impacts are expected to be extremely localized, and the affected areas are expected to recover through natural processes following construction. Broadwater is not aware of any reports or findings detailing continued impacts from either the anchor footprints or cable sweep in Long Island Sound.

Where necessary (i.e., the first 2 miles and at ties-in, valves, and cable crossings), the trench will be backfilled with either side-cast spoil or imported clean material. The remainder of the pipeline within the trench will be allowed to backfill naturally through sediment deposition. The pipeline route is located primarily in portions of the Sound that are considered depositional; therefore, natural oceanographic processes will facilitate the restoration and recovery of physical bottom conditions. Recognizing agency concerns regarding potential impacts from an open trench, modeling was conducted to determine the time required for the trench to backfill naturally. For the majority of the route (where the pipeline is installed within depositional environments), a depression up to approximately 2.7 feet below the surrounding seabed elevation is expected to remain 12 months after installation has been completed; a depression up to approximately 1.8 feet below the surrounding seabed elevation is expected to remain 24 months after installation has been completed; and a depression up to 6 inches below the surrounding seabed elevation is expected to remain 30 months after installation has been completed (*see* Appendix H). The sediment infill to the trench is expected to be comprised of sand, silt, and clay from the spoil pile. As the vast majority of the route is located within a depositional environment, ongoing natural sedimentation of silt and clay will also contribute to infilling of the trench. The benthic macroinvertebrate community, which is important foraging habitat for many species, is expected to recover following construction, primarily as a result of emigration of individuals from nearby undisturbed areas, vertical migration through the sediments, and seasonal reproduction and larval recruitment. An early successional stage dominated by species adapted to migrating through the deposited sediment is expected to begin to recolonize the area immediately following construction and to occupy the affected area during reestablishment of the seabed to, or near, its pre-construction contours. Other benthic species such as lobsters, hermit crabs, and demersal fish may also be attracted to the topographic relief offered by the depression and eroding spoil mounds.

In isolated areas, primarily at the utility crossings and potentially at Stratford Shoal, supplemental clean fill material or concrete armoring may be needed to ensure adequate protection of the pipeline. In areas where armor rock or concrete mats may be needed for protection, some minor modification of the seabed may occur. The introduction of rock or other clean fill material would likely result in some increased habitat diversity, increased populations of forage species, and increased cover. Species such as oysters, barnacles, and mussels are expected to flourish in this additional habitat, providing additional forage for other marine species. These areas also are expected to provide additional cover for lobsters and other shellfish, as well as fish species, such as tautog, that prefer habitat with cover.

Prior to beginning operation, the pipeline will be hydrostatically tested in spring 2010 using water withdrawn from Long Island Sound, potentially resulting in the entrainment of aquatic species. The water intakes used to withdraw the water will be screened to prevent localized entrainment of fish. It is assumed that 100% of the plankton entrained in the test water will be lost. While some plankton mortality is unavoidable, this will be a one-time withdrawal and the volume of water required for hydrostatic testing is an insignificant fraction (0.00000028%) of the total water available in the Sound. Impacts on water quality and aquatic organisms will be minimized through the use of best industry practices, screening, intake of water at 20 to 40 feet (6 to 12 m) below the water surface, treatment/ neutralization of water prior to discharge, and re-oxygenation of water prior to discharge. Potential water quality impacts associated with hydrostatic testing are discussed in detail in Section 2.5.1.1 of Resource Report 2, Water Use and Quality.

Lighting has the potential to attract marine species during construction and operation of the facilities. Lighting during construction will not vary significantly from existing lighting in the Sound resulting from other marine activities such as fishing, lightering, and anchoring of commercial vessels.

3.3.1.2 Tower Structure and FSRU

Installation of the proposed tower structure will result in the disturbance of approximately 25,000 square feet (2,322 m^2) of the seabed and the associated bottom habitat. Although the actual footprint of the tower will be only 13,180 square feet (1,225 m^2), additional disturbance will occur in conjunction with anchor placement during the installation process. Additional discussion of installation of the tower structure and FSRU is provided in Resource Report 1, General Project Description. Long-term impacts are anticipated only at the locations of the pilings, which will be the only area where bottom habitat is eliminated as a result of installation of the tower. The surface of the seabed within the footprint of the mooring tower footings will be affected during installation, but the area impacted is anticipated to recover due to the depositional environment in the central Sound and benthic community recruitment.

To control stability during the lowering of the mooring tower jacket, a shallow frame, or mud mat, is installed at the base of the jacket between the four legs. A mud mat is made of untreated lumber and has the sole purpose of providing stability control during jacket installation. The mud mat will be buried during the installation process by bottom sediments flowing around and through the framing. Sediment from the seabed will flow over the edges of the mud mat as the jacket settles onto the seabed, effectively burying it in the process. While the untreated lumber will remain buried in the sediment and may provide some habitat value, it is not intended as a biological habitat feature. While the sediments will be disturbed, they will continue to function as biological habitat. Some limited injury and mortality of benthic organisms occupying the mooring tower footprint are expected during this process.

In conjunction with installation of the mooring tower, short-term impacts are anticipated due to increased noise and vibration associated with pile installation. The timing of this activity will limit the extent of impact, and mobile species will be able to vacate the Project area to avoid impacts. Injury or mortality of fish and marine mammals may occur in areas where subsurface noise levels reach a peak of 180 dB. These potential impacts are discussed in greater detail in Sections 3.3.4.2 and 3.3.4.6.

The 180 dB threshold for potential injury to marine resources is gleaned from multiple sources. Most recently, NOAA Fisheries/NMFS established this threshold for physical harm in the SR 104 Edmonds Crossing Ferry Terminal Project on Puget Sound Washington (NMFS 2004).

Previous to that, NMFS specified threshold noise levels for Level A harassment at 180 dB for cetaceans and 190 dB for pinnipeds in relation to the construction and operation of offshore oil and gas structures in Beaufort Sea (NMFS 2000).

In a 1999 pile-driving noise study for Sable Island facilities, Greene suggest that temporary threshold shift (TTS) may occur at levels of 180 dB for cetaceans and 190 dB for pinnipeds as a result of pulsive noise, such as that generated from pile-driving. Discussion with the author (Greene 2006) indicates that these threshold levels were based on his review of NMFS decisions.

Finally, in a presentation on offshore energy developments impacts on marine mammals, given at the Mini-Conference on the Impacts of Offshore Energy Development on Coastal Marine Wildlife (C.R.E.S.L.I. and Dowling college-March 23, 2005). Sharon B. Young, Marine Issues Director for the Humane Society, indicated that 180 dB was thought to be the threshold for physiological affects on marine mammals.

Broadwater will continue to consult with NOAA Fisheries to develop procedures to minimize impacts on marine species. Pile driving for four piles is expected to occur in approximately October 2010 over a period of fourteen days, with construction during daylight hours. Selection of installation equipment and procedures cannot be determined until deep bore tests have been made to assess the subsea stratigraphy at the FSRU site. Therefore, only preliminary noise estimates are possible at this time. Preliminary noise estimates, based on existing literature, indicate that noise levels may be as high as 180 dB at distances of 1,920 to 2,950 feet (585 to 900 m) from the source, depending on the hammer energy (*see* Table 3-11). Pile-driving noise is discussed in greater detail in Resource Report 9, Air and Noise Quality. Installation techniques will be determined following deep boring investigations at the piling locations. Broadwater will continue to consult with NOAA Fisheries to develop installation procedures to minimize impacts on marine species.

Table 3-11 Estimated Distance to 190 and 180 Db RMS Level

Hammer Energy (K-Joules)	190 dB RMS Feet (m)	180 dB RMS Feet (m)
750	606 (185)	1,919 (585)
1,000	705 (215)	2,231 (680)
1,250	787 (240)	2,477 (755)
1,500	869 (265)	2,739 (835)
1,750	935 (285)	2,953 (900)

The FSRU will be constructed outside the Project area and towed to Long Island Sound. As such, the potential exists for the FSRU to contain foreign ballast water, which could introduce foreign species to the Sound. To minimize potential impacts resulting from the introduction of potentially invasive species, the FSRU will exchange ballast water in offshore waters prior to being towed into Long Island Sound. Therefore, the ballast water contained in the FSRU when it is towed into the Sound will consist of North Atlantic seawater, which has characteristics similar to the water typically found in Long Island Sound.

Lighting has the potential to attract marine species during installation and operation of the facilities. Lighting during construction will not vary significantly from existing lighting in the Sound resulting from other marine activities such as fishing, lightering, and anchoring of commercial vessels.

3.3.2 General Operational Impacts

3.3.2.1 Pipeline

Operation of the proposed pipeline has the potential to locally impact marine habitats due to maintenance activities and potential thermal impacts from the pipeline.

It is anticipated that pipeline maintenance will be limited to periodic inspection and pigging activities, which may involve accessing mainline valves. These activities would require minimal daylighting of buried facilities, with excavation limited to the use of a submersible pump or by divers using hand-jetting or air-lifting equipment. Any subsea maintenance activities will require localized re-disturbance of sediments. The impacts associated with maintenance activities will be similar to those described for construction, i.e., of short-term duration, likely affect a very limited area, and result in no significant impact on habitat.

The 30-inch-diameter pipeline will be coated with 3 inches of concrete except along the descent through the mooring tower. Depending on the season (winter versus summer) and volume of gas flow (high versus low), natural gas is expected to enter the pipeline at a temperature between slightly higher than 100°F (38°C) and slightly lower than 130°F (54°C) at the top of the mooring tower and to fall to a temperature between 100°F (38°C) and 120°F (49°C) at the bottom of the mooring tower, or at the sediment surface. The heat loss experienced in the pipeline from the surface to the seabed would be transferred to the surrounding water column. Based on the sheer volume of water flowing by the pipeline, any increases in temperature would be readily dissipated in the water column with no significant thermal plume expected. In the winter, the temperature differential between the pipeline and the surrounding water column could reach 80° to 90°F (27° to 32°C). While the additional heat will be readily assimilated into the surrounding water column, a potential microclimate could be established within the immediate vicinity of the pipeline riser and mooring tower. As presented in Appendix J to Resource Report 2, Water Use and Quality, thermal modeling of the heat exchange from the pipeline riser to the surrounding water column will be measurable only within approximately 30 inches (76 cm) from the pipeline. Figure A-2 in Appendix A provides a visual representation of the thermal modeling from the riser. This small area could function as an attractant to the local fishery, increasing the density of fish in immediate proximity to the pipeline riser, and could prove to be attractive to predatory marine mammals, as well. The restricted extent of the thermal influence, due to the normal tidal and current fluctuation within the Sound, minimizes potential impacts on the surrounding ecosystem. The remainder of the pipeline will be coated with 3 inches of concrete and installed to a depth of 3 feet below the sediment surface, or otherwise protected with armor rock or concrete mats. Based on the thermal modeling conducted for the subsea pipeline portion, a localized thermal impact will occur immediately following installation, prior to natural backfilling of the pipeline. The transmission of higher temperature gas through the pipeline could result in some minimal temperature transfer into the surrounding sediments, but the impact will be highly localized and will not result in significant impacts on marine or benthic habitat. Figure A-3 in Appendix A presents the extent of thermal impact based on Project-specific modeling. As with the pipeline riser, impacts will be extremely localized, extending less than 1 pipe diameter away from the pipe. Impacts will decrease over time as natural infilling of the trench provides insulation for the pipeline. Figure A-4 in Appendix A presents the modeling results following the natural infilling of the trench. Although temperature impacts are eliminated from the water column, a localized zone of increased sediment temperature will likely develop around the pipe, resulting in potential shifts in the benthic community. Based on the limited extent of the thermal effect, impacts will be minimal and result in no large-scale alterations to the benthic community. Potential water quality impacts associated with thermal changes are discussed in detail in Section 2.5.2.1 of Resource Report 2, Water Use and Quality.

3.3.2.2 FSRU

Operation of the FSRU will result in both positive and negative impacts on biological resources through alteration of the seabed and existing habitat and through small-scale water exchanges required for ballasting and other FSRU processes. Although specific impacts on water quality are addressed more fully in Resource Report 2, Water Use and Quality, this Resource Report addresses the biological organisms within the water column that could potentially be impacted.

The presence of the FSRU and associated mooring tower will result in the establishment of a microhabitat within Long Island Sound. At the proposed FSRU location, the Sound is characterized primarily as a large expanse of mud-bottomed habitat with little, if any, topographic relief. The FSRU and mooring tower will introduce significant vertical structure into the water column, and the size of the FSRU will introduce a permanent source of shading into the Project area. In addition, based on site-specific conditions and engineering considerations, areas along the pipeline route will be further armored to ensure pipeline integrity. These introduced features will result in considerable habitat diversity on a small scale, in essence creating artificial reef habitat. In addition, any safety and security zone designated by the USGC around the FSRU will become a refuge or sanctuary for marine organisms, due to the removal of fishing pressure. Although small in size relative to the area of Long Island Sound, the Project area will introduce diversity and structure where it is now largely absent except for isolated wrecks and other debris on the Sound floor. Any loss of habitat resulting from installation of the FSRU will be offset by the increased habitat that is created.

Operation of the proposed FSRU has the potential to result in some adverse impacts on the water column and water quality. To maintain in-water stability, both the FSRU and any offloading LNG carriers will be required to withdraw/discharge Sound water. While the FSRU will be required to both discharge and withdraw water, LNG carriers will only take on ballast water to compensate for offloaded LNG. This will eliminate the potential for the introduction of foreign/exotic species into the Sound from carrier ballast systems.

The FSRU will use seawater for its ballast and fire-water systems. Water discharges from the FSRU will be restricted to four primary sources—the fire water bypass, ballast water discharge, rainwater runoff, and the wastewater treatment plant. Additional discussion of the water intakes and discharges is presented in Section 2.5.2.2 of Resource Report 2, Water Use and Quality.

Potential impacts associated with the water intake include impingement and entrainment of organisms as water is drawn into the FSRU. The intake structure for the FSRU will be designed to reduce impacts to the extent practicable. Water intake flow velocities will be maintained at a maximum of 0.5 feet/second (0.15 m/s), which will allow any motile organisms to swim away from the intake, thereby largely limiting entrainment/ impingement impacts. The intake structure will include a pair of screens/grates to further reduce impacts. The intake will contain a grate, flush with the FSRU hull, that will restrict the passage of larger fish. A second internal screen with a mesh size of approximately 5 mm will restrict the intake of all but the smallest planktonic organisms. Intakes for the FSRU will be located approximately 40 feet (12 m) below the water line. LNG carriers calling on the FSRU will have similar screen sizing and intake velocities. However, due to less draft, intakes associated with the carriers may be as shallow as 30 feet (8 m). By situating the intake structure at approximately 30-40 feet (8-12 m) below the surface, in the middle of the water column, impacts are avoided for all buoyant or demersal biological life stages. To minimize marine growth within seawater systems on board the FSRU, sodium hypochlorite will be injected into the water intake stream. Therefore, complete or near complete mortality of all entrained organisms is assumed for the purpose of biological assessment.

Potential impacts from FSRU discharges also have been identified. The injection of sodium hypochlorite to restrict marine growth introduces chlorine into the FSRU seawater systems. However, only residual chlorine levels, estimated to be between 0.01 and 0.05 ppm, will be present in the discharge. These levels will not result in significant adverse impacts on biological resources. Section 2.5.2.2 of Resource Report 2, Water Use and Quality, provides additional details regarding potential impacts attributable to residual chlorine.

The FSRU will contain a waste water treatment facility designed to meet all applicable state and federal discharge standards. Combined with the relatively minor volume of discharge, no significant impacts are anticipated. If a treatment system cannot be designed to meet discharge standards, black and grey water will be held on board the FSRU and shipped to shore for disposal at an approved facility.

In addition to the anticipated daily discharges, potential impacts could result from spills or other accidents at the facility. Impacts on water quality and the local ecosystem will be minimized through a variety of measures, including implementation of a Spill

Prevention, Control, and Countermeasures (SPCC) Plan and other plans, as appropriate, for handling hazardous materials and hazardous and solid waste. Any impacts resulting from operation of the facility, including an LNG spill, would result in short-term, localized impacts. The effects of an LNG spill would likely be limited to the water surface and a limited portion of the upper water column in the vicinity of the FSRU. The impacts of such a spill would include temporary changes in the thermal characteristics of the affected area. A significant release of LNG could result in limited mortality to fish and wildlife in the Project area of species that are unable to vacate the Project area in advance of an approaching plume. However, unlike transshipments of heavy petroleum projects (e.g., fuel oils), an LNG spill would evaporate leaving no residual product. As such, the marine community would be expected to quickly recover.

Operation of the FSRU will require the use of several materials that, if spilled, could potentially adversely affect the ecosystem. Diesel fuel, which is required for daily operations, will be stored in tanks integrated into the hull of the FSRU or associated with equipment internal to the FSRU (e.g., diesel fire pumps), thereby minimizing the potential for spill. Ethylene glycol, integral to the STV process, is incorporated into a closed system, with no potential discharge during normal operations. Aqueous ammonia and mercaptan will be transferred to the FSRU via ISO tanks and properly stored, again minimizing potential impacts on the marine ecosystem.

Maintenance or other actions (such as the application of anti-fouling paint) may be required to reduce marine growth on the external portions of the FSRU. Activities to reduce marine growth will be conducted according to procedures developed in conjunction with federal and state agencies to minimize impacts on marine species. Antifouling paint would be applied to the FSRU hull during construction, with no in-water application proposed throughout the operating lifetime of the FSRU. Broadwater proposes to use a copper-based antifouling paint rather than a tri-butyl tin paint, which has been recognized as having considerably greater ecological impact. Antifouling paint has the potential to leach copper to the water column in small quantities. However, since the antifouling paint will be applied at the shipyard, and the ship will require significant transit time from the shipyard to Long Island Sound, the level of copper leaching likely to occur within Long Island Sound will be minimal. By the time the vessel reaches Long Island Sound, it is expected to have reached a leaching rate of 1.005 µg copper/liter of water, or lower. The water quality criteria promulgated by the EPA for the protection of aquatic organisms indicates that, to a great extent, the saltwater aquatic organisms and their uses should not be impacted if the 4-day average concentration of dissolved copper does not exceed 1.9 µg/L more than once every 3 years and if the 24-hour average concentration for dissolved copper does not exceed 3.1 µg/L more than once every 3 years. Since the expected concentration of 1.005 µg copper/liter of water is below the EPA impact threshold, no impact on aquatic organisms is expected due to the leaching of copper from the antifouling paint present on the FSRU hull. Potential water quality impacts associated with use of antifouling paint are discussed in detail in Section 2.5.1.2 of Resource Report 2, Water Use and Quality.

Operation of the FSRU has the potential to result in some minimal impact on the surround ecosystem by the introduction of a previously non-existing light source. Safe operation of the FSRU will require some level of continuous lighting to facility FSRU operations. This lighting has the potential for some long-term impacts by attracting species to the FSRU. Lighting of the FSRU will be designed to minimize potential impacts, and the following measures will be implemented to mitigate lighting impacts:

- Lighting used during operational activities will be limited to the number of lights and wattage necessary to perform such activities.
- Lights will be shielded so that the beam falls on the workspace, and light beams will not be directly visible more than 1,000 m from the source.
- Lights shining into the water will be limited to the area immediately around vessels, except when essential for safe navigation, the safety of personnel, or other safety reasons.

Simulations of nighttime lighting on the FSRU are presented in the Visual Resource Assessment, which is included as Appendix D of Resource Report 8, Land Use, Recreation, and Aesthetics. As depicted in these simulations, lighting will be minimal, with no significant light exposure to the water surface.

Broadwater will prepare a detailed lighting plan, developed as part of the final design of the facilities, prior to initiation of construction.

Some noise will be generated during operation of the FSRU. Adequate controls will be placed on equipment on the FSRU to minimize undo exposure of the workers to noise. This will have an ancillary benefit of reducing the noise levels, both above and below water, that could potentially impact marine species. In addition, the noise within the water column would be further dampened by the presence of the ballast tanks between the inner and outer hulls of the FSRU.

3.3.3 Long Island Sound Habitats

The coastal areas of Long Island Sound contain a diversity of habitats that contribute to the overall value of the Long Island Sound ecosystem. The USFWS and NYSDOS have identified critical areas that merit protection/conservation to maintain the health of the local ecosystem. In addition to these designated areas (discussed in greater detail in Sections 3.2.1.2 and 3.2.1.3), numerous other wetland and submerged aquatic vegetation complexes provide essential food, cover, and habitat for local populations.

Recognizing the value of these inshore coastal habitats, the Project has been located in the central portion of the Sound to largely avoid these inshore habitats. As such, no impacts on these coastal habitats are anticipated during construction of the Project.

LNG carriers traveling to and from the FSRU facility will enter Long Island Sound through the Race, the eastern access to the Sound. The Project does not include any activities that would substantially alter water currents or result in significant impacts on aquatic species utilizing the area. The LNG carriers will have no significant impact on the overall volume of commercial vessels that currently transit the Race as they enter and depart from Long Island Sound.

Vessels transiting this area have the potential to impact marine mammals through collision. Broadwater will take measures to minimize impacts on marine mammals as discussed in Section 3.3.4.6. LNG carriers transiting the Race have the potential to impact fishing use of the area due to the safety and security zone associated with the transiting vessels. However, no significant impacts on the Race or its use by fishermen are expected due to the short duration of the transit period (approximately 15 minutes) and the small number of shipments per week.

3.3.3.1 Essential Fish Habitat

As discussed in Section 3.2.1.1, much of Long Island Sound is identified as EFH for a number of fish species. Therefore, some degree of impact may occur as a result of construction and operation of the Project.

Construction

Potential impacts on EFH during construction should be localized and short-term, occurring only during the time of installation and shortly thereafter. Impacts have been minimized by siting the facility in a deepwater habitat in the Sound, away from nearshore areas that serve as important spawning and nursery areas for many species. Impacts will be further minimized by installing the facilities during winter, a time of reduced biological activity, and by utilizing appropriate installation technologies. Potential impacts on EFH are summarized below. Specific impacts on EFH species are further discussed in Appendix A.

Construction-related impacts will differ from species to species, depending upon life history, habitat use (e.g., demersal versus pelagic), distribution, and abundance. Potential EFH impacts within the Project area will be limited primarily to demersal (i.e., bottom-oriented) species and life stages and those species whose predominant forage species are demersal. Pelagic species and life stages are expected to continue using the water column following Project installation. During installation, pelagic species might experience disturbance to a small portion of EFH due to the need to avoid the active installation area. Most of the remaining pipeline route and area, however, would remain available. Pelagic larval and egg life stages (i.e., those life stages with limited motility) will be carried through the active Project area with prevailing tides and currents, resulting in limited exposure to construction-related disturbance.

Short-term water quality impacts on EFH due to construction activities will most likely be limited to changes in turbidity levels and suspended solids immediately within the installation corridor of the proposed pipeline route; thus, no significant impact is expected. Based on the water quality and sediment modeling results, increases in TSS and resulting sedimentation outside the central pipeline corridor are predicted to fall within the normal range of variation in ambient TSS levels and sedimentation rates.

Therefore, the modeling results demonstrate that increased sediment in the water column will not result in a significant adverse impact on the water column or on existing ecosystems in Long Island Sound. Detailed water quality/sediment modeling results are presented in Section 2.3.5 of Resource Report 2, Water Use and Quality

Temporary disturbance of bottom habitat will occur along the proposed pipeline route as a result of installation activities. Existing sediments along the proposed pipeline route support a benthic community that is an important food resource for fish, particularly the epibenthos. Disturbance of EFH sediments will be short-term, since natural sedimentation and subsequent recolonization of benthic invertebrates is expected to occur following pipeline installation activities. Because of the widespread occurrence of this benthic community throughout the central and western basins of the Sound and the expected recovery after disturbance, the short-term loss of the benthic community within the pipeline corridor during installation will not have a significant adverse impact on EFH.

Natural deposition will gradually reestablish a layer of sediment that reflects the ubiquitous characteristics of the surrounding area. Due to the short-term nature of the disturbance resulting from installation of the pipeline, no significant impacts on the EFH of the identified species are expected.

Additional short-term impacts are anticipated from installation of the mooring tower, which will require pile-driving activities. However, the short duration of the installation activity and scheduling of this activity during winter will minimize potential impacts. During pile-driving activities, most fish species are expected leave the affected area, and they are expected to return to the area upon cessation of the disturbance.

Operation

As discussed in Section 3.3.2, both positive and negative impacts may be associated with operation of the FSRU. Water quality impacts on EFH due to operation activities will most likely involve extremely limited changes in the thermal characteristics of water and sediment in the immediate vicinity of the pipeline; thus, no significant impact is expected. Based on thermal modeling results (*see* Figure A-2 in Appendix A), some minimal increases in temperature will occur along the pipeline riser, but these increases will be limited to less than one pipe diameter (30 inches) from the riser. Where the pipeline is installed in the seabed, similar thermal impacts in the water column are expected until natural infilling of the trench occurs, after which a localized zone in increased sediment temperature will result.

With the limited extent of thermal impact, the modeling results demonstrate that thermal changes will not have a significant adverse impact on the water column or on existing ecosystems in Long Island Sound. Detailed water quality/sediment modeling results are presented in Section 2.3.5 of Resource Report 2, Water Use and Quality.

3.3.4 Fish and Wildlife Resources

3.3.4.1 Benthos

Construction and operation of the proposed Project have the potential to result in positive and negative impacts on benthic communities. Negative impacts may result from direct disturbance of bottom sediments, increased turbidity, sediment deposition, and decreased water quality. Positive impacts are associated with increased habitat diversity.

Construction

Construction of the proposed Project has the potential to impact the benthic community as a result of direct disturbance of bottom sediments, increased turbidity, sediment deposition, and decreased water quality. However, the negative impacts associated with construction of the Project will be short-term and minor. The area that will be affected by construction is small relative to the size of the Sound, and the benthic community is expected to recover following the completion of construction. Construction of the Project has the potential to result in some increased habitat diversity and associated positive impacts on the benthic community. Therefore, construction of the proposed Project will not result in significant impacts on the benthic community.

Construction of the proposed Project will result in short-term impacts on benthic macro-invertebrate species at and near the footprint of the Project. Construction will result in direct mortality of most individuals in the path of construction due to excavation of sediments, burial during side-casting of spoil, anchor sweep, and pile driving. While some individuals may settle and re-colonize in other areas, it is assumed that most will be lost to construction activities or predation prior to settling. However, the areas that will be affected are small relative to the available habitat in the Sound, and these areas are expected to be recolonized following construction by the emigration of individuals from the unimpacted surrounding areas, through vertical migration, and by seasonal reproduction and larval recruitment. Initial recolonization of the affected area is expected to be by near-surface pioneers that are productive and readily available to demersal predators, typical of McCall's Group I (opportunist) species. This initial recolonization is expected to occur within months following the cessation of construction, and it is expected to be followed by Stage I to Stage II/Stage III assemblages within a few years following completion of natural infilling of the trench. Following construction, an early successional stage dominated by species adapted to migrating through the deposited sediment is expected to develop and occupy the affected area during reestablishment of the seabed to at, or near, its preconstruction contours. Review of the *Six-Month Post-Installation Benthic Monitoring Survey for the Cross Sound Cable Project* (OSI 2003) revealed that significant biogenic activity was evident 6 months after cessation of installation disturbance at Station 3, which is located within the central basin of Long Island Sound. While the Cross Sound Cable was installed using jetting technology (appropriate for that type of facility), the monitoring report demonstrates the resilience of the benthic community. Other offshore monitoring activities have also demonstrated the resiliency of benthic communities. DAMOS (*D*isposal *A*rea Monitoring *S*ystem) is a program begun in 1977 by the New England District of the USACE to manage and monitor offshore dredged material disposal sites from Long Island Sound to Maine. In addition, DAMOS programs have repeatedly documented rapid recolonization of dredge disposal mound surfaces with infaunal assemblages typical of the sediments surrounding the disposal site (SAIC 2001a, 2001b, 2001c). Initial mound recolonization has been shown to occur within months and to proceed from Stage I to Stage II/Stage III assemblages within a few years.

In specific areas (i.e., the first 2 miles and at cable crossings and the IGST tie-in), the pipeline will be backfilled with clean imported materials, resulting in some increased habitat diversity and replacement by a different benthic community type. While the preconstruction mud community will be permanently lost in these areas, the loss is insignificant compared to the presence of this community type in the central and western basins of the Sound. In addition, replacement by a community more suited to structured substrates will add diversity to this portion of the Sound.

Some sediments will become suspended in the water column and dispersed as a result of trenching activity. The resulting impacts on water quality will be short- term and minor and will be consistent with the effects of natural events that increase turbidity in the Sound. Sediment transport modeling was conducted to determine the extent to which sediments will be dispersed and deposited. The Project is located primarily in depositional sedimentary environments, which are routinely subjected to deposition through natural events. Details of the modeling are presented in Section 2.3.5 of Resource Report 2, Water Use and Quality.

Operation

Operation of the proposed FSRU and pipeline has the potential to result in both positive and negative impacts on the benthic community, as discussed in Section 3.3.2.

In addition, operation of the proposed pipeline has the potential to result in long-term impacts on benthos as a result of the dissipation of heat from the pipeline. The temperature of gas in the pipeline will range from 120ºF (49ºC) near the FSRU to around 50ºF (10ºC) at the IGTS pipeline. Dissipation of heat to the active benthic zone (the area from the surface to a depth of about 4 inches [10 cm]) has the potential to alter the benthic community. The impacts from heat dissipation will decrease over time as natural infilling of the trench provides insulation for the pipeline. Figures A-3 and A-4 in Appendix A present the results of thermal modeling for the installed pipeline immediately after installation and following natural infilling, respectively. Based on the limited extent of the thermal impact, impacts will be minimal, and result in no large-scale alterations to the benthic community.

3.3.4.2 Finfish

Potential impacts on the finfish community as a result of construction of the proposed facilities are expected to be minor, short-term, and localized. Potential impacts due to installation of the proposed pipeline are associated with the temporary disturbance of bottom sediments, benthic communities, and habitat along the proposed pipeline route. Potential impacts due to installation of the proposed FSRU are associated primarily with acoustic disturbance. No significant permanent or long-term impacts from installation are expected. Due to the installation scheduling, small area affected, and short duration of activities, construction of the pipeline facilities is unlikely to significantly impact the population or survival of any species within the Project area.

Potential positive and negative impacts that may occur as a result of operation of the facility include habitat conversion, potential water quality impacts, and impingement and entrainment. No significant impacts are expected, as discussed in Section 3.3.2. Table 3-12 summarizes potential impacts by species.

Construction

Finfish occurring along the pipeline route may be temporarily displaced by pipeline installation operations, either directly by pipeline installation equipment or indirectly by exposure to short-term changes in suspended sediments and turbidity. Potential displacement along the proposed pipeline route will be short-term, limited to the period of active installation. Pipeline installation will occur during late fall and winter to take advantage of the period of lowest finfish abundance and to avoid the time of year when most spawning adults and early life stages (eggs and larvae) of most species of fish are present. Finfish that are present during pipeline installation are expected to avoid pipeline installation equipment and areas temporarily affected by increased turbidity.

Pelagic species and life stages are expected to continue using the water column during pipeline installation. Pelagic species might experience disturbance to a small portion of the water column in the vicinity of the active installation area, but most of the pipeline route will remain available. It is expected that motile life stages of these species will be able to avoid the disturbance. Pelagic larval and egg life stages (i.e., those life stages with limited motility) will be carried through the active pipeline installation area with prevailing tides and currents, resulting in only limited exposure to installation-related disturbances. Therefore, no significant impacts on pelagic species or life stages are expected. Since the disturbance is expected to be short-term, no cumulative or permanent impacts are expected.

Potential impacts will be limited primarily to demersal species and life stages, i.e., those that rely on the bottom for food, cover, or spawning habitat. However, due to the installation scheduling, small area affected, and short duration of activities, construction of the facilities is unlikely to significantly impact the population or survival of any species within the area.

Sediments will be disturbed during pipeline installation, resulting in impacts on forage species in the benthic community. However, impacts on the benthic community are expected to be short-term and minor. Most of the fish species occurring in this area routinely experience turbid conditions from natural processes. Most fish species are expected to leave the affected area to avoid impact.

In areas where a protective layer of armor stone or concrete mats may be added (e.g., at the IGTS and FSRU tie-ins and the AT&T and CSC cable crossings), these surfaces may result in positive impacts on finfish species associated with some increased habitat

Table 3-12 Utilization of the Sound by Fish Species

Species	Pelagic (P) Demersal (D)	Where Inshore/ offshore	habitat	prey	LIS Occurrence	Spawning/eggs	larvae	juvenile	Impact Summary
Goosefish (*Lophius americanus*)	D	Depths up to 1500 ft.	Bottoms of sand, mud, broken shell with water temperatures 32° F to 65° F	Adults prey on fish, seabirds & invertebrates.	In LIS have been found in depths greater than 59 ft in the Central Basin. Typically juveniles taken in LISTS surveys and most in spring. Relatively uncommon in LIS otherwise.	Spawning offshore from spring through September. Pelagic eggs deposited in gelatinous masses in continental shelf waters from 41°F to 65°F.	Larvae feed on pelagic copepods, crustacean larvae & glass worms.		No impacts expected.
Tautog (*Tautoga onitis*)	D	Depths up to 79 ft. Generally offshore migration when water temperatures reach 52°F. Below 39°F may find shelter and hibernate.	Hard-bottom reefs and rocky environments, artificial reefs, wrecks and areas with cover.	Invertebrates such as mussels, clams, crabs, sand dollars, amphipods, shrimp, small lobsters and barnacles.	Commonly observed in most months with peaks from May through July and again in October and November. In winter tautog are most abundant over mud bottoms in water >29ft deep.	Spawning inshore from late April to early August. Greatest abundance of eggs found at or near the surface.	Larval stage that last about 3 weeks at water surface during the day and migrating to deeper waters at night.	Demersal in water depths 1 to 30 ft deep with cover.	Potential impacts to larvae from water intakes.
Fourspot Flounder (*Paralichthys oblongus*)	D	Throughout Long Island Sound	Mud bottoms	Invertebrates and fish.	Abundance in LIS typically increases from April to a peak in July, then drops through August, remains low through fall and increases again in November.	Spawning in late spring and early summer then again in fall. Eggs are buoyant.	Larvae are planktonic.		Potential impacts to larvae which are planktonic.

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Table 3-12 Utilization of the Sound by Fish Species

Species	Pelagic (P) Demersal (D)	Where Inshore/ offshore	habitat	prey	LIS Occurrence	Spawning/eggs	larvae	juvenile	Impact Summary
Butterfish (*Peprilus triacanthus*)	P	Inshore in summer and offshore in winter. Adults are abundant in LIS from May to December.		Small fish, squid & crustaceans.	Most abundant species taken in LISTS from 1984 to 1994, observed in LIS from April through November. Peak in August and September.	Spawning June through September in LIS with peaks in July and August. Eggs are buoyant and hatch in 48 to 72 hours.	Larvae are common in LIS from June through November. They range from 2.6 to 16mm standard length. Between 2.6 and 10 mm they are planktonic, from 10 to 15 mm they are more nektonic. Larvae may undertake diel migrations.	Juveniles are pelagic and abundant in LIS from May to December.	Potential impacts to larvae which are planktonic and nektonic and may undertake diel migration.
Striped Bass (*Morone saxatilis*)	P	Anadromous fish that migrate upriver in late winter to early spring to spawn.			During LISTS commonly taken in water less than 59 ft along the CT and LI shorelines near rivers. Peak abundance in May and November.	Spawning from late winter to July in fresh or slightly brackish waters.		Juveniles move downstrea m to higher salinity waters during the first summer or fall.	Use of LIS typically concentrated outside the area of impact and reduced in winter. Therefore no significant impact.
Weakfish (*Cynoscion regalis*)	P	Fish younger than 4 yrs tend to migrate south in winter and north in summer while adults migrate offshore in winter and inshore in summer.		Feed dusk to dawn on anchovy, killifish, silversides, young herring, porgies, mysid shrimp, small crabs, worms & clams.	During LISTS appear in LIS catches in May, adult abundance increases slightly through summer, then from August through October abundance increases dramatically due to yoy, and falls in November.	Spawning along the coast and in estuaries from May to October.	Eggs are buoyant and hatch in 48 hours.	In estuaries from April to August.	

Table 3-12 Utilization of the Sound by Fish Species

Species	Pelagic (P) Demersal (D)	Where Inshore/ offshore	habitat	prey	LIS Occurrence	Spawning/eggs	larvae	juvenile	Impact Summary
Blueback Herring (*Alosa aestivalis*)	P	Seasonal Inshore/offshore pattern. Anadromous fish that migrate upriver in spring to spawn then return to marine waters following spawning.		Plankton, small fish fry and fish eggs.	Seasonal Inshore/offshore pattern during LISTS surveys were found closely associated with the CT shoreline in depths <59 ft except in summer, when spread throughout the Central basin.				Use of LIS typically concentrated outside the area of impact and reduced in winter. Therefore no significant impact.
Alewife (*Alosa pseudoharengus*)	P	Seasonal Inshore/offshore pattern. Anadromous fish that migrate upriver in spring to spawn then return to marine waters following spawning.		Adults feed on shrimp, and small fish. Young feed on diatoms, copepods and ostracods.	Seasonal Inshore/offshore pattern during LISTS surveys were found closely associated with the CT shoreline in depths <59 ft except in summer, when they extend throughout the Sound.				Use of LIS typically concentrated outside the area of impact and reduced in winter. Therefore no significant impact.
American Shad (*Alosa sapidissima*)	P	Seasonal Inshore/offshore pattern Anadromous fish that migrate upriver in spring to spawn and of those that originate in northern rivers many return to marine waters following spawning and migrate north along the coast of Canada.		Adults feed on plankton, crustaceans and small fish. YOY feed on copepods and insect larvae.	Seasonal Inshore/offshore pattern during LISTS surveys were found closely associated with the CT shoreline in depths <59 ft except in summer. In summer they were found across the Central Basin and at the Mattituck Sill in depths greater than 29 ft.		The YOY remain in fresh to brackish water, feeding in copepods and insect larvae, until fall when they enter the sea.		Use of LIS typically concentrated outside the area of impact and absent in winter. Therefore no significant impact.

Table 3-12 Utilization of the Sound by Fish Species

Species	Pelagic (P) Demersal (D)	Where Inshore/ offshore	habitat	prey	LIS Occurrence	Spawning/eggs	larvae	juvenile	Impact Summary
Atlantic Menhaden (Brevoortia tyrannus)	P	Inshore in summer and migrating southward and offshore in winter. Most move south to the NC capes until March and early April.	Adults are found in near-surface waters of shallow areas over the continental shelf.	Prey on phytoplankton and zooplankton.	During LISTS, increased in abundance from April through peak in November. Concentrated along the CT shoreline from April to October. In November, they were most common along the CT shoreline and extending across the Mattituck Sill.	Menhaden spawn between March and May and again between September and October.	Larvae use brackish and fresh water as nursery areas.	Juveniles are pelagic with the smallest farthest upriver. YOY leave estuaries and join southward migration in fall.	Use of LIS typically concentrated outside the area of impact and reduced in winter. Therefore no significant impact.
Hickory Shad (*Alosa mediocris*)	P	Anadromous fish that live in coastal ocean waters as adults and migrate into tidal freshwater areas to spawn.		Feed on squid, small fish, fish eggs, and some invertebrates.	Based on LISTS this species is relatively uoncommon in LIS. Those that have been caught suggest seasonal inshore/offshore patterens similar to other forage species.				Uncommon in LIS and those that are found are typically outside the area of impact. Therefore no significant impact.

diversity, increased populations of forage species, and increased cover. Species such as oysters, barnacles, and mussels are expected to flourish in the additional habitat, providing additional forage for other marine species such as black sea bass.

Potential impacts on fish spawning and migration have been minimized by locating the proposed facilities in the middle of the Sound. Specific construction schedules will be developed in coordination with federal and state agencies, as necessary, to ensure that fish migration and spawning impacts are minimized.

FSRU. The greatest potential for impacts on finfish during construction of the FSRU is related to acoustic disturbances to finfish caused by pile driving. Recent literature on noise levels associated with pile-driving operations frequently cite the work of Miles et al. (1987) (reported in Richardson et al. 1995). In this work, pile-driving noise was reported at levels as high as 135 decibels (dB) at a distance of 0.6 mile (1 km) (Richardson 1995). An increasing body of research suggests that sound pressure levels below 190 dB will not harm fish (Hastings 2002). NOAA Fisheries established the threshold for physical harm to fish as 180 dB(peak) for the SR 104 Edmonds Crossing Ferry Terminal Project on Puget Sound Washington (NOAA 2004). Noise impacts are discussed in Resource Report 9, Air and Noise Quality. During construction, finfish are expected to leave the affected area. The duration of pile-driving activities will be short, and finfish are expected to return to the area upon cessation of the disturbance. Some unavoidable injury or fish mortality would be expected where noise levels exceed 180 dB. Broadwater will continue to consult with NOAA Fisheries to minimize these impacts.

Operation

Both positive and negative impacts on finfish may occur as a result of operation of the proposed facilities, as discussed in Section 3.3.2. In the unlikely event of a significant LNG spill, seawater would be cooled near the surface causing fish to avoid the colder water and potentially cause injury or death to individuals at or near the surface. This impact would be temporary, lasting until the LNG evaporates.

3.3.4.3 Shellfish

Construction and operation of the proposed Project have the potential to result in positive and negative impacts on shellfish. Negative impacts may result from direct disturbance of bottom sediments/habitats, potential water quality impacts, and water intake. Potential positive impacts are associated with increased habitat structure.

Construction

Construction of the proposed FSRU and pipeline have the potential to result in impacts on shellfish as a result of direct disturbance of bottom sediments, increased turbidity, sediment deposition, and decreased water quality. Siting the Project in deep water near the middle of the Sound and away from shallow nearshore habitats that are important to many shellfish species has minimized potential impacts on those species.

Potential impacts on shellfish in all locations along the pipeline route include the temporary disturbance of sediments and bottom habitat during installation. Sediment disturbance may impact shellfish directly through physical disturbance of the substrate and habitat, or indirectly through sediments suspended in the water column. Sediment and habitat disturbance will be short–term, limited primarily to the active period of in-water installation, and localized to the bottom area directly within or immediately adjacent to the proposed pipeline route. The potential for impacts are greatest for sessile benthic species (e.g., mollusks) that are unable to avoid installation activities.

Lobster. American lobster are an important commercial fishery in Long Island Sound. The Project has the potential to impact various lobster life stages, depending on the stages present in the Project area during construction.

Lobster larvae are typically present in the water column from May to June. A late fall to early spring construction schedule would avoid impacts on this life stage during construction of the facilities.

EBP lobster remain in the chosen shelter area for up to 2 years. EBP lobster in the construction path will likely be injured or killed. The majority of the proposed pipeline route and the proposed FSRU location are in areas with fine sediments such as silts and clays. This type of habitat has little structure and is not preferred by EBP lobster. However EBP lobster do occur in these areas. A portion of the proposed pipeline crosses Stratford Shoal, which is characterized by the complex structure preferred by EBP lobster. Pipeline construction could cause injury or mortality to EBP lobsters through direct disturbance by installation equipment or burial by excavated sediment. Construction also may result in indirect impacts by increasing the exposure of EBP lobster to predation and by causing the substrate to become unsuitable for settling larvae. Due to the small area affected by construction and the short duration of construction activities, impacts on EBP lobster will have no significant impact on the lobster population in Long Island Sound. Installation of the pipeline facilities also may result in positive impacts on EPB lobster through the addition of some preferred habitat where armor rock or concrete mats are required.

Adult lobsters are highly mobile and capable of long-distance movement. The subsea plow used for installation is expected to move at speeds of 1 to 3 miles per day, and adult lobsters in the path of the plow could be killed or injured. However, adult lobsters have been shown to move out of the path of danger, and it is expected that they will move out of the path of the slow-moving plow to avoid injury. The greatest potential impact on adult lobsters is from anchor placement and cable sweep. Individuals in the direct area of anchor placement or those within the area affected by cable sweep could be injured or killed. However, due to the small area affected by construction relative to the habitat available and the likelihood that most adult lobster will move out of the construction area, the loss of these individuals is not expected to significantly impact the lobster population in Long Island Sound.

When the pipeline has been installed, an area of low or irregular relief will exist until the natural infilling process is complete. To the extent that additional texture may be added to the seabed, the depression and mounds resulting from installation of the pipeline could be attractive to both juvenile and adult lobsters. Lobsters have been shown to be attracted to dredged materials, and areas previously used as disposal sites have become lobster fishing areas (DAMOS 1985). Thus, there is potential for lobsters to be attracted to trench mounds created by the first plow pass and then to be impacted when the plow makes a second pass over the area. The time between the first and second plow pass at any point along the dredge mound will be 25 days or less. It is unlikely that a significant number of lobster would occupy the trench mounds during that time. However, it is likely that upon cessation of construction, the mounds and relief would provide additional habitat diversity for juvenile and adult lobster until the natural infilling process is complete.

While negative impacts on various life stages of the lobster could occur as a result of pipeline and FSRU construction, potential impacts are expected to be short-term, localized, and minor. Positive long-term impacts on the lobster may occur as a result of increased availability of preferred habitat for cover and increased bottom topography. The overall lobster population in Long Island Sound will not suffer significant or long-term negative impacts as a result of construction.

Operation

Operation of the proposed Project has the potential to result in both positive and negative impacts on lobsters, as described in Section 3.3.2.

Squid are know to be attracted to light sources, and as such, may be attracted to operational lighting on the FSRU. As discussed, Broadwater will implement specific mitigation measures to restrict lighting impacts. With only indirect lighting of the water surface anticipated, the attraction of squid will be significantly less than would be anticipated with direct lighting. While some attraction may be unavoidable, minimal impacts associated with this attraction are expected. Potential lighting impacts on surrounding ecosystems will be minimized as described in Section 3.3.2.

3.3.4.4 Plankton

Construction

Construction of the proposed facilities has the potential to cause minor, short-term impacts on plankton. These impacts would result from hydrostatic test water intake and changes in water quality due to suspended sediments. However, these are not expected to be significant impacts. Impacts due to suspended sediment are expected to be short-term and minor. Studies documenting the effects of suspended sediment on primary producers and zooplankton concluded that little or no measurable impact results from activities such as dredging (O'Connor and Sherk 1976; Sherk et al. 1976).

Prior to operation, the pipeline will be hydrostatically tested using water withdrawn from Long Island Sound, potentially resulting in the entrainment of aquatic species. The water intakes used to withdraw the water will be screened to prevent localized entrainment of fish. It is assumed that 100% of the plankton entrained in the test water will be lost. While some plankton mortality is unavoidable, the volume of water required for hydrostatic testing is an insignificant fraction of the total water available in the Sound and is a onetime withdrawal.

Operation

Operation of the proposed facilities is expected to result in potential water quality and thermal impacts as described in Section 3.3.2. In the unlikely event of a significant LNG release, seawater would be cooled near the surface, potentially resulting in localized mortality. This impact would be temporary, lasting until the LNG evaporates. Normal tidal currents would be expected to quickly repopulate impacted areas.

Operation of the FSRU will result in additional impacts on plankton and ichthyoplankton due to the intake of water for operational use and use as ballast water. The water intakes, volumes, and screening are described in Resource Report 1, General Project Description. The volume of water that will be taken in has been minimized and is restricted to that required for ballast and minimal operational use. In addition, the water intakes have been located at the hull bottom of the FSRU, near the middle of the water column, to minimize impacts on plankton. The number of plankton, eggs, and larvae entrained as a result of water intake will be very small relative to the abundance of marine organisms in the surrounding waters; thus, even assuming 100% mortality of organisms impinged or entrained, the resulting mortality will not be significant.

Systems associated with the Project require the uptake and use of seawater, including the ballast and fire water intake systems for the FSRU, and the cooling and ballast water systems for the LNG carriers. As previously noted, intakes for the FSRU will be located approximately 40 feet (12 m) below the surface, and have an internal screen with a mesh size of 5 mm, with velocities maintained at a maximum of 0.5 feet/second (0.15 m/s). The LNG carriers would have similar screen sizing and intake velocities. Because LNG carriers will have less draft than the FSRU, water intakes would be located at a shallower depth than the FSRU, but below 8 m.

These systems have the potential to impact ichthyoplankton present in Long Island Sound through entrainment when aquatic organisms, eggs, and larvae are drawn into a seawater system, through the sea chests, and then pumped back out. It is assumed that any ichthyoplankton taken in through the intakes will be lost. The Project (inclusive of the FSRU and LNG carriers) will require the uptake and use of approximately 28.2 million gallons of seawater per day (106,750 m^3/day) during operation, based on an average of 2.27 cargos delivered each week. (For additional detail on seawater systems and the assumptions for calculated water use, *see* Section 2.5.2.2. of Resource Report 2, Water Use and Quality.) Broadwater conducted an ichthyoplankton impact analysis to characterize the species and densities of fish eggs and larvae and lobster larvae in the Project area that could be entrained as the FSRU and LNG carriers take in seawater.

Based on data from the 2002 Poletti Ichthyoplankton Program subset to represent the water intake location of the FSRU facility during normal operations (approximately 28.2 MGD, 106,750 m^3/day) approximately 40.6 million eggs and 30.6 million larvae would be entrained from the March 4-August 5 period for which the Poletti Program conducted sampling (*see* Appendix E, Table B-7). Entrainment rates would not be uniform across the March-July period due to the seasonal variation in ichthyoplankton density and species composition typical of Mid-Atlantic nearshore and estuarine regions and the majority of the annual entrainment would take place during the June-July peak in ichthyoplankton density. Diel correction factors and entrainment estimates for August-October based on site specific collections in 2005 were included in modified entrainment estimates to address potential biases in the Poletti methodology and provide a more conservative, upper bound to the entrainment counts. Another conservative assumption is that density is directly proportional to entrainment and no escape behavior is exhibited by larvae. Actual entrainment may be reduced by active avoidance of the seawater intakes. The inclusion of the site specific August and October, 2005 data, applying the diel correction factors to the Poletti data, and including only nighttime samples for bay anchovy and fourspot flounder larvae increased the total entrainment estimate to 47.3 million eggs and 90.9 million larvae from the March-October period (*see* Appendix E Table B-7). A further conservative estimate included the site specific 2005 data and diel correction factors to the Poletti data and considered only nighttime samples for all larvae collected in the 2005 data. This had little effect on the entrainment estimates. Total number of eggs were 47.3 million and total number of larvae was 91.4 million for the March-end of October period, which accounts for the seasonal occurrence for the majority of ichthyoplankton stages for most abundant species in Long Island Sound with the exception of sand lance, which will be evaluated during planned February ichthyoplankton sampling.

To determine the relative loss of eggs and larvae, the daily withdrawal volume of the FSRU and associated LNG carriers (28.2 million gallons, or 106,750 m^3, per day) was compared to the volume of water in the regions selected to represent the central basin (Regions 7, 8 and 9, 3.97×10^{10} m^3). The daily withdrawal represents only 0.0003% of the volume. Even if the intakes operate 365 days a year, the annual FSRU water intake represents only 0.10% of the volume in Regions 7, 8, and 9.

In order to compare standing crop versus potential entrainment based on the bi-weekly surveys, additional analysis was performed. The volume of water in the deep sampling strata of Regions 7, 8, and 9 from the surface to 3 m above the bottom is 7.53×10^9 m^3. Ichthyoplankton densities in this subset data were multiplied by this volume to yield the estimated standing crop, or number of individuals, during each biweekly survey. The egg standing crop ranged from 1.50×10^9 during Survey 11 (July 22 to August 5) to 3.91×10^{10} during Survey 7 (May 27 to June 9), with an average of 1.86×10^{10} over the March to July sampling period. The larval standing crop ranged from 7.03×10^8 during the first survey (March 4 to 17) to 7.74×10^{10} during Survey 8 (June 10 to 23), with an average of 1.40×10^{10} over the March to July sampling period. Because both the entrainment estimates and the standing crop estimates are based on the Poletti ichthyoplankton density data, the percentage of the number entrained in a biweekly survey compared to the regional standing crop during that survey is equal to 0.02%, indicating that these estimates are valid.

Once density values were calculated, potential ichthyoplankton impacts were determined based on water intake. Little reported information currently exists regarding mortality/survivability during ballast entrainment and natural mortality for populations for various species present in Long Island Sound. Ichthyoplankton densities were determined for entrainment assessment of ballast water and other seawater uptakes based on the water volume within the Regions 7 through 10 area. This was used together with the potential for ichthyoplankton in the Project area to be impacted by entrainment in the FSRU and LNG carriers' seawater systems. Although 100% of the ichthyoplankton potentially entrained may not experience mortality or serious injury, 100% mortality was used as a standard, conservative assumption. The following summarizes the results of the calculations used to determine the relative mortality of ichthyoplankton present in Long Island Sound.

The 28.2 million gallons (106,750 m^3) of seawater uptake proposed for the Broadwater Project are significantly (orders of magnitude) lower than typical volumes used by other LNG or power generating facilities' cooling systems in the vicinity of Long Island Sound. (*See* Section 2.5.2.2 of Resource Report 2, Water Use and Quality, for additional information on other facility water uses.)

Based on the results of the analysis, daily egg mortality (assuming 100% mortality when eggs are entrained) is approximately 2.69×10^{-4} % of the eggs present within the central basin region (i.e., Regions 7, 8, and 9). This percentage is based on the ratio of water withdrawal by the FSRU (106,750 m^3/day) to the volume of water in Regions 7, 8, and 9 (3.97×10^{10} m^3).

Impacts on ichthyoplankton can be difficult to interpret due to the low natural survival rates of fish eggs and larvae. In fact, many of the entrained organisms are subject to high rates of natural mortality. Although seasonal and daily density fluctuations occur in Long Island Sound, these fluctuations are represented in the data set used to calculate the average number of eggs and larvae entrained daily in the seawater uptake systems on the FSRU and LNG carriers.

Although no consensus currently exists within the scientific community or responsible agencies regarding what level of impacts on ichthyoplankton are considered significant, the density of ichthyoplankton within Long Island Sound represents values typically expected in this area. The entrainment values represent impacts on fishery populations that can be considered less than significant when considered relative to the potential impact area affected by seawater intake from the FSRU or LNG carriers. The results of this analysis confirm that the Broadwater Project would not have a significant impact on ichthyoplankton. Based on the species, densities, and percentages affected, entrainment impacts on any special status/EFH species would be less than significant.

3.3.4.5 Reptiles

Construction

Installation of the FSRU and pipeline has the potential to result in impacts on sea turtles by disrupting foraging habitat. The area of potentially impacted foraging habitat is minor relative to the availability of this habitat type in Long Island Sound, and the habitat is expected to recover following construction. In addition, potential impacts, including vessel strike impacts, will be avoided during construction by installing the facilities in fall and winter, when sea turtles are not present in Long Island Sound. Therefore, construction of the Project will not result in negative impacts on sea turtles.

Operation

Pipeline. Operation of the proposed pipeline will not result in significant impacts on sea turtles. Foraging habitat impacted as a result of pipeline construction is expected to recover following construction. In the event that maintenance activities require dredging, localized areas of foraging habitat may be temporarily impacted; however, these impacts would be short-term and minor.

FSRU. While operation of the FSRU has the potential to result in impacts on individual sea turtles through sea turtle/vessel collisions or changes in water quality, no significant impacts on sea turtles are expected as a result of operation of FSRU.

The vessels associated with operation of the FSRU will travel at relatively low speeds, will be consistent with vessels already using the Sound, and will utilize existing travel routes, and the increase in traffic will be insignificant compared to existing vessel traffic in the Sound. The relatively low speed of the vessels and the minimal change in vessel traffic in the Sound (two to three additional vessels per week) will minimize increases in the number of collisions with sea turtles. In addition, the safety and security zone associated with the facility will remove the habitat surrounding the facility from the affects of faster-moving recreational boats.

Sea turtles have been shown to be attracted to light, and this attraction has been shown to disrupt the behavior of nesting turtles and hatchlings. Lighting on offshore platforms may attract turtles and prevent them from moving onto beaches to nest, causing them to forego nesting. However, for areas along the East Coast north of South Carolina, this is not a problem since sea turtle nesting does not occur (Standora 2005).

In the unlikely event of a significant LNG release, seawater would be cooled near the surface, potentially resulting in localized impacts. Sea turtles coming in direct contact with the LNG could suffer cryogenic effects, and the evaporation of the LNG could displace normal atmospheric gases depriving the turtles of breathable air. Turtles would however, be expected to vacate the Project area ahead of an advancing plume. Impacts would be temporary, lasting only until the LNG fully evaporates.

3.3.4.6 Marine Mammals

Construction

Construction of the proposed pipeline facilities is not expected to result in significant impacts on marine mammals. While marine mammals will be present in the Sound during construction of these facilities, they are highly mobile and are expected to move away from the active area of construction. In addition, Broadwater will assign biological monitors knowledgeable in the identification of federally listed species during construction and will monitor marine broadcasts for the presence of marine mammals within 5 miles of the daily construction area(s). Avoidance of the construction area is not expected to result in indirect impacts on these species because the disturbance will be short-term and localized, and avoidance of the active installation area is not expected to push marine mammals into areas where they are more susceptible to harm from other sources, such as collisions.

Installation of the tower has the potential to impact marine mammals as a result of acoustic shock from pile-driving activities. Construction of the FSRU requires driving four pilings to support the mooring tower. Pile driving will result in impulsive noise, which may impact marine mammals. Potential impacts range from masking of signals, startling and displacement, to potential injury (Richardson et al. 1995). The impact will depend on the proximity of marine mammals to the source of the noise. Marine mammals may suffer injury if they are in an area in which acoustic shock is 180 dB or greater, which can result in a type of temporary hearing loss known as Temporary Threshold Shift (Greene 1999). Outside of this area, behavioral disruption impacts may occur, including masking of communication, a startled response, or audibility that causes the animals to move out of the area (Young 2005). Pile driving for the four mooring legs will be conducted over a relatively short time frame (approximately 14 days).

During pile-driving activities, marine mammals are expected to leave the affected area, but they are expected to return to the area upon cessation of the disturbance. Mitigation measures include “ramp-up” procedures (i.e., starting pile driving with taps on the hammer at less than full capacity, which may cause marine mammals to leave the area) and the use of trained observers to identify marine mammals within the construction area. Broadwater will continue to consult with NOAA Fisheries to develop procedures to minimize impacts on marine mammals.

Operation

Operation of the proposed Project has the potential to result in impacts on marine mammals if forage species are attracted in significant numbers to the structure and shadow associated with the FSRU facilities. Marine mammals attracted to the forage would have the potential to be struck by vessels. However, marine mammals are highly mobile and are expected to avoid slow moving ships coming in to moor. To minimize potential impacts on marine mammals as a result of vessel collisions, the vessels associated with operation of the FSRU will travel at relatively low speeds, will be consistent with vessels already using the Sound, and will utilize existing travel routes. The LNG carriers that call on the Broadwater terminal will be requested to adhere to speed and other restrictions imposed on all large vessels in Long Island Sound by NOAA Fisheries or other regulatory bodies.

No significant impacts on marine mammals will occur as a result of operation of the Project.

In the unlikely event of a significant LNG release, seawater would be cooled near the surface, potentially resulting in localized impacts. Marine mammals coming in direct contact with the LNG could suffer cryogenic effects, and the evaporation of the LNG could displace normal atmospheric gases depriving the turtles of breathable air. Marine mammals would, however, be expected to vacate the Project area ahead of an advancing plume. Impacts would be temporary, lasting only until the LNG fully evaporates.

3.3.4.7 Avian Species

Siting the Project in deep water near the middle of the Sound and away from shallow nearshore habitats will minimize impacts on avian species by minimizing impacts on nearshore areas in the Sound that are important to avian species for nesting, foraging, rearing young, resting during migration, and overwintering.

Lighting at the facility has the potential to attract avian species. However, the facility is similar to marine vessels and does not contain guy-wires, rotary blades, extensive windows, or other items that pose an unusual or increased threat of collision to avian species.

If the FSRU facility becomes an attractant to wildlife, negative impacts are expected to be minimal. The FSRU will have a relatively low profile, with only the emergency flare stack extending well above the deck line. This profile will limit potential for bird strikes at the facility. Avian species attracted to the facility will either recognize the lack of suitable forage and forage elsewhere, or they will utilize existing forage in proximity to the FSRU. The FSRU may, in fact, become a temporary refuge for species transiting between Long Island and Connecticut.

3.3.4.8 Threatened and Endangered Species

Threatened and endangered species in the Project area include finfish, sea turtles, and marine mammals. Based on correspondence with federal and state resource agencies, threatened and endangered species are expected to occur only on a transient basis in Long Island Sound (*see* Appendix F). Potential impacts on these species will be as described in Sections 3.3.4.2, 3.3.4.5, and 3.3.4.6

3.3.4.9 Commercially Important Species

Impacts on commercially important species will be as described above for EFH, finfish, and shellfish and in the EFH Assessment presented in Appendix A. Impacts on commercial and recreational fishing interests are discussed in Resource Report 8, Land Use, Recreation, and Aesthetics.

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APPENDIX A

ESSENTIAL FISH HABITAT ASSESSMENT

Table of Contents

1. INTRODUCTION A-6
  1.1 Project Description A-6
  1.2 Installation of the Proposed Project Facilities A-8
    1.2.1 Pipeline A-8
    1.2.2 FSRU A-8
  1.3 Operation of Proposed Facilities A-8
    1.3.1 Pipeline A-9
    1.3.2 FSRU A-9
  1.4 General Impacts Associated with Installation of the Proposed Project Facilities A-9
    1.4.1 Pipeline A-9
    1.4.2 Tower Structure and FSRU A-12
  1.5 General Impacts Associated With Operation of the Proposed Project Facilities A-14
    1.5.1 Pipeline A-14
    1.5.2 FSRU A-15
  1.6 Resource-specific Impacts Associated with Construction and Operation of the Proposed Project Facilities A-21
    1.6.1 Long Island Sound Coastal Habitats A-21
    1.6.2 Benthos A-22
      1.6.2.1 Existing Conditions A-22
      1.6.2.2 Construction A-35
      1.6.2.3 Operation A-36
    1.6.3 Ichthyoplankton A-36
      1.6.3.1 Existing Conditions A-36
      1.6.3.2 Construction A-40
      1.6.3.3 Operation A-40

2. ESSENTIAL FISH HABITAT (EFH) A-44

3. EFH ANALYSIS A-47
  3.1 Demersal Species A-47
    3.1.1 Ocean Pout (*Macrozoarces americanus*) A-47
    3.1.2 Red Hake (*Urophycis chuss*) A-48
    3.1.3 Winter Flounder (*Pleuronectes americanus*) A-50
    3.1.4 Summer Flounder (*Paralichthys dentatus*) A-52
    3.1.5 Windowpane Flounder (*Scopthalmus aquosus*) A-53
    3.1.6 Little Skate (*Leucoraja erinacea*) A-55
    3.1.7 Winter Skate (*Leucoraja ocellata*) A-56
    3.1.8 Black Sea Bass (*Centropristus striata*) A-57
    3.1.9 Silver Hake (*Merluccius bilinearis*) A-58
    3.1.10 Scup (*Stenotomus chrysops*) A-59
  3.2 Pelagic Species A-60
    3.2.1 Atlantic Salmon (*Salmo salar*) A-60

3.2.2 Atlantic Herring (*Clupea harengus*) A-61
3.2.3 Bluefish (*Pomatomus saltatrix*) A-62
3.2.4 Atlantic Mackerel (*Scomber scombrus*) A-63
3.2.5 Pollock (*Pollachius virens*) A-64
3.2.6 Sand Tiger Shark (*Carcharias taurus*) A-65
3.2.7 Coastal Migratory Pelagic Species A-66
3.3 Cumulative Impacts and Mitigation A-67

4. CONCLUSION A-70

5. REFERENCES A-72

List of Tables

A-1 Broadwater Pipeline Installation, Summary of Sediment-Related Impacts A-10

A-2 Estimated Distance to 190 and 180 dB RMS Level A-13

A-3 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005 .... A-31

A-4 Species for which EFH has been Designated for Egg and/or Larval Stages in the Vicinity of the Proposed FSRU A-37

A-5 Species with Identified EFH within the Project Area A-46

List of Figures

A-1 Proposed Broadwater Project Location in Long Island Sound A-7

A-2 Potential Extent of Thermal Impacts from the Pipeline Riser A-16

A-3 Potential Extent of Thermal Impacts Prior to Natural Backfilling of the Pipeline Trench A-17

A-4 Potential Extent of Thermal Impacts After Natural Backfilling of the Pipeline Trench A-18

A-5 Benthic Community Species Diversity in the Project Area A-23

A-6 Benthic Faunal Assemblages in the Project Area A-24

A-7 Broadwater Benthic Sampling Stations A-27

A-8 Benthic Community Species Diversity in the Project Area; Based on Spring 2005 Field Surveys A-29

A-9 Broadwater Benthic Communities; Based on Spring 2005 Field Surveys A-30

A-10 Essential Fish Habitats in the Project Area A-45

Acronyms and Abbreviations

bcf	billion cubic feet
bcfd	billion cubic feet per day
^{o}C	degrees Centigrade
EFH	Essential fish habitat
FERC	Federal Energy Regulatory Commission
FMC	Fishery Management Council
FMP	Fishery Management Plan
FSRU	floating storage and regasification unit
HAPC	Habitat Areas of Particular Concern
IGTS	Iroquois Gas Transmission System
km	kilometer
LNG	liquefied natural gas
m	meter
m^2	square meter
MESA	Marine EcoSystem Analysis
mm	millimeter
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NOAA	National Oceanic and Atmospheric Administration
ppm	parts per million
ppt	parts per thousand
SFA	Sustainable Fisheries Act
YMS	yoke mooring system

1. INTRODUCTION

1.1 PROJECT DESCRIPTION

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holdings LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and connecting pipeline for the import, storage, regasification, and transportation of natural gas. The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS). The FERC application for the Project requires the submittal of 13 Resource Reports, with each report evaluating Project effects on a particular aspect of the environment.

This appendix to Resource Report 3 addresses essential fish habitat (EFH) resources in the Project area. This report also discusses the potential impacts on these resources associated with construction and operation of the proposed Project and the methods that will be used to avoid and minimize impacts.

The proposed Broadwater LNG terminal will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters, as shown on Figure A-1. The LNG terminal facilitates the sea-to-land transfer of natural gas. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcfd) and will be capable of delivering a peak day throughput of 1.25 bcfd. The Project will deliver the regasified LNG to the existing interstate natural gas pipeline system via an interconnection to the IGTS pipeline. Onshore facilities are discussed in the Onshore Facilities Resource Reports.

The proposed LNG terminal will consist of a floating storage and regasification unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The freeboard and mean draft of the FSRU will generally not vary throughout operating conditions. This is achieved by ballast control to maintain the FSRU's trim, stability, and draft. The FSRU will be designed with a net storage capacity of approximately 350,000 cubic meters [m^3] of LNG (equivalent to 8 billion cubic feet [bcf] of natural gas), with base vaporization capabilities of 1.0 bcfd using a closed-loop shell and tube vaporization (STV) system. The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from approximately 125,000 m^3 up to a potential future size of 250,000 m^3 at the frequency of two to three carriers per week.

The FSRU will be connected to the send-out pipeline, which rises from the seabed and is supported by a stationary tower structure. In addition to supporting the pipeline, the stationary tower also serves the purpose of securing the FSRU in such a manner to allow

Source: ESRI StreetMap, 2002.

Figure A-1
Proposed Broadwater Project
Location in Long Island Sound

it to orient in response to prevailing wind, wave, and current conditions (i.e., weathervane) around the tower. The tower, which is secured to the seabed by four legs, will house the yoke mooring system (YMS), allowing the FSRU to weathervane around the tower. The total area under the tower structure, which is of open design, will be approximately 13,180 square feet (1,225 square meters [m^2]).

A 30-inch-diameter natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be installed beneath the seafloor from the stationary tower structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. To stabilize and protect the operating components, sections of the pipeline will be covered with engineered back-fill material or spoil removed during the lowering operation. Figure A-1 indicates the proposed pipeline route.

1.2 INSTALLATION OF THE PROPOSED PROJECT FACILITIES

Resource Report 1, General Project Description, provides a detailed discussion of the installation of the proposed Project facilities. For the purposes of this EFH analysis, a brief summary of facility installation is provided below.

1.2.1 Pipeline

Broadwater proposes to install the marine pipeline during late fall, winter, and early spring using a combination of installation technologies. Based on the current schedule, the pipeline would be installed in 2009/2010. While construction will begin October 1 and continue through April 30, the majority of construction work requiring sediment disturbance will occur prior to March 1. Activities occurring later than March 1 will largely be associated with the tie-in points to the IGTS and FSRU, and the cleaning and testing of the pipeline system. Where technically feasible, Broadwater will use a post-lay subsea plow as the primary means of lowering the pipeline. Alternative construction technologies will be used at the IGTS and FSRU tie-in locations, at the AT&T and CSC cable crossings, and potentially in the Stratford Shoal area.

1.2.2 FSRU

The FSRU will be constructed at a qualified shipyard and towed to Long Island Sound. Prior to delivery of the FSRU to the Project area, the YMS and associated mooring tower will be constructed via installation of four piles to depths of 165 to 230 feet (50 to 70 meters), depending on existing geologic conditions at the site. A stabilizing structure will be placed at the base of the tower to maintain orientation of the mooring tower during installation. This structure will be buried beneath the floor of Long Island Sound and naturally be covered with sediment.

1.3 OPERATION OF PROPOSED FACILITIES

Resource Report 1, General Project Description, provides a detailed discussion of the operation of the proposed Project facilities. For the purposes of this EFH analysis, a brief summary of facility operation is provided below.

1.3.1 Pipeline

The proposed pipeline facilities will be lowered to a minimum of 3 feet (1 m) below the sediment surface to the extent practicable; where this is infeasible, the pipeline will be armored. Routine maintenance activities are not expected to disturb the seabed. The entire lowered portion of the pipeline will be coated with 3 inches of concrete. Only the pipeline riser, which will be located within the mooring tower, will not have concrete coating.

1.3.2 FSRU

Operation of the FSRU will likely require a U.S. Coast Guard-regulated safety and security zone. Recreational and commercial fishing activities may be restricted within this zone, which would limit fish harvesting activities. The size of the safety and security zone will be determined by the U.S. Coast Guard.

Installation of the FSRU will result in localized habitat alterations. The permanently moored FSRU will introduce a shadowing effect that may increase cover availability for fish. In addition, the mooring tower will provide vertical structure and habitat diversity that was previously nonexistent in the central portion of the Sound. These modifications will generally increase the habitat value in the Sound.

During operation, the FSRU will ballast continuously to maintain the facility's in-water stability. In combination with the moored LNG carriers, it is estimated that an average of 28.2 million gallons of water per day will be drawn from Long Island Sound waters as a result of both FSRU and moored LNG carrier operations. Water drawn into the FSRU for ballast purposes will be treated with sodium hypochlorite to minimize biological growth, and discharges will have a residual chlorine content of 0.01 to 0.05 parts per million (ppm). Additional discharges will consist of treated waste water and untreated seawater used during routine testing of the fire-water system onboard the FSRU. A more detailed discussion of the potential impacts from facility-related discharges is provided in Resource Report 2, Water Use and Quality.

1.4 GENERAL IMPACTS ASSOCIATED WITH INSTALLATION OF THE PROPOSED PROJECT FACILITIES

Resource Report 3, Fish, Vegetation and Wildlife, provides a detailed discussion of the potential impacts associated with installation of the proposed Project facilities. For the purposes of this EFH analysis, a summary of the potential impacts on relevant marine resources as a result of facility installation is provided below. Impacts on reptiles, marine mammals, and avian species are not summarized here.

1.4.1 Pipeline

Construction of the proposed pipeline will result in temporary direct impacts on the seabed as a result of pipeline installation activities. Where technically feasible, Broadwater will use a post-lay subsea plow as the primary means of lowering the pipeline. Alternative construction methods will be used at the IGTS and FSRU tie-ins, the AT&T and CSC cable crossing, and potentially across Stratford Shoal. Because of the presence of existing utilities, the excavations at these locations will be performed using a submersible pump or by divers using hand-jetting or air-lifting equipment. Information regarding the construction methodologies is provided in Resource Report 1, General Project Description. An installation summary, including affected acreages and volumes, is presented in Table A-1.

Table A-1 Broadwater Pipeline Installation, Summary of Sediment-Related Impacts

Impact Type	Sediment Volume (cu yards)	Impact (acres)	Comment
Pipeline lowering via plow; 19.7 miles to a depth of 3 feet	304,500	179.1	Impacts include both the trench and associated spoil mounds.
Pipeline lowering via plow; 2 miles with 5 feet of cover	39,500	18.2	In proximity to the FSRU, the pipeline will be lowered to a greater depth to accommodate design considerations.
AT&T cable crossing	3,030	0.4	Impacts include excavations for crossing bridge and pipeline trench transition.
Cross Sound Cable crossing	3,030	0.4	Impacts include excavations for crossing bridge and pipeline trench transition.
FSRU tie-in	1,650	0.2	Includes expansion loop.
Check and isolation valve spool	270	< 0.1	Located approximately 2,000 feet from the FSRU.
IGTS tie-in	2,340	0.3	Includes expansion offset.
Anchor footprint	N/A	16	8-point mooring, three anchor sets per mile, and three passes (one lay, and two plow)
Anchor cable sweep	N/A	2,020	8-point mooring, midline buoys on quarter anchors, three anchor sets per mile, and three passes (one lay, and two plow)
Total	354,320	2,234.7	

Installation of the pipeline will directly affect the seabed within the corridor in which the pipeline will be installed and along which anchor placement and cable sweep will occur. In addition to the potential for direct mortality from these construction activities, limited changes in turbidity levels, suspended solids, and sediment deposition in the vicinity of the active construction area are expected from direct disturbance to the seabed. While it is unavoidable that some sediments will become suspended in the water column and dispersed as a result of plowing and dredging activities, the proposed use of the subsea plow for the vast majority of the installation will minimize these impacts. Based on the water quality and sediment modeling results, increases in TSS and resulting sedimentation are predicted to largely fall within the existing variation in ambient TSS levels and sedimentation rates in Long Island Sound. Excessive sedimentation that could adversely impact existing communities would be restricted to the central pipeline corridor, primarily associated with the spoil piles resulting from the subsea plowing. Based on Project-specific modeling to assess potential sedimentation impacts, with the exception of the spoil pile footprints, the maximum increase in sediment deposition would be 0.2 inch (4.99 mm), with most areas falling well below that (*see* Appendix G of Resource Report 3). The sediment transport and sediment deposition modeling results demonstrate that neither increased sediment in the water column nor increased sediment deposition will result in a significant adverse impact on the water column or on existing ecosystems in Long Island Sound. Detailed water quality/sediment modeling results are presented in Section 2.3.5, and Appendix A of Resource Report 2, Water Use and Quality.

As indicated in Table A-1, anchor sweep during installation of the pipeline has the potential to impact up to 2,020 acres of the sediment surface. Unlike the area directly affected by pipeline construction, the impacts resulting from anchor sweep will be limited to surficial disturbance. These impacts are expected to be extremely localized, and the affected areas are expected to recover through natural processes following construction. Broadwater is not aware of any reports or findings detailing continued impacts from either the anchor footprints or cable sweep in Long Island Sound.

Where necessary (i.e., the first 2 miles and at ties-in, valves, and cable crossings), the trench will be backfilled with either side-cast spoil or imported clean material. The remainder of the pipeline within the trench will be allowed to backfill naturally through sediment deposition. The pipeline route is located primarily in portions of the Sound that are considered depositional; therefore, natural oceanographic processes will facilitate the restoration and recovery of physical bottom conditions. Recognizing agency concerns regarding potential impacts from an open trench. Modeing was conducted to determine the time required for the trench to backfill naturally. For the majority of the route (where the pipeline is installed within depositional environments), a depression up to approximately 2.7 feet below the surrounding seabed elevation is expected to remain 12 months after installation has been completed; a depression up to approximately 1.8 feet below the surrounding seabed elevation is expected to remain 24 months after installation has been completed; and a depression up to 6 inches below the surrounding seabed elevation is expected to remain 30 months after installation has been completed (*see* Appendix H). The sediment infill to the trench is expected to be comprised of sand, silt, and clay from the spoil pile. As the vast majority of the route is located within a depositional environment, ongoing natural sedimentation of silt and clay will also contribute to infilling of the trench. The benthic macroinvertebrate community, which is important foraging habitat for many species, is expected to recover following construction, primarily as a result of emigration of individuals from nearby undisturbed areas, vertical migration through the sediments, and seasonal reproduction and larval recruitment. An early successional stage dominated by species adapted to migrating through the deposited sediment is expected to begin to recolonize the area immediately following construction and to occupy the affected area during reestablishment of the seabed to at or near its pre-construction contours. Other benthic species such as lobsters, hermit crabs, and demersal fish may also be attracted to the topographic relief offered by the depression and eroding spoil mounds.

In isolated areas, primarily at the utility crossings and potentially at Stratford Shoal, supplemental clean fill material or concrete armoring may be needed to ensure adequate protection of the pipeline. In areas where armor rock or concrete mats may be needed for protection, some minor modification of the seabed may occur. The introduction of rock or other clean fill material would likely result in some increased habitat diversity, increased populations of forage species, and increased cover. Species such as oysters, barnacles, and mussels are expected to flourish in this additional habitat, providing additional forage for other marine species. These areas also are expected to provide additional cover for lobsters and other shellfish, as well as fish species, such as tautog, that prefer habitat with cover.

Prior to beginning operation, the pipeline will be hydrostatically tested in spring 2010 using water withdrawn from Long Island Sound, potentially resulting in the entrainment of aquatic species. The water intakes used to withdraw the water will be screened to prevent localized entrainment of fish. It is assumed that 100% of the plankton entrained in the test water will be lost. While some plankton mortality is unavoidable, this will be a one-time withdrawal and the volume of water required for hydrostatic testing is an insignificant fraction (0.00000028%) of the total water available in the Sound. Impacts on water quality and aquatic organisms will be minimized through the use of best industry practices, screening, intake of water at 20 to 40 feet (6 to 12 m) below the water surface, treatment/ neutralization of water prior to discharge, and re-oxygenation of water prior to discharge. Potential water quality impacts associated with hydrostatic testing are discussed in detail in Section 2.5.1.1 of Resource Report 2, Water Use and Quality.

Lighting has the potential to attract marine species during construction and operation of the facilities. Lighting during construction will not vary significantly from existing lighting in the Sound resulting from other marine activities such as fishing, lightering, and anchoring of commercial vessels.

1.4.2 Tower Structure and FSRU

Installation of the proposed tower structure will result in the disturbance of approximately 25,000 square feet (2,322 m^2) of the seabed and the associated bottom habitat. Although the actual footprint of the tower will be only 13,180 square feet (1,225 m^2), additional disturbance will occur in conjunction with anchor placement during the installation process. Additional discussion of installation of the tower structure and FSRU is provided in Resource Report 1, General Project Description. Long-term impacts are anticipated only at the locations of the pilings, which will be the only area where bottom habitat is eliminated as a result of installation of the tower. The surface of the seabed within the footprint of the mooring tower footings will be affected during installation, but the area impacted is anticipated to recover due to the depositional environment in the central Sound and benthic community recruitment.

To control stability during the lowering of the mooring tower jacket, a shallow frame, or mud mat, is installed at the base of the jacket between the four legs. A mud mat is made of untreated lumber and has the sole purpose of providing stability control during jacket installation. The mud mat will be buried during the installation process by bottom sediments flowing around and through the framing. Sediment from the seabed will flow over the edges of the mud mat as the jacket settles onto the seabed, effectively burying it in the process. While the untreated lumber will remain buried in the sediment and may provide some habitat value, it is not intended as a biological habitat feature. While the sediments will be disturbed, they will continue to function as biological habitat. Some limited injury and mortality of benthic organisms occupying the mooring tower footprint are expected during this process.

In conjunction with installation of the mooring tower, short-term impacts are anticipated due to increased noise and vibration associated with pile installation. The timing of this activity will limit the extent of impact, and mobile species will be able to vacate the Project area to avoid impacts. Injury or mortality of fish may occur in areas where subsurface noise levels reach a peak of 180 dB. As discussed in Resource Report 3, this threshold level is based on thresholds established by NOAA Fisheries on other projects. Recent literature on noise levels associated with pile-driving operations frequently cite the work of Miles et al. (1987) (reported in Richardson et al. 1995). In this work, pile-driving noise was reported at levels as high as 135 decibels (dB) at a distance of 0.6 mile (1 km) (Richardson 1995). An increasing body of research suggests that sound pressure levels below 190 dB will not harm fish (Hastings 2002). NOAA Fisheries established the threshold for physical harm to fish as 180 dB (peak) for the SR 104 Edmonds Crossing Ferry Terminal Project on Puget Sound Washington (NOAA 2004). Noise impacts are discussed in Resource Report 9, Air and Noise Quality. During construction, finfish are expected to leave the affected area. The duration of pile-driving activities will be short, and finfish are expected to return to the area upon cessation of the disturbance. Some unavoidable injury or fish mortality would be expected where noise levels exceed 180 dB. These potential impacts are discussed in greater detail in Resource Report 3, Sections 3.3.4.2 and 3.3.4.6. Broadwater will continue to consult with NOAA Fisheries to develop procedures to minimize impacts on marine species. Pile driving for four piles is expected to occur in approximately October 2010 over a period of fourteen days, with construction during daylight hours. Selection of installation equipment and procedures cannot be determined until deep bore tests have been made to assess the subsea stratigraphy at the FSRU site. Therefore, only preliminary noise estimates are possible at this time. Preliminary noise estimates, based on existing literature, indicate that impulse noise levels may be as high as 180 dB at distances of 1,920 to 2,950 feet (585 to 900 m) from the source, depending on the hammer energy (*see* Table A-2). Pile-driving noise is discussed in greater detail in Resource Report 9, Air and Noise Quality. Installation techniques will be determined following deep boring investigations at the piling locations. Broadwater will continue to consult with NOAA Fisheries to develop installation procedures to minimize impacts on marine species.

Table A-2 Estimated Distance to 190 and 180 dB RMS Level

Hammer Energy (K-Joules)	190 dB RMS Feet (m)	180 dB RMS Feet (m)
750	606 (185)	1,919 (585)
1,000	705 (215)	2,231 (680)
1,250	787 (240)	2,477 (755)
1,500	869 (265)	2,739 (835)
1,750	935 (285)	2,953 (900)

The FSRU will be constructed outside the Project area and towed to Long Island Sound. As such, the potential exists for the FSRU to contain foreign ballast water, which could introduce foreign species to the Sound. To minimize potential impacts resulting from the introduction of potentially invasive species, the FSRU will exchange ballast water in offshore waters prior to being towed into Long Island Sound. Therefore, the ballast water contained in the FSRU when it is towed into the Sound will consist of North Atlantic seawater, which has characteristics similar to the water typically found in Long Island Sound.

Lighting has the potential to attract marine species during installation and operation of the facilities. Lighting during construction will not vary significantly from existing lighting in the Sound resulting from other marine activities such as fishing, lightering, and anchoring of commercial vessels.

1.5 GENERAL IMPACTS ASSOCIATED WITH OPERATION OF THE PROPOSED PROJECT FACILITIES

Resource Report 3, Fish, Vegetation and Wildlife, provides a detailed discussion of the potential impacts associated with operation of the proposed Project facilities. For the purposes of this EFH analysis, a summary of the potential impacts on relevant marine resources as a result of facility operation is provided below. Impacts on reptiles, marine mammals, and avian species are not summarized here.

1.5.1 Pipeline

Operation of the proposed pipeline has the potential to locally impact marine habitats due to maintenance activities and potential thermal impacts from the pipeline.

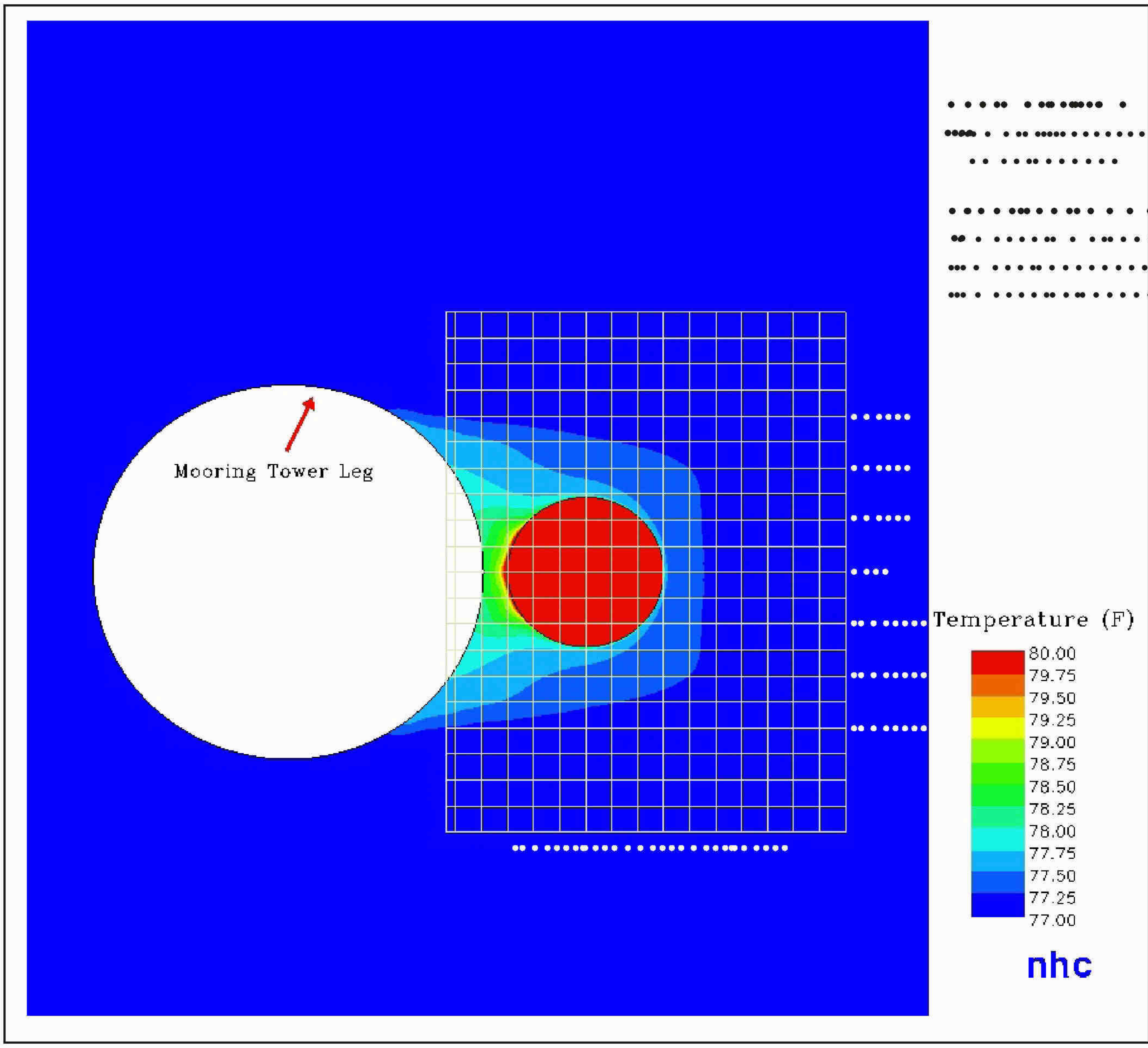
It is anticipated that pipeline maintenance will be limited to periodic inspection and pigging activities, which may involve accessing mainline valves. These activities would require minimal daylighting of buried facilities, with excavation limited to the use of a submersible pump or by divers using hand-jetting or air-lifting equipment. Any subsea maintenance activities will require localized re-disturbance of sediments. The impacts associated with maintenance activities will be similar to those described for construction, i.e., of short-term duration, likely affect a very limited area, and result in no significant impact on habitat.

The 30-inch-diameter pipeline will be coated with 3 inches of concrete except along the descent through the mooring tower. Depending on the season (winter versus summer) and volume of gas flow (high versus low), natural gas is expected to enter the pipeline at a temperature between slightly higher than 100ºF (38ºC) and slightly lower than 130ºF (54ºC) at the top of the mooring tower and to fall to a temperature between 100ºF (38ºC) and 120ºF (49ºC) at the bottom of the mooring tower, or at the sediment surface. The heat loss experienced in the pipeline from the surface to the seabed would be transferred to the surrounding water column. Based on the sheer volume of water flowing by the pipeline, any increases in temperature would be readily dissipated in the water column with no significant thermal plume expected. In the winter, the temperature differential between the pipeline and the surrounding water column could reach 80° to 90°F (27° to 32°C). While the additional heat will be readily assimilated into the surrounding water column, a potential microclimate could be established within the immediate vicinity of the pipeline riser and mooring tower. As presented in Appendix J to Resource Report 2, Water Use and Quality, thermal modeling of the heat exchange from the pipeline riser to the surrounding water column will be measurable only within approximately 30 inches (76 cm) from the pipeline. Figure A-2, taken from the Appendix J to Resource Report 2, provides a visual representation of the thermal modeling from the riser. This small area could function as an attractant to the local fishery, increasing the density of fish in immediate proximity to the pipeline riser, and could prove to be attractive to predatory marine mammals, as well. The restricted extent of the thermal influence, due to the normal tidal and current fluctuation within the Sound, minimizes potential impacts on the surrounding ecosystem. The remainder of the pipeline will be coated with 3 inches of concrete and installed to a depth of 3 feet below the sediment surface, or otherwise protected with armor rock or concrete mats. Based on the thermal modeling conducted for the subsea pipeline portion, a localized thermal impact will occur immediately following installation, prior to natural backfilling of the pipeline. The transmission of higher temperature gas through the pipeline could result in some minimal temperature transfer into the surrounding sediments, but the impact will be highly localized and will not result in significant impacts on marine or benthic habitat. Figure A-3 presents the extent of thermal impact based on Project-specific modeling. As with the pipeline riser, impacts will be extremely localized, extending less than 1 pipe diameter away from the pipe. Impacts will decrease over time as natural infilling of the trench provides insulation for the pipeline. Figure A-4 presents the modeling results following the natural infilling of the trench. Although temperature impacts are eliminated from the water column, a localized zone of increased sediment temperature will likely develop around the pipe, resulting in potential shifts in the benthic community. Based on the limited extent of the thermal effect, impacts will be minimal and result in no large-scale alternations to the benthic community. Potential water quality impacts associated with thermal changes are discussed in detail in Section 2.5.2.1 of Resource Report 2, Water Use and Quality.

1.5.2 FSRU

Operation of the FSRU will result in both positive and negative impacts on biological resources through alteration of the seabed and existing habitat and through small-scale water exchanges required for ballasting and other FSRU processes. Although specific impacts on water quality are addressed more fully in Resource Report 2, Water Use and Quality, this resource report addresses the biological organisms within the water column that could potentially be impacted.

The presence of the FSRU and associated mooring tower will result in the establishment of a microhabitat within Long Island Sound. At the proposed FSRU location, the Sound is characterized primarily as a large expanse of mud-bottomed habitat with little, if any, topographic relief. The FSRU and mooring tower will introduce significant vertical structure into the water column and the size of the FSRU will introduce a permanent source of shading into the Project area. In addition, based on site-specific conditions and engineering considerations, areas along the pipeline route will be further armored to


Mooring Tower Leg
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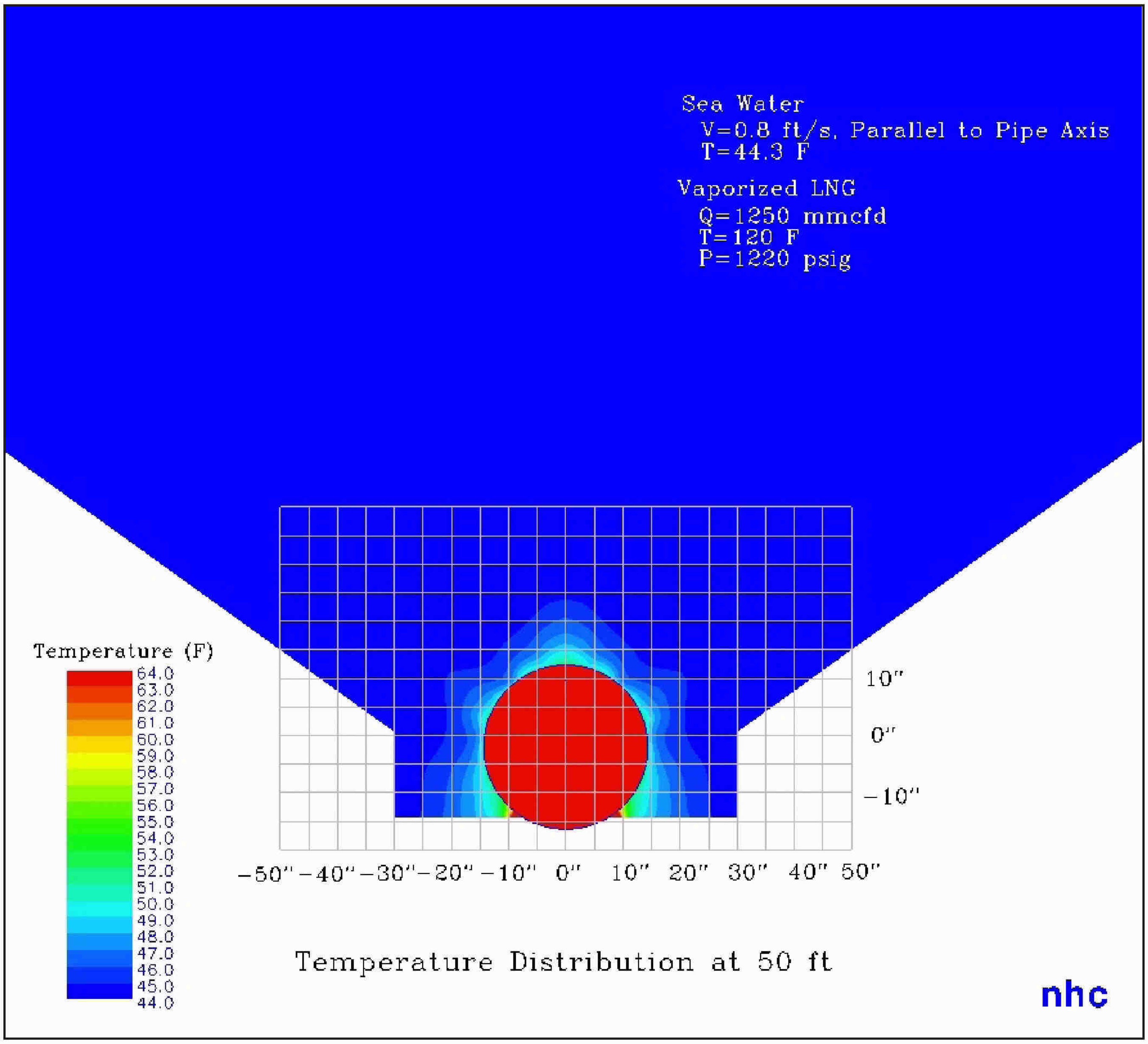
79.25
79.00
78.75
78.50
78.25
78.00
77.75
77.50
77.25
77.00
nhc


Sea Water
V=0.8 ft/s, Parallel to Pipe Axis
T=44.3 F
Vaporized LNG
Q=1250 mmcfd
T=120 F
P=1220 psig
Temperature (F)
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63.0
62.0
61.0
60.0
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57.0
56.0
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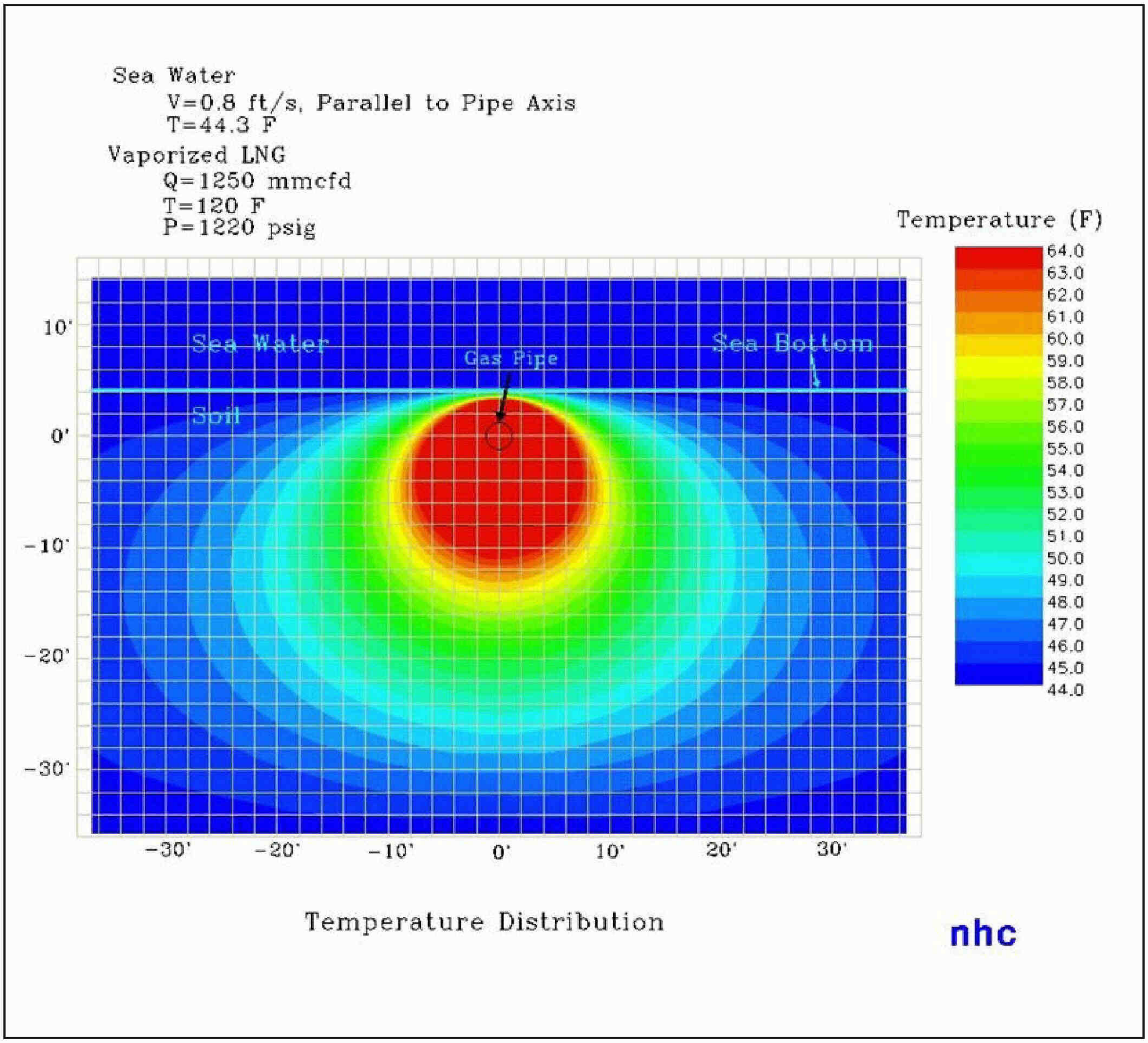
Temperature Distribution at 50 ft
nhc


Sea Water
V=0.8 ft/s, Parallel to Pipe Axis
T=44.3 F
Vaporized LNG
Q=1250 mmcfd
T=120 F
P=1220 psig
Temperature (F)
64.0
63.0
62.0
61.0
60.0
59.0
58.0
57.0
56.0
55.0
54.0
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51.0
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49.0
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46.0
45.0
44.0
Sea Water
Gas Pipe
Sea Bottom
Soil
10'
0'
-10'
-20'
-30'
-30'
-20'
-10'
0'
10'
20'
30'
Temperature Distribution
nhc

ensure pipeline integrity. These introduced features will result in considerable habitat diversity on a small scale, in essence creating artificial reef habitat. In addition, any safety and security zone designated by the USGC around the FSRU will become a refuge or sanctuary for marine organisms, due to the removal of fishing pressure. Although small in size relative to the area of Long Island Sound, the Project area will introduce diversity and structure where it is now largely absent except for isolated wrecks and other debris on the Sound floor. Any loss of habitat resulting from installation of the FSRU will be offset by the increased habitat that is created.

Operation of the proposed FSRU has the potential to result in some adverse impacts on the water column and water quality. To maintain in-water stability, both the FSRU and any offloading LNG carriers will be required to withdraw/discharge Sound water. While the FSRU will be required to both discharge and withdraw water, LNG carriers will only take on ballast water to compensate for offloaded LNG. This will eliminate the potential for the introduction of foreign/exotic species into the Sound from carrier ballast systems.

The FSRU will use seawater for its ballast and fire-water systems. Water discharges from the FSRU will be restricted to four primary sources—the fire water bypass, ballast water discharge, rainwater runoff, and the wastewater treatment plant. Additional discussion of the water intakes and discharges is presented in Section 2.5.2.2 of Resource Report 2, Water Use and Quality.

Potential impacts associated with the water intake include impingement and entrainment of organisms as water is drawn into the FSRU. The intake structure for the FSRU will be designed to reduce impacts to the extent practicable. Water intake flow velocities will be maintained at a maximum of 0.5 feet/second (0.15 m/s), which will allow any motile organisms to swim away from the intake, thereby largely limiting entrainment/ impingement impacts. The intake structure will include a pair of screens/grates to further reduce impacts. The intake will contain a grate, flush with the FSRU hull, that will restrict the passage of larger fish. A second internal screen with a mesh size of approximately 5 mm will restrict the intake of all but the smallest planktonic organisms. However, by situating the intake structure at approximately 40 feet (12 m) below the surface, in the middle of the water column, impacts are avoided for all buoyant or demersal biological life stages. To minimize marine growth within seawater systems on board the FSRU, sodium hypochlorite will be injected into the water intake stream. Therefore, complete or near complete mortality of all entrained organisms is assumed for the purpose of biological assessment.

Potential impacts from FSRU discharges also have been identified. The injection of sodium hypochlorite to restrict marine growth introduces chlorine into the FSRU seawater systems. However, only residual chlorine levels, estimated to be between 0.01 and 0.05 ppm, will be present in the discharge. These levels will not result in significant adverse impacts on biological resources. Section 2.5.2.2 of Resource Report 2, Water Use and Quality, provides additional details regarding potential impacts attributable to residual chlorine.

The FSRU will contain a waste water treatment facility designed to meet all applicable state and federal discharge standards. Combined with the relatively minor volume of discharge, no significant impacts are anticipated. If a treatment system cannot be designed to meet discharge standards, black and grey water will be held on board the FSRU and shipped to shore for disposal at an approved facility.

In addition to the anticipated daily discharges, potential impacts could result from spills or other accidents at the facility. Impacts on water quality and the local ecosystem will be minimized through a variety of measures, including implementation of a Spill Prevention, Control, and Countermeasures (SPCC) Plan and other plans, as appropriate, for handling hazardous materials and hazardous and solid waste. Any impacts resulting from operation of the facility, including an LNG spill, would result in short-term, localized impacts. The effects of an LNG spill would likely be limited to the water surface and a limited portion of the upper water column in the vicinity of the FSRU. The impacts of such a spill would include temporary changes in the thermal characteristics of the affected area. A significant release of LNG could result in limited mortality to fish in the Project area to species that are unable to vacate the Project area in advance of an approaching plume. However, unlike transshipments of heavy petroleum products (e.g. fuel oils), an LNG spill would evaporate, leaving no residual product. As such, the marine community would be expected to quickly recover.

Operation of the FSRU will require the use of several materials that, if spilled, could potentially adversely affect the ecosystem. Diesel fuel, which is required for daily operations, will be stored in tanks integrated into the hull of the FSRU or associated with equipment internal to the FSRU (e.g., diesel fire pumps), thereby minimizing the potential for spill. Ethylene glycol, integral to the STV process, is incorporated into a closed system, with no potential discharge during normal operations. Aqueous ammonia and mercaptan will be transferred to the FSRU via ISO tanks and properly stored, again minimizing potential impacts on the marine ecosystem.

Maintenance or other actions (such as the application of anti-fouling paint) may be required to reduce marine growth on the external portions of the FSRU. Activities to reduce marine growth will be conducted according to procedures developed in conjunction with federal and state agencies to minimize impacts on marine species. Antifouling paint would be applied to the FSRU hull during construction, with no in-water application proposed throughout the operating lifetime of the FSRU. Broadwater proposes to use a copper-based antifouling paint rather than a tri-butyl tin paint, which has been recognized as having considerably greater ecological impact. Antifouling paint has the potential to leach copper to the water column in small quantities. However, since the antifouling paint will be applied at the shipyard, and the ship will require significant transit time from the shipyard to Long Island Sound, the level of copper leaching likely to occur within Long Island Sound will be minimal. By the time the vessel reaches Long Island Sound, it is expected to have reached a leaching rate of 1.005 µg copper/liter of water, or lower. The water quality criteria promulgated by the EPA for the protection of aquatic organisms indicates that, to a great extent, the saltwater aquatic organisms and their uses should not be impacted if the 4-day average concentration of dissolved copper does not exceed 1.9 µg/L more than once every 3 years and if the 24-hour average concentration for dissolved copper does not exceed 3.1 µg/L more than once every 3 years. Since the expected concentration of 1.005 µg copper/liter of water is below the EPA impact threshold, no impact on aquatic organisms is expected due to the leaching of copper from the antifouling paint present on the FSRU hull. Potential water quality impacts associated with use of antifouling paint are discussed in detail in Section 2.5.1.2 of Resource Report 2, Water Use and Quality.

Operation of the FSRU has the potential to result in some minimal impact on the surround ecosystem by the introduction of a previously non-existing light source. Safe operation of the FSRU will require some level of continuous lighting to facilitate FSRU operations. This lighting has the potential for some long-term impacts by attracting species to the FSRU. Lighting of the FSRU will be designed to minimize potential impacts, and the following measures will be implemented to mitigate lighting impacts:

- Lighting used during operational activities will be limited to the number of lights and wattage necessary to perform such activities.

- Lights will be shielded so that the beam falls on the workspace, and light beams will not be directly visible more than 1,000 m from the source.

- Lights shining into the water will be limited to the area immediately around vessels, except when essential for safe navigation, the safety of personnel, or other safety reasons.

Simulations of nighttime lighting on the FSRU are presented in the Visual Resource Assessment, which is included as Appendix D of Resource Report 8, Land Use, Recreation, and Aesthetics. As depicted in these simulations, lighting will be minimal, with no significant light exposure to the water surface.

Broadwater will prepare a detailed lighting plan, developed as part of the final design of the facilities, prior to initiation of construction.

Some noise will be generated during operation of the FSRU. Adequate controls will be placed on equipment on the FSRU to minimize undue exposure of the workers to noise. This will have an ancillary benefit of reducing the noise levels, both above and below water, that could potentially impact marine species. In addition, the noise within the water column would be further dampened by the presence of the ballast tanks between the inner and outer hulls of the FSRU.

1.6 RESOURCE-SPECIFIC IMPACTS ASSOCIATED WITH CONSTRUCTION AND OPERATION OF THE PROPOSED PROJECT FACILITIES

1.6.1 Long Island Sound Coastal Habitats

The coastal areas of Long Island Sound contain a diversity of habitats that contribute to the overall value of the Long Island Sound ecosystem. The USFWS and NYSDOS have identified critical areas that merit protection/conservation to maintain the health of the local ecosystem. In addition to these designated areas (discussed in greater detail in Resource Report 3, Sections 3.2.1.2 and 3.2.1.3), numerous other wetland and submerged aquatic vegetation complexes provide essential food, cover, and habitat for local fish and wildlife populations.

Recognizing the value of these inshore coastal habitats, the Project has been located in the central portion of the Sound to largely avoid these inshore habitats. As such, no impacts on these coastal habitats are anticipated during construction of the Project. Vessels transiting to and from the facility through or in proximity to these significant areas will be consistent with other vessels transiting the Sound and will not result in impacts on these areas.

1.6.2 Benthos

Construction and operation of the proposed Project have the potential to result in positive and negative impacts on benthic communities. Negative impacts may result from direct disturbance of bottom sediments, increased turbidity, sediment deposition, and decreased water quality. Positive impacts are associated with increased habitat diversity.

1.6.2.1 Existing Conditions

Several historical studies of the benthic community structure in Long Island Sound have been conducted. In 1956 Sanders conducted short-term studies at eight locations in the central Sound that led to concepts about the relationship between infaunal species and their sedimentary environment. Sanders recognized a community type, the *Nephtys incisa - Yoldia limatula- Nucula annulata* community, that was consistent among four of the eight sites he sampled. Each of the four sites was found in the central basin at depths of 13 to 98 feet (4 to 30 m) in sediments of >25% silt-clay content (Sanders 1956).

In 1972 Reid et al. conducted the first Sound-wide survey of benthic communities in Long Island Sound, sampling 142 stations located every 1.8 to 3 miles (3 to 5 km) on north-south transects spaced 5.4 miles (8.7 km) apart for the length of the Sound (100 sampling stations in the central and western basins) (Reid et al. 1979). A subset of the stations were resampled in April and September 1973, and 45 of the stations were revisited annually between 1975 and 1978.

Annelids, mollusks, and arthropods accounted for the majority of the 248 species collected. When these taxa were totaled, the relative abundance was annelids 46%, arthropods 33%, and mollusks 21%. The studies also showed that the lowest species diversity was often found at deepwater stations in sediments with a high silt-clay content (*see* Figure A-5).

Three consistent faunal groups were recognized in the central and western basins of the Sound (*see* Figure A-6): a muddy, deep-water assemblage distributed throughout much of the central and western basins; a shallow, sandy assemblage along much of the north shore of Long Island; and a transitional shallow-water assemblage in the western portion of the Sound and along the Connecticut shore. While additional benthic communities

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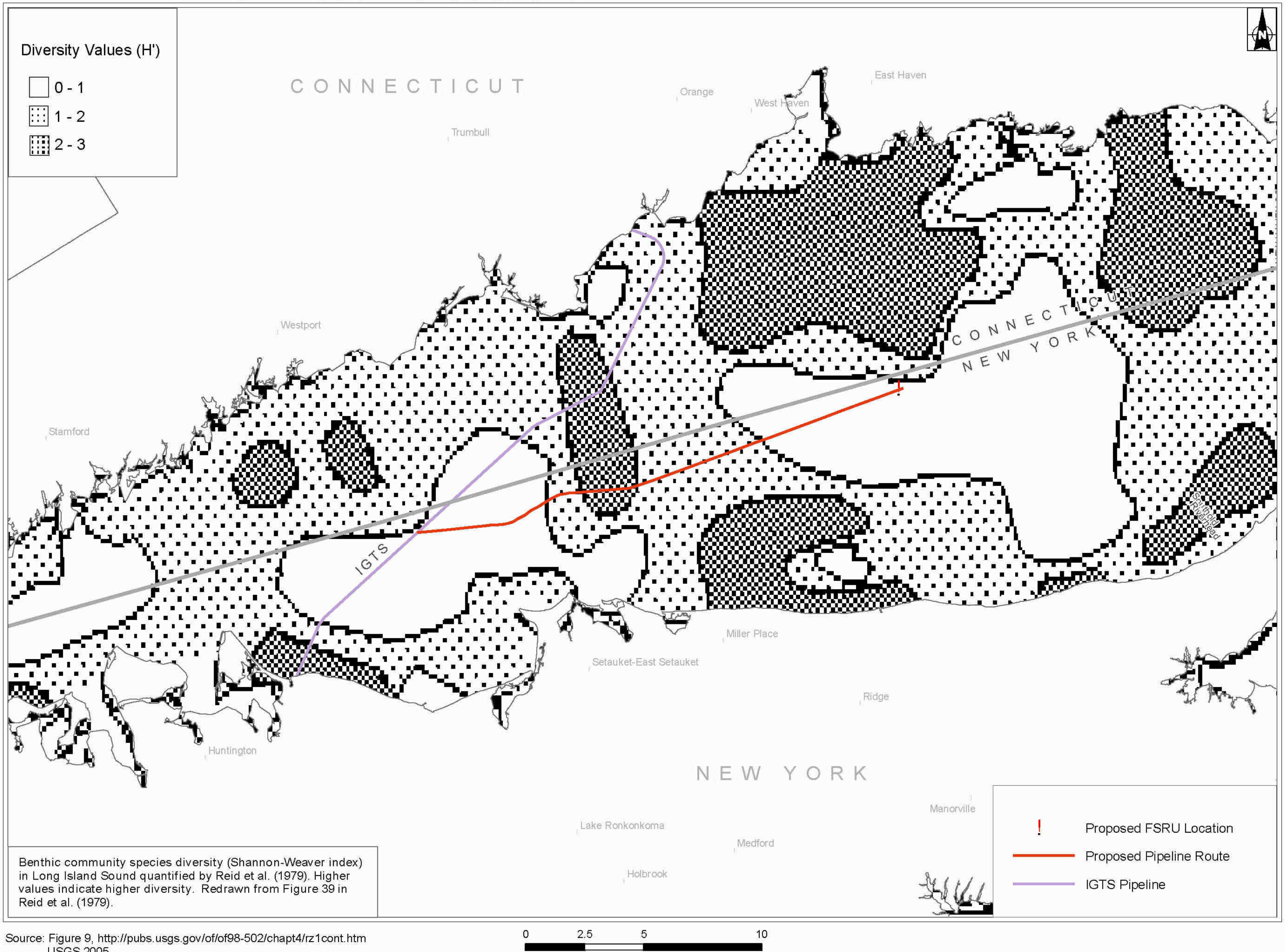

Source: Figure 9, http://pubs.usgs.gov/of/of98-502/chapt4/rz1cont.htm
USGS 2005.

Figure A-5 Benthic Community Species Diversity in the Project Area

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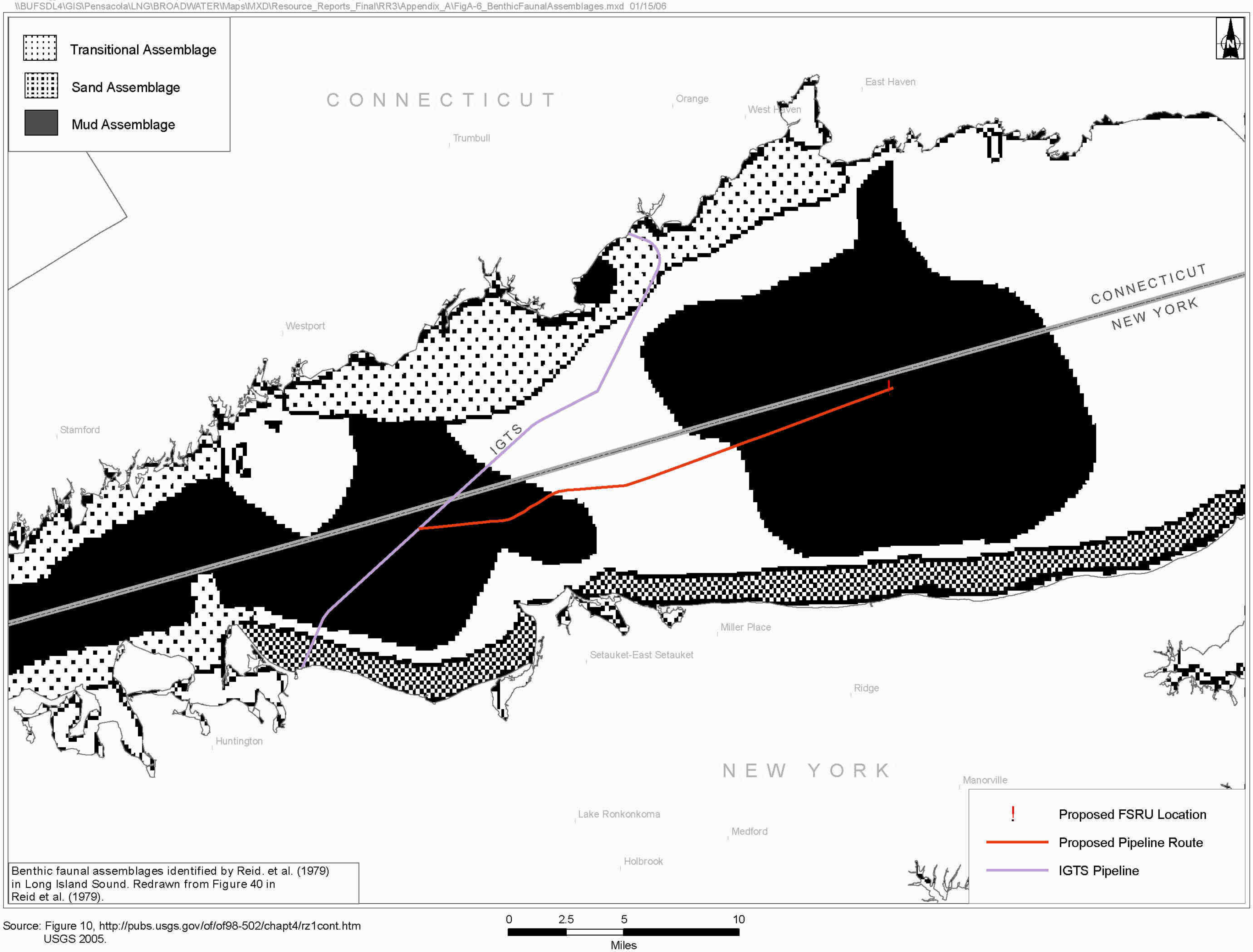

Source: Figure 10, http://pubs.usgs.gov/of/of98-502/chapt4/rz1cont.htm
USGS 2005.

Figure A-6 Benthic Faunal Assemblages in the Project Area existed outside of these groupings and these areas, they were not as consistent as the species assemblages described for these areas. A muddy assemblage, consistent with that described by Sanders (1956), was found to occupy the flat seabed in the central and western basins. This assemblage consists of polycheate worms (*Nephtys incisa*, *Mediomastus ambiseta*, and *Polydora cornuta*); clams (*Nucula annulata* and *Yoldia limatula*); and the amphipod *Ampelisca abdita* (Reid et al. 1979).

A study conducted by Pellegrino and Hubbard (1983) in Connecticut waters of Long Island Sound confirmed several general trends in community structure that were found previously by Reid et al. (1979). Species richness increased from west to east in the Sound, the mean density of individuals per sample was generally higher in the central and eastern basins of the Sound than in the western basin, and the western and central basins were dominated by the bivalves *Mulinia lateralis* and *Nucula annulata* and the polychaete *Nephtys incisa* (Pellegrino and Hubbard 1983). The inclusion of *Mulinia lateralis* as one of the dominant species is significant because it is considered an opportunistic species (Williams et al.1986). The dominance of an opportunistic species may indicate recent disturbance or other habitat degradation.

Zajac (1998) and Zajac et al. (2000) reviewed the existing literature and reanalyzed portions of the data to characterize Sound-wide trends in community structure and variability in community structure at different spatial scales. Sound-wide trends are evident in the general makeup of communities, and there also is a fair degree of local variation in community structure. Consistent groups of species form community types that are recognizable in portions of the Sound such as the central basin.

Based on Zajac's reanalysis of the previously collected data, benthic communities were found to be highly variable and were grouped into more than a dozen assemblages. Assemblages in the central and western basins were found to be similar to those reported in previous studies.

Stations along Stratford Shoal were found to be the most species-rich, with 31 of the possible 35 dominant species present. Species that occurred at moderate to high abundances included *Asabellides occulata*, *Tellina agilis*, *Spiophanes bombyx*, and *lymenella zonalis*. Other sub-clusters near Stratford Shoal were found to be species-rich but dominated by crustaceans, including *Ampelisca abdita*, *Ampelisca vadorum*, and *Corophium acheruscum* (Zajac et al. 2000).

The analysis suggests that spatial variation in community structure is low for large areas of the western and central basins and relatively higher in the Narrows to the west and in the eastern basin, where greater interaction with the Atlantic Ocean occurs. Overall trends in community variation may be related to several habitat characteristics, including sediment grain-size, the geographic location of the habitat, and size of the habitat. General community types appear to be consistent, but longer-term changes may occur in the populations of some of the dominant organisms (Zajac et al. 2000).

McCall (1977, 1978) conducted studies in Long Island Sound between 1972 and 1973 that were designed to address how infaunal communities responded to disturbance, as well as subsequent successional dynamics leading to the reestablishment of the benthic community. McCall (1977) determined that there were three successional groups of species: Group I, those that initially colonized disturbed areas in very high numbers; Group II, those that are typical of intermediary succession following disturbance; and Group III, those that represent the successional endpoint community. Based on McCall's work, the communities sampled during Broadwater's field efforts, which are described in greater detail below, resemble a gradiation between secondary and tertiary successional stages. These stages exhibit species that are similar to those noted by McCall as Groups II and III, which typically attain peak abundance during middle to late portions of succession and include bivalves and polycheates. These species represent larger, mobile, and deeper-living organisms (especially Group III). In contrast, the first stage successional community (Group I) typically consists of early colonizers, which are very high in number and opportunistic in nature. They are generally small, live in tubes within upper layers of the sediment, and have rapid colonization life history strategies.

In April and May 2005, a site-specific benthic survey was conducted to verify and refine information on the benthic communities in the Project area. Samples were collected at the proposed location of the FSRU, and at 27 stations along the proposed pipeline route (*see* Figure A-7). Each location was sampled in triplicate, with one sample centered on the proposed centerline of the pipeline and two additional samples offset by approximately 200 feet from the centerline. Appendix C of Resource Report 3 provides the laboratory analysis results for the benthic identification at each sampling location.

In addition to the benthic collection, videos of the bottom were obtained for 23 of the stations, which were analyzed to supplement benthic sampling. To collect videos of the bottom, a drop camera was lowered to the depth for the specific sample location as indicated by the fathometer on the survey vessel. The drop camera was allowed to stabilize in the water column until it remained steady enough to obtain a good image. An onboard monitor was used to ensure that the camera was steady and to make initial observations of the benthic community. Once the image was steady, a slow trawl across the bottom captured the bottom video for that location. The video collected during the field surveys is provided in the Spring 2005 Environmental Sampling Report (E & E 2005).

Underwater video observations are best used to supplement existing benthic data. Due to the camera movement, shadows, camera magnification, and video quality, it is often difficult to confirm species identification and to determine abundances using only video observations. Results of the benthic characterization based on the video observations are provided below.

In addition to the benthic analyses, sediment and chemical analyses also were conducted at each station. Chemical analysis revealed that sediments were essentially clean, with no stations exceeding established regulatory guidance values. The results of the chemical analysis are discussed in greater detail in Section 2.3.6 of Resource Report 2, Water Use and Quality. Grain-size analysis showed that the sediments were generally consistent

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Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

Figure A-7 Broadwater Benthic Sampling Stations with those mapped for the Sound. Sediment results are discussed in greater detail in Resource Report 7, Soils. The majority of the stations were characterized by fine-grained sediments (fine sand, silt, and clay), with few rock mounds (sites MG 1, MG2, and MG3 in the vicinity of Stratford Shoal) and amphipod mats (site C28) in the Project area.

Based on field surveys, soft-sediment communities in the Project area were dominated by several burrowing and tube-dwelling polychaetes, amphipods, tunicates, and anemones. In general, shell hash (*Mercenaria mercenaria*, other clam species, *Crepidula* sp., and *Ensis directis*) varied in abundance within the Project area. Based on video observation, no live individuals of shellfish (hard clams, surf clams, or oysters) were observed, which suggests that a low density of shellfish occur in this area. However, at several locations the video showed evidence of burrows, which are most likely used by lobsters, other invertebrates (e.g., the mud shrimp [*Axius serratus*]), and fish species in the area. The greatest differences in species composition were found when comparing the soft-sediment community (the majority of the proposed Project area) compared to the community inhabiting the rock mounds (sites MG1, MG2, and MG3 across Stratford Shoal). The results of the benthic sampling are summarized in Table A-3.

In order to characterize the benthic community in the Project area, three benthic samples (centerline, and north and south of the centerline) were collected at each sampling location. Underwater video also was used to make general observations about the benthic communities.

Benthic community biodiversity was assessed for each of the sampling locations from the benthic grab data (*see* Table A-3). Diversity was calculated for each sampling location using the Shannon-Weiner Index. While benthic diversity in the mud assemblages was generally greater than expected based on existing literature, the field data show the diversity to be consistent within a given portion of the Project area. Diversity values (H^1) were expected to be lowest along the floors of the western and central basins (ranging from 0 to 1), moderate within the transitional areas around Stratford Shoal (ranging from 1 to 2), and highest along Stratford Shoal (ranging from 2 to 3) (*see* Figure A-5). Values calculated from the samples collected revealed moderate diversity west of Stratford Shoal (typically from 1 to 2), and values at and east of Stratford Shoal were generally higher (typically from 2 to 3).

The benthic survey revealed that benthic communities are generally consistent with what would be expected based on depth, substrate, and sedimentary environment in the Project area (*see* Figure A-8). Four general benthic communities were identified in the Project area: a Deep Basin Mud Community, a Western Transition Community, a Shoal Community, and an Eastern Transition Community (*see* Figure A-9).

Deep Basin Mud Community

(Stations C-1, -2 , -3, -4, -19, -21, -22, -23, -24, -26, -27, and -28)
A Deep Basin Mud Community was found at stations located at the eastern and western edges of the proposed Project area, along the floor of the western and central basins. Bottom substrates are comprised of fine silt and sand and a patchy distribution of clay.

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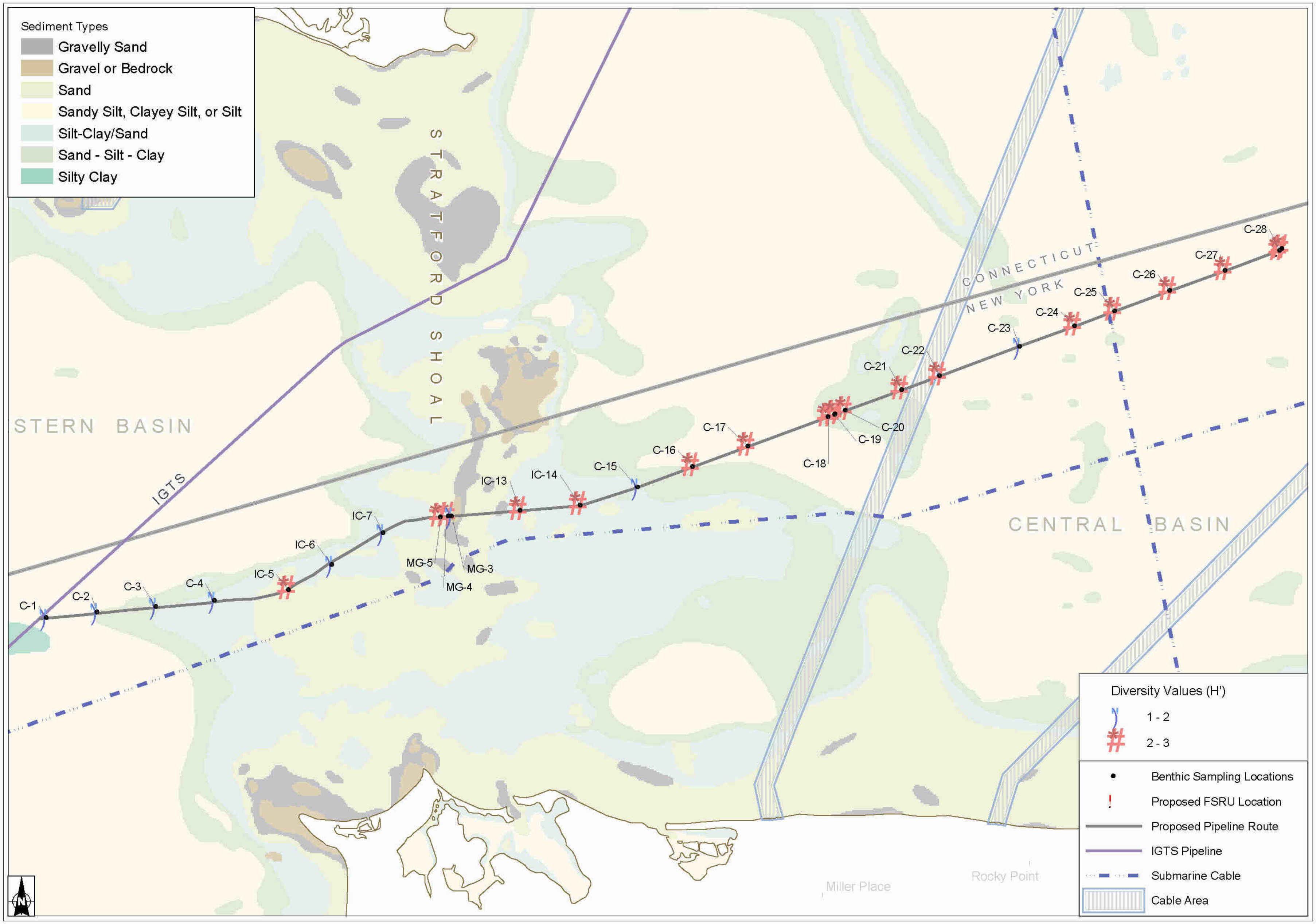

Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

Figure A-8 Benthic Community Species Diversity in the Project Area; Based on Spring 2005 Field Surveys

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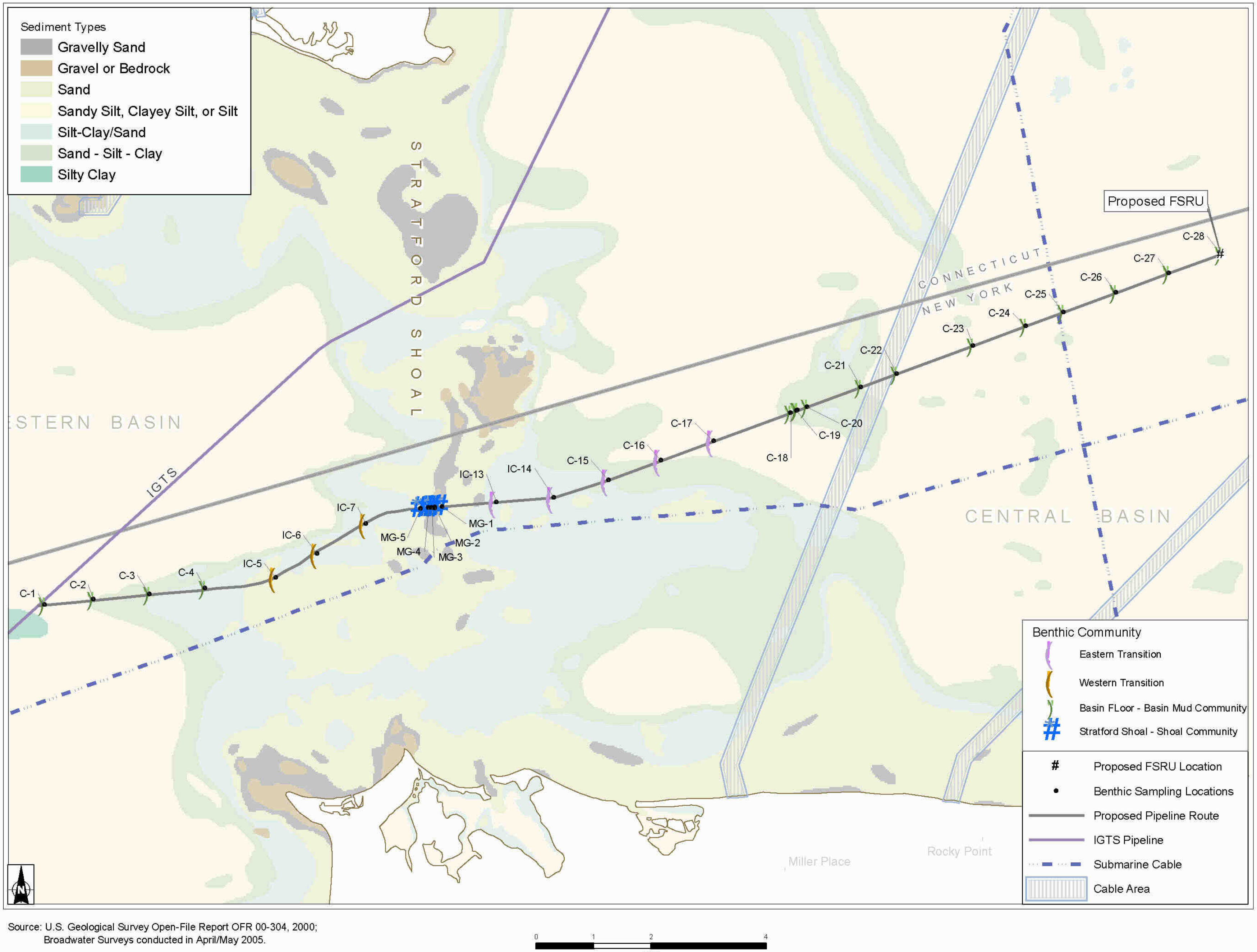


Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

Figure A-9 Broadwater Benthic Communities; Based on Spring 2005 Field Surveys

Table A-3 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	Sample ID		
	C1N	**C1C**	**C1S**
Total # of Organisms Identified	125	295	205
Total # of Organisms in Sample	125	295	205
Taxa Richness	15	14	19
Diversity (H_1)	2.13	1.26	2.01
Eveness	1.81	1.10	1.57

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Copepoda *Nephtys* sp.

	C2N	**C2C**	**C2S**
Total # of Organisms Identified	108	107	109
Total # of Organisms in Sample	630	510	625
Taxa Richness	11	11	14
Diversity (H_1)	1.11	1.53	1.87
Eveness	1.06	1.47	1.63

Notes: dominant species, when totaled = at least 50% sample

Copepoda Bivalvia (juv.)

	C3N	**C3C**	**C3S**
Total # of Organisms Identified	101	111	154
Total # of Organisms in Sample	346	368	856
Taxa Richness	16	12	14
Diversity (H_1)	2.00	1.55	1.68
Eveness	1.66	1.44	1.47

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Cirratulidae

	C4N	**C4C**	**C4S**
Total # of Organisms Identified	107	114	107
Total # of Organisms in Sample	402	783	1160
Taxa Richness	13	11	13
Diversity (H_1)	1.86	1.57	1.70
Eveness	1.67	1.50	1.52

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda Cirratulidae

	IC5N	**IC5C**	**IC5S**
Total # of Organisms Identified	129	126	138
Total # of Organisms in Sample	698	788	347
Taxa Richness	17	17	18
Diversity (H_1)	2.35	2.53	2.12
Eveness	1.91	2.06	1.69

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Bivalvia (juv.) *Pinnixa* sp. Copepoda

	IC6N	**IC6C**	**IC6S**
Total # of Organisms Identified	96	61	115
Total # of Organisms in Sample	330	61	407
Taxa Richness	13	13	13
Diversity (H_1)	1.69	2.02	1.70
Eveness	1.52	1.82	1.52

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda *Nephtys* sp. *Molgula* sp. *Leptocheirus pinguis* Cirratulidae

	IC7N	**IC7C**	**IC7S**
Total # of Organisms Identified	62	96	77
Total # of Organisms in Sample	62	96	77
Taxa Richness	13	15	13
Diversity (H_1)	2.04	2.08	1.52
Eveness	1.83	1.77	1.36

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp. *Nephtys* sp. Cirratulidae Copepoda *Molgula* sp. *Haminoea solitaria*

	MG3N	**MG3C**	**MG3S**
Total # of Organisms Identified	112	99	95
Total # of Organisms in Sample	700	438	906
Taxa Richness	13	14	15
Diversity (H_1)	1.89	2.01	1.94
Eveness	1.69	1.75	1.65

Notes: dominant species, when totaled = at least 50% sample

Ampelisca sp. *Ampharete arctica*

		MG4C	
Total # of Organisms Identified		103	
Total # of Organisms in Sample		774	
Taxa Richness		18	
Diversity (H_1)		$2.10	
Eveness		$1.67	

Notes: dominant species, when totaled = at least 50% sample

Ampelisca sp. *Ampharete arctica*

	MG5N	**MG5C**	**MG5S**
Total # of Organisms Identified	100	105	92
Total # of Organisms in Sample	480	767	400
Taxa Richness	13	14	14
Diversity (H_1)	2.06	2.04	2.08
Eveness	1.85	1.78	1.81

Notes: dominant species, when totaled = at least 50% sample

Ampharete arctica Ampeliscidae Aoridae *Astarte undata*

Table A-3 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	IC13N	IC13C	IC13S
Total # of Organisms Identified	113	134	114
Total # of Organisms in Sample	920	1130	751
Taxa Richness	18	17	12
Diversity (H_1)	2.41	2.42	2.06
Eveness	1.92	1.97	1.91

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Pinnixa* sp., Aoridae, *Ampelisca sp.*, *Nephtys* sp., *Asychis elongata*, *Anadara traversa*

	IC14N	IC14C	IC14S
Total # of Organisms Identified	120	144	182
Total # of Organisms in Sample	120	144	182
Taxa Richness	16	20	15
Diversity (H_1)	2.21	2.24	1.58
Eveness	1.83	1.73	1.34

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), Copepoda, Aoridae

	C15N	C15C	C15S
Total # of Organisms Identified	98	116	105
Total # of Organisms in Sample	211	500	273
Taxa Richness	18	14	14
Diversity (H_1)	2.25	1.66	1.65
Eveness	1.80	1.45	1.44

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Tellina* sp., Copepoda, *Nephtys* sp.

	C16N	C16C	C16S
Total # of Organisms Identified	101	94	95
Total # of Organisms in Sample	240	270	365
Taxa Richness	14	20	15
Diversity (H_1)	2.02	2.39	2.01
Eveness	1.77	1.83	1.71

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), Copepoda, *Pinnixa* sp.

	C17N	C17C	C17S
Total # of Organisms Identified	76	77	73
Total # of Organisms in Sample	76	77	73
Taxa Richness	16	15	15
Diversity (H_1)	2.50	2.33	2.28
Eveness	2.08	1.98	1.94

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.), *Pinnixa* sp., Sabellidae, *Ateocina canaliculata* [2], Copepoda, *Tellina* sp., *Molgula* sp.

	C18N	C18C	C18S
Total # of Organisms Identified	123	112	94
Total # of Organisms in Sample	1386	1220	1400
Taxa Richness	16	18	19
Diversity (H_1)	2.29	2.35	2.50
Eveness	1.90	1.87	1.95

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp., *Nephtys* sp., Copepoda, *Leptocheirus pinguis*, *Ampharete arctica*, *Clymenella* sp., *Asychis elongata*

	C19N	C19C	C19S
Total # of Organisms Identified	92	106	126
Total # of Organisms in Sample	1034	1220	970
Taxa Richness	19	19	17
Diversity (H_1)	2.41	2.58	2.03
Eveness	1.89	2.02	1.65

Notes: dominant species, when totaled = at least 50% sample

Copepoda, *Ampharete arctica*, *Crepidula fornicata*, *Nephtys* sp.

	C20N	C20C	C20S
Total # of Organisms Identified	91	113	150
Total # of Organisms in Sample	483	113	150
Taxa Richness	17	17	18
Diversity (H_1)	2.41	2.28	2.50
Eveness	1.96	1.85	1.99

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp., *Ampharete arctica*, *Crepidula plana*, *Asychis elongata*, *Ampelisca* sp., Aoridae

	C21	C21C	C21S
	108	128	118
Total # of Organisms in Sample	690	1120	674
Taxa Richness	15	16	18
Diversity (H_1)	2.26	2.42	2.42
Eveness	1.92	2.01	1.92

Notes: dominant species, when totaled = at least 50% sample

Pinnixa sp., *Ampelisca* sp., *Nephtys* sp., *Ampharete arctica*, Copepoda

	C22N	C22C	C22S
Total # of Organisms Identified	60	62	50
Total # of Organisms in Sample	60	62	50
Taxa Richness	14	13	13
Diversity (H_1)	2.27	2.08	2.25
Eveness	1.98	1.87	2.02

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp., *Molgula* sp., Copepoda, Aoridae, *Asychis elongata*

Table A-3 Benthic Data Results Summary for Proposed Pipeline Route, April-May 2005

	C23N	C23C	C23S
Total # of Organisms Identified	124	112	157
Total # of Organisms in Sample	481	112	157
Taxa Richness	10	16	20
Diversity (H_1)	1.28	1.81	2.55
Eveness	1.28	1.50	1.96

Notes: dominant species, when totaled = at least 50% sample

Bivalvia (juv.) Copepoda Pyramellidae *Nephtys* sp. *Asychis elongata* Sabellidae *Molgula* sp.

	C24N	C24C	C24S
Total # of Organisms Identified	102	96	113
Total # of Organisms in Sample	102	96	113
Taxa Richness	16	17	21
Diversity (H_1)	2.27	2.33	2.61
Eveness	1.88	1.89	1.98

Notes: dominant species, when totaled = at least 50% sample

Nephtys sp. *Pinnixa* sp. Copepoda *Molgula* sp. Bivalvia (juv.) *Ampelisca* sp.

	C25N	C25C	C25S
Total # of Organisms Identified	100	132	109
Total # of Organisms in Sample	100	132	109
Taxa Richness	21	21	16
Diversity (H_1)	2.60	2.61	2.24
Eveness	1.97	1.98	1.86

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Bivalvia (juv.) *Nephtys* sp. *Asychis elongata* Sabellidae *Ampelisca* sp. *Pinnixa* sp. Copepoda

	C26N	C26C	C26S
Total # of Organisms Identified	195	18	99
Total # of Organisms in Sample	195	18	99
Taxa Richness	15	7	18
Diversity (H_1)	2.14	1.74	2.55
Eveness	1.82	2.06	2.04

Notes: dominant species, when totaled = at least 50% sample

Cirratulidae *Nephtys* sp. *Ampelisca* sp. *Pinnixa* sp. Copepoda Bivalvia (juv.) *Molgula* sp.

	C27N	C27C	C27S
Total # of Organisms Identified	156	138	123
Total # of Organisms in Sample	156	138	123
Taxa Richness	15	19	16
Diversity (H_1)	2.14	2.29	2.05
Eveness	1.82	1.79	1.70

Notes: dominant species, when totaled = at least 50% sample

Cirratulidae *Nephtys* sp. Copepoda

	C28N	C28C	C28S
Total # of Organisms Identified	118	122	197
Total # of Organisms in Sample	118	122	197
Taxa Richness	13	17	13
Diversity (H_1)	1.87	2.44	1.97
Eveness	1.67	1.98	1.77

Notes: dominant species, when totaled = at least 50% sample

Molgula sp. Copepoda Cirratulidae *Nephtys* sp. *Ampelisca* sp. Bivalvia (juv.)

Based on video observations, these 12 analyzed stations were similar with regard to abundance of worm tubes and burrowing anemones, as well as the occasional presence of the tunicate *Molgula* sp. The mud tubes are comprised of mud and mucous. Shrimp, amphipods, and a few solitary hydroids were present at these stations. Burrows were also observed. These burrows are most likely used by lobsters, other invertebrates (e.g., mud shrimp [*Axius serratus*]), and fish species in the area. Shell debris is sparse at these stations. The benthic samples collected at these sites were dominated by polychaetes, amphipods, and juvenile bivalves (*see* Table A-3). These organisms are typically found in soft sediments.

Western Transition Community

(Stations IC-5, -6, and -7)
The Western Transition Community is located in the western portion of the Project area, along the transition from the western basin floor to Stratford Shoal. The bottom sediment observed in the underwater video is composed of fine-grain silt, which is similar to the existing sediment mapping classifications. Worm tubes and anemones are present. One of the dominant organisms collected in the benthic samples was the pea crab (*Pinnixia* sp). Pea crabs are typically found living on mud bottoms and in tubes of the polychaete worms *Arenicola* and *Chaetopterus variopedatus*, which also were present in benthic samples. These polychaete species are found in soft offshore sediments. The solitary tunicate *Molgula* sp. and the polychaete worm *Nephtys* sp. also were dominant species identified in the benthic samples. Both of these species are found in areas with a mixture of fine-grained sand and silt.

Shoal Community

(Stations MG -1, -2 and -3)
The Shoal Community is located at Stratford Shoal. Based on sediment samples collected using a Vibracore, the bottom sediments found in this area are classified as gravely sand and bedrock. The benthic community found in the sediment at these sites is diverse and complex. Bivalves are present, and the shell hash is comprised of *Mercenaria mercenaria*, other clam species, *Crepidula* sp., and *Ensis directis*. The bottom sediment is covered by colonies of hydroids and amphipod mats. A spider crab and whelk were observed. Motile organisms at these stations include shrimp and amphipods. The two dominant organisms identified in benthic samples collected at these sites were the amphipod *Ampelisca* sp. and the polychaete *Ampharete artica*. *Ampelisca* sp., which are found on sandy and muddy bottoms, build parchlike tubes and form mats. One common species is *A. abdita*, which construct tubes of fine sand grains approximately 3.5 centimeters in length and 2 to 3 millimeters wide. Most of the tube is below the substrate, with approximately 1 centimeter above the surface.

Eastern Transition Community

(Stations IC-13 and -14, and C-15, -16, and -17)
The Eastern Transition Community is located in the middle of the proposed Project area, along the transition from Stratford Shoal to the central basin floor. Bottom sediments are comprised of silt and sand. Polychaete worm tubes, burrowing anemones, and tunicates are present in the greatest numbers. Colonial hydroids are present on shell debris, and

solitary hydroids are scattered throughout each area. The dominant organisms found living in the sediment in this transition community included polychaetes, amphipods, and bivalves. These organisms are found in deep and shallow water and are typical of sand and silt sediment types. The results of the benthic sampling are summarized in Table A-3.

1.6.2.2 Construction

Construction of the proposed Project has the potential to impact the benthic community as a result of direct disturbance of bottom sediments, increased turbidity, sediment deposition, and decreased water quality. However, the negative impacts associated with construction of the Project will be short-term and minor. The area that will be affected by construction is small relative to the size of the Sound, and the benthic community is expected to recover following the completion of construction. Construction of the Project has the potential to result in some increased habitat diversity and associated positive impacts on the benthic community. Therefore, construction of the proposed Project will not result in significant impacts the benthic community.

Construction of the proposed Project will result in short-term impacts on benthic macro-invertebrate species at and near the footprint of the Project. Construction will result in direct mortality of most individuals in the path of construction due to excavation of sediments, burial during side-casting of spoil, anchor sweep, and pile driving. While some individuals may settle and re-colonize in other areas, it is assumed that most will be lost to construction activities or predation prior to settling. However, the areas that will be affected are small relative to the available habitat in the Sound, and these areas are expected to be recolonized following construction by the emigration of individuals from the unimpacted surrounding areas, through vertical migration, and by seasonal reproduction and larval recruitment. Initial recolonization of the affected area is expected to be by near-surface pioneers that are productive and readily available to demersal predators, typical of McCall's Group I (opportunist) species. This initial recolonization is expected to occur within months following the cessation of construction, and it is expected to be followed by Stage I to Stage II/Stage III assemblages within a few years following completion of natural infilling of the trench. Following construction, an early successional stage dominated by species adapted to migrating through the deposited sediment is expected to develop and occupy the affected area during reestablishment of the seabed to at or near its preconstruction contours. Review of the *Six-Month Post-Installation Benthic Monitoring Survey for the Cross Sound Cable Project* (OSI 2003) revealed that significant biogenic activity was evident 6 months after cessation of installation disturbance at Station 3, which is located within the central basin of Long Island Sound. While the Cross Sound Cable was installed using jetting technology (appropriate for that type of facility), the monitoring report demonstrates the resilience of the benthic community. DAMOS (*D*isposal *A*rea *MO*nitoring *S*ystem) is a program begun in 1977 by the New England District of the USACE to manage and monitor offshore dredged material disposal sites from Long Island Sound to Maine. In addition, DAMOS programs have repeatedly documented rapid recolonization of dredge disposal mound surfaces with infaunal assemblages typical of the sediments surrounding the disposal site (SAIC 2001a, 2001b, 2001c). Initial mound recolonization has been shown to occur within months and to proceed from Stage I to Stage II/Stage III assemblages within a few years.

In some areas the pipeline will be backfilled with clean imported materials, resulting in some increased habitat diversity and replacement by a different benthic community type. While the preconstruction mud community will be permanently lost in these areas, the loss is insignificant compared to the presence of this community type in the central and western basins of the Sound. In addition, replacement by a community more suited to structured substrates will add diversity to this portion of the Sound.

Some sediments will become suspended in the water column and dispersed as a result of trenching activity. The resulting impacts on water quality will be short- term and minor and will be consistent with the effects of natural events that increase turbidity in the Sound. Sediment transport modeling was conducted to determine the extent to which sediments will be dispersed and deposited. The Project is located primarily in depositional sedimentary environments, which are routinely subjected to deposition through natural events. Details of the modeling are presented in Section 2.3.5 of Resource Report 2, Water Use and Quality.

1.6.2.3 Operation

Operation of the proposed FSRU and pipeline has the potential to result in both positive and negative impacts on the benthic community, as discussed in Section 3.3.2.

In addition, operation of the proposed pipeline has the potential to result in long-term impacts on benthos as a result of the dissipation of heat from the pipeline. The temperature of gas in the pipeline will range from 120ºF (49ºC) near the FSRU to around 50ºF (10ºC) at the IGTS pipeline. Dissipation of heat to the active benthic zone (the area from the surface to a depth of about 4 inches [10 cm]) has the potential to alter the benthic community. The impacts from heat dissipation will decrease over time as natural infilling of the trench provides insulation for the pipeline. Figures A-3 and A-4 present the results of thermal modeling for the installed pipeline immediately after installation and following natural in-filling, respectively. Based on the limited extent of the thermal impact, impacts will be minimal and result in no large-scale alterations to the benthic community.

1.6.3 Ichthyoplankton

Construction and operation of the proposed Project have the potential to result in positive and negative impacts on ichthyoplankton communities. Negative impacts may result from direct disturbance of bottom sediments, increased turbidity, sediment deposition, impingement and entrainment from water withdrawals, and decreased water quality. Positive impacts are associated with increased habitat diversity.

1.6.3.1 Existing Conditions

NOAA Fisheries is charged with managing fishery resources in Long Island Sound. In an effort to accomplish this, NOAA Fisheries designates Essential Fish Habitat (EFH) for species and life stages. The proposed FSRU area is EFH for the egg and/or larval life stages of Atlantic mackeral, cobia, king mackerel, red hake, sand tiger shark, scup, Spanish mackerel, windowpane flounder, and winter flounder (*see* Table A-4). While 95 species of finfish were identified in Long Island Sound between 1984 and 2003 (Gottschall et al. 2004), and additional species are assumed to be present in the area, this table presents a listing of species for which EFH is managed for egg and larval stages in the vicinity of the FSRU. Table A-4 provides a summary of general habitat parameters for egg and larval life stages of species with designated EFH for these life stages in the Project area.

Table A-4 Species for which EFH has been Designated for Egg and/or Larval Stages in the Vicinity of the Proposed FSRU

Species	Egg	Larvae
Atlantic mackerel (*Scomber scombrus*)	X	X
Cobia (*Rachycentron canadum*)	X	X
King mackerel (*Scomberomorus cavalla*)	X	X
Red hake (*Urophycis chuss*)	X	X
Sand tiger shark (*Odontaspis taurus*)		X
Scup (*Stenotomus chrysops*)	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X
Windowpane flounder (*Scopthalmus aquosus*)	X	X
Winter flounder (*Pleuronectes americanus*)	X	X

The ichthyoplankton data available for Long Island Sound is very limited. Although NOAA Fisheries maintains extensive ichthyoplankton databases, they are for federal waters only. Because Long Island Sound is comprised entirely of state waters, no defined data collection efforts have been undertaken by NOAA Fisheries. As part of various power relicensing projects throughout the region, some level of ichthyoplankton data has been collected, although much of the data has not been publicly released.

Broadwater, however, obtained and evaluated data collected by the New York Power Authority's (NYPA) 2002 Poletti Ichthyoplankton Program to estimate ichthyoplankton abundance and distribution in the Project area. This program collected data on the distribution of fish eggs and larvae in Long Island Sound, the East River, the Hudson River, and New York Harbor during March through August 2002. In addition, Broadwater conducted its own ichthyoplankton sampling efforts in August and October 2005. The protocols followed for these surveys are presented as Attachment 3 of Appendix E of Resource Report 3.

The sampling area for the 2002 Poletti Ichthyoplankton Program extended from Raritan Bay in the west to the Connecticut/Rhode Island border in the east, including all of Long Island Sound, Upper and Lower New York Bays, the East River, and part of the Hudson River. The Poletti data was divided into 10 regions, with the data from Regions 7 through 10 representing Long Island Sound, and Regions 7 through 9 specifically representing the central basin of Long Island Sound.

Sampling for the 2002 Poletti Ichthyoplankton Program was conducted during daylight hours on a biweekly basis from March to July 2002. A Tucker trawl was used to collect a water column plankton tow at a randomly selected depth in the water column (between the surface and 10 feet [3 m] above the bottom), and an epibenthic sled was used to collect near-bottom samples. To determine ichthyoplankton abundance in the vicinity of proposed FSRU facility, Broadwater evaluated sampling results for samples collected in sample Regions 7 through 9 (which represent the central basin of Long Island Sound) using a Tucker trawl in water depths greater than 98 feet (30 m). Samples collected in water greater than 98 feet (30 m) deep were used because they best represented the location of the FSRU facility in water approximately 95 feet (29 m) deep in the central basin of Long Island Sound. Although the mid-depth [20- to 98-foot, 6- to 30-m] sampling strata also represents the FSRU location at the upper end of its depth range, the inclusion of samples from water as shallow as 20 feet in the lab composites for the mid-depth strata was not considered to be as representative of the proposed FSRU intake location (95 feet [29 m] deep) as data from the deep sampling strata. Only samples collected using the Tucker trawl were used for the Broadwater estimates because they best represented the location of the FSRU facility's water withdrawal from 35 to 45 feet (11 to 14 m) below the surface. For additional details on sample collection procedures and laboratory methods, *see* Appendix E, *Broadwater FSRU 2002 Poletti Ichthyoplankton Program Summary Report*.

Using the Poletti data subset, the species and life stages occurring during each biweekly survey were identified (11 surveys were conducted from March through August 2002), and the mean number of eggs and larvae per 1,000 m^3 of seawater were calculated as an estimate of the density in the vicinity of the proposed FSRU. Mean egg density ranged from approximately 200/1,000m^3 during the last two surveys (July 8 to August 5) to about 5,000/1,000 m^3 during Survey 3 (April 1 to 14) and Survey 7 (May 27 to June 9). Mean larvae density ranged from approximately 100/1,000 m^3 during Survey 1 (March 4 to 17) to >10,000/1,000 m^3 during Survey 8 (June 10 to 23).

Ichthyoplankton densities are not expected to be uniform across the March to July period due to the seasonal variation in ichthyoplankton density and species composition typical of Mid-Atlantic nearshore and estuarine regions. Based on the Poletti data, egg density had two peaks in 2002, one in April dominated by fourbeard rockling, and a second peak in late May to June with a more diverse assemblage comprising summer spawning species such as tautog, weakfish/scup, Atlantic menhaden, and sea robin. Larval density peaked during July. Prior to July, larval fish density and diversity was low and was comprised primarily of winter/early spring spawning species such as American sand lance, winter flounder, fourbeard rockling, rock gunnel, and grubby. Larval fish diversity and density increased markedly during July when summer spawning species such as Atlantic menhaden, tautog, cunner, scup, sea robin, weakfish, and bay anchovy were present.

Both fish egg and larvae density dropped noticeably after their respective June to July peaks, suggesting that the peak period of ichthyoplankton occurrence was captured by the

March to July sampling window of the 2002 Poletti Ichthyoplankton Program. Comparison with other regional ichthyoplankton surveys in Long Island Sound (Wheatland 1956; Pearcy and Richards 1962), Great South Bay, New York (Monteleone 1992), Narragansett Bay (Bourne and Govone 1988; Keller et al. 1999), and Buzzards Bay (Chute and Turner 2001) suggest that abundance and diversity of ichthyoplankton are low in the winter, when few species (with the exception of American sand lance) spawn. Both egg abundance and diversity increase during the early spring, when winter flounder begin to spawn in estuaries and shallow nearshore areas. Egg and larval diversity and density peak during the summer, when many migrant and resident species spawn. Spawning is curtailed in the fall as water temperatures drop.

In addition to assessing the Poletti data, which were collected between March and August, Broadwater conducted ichthyoplankton sampling in the vicinity of the proposed FSRU in August and October 2005 to assess late summer and fall ichthyoplankton densities. The results of these sampling efforts are discussed below, and summary reports for each of these efforts are included as Attachments 1 and 2 of Appendix E.

Eggs from seven taxa and larvae from 13 taxa were collected during day and night sampling conducted on August 23, 2005, in the vicinity of the proposed Broadwater FSRU location. The ichthyoplankton community was dominated by bay anchovy (*Anchoa mitchilli*) eggs and larvae which accounted for approximately 80% of all eggs and larvae collected.

Samples of the ichthyoplankton community in the vicinity of the proposed Broadwater FSRU location were collected during day and night sampling on October 4, 2005. The samples were dominated by bay anchovy and Atlantic menhaden (*Brevoortia tyrannus*). Atlantic menhaden was the only fish egg collected during this sampling, and Atlantic menhaden, bay anchovy, and feather blenny (*Hypsoblennius hentzi*) were the only larvae collected during this sampling.

Ichthyoplankton abundance and diversity in the vicinity of the proposed FSRU location was considerably lower during the October 4, 2005, sampling event than on August 23, 2005, reflecting the seasonality of the ichthyoplankton community in Long Island Sound (*see* Figure 7 in Attachment 2 of Appendix E). In water depths representing the FSRU intake location (mid-depth strata), the average egg density during day and night sampling was 74.7/100 m^3 in August, compared to 5.9/100 m^3 in October; the average larvae density was 639.5/100 m^3 in August, compared to 49.3/100 m^3 in October. In August, eggs from seven taxa and larvae from 13 taxa were collected. Catches were dominated by bay anchovy, which accounted for approximately 80% of all eggs and larvae collected. In October, eggs from one taxa (Atlantic menhaden) and larvae from three taxa were collected. Larval catches were dominated again by bay anchovy, which accounted for 81.5% of all larvae.

This is typical of estuarine systems in the Mid-Atlantic Bight (Able and Fahay 1998). Ichthyoplankton abundance and diversity are low in the winter when few species spawn. Ichthyoplankton abundance and diversity begin to increase in the early spring, reaching a peak during mid-late summer when many species reproduce. Ichthyoplankton abundance and diversity decline in the fall when spawning is curtailed (Able and Fahay 1998).

This dominance of bay anchovy is consistent with other regional studies, including Narragansett Bay (Bourne and Govoni 1988; Keller et al. 1999), Great South Bay, New York (Monteleone 1992), Long Island Sound (Wheatland 1956), the lower Hudson River estuary (Dovel 1981), and the Mystic River estuary (Pearcy and Richards 1962). Young stages of bay anchovy occur in every estuary in the Middle Atlantic Bight (Able and Fahay 1998), and bay anchovy are generally considered to be the most abundant western Atlantic coastal fish (McHugh 1967; Haedrich 1983). Based on available information, bay anchovy eggs can reasonably be expected to occur in Long Island Sound from June to September, and bay anchovy larvae can reasonably be expected to occur from June to November, with peak densities in July and August. Bay anchovy eggs and larvae were likely at or near their seasonal peak density in Long Island Sound during the August 23, 2005, sampling event, and their seasonal decline in abundance during the fall is clearly demonstrated by the reduced density during the October 4, 2005, sampling event (*see* Figure 7 in Attachment 2 of Appendix E).

Atlantic menhaden was the only species collected in greater density in October than in August. Atlantic menhaden spawn at night and during nearly every month in some part of its range (McHugh et al. 1959). There is limited spawning activity during the northward spring migration, limited summer spawning as far north as Cape Cod and the Gulf of Maine, then increased spawning activity during the southward fall migration (Able and Fahay 1998). This pattern is followed by intense spawning in the South Atlantic Bight during winter (Higham and Nicholson 1964).

1.6.3.2 Construction

Construction of the proposed facilities has the potential to cause minor, short-term impacts on plankton. These impacts would result from hydrostatic test water intake and changes in water quality due to suspended sediments. However, these are not expected to be significant impacts. Impacts due to suspended sediment are expected to be short-term and minor. Studies documenting the effects of suspended sediment on primary producers and zooplankton concluded that little or no measurable impact results from activities such as dredging (O'Connor and Sherk 1976; Sherk et al. 1976).

Prior to operation, the pipeline will be hydrostatically tested using water withdrawn from Long Island Sound, potentially resulting in the entrainment of aquatic species. The water intakes used to withdraw the water will be screened to prevent localized entrainment of fish. It is assumed that 100% of the plankton entrained in the test water will be lost. While some plankton mortality is unavoidable, the volume of water required for hydrostatic testing is an insignificant fraction of the total water available in the Sound.

1.6.3.3 Operation

Operation of the proposed facilities is expected to result in potential water quality and thermal impacts as described in Resource Report 3, Section 3.3.2. In the unlikely event of a significant LNG release, seawater would be cooled near the surface, potentially resulting in localized mortality. This impact would be temporary, lasting until the LNG evaporates. Normal tidal currents would be expected to quickly repopulate impacted areas.

Operation of the FSRU will result in additional impacts on plankton and ichthyoplankton due to the intake of water for limited industrial use and use as ballast water. The water intakes, volumes, and screening are described in Resource Report 1, General Project Description. The volume of water that will be taken in has been minimized and is restricted to that required for ballast and minimal operational use. In addition, the water intakes have been located at the hull bottom of the FSRU, near the middle of the water column, to minimize impacts on plankton. The number of plankton, eggs, and larvae entrained as a result of water intake will be very small relative to the abundance of marine organisms in the surrounding waters; thus, even assuming 100% mortality of organisms impinged or entrained, the resulting mortality will not be significant.

Systems associated with the Project require the uptake and use of seawater, including the ballast and fire water intake systems for the FSRU, and the cooling and ballast water systems for the LNG carriers. As previously noted, intakes for the FSRU will be located approximately 40 feet (12 m) below the surface, and have an internal screen with a mesh size of 5 mm, with velocities maintained at a maximum of 0.5 feet/second (0.15 m/s). The LNG carriers would have similar screen sizing and intake velocities. Because LNG carriers will have less draft than the FSRU, water intakes would be located at a shallower depth than the FSRU, but below 8 m.

These systems have the potential to impact ichthyoplankton present in Long Island Sound through entrainment when aquatic organisms, eggs, and larvae are drawn into a seawater system, through the sea chests, and then pumped back out. It is assumed that any ichthyoplankton taken in through the intakes will be lost. The Project (inclusive of the FSRU and LNG carriers) will require the uptake and use of approximately 28.2 million gallons of seawater per day (106,750 m^3/day) during operation, based on an average of 2.27 cargos delivered each week. (For additional detail on seawater systems and the assumptions for calculated water use, *see* Section 2.5.2.2. of Resource Report 2, Water Use and Quality.) Broadwater conducted an ichthyoplankton impact analysis to characterize the species and densities of fish eggs and larvae and lobster larvae in the Project area that could be entrained as the FSRU and LNG carriers take in seawater.

Based on data from the 2002 Poletti Ichthyoplankton Program subset to represent the water intake location of the FSRU facility during normal operations (approximately 28.2 MGD, 106,750 m^3/day) approximately 40.6 million eggs and 30.6 million larvae would be entrained from the March 4-August 5 period for which the Poletti Program conducted sampling (*see* Appendix E, Table B-7). Entrainment rates would not be uniform across the March-July period due to the seasonal variation in ichthyoplankton density and species composition typical of Mid-Atlantic nearshore and estuarine regions and the majority of the annual entrainment would take place during the June-July peak in ichthyoplankton density. Diel correction factors and entrainment estimates for August-October based on site specific collections in 2005 were included in modified entrainment estimates to address potential biases in the Poletti methodology and provide a more conservative, upper bound to the entrainment counts. Another conservative assumption is that density is directly proportional to entrainment and no escape behavior is exhibited by larvae. Actual entrainment may be reduced by active avoidance of the seawater intakes. The inclusion of the site specific August and October, 2005 data, applying the diel correction factors to the Poletti data, and including only nighttime samples for bay anchovy and fourspot flounder larvae increased the total entrainment estimate to 47.3 million eggs and 90.9 million larvae from the March-October period (*see* Appendix E Table B-7). A further conservative estimate included the site specific 2005 data and diel correction factors to the Poletti data and considered only nighttime samples for all larvae collected in the 2005 data. This had little effect on the entrainment estimates. Total number of eggs were 47.3 million and total number of larvae was 91.4 million for the March-end of October period, which accounts for the seasonal occurrence for the majority of ichthyoplankton stages for most abundant species in Long Island Sound with the exception of sand lance, which will be evaluated during planned February ichthyoplankton sampling.

To determine the relative loss of eggs and larvae, the daily withdrawal volume of the FSRU and associated LNG carriers (28.2 million gallons, or 106,750 m^3, per day) was compared to the volume of water in the regions selected to represent the central basin (Regions 7, 8 and 9, 3.97×10^{10} m^3). The daily withdrawal represents only 0.0003% of the volume. Even if the intakes operate 365 days a year, the annual FSRU water intake represents only 0.10% of the volume in Regions 7, 8, and 9.

In order to compare standing crop versus potential entrainment based on the bi-weekly surveys, additional analysis was performed. The volume of water in the deep sampling strata of Regions 7, 8, and 9 from the surface to 3 m above the bottom is 7.53×10^9 m^3. Ichthyoplankton densities in this subset data were multiplied by this volume to yield the estimated standing crop, or number of individuals, during each biweekly survey. The egg standing crop ranged from 1.50×10^9 during Survey 11 (July 22 to August 5) to 3.91×10^{10} during Survey 7 (May 27 to June 9), with an average of 1.86×10^{10} over the March to July sampling period. The larval standing crop ranged from 7.03×10^8 during the first survey (March 4 to 17) to 7.74×10^{10} during Survey 8 (June 10 to 23), with an average of 1.40×10^{10} over the March to July sampling period. Because both the entrainment estimates and the standing crop estimates are based on the Poletti ichthyoplankton density data, the percentage of the number entrained in a biweekly survey compared to the regional standing crop during that survey is equal to 0.02%, indicating that these estimates are valid.

Once density values were calculated, potential ichthyoplankton impacts were determined based on water intake. Little reported information currently exists regarding mortality/survivability during ballast entrainment and natural mortality for populations for various species present in Long Island Sound. Ichthyoplankton densities were determined for entrainment assessment of ballast water and other seawater uptakes based on the water volume within the Regions 7 through 10 area. This was used together with the potential for ichthyoplankton in the Project area to be impacted by entrainment in the

FSRU and LNG carriers' seawater systems. Although 100% of the ichthyoplankton potentially entrained may not experience mortality or serious injury, 100% mortality was used as a standard, conservative assumption. The following summarizes the results of the calculations used to determine the relative mortality of ichthyoplankton present in Long Island Sound.

The 28.2 million gallons (106,750 m^3) of seawater uptake proposed for the Broadwater Project are significantly (orders of magnitude) lower than typical volumes used by other LNG or power generating facilities' cooling systems in the vicinity of Long Island Sound. (*See* Section 2.5.2.2 of Resource Report 2, Water Use and Quality, for additional information on other facility water uses.)

Based on the results of the analysis, daily egg mortality (assuming 100% mortality when eggs are entrained) is approximately 2.69×10^{-4} % of the eggs present within the central basin region (i.e., Regions 7, 8, and 9). This percentage is based on the ratio of water withdrawal by the FSRU (106,750 m^3/day) to the volume of water in Regions 7, 8, and 9 (3.97×10^{10} m^3).

Impacts on ichthyoplankton can be difficult to interpret due to the low natural survival rates of fish eggs and larvae. In fact, many of the entrained organisms are subject to high rates of natural mortality. Although seasonal and daily density fluctuations occur in Long Island Sound, these fluctuations are represented in the data set used to calculate the average number of eggs and larvae entrained daily in the seawater uptake systems on the FSRU and LNG carriers.

Although no consensus currently exists within the scientific community or responsible agencies regarding what level of impacts on ichthyoplankton are considered significant, the density of ichthyoplankton within Long Island Sound represents values typically expected in this area. The entrainment values represent impacts on fishery populations that can be considered less than significant when considered relative to the potential impact area affected by seawater intake from the FSRU or LNG carriers. The results of this analysis confirm that the Broadwater Project would not have a significant impact on ichthyoplankton. Based on the species, densities, and percentages affected, entrainment impacts on any special status/EFH species would be less than significant.

2. ESSENTIAL FISH HABITAT (EFH)

Essential fish habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (PL 94-265), as amended by the Sustainable Fisheries Act (SFA) of 1996 (PL 104-267), as "those waters and substrate necessary to fish for spawning, breeding, and feeding or growth to maturity." The SFA requires that EFHs be identified for those species actively managed under Federal Fishery Management Plans (FMPs). This includes species managed by the regional Fishery Management Councils (FMCs), established under the MSFCMA, as well as those managed by the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) under FMPs developed by the Secretary of Commerce.

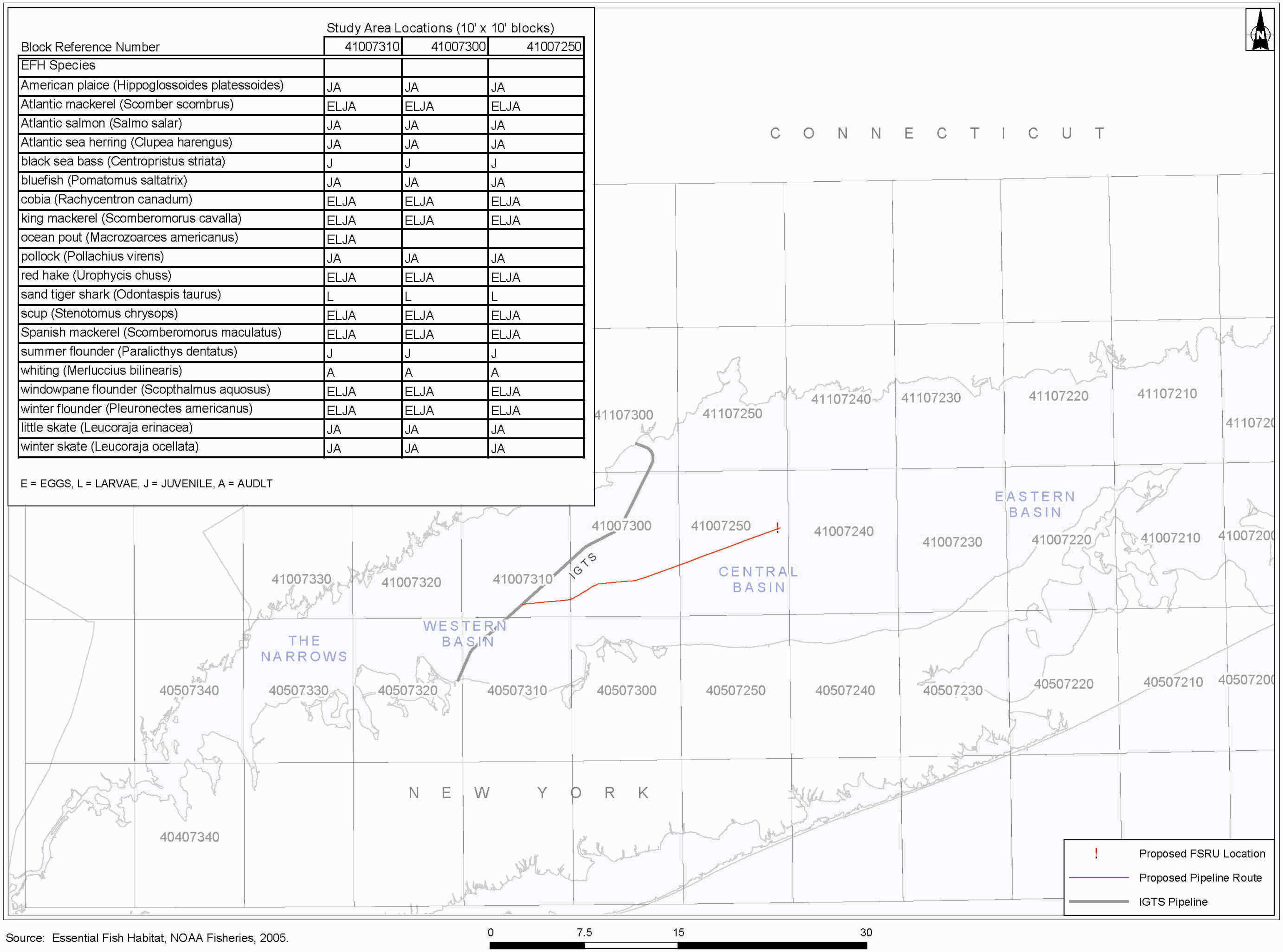
EFH designations emphasize the importance of habitat protection to healthy fisheries and serve to protect and conserve the habitat of marine and estuarine finfish, mollusks, and crustaceans, as well as anadromous finfish. EFH includes both the water column (including its physical, chemical, and biological growth properties) and its underlying substrate (including sediment, hard bottom, and other submerged structures). Under the EFH definition, necessary habitat is that which is required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. EFH is designated for a species' complete life cycle, including spawning, feeding, and growth to maturity, and may be specific for each life stage (e.g., eggs, larvae). EFH designations are based on various levels of information available for a species' life stage distribution, abundance, and habitat-productivity relationships. Information levels include: presence/absence (Level 1); habitat-related densities (Level 2); growth, reproduction, and survival rates within habitats (Level 3); and production rates by habitat types (Level 4).

EFH designations have been defined by NOAA Fisheries for specific life stages based on their occurrence in tidal freshwater and estuarine (i.e., mixing/brackish salinity zone) and marine (i.e., seawater salinity zone) waters. This information is provided in the *Guide to Essential Fish Habitat Designations in the Northeastern United States* (NOAA Fisheries http://www.nero.noaa.gov/ro/doc/webintro.html). A summary of the 10-minute by 10-minute latitude and longitude squares and a summary of the species for which EFH has been designated within or adjacent to the proposed pipeline route and the FSRU are provided on Figure A-10.

EFH that is judged to be particularly important to the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation, may also be identified by FMCs and NOAA Fisheries as Habitat Areas of Particular Concern (HAPC). For an EFH to be designated an HAPC, one or more of the following must be demonstrated: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are negatively impacting, or will negatively impact, the habitat type; or (4) the rarity of the habitat (NEFMC 1998). No HAPC have been identified along the proposed pipeline route or at the FSRU site.

Block Reference Number	Study Area Locations (10' x 10' blocks)		
	41007310	41007300	41007250
EFH Species			
American plaice (Hippoglossoides platessoides)	JA	JA	JA
Atlantic mackerel (Scomber scombrus)	ELJA	ELJA	ELJA
Atlantic salmon (Salmo salar)	JA	JA	JA
Atlantic sea herring (Clupea harengus)	JA	JA	JA
black sea bass (Centropristus striata)	J	J	J
bluefish (Pomatomus saltatrix)	JA	JA	JA
cobia (Rachycentron canadum)	ELJA	ELJA	ELJA
king mackerel (Scomberomorus cavalla)	ELJA	ELJA	ELJA
ocean pout (Macrozoarces americanus)	ELJA		
pollock (Pollachius virens)	JA	JA	JA
red hake (Urophycis chuss)	ELJA	ELJA	ELJA
sand tiger shark (Odontaspis taurus)	L	L	L
scup (Stenotomus chrysops)	ELJA	ELJA	ELJA
Spanish mackerel (Scomberomorus maculatus)	ELJA	ELJA	ELJA
summer flounder (Paralicthys dentatus)	J	J	J
whiting (Merluccius bilinearis)	A	A	A
windowpane flounder (Scopthalmus aquosus)	ELJA	ELJA	ELJA
winter flounder (Pleuronectes americanus)	ELJA	ELJA	ELJA
little skate (Leucoraja erinacea)	JA	JA	JA
winter skate (Leucoraja ocellata)	JA	JA	JA

E = EGGS, L = LARVAE, J = JUVENILE, A = AUDLT



Source: Essential Fish Habitat, NOAA Fisheries, 2005.

Figure A-10 Essential Fish Habitats in the Project Area

EFH has been designated for 20 species within the Project area (*see* Table A-5). Nine species have designated EFH for every life stage, including Atlantic mackerel, cobia, king mackerel, red hake, scup, Spanish mackerel, ocean pout, windowpane flounder, and winter flounder.

Table A-5 Species with Identified EFH within the Project Area

Species	Eggs	Larvae	Juvenile	Adult
American plaice (*Hippoglossoides platessoides*)*			X	X
Atlantic mackerel (*Scomber scombrus*)	X	X	X	X
Atlantic salmon (*Salmo salar*)			X	X
Atlantic sea herring (*Clupea harengus)*			X	X
Black sea bass (*Centropristus striata*)			X	
Bluefish (*Pomatomus saltatrix*)			X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Little skate (*Leucoraja erinacea*)			X	X
Ocean pout (*Macrozoarces americanus*)	X	X	X	X
Pollock (*Pollachius virens*)			X	X
Red hake (*Urophycis chuss*)	X	X	X	X
Sand tiger shark (*Odontaspis taurus*)		X		
Scup (*Stenotomus chrysops*)	X	X	X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Summer flounder (*Paralicthys dentatus*)			X	
Silver hake (*Merluccius bilinearis*)				X
Windowpane flounder (*Scopthalmus aquosus*)	X	X	X	X
Winter flounder (*Pleuronectes americanus*)	X	X	X	X
Winter skate (*Leucoraja ocellata*)			X	X

* While the summaries for EFH square 41007310, 41007300 and 41007250 (listed in the on-line geographic Guide to EFH Designations) identifies these areas as EFH for J and A life stages of American Plaice, no EFH designation for any life stage of this species is indicated for Long Island Sound in the NEFMC EFH Amendment dated October 7, 1998. In addition, this species has not been encountered during LISTS surveys conducted by CTDEP from 1984-2003. There, this species is not discussed in this assessment.

3. EFH ANALYSIS

This EFH assessment addresses potential impacts on the 20 species for which EFH has been identified within the Project area. To facilitate discussions, the species were generally grouped by habitat requirements to differentiate between demersal and pelagic species.

Construction and operation of the Project will result in disturbances to bottom habitats and the water column as well as acoustic disturbances, which will, in turn, impact species for which EFH has been identified within the Project area. Based on the proposed methods for constructing and operating the facilities, negative impacts are expected to be short-term and minor, whereas positive impacts are expected to be long-term. Potential direct and indirect impacts on EFH for each species are discussed, by life stage, in the individual species assessments below. Cumulative impacts on the EFH of all 20 species are addressed in a separate assessment at the end of this section.

3.1 DEMERSAL SPECIES

3.1.1 Ocean Pout (*Macrozoarces americanus*)

EFH has been designated in the western portion of the Project area for all four life stages of ocean pout (*see* Table A-5). The ocean pout is a bottom-dwelling, cool to temperate water species (less than 15 ^{o}C) found north of Cape Hatteras, North Carolina, to Labrador and the southern Grand Banks. The species prefers depths of 15 to 110 m. Since ocean pout are demersal and do not make extensive migrations, temporary disturbance of pout EFH is likely to occur during the proposed action, but the disturbance is not expected to be significant. Since pout EFH is limited primarily to the western portion of the Project area, potential impacts will only be associated with construction of the pipeline.

Egg

Ocean pout eggs occur in gelatinous masses in hard-bottom habitats from late fall to winter. Habitat characteristics include water temperatures less than 10 ^{o}C, depths less than 50 m, and salinities greater than 25 ppt. Eggs have the potential to be in the Project area for approximately two to three months during late fall and winter. Suitable hard-bottom habitat for ocean pout egg masses would likely be found only along the pipeline route at Stratford Shoal, where field surveys identified a cobble substrate.

Larvae

Larvae are found in smooth-bottomed habitats near rocks or algae from late fall to spring. The lack of significant rock structure in the Project area, except in the Stratford Shoal area, minimizes potential impacts from the Project. Habitat characteristics include water temperatures less than 10 ^{o}C, depths less than 50 m, and salinities greater than 25 ppt. Larvae have the potential to be present in the Project area from late fall to early spring, and typically remain near their nest.

Juvenile

Juveniles are found in shallow coastal waters around rocks and structure and in rivers with saline bottom water. They feed primarily on gammarid amphipods and polychaetes by sorting mouthfuls of sediment. Habitat characteristics of juveniles found in Long Island Sound include bottom temperatures of 3 to 13 ^{o}C, depths ranging from 14 to 40 m, and salinities greater than 25 ppt (NMFS 1999). Most ocean pout have been collected in the western portion of Long Island Sound, which overlaps with the Project area. As with the larvae, the lack of rocks and other structure minimizes the importance of habitat in the Project area for the pout. Following construction of the Project, preferred habitat for the ocean pout may actually increase since portions of the pipeline route may require rock/concrete armoring when adequate burial depth cannot be achieved.

Adult

Habitat characteristics of adults are similar to those of juveniles. Adult ocean pout remain demersal and do not form schools. They are found on most sediment types, though rocky areas are important for spawning. Their diet consists primarily of sand dollars, mollusks, crustaceans, and echinoderms. Spawning occurs in hard-bottomed, sheltered areas between late summer and early winter, with a peak in August and October. The eggs are laid in gelatinous masses and are guarded by one or both parents until hatching in 2 to 3 months later.

Impacts

Potential direct impacts on ocean pout EFH include disturbances affecting all four life stages. By scheduling pipeline installation operations to occur in the winter in order to minimize impacts on a variety of other species, potential disruption of ocean pout eggs and larvae could occur. However, due to the limited extent of pipeline ROW through the Stratford Shoal, any impacts on ocean pout eggs and larvae are expected to be minor and not significantly affect the ocean pout population or its habitat. Minor disturbance to ocean pout habitat is expected to be short-term, and suitable habitat is readily available adjacent to the FSRU and pipeline ROW. Juvenile and adult ocean pout may be attracted to the micro-topography offered by the trench depression that will exist until natural infilling is complete. Attraction to the trench is not expected to result in impacts on ocean pout because the trench is not expected to present any unusual or increased threat.

Potential indirect impacts on ocean pout EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. Ocean pout are opportunistic feeders and can forage for prey along the remaining portions of the pipeline route and elsewhere in the vicinity of the proposed Project.

3.1.2 Red Hake (*Urophycis chuss*)

EFH is designated within the Project area for egg, larval, juvenile, and adult red hake. Adult red hake are demersal, relatively short-lived (less than 14 years), and reach a maximum size of approximately 630 millimeters (mm) (NMFS 1999). Adult red hake make extensive seasonal migrations based on depth and temperature. They are most commonly found in depths less than 100 m during warmer months and in depths greater than 100 m during colder months. In the Middle Atlantic Bight, including Long Island Sound, red hake occur most frequently in coastal waters in the spring and fall. They move offshore in summer to avoid warm water temperatures (USEPA 2002).

Egg

Eggs are laid from May to November, with a peak in September and October. Red hake eggs are buoyant and are found primarily in surface waters off the continental shelf.

Larvae

Larval red hake are initially pelagic, becoming demersal when seeking some form of shelter for survival. Habitat characteristics include depths less than 200 m, temperatures less than 19°C, and salinities greater than 24 to 32 ppt. The larvae diet consists mostly of arthropods (NMFS 1999). Seasonal occurrence ranges from May to December, with peaks in September and October. Larvae are most often observed from May through December, with peaks in September through October.

Juvenile

Juvenile red hake are primarily demersal after reaching a length of 23 to 41 mm. Juveniles seek shelter along the continental shelf bottom among protective structures, but they are most commonly associated with sea scallop beds (NMFS 1999). Juveniles remain associated with sea scallop beds through their first fall and winter (until reaching a length of approximately 89 to 117 mm), and then occupy either estuarine or inshore marine waters over sand or mud substrate prior to joining adults in the offshore migration during their second winter (NMFS 1999). The lack of scallop beds in the Project area minimizes potential impacts on juvenile red hake. Juveniles prey on benthic and pelagic crustaceans such as decapod shrimp, mysids, euphausiids, and amphipods (Steimle et al. 1999). Juveniles are most abundant in Long Island Sound during the summer, and they are most abundant in the central portion of the Sound during the spring (NMFS 1999).

Adult

Adult red hake are demersal, occurring in bottom habitats consisting of sand, muddy sand, and mud and gravels (NMFS 1999). Other habitat requirements include water depths of approximately 10 to 130 m, temperatures less than 12 °C, and salinities ranging from 33 to 34 ppt. Adults have a diet similar to that of juveniles and also consume pelagic fish and squid. In Long Island Sound, adult red hake are most abundant on soft mud substrates in depths less than 25 meters and in salinities ranging from 20 to 33 ppt (NMFS 1999). They are abundant in the Sound in both the spring and fall. Adults spawn in depressions with substrates dominated by sand and mud from May to November, with peaks in June and July.

Impacts

Potential direct impacts on red hake EFH include disturbances potentially affecting three of the four life stages. While red hake eggs may be present in the Project area during the early construction period and seasonally during operations, the buoyant eggs are restricted to the upper portion of the water column. Potential impacts from water intakes are limited, since the intakes will be located at a depth of approximately 30-40 feet (8-12 m). The red hake larvae are planktonic, and, as such, some limited entrainment/impingement could occur in conjunction with water intakes on the FSRU. However, the volume of water entrained through the intake screens on a daily basis is insignificant when compared to the total volume of water available in the Sound. Because the adult red hake are demersal, impacts on adults would be limited to the construction phase of the Project. While adults are expected to utilize this portion of the Sound during the construction period, they are expected to leave the area of active construction, thereby avoiding direct impacts. The substrate in areas around the pipeline will be restored within several months of construction. Minor disturbance to red hake habitat is expected to be short-term, and suitable habitat readily available adjacent to the FSRU and pipeline ROW.

Potential indirect impacts on red hake EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. For early juveniles (i.e., those inhabiting scallop beds), these potential impacts would be further limited to those areas primarily associated with protective structures. Adult red hake feed predominately on pelagic species, which should not be impacted by the Project.

3.1.3 Winter Flounder (*Pleuronectes americanus*)

Winter flounder is a demersal species that is commercially and recreationally important in Long Island Sound. EFH is designated within the Project area for all life stages of winter flounder.

Egg

Eggs are laid from February to June, with peaks in April. Eggs of the winter flounder are adhesive and collect in clusters near the bottom in shallow water (typically less than 5 m) with varied substrate. Other habitat characteristics include temperatures less than 10 ^{o}C and salinities ranging from 10 to 30 ppt. The preferred habits for flounder eggs limit any potential impact from the construction and operation of the Project.

Larvae

Larvae are initially planktonic but become increasingly demersal as metamorphosis of the eye and body orientation occurs (NMFS 1999). Winter flounder larvae are typically present from March to July. Since the early life stages of this species are nondispersive, the spawning grounds and nursery grounds are essentially the same (Pearcy 1962). Howell et al. (1992) indicate that the nursery habitat for larvae and juveniles includes littoral and sub-littoral saltwater coves, coastal salt ponds, estuaries, and protected embayments. Prey species for larval winter flounder include primarily nauplii, polychaetes, and eggs of invertebrates (Pereira et al. 1994). The Poletti data (*see* Appendix E) demonstrates the presence of winter flounder larvae in the central portion of the Sound primarily between March and early June.

Juvenile

Surveys in Long Island Sound have shown inconsistent habitat utilization by juvenile winter flounder, ranging from unvegetated to vegetated substrates (NMFS 1999). EFH for early juvenile (i.e., young-of-year) and juvenile winter flounder also includes shallow water, as well as deep water, estuarine, and marine waters. Although found within the Sound throughout the year, juvenile abundance peaks in April and May (NMFS 1999). Juvenile winter flounder are opportunistic feeders and their diet may include amphipods, annelids copepods, bivalve siphons, and crustaceans.

Adult

Adult winter flounder are demersal, occurring in bottom habitats in estuaries with a range of substrates (NMFS 1999). These bottom types are typically located in shallow water shoals and subtidal areas less than 20 feet deep. Habitat characteristics include depths ranging from 1 to 100 m, temperatures less than 25 ^{o}C, and salinities ranging from 15 to 33 ppt. Adults move into shallow bays and estuaries in early fall in preparation for spring spawning. Spawning occurs from February to June in estuaries and bays (Howe et al. 1976). Adult winter flounder are opportunistic feeders and their diet may include amphipods, annelids, copepods, bivalve siphons, and crustaceans. Studies have shown that adults may be sensitive to reductions in dissolved oxygen levels (Howell and Simpson 1994).

Impacts

Potential direct impacts on winter flounder EFH include disturbances that affect all four life stages. As a result of locating the facilities away from shallow, nearshore areas that are important for spawning and the larval life stage, potential impacts on winter flounder egg and larval life stages and habitat have been minimized. As demonstrated by the Poletti data, some larvae occurrence is likely in the Project area, resulting in a minor impact. Due to the location of the Project and the distance from nearshore spawning areas, any impacts on winter flounder eggs and larvae are expected to be minor and not significantly affect the flounder population or its habitat. By scheduling pipeline installation operations in the winter in order to minimize impacts on a variety of other species, potential disruption of winter flounder juvenile and adult EFH could occur. Following construction, natural infilling of the pipeline trench will reestablish bottom habitat. Minor disturbance to winter flounder habitat is expected to be short-term, and suitable habitat is readily available adjacent to the FSRU and pipeline ROW. Limited flounder mortality is possible during pipe-laying, pipe-lowering, and backfilling activities; however, the limited extent of the Project area relative to the overall amount of available flounder habitat will minimize the extent of this impact. Due to the limited extent of the Project, the ability of these life stages to avoid the active area of construction, the availability of suitable habitat outside of the construction area, and the expectation that the construction area will recover upon cessation of construction, any impacts on winter flounder juveniles and adults are expected to be minor and not significantly affect the flounder population or its habitat.

Potential indirect impacts on winter flounder EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. Winter flounder are opportunistic feeders and can forage for prey along the remaining portions of the pipeline route and elsewhere in the vicinity of the proposed Project. Disturbance to benthic organisms would be short-term and limited to the immediate vicinity of the proposed FSRU and pipeline route.

3.1.4 Summer Flounder (*Paralichthys dentatus*)

EFH is designated within the Project area only for the juvenile life stage of summer flounder. Summer flounder, also known as fluke, are found from shallow estuarine waters to the outer continental shelf from Nova Scotia to Florida. The bulk of the population occurs between Cape Cod and Cape Hatteras. They have seasonal in- and offshore movements, moving offshore to escape colder temperatures. Spawning occurs in the open ocean waters of the continental shelf during the time when the flounder are migrating to their wintering grounds. Spawning begins as early as mid-August in the northern part of the range and continues through December. The demersal nature of the species limits potential impacts to the construction phase of the Project.

Juvenile

Juvenile summer flounder make use of several estuarine habitats for nurseries, including marsh creeks, seagrass beds, mud flats, and open bays. They seem to prefer sandy bottom areas where they feed on mysids and small fish. The adult and juvenile flounder migrate inshore in late April and May and are found in Long Island Sound until November, with abundance in the Sound peaking in September. Juvenile summer flounder may remain inshore through the winter months. Between May and August the flounder are most commonly found in the shallows; before and after this period, they are typically located in the deeper waters of the Sound. Flounder abundance is generally higher within the central portion of the Sound.

Impacts

Potential direct impacts on juvenile summer flounder EFH include temporary disturbance as a result of installation activities. As a result of locating the facilities away from shallow, nearshore areas that are important for spawning and the larval life stages of many other species, and installing the facilities primarily during winter when use by most species is reduced, there is a potential for impacts on juvenile summer flounder that may overwinter in deep areas in the central portion of the Sound. Any impacts on juvenile summer flounder are expected to be minor and not significantly affect the flounder population or its habitat. Minor disturbance to winter flounder habitat is expected to be short-term, and suitable habitat readily available adjacent to the Project area. The substrate in areas around the pipeline is expected to become reestablished through natural processes following construction. Due to the limited extent of the Project area relative to the amount of flounder habitat available in the Sound, the ability of juvenile summer flounder to avoid the active area of construction, the availability of suitable habitat outside of the construction area, and the expectation that the construction area will recover following the completion of construction activities, any impacts on summer flounder juveniles are expected to be minor and not significantly affect the flounder population or its habitat.

Potential indirect impacts on summer flounder EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juveniles' diet. Summer flounder can forage for prey along the remaining portions of the pipeline route and elsewhere in the vicinity of the proposed Project. Disturbance to benthic organisms would be short-term and limited to the immediate vicinity of the proposed FSRU and pipeline route.

3.1.5 Windowpane Flounder (*Scopthalmus aquosus*)

EFH is designated for all life stages of the windowpane flounder within the Project area. The windowpane flounder is a demersal species, and its life history indicates that impacts could result from both construction and operation of the Project.

Egg

Eggs of the windowpane flounder are buoyant and are found in the surface waters of estuaries from February to November, with peak abundances occurring in May and October. The Poletti data (*see* Appendix E) confirmed the presence of windowpane eggs in the central portion of the Sound. Hatching occurs in eight days at the typical spawning temperature of 8 ^{o}C (Miller et al. 1991). Habitat characteristics include surface waters over depths less than 70 m and temperatures below 20 ^{o}C. The water intake structures on the FSRU and LNG carriers will be located at a depth of approximately 30-40 feet (8-12 m); thus, the buoyancy of the eggs will limit the potential impacts from the Project.

Larvae

Larvae are pelagic (settling to the bottom when attaining approximately 10 to 20 mm in length) and are typically found in the polyhaline portions of estuaries (Morse and Able 1995) from February to November, with peaks occurring in May and October. Any impacts on the larval stage would most likely occur as the larvae settle to the bottom following the early pelagic larval stage. The Poletti data confirmed the presence of windowpane larvae in the Sound, with the highest densities in May and June. August and October sampling identified low to no densities of larvae. As they descend through the water column, the larvae could be subject to entrainment/impingement from the intake structures. However, the volume of water entrained through the intake screens on a daily basis is insignificant when compared to the total volume of water available in the Sound within which windowpane flounder can successfully settle to the bottom.

Juvenile

Juveniles are most abundant in Long Island Sound during the spring (NMFS 1999). The diet of juvenile windowpane flounder includes mysid shrimps and various fish larvae (Chang et al. 1998). Able and Fahay (1998) considered the habitats of juvenile windowpane flounder not well-defined but noted that during extensive collections in estuarine shallows, juveniles were never collected in intertidal areas (Able and Fahay 1998) but occurred frequently along subtidal shores and in a variety of habitats at depths from 1 to 8m (Szedlmayer and Able 1996). Although juveniles may be found to some degree in the Project area, they would more typically be found in the protected in-shore areas, minimizing the potential for Project-related impacts.

Adult

Adults are most abundant in Long Island Sound during the spring (NMFS 1999). Habitat characteristics in the spring include temperatures less than 18 ^{o}C, salinities ranging from 21 to 31 ppt, and depths less than 60 m. The diet of adult windowpane flounder includes mysid shrimp and various fish larvae (Chang et al. 1998). Spawning in Long Island occurs during a split season from February through December, with peaks occurring in spring and fall (NMFS 1999). Windowpane flounder spawn in the evening or at night, on or near the bottom (Bigelow and Schroeder 1953; Ferraro 1980).

Adult windowpane flounder are distributed throughout Long Island Sound, typically over mud substrate. The regions of highest abundance include areas in the central and western basins containing mud and transitional sediments. As such, windowpane flounder would be expected to occur throughout the Project area, with the greatest abundance expected to occur in April through June. However, the spring abundance of windowpane flounder has decreased considerably since trawl surveys by the Connecticut Department of Environmental Protection were initiated in 1984. In the spring of 1984, an average of 231 fish were collected per tow, while in the spring of 2000, only 23 fish were captured per tow (Gottschall 2000).

Impacts

While all life stages of the windowpane flounder occur in the Sound, impacts would be limited primarily to adult flounder during the construction phase of the Project and larval flounder during operation of the FSRU. Minor disturbance to adult windowpane flounder and associated habitat is expected to be short-term, and suitable habitat is readily available adjacent to the Project area. Limited mortality is possible during the pipe-laying, pipe-lowering, and backfilling activities. The substrate in areas around the pipeline is expected to become reestablished through natural processes following the completion of construction activities. Due to the limited extent of the Project area relative to the amount of windowpane flounder habitat available in the Sound, the ability of flounder to avoid the active area of construction, the availability of suitable habitat outside of the construction area, and the expectation that the construction area will recover following the completion of construction activities, any impacts on windowpane flounder are expected to be minor and not significantly affect the flounder population or its habitat.

Larval windowpane flounder could potentially be impacted by the water intake structures on the FSRU. However, the volume of water entrained through the intake screens on a daily basis is insignificant when compared to the total volume of water available in the Sound within which windowpane flounder can successfully settle to the bottom.

Potential indirect impacts on windowpane flounder EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. Winter flounder feed predominately on shrimp and larval fish and can forage for prey in undisturbed areas adjacent to the pipeline route and elsewhere in the vicinity of the proposed Project. Disturbance to benthic organisms would be short-term and limited to the immediate vicinity of the proposed FSRU location and pipeline route.

3.1.6 Little Skate (*Leucoraja erinacea*)

EFH has been designated for little skate juveniles and adults in the Project area. The little skate is demersal, typically found on sandy or gravely bottoms but also on mud (Packer et al. 2003a). Little skates are known to remain buried in depressions during the day and are more active at night. EFH for the egg and larval stages of the little skate are not identified in the Project area; thus, impacts from the Project will be limited primarily to short-term construction impacts.

Juvenile

Juvenile skates are found in the Mid-Atlantic Bight in shallow waters and at depths up to 110 m. The temperature range of the little skate is generally 1 to 21 °C, although most are found in between 2 and 15 °C. The little skate can tolerate salinities as low as 15 to 20 ppt, but their optimal range is 29 to 33 ppt. Surveys in Long Island Sound have shown that juvenile little skates are most abundant in spring and fall on transitional bottoms (Gotschall et al. 2000, as cited in NOAA Fisheries 2003). In the spring, little skates are found in waters less than 9 m deep, while in the summer they are found in waters greater than 27 m deep. During the fall, most little skates are found near Mattituck, New York, at depths ranging from 9 to 27 m, and near Guilford, Connecticut, at depths less than 18 m (Gotschall et al. 2000, as cited in NOAA Fisheries 2003). Based on their preference for transitional bottoms, the skate is expected to occur primarily in the Stratford Shoal area between the central and western basins.

Adult

In Long Island Sound, the timing and abundance of adult little skates are similar to those of juveniles (Gotschall et al. 2000, as cited in NOAA Fisheries 2003). Little skate adults do not appear to have large-scale migrations, but they do move into shallower water during the summer and into deeper water in the fall or early winter. Little skates feed on decapod crustaceans, amphipods, and polychaetes (Packer et al. 2003a). Little skates often associate with particular microhabitat features on the surface of sediment during the day, including biogenic depressions and flat sand, but are randomly distributed at night. Little skates can reproduce year-round and multiple times per year. Several studies have shown eggs to be most abundant in late fall to winter and in early summer (NOAA Fisheries 2003).

Impacts

Potential direct impacts on little skate EFH include temporary disturbances from construction activities that can affect juveniles and adults. Scheduling pipeline installation operations to occur primarily in winter will minimize potential impacts on little skates. Juveniles have peak abundances in the Sound during spring and fall; however, in the spring, juveniles and adults are most abundant in depths less than 9 m, indicative of more inshore areas outside of the Project area. Therefore, few or no direct impacts are expected as a result of construction of the FSRU and pipeline. The mobility of the skates would likely allow them to vacate the Project area during construction activities, minimizing potential impacts. Due to the limited extent of the Project area relative to the amount of skate habitat available in the Sound, impacts on the skate will be insignificant. Juvenile and adult little skate may be attracted to the micro-topography offered by the trench depression that will exist until natural infilling is complete. Attraction to the trench is not expected to result in impacts on little skate because the trench is not expected to present any unusual or increased threat.

Potential indirect impacts on little skate EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. Little skate feed predominately on crustaceans and amphipods. These prey items are abundant in the Sound, and juveniles and adults can forage for prey along the remaining portions of the pipeline route and elsewhere in the vicinity of the proposed Project. Temporary disturbance to benthic organisms would be limited to the immediate vicinity of the proposed FSRU location and pipeline route.

3.1.7 Winter Skate (*Leucoraja ocellata*)

EFH is designated for winter skate juveniles and adults within the Project area. The winter skate is typically found on sandy or gravelly bottoms, but it has also been reported on mud bottoms (Packer et al. 2003b). Winter skates remain buried in depressions during the day and are active at night.

Juvenile

The seasonal distribution of juvenile winter skates is variable in Long Island Sound, with greatest abundance on sand bottoms along the Mattituck Sill and in the eastern basin during the spring (Gotschall et al. 2000, as cited in NOAA Fisheries 2003) and low abundance throughout the remainder of the year. Given that their low abundance in the Project area and ability to move out of the Project area, no significant impacts on juvenile winter skates are expected.

Adults

The distribution of adult winter skates in Long Island Sound is similar to that of juveniles. Winter skates typically feed on polychaetes, amphipods, decapods, isopods, bivalves, and smaller fishes such as alewives, blueback herring, and butterfish (Packer et al. 2003b). Reproduction appears to occur year-round, but gravid females are most abundant during summer and fall (Gotschall et al. 2000, as cited in NOAA Fisheries 2003). Given their limited use of the Project area, no significant impacts on adult winter skates are expected.

Impacts

Potential direct impacts on winter skate EFH would be limited to temporary disturbance to the few juveniles and adults that utilize the Project area. Scheduling pipeline installation operations to occur primarily in winter further minimizes potential impacts on winter skates. Juveniles have peak abundances in the Sound during spring and fall. However, in the spring juveniles and adults are most abundant along the Mattituck Sill and in adjacent portions of the central basin, which are outside of the Project area. Therefore, few direct impacts on juvenile and adult winter skate are expected as a result of construction of the FSRU and pipeline. Juvenile and adult winter skate may be attracted to the micro-topography offered by the trench depression that will exist until natural infilling is complete. Attraction to the trench is not expected to result in impacts on winter skate because the trench is not expected to present any unusual or increased threat.

Potential indirect impacts on winter skate EFH would be expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. Given that construction activities will largely avoid sandy habitats, and that benthic habitats toward the eastern extent of the Project area are mud substrates, which are not preferred habitat, potential impacts on the skate are minimized.

3.1.8 Black Sea Bass (*Centropristus striata*)

EFH for the black sea bass has been designated for juveniles within the study area. The black sea bass is a warm temperate, demersal species that uses structured habitats (e.g., reefs and shipwrecks) but can also be found ranging over open benthic habitats for feeding (NMFS 1999). The black sea bass, which is generally considered a reef fish, occurs only rarely in Long Island Sound. Construction impacts would be limited to temporary impacts associated with pipeline construction.

Although not defined as having larval stage EFH, late July Poletti sampling and Broadwater's August sampling identified limited black sea bass larvae in the central portion of the Sound.

Juvenile

Based on trawl surveys, juveniles are present primarily in central Long Island Sound in September and October (NMFS 1999). This species has a strong affinity for structured habitats and rough bottoms, which are found along the Stratford Shoal portion of the proposed pipeline route. Other habitat characteristics observed for Long Island Sound juvenile black sea bass include bottom temperatures of 14 to 19 ^{o}C, depths of 5 to 50 m, and salinities ranging from 23 to 32 ppt (NMFS 1999). Juvenile black sea bass feed on benthic crustaceans such as isopods, small crabs, shrimp, and copepods (Steimle et al. 1999).

Impacts

Potential impacts on black sea bass EFH would be limited to temporary habitat disturbances. The mobility of the species would likely preclude direct impacts, but short-term habitat modification would result from construction of the pipeline. Due to the strong affinity of this species for structured habitats and rough bottoms, potential direct and indirect impacts on black sea bass EFH, including potential impacts on forage species, within the study area is expected to be minimal and restricted to the Stratford Shoal area. Some impacts may occur due to the temporary disturbance of benthic habitat in this area. However, the affected area is small and the impacts are expected to be short term and minor.

Based on this species' affinity for structure, the presence of the tower structure would increase the mount of vertical structure in the Project area, potentially increasing the population of black sea bass in the Sound.

3.1.9 Silver Hake (*Merluccius bilinearis*)

EFH has been defined for adult silver hake (also known as whiting) in the Project area. During spring and summer, silver hake move into nearshore waters, returning to deeper continental shelf waters by autumn. Silver hake are a demersal fish that is typically found in dense schools.

Adult

Adult silver hake migrate seasonally, inhabiting waters shallower than 90 m in summer and autumn and deeper offshore waters in winter and spring (Anderson 1982). Adults are commonly observed in the central and western basins of Long Island Sound during all months, with a peak abundance occurring in June and again in October and November (NOAA Fisheries 2004). Silver hake are primarily nocturnal predators, resting by day on sandy, pebbly, or mud substrates but seldom over rocks. They feed primarily on fish, crustaceans, and squid (NOAA Fisheries 2004).

Spawning occurs year-round over a wide range of temperatures and depths (NOAA Fisheries 1999). Other habitat characteristics include depths ranging from 30 to 325 m, temperatures less than 13 ^{o}C, and bottom habitats of all substrates. Based on the life history of the silver hake, Project-related impacts are expected to be minimal.

Impacts

Potential direct impacts on silver hake EFH include potential temporary disturbance to adults. Scheduling pipeline installation operations to occur primarily in winter will minimize potential impacts on silver hake. Since their peak occurrence occurs during June and again in October and November, adult silver hake will be present during the early stages of the construction period. However, the area that will be affected by construction is small relative to the amount of suitable available habitat, construction impacts will be short term, and the adult fish are expected to leave the Project area during the period of active construction. In addition, due to their highly migratory nature, any silver hake in the Project area would be expected to vacate the area during construction in pursuit of their primary prey, which would also vacate the construction area. Therefore, direct impacts resulting from construction of the Project are expected to be minimal.

Potential indirect impacts on silver hake EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the adults' diet. Silver hake feed on a variety of benthic organisms. These prey items are abundant in the Sound, and adults can forage for prey along the remaining portions of the pipeline route and elsewhere in the vicinity of the proposed Project. Temporary disturbance to benthic organisms would be limited, and the majority of construction will occur outside of the period when silver hake utilization peaks in the Sound.

3.1.10 Scup (*Stenotomus chrysops*)

EFH is designated within the Project area for all life stages of scup. Scup occur from Massachusetts to South Carolina. During the summer months they are commonly found in large estuaries and coastal waters. They typically overwinter in areas of the outer continental shelf. The preferred habitat of scup in the Long Island Sound tends to be a mixed mud and sand substrate near structure, and they feed on a variety of small benthic vertebrates. No scup of any life stage are typically found in the Sound from December through March.

Egg

Scup spawn along the intercontinental shelf off the coast of southern New England from May to August, with the peak occurring during June and July. Scup eggs are pelagic and hatch within three days, depending on temperature. Eggs are variably abundant from year to year in the eastern portion of Long Island Sound from May until August. Since eggs are more prevalent in the eastern portion of the Sound, potential impacts from FSRU operations may occur. The Poletti data confirmed the presence of scup eggs in the central portions of the Sound from mid-May through July.

Larvae

Larvae also are pelagic and can be found along the coast during the warmer months feeding on small zooplankton. Generally, Scup larvae occur in waters between 55 and 73 °F and in salinities greater than 15ppt. The Poletti data confirmed the presence of scup larvae in the central portion of the Sound, primarily in June and July.

Juvenile

Juveniles and adults are demersal and common in the larger estuaries and coastal waters during the summer and fall. In Long Island Sound, juvenile scup feed during the day, mostly preying on polychaetes, amphipods, crustaceans, mollusks, and fish eggs and larvae. Juvenile scup are common from July through October and have been known to overwinter in the Sound during milder winters.

Adult

Scup spawn along the continental shelf off of southern New England from May to August, with the peak occurring during June and July. Adult scup are benthic feeders and have a diet similar to that of juveniles. During the warmer months, adult scup are found near or in the mouths of larger bays, including Long Island Sound, and they typically overwinter in the outer intercontinental shelf areas.

Impacts

Impacts on scup life stages could result from both construction and operation of the Project. Scup eggs and larvae, which are found in Long Island Sound from May to September, would likely be impacted through impingement/entrainment at the FSRU water intake structures. However, the volume of water entrained through the intake screens on a daily basis is insignificant when compared to the total volume of water available in the Sound.

Potential construction-related impacts on scup EFH include temporary disturbance to juvenile and adult habitats. Scheduling pipeline installation operations to occur primarily in winter will minimize potential impacts on scup. While juveniles are common in October, when construction will begin, and they occasionally overwinter in the Sound, installation of the proposed facilities will affect a relatively small area, and suitable habitat will be available for use adjacent to the construction area. Adult scup typically leave the Sound in fall to overwinter on the outer continental shelf; therefore, they are expected to be present only in limited numbers during the construction period, thereby minimizing potential impacts.

Potential indirect impacts on scup EFH are expected to be temporary and minor, limited to the disturbance and temporary loss of benthic forage organisms included in the juvenile and adult diets. These prey items are abundant in the Sound, and juveniles and adults will be able to forage for prey outside the Project area. Temporary disturbance to benthic organisms will be limited to the immediate vicinity of the proposed FSRU location and pipeline route. The bottom substrates are expected to become reestablished through natural processes following construction.

3.2 PELAGIC SPECIES

3.2.1 Atlantic Salmon (*Salmo salar*)

EFH is designated for adult and juvenile salmon within the Project area. Historically, the Connecticut River, which flows into Long Island Sound, maintained one of the largest populations of Atlantic salmon in North America. This population was extirpated by the late 1800s/early 1900s. However, native populations remain in the Gulf of Maine, and these populations are currently listed as endangered under the Endangered Species Act. These native fish can be found from Long Island Sound north to the Labrador Sea; thus, there is potential for juveniles and adults to be found in the Project area. Atlantic salmon exhibit an anadromous life history, i.e., they reproduce in freshwater but spend the majority of their life in the ocean. Based on the lack of egg and larval stage EFH in the Long Island Sound, impacts from the Project would be restricted primarily to the pipeline construction activities.

Juvenile

Juveniles rear in freshwater for 2 to 3 years, then smolt and migrate to the ocean. In the riverine environment, juveniles feed predominately on invertebrates and switch to a more piscivorous diet during smoltification. Post-smolt juvenile salmon are primarily pelagic in the ocean.

Adult

Adults are iteroparous, meaning they may return to the ocean after spawning in freshwater and return to spawn in subsequent years. Generally, adult Atlantic salmon spawn in freshwater streams and rivers where water temperatures are below 22.8 °C and dissolved oxygen concentrations are above 5 ppm. Oceanic adult Atlantic salmon are primarily pelagic and range from the waters of the continental shelf off southern New

England north throughout the Gulf of Maine. Adult Atlantic salmon feed primarily on fish such as Atlantic herring, alewife, rainbow smelt, mummichog, Atlantic mackerel, and various flatfishes (Collette and Klein-MacPhee 2002).

Impacts

Since Atlantic salmon are pelagic, they can easily avoid construction activities and turbid water; therefore, direct impacts are expected to be negligible. In addition, Atlantic salmon are rare in Long Island Sound and are not expected to be impacted by the Project. Indirect impacts resulting from impacts on the salmon's forage species also are expected to be negligible. The vast majority of the adult Atlantic salmon diet is comprised of pelagic fish species which, like the salmon, will be able to avoid areas of disturbance.

3.2.2 Atlantic Herring (*Clupea harengus*)

EFH for juvenile and adult Atlantic herring has been designated within the Project area. Herring are a pelagic species, with the adults making extensive feeding, spawning, and overwintering migrations in dense schools (NMFS 1999).

Juvenile

Juveniles can be found in the Project area year-round but prefer water temperatures below 10°C. Herring perform vertical migrations that are linked to changing light intensity but are most common at mid-water depths. Juveniles prefer a diet of copepod and decapod larvae (Reid et al. 1999). Juvenile and adult Atlantic herring undergo complex north-south and inshore-offshore migrations (Reid et al. 1998). Juveniles are most abundant in Long Island Sound in the fall, with as many as 80,000 taken in 15-minute trawls (NMFS 1999).

Adult

The habits and distribution of the adult herring is similar to the juvenile, although adult herring are known to make extensive feeding, spawning, and overwintering migrations (NMFS 1999). Adults feed primarily on euphausiids, chaetognaths, and copepods (Reid et al. 1999).

The complex migrations of adult herring involve three general migratory patterns and three distinct spawning stocks off the northeast Atlantic coast (Sindermann 1979). Juvenile and adult Atlantic herring that occur in the Project area are most likely from the Georges Bank/Nantucket Shoal stock, which spawns over Georges Bank and Nantucket Shoals during September and October and overwinters south of Cape Cod and along the mid-Atlantic coast (Anthony 1982; Reid et al. 1998).

Atlantic herring can be found in either seawater or mixing zones. While adult herring can be found in mixing zones, they are most abundant in the seawater portions of the Sound. A Connecticut Fisheries Division survey found that the greatest abundance of adults occurred during the spring in the central portion of Long Island Sound (NMFS 1999). In the fall, catches were smaller and were mostly from the west-central portion of the Sound. In the spring, adult herring are most abundant in areas with temperatures of 9 to 10 ^{o}C, salinities of 25 to 28 ppt, and depths of 10 to 18 m (NMFS 1999). In the fall, the largest catches were recorded in areas with similar depths and salinities but with temperatures of 17 to 21 °C.

Impacts

Atlantic herring are most abundant in the fall through spring, when water temperatures are lower. However, since Atlantic herring are pelagic, they can easily avoid construction activities and turbid water; therefore, direct impacts are expected to be negligible. Indirect impacts resulting from impacts on the herring's forage species also are expected to be negligible due to the availability of suitable habitat adjacent to the proposed Project.

3.2.3 Bluefish (*Pomatomus saltatrix*)

EFH for juvenile and adult bluefish has been designated within the Project area. The bluefish is a seasonally migrating, pelagic schooling fish found from Nova Scotia to Argentina; however, it is rare between southern Florida and northern South America. They tend to school in groups containing the same year class. Potential impacts from the Project would likely be restricted to construction, since adults would be able to avoid water intake structures associated with the FSRU.

Juveniles

Young-of-the-year fish appear in Long Island Sound during June, and by mid-August they compose over 90% of the bluefish catches in the Sound (Reid et al. 1999). Abundance is highest on the Connecticut side of the Sound in depths less than 18 m. In September, juvenile abundance is highest in depths of 9 to 27 m over mud bottoms in three areas: on the Connecticut side of the Sound from New Haven to Norwalk, across the western basin into Smithtown Bay, and across the central basin from New Haven to Mattituck (NOAA Fisheries 1999). The abundance of both juveniles and adults decreases rapidly after September, and it appears that the juveniles leave the Sound first.

During the day, juveniles are usually near the shoreline or in tidal creeks, while at night they move into open bay and channel waters. They feed on a variety of fish, including striped bass, bay anchovy, and Atlantic silversides. Juvenile bluefish produced in the spring travel north with the Gulf Stream (Hare and Cowen 1993), and in early to mid-June they migrate across the continental shelf to nursery areas in the mid-Atlantic bays and estuaries (McBride and Conover 1991). The preference of bluefish for the inshore waters of the Sound minimizes potential impacts from the Project.

Adults

Adult bluefish occur in the open ocean, large embayments, and most estuarine systems, preferring water temperatures ranging from 14 to 16°C. Adults are sight feeders, preying almost entirely on other fish. The adults begin to arrive in Long Island Sound around May, when the water temperature is 9 to 18°C. Adults are more widespread geographically in the Sound than juveniles, but less abundant.

Bluefish found along the U.S. Atlantic coast are believed to have two distinct spawning events per year. The first occurs during spring (March through May) near the edge of the continental shelf of the South Atlantic Bight, and the second occurs during the summer (June through July) in the Middle Atlantic Bight.

Impacts

Bluefish are pelagic and thus can easily avoid construction activities and the resulting turbid water; therefore, direct impacts on bluefish expected to be negligible. In addition, bluefish densities are highest in late summer; by winter, they are uncommon or absent, and are not expected to be impacted by the Project.

The proposed subsea plow installation method will significantly limit the extent of in-water turbidity that could affect the forage species of bluefish. In addition, the vast majority of the adult bluefish's diet is comprised of pelagic fish species that also will be able to avoid areas of disturbance. Thus, indirect impacts resulting from impacts on the bluefish's forage species also are expected to be negligible.

3.2.4 Atlantic Mackerel (*Scomber scombrus*)

EFH is designated in the Project area for all life stages of Atlantic mackerel. A fast-swimming, pelagic fish that travels in schools, the Atlantic mackerel can be found from the Gulf of St. Lawrence to Cape Lookout, North Carolina. They are obligate swimmers due to their lack of a swim bladder and use of ram gill ventilation.

Egg

Studies have found eggs and larvae to be highly abundant in Long Island Sound during April and May (NMFS 1999). The Poletti data (*see* Appendix E) only identified Atlantic mackeral in a single survey (April 29-May 12, 2002) and in very limited numbers. The eggs are pelagic and most abundant in areas of high salinity, i.e., greater than 30 ppt. Other habitat characteristics include temperatures of 5 to 23 ^{o}C and depths ranging from 0 to 15 m. Because the pelagic eggs are found primarily in the upper strata of the water column, the potential for impingement/entrainment impacts resulting from the water intakes on the bottom of the FSRU and LNG carriers, at depths of approximately 30-40 feet (8-12 m), is greatly reduced.

Larvae

Larvae have been collected both inshore and offshore in the Long Island Sound area from May through August, with the highest densities occurring in June (NMFS 1999). Larvae were identified in limited numbers in two Poletti samples, as well as Broadwater's August sampling effort. Habitat characteristics include temperatures ranging from 6 to 22 ^{o}C, salinities ranging from 18 ppt to greater than 30 ppt, and depths ranging from 10 to 130 m. Larval Atlantic mackerel prey on zooplankton, copepods, and fish larvae (Studholme et al. 1999).

Juvenile

In Long Island Sound, juveniles are most abundant in the fall, primarily September and October, along the Connecticut shore from Norwalk to the Housatonic River at depths less than 18 m (NMFS 1999). Juveniles feed primarily on small crustaceans such as copepods, amphipods, and decapods. The preference of juveniles for shallower inshore waters will minimize potential impacts from the Project.

Adult

Adult mackerel are present in low numbers in Long Island Sound (NMFS Fisheries 1999). The distribution of mackerel is seasonal, with adults making up the largest portion in Long Island Sound during the spring and mid-summer months. Adults have been collected throughout the Sound during these times. Habitat characteristics include temperatures ranging from 4 to 16 ^{o}C, salinities greater than 25 ppt, and depths ranging from 1 to 380 m. Atlantic mackerel are opportunistic feeders, using both direct ingestion and filter feeding methods. Adult Atlantic mackerel have a diet similar to that of juveniles, but they also consume euphausiids, fish, squid, and shrimp.

The shoreward portion of the continental shelf between southern New England and the Mid-Atlantic states is classified as the most important spawning ground for the mackerel. Peak spawning activity occurs in waters with salinity greater than 30 ppt.

Impacts

Based on the low numbers of Atlantic mackerel found in Long Island Sound, EFH for this species appears to be limited in the Project area. Potential direct impacts are likely to include only temporary seabed disturbance and associated sedimentation in the water column during active pipeline installation. The use of a subsea plow for the vast majority of construction further minimizes the potential for impacts. In addition, eggs, larvae, and adults are primarily abundant in the spring and summer periods, avoiding the primary construction period of October through April. Juveniles are most abundant in the fall but prefer the shallower inshore habitats, which fall outside the area of construction activities.

Potential indirect impacts are expected to be negligible, limited only to the loss of some benthic organisms that comprise a portion of Atlantic mackerel juvenile and adult EFH. However, this potential indirect impact would be short-term and occur only within the areas directly disturbed during pipeline installation.

The pelagic nature of the eggs and larvae of Atlantic mackerel result in some potential impact from water intake activities associated with the FSRU. However, the volume of water entrained through the intake screens on a daily basis is insignificant when compared to the total volume of water available in the Sound.

3.2.5 Pollock (*Pollachius virens*)

EFH has been designated within the study area for juvenile and adult pollock. Pollock are pelagic, inhabiting both sides of the Atlantic Ocean, but they are uncommon in the waters of Long Island Sound. Based on the lack of egg and larval stage EFH in the Sound, impacts from the Project would be restricted primarily to pipeline construction activities.

Juvenile

In surveys conducted by the Connecticut Department of Environmental Protection Fisheries Division between 1984 and 1990, only 24 juveniles were caught throughout Long Island Sound (NMFS 1999). All of the fish were caught during the summer over all bottom types except sand. Inshore subtidal and intertidal zones are used by juveniles as nursery areas (Steele 1963; Ojeda and Dearborn 1990; Rangeley and Kramer 1995). Outside of Long Island Sound, juvenile pollock are found at depths ranging from 0 to 250 m, but they generally occur at depths ranging from 25 to 76 m (Hardy 1978; Fahay 1983; Clay et al. 1989). Other general habitat characteristics include temperatures less than 18 ^{o}C and salinities ranging from 29 to 32 ppt. Prey species include crustaceans (e.g., euphausiids), fish (e.g., Atlantic herring), and mollusks (Cargnelli et al. 1999).

Adult

Adult pollock have not been caught in Long Island Sound trawl surveys in over 20 years (NMFS 1999). In spring and summer, adults outside of the Sound tend to be found at depths ranging from 35 to 365 m, particularly at depths of 100 to 125 m. The diet of adults includes crustaceans, fish, and mollusks.

Spawning occurs from September to April, with peaks in December to February, in waters ranging from 15 to 365 m deep. Spawning occurs in benthic areas with substrates of hard, stony or rocky bottoms, including artificial reefs.

Impacts

The general lack of pollock in Long Island Sound, as indicated by historic data, minimizes the potential impact of the Project. In addition, based on the seasonal occurrence of pollock in nearshore waters and the proposed pipeline installation schedule, potential direct impacts on juvenile and adult EFH would likely be avoided. Since pollock are pelagic, they can easily avoid construction activities and the resulting turbid water; therefore, direct impacts are expected to be negligible.

Potential indirect impacts may include the disturbance of bottom habitat and resulting potential loss of benthic forage species. However, these potential indirect impacts would be limited to the area of active pipeline installation and bottom sediment disturbance.

3.2.6 Sand Tiger Shark (*Carcharias taurus*)

EFH has been designated in the Project area for larval sand tiger sharks. Insufficient information is known regarding the late juvenile and sub-adult life stages of this species. Adult sand tiger sharks are found in shallow coastal waters south of Long Island Sound from New Jersey to Florida.

Larvae

Sand tiger shark neonate/early juvenile EFH is defined as the shallow coastal waters from Barnegat Inlet, New Jersey, south to Cape Canaveral, Florida, out to the to the 25-m isobath (NMFS 2001). Little is known about the larval stage, but this life stage is likely to feed on a variety of invertebrates. The preference of the sand tiger shark for shallower inshore areas minimizes potential impacts on the species from the Project.

Impacts

Installation of the proposed facilities will result in minor, short-term impacts on the benthic habitat and water column along the construction ROW. Due to the small area affected relative to the amount of habitat available in the Sound, installation of the proposed facilities is not expected to result in significant impacts on the sand tiger shark.

3.2.7 Coastal Migratory Pelagic Species

King mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), and Cobia (*Rachycentron canadum*) are considered highly migratory species by NOAA Fisheries. EFH has been designated the Project area for all life stages of these species. EFH includes sandy shoals of capes and offshore bars, high-profile rocky bottoms, and barrier island ocean-side waters, from the surf to the shell-break zone, including coastal inlets. No eggs or larvae of any of these species were identified in either the Poletti or Broadwater sampling efforts.

King mackerel inhabit coastal waters from Maine to Florida and the Gulf of Mexico. Larval distribution indicates that spawning most likely occurs off the Carolinas, Cape Canaveral, and Miami, Florida. Adults are solitary and tend to be found among underwater structures. Juvenile and adult king mackerel feed on fish such as menhaden, alewives, and anchovies, and, to a lesser extent, on shrimp and squid (DeVane 1978; Bowman et al. 2000). The potential direct, indirect, and cumulative impacts on eggs and larvae are negligible because they are not expected to occur in the Project area. The potential direct impacts on juvenile and adult EFH for this species may include temporary loss of in-water habitat during active pipeline installation. Potential indirect impacts on king mackerel forage species are expected to be negligible because the vast majority of these species are pelagic and able to avoid areas of active pipeline installation. Therefore, no cumulative impacts on this species are expected to occur.

Spanish mackerel are found from the Florida Keys to New York, wintering in the warmer waters off Florida and moving northward to North Carolina in early April and to New York waters in June. Spanish mackerel are schooling fish and prefer coastal waters. They are pelagic (all life stages) and are not typically associated with bottom habitat. The diet of Spanish mackerel includes fish such as menhaden, alewives, and anchovies, and, to a lesser extent, shrimp and squid (DeVane 1978; Bowman et al. 2000).

Impacts

The majority of impacts related to installation of the Project are limited to disturbance to sediment and demersal habitat; therefore, potential direct, indirect, and cumulative impacts on Spanish mackerel EFH are not expected from construction. There is a potential for impacts on egg and larval life stages during operation of the FSRU, as well as some impact on prey species in association with water intakes on the FSRU during operation of the facility. However, due to the low volume of water taken in and the incorporation of small mesh screening on the intake, no significant impacts on egg or larval life stages are expected.

Cobia are found along the eastern seaboard from Florida to Massachusetts. Cobia eggs and larvae are found in offshore coastal waters (Vaught-Shaffer and Nakanura 1989). Early juveniles move inshore and inhabit coastal areas and the lower reaches of bays and inlets. Adult cobia undergo a northerly migration from overwintering grounds near the Florida Keys to more northerly spawning and feeding grounds in spring and summer (Richards 1977). Juveniles tolerate temperatures as low as 17.7 °C but stop feeding at 18.3 °C; their upper lethal limit is 37.7 °C. Generally, adult cobia occur in coastal waters along the continental shelf. Although cobia will eat fish and squid, the bulk of their diet consists of crabs and shrimp (Murdy et al. 1997). No impact on egg or larval cobia EFH is expected because cobia of these life stages are absent from scientific collections from previous studies and they tend to occur offshore.

Although juvenile and adult Cobia are occasionally found in estuaries (Vaught-Shaffer and Nakanura 1989) they have not been found in samples collected in the Project area; this along with the species' pelagic nature, makes it unlikely that juvenile or adult EFH will be impacted directly or indirectly by the proposed Project. Therefore, potential impacts on cobia EFH are not expected.

3.3 CUMULATIVE IMPACTS AND MITIGATION

Construction and operation of the Project will result in some unavoidable impacts on EFH species and associated habitats. Construction of the Project will result in minor, short-term impacts associated with the pipe laying, installation, and backfilling operations. Operation of the FSRU, and the need for water intake associated primarily with ballasting activities, has the potential to impinge/entrain pelagic eggs and larvae of some EFH species.

Potential direct impacts on EFH resulting from construction would be minimized by constructing the facilities primarily in winter (a time of reduced biological activity), minimizing the area affected by construction, allowing the trench to infill through natural processes rather than subjecting the habitat and species to an additional plow pass for burial, utilizing clean fill material where backfill is required, exchanging FSRU ballast water in offshore waters prior to entrance to the Sound, and utilizing trained observers during pile driving. Impacts associated with water withdrawal for hydrostatic testing have been minimized by minimizing the amount of water withdrawn from the Sound, use of best industry practices, screening, withdrawal of water at 20 to 40 feet (6 to 12m) below the water surface, treatment/neutralization of water prior to discharge, and re-oxygenation of water prior to discharge to the Sound.

Potential direct impacts on EFH resulting from operation would be minimized by utilizing an open structure for the base of mooring tower rather than a closed, solid base; use of best industry practices; implementation of a Spill Prevention, Control, and Countermeasures (SPCC) Plan and other plans, as appropriate, for handling hazardous materials and hazardous and solid waste; application of antifouling paint to the FSRU hull prior to delivery (which will allow for a reduction of copper leaching to levels below EPA water quality criteria prior to delivery to Long Island Sound); limiting lighting used to the number of lights and wattage necessary to perform operational activities; shielding lights so that the beam falls on the workspace and to ensure that the light beams will not be directly visible more than 1,000 m from the source; limiting lights shining into the water to the area immediately around vessels, except when essential for safe navigation, the safety of personnel, or other safety reasons; and locating facilities in the middle of the Sound and away from nearshore areas that are important spawning and nursery areas for many EFH species.

Water withdrawal and discharge impacts associated with operation of the facility have been minimized by minimizing the amount of water withdrawn from the Sound, use of best industry practices, use of an external grate to restrict passage of large species, additional screening with a mesh size of 5mm, withdrawal of water at approximately 40 feet (12m) below the water surface, and maintaining intake flow velocities at a maximum of 0.5 feet/second (0.15 m/s). In addition, for hydrostatic test water, treatment/ neutralization of water and re-oxygenation of water will occur prior to discharge, and water will be withdrawn from the Sound at 20 to 40 feet (6 to 12m) below the water surface.

Minimal long-term habitat alterations will occur at the FSRU site and in areas where the pipeline trench is backfilled with clean fill. The minimal negative impact of these alterations will be offset by the positive impact of the added structure of the FSRU and fill material.

Potential direct impacts on EFH resulting from construction would be minimized by constructing the facilities primarily in winter, a time of reduced biological activity. This also would avoid critical reproduction periods, with the exception of several demersal species. While most adults and juveniles would be able to vacate the Project area in advance of construction activities, the Long Island seabed will be disturbed by construction activities. Since the majority of the habitats traversed are mud-bottomed assemblages and transitional areas, communities would be expected to reestablish within a relatively short time following construction. Broadwater will continue to seek consultation with NOAA Fisheries to develop strategies to minimize potential direct impacts as required. An approximately 13,180 square foot (1,225 square meters) area of the seabed would be subjected to long-term alteration in conjunction with the FSRU mooring structure. While natural bottom conditions would be expected to reestablish beneath the mooring tower, the combination of the introduced structure and shadowing from the FSRU would likely increase the value and diversity of habitat near the FSRU.

Indirect impacts, primarily related the disturbance of benthic habitat and associated forage species for benthic foraging fish, have been characterized as temporary and limited to the area of direct pipeline installation (an approximately 75-foot-wide pipeline corridor) and FSRU work area (an approximately 13,180-square-foot area). Substrate and bottom habitat temporarily disturbed during pipeline installation will be restored through natural sedimentation and deposition processes. The trenching required for placement of the pipeline will impact the associated benthic community within the vicinity immediately surrounding the pipeline route and FSRU. Shellfish and benthic macro-invertebrates, which live in the sediments, serve as important food sources for some fish species, as noted above. Immediately after the pipeline is installed and the habitat becomes available to the fish community, benthic organisms will not be present for a short period of time prior to recolonization.

However, following construction, the disturbed habitat will recover because there is similar habitat immediately adjacent to the pipeline route, which will serve as a source of the benthic organisms that live in the affected substrates and occur in the water over those substrates. Benthic species generally have life cycles of one year or less; thus, prevailing currents would bring these species, in their early life stages, into the affected area during the next reproductive cycle and very soon after pipeline installation is completed.

The total area of aquatic habitat that would be impacted during construction is a small fraction of the total available habitat that exists adjacent to the Project area. Furthermore, the majority of the disturbed habitat is expected to undergo natural re-colonization shortly after the construction phase and ultimately return to is original state. Therefore, cumulative impacts due to pipeline installation and associated activities are considered negligible.

Operation of the FSRU and LNG carriers will result in an average daily intake of approximately 28.2 million gallons of seawater per day. Although the intake flow will be restricted to 0.5 ft/s (0.15 m/s), which will largely eliminate potential impacts on juvenile and adult EFH species, non-motile eggs and larvae could experience some impingement/entrainment impact. Locating the water intakes on the bottom of the FSRU and incoming LNG carriers will limit the extent of impact, as the vast majority of EFH eggs and larvae are either buoyant, demersal, or restricted primarily to shallower estuarine areas. The water intakes will be located in the middle (at approximately 30-40 feet below the surface) of the water column in 90-plus feet of water. As noted above, the majority of EFH eggs and larvae tend to be either buoyant, demersal, or restricted primarily to shallower estuarine areas. The location of the FSRU in the central portion of the Sound, coupled with locating the intakes at mid-water depths, will largely limit the EFH species that could be impacted by the Project. In addition, the volume of water required for ballast over any given period is insignificant relative to the total volume of the water available in the Sound and the frequency of flushing/water turnover that occurs due to the proximity of the Sound to the Atlantic Ocean. As a result, implementation of the Project is not expected to have any adverse impact on EFH within the Sound.

4. CONCLUSION

Potential construction-related impacts on EFH are expected to be localized and short-term, occurring only during the time of installation and shortly thereafter. Impacts have been minimized by siting the facility in deepwater habitat in the Sound and away from nearshore areas, which serve as important spawning and nursery areas for many species. Impacts would be further minimized by installing the facilities primarily during winter, a time of reduced biological activity.

Impacts would differ from species to species, depending upon life history, habitat use (demersal vs. pelagic), distribution, and abundance. Potential EFH impacts along the proposed pipeline route would be limited primarily to demersal (i.e., bottom-oriented) species and life-stages and those species whose predominant forage species are demersal. Pelagic species and life-stages are expected to continue using the water column following pipeline installation. During installation, pelagic species might experience disturbance to a small portion of EFH due to a need to avoid the active installation area. Most of the remaining pipeline route and area, however, would remain available. Pelagic larval and egg life stages (i.e., those life stages with limited motility) would be carried through the active Project area with prevailing tides and currents, resulting in limited exposure to construction-related disturbance.

Short-term water quality impacts on EFH due to pipeline installation would most likely be limited to changes in turbidity levels and suspended solids along and immediately adjacent to the proposed route; therefore, no significant impact is expected. Temporary disturbance of bottom habitat would occur along the proposed pipeline route as a result of the installation. Existing sediments along the pipeline route support a benthic community that is an important food resource for fish, particularly the epibenthos. Disturbance of EFH sediments would be short- term, since natural sedimentation and subsequent recolonization of benthic invertebrates is expected to occur following pipeline installation activities. Because of the widespread presence of this benthic community throughout the central and western basins of the Sound, and the recovery of affected areas following disturbance, the short-term loss of the benthic community during pipeline installation would not be a significant adverse impact on EFH.

The substrate in areas surrounding the pipeline route would be reestablished through natural processes following installation. Natural deposition will gradually reestablish a layer of sediment that reflects the ubiquitous characteristics of the surrounding area. Due to the short-term nature of the disturbance from installation of the pipeline, no significant impacts on the EFH of the identified species are expected.

Additional short-term impacts are anticipated from installation of the mooring tower, which will require pile-driving activities. However, the short duration of the installation activity and scheduling of this activity during winter will minimize potential impacts. During pile-driving activities, most fish species are expected leave the affected area, and they are expected to return to the area upon cessation of the disturbance.

Operation of the proposed pipeline has the potential to locally impact EFH due to maintenance activities and thermal impacts from the pipeline. In the event that maintenance activities require trenching, EFH could be impacted. Because the resulting impacts would be short-term, similar to those described for construction, and likely affect a very limited area, no significant impact on EFH would result.

The 30-inch-diameter pipeline will be coated with 3 inches of concrete except along the descent through the mooring tower. Depending on the season (winter versus summer) and volume of gas flow (high versus low), natural gas is expected to enter the pipeline at a temperature between slightly higher than 100ºF (38ºC) and slightly lower than 130ºF (54ºC) at the top of the mooring tower and to fall to a temperature between 100ºF (38ºC) and 120ºF (49ºC) at the bottom of the mooring tower, or at the sediment surface. The heat loss experienced in the pipeline from the surface to the seafloor would be transferred to the surrounding water column. Based on the sheer volume of water flowing by the pipeline, any increases in temperature would be readily dissipated in the water column with no significant thermal plume expected. In the winter, the temperature differential between the pipeline and the surrounding water column could reach 80° to 90ºF (27° to 32ºC). While the additional heat will be readily assimilated into the surrounding water column, a potential microclimate could be established within the immediate vicinity of the pipeline riser and mooring tower. This small area could function as an attractant to the local fishery, increasing the density of fish in immediate proximity to the pipeline riser, and could prove to be attractive to predatory marine mammals, as well. The remainder of the pipeline will be coated with 3 inches of concrete and installed to a depth of 3 feet below the sediment surface, or otherwise protected with armor rock or concrete mats. The transmission of higher temperature gas through the pipeline could result in some minimal temperature transfer into the surrounding sediments, but the impact would be highly localized and not result in significant impacts on marine or benthic habitat. Increased sediment temperature associated with the heated gas flowing through the pipeline would be largely restricted to within the disturbed trench line.

Operation of the FSRU will result in positive and negative impacts on EFH due to potential water quality impacts, the loss of habitat, the institution of a safety and security zone, and the addition of habitat structure. Operation of the facility has the potential to result in impacts on water quality in association with spills and maintenance to prevent biofouling on the FSRU facility. Any impacts associated with spills are expected to be short-term and localized; therefore, no significant impacts on water quality and EFH are anticipated. Biofouling maintenance procedures will be designed in coordination with relevant agencies. The mooring structure will result in direct impact on approximately 13,180 square feet (1,225 square meters) of seabed and associated benthos. However, this loss is insignificant compared to the availability of this habitat type in the central basin of the Sound. The addition of the tower structure will add structure to this portion of the Sound, acting as an artificial reef and increasing habitat diversity and potentially increasing the availability of forage species. Finally, the safety and security zone associated with the facility will remove the habitat surrounding the facility from fishing pressure.

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APPENDIX B

BENTHIC VIDEO SURVEY REPORT

Broadwater Benthic Video

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Pearl River, NY 10965

1. Introduction

Broadwater Energy (Broadwater) is a joint venture between TCPL USA LNG, Inc., and Shell Broadwater Holding, LLC. Broadwater Energy is planning to import liquefied natural gas (LNG) to a floating terminal in Long Island Sound. The proposed location of the terminal is nine miles off of Riverhead, NY and 11 miles from the Connecticut shoreline. The terminal, known as a Floating Storage Re-Gasification Unit (FSRU) will be connected to the existing Iroquois Gas Transmission system via a submarine pipeline. The pipeline will be approximately 25 miles long.

Long Island Sound (the Sound) is home to a well developed and mature (high abundance and diversity) invertebrate community. The benthic invertebrate community in particular is an important part of the marine environment in the Sound. The benthic community consists of a wide variety of small aquatic invertebrates which live burrowed into or in contact with the substrate, such as worms (polychaetes and oligochaetes), crustaceans (shrimp, lobster and amphipods) and bivalves (clams and mussels). Because they are suspension and deposit feeders, benthic organisms cycle nutrients from the sediment and water column to higher trophic levels. The sediment is modified by the benthos through bioturbation and formation of fecal pellets (Wildish and Kristmanson, 1997).

Life strategies of the benthos are tightly coupled with sediment characteristics. The distribution and abundance of benthic invertebrates is influenced by a wide variety of physical parameters (substrate, water temperature, dissolved oxygen, pH, salinity, and hydrodynamics). Benthic organisms can provide information about local environmental conditions because they live and feed on the sediment and have limited mobility. The abundance, diversity, and composition of benthic species, in combination with their relative pollution tolerance, are indicators of habitat quality. When an area is disturbed, the benthic community is often the first to reestablish, especially if sediment conditions are improved relative to previous conditions. Due to the dependence of the benthic community on sediment properties and its importance as a food source for fish, it is important to understand how activities associated with pipeline installation may affect the benthic community and further to understand the timing of reestablishment.

2. Methods

In April and May 2005 underwater video was taken along transects to characterize the benthic community along the proposed pipeline route. A drop camera was lowered over the side of the research vessel at twenty-seven (27) sites. It was lowered to the depth for the specific sample location as indicated by the fathometer on the research vessel. The drop camera was allowed to stabilize in the water column until it remained steady enough to obtain a good image. An onboard monitor was used to make sure that the camera was steady and to make initial observations of the benthic community. Once the image was steady, a slow trawl across the bottom captured the bottom video for that location.

Underwater video observations are best used to supplement existing benthic data. Due to the camera movement, shadows, camera magnification and video quality it is often difficult to confirm species identification and to determine abundances using only video observations. The underwater video was reviewed by LMS. Results of the benthic characterization based on the video observations are provided below. Video locations are depicted on Figure 1.

3. Existing Benthic Community

The sea floor along the proposed pipeline route is comprised of fine-grained sediments (fine sand, silt and clay) with few rock mounds (sites MG 1, MG2 and MG3 in the vicinity of Stratford Shoal) and amphipod mats (sites C 6, and 28) in the project area. This is consistent with sediment core samples collected by Aqua Survey, Inc.

Soft sediment communities in the proposed project area were dominated by several burrowing and tube dwelling polychaetes, amphipods, tunicates and anemones. In general, shell hash (Mercenaria mercenaria, other clam species, Crepidula sp. and Ensis directis) varied in abundance within the project area. Based on video observation, no live individuals of shellfish (hard clams, surf clams and oysters) were observed, which suggests a low density of shellfish occur in this area. However, at several locations within C sites burrows were observed. These burrows are most likely used by lobsters, other invertebrates (i.e. the mud shrimp, Axius serratus) and fish species in the area.

The greatest differences in species number and diversity were between the soft sediment community (the majority of the proposed project area) compared to the community inhabiting the rock mounds (sites MG2, MG3 and MG4). The following descriptions of the benthic video sites are grouped by sediment type, number of organisms and species diversity (number of different types of organisms) observed in the video.

<u>Basin Mud Community (Stations C-1, 2 , 3, 4, 6,19,21, 22, 23, 24, 26, 27, 28)</u>
These stations are located at the eastern and western edges of the proposed project area within the western and central basins. The seafloor is flat at these locations. Bottom substrates are comprised of fine silt and sand and a patchy distribution of clay. The vibracore sediment samples collected by Aqua Survey, Inc. verified existing sediment mapping classified as sandy silt, clayey silt or silt. The eleven analyzed stations were similar in abundance of burrowing anemones and of worm tubes and the occasional presence of the tunicate, Molgula sp. The mud tubes are comprised of mud and mucous. They do not resemble the tubes created by the junk worm and cone worm, Pectinaria gouldi. Shrimp, amphipods and a few solitary hydroids were present at these stations. Burrows were also observed. These burrows are most likely used by lobsters, other invertebrates (i.e. the mud shrimp, Axius serratus) and fish species in the area. Shell debris is sparse at these stations.

Broadwater Benthic Video Summary – June 2005

The Western Transition Community (Stations IC-5, 6, and 7)
The IC stations are located towards the western end of the project area along the transition from the western basin floor to the Stratford Shoal. The bottom sediment observed in the underwater video is composed of fine grain silt which is similar to the existing sediment mapping classifications. Overall, fewer species were observed at these stations than the stations described above. Worm tubes and anemones are present. Marine particles in the water column made it difficult to accurately identify and view the benthic community at these stations.

The Eastern Transition Community (Stations C-13, 14, 15, 16 and 17)
These stations are located in the middle of the proposed project area along the transition from the Stratford Shoal to the Central basin floor. Bottom sediments are comprised of silt and sand. Polychaete worm tubes, burrowing anemones and tunicates are present in the greatest numbers. Colonial hydroids are present on shell debris and solitary hydroids are scattered throughout each area.

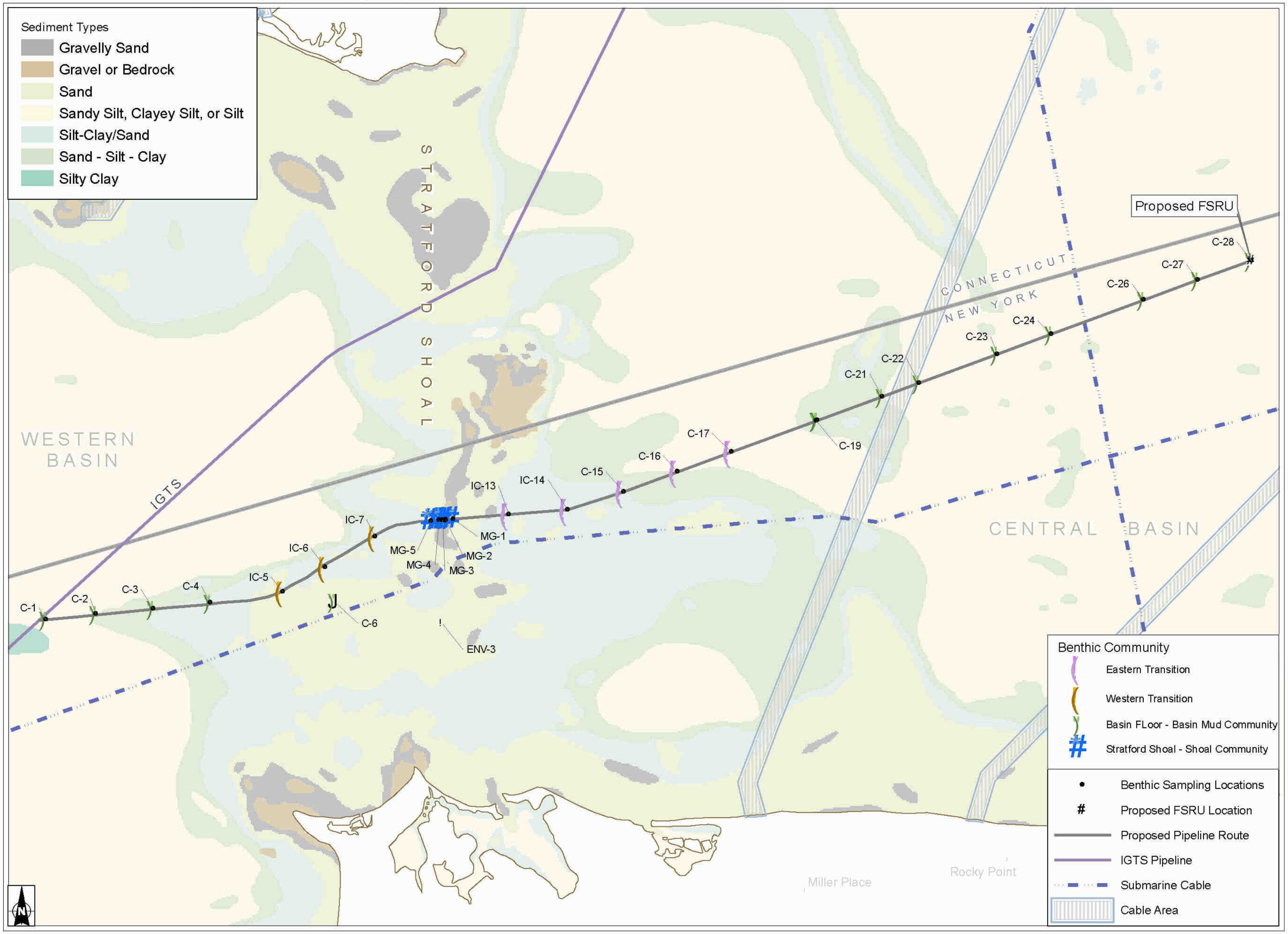
Shoal Community
Stations MG-1, 2 and 3 are located at the Stratford Shoal. Sediment samples collected using a Vibracore classified the bottom sediments found in this area as gravely sand and bedrock. The benthic community found in the sediment at these sites is diverse and complex. Bivalves are present but it is difficult to tell whether the animals are living or the shells are filled with mud. The shell hash is comprised of Mercenaria mercenaria, other clam species, Crepidula sp. and Ensis directis. The bottom sediment is covered by colonies of hydroids and amphipod mats. A spider crab and whelk were observed. Motile organisms at these stations include shrimp and amphipods.

Station ENV -3
The bottom sediment is classified as sandy silt at this location. The benthic community is similar to the rest of the project area with the addition of several species. There is some bottom relief in this area due to shell hash mounds. Horseshoe crabs and two species of fish, one in the Family Gadidae, possibly a four beard rockling, and an unidentified juvenile flatfish, were observed at this site.

IGTS Drift Over
There is some sediment relief and areas of disturbance along this site. The bottom sediments are comprised of silt and sand. Shell hash presence varies from absence to shell mounds. Burrow holes were present but it was difficult to determine if there were animals present. Overall, this station is similar to the other western stations.

References:

Wildish, David and D. Kristmanson. 1997. Benthic Suspension Feeders and Flow. Cambridge University Press:NY.



Source: U.S. Geological Survey Open-File Report OFR 00-304, 2000;
Broadwater Surveys conducted in April/May 2005.

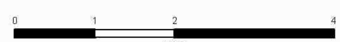


Figure 1 Broadwater Video Locations Based on Spring 2005 Field Surveys

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APPENDIX C

BENTHIC LABORATORY ANALYTICAL RESULTS

Broadwater Energy Benthic Laboratory Analysis
Station C1

TAXON				Sample ID					
				20050471a		20050471b		20050471c	
Class	Order	Family	Genus	C1N	% Abd	C1C	% Abd	C1S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	30	0.240	11	0.037	18	0.088
Bivalvia (juv.)						7	0.024	24	0.117
	Veneroida	Veneridae	*Mercenaria mercenaria*	1	0.008				
		Tellinidae	*Tellina* sp.	1	0.008	2	0.007	4	0.020
	Pholamyoida	Pandoridae	*Pandora gouldiana*	1	0.008				
	Arcoida	Arcidae (juv.)	*Anadara* sp.					1	0.005
	Nuculoida	Nuculidae	*Nucula* sp.					1	0.005
		Nuculanidae	*Yoldia* sp.	6	0.048	3	0.010	3	0.015
Copepoda				26	0.208	207	0.702	81	0.395
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	4	0.032	9	0.031	2	0.010
	Cumacea							1	0.005
	Amphipoda	Aoridae	*Leptocheirus pinguis*			2	0.007	3	0.015
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata*[1]	1	0.008				
	Cephalaspidea	Scphanidridae	*Acteocina canaliculata*[2]					1	0.005
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	15	0.120	4	0.014	5	0.024
	Terebellida	Pectinariidae	*Pectinaria gouldii*					1	0.005
		Ampharetidae	*Ampharete arctica*	2	0.016			3	0.015
			Pista palmata			2	0.007		
	Phyllodocida	Arabellidae	*Driloneries* sp.			1	0.003		
		Nephtyidae	*Nephtys* sp.	22	0.176	22	0.075	29	0.141
		Glyceridae	*Glycera* sp.					1	0.005
	Sabellida	Sabellidae		6	0.048	10	0.034	5	0.024
	Cirratulida	Cirratulidae		6	0.048	14	0.047	21	0.102
	Capitellida	Maldanidae	*Asychis elongata*	3	0.024			1	0.005
	Opheliida	Opheliidae	*Travisia carnea*	1	0.008	1	0.003		
Total # of Organisms Identified				**125**		**295**		**205**	
Total # of Organisms in Sample				**125**		**295**		**205**	
Taxa Richness				**15**		**14**		**19**	
Diversity (H_1)				**2.1**		**1.3**		**2.0**	
Eveness				**1.8**		**1.1**		**1.6**	

Notes:
[1] = *Nassarius trivittata*
[2]= *Retusa canaliculata*

dominant taxa — dominant species, when totaled = at least 50%

Broadwater Energy Benthic Laboratory Analysis
Station C2

TAXON				Sample ID					
Class	Order	Family	Genus	20050346a		20050346b		20050346c	
				C2N	% Abd	C2C	% Abd	C2S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.			4	0.037	2	0.018
Bivalvia (juv.)				8	0.074	47	0.439	39	0.358
	Pholadomyoida	Pandoridae	*Pandora gouldiana*					1	0.009
	Veneroida	Tellinidae	*Tellina* sp.	5	0.046	4	0.037	2	0.018
	Nuculoida	Nuculidae	*Nucula* sp.	2	0.019			2	0.018
		Nuculanidae	*Yoldia* sp.	1	0.009			1	0.009
Copepoda				79	0.731	35	0.327	27	0.248
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.			1	0.009	3	0.028
	Cumacea							1	0.009
Gastropoda	Cephalaspidea	Scaphandridae	*Acteocina canaliculata* [1]	1	0.009	3	0.028		
		Atyidae	*Haminoea solitaria*			2	0.019	2	0.018
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.009	1	0.009	1	0.009
	Terebellida	Ampharetidae	*Ampharete arctica*					4	0.037
			Ampharete sp.			2	0.019		
	Phyllodocida	Glyceridae	*Gylcera* sp.	1	0.009				
		Nephtyidae	*Nephtys* sp.	2	0.019	1	0.009	8	0.073
	Sabellida	Sabellidae		1	0.009				
	Cirratulida	Cirratulidae		7	0.065	7	0.065	16	0.147
Total # of Organisms Identified				**108**		**107**		**109**	
Total # of Organisms in Sample				**630**		**510**		**625**	
Taxa Richness				**11**		**11**		**14**	
Diversity (H_1)				**1.1**		**1.5**		**1.9**	
Eveness				**1.1**		**1.5**		**1.6**	

Notes:
[1] = *Retusa canaliculata*

dominant taxa dominant species

Broadwater Energy Benthic Laboratory Analysis
Station C3

TAXON				Sample ID					
Class	Order	Family	Genus	20050372a		20050372b		20050372c	
				C3N	% Abd	C3C	% Abd	C3S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	3	0.030			6	0.039
Bivalvia (juv.)				37	0.366	62	0.559	78	0.506
	Veneroida	Veneridae	*Mercenaria mercenaria*	1	0.010	2	0.018		
		Tellinidae	*Tellina* sp.	4	0.040	2	0.018	5	0.032
	Nuculoida	Nuculiidae	*Nucula* sp.	1	0.010	5	0.045	6	0.039
		Nuculanidae	*Yoldia* sp.			2	0.018	1	0.006
Copepoda				15	0.149	12	0.108	11	0.071
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.					2	0.013
	Cumacea							1	0.006
	Amphipoda	Aoridae		1	0.010				
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]	2	0.020	3	0.027		
	Cephalaspidea	Atyidae	*Haminoea solitaria*	1	0.010			1	0.006
		Scaphandridae	*Acteocina canaliculata* [2]	1	0.010	1	0.009		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	2	0.020				
	Terebellida	Ampharetidae [3]		1	0.010				
			Ampharete arctica			1	0.009	2	0.013
	Phyllodocida	Nephtyidae	*Nephtys* sp.	6	0.059	9	0.081	13	0.084
	Sabellida	Sabellidae		5	0.050			1	0.006
	Cirratulida	Cirratulidae		20	0.198	12	0.108	26	0.169
	Capitellida	Maldanidae	*Clymenella* sp.	1	0.010				
			Asychis elongata			2	0.018		
Oligochaeta								1	0.006
Total # of Organisms Identified				**101**		**111**		**154**	
Total # of Organisms in Sample				**346**		**368**		**856**	
Taxa Richness				**16**		**12**		**14**	
Diversity (H_1)				**2.0**		**1.5**		**1.7**	
Eveness				**1.7**		**1.4**		**1.5**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* [3]= damaged dominant taxa dominant species

BW001371

Broadwater Energy Benthic Laboratory Analysis
Station C4

TAXON				Sample ID					
Class	Order	Family	Genus	20050345a		20050345b		20050345c	
				C4N	% Abd	C4C	% Abd	C4S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.					2	0.019
Bivalvia (juv.)				39	0.364	59	0.518	42	0.393
	Veneroida	Tellinidae	*Tellina* sp.	7	0.065	3	0.026	1	0.009
	Arcoida	Arcidae (juv.)	*Anadara* sp.					1	0.009
	Nuculoida	Nuculanidae	*Yoldia* sp.	1	0.009				
		Nuculidae	*Nucula* sp.	2	0.019	4	0.035	2	0.019
Copepoda				20	0.187	19	0.167	33	0.308
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	2	0.019				
		Xanthidae	*Panopeus herbstii*	1	0.009				
	Cumacea							1	0.009
	Amphipoda	Ampeliscidae				2	0.018		
Gastropoda	Caernogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.009		
	Cephalspidea	Scaphanidridae	*Acteocina canaliculata* [2]	3	0.028	2	0.018		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.			3	0.026	1	0.009
	Terebellida	Ampharetidae	*Ampharete arctica*	1	0.009			3	0.028
			Melina cristata	1	0.009				
	Phyllodocida	Nephtyidae	*Nephtys* sp.	7	0.065	4	0.035	7	0.065
	Sabellida	Sabellidae						3	0.028
	Cirratulida	Cirratulidae		21	0.196	16	0.140	10	0.093
	Capitellida	Maldanidae	*Clymenella* sp.					1	0.009
			Asychis elongata	2	0.019	1	0.009		
Total # of Organisms Identified				**107**		**114**		**107**	
Total # of Organisms in Sample				**402**		**783**		**1160**	
Taxa Richness				**13**		**11**		**13**	
Diversity (H_1)				**1.9**		**1.6**		**1.7**	
Eveness				**1.7**		**1.5**		**1.5**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* dominant taxa dominant species

Broadwater Energy Benthic Laboratory Analysis
Station IC5

TAXON				Sample ID					
Class	Order	Family	Genus	20050472a		20050472b		20050472c	
				IC5N	% Abd	IC5C	% Abd	IC5S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	28	0.217	14	0.111	10	0.072
Bivalvia (juv.)								42	0.304
	Veneroida	Veneridae	*Mercenaria mercenaria*	2	0.016			2	0.014
		Astartidae	*Astarte undata*	1	0.008				
	Arcoida	Arcidae (juv.)	*Anadara* sp.	4	0.031	12	0.095	5	0.036
	Pholadomyoida	Pandoridae	*Pandora gouldiana*			1	0.008		
Copepoda				21	0.163	13	0.103	28	0.203
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	11	0.085	23	0.183	13	0.094
		Xanthidae	*Panopeus herbstii*	1	0.008				
	Amphipoda	Caprellidae	*Caprella* sp.	1	0.008				
		Ampeliscidae	*Ampelisca* sp.	8	0.062	6	0.048	1	0.007
		Aoridae		2	0.016	6	0.048		
			Leptocheirus pinguis			17	0.135	2	0.014
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]	3	0.023				
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	2	0.016	5	0.040	2	0.014
	Terebellida	Ampharetidae	*Ampharete arctica*	12	0.093	3	0.024	3	0.022
	Phyllodocida	Arabellidae	*Drilonereis* sp.					1	0.007
		Nephtyidae	*Nephtys* sp.	10	0.078	8	0.063	8	0.058
		Phyllodocidae	*Phyllodoce* sp.			3	0.024	2	0.014
	Opheliida	Opheliidae	*Travisia carnea*			2	0.016		
	Sabellida	Sabellidae						2	0.014
	Cirratulida	Cirratulidae		18	0.140	4	0.032	11	0.080
	Capitellida	Maldanidae	*Ayschis elongata*	4	0.031	3	0.024	3	0.022
		Arenicolidae	*Arenicola* sp.			4	0.032	2	0.014
	Eunicida	Onuphidae	*Diopatra cuprea*	1	0.008			1	0.007
Oligochaeta						2	0.016		
Total # of Organisms Identified				**129**		**126**		**138**	
Total # of Organisms in Sample				**698**		**788**		**347**	
Taxa Richness				**17**		**17**		**18**	
Diversity (H_1)				**2.4**		**2.5**		**2.1**	
Eveness				**1.9**		**2.1**		**1.7**	

Notes:
[1] = *Nassarius trivittata* — dominant taxa — dominant species

Broadwater Energy Benthic Laboratory Analysis
Station IC6

TAXON				Sample ID					
Class	Order	Family	Genus	20050371a		20050371b		20050371c	
				IC6N	% Abd	IC6C	% Abd	IC6S	% Abd
Ascidiacea	Pluerogona	Molgulidae	*Molgula* sp.	3	0.031	9	0.148		
Bivalvia (juv.)				3	0.031	21	0.344	43	0.374
	Veneroida	Tellinidae	*Tellina* sp.	1	0.010	2	0.033	2	0.017
	Arcoida	Arcidae (juv.)	*Anadara* sp.			1	0.016	2	0.017
	Pholadomyoida	Pandoridae	*Pandora gouldiana*					1	0.009
Copepoda				48	0.500	7	0.115	38	0.330
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	14	0.146			5	0.043
		Callinassidae	*Gilvossius setimanus* [2]	2	0.021	1	0.016		
Cumacea				1	0.010			1	0.009
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]					4	0.035
		Nactidae	*Euspera heros*			1	0.016	1	0.009
	Cephalaspidea	Atyidae	*Haminoea solitaria*			1	0.016		
		Scaphandridae	*Acteocina canliculata* [3]			4	0.066	1	0.009
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.010				
		Ampharetidae	*Ampharete arctica*	1	0.010	1	0.016		
	Phyllodcida	Arabellidae	*Drilonereis* sp.			1	0.016	1	0.009
		Nephtyidae	*Nephtys* sp.	7	0.073	9	0.148	4	0.035
	Sabellida	Sabellidae		1	0.010				
	Cirratulida	Cirratulidae		12	0.125	3	0.049	13	0.113
	Capitellida	Maldanidae	*Clymenella* sp.	2	0.021				
Total # of Organisms Identified				**96**		**61**		**115**	
Total # of Organisms in Sample				**330**		**61**		**407**	
Taxa Richness				**13**		**13**		**13**	
Diversity (H_1)				**1.7**		**2.0**		**1.7**	
Eveness				**1.5**		**1.8**		**1.5**	

Notes:
[1] = *Nassarius trivittata* [2]= *Callinassa atlantica* [3]= *Retusa canaliculata* dominant taxa

Broadwater Energy Benthic Laboratory Analysis
Station IC7

TAXON				Sample ID					
Class	Order	Family	Genus	20050370a		20050370b		20050370c	
				IC7N	% Abd	IC7C	% Abd	IC7S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	3	0.048	1	0.010	3	0.039
Bivalvia (juv.)				7	0.113	1	0.010	5	0.065
	Veneroida	Tellinidae	*Tellina* sp.	3	0.048				
	Nuculoida	Nuculanidae	*Yoldia* sp.	2	0.032				
Copepoda				2	0.032	16	0.167	2	0.026
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	2	0.032	17	0.177	48	0.623
		Callianassidae	*Gilvossius setimanus* [4]					1	0.013
	Amphipoda[3]			2	0.032				
		Corophiidae	*Corophium sp.*			1	0.010		
		Ampeliscidae				5	0.052		
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			4	0.042	1	0.013
	Cephalaspidea	Atyidae	*Haminoea solitaria*	3	0.048				
		Scaphandridae	*Acteocina canaliculata* [2]	2	0.032	5	0.052	2	0.026
Polychaeta	Terebellida	Pectinariidae	*Pectinaria gouldii*					1	0.013
		Ampharetidae	*Ampharete arctica*			2	0.021	1	0.013
		Arabellidae	*Drilonereis* sp.			1	0.010	2	0.026
	Phyllodocida	Nephtyidae	*Nephtys* sp.	12	0.194	19	0.198	6	0.078
		Glyceridae	*Glycera* sp.	1	0.016	1	0.010		
		Syllidae[3]				2	0.021		
	Sabellida	Sabellidae		2	0.032	2	0.021		
	Cirratulida	Cirratulidae		11	0.177	10	0.104	4	0.052
	Capitellida	Maldanidae	*Clymenella* sp.					1	0.013
Total # of Organisms Identified				**62**		**96**		**77**	
Total # of Organisms in Sample				**62**		**96**		**77**	
Taxa Richness				**13**		**15**		**13**	
Diversity (H_1)				**2.0**		**2.1**		**1.5**	
Eveness				**1.8**		**1.8**		**1.4**	

Notes: [1] = *Nassarius trivittata* [2]= *Retusa canaliculata*
[3]= damaged 4= *Callinassa atlantica*

dominant taxa dominant species, when totaled = at least 50% sam

Broadwater Energy Benthic Laboratory Analysis
Station MG3

TAXON				Sample ID					
Class	Order	Family	Genus	20050343a		20050343b		20050343c	
				MG3N	% Abd	MG3C	% Abd	MG3S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.					1	0.011
Bivalvia	Veneroida	Astartidae	*Astarte undata*	2	0.018			2	0.021
		Solenidae	*Ensis directus*	1	0.009				
	Arcoida	Arcidae (juv.)	*Anadara* sp.			1	0.010	1	0.011
Copepoda						6	0.061		
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	2	0.018	4	0.040		
	Cumacea					1	0.010		
	Amphipoda	Caprellidae	*Caprella* sp.			2	0.020		
		Ampeliscidae	*Ampelisca* sp.	46	0.411	31	0.313	26	0.274
		Aoridae		6	0.054	6	0.061		
			Unciola sp.	17	0.152			12	0.126
Gastropoda	Caenogastropoda	Calyptraeidae	*Crepidula fornicata*					2	0.021
Polychaeta	Spionida	Spionidae	*Polydora* sp.					1	0.011
	Terebellida	Ampharetidae	*Ampharete arctica*	18	0.161	27	0.273	27	0.284
	Phyllodocida	Glyceridae	*Glycera* sp.					1	0.011
		Arabellidae	*Arabella iricolor*					1	0.011
		Nephtyidae	*Nephtys* sp.	9	0.080	10	0.101	14	0.147
		Phyllodocidae	*Eteone* sp.	1	0.009				
			Paraintis speciosa	3	0.027				
			Phyllodoce sp.			2	0.020		
	Cirratulida	Cirratulidae	*Tharyx* sp.					1	0.011
	Capitellida	Maldanidae	*Clymenella* sp.	3	0.027	1	0.010		
	Opheliida	Opheliidae	*Travisia carnea*			1	0.010	1	0.011
		Scalibregmidae	*Scalibregma inflatum*	1	0.009	1	0.010	3	0.032
	Archiannelida	Polygordiidae	*Polygordius* sp.	4	0.036	5	0.051	2	0.021
Stelleroida	Forcipulatida	Asteriidae	*Asterias* sp.			1	0.010		
Total # of Organisms Identified				**112**		**99**		**95**	
Total # of Organisms in Sample				**700**		**438**		**906**	
Taxa Richness				**13**		**14**		**15**	
Diversity (H_1)				**1.9**		**2.0**		**1.9**	
Eveness				**1.7**		**1.8**		**1.7**	

Notes:
[1] = *Nassarius trivittata* dominant taxa

Broadwater Energy Benthic Laboratory Analysis
Station MG4

TAXON				Sample ID					
Class	Order	Family	Genus			20050341b			
						MG4C	% Abd		
Bivalvia	Veneroida	Veneridae	*Mercenaria mercenaria*			1	0.010		
		Astartidae	*Astarte undata*			4	0.039		
Copepoda						6	0.058		
Crustacea	Decapoda	Xanthidae	*Panopues herbstii*			3	0.029		
	Amphipoda	Ampeliscidae	*Ampelisca* sp.			40	0.388		
		Pleustidae				1	0.010		
		Aoridae				3	0.029		
			Leptocheirus pinguis			4	0.039		
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.010		
		Calyptraeidae	*Crepidula fornicata*			2	0.019		
			Crepidula plana			1	0.010		
Polychaeta	Terebellida	Ampharetidae	*Ampharete arctica*			14	0.136		
	Phyllodocida	Glyceridae	*Glycera* sp.			2	0.019		
		Nephtyidae	*Nephtys* sp.			9	0.087		
		Phyllodocidae	*Paranaitis speciosa*			2	0.019		
	Sabellida	Sabellidae				1	0.010		
	Cirratulida	Cirratulidae				3	0.029		
	Opheliida	Opheliidae	*Travisia carnea*			6	0.058		
Total # of Organisms Identified						**103**			
Total # of Organisms in Sample						**774**			
Taxa Richness						**18**			
Diversity (H_1)						**2.1**			
Eveness						**1.7**			

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station MG5

TAXON				Sample ID					
Class	Order	Family	Genus	20050344a		20050344b		20050344c	
				MG5N	% Abd	MG5C	% Abd	MG5S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.			2	0.019		
Bivalvia	Veneroida	Solenidae	*Ensis directus*			1	0.010		
		Astartidae	*Astarte undata*	3	0.030	8	0.076	10	0.109
		Veneridae	*Mercenaria mercenaria*	2	0.020	1	0.010	1	0.011
	Pholadomyoida	Pandoridae	*Pandora gouldiania*	2	0.020				
	Arcoida	Arcidae	*Anadara traversa*	3	0.030			1	0.011
Copepoda				8	0.080	12	0.114	9	0.098
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	1	0.010			2	0.022
		Xanthidae	*Panopeus herbstii*					1	0.011
		Paguridae	*Pagurus longicarpus*	1	0.010				
	Amphipoda	Ampeliscidae		19	0.190	25	0.238	19	0.207
		Aoridae		21	0.210	8	0.076	10	0.109
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.010	2	0.022
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.					1	0.011
	Terebellida	Ampharetidae	*Ampharete arctica*	26	0.260	29	0.276	25	0.272
	Phyllodocida	Nephtyidae	*Nephtys* sp.	12	0.120	11	0.105	9	0.098
		Phyllodocidae	*Eteone* sp.						
		Glyceridae	*Glycera* sp.	1	0.010	1	0.010		
	Cirratulida	Cirratulidae						1	0.011
			Tharyx sp.	3	0.030			1	0.011
	Capitellida	Maldanidae	*Clymenella* sp.			4	0.038		
	Orbiniida	Paraonidae				1	0.010		
Oligochaeta						1	0.010		
Total # of Organisms Identified				**100**		**105**		**92**	
Total # of Organisms in Sample				**480**		**767**		**400**	
Taxa Richness				**13**		**14**		**14**	
Diversity (H_1)				**2.1**		**2.0**		**2.1**	
Eveness				**1.8**		**1.8**		**1.8**	

Notes:
[1] = *Nassarius trivittata*   dominant taxa   dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station IC13

TAXON				Sample ID					
Class	Order	Family	Genus	20050473a		20050473b		20050473c	
				IC13N	% Abd	IC13C	% Abd	IC13S	% Abd
Bivalvia (juv.)						24	0.179	13	0.114
	Veneroida	Veneridae	*Mercenaria mercenaria*	1	0.009			2	0.018
	Pholadomyoida	Pandoridae	*Pandora gouldiana*			1	0.007		
		Lyonsiidae	*Lyonsia hyalina*	2	0.018				
	Arcoida	Arcidae	*Anadara traversa*	4	0.035	21	0.157	8	0.070
Copepoda				6	0.053	16	0.119	10	0.088
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	20	0.177	8	0.060	8	0.070
	Amphipoda	Aoridae		14	0.124	18	0.134	11	0.096
			Leptocheirus pinguis	6	0.053	2	0.015	8	0.070
		Ampelliscidae	*Ampelisca sp.*	20	0.177	5	0.037	14	0.123
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]	1	0.009	2	0.015		
		Calyptraedae	*Crepidula plana*	1	0.009				
	Pyramidellamorpha	Pyramidellidae				5	0.037		
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.					1	0.009
		Ampharetidae	*Ampharete arctica*	8	0.071	9	0.067	5	0.044
	Phyllodocida	Arabellidae	*Arabella iricolor*						
		Nephtyidae	*Nephtys* sp.	10	0.088	8	0.060	16	0.140
		Glyceridae	*Glycera sp.*	2	0.018	3	0.022		
		Phyllodocidae	*Phyllodoce* sp.			1	0.007		
		Syllidae		2	0.018				
	Sabellida	Sabellidae		1	0.009	1	0.007		
	Opheliida	Opheliidae	*Travisia carnea*			1	0.007		
	Capitellida	Maldanidae	*Asychis elongata*	11	0.097	9	0.067	18	0.158
		Arenicolidae	*Arenicola* sp.	3	0.027				
Oligochaeta				1	0.009				
Total # of Organisms Identified				**113**		**134**		**114**	
Total # of Organisms in Sample				**920**		**1130**		**751**	
Taxa Richness				**18**		**17**		**12**	
Diversity (H_1)				**2.4**		**2.4**		**2.1**	
Eveness				**1.9**		**2.0**		**1.9**	

Notes:
[1] = *Nassarius trivittata*   dominant taxa   dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station IC14

TAXON				Sample ID					
Class	Order	Family	Genus	20050474a		20050474b		20050474c	
				IC14N	% Abd	IC14C	% Abd	IC14S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	2	0.017	6	0.042	5	0.027
Bivalvia (juv.)				30	0.250	28	0.194	6	0.033
	Veneroida	Veneridae	*Mercenaria mercenaria*	2	0.017				
		Tellinidae	*Tellina* sp.	1	0.008	3	0.021	1	0.005
	Arcoida	Arcidae (juv.)	*Anadara* sp.	4	0.033	1	0.007	7	0.038
	Pholadomyoida	Pandoridae	*Pandora gouldiana*	3	0.025	3	0.021	1	0.005
	Nuculoida	Nuculanidae	*Yoldia* sp.			2	0.014	1	0.005
Copepoda				27	0.225	44	0.306	112	0.615
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	1	0.008	6	0.042	7	0.038
		Xanthidae	*Panopeus herbstii*			1	0.007	1	0.005
	Amphipoda	Aoridae		15	0.125	9	0.063	7	0.038
			Leptocheirus pinguis	2	0.017	2	0.014		
		Ampeliscidae	*Ampelisca sp.*	12	0.100	17	0.118	12	0.066
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.007		
	Pyramidellomorpha	Pyramellidae						2	0.011
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.			1	0.007		
	Terebellida	Ampharetidae	*Ampharete arctica*	2	0.017	1	0.007		
	Phyllodocida	Arabellidae	*Driloneries* sp.			1	0.007		
		Nephtyidae	*Nephtys* sp.	7	0.058	10	0.069	10	0.055
		Sylliidae				1	0.007		
	Sabellida	Sabellidae		3	0.025	1	0.007	2	0.011
	Cirratulida	Cirratulidae		1	0.008			8	0.044
	Capitellida	Maldanidae	*Asychis elongata*	8	0.067	6	0.042		
Total # of Organisms Identified				**120**		**144**		**182**	
Total # of Organisms in Sample				**120**		**144**		**182**	
Taxa Richness				**16**		**20**		**15**	
Diversity (H_1)				**2.2**		**2.2**		**1.6**	
Eveness				**1.8**		**1.7**		**1.3**	

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C15

TAXON				Sample ID					
Class	Order	Family	Genus	20050369a		20050369b		20050369c	
				C15N	% Abd	C15C	% Abd	C15S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	5	0.051	11	0.095		
Bivalvia (juv.)				37	0.378	67	0.578	63	0.600
	Veneroida	Veneridae	*Mercenaria mercenaria*			3	0.026		
		Tellinidae	*Tellina* sp.	9	0.092	3	0.026		
	Arcoida	Arcidae (juv.)	*Anadara* sp.					2	0.019
	Pholadomyoida	Pandoridae	*Pandora gouldiana*	1	0.010	1	0.009		
Copepoda				9	0.092				
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	2	0.020	5	0.043	3	0.029
		Xanthidae	*Panopeus herbstii*	1	0.010				
	Cumacea							2	0.019
	Amphipoda	Ampeliscidae						6	0.057
		Corophiidae	*Corophium sp.*					5	0.048
		Aoridae				2	0.017		
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata*[1]	2	0.020			2	0.019
	Cephalaspidea	Atyidae	*Haminoea solitaria*	3	0.031	1	0.009	1	0.010
		Scaphanidridae	*Acteocina canaliculata*[2]	4	0.041	4	0.034	3	0.029
	Pyramidellomorpha	Pyramellidae		2	0.020	3	0.026		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.010	1	0.009		
	Phyllodocida	Arabellidae	*Drilonereis* sp.	1	0.010				
		Nephtyidae	*Nephtys* sp.	9	0.092	8	0.069	6	0.057
	Sabellida	Sabellidae		1	0.010			2	0.019
	Cirratulida	Cirratulidae		3	0.031			2	0.019
	Capitellida	Maldanidae	*Clymenella* sp.	4	0.041	4	0.034	4	0.038
			Asychis elongata	4	0.041	3	0.026	4	0.038
Total # of Organisms Identified				**98**		**116**		**105**	
Total # of Organisms in Sample				**211**		**500**		**273**	
Taxa Richness				**18**		**14**		**14**	
Diversity (H_1)				**2.3**		**1.7**		**1.7**	
Eveness				**1.8**		**1.5**		**1.4**	

Notes:
[1] = *Nassarius trivittata* [2] =*Retusa canaliculata* dominant taxa dominant species, when totaled = at least 50% sam|

Broadwater Energy Benthic Laboratory Analysis
Station C16

TAXON				Sample ID					
Class	Order	Family	Genus	20050349a		20050349b		20050349c	
				C16N	% Abd	C16C	% Abd	C16S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	4	0.040	2	0.021	2	0.021
Bivalvia (juv.)				11	0.109	10	0.106	21	0.221
	Veneroida	Veneridae	*Mercenaria mercenaria*			3	0.032		
		Tellinidae	*Tellina* sp.			1	0.011		
	Nuculoida	Nuculidae	*Nucula* sp.	2	0.020				
		Nuculanidae	*Yoldia* sp.	4	0.040	4	0.043		
Copepoda				44	0.436	33	0.351	18	0.189
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	5	0.050	10	0.106	16	0.168
		Xanthidae	*Panopeus herbstii*	1	0.010			1	0.011
	Cumacea					3	0.032	2	0.021
	Amphipoda	Caprellidae	*Caprella* sp.					3	0.032
		Corophiidae						3	0.032
			Corophium sp.			1	0.011		
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.011		
	Cephalaspidea	Atyidae	*Haminoea solitaria*	4	0.040	1	0.011		
		Scaphanidridae	*Acteocina canaliculata* [2]	6	0.059	4	0.043	2	0.021
	Pyramidellomorpha	Pyramellidae		8	0.079	4	0.043		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	2	0.020	2	0.021	4	0.042
	Terebellida	Ampharetidae	*Ampharete arctica*			3	0.032	1	0.011
	Phyllodocida	Nereidae	*Nereis succinea*					1	0.011
		Glyceridae	*Glycera* sp.			1	0.011		
		Arabellidae	*Arabella iricolor*						
		Nephtyidae	*Nephtys* sp.	6	0.059	4	0.043	5	0.053
	Sabellida	Sabellidae		3	0.030	3	0.032	2	0.021
	Cirratulida	Cirratulidae				3	0.032		
	Capitellida	Maldanidae	*Clymenella* sp.	1	0.010	1	0.011	2	0.021
Total # of Organisms Identified				**101**		**94**		**95**	
Total # of Organisms in Sample				**240**		**270**		**365**	
Taxa Richness				**14**		**20**		**15**	
Diversity (H_1)				**2.0**		**2.4**		**2.0**	
Eveness				**1.8**		**1.8**		**1.7**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C17

TAXON				Sample ID					
				20050348a		20050348b		20050348c	
Class	Order	Family	Genus	C17N	% Abd	C17C	% Abd	C17S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	8	0.105	3	0.039	2	0.027
Bivalvia (juv.)				14	0.184	11	0.143	8	0.110
	Pholadomyoida	Pandoridae	*Pandora gouldiana*			1	0.013	1	0.014
	Veneroida	Veneridae	*Mercenaria mercenaria*	2	0.026				
		Tellinidae	*Tellina* sp.	6	0.079	9	0.117	3	0.041
	Arcoida	Arcidae (juv.)	*Anadara* sp.			1	0.013		
	Nuculoida	Nuculidae	*Nucula* sp.	2	0.026	2	0.026	2	0.027
Copepoda				6	0.079	8	0.104	14	0.192
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	8	0.105	7	0.091	17	0.233
	Cumacea							1	0.014
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]	1	0.013				
	Cephalaspidea	Atyidae	*Haminoea solitaria*	4	0.053	1	0.013		
		Scaphanidridae	*Ateocina canaliculata* [2]	9	0.118	7	0.091	4	0.055
	Pyramidellomorpha	Pyramellidae		1	0.013	4	0.052	1	0.014
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	4	0.053			1	0.014
	Terebellida	Ampharetidae	*Ampharete arctica*	1	0.013	2	0.026		
	Phyllodocida	Arabellidae	*Drilonereis* sp.					1	0.014
		Nephtyidae	*Nephtys* sp.	5	0.066	2	0.026	8	0.110
	Sabellida	Sabellidae		4	0.053	18	0.234	7	0.096
	Cirratulida	Cirratulidae							
	Capitellida	Maldanidae	*Clymenella* sp.	1	0.013			3	0.041
			Asychis elongata			1	0.013		
Total # of Organisms Identified				**76**		**77**		**73**	
Total # of Organisms in Sample				**76**		**77**		**73**	
Taxa Richness				**16**		**15**		**15**	
Diversity (H_1)				**2.5**		**2.3**		**2.3**	
Eveness				**2.1**		**2.0**		**1.9**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa cnaliculata* dominant taxa dominant species, when totaled = at least 50% sam

Broadwater Energy Benthic Laboratory Analysis
Station C18

TAXON				Sample ID					
Class	Order	Family	Genus	20050318a		20050318b		20050318c	
				C18N	% Abd	C18C	% Abd	C18S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	5	0.041	3	0.027	5	0.053
Bivalvia (juv.)				7	0.057	3	0.027	3	0.032
	Veneroida	Solenidae	*Ensis directus*	1	0.008				
		Tellinidae	*Tellina* sp.	4	0.033	1	0.009	2	0.021
	Arcoida	Arcidae (juv.)	*Anadara traversa*			1	0.009		
	Nuculoida	Nuculanidae							
Copepoda				17	0.138	6	0.054	17	0.181
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	29	0.236	8	0.071	3	0.032
		Xanthidae	*Panopeus herbstii*					2	0.021
	Cumacea					1	0.009		
	Amphipoda	Aoridae	*Leptocheirus pinguis*	14	0.114	19	0.170	6	0.064
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]	3	0.024			3	0.032
		Calyptraedae	*Crepidula fornicata*	1	0.008			2	0.021
	Pyramidellomorpha	Pyramellidae						1	0.011
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.008			1	0.011
	Terebellida	Pectinariidae	*Pectinaria gouldii*			1	0.009	1	0.011
		Ampharetidae	*Ampharete arctica*	8	0.065	13	0.116	8	0.085
	Phyllodocida	Glyceridae	*Glycera* sp.	2	0.016	1	0.009	1	0.011
		Nephtyidae	*Nephtys* sp.	22	0.179	22	0.196	21	0.223
		Phyllodocidae	*Phyllodoce* sp.			2	0.018		
			Paranaitis speciosa	2	0.016			3	0.032
	Sabellida	Sabellidae		2	0.016	2	0.018		
	Cirratulida	Cirratulidae				1	0.009	1	0.011
	Capitellida	Maldanidae	*Clymenella* sp.	5	0.041	21	0.188	6	0.064
			Asychis elongata					8	0.085
	Opheliida	Ophellidae	*Travisia carnea*			2	0.018		
Oligochaeta						6	0.054		
Total # of Organisms Identified				**123**		**112**		**94**	
Total # of Organisms in Sample				**1386**		**1220**		**1400**	
Taxa Richness				**16**		**18**		**19**	
Diversity (H_1)				**2.3**		**2.3**		**2.5**	
Eveness				**1.9**		**1.9**		**2.0**	

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C19

TAXON				Sample ID					
Class	Order	Family	Genus	20050319a		20050319b		20050319c	
				C19N	% Abd	C19C	% Abd	C19S	% Abd
Bivalvia (juv.)				3	0.033	3	0.028	7	0.056
	Veneroida	Veneridae	*Mercenaria mercenaria*	1	0.011				
		Tellinidae	*Tellina* sp.			4	0.038	3	0.024
	Arcoida	Arcidae (juv.)	*Anadara* sp.	2	0.022	3	0.028		
Copepoda				17	0.185	26	0.245	53	0.421
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.			3	0.028	2	0.016
		Paguridae	*Pagurus longicarpus*	1	0.011			2	0.016
		Callinassidae	*Gilvossius setimenus* [2]			1	0.009	1	0.008
	Amphipoda	Ampelliscidae	*Ampelisca* sp.	2	0.022	2	0.019	7	0.056
		Aoridae		4	0.043	6	0.057	3	0.024
			Leptocheirus pinguis	4	0.043	6	0.057		
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			2	0.019	1	0.008
		Calyptereidae	*Crepidula fornicata*			7	0.066		
	Pyramidellomorpha	Pyramellidae				5	0.047		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.011	4	0.038	2	0.016
	Orbiniida	Orbiniidae	*Scoloplos fragilis*			1	0.009		
	Terebellida	Ampharetidae	*Ampharete arctica*	24	0.261	13	0.123	17	0.135
	Phyllodocida	Glyceridae	*Glycera* sp.	2	0.022			1	0.008
		Nephtyidae	*Nephtys* sp.	14	0.152	13	0.123	16	0.127
		Phyllodocidae	*Phyllodoce* sp.	1	0.011			1	0.008
	Sabellida	Sabellidae		2	0.022	3	0.028	2	0.016
	Cirratulida	Cirratulidae		2	0.022			3	0.024
	Capitellida	Maldanidae	*Asychis elongata*	5	0.054	5	0.047	5	0.040
	Opheliida	Opheliidae	*Travisia carnea*	6	0.065	1	0.009		
		Scalibregmidae	*Scalibregma inflatum*	1	0.011				
Oligochaeta				2	0.022				
Total # of Organisms Identified				**92**		**106**		**126**	
Total # of Organisms in Sample				**1034**		**1220**		**970**	
Taxa Richness				**19**		**19**		**17**	
Diversity (H_1)				**2.4**		**2.6**		**2.0**	
Eveness				**1.9**		**2.0**		**1.6**	

Notes:
[1] = *Nassarius trivittata* [2]= *Callinassa atlantica* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C20

TAXON				Sample ID					
Class	Order	Family	Genus	20050342a		20050342b		20050342c	
				C20N	% Abd	C20C	% Abd	C20S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.			2	0.018		
Bivalvia	Veneroida	Veneridae	*Mercenaria mercenaria*	2	0.022	7	0.062	1	0.007
		Tellinidae	*Tellina* sp.			1	0.009	1	0.007
	Arcoida	Arcidae (juv.)	*Anadara* sp.	2	0.022	1	0.009	4	0.027
Copepoda				1	0.011	3	0.027		
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.			2	0.018	7	0.047
		Xanthidae	*Panopeus herbstii*	2	0.022			9	0.060
	Cumacea					1	0.009		
	Amphipoda	Aoridae		5	0.055	15	0.133	14	0.093
			Leptocheirus pinguis	6	0.066	1	0.009	4	0.027
		Ampeliscidae	*Ampelisca* sp.	7	0.077	16	0.142	26	0.173
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			1	0.009		
		Calyptraeidae	*Crepidula plana*	12	0.132			34	0.227
			Crepidula fornicata	6	0.066			10	0.067
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.011	4	0.035	2	0.013
	Terebellida	Pectinariidae	*Pectinaria gouldii*						
		Ampharetidae	*Ampharete arctica*	17	0.187	19	0.168	14	0.093
	Phyllodocida	Glyceridae	*Glycera* sp.	1	0.011				
		Nephtyidae	*Nephtys* sp.	19	0.209	14	0.124	9	0.060
		Phyllodocidae	*Paranaitis speciosa*					1	0.007
	Sabellida	Sabellidae		3	0.033	4	0.035	2	0.013
	Cirratulida	Cirratulidae		1	0.011			4	0.027
	Capitellida	Maldanidae	*Asychis elongata*	3	0.033	16	0.142	10	0.067
	Opheliida	Opheliidae	*Travisia carnea*	3	0.033	1	0.009	1	0.007
Oligochaeta								1	0.006667
Total # of Organisms Identified				**91**		**113**		**150**	
Total # of Organisms in Sample				**483**		**113**		**150**	
Taxa Richness				**17**		**17**		**18**	
Diversity (H_1)				**2.4**		**2.3**		**2.5**	
Eveneness				**2.0**		**1.9**		**2.0**	

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C21

TAXON				Sample ID					
Class	Order	Family	Genus	20050475a		20050475b		20050475c	
				C21	% Abd	C21C	% Abd	C21S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	4	0.037	2	0.016	4	0.034
Bivalvia	Veneroida	Solenidae	*Ensis directus*	4	0.037	2	0.016		
		Veneridae	*Mercenaria mercenaria*			2	0.016	2	0.017
		Tellinidae	*Tellina* sp.	2	0.019	5	0.039	3	0.025
		Astartidae	*Astarte undata*	1	0.009			1	0.008
	Pholadomyoida	Pandoridae	*Pandora gouldiana*	1	0.009	3	0.023	1	0.008
Copepoda				13	0.120	12	0.094	15	0.127
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	23	0.213	18	0.141	23	0.195
		Majidae	*Libinia emarginata*					1	0.008
	Amphipoda	Aoridae				10	0.078	4	0.034
			Leptocheirus pinguis	13	0.120	7	0.055	13	0.110
		Ampeliscidae	*Ampelisca* sp.	15	0.139	21	0.164	21	0.178
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	1	0.009			5	0.042
	Terebellida	Ampharetidae	*Ampharete arctica*	8	0.074	19	0.148	6	0.051
		Nephtyidae	*Nephtys* sp.	17	0.157	15	0.117	11	0.093
		Phyllodocidae	*Phyllodoce* sp.			1	0.008		
		Glyceridae	*Glycera* sp.	2	0.019	3	0.023	1	0.008
	Sabellida	Sabellidae		1	0.009			2	0.017
	Cirratulida	Cirratulidae				1	0.008	1	0.008
	Capitellida	Maldanidae	*Asychis elongata*			7	0.055	4	0.034
		Arenicolidae	*Arenicola* sp.	3	0.028				
Total # of Organisms Identified				**108**		**128**		**118**	
Total # of Organisms in Sample				**690**		**1120**		**674**	
Taxa Richness				**15**		**16**		**18**	
Diversity (H_1)				**2.3**		**2.4**		**2.4**	
Eveness				**1.9**		**2.0**		**1.9**	

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C22

TAXON				Sample ID					
Class	Order	Family	Genus	20050476a		20050476b		20050476c	
				C22N	% Abd	C22C	% Abd	C22S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	12	0.200	8	0.129	7	0.140
Bivalvia (juv.)						4	0.065	2	0.040
	Veneroida	Veneridae	*Mercenaria mercenaria*					2	0.040
	Pholadomyoida	Pandoridae	*Pandora gouldiana*	2	0.033				
	Nuculoida	Nuculanidae	*Yoldia* sp.	2	0.033	1	0.016		
Copepoda				11	0.183	3	0.048	2	0.040
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	7	0.117	6	0.097	4	0.080
		Callinassidae	*Gilvossius setamanus* [2]	1	0.017				
	Cumacea							1	0.020
	Amphipoda	Ampellisicidae	*Ampelisca* sp.	2	0.033	3	0.048	3	0.060
		Aoridae		3	0.050	7	0.113	7	0.140
Gastropoda	Cephalaspidea	Scaphanidridae	*Acteocina canaliculata* [1]					1	0.020
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	1	0.017				
	Terebellida	Pectinariidae	*Pectinaria gouldii*						
		Ampharetidae	*Pista palmata*	2	0.033				
			Ampharete sp.			3	0.048		
	Phyllodocida	Arabellidae	*Drilonereis* sp.	1	0.017				
		Nephtyidae	*Nephtys* sp.	10	0.167	13	0.210	13	0.260
		Glyceridae	*Glycera* sp.			1	0.016	1	0.020
		Nereidae	Nereis succinea			1	0.016		
	Sabellida	Sabellidae		1	0.017	3	0.048	5	0.100
	Cirratulida	Cirratulidae							
	Capitellida	Maldanidae	*Asychis elongata*	5	0.083	9	0.145	2	0.040
Total # of Organisms Identified				**60**		**62**		**50**	
Total # of Organisms in Sample				**60**		**62**		**50**	
Taxa Richness				**14**		**13**		**13**	
Diversity (H_1)				**2.3**		**2.1**		**2.3**	
Eveness				**2.0**		**1.9**		**2.0**	

Notes:

[1] = *Retusa canaliculata* [2]= *Callinassa atlantica* dominant taxa dominant species, when totaled = at least 50%

Broadwater Energy Benthic Laboratory Analysis
Station C23

TAXON				Sample ID					
Class	Order	Family	Genus	20050479a		20050479b		20050479c	
				C23N	% Abd	C23C	% Abd	C23S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	11	0.089	4	0.036	9	0.057
Bivalvia (juv.)				9	0.073	11	0.098	20	0.127
	Veneroida	Veneridae	*Mercenaria mercenaria*					6	0.038
	Pholadomyoida	Pandoridae	*Pandora gouldiana*					3	0.019
	Arcidae	Arcidae (juv.)	*Anadara* sp.			1	0.009		
	Nuculoida	Nuculanidae	Sabellidae			2	0.018	16	0.102
Copepoda				83	0.669	55	0.491	9	0.057
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	4	0.032	3	0.027	2	0.013
		Xanthidae	*Panopeus herbstii*						
	Cumacea			1	0.008			6	0.038
	Amphipoda	Aoridae		2	0.016	3	0.027	2	0.013
		Ampeliscidae	*Ampelisca* sp.					8	0.051
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]			3	0.027	3	0.019
	Pyramidellomorpha	Pyramellidae		1	0.008	16	0.143	20	0.127
	Cephalaspidea	Atyidae	*Haminoea solitaria*					4	0.025
		Scaphanidrdae	*Acteocina canaliculata* [2]	4	0.032	2	0.018	2	0.013
Polychaeta	Terebellida	Pectinariidae	*Pectinaria gouldii*			1	0.009		
		Ampharetidae	*Ampharete arctica*						
			Melina cristata					1	0.006
	Phyllodocida	Arabellidae	*Drilonereis* sp.					1	0.006
		Nephtyidae	*Nephtys* sp.	6	0.048	4	0.036	12	0.076
		Nereidae	*Nereis succinea*			1	0.009	2	0.013
	Sabellida	Sabellidae		3	0.024	1	0.009	9	0.057
	Cirratulida	Cirratulidae				1	0.009		
	Capitellida	Maldanidae	*Asychis elongata*			2	0.018	10	0.064
Total # of Organisms Identified				**124**		**112**		**157**	
Total # of Organisms in Sample				**481**		**112**		**157**	
Taxa Richness				**10**		**16**		**20**	
Diversity (H_1)				**1.3**		**1.8**		**2.6**	
Eveness				**1.3**		**1.5**		**2.0**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* dominant taxa dominant species, when totaled = at least 50% sa

Broadwater Energy Benthic Laboratory Analysis
Station C24

TAXON				Sample ID					
Class	Order	Family	Genus	20050480a		20050480b		20050480c	
				C24N	% Abd	C24C	% Abd	C24S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	7	0.069	15	0.156	15	0.133
Bivalvia (juv.)				8	0.078	5	0.052	13	0.115
	Veneroida	Veneridae	*Mercenaria mercenaria*			1	0.010		
		Tellinidae	*Tellina* sp.					3	0.027
	Pholadomyoida	Pandoridae	*Pandora gouldiana*			1	0.010	2	0.018
	Nuculoida	Nuculanidae	*Yoldia* sp.	2	0.020	3	0.031	2	0.018
Copepoda				17	0.167	9	0.094	13	0.115
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	21	0.206	7	0.073	4	0.035
		Callinassidae	*Gilvossius setimenus* [3]	1	0.010	1	0.010		
	Cumacea			1	0.010	3	0.031	1	0.009
	Amphipoda	Aoridae		6	0.059	5	0.052	7	0.062
		Ampeliscidae	*Ampelisca* sp.	5	0.049	9	0.094	2	0.018
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]					2	0.018
	Pyramidellamorpha	Pyramidellidae		1	0.010			2	0.018
	Cephalaspidea	Atyidae	*Haminoea solitaria*			1	0.010	1	0.009
		Scaphanididrae	*Acteocina canaliculata* [2]	1	0.010	2	0.021	1	0.009
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	3	0.029			3	0.027
	Terebellida	Ampharetidae	*Ampharete arctica*	4	0.039			6	0.053
			Melina cristata			1	0.010	1	0.009
	Phyllodocida	Nephtyidae	*Nephtys* sp.	12	0.118	20	0.208	22	0.195
		Nereidae	*Nereis succinea*					3	0.027
		Sylliidae				2	0.021		
	Sabellida	Sabellidae		7	0.069			3	0.027
	Capitellida	Maldanidae	*Asychis elongata*	6	0.059	5	0.052	7	0.062
Total # of Organisms Identified				**102**		**96**		**113**	
Total # of Organisms in Sample				**102**		**96**		**113**	
Taxa Richness				**16**		**17**		**21**	
Diversity (H_1)				**2.3**		**2.3**		**2.6**	
Eveness				**1.9**		**1.9**		**2.0**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* [3]= *Callinassa atlantica* dominant taxa dominant species, when totaled = at least !

Broadwater Energy Benthic Laboratory Analysis
Station C25

TAXON				Sample ID					
Class	Order	Family	Genus	20050482a		20050482b		20050482c	
				C25N	% Abd	C25C	% Abd	C25S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	5	0.050	24	0.182	4	0.037
Bivalvia (juv.)				6	0.060	8	0.061	34	0.312
	Veneroida	Veneridae	*Mercenaria mercenaria*	1	0.010	3	0.023		
	Pholadomyoida	Pandoridae	*Pandora gouldinana*	2	0.020	2	0.015		
	Arcoida	Arcidae (juv.)	*Anadara* sp.			2	0.015	1	0.009
	Nuculoida	Nuculanidae	*Yoldia* sp.	3	0.030	2	0.015	4	0.037
		Nuculidae	*Nucula* sp.	1	0.010				
Copepoda				6	0.060	9	0.068	2	0.018
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	12	0.120	5	0.038	8	0.073
		Xanthidae	*Panopeus herbstii*			2	0.015		
	Cumacea					1	0.008		
	Amphipoda	Aoridae		1	0.010	5	0.038		
		Ampeliscidae	*Ampelisca* sp.	3	0.030	17	0.129	7	0.064
Gastropoda	Pyramidellomorpha	Pyramidellidae		1	0.010				
	Cephalaspidea	Atyidae	*Haminoea solitaria*	3	0.030	1	0.008	1	0.009
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.	4	0.040	2	0.015	4	0.037
	Terebellida	Ampharetidae	*Ampharete arctica*	2	0.020			3	0.028
			Melina cristata	2	0.020	3	0.023	4	0.037
			Pista palmata			2	0.015		
	Phyllodocida	Arabellidae	*Drilonereis* sp.					1	0.009
		Nephtyidae	*Nephtys* sp.	16	0.160	19	0.144	21	0.193
		Phyllodocidae	*Eteone* sp.						
		Nereidae	*Nereis succinea*	4	0.040	4	0.030	2	0.018
		Polynoidae	*Harmothoe* sp.	1	0.010				
	Sabellida	Sabellidae		13	0.130	11	0.083	4	0.037
	Cirratulida	Cirratulidae		1	0.010	7	0.053		
	Capitellida	Maldanidae	*Asychis elongata*	13	0.130	2	0.015	9	0.083
Total # of Organisms Identified				**100**		**132**		**109**	
Total # of Organisms in Sample				**100**		**132**		**109**	
Taxa Richness				**21**		**21**		**16**	
Diversity (H_1)				**2.6**		**2.6**		**2.2**	
Eveness				**2.0**		**2.0**		**1.9**	

Notes: dominant taxa; dominant species, when totaled = at least 50% sample

Broadwater Energy Benthic Laboratory Analysis
Station C26

TAXON				Sample ID					
Class	Order	Family	Genus	20050481a		20050481b		20050481c	
				C26N	% Abd	C26C	% Abd	C26S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	11	0.056			11	0.111
Bivalvia (juv.)				13	0.067	1	0.056	11	0.111
	Veneroida	Veneridae	*Mercenaria mercenaria*	5	0.026			4	0.040
	Nuculoida	Nuculanidae	*Yoldia* sp.	2	0.010			4	0.040
Copepoda				33	0.169			12	0.121
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	22	0.113	3	0.167	5	0.051
		Porcellanidae	*Polyonyx gibbesi*			2	0.111		
		Callinassidae	*Gilvossius setemanus* [2]	1	0.005				
	Cumacea			4	0.021			1	0.010
	Amphipoda	Ampeliscidae	*Ampelisca* sp.	11	0.056	3	0.167	9	0.091
		Aoridae						1	0.010
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]					2	0.020
	Cephalaspidea	Scaphanidridae	*Acteocina canaliculata* [3]	1	0.005				
		Atyidae	*Haminoea solitaria*					2	0.020
Polychaeta	Flabellgerida	Flabelligeridae	*Pherusa* sp.					2	0.020
	Terebellida	Ampharetidae	*Ampharete arctica*	6	0.031				
	Phyllodocida	Nephtyidae	*Nephtys* sp.	17	0.087	4	0.222	18	0.182
		Sylliidae				1	0.056	5	0.051
	Sabellida	Sabellidae		4	0.021	2	0.111	6	0.061
	Cirratulida	Cirratulidae		63	0.323			4	0.040
	Capitellida	Maldanidae	*Clymenella* sp.					1	0.010
			Asychis elongata	2	0.010			1	0.010
Total # of Organisms Identified				**195**		**18**		**99**	
Total # of Organisms in Sample				**195**		**18**		**99**	
Taxa Richness				**15**		**7**		**18**	
Diversity (H_1)				**2.1**		**1.7**		**2.6**	
Eveness				**1.8**		**2.1**		**2.0**	

Notes:
[1] = *Nassarius trivittata* [2]= *Callinassa atlantica* [3]= *Retusa canaliculata* dominant taxa dominant species, when totaled = at least

Broadwater Energy Benthic Laboratory Analysis
Station C27

TAXON				Sample ID					
Class	Order	Family	Genus	20050477a		20050477b		20050477c	
				C27N	% Abd	C27C	% Abd	C27S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	15	0.096	10	0.072	11	0.089
Bivalvia (juv.)								4	0.033
	Veneroida	Veneridae	*Mercenaria mercenaria*	6	0.038	4	0.029	3	0.024
		Tellinidae	*Tellina* sp.	2	0.013	2	0.014		
	Nuculoida	Nuculidae	*Nucula* sp.	1	0.006	2	0.014		
		Nuculanidae	*Yoldia* sp.			3	0.022		
Copepoda				26	0.167	27	0.196	9	0.073
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	10	0.064	2	0.014	2	0.016
	Cumacea					2	0.014		
	Amphipoda	Ampelisicidae	*Ampelisca* sp.	10	0.064	3	0.022	6	0.049
Gastropoda	Caenogastropoda	Nassariidae	*Ilyanassa trivittata* [1]					1	0.008
	Cephalaspidea	Atyidae	*Haminoea solitaria*			5	0.036		
		Scaphanidridae	*Acteocina canaliculata* [2]			1	0.007		
	Pyramidellomorpha	Pyramellidae		1	0.006	1	0.007		
Polychaeta	Flabelligerida	Flabelligeridae	*Pherusa* sp.	1	0.006	1	0.007	1	0.008
	Terebellida	Pectinariidae	*Pectinaria gouldii*						
		Ampharetidae	*Ampharete arctica*	5	0.032			1	0.008
			Pista palmata			1	0.007		
			Melina cristata			3	0.022	1	0.008
	Phyllodocida	Nephtyidae	*Nephtys* sp.	21	0.135	10	0.072	29	0.236
		Nereididae	*Nereis succinea*					1	0.008
	Sabellida	Sabellidae		8	0.051	13	0.094	7	0.057
	Cirratulida	Cirratulidae		47	0.301	43	0.312	42	0.341
	Capitellida	Maldanidae	*Asychis elongata*	1	0.006			2	0.016
			Clymenella sp.	2	0.013	5	0.036	3	0.024
Total # of Organisms Identified				**156**		**138**		**123**	
Total # of Organisms in Sample				**156**		**138**		**123**	
Taxa Richness				**15**		**19**		**16**	
Diversity (H_1)				**2.1**		**2.3**		**2.0**	
Eveness				**1.8**		**1.8**		**1.7**	

Notes:
[1] = *Nassarius trivittata* [2]= *Retusa canaliculata* dominant taxa dominant species, when totaled = at least 50% samp

Broadwater Energy Benthic Laboratory Analysis
Station C28

TAXON				Sample ID					
Class	Order	Family	Genus	20050478a		200504787b		20050478c	
				C28N	% Abd	C28C	% Abd	C28S	% Abd
Ascidiacea	Pleurogona	Molgulidae	*Molgula* sp.	27	0.229	21	0.172	12	0.061
Bivalvia (juv.)				2	0.017	13	0.107	10	0.051
	Veneroida	Veneridae	*Mercenaria mercenaria*			7	0.057	6	0.030
		Tellinidae	*Tellina* sp.	1	0.008	1	0.008		
	Pholadomyoida	Pandoridae	*Pandora gouldiana*			1	0.008	4	0.020
	Nuculoida	Nuculanidae	*Yoldia* sp.	1	0.008	1	0.008		
Copepoda				51	0.432	16	0.131	49	0.249
Crustacea	Decapoda	Pinnotheridae	*Pinnixa* sp.	12	0.102	9	0.074	2	0.010
		Callinassidae	*Gilvossius setemanus*	1	0.008				
	Cumacea			5	0.042	3	0.025	4	0.020
	Amphipoda	Aoridae				2	0.016		
			Leptocheirus pinguis			1	0.008		
		Ampeliscidae	*Ampelisca* sp.	1	0.008	13	0.107	5	0.025
Polychaeta	Terebellida	Ampharetidae	*Ampharete arctica*	3	0.025	7	0.057	5	0.025
	Phyllodocida	Arabellidae	*Drilonereis* sp.			1	0.008		
		Nephtyidae	*Nephtys* sp.	10	0.085	17	0.139	24	0.122
		Syllidae						5	0.025
	Sabellida	Sabellidae		2	0.017	3	0.025	5	0.025
	Cirratulida	Cirratulidae		9	0.076	6	0.049	66	0.335
Total # of Organisms Identified				**118**		**122**		**197**	
Total # of Organisms in Sample				**118**		**122**		**197**	
Taxa Richness				**13**		**17**		**13**	
Diversity (H_1)				**1.9**		**2.4**		**2.0**	
Eveness				**1.7**		**2.0**		**1.8**	

Notes:
[1] = *Nassarius trivittata* dominant taxa dominant species, when totaled = at least 50% sample

APPENDIX D

DROP CAMERA VIDEO

See enclosed CD

APPENDIX E

ICHTHYOPLANKTON ENTRAINMENT ESTIMATES AT THE BROADWATER FSRU FACILITY BASED ON DATA COLLECTED DURING THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM

ICHTHYOPLANKTON ENTRAINMENT ESTIMATES AT THE BROADWATER FSRU FACILITY BASED ON DATA COLLECTED DURING THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM

JANUARY 2006

Ichthyoplankton Entrainment Estimates at the Broadwater FSRU Facility Based on Data Collected During the 2002 Poletti Ichthyoplankton Program

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R-20546.000

January 2006

Table of Contents

Page

1.0 INTRODUCTION 1
- 1.1 BACKGROUND 1

2.0 2002 POLETTI ICHTHYOPLANKTON PROGRAM STUDY DESIGN 1
- 2.1 STUDY AREA 1
- 2.2 SAMPLING SCHEDULE 2
- 2.3 SAMPLING DESIGN 2
- 2.4 SAMPLE ALLOCATIONS 2

3.0 FIELD METHODS 4
- 3.1 SAMPLING GEAR 4
- 3.2 SAMPLE COLLECTION PROCEDURES 5
- 3.3 WATER QUALITY MEASUREMENTS 5

4.0 LABORATORY METHODS 5
- 4.1 COMPOSITE SAMPLES 5
- 4.2 SUBSAMPLING 5
- 4.3 SORTING 17
- 4.4 IDENTIFICATION 17

5.0 ADHERENCE TO SAMPLING DESIGN 18
- 5.1 ACTUAL COMPARED TO ALLOCATED SAMPLES 18
- 5.2 MODIFIED DURATION SAMPLING 18

6.0 QUALITY CONTROL OF DATA FILES 20

7.0 ANALYTICAL METHODS 20

8.0 RESULTS 22
- 8.1 ICHTHYOPLANKTON SPECIES COMPOSITION IN ALL THREE SAMPLING STRATA IN LONG ISLAND SOUND WITH BOTH GEAR TYPES COMBINED 22
- 8.2 ICHTHYOPLANKTON SPECIES COMPOSITION IN WATER COLUMN (TUCKER TRAWL) TOWS CONDUCTED IN THE DEEP SAMPLING STRATA IN THE CENTRAL BASIN AREA OF LONG ISLAND SOUND (SUBSET DATA) 38
- 8.3 LIFE HISTORY SUMMARY AND ENTRAINMENT ESTIMATES FOR ABUNDANT SPECIES AND OTHER SPECIES OF INTEREST AT THE PROPOSED FSRU 50

9.0 DISCUSSION 87

10.0 LITERATURE CITED 92

APPENDIX

A DAY–NIGHT DIFFERENCES IN ICHTHYOPLANKTON ABUNDANCE BASED ON COMPARISON OF THE POLETTI AND LONG RIVER DATA AND THE SITE SPECIFIC DATA COLLECTED DURING AUGUST AND OCTOBER, 2005 .... A-1

B MODIFIED ENTRAINMENT ESTIMATES BASED ON DIEL CORRECTION FACTORS AND INCLUSION OF THE SITE SPECIFIC DATA COLLECTED IN AUGUST AND OCTOBER, 2005 .... B-1

C AVERAGE TEMPERATURE, DISSOLVED OXYGEN, AND SALINITY MEASURED AT THE SURFACE, MID-DEPTH, AND BOTTOM DURING EACH BIWEEKLY SURVEY IN REGIONS 7-9 OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM C-1

D VOLUME OF WATER (m^3) IN EACH GEAR/SAMPLING STRATA OF REGIONS 7-10 OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM. DATA PROVIDED BY PBS&J/LMS JOINT VENTURE (2003) D-1

List of Figures

Page

Figure 1. Sampling regions for the 2002 Poletti Ichthyoplankton Program. 3

Figure 2. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #1 (March 4-March 17) in Regions 7-10. 6

Figure 3. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #2 (March 18-March 31) in Regions 7-10. 7

Figure 4. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #3 (April 1-April 14) in Regions 7-10. 8

Figure 5. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 4 (April 15-April 28) in Regions 7-10. 9

Figure 6. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 5 (April 29-May 12) in Regions 7-10. 10

Figure 7. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 6 (May 13-May 26) in Regions 7-10. 11

Figure 8. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 7 (May 27-June 9) in Regions 7-10. 12

Figure 9. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 8 (June 10-June 23) in Regions 7-10. 13

Figure 10. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 9 (June 24-July 7) in Regions 7-10. 14

Figure 11. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 10 (July 8-July 21) in Regions 7-10. 15

Figure 12. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 11 (July 22-August 5) in Regions 7-10. 16

Figure 13. Estimated total (A) and percentage (B) of the ichthyoplankton (and lobster larvae) standing crop (in millions) for eggs, larvae (yolk sac + post yolk sac stage), and young of the year (YOY) for all species combined from Long Island Sound (Regions 7-10) during the March-July 2002 Poletti Ichthyoplankton Program (surveys 2-11). Percentages sum to 100% within each life stage. 37

Figure 14. Mean egg and larvae density (#/1000m^3) in Regions 7-9 (Central Basin Area) during biweekly surveys 2-11 by gear type (Epibenthic sled or Tucker trawl) and samping strata (shallow, intermediate, or deep) in the 2002 Poletti Ichthyoplankton Program. The data subset to represent the proposed FSRU location (deep-Tucker trawl) is plotted with the heavy weight Red line for comparison. 40

Figure 15. Estimated total (A) and percentage (B) of the ichthyoplankton (and lobster larvae) standing crop (in millions) for eggs, larvae (yolk sac + post yolk sac stage), and young of the year (YOY)) for all species combined from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl). Percentages sum to 100% within each life stage. 46

Figure 16. Estimated total (A) standing crop (in millions) of common fish eggs and (B) % species composition during each of the eleven biweekly surveys from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl). 48

Figure 17. Estimated total (A) standing crop (in millions) of common fish larvae and (B) % species composition during each of the eleven biweekly surveys from the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl). 49

Figure 18. Total number of eggs and larvae per cubic meter from Long Island Sound taken each month during 1952-1954. Figure is taken from Wheatland (1956), vertical bars have been added to mark the Poletti sampling window. 51

Figure 19. Temporal distribution of ichthyoplankton in Great South Bay, NY collected in 1985 with a 0.505 mm net adapted from Monteleone (1992). Vertical bars have been added to mark the Poletti sampling window from March-July. 52

Figure 20. Seasonal distribution of ichthyoplankton in Narrangansett Bay, RI during 1990 collected with a 0.505 mm mesh net adapted from Keller et al. (1999). Vertical bars have been added to mark the Poletti sampling window from March-July. 52

Figure 21. Average monthly density (#/1000m^3) of eggs and larvae of selected species in Long Island Sound during 1953 (Wheatland 1956) and the 2002 Poletti data subset to represent the FSRU intake. Vertical bars bracket the March-July sampling period of the Poletti Program data. 54

Figure 22. Mean density (#/1000m^3) of eggs and larvae of selected species during each biweekly survey in the 2002 Poletti Ichthyoplankton data subset to represent the FSRU facility's intake (Regions 7-9, deep sampling strata, Tucker trawl). Note- the scale on the Y axis (density) differs depending on species. 61

Figure 23. Fraction of entrained Atlantic menhaden larvae taken during the summer (solid bars; June 1-September 15) and fall (open bars; September 16-December 31) periods of entrainment. Source: NUSCO 2005. 70

List of Tables

Page

Table 1. Number of samples allocated to each sampling stratum (gear, region, and depth) for each of the 11 biweekly surveys in the Poletti Ichthyoplankton Program. 4

Table 2. Number of field samples collected by the Tucker trawl and epibenthic sled in the three sampling strata during each biweekly survey in Long Island Sound Regions (7-10) of the 2002 Poletti Ichthyoplankton Program. 19

Table 3. Species and lifestage (E= eggs, L= larvae (yolk sac+ post yolk sac), Y= young of the year) occurrence in Long Island Sound (Regions 7-10) during each of the eleven biweekly surveys collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, and deep) during the 2002 Poletti Ichthyoplankton Program. 23

Table 4. Fish egg count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in the three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program. 25

Table 5. Fish and lobster larvae count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.......... 27

Table 6. Fish young of the year (YOY) count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.......... 28

Table 7. Ichthyoplankton+ larval lobster density (#/1000m^3) by life stage (egg, larvae, and young of the year (YOY) for all species combined in the laboratory composite samples collected with either the Tucker trawl or epibenthic sled in Regions 7-10 during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program. NS indicates no samples were collected in that Region/survey/gear sampling stratum. 29

Table 8. Ichthyoplankton standing crop (in millions) by life stage (egg, larvae , and young of the year (YOY)) for all species (including American lobster) combined in the laboratory composite samples collected with either the Tucker trawl or epibenthic sled in Regions 7-10 during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program. 33

Table 9. Species and lifestage (E= eggs, L= larvae (yolk sac+ post yolk sac), Y= young of the year) occurrence during each of the eleven biweekly (March-July) surveys in the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*. 39

Table 10. Mean biweekly ichthyoplankton and larval lobster density (#/1000m^3) and estimated standing crop (in millions) by species and lifestage from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*................ 41

Table 11. Egg, larvae (fish yolk sac + post yolk-sac, lobster stages 1-4) and young of the year (YOY) count (estimated total count from laboratory composite samples) and percentage of the total comprised by each species collected from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*................ 47

Table 12. Seasonal occurrence and mean density (#/1000m^3) of eggs and larvae for selected species in 1953 (Wheatland 1956) and during the 2002 Poletti Ichthyoplankton Program data subset to represent the FSRU facility's intake*. The % overlap index represents the percent of the total annual density in Wheatland (1956) that occurred during March through July (the 2002 Poletti Ichthyoplankton Program sampling period). A blank cell indicates no sampling in that month. 53

Table 13. Mean egg density and the percentage of the overall catch (for a given species) of common species collected with both gear types (sled and Tucker trawl) in each sampling strata (shallow, intermediate, and deep) averaged over all eleven biweekly surveys (March-July) and Regions 7-9 (Central Basin area) of the 2002 Poletti Ichthyoplankton Program. 60

Table 14. Mean larval (yolk sac + post yolk sac) density and the percentage of the overall catch (for a given species) of common species and species of interest collected with both gear types (sled and Tucker trawl) in each sampling strata (shallow, intermediate, and deep) averaged over all eleven biweekly surveys (March-July) and Regions 7-9 (Central Basin area) of the 2002 Poletti Ichthyoplankton Program. 65

Table 15. Life-stage specific standing crop (in millions), mean density (#/1000m^3), and entrainment estimates for species of interest from the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location* during each biweekly survey (March-July). Entrainment estimates were calculated by multiplying the average density (#/1000m^3) of eggs, larvae and young of the year by the maximum estimated annual daily water intake of the proposed FSRU facility to yield the estimated number entrained per day... 66

1.0 INTRODUCTION

1.1 BACKGROUND

The New York Power Authority (NYPA) owns and operates the Charles Poletti Power Plant (the Facility) located on the north shore of western Long Island, on the East River. Entrainment and impingement sampling have been conducted at the Facility from 1999-2002. Estimates of numbers of fish eggs, larvae, and juveniles entrained and impinged in the once through condenser cooling water flows at the Facility exceed 100 million organisms annually. Despite the high numbers entrained and impinged at the Facility, the total number of fish that die as a result may be small in comparison to the numbers of fish in the populations from which the entrained and impinged fish are drawn. NYPA funded a research program in 2002 (Charles Poletti Power Project, Studies to Determine the Effects of Entrainment and Impingement, PBS&J/LMS Joint Venture 2003) to address this issue and make informed decisions about options for protecting fish from entrainment and impingement at the Facility. One of the projects sponsored by this 2002 research program was an ichthyoplankton trawl survey. The objectives of the Poletti Ichthyoplankton Program were to provide data on the distribution of fish eggs and larvae in Long Island Sound, East River, Hudson River and New York Harbor during March-July 2002.

The proposed Broadwater Floating Storage and Re-gassification Unit (FSRU) location is in the Central Basin of Long Island Sound, approximately 9 miles (14.5 km) from the shore of Long Island in water that is approximately 95 feet (29 m) deep. Water intakes for the FSRU and any Liquid Natural Gas Carriers (LNGCs) moored on facility during offloading will both be located between 35-45 feet below surface and intake rates will be restricted to 0.5 feet/second (0.15 m/sec.). The estimated annual water intake is approximately 28.2 million gallons per day (MGD; 106,750 m^3/day), based on an average of 2.27 cargos delivered each week. The proposed project has the potential to entrain ichthyoplankton through intake structures of the FSRU. The objectives of this report are to 1) use the 2002 Poletti Ichthyoplankton results to describe the species composition and general abundance patterns of the ichthyoplankton community in Long Island Sound and 2) to subset the 2002 Poletti Ichthyoplankton Program data to reflect the ichthyoplankton community likely to be present in the nearfield area of the FSRU withdrawls, and 3) analyze the subset 2002 Poletti ichthyoplankton data to asses the magnitude of entrainment effects of the proposed water use at the FSRU based on density of organisms in the nearfield area in relation to regional standing stocks during the March-July period. Assessment will focus on abundant species and species of concern due to commercial and recreational value. The degree to which entrainment estimates using data from the March-July sampling period of the 2002 Poletti Ichthyoplankton Program represent an annual estimate were based on the seasonal occurrence of species of interest in comparable regional ichthyoplankton studies. Site specific samples collected in August and October, 2005 are also included in the entrainment estimates to expand the seasonal coverage beyond the Poletti window.

2.0 2002 POLETTI ICHTHYOPLANKTON PROGRAM STUDY DESIGN

2.1 STUDY AREA

The sampling area for the 2002 Poletti Ichthyoplankton Program encompassed a broad area of potentially entrained water. It extended from Raritan Bay on the west to the Connecticut/Rhode

Island border on the east, including all of Long Island Sound as well as Upper and Lower New York Bays, the East River, and part of the Hudson River (to the northern end of Manhattan) because these waters were determined to have a probability of being drawn into the Poletti intake structure that was significantly greater than zero. The study area was divided into ten sampling regions (Figure 1), of which the following nine were sampled during the 2002 Poletti Ichthyoplankton Program: Region 1 (the Lower Hudson River), Region 2 (Upper Bay of New York Harbor), Region 3 (Lower Bay of New York Harbor), Region 5 (western Long Island Sound), and Regions 7-10 (Long Island Sound). Region 4 (East River) was not sampled because of strong tidal currents and heavy boat traffic.

2.2 SAMPLING SCHEDULE

The 2002 Poletti Ichthyoplankton Program consisted of eleven biweekly sampling intervals ("surveys" 1-11) defined by their beginning dates (Mondays) as follows:

Survey 1	4 March 2002	Survey 7	27 May 2002
Survey 2	18 March 2002	Survey 8	10 June 2002
Survey 3	1 April 2002	Survey 9	24 June 2002
Survey 4	15 April 2002	Survey 10	8 July 2002
Survey 5	29 April 2002	Survey 11	22 July 2002
Survey 6	13 May 2002		

Sampling was completed within the first week of each biweekly interval if possible (Monday-Friday), with any unfinished sampling being completed early the following week. All sampling was conducted during daylight hours, between one-half hour after sunrise and one-half hour before sunset, so that the boat captains could more easily locate lobster pot buoys in Long Island Sound (reducing the likelihood of disturbing lobster pots) and reduce the risk of encounters with shipping traffic while deploying the sampling gear.

2.3 SAMPLING DESIGN

Each of the 10 sampling regions was subdivided into the following sampling strata depending on the available water depths in the region: Shallow (3-6 m total depth), Intermediate (6-30 m total depth), and Deep (>30 m total depth). The Shallow, Intermediate, and Deep sampling strata refer to the overall depth of the water column from surface to bottom and not to the position in the water column from which a sample was taken. Sampling was conducted with two different sampling gear (Section 3.1) in each sampling stratum: Tucker trawls and epibenthic sleds (sled). Tucker trawls were used for water column (surface to 3 m above bottom) collections and sleds were used for near bottom collections. The overall sampling design called for the collection of 2,200 samples in 2002, divided among the eleven biweekly survey periods, the two sampling gears, the 10 sampling regions, and the three depth strata.

2.4 SAMPLE ALLOCATIONS

Within each sampling stratum of each sampling region, the specific sampling locations for each survey were randomly selected without replacement. For Tucker trawls, this included a randomly selected depth within the water column from the surface to 3 m above bottom in addition to the geographic location. The number of sites selected for each depth stratum of a sampling region was

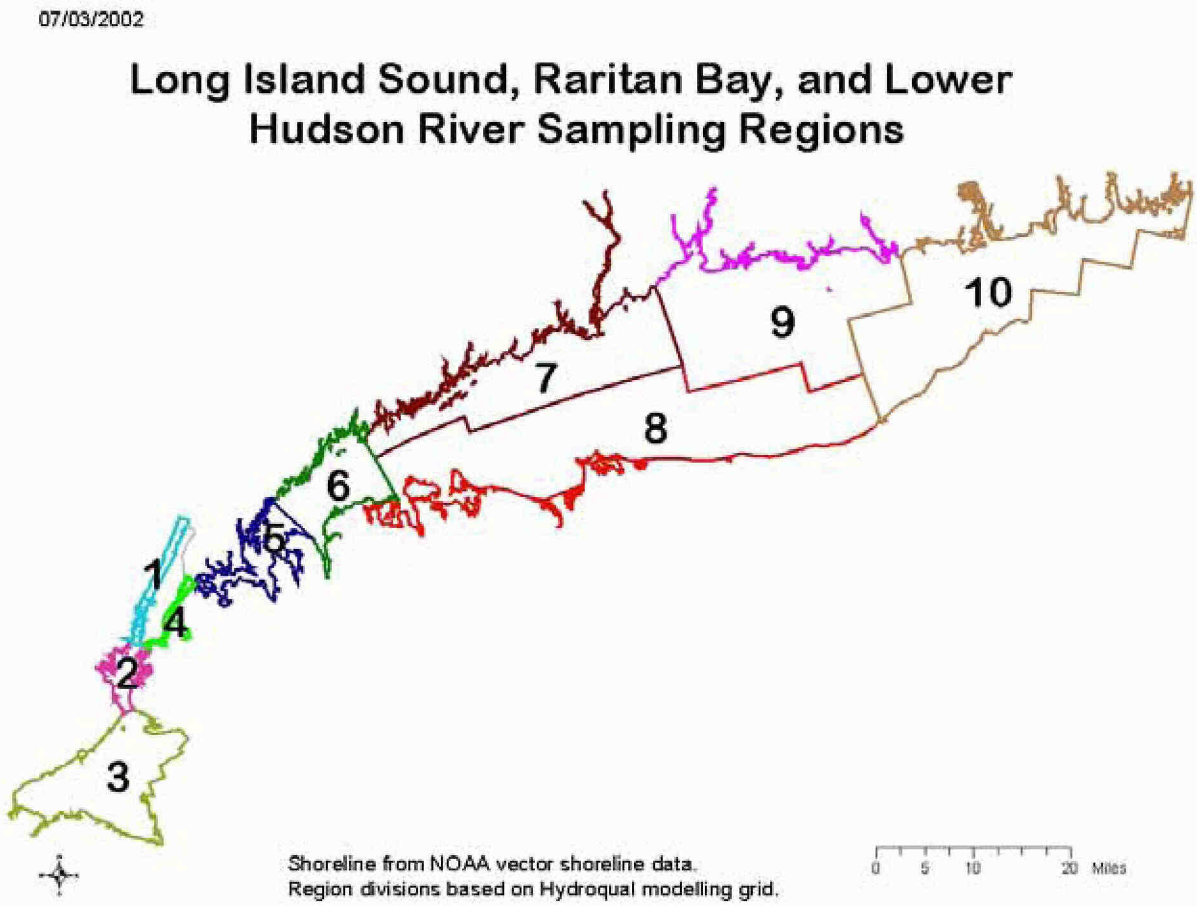

Figure 1. Sampling regions for the 2002 Poletti Ichthyoplankton Program.

proportional to the volume of the stratum. No sampling was scheduled for the deep stratum in regions 1, 2, 3, or 6 because of the lack of deep (> 30 m) areas in those regions. Specific sites in some of the sampling strata were excluded from the random selection process because of known hazards or obstructions such as oyster farms. The Tucker trawl could not be deployed within 3.0 m of the bottom in the intermediate and deep sampling strata. A minimum depth of 3.0 m was required to deploy the net in the shallow stratum. Areas leased for oyster depuration were also excluded, as were some areas of active lobster fishing. The total number of samples scheduled for each biweekly survey was 200 (100 Tucker trawl samples and 100 sled samples). The number of samples allocated to each depth stratum and region is shown in Table 1.

Table 1. Number of samples allocated to each sampling stratum (gear, region, and depth) for each of the 11 biweekly surveys in the Poletti Ichthyoplankton Program.

Gear	Region	Sampling Stratum		
		Shallow (3-6 m)	Intermediate (6-30 m)	Deep (>30 m)
Tucker Trawl	1	2	2	0
	2	2	2	0
	3	11	2	0
	4	0	0	0
	5	3	3	2
	6	3	3	0
	7	3	4	2
	8	6	9	7
	9	4	8	2
	10	5	6	9
	Total	**39**	**39**	**22**
Epibenthic Sled	1	2	2	0
	2	2	2	0
	3	10	3	0
	4	0	0	0
	5	4	2	2
	6	3	3	0
	7	3	5	2
	8	6	8	8
	9	4	8	2
	10	5	6	8
	Total	**39**	**39**	**22**

Region 4 (East River) was not sampled due to the strong tidal currents there.

3.0 FIELD METHODS

3.1 SAMPLING GEAR

A Tucker trawl was used for midwater plankton tows. The sampling net was mounted in a 1 m by 1 m square frame equipped with a opening/closing mechanism so that sampling could be conducted at a specific depth without contamination from shallower water while it was being deployed and retrieved. The net was 8 m long, constructed of 500 micron Nytex monofilament nylon. The collection cup was 30 cm long (37 cm including the net retaining ring), with 500-micron Nytex monofilament nylon mesh.

An epibenthic sled was used for conducting near-bottom plankton tows. An identical net to the one used in the Tucker trawl (1 m square mouth, 8 m long, 500 micron mesh) was mounted in a frame with skids. The skids enabled the gear to be towed along in contact with the bottom sediment while holding the net mouth above the sediment/water interface. Similar to the Tucker trawl, the epibenthic sled was equipped with an opening/closing mechanism.

A General Oceanics model 2030R flowmeter was mounted in the net mouth to measure the volume of water strained during each trawl or sled sample. Each flowmeter was flume-calibrated before placing into service, and rotated out of service after one week to be recalibrated.

3.2 SAMPLE COLLECTION PROCEDURES

The sampling gear was deployed while the vessel was moving forward (into any current). The necessary amount of wire was let out to maintain a 45• wire angle at approximately 90 cm/s vessel speed for the trawl or a 65• wire angle from vertical at approximately 100 cm/s for the sled. The net mouth was closed while the gear was being lowered into sampling position, except for water depths <6 m. The sample began when a messenger was sent down the wire to open the net. After five minutes (by stopwatch) a second messenger was sent down to close the net, and the gear was retrieved. When the gear was deployed with the net open in shallow water, the duration was timed from when the gear reached sampling position to when the flowmeter exited the water during retrieval.

After the gear was retrieved, the net was washed down from the outside with a deck hose. The sample was concentrated in the collection cup and transferred to a sieve to remove excess water. If no sampling problems were encountered, the difference between start and end flowmeter readings was in the acceptable range, and the sample did not fill more than six jars, it was considered a valid sample. The sample was preserved with 10% formalin and rose bengal stain was added.

3.3 WATER QUALITY MEASUREMENTS

Temperature, salinity, and dissolved oxygen measurements were taken with a YSI model 85 analyzer at two randomly selected sample sites per depth stratum in each sampling region and survey if more than two were sampled. For sampling strata with more than two sampling stations, those selected as water quality stations were designated on the digitized NOAA charts. Readings were taken at 0.3 m below the surface, at mid-depth (except in the shallow depth stratum), and 0.3 m above the bottom. Data were recorded to the nearest 0.1°C, 0.1 mg/l, and 0.1 ppt on preprinted field data sheets.

4.0 LABORATORY METHODS

4.1 COMPOSITE SAMPLES

Instead of analyzing each field sample individually, a single composite sample was analyzed from among all of the samples collected by the same gear in each region and sampling stratum in each biweekly survey. For example, in survey 1 in the shallow (3-6 m) sampling stratum in region 1 a composite sample was formed by combining the two Tucker trawl tows taken (Table 1), in survey 1, region 3 a single composite sample was formed by combining the 11 Tucker Trawl tows taken, and so on. All field samples were split in half before combining into composite samples, and one of the halves was randomly chosen to contribute to the appropriate composite sample. The actual field sampling locations used to create the lab composite samples in each gear/sampling strata for each of the eleven biweekly surveys in Regions 7-10 (Long Island Sound) are presented in Figures 2 through 12.

4.2 SUBSAMPLING

Besides the splitting of the original field samples in half to make the lab composites, further subsampling was used if a composite contained excessively high numbers of eggs or larvae. For both types of subsampling, the sample material was divided in half one or more times using a Motoda

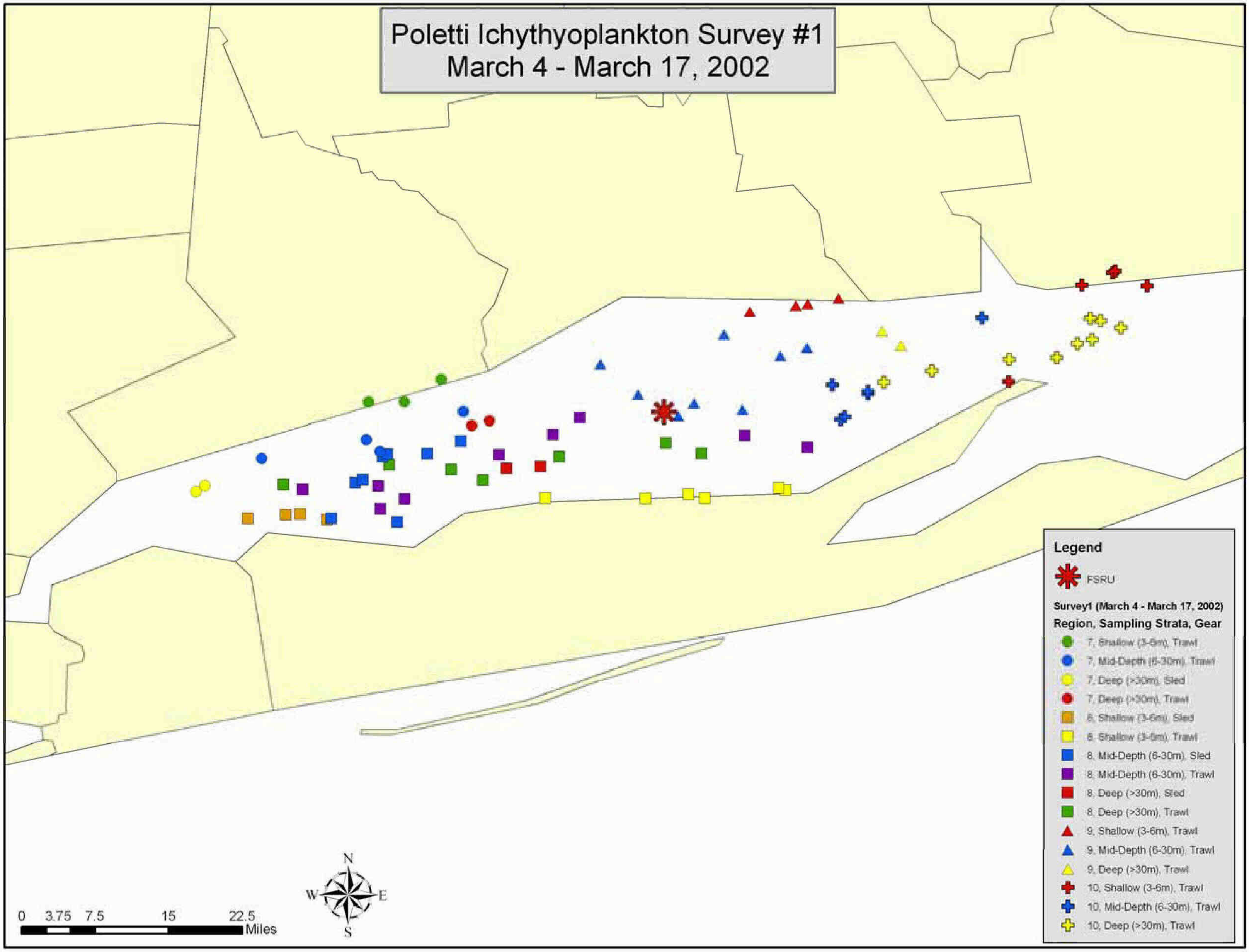

Figure 2. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #1 (March 4-March 17) in Regions 7-10.

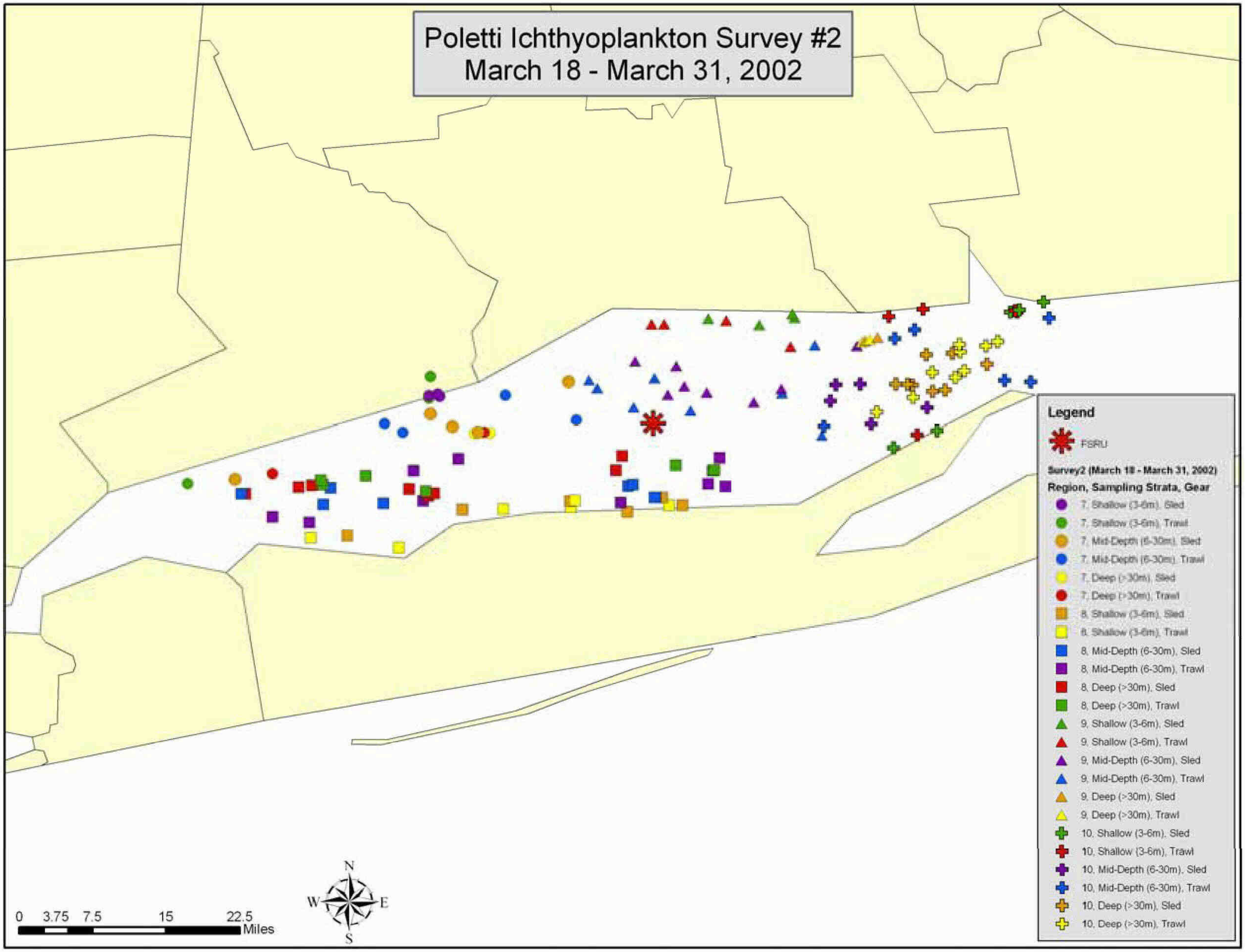

Figure 3. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #2 (March 18-March 31) in Regions 7-10.

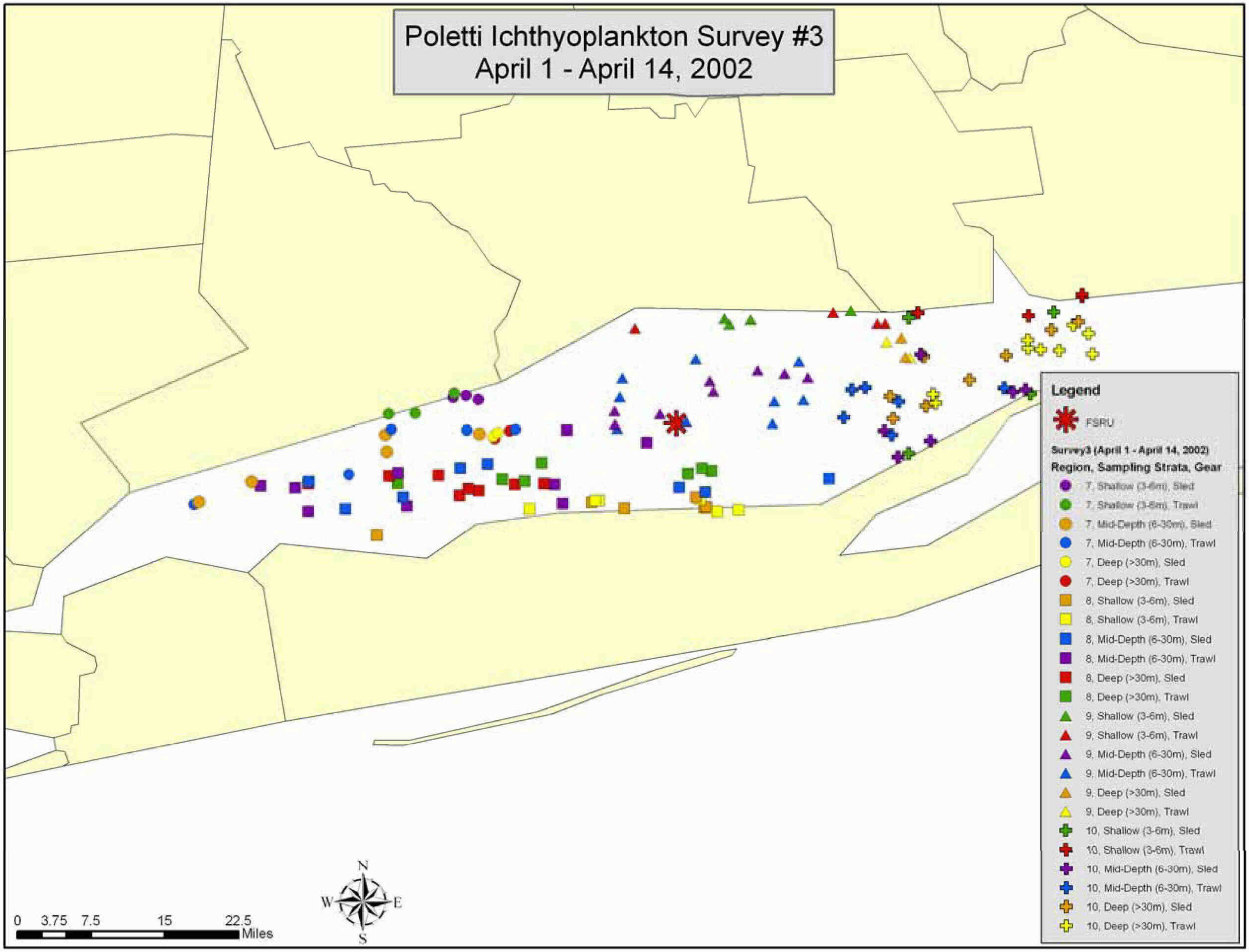

Figure 4. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey #3 (April 1-April 14) in Regions 7-10.

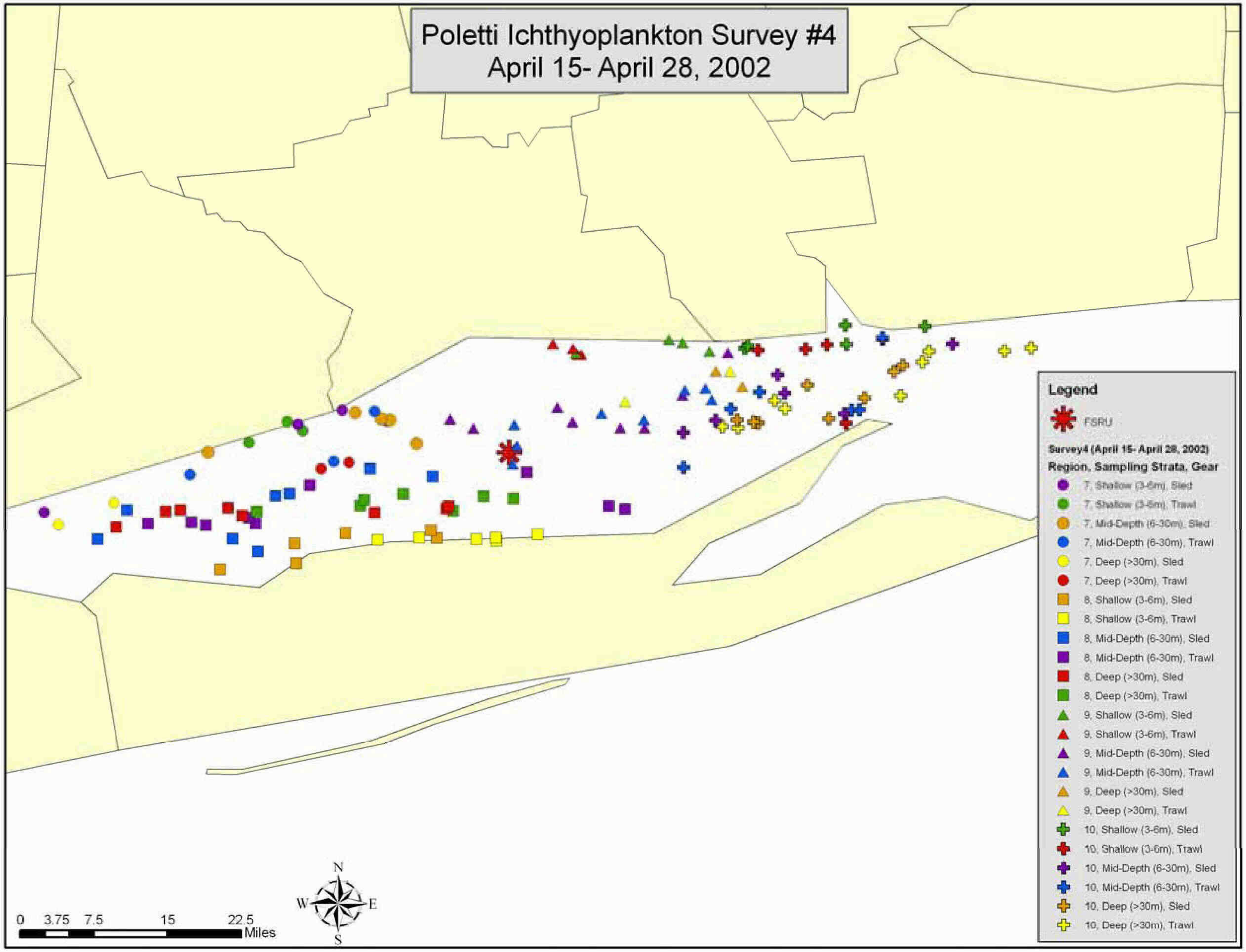

Figure 5. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 4 (April 15-April 28) in Regions 7-10.

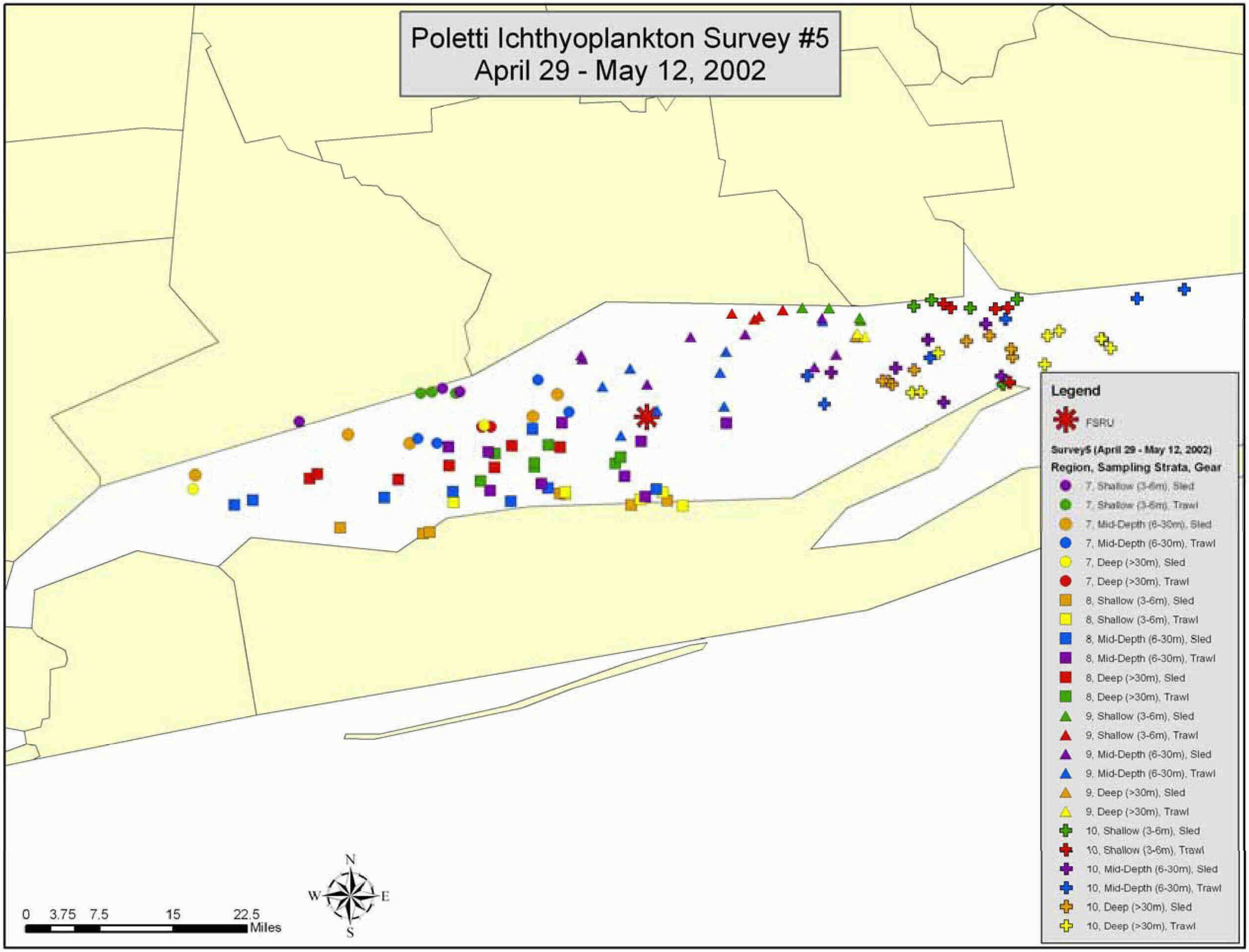

Figure 6. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 5 (April 29-May 12) in Regions 7-10.

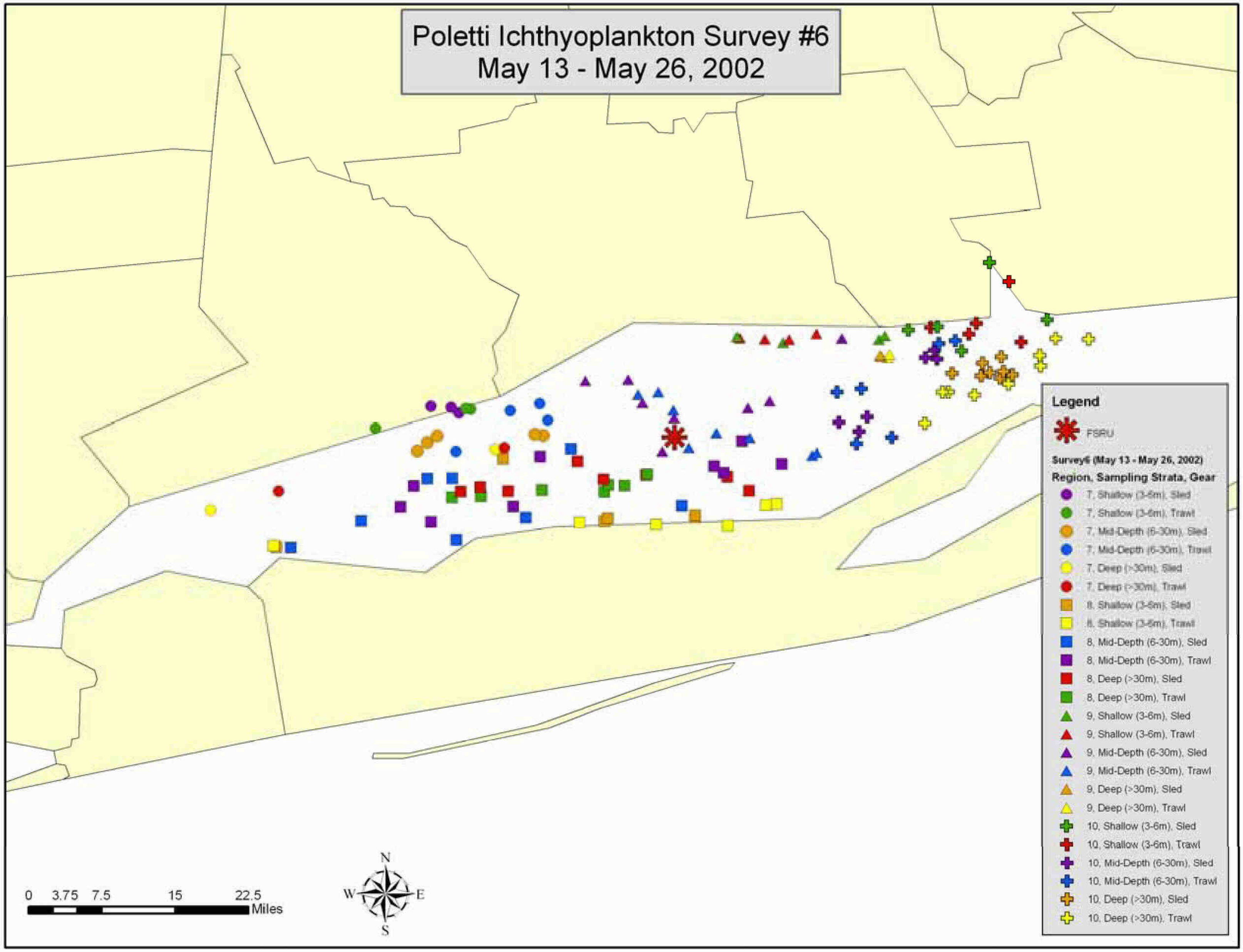

Figure 7. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 6 (May 13-May 26) in Regions 7-10.

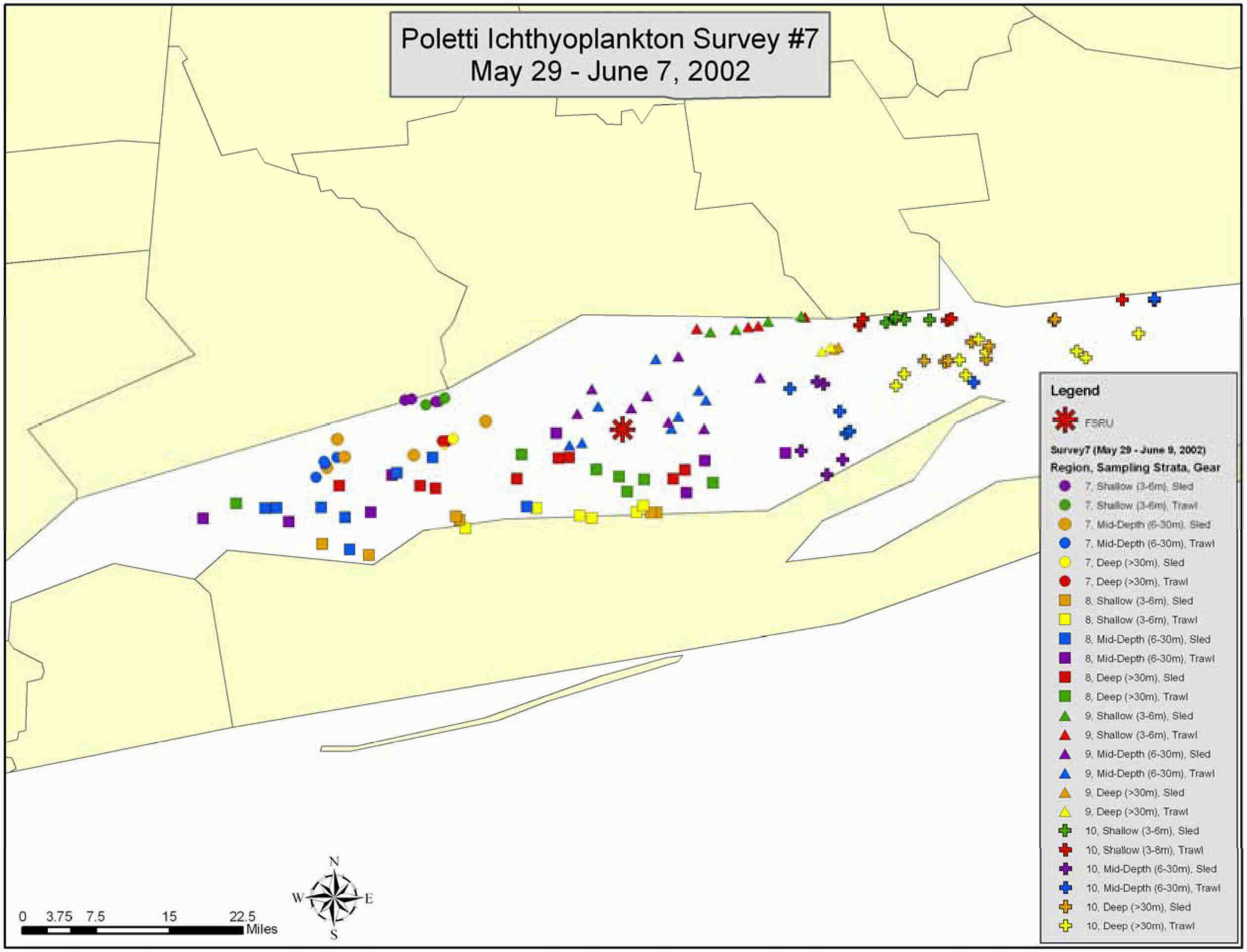

Figure 8. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 7 (May 27-June 9) in Regions 7-10.

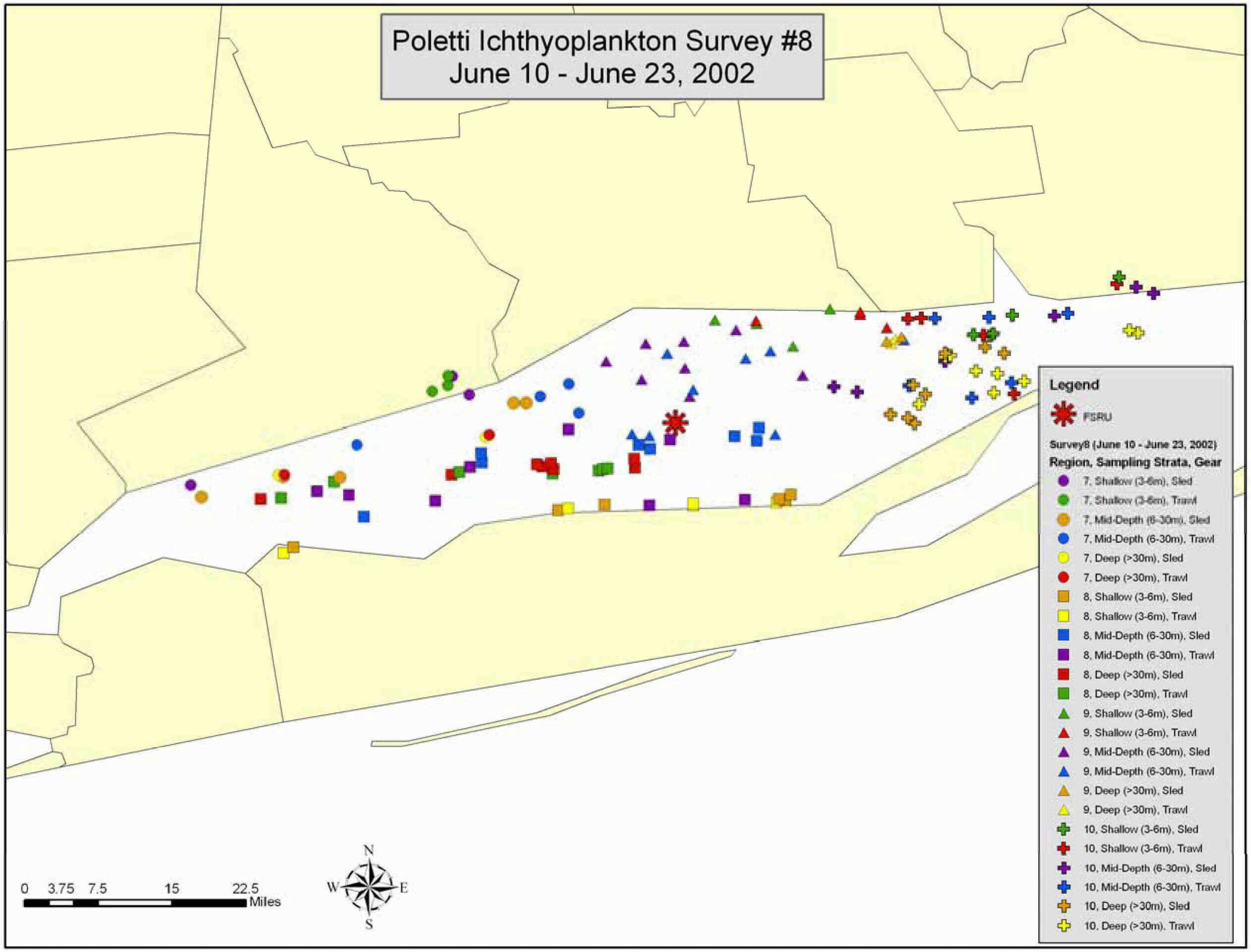

Figure 9. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 8 (June 10-June 23) in Regions 7-10.

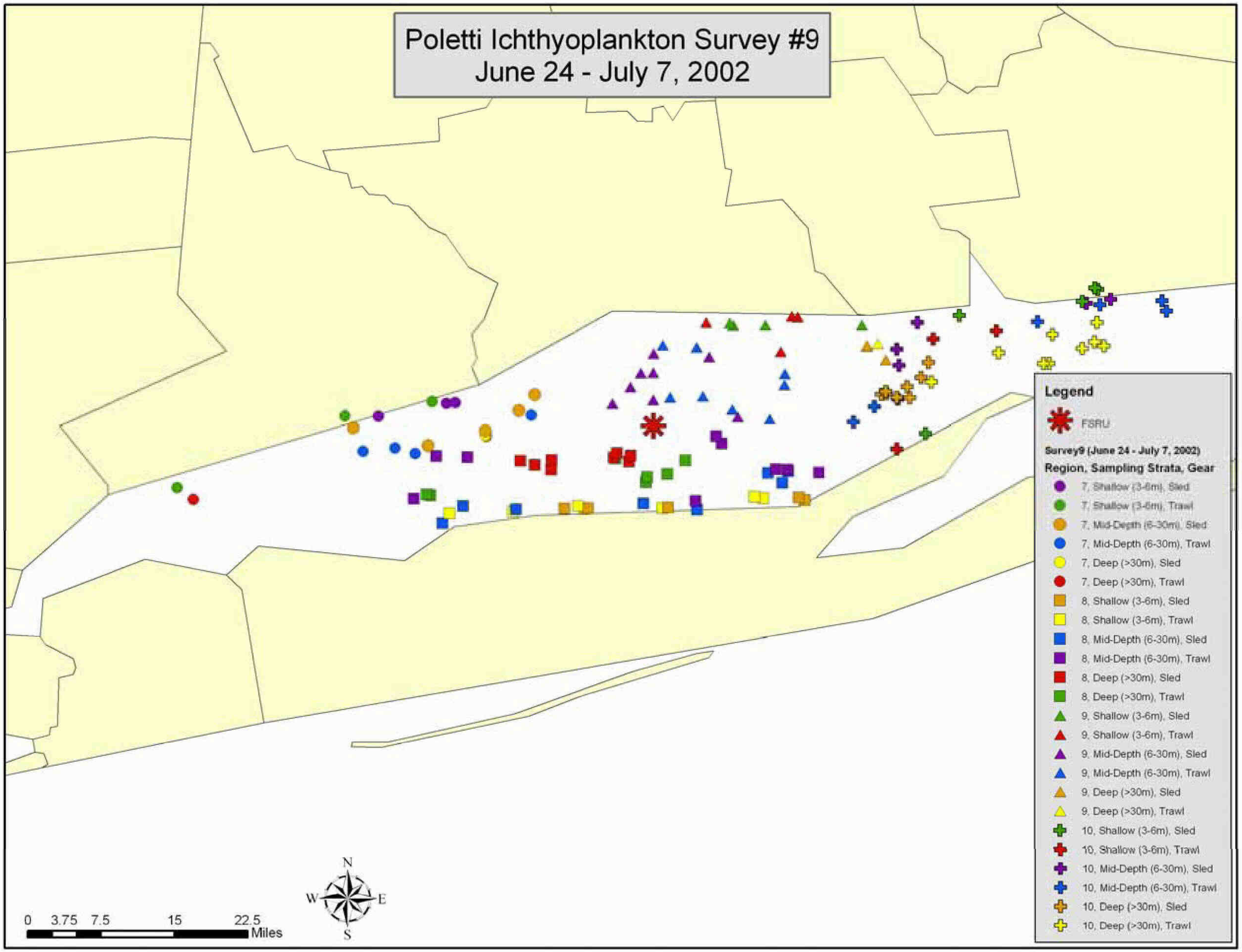

Figure 10. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 9 (June 24-July 7) in Regions 7-10.

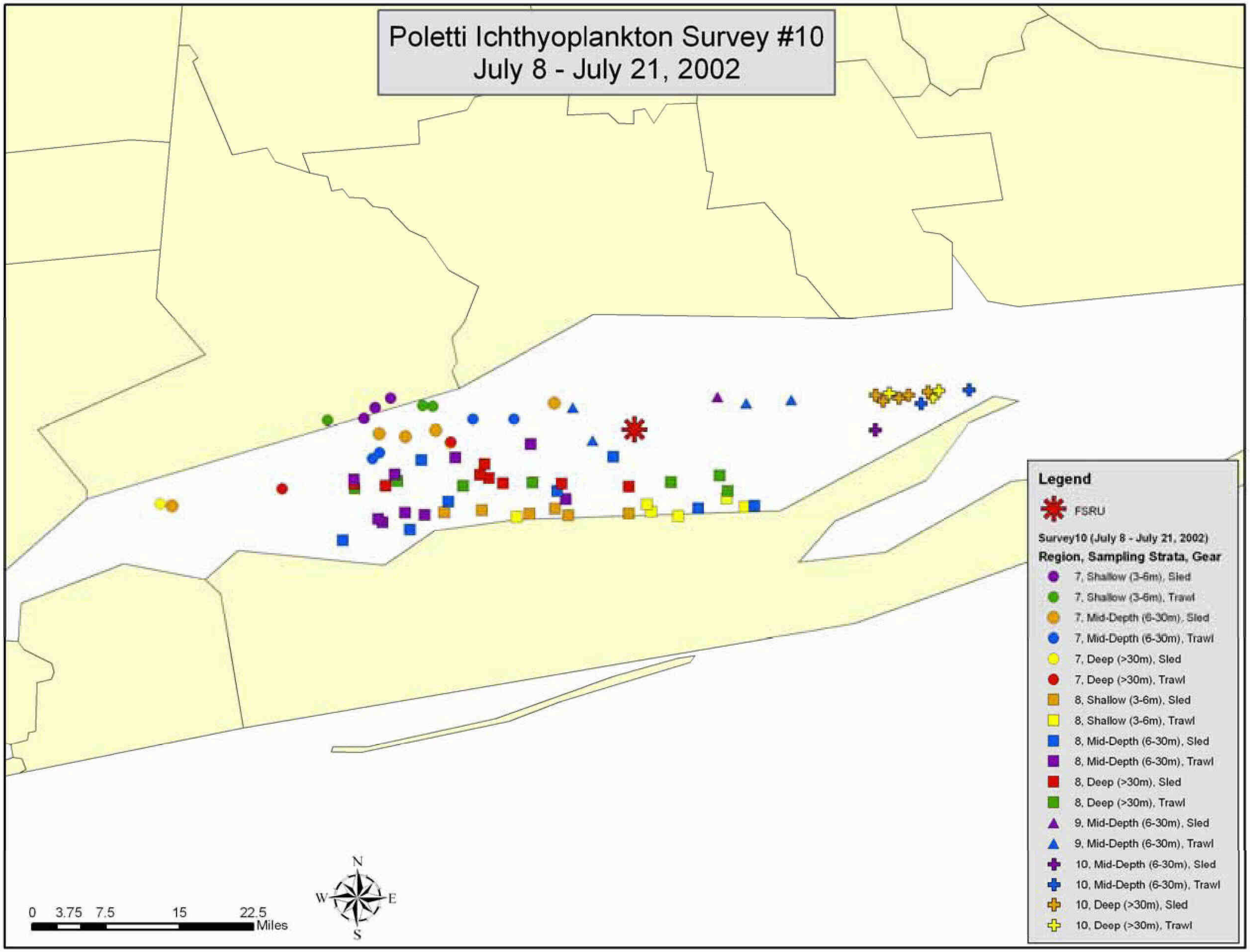

Figure 11. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 10 (July 8-July 21) in Regions 7-10.

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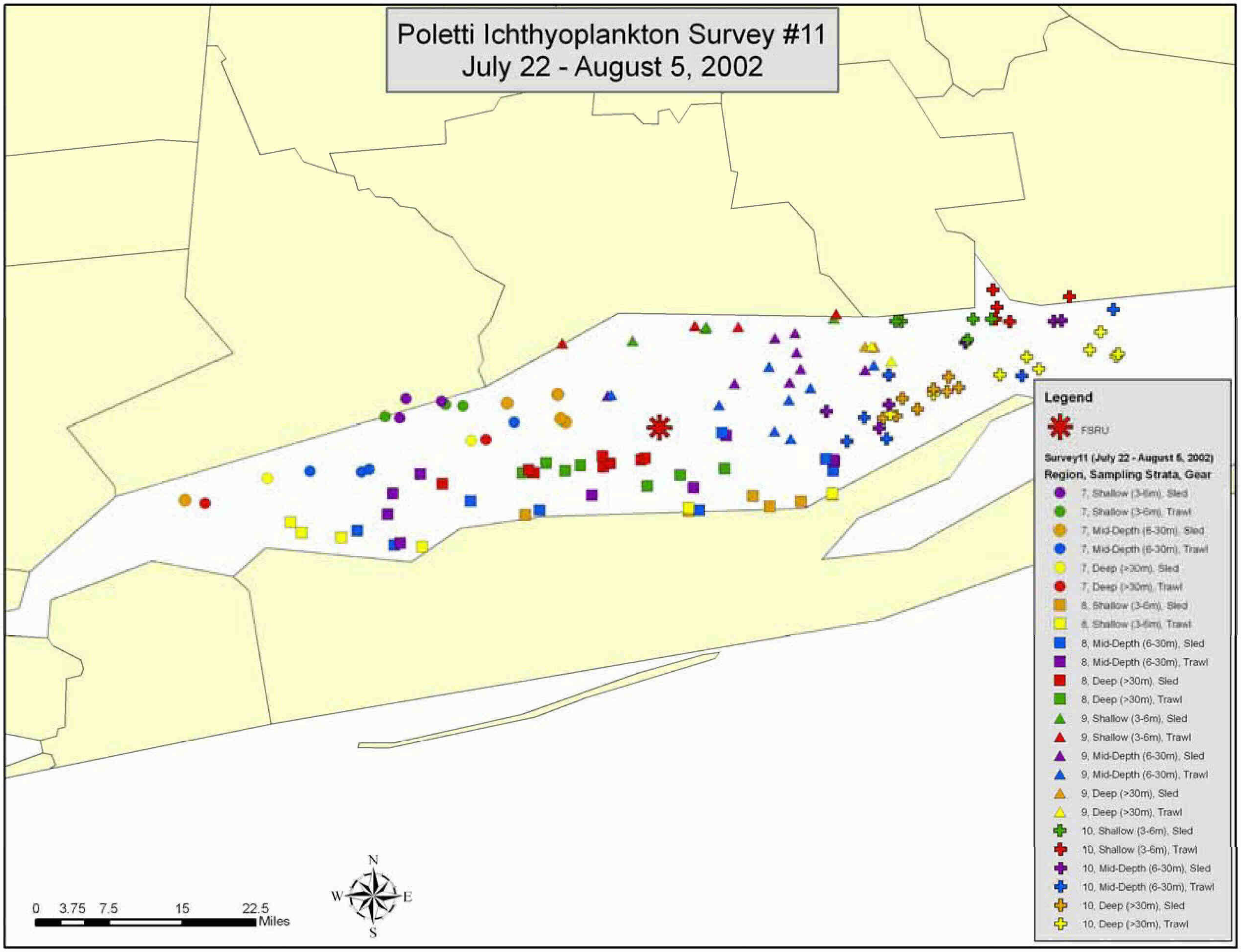


Figure 12. 2002 Poletti Ichthyoplankton Program, sampling sites for Survey # 11 (July 22-August 5) in Regions 7-10.

plankton splitter (Motoda 1959). When composites were subsampled, a minimum of 200 eggs and a minimum of 100 larvae and juveniles combined were analyzed (total of all species combined). Eggs were sorted from a different fraction of the composite than larvae and juveniles if the quotas were met in different size subsamples. Subsampling was subjected to quality control checks according to a continuous sampling plan to verify the randomness of the splitting procedure. For the half-splits of field samples, both halves of the QC sample were sorted and compared for total count (eggs, larvae, and juveniles combined) by a chi-square test. For subsampling of composites, the splitting QC compared three splits of the same size with a chi-square test for eggs and larvae separately.

4.3 SORTING

Sorting consisted of removing fish eggs, fish larvae and juveniles, and lobster larvae from the composite samples prior to making species identifications, life stage determinations, enumeration and measurements. Yearling or older fish were not processed in these composite ichthyoplankton samples. The preservative was drained from the sample in a mesh finer than the sampling mesh and water was added to the sample. Portions of the sample were poured into a shallow pan and examined under magnification. Ichthyoplankton and lobster larvae were removed with forceps or pipettes and placed in vials. If eggs or larvae were subsampled, sorting continued until the entire subsample was sorted even though the subsampling quota was usually reached before finishing the subsample.

The efficiency of the sorting task was monitored and controlled by quality control ("QC") checks. A subset of the samples were randomly selected for re-sorting by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, those samples were rectified and also the proportion of samples checked was increased. A sample failed sorting QC if the number of organisms missed by the original sorter and subsequently found by the QC inspector was 10% or more of the total (or more than two if the total was 20 or less).

4.4 IDENTIFICATION

Sorted organisms were identified, classified to life stage, enumerated and measured with the aid of dissecting microscopes. Identifications were made to the lowest possible taxon (usually species). Anchovies in the early post yolk-sac stage were all counted as bay anchovy despite the theoretically possible presence of the relatively rare striped anchovy, which cannot be distinguished from the abundant bay anchovy at this stage. Larval and early juvenile alewife and blueback herring cannot be reliably distinguished from each other, so they were counted as unidentified herring (family Clupeidae). Ichthyoplankton, except for winter flounder larvae, were enumerated into four life stages: eggs, yolk-sac larvae, post yolk-sac larvae, and juveniles (young-of-the-year). Damaged eggs were only counted if an embryo was present (excluding empty egg capsules). Eel leptocephali were counted as post yolk-sac larvae and eels up to age 2 were counted as juveniles. Winter flounder larvae were classified into the following four stages, following criteria consistent with the stage definitions in Millstone Nuclear Power Station monitoring reports submitted to the Connecticut DEP (e.g., NUSCo 2005):

- Stage 1 yolk-sac present or eyes not pigmented
- Stage 2 no yolk-sac present, eyes pigmented, and either no fin ray development or no flexion of the notochord

Stage 3 fin rays present and flexion of the notochord has begun, but left eye has not yet migrated to the midline
Stage 4 left eye has reached the midline, but juvenile characteristics are not present

Planktonic lobster larvae were enumerated according to the classification of Herrick (1895). These consist of stages 1-4, which range from about 8 to 15 mm in total length. The first three stages are zoeae that are characterized by a long rostral spine and prominent abdominal spines. The fourth stage is a megalops and resembles a small adult.

Stage 1 pleopods (swimmerets) are not yet present on the abdomen
Stage 2 pleopods are present, but uropods have not yet appeared beside the telson
Stage 3 uropods are present
Stage 4 enlarged claws are present

The accuracy of identifications, assignment to life stage, and counting was monitored and controlled by QC checks. A subset of the samples were randomly selected for re-identification by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, data from those samples were corrected and the proportion of samples checked was increased. A sample failed identification QC if the original identifier's count differed from the QC inspector's count by 10% or more (or by more than two if the QC total was 20 or less). This acceptance criterion was applied separately by life stage to each taxon. An additional requirement for a sample to pass was that for each taxon, the sum of the percent errors for all life stages was required to be less than 10%.

5.0 ADHERENCE TO SAMPLING DESIGN

5.1 ACTUAL COMPARED TO ALLOCATED SAMPLES

During the first biweekly survey, at some of the randomly assigned sampling locations, lobster fisherman who opposed sampling in actively fished areas confronted the sampling crews. Sled sampling in Long Island Sound was abandoned for the remainder of survey 1 so the issue could be resolved. The original Poletti ichthyoplankton sampling design had called for changing from daytime to nighttime sampling for some of the later biweekly surveys. This was changed so that sampling for all surveys would be during daylight to enable crews to avoid lobster gear. All of the unsampled sampling strata were epibenthic sled samples, and most of those were in biweekly survey 1 when sled sampling was cancelled in areas with lobster gear. Some scheduled samples could not be collected due to strong winds and large waves in the open waters of Long Island Sound at times did not allow the gear to be safely deployed. The actual number of field samples collected in each biweekly survey for both gear types and all three sampling strata that were used to form the laboratory composite samples for regions considered in this report (Regions 7-10, Long Island Sound) are listed in Table 2.

5.2 MODIFIED DURATION SAMPLING

In a few instances, the presence of large concentrations of organisms such as ctenophores caused clogging of the net mesh before the completion of the standard five-minute tow. The crew has a calibration table that related the number of revolutions of the flowmeter in the net to distance through

Table 2. Number of field samples collected by the Tucker trawl and epibenthic sled in the three sampling strata during each biweekly survey in Long Island Sound Regions (7-10) of the 2002 Poletti Ichthyoplankton Program.

Region	Sampling Stratum	Gear	No. of Samples Scheduled		Number of Samples Collected By Biweekly Survey											
			Biweekly	Total	1	2	3	4	5	6	7	8	9	10	11	Total
7	shallow	trawl	3	33	3	3	3	3	3	3	3	3	3	3	3	33
		sled	3	33	0	3	0	3	2	3	3	3	3	3	3	26
	intermediate	trawl	4	44	4	4	5	4	4	4	4	4	4	4	4	45
		sled	5	55	0	4	5	5	5	5	5	5	5	5	5	49
	deep	**trawl**	2	22	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**21**
		sled	2	22	2	2	2	2	2	2	2	2	1	2	2	21
8	shallow	trawl	6	66	6	6	6	6	6	6	6	5	6	6	6	65
		sled	6	66	4	6	6	6	6	6	6	6	6	6	6	64
	intermediate	trawl	9	99	9	9	9	9	9	9	8	9	9	9	9	98
		sled	8	88	8	8	7	8	8	8	8	8	8	8	8	87
	deep	**trawl**	7	77	**7**	**7**	**7**	**7**	**6**	**7**	**7**	**7**	**7**	**7**	**7**	**76**
		sled	8	88	2	8	8	7	7	8	9	8	8	8	8	81
9	shallow	trawl	4	44	4	4	4	4	3	4	4	4	4	4	4	43
		sled	4	44	0	4	4	4	4	3	4	4	4	4	4	39
	intermediate	trawl	8	88	8	8	9	8	8	8	8	8	8	8	8	89
		sled	8	88	0	8	8	8	8	8	8	8	8	8	8	80
	deep	**trawl**	2	22	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**21**
		sled	2	22	0	1	2	1	2	2	2	2	2	2	1	17
10	shallow	trawl	5	55	5	5	5	4	5	5	5	5	5	4	5	53
		sled	5	55	0	5	5	5	5	5	5	5	5	5	5	50
	intermediate	trawl	6	66	6	6	6	6	6	6	6	6	6	6	6	66
		sled	6	66	0	5	6	6	6	6	6	6	6	6	6	59
	deep	trawl	9	99	9	9	9	9	8	9	9	9	9	9	9	98
		sled	8	88	0	8	8	8	8	8	8	8	8	8	8	80

water. When the distance through the water, measured by the flowmeter, deviated by more than 15% from the known distance from GPS, clogging was considered to be significant enough to reduce tow duration. When that occurred, the sample was attempted again with the tow duration reduced. If the total sampling duration at a station was less than five minutes, the laboratory procedures were modified to restore an equal contribution of stations within the sampling stratum.

6.0 QUALITY CONTROL OF DATA FILES

Data from data sheets were double-keyed and verified (the computer identified all discrepancies between the two data sets and the operator resolved them by re-examining the data sheets). Then systematic error checks were performed to identify missing values and values out of their expected ranges, by means of univariate, bivariate, and multivariate comparisons within the data sets. The final data files were inspected according to a 1% AOQL sampling plan by comparing values in the data files to the entries on the original data sheets.

7.0 ANALYTICAL METHODS

The ichthyoplankton community of Long Island Sound is described from samples collected in Regions 7-10 (Long Island Sound, Figure 1). Results from the Long Island Sound analysis are presented in Section 8.1. Ichthyoplankton and lobster larvae counts were converted to density (#/1000m^3) by dividing by composite sample volume obtained from the flowmeter readings. Standing crop (# of individuals) estimates were obtained by multiplying ichthyoplankton density in each gear/sampling strata during each survey by its corresponding volume in Regions 7-10 as used in the PBS&J/LMS Joint Venture (2003). There are up to six gear/sampling strata combinations in each region depending on depth, each with its associated volume: shallow trawls, shallow sleds, intermediate trawls, intermediate sleds, deep trawls and deep sleds. PBS&J/LMS Joint Venture (2003) provided the areas and volumes for each depth stratum of each Poletti region. The figure of 3.0 m above the bottom for the boundary between trawls and sleds within depth stratum is what PBS&J used in their analysis. For sled (near bottom) volume we used 3 m times the area of the depth stratum, and for Tucker trawl (mid-water) volume we used the volume of the depth stratum minus the sled volume.

The 2002 Poletti Ichthyoplankton Program data was further subset to represent the geographic regions and sampling strata most likely exposed to water withdrawl by the proposed Broadwater FSRU facility (subset data). The subset most directly exposed to withdrawl by the FSRU included regions 7-9 (Figure 1) to represent the Central Basin of Long Island Sound. The sampling strata for the FSRU subset was restricted to deep (> 30 m or 98 ft) because the water depth at the proposed FSRU location is approximately 95 feet, and sampling gear was restricted to the Tucker trawl to represent water column collections because water will be withdrawn from 35-45 feet below surface. One-hundred and eighteen samples were taken during the eleven surveys in the subset data (Table 2 in Bold). Although the intermediate depth (6-30 m, 20-98 ft) sampling strata also represents the FSRU location at the upper end of its depth range, the inclusion of samples from water as shallow as 20 feet in the lab composites for the intermediate depth strata was not considered to represent the Proposed FSRU intake location 9 miles offshore in 95 feet of water as well as the deep sampling strata. Although in many cases, sites included in the intermediate depth strata were closest to the proposed FSRU location; individual samples were not available for analysis due to the laboratory composites as discussed in Section 4.1.

Long Island Sound is considered vertically homogeneous with turbulent tidal mixing resulting in little to no physical stratification during periods of both high and low freshwater runoff (Able and Fahay 1998). Temperature, salinity, and dissolved oxygen measurements taken during the 2002 Poletti Ichthyoplankton survey were relatively homogeneous throughout March-July 2002 period (Appendix Table C-1). The depth range sampled by the Tucker trawl in deep sampling strata (surface to 3 m above bottom) represents surface, mid-depth and deep occurring larvae because sample depth was randomly selected, samples were combined into composites (Section 4.1) and the entire water column is subject to mixing without a thermocline. The presence of a thermocline or halocline may affect vertical distribution of fish (Smith et al. 1978, Kendall and Naplin 1981, Sameoto 1982) and lobster (Boudreau et al. 1992) larvae. Analysis of this subset data (regions 7-9, deep sampling strata, Tucker trawl) which is more specifically focused on the proposed location of the FSRU facility's water intake is presented in Section 8.2.

Standing crops for the Long Island Sound analysis (Sections 8.1) for survey 1 are not comparable to surveys 2-11 because sled sampling was not completed in all regions and sampling strata due to the temporary change in design to accommodate lobster fisherman (Table 2). For the subset analysis (Section 8.2) standing crop estimates for Survey 1 are included because all sampling with the Tucker trawl was completed during that survey.

In Section 8.3 the density of abundant species and species of economic importance (American lobster, winter flounder) during each biweekly survey in the subset data was multiplied by the daily water intake (28.2 MGD, 106,750 m^3/day) of the proposed FSRU facility to estimate number entrained per day. The daily entrainment estimate was multiplied by fourteen to estimate the number entrained in each of the eleven biweekly surveys. The entrainment estimates for each biweekly survey by species and life stage were summed for the eleven biweekly surveys to estimate the number entrained based on the March 4-August 5 sampling period of the 2002 Poletti Ichthyoplankton Program.

Night catches of fish larvae often exceed daylight catches, suggesting visual avoidance of sampling gear (Ahlstrom 1959, Clutter and Anraku 1968, Kendall and Naplin 1981, Bourne and Govoni 1988). Net avoidance involves complex reactions of fish larvae to the approach of the net, including sensory perception of the net and a variety of avoidance reactions that are both size and species specific. Because all Poletti sampling occurred during daylight, entrainment estimates based on this data may be underestimates if daytime gear avoidance occurs. In order to investigate diel differences in ichthyoplankton abundance, Poletti daytime samples were compared with nighttime samples from the Hudson River Generators Long River Survey (LRS). Subsets of the data from the two sampling programs were selected so that density estimates could be calculated from samples during the same weeks in 2002 within the same geographic boundaries. Diel differences were also investigated using the site-specific data collected at the proposed FSRU location on August 23 and October 4, 2005 (NAI 2005a,b). Further details and results of this analysis are presented in **Appendix A**.

If there was a significantly higher density in nighttime compared to daytime samples for a species/lifestage, a diel correction factor was added to the entrainment estimates in Section 8.3. Ichthyoplankton data collected during the site specific locations at the proposed FSRU location in August and October, 2005 are also included to extrapolate entrainment estimates beyond the March-July Poletti sampling period in the modified entrainment tables in **Appendix B**.

8.0 RESULTS

8.1 ICHTHYOPLANKTON SPECIES COMPOSITION IN ALL THREE SAMPLING STRATA IN LONG ISLAND SOUND WITH BOTH GEAR TYPES COMBINED

Fifty taxa classified as eggs, larvae (yolk-sac + post yolk-sac stage) or young of the year (42 identified to the species level) were collected during the eleven biweekly surveys with the Tucker trawl or epibenthic sled in Regions 7-10 during the 2002 Poletti Ichthyoplankton Program. The temporal occurrence of fish (and American lobster) species and life stages (egg, larvae (yolk sac + post yolk sac stage), young of the year) collected during each biweekly survey with both gear types and in all three sampling strata is presented in Table 3. Eggs and larvae were collected throughout the 2002 Poletti Ichthyoplankton Program from March 4 through August 5. Young of the year were relatively uncommon, most likely due to increased mobility and ability to avoid the fine mesh collection gear. Although young of the year fish were not adequately sampled with the fine mesh used for the Poletti Ichthyoplankton Program, juvenile fish abundance was sampled during a separate program (Poletti Juvenile Trawl Survey, August-November 2002, PBS&J/LMS Joint Venture 2003) not reported here because young of the year are not typically entrained (by definition, organisms that pass through a screen are entrained, while those too large to pass through the screen are impinged: a 3/8" mesh screen is the conventional separation between the two applied to baseline conditions of the 316b rule, the FSRU will have a 5 mm screen size). Species abundance by life stage is presented in Tables 4 through 6. The number collected represents the estimated number that would have been present in a composite sample if the whole sample was enumerated, i.e. the number collected is adjusted to the whole sample for any subsampling and lab splits.

Twenty-one taxa of eggs were observed with weakfish/scup and fourbeard rockling (*Enchelyopus cimbrius*) comprising the greatest percentage of the overall catch (Table 4). Eggs of weakfish (*Cynoscion regalis*) and scup (*Stenotomus chrysops*) are difficult to distinguish in early stages due to an overlap in size, shape, color and number of oil globules (Johnson 1978). Weakfish/scup eggs were collected during surveys 6-11 (May 13-August 5, Table 3). Fourbeard rockling eggs were collected during every survey (Mar 4-August 5). Other species with eggs comprising > 1% of the estimated number from the composite samples include tautog (*Tautoga onitis*, 12.6%), northern (*Prionotus carolinus*) or striped (*P. evolans*) searobin (Unidentified searobins, *Prionotus* sp., 9.7%), Atlantic menhaden (*Brevoortia tyrannus*, 9.3%), windowpane (*Scophthalmus aquosus*, 5.8%), cunner (*Tautogolabrus adspersus*, 5.6%), and bay anchovy (*Anchoa mitchilli*, 3.1%). For most species, eggs were not collected during the first several surveys, with the exception of winter and early spring spawning species such as fourbeard rockling, windowpane (*Scophthalmus aquosus*), yellowtail flounder (*Limanda ferruginea*), and winter flounder (*Pseudopleuronectes americanus*). Winter flounder eggs made up a relatively small proportion of the total and were collected during the first three surveys (Mar 4-April 14). Eggs of many winter and early spring spawners such as winter flounder, American sand lance, grubby and rock gunnel are demersal and adhesive and therefore less vulnerable to entrainment mortality, and often rare in ichthyoplankton samples.

Table 3. Species and lifestage (E= eggs, L= larvae (yolk sac+ post yolk sac), Y= young of the year) occurrence in Long Island Sound (Regions 7-10) during each of the eleven biweekly surveys collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, and deep) during the 2002 Poletti Ichthyoplankton Program.

Common Name	Scientific Name	2002 Biweekly Survey Start Date										
		4-Mar	18-Mar	1-Apr	15-Apr	29-Apr	13-May	27-May	10-Jun	24-Jun	8-Jul	22-Jul
American eel	*Anguilla rostrata*		Y									
American lobster	*Homarus americanus*						L	L	L	L	L	
American plaice	*Hippoglossoides platessoides*						E					
American sandlance	*Ammodytes americanus*	L	L	L	LY	LY	LY					
Atlantic cod	*Gadus morhua*		L		L							
Atlantic herring	*Clupea harengus*		L	L	L		Y					
Atlantic mackerel	*Scomber scombrus*				E	EL	EL	L				
Atlantic menhaden	*Brevoortia tyrannus*		L	L	E	EL	EL	EL	EL	EL	ELY	ELY
Atlantic seasnail	*Liparis atlanticus*				L	L		L				
Atlantic silverside	*Menidia menidia*							L			L	E
Bay anchovy	*Anchoa mitchilli*				L	E	L	E	EL	EL	EL	EL
Black seabass	*Centropristis striata*									L	L	L
Butterfish	*Peprilus triacanthus*							E	EL	EL	ELY	ELY
Conger eel	*Conger oceanicus*						L	L	L		L	
Cunner	*Tautogolabrus adspersus*				E	EL	E	EL	EL	EL	ELY	ELY
Feather blenny	*Hypsoblennius hentzi*						E				L	L
Fourbeard rockling	*Enchelyopus cimbrius*	E	EL	EL	EL	EL	EL	EL	ELY	E	E	E
Fourspot flounder	*Paralichthys oblongus*								L	L	L	L
Goosefish	*Lophius americanus*									E	L	
Grubby	*Myoxocephalus aenaeus*	L	L	L	L	L	L	L				
Herrings	Clupeidae sp.					L		L	L	L		
Hogchoker	*Trinectes maculatus*									E	EL	E
Northern pipefish	*Syngnathus fuscus*							L	L	L	LY	LY
Northern puffer	*Sphoeroides maculatus*									L	Y	L
Pollock	*Pollachius virens*		Y				L					
Radiated shanny	*Ulvaria subbifurcata*				L	L						
Rock gunnel	*Pholis gunnellus*	L	L	L								

(continued)

Table 3. (Continued)

Common Name	Scientific Name	2002 Biweekly Survey Start Date										
		4-Mar	18-Mar	1-Apr	15-Apr	29-Apr	13-May	27-May	10-Jun	24-Jun	8-Jul	22-Jul
Scup	*Stenotomus chrysops*							L	L	L	LY	ELY
Smallmouth flounder	*Etropus microstomus*										L	L
Speckled worm eel	*Myrophis punctatus*							L				
Spotted hake	*Urophycis regia*		E			Y						
Striped anchovy	*Anchoa hepsetus*								E			
Striped bass	*Morone saxatilis*							L				
Striped cusk eel	*Ophidion marginatum*				L							L
Striped searobin	*Prionotus evolans*										LY	Y
Summer flounder	*Paralichthys dentatus*		L	Y								
Tautog	*Tautoga onitis*				E	E	EL	EL	EL	EL	EL	EL
Tessellated darter	*Etheostoma olmstedi*						L					
Unidentifiable			E	E		E	EL		L	EL	L	
Unidentified blenny	Blenniidae sp.										L	
Unidentified cods	Gadidae sp.						E				E	
Unidentified gobies	Gobiidae sp.			L	L	L	L			L	L	L
Unidentified minnows	Cyprinidae sp.						L					
Unidentified searobin	*Prionotus* sp.					E	E	E	EL	EL	EL	EL
Unidentified silversides	*Menidia* sp.							L	L			
Weakfish	*Cynoscion regalis*						L	L	L	L	LY	ELY
Weakfish/Scup	*Cynoscion regalis/Stenotomus chrysops*						E	E	E	E	E	E
White perch	*Morone americana*							L				
Windowpane	*Scophthalmus aquosus*	E	E	E	EL	EL	EL	ELY	ELY	ELY	ELY	E
Winter flounder	*Pseudopleuronectes americanus*	EL	EL	EL	L	LY	L	LY	LY		L	
Yellow perch	*Perca flavescens*					L						
Yellowtail flounder	*Limanda ferruginea*		E	E	E		L	L	L		L	

Table 4. Fish egg count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in the three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.

Scientific Name	Common Name	# Eggs	% of Total Catch
Cynoscion regalis/Stenotomus chrysops	Weakfish/Scup	401,455	28.7
Enchelyopus cimbrius	Fourbeard rockling	340,052	24.3
Tautoga onitis	Tautog	176,678	12.6
Prionotus sp.	Unidentified searobin	135,111	9.7
Brevoortia tyrannus	Atlantic menhaden	130,338	9.3
Scophthalmus aquosus	Windowpane	80,818	5.8
Tautogolabrus adspersus	Cunner	78,651	5.6
Anchoa mitchilli	Bay anchovy	42,693	3.1
Peprilus triacanthus	Butterfish	9,189	0.7
Scomber scombrus	Atlantic mackerel	954	0.1
Pseudopleuronectes americanus	Winter flounder	774	0.1
Trinectes maculatus	Hogchoker	664	< 0.1
	Unidentifiable	605	< 0.1
Anchoa hepsetus	Striped anchovy	256	< 0.1
Gadidae sp.	Unidentified cods	192	< 0.1
Urophycis regia	Spotted hake	160	< 0.1
Limanda ferruginea	Yellowtail flounder	60	< 0.1
Lophius americanus	Goosefish	32	< 0.1
Cynoscion regalis	Weakfish	20	< 0.1
Hippoglossoides platessoides	American plaice	8	< 0.1
Hypsoblennius hentzi	Feather blenny	8	< 0.1
Stenotomus chrysops	Scup	8	< 0.1
Menidia menidia	Atlantic silverside	4	< 0.1

Forty-five taxa of larvae (39 identified to species level) were collected in Long Island Sound (Regions 7-10) with both gear types in all three sampling strata (shallow, intermediate, deep, Table 5). Estimated larvae catch in the composite samples was dominated by Atlantic menhaden (42.3%). Atlantic menhaden larvae were collected during surveys 2-3 (March 18-April 14) and 5-11 (April 29-August 5). Other larvae accounting for >1% of the estimated number in the composite samples include tautog (12.2%), cunner (7.1%), weakfish (5.0%), fourbeard rockling (4.8%), bay anchovy (4.7%), winter flounder (2.6%), windowpane (2.5%), butterfish (*Peprilus triacanthus*, 2.1%), unidentified searobin (*Prionotus* sp., 2.0%), and unidentified gobies (1.1%). American lobster larvae were relatively rare in the 2002 Poletti Ichthyoplankton Program collections. Lobster larvae were collected during surveys 6-10 (May 13-July 21) and comprised only 0.1% of the total number of larvae collected.

Seventeen species were collected in the young of the year life stage (Table 6). Estimated catch in the composite samples was dominated by cunner (65.6%) and no other species accounted for > 10% of the total catch. Other species accounting for >1% include scup (8.7%), butterfish (6.4%), striped searobin (5.8%), Atlantic menhaden (3.5%), American sandlance (*Ammodytes americanus,* 2.7%), windowpane (2.5%), fourbeard rockling (1.7%), and weakfish (1.5%).

Biweekly density of eggs, larvae (including lobster) and young of the year from the composite samples for both gear types in each sampling strata of Regions 7-10 during the eleven biweekly surveys was highly variable (Table 7). This variability is typical for ichthyoplankton densities, which vary over several orders of magnitude reflecting the patchy distribution of planktonic early life stages (Able and Fahay 1998). The density values in Table 7 were scaled up to standing crop estimates (Table 8). For example, the density of fish eggs for the composite sample collected with the epibenthic sled in the deep sampling strata of Region 7 during survey 1 (March 4-March 17, 282/1000m^3, 0.288/ m^3, Table 7) is multiplied by the volume of water in the bottom 3 m of the deep sampling strata in Region 7 (16,286,400 m^3, Appendix Table D-1) resulting in a standing crop estimate of 4.6 million eggs in the bottom 3 m of Region 7 during survey 1 (March 4-March 17, 2002, Table 8). Standing crop estimates were summed for Regions 7-10 and both gear types to examine seasonality of standing crop (between March and July 2002) by lifestage in Long Island Sound (Figure 13).

Biweekly standing crop estimates for fish eggs in Long Island Sound from the 2002 Poletti Ichthyoplankton Program shows that eggs were present in relatively similar numbers from survey 2-5 (March 18-May 12), increased during survey 6 (May 13-May 26) and peaked during survey 8 (June 10-June 23, Figure 13). After survey 9 (June 24-July 7) egg abundance decreased markedly. Standing crop of larvae was relatively low from the beginning of the 2002 Poletti Ichthyoplankton Program through survey 6 (March 4-May 26, Figure 13). Standing crop of larvae peaked during surveys 8-9 (June 10-July 7) and dropped markedly during survey 10 (July 8-July 21). Young of the year standing crops were considerably lower than egg or larval stages (due to undersampling by the ichthyoplankton focused methods), however the peak percentage of total young of the year standing crop occurred during survey 10 (July 8-July 21) following the larval peak during the previous survey.

Table 5. Fish and lobster larvae count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.

Scientific Name	Common Name	# Larvae	% of Total Catch
Brevoortia tyrannus	Atlantic menhaden	463,417	42.2
Stenotomus chrysops	Scup	134,201	12.2
Tautoga onitis	Tautog	133,152	12.1
Tautogolabrus adspersus	Cunner	77,444	7.1
Cynoscion regalis	Weakfish	54,305	5.0
Enchelyopus cimbrius	Fourbeard rockling	52,423	4.8
Anchoa mitchilli	Bay anchovy	51,033	4.7
Pseudopleuronectes americanus	Winter flounder	28,664	2.6
Scophthalmus aquosus	Windowpane	24,352	2.2
Peprilus triacanthus	Butterfish	23,040	2.1
Prionotus sp.	Unidentified searobin	21,466	2.0
Gobiidae sp.	Unidentified gobies	12,452	1.1
Paralichthys oblongus	Fourspot flounder	6,530	0.6
Ammodytes americanus	American sandlance	6,127	0.6
Myoxocephalus aenaeus	Grubby	2,467	0.2
Homarus americanus	American lobster	1480	0.1
Scomber scombrus	Atlantic mackerel	1,179	0.1
	Unidentifiable	1,078	0.1
Centropristis striata	Black seabass	471	< 0.1
Syngnathus fuscus	Northern pipefish	417	< 0.1
Clupeidae sp.	Herrings	340	< 0.1
Pholis gunnellus	Rock gunnel	262	< 0.1
Trinectes maculatus	Hogchoker	144	< 0.1
Limanda ferruginea	Yellowtail flounder	124	< 0.1
Morone americana	White perch	48	< 0.1
Menidia sp.	Unidentified silversides	44	< 0.1
Liparis atlanticus	Atlantic seasnail	26	< 0.1
Menidia menidia	Atlantic silverside	25	< 0.1
Etropus microstomus	Smallmouth flounder	24	< 0.1
Hypsoblennius hentzi	Feather blenny	23	< 0.1
Ulvaria subbifurcata	Radiated shanny	22	< 0.1
Conger oceanicus	Conger eel	20	< 0.1
Clupea harengus	Atlantic herring	19	< 0.1
Cyprinidae sp.	Unidentified minnows	8	< 0.1
Morone saxatilis	Striped bass	6	< 0.1
Blenniidae sp.	Unidentified blenny	6	< 0.1
Gadus morhua	Atlantic cod	5	< 0.1
Sphoeroides maculatus	Northern puffer	4	< 0.1

(continued)

Table 5. (Continued)

Scientific Name	Common Name	# Larvae	% of Total Catch
Myrophis punctatus	Speckled worm eel	4	< 0.1
Ophidion marginatum	Striped cusk eel	4	< 0.1
Paralichthys dentatus	Summer flounder	4	< 0.1
Etheostoma olmstedi	Tessellated darter	4	< 0.1
Perca flavescens	Yellow perch	4	< 0.1
Lophius americanus	Goosefish	2	< 0.1
Pollachius virens	Pollock	2	< 0.1
Prionotus evolans	Striped searobin	2	< 0.1

Table 6. Fish young of the year (YOY) count and percentage of the total comprised by each species collected with the Tucker trawl and epibenthic sled in all three sampling strata (shallow, intermediate, deep) in Long Island Sound (Regions 7-10) during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.

Scientific Name	Common Name	# YOY	% of Total Catch
Tautogolabrus adspersus	Cunner	2487	65.6
Stenotomus chrysops	Scup	330	8.7
Peprilus triacanthus	Butterfish	243	6.4
Prionotus evolans	Striped searobin	221	5.8
Brevoortia tyrannus	Atlantic menhaden	132	3.5
Ammodytes americanus	American sandlance	102	2.7
Scophthalmus aquosus	Windowpane	96	2.5
Enchelyopus cimbrius	Fourbeard rockling	64	1.7
Cynoscion regalis	Weakfish	56	1.5
Syngnathus fuscus	Northern pipefish	32	0.8
Pseudopleuronectes americanus	Winter flounder	13	0.3
Sphoeroides maculatus	Northern puffer	3	0.1
Anguilla rostrata	American eel	2	0.1
Clupea harengus	Atlantic herring	2	0.1
Pollachius virens	Pollock	2	0.1
Urophycis regia	Spotted hake	2	0.1
Paralichthys dentatus	Summer flounder	2	0.1

Table 7. Ichthyoplankton+ larval lobster density (#/1000m^3) by life stage (egg, larvae, and young of the year (YOY) for all species combined in the laboratory composite samples collected with either the Tucker trawl or epibenthic sled in Regions 7-10 during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program. NS indicates no samples were collected in that Region/survey/gear sampling stratum.

REGION 7 Biweekly Survey Date Range	Sampling Strata	Density (#/1000m^3)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	44	39	
	Intermediate	NS	NS	NS	1118	227	
	Deep	282	94		16	38	
March 18-March 31	Shallow	2	341		99	53	
	Intermediate	134	61		101	98	
	Deep	288	3		902	1590	
April 1-April 14	Shallow	101	332		231	120	
	Intermediate	8	137		4185	153	
	Deep	17	20		1259	72	
April 15-April 28	Shallow	3202	203		365	46	
	Intermediate	4859	384		1300	151	2
	Deep	1982	80		270	34	
April 29-May 12	Shallow	2168	235	4	371	34	
	Intermediate	147	246		3328	134	
	Deep	184	73		107	33	
May 13-May 26	Shallow	4241	81		1375	30	
	Intermediate	1662	77		44184	163	
	Deep	1044	53		1162	274	
May 27-June 9	Shallow	5589	259		3063	16	
	Intermediate	85	634		1514	6255	
	Deep	446	57		12	8	
June 10- June 23	Shallow	2024	1057		20308	3669	
	Intermediate	932	4413		19447	14427	
	Deep	419	2371		4117	5187	
June 24-July 7	Shallow	846	1270		20479	28653	
	Intermediate	376	3415		6971	58307	
	Deep	1781	1593		3675	7245	
July 8-July 21	Shallow	4090	23532	468	62	286	
	Intermediate	36	2759		10	4855	
	Deep	26	1579		455	1591	74
July 22-August 5	Shallow	163	587		282	10	
	Intermediate	414	266	33	32	182	28
	Deep	66	209	4	447	345	27

(continued)

Table 7. (Continued)

REGION 8 Biweekly Survey	Sampling Strata	Density (#/1000m³)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	1633	535		37	42	
	Intermediate	4	104		935	212	
	Deep		108		1488	112	
March 18-March 31	Shallow	1815	300		647	383	
	Intermediate	106	37		5020	268	
	Deep	147	20		8308	331	
April 1-April 14	Shallow	8244	342		2405	123	
	Intermediate	1451	117		5706	558	
	Deep	644	1739		13311	243	
April 15-April 28	Shallow	925	236		1935	45	
	Intermediate	8940	308		4585	170	
	Deep	1570	154		6313	103	
April 29-May 12	Shallow	4342	433		5817	257	
	Intermediate	1858	289		2919	174	
	Deep	1015	62		4783	368	
May 13-May 26	Shallow	15820	902		6605	170	
	Intermediate	9047	886		2857	586	
	Deep	1947	144		1787	328	
May 27-June 9	Shallow	34146	1499		106126	1046	
	Intermediate	4620	271		5805	3060	
	Deep	1874	302	2	3775	1212	
June 10- June 23	Shallow	12799	45086		5069	52414	
	Intermediate	534	2085		7946	24873	
	Deep	150	1327		6408	25497	
June 24-July 7	Shallow	2566	46310		4407	16925	
	Intermediate	7379	26525		5497	26256	
	Deep	576	3594		3318	8783	
July 8-July 21	Shallow	73	1051	108	58	194	
	Intermediate	436	1210	60	211	1521	172
	Deep	746	102	28	77	2001	17
July 22-August 5	Shallow	2	69	11	52	34	85
	Intermediate	359	348	120	1272	47	122
	Deep	34	58		43	69	

(continued)

Table 7. (Continued)

REGION 9 Biweekly Survey	Sampling Strata	Density (#/1000m^3)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	4	214	
	Intermediate	NS	NS	NS	7	330	
	Deep	NS	NS	NS	595	130	
March 18-March 31	Shallow		104		12	133	1
	Intermediate	344	19		10	80	
	Deep	93	26			47	
April 1-April 14	Shallow	394	262		1	63	
	Intermediate	2	37		69	263	
	Deep	19	135		70	142	
April 15-April 28	Shallow	402	202		472	114	
	Intermediate	1557	668		2439	147	
	Deep	939	459		1847	147	
April 29-May 12	Shallow	219	354	76	142	28	
	Intermediate	729	348		775	221	
	Deep	86	68		381	343	
May 13-May 26	Shallow	89	141	2	8808	20	
	Intermediate	263	127		586	374	
	Deep	658	226		1058	593	
May 27-June 9	Shallow	1440	254		2667	358	
	Intermediate	2708	457	3	1644	5034	
	Deep	2059	592		11787	2717	
June 10- June 23	Shallow	5084	2747		1180	443	
	Intermediate	1299	2985	23	16019	9854	
	Deep	3153	856	13	390	174	
June 24-July 7	Shallow	4919	3506		6675	3032	
	Intermediate	8437	5773		6510	29194	
	Deep	2404	245		3130	1097	
July 8-July 21	Shallow	374	6033	53	3499	312	8
	Intermediate	2398	2518		445	572	270
	Deep	1053	47	8	170	472	3
July 22-August 5	Shallow	1063	2894	52	85	307	3
	Intermediate	1323	707	7	1705	78	18
	Deep	115	74		109	101	14

(continued)

Table 7. (Continued)

REGION 10 Biweekly Survey	Sampling Strata	Density (#/1000m³)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	1	19	
	Intermediate	NS	NS	NS	202	134	
	Deep	NS	NS	NS	45	45	
March 18-March 31	Shallow	10	133		1	140	1
	Intermediate	268	38		70	81	
	Deep	410	28			82	
April 1-April 14	Shallow	95	201				
	Intermediate	260	160	1	5157	76	
	Deep	620	217		42	83	
April 15-April 28	Shallow	9	96		102	169	
	Intermediate	1058	273		1173	57	
	Deep	554	225		963	326	
April 29-May 12	Shallow	89	218		427	257	
	Intermediate	1263	572		631	385	
	Deep	284	178		402	313	
May 13-May 26	Shallow	396	192		13	15	
	Intermediate	1549	88		4169	660	
	Deep	128	103	1	208	250	
May 27-June 9	Shallow	2563	169		843	252	
	Intermediate	16680	2928		12945	3517	
	Deep	1420	280	2	3404	394	
June 10- June 23	Shallow	1782	3739		11601	1907	
	Intermediate	12324	1857		2757	850	
	Deep	5415	1710		7081	4738	
June 24-July 7	Shallow	2861	4212		2315	1168	
	Intermediate	2006	1578		7564	4187	
	Deep	3726	2112	21	2192	7529	
July 8-July 21	Shallow	898	1300		2591	130	2
	Intermediate	741	133	38	149	485	10
	Deep	159	212	7	898	1038	29
July 22-August 5	Shallow	700	1539	11	45	49	2
	Intermediate	99	102	3	193	48	
	Deep	76	51		102	75	3

Table 8. Ichthyoplankton standing crop (in millions) by life stage (egg, larvae , and young of the year (YOY)) for all species (including American lobster) combined in the laboratory composite samples collected with either the Tucker trawl or epibenthic sled in Regions 7-10 during the eleven biweekly surveys (March-July) of the 2002 Poletti Ichthyoplankton Program.

REGION 7		Standing Crop ($x10^6$)					
		Epibenthic sled			Tucker trawl		
Biweekly Survey Date Range	Sampling Strata	Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	4.3	3.8	
	Intermediate	NS	NS	NS	4865.2	986.9	
	Deep	4.6	1.5		2.7	6.6	
March 18-March 31	Shallow	0.3	55.6		9.6	5.1	
	Intermediate	140.9	64.1		439.4	425.7	
	Deep	4.7	0.1		155.2	273.7	
April 1-April 14	Shallow	16.4	54.1		22.4	11.7	
	Intermediate	8.3	144.2		18219.3	665.8	
	Deep	0.3	0.3		216.7	12.3	
April 15-April 28	Shallow	521.7	33.0		35.3	4.5	
	Intermediate	5109.5	404.0		5659.5	657.4	7.1
	Deep	32.3	1.3		46.5	5.8	
April 29-May 12	Shallow	353.2	38.4	0.7	35.9	3.3	
	Intermediate	154.5	258.3		14485.6	582.5	
	Deep	3.0	1.2		18.4	5.7	
May 13-May 26	Shallow	690.9	13.2		133.3	2.9	
	Intermediate	1747.5	80.5		192346.0	708.5	
	Deep	17.0	0.9		200.0	47.1	
May 27-June 9	Shallow	910.4	42.1		296.8	1.6	
	Intermediate	88.9	666.2		6590.8	27227.7	
	Deep	7.3	0.9		2.1	1.4	
June 10- June 23	Shallow	329.7	172.2		1967.5	355.5	
	Intermediate	980.1	4641.2		84658.4	62804.2	
	Deep	6.8	38.6		708.5	892.6	
June 24-July 7	Shallow	137.8	206.8		1984.1	2775.9	
	Intermediate	395.5	3591.7		30348.5	253824.2	
	Deep	29.0	25.9		632.4	1246.9	
July 8-July 21	Shallow	666.4	3833.6	76.3	6.0	27.7	
	Intermediate	37.6	2901.7		44.0	21135.2	
	Deep	0.4	25.7		78.3	273.8	12.7
July 22-August 5	Shallow	26.6	95.7		27.3	1.0	
	Intermediate	435.3	279.8	34.3	137.7	791.6	123.9
	Deep	1.1	3.4	0.1	76.9	59.3	4.7

(continued)

Table 8. (Continued)

REGION 8 Survey	Sampling Strata	Standing Crop ($x10^6$)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	315.3	103.3		3.7	4.3	
	Intermediate	7.3	196.8		10390.1	2361.4	
	Deep		74.3		10863.8	814.8	
March 18-March 31	Shallow	350.5	58.0		65.0	38.5	
	Intermediate	200.1	69.0		55805.8	2977.4	
	Deep	101.0	13.8		60657.0	2419.1	
April 1-April 14	Shallow	1591.7	66.0		241.6	12.4	
	Intermediate	2734.1	220.7		63430.3	6200.7	
	Deep	441.5	1192.1		97192.1	1775.5	
April 15-April 28	Shallow	178.6	45.6		194.4	4.5	
	Intermediate	16850	580.7		50967.8	1891.4	
	Deep	1076.3	105.4		46096.1	749.8	
April 29-May 12	Shallow	838.2	83.7		584.4	25.8	
	Intermediate	3501.7	545.0		32444.0	1936.1	
	Deep	695.5	42.6		34919.3	2684.0	
May 13-May 26	Shallow	3054.2	174.1		663.5	17.1	
	Intermediate	17052	1669.2		31759.2	6513.1	
	Deep	1334.7	98.8		13051.1	2396.9	
May 27-June 9	Shallow	6592.3	289.4		10661.9	105.1	
	Intermediate	8706.8	510.5		64535.1	34011.7	
	Deep	1285.0	206.9	1.1	27565.9	8852.0	
June 10- June 23	Shallow	2471.0	8704.4		509.3	5265.7	
	Intermediate	1006.6	3930.4		88327.9	276504.8	
	Deep	102.9	910.0		46785.4	186161.6	
June 24-July 7	Shallow	495.5	8940.6		442.8	1700.3	
	Intermediate	13908	49992.1		61104.8	291879.3	
	Deep	394.7	2463.9		24225.5	64126.2	
July 8-July 21	Shallow	14.1	202.9	20.8	5.9	19.4	
	Intermediate	822.2	2280.7	113.4	2344.4	16913.4	1910.0
	Deep	511.8	70.3	18.9	562.0	14611.4	124.9
July 22-August 5	Shallow	0.4	13.3	2.2	5.3	3.4	8.6
	Intermediate	676.7	655.9	226.6	14138.7	524.8	1358.0
	Deep	23.6	39.5		310.9	501.7	

(continued)

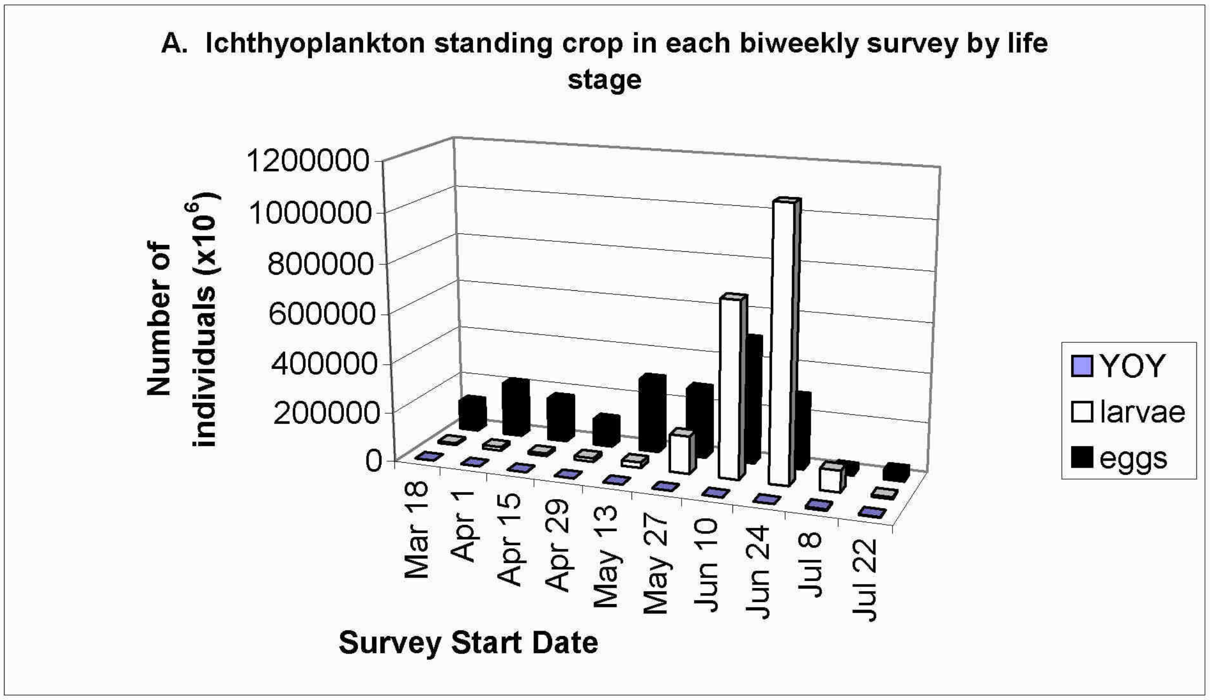
Table 8. (Continued)

REGION 9 Survey	Sampling Strata	Standing Crop ($x10^6$)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	0.3	15.2	
	Intermediate	NS	NS	NS	69.7	3451.8	
	Deep	NS	NS	NS	31.4	6.9	
March 18-March 31	Shallow		13.7		0.8	9.5	0.1
	Intermediate	635.2	34.1		100.8	834.1	
	Deep	0.5	0.1			2.5	
April 1-April 14	Shallow	51.9	34.5		0.1	4.5	
	Intermediate	3.0	68.2		724.5	2747.8	
	Deep	0.1	0.7		3.7	7.5	
April 15-April 28	Shallow	53.0	26.6		33.6	8.1	
	Intermediate	2874.0	1232.9		25491.2	1540.9	
	Deep	5.2	2.5		97.4	7.8	
April 29-May 12	Shallow	28.9	46.6	10.0	10.1	2.0	
	Intermediate	1344.6	642.4		8096.3	2306.1	
	Deep	0.5	0.4		20.1	18.1	
May 13-May 26	Shallow	11.7	18.6	0.2	626.0	1.4	
	Intermediate	484.5	235.0		6125.3	3909.8	
	Deep	3.6	1.3		55.8	31.3	
May 27-June 9	Shallow	189.6	33.4		189.6	25.4	
	Intermediate	4998	843.4	5.4	17177.8	52606.9	
	Deep	11.4	3.3		621.8	143.3	
June 10- June 23	Shallow	669.4	361.8		83.9	31.5	
	Intermediate	2396.8	5508.5	42.0	167418	102980.3	
	Deep	17.4	4.7	0.1	20.6	9.2	
June 24-July 7	Shallow	647.6	461.7		474.4	215.5	
	Intermediate	15569.0	10652.5		68034.9	305103	
	Deep	13.3	1.4		165.1	57.9	
July 8-July 21	Shallow	49.2	794.4	7.0	248.7	22.2	0.6
	Intermediate	4425.0	4646.3		4651.4	5978	2821.0
	Deep	5.8	0.3	0.0	8.9	24.9	0.2
July 22-August 5	Shallow	139.9	381.1	6.8	6.1	21.8	0.2
	Intermediate	2441.1	1305.1	12.1	17815.2	811.2	182.9
	Deep	0.6	0.4		5.8	5.3	0.8

(continued)

Table 8. (Continued)

REGION 10 Survey	Sampling Strata	Standing Crop ($x10^6$)					
		Epibenthic sled			Tucker trawl		
		Eggs	Larvae	YOY	Eggs	Larvae	YOY
March 4-March 17	Shallow	NS	NS	NS	0.1	1.7	
	Intermediate	NS	NS	NS	1192.0	791.0	
	Deep	NS	NS	NS	422.9	422.9	
March 18-March 31	Shallow	1.7	22.0		0.1	12.0	0.1
	Intermediate	303.8	42.6		411.5	480.1	
	Deep	297.2	20.6			772.0	
April 1-April 14	Shallow	15.6	33.2				
	Intermediate	295.3	181.2	1.3	30409.7	447.5	
	Deep	450.1	157.6		397.1	788.3	
April 15-April 28	Shallow	1.5	15.8		8.7	14.4	
	Intermediate	1199.9	309.6		6916.6	337.0	
	Deep	402.2	162.9		9117.8	3087.9	
April 29-May 12	Shallow	14.7	36.0		36.4	22.0	
	Intermediate	1431.7	648.3		3719.2	2268.1	
	Deep	206.1	129.1		3811.8	2967.7	
May 13-May 26	Shallow	65.4	31.7		1.1	1.3	
	Intermediate	1755.7	99.4		24583.4	3889.3	
	Deep	92.9	74.4	0.6	1973.5	2368.2	
May 27-June 9	Shallow	423.7	27.9		71.9	21.5	
	Intermediate	18910.0	3319.7		76326.9	20738.7	
	Deep	1030.2	202.8	1.1	32237.6	3730.7	
June 10- June 23	Shallow	294.5	618.1		990.3	162.8	
	Intermediate	13971.0	2105.5		16255.7	5011.5	
	Deep	3930.1	1240.7		67072.0	44875.5	
June 24-July 7	Shallow	472.9	696.1		197.6	99.7	
	Intermediate	2273.8	1789.2		44598.9	24688.7	
	Deep	2703.8	1532.9	15.4	20763.2	71308.0	
July 8-July 21	Shallow	148.4	214.9		221.2	11.1	0.2
	Intermediate	839.9	150.6	42.9	877.5	2858.9	56.6
	Deep	115.5	154.0	5.3	8501.9	9835.6	277.8
July 22-August 5	Shallow	115.7	254.4	1.8	3.8	4.2	0.2
	Intermediate	112.6	115.2	3.8	1136.1	284.0	
	Deep	54.9	36.8		970.4	707.6	27.0



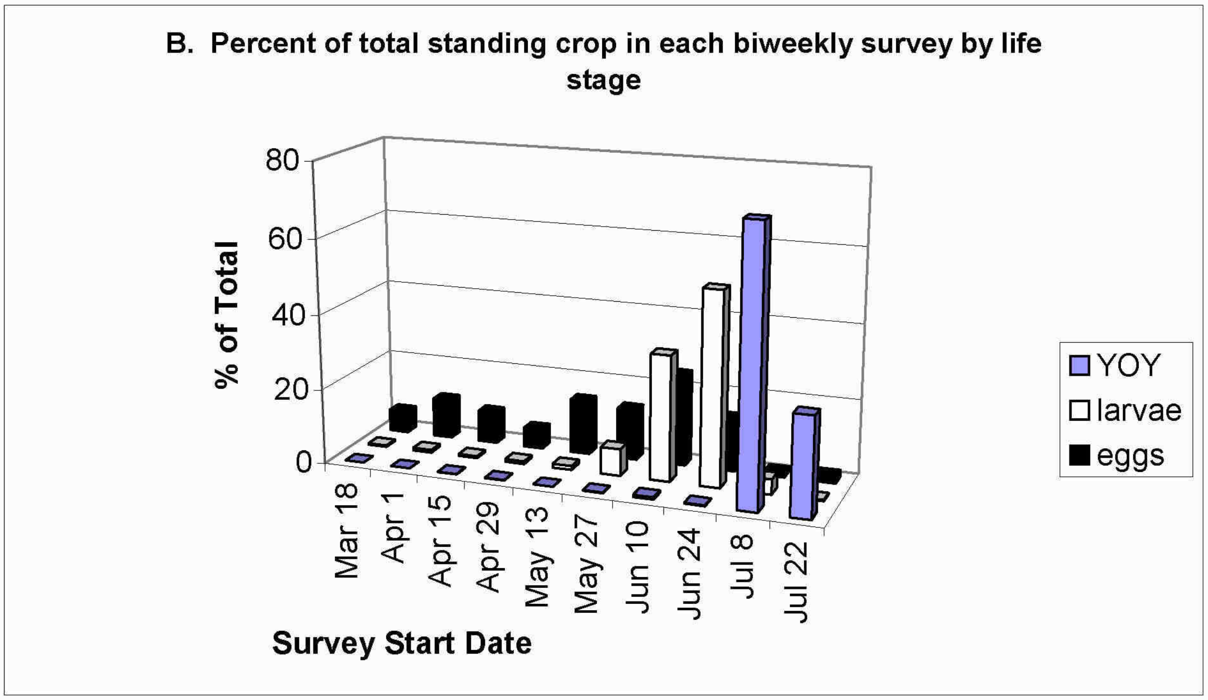


Figure 13. Estimated total (A) and percentage (B) of the ichthyoplankton (and lobster larvae) standing crop (in millions) for eggs, larvae (yolk sac + post yolk sac stage), and young of the year (YOY) for all species combined from Long Island Sound (Regions 7-10) during the March-July 2002 Poletti Ichthyoplankton Program (surveys 2-11). Percentages sum to 100% within each life stage.

8.2 ICHTHYOPLANKTON SPECIES COMPOSITION IN WATER COLUMN (TUCKER TRAWL) TOWS CONDUCTED IN THE DEEP SAMPLING STRATA IN THE CENTRAL BASIN AREA OF LONG ISLAND SOUND (SUBSET DATA)

The 2002 Poletti Ichthyoplankton Program data was subset to represent the waterbody most likely to be exposed to withdrawl from the proposed FSRU (Regions 7-9, deep sampling strata, Tucker trawl collections, Section 7.0). Twenty-seven taxa of fish and American lobster were collected during the eleven biweekly surveys in the subset data, temporal occurrence of each species and lifestage is presented in Table 9. Young of the year were not collected in large numbers and were not observed until the last two surveys (July 8-August 5). Temperature, dissolved oxygen and salinity measurements taken at the surface, mid-depth and bottom during each biweekly survey in Regions 7-9 are presented in Appendix Table C-1. Temperature, salinity, and dissolved oxygen were relatively homogeneous throughout March-August 2002 period as discussed in Section 7. Comparison of mean egg and larvae density in the Central Basin area (Regions 7-9) for the six gear/sampling strata combinations (shallow-sled, shallow-Tucker trawl, intermediate-sled, intermediate-Tucker trawl, deep-sled, and deep-Tucker trawl) demonstrates that the strata subset to best represent the FSRU facility (deep-Tucker trawl) generally had lower ichthyoplankton densities than the shallow and intermediate sampling strata (Figure 14).

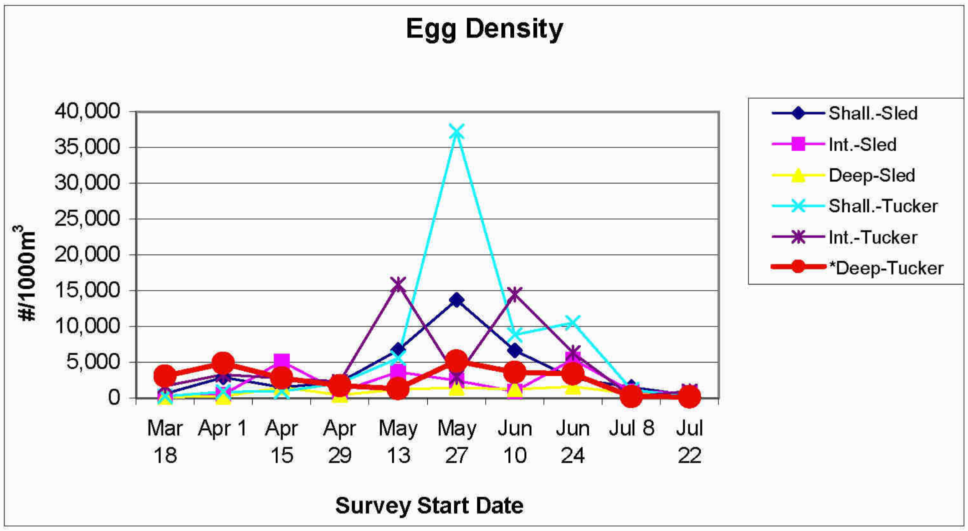
Ichthyoplankton and lobster larvae densities for each species and lifestage collected with the Tucker trawl in the deep sampling strata were averaged across the three Regions (7-9) and multiplied by stratum volumes (Appendix Table D-1) to yield standing crop estimates for each biweekly survey (Table 10). For example, the average density of fourbeard rockling eggs from composite samples collected with the Tucker trawl in the deep sampling strata of Regions 7-9 during survey 1 (March 4-March 17; 693.9/1000m^3, 0.7/m^3, Table 10) is multiplied by the volume of water from the surface to 3 m above bottom in Regions 7-9 ($1.7x10^8 + 7.3x10^9 + 5.3x10^7 = 7.5x10^9$ m^3 Appendix Table D-1) to yield an estimate of 5.2 x10^9 (5,222 million) fourbeard rockling eggs (Table 10). Standing crops were summed by life stage (egg, larvae, YOY) to examine changes throughout the March-July sampling period. Egg standing crop was bimodal with a peak during survey 3 (April 1-April 14), and a peak during week 7 (May 27-June 9, Figure 15). Egg standing crop dropped markedly during surveys 10-11 (July 8-August 5). Although overall egg composition summed over all eleven biweekly surveys of the program was dominated by fourbeard rockling (71%, Table 11) there is a distinct shift in species composition and increase in species diversity during surveys 6-7 (May 13-June 9) when the relative proportion of fourbeard rockling declines and eggs of summer spawning species such as tautog, searobin, weakfish/scup, Atlantic menhaden, windowpane and cunner associated with increasing water temperatures (Appendix Table C-1) occur in the water column (Figure 16, Table 10).

Larval standing crop increased noticeably during survey 8 (June 10-June 23) following the peak in egg abundance observed during the previous survey (Figure 15). Larval abundance remained relatively high during survey 9 (June 24-July 7) and dropped noticeably during the last 2 surveys (July 8-August 5) as abundant larval species were likely recruiting to benthic habitats. Atlantic menhaden were the dominant larval species collected over the entire eleven biweekly period (March-July 2002, 44.7%, Table 11), although they were not a prominent component of the larval fish community prior to survey 8 (June 10-23, Figure 17). A distinct seasonal shift in the larval fish community composition was observed with winter and early spring spawning species such as winter flounder, American sand lance, grubby and rock gunnel present in low abundance during the earliest

Table 9. Species and lifestage (E= eggs, L= larvae (yolk sac+ post yolk sac), Y= young of the year) occurrence during each of the eleven biweekly (March-July) surveys in the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*.

Common Name	Scientific Name	2002 Bi-weekly Survey Week										
		4-Mar	18-Mar	1-Apr	15-Apr	29-Apr	13-May	27-May	10-Jun	24-Jun	8-Jul	22-Jul
American lobster	*Homarus americanus*						L	L	L	L	L	
American sandlance	*Ammodytes americanus*	L	L	L	L	L						
Atlantic mackerel	*Scomber scombrus*					E	L	L				
Atlantic menhaden	*Brevoortia tyrannus*						E	EL	EL	L	L	L
Atlantic silverside	*Menidia menidia*										L	
Bay anchovy	*Anchoa mitchilli*				L			E	E	EL	EL	EL
Black seabass	*Centropristis striata*											L
Butterfish	*Peprilus triacanthus*							E	EL	EL	ELY	ELY
Cunner	*Tautogolabrus adspersus*						E	EL	EL	EL	ELY	ELY
Feather blenny	*Hypsoblennius hentzi*										L	L
Fourbeard rockling	*Enchelyopus cimbrius*	E	E	EL	EL	EL	EL	EL	EL	E	E	E
Fourspot flounder	*Paralichthys oblongus*								L	L	L	L
Grubby	*Myoxocephalus aenaeus*	L	L	L	L		L					
Herrings	Clupeidae sp.							L		L		
Hogchoker	*Trinectes maculatus*										E	
Northern pipefish	*Syngnathus fuscus*								L		L	L
Rock gunnel	*Pholis gunnellus*	L	L									
Scup	*Stenotomus chrysops*								L	L	L	LY
Smallmouth flounder	*Etropus microstomus*											L
Striped cusk eel	*Ophidion marginatum*				L							
Striped searobin	*Prionotus evolans*										Y	
Tautog	*Tautoga onitis*					E	EL	EL	EL	EL	EL	E
Unidentifiable										L	L	
Unidentified gobies	Gobiidae sp.									L	L	L
Unidentified searobin	*Prionotus* sp.						E	E	EL	EL	EL	EL
Weakfish	*Cynoscion regalis*								L	L	L	L
Weakfish/Scup	*Cynoscion regalis/Stenotomus chrysops*						E	E	E	E	E	E
Windowpane	*Scophthalmus aquosus*	E	E	E		EL	EL	EL	EL	EL	EL	E
Winter flounder	*Pseudopleuronectes americanus*	EL	L	L	L	L	L	L			L	
Yellowtail flounder	*Limanda ferruginea*			E								

* Regions 7-9, Tucker trawl collections, deep (>30 m, 98 ft) sampling strata.



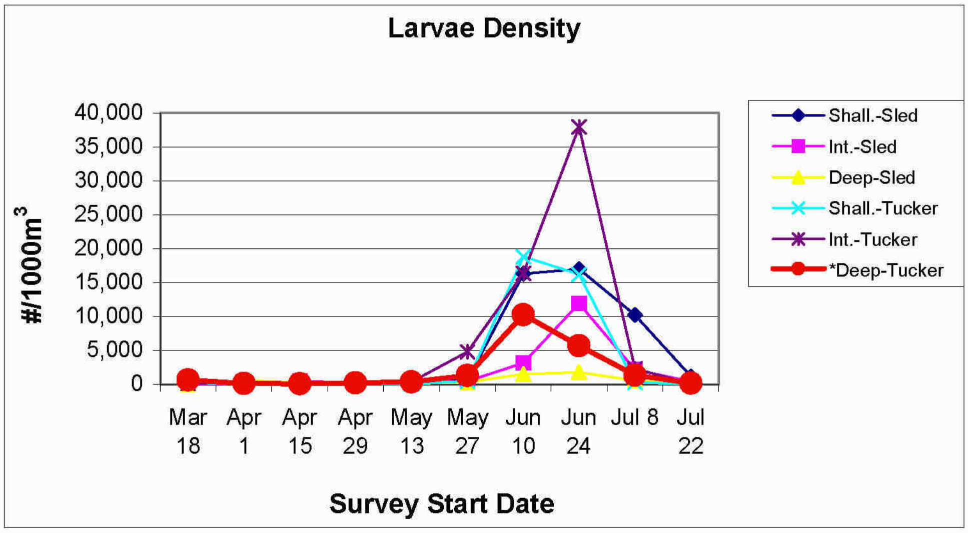


Figure 14. Mean egg and larvae density (#/1000m^3) in Regions 7-9 (Central Basin Area) during biweekly surveys 2-11 by gear type (Epibenthic sled or Tucker trawl) and samping strata (shallow, intermediate, or deep) in the 2002 Poletti Ichthyoplankton Program. The data subset to represent the proposed FSRU location (deep-Tucker trawl) is plotted with the heavy weight Red line for comparison.

Table 10. Mean biweekly ichthyoplankton and larval lobster density (#/1000m^3) and estimated standing crop (in millions) by species and lifestage from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*.

Survey	Common Name	Life stage	Mean Density (#/1000m^3)	Standing Crop (x10^6)
March 4-March 17	Fourbeard rockling	Eggs	693.9	5222.2
	American sandlance	Larvae	81.9	616.1
	Grubby	Larvae	1.8	13.9
	Rock gunnel	Larvae	0.6	4.6
	Windowpane	Eggs	2.5	18.5
	Winter flounder	Eggs	3.4	25.7
		Larvae	9.0	68.0
March 18-March 31	Fourbeard rockling	Eggs	3061.0	23038.0
	American sandlance	Larvae	139.4	1048.9
	Grubby	Larvae	9.3	70.3
	Rock gunnel	Larvae	0.9	6.9
	Windowpane	Eggs	8.8	66.2
	Winter flounder	Larvae	506.5	3812.2
April 1-April 14	Fourbeard rockling	Eggs	4857.7	36560.1
		Larvae	1.0	7.7
	American sandlance	Larvae	36.3	273.3
	Grubby	Larvae	8.1	61.0
	Windowpane	Eggs	21.3	159.9
	Winter flounder	Larvae	106.9	804.7
	Yellowtail flounder	Eggs	1.1	7.9
April 15-April 28	Fourbeard rockling	Eggs	2810.2	21150.5
		Larvae	8.8	66.0
	American sandlance	Larvae	3.0	22.4
	Bay anchovy	Larvae	0.8	6.3
	Grubby	Larvae	8.4	63.2
	Striped cusk-eel	Larvae	0.8	6.3
	Winter flounder	Larvae	72.8	547.7
April 29-May 12	Fourbeard rockling	Eggs	1606.9	12094.0
		Larvae	96.3	724.8
	American sandlance	Larvae	1.2	9.3
	Atlantic mackerel	Eggs	15.2	114.3
	Tautog	Eggs	2.7	20.2
	Windowpane	Eggs	131.9	992.6
		Larvae	0.9	6.7
	Winter flounder	Larvae	149.5	1125.0

(continued)

* Regions 7-9, Tucker trawl collections, deep (>30 m, 98 ft) sampling strata

Table 10. (Continued)

Survey	Common Name	Life stage	Mean Density (#/1000m^3)	Standing Crop (x10^6)
May 13-May 26	Fourbeard rockling	Eggs	667.3	5022.5
		Larvae	208.1	1566.0
	American lobster	Larvae	1.4	10.8
	Atlantic mackerel	Larvae	12.0	90.2
	Atlantic menhaden	Eggs	197.0	1482.3
	Cunner	Eggs	38.9	292.5
	Grubby	Larvae	1.1	8.6
	Sea robin	Eggs	36.5	274.9
	Tautog	Eggs	191.8	1443.2
		Larvae	1.1	8.6
	Weakfish/scup	Eggs	45.8	344.8
	Windowpane	Eggs	158.8	1195.0
		Larvae	96.5	726.2
	Winter flounder	Larvae	79.4	597.6
May 27-June 9	Fourbeard rockling	Eggs	6.5	49.0
		Larvae	673.3	5067.2
	American lobster	Larvae	12.2	92.0
	Atlantic mackerel	Larvae	45.6	343.3
	Atlantic menhaden	Eggs	509.6	3835.7
		Larvae	175.9	1323.8
	Bay anchovy	Eggs	13.0	98.1
	Butterfish	Eggs	6.5	49.0
	Cunner	Eggs	632.0	4756.7
		Larvae	19.5	147.1
	Herrings	Larvae	8.1	61.2
	Sea robin	Eggs	230.2	1732.5
	Tautog	Eggs	2254.3	16966.2
		Larvae	83.6	629.3
	Weakfish/scup	Eggs	1072.4	8071.3
	Windowpane	Eggs	466.8	3513.6
		Larvae	291.5	2194.0
	Winter flounder	Larvae	14.9	112.3
June 10- June 23	Fourbeard rockling	Eggs	365.8	2753.2
		Larvae	23.9	179.9
	American lobster	Larvae	1.2	9.2
	Atlantic menhaden	Eggs	374.3	2817.0
		Larvae	5733.5	43151.9
	Bay anchovy	Eggs	258.5	1945.9

(continued)

Table 10. (Continued)

Survey	Common Name	Life stage	Mean Density (#/1000m^3)	Standing Crop (x10^6)
June 10- June 23 (continued)	Butterfish	Eggs	24.4	183.8
		Larvae	29.3	220.5
	Cunner	Eggs	399.4	3006.1
		Larvae	1181.0	8888.5
	Fourspot flounder	Larvae	44.7	336.7
	Northern pipefish	Larvae	1.1	8.2
	Scup	Larvae	654.0	4922.1
	Sea robin	Eggs	955.6	7191.9
		Larvae	614.9	4628.0
	Tautog	Eggs	668.5	5031.1
		Larvae	1650.4	12421.3
	Weakfish	Larvae	205.8	1549.2
	Weakfish/scup	Eggs	407.9	3070.3
	Windowpane	Eggs	183.8	1383.4
		Larvae	147.0	1106.6
June 24-July 7	Fourbeard rockling	Eggs	578.0	4350.4
	American lobster	Larvae	12.5	94.4
	Atlantic menhaden	Larvae	2760.0	20772.3
	Bay anchovy	Eggs	98.8	743.6
		Larvae	192.1	1445.5
	Butterfish	Eggs	40.2	302.3
		Larvae	94.1	707.9
	Cunner	Eggs	245.1	1844.7
		Larvae	378.0	2845.2
	Fourspot flounder	Larvae	39.1	294.0
	Gobiidae	Larvae	8.7	65.4
	Herrings	Larvae	7.3	55.0
	Scup	Larvae	759.0	5712.7
	Sea robin	Eggs	1207.3	9086.2
		Larvae	65.2	490.4
	Tautog	Eggs	683.4	5143.4
		Larvae	862.2	6489.4
	Unidentifiable	Larvae	2.4	18.3
	Weakfish	Larvae	508.8	3829.7
	Weakfish/scup	Eggs	477.0	3589.7
	Windowpane	Eggs	44.5	334.8
		Larvae	31.5	236.8

(continued)

Table 10. (Continued)

Survey	Common Name	Life stage	Mean Density (#/1000m^3)	Standing Crop (x10^6)
July 8-July 21	Fourbeard rockling	Eggs	14.6	110.0
	American lobster	Larvae	1.8	13.4
	Atlantic menhaden	Larvae	553.4	4164.7
	Atlantic silverside	Larvae	3.1	23.1
	Bay anchovy	Eggs	2.6	19.4
		Larvae	395.2	2974.2
	Butterfish	Eggs	23.0	173.0
		Larvae	20.2	152.2
		YOY	9.9	74.5
	Cunner	Eggs	17.7	133.3
		Larvae	250.9	1888.5
		YOY	18.4	138.4
	Feather blenny	Larvae	3.1	23.1
	Fourspot flounder	Larvae	5.7	42.9
	Gobiidae	Larvae	13.4	100.8
	Hogchoker	Eggs	24.9	187.3
	Northern pipefish	Larvae	3.4	25.5
	Scup	Larvae	52.0	391.5
	Sea robin	Eggs	9.4	70.7
		Larvae	12.5	94.3
	Striped searobin	YOY	3.1	23.1
	Tautog	Eggs	121.2	912.3
		Larvae	20.1	151.1
	Unidentifiable	Larvae	6.1	46.1
	Weakfish	Larvae	11.4	85.5
	Weakfish/scup	Eggs	17.2	129.2
	Windowpane	Eggs	3.4	25.7
		Larvae	3.1	23.1
	Winter flounder	Larvae	1.1	8.5
July 22-August 5	Fourbeard rockling	Eggs	32.7	246.1
	Atlantic menhaden	Larvae	25.1	189.2
	Bay anchovy	Eggs	16.9	127.1
		Larvae	19.1	143.9
	Black sea bass	Larvae	2.9	21.7
	Butterfish	Eggs	5.7	42.8
		Larvae	5.6	42.4
		YOY	8.2	61.8
	Cunner	Eggs	33.0	248.1
		Larvae	1.0	7.2
		YOY	4.6	34.2

(continued)

Table 10. (Continued)

Survey	Common Name	Life stage	Mean Density (#/1000m^3)	Standing Crop (x10^6)
July 22-August 5 (continued)	Feather blenny	Larvae	2.3	17.1
	Fourspot flounder	Larvae	0.3	2.4
	Gobiidae	Larvae	93.4	702.6
	Northern pipefish	Larvae	1.5	11.0
	Scup	Larvae	15.7	118.2
		YOY	1.1	8.6
	Sea robin	Eggs	51.9	390.8
		Larvae	1.3	9.6
	Smallmouth flounder	Larvae	2.1	15.8
	Tautog	Eggs	40.7	306.3
	Weakfish	Larvae	1.1	8.6
	Weakfish/scup	Eggs	1.3	9.7
	Windowpane	Eggs	17.5	131.9

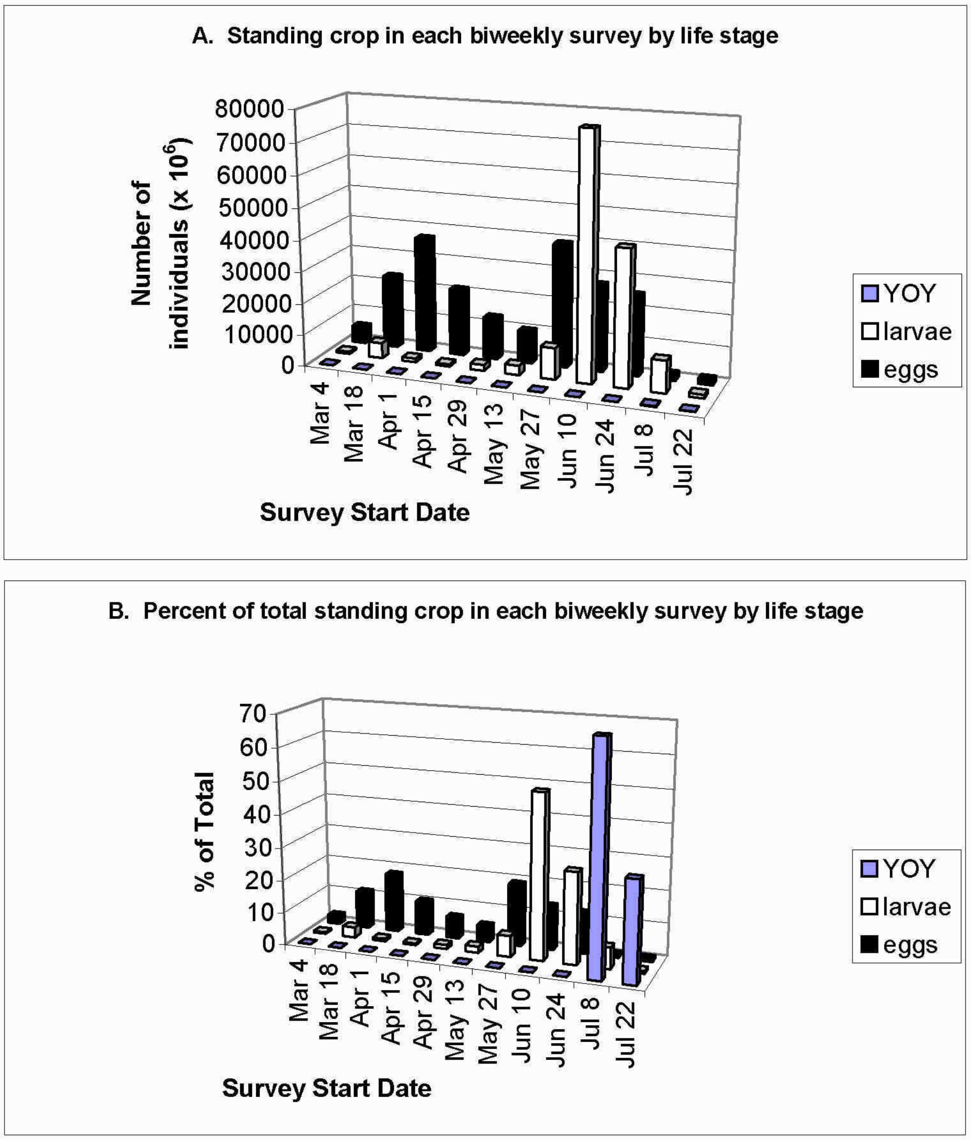


Figure 15. Estimated total (A) and percentage (B) of the ichthyoplankton (and lobster larvae) standing crop (in millions) for eggs, larvae (yolk sac + post yolk sac stage), and young of the year (YOY)) for all species combined from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl). Percentages sum to 100% within each life stage.

Table 11. Egg, larvae (fish yolk sac + post yolk-sac, lobster stages 1-4) and young of the year (YOY) count (estimated total count from laboratory composite samples) and percentage of the total comprised by each species collected from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location*.

Scientific Name	Common Name	Eggs		Larvae		YOY	
		#	% Total	#	% Total	#	% Total
Homarus americanus	American lobster			144	0.2		
Ammodytes americanus	American sandlance			926	1.0		
Scomber scombrus	Atlantic mackerel	34	<0.1	105	0.1		
Brevoortia tyrannus	Atlantic menhaden	5657	4.2	39767	44.7		
Menidia menidia	Atlantic silverside			5	<0.1		
Anchoa mitchilli	Bay anchovy	1441	1.1	2183	2.5		
Centropristis striata	Black seabass			6	<0.1		
Peprilus triacanthus	Butterfish	197	0.1	647	0.7	55	53.9
Tautogolabrus adspersus	Cunner	3403	2.5	9470	10.7	40	39.0
Hypsoblennius hentzi	Feather blenny			9	<0.1		
Enchelyopus cimbrius	Fourbeard rockling	94419	70.6	3807	4.3		
Paralichthys oblongus	Fourspot flounder			450	0.5		
Myoxocephalus aenaeus	Grubby			133	0.1		
Clupeidae sp.	Herrings			60	0.1		
Trinectes maculatus	Hogchoker	44	<0.1				
Syngnathus fuscus	Northern pipefish			12	<0.1		
Pholis gunnellus	Rock gunnel			6	<0.1		
Stenotomus chrysops	Scup			7955	8.9	2	1.9
Etropus microstomus	Smallmouth flounder			8	<0.1		
Ophidion marginatum	Striped cusk eel			2	<0.1		
Prionotus evolans	Striped searobin					5	5.2
Tautoga onitis	Tautog	8537	6.4	12900	14.5		
	Unidentifiable			15	<0.1		
Gobiidae sp.	Unidentified gobies			241	0.3		
Prionotus sp.	Unidentified searobin	9893	7.4	3390	3.8		
Cynoscion regalis	Weakfish			2282	2.6		
Cynoscion regalis/Stenotomus chrysops	Weakfish/Scup	6511	4.9				
Scophthalmus aquosus	Windowpane	3655	2.7	1485	1.7		
Pseudopleuronectes americanus	Winter flounder	15	<0.1	2892	3.3		
Limanda ferruginea	Yellowtail flounder	2	<0.1				

* Regions 7-9, Tucker trawl collections, deep (>30 m, 98 ft) sampling strata

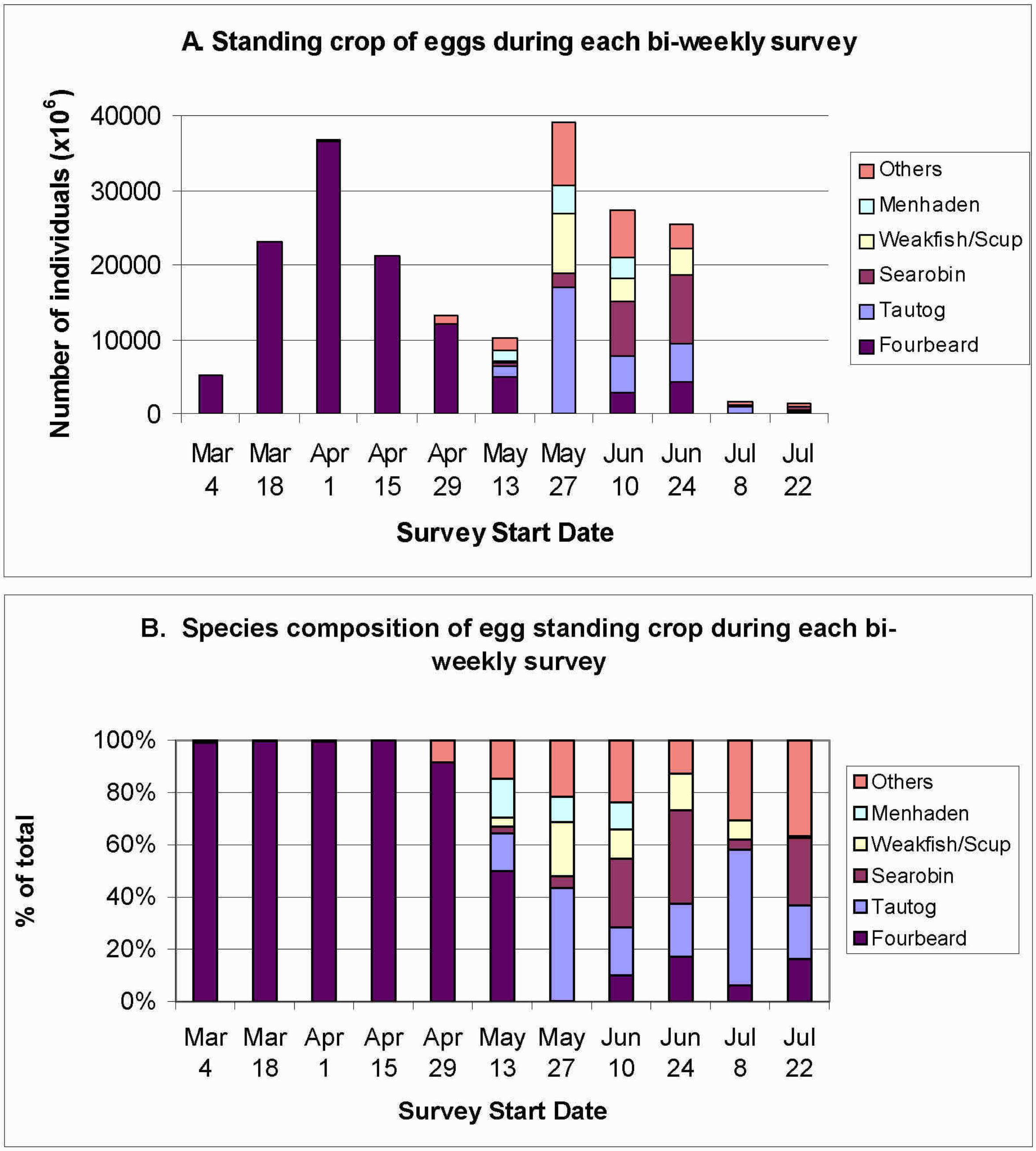
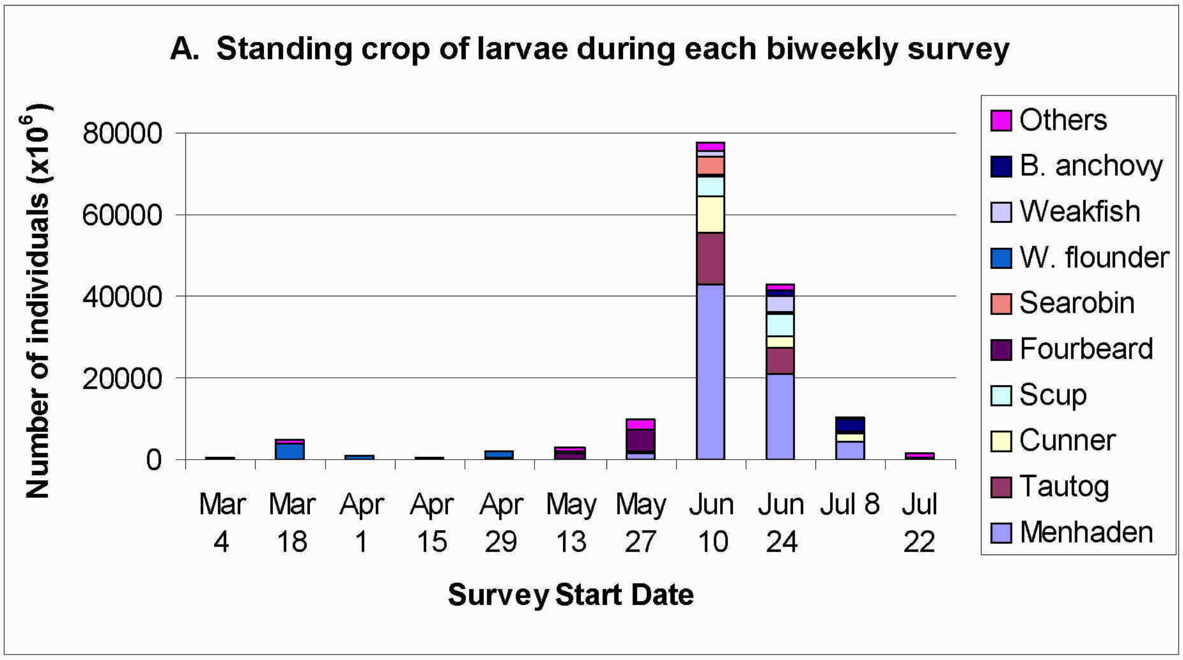


Figure 16. Estimated total (A) standing crop (in millions) of common fish eggs and (B) % species composition during each of the eleven biweekly surveys from 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl).



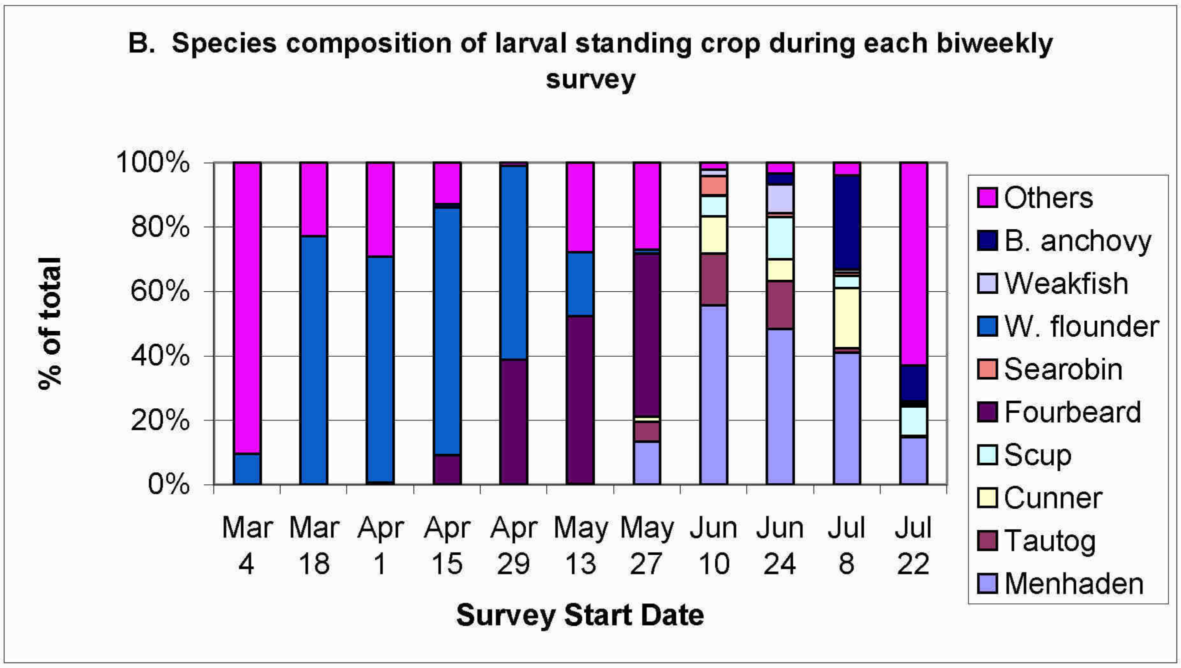


Figure 17. Estimated total (A) standing crop (in millions) of common fish larvae and (B) % species composition during each of the eleven biweekly surveys from the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location (Regions 7-9, deep sampling strata, Tucker trawl).

surveys 1-4 (March 4- April 28, Figure 17). Fourbeard rockling larvae form a relatively large proportion of the larval community along with the previously mentioned cold-water spawners through survey 6 (May 13-May 26). A shift in species composition and increase in diversity influenced the increase in standing crop during survey 8 (June 10-23) when species such as Atlantic menhaden, tautog, cunner, scup, and searobin larvae appear. Standing crop and relative proportion of Atlantic menhaden, tautog, cunner, scup, and searobin decline during the last two surveys (July 8-August 5) when the proportion of bay anchovy and unidentified goby larvae increase (Figure 17, Table 10).

Four species of young of the year were collected with the Tucker trawl in the deep sampling strata of Regions 7-9 (Table 11). Young of the year were collected during the last 2 surveys (July 8- Aug 5) in low numbers. Butterfish (53.9%) and cunner (39%) comprised most of the catch, striped searobin (5.2%) and scup (1.9%) were also collected.

8.3 LIFE HISTORY SUMMARY AND ENTRAINMENT ESTIMATES FOR ABUNDANT SPECIES AND OTHER SPECIES OF INTEREST AT THE PROPOSED FSRU

The life history and entrainment estimates of abundant species and other species of interest due to commercial or recreational importance collected during the 2002 Poletti Ichthyoplankton Program are discussed in this section. Because the 2002 Poletti Ichthyoplankton Program sampled from March-July, entrainment estimates represent the sum of the March-July, 2002 period. The applicability of these March-July entrainment estimates to annual estimates was evaluated by comparison with other published regional ichthyoplankton surveys from Long Island Sound (Wheatland 1956), Great South Bay, N.Y (Monteleone 1992), Buzzards Bay (Chute and Turner 2001), and Narragansett Bay (Bourne and Govoni 1988, Keller et al. 1999). Stone et al. (1994) presents information on the relative temporal abundance and distribution of selected species and life stages in Mid-Atlantic estuaries (including Long Island Sound) compiled from available data as part of NOAA's Estuarine Living Marine Resources (ELMR) Program, this reference was also used to characterize the seasonal occurrence of species and life stages in Long Island Sound.

Wheatland (1956) conducted oblique plankton tows in the Central Basin area of Long Island Sound with a No. 2 (0.366 mm) mesh net at biweekly intervals from March 1952-March 1954, this study represents the only published, year-round ichthyoplankton data from offshore locations available for Long Island Sound. Figure 18 (taken from Wheatland 1956) suggests that the Poletti sampling window from March through July may have missed periods of relatively high ichthyoplankton abundance in the fall (primarily Atlantic menhaden). Comparison of more recently collected data from regionally proximal areas in Great South Bay, NY (Monteleone et al. 1992, Figure 19) and Narragansett Bay, RI (Keller et al. 1999, Figure 20) suggest that the March-July Poletti sampling window coincided with the seasonal distribution of eggs in the water column and the majority of the seasonal occurrence of larvae.

Wheatland (1956) was used to approximate the proportion of the annual abundance of egg and larval stages of selected species that would have occured from March-July based on the average monthly density from January-December, 1953. The Wheatland data was not used to extrapolate entrainment numbers beyond the March-July Poletti sampling window, but rather as an estimation of the annual (January-December) number entrained based on the March-July period. Average monthly egg and larvae density of selected species from 1953 from Wheatland (1956) and the 2002 Poletti Ichthyoplankton Program are presented in Table 12 and Figure 21. Densities of fish eggs and larvae

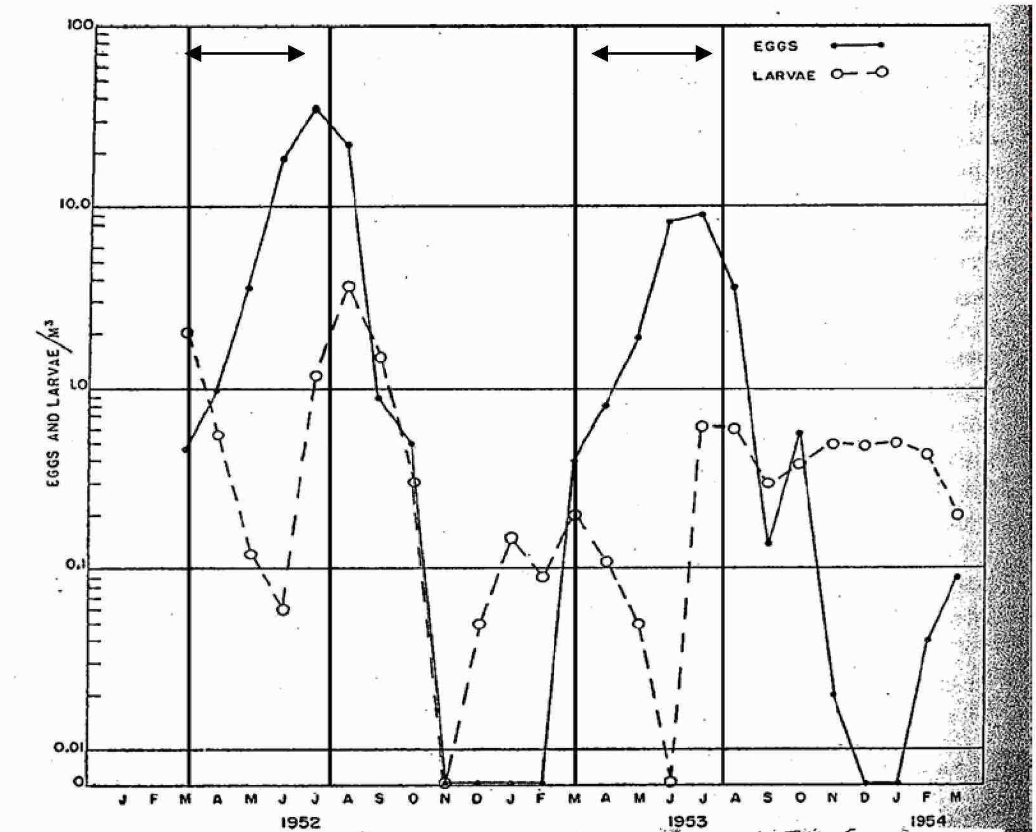


Figure 2. Total number of eggs and larvae per cubic meter from L. I. S. taken each month during 1952–1954.

Figure 18. Total number of fish eggs and larvae per cubic meter from Long Island Sound taken each month during 1952-1954. Figure is taken from Wheatland (1956), vertical bars have been added to mark the Poletti sampling window.

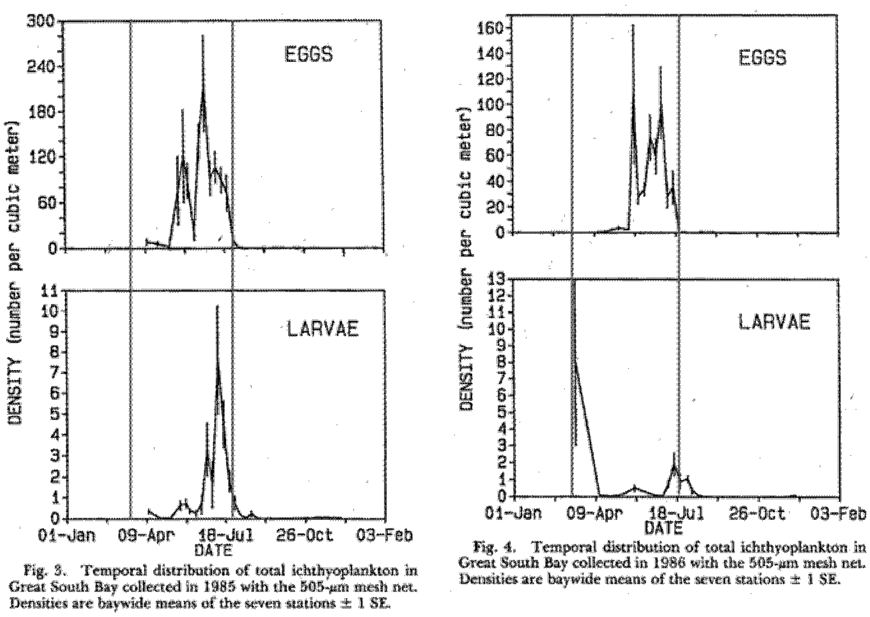


Fig. 3. Temporal distribution of total ichthyoplankton in Great South Bay collected in 1985 with the 505-μm mesh net. Densities are baywide means of the seven stations ± 1 SE.

Fig. 4. Temporal distribution of total ichthyoplankton in Great South Bay collected in 1986 with the 505-μm mesh net. Densities are baywide means of the seven stations ± 1 SE.

Figure 19. Temporal distribution of ichthyoplankton in Great South Bay, NY collected in 1985 with a 0.505 mm net adapted from Monteleone (1992). Vertical bars have been added to mark the Poletti sampling window from March-July.

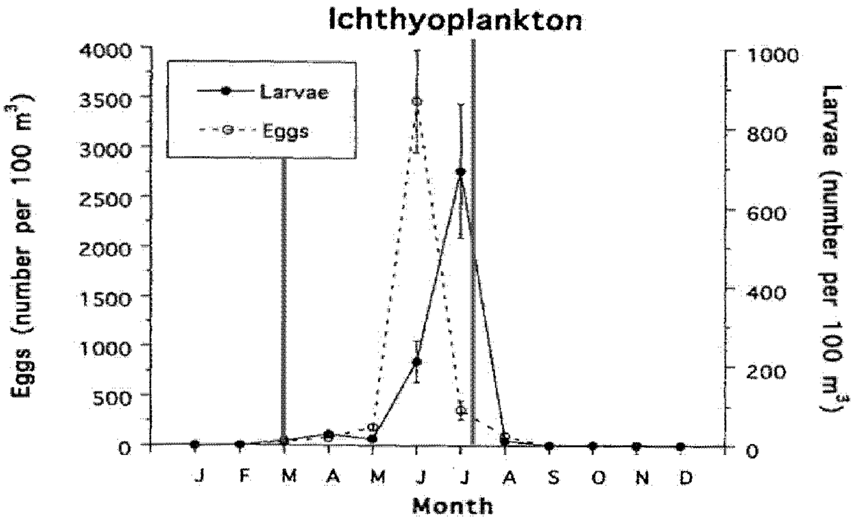


Figure 20. Seasonal distribution of ichthyoplankton in Narragansett Bay, RI during 1990 collected with a 0.505 mm mesh net adapted from Keller et al. (1999). Vertical bars have been added to mark the Poletti sampling window from March-July.

Table 12. Seasonal occurrence and mean density (#/1000m³) of eggs and larvae for selected species in 1953 (Wheatland 1956) and during the 2002 Poletti Ichthyoplankton Program data subset to represent the FSRU facility's intake*. The % overlap index represents the percent of the total annual density in Wheatland (1956) that occurred during March through July (the 2002 Poletti Ichthyoplankton Program sampling period). A blank cell indicates no sampling in that month.

Species	Lifestage	Source	Average Density (#/1000m³)												% Overlap Index
			Jan	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	Aug	Sept	Oct	Nov	Dec	
American sandlance	egg	Poletti			**0**	**0**	**0**	**0**	**0**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	NA
	larvae	Poletti			**111**	**19.6**	**0.4**	**0**	**0**						
		Wheatland	130	180	**220**	**80**	**20**	**0**	**0**	0	0	0	0	460	29
Atlantic menhaden	egg	Poletti			**0**	**0**	**236**	**187**	**0**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**0**	10	140	270	0	0	0
	larvae	Poletti			**0**	**0**	**59**	**4247**	**289**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**0**	0	70	350	470	20	0
Bay anchovy	egg	Poletti			**0**	**0**	**4**	**179**	**10**						
		Wheatland	0	0	**0**	**0**	**0**	**40**	**5680**	3160	0	0	0	0	64
	larvae	Poletti			**0**	**0**	**0**	**96**	**207**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**680**	780	220	0	20	0	40
cunner	egg	Poletti			**0**	**0**	**224**	**322**	**25**						
		Wheatland	0	0	**0**	**0**	**1140**	**7080**	**1730**	2080	0	0	0	0	83
	larvae	Poletti			**0**	**0**	**7**	**780**	**126**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**50**	0	0	0	0	0	100
Fourbeard rockling	egg	Poletti			**1877**	**3834**	**760**	**472**	**24**						
		Wheatland	0	0	**410**	**940**	**290**	**70**	**0**	0	0	0	0	0	100
	larvae	Poletti			**0**	**5**	**326**	**12**	**0**						
		Wheatland	0	0	**0**	**10**	**0**	**0**	**0**	0	0	0	0	0	100
Searobin	egg	Poletti			**0**	**0**	**89**	**1081**	**31**						
		Wheatland	0	0	**0**	**0**	**0**	**16**	**20**	70	0	0	0	0	34
	larvae	Poletti			**0**	**0**	**0**	**340**	**7**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	NA
Scup	egg	Poletti			**0**	**0**	**242**	**288**	**6**						
		Wheatland	0	0	**0**	**0**	**0**	**140**	**220**	0	0	0	0	0	100
	larvae	Poletti			**0**	**0**	**0**	**707**	**34**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**20**	0	0	0	0	0	100
Tautog	egg	Poletti			**0**	**0**	**816**	**676**	**81**						
		Wheatland	0	0	**0**	**0**	**240**	**890**	**50**	30	0	0	0	0	98
	larvae	Poletti			**0**	**0**	**28**	**1256**	**10**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**10**	0	0	0	0	0	100
Weakfish	egg	Poletti			**0**	**0**	**130**	**155**	**3**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**250**	70	0	0	0	0	78
	larvae	Poletti			**0**	**0**	**0**	**357**	**6**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**50**	20	0	0	0	0	71
Winter flounder	egg	Poletti			**2**	**0**	**0**	**0**	**0**						
		Wheatland	0	0	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	NA
	larvae	Poletti			**258**	**90**	**81**	**0**	**1**						
		Wheatland	0	0	**20**	**70**	**30**	**0**	**0**	0	0	0	0	0	100

Regions 7-9, Tucker trawl collections, deep sampling strata (>30 m, 98 ft)

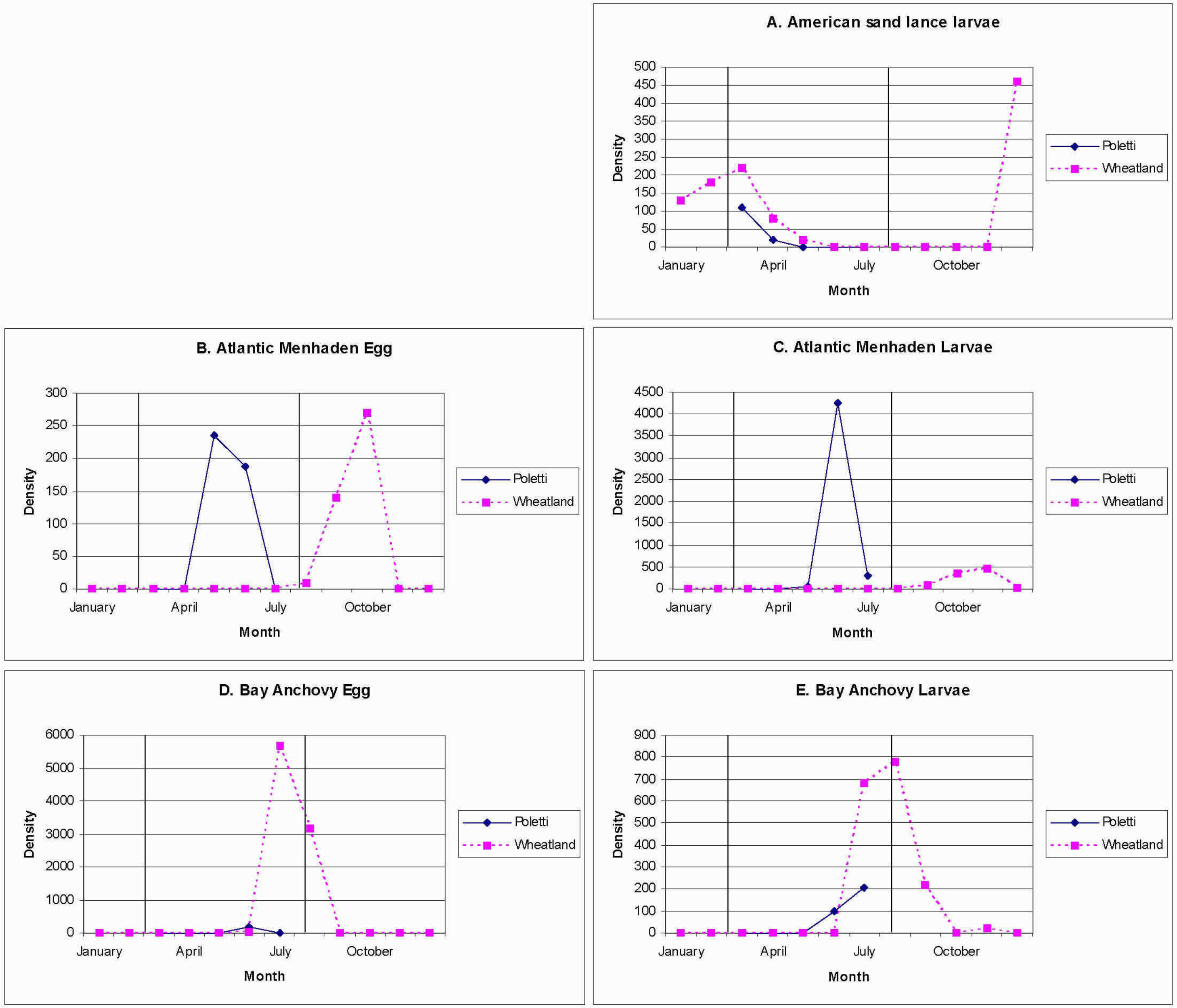
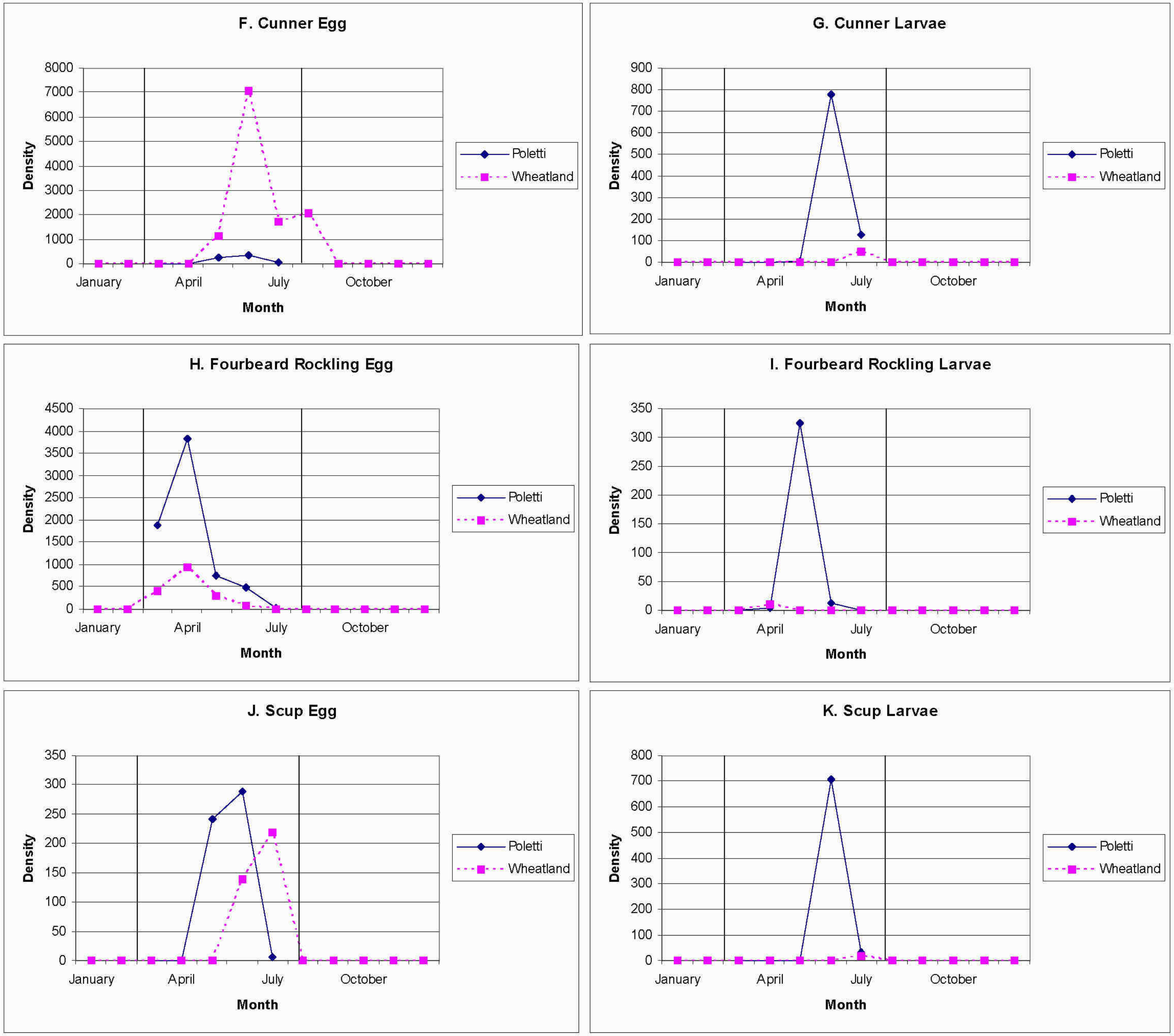


Figure 21. Average monthly density (#/1000m^3) of eggs and larvae of selected species in Long Island Sound during 1953 (Wheatland 1956) and the 2002 Poletti data subset to represent the FSRU intake. Vertical bars bracket the March-July sampling period of the Poletti Program data.



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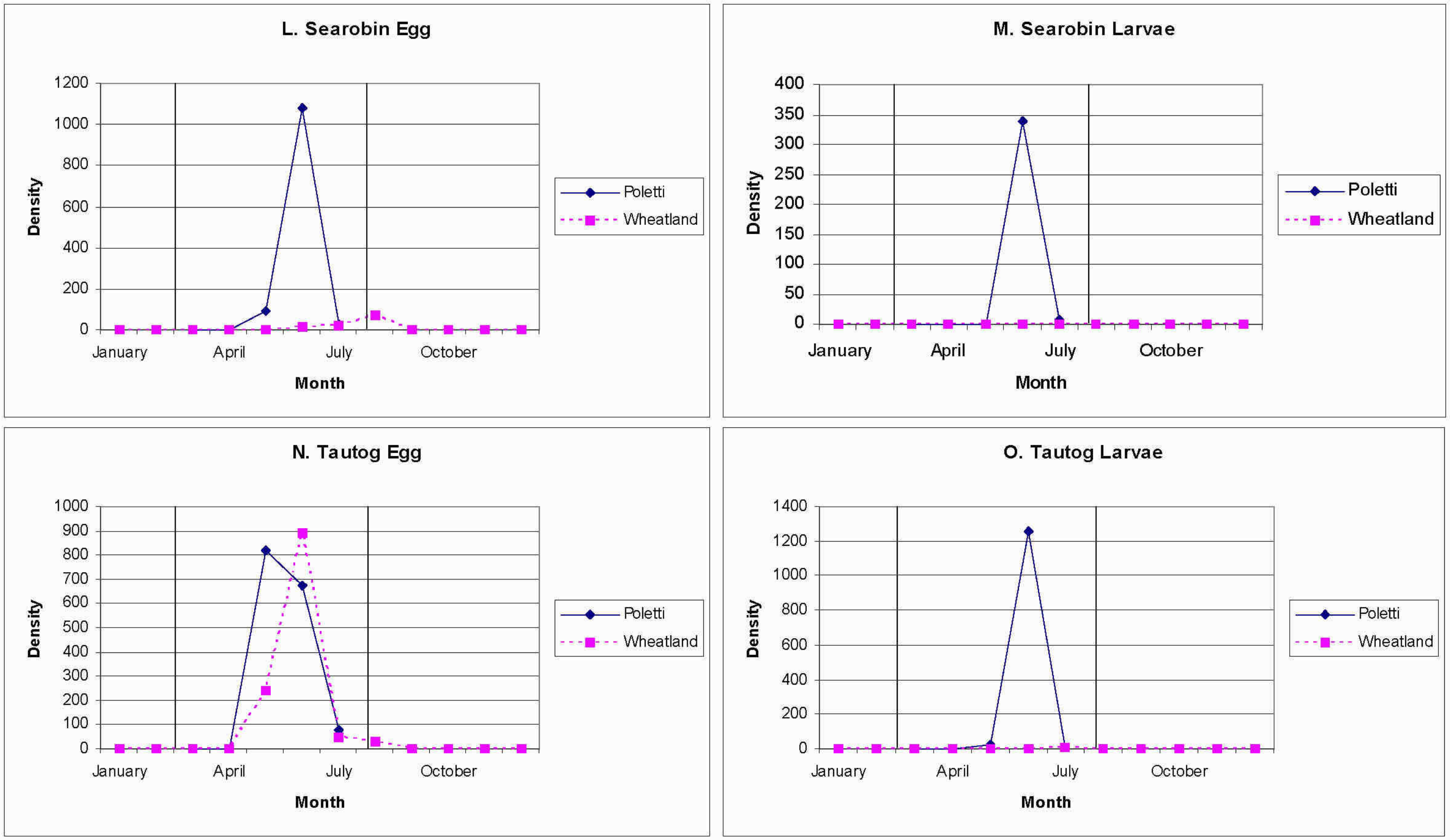

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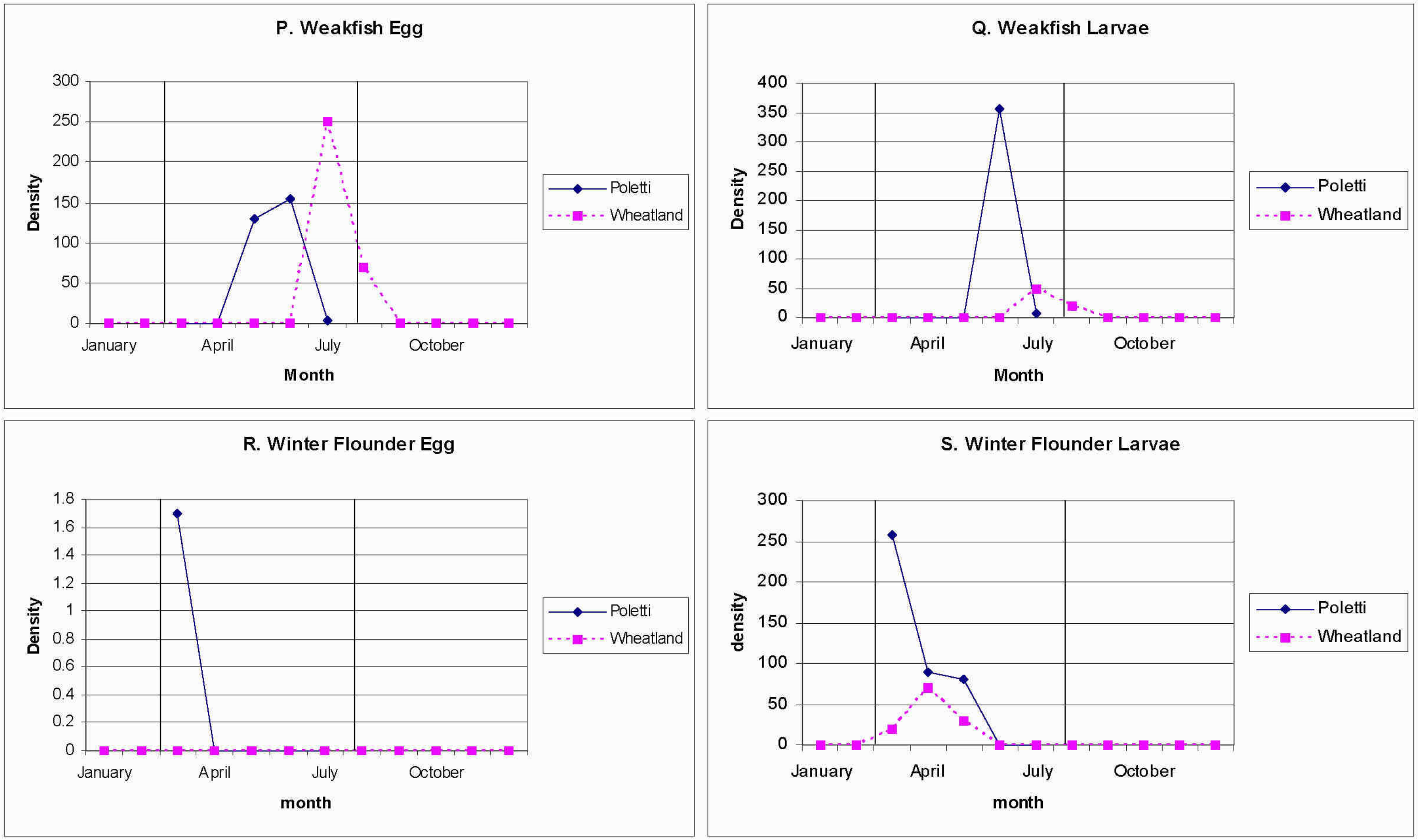

Figure 21 continued.

during each month in 1953 from Wheatland (1956) were summed to an annual total. The percent of the annual total of the 1953 data in Wheatland (1956) that were collected from March-July represents the proportion of the annual total density collected during the March-July period. This percentage represents the percent of the area under the curve of the Wheatland (1956) data presented in Figure 21 that was collected from March-July. The percentage is referred to in this section as the annual percent overlap index, and is used, in addition to other available regional information, to approximate the proportion of the annual abundance of egg and larval stages for selected species that was sampled during the March-July window of the 2002 Poletti Program. For example, Wheatland (1956) collected cunner eggs from May-August in 1953 (Table 12). Rather than use Wheatland's August density values to estimate the annual number of cunner eggs entrained that the Poletti sampling window missed, the percent overlap index was used. For cunner eggs, this index is generated by summing the monthly density of eggs from March-July, 1953 by the annual (January-December, 1953) total to determine the proportion collected during the March-July period (83%) based on the Wheatland data. Based on this index, about 83% of the estimated annual entrainment of cunner eggs would be expected to occur from March-July and in Figure 21f, the March-July period represents 83% of the area under the curve for the 1953 monthly cunner egg density from Wheatland (1956). Entrainment estimates in the FSRU facility for cunner eggs from March-July based on the 2002 Poletti Ichthyoplankton data would approximate 83% of the annual total based on the density weighted seasonal occurrence data from 1953 reported by Wheatland (1956) using this annual percent overlap index.

This annual percent overlap index is meant to serve only as an approximation of entrainment estimates from the March-July sampling period of the 2002 Poletti Ichthyoplankton Program and requires the assumption that seasonal occurrence patterns observed by Wheatland (1956) in 1953 were similar to those of the 2002 Poletti Program. Although the Wheatland (1956) data is 50 years old and environmental conditions have changed in the Sound during this period it is still a useful reference, particularly in regards to the seasonal occurrence of species which is what it was used for in the Poletti analysis. Mid-Atlantic estuarine fish communities are comprised of a consistent, predictable, annually repeated seasonal progression of species assemblages (Able and Fahay 1998, Witting et al. 1999). Spawning is timed such that the arrival of early life history stages into estuarine and nearshore nursery grounds takes advantage of favorable conditions relative to feeding, thus producing a seasonal pattern in the species composition of eggs and larvae. Larval assemblage structure is largely consistent from year to year with the timing and duration of the assemblage largely influenced by temperature (Witting et al. 1999). Another attempt to consider entrainment estimates beyond the March-June Poletti sampling window is presented in the modified entrainment tables in Appendix B where the site specific collections conducted on August 23 and October 4, 2005 are included in entrainment estimates.

Atlantic Menhaden

Atlantic menhaden, a member of the Clupeidae (herring) family, is a pelagic, euryhaline species occupying coastal and estuarine habitats. It is commonly found along the Atlantic coast of North America from the Gulf of Maine to central Florida (Dahlberg 1970). Adults congregate in large schools in coastal areas, particularly adjacent to estuaries. Seasonal migrations during spring and fall reportedly coincide with shifts in the position of the 10 °C isotherm (Reintjes 1969). They migrate north through the central part of the Mid-Atlantic Bight during spring and return south during a fall migration (Nicholson 1971). Most overwinter in waters south of Cape Hatteras (Able and Fahay

1998). These coastal migrations account for the occurrence of early life history stages in all estuaries of the Mid-Atlantic Bight (Able and Fahay 1998). They consume phytoplankton and zooplankton, which they filter from the water through elaborate gill rakes. Menhaden are consumed by almost all commercially and recreationally important piscivorous fish throughout their range as well as by dolphins and birds (Hall 1995). The menhaden fishery, one of the most important in North America, is a multimillion dollar enterprise (Hall 1995). Menhaden are used for fish meal, oil, and as bait for other fisheries.

Extensive egg collections in the Mid-Atlantic Bight show that most spawning occurs over the inner continental shelf, but some activity may extend into the lower regions of major bays and estuaries (Able and Fahay 1998). Spawning occurs at night and during nearly every month in some part of its range (McHugh et al. 1959). There is limited spawning activity during the northward spring migration, limited summer spawning as far north as Cape Cod and the Gulf of Maine, then increased spawning activity during the southward fall migration (Able and Fahay 1998). This pattern is followed by intense spawning in the South Atlantic Bight during winter (Higham and Nicholson 1964). Eggs are pelagic and buoyant and typically occur in the upper water column to depths of 10 m and usually hatch in less than 48 hours (Collete and Klein-Macphee 2002). Although evidence is still inconclusive, support exists for the existence of two subpopulations: one that spawns in summer and is responsible for primary recruitment in the northern end of its distribution, and one that spawns in autumn through spring and contributes the majority of recruitment in the Middle and Southern Atlantic areas (Collette and Klein-MacPhee 2002). Apparently, little contribution to the overall stock is made from spawning that takes place in areas north of northern New Jersey-Long Island Sound and the majority of new recruits are probably produced in estuaries of the Carolinas, Virginia and north to New Jersey (Collette and Klein-MacPhee 2002).

Atlantic menhaden eggs accounted for about 9 % of the total number of eggs collected in all sampling strata of Long Island Sound (Table 4) and about 4% of the eggs in the subset data of the 2002 Poletti Ichthyoplankton Program (Table 11). Atlantic menhaden eggs had the highest density in the Tucker trawl collections from the intermediate depth stratum of Regions 7-9 (Table 13). Eggs were present in Long Island Sound (Table 3) from surveys 4-11 (April 15-August 5) and in the subset data during surveys 6-8 (May 13-June 23, Table 9, Figure 22 b) of the 2002 Poletti Ichthyoplankton Program. In the Mid-Atlantic Bight, peak spawning occurs in mid-May to early June and in September and October (Ferraro 1980, Able and Fahay 1998). Richards (1959) collected menhaden eggs in Long Island Sound from May-October and Stone et al. (1994) report Atlantic menhaden eggs as common in Long Island Sound from May through September and abundant in June and July. Monteleone (1992) found Atlantic menhaden eggs from April-May and in November is Great South Bay, N.Y., and Keller et al. (1999) found Atlantic menhaden eggs from May-August in Narragansett Bay. Wheatland (1956) collected Atlantic menhaden eggs in Long Island Sound during June to October in 1952, however in 1953 they were only collected from August-October (Table 12) resulting in no overlap in seasonal occurrence between the year-round 1953 Wheatland (1956) data and the 2002 Poletti Ichthyoplankton Program (Table 12, Figure 21b). In 1952, there were two spawning peaks, one in June and one during September-October, eight times as many menhaden eggs were taken in June as in September (Wheatland 1956). The Poletti Ichthyoplankton Program sampling period (March-July) coincided with the spring-summer spawning peak of Atlantic menhaden, but missed the fall peak. Atlantic menhaden eggs were not collected during the site-specific collections at the FSRU location in August 2005, they were present in low abundance during the October sample (NAI 2005a,b, Appendix Figure A-1). Although eggs and larvae occurring in estuaries in the northern Mid-Atlantic

Table 13. **Mean egg density and the percentage of the overall catch (for a given species) of common species collected with both gear types (sled and Tucker trawl) in each sampling strata (shallow, intermediate, and deep) averaged over all eleven biweekly surveys (March-July) and Regions 7-9 (Central Basin area) of the 2002 Poletti Ichthyoplankton Program.**

Fish eggs	Epibenthic sled						Tucker trawl						All	
	Shallow		Intermediate		Deep		Shallow		Intermediate		Deep			
	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%
Atlantic menhaden	380	17	168	8	65	3	143	6	1389	62	98	4	374	100
Fourbeard rockling	659	15	630	14	264	6	435	10	1230	27	1336	29	759	100
Tautog	630	21	128	4	104	4	1311	44	431	15	360	12	494	100
Unidentified searobin	123	9	121	9	139	10	234	17	516	38	226	17	227	100
Weakfish/Scup	1248	23	453	8	113	2	2882	53	599	11	184	3	913	100

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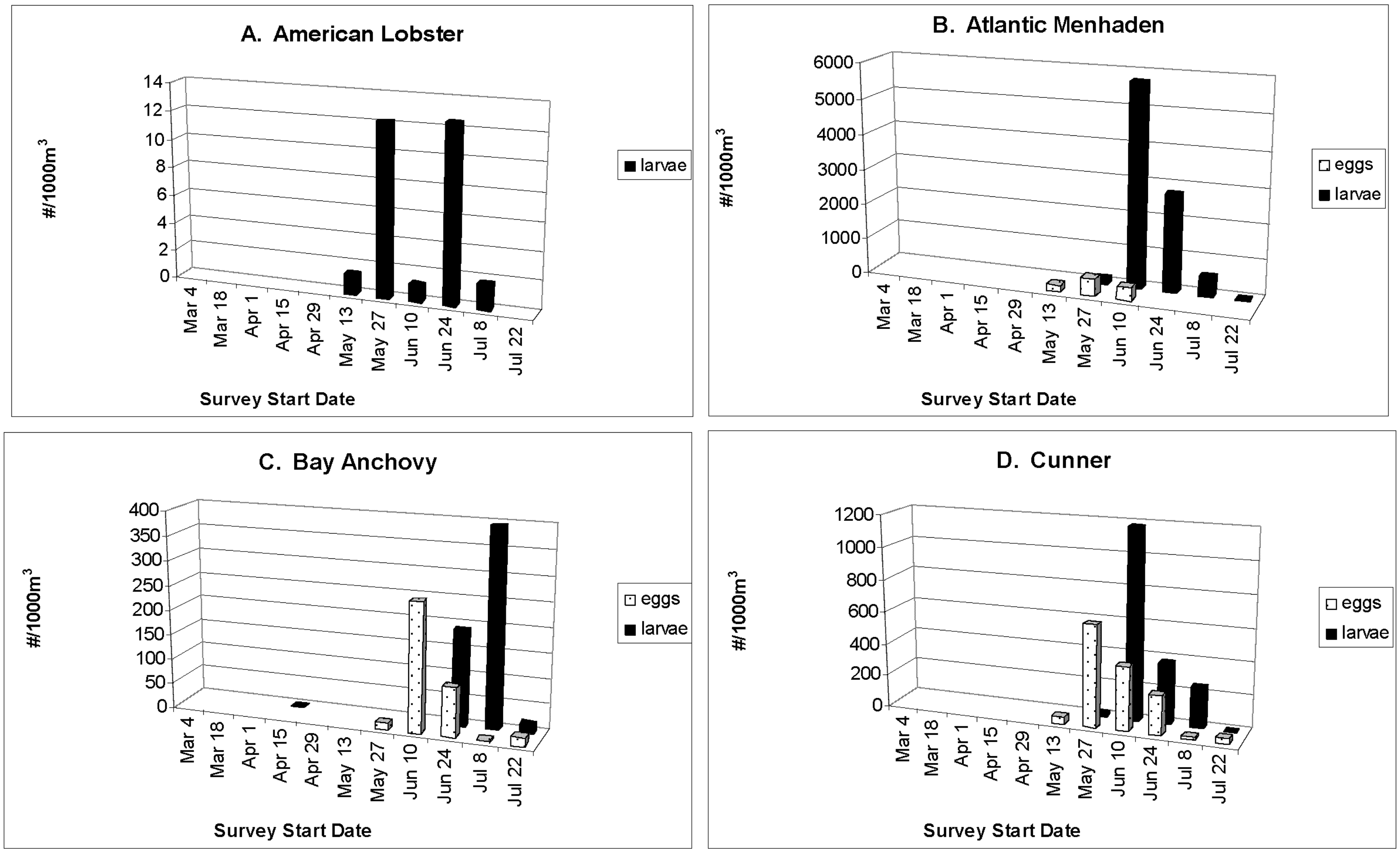
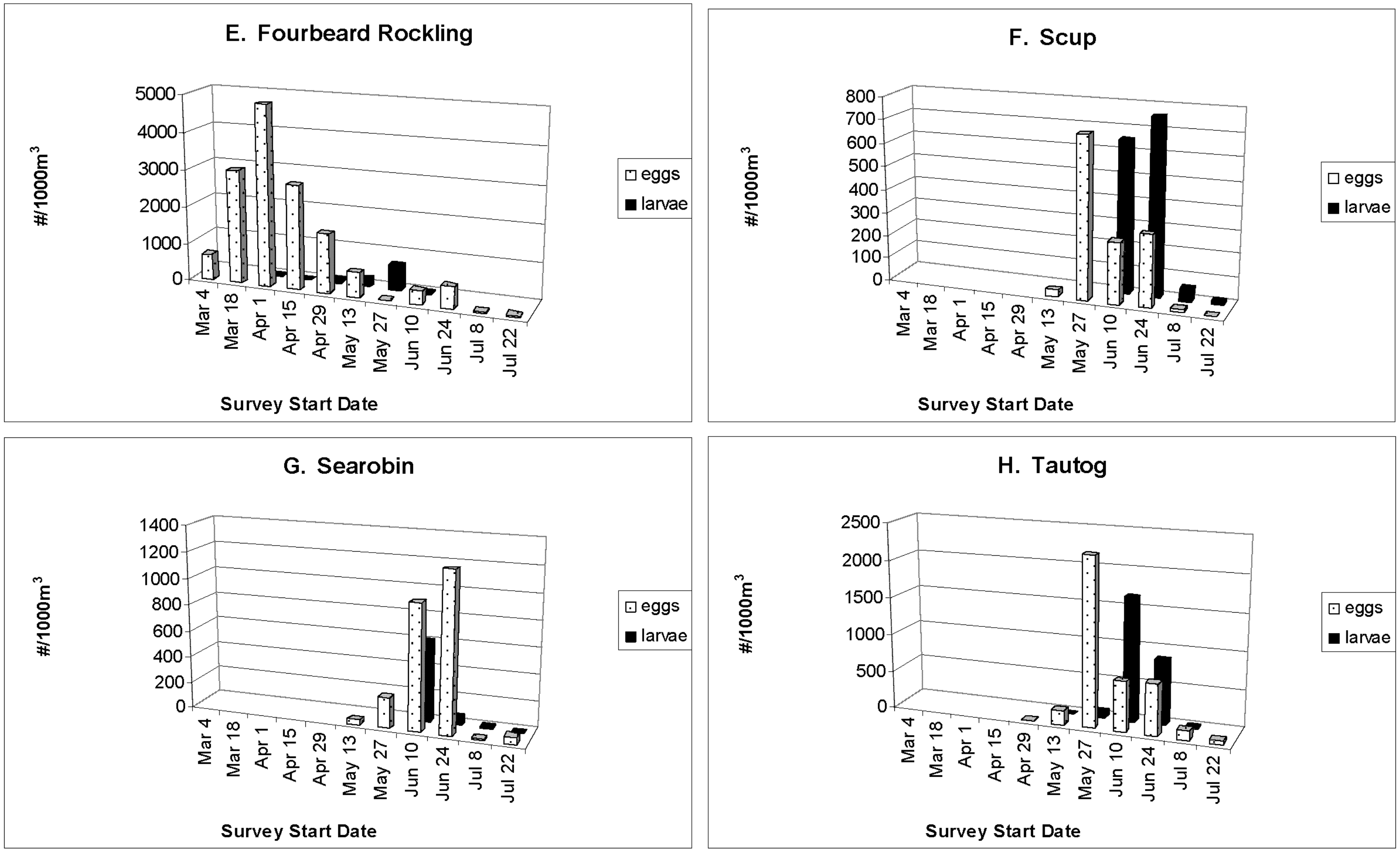


Figure 22. Mean density (#/1000m^3) of eggs and larvae of selected species during each biweekly survey in the 2002 Poletti Ichthyoplankton data subset to represent the FSRU facility's intake (Regions 7-9, deep sampling strata, Tucker trawl). Note- the scale on the Y axis (density) differs depending on species.



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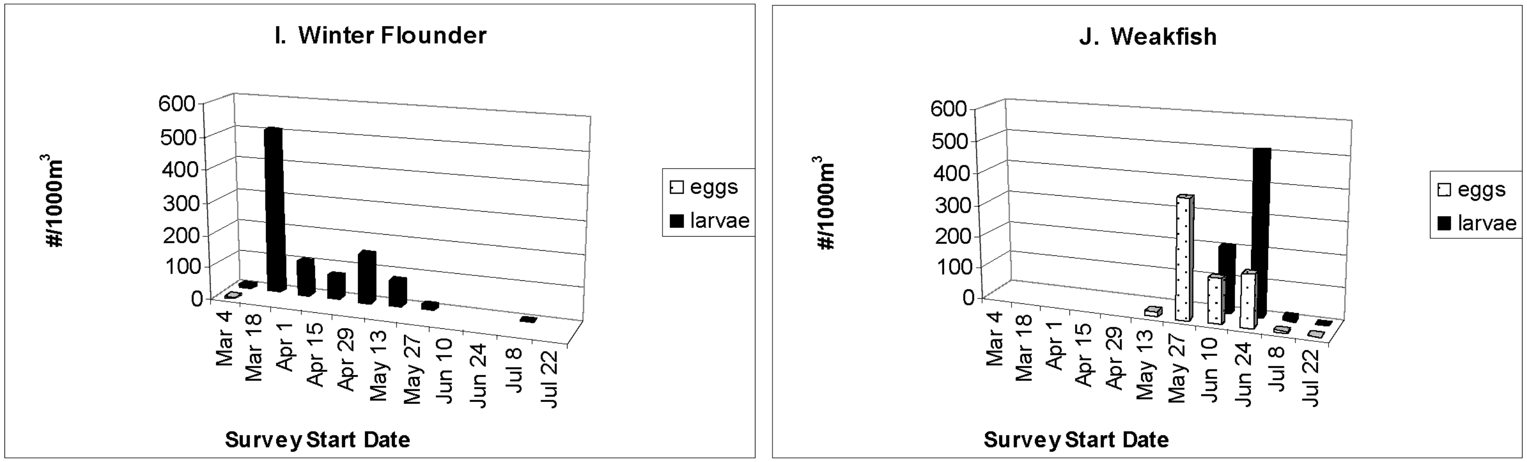

Figure 22 continued.

Bight spawned during the fall likely experience lower survival due to cold-induced mortality compared to those spawned in the spring (Able and Fahay 1998), and eggs spawned in the summer are thought to be responsible for the majority of recruitment in the northern end of Atlantic menhaden's distribution (Collette and Klein-MacPhee 2002), the estimated number of menhaden eggs entrained from March-July based on the Poletti Ichthyoplankton Program data likely represents at least half those that could be expected over the course of a year.

Estimated numbers of Atlantic menhaden eggs that would be entrained in the proposed FSRU facility based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27-June 9) with 54,400 eggs/day (Table 15). The sum of the estimated total number of menhaden eggs entrained during the eleven biweekly surveys from March 4-August 5 based on the subset data from the 2002 Poletti Ichthyoplankton program is about 1.6 million (Table 15). Inclusion of the site specific collections in August and October, 2005 to the entrainment estimates as described in Appendix B brings the entrainment estimates for Atlantic menhaden eggs to about 1.9 million for the March-October period (Appendix Table B-1 and B-4).

Atlantic menhaden larvae are pelagic and most hatching and early larval development occurs at sea. In the ocean, larvae appear to be most concentrated in the upper water column (Kendall and Reintjes 1975, Nelson et al. 1977, Judy and Lewis 1983). Larval menhaden spawned offshore may spend up to several months in the continental shelf waters before being transported to estuaries at lengths of 10-22 mm (Massmann et al. 1962, Nelson et al. 1977). Larvae are transported to estuarine nursery areas by onshore and along-shore currents, and metamorphosis to juveniles is thought to occur exclusively within estuaries as no metamorphic larvae or prejuveniles have been collected at sea (Kendall and Reintjes 1975). The presence of eggs in the 2002 Poletti Ichthyoplankton Program suggests that some spawning likely takes place in Long Island Sound, but the larger density of menhaden larvae (Figure 22b) suggest that ingress of larvae spawned elsewhere (i.e. inner continental shelf) is significant. Atlantic menhaden were by far the most abundant fish larvae collected in the 2002 Poletti Ichthyoplankton Program in Regions 7-10 and accounted for about 40% of all larvae collected in the 2002 Poletti Ichthyoplankton Program (Table 5, Table 11). In regions 7-9, Atlantic menhaden larvae occurred in higher density in shallow and intermediate sampling strata than in the deep sampling strata with both gear types (Table 14). In the subset data, Atlantic menhaden larvae were most abundant during surveys 8-9 (June 10- July 7) and their density declined noticeably during surveys 10-11 (July 8-August 5, Figure 22b). Wheatland (1956) collected menhaden larvae from September to December in 1953 resulting in no overlap in seasonal occurrence between the year-round 1953 Wheatland (1956) data and the 2002 Poletti Ichthyoplankton Program (Table 12, Figure 21c) as discussed for menhaden eggs previously. However, Stone et al. (1994) consider Atlantic menhaden larvae common in Long Island Sound from May through November and abundant in June and July. Keller et al. (1999) found menhaden larvae in Narragansett Bay from June-July and Chute and Turner (2001) found them in Buzzards Bay in June and November. A bimodal distribution of menhaden larvae found in Millstone Power Station samples suggests two distinct spawning periods in or near LIS, a larger one in the summer and a smaller event during the fall (Figure 23, NUSCO 2005).

Fall spawners dominated larval production during some years in the mid 1970s-mid 1980's, but in recent years (including 2002) most spawning and the majority of larval production occurred during the summer peak. Figure 23 corresponds with the 2002 Poletti data demonstrating a June peak in menhaden larvae with abundance dropping noticeably by mid July. Atlantic menhaden were absent

Table 14. Mean larval (yolk sac + post yolk sac) density and the percentage of the overall catch (for a given species) of common species and species of interest collected with both gear types (sled and Tucker trawl) in each sampling strata (shallow, intermediate, and deep) averaged over all eleven biweekly surveys (March-July) and Regions 7-9 (Central Basin area) of the 2002 Poletti Ichthyoplankton Program.

	Epibenthic sled						Tucker trawl						All	
	Shallow		Intermediate		Deep		Shallow		Intermediate		Deep			
Fish and lobster larvae	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%	# /1000 m³	%
American lobster	< 1	1	1	14	2	16	1	11	3	31	3	28	2	100
Atlantic menhaden	1717	22	865	11	113	2	2262	29	1940	25	841	11	1290	100
Bay anchovy	713	66	110	10	19	2	94	9	87	8	55	5	180	100
Cunner	94	7	124	9	61	5	246	18	663	49	166	12	226	100
Fourbeard rockling	38	6	61	10	33	5	18	3	381	61	92	15	104	100
Scup	463	22	118	6	17	1	69	3	1278	61	135	7	347	100
Tautog	709	32	150	7	36	2	406	18	703	31	238	11	374	100
Weakfish	85	18	97	20	67	14	117	24	47	10	66	14	80	100
Winter flounder	105	26	60	15	61	15	32	8	59	15	85	21	67	100

Table 15. **Life-stage specific standing crop (in millions), mean density (#/1000m³), and entrainment estimates for species of interest from the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location* during each biweekly survey (March-July). Entrainment estimates were calculated by multiplying the average density (#/1000m³) of eggs, larvae and young of the year by the maximum estimated annual daily water intake of the proposed FSRU facility to yield the estimated number entrained per day and per survey (14 days).**

		Eggs				Larvae				Young of the Year			
Species	Survey	Standing Crop (millions)	#/ 1000 m³	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m³	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m³	# Entrained/ Day	# Entrained/ Survey
American Lobster	1												
	2												
	3												
	4												
	5												
	6					10.8	1.4	149	2092				
	7					92	12.2	1,302	18233				
	8					9.2	1.2	128	1793				
	9					94.4	12.5	1,334	18681				
	10					13.4	1.8	192	2690				
	11												
	SUM								43,490				
American Sandlance	1					616.1	81.9	8743	122400				
	2					1048.9	139.4	14881	208333				
	3					273.3	36.3	3875	54250				
	4					22.4	3	320	4484				
	5					9.3	1.2	128	1793				
	6												
	7												
	8												
	9												
	10												
	11												
	SUM								391,260				

(continued)

* Regions 7-9, Tucker trawl collections, deep (>30 m, 98 ft) sampling strata

Table 15. (Continued)

Species	Survey	Eggs Standing Crop (millions)	Eggs #/ 1000 m^3	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae Standing Crop (millions)	Larvae #/ 1000 m^3	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	Young of the Year Standing Crop (millions)	Young of the Year #/ 1000 m^3	Young of the Year # Entrained/ Day	Young of the Year # Entrained/ Survey
Atlantic Menhaden	1												
	2												
	3												
	4												
	5												
	6	1,482	197	21,030	294,417								
	7	3,836	510	54,400	761,597	1,324	176	18,777	262,883				
	8	2,817	374	39,957	559,391	43,152	5,734	612,051	8,568,716				
	9					20,772	2,760	294,630	4,124,820				
	10					4,165	553	59,075	827,056				
	11					189	25	2,679	37,512				
	SUM				1,615,405				13,820,987				
Bay Anchovy	1												
	2												
	3												
	4					6	1	85	1,196				
	5												
	6												
	7	98	13	1,388	19,429								
	8	1,946	259	27,595	386,328								
	9	744	99	10,547	147,657	1,446	192	20,507	287,093				
	10	19	3	278	3,886	2,974	395	42,188	590,626				
	11	127	17	1,804	25,257	144	19	2,039	28,545				
	SUM				582,556				907,460				
Cunner	1												
	2												
	3												
	4												
	5												
	6	293	39	4,153	58,136								
	7	4,757	632	67,466	944,524	147	20	2,082	29,143				
	8	3,006	399	42,636	596,903	8,889	1,181	126,072	1,765,005				
	9	1,845	245	26,164	366,302	2,845	378	40,352	564,921				
	10	133	18	1,889	26,453	1,889	251	26,784	374,970	138	18	1,964	27,499
	11	248	33	3,523	49,319	7	1	107	1,495	34	5	491	6,875
	SUM				2,041,636				2,735,533				34,374

(continued)

Table 15. (Continued)

Species	Survey	Eggs				Larvae				Young of the Year			
		Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey
Fourbeard Rockling	1	5,222	694	74,074	1,037,034								
	2	23,038	3,061	326,762	4,574,665								
	3	36,560	4,858	518,559	7,259,833	8	1	107	1,495				
	4	21,151	2,810	299,989	4,199,844	66	9	939	13,152				
	5	12,094	1,607	171,537	2,401,512	725	96	10,280	143,920				
	6	5,023	667	71,234	997,280	1,566	208	22,215	311,005				
	7	49	7	694	9,714	5,067	673	71,875	1,006,247				
	8	2,753	366	39,049	546,688	180	24	2,551	35,719				
	9	4,350	578	61,702	863,821								
	10	110	15	1,559	21,820								
	11	246	33	3,491	48,870								
	SUM				21,961,080				1,511,537				
Scup	1												
	2												
	3												
	4												
	5												
	6	224	30	3,178	44,491								
	7	5,246	697	74,411	1,041,756								
	8	1,996	265	28,303	396,244	4,922	654	69,815	977,403				
	9	2,333	310	33,098	463,370	5,713	759	81,023	1,134,326				
	10	84	11	1,193	16,709	392	52	5,551	77,714				
	11	6	1	90	1,263	118	16	1,676	23,464	9	1	117	1,644
	SUM				1,963,833				2,212,906				1,644
Searobin	1												
	2												
	3												
	4												
	5												
	6	275	37	3,896	54,549								
	7	1,733	230	24,574	344,034								
	8	7,192	956	102,010	1,428,144	4,628	615	65,641	918,968				
	9	9,086	1,207	128,879	1,804,310	490	65	6,960	97,441				
	10	71	9	1,003	14,048	94	13	1,334	18,681	23	3	331	4,633
	11	391	52	5,540	77,565	10	1	139	1,943				
	SUM				3,722,650				1,037,034				4,633

(continued)

Table 15. (Continued)

Species	Survey	Eggs				Larvae				Young of the Year			
		Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey	Standing Crop (millions)	#/ 1000 m^3	# Entrained/ Day	# Entrained/ Survey
Tautog	1												
	2												
	3												
	4												
	5	20	3	288	4,035								
	6	1,443	192	20,475	286,645	9	1	117	1,644				
	7	16,966	2,254	240,647	3,369,051	629	84	8,924	124,940				
	8	5,031	669	71,362	999,073	12,421	1,650	176,180	2,466,523				
	9	5,143	683	72,953	1,021,341	6,489	862	92,040	1,288,558				
	10	912	121	12,938	181,133	151	20	2,146	30,039				
	11	306	41	4,345	60,826								
	SUM				5,922,106				3,911,704				0
Winter flounder	1	26	3	363	5,081	68	9	961	13,451				
	2					3,812	507	54,069	756,964				
	3					805	107	11,412	159,762				
	4					548	73	7,771	108,800				
	5					1,125	150	15,959	223,428				
	6					598	79	8,476	118,663				
	7					112	15	1,591	22,268				
	8												
	9												
	10					9	1	117	1,644				
	11												
	SUM				5,081				1,404,979				0
Weakfish	1												
	2												
	3												
	4												
	5												
	6	121	16	1,711	23,957								
	7	2,825	375	40,068	560,946								
	8	1,075	143	15,240	213,362	1,549	206	21,969	307,568				
	9	1,256	167	17,822	249,507	3,830	509	54,314	760,402				
	10	45	6	643	8,997	86	11	1,217	17,037				
	11	3	0	49	680	9	1	117	1,644				
	SUM				1,057,448				1,086,651				0

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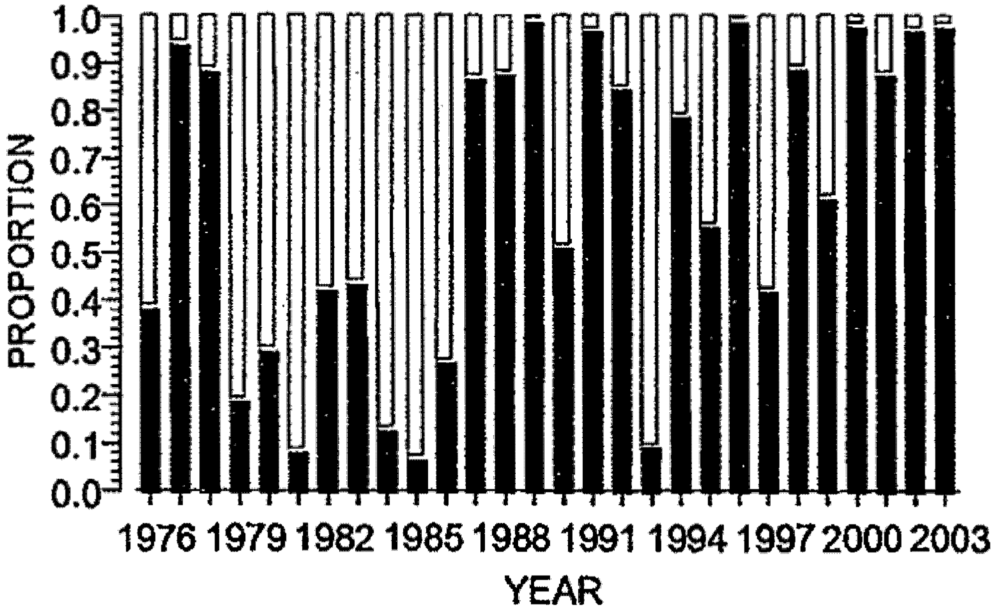

Figure 23. Fraction of entrained Atlantic menhaden larvae taken during the summer (solid bars; June 1-September 15) and fall (open bars; September 16-December 31) periods of entrainment. Source: NUSCO 2005.

from the August 23, 2005 samples and the occurrence (in relatively low density) of Atlantic menhaden in the October 4, 2005 samples (Appendix Table A-1) likely represent the smaller fall recruiting cohort spawned during the late summer. Because Atlantic menhaden larvae can reasonably be expected to occur in Long Island Sound from May-December based on available information, entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program may underestimate the annual number that would be entrained by not including this fall peak, although the period of peak density in recent years (June-July) was sampled. Eggs and larvae present in Long Island Sound in the fall are more likely to suffer hypothermal mortality than those recruiting in the summer (Able and Fahay 1998). Due to the bimodal spawning nature of Atlantic menhaden in the northern Mid-Atlantic discussed previously, the estimated number of menhaden larvae entrained from March-July based on the Poletti Ichthyoplankton Program data likely conservatively represents at least half those that could be expected over the course of a year, although Figure 23 suggests that in recent years, this fall peak accounts for a small proportion of larval menhaden production in Lond Island Sound.

The estimated numbers of Atlantic menhaden larvae that would be lost due to entrainment at the FSRU based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 8 (June 10-June 23) with about 600,000 eggs/day (Table 15). The estimated total number of menhaden larvae entrained between March 4 and August 5 is about 14 million. There was no evidence to suggest an underestimation of menhaden larval abundance due to daytime sampling, therfore no diel correction factor was applied to the Poletti data (Appendix A). Entrainment estimates of menhaden larvae from August to October based on the site specific collections in 2005 (Appendix B) were relatively low (about 230,000) as suggested by Figure 23, and the estimated number of larvae entrained from March through the end of October is about 14 million (Appendix Table B-1, Appendix Table B-4).

Bay Anchovy

Bay anchovy is a coastal species found from Maine to the Gulf of Mexico and is widely considered to be the most abundant western north Atlantic coastal fish (McHugh 1967, Haedrich, 1983). It is found in a wide variety of habitats over a broad range of salinities from the ocean to tidal freshwaters. In the Mid-Atlantic Bight, bay anchovy undergo seasonal migrations along the inner continental shelf to the southern portion of the bight and beyond during the fall and a return migration in the spring (Vouglitois et al. 1987). Young stages of bay anchovy occur in every estuary in the Mid-Atlantic Bight (Able and Fahay 1998).

Bay anchovy adults are common year round in Long Island Sound and most abundant from July-September (Stone et al. 1994). Adult bay anchovy may live to be slightly more than 3 years old, although it appears they rarely do so (Newberger and Houde 1995) Juveniles and adults are important forage for many recreationally and commercially important fishes (Vouglitois et al. 1987) and production of young of the year is of such large magnitude that it may influence the total fish production of many estuaries (Able and Fahay 1998).

Bay anchovy can mature at 3 months and individuals spawn repeatedly at night during the summer (Luo and Musick 1991). In Long Island Sound, spawning takes place at depths of 20 m (66 ft.) or less from May through September, with a peak in June and July (Wheatland 1956, Richards 1959). Eggs are pelagic and typically hatch in about 24 hours at summer temperatures (Mansueti and Hardy 1967, Monteleone 1992). Mortality rates of eggs and larvae are high, mesocosm experiments with eggs and yolk sac larvae in Chesapeake Bay indicated that 95% of a cohort died within 2 days of hatching (Houde et al. 1994). There is also high egg and larval mortality due to predation by ctenophores and jellyfish (Purcell et al. 1994).

Bay anchovy eggs were collected from the subset Poletti Ichthyoplankton Program data from surveys 7-11 (May 27-August 5) and accounted for about 1% of the eggs collected in the subset data (Table 11). Richards (1959) found bay anchovy eggs in Long Island Sound most abundant near shore in depths < 20 m during June-August. Wheatland (1956) also collected bay anchovy eggs in Long Island Sound from June-August (Table 12) and peak density occurred in July in 1953 (Figure 21d). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 64% with the 1953 data reported by Wheatland (1956) for bay anchovy eggs. Stone et al. (1994) consider bay anchovy eggs abundant in Long Island Sound from May-September and highly abundant from June-August. Monteleone (1992) found bay anchovy eggs from May-August in Great South Bay, N.Y., Keller et al. (1999) and Chute and Turner (2001) found them June-September in Narragansett Bay and Buzzards Bay respectively. Because bay anchovy eggs can reasonably be expected to occur in Long Island Sound from June-September based on available information, entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely underestimate the annual number that would be entrained.

Estimated numbers of bay anchovy eggs that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 8 (June 10-June 23) with about 28,000 eggs/day (Table 15). The estimated total number of bay anchovy eggs entrained in the FSRU facility from March 4 through August 5 based on the Polletti Ichthyoplankton Program data is about 600,000 (Table 15).

Bay anchovy was the most abundant egg collected during the 2005 site specific collections on August 23, they were not collected during October 4 (NAI 2005a,b, Appendix Figure A-1). There was a significantly higher number of bay anchovy eggs collected at night due to the spawning behavior and short incubation times of bay anchovy eggs, therefore a diel correction factor was applied to entrainment estimates of bay anchovy eggs collected from the Poletti program as discussed in Appendix A. The estimated number of bay anchovy eggs entrained from March 4-August 5 based on the Poletti data after correcting for diel differences is about 3.8 million (Appendix Table B-2, Appendix Table B-5). Inclusion of the site specific data collected in August and October 2005 to estimate the number entrained from August through October (about 2 million) brings the entrainment estimate to about 5.8 million eggs from March through the end of October (Appendix Table B-2, Appendix Table B-5) which covers the seasonal occurrence of bay anchovy eggs in Long Island Sound.

Bay anchovy larvae were most abundant in the shallow sled collections and least abundant in the deep sampling strata in the Central Basin (Regions 7-9) area (Table 14). Bay anchovy larvae were collected from the subset Poletti Ichthyoplankton Program data during survey 4 (April 15-April 28) and during surveys 9-11 (June 24-August 5) and they accounted for 2.5% of the larvae collected (Table 11). Wheatland (1956) collected bay anchovy larvae from July-September and in November with peak density in August in Long Island Sound (Table 12, Figure 21e). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 40% with the 1953 data reported by Wheatland (1956). Stone et al. (1994) consider bay anchovy larvae abundant in Long Island from June-September with a peak in July. In Narragansett Bay, Keller et al. (1999) collected bay anchovy larvae from June-September and in Great South Bay, N.Y., Monteleone collected bay anchovy larvae from May-December. Because bay anchovy larvae can reasonably be expected to occur in Long Island Sound from June-November and are at peak densities in July-August based on available information, entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely underestimate the annual number that would be entrained.

The estimated numbers of bay anchovy larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 10 (July 8-July 21) with about 42,000 larvae/day (Table 15). The estimated total number of bay anchovy larvae entrained in the FSRU from March 4 through August 5 is about 900,000 (Table 15).

Bay anchovy larvae dominated the site specific collections in August, 2005 and their abundance dropped noticeably by October (NAI 2005a,b, Appendix Figure A-1). Bay anchovy larvae were significantly more abundant at night during the August, 2005 collections so a diel correction factor was applied to the entrainment estimates as discussed in Appendix A. The estimated number of bay anchovy larvae entrained from March 4-August 5 based on the Poletti data with the diel correction factor is about 12 million (Appendix Table B-2, Appendix Table B-5). Inclusion of the site specific data collected in August and October 2005 to estimate the number entrained from August through the end of October (about 44 million) brings the entrainment estimate to about 55 million for March through the end of October (Appendix Table B-2, Appendix Table B-5) which covers the seasonal occurrence of bay anchovy larvae in Long Island Sound.

Cunner

Cunner are a member of the Labridae family and commonly occur from Newfoundland and the Gulf of St. Lawrence to the Chesapeake Bay. Cunner are coastal fish and typically abundant around structure such as shipwrecks, pilings, rocky reefs, oyster beds, submerged aquatic vegetation or just about any other object providing shelter. Although they are abundant in areas they inhabit, their numbers drop off rapidly a short distance from cover. Spawning in the Mid-Atlantic Bight occurs between May and October, based on the occurrences of eggs and larvae (Able and Fahay 1998). Eggs are common over the inner continental shelf from May to November, with a peak in June and July (Able and Fahay 1998). Spawning begins earlier in waters north and east of the central part of the Middle-Atlantic Bight. Adult cunner occur year round in Long Island Sound (Stone et al. 1994) and abundance is generally highest from April through July (Gottschall et al. 2000).

Cunner eggs are nonadhesive and buoyant. Cunner eggs and larvae are vertically stratified in Long Island Sound with 96% floating in the upper 5 m (16 ft.) of the water column (Williams 1968). During the 2002 Poletti Ichthyoplankton Program, cunner eggs occurred during surveys 4-11 (April 15-August 5) in Long Island Sound (Table 3) and during surveys 6-11 (May 13-August 5) in the subset data (Table 9) where they accounted for about 2.5% of the total number collected in the composite samples (Table 11). Wheatland (1956) collected cunner eggs from May through August (Table 12) with peak density in June (Figure 21f). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 83% with the 1953 data reported by Wheatland (1956, Table 12). Stone et al. (1994) consider cunner eggs common in Long Island Sound from May through August and highly abundant June-July. In Narragansett Bay, Keller et al. (1999) found cunner/tautog eggs April through September and they were the second most abundant eggs collected (behind bay anchovy) accounting for 36% of the total. Monteleone (1992) found cunner eggs from April-August in Great South Bay, N.Y. Cunner eggs can reasonably be expected to occur in Long Island Sound from May-August with a peak in June-July based on available information, so the seasonal occurrence largely coincides with the 2002 Poletti Ichthyoplankton Program March-July sampling window. Although entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely underestimate the annual number that would be entrained because values for August are not included, the entrainment estimates account for the majority of time cunner eggs are present in the water column in significant numbers and can be considered a reasonable annual estimate based on available information and the 83 percent overlap index with Wheatland (1956).

Estimated numbers of cunner eggs that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27-June 9) with about 67,000 eggs/day (Table 15). The estimated total number of cunner eggs that would have been entrained from March 4 through August 5 based on the 2002 Poletti Ichthyoplankton data subset to represent the proposed FSRU intake location is about 2 million (Table 15). There was no evidence to support a diel difference for cunner eggs (Appendix A) and cunner eggs were not collected during the site specific collections in August and October, 2005, supporting the conclusion of the percent overlap index that the March-July period represents a reasonable annual estimate.

Newly hatched cunner larvae are planktonic and 2.0 – 3.4 mm in length (Collette and Klein-MacPhee 2002). During the 2002 Poletti Ichthyoplankton Program, cunner larvae were collected in Long Island Sound during surveys 4-11 (April 15-August 5, Table 3) and during surveys 7-11 (May 27-August 5, Table 9) in the subset data where they accounted for about 11% of the larvae collected. Cunner larvae were more abundant in the Tucker trawl collections than in the sled as would be expected of pelagic larvae and were most abundant in the intermediate depth strata (Table 14). Density of cunner larvae in the subset data was greatest from surveys 8-10 (June 10- July 21, Figure 22d). Wheatland (1956) collected cunner larvae in July during sampling in 1953 (Table 12) so the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956). Stone et al. (1994) consider cunner larvae common in Long Island Sound May through August and abundant in July and August. Monteleone (1992) collected cunner larvae in July in Great South Bay, N.Y. In Narragansett Bay, Keller et al. (1999) found cunner larvae from May through August and they were the second most abundant species behind bay anchovy. Chute and Turner (2001) found cunner larvae during June through August in Buzzards Bay. Cunner larvae can reasonably be expected to occur in Long Island Sound from May-August with a peak in July based on available information, so the seasonal occurrence largely coincides with the 2002 Poletti Ichthyoplankton Program March-July sampling window. Although entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely underestimate the annual number that would be entrained because values for August are not included, the entrainment estimates account for the majority of time cunner larvae are present in the water column in significant numbers and can be considered a reasonable annual estimate.

The estimated numbers of cunner larvae that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 8 (June 10-June 23) with about 126,000 larvae/day (Table 15). The estimated total number of cunner larvae that would be entrained in the proposed FSRU facility's intake from March 4-August 5 is about 2.7 million (Table 15). There was no evidence to apply a diel correction factor to cunner larvae (Appendix A). Cunner larvae were collected in low abundance during the site specific collection August, 2005 and they were absent in October. Inclusion of the site specific data collected in August and October 2005 to estimate the number entrained from August through October (about 85,000) brings the entrainment estimate from March through the end of October to about 2.8 million (Appendix Table B-1, Appendix Table B-4) which is a reasonable annual estimate based on the seasonal occurrence of cunner larvae in Long Island Sound.

Fourbeard Rockling

The fourbeard rockling is a small gadid (cod family) fish occurring over soft mud or sand bottoms on both sides of the North Atlantic. The Western Atlantic range is from the northern Gulf of Mexico to Newfoundland and western Greenland (Collette and Klein-MacPhee 2002). Fourbeard rockling live in burrows during the daytime and forage at night (Keats and Steele 1990). Although occasionally found in shallow water, they appear to be more plentiful at depths > 45 m (Deree 1999, Collette and Klein-MacPhee 2002). Although there is not a direct commercial value due to the small size of this species, they are likely important forage fish in deep water habitats. Fourbeard rockling were collected in Long Island Sound during the Connecticut Department of Environmental Protection's (CTDEP) Trawl Survey from April through November, with percent occurrence ranging from 6% in October to 39% in June and most were found in depths > 18 m over mud bottom in the Central and Western Basins (Gottschall et al. 2000).

Fourbeard rockling eggs hatch in about 108 hours at 15°C and in 130 hours at 13 °C (Hardy 1978) and average about 2.0 mm in length (Colton and Marak 1969). Fourbeard rockling eggs were collected during all eleven biweekly surveys in the 2002 Poletti Ichthyoplankton Program and were the most abundant egg collected in the data subset to represent the proposed FSRU intake location where they accounted for 71% of the eggs collected (Table 11). In Regions 7-9, fourbeard rockling eggs were most abundant in the Tucker trawl collections in the intermediate and deep sampling strata and were

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less abundant in sled collections (Table 13) as would be expected of pelagic eggs. In Long Island Sound, Williams (1968) found fourbeard rockling eggs to be strongly stratified with most eggs occurring in the top 5 m of the water column. Wheatland (1956) found fourbeard rockling eggs from March-June, 1953 (Table 12) with peak density in April (Figure 21h). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956). In Narragansett Bay, fourbeard rockling eggs were collected January-October and ranked third in abundance (5% of the total catch) behind bay anchovy and tautog/cunner eggs (Keller et al. 1999). Although fourbeard rockling eggs were dominant in the subset data from March through survey 5 (April 29-May 12) their abundance and contribution to the overall egg catch was much lower from surveys 7-11 (May 27-August 5, Figure 16). It is probable that fourbeard rockling eggs were present before the start of the 2002 Poletti Ichthyoplankton Program on March 4. However, Figure 16 suggests that the peak standing crop in the subset data for fourbeard rockling eggs occurred from surveys 2-4 (March 18-April 28) and that the Poletti Ichthyoplankton Program coincided with the seasonal occurrence of fourbeard rockling eggs in Long Island Sound. Fourbeard rockling eggs were not collected during the site specific collections in August and October, 2005. Therefore, the estimated entrainment numbers for fourbeard rockling eggs based on the March-July period sampled by the 2002 Poletti Ichthyoplankton Program can be considered to represent the annual total.

Estimated numbers of fourbeard rockling eggs that would be entrained in the proposed FSRU from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake location was highest during survey 3 (April 1-April 14) with about 520,000 eggs/day (Table 15). The estimated total number of fourbeard rockling eggs that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 22 million (Table 15).

Fourbeard rockling larvae are typically found at the surface and show no evidence of vertical migration (Hermes 1985). In Regions 7-9, fourbeard rockling larvae generally had higher densities in the intermediate and deep sampling strata and in Tucker trawl collections than in the sled (Table 14). In the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake, fourbeard rockling larvae were collected during surveys 3-8 (April 1-June 23) although their contribution to the overall larvae catch was not as high as would be expected based on their dominance in the egg collections. Fourbeard rockling accounted for only 4.3% of the larvae collected in the subset Poletti Ichthyoplankton data compared to 71% of the eggs (Table 11). Keller et al. (1999) observed a similar phenomenon in Narragansett Bay where eggs were common but larvae were rare. The proportion of fourbeard rockling larvae in the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake was greatest from survey 5-7 (April 29-June 9, Figure 17) suggesting that the sampling window coincided with peak seasonal density. Wheatland (1956) collected fourbeard rockling larvae in April, 1953 in Long Island Sound, therefore the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956). No fourbeard rockling larvae were collected during the site specific collections in August and October, 2005. Therefore, the estimated entrainment numbers for fourbeard rockling larvae based on the March-July period sampled by the 2002 Poletti Ichthyoplankton Program can be considered to represent the annual total.

The estimated numbers of fourbeard rockling larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27- June 9) with about 72,000 larvae/day (Table 15). The estimated total number of fourbeard rockling larvae entrained during the eleven biweekly surveys (March 4-August 5) in the 2002 Poletti Ichthyoplankton Program is about 1.5 million (Table 15).

Scup

Scup are a member of the porgy family (Sparidae) and range from Nova Scotia to South Carolina. They are typically more abundant in larger and deeper estuaries (Berg and Levinton 1985). Scup are bottom feeders and feed on jellyfish, squid, polychaetes, crustaceans and fishes (Collette and Klein-MacPhee 2002). In the northern Mid-Atlantic Bight, schools move inshore during April and May and spend the summer in bays and coastal waters within 10 km of the coast where they prefer hard bottoms and structured habitats (Bigelow and Schroder 1953, Wheatland 1956). Stone et al. (1994) report adult scup as common in Long Island Sound from May-November and abundant June-October with greatest abundance in October. Gottschall et al. (2000) found adult and juvenile scup to be one of the most common fish in Long Island Sound trawl collections and they were most common between April and November. Young of the year first recruited to their trawl gear in August and were collected throughout the fall, typically in depths > 18m (Gottschall et al. 2000). Sexual maturity is reached at age 2 (Morse 1982). The precise location of spawning and of major concentrations of eggs and larvae has remained enigmatic (Able and Fahay 1998). Spawning appears to take place in larger bodies of water, such as Long Island Sound, particularly in the more saline eastern Sound (Richards 1959). It has been suggested that spawning occurs over sandy bottoms and submerged aquatic vegetation (Morse 1978). Spawning presumably does not occur over the continental shelf based on rare occurrences of larvae during 11 years (1977-1987) of MARMAP surveys (Able and Fahay 1998). Spawning occurs between May and August and peaks in June (Stone et al. 1994, Able and Fahay 1998). Younger scup are found in bays and sounds but do not penetrate low salinity areas (Morse 1982). While juveniles have been reported from all estuaries between Buzzards Bay and Chesapeake Bay, eggs and larvae have only been recorded in estuaries north and east of the Hudson River estuary (Able and Fahay 1998).

Scup eggs are buoyant and hatch in 70-75 hours at 18 °C, and 44-54 hours at 21 °C (Griswold and McKenney 1984). Scup eggs were not distinguished from those of weakfish in the 2002 Poletti Ichthyoplankton Program due to an overlap in size, shape, color and number of oil globules (Johnson 1978). In Poletti Ichthyoplankton Program regions selected to represent the Central Basin area (regions 7-9), scup/weakfish eggs were collected in highest density in the shallow sampling strata in both the epibenthic sled and Tucker trawl and were less dense in the deeper areas (Table 13). Scup/weakfish eggs were found in Long Island Sound during the 2002 Poletti Ichthyoplankton Program from survey 6-11 (May 13-August 5, Table 3) and they accounted for about 30% of the overall number of eggs collected (Table 4). In the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake, scup/weakfish eggs were also collected from survey 6-11 (May 13-August 5, Table 9) and they accounted for only 5% of the eggs collected in the deep sampling strata of Regions 7-9 (Table 11). Wheatland (1956) found scup eggs in June-July, 1953 in Long Island Sound, therefore the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956, Table 12). Scup eggs were not collected during the site specific collections in August and October, 2005. Stone et al. (1994) considers scup eggs common in Long Island sound from May-July and abundant in June. Because the 2002 Poletti Ichthyoplankton Program sampling window from March-

July coincided with the seasonality of scup eggs in Long Island Sound, entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely represent the annual number that would be entrained.

Because scup/weakfish eggs were not separated by species, a ratio of 3.5:1 based on the ratio of scup:weakfish larvae (Table 11) was applied to the egg entrainment counts for the two species. Estimated numbers of scup eggs that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27-June 9) with about 75,000 eggs/day (Table 15). The estimated total number of scup eggs that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 2 million (Table 15).

Scup larvae hatch at about 2.0 mm and their yolk is absorbed in about 2-3 days (Griswold and McKenney 1984). In the Poletti Ichthyoplankton Program regions selected to represent the Central Basin area (regions 7-9), scup larvae were collected in highest density in the intermediate sampling strata with the Tucker trawl and occurred in lowest density in the deep sampling strata (Table 14). Scup larvae were found in Long Island Sound during the 2002 Poletti Ichthyoplankton Program from surveys 7-11 (May 27-August 5, Table 3) and they accounted for about 12 % of the overall number of larvae collected (Table 4). In the 2002 Long Island Sound Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, scup larvae were collected from surveys 8-11 (June 10-August 5, Table 9) and they accounted for about 9% of the larvae collected (Table 11). Wheatland (1956) collected scup larvae in July, 1953 (Table 12) therefore the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956). Stone et al. (1994) considers scup larvae common in Long Island sound from May-August and abundant in June. Scup larvae were collected in Narragansett Bay from May-September (Keller et al. 1999) and June-August in Buzzards Bay (Chute and Turner 2001). Although, based on available information, scup larvae can reasonably be expected to occur in Long Island Sound from May-September, the 2002 Poletti Ichthyoplankton Program sampling window from March-July likely coincided with the period of time when scup larvae were present in greatest density in Long Island Sound (June-July). Scup larvae were not collected during the site specific collections in August or October, 2005. Entrainment estimates of scup larvae from March-July based on the 2002 Poletti Ichthyoplankton Program can be considered to represent an annual entrainment estimate based on available information.

The estimated numbers of scup larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 9 (June 24-July 7) with about 80,000 larvae/day (Table 15). The estimated total number of scup larvae that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 2.2 million (Table 15) and this value can be considered a reasonable representive of the annual total based on available seasonal occurrence information.

Searobin

Although searobins of the genus *Prionotus* are often abundant constituents of ichthyoplankton surveys in the Mid-Atlantic Bight, they lack distinctive characters and are usually not identified to species (Able and Fahay 1998). Consequently, little has been reported concerning their early life histories. The two most common searobins in the mid-Atlantic region are the northern searobin

(*Prionotus carolinus*) and the striped searobin (*P. evolans*). Northern searobin occur from the Gulf of Maine to South Carolina where it is found from estuaries to the edge of the continental shelf. Northern searobin prefer sandy substrates in coastal waters between May and October and spends winter months at mid-outer depths (Roberts 1978). Northern searobin are generally more abundant than striped searobin in the Mid-Atlantic Bight (McBride and Able 1994), and juveniles and adults are generally more common in estuaries in the northern part of the Mid-Atlantic Bight than in the southern part (Stone et al. 1994). Eggs, larvae and juveniles have been reported from most estuaries in the Mid-Atlantic Bight (Able and Fahay 1998). Northern searobin adults are common in Long Island Sound from April-November (Stone et al. 1994). Striped searobin occur from Cape Cod to South Carolina, from estuaries to the edge of the continental shelf. The two species often co-occur, striped searobin tend to occur in warmer, less oxygenated, more turbid habitats than northern searobin, and also arrives at, and departs from, coastal areas later than northern searobin (McBride and Able 1994). Both species have similar ecology and are bottom feeders on small crustaceans and fish. Both searobins spawn during the summer in continental shelf and estuarine waters throughout the Mid-Atlantic Bight. Gonadosomadic index levels of females suggest peak spawning in July in the New York Bight (Wilk et al. 1990).

Regions in the 2002 Poletti Ichthyoplankton Program selected to represent the Central Basin area (regions 7-9), had highest density of searobin eggs in the Tucker trawl collections, particularly in the intermediate depth strata (Table 13). Searobin eggs were found in Long Island Sound during the 2002 Poletti Ichthyoplankton Program from surveys 5-11 (April 29-August 5, Table 3) and they accounted for about 10% of the overall number of eggs collected (Table 4). In the 2002 Long Island Sound Poletti Ichthyoplankton Program data subset to represent proposed FSRU facility's intake location, searobin eggs were also collected from surveys 6-11 (Table 9) and they accounted for about 7% of the eggs collected (Table 11). Although density of searobin eggs in the subset Poletti Ichthyoplankton Program data declined noticeably after survey 9 (June 24- July 7, Figure 22g), they continued to comprise a relatively large proportion of the overall egg catch until the end of the Program (Figure 16). Although Wheatland (1956) did not collect searobin eggs in large numbers, they were observed from June-August, 1953 (Table 12). Greatest density of searobin eggs in 1953 occurred in August (Wheatland 1956) so the percent overlap index between the 2002 Poletti Ichthyoplankton Program (March-July) and Wheatland (1956) was only 34% (Table 12). At an inner continental shelf site off the coast of New Jersey, eggs (identified only to *Prionotus*) were present from May to October with a peak in July-August (McBride and Able 1994). In Narragansett Bay, *Prionotus* eggs occurred between June and August (Bourne and Govoni 1988) and May and August (Keller et al. 1999). In Great South Bay, N.Y, Monteleone (1992) found eggs from May to July. Available information suggests that the 2002 Poletti Ichthyoplankton Program sampling window from March-July largely coincided with the seasonal peak density of searobin eggs in Long Island Sound, although entrainment estimates of eggs scaled up to an annual basis are likely underestimates because searobin eggs can reasonably be expected to occur in the area during August and September. Searobin eggs were collected during the site specific collections in August, they were absent in October, 2005.

Estimated numbers of searobin eggs that would be entrained from March 4-August 5 in the proposed FSRU facility based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 9 (June 24-July 7) with about 130,000 eggs/day (Table 15). The estimated total number of searobin eggs that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 3.7 million (Table 16). Inclusion of the site specific data collected in August and October 2005 to estimate the number of searobin eggs entrained from August through October (about 300,000) brings the entrainment estimate to about 4 million (Appendix Table B-1, Appendix Table B-4) which covers the seasonal occurrence of searobin eggs in Long Island Sound over an annual cycle.

Data suggest that continental shelf habitats are the primary nursery ground for *Prionotus* larvae rather than estuaries (Able and Fahay 1998). Searobin larvae are most abundant in Mid-Atlantic Bight continental shelf waters from July through October (Able and Fahay 1998). Pelagic larvae settle to benthic habitats on the continental shelf at 7-12 mm when they are 18-19 days old (Able and Fahay 1998). Searobin larvae were found in Long Island Sound during the 2002 Poletti Ichthyoplankton Program from surveys 8-11 (June 10-August 5, Table 3) and they accounted for 2 % of the overall number of larvae collected (Table 5). In the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake, searobin larvae were also collected from surveys 8-11 (Table 9) and they accounted for about 4% of the larvae collected (Table 11). Searobins did not comprise as high a percentage of the overall 2002 Poletti Ichthyoplankton Program larval collections as they did for eggs, likely because continental shelf habitats are their primary nursery areas (Able and Fahay 1998). Wheatland (1956) did not collect searobin larvae in 1953 (Table 12), however they were collected in low densities (20/1000m^3, 10/1000m^3) during July-August, 1952 (Wheatland 1956). Stone et al. (1994) consider searobin larvae common in Long Island Sound from June-August. Searobin larvae were collected in Narragansett Bay from June-August (Keller et al. 1999) and in Buzzards Bay from June-September (Chute and Turner 2001). The noticeable decline in searobin larvae density during the last three surveys (June 24-August 4, Figure 22g) suggests that the peak period in density was sampled during the March-July Poletti Ichthyoplankton Program. However, based on available information, searobin larvae can reasonably be expected to occur in Long Island Sound from May-September and searobin larvae were collected during the site specific collections in August, they were absent in October, 2005. Therefore, entrainment estimates based on the March-July 2002 Poletti Ichthyoplankton Program with the inclusion of the site specific 2005 data are reasonable annual estimates based on the seasonal occurrence of searobin eggs and larvae in Long Island Sound.

Estimated numbers of searobin larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 8 (June 10-June 23) with about 65,000 larvae/day (Table 15). Estimated number of searobin larvae entrained per day declines noticeably after survey 8 (Table 15). The estimated total number of searobin larvae that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 1 million (Table 15). There is no evidence to apply a diel correction factor to searobin larvae (Appendix A). Inclusion of the site specific data collected in August and October 2005 to estimate the number of searobin larvae entrained from August through October (about 1 million) brings the entrainment estimate to about 2 million (Appendix Table B-1, Appendix Table B-4) which covers the seasonal occurrence of searobin larvae in Long Island Sound and is therefore a reasonable annual estimate.

Tautog

Tautog are members of the Labridae family and are found in coastal areas from New Brunswick to South Carolina, however they are most abundant from Cape Cod to Delaware Bay. Tautog are most frequently found close to shore where they occupy a variety of structured habitats such as rocky reefs, mussel beds, submerged aquatic vegetation, pilings etc… Tautog support one of the principal sport and commercial fisheries in Long Island Sound (Smith et al. 1989). There is evidence that the fishery is declining, with lower recreational and commercial catch rates (Simpson et al. 1995, EPA 2004). Tautog are susceptible to overfishing due to their slow growth and because centers of abundance are easy to locate near wrecks and rock piles (ASMFC 2000). Tautog migrate inshore in the spring to spawn near the mouths of estuaries (Sogard et al. 1992, Able and Fahay 1998). Peak spawning occurs in inshore waters from Chesapeake Bay to Nantucket Shoals in June and July (Collette and Klein-MacPhee 2002). Spawning appears to follow a northward progression through the summer, beginning as early as April in the southern part of the Mid-Atlantic Bight and by May progresses north into southern New England waters (Able and Fahay 1998). Based on egg and larval occurrences in ichthyoplankton collections, it is evident that tautog begin spawning at water temperatures of 9-10°C and continue throughout the summer into early fall (Collette and Klein MacPhee 2002). Adult tautog are common in Long Island Sound from April through November (Stone et al. 1994, Gottschall et al. 2000). In the Middle Atlantic Bight, early life history stages are reported from most estuaries, although they are more common in the northern part of the bight.

Tautog eggs are pelagic and buoyant and hatch in approximately 2 to 3 days (Auster 1989). Tautog eggs were most abundant in the shallow water strata and were more abundant in the Tucker trawls than in the sleds (Table 13) as would be expected of pelagic eggs. During the 2002 Poletti Ichthyoplankton Program, tautog eggs were collected in Long Island Sound from surveys 4-11 (April 15-August 5) and they accounted for about 13 % of the total number collected (Table 4). In the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, tautog eggs were collected from surveys 5-11 (April 29-August 5) and they accounted for about 6% of the total number of eggs collected (Table 11). Standing crop of tautog eggs peaked during survey 7 (May 27-June 9) when they accounted for > 40% of the eggs collected (Figure 16). Although tautog eggs were still collected during survey 11 (July 22-August 5) and were likely present in low density during August, the noticeable decline in egg density during surveys 10-11 (July 8-August 5, Figure 22h, Table 15) suggests the sampling window of the 2002 Poletti Ichthyoplankton Program (March-July) coincided with the peak density of tautog eggs in Long Island Sound in 2002. Wheatland (1956) collected tautog eggs from May-August, 1953 (Table 12) and density peaked in June (Figure 21n). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 98% with the 1953 tautog egg data reported by Wheatland (1956). Monteleone (1992) collected tautog eggs from April-August in Great South Bay, N.Y. Tautog eggs were collected from May through August in Buzzards Bay (Chute and Turner 2001) and tautog/cunner eggs were collected from April-September in Narragansett Bay (Keller et al. 1999). Stone et al. (1994) considers tautog eggs common in Long Island Sound from May through September and abundant June-July (Stone et al. 1994). Based on available information, tautog eggs can reasonably be expected to occur in Long Island Sound from May-early September, however the period of peak density (June-July) was sampled during the 2002 Poletti Ichthyoplankton Program. No tautog eggs were collected in the site specific collections in August or October, 2005. Therefore, entrainment estimates based on the March-July Poletti Ichthyoplankton Program sampling period likely represent reasonable annual estimates.

Estimated numbers of tautog eggs that would be entrained in the proposed FSRU from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27-June 9) with about 240,000 eggs/day (Table 15). The estimated total number of tautog eggs that would have been entrained in the proposed FSRU facility from March 4 through August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the FSRU intake is about 6 million (Table 16).

Tautog larvae hatch out at 2-4 mm and migrate vertically in the water column, surfacing during the day and remaining near the bottom at night (Steimle and Shaheen 1999). Tautog larvae occurred in higher densities in the shallow and intermediate depth sampling strata than in deep areas in both the Tucker trawl and sled collections (Table 14). During the 2002 Poletti Ichthyoplankton Program, tautog larvae were observed from surveys 4-11 (April 15-August 5) in Long Island Sound (Table 3) and during surveys 5-11 (April 29-August 5) in the data subset to represent to location of the FSRU intake where they were the second most abundant species and accounted for 14.5 % of the larvae collected (Table 11). Tautog larvae density in the subset data was highest during survey 8 (June10-June 23) and dropped off noticeably during survey 10 (July 8-July 21, Figure 22h). No tautog larvae were collected in the subset Poletti Ichthyoplankton Program data during survey 11 (July 22-August 5) suggesting that the sampling window coincided with the peak abundance period of tautog larvae in the data subset to represent the location of the FSRU intake. Wheatland collected tautog larvae in low densities ($10/1000m^3$) in July, 1953, therefore the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956). In Long Island Sound, tautog larvae are considered common from June-August (Stone et al. 1994). Tautog larvae were collected from April-August in Narragansett Bay by Keller et al. (1999) and May-August in Buzzards Bay by Chute and Turner (2001). Monteleone (1992) collected tautog larvae from May-July in Great South Bay, N.Y. Tautog larvae can reasonably be expected to occur in Long Island Sound from May-August with a peak in June-July based on available information. Tautog larvae were not collected during the site specific collections in August and October, 2005. Therefore, entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely represent the majority of the annual number of tautog larvae that would be entrained in the FSRU facility.

There was no evidence to suggest diel differences in tautog larvae based on comparison of the nighttime LRS samples and daytime Poletti samples (Appendix A). Estimated numbers of tautog larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 8 (June 10-June 23) with about 175,000 larvae/day (Table 15). The estimated total number of tautog larvae that would have been entrained in the proposed FSRU facility from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake is about 4 million (Table 16) and this value likely represents the majority that would be entrained on an annual basis based on available seasonal occurrence information.

Weakfish

Weakfish are a member of the drum family (Sciaenidae) and range between Nova Scotia and Cape Canaveral, with a center of abundance between New York and North Carolina (Shepherd and Grimes 1983). Weakfish are a common member of the ichthyofaunal community in the Mid-Atlantic Bight migrating northward and inshore in spring and summer, offshore and southward in fall and winter

(Wilk 1976). Adults are found in a variety of estuarine habitats with a preference for sandy bottoms in shallow coastal and estuarine waters (Able and Fahay 1998). Eggs and larvae are found in most Mid-Atlantic estuaries and typically have wide annual fluctuations in local abundances (Able and Fahay 1998). Most spawning activity occurs close to the coast, near major inlets or within bays during May through July (Able and Fahay 1998) and spawning adults are considered rare in Long Island Sound by Stone et al. (1994).

Weakfish eggs are buoyant and spherical and resemble those of scup. Weakfish eggs were not distinguished from those of scup in the 2002 Poletti Ichthyoplankton Program due to an overlap in size, shape, color and number of oil globules (Johnson 1978). In Poletti Ichthyoplankton Program regions selected to represent the Central Basin area (regions 7-9), scup/weakfish eggs were collected in highest density in the shallow sampling strata in both the epibenthic sled and Tucker trawl and were less dense in the deeper areas (Table 13). Scup/weakfish eggs were found in Long Island Sound during the 2002 Poletti Ichthyoplankton Program from survey 6-11 (May 13-August 5, Table 3) and they accounted for about 30% of the overall number of eggs collected (Table 4). In the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake, scup/weakfish eggs were also collected from survey 6-11 (May 13-August 5, Table 9) and they accounted for only 5% of the eggs collected (Table 11). Wheatland (1956) found weakfish eggs in Long Island Sound between June-August, 1952 with a peak in June. In 1953, weakfish eggs were collected in July-August (Table 12) with a peak in July (Figure 21p, Wheatland 1956). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 78% with the 1953 data reported by Wheatland (1956, Table 12). Keller et al. (1999) found weakfish eggs during July in Narragansett Bay. Available data suggests that the 2002 Poletti Ichthyoplankton Program sampling window from March- July coincides with the majority of the seasonal occurrence of weakfish eggs in Long Island Sound. Weakfish eggs were not collected during the site specific collections in August and October, 2005 and entrainment estimates from March-July based on the 2002 Poletti Ichthyoplankton Program likely represent the majority of the annual number of weakfish eggs that would be entrained.

Because scup/weakfish eggs were not separated by species, a ratio of 3.5:1 based on the ratio of scup:weakfish larvae (Table 11) was applied to the egg entrainment counts for the two species. Estimated numbers of weakfish eggs that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 7 (May 27-June 9) with about 40,000 eggs/day (Table 15). The estimated total number of weakfish eggs that would have been entrained in the proposed FSRU facility during the eleven biweekly surveys (March 4-August 5) of the 2002 Poletti Ichthyoplankton Program is about 1 million (Table 15) and this is a reasonable annual estimate based on the seasonal occurrence of weakfish eggs.

Weakfish larvae hatch at about 1.5-1.7 mm standard length and have been collected from near shore to 70 km offshore, as well as in estuaries and tidal passes (Collette and Klein-MacPhee 2002). Laboratory observations suggest larvae are buoyant (J. Duffy pers. comm. cited in Able and Fahay 1998). During a 2 year study in the Beach Haven Ridge area in New Jersey, larvae were commonly collected during July with sparse occurrences into September (Able and Fahay 1998). In Great Bay-Little Egg Harbor New Jersey, larvae reached peak abundance during July, but annual abundances varied and they were not present every year (Able and Fahay 1998). In the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU location, weakfish larvae were collected from surveys 8-11 (June 10-August 5) and density peaked during survey 9 (June 24-July 7, Figure 19j). Wheatland (1956) collected weakfish larvae during July-August 1953 (Table 12) with peak density in July (Figure 21q). The 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 71% with the 1953 data reported by Wheatland (1956, Table 12). Monteleone (1992) collected weakfish larvae in Great South Bay, N.Y. during July, Chute and Turner (2001) also collected weakfish larvae in July in Buzzards Bay. Weakfish larvae were collected in relatively low abundance during the site specific sampling in August, they were absent in October, 2005. Available data suggests that the 2002 Poletti Ichthyoplankton Program sampling window from March- July coincides with the majority of the seasonal occurrence of weakfish larvae in Long Island Sound, and the inclusion of the site specific data from August-October, 2005 provides a reasonable annual estimate based on seasonal occurrence.

There was no evidence from comparison of nighttime LRS samples to daytime Poletti samples to suggest a diel difference in the abundance of weakfish larvae (Appendix A). The estimated numbers of weakfish larvae that would be entrained from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 9 (June 24-July 7) with about 54,000 larvae/day (Table 15). Estimated numbers of weakfish larvae entrained/day drop noticeably during surveys 10-11 (July 8-August 5). The total number of weakfish larvae entrained from March 4-August 5 based on the 2002 Poletti data is about 1 million (Table 15). Inclusion of the site specific data collected in August and October 2005 to estimate the number of weakfish larvae entrained from August through October (about 35,000) brings the entrainment estimate from March through the end of October to about 1.1 million (Appendix Table B-1, Appendix Table B-4) which covers the seasonal occurrence of weakfish larvae in Long Island Sound and is therefore a reasonable annual estimate.

Winter Flounder

Winter flounder is in the family Pleuronetidae (righteye flounders) and is found in estuarine and continental shelf habitats from Labrador to Georgia. It is a bottom feeder, occupying sandy or muddy habitats and eelgrass. Both commercial and recreational fisheries for winter flounder are important throughout its range. In Long Island Sound, adults occur year round and are highly abundant from April through June (Stone et al. 1994). They were one of the most commonly taken species in all months in Long Island Sound by Gottschall et al. (2000).

Winter flounder migrate into shallow water in estuaries and coastal ponds to spawn (Collette and Klein-MacPhee 2002). Winter flounder spawn demersal, adhesive eggs that stick together in clusters on sandy bottoms and algal mats in the winter to early spring, spawning activity peaks during February and March south of Cape Cod (Collette and Klein-MacPhee 2002). Because winter flounder eggs are demersal and adhesive, they are relatively uncommon in ichthyoplankton surveys. Even with the epibenthic sled gear, few winter flounder eggs were collected in the 2002 Poletti Ichthyoplankton Program. In the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, winter flounder eggs were only collected during the first survey (March 4-March 18) and in low density ($3/1000m^3$, Table 15). Wheatland (1956) did not collect winter flounder eggs during year-round sampling in Long Island Sound. Stone et al. (1994) consider winter flounder eggs common from February-May in Long Island Sound with peak abundance March-May. Monteleone (1992) collected winter flounder eggs in April in Great South Bay, N.Y. Based on available information, the sampling period of the Poletti Ichthyoplankton

Program coincides with the period of occurrence of winter flounder eggs in Long Island Sound and entrainment estimates from March-July represent annual estimates. Because winter flounder eggs are benthic and adhesive and concentrated in shallow, nearshore and estuarine areas they are not likely to be entrained in the proposed FSRU facility in large numbers.

Incubation of winter flounder eggs takes about 15-18 days at about 3 °C which is what they encounter in nature (Collette and Klein-MacPhee 2002). Young larvae hatch at about 3.0-3.5 mm. Bourne and Govoni (1988) found winter flounder larvae to be most common in shoal water, in or near coves and small bays and rare in deeper waters in Narragansett Bay. Small larvae are planktonic and although many remain near the estuarine spawning grounds, others are carried into coastal waters by tidal currents (Smith et al. 1975). Pearcy (1962) found larvae most common from March to June in the Mystic River estuary and they were typically more abundant near the bottom. In the 2002 Poletti Ichthyoplankton Program, winter flounder were relatively evenly distributed in the Central Basin area (Regions 7-9) between the three sampling strata and two gear types, although the greatest proportion of the catch did occur in the shallow, sled samples (Table 14). In the 2002 Poletti Ichthyoplankton Program, winter flounder larvae were present in Long Island Sound from March to June (Table 3) and they accounted for about 3 % of the larvae collected (Table 5). In the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, density of larval winter flounder peaked during survey 2 (March 18-March 31, Figure 22i) when they comprised a large proportion of the overall larval catch (Figure 17). Although some winter flounder larvae were likely present in Long Island Sound prior to survey 1 (March 4-March 17), published accounts suggest that the sampling window of the 2002 Poletti Ichthyoplankton Program coincided with the period of peak winter flounder larvae density in Long Island Sound. Wheatland (1956) collected winter flounder larvae from March-May, 1953, therefore the 2002 Poletti Ichthyoplankton Program sampling period (March-July) has an annual percent overlap index of 100% with the 1953 data reported by Wheatland (1956, Table 12). Stone et al. (1994) considers winter flounder larvae common from February-June and most abundant in April and May in Long Island Sound. In Narragansett Bay, Keller et al. (1999) observed larvae from March-June, Chute and Turner (2001) collected larvae from April-June in Buzzards Bay, and Monteleone (1992) collected winter flounder larvae in Great South Bay, N.Y from March-April. Winter flounder larvae were not collected during site specific sampling in August or October, 2005. Because the sampling period of the 2002 Poletti Ichthyoplankton Program coincides with the seasonal occurrence of winter flounder larvae in Long Island Sound based on available information, the entrainment estimates from March-July can be considered representative of annual estimates.

There was no evidence from comparison of nighttime LRS samples to daytime Poletti samples to suggest a diel difference in the abundance of winter flounder larvae (Appendix A). Estimated numbers of winter flounder larvae that would be entrained based on the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's water intake was highest during survey 2 (March 18-March 31) with about 54,000 larvae/day (Table 15). The estimated total number of winter flounder larvae that would have been entrained in the proposed FSRU facility from March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program data subset to represent the FSRU intake location is about 1.4 million (Table 15) and this value can be considered representative of the annual total based on available seasonal occurrence information.

American Lobster

The American lobster occurs in the Northwest Atlantic from Labrador to Cape Hatteras and supports one of the most active commercial fisheries in the northeast United States. They live from the intertidal zone to a depth of 720 m (McRae 1960). Major coastal concentrations of lobster are in the Gulf of Maine and the coastal waters of New Brunswick and Nova Scotia (Cooper and Uzmann 1980). American lobster adults, juveniles and eggs are considered highly abundant in Long Island Sound throughout the year by Stone et al. (1994). Spawning adults are considered highly abundant between June and November (Stone et al. 1994).

When spawning, lobsters pair for about 2 weeks (Atema et al. 1979). Females leave their shelters about 7 days before molting and share the shelter of a male. Mating must take place within a few hours (rarely more than one) after the female has molted. Eggs are normally extruded 11 to 13 months after mating. Freshly extruded eggs are dark green and irregularly shaped, they soon become spherical and are about 1.5 to 1.7 mm in diameter. As eggs develop, they increase in size and become elongated and lighter in color. The number of eggs in a clutch ranges from 3,000 to 115,000 (Herrick 1909, Saila et al. 1969, Perkins 1971). After extrusion, fertilized eggs are firmly attached to the female's pleopods where they develop for 9-11 months. Because lobster eggs are not planktonic, they are not unlikely to entrained in the proposed FSRU facility's intake. Lobster eggs hatch from May to October, hatching earlier in warmer water. The time required to hatch all the eggs within a brood depends on water temperature. All eggs within a brood usually hatch in 2 to 3 days at 20 °C, and in 10-14 days at 15 °C (Hughes and Matthiessen 1962).

American lobster larvae are released during a brief period at night by actively beating their pleopods (Ennis 1975). American lobsters pass through one prelarval and four free-swimming larval stages. At the end of the stage IV, larvae settle to the bottom and burrow into the substrate where they molt into juveniles (Cooper and Uzmann 1980). All larval stages are normally completed in 25-35 days but the length of time is temperature dependent. The distribution and abundance of larvae is affected by the distribution of spawning females, surface current velocity and direction, temperature, salinity, light intensity and larval mortality (Phillips and Sastry 1980). The larvae are planktonic from late May to October and they appear earlier in the plankton in the southern end of their distribution (Fogarty and Lawton 1983). Larvae occur in Long Island Sound from May-August and are most abundant in June-July (Stone et al. 1994). The larval stages are confined to the upper 3 m (typically upper 1 m) of the water column (Templeman 1937, Sherman and Lewis 1967, Scarratt 1973). However, stage I larvae may exhibit semidiurnal vertical migrations that are based on responses to light intensity that concentrate them at the surface in early morning and late afternoon/early evening and involve depth changes of several meters (Scarratt 1973, Harding et al. 1987). After metamorphosing, the stage IV larvae undertake periodic excursions from the pelagic to the benthic realm to locate suitable habitat and are considered transitional forms, neither fully pelagic nor fully benthic (Lavalli and Krupp 1998). Thermal gradients of 4–5° C appear to be a barrier to settling stage IV larvae and they will not typically swim from the warmer surface waters through the colder gradient and below the thermocline (Boudreau et al. 1992). Because of their thermal preferences, settling larvae are thought to exploit warmer, shallower, inshore waters where such gradients are absent (Wahle and Steneck 1991, Boudreau et al. 1992). Stage IV larvae settle primarily in shallow coastal bays from the lower intertidal/shallow subtidal interface to between 5–10 m in depth in the subtidal (Wahle and Steneck 1991, Lavalli and Krupp 1998). However, this does not mean that lobster only settle in shallow regions, but it strongly suggests that shallow waters support higher populations of young of the year lobsters than deeper waters (Lavalli and Krupp 1998). While newly settled lobsters are capable of using a variety of habitats such as peat beds in salt marshes and eelgrass, environments comprised of rocks and boulders represent the “safest” habitat against predation (Lavalli and Barshaw, 1986; Barshaw and Lavalli, 1988, Wahle and Steneck 1992). Featureless habitats (those lacking in significant relief or vegetation) represent the “worst” habitats (Lavalli and Krupp 1998).

American lobster larvae were relatively rare in the 2002 Poletti Ichthyoplankton Survey and accounted for only 0.2% of the larvae collected in the subset data. Within regions 7-9 (Central Basin) lobster larvae density was highest in the Tucker trawl collections in the intermediate and deep sampling strata (Table 14). Lobster larvae were collected during surveys 6-10 (May 13-July 21) and average densities during their period of occurrence in the subset data ranged from 1.2/1000m^3 during survey 8 (June 10-June 23) to 12.5/1000m^3 during survey 9 (June 24-July 7, Figure 22a, Table 15). The maximum estimated number per day that would be entrained by the proposed FSRU facility based on the subset data is about 1,300 during survey 9 (June 24-July 7, Table 15). The total estimated number of lobster larvae that would be entrained in the proposed FSRU facility’s intakes between March 4-August 5 based on the 2002 Poletti Ichthyoplankton Program subset to represent the FSRU intake location is about 44,000 (Table 15). Larvae occur in Long Island Sound from May-August and are most abundant in June-July (Stone et al. 1994) so the sampling window of the 2002 Poletti Ichthyoplankton Program (March 4-August 5) did align with the period of maximum density of American lobster larvae in Long Island Sound as suggested by the noticeable decline in lobster larvae abundance during the last two surveys (July 8-August 5, Figure 22a). American lobster larvae were not collected during the site specific sampling in August or October, 2005.

Evaluation of the effect of entrainment on lobster larvae recruitment is difficult for several reasons (NUSCO 2005): 1) variability in larval lobster abundance and stage composition is high (Bibb et al. 1983, Fogarty 1983, Lux et al. 1983, Blake 1984, 1988); 2) reliable estimates of larval and post-larval survival rates are lacking (Phillips and Sastry 1980, Caddy and Campbell 1986, Cobb 1986, Blake 1991); 3) post-settlement processes of early benthic phase lobsters controlling recruitment to the fishery are uncertain (Hudon 1987, Incze and Wahle 1991, Wahle et al. 2004). Natural mortality is extremely high during the planktonic larval stages (MacKenzie and Moring 1985). Disagreement among researches as to the source and dispersion mechanism of lobster larvae, and on egg and larval mortality, led to a range of survival estimates during the larval life history phase from 0.9% in Canadian waters (Scaratt 1964, 1973, Harding et al. 1982) to more than 50% in Long Island Sound (Lund and Stewart 1970). Incze et al. (2003) estimate about 2.5% of planktonic lobster postlarvae (stage IV) settle successfully. Running a conservative estimate and considering all larvae entrained (44,000) to be stage IV results in about 1,100 lobster young of the year settlers lost to entrainment during the March 4-August 5, 2002 period based on the subset data of the Poletti Ichthyoplankton Program. Tucker trawl collections represent the integrated water column from the surface to 3 m above the bottom, because lobster larvae are typically concentrated near the surface, their densities in the upper 1-3 m were likely underestimated by the Poletti Ichthyoplankton Program. However, the location of the FSRU intakes is 35-45 feet below the surface, which is deeper than the zone typically occupied by planktonic lobster larvae. Therefore, the density of lobster larvae in the Tucker Trawl collections more accurately represents the portion of the larval lobster population that would be at risk of entrainment in the FSRU intakes than samples conducted strictly in surface waters because the intakes are 35-45 feet below surface.

9.0 DISCUSSION

The ichthyofaunal community of Long Island Sound (Regions 7-10) as described from the 2002 Poletti Ichthyoplankton Program during March-July is similar to that described for other polyhaline estuaries in the northern Middle Atlantic Bight (Wheatland 1956, Richards 1959, Bourne and Govoni 1988, Moneleone 1988, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001). The community represents the faunal diversity of southern New England and its relative proximity to the biogeographical boundary at Cape Cod (Azarovitz and Grosslein 1982, Ayvazian et al. 1992). Peak density and standing crop of fish eggs occurred between mid-May and early July and peak density and standing crop of fish larvae occurred during June-July. Eggs were dominated by scup/weakfish, fourbeard rockling, tautog, searobin and Atlantic menhaden which together comprised about 85% of the total number of eggs collected. Fish larvae were dominated by Atlantic menhaden which comprised > 40% of the catch, scup and tautog were also common and each represented about 12% of the catch.

Ichthyoplankton entrainment analysis focused on 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake in the Central Basin of Long Island Sound from 35-45 feet below surface in water that is approximately 95 feet deep. Poletti Regions 7-9 were selected to represent the Central Basin (Figure 1), the deep (>30m, 98 feet) sampling strata was selected to represent the FSRU location in deep water 9 miles offshore, and the Tucker trawl gear was selected to represent water column collections rather than the epibenthic sled which sampled near bottom. Egg abundance was bi-modal with a peak during late March- late April and a second peak between late May-early July. Egg diversity was low during March-April and was dominated by fourbeard rockling which comprised the vast majority of eggs collected between March and mid-May. A distinct increase in egg diversity and shift in species composition took place in mid-late May when eggs of summer spawning species such as tautog, searobin, weakfish/scup, Atlantic menhaden, windowpane, bay anchovy and cunner were collected. Egg density dropped markedly in early July and remained low during the last survey in late July. Mean egg density in the data subset to represent the FSRU facility's water intake ranged from about 200/1000m^3 during the last 2 surveys (July 8-August 5) to about 5,000/1000 m^3 during survey 3 (April 1-April 14) and 7 (May 27-June 9). Egg density in the deep sampling strata of Regions 7-9 was generally lower than in the shallow and intermediate depth strata (Figure 14) suggesting that potential entrainment of eggs in the FSRU facility is lower than would be expected if the facility was located in a more shallow, nearshore location in the Central Basin of the Sound.

Abundance of fish larvae in the 2002 Poletti Ichthyoplankton Program data subset to represent the proposed FSRU facility's intake location demonstrated a pronounced peak in mid-June which was driven largely by Atlantic menhaden with significant contribution by tautog, cunner, scup, and searobin. There was a distinct increase in diversity and shift in species composition in the larval fish community in early June. Larval collections prior to June were relatively low in abundance and dominated by winter and early spring spawners such as winter flounder, American sand lance, grubby, rock gunnel, and fourbeard rockling. Larval abundance dropped markedly in mid-July. Mean fish larvae density in the subset data ranged from about 100/1000 m^3 during the first survey (March 4-March 17) to >10,000/1000 m^3 during survey 8 (June 10-June 23).

The seasonal changes in ichthyoplankton species composition and abundance is typical of estuarine and coastal systems in the Mid-Atlantic Bight (Able and Fahay 1998, Witting et al. 1999). The regional ichthyofauna is temperate, but influenced by subtropical and boreal species that make seasonal migrations into the area. Many species are transients that occur in the region during the summer and move offshore and or south during winter. Few species spawn in the region during mid-winter (American sand lance being an exception). Ichthyoplankton abundance and diversity begin to increase in the early spring and abundance and diversity reach a peak during mid-late summer when many species reproduce, spawning is curtailed in the fall (Able and Fahay 1998). In Great South Bay, New York, Monteleone (1992) found a peak in fish egg density during late spring to early summer in 1985 and 1986 that was dominated by bay anchovy, in 1986 there was also a second peak in March comprised of winter flounder and American sand lance. In Buzzards Bay, Chute and Turner (2001) describe a peak of fish eggs and larvae from June-August dominated by cunner, tautog, and bay anchovy, diversity was highest in July. They also found a smaller spring peak comprised of winter flounder and American sand lance larvae. In Narragansett Bay, Keller et al. (1999) found a peak in fish egg density during June, and a peak in larvae during July with greatest diversity in July. In Long Island Sound, Wheatland (1956) found a peak in egg diversity and density in late spring and summer with a peak in June and July. The pattern was similar for fish larvae although density remained high into the fall when Atlantic menhaden larvae were abundant. In Long Island Sound, Richards (1959) found a seasonal ichthyoplankton cycle of increasing density and diversity in the spring to a peak in summer followed by a decline in autumn, with only American sand lance larvae collected in significant numbers in the winter. Although the 2002 Poletti Ichthyoplankton Program did not sample year round, based on available information from comparable regional surveys, the March-July sampling schedule did capture the period of peak ichthyoplankton diversity and abundance for most species in the region and is therefore representative of the period when entrainment impacts would be most prominent. Density of eggs and larvae for all species combined (Figure 15) and for abundant species (Figure 22) declined noticeably during the last two biweekly surveys suggesting that the summer peak was sampled. Inclusion of the site specific samples from August 23 and October 4, 2005 in the entrainment estimates addresses this bias and includes ichthyoplankton species likely to occur in the fall beyond the scope of the Poletti sampling window. Diversity was low in these site specific samples (NAI 2005 a,b) and bay anchovy dominated the August collection. Overall ichthyoplankton abundance was greatly reduced in the October samples and dominated by Atlantic menhaden and bay anchovy (Appendix Figure A-1).

Entrainment estimates summed over the March-July, 2002 Poletti Program sampling period likely represent the majority that would be entrained on an annual basis based on available information and the annual percent overlap index discussed for each species examined in Section 8.3. Abundant species in the subset 2002 Poletti Ichthyoplankton Program data for which the March-July period likely underestimates the annual entrainment estimate include Atlantic menhaden, bay anchovy, and searobin which can be expected to have significant densities of eggs and larvae in the area during August and into the fall (Wheatland 1956, Richards 1959, Bourne and Govoni 1988, Moneleone 1988, Stone et al. 1994, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001, Figure 21). These species were all collected during site specific sampling in August, 2005 and this data was included in the modified entrainment estimates in Appendix B to address this bias. Although the 2002 Poletti Ichthyoplankton Program did not sample during the winter, comparable studies demonstrate that few fish spawn in the region during this time and eggs and larvae would not be present in high densities in the water column with the exception of American sand lance larvae. American sand lance spawn in the winter, eggs are demersal and adhesive and therefore rarely collected in ichthyoplankton surveys. Larvae, however, are pelagic and are common in Long Island Sound from December-April and most abundant December-February (Stone et al. 1994) and exhibit high annual variability (Monteleone et al. 1987). Wheatland (1956) collected American sand lance larvae during December through May with greatest density in December (Table 12, Figure 21a). The number of sand lance larvae entrained from March-July (about 400,000 Table 15) based on the subset Poletti data is an underestimate of the annual number because sampling did not occur from December-February when sand lance larvae would be present in Long Island Sound. Wheatland (1956) collected about 30% (Table 12) of the summed average monthly density of sand lance larvae from January-December, 1953 during March-July. Applying the annual percent overlap index with the Wheatland (1956) data as discussed in Section 8.3 to the entrainment estimate of sand lance larvae based on the 2002 Poletti data suggests that the number of larvae entrained from March-July (about 390,000, Table 15) is roughly 30% of the annual total. Site specific collections scheduled for Feburary, 2005 will be used to generate a more accurate estimation of sand lance entrainment in the FSRU facility.

Results of ichthyoplankton studies are highly dependent upon sampling protocols. Numerous studies have found significantly higher catches of fish larvae at night compared to day, suggesting that visual perception of the net by larvae affects catch rates (Ahlstrom 1954, Clutter and Anraku 1968, Bourne and Govoni 1988). Night sampling may therefore mitigate the effect of some behavioral factors on density estimations. The day-night comparisons between the Long River Survey and the Poletti data and for the site-specific collections in August and October, 2005 in Appendix A were included to address this potential bias. Significantly higher densities of bay anchovy eggs and larvae and fourspot flounder larvae were detected and a diel correction factor was incorporated in the modified entrainment estimates in Appendix B. The original Poletti ichthyoplankton sampling design had called for changing from daytime to nighttime sampling for some of the later biweekly surveys; due to negative interactions with lobstermen this schedule was changed to daytime sampling to enable crews to avoid lobster gear. Gear avoidance and clogging can occur with small mesh nets, conversely, nets with larger mesh may extrude smaller or thinner larvae (Colton et al. 1980) such as bay anchovy, cunner and tautog (Chute and Turner 2001). There is a tradeoff in using a smaller mesh to avoid extrustion of small eggs and larvae, because the more water filtered through a coarser mesh net, the greater the chance of capturing larvae present in low numbers (Chute and Turner 2001).

Ichthyoplankton and lobster larvae are generally more abundant in surface waters (Templeman 1937, Williams 1968, Scarrat 1973, Kendall and Naplin 1981,Bourne and Govoni 1988, Sundby 1991). In general, there is a feeding advantage in being distributed in the upper, more productive layers of the water column, where food is present in higher abundance (e.g. Coombs et al. 1992, 1994). Larval fish are predominantly visual feeders and require sufficient light to feed (Blaxter 1988, Gerking 1994). Entrainment of ichthyoplankton and lobster larvae in proposed FSRU facility's intake from 35-45 feet below the surface is therefore likely lower than would be expected from intake locations closer to the surface, although this cannot be verified with the 2002 Poletti Ichthyoplankton Program data due to the protocol requiring the combination of samples in the lab composites representative of the entire water column in each stratum. Laboratory composites from Tucker trawl contain samples collected anywhere in the water column from surface to 3 feet above the bottom. Site specific samples in August, 2005 collected significantly higher numbers of eggs in surface (20 ft) than in mid-depth (40 ft) tows (NAI 2005a) suggesting the entrainment estimates for eggs based on the entire water column may be conservative because the majority of eggs are present in the water column above the intake zone of the FSRU facility. Larvae (primarily bay anchovy) were abundant at the mid-depth (40 ft) strata during the daytime, but moved closer to the surface at night. Migration of bay anchovy larvae towards surface waters at night was also observed by Bourne and Govoni (1988) in Narragansett Bay where they observed swarms of larval anchovy just below the water's surface at night. This suggests that bay anchovy entrainment estimates based on the entire water column may be conservative because bay anchovy larvae do not occur at the depth of seawater intake during night in high density. Limited exposure to entrainment on a daily basis would occur for any larval species exhibiting diel vertical migration above and below the intake zone.

Bay anchovy are typically the most abundant ichthyoplankton species collected in the estuaries of the northern Mid-Atlantic Bight (Wheatland 1956, Dovel 1981,Vouglitois et al. 1987, Bourne and Govoni 1988, Monteleone 1992, Keller et al. 1999, Chute and Turner 2001). Although large numbers of bay anchovy were collected in the 2002 Poletti Ichthyoplankton program, they comprised only 5% of the total number of larvae. Olney and Boehlert (1988) demonstrated that densities of bay anchovy larvae collected at night exceed those during daytime and this diel difference was also observed with the site specific collections in 2005. However, catches from daytime ichthyoplankton sampling conducted by Bourne and Govoni (1988) and Keller et al. (1999) in Narragansett Bay with a 0.505 mm mesh bongo net was dominated by bay anchovy. Although daytime sampling with a 0.505 mm mesh likely underestimated the abundance of bay anchovy eggs and early larvae due to extrusion, early life history stages of this species demonstrate considerable annual variation in abundance (Vouglitois et al. 1987, Dovel 1981, Able and Fahay 1998). Entrainment monitoring at the Millstone Power Station near New London on the Connecticut shore of Long Island Sound has observed a decline in bay anchovy abundance over the last 10 years that is corroborated by other agencies in Narragansett Bay (Tim Lynch, RI DEM, personal communication cited in NUSCO 2003) and Maryland (Price 1999).

Millstone entrainment monitoring has observed a dramatic increase in Atlantic menhaden larvae and young of the year coinciding with the decrease in bay anchovy (NUSCO 2005). Atlantic menhaden was the most abundant larvae collected in the 2002 Poletti Ichthyoplankton Survey and an estimated 1.6 million Atlantic menhaden eggs and 14 million larvae would be entrained between March 4 and August 5. Atlantic menhaden eggs and larvae were absent in the site specific collections in August, but they were collected in low density in October (NAI 2005a,b, Appendix Figure 1). Monitoring at Millstone Power Station demonstrates a bimodal distribution of menhaden larvae in Long Island Sound with a peak in the summer and one in the fall (NUSCO 2005). In recent years, the summer (June 1-September 15) peak has dominated larval production (Figure 23) and the June peak of Atlantic menhaden in 2002 (Figure 22) suggests that the period of maximum larval production was sampled. Inclusion of the site specific October, 2005 sample in the modified entrainment estimates in Appendix B include entrainment numbers from this fall peak, although the contribution (about 230,000) was small compared to the total (about 14 million, Appendix Table B-1, Appendix Table B-4). Entrainment modeling of Atlantic menhaden at Millstone Power Station indicated that the Atlantic menhaden population could withstand losses of 210 million young of the year for 50 consecutive years with a projected reduction of 0.08-1.1% in abundance (NUSCO 1983).

Estimates of entrainment mortality are difficult to assess as many biological processes including predation, density-dependent growth and mortality, age at maturity, fecundity, population age structure, stock size, species range and fishing mortality influence population dynamics. In addition, entrainment takes place in an environment of significant natural variability, including other stressors, and one that is influenced by the large natural mortality of fish eggs and larvae. The goal of quantifying entrainment mortality is to put it in perspective with other anthropogenic sources of conditional mortality such as fishing mortality and habitat degradation as well as natural mortality components such as predation to determine the relative magnitude of entrainment losses. The relatively low intake velocity (0.5 ft/sec) and estimated daily water volume entrained (28.2 MGD, 106,750 m^3/day) into the proposed FSRU facility and associated LNG carriers will likely result in minimal ichthyoplankton entrainment losses. The daily withdrawl rate of 106,750 m^3/day represents only 0.0003 % of the volume of water in the Central Basin (Regions 7-9, 3.97 x $10^{10}m^3$, Appendix Table D-1). Even with a conservative estimate of running at full capacity 365 days a year, the annual FSRU water intake only represents 0.10% of the water volume in Regions 7-9. Ichthyoplankton density values used to estimate entrainment losses were based on Poletti data subset to represent the FSRU location: regions 7-9 (Central Basin area), deep sampling strata (>30 m to represent the FSRU location in water 95 feet deep) and gear was the Tucker trawl to represent the FSRU withdrawl from 35-45 feet below surface. The volume of water in the deep sampling strata of regions 7-9 from the surface to 3 m above the bottom is 7.53x10^9 m^3. Ichthyoplankton densities in this subset data were multiplied by this volume to yield the estimated standing crop or number of individuals during each biweekly survey. Egg standing crop ranged from 1.50 x10^9 during survey 11 (July 22-Aug 5) to 3.91 x 10^{10} during survey 7 (May 27-June 9) with an average of 1.86 x 10^{10} over the March-July sampling period. Larval standing crop ranged from 7.03 x 10^8 during the first survey (March 4- March 17) to 7.74 x 10^{10} during survey 8 (June 10-June 23) with an average of 1.40 x 10^{10} over the March-July sampling period. Because both the entrainment estimates and the standing crop estimates are based on the Poletti ichthyoplankton density data, the percentage of the number entrained in a biweekly survey to the regional standing crop during that survey is equal to the percentage of the FSRU water withdrawl to the total volume of water in the deep sampling strata of regions 7-9 from the surface to 3 m above the bottom (106,750 m^3/day used by FSRU x 14 days in a biweekly survey) / (7.5x10^9 m^3 in the deep water strata from the surface to 3 m above bottom in Regions 7-9) = 0.02%.

Based on data from the 2002 Poletti Ichthyoplankton Program subset to represent the water intake location of the FSRU facility during normal operations (approximately 28.2 MGD, 106,750 m^3/day) approximately 40.6 million eggs and 30.6 million larvae would be entrained from the March 4-August 5 period for which the Poletti Program conducted sampling (Appendix Table B-7). Entrainment rates would not be uniform across the March-July period due to the seasonal variation in ichthyoplankton density and species composition typical of Mid-Atlantic nearshore and estuarine regions and the majority of the annual entrainment would take place during the June-July peak in ichthyoplankton density. Diel correction factors (Appendix A) and entrainment estimates for August-October based on site specific collections in 2005 were included in the modified entrainment estimates in Appendix B to address potential biases in the Poletti methodology and provide a more conservative, upper bound to the entrainment counts. Another conservative assumption is that density is directly proportional to entrainment and no escape behavior is exhibited by larvae. Actual entrainment may be reduced by active avoidance of the seawater intakes. For example, Zeitoun et al. (1981) estimated that 90 % of fish larvae in a Lake Michigan study avoided entrainment in both screened and open intakes at a flow velocity of 0.5 ft/sec. based on comparions of nearfield net tows and entrainment collections. The inclusion of the site specific August and October, 2005 data, applying the diel correction factors to the Poletti data, and including only nighttime samples for bay anchovy and fourspot flounder larvae increased the total entrainment estimate to 47.3 million eggs and 90.9 million larvae from the March-October period (Appendix Table B-7). A further conservative estimate included the site specific 2005 data and diel correction factors to the Poletti data and considered only nighttime samples for all larvae collected in the 2005 data (Scenario 3-Appendix B). This had little effect on the entrainment estimates, total number of eggs were 47.3

million and total number of larvae was 91.4 million for the March-end of October period (Appendix Table B-7) which accounts for the seasonal occurrence for the majority of ichthyoplankton stages for most abundant species in Long Island Sound with the exception of sand lance.

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APPENDIX A

Day–Night Differences in Ichthyoplankton Abundance Based On Comparison of the Poletti And Long River Data and the Site Specific Data Collected During August and October, 2005

Night catches of fish larvae often exceed daylight catches, suggesting visual avoidance of sampling gear (Ahlstrom 1954, Clutter and Anraku 1968, Kendall and Naplin 1981, Bourne and Govoni 1988). Net avoidance involves complex reactions of fish larvae to the approach of the net, including sensory perception of the net and a variety of avoidance reactions that are both size and species specific.

The Long River Survey (LRS) is conducted annually for the Hudson River Generators and is used to generate density and standing crop estimates for ichthyoplankton in the Hudson River using identical gear and methods to the 2002 Poletti Ichthyoplankton Program (Poletti). However, the LRS does not sample outside the Hudson River. A region of spatial overlap exists between the LRS and Poletti region 1 (Figure 1) from the Battery at Hudson River Mile (RM) 0 north to RM 15. This area includes all of LRS sampling region 0 (RM 0-11) and RM 12-14 of LRS region 1. From mid-May through late July, LRS sampling is conducted at night to correspond with the seasonal occurrence of striped bass PYSL in the Hudson River. Therefore, there was a 12 week period from mid-May through late July, 2002 (Poletti biweekly surveys 6-11) during which daytime (Poletti) and nighttime (LRS) ichthyoplankton sampling occurred in the same geographic region with similar gear and methods that was compared for day:night differences for abundant species and life stages. Subsets of the data from the two sampling programs were selected so that abundance estimates could be calculated from samples collected during the same weeks in 2002 within the same geographic boundaries.

The number of LRS samples available for this comparison from the shallow depth stratum (<6 m river depth) was limited. No sampling was done in the shallow stratum of LRS region 0 and many samples from the shallow stratum of LRS region 1 were outside the Poletti sampling area, i.e. in RM 15 or above. Appendix Table A-1 shows the number of samples collected and analyzed for each biweekly period from each of the two programs, for each gear type and depth stratum, during the weeks of interest. There were a total of 19 cells in the sampling design (biweekly survey/gear/depth stratum) for which there were both Poletti and LRS samples.

APPENDIX TABLE A-1. NUMBERS OF ICHTHYOPLANKTON SAMPLES TAKEN WITHIN EACH STRATUM OF THE SAMPLING DESIGN FOR THE POLETTI AND LONG RIVER SURVEYS DURING 2002.

Survey or River Run Number			Trawls				Sleds			
			Shallow		Mid-Depth		Shallow		Mid-Depth	
Poletti	LRS	Date Range	Poletti	LRS	Poletti	LRS	Poletti	LRS	Poletti	LRS
6	9-10	13-26 May	2	0	2	8	2	2	2	10
7	11-12	27 May–9 Jun	1	1	2	10	2	2	2	10
8	13-14	10-23 Jun	2	0	2	10	2	3	2	10
9	15-16	24 Jun–7 Jul	2	1	2	9	2	0	2	9
10	17	8-21 Jul	2	0	2	3	2	2	2	5
11	18	22 Jul–4 Aug	2	1	2	6	2	0	2	6

Eggs are abundant, but they are not capable of gear avoidance or diel vertical migration. Therefore, egg data were examined for comparison with the PYSL data. If no day-night differences were found for eggs but they did occur for PYSL, it would lend further support to the PYSL differences as being genuine, rather than being due to random variation. Eggs that occurred most commonly in these samples were bay anchovy, cunner, and tautog. The life stage of greatest interest is post yolk-sac larvae, because of its abundance, long stage duration, and potential for active gear avoidance or dirunal vertical migration. Examination of diel differences in abundance for PYSL of abundant species in these samples included Atlantic menhaden, bay anchovy, striped bass, tautog, weakfish, windowpane, and winter flounder.

The average density of bay anchovy eggs was about 50% higher in LRS samples (10,462/1000 m^3) than the corresponding Poletti samples (6,923/1000 m^3, Appendix Table A-2). A paired t-test using log (x+1) transformed densities indicated that the LRS bay anchovy egg densities were significantly higher ($p < 0.05$). Even after the log transformation, the data were not normally distributed so the corresponding nonparametric Wilcoxon's signed rank test was also applied to untransformed data, and this test did not detect a significant difference (Appendix Table A-2). The conflicting results of the two tests, along with the low level of significance in the t-test, suggest that if there is a day-night difference for bay anchovy eggs in the Hudson River, it is not a strong one. Gear avoidance would not explain a day-night difference between the Poletti and LRS egg densities, but for bay anchovy there is another possible explanation. Bay anchovy are serial spawners typically spawning every 1.3 to 1.4 days during the evening hours between 2100 and midnight, eggs hatch after about 24 hours (Collette and Klein-MacPhee 2002). Coupled with the high natural mortality rate typical of the egg stage (Houde et al. 1994), the bay anchovy spawning and hatching schedule would tend to result in a 24-hour pattern in egg abundance, peaking during the night. Eggs of the two other abundant species examined, cunner and tautog, did not show any significant difference in mean density between Poletti day samples and LRS night samples (Appendix Table A-2).

Bay anchovy PYSL densities tended to be higher in LRS samples at night than in Poletti collections during the day, but the difference between the means was not significant (Appendix Table A-2). Densities of striped bass PYSL were also higher at night. None of the other PYSL species examined (Atlantic menhaden, tautog, weakfish, windowpane, and winter flounder) showed any significant difference between day and night (Appendix Table A-2).

In samples conducted at the proposed FSRU location on August 23 and October 4, 2005 egg density was significantly higher at night as determined by analysis of variance (NAI 2005a, b). However, this diel difference was primarily driven by bay anchovy (Appendix Figure A-1), and there was no diel difference in overall egg density when bay anchovy was removed from the analysis. There was also no diel difference in egg density for other species in which sufficient numbers of eggs were collected to warrant statistical analysis (butterfish, searobin, smallmouth flounder) during the August 23 sampling event (Appendix Table A-3). Atlantic menhaden were the only eggs collected during the October 4 sampling event and they were collected in significantly higher density during daytime sampling (Appendix Table A-3).

Bay anchovy PYSL dominated the larval fish community during the August 23 sampling event (Appendix Figure A-1) and mean density across the three depth strata was approximately 13 times greater at night (7,156/1000 m^3) than during day (554/1000 m^3). This difference was statistically significant as determined by a paired t-test (Appendix Table A-3). Bay anchovy PYSL were considerably less abundant during the October 4 sampling event (Appendix Figure A-1), although density was also significantly higher at night (419/1000 m^3) than during daytime (77/1000 m^3, Appendix Table A-3). Fourspot flounder PYSL were collected in significantly higher density at night (107/ 1000 m^3) than during daytime (47/1000 m^3) in the August 23 samples. There was no statistical difference between day and night PYSL densities for other abundant species collected during the August 23 sample (butterfish, searobin, smallmouth flounder) or the October 4 sample (Atlantic menhaden, Appendix Table A-3).

Atlantic menhaden were the most abundant larvae collected in the Poletti data subset to represent the FSRU location and accounted for nearly 45 % of the total larvae. However, there is no evidence from either the comparison of the LRS and Poletti data or the project specific collections in August and October, 2005 to support underestimation of menhaden density by daytime sampling for either eggs or larvae. Daytime density of menhaden eggs was actually significantly higher during the daytime in the October 4 collections, and mean PYSL density was also higher during the day- although this difference was not statistically significant (Appendix Table A-3). Thayer et al. (1983) found Atlantic menhaden larvae in greater densities during day than night in both surface (0.5 m) and near bottom (5-10 m) samples conducted in Beaufort Inlet, North Carolina with a 20 cm. bongo net with 0.333 mm mesh. Kendall and Reintjes (1975) found Atlantic menhaden larvae equally distributed in shallow (0-15 m) and deep (18-33 m) tows during day and night tows conducted with a 0.520 mm mesh along the Mid-Atlantic coast from Martha's Vinyard to Cape Lookout, North Carolina.

Bay anchovy and fourspot flounder are the only species included in the Poletti analysis for which there is sufficient evidence to warrant a diel correction factor. Because eggs are not capable of gear avoidance, the most likely explanation for diel differences in bay anchovy eggs is the 24-hour pattern in egg abundance generated by nocturnal spawning behavior as discussed previously. Mean bay anchovy egg density was 13.1 times greater at night (1,533/1000 m^3) than during day (117/1,000 m^3) in the 2005 collections, therefore a correction factor of 6.6 will be applied to the bay anchovy egg entrainment estimates generated from the daytime Poletti sampling. Mean bay anchovy egg density from the Poletti data subset to represent the proposed FSRU location will be multiplied by 6.6 to integrate the higher entrainment estimates occurring at night based on the assumption of 12 hours daylight: 12 hours night. Mean bay anchovy PYSL density was 12.9 times greater at night during the August 23 sampling event so entrainment estimates generated from daytime Poletti samples subset to represent the proposed FSRU location will be multipled by 12.9. Fourspot flounder PYSL were collected in significantly higher density at night (107/1000 m^3) compared to daytime (47/1000 m^3) in the August 23, 2005 collections, therefore daytime entrainment estimates from the Poletti data will be multiplied by 2.3 in the modified entrainment estimate tables in Appendix B.

APPENDIX TABLE A-2. COMPARISONS BY SPECIES AND LIFE STAGE BETWEEN 2002 DAYTIME POLETTI ICHTHYOPLANKTON DENSITIES AND NIGHTIME LONG RIVER SURVEY DENSITIES.

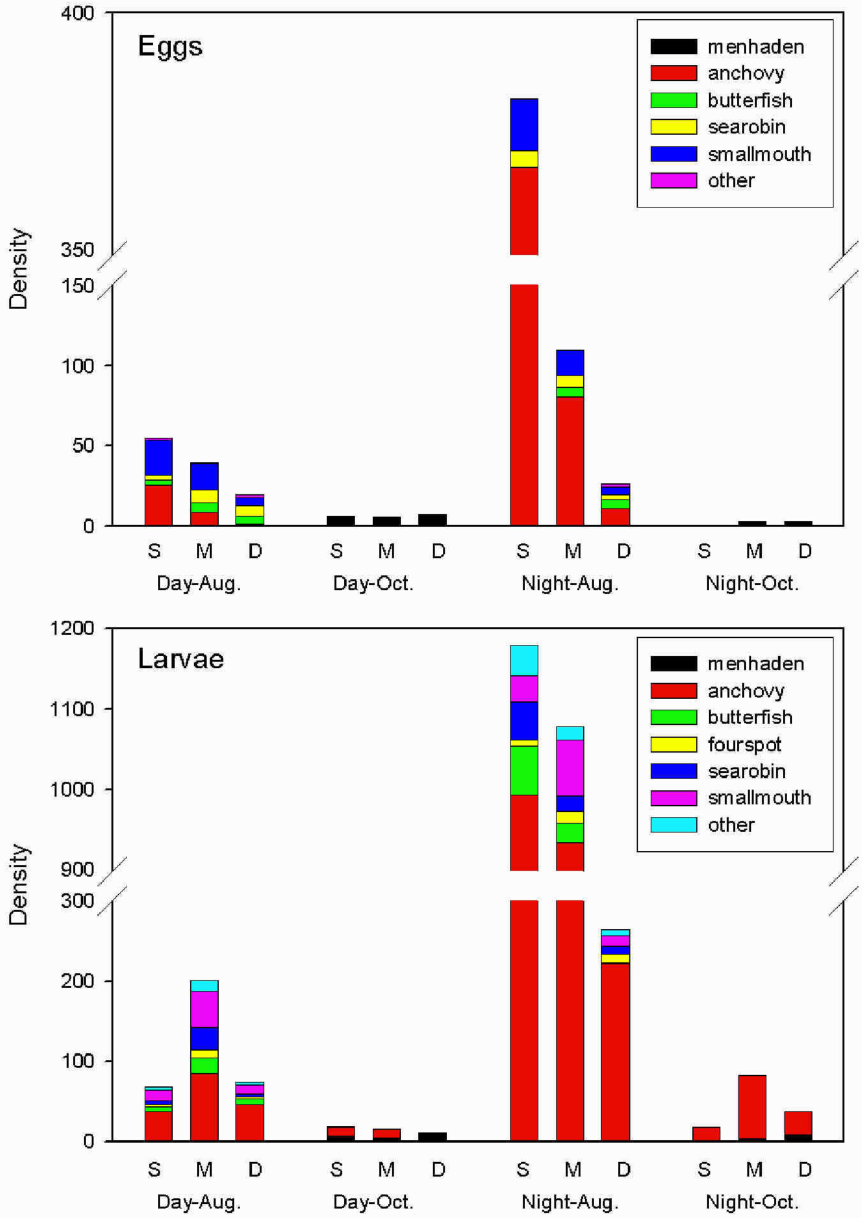
Life stage	Species	Mean density (per 1,000 m^3)		Paired t-test[1]	Wilcoxon's signed ranks test[1]
		Day	Night		
Eggs	Bay anchovy	6,923	10,462	*	NS
	Cunner	161	73	NS	NS
	Tautog	307	67	NS	NS
PYSL	Atlantic menhaden	307	15	NS	NS
	Bay anchovy	1,352	2,096	NS	NS
	Striped bass	15	33	**	NS
	Tautog	11	5	NS	NS
	Weakfish	100	56	NS	NS
	Windowpane	67	9	NS	NS
	Winter flounder	14	05	NS	NS

[1] * = $p < 0.05$, ** = $p < 0.01$, NS = not significant ($p > 0.05$)

APPENDIX TABLE A-3. COMPARISONS BY SPECIES AND LIFE STAGE BETWEEN DAY AND NIGHT SAMPLES CONDUCTED IN THE VICINITY OF THE PROPOSED FSRU FACILITY ON AUGUST 23 AND OCTOBER 4, 2005.

Life stage	Date	Species	Mean density (per 1,000 m^3)		Paired t-test[a]	Wilcoxon's signed ranks test[b]
			Day	Night		
Eggs	23-Aug	Bay anchovy	117	1,533	***	*
	4-Oct	Atlantic menhaden	83	32	*	**
	23-Aug	Butterfish	49	38	NS	NS
	23-Aug	Searobins	59	47	NS	NS
	23-Aug	Smallmouth flounder	147	103	NS	NS
PYSL	23-Aug	Bay anchovy	554	7,156	***	***
	4-Oct	Bay anchovy	77	419	***	**
	4-Oct	Atlantic menhaden	71	46	NS	NS
	23-Aug	Butterfish	113	287	NS	NS
	23-Aug	Fourspot flounder	47	107	*	*
	23-Aug	Searobins	127	254	NS	NS
	23-Aug	Smallmouth flounder	187	333	NS	NS

1 * = $p < 0.05$, ** = $p < 0.01$, NS = not significant ($p > 0.05$)



Appendix Figure A-1. Density (#/100 m^3) of eggs and larvae of abundant species (Atlantic menhaden, bay anchovy, butterfish, fourspot flounder, searobin, smallmouth flounder, other) collected during day and night sampling in each depth strata (S=surface, M=mid-depth, D=deep) on August 23 and October 4, 2005.

APPENDIX B

Modified Entrainment Estimates Based On Diel Correction Factors and Inclusion of the Site Specific Data Collected in August and October, 2005

Stage-specific entrainment estimates for species of interest collected in the 2002 Poletti Ichthyoplankton data subset to represent the proposed FSRU location as presented in Table 15 were modified to include all species and the site specific data collected during August 23 and October 4, 2005 (NAI 2005a,b) to approximate entrainment that may occur in the fall beyond the scope of the Poletti sampling window. The 2005 entrainment estimates were based on the mean density of the three replicate day and three replicate night samples taken from the mid-depth strata (35-65 feet). The August 23, 2005 data was used to extrapolate an August estimate beyond the cutoff date of the Poletti Program (August 5). The October 4, 2005 data was used for entrainment estimates for the month of October. The average density of the August and October samples was used to represent the September 2005 entrainment estimates. The site specific, 2005 data was included along with the diel correction factors from Appendix A to generate entrainment estimates using three different scenarios. For the first, the Poletti data is unadjusted for diel differences and the 2005 data is the average density of the six (three day, three night) replicate tows from the mid-depth stratum (Appendix Table B-1). For the second scenario, bay anchovy egg density is multiplied by 6.6, bay anchovy larvae density is multiplied by 12.9 and fourspot flounder larvae are multiplied by 2.3 for diel correction factors to the Poletti data as discussed in Appnedix A. For the second scenario, the site specific 2005 data was the same as scenario one except that only night data was used for bay anchovy and fourspot flounder larvae (Appendix Table B-2). The third entrainment scenario was the same as the second, except only night samples were considered for all larvae for the site specific, 2005 collections (Appendix Table B-3). Total entrainment by species and lifestage for the March through the end of October period under these three scenarios is summarized in Appendix Tables B-4, B-5, and B-6 and a summary of egg and larval entrainment for all species combined is presented in Appendix Table B-7.

APPENDIX TABLE B-1. LIFE-STAGE SPECIFIC MEAN DENSITY (#/1000M^3) AND ENTRAINMENT ESTIMATES FOR SPECIES COLLECTED FROM THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM DATA SUBSET TO REPRESENT THE PROPOSED FSRU LOCATION DURING EACH BIWEEKLY SURVEY AND DURING THE AUGUST 23 AND OCTOBER 4, 2005 SAMPLES CONDUCTED AT THE SITE OF THE PROPOSED FSRU FACILITY USING THE ASSUMPTIONS OF SCENARIO 1 AS DESCRIBED IN APPENDIX B. ENTRAINMENT ESTIMATES WERE CALCULATED BY MULTIPLYING THE AVERAGE DENSITY (#/1000M^3) OF EGGS, LARVAE AND YOUNG OF THE YEAR BY THE MAXIMUM ESTIMATED ANNUAL DAILY WATER INTAKE OF THE PROPOSED FSRU FACILITY TO YIELD THE ESTIMATED NUMBER ENTRAINED PER DAY. THIS VALUE WAS MULTIPLIED BY 14 TO ESTIMATE THE NUMBER ENTRAINED PER BIWEEKLY SURVEY FOR THE 2002 POLETTI DATA FOR THE PERIOD OF MARCH 4-AUGUST 5, 2002. DATA COLLECTED AT THE FSRU FACILITY IN AUGUST AND OCTOBER 2005 WAS USED TO ESTIMATE ENTRAINMENT BEYOND THE POLETTI SAMPLING WINDOW (SEE FOOTNOTES). 2005 DATA IS THE AVERAGE OF THREE DAYTIME AND THREE NIGHTTIME REPLICATES.

		Eggs			Larvae			YOY		
Species	**Survey**	**#/ 1000m^3**	**# Entrained/ Day**	**# Entrained/ Survey**	**#/ 1000m^3**	**# Entrained/ Day**	**# Entrained/ Survey**	**#/ 1000m^3**	**# Entrained/ Day**	**# Entrained/ Survey**
American Lobster	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.4	149	2,092			
	7 (May 27-June 9, 2002)				12.2	1,302	18,233			
	8 (June 10-23, 2002)				1.2	128	1,793			
	9 (June 24-July 7, 2002)				12.5	1,334	18,681			
	10 (July 8-July 21, 2002)				1.8	192	2,690			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			43,490			
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			
	Total Sum[4]			0			43,490			

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
American Sandlance	1 (March 4 - 27, 2002)				81.9	8,743	122,400			
	2 (March 18-31, 2002)				139.4	14,881	208,333			
	3 (April 1-14, 2002)				36.3	3,875	54,250			
	4 (April 15-28, 2002)				3.0	320	4,484			
	5 (April 29-May 12, 2002)				1.2	128	1,793			
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			391,260			
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			
	Total Sum[4]			0			391,260			
Atlantic Mackerel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	15.2	1,623	22,716						
	6 (May 13-26, 2002)				12.0	1,281	17,934			
	7 (May 27-June 9, 2002)				45.6	4,868	68,149			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			22,716			86,083			
	August, 2005[1]				41.7	4,451	111,287			
	September, 2005[2]				20.9	2,226	66,772			
	October, 2005[1]									
	2005 Sum[3]			0			178,059			
	Total Sum[4]			22,716			264,142			

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Atlantic Menhaden	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	197.0	21,030	294,417						
	7 (May 27-June 9, 2002)	509.6	54,400	761,597	175.9	18,777	262,883			
	8 (June 10-23, 2002)	374.3	39,957	559,391	5,733.5	612,051	8,568,716			
	9 (June 24-July 7, 2002)				2,760.0	294,630	4,124,820			
	10 (July 8-July 21, 2002)				553.4	59,075	827,056			
	11 (July 22-August 5, 2002)				25.1	2,679	37,512			
	March 4-August 5, 2002 Poletti Sum			1,615,405			13,820,987			
	August, 2005[1]									
	September, 2005[2]	29.3	3,122	93,673	23.8	2,535	76,059			
	October, 2005[1]	58.5	6,245	187,346	47.5	5,071	152,119			
	2005 Sum[3]			281,019			228,178			
	Total Sum[4]			1,896,424			14,049,165			
Atlantic Silverside	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			4,633			
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			
	Total Sum[4]			0			4,633			

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Bay Anchovy	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				0.8	85	1,196			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	13.0	1,388	19,429						
	8 (June 10-23, 2002)	258.5	27,595	386,328						
	9 (June 24-July 7, 2002)	98.8	10,547	147,657	192.1	20,507	287,093			
	10 (July 8-July 21, 2002)	2.6	278	3,886	395.2	42,188	590,626			
	11 (July 22-August 5, 2002)	16.9	1,804	25,257	19.1	2,039	28,545			
	March 4-August 5, 2002 Poletti Sum			582,556			907,460			
	August, 2005[1]	448.3	47,856	1,196,401	5,093.3	543,710	13,592,744			
	September, 2005[2]	224.2	23,928	717,840	2,770.0	295,698	8,870,925	5.9	628	18,847
	October, 2005[1]				446.7	47,685	1,430,557	11.8	1,256	37,693
	2005 Sum[3]			1,914,241			23,894,226			56,540
	Total Sum[4]			2,496,797			24,801,687			56,540
Black Seabass	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.9	310	4,334			
	March 4-August 5, 2002 Poletti Sum			0			4,334			0
	August, 2005[1]				35.0	3,736	93,406			
	September, 2005[2]				17.5	1,868	56,044			
	October, 2005[1]									
	2005 Sum[3]			0			149,450			0
	Total Sum[4]			0			153,784			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Butterfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	6.5	694	9,714						
	8 (June 10-23, 2002)	24.4	2,605	36,466	29.3	3,128	43,789			
	9 (June 24-July 7, 2002)	40.2	4,291	60,079	94.1	10,045	140,632			
	10 (July 8-July 21, 2002)	23.0	2,455	34,374	20.2	2,156	30,189	9.9	1,057	14,796
	11 (July 22-August 5, 2002)	5.7	608	8,519	5.6	598	8,369	8.2	875	12,255
	March 4-August 5, 2002 Poletti Sum			149,151			222,979			27,050
	August, 2005[1]	61.7	6,583	164,582	220.0	23,485	587,125			
	September, 2005[2]	30.8	3,292	82,291	110.0	11,743	293,563			
	October, 2005[1]									
	2005 Sum[3]			246,873			880,688			0
	Total Sum[4]			396,024			1,103,667			27,050
Cunner	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	38.9	4,153	58,136						
	7 (May 27-June 9, 2002)	632.0	67,466	944,524	19.5	2,082	29,143			
	8 (June 10-23, 2002)	399.4	42,636	596,903	1,181.0	126,072	1,765,005			
	9 (June 24-July 7, 2002)	245.1	26,164	366,302	378.0	40,352	564,921			
	10 (July 8-July 21, 2002)	17.7	1,889	26,453	250.9	26,784	374,970	18	1,964	27,499
	11 (July 22-August 5, 2002)	33.0	3,523	49,319	1.0	107	1,495	5	491	6,875
	March 4-August 5, 2002 Poletti Sum			2,041,636			2,735,533			34,374
	August, 2005[1]				20.0	2,135	53,375			
	September, 2005[2]				10.0	1,068	32,025			
	October, 2005[1]									
	2005 Sum[3]			0			85,400			0
	Total Sum[4]			2,041,636			2,820,933			34,374

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/1000m^3	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m^3	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m^3	YOY # Entrained/Day	YOY # Entrained/Survey
Feather blenny	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)				2.3	246	3,437			
	March 4-August 5, 2002 Poletti Sum			0			8,070			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,070			0
Fourbeard Rockling	1 (March 4 - 27, 2002)	693.9	74,074	1,037,034						
	2 (March 18-31, 2002)	3061.0	326,762	4,574,665						
	3 (April 1-14, 2002)	4857.7	518,559	7,259,833	1.0	107	1,495			
	4 (April 15-28, 2002)	2810.2	299,989	4,199,844	8.8	939	13,152			
	5 (April 29-May 12, 2002)	1606.9	171,537	2,401,512	96.3	10,280	143,920			
	6 (May 13-26, 2002)	667.3	71,234	997,280	208.1	22,215	311,005			
	7 (May 27-June 9, 2002)	6.5	694	9,714	673.3	71,875	1,006,247			
	8 (June 10-23, 2002)	365.8	39,049	546,688	23.9	2,551	35,719			
	9 (June 24-July 7, 2002)	578.0	61,702	863,821						
	10 (July 8-July 21, 2002)	14.6	1,559	21,820						
	11 (July 22-August 5, 2002)	32.7	3,491	48,870						
	March 4-August 5, 2002 Poletti Sum			21,961,080			1,511,537			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			21,961,080			1,511,537			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Fourspot Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				44.7	4,772	66,804			
	9 (June 24-July 7, 2002)				39.1	4,174	58,435			
	10 (July 8-July 21, 2002)				5.7	608	8,519			
	11 (July 22-August 5, 2002)				0.3	32	448			
	March 4-August 5, 2002 Poletti Sum			0			134,206			0
	August, 2005[1]				125.0	13,344	333,594			
	September, 2005[2]				62.5	6,672	200,156			
	October, 2005[1]									
	2005 Sum[3]			0			533,750			0
	Total Sum[4]			0			667,956			0
Gobiidae	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				8.7	929	13,002			
	10 (July 8-July 21, 2002)				13.4	1,430	20,026			
	11 (July 22-August 5, 2002)				93.4	9,970	139,586			
	March 4-August 5, 2002 Poletti Sum			0			172,615			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			172,615			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Grubby	1 (March 4 - 27, 2002)				1.8	192	2,690			
	2 (March 18-31, 2002)				9.3	993	13,899			
	3 (April 1-14, 2002)				8.1	865	12,105			
	4 (April 15-28, 2002)				8.4	897	12,554			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.1	117	1,644			
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			42,892			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			42,892			0
Herrings	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)				8.1	865	12,105			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				7.3	779	10,910			
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			23,015			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			23,015			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Hogchoker	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)	24.9	2,658	37,213						
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			37,213			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			37,213			0			0
Northern Pipefish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				1.1	117	1,644			
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.4	363	5,081			
	11 (July 22-August 5, 2002)				1.5	160	2,242			
	March 4-August 5, 2002 Poletti Sum			0			8,967			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,967			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/ 1000m^3	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m^3	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m^3	YOY # Entrained/ Day	YOY # Entrained/ Survey
Northern Puffer	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			0			0
	August, 2005[1]				3.3	352	8,807			
	September, 2005[2]				1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			0			14,091			0
	Total Sum[4]			0			14,091			0
Rock Gunnel	1 (March 4 - 27, 2002)				0.6	64	897			
	2 (March 18-31, 2002)				0.9	96	1,345			
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			2,242			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			2,242			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Scup	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	29.8	3,178	44,491						
	7 (May 27-June 9, 2002)	697.1	74,411	1,041,756						
	8 (June 10-23, 2002)	265.1	28,303	396,244	654.0	69,815	977,403			
	9 (June 24-July 7, 2002)	310.1	33,098	463,370	759.0	81,023	1,134,326			
	10 (July 8-July 21, 2002)	11.2	1,193	16,709	52.0	5,551	77,714			
	11 (July 22-August 5, 2002)	0.8	90	1,263	15.7	1,676	23,464	1	117	1,644
	March 4-August 5, 2002 Poletti Sum			1,963,833			2,212,906			1,644
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,963,833			2,212,906			1,644
Searobin	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	36.5	3,896	54,549						
	7 (May 27-June 9, 2002)	230.2	24,574	344,034						
	8 (June 10-23, 2002)	955.6	102,010	1,428,144	614.9	65,641	918,968			
	9 (June 24-July 7, 2002)	1207.3	128,879	1,804,310	65.2	6,960	97,441			
	10 (July 8-July 21, 2002)	9.4	1,003	14,048	12.5	1,334	18,681	3	331	4,633
	11 (July 22-August 5, 2002)	51.9	5,540	77,565	1.3	139	1,943			
	March 4-August 5, 2002 Poletti Sum			3,722,650			1,037,034			4,633
	August, 2005[1]	71.7	7,651	191,269	238.3	25,439	635,963			
	September, 2005[2]	35.8	3,825	114,762	119.2	12,719	381,578			
	October, 2005[1]									
	2005 Sum[3]			306,031			1,017,541			0
	Total Sum[4]			4,028,681			2,054,575			4,633

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Smallmouth Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.1	224	3,138			
	March 4-August 5, 2002 Poletti Sum			0			3,138			0
	August, 2005[1]	160.0	17,080	427,000	563.3	60,132	1,503,307			
	September, 2005[2]	80.0	8,540	256,200	281.7	30,066	901,984			
	October, 2005[1]									
	2005 Sum[3]			683,200			2,405,291			0
	Total Sum[4]			683,200			2,408,429			0
Striped cusk-eel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				0.8	85	1,196			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			1,196			0
	August, 2005[1]				38.3	4,089	958			
	September, 2005[2]				19.2	2,044	575			
	October, 2005[1]									
	2005 Sum[3]			0			1,532			0
	Total Sum[4]			0			2,728			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Tautog	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	2.7	288	4,035						
	6 (May 13-26, 2002)	191.8	20,475	286,645	1.1	117	1,644			
	7 (May 27-June 9, 2002)	2254.3	240,647	3,369,051	83.6	8,924	124,940			
	8 (June 10-23, 2002)	668.5	71,362	999,073	1,650.4	176,180	2,466,523			
	9 (June 24-July 7, 2002)	683.4	72,953	1,021,341	862.2	92,040	1,288,558			
	10 (July 8-July 21, 2002)	121.2	12,938	181,133	20.1	2,146	30,039			
	11 (July 22-August 5, 2002)	40.7	4,345	60,826						
	March 4-August 5, 2002 Poletti Sum			5,922,106			3,911,704			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,922,106			3,911,704			0
Unidentified	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				2.4	256	3,587			
	10 (July 8-July 21, 2002)				6.1	651	9,116			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			12,703			0
	August, 2005[1]	3.3	352	8,807	3.3	352	8,807			
	September, 2005[2]	1.7	176	5,284	1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			14,091			14,091			0
	Total Sum[4]			14,091			26,794			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ $1000m^3$	# Entrained/ Day	# Entrained/ Survey	#/ $1000m^3$	# Entrained/ Day	# Entrained/ Survey	#/ $1000m^3$	# Entrained/ Day	# Entrained/ Survey
Windowpane	1 (March 4 - 27, 2002)	2.5	267	3,736						
	2 (March 18-31, 2002)	8.8	939	13,152						
	3 (April 1-14, 2002)	21.3	2,274	31,833						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	131.9	14,080	197,125	0.9	96	1,345			
	6 (May 13-26, 2002)	158.8	16,952	237,327	96.5	10,301	144,219			
	7 (May 27-June 9, 2002)	466.8	49,831	697,633	291.5	31,118	435,647			
	8 (June 10-23, 2002)	183.8	19,621	274,689	147.0	15,692	219,692			
	9 (June 24-July 7, 2002)	44.5	4,750	66,505	31.5	3,363	47,077			
	10 (July 8-July 21, 2002)	3.4	363	5,081	3.1	331	4,633			
	11 (July 22-August 5, 2002)	17.5	1,868	26,154						
	March 4-August 5, 2002 Poletti Sum			1,553,234			852,612			0
	August, 2005[1]				3.3	352	8,807			
	September, 2005[2]				1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			0			14,091			0
	Total Sum[4]			1,553,234			866,703			0
Weakfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	16.0	1,711	23,957						
	7 (May 27-June 9, 2002)	375.3	40,068	560,946						
	8 (June 10-23, 2002)	142.8	15,240	213,362	205.8	21,969	307,568			
	9 (June 24-July 7, 2002)	167.0	17,822	249,507	508.8	54,314	760,402			
	10 (July 8-July 21, 2002)	6.0	643	8,997	11.4	1,217	17,037			
	11 (July 22-August 5, 2002)	0.5	49	680	1.1	117	1,644			
	March 4-August 5, 2002 Poletti Sum			1,057,448			1,086,651			0
	August, 2005[1]				8.3	886	22,151			
	September, 2005[2]				4.2	443	13,290			
	October, 2005[1]									
	2005 Sum[3]			0			35,441			0
	Total Sum[4]			1,057,448			1,122,092			0

(continued)

Appendix Table B-1. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Winter flounder	1 (March 4 - 27, 2002)	3.4	363	5,081	9.0	961	13,451			
	2 (March 18-31, 2002)				506.5	54,069	756,964			
	3 (April 1-14, 2002)				106.9	11,412	159,762			
	4 (April 15-28, 2002)				72.8	7,771	108,800			
	5 (April 29-May 12, 2002)				149.5	15,959	223,428			
	6 (May 13-26, 2002)				79.4	8,476	118,663			
	7 (May 27-June 9, 2002)				14.9	1,591	22,268			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				1.1	117	1,644			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			5,081			1,404,979			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,081			1,404,979			0
Yellowtail flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)	1.1	117	1,644						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			1,644			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,644			0			0

(continued)

BW001525

Appendix Table B-1. (Continued)

[1] Entrainment for August 2005 was estimated for the period of August 6-August 31 by multiplying the daily entrainment estimates obtained from the August 23, 2005 mid-depth samples by 25 days. Entrainment for October, 2005 was estimated by multiplying the daily entrainment estimates obtained from the October 4, 2005 mid-depth samples by 31 days.

[2] September, 2005 entrainment estimates were obtained by averaging ichthyoplankton density from the August 23 and October 4, 2005 samples.

[3] The 2005 sum includes the period of August 6-October 31, 2005 estimated from data collected in the mid-depth strata at the site of the FSRU facility on August 23, 2005 and October 4, 2005.

[4] Total sum includes the March 4-August 5, 2002 period from Poletti data and the August 6-October 31, 2005 period obtained from site specific collections at the FSRU location on August 23 and October 4, 2005.

Note: a blank space indicates that a given species/lifestage was not collected.

APPENDIX TABLE B-2. LIFE-STAGE SPECIFIC MEAN DENSITY (#/1000M^3) AND ENTRAINMENT ESTIMATES FROM THE 2002 POLETTI PROGRAM DATA SUBSET TO REPRESENT THE FSRU LOCATION AND DURING THE AUGUST 23 AND OCTOBER 4, 2005 SAMPLES CONDUCTED AT THE SITE OF THE FSRU FACILITY USING THE ASSUMPTIONS OF SCENARIO 2 AS DESCRIBED IN APPENDIX B. ENTRAINMENT ESTIMATES ARE THE SAME AS APPENDIX TABLE B-1 EXCEPT THE POLETTI DATA INCLUDES A DIEL CORRECTION FACTOR FOR BAY ANCHOVY EGGS AND LARVAE, AND FOURSPOT FLOUNDER LARVAE. SITE-SPECIFIC DATA COLLECTED IN 2005 IS THE AVERAGE OF DAY AND NIGHT SAMPLES TAKEN FROM THE MID-DEPTH STRATA FOR ALL SPECIES EXCEPT FOR BAY ANCHOVY AND FOURSPOT FLOUNDER LARVAE WHICH ARE REPRESENTED BY NIGHTTIME SAMPLES ONLY.

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
American Lobster	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.4	149	2092			
	7 (May 27-June 9, 2002)				12.2	1,302	18233			
	8 (June 10-23, 2002)				1.2	128	1793			
	9 (June 24-July 7, 2002)				12.5	1,334	18681			
	10 (July 8-July 21, 2002)				1.8	192	2690			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			43,490			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			43,490			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
American Sandlance	1 (March 4 - 27, 2002)				81.9	8,743	122,400			
	2 (March 18-31, 2002)				139.4	14,881	208,333			
	3 (April 1-14, 2002)				36.3	3,875	54,250			
	4 (April 15-28, 2002)				3.0	320	4,484			
	5 (April 29-May 12, 2002)				1.2	128	1,793			
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			391,260			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			391,260			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Atlantic Mackerel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	15.2	1,623	22,716						
	6 (May 13-26, 2002)				12.0	1,281	17,934			
	7 (May 27-June 9, 2002)				45.6	4,868	68,149			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			22,716			86,083			0
	August, 2005[1]				41.7	4,451	111,287			
	September, 2005[2]				20.9	2,226	66,772			
	October, 2005[1]									
	2005 Sum[3]			0			178,059			0
	Total Sum[4]			22,716			264,142			0
Atlantic Menhaden	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	197.0	21,030	294,417						
	7 (May 27-June 9, 2002)	509.6	54,400	761,597	175.9	18,777	262,883			
	8 (June 10-23, 2002)	374.3	39,957	559,391	5,733.5	612,051	8,568,716			
	9 (June 24-July 7, 2002)				2,760.0	294,630	4,124,820			
	10 (July 8-July 21, 2002)				553.4	59,075	827,056			
	11 (July 22-August 5, 2002)				25.1	2,679	37,512			
	March 4-August 5, 2002 Poletti Sum			1,615,405			13,820,987			0
	August, 2005[1]									
	September, 2005[2]	29.3	3,122	93,673	23.8	2,535	76,059			
	October, 2005[1]	58.5	6,245	187,346	47.5	5,071	152,119			
	2005 Sum[3]			281,019			228,178			0
	Total Sum[4]			1,896,424			14,049,165			0

(continued)

Appendix Table B-2. (Continued)

		Eggs			Larvae			YOY		
Species	Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Atlantic Silverside	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			4,633			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			4,633			0
Bay Anchovy	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				10.3	1,102	15,423			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	85.8	9,159	128,228						
	8 (June 10-23, 2002)	1706.1	182,126	2,549,766						
	9 (June 24-July 7, 2002)	652.1	69,610	974,534	2,478.1	264,536	3,703,506			
	10 (July 8-July 21, 2002)	17.2	1,832	25,646	5,098.1	544,220	7,619,081			
	11 (July 22-August 5, 2002)	111.5	11,907	166,697	246.4	26,302	368,230			
	March 4-August 5, 2002 Poletti Sum			3,844,870			11,706,239			
	August, 2005[1]	448.3	47,856	1,196,401	9,333.3	996,330	24,908,244			
	September, 2005[2]	224.2	23,928	717,840	5,061.7	540,331	16,209,934	11.7	1,244	37,309
	October, 2005[1]				790.0	84,333	2,529,975	23.3	2,487	74,618
	2005 Sum[3]			1,914,241			43,648,154			111,927
	Total Sum[4]			5,759,111			55,354,393			111,927

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Black Seabass	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.9	310	4,334			
	March 4-August 5, 2002 Poletti Sum			0			4,334			0
	August, 2005[1]				35.0	3,736	93,406			
	September, 2005[2]				17.5	1,868	56,044			
	October, 2005[1]									
	2005 Sum[3]			0			149,450			0
	Total Sum[4]			0			153,784			0
Butterfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	6.5	694	9,714						
	8 (June 10-23, 2002)	24.4	2,605	36,466	29.3	3,128	43,789			
	9 (June 24-July 7, 2002)	40.2	4,291	60,079	94.1	10,045	140,632			
	10 (July 8-July 21, 2002)	23.0	2,455	34,374	20.2	2,156	30,189	9.9	1,057	14,796
	11 (July 22-August 5, 2002)	5.7	608	8,519	5.6	598	8,369	8.2	875	12,255
	March 4-August 5, 2002 Poletti Sum			149,151			222,979			27,050
	August, 2005[1]	61.7	6,583	164,582	220.0	23,485	587,125			
	September, 2005[2]	30.8	3,292	82,291	110.0	11,743	293,563			
	October, 2005[1]									
	2005 Sum[3]			246,873			880,688			0
	Total Sum[4]			396,024			1,103,667			27,050

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Cunner	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	38.9	4,153	58,136						
	7 (May 27-June 9, 2002)	632.0	67,466	944,524	19.5	2,082	29,143			
	8 (June 10-23, 2002)	399.4	42,636	596,903	1,181.0	126,072	1,765,005			
	9 (June 24-July 7, 2002)	245.1	26,164	366,302	378.0	40,352	564,921			
	10 (July 8-July 21, 2002)	17.7	1,889	26,453	250.9	26,784	374,970	18	1,964	27,499
	11 (July 22-August 5, 2002)	33.0	3,523	49,319	1.0	107	1,495	5	491	6,875
	March 4-August 5, 2002 Poletti Sum			2,041,636			2,735,533			34,374
	August, 2005[1]				20.0	2,135	53,375			
	September, 2005[2]				10.0	1,068	32,025			
	October, 2005[1]									
	2005 Sum[3]			0			85,400			0
	Total Sum[4]			2,041,636			2,820,933			34,374
Feather blenny	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)				2.3	246	3,437			
	March 4-August 5, 2002 Poletti Sum			0			8,070			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,070			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Fourbeard Rockling	1 (March 4 - 27, 2002)	693.9	74,074	1,037,034						
	2 (March 18-31, 2002)	3061.0	326,762	4,574,665						
	3 (April 1-14, 2002)	4857.7	518,559	7,259,833	1.0	107	1,495			
	4 (April 15-28, 2002)	2810.2	299,989	4,199,844	8.8	939	13,152			
	5 (April 29-May 12, 2002)	1606.9	171,537	2,401,512	96.3	10,280	143,920			
	6 (May 13-26, 2002)	667.3	71,234	997,280	208.1	22,215	311,005			
	7 (May 27-June 9, 2002)	6.5	694	9,714	673.3	71,875	1,006,247			
	8 (June 10-23, 2002)	365.8	39,049	546,688	23.9	2,551	35,719			
	9 (June 24-July 7, 2002)	578.0	61,702	863,821						
	10 (July 8-July 21, 2002)	14.6	1,559	21,820						
	11 (July 22-August 5, 2002)	32.7	3,491	48,870						
	March 4-August 5, 2002 Poletti Sum			21,961,080			1,511,537			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			21,961,080			1,511,537			0
Fourspot Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				102.8	10,975	153,650			
	9 (June 24-July 7, 2002)				89.9	9,600	134,400			
	10 (July 8-July 21, 2002)				13.1	1,399	19,593			
	11 (July 22-August 5, 2002)				0.7	74	1,031			
	March 4-August 5, 2002 Poletti Sum			0			308,674			0
	August, 2005[1]				146.7	15,660	391,506			
	September, 2005[2]				73.4	7,830	234,903			
	October, 2005[1]									
	2005 Sum[3]			0			626,409			0
	Total Sum[4]			0			935,083			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Gobiidae	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				8.7	929	13,002			
	10 (July 8-July 21, 2002)				13.4	1,430	20,026			
	11 (July 22-August 5, 2002)				93.4	9,970	139,586			
	March 4-August 5, 2002 Poletti Sum			0			172,615			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			172,615			0
Grubby	1 (March 4 - 27, 2002)				1.8	192	2,690			
	2 (March 18-31, 2002)				9.3	993	13,899			
	3 (April 1-14, 2002)				8.1	865	12,105			
	4 (April 15-28, 2002)				8.4	897	12,554			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.1	117	1,644			
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			42,892			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			42,892			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Herrings	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)				8.1	865	12,105			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				7.3	779	10,910			
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			23,015			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			23,015			0
Hogchoker	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)	24.9	2,658	37,213						
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			37,213			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			37,213			0			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Northern Pipefish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				1.1	117	1,644			
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.4	363	5,081			
	11 (July 22-August 5, 2002)				1.5	160	2,242			
	March 4-August 5, 2002 Poletti Sum			0			8,967			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,967			0
Northern Puffer	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			0			0
	August, 2005[1]				3.3	352	8,807			
	September, 2005[2]				1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			0			14,091			0
	Total Sum[4]			0			14,091			0

(continued)

BW001536

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Rock Gunnel	1 (March 4 - 27, 2002)				0.6	64	897			
	2 (March 18-31, 2002)				0.9	96	1,345			
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			2,242			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			2,242			0
Scup	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	29.8	3,178	44,491						
	7 (May 27-June 9, 2002)	697.1	74,411	1,041,756						
	8 (June 10-23, 2002)	265.1	28,303	396,244	654.0	69,815	977,403			
	9 (June 24-July 7, 2002)	310.1	33,098	463,370	759.0	81,023	1,134,326			
	10 (July 8-July 21, 2002)	11.2	1,193	16,709	52.0	5,551	77,714			
	11 (July 22-August 5, 2002)	0.8	90	1,263	15.7	1,676	23,464	1	117	1,644
	March 4-August 5, 2002 Poletti Sum			1,963,833			2,212,906			1,644
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,963,833			2,212,906			1,644

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Searobin	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	36.5	3,896	54,549						
	7 (May 27-June 9, 2002)	230.2	24,574	344,034						
	8 (June 10-23, 2002)	955.6	102,010	1,428,144	614.9	65,641	918,968			
	9 (June 24-July 7, 2002)	1207.3	128,879	1,804,310	65.2	6,960	97,441			
	10 (July 8-July 21, 2002)	9.4	1,003	14,048	12.5	1,334	18,681	3	331	4,633
	11 (July 22-August 5, 2002)	51.9	5,540	77,565	1.3	139	1,943			
	March 4-August 5, 2002 Poletti Sum			3,722,650			1,037,034			4,633
	August, 2005[1]	71.7	7,651	191,269	238.3	25,439	635,963			
	September, 2005[2]	35.8	3,825	114,762	119.2	12,719	381,578			
	October, 2005[1]									
	2005 Sum[3]			306,031			1,017,541			0
	Total Sum[4]			4,028,681			2,054,575			4,633
Smallmouth Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.1	224	3,138			
	March 4-August 5, 2002 Poletti Sum			0			3,138			0
	August, 2005[1]	160.0	17,080	427,000	563.3	60,132	1,503,307			
	September, 2005[2]	80.0	8,540	256,200	281.7	30,066	901,984			
	October, 2005[1]									
	2005 Sum[3]			683,200			2,405,291			0
	Total Sum[4]			683,200			2,408,429			0

(continued)

BW001538

Appendix Table B-2. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Striped cusk-eel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				0.8	85	1,196			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			1,196			0
	August, 2005[1]				38.3	4,089	958			
	September, 2005[2]				19.2	2,044	575			
	October, 2005[1]									
	2005 Sum[3]			0			1,532			0
	Total Sum[4]			0			2,728			0
Tautog	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	2.7	288	4,035						
	6 (May 13-26, 2002)	191.8	20,475	286,645	1.1	117	1,644			
	7 (May 27-June 9, 2002)	2254.3	240,647	3,369,051	83.6	8,924	124,940			
	8 (June 10-23, 2002)	668.5	71,362	999,073	1,650.4	176,180	2,466,523			
	9 (June 24-July 7, 2002)	683.4	72,953	1,021,341	862.2	92,040	1,288,558			
	10 (July 8-July 21, 2002)	121.2	12,938	181,133	20.1	2,146	30,039			
	11 (July 22-August 5, 2002)	40.7	4,345	60,826						
	March 4-August 5, 2002 Poletti Sum			5,922,106			3,911,704			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,922,106			3,911,704			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Unidentified	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				2.4	256	3,587			
	10 (July 8-July 21, 2002)				6.1	651	9,116			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			12,703			0
	August, 2005[1]	3.3	352	8,807	3.3	352	8,807			
	September, 2005[2]	1.7	176	5,284	1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			14,091			14,091			0
	Total Sum[4]			14,091			26,794			0
Windowpane	1 (March 4 - 27, 2002)	2.5	267	3,736						
	2 (March 18-31, 2002)	8.8	939	13,152						
	3 (April 1-14, 2002)	21.3	2,274	31,833						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	131.9	14,080	197,125	0.9	96	1,345			
	6 (May 13-26, 2002)	158.8	16,952	237,327	96.5	10,301	144,219			
	7 (May 27-June 9, 2002)	466.8	49,831	697,633	291.5	31,118	435,647			
	8 (June 10-23, 2002)	183.8	19,621	274,689	147.0	15,692	219,692			
	9 (June 24-July 7, 2002)	44.5	4,750	66,505	31.5	3,363	47,077			
	10 (July 8-July 21, 2002)	3.4	363	5,081	3.1	331	4,633			
	11 (July 22-August 5, 2002)	17.5	1,868	26,154						
	March 4-August 5, 2002 Poletti Sum			1,553,234			852,612			0
	August, 2005[1]				3.3	352	8,807			
	September, 2005[2]				1.7	176	5,284			
	October, 2005[1]									
	2005 Sum[3]			0			14,091			0
	Total Sum[4]			1,553,234			866,703			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Weakfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	16.0	1,711	23,957						
	7 (May 27-June 9, 2002)	375.3	40,068	560,946						
	8 (June 10-23, 2002)	142.8	15,240	213,362	205.8	21,969	307,568			
	9 (June 24-July 7, 2002)	167.0	17,822	249,507	508.8	54,314	760,402			
	10 (July 8-July 21, 2002)	6.0	643	8,997	11.4	1,217	17,037			
	11 (July 22-August 5, 2002)	0.5	49	680	1.1	117	1,644			
	March 4-August 5, 2002 Poletti Sum			1,057,448			1,086,651			0
	August, 2005[1]				8.3	886	22,151			
	September, 2005[2]				4.2	443	13,290			
	October, 2005[1]									
	2005 Sum[3]			0			35,441			0
	Total Sum[4]			1,057,448			1,122,092			0
Winter flounder	1 (March 4 - 27, 2002)	3.4	363	5,081	9.0	961	13,451			
	2 (March 18-31, 2002)				506.5	54,069	756,964			
	3 (April 1-14, 2002)				106.9	11,412	159,762			
	4 (April 15-28, 2002)				72.8	7,771	108,800			
	5 (April 29-May 12, 2002)				149.5	15,959	223,428			
	6 (May 13-26, 2002)				79.4	8,476	118,663			
	7 (May 27-June 9, 2002)				14.9	1,591	22,268			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				1.1	117	1,644			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			5,081			1,404,979			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,081			1,404,979			0

(continued)

Appendix Table B-2. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Yellowtail flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)	1.1	117	1643.95						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			1,644			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,644			0			0

1 Entrainment for August 2005 was estimated for the period of August 6-August 31 by multiplying the daily entrainment estimates obtained from the August 23, 2005 mid-depth samples by 25 days. Entrainment for October, 2005 was estimated by multiplying the daily entrainment estimates obtained from the October 4, 2005 mid-depth samples by 31 days.

2 September, 2005 entrainment estimates were obtained by averaging ichthyoplankton density from the August 23 and October 4, 2005 samples.

3 The 2005 sum includes the period of August 6-October 31, 2005 estimated from data collected in the mid-depth strata at the site of the FSRU facility on August 23, 2005 and October 4, 2005.

4 Total sum includes the March 4-August 5, 2002 period from Poletti data and the August 6-October 31, 2005 period obtained from site specific collections at the FSRU location on August 23 and October 4, 2005.

Note: a blank space indicates that a given species/lifestage was not collected.

APPENDIX TABLE B-3. LIFE-STAGE SPECIFIC MEAN DENSITY (#/1000M^3) AND ENTRAINMENT ESTIMATES FROM THE 2002 POLETTI PROGRAM DATA SUBSET TO REPRESENT THE FSRU LOCATION AND DURING THE AUGUST 23 AND OCTOBER 4, 2005 SAMPLES CONDUCTED AT THE SITE OF THE FSRU FACILITY USING THE ASSUMPTIONS OF SCENARIO 3 AS DESCRIBED IN APPENDIX B. ENTRAINMENT ESTIMATES ARE THE SAME AS APPENDIX TABLE B-2 EXCEPT SITE-SPECIFIC DATA COLLECTED IN 2005 IS REPRESENTED BY NIGHTTIME SAMPLES ONLY FOR LARVAE OF ALL SPECIES.

		Eggs			Larvae			YOY		
Species	Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
American Lobster	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.4	149	2,092			
	7 (May 27-June 9, 2002)				12.2	1,302	18,233			
	8 (June 10-23, 2002)				1.2	128	1,793			
	9 (June 24-July 7, 2002)				12.5	1,334	18,681			
	10 (July 8-July 21, 2002)				1.8	192	2690			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			43,490			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			43,490			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
American Sandlance	1 (March 4 - 27, 2002)				81.9	8743	122400			
	2 (March 18-31, 2002)				139.4	14881	208333			
	3 (April 1-14, 2002)				36.3	3875	54250			
	4 (April 15-28, 2002)				3.0	320	4484			
	5 (April 29-May 12, 2002)				1.2	128	1793			
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			391,260			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			391,260			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Atlantic Mackerel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	15.2	1,623	22,716						
	6 (May 13-26, 2002)				12.0	1,281	17,934			
	7 (May 27-June 9, 2002)				45.6	4,868	68,149			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			22,716			86,083			0
	August, 2005[1]				83.3	8,892	222,307			
	September, 2005[2]				41.7	4,446	133,384			
	October, 2005[1]									
	2005 Sum[3]			0			355,691			0
	Total Sum[4]			22,716			441,774			0
Atlantic Menhaden	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	197.0	21,030	294,417						
	7 (May 27-June 9, 2002)	509.6	54,400	761,597	175.9	18,777	262,883			
	8 (June 10-23, 2002)	374.3	39,957	559,391	5,733.5	612,051	8,568,716			
	9 (June 24-July 7, 2002)				2,760.0	294,630	4,124,820			
	10 (July 8-July 21, 2002)				553.4	59,075	827,056			
	11 (July 22-August 5, 2002)				25.1	2,679	37,512			
	March 4-August 5, 2002 Poletti Sum			1,615,405			13,820,987			0
	August, 2005[1]									
	September, 2005[2]	29.3	3,122	93,673	23.8	2,535	76,059			
	October, 2005[1]	58.5	6,245	187,346	47.5	5,071	152,119			
	2005 Sum[3]			281,019			228,178			0
	Total Sum[4]			1,896,424			14,049,165			0

(continued)

BW001545

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Atlantic Silverside	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			4,633			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			4,633			0
Bay Anchovy	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				10.3	1,102	15,423			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	85.8	9,159	128,228						
	8 (June 10-23, 2002)	1706.1	182,126	2,549,766						
	9 (June 24-July 7, 2002)	652.1	69,610	974,534	2,478.1	264,536	3,703,506			
	10 (July 8-July 21, 2002)	17.2	1,832	25,646	5,098.1	544,220	7,619,081			
	11 (July 22-August 5, 2002)	111.5	11,907	166,697	246.4	26,302	368,230			
	March 4-August 5, 2002 Poletti Sum			3,844,870			11,706,239			
	August, 2005[1]	448.3	47,856	1,196,401	9,333.3	996,330	24,908,244			
	September, 2005[2]	224.2	23,928	717,840	5,061.7	540,331	16,209,934	11.7	1,244	37,309
	October, 2005[1]				790.0	84,333	2,529,975	23.3	2,487	74,618
	2005 Sum[3]			1,914,241			43,648,154			111,927
	Total Sum[4]			5,759,111			55,354,393			111,927

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Black Seabass	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.9	310	4,334			
	March 4-August 5, 2002 Poletti Sum			0			4,334			0
	August, 2005[1]				13.3	1,420	35,494			
	September, 2005[2]				6.7	710	21,297			
	October, 2005[1]									
	2005 Sum[3]			0			56,791			0
	Total Sum[4]			0			61,125			0
Butterfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)	6.5	694	9,714						
	8 (June 10-23, 2002)	24.4	2,605	36,466	29.3	3,128	43,789			
	9 (June 24-July 7, 2002)	40.2	4,291	60,079	94.1	10,045	140,632			
	10 (July 8-July 21, 2002)	23.0	2,455	34,374	20.2	2,156	30,189	9.9	1,057	14,796
	11 (July 22-August 5, 2002)	5.7	608	8,519	5.6	598	8,369	8.2	875	12,255
	March 4-August 5, 2002 Poletti Sum			149,151			222,979			27,050
	August, 2005[1]	61.7	6,583	164,582	250.0	26,688	667,188			
	September, 2005[2]	30.8	3,292	82,291	125.0	13,344	333,594			
	October, 2005[1]									
	2005 Sum[3]			246,873			1,000,781			0
	Total Sum[4]			396,024			1,223,761			27,050

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Cunner	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	38.9	4,153	58,136						
	7 (May 27-June 9, 2002)	632.0	67,466	944,524	19.5	2,082	29,143			
	8 (June 10-23, 2002)	399.4	42,636	596,903	1,181.0	126,072	1,765,005			
	9 (June 24-July 7, 2002)	245.1	26,164	366,302	378.0	40,352	564,921			
	10 (July 8-July 21, 2002)	17.7	1,889	26,453	250.9	26,784	374,970	18	1,964	27,499
	11 (July 22-August 5, 2002)	33.0	3,523	49,319	1.0	107	1,495	5	491	6,875
	March 4-August 5, 2002 Poletti Sum			2,041,636			2,735,533			34,374
	August, 2005[1]				30.0	3,203	80,063			
	September, 2005[2]				15.0	1,601	48,038			
	October, 2005[1]									
	2005 Sum[3]			0			128,100			0
	Total Sum[4]			2,041,636			2,863,633			34,374
Feather blenny	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.1	331	4,633			
	11 (July 22-August 5, 2002)				2.3	246	3,437			
	March 4-August 5, 2002 Poletti Sum			0			8,070			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,070			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Fourbeard Rockling	1 (March 4 - 27, 2002)	693.9	74,074	1,037,034						
	2 (March 18-31, 2002)	3061.0	326,762	4,574,665						
	3 (April 1-14, 2002)	4857.7	518,559	7,259,833	1.0	107	1,495			
	4 (April 15-28, 2002)	2810.2	299,989	4,199,844	8.8	939	13,152			
	5 (April 29-May 12, 2002)	1606.9	171,537	2,401,512	96.3	10,280	143,920			
	6 (May 13-26, 2002)	667.3	71,234	997,280	208.1	22,215	311,005			
	7 (May 27-June 9, 2002)	6.5	694	9,714	673.3	71,875	1,006,247			
	8 (June 10-23, 2002)	365.8	39,049	546,688	23.9	2,551	35,719			
	9 (June 24-July 7, 2002)	578.0	61,702	863,821						
	10 (July 8-July 21, 2002)	14.6	1,559	21,820						
	11 (July 22-August 5, 2002)	32.7	3,491	48,870						
	March 4-August 5, 2002 Poletti Sum			21,961,080			1,511,537			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			21,961,080			1,511,537			0
Fourspot Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				102.8	10,975	153,650			
	9 (June 24-July 7, 2002)				89.9	9,600	134,400			
	10 (July 8-July 21, 2002)				13.1	1,399	19,593			
	11 (July 22-August 5, 2002)				0.7	74	1,031			
	March 4-August 5, 2002 Poletti Sum			0			308,674			0
	August, 2005[1]				146.7	15,660	391,506			
	September, 2005[2]				73.4	7,830	234,903			
	October, 2005[1]									
	2005 Sum[3]			0			626,409			0
	Total Sum[4]			0			935,083			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey	#/ 1000m³	# Entrained/ Day	# Entrained/ Survey
Gobiidae	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				8.7	929	13,002			
	10 (July 8-July 21, 2002)				13.4	1,430	20,026			
	11 (July 22-August 5, 2002)				93.4	9,970	139,586			
	March 4-August 5, 2002 Poletti Sum			0			172,615			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			172,615			0
Grubby	1 (March 4 - 27, 2002)				1.8	192	2,690			
	2 (March 18-31, 2002)				9.3	993	13,899			
	3 (April 1-14, 2002)				8.1	865	12,105			
	4 (April 15-28, 2002)				8.4	897	12,554			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)				1.1	117	1,644			
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			42,892			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			42,892			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ $1000m^3$	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ $1000m^3$	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ $1000m^3$	YOY # Entrained/ Day	YOY # Entrained/ Survey
Herrings	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)				8.1	865	12,105			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				7.3	779	10,910			
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			23,015			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			23,015			0
Hogchoker	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)	24.9	2,658	37,213						
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			37,213			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			37,213			0			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/1000m³	Eggs # Entrained/Day	Eggs # Entrained/Survey	Larvae #/1000m³	Larvae # Entrained/Day	Larvae # Entrained/Survey	YOY #/1000m³	YOY # Entrained/Day	YOY # Entrained/Survey
Northern Pipefish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)				1.1	117	1,644			
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				3.4	363	5,081			
	11 (July 22-August 5, 2002)				1.5	160	2,242			
	March 4-August 5, 2002 Poletti Sum			0			8,967			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			8,967			0
Northern Puffer	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			0			0
	August, 2005[1]				0.0	0	0			
	September, 2005[2]				0.0	0	0			
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			0			0

(continued)

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Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Rock Gunnel	1 (March 4 - 27, 2002)				0.6	64	897			
	2 (March 18-31, 2002)				0.9	96	1,345			
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			2,242			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			0			2,242			0
Scup	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	29.8	3,178	44,491						
	7 (May 27-June 9, 2002)	697.1	74,411	1,041,756						
	8 (June 10-23, 2002)	265.1	28,303	396,244	654.0	69,815	977,403			
	9 (June 24-July 7, 2002)	310.1	33,098	463,370	759.0	81,023	1,134,326			
	10 (July 8-July 21, 2002)	11.2	1,193	16,709	52.0	5,551	77,714			
	11 (July 22-August 5, 2002)	0.8	90	1,263	15.7	1,676	23,464	1	117	1,644
	March 4-August 5, 2002 Poletti Sum			1,963,833			2,212,906			1,644
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,963,833			2,212,906			1,644

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Searobin	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	36.5	3,896	54,549						
	7 (May 27-June 9, 2002)	230.2	24,574	344,034						
	8 (June 10-23, 2002)	955.6	102,010	1,428,144	614.9	65,641	918,968			
	9 (June 24-July 7, 2002)	1207.3	128,879	1,804,310	65.2	6,960	97,441			
	10 (July 8-July 21, 2002)	9.4	1,003	14,048	12.5	1,334	18,681	3	331	4,633
	11 (July 22-August 5, 2002)	51.9	5,540	77,565	1.3	139	1,943			
	March 4-August 5, 2002 Poletti Sum			3,722,650			1,037,034			4,633
	August, 2005[1]	71.7	7,651	191,269	196.7	20,998	524,943			
	September, 2005[2]	35.8	3,825	114,762	98.4	10,499	314,966			
	October, 2005[1]									
	2005 Sum[3]			306,031			839,909			0
	Total Sum[4]			4,028,681			1,876,943			4,633
Smallmouth Flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)				2.1	224	3,138			
	March 4-August 5, 2002 Poletti Sum			0			3,138			0
	August, 2005[1]	160.0	17,080	427,000	690.0	73,658	1,841,438			
	September, 2005[2]	80.0	8,540	256,200	345.0	36,829	1,104,863			
	October, 2005[1]									
	2005 Sum[3]			683,200			2,946,300			0
	Total Sum[4]			683,200			2,949,438			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Striped cusk-eel	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)				0.8	85	1,196			
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			1,196			0
	August, 2005[1]				43.3	4,622	1,083			
	September, 2005[2]				21.7	2,311	650			
	October, 2005[1]									
	2005 Sum[3]			0			1,732			0
	Total Sum[4]			0			2,928			0
Tautog	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	2.7	288	4,035						
	6 (May 13-26, 2002)	191.8	20,475	286,645	1.1	117	1,644			
	7 (May 27-June 9, 2002)	2254.3	240,647	3,369,051	83.6	8,924	124,940			
	8 (June 10-23, 2002)	668.5	71,362	999,073	1,650.4	176,180	2,466,523			
	9 (June 24-July 7, 2002)	683.4	72,953	1,021,341	862.2	92,040	1,288,558			
	10 (July 8-July 21, 2002)	121.2	12,938	181,133	20.1	2,146	30,039			
	11 (July 22-August 5, 2002)	40.7	4,345	60,826						
	March 4-August 5, 2002 Poletti Sum			5,922,106			3,911,704			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,922,106			3,911,704			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Unidentified	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)				2.4	256	3,587			
	10 (July 8-July 21, 2002)				6.1	651	9,116			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			0			12,703			0
	August, 2005[1]	3.3	352	8,807	0.0	0	0			
	September, 2005[2]	1.7	176	5,284	0.0	0	0			
	October, 2005[1]									
	2005 Sum[3]			14,091			0			0
	Total Sum[4]			14,091			12,703			0
Windowpane	1 (March 4 - 27, 2002)	2.5	267	3,736						
	2 (March 18-31, 2002)	8.8	939	13,152						
	3 (April 1-14, 2002)	21.3	2,274	31,833						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)	131.9	14,080	197,125	0.9	96	1,345			
	6 (May 13-26, 2002)	158.8	16,952	237,327	96.5	10,301	144,219			
	7 (May 27-June 9, 2002)	466.8	49,831	697,633	291.5	31,118	435,647			
	8 (June 10-23, 2002)	183.8	19,621	274,689	147.0	15,692	219,692			
	9 (June 24-July 7, 2002)	44.5	4,750	66,505	31.5	3,363	47,077			
	10 (July 8-July 21, 2002)	3.4	363	5,081	3.1	331	4,633			
	11 (July 22-August 5, 2002)	17.5	1,868	26,154						
	March 4-August 5, 2002 Poletti Sum			1,553,234			852,612			0
	August, 2005[1]				0.0	0	0			
	September, 2005[2]				0.0	0	0			
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,553,234			852,612			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs #/ 1000m³	Eggs # Entrained/ Day	Eggs # Entrained/ Survey	Larvae #/ 1000m³	Larvae # Entrained/ Day	Larvae # Entrained/ Survey	YOY #/ 1000m³	YOY # Entrained/ Day	YOY # Entrained/ Survey
Weakfish	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)									
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)	16.0	1,711	23,957						
	7 (May 27-June 9, 2002)	375.3	40,068	560,946						
	8 (June 10-23, 2002)	142.8	15,240	213,362	205.8	21,969	307,568			
	9 (June 24-July 7, 2002)	167.0	17,822	249,507	508.8	54,314	760,402			
	10 (July 8-July 21, 2002)	6.0	643	8,997	11.4	1,217	17,037			
	11 (July 22-August 5, 2002)	0.5	49	680	1.1	117	1,644			
	March 4-August 5, 2002 Poletti Sum			1,057,448			1,086,651			0
	August, 2005[1]				0.0	0	0			
	September, 2005[2]				0.0	0	0			
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,057,448			1,086,651			0
Winter flounder	1 (March 4 - 27, 2002)	3.4	363	5,081	9.0	961	13,451			
	2 (March 18-31, 2002)				506.5	54,069	756,964			
	3 (April 1-14, 2002)				106.9	11,412	159,762			
	4 (April 15-28, 2002)				72.8	7,771	108,800			
	5 (April 29-May 12, 2002)				149.5	15,959	223,428			
	6 (May 13-26, 2002)				79.4	8,476	118,663			
	7 (May 27-June 9, 2002)				14.9	1,591	22,268			
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)				1.1	117	1,644			
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			5,081			1,404,979			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			5,081			1,404,979			0

(continued)

Appendix Table B-3. (Continued)

Species	Survey	Eggs			Larvae			YOY		
		#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey	#/ 1000m^3	# Entrained/ Day	# Entrained/ Survey
Yellowtail flounder	1 (March 4 - 27, 2002)									
	2 (March 18-31, 2002)									
	3 (April 1-14, 2002)	1.1	117	1643.95						
	4 (April 15-28, 2002)									
	5 (April 29-May 12, 2002)									
	6 (May 13-26, 2002)									
	7 (May 27-June 9, 2002)									
	8 (June 10-23, 2002)									
	9 (June 24-July 7, 2002)									
	10 (July 8-July 21, 2002)									
	11 (July 22-August 5, 2002)									
	March 4-August 5, 2002 Poletti Sum			1,644			0			0
	August, 2005[1]									
	September, 2005[2]									
	October, 2005[1]									
	2005 Sum[3]			0			0			0
	Total Sum[4]			1,644			0			0

[1] Entrainment for August 2005 was estimated for the period of August 6-August 31 by multiplying the daily entrainment estimates obtained from the August 23, 2005 mid-depth samples by 25 days. Entrainment for October, 2005 was estimated by multiplying the daily entrainment estimates obtained from the October 4, 2005 mid-depth samples by 31 days.

[2] September, 2005 entrainment estimates were obtained by averaging ichthyoplankton density from the August 23 and October 4, 2005 samples.

[3] The 2005 sum includes the period of August 6-October 31, 2005 estimated from data collected in the mid-depth strata at the site of the FSRU facility on August 23, 2005 and October 4, 2005.

[4] Total sum includes the March 4-August 5, 2002 period from Poletti data and the August 6-October 31, 2005 period obtained from site specific collections at the FSRU location on August 23 and October 4, 2005.

Note: a blank space indicates that a given species/lifestage was not collected.

APPENDIX TABLE B-4. SPECIES-SPECIFIC EGG AND LARVAE ENTRAINMENT ESTIMATES SUMMED FOR ALL ELEVEN BIWEEKLY SURVEYS OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM (MAR. 4-AUG. 5) AND FOR THE SITE SPECIFIC COLLECTIONS CONDUCTED IN AUGUST AND OCTOBER, 2005 USED TO EXTRAPOLATE ESTIMATES BEYOND THE POLETTI SAMPLING WINDOW. THIS TABLE SUMMARIZES APPENDIX TABLE B-1, POLETTI DATA IS UNADJUSTED FOR DIEL DIFFERENCES, SITE SPECIFIC COLLECTIONS IN 2005 REPRESENT THE AVERAGE OF DAY AND NIGHT SAMPLES.

Species	Eggs Entrainment Estimates for Period			Larvae Entrainment Estimates for Period		
	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL
American Lobster	0	0	0	43,490	0	43,490
American Sandlance	0	0	0	391,260	0	391,260
Atlantic Mackerel	22,716	0	22,716	86,083	178,059	264,142
Atlantic Menhaden	1,615,405	281,019	1,896,424	13,820,987	228,178	14,049,165
Atlantic Silverside	0	0	0	4,633	0	4,633
Bay Anchovy	582,556	1,914,241	2,496,797	907,460	23,894,226	24,801,686
Black Seabass	0	0	0	4,334	149,450	153,784
Butterfish	149,151	246,873	396,024	222,979	880,688	1,103,667
Cunner	2,041,636	0	2,041,636	2,735,533	85,400	2,820,933
Feather blenny	0	0	0	8,070	0	8,070
Fourbeard Rockling	21,961,080	0	21,961,080	1,511,537	0	1,511,537
Fourspot Flounder	0	0	0	134,206	533,750	667,956
Gobiidae	0	0	0	172,615	0	172,615
Grubby	0	0	0	42,892	0	42,892
Herrings	0	0	0	23,015	0	23,015
Hogchoker	37,213	0	37,213	0	0	0
Northern Pipefish	0	0	0	8,967	0	8,967
Northern Puffer	0	0	0	0	14,091	14,091
Rock Gunnel	0	0	0	2,242	0	2,242
Scup	1,963,833	0	1,963,833	2,212,906	0	2,212,906
Searobin	3,722,650	306,031	4,028,681	1,037,034	1,017,541	2,054,575
Smallmouth Flounder	0	683,200	683,200	3,138	2,405,291	2,408,429
Striped cusk-eel	0	0	0	1,196	1,532	2,728
Tautog	5,922,106	0	5,922,106	3,911,704	0	3,911,704
Unidentified	0	14,091	14,091	12,703	14,091	26,794
Weakfish	1,057,448	0	1,057,448	1,086,651	35,441	1,122,092
Windowpane	1,553,234	0	1,553,234	852,612	14,091	866,703
Winter flounder	5,081	0	5,081	1,404,979	0	1,404,979
Yellowtail flounder	1,644	0	1,644	0	0	0
TOTAL	**40,635,753**	**3,445,455**	**44,081,208**	**30,643,226**	**29,451,829**	**60,095,055**

APPENDIX TABLE B-5. SPECIES-SPECIFIC EGG AND LARVAE ENTRAINMENT ESTIMATES SUMMED FOR ALL ELEVEN BIWEEKLY SURVEYS OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM (MAR. 4-AUG. 5) AND FOR THE SITE SPECIFIC COLLECTIONS CONDUCTED IN AUGUST AND OCTOBER, 2005 USED TO EXTRAPOLATE ESTIMATES BEYOND THE POLETTI SAMPLING WINDOW. THIS TABLE SUMMARIZES APPENDIX TABLE B-2, POLLETTI DATA IS ADJUSTED FOR DIEL DIFFERENCES FOR BAY ANCHOVY EGGS AND LARVAE AND FOURSPOT FLOUNDER LARVAE, SITE SPECIFIC COLLECTIONS IN 2005 REPRESENT NIGHT ONLY COLLECTIONS FOR BAY ANCHOVY AND FOURSPOT FLOUNDER LARVAE.

	Eggs			Larvae		
	Entrainment Estimates for Period			Entrainment Estimates for Period		
Species	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL
American Lobster	0	0	0	43,490	0	43,490
American Sandlance	0	0	0	391,260	0	391,260
Atlantic Mackerel	22,716	0	22,716	86,083	178,059	264,142
Atlantic Menhaden	1,615,405	281,019	1,896,424	13,820,987	228,178	14,049,165
Atlantic Silverside	0	0	0	4,633	0	4,633
Bay Anchovy	3,844,870	1,914,241	5,759,111	11,706,239	43,648,154	55,354,393
Black Seabass	0	0	0	4,334	149,450	153,784
Butterfish	149,151	246,873	396,024	222,979	880,688	1,103,667
Cunner	2,041,636	0	2,041,636	2,735,533	85,400	2,820,933
Feather blenny	0	0	0	8,070	0	8,070
Fourbeard Rockling	21,961,080	0	21,961,080	1,511,537	0	1,511,537
Fourspot Flounder	0	0	0	308,674	626,409	935,083
Gobiidae	0	0	0	172,615	0	172,615
Grubby	0	0	0	42,892	0	42,892
Herrings	0	0	0	23,015	0	23,015
Hogchoker	37,213	0	37,213	0	0	0
Northern Pipefish	0	0	0	8,967	0	8,967
Northern Puffer	0	0	0	0	14,091	14,091
Rock Gunnel	0	0	0	2,242	0	2,242
Scup	1,963,833	0	1,963,833	2,212,906	0	2,212,906
Searobin	3,722,650	306,031	4,028,681	1,037,034	1,017,541	2,054,575
Smallmouth Flounder	0	683,200	683,200	3,138	2,405,291	2,408,429
Striped cusk-eel	0	0	0	1,196	1,532	2,728
Tautog	5,922,106	0	5,922,106	3,911,704	0	3,911,704
Unidentified	0	14,091	14,091	12,703	14,091	26,794
Weakfish	1,057,448	0	1,057,448	1,086,651	35,441	1,122,092
Windowpane	1,553,234	0	1,553,234	852,612	14,091	866,703
Winter flounder	5,081	0	5,081	1,404,979	0	1,404,979
Yellowtail flounder	1,644	0	1,644	0	0	0

TOTAL	**43,898,067**	**3,445,455**	**47,343,522**	**41,616,473**	**49,298,416**	**90,914,889**

APPENDIX TABLE B-6. SPECIES-SPECIFIC EGG AND LARVAE ENTRAINMENT ESTIMATES SUMMED FOR ALL ELEVEN BIWEEKLY SURVEYS OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM (MAR. 4-AUG. 5) AND FOR THE SITE SPECIFIC COLLECTIONS CONDUCTED IN AUGUST AND OCTOBER, 2005 USED TO EXTRAPOLATE ESTIMATES BEYOND THE POLETTI SAMPLING WINDOW. THIS TABLE SUMMARIZES APPENDIX TABLE B-3, POLLETTI DATA IS ADJUSTED FOR DIEL DIFFERENCES FOR BAY ANCHOVY EGGS AND LARVAE AND FOURSPOT FLOUNDER LARVAE, SITE SPECIFIC COLLECTIONS IN 2005 REPRESENT NIGHT ONLY COLLECTIONS FOR ALL LARVAE SPECIES.

Species	Eggs Entrainment Estimates for Period			Larvae Entrainment Estimates for Period		
	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL	Mar. 4-Aug. 5, 2002 (Poletti)	Aug. 6-Oct. 31, 2005	TOTAL
American Lobster	0	0	0	43,490	0	43,490
American Sandlance	0	0	0	391,260	0	391,260
Atlantic Mackerel	22,716	0	22,716	86,083	355,691	441,774
Atlantic Menhaden	1,615,405	281,019	1,896,424	13,820,987	228,178	14,049,165
Atlantic Silverside	0	0	0	4,633	0	4,633
Bay Anchovy	3,844,870	1,914,241	5,759,111	11,706,239	43,648,154	55,354,393
Black Seabass	0	0	0	4,334	56,791	61,125
Butterfish	149,151	246,873	396,024	222,979	1,000,781	1,223,760
Cunner	2,041,636	0	2,041,636	2,735,533	128,100	2,863,633
Feather blenny	0	0	0	8,070	0	8,070
Fourbeard Rockling	21,961,080	0	21,961,080	1,511,537	0	1,511,537
Fourspot Flounder	0	0	0	308,674	626,409	935,083
Gobiidae	0	0	0	172,615	0	172,615
Grubby	0	0	0	42,892	0	42,892
Herrings	0	0	0	23,015	0	23,015
Hogchoker	37,213	0	37,213	0	0	0
Northern Pipefish	0	0	0	8,967	0	8,967
Northern Puffer	0	0	0	0		0
Rock Gunnel	0	0	0	2,242	0	2,242
Scup	1,963,833	0	1,963,833	2,212,906	0	2,212,906
Searobin	3,722,650	306,031	4,028,681	1,037,034	839,909	1,876,943
Smallmouth Flounder	0	683,200	683,200	3,138	2,946,300	2,949,438
Striped cusk-eel	0	0	0	1,196	1,732	2,928
Tautog	5,922,106	0	5,922,106	3,911,704	0	3,911,704
Unidentified	0	14,091	14,091	12,703	0	12,703
Weakfish	1,057,448	0	1,057,448	1,086,651	0	1,086,651
Windowpane	1,553,234	0	1,553,234	852,612	0	852,612
Winter flounder	5,081	0	5,081	1,404,979	0	1,404,979
Yellowtail flounder	1,644	0	1,644	0	0	0

TOTAL	**43,898,067**	**3,445,455**	**47,343,522**	**41,616,473**	**49,832,045**	**91,448,518**

APPENDIX TABLE B-7. SUMMARY OF ENTRAINMENT ESTIMATES (IN MILLIONS) FOR EGGS AND LARVAE OF ALL SPECIES COMBINED BASED ON THE COMBINED 2002 POLETTI ICHTHYOPLANKTON PROGRAM (MARCH 4-AUGUST 5) AND SITE SPECIFIC 2005 DATA (AUGUST 6-OCTOBER 31) UNDER THE THREE ENTRAINMENT SCENARIOS AS DESCRIBED IN APPENDIX B.

Data Set	Eggs			Larvae		
	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]
Poletti (Mar. 4-Aug. 5, 2002)	40.6	43.9	43.9	30.6	41.6	41.6
Site Specific (Aug. 6-Oct. 31, 2005)	3.4	3.4	3.4	29.5	49.3	49.8
SUM	44.1	47.3	47.3	60.1	90.9	91.4

[a] Poletti data is unadjusted for diel differences. Site specific 2005 data estimates are based on the average of day and night samples from the mid-depth strata.
[b] Poletti data is adjusted for diel differences for bay anchovy eggs and larvae, and fourspot flounder larvae. Site specific 2005 data is the same as scenario one except only nighttime samples are considered for estimates of bay anchovy and fourspot flounder larvae.
[c] Same as scenario 2 except nighttime samples only are considered for **all** larvae.

APPENDIX TABLE C-1. AVERAGE TEMPERATURE, DISSOLVED OXYGEN, AND SALINITY MEASURED AT THE SURFACE, MID-DEPTH, AND BOTTOM DURING EACH BIWEEKLY SURVEY IN REGIONS 7-9 OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM.

Survey	Water Column Location	Depth (ft)	Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt)
March 4-March 17	**Surface**	0.7	4.8	10.6	28.9
	Mid-depth	17.1	4.7	10.5	29.3
	Bottom	29.0	4.8	11.4	29.3
March 18-March 31	**Surface**	0.3	5.7	10.2	28.4
	Mid-depth	15.5	5.3	10.2	28.6
	Bottom	31.0	5.2	10.2	28.7
April 1-April 14	**Surface**	0.3	6.3	10.3	28.1
	Mid-depth	15.2	6.2	10.4	28.4
	Bottom	30.5	6.0	10.3	28.4
April 15-April 28	**Surface**	0.4	10.4	10.7	26.2
	Mid-depth	21.0	8.6	10.6	27.1
	Bottom	30.4	8.5	10.4	27.2
April 29-May 12	**Surface**	0.4	10.5	9.5	26.2
	Mid-depth	22.3	9.5	9.3	27.0
	Bottom	30.7	8.9	9.5	27.2
May 13-May 26	**Surface**	0.3	11.9	9.2	27.1
	Mid-depth	15.2	11.2	9.2	27.9
	Bottom	30.5	10.9	9.1	28.0
May 27-June 9	**Surface**	0.3	14.6	8.7	27.5
	Mid-depth	15.2	13.0	8.5	27.8
	Bottom	30.5	12.4	8.3	28.0
June 10- June 23	**Surface**	0.3	16.9	8.2	26.2
	Mid-depth	15.1	15.2	8.0	26.7
	Bottom	30.0	14.7	7.6	26.9
June 24-July 7	**Surface**	0.3	18.9	8.6	26.6
	Mid-depth	15.2	16.1	7.9	27.0
	Bottom	30.5	15.5	7.7	27.2
July 8-July 21	**Surface**	0.3	21.6	7.6	28.1
	Mid-depth	15.2	18.7	5.6	28.6
	Bottom	30.5	18.1	5.4	28.8
July 22-August 5	**Surface**	0.3	22.2	7.6	28.1
	Mid-depth	15.2	20.2	5.8	28.5
	Bottom	30.5	19.6	5.2	28.8

APPENDIX TABLE D-1. VOLUME OF WATER (M^3) IN EACH GEAR/SAMPLING STRATA OF REGIONS 7-10 OF THE 2002 POLETTI ICHTHYOPLANKTON PROGRAM. DATA PROVIDED BY PBS&J/LMS JOINT VENTURE (2003).

Region	Depth Strata	Volume (m^3)		
		Tucker Trawl	Epibenthic Sled	Sum
7	Deep (> 30m)	172,094,184	16,286,400	188,380,584
7	Intermediate (6-30m)	4,353,263,021	1,051,660,800	5,404,923,821
7	Shallow (3-6m)	96,881,962	162,907,200	259,789,162
8	Deep (> 30m)	7,301,409,653	685,540,800	7,986,950,453
8	Intermediate (6-30m)	11,116,497,038	1,884,686,400	13,001,183,438
8	Shallow (3-6m)	100,464,394	193,060,800	293,525,194
9	Deep (> 30m)	52,755,437	5,529,600	58,285,037
9	Intermediate (6-30m)	10,450,933,704	1,845,331,200	12,296,264,904
9	Shallow (3-6m)	71,067,960	131,673,600	202,741,560
10	Deep (> 30m)	9,471,580,646	725,716,800	10,197,297,446
10	Intermediate (6-30m)	5,896,229,789	1,133,697,600	7,029,927,389
10	Shallow (3-6m)	85,355,842	165,283,200	250,639,042

Attachment 1

Summary of Ichthyoplankton Sampling Conducted on August 23, 2005

October 5, 2005
Ref No. 20546.000

Mike Donnelly
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Dr.
Lancaster, NY 14086

RE: Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 1, August, 2005.

FIELD METHODS

Normandeau Associates, Inc. (Normandeau) conducted ichthyoplankton sampling in the vicinity of the proposed Broadwater Energy floating storage and regasification unit (FSRU) in the Central Basin of Long Island Sound on August 23, 2005. A one by one nautical mile square block centered on the location of the proposed FSRU facility was designated as the sampling area. Three random stations were selected within the sampling area using the Random Point Generator extension in Arcview (Figure 1). At each station the water column was divided into three depth strata based on an assumed depth of about 95 feet: near surface (surface, 0-30 feet), mid-depth (mid-depth, 35-65 feet), near bottom (bottom, 70-95 feet). One ichthyoplankton tow was collected in each depth stratum of each station during daylight (defined as occurring between 1 hour after sunrise and 1 hour before sunset) and the daytime sampling was repeated again at night at the same three stations (defined as occurring between 1 hour after sunset and 1 hour before sunrise). A total of 18 valid samples (3 stations x 3 depths x 2 diel periods, Table 1) were collected on August 23, 2005 between 2:00-5:00 PM (day) and 8:45-11:00 PM (night).

All samples were collected with a 1.0 m^2 Tucker trawl with a 0.335 mm net and an 8:1 length to mouth ratio. The tucker trawl has a closing device that uses a double-trip release mechanism and a weighted lead bar to close the mouth of the net and insure that each sample is collected in each of the three discrete depth strata. Net towing speed was 1.0 m/sec. The original sampling protocol called for a for a 5 minute tow duration to insure an approximate 300 m^3 sample. However, during the August sampling event, high concentrations of comb jellies (ctenophores) throughout the water column clogged the net mesh during the initial five minute tows and reduced gear efficiency. Therefore, the five minute tows were voided and all sampling was conducted with a one minute tow resulting in tow volumes approximately 1/5 of 300 m^3 (Table 1). A flume-calibrated digital flowmeter (GO Model 2030R) was placed in the mouth of the Tucker trawl to measure the distance (volume) of each tow. Tow depth was determined in the field using a cosine function relating wire length and wire angle to sampling depth. The start and end of each towpath was recorded using GPS. Samples were fixed at sea in 4% buffered formaldehyde and changed over to 80% ethanol within 18 hours. A conductivity, salinity, temperature, dissolved oxygen and depth profile was made at 5 foot intervals from one foot below the surface to one foot above the bottom at each of the three stations and two diel periods (6 total profiles) using a YSI Model 85 meter.

LABORATORY METHODS

Because tow duration was reduced to one minute, samples were analyzed without subsampling with the exceptions of five samples in which large catches of larval bay anchovy (*Anchoa mitchilli*) necessitated a half split with a Folsom Plankton Splitter. Samples were sorted under magnification to remove all fish eggs, fish larvae, and lobster larvae which were then enumerated and identified to the lowest possible taxon (generally genus and species). Samples were further identified into the following life stages: egg, yolk-sac larvae and post yolk-sac larvae.

The accuracy of identifications, assignment to life stage, and counting was monitored and controlled by QC checks. A subset of the samples were randomly selected for re-identification by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, data from those samples were corrected and the proportion of samples checked was increased. A sample failed identification QC if the original identifier's count differed from the QC inspector's count by 10% or more (or by more than two if the QC total was 20 or less). This acceptance criterion was applied separately by life stage to each taxon. An additional requirement for a sample to pass was that for each taxon, the sum of the percent errors for all life stages was required to be less than 10%.

RESULTS

Physical Profiles of Water Column

Water temperature, dissolved oxygen, and salinity were similar among the three stations (Table 2, Figures 2-4). Water temperature typically ranged from 21-24 °C, dissolved oxygen from 4.5-6.1 mg/l, and salinity 24.4-25.8 $^{o}/_{oo}$. At all three stations, the water column was relatively well mixed for the first 20-40 feet (Figures 2-4). A slight (3.0 °C) thermocline was apparent between 30-40 feet, below this thermocline the water temperature and dissolved oxygen concentrations were lower and salinities were greater relative to the mixed surface waters.

Total Species Composition

Eggs from seven fish taxa were found among the 18 samples collected on 23 August, 2005 (Table 3). Bay anchovy was the dominant species accounting for about 79% of all eggs. Other common eggs included those of smallmouth flounder (*Etropus microstomus*, 11.0% of total), striped and/or northern searobins (*Prionotus* sp., 4.8%), and butterfish (*Peprilus triacanthus*, 4.0 %). Other species of eggs collected include fourspot flounder (*Paralichthys oblongus*), weakfish (*Cynoscion regalis*), windowpane (*Scophthalmus aquosus*), and Atlantic menhaden (*Brevoortia tyrannus*).

Larvae (yolk-sac + post yolk-sac stages combined) from 13 fish taxa were found among the 18 samples collected on 23 August, 2005 (Table 3). Bay anchovy was the dominant species and accounted for about 81% of the larvae collected. Other common larval species included smallmouth flounder (6.1 % of the total), butterfish (4.3%), striped and/or northern searobins (4.1 %), and fourspot flounder (1.6 %). Other species accounting for less than 1.0 % of the total number of larvae collected include striped cuskeel (*Ophidion marginatum*), black sea bass (*Centropristis striata*), Atlantic mackerel (*Scomber scombrus*), cunner (*Tautogalabrus adspersus*), weakfish, northern puffer (*Sphoeroides maculatus*), tautog (*Tautoga onitis*), and windowpane.

Ichthyoplankton Density Across Diel Period and Depth Strata

Examination off egg density for common species (species accounting for > 1% of total number of eggs collected, Table 3) suggests that egg distribution was not uniform over all three depth strata and that bay anchovy egg density was considerably higher at night (Table 4). The influence of diel period and depth strata on egg distribution was further explored with a two-way analysis of variance (ANOVA). Egg densities (all species combined) were log (x+1) transformed to better meet parametric assumptions. Mean egg density was significantly higher at night and there was a significant difference across the three depth strata (Table 5). Multiple range comparisons (Tukey's Studentized Range Test) revealed that all three depth strata differed from each other with greatest egg density in the surface strata, followed by mid-depth and then bottom. The significant interaction term (diel period*depth strata) suggests that depth differences were not consistent in both diel periods. Egg density differences between the three depth strata were further examined with a one-way ANOVA for each diel period separately in order to explain the significant interaction. In daytime samples, there was a significant difference in mean egg density between the three depth strata ($p = 0.03$) and multiple range comparisons reveal that density was higher in the surface strata than in the mid-depth or bottom strata which did not differ from each other. In nighttime samples, there was also a significant difference in mean egg density between the three depth strata ($p = 0.001$) and multiple range comparisons reveal that density was different between all three depth strata with surface > mid-depth > bottom. This response is driven largely by bay anchovy (79% of all eggs, Table 3) which had an order of magnitude higher egg density at night than in the day samples (Tables 4). Bay anchovy are serial spawners and spawn every 1-4 days during April-November in the study area (Able and Fahay, 1998). Bay anchovy spawn at night usually between the hours of 1800 and 2400 and eggs are pelagic suggesting the large numbers collected in the surface and mid-depth strata were spawned on the evening of August 23, 2005, after completion of the daytime sampling. Two-way ANOVA of bay anchovy egg density across the diel periods and depth strata was similar to that of all species combined as would be expected except the interaction term was insignificant (Table 5). Mean bay anchovy egg density was significantly higher at night and multiple range comparisons revealed that egg density was significantly higher in the surface, followed by the mid-depth, then the bottom depth strata. There is a clear decrease in the proportion of the total catch accounted for by bay anchovy eggs from the surface, to mid-depth, to the bottom depth strata in both diel periods (Table 4). When bay anchovy are removed from analysis there is no difference in egg density between day and night samples as would be expected from passive particles with no means of gear avoidance. There was also no difference in mean egg density with bay anchovy excluded between the three depth strata (Table 5).

Larval density of common species (those comprising > 1% of the total number collected, Table 3) was generally higher at night, particularly for bay anchovy (Table 6). This is likely partially due to differences in gear avoidance and sampling efficiencies between day and night sampling (Clutter and Anraku 1968). Bay anchovy comprised a greater percentage of the overall catch in all three depth strata at night than during the day. Larval density of common species was generally higher in the mid-depth stratum than in the surface or bottom stratum during daytime, while at night density was similar in the surface and mid-depth strata and lower in the bottom (Table 6). The influence of diel period and depth strata on mean larval fish density was further explored with a two-way analysis of variance (ANOVA) on log (x+1) transformed data (Table 5). Mean larval density (all species combined) was significantly different between the two diel periods and the three depth strata. Multiple range comparisons (Tukey's Studentized Range Test) revealed that mean larval density did not differ between the surface and mid-depth strata, however both were significantly higher than in the bottom strata. There was a significant diel period*depth strata interaction suggesting that depth differences were not the same in both diel periods. Larval fish density differences between the three depth strata were further examined with a one-way ANOVA for each diel period separately in order to explain the significant interaction. In daytime samples, there was no significant difference in mean larval density between the three depth strata ($p = 0.06$). In nighttime samples, there was a significant difference in mean larval density between the three depth strata ($p = 0.004$) and multiple range comparisons revealed that larval density was significantly higher in the surface and mid-depth strata than in the bottom strata. Two-way ANOVA on bay anchovy larval density was similar to that for all species combined (Table 5) as would be expected considering the dominance of bay anchovy to the overall catch (Table 3). There was a significant difference in mean bay anchovy larval density between the two diel periods and three depth strata (Table 5). Multiple range comparisons revealed that bay anchovy larval density was greatest in the mid-depth strata, while the surface and bottom strata were not significantly different. The significant interaction term is likely driven by the generally higher relative density of bay anchovy larvae in the mid-depth and bottom strata during the daytime compared to nighttime (Table 6) when density between surface and mid-depth strata appear more similar and considerably higher relative to density in the bottom strata. One-way ANOVA on daytime samples revealed no significant difference in mean bay anchovy larvae between the three depth strata ($p = 0.21$). During daytime sampling 14.6% of bay anchovy larvae collected occurred in the surface strata, 55.4% were mid-depth, and 30.0% were in the bottom strata. One-way ANOVA on nighttime samples revealed a significant difference in mean bay anchovy larval density between the three depth strata ($p = 0.003$) and multiple range comparisons support Table 4 demonstrating that larval bay anchovy density was significantly higher in the surface and mid-depth strata than in the bottom strata. During nighttime sampling 44.7% of bay anchovy larvae collected occurred in the surface strata, 42.0% were mid-depth, and 13.3% were in the bottom strata. Two-way ANOVA on larval density with bay anchovy excluded revealed that mean larval density was significantly greater at night and was significantly different across the three depth strata (Table 5). Multiple range comparisons demonstrated that there was no difference between the surface and mid-depth strata, however both were significantly higher than the bottom strata. The significant interaction term suggests that depth differences were not the same in both diel periods and was further investigated with one-way ANOVA for each diel period. One-way ANOVA for daytime samples reveal a significant difference in mean larval density (bay anchovy excluded, $p = 0.04$) between the three depth strata and multiple range comparisons demonstrate higher mean density in the mid-depth strata than in the surface and the bottom strata which did not differ from each other. One-way ANOVA for nighttime samples reveal a significant difference in larval density (bay anchovy excluded, $p = 0.03$) between the three depth strata and multiple range comparisons demonstrate higher mean density in the surface strata than in the mid-depth and bottom strata which did not differ from each other.

A more refined breakdown of egg and larval (yolk-sac and post yolk sac larvae separately) densities for all species collected in each of the three replicate stations in each depth stratum for daytime and nighttime sampling are presented in Table 7 and Table 8. Table 9 presents species richness (# of species identified to at least the genus level), Shannon-Wiener diversity index, and density (all species combined) for eggs and larvae in each of the 18 samples conducted on August 23, 2005.

Ichthyoplankon Community Similarity Across Diel Period and Depth Strata

Community similarity between the two diel periods and three depth strata was evaluated through ordination using non-metric multidimensional scaling (NMDS). Analysis was based on the Bray-Curtis similarity index generated from all pairwise sample comparisons on untransformed and 4^{th} root transformed egg and larval (yolk-sac + post yolk-sac stages) densities. Data was 4^{th} root transformed following the recommendations of Clarke and Warwick (1994) in order to down-weigh the importance of very abundant species (i.e. bay anchovy) so that less dominant species play some role in determining similarity of two samples while retaining some information that more abundant species are given greater weight than the rare ones. Like all multivariate techniques, NMDS is based on a similarity coefficient matrix calculated between every pair of samples. The Bray-Curtis similarity values were then transformed to ranks (the highest similarity between a pair of sites has the lowest rank, 1, and the lowest similarity has the highest rank, (n(n-1)/2). NMDS then constructs a "map" or configuration of the samples. The NMDS map is constructed to preserve the similarity ranking as Euclidean distances on the two dimensional plot and attempts to satisfy all conditions imposed by the rank similarity matrix, e.g. if sample 1 has higher similarity to sample 2 than it does to sample 3 then sample 1 will be placed closer on the map to sample 2 than it is to 3. The principle of the NMDS algorithm is to choose a configuration of points which minimize the degree of *stress* or distortion between the similarity rankings and the corresponding distance rankings in the ordination plot. The stress value provides a "goodness of fit" measure, in general, stress < 0.05 gives an excellent representation with no prospect of misinterpretation, stress < 0.1 corresponds to a good ordination with no real prospect of a misleading interpretation, and stress < 0.2 still gives a potentially useful 2-dimensional picture, though for values at the upper end of this range too much reliance should not be placed on the detail of the plot (Clarke and Warwick 1994). NMDS is based on rank order about which samples are most or least similar, axes are non-metric and the ordination plot can say nothing about which direction is "up" or "down", or the absolute "distance apart" of two samples, what can be interpreted is relative distances apart (Clarke and Warwick 1994). NMDS can be recommended as one of the best (arguably the best) ordination technique available (Everitt 1978, Clarke and Warwick 1994). The few comprehensive studies that have compared ordination methods for community data give NMDS a high rating (Kenkel and Orloci 1986).

A two-way crossed ANOSIM (analysis of similarities, Clarke and Warwick 1994) test was used to evaluate differences in the ichthyofaunal community between the two diel periods and three depth strata based on the corresponding rank similarities between samples in the similarity matrix. ANOSIM is a non-parametric permutation applied to the rank similarity matrix underlying the NMDS ordination. If r_w is defined as the average of all rank similarities among replicates within a diel or depth group, and r_b is the average of rank similarities arising from all pairs of replicates between a diel or depth group then the test statistic is:

> $R = (r_b - r_w)/ (M/2)$ where $M = n(n-1)/2$ and n is the total number of samples under consideration (Clarke and Warrick 1994).

The R statistic usually falls between 0 and 1, R is approximately zero if similarities between and within groups are the same, and R = 1 if all replicates within a group are more similar to each other than any replicates from different groups. The R statistic itself is a useful comparative measure of the degree of separation of sites, though the main interest usually centers on whether it is significantly different from zero (Clarke and Warwick 1994). Further discussion of ANOSIM is provided by Clarke and Green (1988) and Clarke and Warwick (1994).

Untransformed egg density similarity shows a general separation of day and night samples and a large relative distance between the surface and bottom depth strata (Figure 5). ANOSIM detected a significant difference between diel period averaged across all depth strata (R= 0.617, p = 0.012) and between depth strata averaged across both diel groups (R= 0.605, p = 0.001). The above is a "global" test indicating that there are site differences somewhere, specific pairs of sites are compared with pairwise tests. Pairwise tests suggest the egg community is well separated between the bottom and surface depth strata (R= 0.833), overlapping but clearly different between the mid-depth and surface strata (R= 0.722) and more similar between the mid-depth and bottom strata (R= 0.389). The important message of the pairwise tests is usually not so much the significance level (which can often be low because of few replicates in each group), but the pairwise R values, since that gives an absolute measure of how separated the groups are on a scale of 0 to 1 (Clarke and Gorley 2001). The effect of the 4^{th} root transform can be observed in Figure 6. Day and night groups are less distinguishable (R = 0.358, p = 0.03) likely due to down-weighing the influence of bay anchovy egg density which was an order of magnitude greater at night (Table 4, 7, 8). Although the ordination shows considerable scatter, ANOSIM reveals a significant difference in the egg community between the depth strata averaged across diel groups (R= 0.313, p = 0.001). The general separation of bottom and surface strata in Figure 6 is supported by pairwise tests on 4^{th} root transformed egg density similarities which suggest the bottom and surface strata (R = 0.500) overlap but differ more than the mid-depth and surface strata (R = 0.389) and the mid-depth and bottom strata (R = 0.222).

Ordination of untransformed larval density similarity shows separation of day and night samples with high similarity between the night samples in the surface and mid-depth strata (Figure 7). This is not surprising because larval bay anchovy were an order of magnitude greater at night and were generally greater in surface and mid-depth strata than in the bottom strata (Table 6, 7, 8). ANOSIM revealed a clear separation between diel periods averaged across all depth strata ($R= 0.938$, $p = 0.005$) and a less clear (although significant) separation between depth strata averaged across diel groups ($R= 0.399$, $p = 0.002$). Pairwise comparisons reveal clear separation between the mid-depth and bottom strata ($R= 0.796$), more similarity between the bottom and surface strata ($R= 0.389$) and high similarity between the mid-depth and surface strata ($R= 0.185$). The effect of the 4th root transformation (Figure 8) reveals less distinction between the larval community with diel group although there is still a clear similarity between night samples in the surface and mid-depths. The R value comparing the similarity between diel periods is less than on the untransformed data ($R= 0.605$), although still significant ($p = 0.004$). Similarity was also higher on 4th root transformed data between depth strata ($R= 0.284$, $p = 0.021$) than raw data. Pairwise comparisons reveal overlapping but clear distinction between the between the mid-depth and bottom strata ($R = .463$), and higher similarity (less separation) between mid-depth and surface strata ($R = 0.222$) and bottom and surface strata ($R= 0.148$).

Impact Analysis Based on Ichthyoplankton Densities

The average density (#/100m^3) for eggs and larvae collected from the mid-depth strata (40 ft. below surface) during daytime sampling (n=3) and during nighttime sampling (n=3) was multiplied by the daily water intake of the FSRU and associated LNG carriers (28.2 million gallons/day, 106,750 m^3/day) to estimate daily entrainment rates for species and life stage (Table 10). Average egg density was 74.7 eggs/100 m^3 (0.7/ m^3) and average larvae (yolk sac + post-yolk sac) density was 639.5/100m^3 (6.4/m^3). These average densities correspond to a daily entrainment estimate of 79,707 eggs and 682,666 larvae per day. Approximately 60 % of the eggs and 80% of the larvae estimated to be entrained are bay anchovy. Bay anchovy entrainment estimates are expressed in terms of Age 1 fish using the Equivalent Adult Model. The Equivalent Adult Model (EAM) is a method for expressing entrainment losses as an equivalent number of individuals at some other common life stage, referred to as the age of equivalency (Goodyear 1978). The method provides a convenient means of converting losses of fish eggs and larvae into units of individual fish and provides a standard metric for comparing losses among species, years, and facilities (EPA 2004). The age of equivalency can be any life stage of interest. For the 316(b) cooling water intake case studies, EPA (2004) expressed impingement and entrainment losses as an equivalent number of Age 1 individuals.

The EAM calculation requires life-stage specific entrainment counts and life-stage specific mortality rates from the life stage of entrainment to the life stage of equivalence. The losses at any given stage are simply multiplied by the fraction of fish at that stage or age that would be expected to survive to the age of equivalence:

$EA= S_A N$

Where: EA = equivalent adult loss, N= number of fish lost due to entrainment, S_A= fraction of fish expected to survive from the age at which they are entrained to the age of equivalence.

Survival rates of early life stages of fish are often expressed on a life-stage specific basis so that the fraction surviving from any particular life stage to the age of equivalency is expressed as the cumulative product of survival fractions for all of the life stages through which a fish must pass before reaching the age of equivalency. Life-stage specific mortality rates for bay anchovy were obtained from EPA (2004) values used to evaluate impingement and entrainment in the Mid-Atlantic Region (http://www.epa.gov/waterscience/316b/casestudy/final/appd1.pdf). Instantaneous total mortality (Z) is the sum of mortality from natural causes (M) and mortality from recreational and commercial fishing (F), ($Z = M+F$). Fishing mortality is equal to zero for bay anchovy. Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S= e^{-z}$). It was assumed that no bay anchovy eggs or larvae survived entrainment at the FSRU. Natural mortality of bay anchovy eggs and larvae is very high, mesocosm experiments with eggs and yolk sac larvae in Chesapeake Bay indicated that 95% of a cohort died within 2 days of hatching (Houde et al. 1994). There is also high egg and larval mortality due to predation by ctenophores and jellyfish (Purcell et al. 1994). Despite the seemingly large estimated daily entrainment rates (Table 10), the estimated number of entrained bay anchovy eggs and larvae scales up to only 65 Age 1 equivalents per day (Table 11).

This daily entrainment estimates are based on sampling conducted on August 23, 2005 and does not represent the daily numbers that would be entrained throughout the year. Ichthyoplankton abundance and diversity in estuaries and nearshore areas of the Mid-Atlantic and southern New England are low during the winter when few species spawn. Ichthyoplankton abundance and diversity begin to increase in the spring and reach a peak during mid to late summer when many species reproduce and spawning is curtailed in the fall (Wheatland 1956, Bourne and Govoni 1988, Monteleone 1992, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001). The daily entrainment estimates were largely driven by bay anchovy eggs and larvae which were at or near their seasonal peak during the August 23, 2005 sampling event. Bay anchovy are typically the most abundant ichthyoplankton species collected in the estuaries of the northern Mid-Atlantic Bight (Wheatland 1956, Dovel 1981,Vouglitois et al. 1987, Bourne and Govoni 1988, Monteleone 1992, Keller et al. 1999, Chute and Turner 2001). Bay anchovy spawning in the Mid-Atlantic peaks during mid-late summer and declines in the fall when egg and larval densities are greatly reduced (Wheatland 1956, Vouglitois et al. 1987, Bourne and Govoni 1988, Monteleone 1992, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001, Monteleone 1992, Able and Fahay 1998).

The relatively small intake velocity (0.5 ft/sec) and estimated daily water intake (28.2 MGD, 106,750 m^3/day) of the proposed FSRU facility will likely result in minimal ichthyoplankton entrainment losses. The daily withdrawl rate of 106,750 m^3/day represents only 2.69×10^{-4} % of the volume of water in the Central Basin ($3.97 \times 10^{10} m^3$, Appendix Table 2 in Poletti Report). Even running 365 days a year, the annual FSRU water intake only represents 0.10% of the volume in the Central Basin.

Summary

In summary, the ichthyoplankton community in the vicinity of the proposed Broadwater FSRU in the central basin of Long Island Sound during day and night sampling on 23 August, 2005 was dominated by bay anchovy. This is consistent with other regional studies such as: Narragansett Bay (Bourne and Govoni 1988, Keller et al. 1999), Great South Bay, N.Y (Monteleone 1992), Long Island Sound (Wheatland 1956), the lower Hudson River estuary (Dovel 1981) and the Mystic River estuary (Pearcy and Richards 1962). Young stages of bay anchovy occur in every estuary in the Middle Atlantic Bight (Able and Fahay 1998) and bay anchovy are generally considered to be the most abundant western Atlantic coastal fish (McHugh 1967, Haedrich, 1983).

In temperate neritic waters, the majority of marine fish eggs are neutrally or positively buoyant which favors hatching in more productive surface waters (Sundby 1991). The vertical distribution of pelagic eggs is determined by the relationship between physical properties of the eggs, seawater density, and the degree of vertical mixing of the water column (Sundby 1991, Nissling et al. 1994). Eggs collected in the vicinity of the proposed Broadwater FSRU on August 23, 2005 were dominated by bay anchovy. Bay anchovy egg density was an order of magnitude higher at night and they were highest in the surface strata. Bay anchovy eggs were also highest in the surface strata during daytime sampling. Bay anchovy are serial spawners and spawn every 1-4 days during April-November in the study area (Able and Fahay, 1998).

Bay anchovy spawn at night usually between the hours of 1800 and 2400 and pelagic eggs typically hatch in about 24 hours at summer temperatures (Mansueti and Hardy 1967, Monteleone 1992) suggesting the large numbers collected were spawned on the evening of August 23, 2005, after completion of the daytime sampling.

Fish larvae were collected in higher densities at night and were dominated by bay anchovy. Bay anchovy larval density was an order of magnitude greater at night and larvae were more abundant in the surface and mid-depth strata than near bottom. During daytime sampling, bay anchovy larvae were more evenly distributed throughout the three depth strata. With bay anchovy excluded, there was significantly greater fish larvae density at night. Distribution across depth strata differed with diel period, during the day larval density was greatest mid-depth while at night larval density was greatest in the surface.

The vertical distribution of fish larvae is influenced by the same physical factors as for eggs but with the additional effects of specific and ontogenetic behavioral responses to environmental factors. In general, there is a feeding advantage in being distributed in the upper, more productive layers of the water column, where food is present in higher abundance (e.g. Coombs et al. 1992, 1994). Additionally, there is the influence of predation which may lead to the observed peak of larval abundance representing a tradeoff between avoidance of predators and food availability (Fortier and Harris 1989). The observed differences in depth distribution of larval fish during day and night may also reflect some aspect of diel migration and/or net avoidance in the more illuminated surface waters.

Net avoidance is an important source of uncertainty in abundance estimates of fish larvae using towed nets (Tranter and Smith 1968). Avoidance involves complex reactions of fish larvae to the approach of the net, including sensory perception of the net and a variety of avoidance reactions. Because net avoidance is both size and species related, estimates of population size, species diversity, and vertical distribution of larval fish within the water column may be biased (Thayer et al. 1983). Numerous studies have found significantly higher catches of fish larvae at night compared to day, suggesting that visual perception of the net by larvae affects catch rates (Ahlstrom 1954, Clutter and Anraku 1968). Also, night to day density ratios of fish larvae have been shown to increase with increasing size (and increasing mobility) of the larvae (Ahlstrom 1954, Smith 1981). Night sampling may therefore mitigate the effect of some environmental factors on density estimations. The higher observed larval densities in the surface and mid-depth strata at night are likely partially attributable a reduction in net avoidance through visual stimuli at night.

Although higher catches at night is partly explained by reduced nighttime visibility of the gear (Noble 1970, Murphy and Clutter 1972), diel migrations may also contribute (Noble 1970, Stickney 1972). Fish larvae are nonrandom in their distribution in both vertical and horizontal dimensions and are capable of changing their position in the water column in response to certain biological or physical stimuli such as avoiding predators in well lit surface waters or to follow zooplankton prey. Larvae of many species rise to the surface by night and descend by day (e.g., Seliverstov 1974, Smith et al. 1978, Kendall and Naplin 1981, Sameoto 1982, 1984, Leis 1986). Speculation about causes of vertical migration has centered around diel feeding behavior and predator avoidance. Most larval fishes are visual feeders on zooplankton, which are well documented to migrate up from depth during the day to occupy shallower waters at night (Haney 1988). Substantial data suggest that light plays an important but different role in structuring vertical distribution patterns in zooplankton versus ichthyoplankton (Munk et al. 1989, Falkenhaug et al. 1997, Gronkjaer and Wieland 1997). While zooplankton are able to use depth as a refuge during the day and rise to surface waters to feed at night, larval fishes are predominantly visual feeders and require sufficient light to feed (Blaxter 1988, Gerking 1994). Larval fish will, therefore, be limited in terms of maximum sustainable depths by the exponential decline in light intensity with depth

(Job and Bellwood 2000). The lower limit of larval fish vertical distributions may be set by the minimum light intensity at which feeding is possible. In addition, Zaret and Suffern (1976) concluded that vertical migration patterns occur in prey species that are vulnerable to visually dependent predators, thus larvae may reduce predation by moving to deeper water during the day. Diel migrations may be triggered by the search for an optimum light intensity in which to minimize predation while maximizing feeding rates, in the evening this hypothetical level of optimum illumination will progressively reach the surface (Fortier and Leggett 1983).

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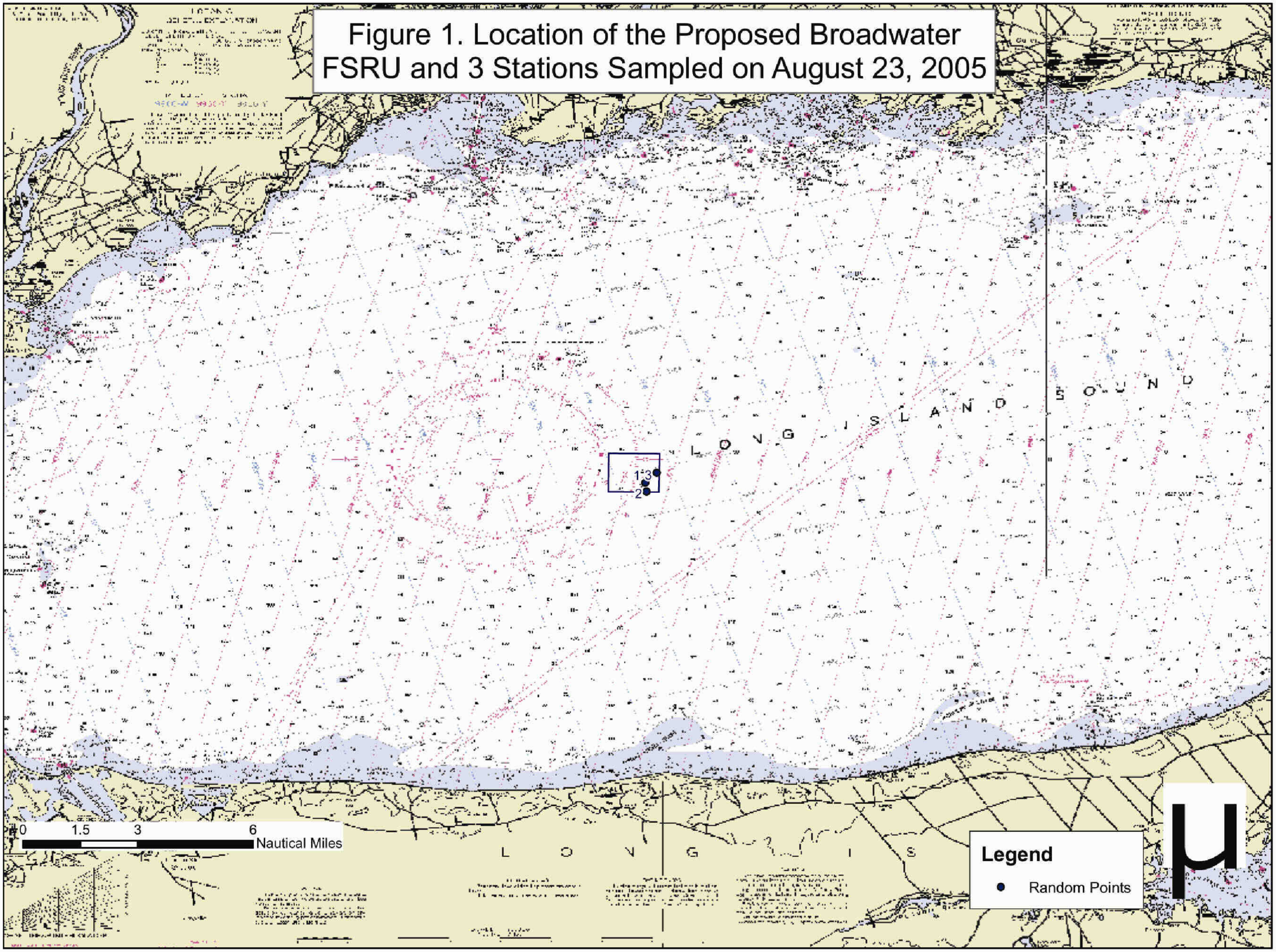
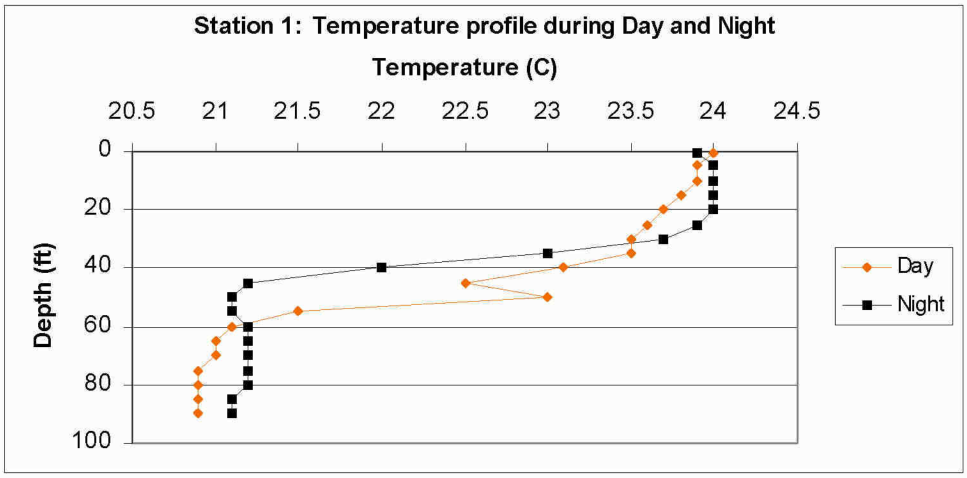
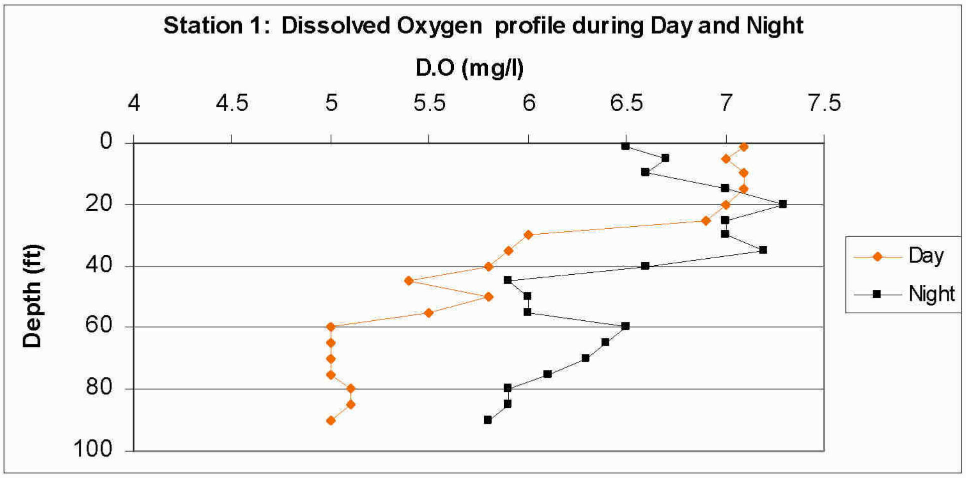


Figure 1. Location of the Proposed Broadwater
FSRU and 3 Stations Sampled on August 23, 2005
L O N G I S L A N D S O U N D
1
3
2
0
1.5
3
6
Nautical Miles
Legend
Random Points
L O N G I S





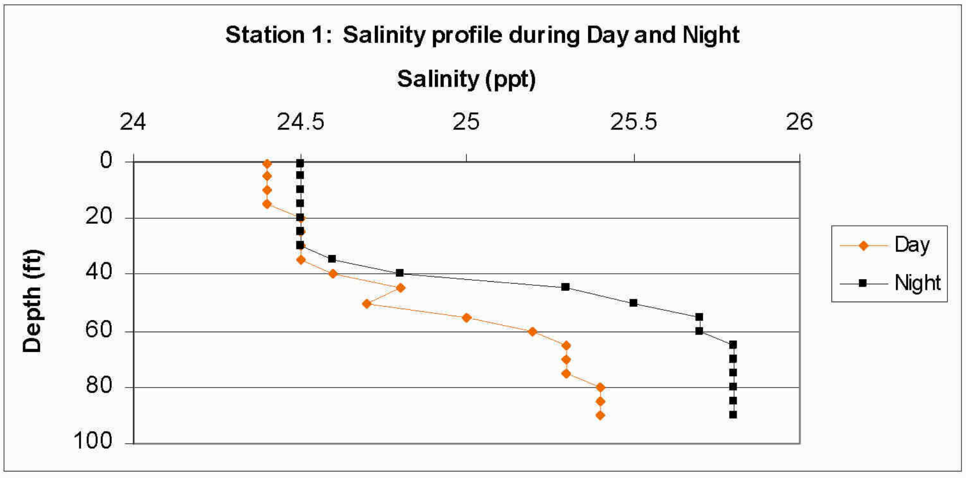


Figure 2. Physical profile (temperature, dissolved oxygen, and salinity) of water column during Day and Night sampling at Station 1 on 23 August, 2005.

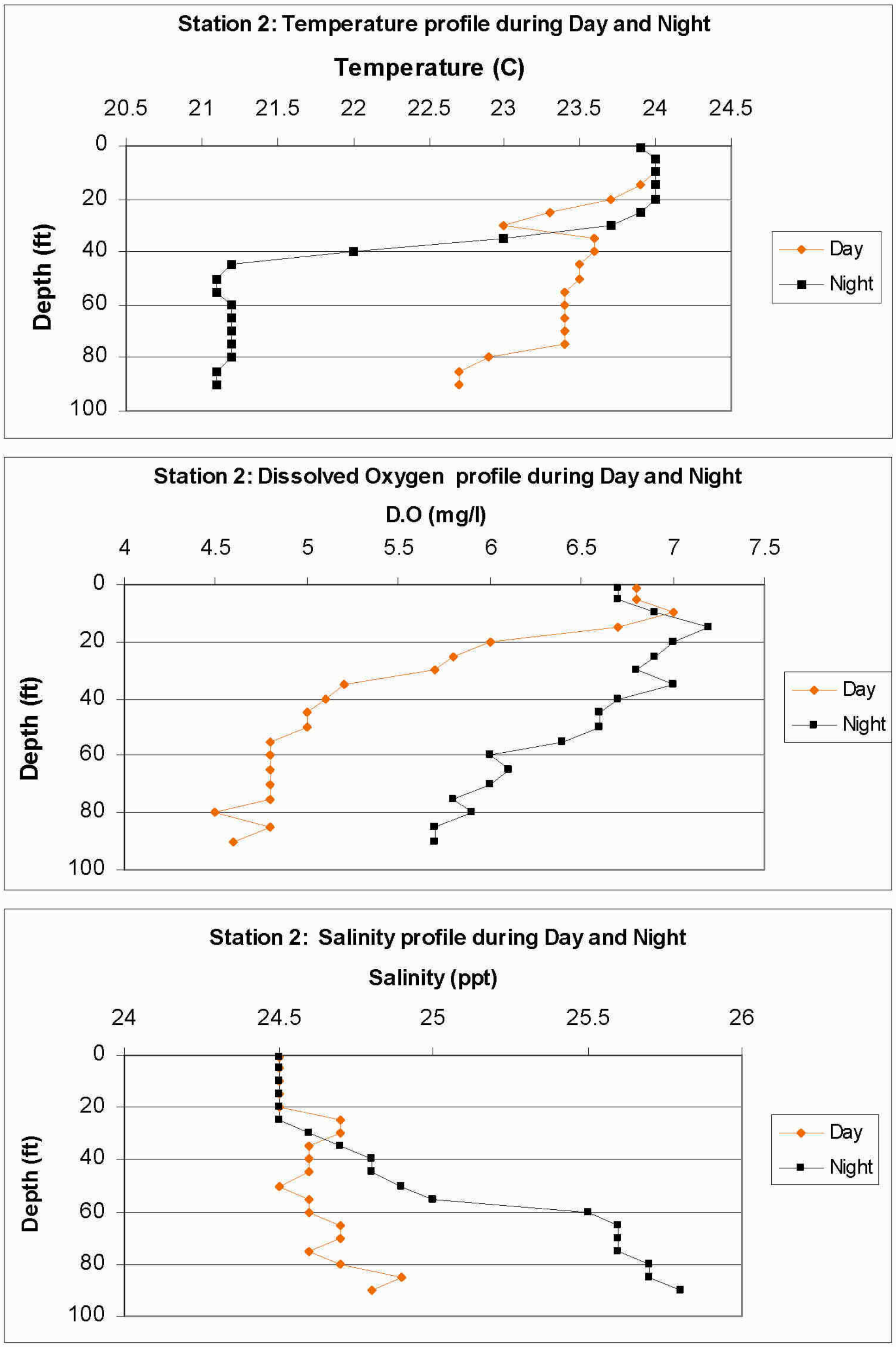


Figure 3. Physical profile (temperature, dissolved oxygen, and salinity) of water column during Day and Night sampling at Station 2 on 23 August, 2005.

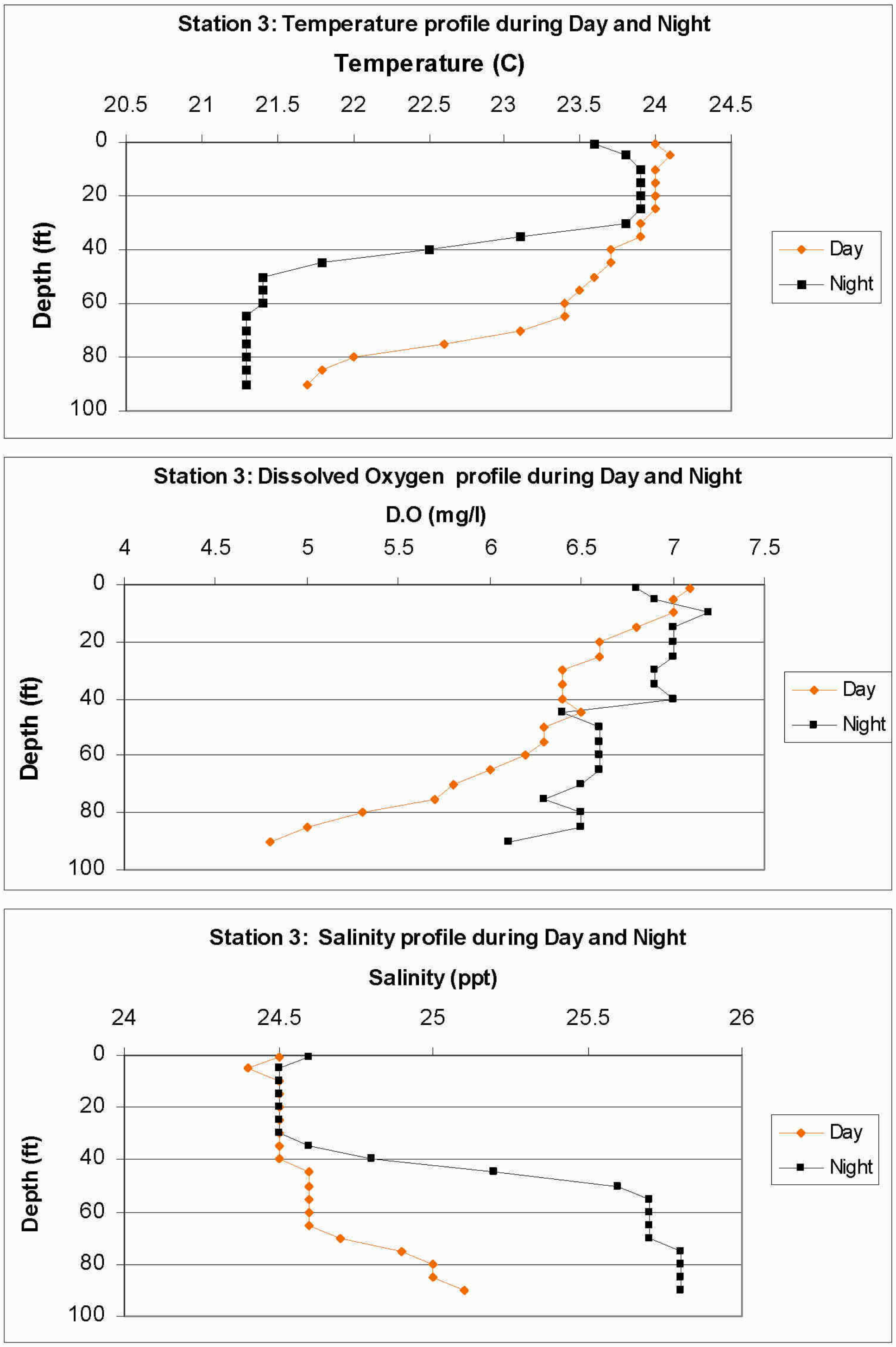


Figure 4. Physical profile (temperature, dissolved oxygen, and salinity) of water column during Day and Night sampling at Station 3 on 23 August, 2005.

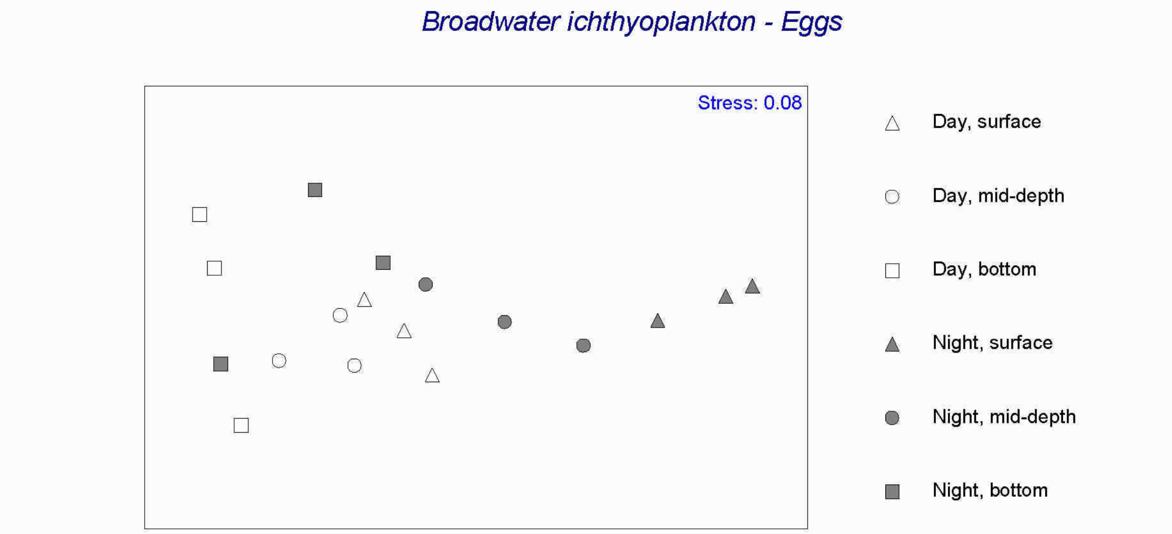


Figure 5. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on August 23, 2005 for untransformed egg density (#/100m^3) based on Bray-Curtis similarities.

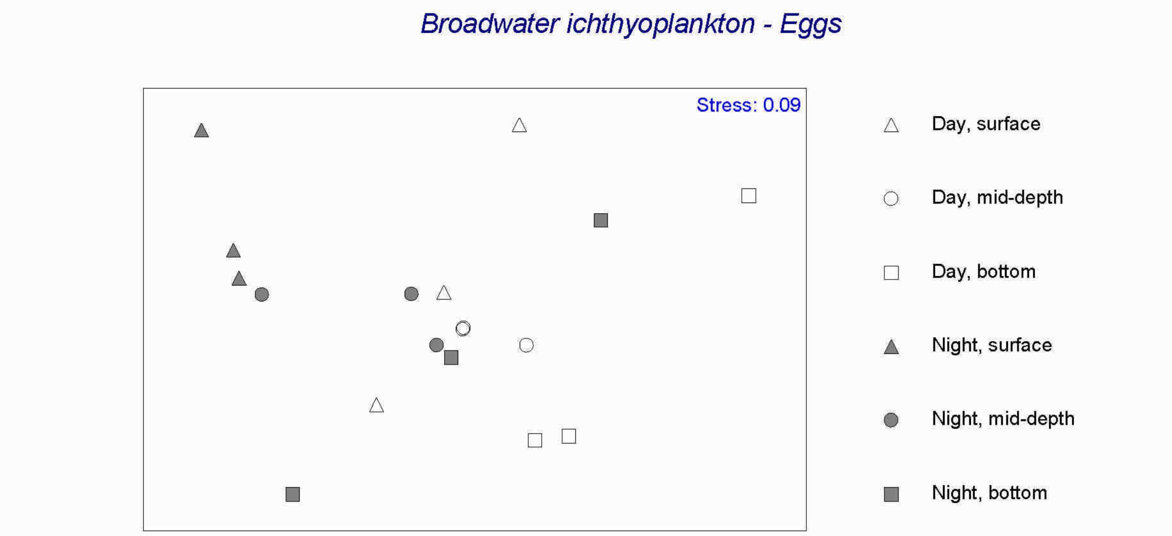


Figure 6. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on August 23, 2005 for 4th root transformed egg density (#/100m^3) based on Bray-Curtis similarities.

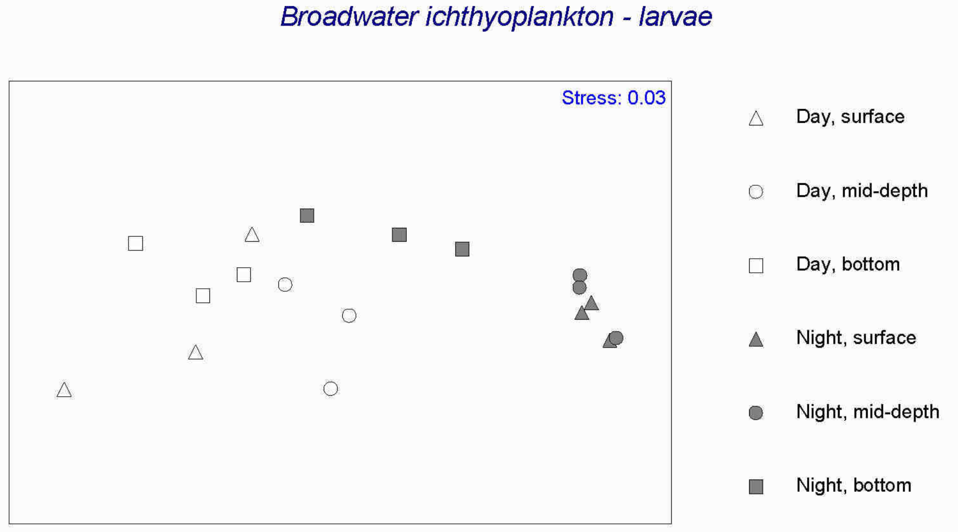


Figure 7. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on August 23, 2005 for untransformed larval density (#/100m^3) based on Bray-Curtis similarities..

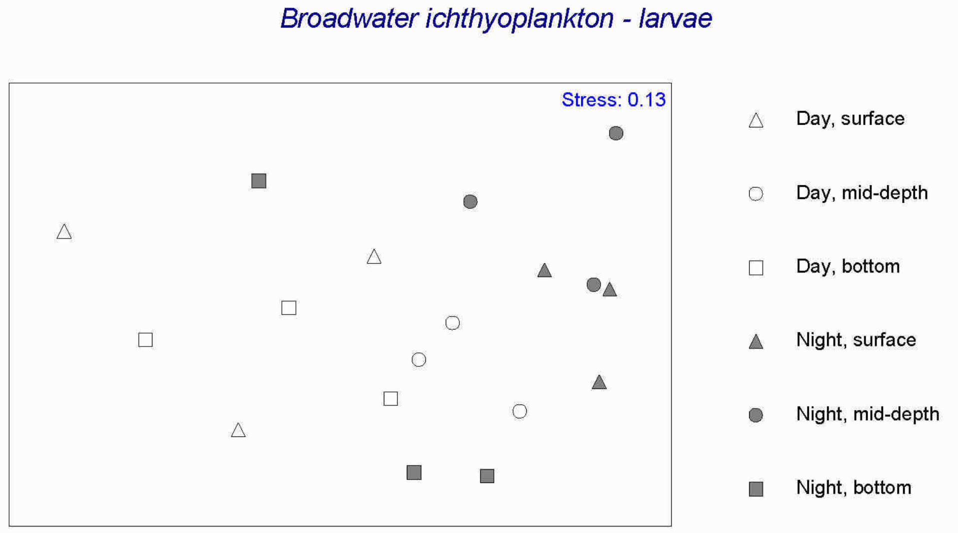


Figure 8. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on August 23, 2005 for 4th root transformed larval density (#/100m^3) based on Bray-Curtis similarities.

Table 1. **Sample allocation, sample depths and volume of water sampled (m^3) among the three stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on August 23, 2005.**

Station	Depth Strata	Sample Depth (ft.)	Diel Period	Volume Sampled
1	Surface	20	Day	40
	Mid-depth	40		68
	Bottom	80		67
	Surface	20	Night	51
	Mid-depth	40		48
	Bottom	79		65
2	Surface	20	Day	51
	Mid-depth	40		43
	Bottom	80		71
	Surface	20	Night	58
	Mid-depth	40		43
	Bottom	80		68
3	Surface	20	Day	61
	Mid-depth	40		47
	Bottom	80		54
	Surface	20	Night	64
	Mid-depth	40		48
	Bottom	79		43

Table 2. **Temperature, dissolved oxygen, and salinity at the three stations during day and night sampling in the vicinity of the proposed Broadwater FSRU on August 23, 2005.**

	Temperature (°C)				Dissolved Oxygen (mg/l)				Salinity ($^0/_{00}$)			
	min	max	mean	stdev.	min	max	mean	stdev.	min	max	mean	stdev.
Station 1												
Day	20.9	24.0	22.5	1.3	5.00	7.10	5.88	0.87	24.4	25.4	24.8	0.4
Night	21.1	24.0	22.3	1.3	5.80	7.30	6.46	0.48	24.5	25.8	25.2	0.6
Station 2												
Day	22.7	24.0	23.4	0.4	4.50	7.00	5.42	0.84	24.5	24.9	24.6	0.1
Night	21.0	23.9	22.3	1.2	5.70	7.20	6.46	0.49	24.5	25.8	25.0	0.5
Station 3												
Day	21.7	24.1	23.4	0.8	4.80	7.10	6.22	0.65	24.4	25.1	24.6	0.2
Night	21.3	23.9	22.4	1.2	6.10	7.20	6.71	0.29	24.5	25.8	25.2	0.6

Table 3. Number of eggs and larval (yolk-sac + post yolk-sac stages) fish and the percent contribution to the total catch by species in the 18 ichthyoplankton tows conducted in the vicinity of the proposed Broadwater FSRU on August 23, 2005.

Common Name	Scientific Name	# Larvae	% Total Larvae	# Eggs	% Total Eggs
Bay Anchovy	*Anchoa mitchilli*	3,639	81.0	826	79.4
Smallmouth Flounder	*Etropus microstomus*	276	6.1	114	11.0
Butterfish	*Peprilus triacanthus*	193	4.3	42	4.0
Searobin	*Prionotus* sp.	182	4.1	50	4.8
Fourspot Flounder	*Paralichthys oblongus*	73	1.6	1	0.1
Striped Cuskeel	*Ophidion marginatum*	31	0.7		
Black Sea Bass	*Centropristis striata*	26	0.6		
Atlantic Mackerel	*Scomber scombrus*	24	0.5		
Cunner	*Tautogalabrus adspersus*	17	0.4		
Weakfish	*Cynoscion regalis*	15	0.3		
Unidentified		11	0.2	3	0.3
Northern Puffer	*Sphoeroides maculatus*	3	0.1		
Tautog	*Tautoga onitis*	2	<0.1		
Windowpane	*Scophthalmus aquosus*	2	<0.1	4	0.4
Atlantic Menhaden	*Brevoortia tyrannus*			1	0.1
TOTAL		4,494		1,041	

Table 4. **Egg densities (#/100m^3) for common species (accounting for > 1% of the total number collected) and percent of the total for the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on August 23, 2005.**

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**
Bay anchovy	25	47	9	20	1	5	367	96	81	74	11	41
Butterfish	3	6	6	18	5	26	0	0	6	5	5	19
Searobin	3	5	8	20	7	34	4	1	7	7	3	12
Smallmouth flounder	22	39	16	41	5	26	11	3	16	15	5	21
Total	54	97	39	98	18	92	382	100	110	100	25	93

Table 5. **Two-way ANOVA evaluating the effect of diel period (day or night) and depth strata (surface, mid-depth, or near bottom) on log (x+1) transformed larval (yolk-sac larvae + post yolk-sac larvae) and egg densities (#/100m^3) for: all species combined, bay anchovy, and all species with bay anchovy excluded. * = 0.05>P>0.01, ** = 0.01<P>0.001, *** = P<0.001, NS = not significant.**

Response Variable	Source of Variation	DF	SS	MS	F	P	Significance
Larval Density	Diel Period	1	3.23	3.23	85.19	< 0.0001	***
	Depth Strata	2	0.87	0.44	11.49	0.0016	**
	Diel*Depth	2	0.48	0.24	6.33	0.0133	*
Egg Density	Diel Period	1	0.91	0.91	29.85	0.0001	***
	Depth Strata	2	1.87	0.94	30.76	< 0.0001	***
	Diel*Depth	2	0.45	0.23	7.42	0.0080	**
Bay Anchovy Larval Density	Diel Period	1	5.28	5.28	91.45	< 0.0001	***
	Depth Strata	2	0.65	0.33	5.65	0.0187	*
	Diel*Depth	2	0.64	0.32	5.55	0.0196	*
Bay Anchovy Egg Density	Diel Period	1	4.00	4.00	48.35	< 0.0001	***
	Depth Strata	2	5.47	2.73	33.07	< 0.0001	***
	Diel*Depth	2	0.16	0.08	0.97	0.4079	NS
Larval Density	Diel Period	1	0.53	0.53	9.47	0.0096	**
(Bay anchovy excluded)	Depth Strata	2	0.85	0.42	7.56	0.0075	**
	Diel*Depth	2	0.50	0.25	4.43	0.0363	*
Egg Density	Diel Period	1	0.08	0.08	2.08	0.1752	NS
(Bay anchovy excluded)	Depth Strata	2	0.20	0.10	2.62	0.1136	NS
	Diel*Depth	2	0.04	0.02	0.54	0.5956	NS

Table 6. **Larval (yolk sac + post yolk sac stage) densities (#/100m^3) for common species (accounting for > 1% of the total number collected) and percent of the total for the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on August 23, 2005**

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**	**# per 100m³**	**% Total**
Bay anchovy	37	59	85	44	46	61	994	84	933	86	222	84
Butterfish	7	10	19	9	8	11	61	5	25	2	1	0
Fourspot flounder	2	2	10	5	2	3	7	1	15	1	11	5
Searobin	5	8	28	14	5	6	47	4	20	2	10	4
Smallmouth flounder	13	17	44	21	11	14	34	3	69	6	13	5
Total	64	95	187	93	71	94	1142	97	1061	98	256	97

Table 7. Egg, yolk-sac larvae (YSL) and post yolk-sac larval (PYSL) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during daytime sampling in the vicinity of the proposed Broadwater FSRU on 23 August, 2005.

Species	Life Stage	Station 1			Station 2			Station 3		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Atlantic mackerel	PYSL	5								
Atlantic menhaden	Egg							2		
Bay anchovy	Egg	28	1	2	29	12		18	13	2
	YSL	3						5		
	PYSL	25	79	32	8	63	42	72	114	64
Black sea bass	PYSL	3	4			9	3		4	
Butterfish	Egg	3	10	3	4	7	8	3	2	4
	PYSL	13	7	8		42	10	8	8	6
Cunner	PYSL		1				1		2	
Fourspot flounder	Egg									2
	PYSL	5	3			9	4		19	2
Northern puffer	PYSL					2				
Searobins	Egg	8	7	15	2	7			8	6
	YSL		1							
	PYSL	8	15	2	4	30	3	5	38	9
Smallmouth flounder	Egg	45	13	2	14	23	10	8	13	4
	YSL	8	1		12	2	1	3	4	4
	PYSL	13	19	5	2	63	11	2	42	11
Striped cuskeel	PYSL		3			7	1	2		
Unidentified	Egg					2	3			
	YSL								2	4
Weakfish	PYSL					5	3	2		
Windowpane	Egg	3								
	PYSL								2	

Table 8. Egg, yolk-sac larvae (YSL) and post yolk-sac larval (PYSL) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during nighttime sampling in the vicinity of the proposed Broadwater FSRU on 23 August, 2005.

Species	Life Stage	Station 1 Surface	Station 1 Mid-depth	Station 1 Bottom	Station 2 Surface	Station 2 Mid-depth	Station 2 Bottom	Station 3 Surface	Station 3 Mid-depth	Station 3 Bottom
Atlantic mackerel	YSL					2				
	PYSL		17		7	2		9	4	
Bay anchovy	Egg	240	125	8	434	80	3	428	38	24
	YSL				3	2				
	PYSL	1130	1171	216	913	772	103	934	855	346
Black sea bass	PYSL	12	4	2	3			3		2
Butterfish	Egg					14	4		4	12
	YSL				3					
	PYSL	83	58		35			63	17	2
Cunner	PYSL	4	4		10	5				5
Fourspot flounder	YSL									2
	PYSL	4	17	5	3	14	18	13	13	9
Northern puffer	PYSL				3					
Searobins	Egg	4	4	5	7	9			8	5
	PYSL	51	42	14	52		1	38	17	14
Smallmouth flounder	Egg	16	29	5	10	14	7	6	4	2
	YSL		33	3			1	6		2
	PYSL	63	100	11	7	40	6	25	34	14
Striped cuskeel	PYSL	12	8	3	10	5		6		
Tautog	PYSL			2						2
Unidentified	YSL	12								
	PYSL							3		
Weakfish	PYSL	16		2						2
Windowpane	Egg			5						
	PYSL									2

Table 9. Species richness (# species identified to at least genus level in a sample), Shannon-Wiener diversity index (H'), and density (#/100m^3) of eggs and larvae (yolk-sac + post yolk-sac stage) at the three sampling stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on August 23, 2005

Station	Depth Strata	Diel Period	Species Richness		Diversity (H')		Density	
			Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
1	Surface	Day	5	7	1.12	1.68	85	80
	Mid-depth		4	8	1.21	1.34	32	135
	Bottom		4	4	0.90	0.89	21	45
	Surface	Night	3	9	0.31	0.76	260	1374
	Mid-depth		3	9	0.59	0.79	158	1454
	Bottom		4	8	1.36	0.68	22	257
2	Surface	Day	4	3	0.99	0.98	49	25
	Mid-depth		4	9	1.25	1.77	49	232
	Bottom		2	9	0.69	1.54	18	80
	Surface	Night	3	10	0.19	0.60	451	1052
	Mid-depth		4	6	0.97	0.38	118	842
	Bottom		3	4	1.03	0.67	15	130
3	Surface	Day	4	6	1.06	0.83	31	98
	Mid-depth		4	8	1.24	1.45	36	235
	Bottom		5	5	1.52	1.02	17	96
	Surface	Night	2	8	0.08	0.65	434	1097
	Mid-depth		4	6	0.94	0.43	55	939
	Bottom		4	10	1.09	0.69	42	405

Table 10. **Average density (#/100m^3) of ichthyoplankton collected during Day (n=3) and Night Tows (n=3) from the Mid-depth strata in the vicinity of the proposed Broadwater FSRU on August 23, 2005. Daily entrainment estimates were determined by multiplying the average density by the daily withdrawl by the FSRU and associated LNG carriers (28.2 MGD, 106,750 m^3/day).**

Species	Stage	Average Density (#/100m^3)	Daily Entrainment Estimate
Atlantic mackerel	Egg	0.0	0
	YSL	0.3	356
	PYSL	3.8	4,092
Bay Anchovy	Egg	44.8	47,860
	YSL	0.3	356
	PYSL	509.0	543,358
Black sea bass	Egg	0.0	0
	YSL	0.0	0
	PYSL	3.5	3,736
Butterfish	Egg	6.2	6,583
	YSL	0.0	0
	PYSL	22.0	23,485
Cunner	Egg	0.0	0
	YSL	0.0	0
	PYSL	2.0	2,135
Fourspot Flounder	Egg	0.0	0
	YSL	0.0	0
	PYSL	12.5	13,344
Northern Puffer	Egg	0.0	0
	YSL	0.0	0
	PYSL	0.3	356
Searobin	Egg	7.2	7,650
	YSL	0.2	178
	PYSL	23.7	25,264
Smallmouth Flounder	Egg	16.0	17,080
	YSL	6.7	7,117
	PYSL	49.7	53,019
Striped Cuskeel	Egg	0.0	0
	YSL	0.0	0
	PYSL	3.8	4,092
Unidentified	Egg	0.3	356
	YSL	0.3	356
	PYSL	0.0	0
Weakfish	Egg	0.0	0
	YSL	0.0	0
	PYSL	0.8	890
Windowpane	Egg	0.0	0
	YSL	0.0	0
	PYSL	0.3	356

Table 11. Bay anchovy life history parameter values used by EPA (2004) to calculate age 1 equivalents. Instantaneous Total Mortality (Z) is the sum of Natural Morality (M) and Fishing Mortality (F), (Z = M+F). Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage (S= e-z).

						Estimated Number Entrained that would Survive			
Species	**Stage Name**	**M[a]**	**F[a]**	**Z**	**S**	**Egg to Later Stages**	**Yolksac Larvae to Later Stages**	**Post Yolksac Larve to Later Stages**	**Estimated Total # Age 1 Entrained**
Bay Anchovy	Eggs	1.04	0	1.04	0.353	16,916			
	Yolksac Larvae	1.57	0	1.57	0.208	3,519	74		
	Post-yolksac larvae	6.12	0	6.12	0.002	8	0	1195	
	Juvenile	1.29	0	1.29	0.275	2	0	329	
	Age 1+	1.62	0	1.62	0.198	0	0	65	65

[a] From Table D1-11 in EPA (2004)

Attachment 2

Summary of Ichthyoplankton Sampling Conducted on October 4, 2005

November 10, 2005
Ref No. 20546.000

Mike Donnelly
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Dr.
Lancaster, NY 14086

RE: Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 2, October, 2005.

FIELD METHODS

Normandeau Associates, Inc. (Normandeau) conducted ichthyoplankton sampling in the vicinity of the proposed Broadwater Energy floating storage and regasification unit (FSRU) in the Central Basin of Long Island Sound on October 4, 2005. A one by one nautical mile square block centered on the location of the proposed FSRU facility was designated as the sampling area. Three random stations were selected within the sampling area using the Random Point Generator extension in Arcview (Figure 1). At each station the water column was divided into three depth strata based on an assumed depth of about 95 feet: near surface (surface, 0-30 feet), mid-depth (mid-depth, 35-65 feet), near bottom (bottom, 70-95 feet). One ichthyoplankton tow was collected in each depth stratum of each station during daylight (defined as occurring between 1 hour after sunrise and 1 hour before sunset) and the daytime sampling was repeated again at night at the same three stations (defined as occurring between 1 hour after sunset and 1 hour before sunrise). A total of 18 valid samples (3 stations x 3 depths x 2 diel periods, Table 1) were collected on October 4, 2005 between 2:00-4:00 PM (day) and 7:30-11:00 PM (night).

All samples were collected with a 1.0 m^2 Tucker trawl with a 0.335 mm net and an 8:1 length to mouth ratio. The tucker trawl has a closing device that uses a double-trip release mechanism and a weighted lead bar to close the mouth of the net and insure that each sample is collected in each of the three discrete depth strata. Net towing speed was 1.0 m/sec. The original sampling protocol called for a 5 minute tow duration to insure an approximate 300 m^3 sample. However, during the October sampling event, high concentrations of comb jellies (ctenophores) throughout the water column clogged the net mesh during the initial five minute tows and reduced gear efficiency. Therefore, the five minute tows were voided and all sampling was conducted with a one or two minute tow resulting in tow volumes approximately 1/5 – 2/5 of 300 m^3 (43-122 m^3, Table 1). A flume-calibrated digital flowmeter (GO Model 2030R) was placed in the mouth of the Tucker trawl to measure the distance (volume) of each tow. Tow depth was determined in the field using a cosine function relating wire length and wire angle to sampling depth. The start and end of each towpath was recorded using GPS. Samples were fixed at sea in 4% buffered formaldehyde and changed over to 80% ethanol within 18 hours. A conductivity, salinity, temperature, dissolved oxygen and depth profile was made at 5 foot intervals from one foot below the surface to one foot above the bottom at each of the three stations and two diel periods (6 total profiles) using a YSI Model 85 meter.

LABORATORY METHODS

Because tow duration was reduced to one-two minutes, samples were analyzed without subsampling. Samples were sorted under magnification to remove all fish eggs, fish larvae, and lobster larvae which were then enumerated and identified to the lowest possible taxon (generally genus and species). Samples were further identified into the following life stages: egg, yolk-sac larvae and post yolk-sac larvae.

The accuracy of identifications, assignment to life stage, and counting was monitored and controlled by QC checks. A subset of the samples were randomly selected for re-identification by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, data from those samples were corrected and the proportion of samples checked was increased. A sample failed identification QC if the original identifier's count differed from the QC inspector's count by 10% or more (or by more than two if the QC total was 20 or less). This acceptance criterion was applied separately by life stage to each taxon. An additional requirement for a sample to pass was that for each taxon, the sum of the percent errors for all life stages was required to be less than 10%.

RESULTS

Physical Profiles of Water Column

Water temperature, dissolved oxygen, and salinity were similar among the three stations (Table 2, Figures 2-4). Water temperature typically ranged from 21-23 °C, dissolved oxygen from 4.9-7.5 mg/l, and salinity 27.5-28.0 $^{o}/_{oo}$. At all three stations, the water column was relatively homogeneous and well mixed. A slight (1-2 °C) thermocline was apparent between the surface and 20 feet, below this thermocline the water temperature and dissolved oxygen concentrations were lower and salinities were greater relative to the surface water.

Total Species Composition

Atlantic menhaden (*Brevoortia tyrannus*) was the only fish egg collected during sampling on October 4, 2005 (Table 3). Atlantic menhaden, bay anchovy (*Anchoa mitchilli*), and feather blenny (*Hypsoblennius hentzi*) were the only larvae collected during sampling on October 4, 2005 (Table 3). The majority (99%) of the larvae were in the post yolk-sac stage. Bay anchovy comprised the majority of larvae collected (81.5%), Atlantic menhaden comprised 18.3 %, and feather blenny 0.3% (Table 3). Eight bay anchovy young of the year were collected; six in the mid-depth and two in the deep strata, all were collected at night.

Ichthyoplankton Density Across Diel Period and Depth Strata

Atlantic menhaden eggs were collected in all three depth strata during both diel periods and mean egg density ranged from 1.4 eggs/100m^3 in the surface samples at night to 9.6 eggs/100m^3 in the bottom samples during the day (Table 4). The influence of diel period and depth strata on Atlantic menhaden egg distribution was further explored with a two-way analysis of variance (ANOVA). Egg density was log (x+1) transformed to better meet parametric assumptions. Atlantic menhaden egg density was significantly higher in the daytime samples than in the nighttime samples (p= < 0.01) and there was no significant difference between the three depth strata (p= 0.24, Table 5).

A two-way ANOVA on log (x+1) transformed larvae (yolk sac+post yolk sac stages, all three species pooled) density resulted in significantly (p= <0.001) higher densities at night and no difference (p= >0.50) between the three depth strata (Table 5). Because the larvae catch was dominated by bay anchovy, a separate two-way ANOVA was run for bay anchovy and Atlantic menhaden (only 1 feather blenny larvae was collected so statistics were not run separately for this species). Bay anchovy larvae density was significantly (p= <0.0001) higher at night (Table 5), and multiple range comparisons (Tukey's Studentized Range Test) revealed that density was higher in the mid-depth strata than in the surface and bottom which did not differ from each other. However, there was a significant (p= 0.01) diel*depth strata interaction suggesting that the depth differences were not the same during day and night. Separate one-way ANOVAs were run to determine if bay anchovy larvae density differed with depth strata during daytime and nighttime samples in order to explain the significant interaction. One way ANOVA revealed that during daytime sampling, bay anchovy larvae were collected in equal density in the surface and mid-depth collections and in significantly lower density (p= 0.04) in the deep strata as suggested by Table 6. During nighttime sampling, bay anchovy larvae were collected in significantly (p= 0.01) higher density in the mid-depth than in the surface or bottom strata which did not differ from each other (Table 6).

Two way ANOVA revealed that Atlantic menhaden larvae were collected in greater density during daytime (Table 5) and that density was higher in the bottom strata than in the surface or mid-depth which did not differ from each other (Tukey's Studentized Range Test) as suggested by Table 6.

A more detailed breakdown of egg and larval (yolk-sac and post yolk sac larvae separately) densities for all species collected in each of the three replicate stations in each depth stratum for daytime and nighttime sampling are presented in Table 7 and Table 8. Table 9 presents species richness (# of species identified to at least the genus level), Shannon-Wiener diversity index, and density (all species combined) for eggs and larvae in each of the 18 samples conducted on October 4, 2005.

Ichthyoplankton Community Similarity Across Diel Period and Depth Strata

Community similarity between the two diel periods and three depth strata was evaluated through ordination using non-metric multidimensional scaling (NMDS). Analysis was based on the Bray-Curtis similarity index generated from all pairwise sample comparisons on untransformed transformed egg and larval (yolk-sac + post yolk-sac stages) densities. Like all multivariate techniques, NMDS is based on a similarity coefficient matrix calculated between every pair of samples. The Bray-Curtis similarity values were then transformed to ranks (the highest similarity between a pair of sites has the lowest rank, 1, and the lowest similarity has the highest rank, (n(n-1)/2). NMDS then constructs a "map" or configuration of the samples. The NMDS map is constructed to preserve the similarity ranking as Euclidean distances on the two dimensional plot and attempts to satisfy all conditions imposed by the rank similarity matrix, e.g. if sample 1 has higher similarity to sample 2 than it does to sample 3 then sample 1 will be placed closer on the map to sample 2 than it is to 3. The principle of the NMDS algorithm is to choose a configuration of points which minimize the degree of *stress* or distortion between the similarity rankings and the corresponding distance rankings in the ordination plot. The stress value provides a "goodness of fit" measure, in general, stress < 0.05 gives an excellent representation with no prospect of misinterpretation, stress < 0.1 corresponds to a good ordination with no real prospect of a misleading interpretation, and stress < 0.2 still gives a potentially useful 2-dimensional picture, though for values at the upper end of this range too much reliance should not be placed on the detail of the plot (Clarke and Warwick 1994). NMDS is based on rank order about which samples are most or least similar, axes are non-metric and the ordination plot can say nothing about which direction is "up" or "down", or the absolute "distance apart" of two samples, what can be interpreted is relative distances apart (Clarke and Warwick 1994). NMDS can be recommended as one of the best (arguably the best) ordination technique available (Everitt 1978, Clarke and Warwick 1994). The few comprehensive studies that have compared ordination methods for community data give NMDS a high rating (Kenkel and Orloci 1986).

A two-way crossed ANOSIM (analysis of similarities, Clarke and Warwick 1994) test was used to evaluate differences in the ichthyofaunal community between the two diel periods and three depth strata based on the corresponding rank similarities between samples in the similarity matrix. ANOSIM is a non-parametric permutation applied to the rank similarity matrix underlying the NMDS ordination. If r_w is defined as the average of all rank similarities among replicates within a diel or depth group, and r_b is the average of rank similarities arising from all pairs of replicates between a diel or depth group then the test statistic is:

$R = (r_b - r_w)/ (M/2)$ where $M = n(n-1)/2$ and n is the total number of samples under consideration (Clarke and Warrick 1994).

The R statistic usually falls between 0 and 1, R is approximately zero if similarities between and within groups are the same, and R = 1 if all replicates within a group are more similar to each other than any replicates from different groups. The R statistic itself is a useful comparative measure of the degree of separation of sites, though the main interest usually centers on whether it is significantly different from zero (Clarke and Warwick 1994). Further discussion of ANOSIM is provided by Clarke and Green (1988) and Clarke and Warwick (1994).

Because there was only one species of egg collected (Atlantic menhaden) and three species of larvae (Atlantic menhaden, bay anchovy and feather blenny), the results of NMDS based on the Bray-Curtis similarity indices are driven largely by differences in abundance between the samples because ichthyofaunal diversity was so low.

Untransformed egg density similarity shows a general separation of day and night samples (Figure 5) and less distinction between the three depth strata consistent with the results of the two way ANOVA demonstrating higher density during the daytime and no significant differences between depth strata (Table 5). ANOSIM detected a significant difference between diel period averaged across all depth strata (R= 0.274, p = 0.03). ANOSIM did not detect a difference between the three depth strata averaged across both diel groups and the negative R value (R= -0.222) indicates that similarity across depth strata was greater than similarity within depth strata reflecting the uniform depth distribution of menhaden eggs.

Ordination of untransformed larval density similarity shows a general separation of day and night samples (Figure 6). ANOSIM revealed a clear separation between diel periods averaged across all depth strata (R= 0.728, p = 0.002) and between depth strata averaged across diel groups (R= 0.498, p = 0.003). Pairwise comparisons reveal overlapping but clear separation between the mid-depth and bottom strata (R= 0.556), and higher similarity (less separation) between the bottom and surface strata (R= 0.500) and between the mid-depth and surface strata (R= 0.389).

Impact Analysis Based on Ichthyoplankton Densities

The average density (#/100m^3) for eggs and larvae collected from the mid-depth strata during daytime sampling (n=3) and during nighttime sampling (n=3) was multiplied by the daily water intake of the FSRU and associated LNG carriers (28.2 million gallons/day, 106,750 m^3/day) to estimate daily entrainment rates for species and life stage (Table 10) because water intake will occur from 35-45 feet below surface. Average Atlantic menhaden egg density in the mid-depth strata was 7.4 eggs/100 m^3 (0.07/m^3) during the daytime, 4.3 eggs/100 m^3 (0.04/m^3) during night and 5.9 eggs/100 m^3 (0.06/m^3) during day and night samples. Average larvae (yolk sac + post-yolk sac) density in the mid-depth strata was 15.7/100m^3 (0.16/m^3) during the daytime, 82.9/100m^3 (0.83/m^3) during night and was 49.3/100m^3 (0.49/m^3) during day and night samples. These average densities correspond to a daily entrainment estimate of 6,245 eggs (all Atlantic menhaden) and 52,628 larvae (approximately 80% bay anchovy, 20% Atlantic menhaden) per day. Atlantic menhaden and bay anchovy entrainment estimates are expressed in terms of Age 1 fish using the Equivalent Adult Model. The Equivalent Adult Model (EAM) is a method for expressing entrainment losses as an equivalent number of individuals at some other common life stage, referred to as the age of equivalency (Goodyear 1978). The method provides a convenient means of converting losses of fish eggs and larvae into units of individual fish and provides a standard metric for comparing losses among species, years, and facilities (EPA 2004). The age of equivalency can be any life stage of interest. For the 316(b) cooling water intake case studies, EPA (2004) expressed impingement and entrainment losses as an equivalent number of Age 1 individuals.

The EAM calculation requires life-stage specific entrainment counts and life-stage specific mortality rates from the life stage of entrainment to the life stage of equivalence. The losses at any given stage are simply multiplied by the fraction of fish at that stage or age that would be expected to survive to the age of equivalence:

$EA = S_A N$

Where: EA = equivalent adult loss, N= number of fish lost due to entrainment, S_A= fraction of fish expected to survive from the age at which they are entrained to the age of equivalence.

Survival rates of early life stages of fish are often expressed on a life-stage specific basis so that the fraction surviving from any particular life stage to the age of equivalency is expressed as the cumulative product of survival fractions for all of the life stages through which a fish must pass before reaching the age of equivalency. Life-stage specific mortality rates for bay anchovy were obtained from EPA (2004) values used to evaluate impingement and entrainment in the Mid-Atlantic Region (http://www.epa.gov/waterscience/316b/casestudy/final/appd1.pdf). Instantaneous total mortality (Z) is the sum of mortality from natural causes (M) and mortality from recreational and commercial fishing (F), (Z = M+F). Fishing mortality is equal to zero for Age 1 and younger Atlantic menhaden and bay anchovy. Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S= e^{-z}$). It was assumed that no Atlantic menhaden or bay anchovy eggs or larvae survived entrainment at the FSRU. Despite the seemingly large estimated daily entrainment rates (Table 10), the estimated number of entrained Atlantic menhaden eggs and larvae scales up to only 1 Age 1 equivalent per day and the estimated number of bay anchovy eggs, larvae and young of the year scales up to only 74 Age 1 equivalents per day (Table 11).

This daily entrainment estimates are based on sampling conducted on October 4, 2005 and does not represent the daily numbers that would be entrained throughout the year. Ichthyoplankton abundance and diversity in estuaries and nearshore areas of the Mid-Atlantic and southern New England are low during the winter when few species spawn. Ichthyoplankton abundance and diversity begin to increase in the spring and reach a peak during mid to late summer when many species reproduce, and spawning is curtailed in the fall (Wheatland 1956, Bourne and Govoni 1988, Monteleone 1992, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001). The relatively small intake velocity (0.5 ft/sec) and estimated daily water intake (28.2 MGD, 106,750 m^3/day) of the proposed FSRU facility will likely result in minimal ichthyoplankton entrainment losses. The daily withdrawl rate of 106,750 m^3/day represents only 2.69×10^{-4} % of the volume of water in the Central Basin. Even running 365 days a year, the annual FSRU water intake only represents 0.10% of the volume in the Central Basin.

Comparison of August and October Sampling Events and Discussion of Seasonal Occurrence Patterns

Ichthyoplankton abundance and diversity in the vicinity of the FSRU facility was considerably lower during the October 4, 2005 sampling event than on August 23, 2005 (Figure 7). In water depths representing the FSRU intake location (mid-depth strata), average egg density during day and night samples was 74.7/100m^3 in August compared to 5.9/100m^3 in October and average larvae density was 639.5/100m^3 in August compared to 49.3/100m^3 in October. In August, eggs from seven taxa and larvae from thirteen taxa were collected, catches were dominated by bay anchovy which accounted for about 80% of all eggs and larvae collected.

Bay anchovy are typically the most abundant ichthyoplankton species collected in the estuaries of the northern Mid-Atlantic Bight (Wheatland 1956, Dovel 1981,Vouglitois et al. 1987, Bourne and Govoni 1988, Monteleone 1992, Keller et al. 1999, Chute and Turner 2001). Bay anchovy spawning in the Mid-Atlantic peaks during mid-late summer and declines in the fall when egg and larval densities are greatly reduced (Wheatland 1956, Vouglitois et al. 1987, Bourne and Govoni 1988, Monteleone 1992, Able and Fahay 1998, Keller et al. 1999, Chute and Turner 2001, Monteleone 1992, Able and Fahay 1998). Richards (1959) found bay anchovy eggs in Long Island Sound most abundant near shore in depths < 20 m during June-August. Wheatland (1956) also collected bay anchovy eggs in Long Island Sound from June-August and peak density occurred in July in 1953. Stone et al. (1994) consider bay anchovy eggs abundant in Long Island Sound from May-September and highly abundant from June-August. Monteleone (1992) found bay anchovy eggs from May-August in Great South Bay, N.Y., Keller et al. (1999) and Chute and Turner (2001) found them June-September in Narragansett Bay and Buzzards Bay respectively. Based on available information, bay anchovy eggs can reasonably be expected to occur in Long Island Sound from June-September and the August 23, 2005 sampling event likely represents near peak seasonal density for bay anchovy eggs in Long Island Sound.

Wheatland (1956) collected bay anchovy larvae from July-September and in November with peak density in August in Long Island Sound. Stone et al. (1994) consider bay anchovy larvae abundant in Long Island from June-September with a peak in July. In Narragansett Bay, Keller et al. (1999) collected bay anchovy larvae from June-September and in Great South Bay, N.Y., Monteleone collected bay anchovy larvae from May-December. Based on available information, bay anchovy larvae can reasonably be expected to occur in Long Island Sound from June-November with peak densities in July-August. Bay anchovy eggs and larvae were likely at or near their seasonal peak in Long Island Sound during the August 23, 2005 sampling event and their seasonal decline in abundance during the fall is clearly demonstrated in the reduced density during sampling on October 4, 2005 Figure (7).

Atlantic menhaden was the only species collected in greater density in October than in August (Figure 7). Atlantic menhaden spawn at night and during nearly every month in some part of its range (McHugh et al. 1959). There is limited spawning activity during the northward spring migration, limited summer spawning as far north as Cape Cod and the Gulf of Maine, then increased spawning activity during the southward fall migration (Able and Fahay 1998). This pattern is followed by intense spawning in the South Atlantic Bight during winter (Higham and Nicholson 1964). Eggs are pelagic and buoyant and typically occur in the upper water column to depths of 10 m and usually hatch in less than 48 hours (Collete and Klein-Macphee 2002). Although evidence is still inconclusive, support exists for the existence of two subpopulations: one that spawns in summer and is responsible for primary recruitment in the northern end of its distribution, and one that spawns in autumn through spring and contributes the majority of recruitment in the Middle and Southern Atlantic areas (Collette and Klein-MacPhee 2002). Apparently, little contribution to the overall stock is made from spawning that takes place in areas north of northern New Jersey-Long Island Sound and the majority of new recruits are probably produced in estuaries of the Carolinas, Virginia and north to New Jersey (Collette and Klein-MacPhee 2002).

Wheatland (1956) collected Atlantic menhaden eggs in Long Island Sound during June to October during year round sampling in 1952, however in 1953 they were only collected from August-October . In 1952, there were two spawning peaks, one in June and one during September-October, eight times as many menhaden eggs were taken in June as in September (Wheatland 1956). The fall peak of menhaden eggs observed by Wheatland likely originated from spawning activity during the southward fall migration. In the Mid-Atlantic Bight, peak spawning occurs in mid-May to early June and in September and October (Ferraro 1980, Able and Fahay 1998). Richards (1959) collected menhaden eggs in Long Island Sound from May-October and Stone et al. (1994) report Atlantic menhaden eggs as common in Long Island

Sound from May through September and abundant in June and July. Monteleone (1992) found Atlantic menhaden eggs from April-May and in November is Great South Bay, N.Y., and Keller et al. (1999) found Atlantic menhaden eggs from May-August in Narragansett Bay.

Atlantic menhaden larvae are pelagic and most hatching and early larval development occurs at sea. In the ocean, larvae appear to be most concentrated in the upper water column (Kendall and Reintjes 1975, Nelson et al. 1977, Judy and Lewis 1983). Larval menhaden spawned offshore may spend up to several months in the continental shelf waters before being transported to estuaries at lengths of 10-22 mm (Massmann et al. 1962, Nelson et al. 1977). Larvae are transported to estuarine nursery areas by onshore and along-shore currents, and metamorphosis to juveniles is thought to occur exclusively within estuaries as no metamorphic larvae or prejuveniles have been collected at sea (Kendall and Reintjes 1975). Wheatland (1956) collected larvae from September to December in 1953. Stone et al. (1994) consider Atlantic menhaden larvae common in Long Island Sound from May through November and abundant in June and July. Keller et al. (1999) found menhaden larvae in Narragansett Bay from June-July and Chute and Turner (2001) found them in Buzzards Bay in June and November. Atlantic menhaden larvae can reasonably be expected to occur in Long Island Sound from May-December based on available information.

Discussion

In summary, the ichthyoplankton community in the vicinity of the proposed Broadwater FSRU in the central basin of Long Island Sound during day and night sampling on October 4, 2005 was dominated by bay anchovy and Atlantic menhaden. Diversity and abundance was considerably lower than during the August 23 sampling event reflecting the seasonality of the ichthyoplankton community in Long Island Sound typical of estuarine systems in the Mid-Atlantic Bight (Able and Fahay 1998). Ichthyoplankton abundance and diversity are low in the winter when few species spawn (American sand lance being an exception). Ichthyoplankton abundance and diversity begin to increase in the early spring, reaching a peak during mid-late summer when many species reproduce. Ichthyoplankton abundance and diversity decline in the fall when spawning is curtailed (Able and Fahay 1998). In Great South Bay, New York, Monteleone (1992) found a peak in fish egg density during late spring to early summer in 1985 and 1986 that was dominated by bay anchovy, in 1986 there was also a second peak in March comprised of winter flounder and American sand lance. In Buzzards Bay, Chute and Turner (2001) describe a peak of fish eggs and larvae from June-August dominated by cunner, tautog, and bay anchovy, diversity was highest in July. They also found a smaller spring peak comprised of winter flounder and American sand lance larvae. In Narragansett Bay, Keller et al. (1999) found a peak in fish egg density during June, and a peak in larvae during July with greatest diversity in July. In Long Island Sound, Wheatland (1956) found a peak in egg diversity and density in late spring and summer with a peak in June and July. The pattern was similar for fish larvae although density remained high into the fall when Atlantic menhaden larvae were abundant. In Long Island Sound, Richards (1959) found a seasonal ichthyoplankton cycle of increasing density and diversity in the spring to a peak in summer followed by a decline in autumn, with only American sand lance larvae collected in significant numbers in the winter.

In temperate neritic waters, the majority of marine fish eggs are neutrally or positively buoyant which favors hatching in more productive surface waters (Sundby 1991). The vertical distribution of pelagic eggs is determined by the relationship between physical properties of the eggs, seawater density, and the degree of vertical mixing of the water column (Sundby 1991, Nissling et al. 1994). Atlantic menhaden were the only eggs collected in the vicinity of the proposed FSRU facility on October 4, 2005. Atlantic menhaden egg density was evenly distributed between the three depth strata. Atlantic menhaden eggs are buoyant and reported to occur in the upper water column to depths of 10 m (Reintjes 1969, Judy and

Lewis 1983). Long Island Sound is considered vertically homogeneous with turbulent tidal mixing resulting in little to no physical stratification during periods of both high and low freshwater runoff (Able and Fahay 1998) and water column profiles (Figures 2-4) demonstrate the water column in the vicinity of the FSRU was well mixed on October 4, 2005. Williams (1968) also found Atlantic menhaden eggs to be relatively uniform from the surface to depths of 30 m in Long Island Sound.

Fish larvae were dominated by bay anchovy (82% total catch) in the samples on October 4, 2005. Bay anchovy also comprised about 80% of the larvae in samples from August 23, 2005 although densities were 1-2 orders of magnitude higher than in October (Figure 7). Bay anchovy larval density was greater at night although the diel difference was not as pronounced as it was in the August samples (Figure 7). Olney and Boehlert (1988) found higher densities of bay anchovy larvae at night than during daytime. During the daytime samples bay anchovy larvae were more abundant in the surface and mid-depth strata than near bottom, while at night they were most abundant mid-depth. This pattern differed from the August samples where bay anchovy appeared to migrate to surface waters at night, a pattern also observed by Bourne and Govoni (1988) in Narragansett Bay.

Atlantic menhaden larvae were collected in higher densities during the daytime and were most concentrated in the deep sampling strata. Menhaden larvae are pelagic and those spawned offshore may spend up to several months in continental shelf waters before being transported to estuaries at lengths of 10-22 mm (Massmann et al. 1962, Nelson et al. 1977). In the ocean, larvae appear to be most concentrated in upper water column (Kendall and Reintjes 1975, Nelson et al. 1977, Judy and Lewis 1983). With movement inshore, larval menhaden are found closer to the bottom (Kjelson et al. 1976 cited in Collette and Klein-MacPhee 2002) which may partially explain why they were most concentrated in the deep strata during sampling on October 4, 2005.

The vertical distribution of fish larvae is influenced by the same physical factors as for eggs but with the additional effects of specific and ontogenetic behavioral responses to environmental factors. In general, there is a feeding advantage in being distributed in the upper, more productive layers of the water column, where food is present in higher abundance (e.g. Coombs et al. 1992, 1994). Additionally, there is the influence of predation which may lead to the observed peak of larval abundance representing a tradeoff between avoidance of predators and food availability (Fortier and Harris 1989). The observed differences in depth distribution of larval fish during day and night may also reflect some aspect of diel migration and/or net avoidance in the more illuminated surface waters.

Net avoidance is an important source of uncertainty in abundance estimates of fish larvae using towed nets (Tranter and Smith 1968). Avoidance involves complex reactions of fish larvae to the approach of the net, including sensory perception of the net and a variety of avoidance reactions. Because net avoidance is size and species related, estimates of population size, species diversity, and vertical distribution of larval fish within the water column may be biased (Thayer et al. 1983). Numerous studies have found significantly higher catches of fish larvae at night compared to day, suggesting that visual perception of the net by larvae affects catch rates (Ahlstrom 1954, Clutter and Anraku 1968). Also, night to day density ratios of fish larvae have been shown to increase with increasing size (and increasing mobility) of the larvae (Ahlstrom 1954, Smith 1981). Night sampling may therefore mitigate the effect of some environmental factors on density estimations. The higher observed larval densities in the surface and mid-depth strata at night are likely partially attributable a reduction in net avoidance through visual stimuli at night.

Although higher catches at night is partly explained by reduced nighttime visibility of the gear (Noble 1970, Murphy and Clutter 1972), diel migrations may also contribute (Noble 1970, Stickney 1972). Fish larvae are nonrandom in their distribution in both vertical and horizontal dimensions and are capable of changing their position in the water column in response to certain biological or physical stimuli such as avoiding predators in well lit surface waters or to follow zooplankton prey. Larvae of many species rise to the surface by night and descend by day (e.g., Seliverstov 1974, Smith et al. 1978, Kendall and Naplin 1981, Sameoto 1982, 1984, Leis 1986). Speculation about causes of vertical migration has centered around diel feeding behavior and predator avoidance. Most larval fishes are visual feeders on zooplankton, which are well documented to migrate up from depth during the day to occupy shallower waters at night (Haney 1988). Substantial data suggest that light plays an important but different role in structuring vertical distribution patterns in zooplankton versus ichthyoplankton (Munk et al. 1989, Falkenhaug et al. 1997, Gronkjaer and Wieland 1997). While zooplankton are able to use depth as a refuge during the day and rise to surface waters to feed at night, larval fishes are predominantly visual feeders and require sufficient light to feed (Blaxter 1988, Gerking 1994). Larval fish will, therefore, be limited in terms of maximum sustainable depths by the exponential decline in light intensity with depth (Job and Bellwood 2000). The lower limit of larval fish vertical distributions may be set by the minimum light intensity at which feeding is possible. In addition, Zaret and Suffern (1976) concluded that vertical migration patterns occur in prey species that are vulnerable to visually dependent predators, thus larvae may reduce predation by moving to deeper water during the day. Diel migrations may be triggered by the search for an optimum light intensity in which to minimize predation while maximizing feeding rates, in the evening this hypothetical level of optimum illumination will progressively reach the surface (Fortier and Leggett 1983).

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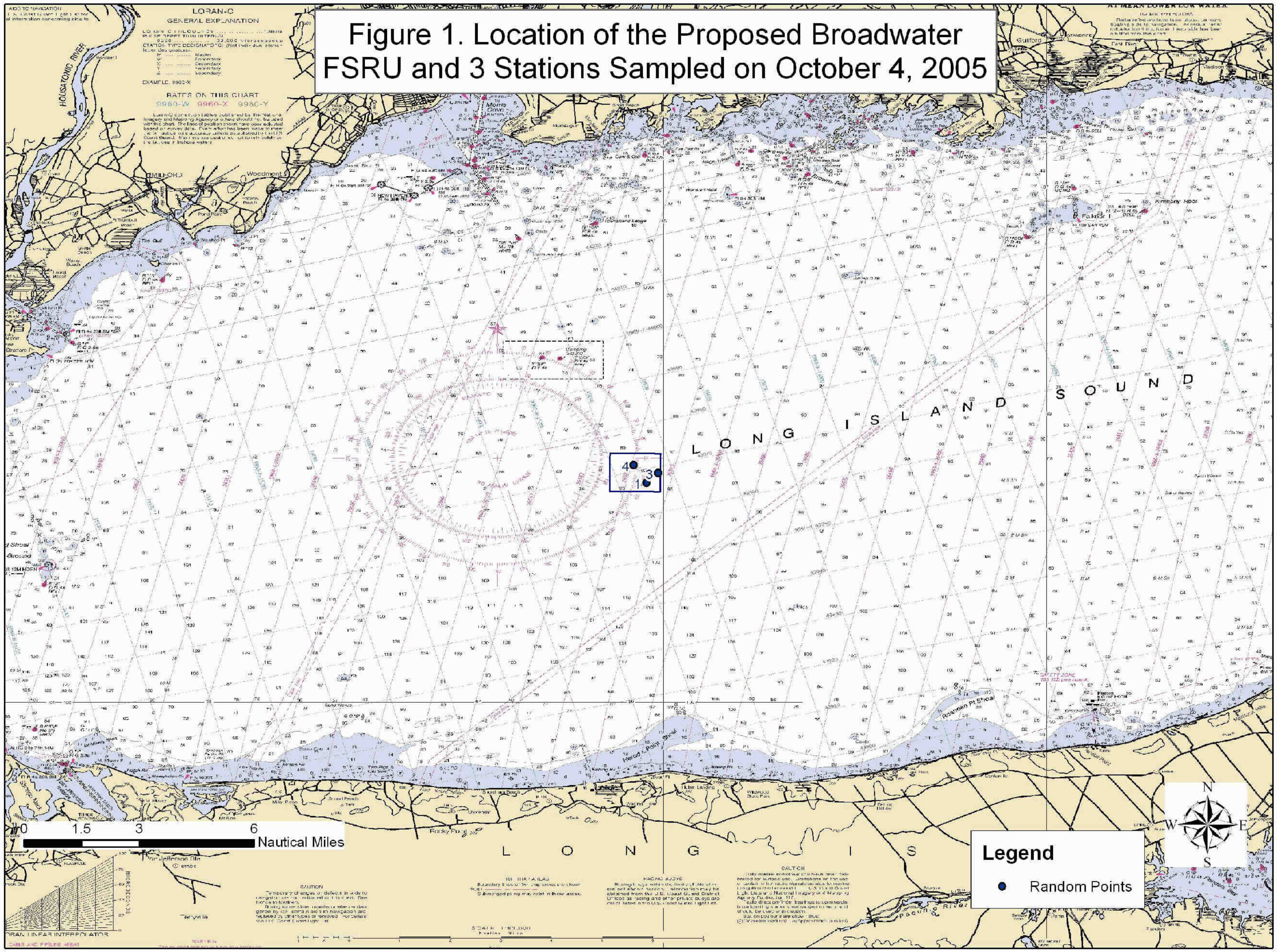
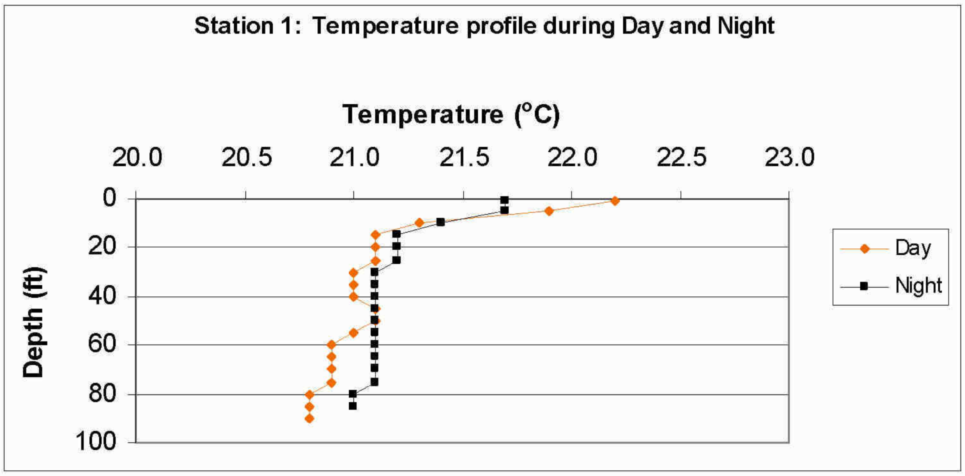
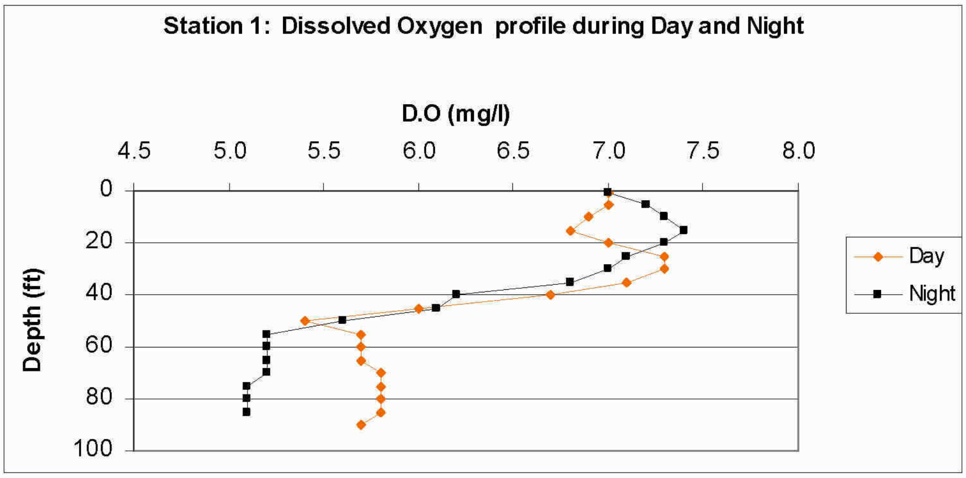


Figure 1. Location of the Proposed Broadwater FSRU and 3 Stations Sampled on October 4, 2005





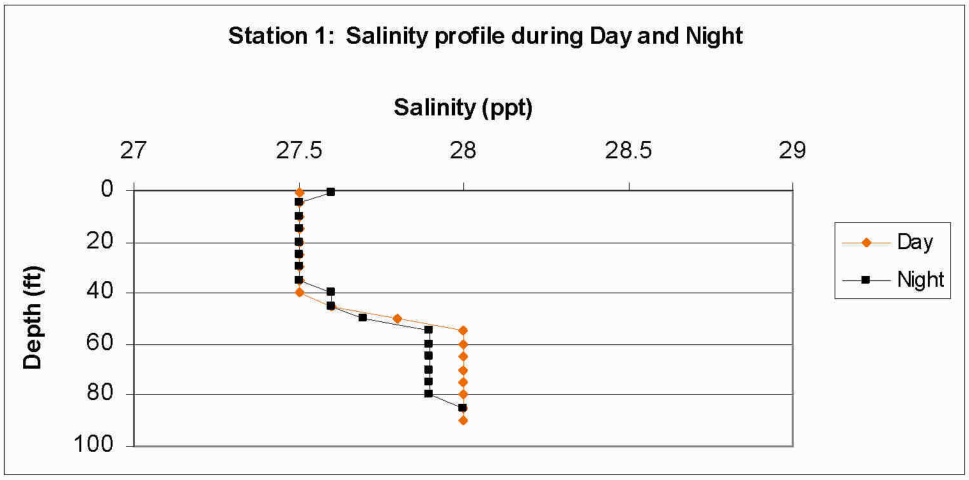


Figure 2. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 1 on October 4, 2005.

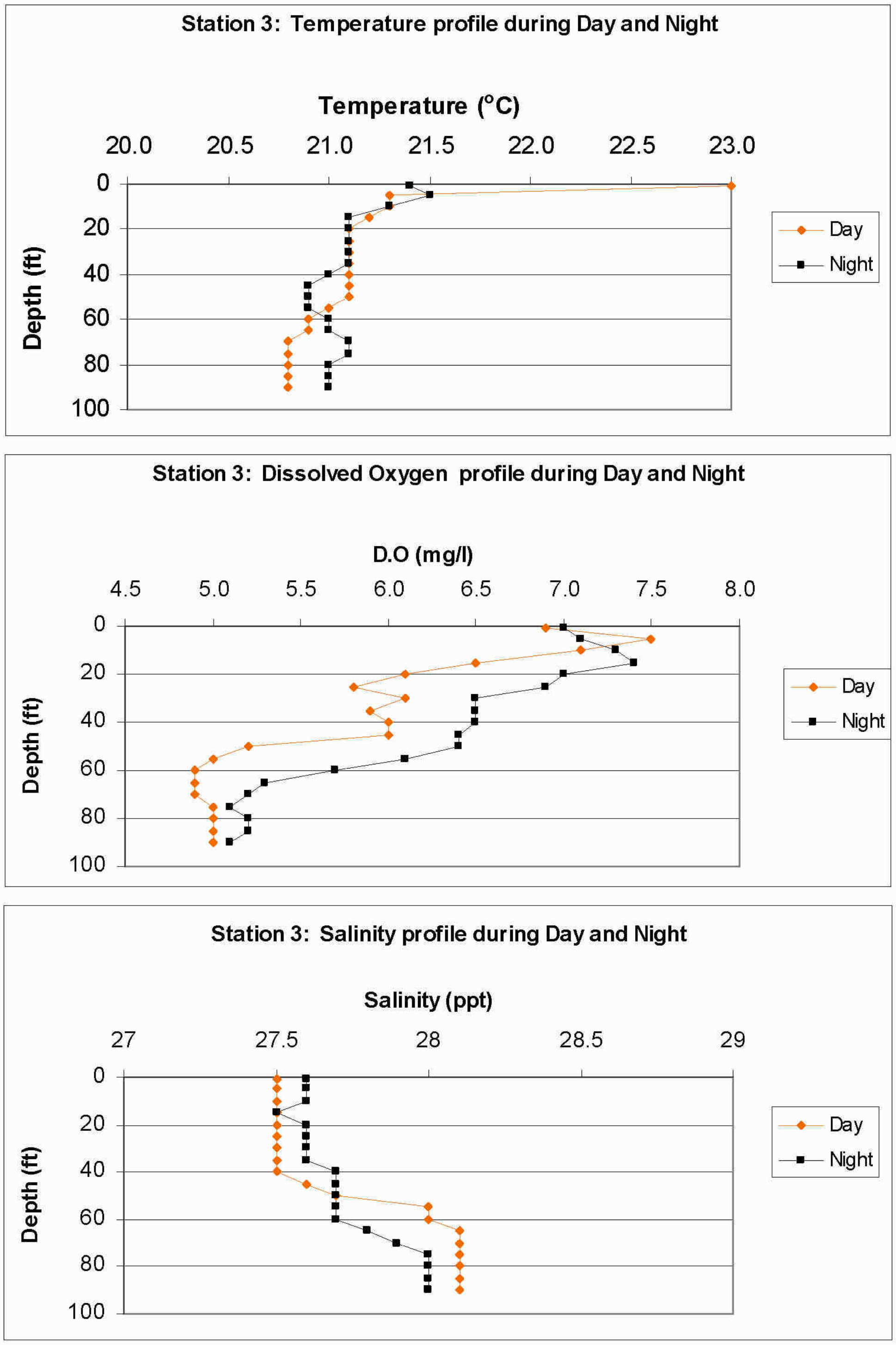


Figure 3. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 3 on October 4, 2005.

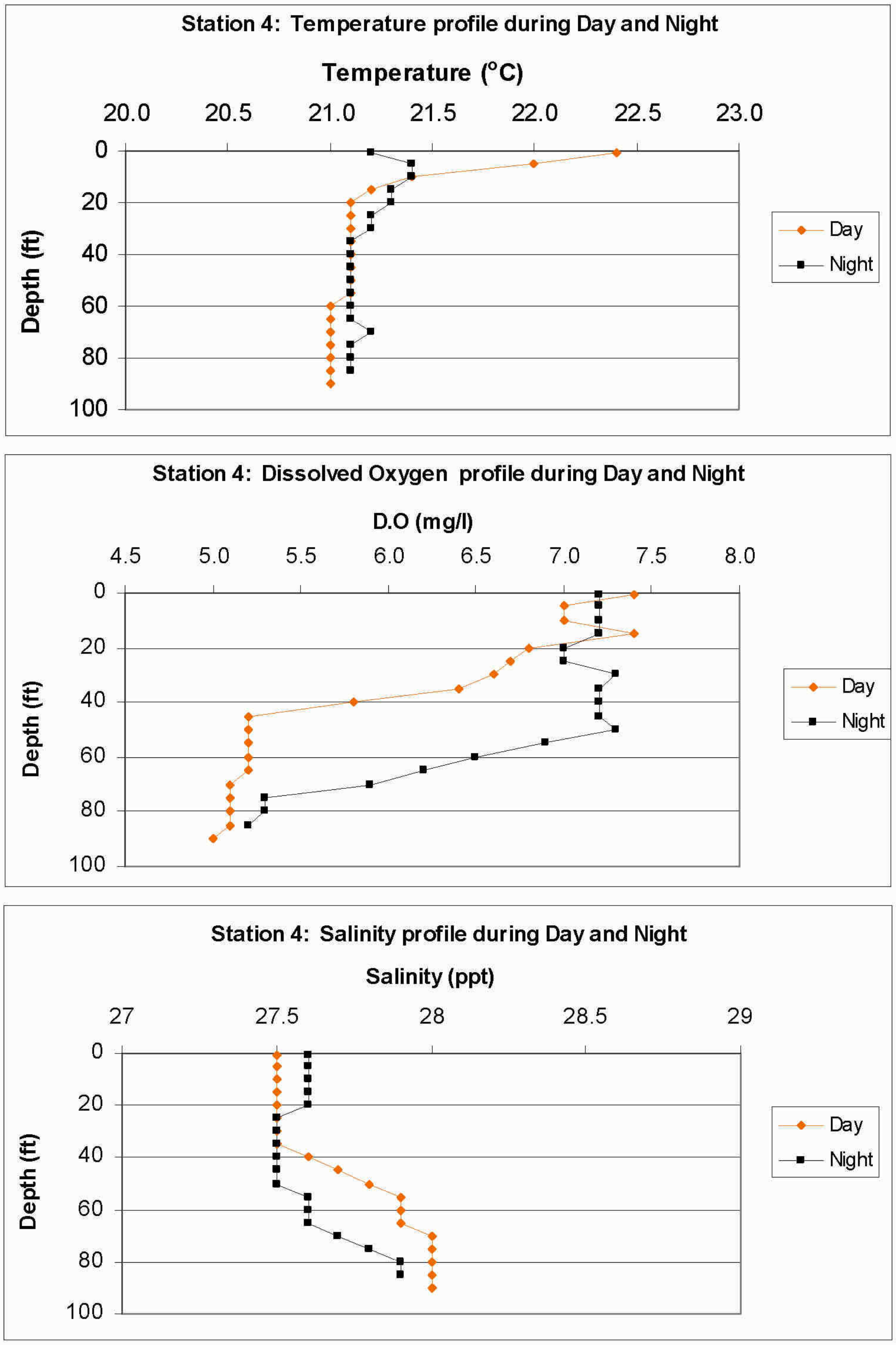


Figure 4. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 4 on October 4, 2005.

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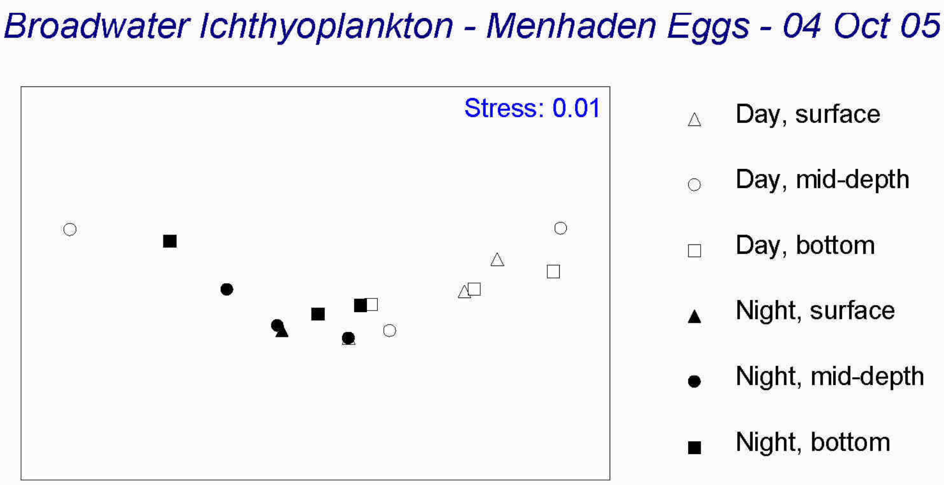


Figure 5. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on October 4, 2005 for untransformed egg density (#/100m^3) based on Bray-Curtis similarities.

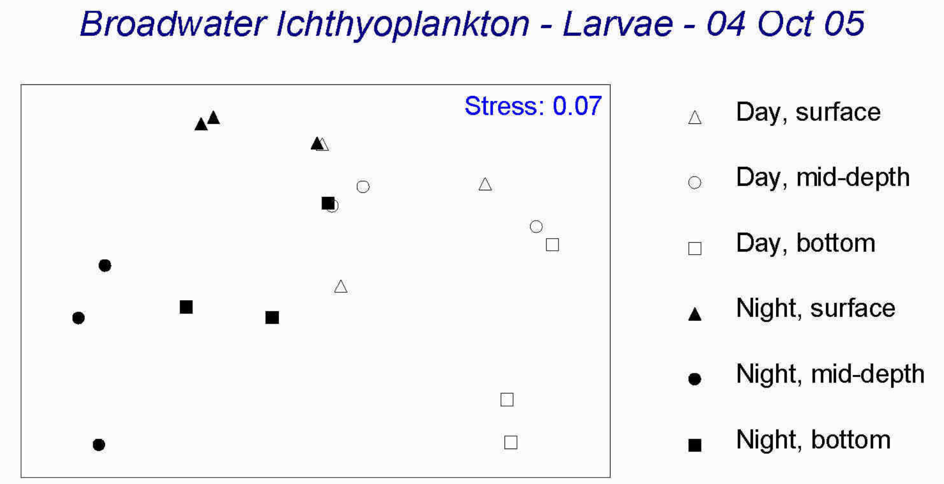


Figure 6. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on October 4, 2005 for untransformed egg density (#/100m^3) based on Bray-Curtis similarities.

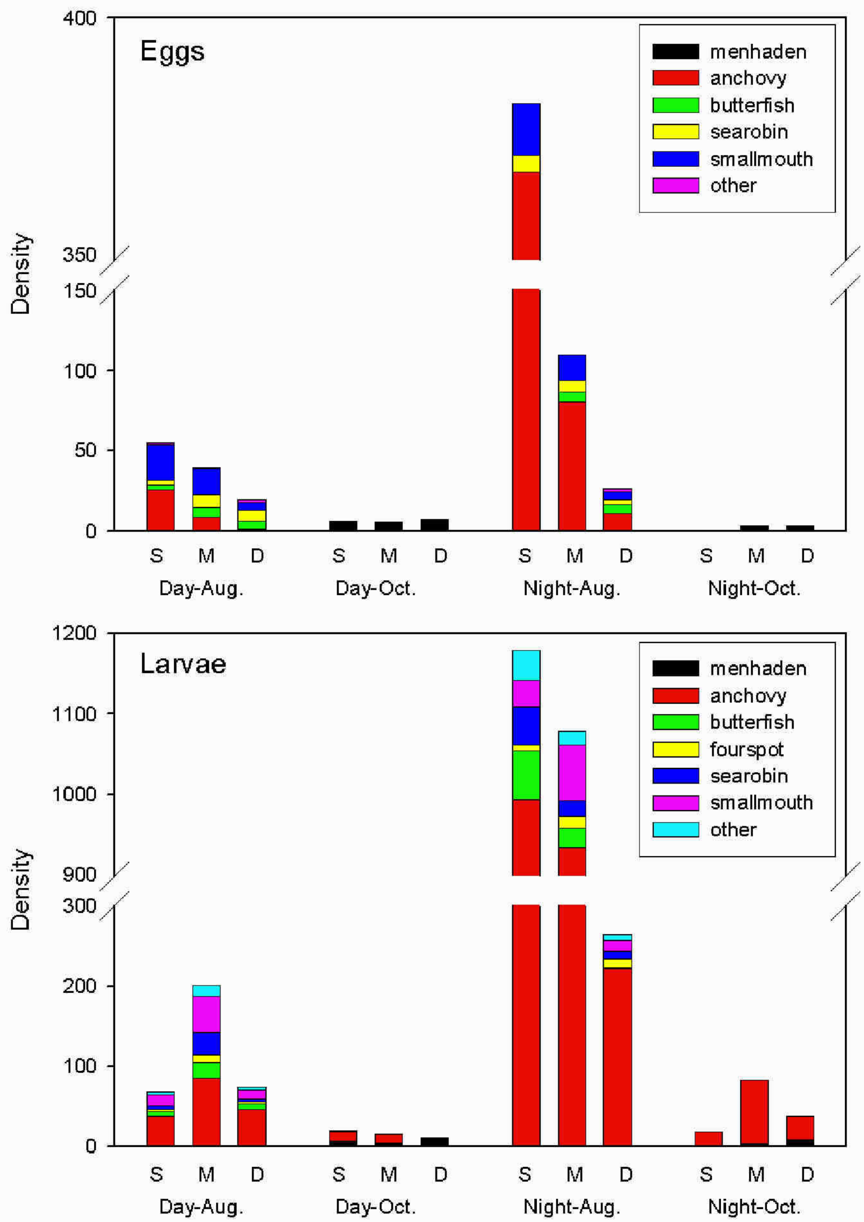


Figure 7. Density (#/100 m^3) of eggs and larvae of abundant species (Atlantic menhaden, bay anchovy, butterfish, fourspot flounder, searobin, smallmouth flounder, other) collected during day and night sampling in each depth strata (S=surface, M=mid-depth, D=deep) on August 23 and October 4, 2005.

Table 1. Sample allocation, sample depths and volume of water sampled (m^3) among the three stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on October 4, 2005.

Station	Depth Strata	Sample Depth (ft.)	Diel Period	Volume Sampled
1	Surface	20	Day	56.8
	Mid-depth	45		63.2
	Bottom	80		49.8
	Surface	20	Night	72.6
	Mid-depth	43		55.1
	Bottom	75		51.7
3	Surface	20	Day	55
	Mid-depth	46		55.8
	Bottom	82		52.7
	Surface	20	Night	56.1
	Mid-depth	45		60.6
	Bottom	80		122.1
4	Surface	20	Day	66.5
	Mid-depth	45		46.7
	Bottom	80		42.7
	Surface	20	Night	47.9
	Mid-depth	42		97.5
	Bottom	75		103.2

Table 2. Temperature, dissolved oxygen, and salinity at the three stations during day and night sampling in the vicinity of the proposed Broadwater FSRU on October 4, 2005.

	Temperature (°C)				Dissolved Oxygen (mg/l)				Salinity ($^0/_{00}$)			
	min	max	mean	stdev.	min	max	mean	stdev.	min	max	mean	stdev.
Station 1												
Day	20.8	22.2	21.1	0.4	5.40	7.30	6.34	0.67	27.5	28.0	27.7	0.3
Night	21.0	21.7	21.2	0.2	5.10	7.40	6.17	0.95	27.5	28.0	27.7	0.2
Station 3												
Day	20.8	23.0	21.1	0.5	4.90	7.50	5.73	0.83	27.5	28.1	27.8	0.3
Night	20.9	21.5	21.1	0.2	5.10	7.40	6.21	0.82	27.5	28.0	27.7	0.2
Station 4												
Day	21.0	22.4	21.2	0.4	5.00	7.40	5.92	0.91	27.5	28.0	27.7	0.2
Night	21.1	21.4	21.2	0.1	5.20	7.30	6.68	0.76	27.5	27.9	27.6	0.1

Table 3. **Number of eggs and larval (yolk-sac + post yolk-sac stages) and young of the year (YOY) fish and the percent contribution to the total catch by species in the 18 ichthyoplankton tows conducted in the vicinity of the proposed Broadwater FSRU on October 4, 2005.**

Common Name	Scientific Name	# Eggs	% Total Eggs	# YSL	# PYSL	# Larvae	% Total Larvae	# YOY	% Total YOY
Atlantic Menhaden	*Brevoortia tyrannus*	63	100	4	69	73	18.3		
Bay Anchovy	*Anchoa mitchilli*				325	325	81.5	8	100
Feather Blenny	*Hypsoblennius hentzi*				1	1	0.3		
TOTAL		63		4	395	399		8	

Table 4. Mean egg density (#/100m³) and percent of the total egg catch comprised by Atlantic menhaden in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on October 4, 2005.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total
Atlantic menhaden	8.3	100	7.4	100	9.6	100	1.4	100	4.3	100	4.4	100
Total	8.3		7.4		9.6				4.3		4.4	

Table 5. Two-way ANOVA evaluating the effect of diel period (day or night) and depth strata (surface, mid-depth, or near bottom) on log (x+1) transformed larval (yolk-sac larvae + post yolk-sac larvae) and egg densities (#/100m^3). * = 0.05>P>0.01, ** = 0.01<P>0.001, *** = P<0.001, NS = not significant.

Response Variable	Source of Variation	DF	SS	MS	F	P	Significance
Atlantic Menhaden Egg Density	Diel Period	1	0.63	0.63	9.53	<0.01	**
	Depth Strata	2	0.21	0.11	1.61	0.24	NS
	Diel*Depth	2	0.30	0.15	2.26	0.15	NS
Larval Density	Diel Period	1	0.71	0.71	24.09	<0.001	***
	Depth Strata	2	0.24	0.12	4.02	0.05	NS
	Diel*Depth	2	0.39	0.19	6.53	0.01	*
Bay Anchovy Larvae Density	Diel Period	1	2.46	2.46	46.25	<0.0001	***
	Depth Strata	2	0.89	0.44	8.35	<0.01	**
	Diel*Depth	2	0.67	0.33	6.30	0.01	*
Atlantic Menhaden Larvae Density	Diel Period	1	0.39	0.39	6.53	0.03	*
	Depth Strata	2	0.65	0.33	5.47	0.02	*
	Diel*Depth	2	0.34	0.17	2.84	0.10	NS

Table 6. Mean larvae (yolk sac + post yolk sac stage) density (#/100m^3) and percent of the total catch comprised for each species collected in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on October 4, 2005.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total
Atlantic menhaden	7.6	38.2	5.5	36.0	10.0	88.2	0.9	6.3	4.0	4.6	8.9	22.2
Bay anchovy	11.1	58.8	10.2	64.0	1.4	11.8	17.4	93.8	78.9	95.4	29.3	77.8
Feather Blenny	0.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	19.3	100.0	15.7	100.0	11.4	100.0	18.3	100.0	82.9	100.0	38.1	100.0

Table 7. **Egg, yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during daytime sampling in the vicinity of the proposed Broadwater FSRU on October 4, 2005.**

Daytime Survey

Species	Life Stage	Station 1			Station 3			Station 4		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Atlantic menhaden	Egg	11	2	6	5	14	13	9	6	9
	YSL						2			2
	PYSL	5	5	12	15	5	11	3	6	2
Bay anchovy	PYSL	5	3		15	13	2	14	15	2
Feather blenny	PYSL	2								
Unidentified	N/A		2							

Table 8. **Egg, yolk-sac larvae (YSL), post yolk-sac larvae (PYSL) and young of the year (YOY) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during nighttime sampling in the vicinity of the proposed Broadwater FSRU on October 4, 2005.**

Nighttime Survey

Species	Life Stage	Station 1			Station 3			Station 4		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Atlantic menhaden	Egg		5	6		3	2	4	4	5
	YSL						2			
	PYSL	3	2	6		8	7		2	13
Bay anchovy	PYSL	14	51	15	20	117	44	19	69	28
	YOY		2	4					5	

Table 9. **Species richness (# species identified to at least genus level in a sample), Shannon-Wiener diversity index (H'), and density (#/100m^3) of eggs and larvae (yolk-sac + post yolk-sac stage) at the three sampling stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on October 4, 2005.**

Station	Depth Strata	Diel Period	Species Richness		Diversity (H')		Density	
			Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
1	Surface	Day	1	3	0	1.0	11	12
	Mid-depth		1	2	0	0.7	2	8
	Bottom		1	1	0	0.0	6	12
	Surface	Night	1	2	0	0.5	0	17
	Mid-depth		1	2	0	0.2	5	53
	Bottom		1	2	0	0.6	6	21
3	Surface	Day	1	2	0	0.7	5	29
	Mid-depth		1	2	0	0.6	14	18
	Bottom		1	2	0	0.4	13	15
	Surface	Night	1	1	0	0.0	0	20
	Mid-depth		1	2	0	0.2	3	125
	Bottom		1	2	0	0.4	2	52
4	Surface	Day	1	2	0	0.5	9	17
	Mid-depth		1	2	0	0.6	6	21
	Bottom		1	2	0	0.6	9	7
	Surface	Night	1	1	0	0.0	4	19
	Mid-depth		1	2	0	0.1	4	71
	Bottom		1	2	0	0.6	5	41

Table 10. Average density (#/100m^3) of Atlantic menhaden and bay anchovy ichthyoplankton collected during Day (n=3) and Night Tows (n=3) from the Mid-depth strata in the vicinity of the proposed Broadwater FSRU on October 4, 2005. Daily entrainment estimates were determined by multiplying the average density by the daily withdrawl by the FSRU and associated LNG carriers (28.2 MGD, 106,750 m^3/day).

Species	Stage	Average Density (#/100m^3)	Daily Entrainment Estimate
Atlantic menhaden	Egg	5.9	6,245
	YSL	0.0	0
	PYSL	4.8	5,071
Bay Anchovy	Egg	0.0	0
	YSL	0.0	0
	PYSL	44.6	47,557
	YOY	1.2	1,245

Table 11. Life history parameter values used by EPA (2004) to calculate daily age 1 equivalent estimates lost to entrainment in the FSRU facility for Atlantic menhaden and bay anchovy. Instantaneous Total Mortality (Z) is the sum of Natural Morality (M) and Fishing Mortality (F), (Z = M+F). Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S= e^{-z}$).

Species	Stage Name	M[a]	F[a]	Z	S	Estimated Number Entrained that would Survive			
						Egg to Later Stages	Yolksac Larvae to Later Stages	Post Yolksac Larvae to Later Stages	Estimated Total # Age 1 Entrained
Atlantic menhaden	Eggs	2.08	0	2.08	0.125	780			
	Yolksac Larvae	2.85	0	2.85	0.058	45	293		
	Post-yolksac larvae	2.85	0	2.85	0.058	3	17		
	Juvenile	2.85	0	2.85	0.058	0	1		
	Age 1+	0.45	0	0.45	0.638	0	1		1
Bay Anchovy	Eggs	1.04	0	1.04	0.353	0			
	Yolksac Larvae	1.57	0	1.57	0.208	0			
	Post-yolksac larvae	6.12	0	6.12	0.002	0	105		
	Juvenile	1.29	0	1.29	0.275	0	29	343	
	Age 1+	1.62	0	1.62	0.198	0	6	68	74

[a] From Table D1-6 (Atlantic menhaden) and Table D1-11 (bay anchovy) in EPA (2004).

Attachment 3

Broadwater Ichthyoplankton Assessment Protocols

BROADWATER ICHTHYOPLANKTON ASSESSMENT PROTOCOLS

INTRODUCTION

Broadwater Energy, a joint venture between TCPL USA LNG, Inc., and Shell US Gas & Power LLC, is filing an application with the Federal Energy Regulatory Commission (FERC) seeking all of the necessary authorizations pursuant to the Natural Gas Act to construct and operate a marine liquefied natural gas (LNG) terminal and subsea pipeline for the importation, storage, regasification, and transportation of natural gas. The Broadwater LNG Project (the Project) will increase the availability of natural gas to the New York and Connecticut markets through an interconnection with the Iroquois Gas Transmission System (IGTS). The FERC application for the Project requires the submittal of 13 Resource Reports, with each report evaluating Project effects on a particular aspect of the environment.

The proposed Broadwater LNG terminal will be located in Long Island Sound (the Sound), approximately 9 miles (14.5 kilometers [km]) from the shore of Long Island in New York State waters. It will be designed to receive, store, and regasify LNG at an average throughput of 1.0 billion cubic feet per day (bcf/d) and will be capable of delivering a peak throughput of 1.25 bcf/d. The Project will deliver the regasified LNG to the existing natural gas pipeline system via a subsea interconnection to the IGTS pipeline.

The proposed LNG terminal will consist of a Floating Storage and Regasification Unit (FSRU) that is approximately 1,215 feet (370 meters [m]) in length, 200 feet (60 m) in width, and rising approximately 80 feet (25 m) above the water line to the trunk deck. The FSRU's draft is approximately 40 feet (12 m). The FSRU will be designed to accommodate a net storage capacity of approximately 8 billion cubic feet (bcf) (350,000 cubic meters [m^3]) of LNG, with base vaporization capabilities of 1.0 bcf/d using a closed-loop shell and tube vaporization (STV) system. The LNG will be delivered to the FSRU in LNG carriers with cargo capacities ranging from 125,000 m^3 to 250,000 m^3 at the frequency of two to three carriers per week.

The FSRU will be moored in place using a yoke mooring system (YMS) that allows the FSRU to weathervane around the mooring tower base. The YMS includes a stationary tower structure, secured to the seafloor by four legs. The total area under the tower structure, which houses the connection between the FSRU and the proposed new subsea connecting pipeline, is of open design and will be approximately 13,180 square feet (1,225 square meters [m^2]).

A 30-inch-diameter subsea natural gas pipeline will deliver the vaporized natural gas to the existing IGTS pipeline. It will be lowered below the seafloor from the FSRU mooring structure to an interconnection location at the existing 24-inch-diameter subsea section of the IGTS pipeline, approximately 22 miles (35 km) west of the proposed FSRU site. To stabilize and protect the operating components, sections of the pipeline will be covered with engineered back-fill material or spoil removed during the lowering operation.

During the course of the FERC NEPA Pre-file process, concern has been raised regarding potential impacts to the ichthyoplankton (IP) resulting from operation of the proposed FSRU. Based on the current design of the Project, it is estimated that average daily intake volume for the FSRU is about 5.5 million gallons, assuming an annual average of 118 carriers per year calling at the FSRU. Additional water intake will be required for the LNG carriers to take on ballast water and to use seawater as once-through cooling water. Average daily water intake associated with the LNG carriers is about 23 million gallons.

Based on available literature, much of the IP existing within the Sound *a)* rely on inshore estuarine habitats, *b)* are buoyant restricting them to the upper few feet of the water column, or *c)* are demersal, found primarily at the bottom of the Sound. The FSRU and the LNG will withdraw water for ballasting purposes, and general purpose usage, from intake structures located either at the bottom of the hull or at the turn of the bilge on the hull. Water withdrawal, therefore, will occur from the approximate middle of the water column, at depths between 30 and 45 feet of water, depending on the actual draft of the facility/vessel. Additionally, water intakes on the FSRU will be designed to minimize the uptake flow rate, with anticipated withdrawal rates at 0.5 feet/second or less. Based on the design of the intakes and intake depths, impacts would be primarily limited to a few species; those that have pelagic egg and larval stages, or those that transform from a buoyant to demersal stage between egg and larval stages.

To define the IP communities that exist within the Central Basin of the Sound and to confirm that anticipated minimal impact to existing IP within the Sound, Broadwater will be assessing the distribution and density of IP in proximity to the proposed FSRU.

Assessment Design

Broadwater proposes to use a combination of field collected data and existing research data to assess potential impacts to IP. In general, IP data is relatively sparse within the Sound. While NOAA has undertaken large scale IP surveys along the eastern seaboard, these surveys are focused on federal waters, and have largely excluded the state waters of Long Island Sound. Existing research data has been collected largely on a project-by-project basis within the Sound, with no annual programs identified. Projects such as Millstone Nuclear Power Plant are required to conduct annual IP sampling. However, due to the inshore, shallow estuarine conditions that are proximate to the facility, no correlation of this data can be made to the Broadwater Project. The New York Power Authority (NYPA) did undertake a broad IP sampling regime in 2002, across all New York State marine waters, including the Hudson River, New York/New Jersey Harbor, and Long Island Sound. Although not publicly available, the NYPA has agreed to provide this data to Broadwater. NYPA conducted a biweekly sampling effort between March on August in 2002 with samples taken in three distinct water column strata (Shallow: 3-6 meters, Mid Depth: 6-30 meters, and Deep: >30 meters).

This NYPA data will form the basis of the IP analysis for Broadwater. To complement the NYPA data, Broadwater is proposing to conduct limited IP sampling as QA of the existing data, and to evaluate seasonal distributions of IP not covered in the NYPA study.

Field Sampling

Broadwater proposes a seasonal ichthyoplankton sampling program to be completed in Long Island Sound. Three sampling stations will be randomly selected within an approximate 1 x 1 nautical mile block centered on the proposed FSRU facility. The sampling at each station was designed to approximate the data collected for NYPA to allow reasonable comparison of the data.

At each station the water column will be divided into three depth strata. Assuming a bottom depth of approximately 95 feet, the first depth stratum (surface) will include the surface to 30 ft, the second depth stratum (middle) will include water from 35 ft to 65 ft, and the third (bottom) stratum will include water from 70 ft to near bottom (95 feet). One sample will be collected in each depth stratum during daylight (defined as occurring between 1 hour after sunrise and 1 hour before sunset) and the daytime sampling will be repeated again at night (defined as occurring between 1 hour after sunset and 1 hour before sunrise) on six sampling dates (August 2005, September or October 2005, Feb. /March 2006, April 2006, May 2006, and June 2006). Sampling will occur during good weather windows in the specified months and may not necessarily occur on the same days each month. Therefore, the total number of samples to be collected in the proposed study design includes: 3 stations x 3 depths x 2 diel periods x 6 dates for a total of 108 samples. If initial sampling of the data provides close correlation to the NYPA data, Broadwater, under consultation with the resource agencies, may elect to discontinue sampling and rely primarily on the NYPA data.

Broadwater has retained Normandeau Associates to collect the IP data. Normandeau was also involved with the sampling for the NYPA survey. Sampling will be conducted using Normandeau's 25 ft R/V *Privateer* which will be launched from Milford, CT. All samples will be collected with a 1.0 m^2 Tucker trawl with a 0.335 mm net and an 8:1 length to mouth ratio. The tucker trawl has a closing device that uses a double-trip release mechanism and a weighted lead bar to close the mouth of the net and insure that each sample is collected in each of the three discrete depth strata. Net towing speed will be 1.0 m/sec. for a sufficient duration (5 minutes) to insure that a 300 m^3 sample ($\pm$10%) is collected. A flume-calibrated digital flowmeter (GO Model 2030R) will be placed in the mouth of the Tucker trawl to measure the distance (volume) of each tow. While approximate 5 minute tow duration is proposed, infield modification may be required to reflect existing conditions. For example, the tow durations for the sampling conducted in August of 2006 were reduced due to the densities of comb jellies throughout the water column, which clogged the nets. Tow depth will be determined in the field using a cosine function relating wire length and wire angle to sampling depth. The start and end of each towpath will be recorded along with tow distance using GPS. Samples will be fixed at sea in 4% buffered formaldehyde and changed over to 80% ethanol within 12-18 hours. A conductivity, salinity, temperature, dissolved oxygen and depth profile will be made at

5 foot intervals from one foot below the surface to one foot above the bottom at each station and diel period using a YSI Model 85 (or the equivalent) meter (36 total profiles).

To assure proper coordination with the existing lobster fishery within the project area, Broadwater will staff all field surveys with a fisheries observer from the local community to assure no adverse impacts to deployed lobster fishing gear.

Laboratory Analysis

Each of the 108 samples collected will be split in half using a Folsom Plankton Splitter, and one randomly selected half representing approximately $150m^3$ of sample volume will be sorted under magnification to remove all fish eggs, fish larvae, and lobster larvae. Normandeau's laboratory will then enumerate and identify the fish eggs, fish larvae, and any lobster larvae removed from the sorted fraction in each of the 108 samples to the lowest possible taxon (generally genus and species). A reference collection will be established and ichthyoplankton taxonomy will include enumeration of all fish into the following life stages: egg, yolk sac larvae and post yolk sac larvae. In addition, winter flounder will be enumerated into four life stage categories, and lobster larvae will also be enumerated into four life stage categories. The sort residue will be disposed of after quality control checks. The unanalyzed half of each sample will be returned to the original container, archived, and held for a period of one year following the end of sampling (i.e. held until 1 September 2007).

Normandeau will prepare and implement a QA/QC program that provides a 10% average outgoing quality limit (AOQL) for all laboratory measurement parameters and a 1% AOQL for all data calculations. For each sample, ichthyoplankton counts will be standardized to densities (number of larvae per $1000m^3$ of water filtered) for each species/taxa. The report will include a description of the field and laboratory methods, including the QA/QC plan, and present a graphical, tabular and narrative summary of the results with respect to water quality and the ichthyofauna community observed during each sampling event. Dominant species/taxa, total larval fish and lobster densities, species richness and diversity (Shannon-Weiner index) will be described for each sample. Comparison of the ichthyofauna community among the three depth strata over time will utilize either the Schoener index of niche overlap or the Bray-Curtis index of similarity. Only fish identified to at least the genus level will be used in diversity and similarity analyses.

APPENDIX F

CORRESPONDENCE

ecology and environment, inc.
International Specialists in the Environment

BUFFALO CORPORATE CENTER
368 Pleasant View Drive, Lancaster, New York 14086
Tel: (716) 684-8060, Fax: (716) 684-0844

February 24, 2005

Ms. Jean Pietrusiak
New York State Department of
Environmental Conservation
Natural Heritage Program
625 Broadway
Albany, NY 12233-4757

Re: Broadwater LNG Project, Long Island Sound, New York

Dear Ms. Pietrusiak:

Broadwater Energy, a joint venture between Shell US Gas and Power, LLC, and TransCanada Pipeline USA Ltd., is proposing to construct a liquefied natural gas (LNG) import terminal in the New York State waters of Long Island Sound, and an approximately 25 mile marine pipeline connecting the terminal to the existing Iroquois Gas Transmission System pipeline. The proposed location for the terminal and interconnecting pipeline was developed through a rigorous alternatives assessment and input from various federal and state agencies. Broadwater has initiated the design phases for both the terminal and the marine pipeline. Since the current proposed location has been developed solely from a desktop study, the final location may be slightly modified based on more detailed engineering and environmental surveys to be conducted in the winter and spring of 2005. The preliminary siting area for the terminal and pipeline are depicted on the attached figure. Coordinates for the siting area are also depicted.

Broadwater is requesting information regarding the presence of endangered or threatened plant and animal species, species of special concern and the existence of critical or significant habitats on or within 1.5 miles of the potential project site and pipeline route identified on the attached maps. This information is being requested in order to facilitate site selection, selection of installation technologies and completion of permit and licensing applications.

The proposed terminal consists of a ship-like vessel (a Floating Storage Re-gasification Unit (FSRU)) moored in Long Island Sound approximately 9 miles off the coast of Riverhead, New York and approximately 11 miles from the nearest Connecticut shoreline. The proposed FSRU would be approximately 1,200 feet long and 180 feet wide, with a deck that would rise 75 to 100 feet above the water line. The FSRU would be constructed at a shipyard, towed to a site in the Sound, and attached to a yoke mooring system. The yoke mooring system would be supported by a tower structure, which would be attached to a base that occupies approximately 7000 square feet of the seafloor. The FSRU would pivot around the mooring tower.

The LNG would be re-gasified aboard the FSRU and distributed to the New York and Connecticut markets via the existing Iroquois pipeline. The marine pipeline, approximately 25 miles in length, would connect the FSRU with the existing sub sea Iroquois natural gas pipeline via a subsea interconnect. The concrete coated, 30-inch diameter, gas pipeline would be installed beneath the seabed using a trenching operation. Depending on the trenching method used, the pipe would be either laid directly into the trench or would be placed on the seabed then lowered beneath.

Additional information regarding the project is available at www.broadwaterenergy.com.

Corresponding requests have been submitted to the U. S. Department of the Interior; Fish and Wildlife Service, 3817 Luker Road, Cortland, New York 13045; and to NOAA Fisheries, Habitat Conservation Division, 212 Rogers Avenue, Milford CT 06460-6499.

Thank you for your consideration in this matter. We look forward to coordinating further with you on this project. If you have any questions or require additional information, please feel free to contact me, or Michael Donnelly, at (716) 684-8060 or by e-mail at lweaver@ene.com.

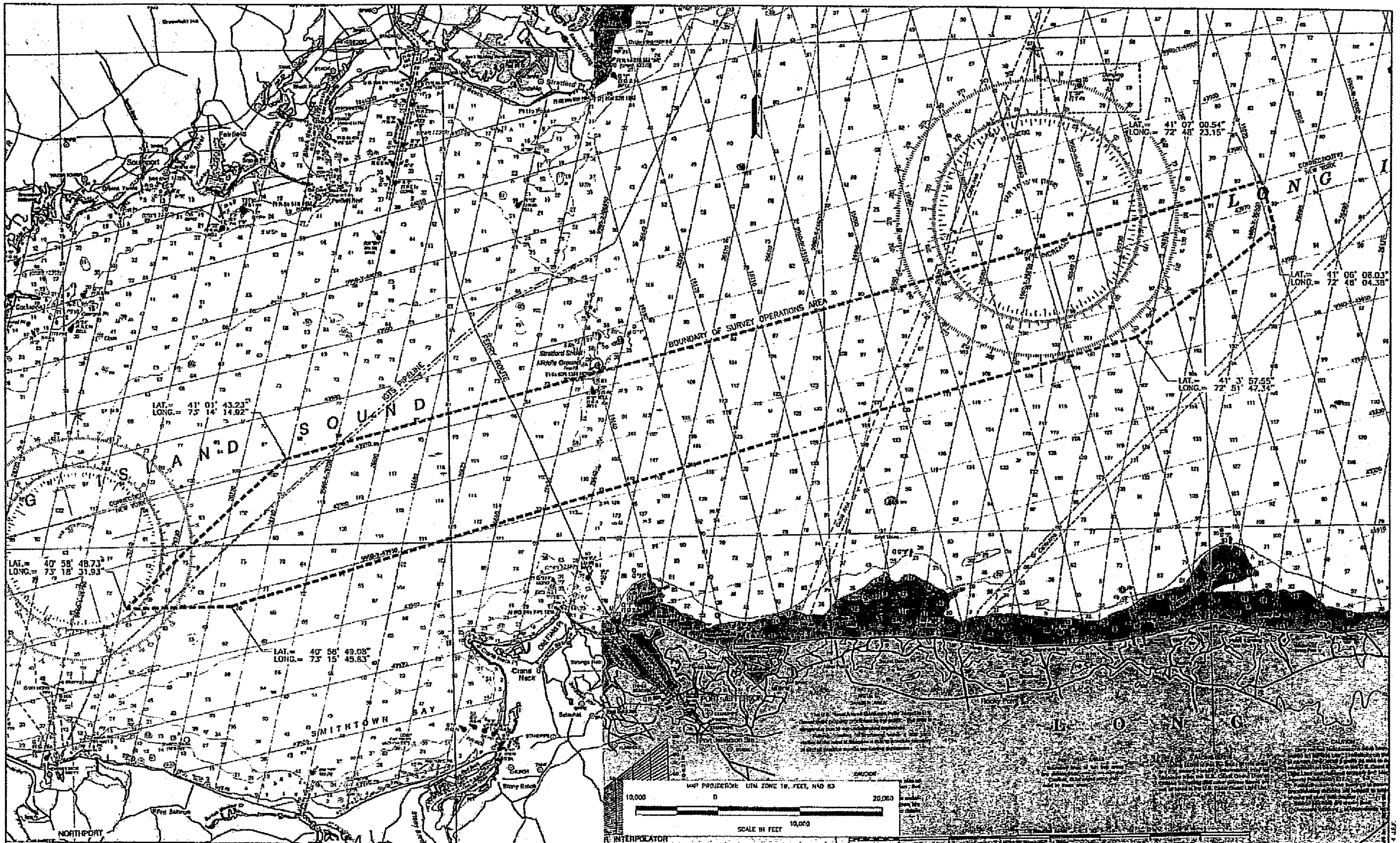
Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

Laurie K. Weaver

Laurie K. Weaver
Project Biologist

CC: Sandra Barnett, Broadwater
Stephen Marr, Broadwater
Michael Donnelly, E & E
Jeff Gregg, NYSDEC Project Manager



REFERENCE DRAWINGS			
DRAWING NO.	TITLE	DRAWING NO.	TITLE
12363	CONNECTICUT – NEW YORK, LONG ISLAND SOUND WESTERN PART, NOAA CHART, 35TH ED. DATED JULY 15/03		
12354	CONNECTICUT – NEW YORK, LONG ISLAND SOUND EASTERN PART, NOAA CHART, 35TH ED. DATED DEC. 20/37		

REVISIONS						
REV.	DATE	DESCRIPTION	BY	CHK'D	ENG	APP
A	1-17-05	PRELIMINARY	J.E.F.	D.P.T.		

BROADWATER
BROADWATER ENERGY

DRAWN BY J.E.F.	DATE 1-17-05
CHECKED BY D.P.T.	DATE 1-17-05
TITLE TO BE DETERMINED	SCALE 1" = 5,000'
FILE NO. 04097-010.dwg	

BROADWATER ENERGY
SURVEY OPERATIONS AREA
LONG ISLAND SOUND, NEW YORK

TOWN OF "NAME" COUNTY, STATE

DWG. NO. 04097-010

ecology and environment, inc.
International Specialists in the Environment

BUFFALO CORPORATE CENTER
368 Pleasant View Drive, Lancaster, New York 14086
Tel: (716) 684-8060, Fax: (716) 684-0844

February 24, 2005

Mr. David Stilwell
U. S. Department of the Interior
Fish and Wildlife Service
3817 Luker Road
Cortland, New York 13045

Re: Broadwater LNG Project, Long Island Sound, New York

Dear Mr. Stilwell:

Broadwater Energy, a joint venture between Shell US Gas and Power, LLC, and TransCanada Pipeline USA Ltd., is proposing to construct a liquefied natural gas (LNG) import terminal in the New York State waters of Long Island Sound, and an approximately 25 mile marine pipeline connecting the terminal to the existing Iroquois Gas Transmission System pipeline. The proposed location for the terminal and interconnecting pipeline was developed through a rigorous alternatives assessment and input from various federal and state agencies. Broadwater has initiated the design phases for both the terminal and the marine pipeline. Since the current proposed location has been developed solely from a desktop study, the final location may be slightly modified based on more detailed engineering and environmental surveys to be conducted in the winter and spring of 2005. The preliminary siting area for the terminal and pipeline are depicted on the attached figure. Coordinates for the siting area are also depicted.

Broadwater is requesting information regarding the presence of endangered or threatened plant and animal species, species of special concern and the existence of critical or significant habitats on or within 1.5 miles of the potential project site and pipeline route identified on the attached maps. This information is being requested in order to facilitate site selection, selection of installation technologies and completion of permit and licensing applications.

The proposed terminal consists of a ship-like vessel (a Floating Storage Re-gasification Unit (FSRU)) moored in Long Island Sound approximately 9 miles off the coast of Riverhead, New York and approximately 11 miles from the nearest Connecticut shoreline. The proposed FSRU would be approximately 1,200 feet long and 180 feet wide, with a deck that would rise 75 to 100 feet above the water line. The FSRU would be constructed at a shipyard, towed to a site in the Sound, and attached to a yoke mooring system. The yoke mooring system would be supported by a tower structure, which would be attached to a base that occupies approximately 7000 square feet of the seafloor. The FSRU would pivot around the mooring tower.

The LNG would be re-gasified aboard the FSRU and distributed to the New York and Connecticut markets via the existing Iroquois pipeline. The marine pipeline, approximately 25 miles in length, would connect the FSRU with the existing sub sea Iroquois natural gas pipeline via a subsea interconnect. The concrete coated, 30-inch diameter, gas pipeline would be installed beneath the seabed using a trenching operation. Depending on the trenching method used, the pipe would be either laid directly into the trench or would be placed on the seabed then lowered beneath.

Additional information regarding the project is available at www.broadwaterenergy.com.

Corresponding requests have been submitted to the New York State Department of Environmental Conservation, Natural Heritage Program at 625 Broadway, Albany, NY 12233-4757; and to NOAA Fisheries, Habitat Conservation Division, 212 Rogers Avenue, Milford CT 06460-6499.

Thank you for your consideration in this matter. We look forward to coordinating further with you on this project. If you have any questions or require additional information, please feel free to contact me, or Michael Donnelly, at (716) 684-8060 or by e-mail at lweaver@ene.com.

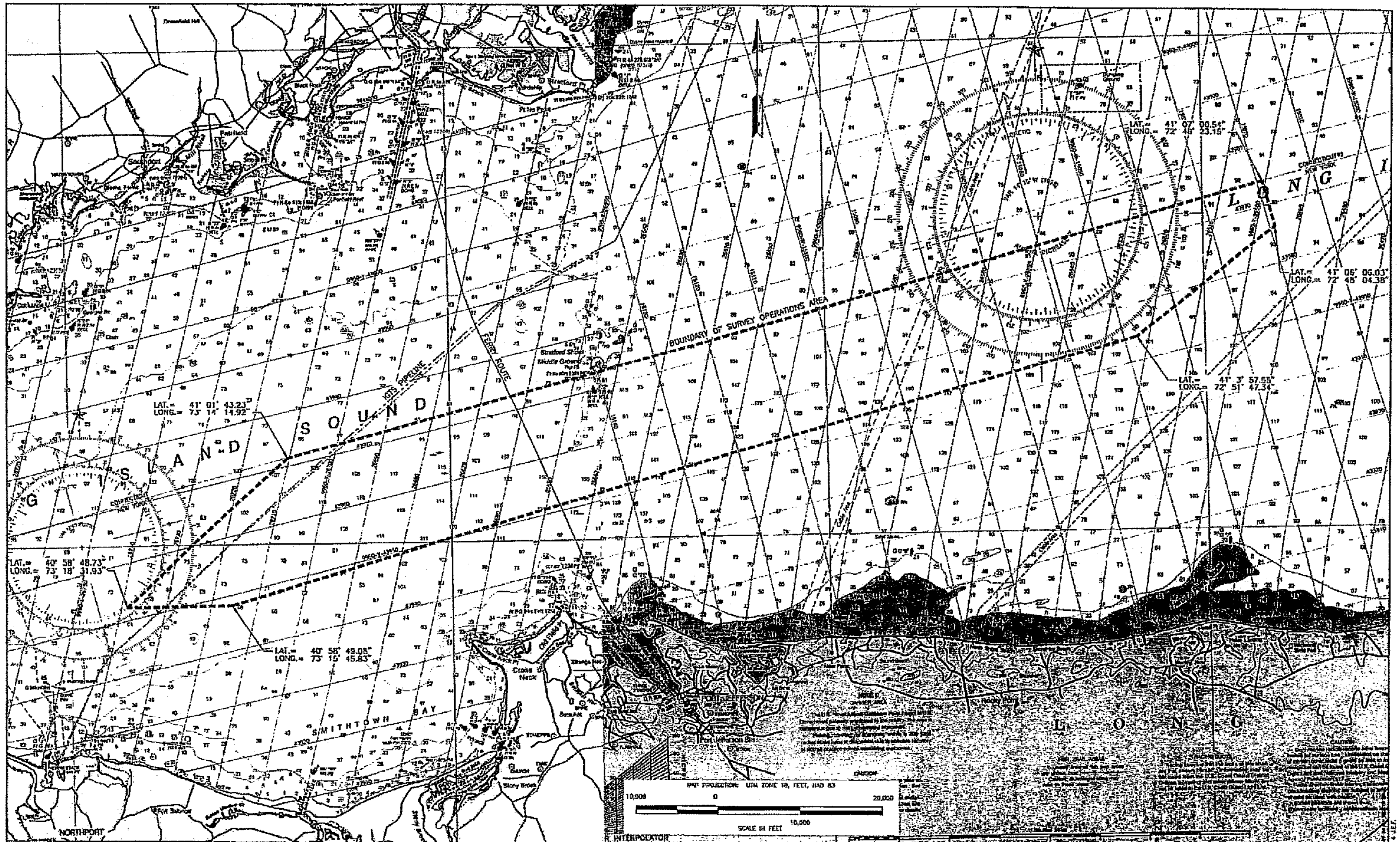
Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

Laurie K Weaver

Laurie K. Weaver
Project Biologist

CC: Sandra Barnett, Broadwater
Stephen Marr, Broadwater
Michael Donnelly, E & E



REFERENCE DRAWINGS

DRAWING NO.	TITLE	DRAWING NO.	TITLE
12363	CONNECTICUT – NEW YORK, LONG ISLAND SOUND WESTERN PART, NOAA CHART, 33TH ED. DATED JULY 15/??		
12354	CONNECTICUT – NEW YORK, LONG ISLAND SOUND EASTERN PART, NOAA CHART, 39TH ED. DATED DEC. 20/??		

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK'D	ENG	APP
1	1-17-03	PRELIMINARY	J.E.F.	D.P.T.		

BROADWATER
BROADWATER ENERGY

DRAWN BY: J.E.F.	DATE: 1-17-05
CHECKED BY: D.P.T.	DATE: 1-17-05
DRAFT. SUPV.	DATE
ENGR.	DATE
AREA: TO BE DETERMINED	TRACT SECTION: M.P # – M.P #
FILE NO.: 04097-010.dwg	SCALE: 1" = 5,000'

BROADWATER ENERGY
SURVEY OPERATIONS AREA
LONG ISLAND SOUND, NEW YORK

TOWN OF "NAME" COUNTY, STATE

DWG. NO. 04097-010

01-19-05 15:53 04097-010 4 J.E.F.

BW001635

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International Specialists in the Environment

BUFFALO CORPORATE CENTER
368 Pleasant View Drive, Lancaster, New York 14086
Tel: (716) 684-8060, Fax: (716) 684-0844

CONTACT REPORT

Meeting [ ] Telephone [X] Other [ ]

ORGANIZATION: Riverhead Foundation

ADDRESS:

PHONE NO.: 631 369-9840

PERSON CONTACTED: Kim Durham

TO: Mike Donnelly, Mike Kane

FROM: Laurie Weaver

DATE: March 17, 2005

RE: Broadwater

XC:

As suggested by NYSDEC staff during our February 2 meeting, I contacted the Riverhead Foundation regarding the occurrence of sea turtles and marine mammals in Long Island Sound. Kim verified that 4 species of sea turtles- Kemp's Ridley, loggerhead, green and leatherback sea turtles occur in Long Island Sound, in addition to 5 species of seals- harbor, harp, gray, hooded and ringed seals. She confirmed that most larger whales are not found in LIS (finback, humpback and Northern Right) but that there have been occasional stranding of Minke and Pilot whales in the sound, that Atlantic white sided dolphins are not found in LIS and that common dolphins and harbor porpoises are. She indicated that harbor porpoises are sometime reported in large numbers in the sound and the current estimates of this species is likely underestimated.

The Riverhead Foundation maintains a database of strandings in the Sound which indicates what is reported as stranded, when, where and in what numbers. We can obtain the data by sending a request with an accompanying Letter of Intent, indicating who we are and what the data will be used for. I'll draft the letter first thing tomorrow.

FAX TRANSMITTAL RE: LISTED SPECIES REQUEST
U.S. FISH AND WILDLIFE SERVICE
Long Island Field Office
500 St. Marks Lane, Islip, NY 11751
Phone: (631) 581.2941 Fax: (631) 581.2972

March 17, 2005

FAX RECEIVED
MAR 1 7 2005
TIME: 15:57

To: Laurie K. Weaver, Project Biologist
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Drive
Lancaster, NY 14086

This responds to your February 24, 2005 request for listed species information in the vicinity of the Broadwater LNG Project, Long Island Sound, New York.

Except for occasional transient individuals, no Federally-listed or proposed endangered or threatened species under our jurisdiction are known to exist within the project impact area. In addition, no habitat in the project impact area is currently designated or proposed "critical habitat" in accordance with provisions of the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Therefore, no further ESA coordination or consultation with the U.S. Fish and Wildlife Service (Service) is required. Should project plans change, or if additional information on listed or proposed species or critical habitat becomes available, this determination may be reconsidered. The most recent compilation of Federally-listed and proposed endangered and threatened species in New York* is available for your information. If the proposed project is not completed within one year from the date of this FAX, we recommend that you contact us to ensure that the listed species presence/absence information for the proposed project is current. Should our determination change and any part of the proposed project be authorized, funded, or carried out, in whole or in part, by a Federal agency, further consultation between the Service and that Federal agency pursuant to the ESA may be necessary.

The above comments pertaining to endangered species under our jurisdiction are provided pursuant to the ESA. This response does not preclude additional Service comments under other legislation.

For additional information on fish and wildlife resources or State-listed species, we suggest you contact the appropriate State regional office(s),* and:

New York State Department of Environmental Conservation
New York Natural Heritage Program Information Services
625 Broadway
Albany, NY 12233-4757
(518) 402-8935

Thank you for your time. If you require additional information please contact me at 631.581.2941.

Sincerely,

Jill A. Olin
Fish and Wildlife Biologist

*Additional information referred to above may be found on our website at:
http://nyfo.fws.gov/es/section7.htm

ecology and environment, inc.
International Specialists in the Environment

BUFFALO CORPORATE CENTER
368 Pleasant View Drive, Lancaster, New York 14086
Tel: (716) 684-8060, Fax: (716) 684-0844

June 13, 2005

Mr. Robert DiGiovanni
The Riverhead Foundation
for Marine Research and Preservation
467 East Main Street
Riverhead, NY 11901

Re: Broadwater LNG Project, Long Island Sound, New York

Dear Mr. DiGiovanni:

Broadwater Energy, a joint venture between Shell US Gas and Power, LLC, and TransCanada Pipeline USA Ltd., is proposing to construct a liquefied natural gas (LNG) import terminal in the New York State waters of Long Island Sound, and an approximately 25 mile marine pipeline connecting the terminal to the existing Iroquois Gas Transmission System pipeline. The preliminary siting area for the terminal and pipeline are depicted on the attached figure. Coordinates for the siting area are also depicted.

Broadwater is requesting stranding data for sea turtles and marine mammals in Long Island Sound. We would very much appreciate any siting or population data for these species as well as any information on timing and patterns of use that you may be able to provide. This information is being requested in order to facilitate final site selection, selection of installation technologies, assessment of potential impacts on these species, development of appropriate mitigation to avoid and minimize potential impacts (including appropriate installation windows, vessel selection, vessel speed, monitoring programs, etc…), and completion of permit and licensing applications.

Additional information regarding the project is available at www.broadwaterenergy.com.

Thank you for your consideration in this matter. If you have any questions or require additional information, please feel free to contact me at (716) 684-8060 or by e-mail at lweaver@ene.com.

Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

Laurie K. Weaver
Project Biologist

CC: Sandra Barnett, Broadwater
Stephen Marr, Broadwater
Michael Donnelly, E & E

From: Jeff Gregg [jagregg@gw.dec.state.ny.us]
Sent: Wednesday, June 22, 2005 2:37 PM
To: Weaver, Laurie
Cc: Charles deQuillfeldt; William Little
Subject: Natural Heritage Request

Laurie -

First, apologies for this delayed response. I spoke with Charlie deQuillfeldt today and it is my understanding that the only significant habitats anywhere near the Broadwater project are those which are along the Long Island shoreline, so this is not a concern in this case. As for particular endangered or threatened species, it will only be transient species and for that information you are advised to seek it through the National Marine Fisheries Service.

If you have any questions, please let me know.

Jeff

From: Daniel Rosenblatt [dlrosenb@gw.dec.state.ny.us]
Sent: Thursday, June 30, 2005 3:26 PM
To: Weaver, Laurie
Cc: Chuck Hamilton; Charles deQuillfeldt
Subject: Fwd: RE: Broadwater's Natural Heritage Request

Hello Laurie,

The Region has no specific endangered species information for the proposed platform location. Roseate, least and common terns, Harbor seals, harp seals, and marine turtles (Green, Kemps) periodically forage and move through this area. Nearest land-based endangered wildlife areas are plover and tern nesting areas at the mouth of Wading River Creek, Baiting Hollow Tidal Wetlands and the Sound beach on the new State Park property in Jamesport, just north of Hallock Pond. The terns forage on bait fish throughout the sound, but seem to concentrate their activity near shoals and creek mouths.

Thanks,
Dan

Dan Rosenblatt, Ph.D.
Regional Wildlife Manager
NYS Department of Environmental Conservation Building 40, SUNY Stony Brook, NY 11790
(631) 444-0270
dlrosenb@gw.dec.state.ny.us

>>> Chuck Hamilton 6/24/2005 11:22:40 AM >>>
Could you provide this information to these people,thanks CTH

>>> "Weaver, Laurie" <LWeaver@ene.com> 05/06/05 11:13AM >>>
Chuck and Charles,

Could you please update me on the status of the attached request? If you have any questions or need any additional information, I would be happy to discuss that with you.

Thank you.

Laurie

-----Original Message-----
From: Weaver, Laurie
Sent: Wednesday, March 16, 2005 2:02 PM
To: Chuck Hamilton; Charles deQuillfeldt
Cc: Donnelly, Mike; 'Jeff Gregg'; William Little
Subject: RE: Broadwater's Natural Heritage Request

Gentlemen,

As per Jeff's e-mail below, I am requesting information on endangered and threatened species and critical or significant habitats in the Broadwater project area. I have attached a copy of the request that was originally sent to the New York Natural Heritage Program on February 24, 2005.

I would appreciate anything you could do to expedite your review.

Thank you for your attention to this matter. If you have any questions or require additional information, please contact me.

Sincerely,

Laurie Weaver

****
Laurie K. Weaver
Ecology and Environment, inc.
Buffalo Corporate Center
368 Pleasant View Drive
Lancaster, N Y 14086
Phone: (716) 684 - 8060
Fax: (716) 684 - 0844
http:\\www.ene.com
lweaver@ene.com
****

-----Original Message-----
From: Jeff Gregg [mailto:jagregg@gw.dec.state.ny.us]
Sent: Wednesday, March 16, 2005 12:59 PM
To: Weaver, Laurie
Cc: Donnelly, Mike; Chuck Hamilton; Charles deQuillfeldt; William Little
Subject: Broadwater's Natural Heritage Request

Laurie -

I don't know if you have gotten any reply from our Natural Heritage Program to your Feb. 24 request re: info on endangered and threatened species and critical or significant habitats, but I have an unsigned note from that office that it does not maintain such records for offshore areas. They suggest that you seek such information from the Marine Resources office and from the Region 1 Natural Resources Supervisor. I've copied Charlie deQuillfeldt and Chuck Hamilton, respectively, with this message to let them know you may be approaching them on this.

Jeff

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
One Blackburn Drive
Gloucester, MA 01930-2298

AUG 16 2005

Ms. Laurie K. Weaver
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Drive
Lancaster, NY 14086

Dear Ms. Weaver:

This responds to your letter dated February 24, 2005 (received via email on August 12, 2005) requesting information on the presence of any species listed as threatened or endangered under the Endangered Species Act of 1973 (ESA), as amended, in the vicinity of the proposed Broadwater Liquefied Natural Gas (LNG) project within the New York State waters of Long Island Sound.

Four species of federally threatened or endangered sea turtles under the jurisdiction of NOAA's National Marine Fisheries Service (NMFS) may be found seasonally in New York waters: loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and green (*Chelonia mydas*) sea turtles. The federally threatened loggerhead and endangered Kemp's ridley sea turtles are the most common sea turtle species in northeast nearshore waters. The general trend is for sea turtles to migrate to the area in early summer (typically in May when water temperatures reach 11°C) and return south when the water temperature decreases around October/November. The three species of chelonid turtles found in the northeast are typically small juveniles that remain very briefly in open ocean waters and spend most of their time during the summer months foraging in shallow harbors and estuarine waters. Very little site-specific sighting and density data are available for sea turtles in Long Island Sound—most of our knowledge about sea turtle presence in the Sound comes from stranding data. For example, from November to March in 1985 through 1988, 130 cold-stunned turtles were collected along the Long Island shoreline, including 97 Kemp's ridleys.

Endangered leatherback sea turtles are located in New York waters during the warmer months as well, although they tend to be more pelagic and do not frequent shallow harbors and bays. Concentrations of leatherbacks have been observed during the summer off the south shore of Long Island and off New Jersey. Leatherbacks in these waters are thought to be pursuing their preferred jellyfish prey.

Although typically not present within Long Island Sound, federally endangered North Atlantic right whales (*Eubalaena glacialis*), humpback whales (*Megaptera novaeangliae*), and fin whales (*Balaenoptera physalus*) may all be found seasonally in New York waters. North Atlantic right, humpback, and fin whales have all been documented transiting past the entrance to Long Island Sound (south and east of Block Island Sound) and along the south side of Long Island. These species should be considered when evaluating any indirect effects of the project that extend beyond the waters of Long Island Sound, e.g. the increased risk of vessel collision with listed species due to increased vessel traffic into and out of Long Island Sound.

Section 7(a)(2) of the ESA states that each Federal agency shall, in consultation with the Secretary, insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Because federally listed sea turtles may be seasonally present in the project area, any discretionary federal action that may affect these species must undergo section 7 consultation. The federal action agency, in this case the Federal Energy Regulatory Commission (FERC), is responsible for initiating section 7 consultation. Once project details are established, FERC should commence the consultation process by submitting the project details along with an assessment of the project's effects on listed species and a letter requesting that consultation be initiated to the attention of the Endangered Species Coordinator, NOAA Fisheries Service, Northeast Regional Office, One Blackburn Drive, Gloucester, MA 01930. After reviewing this information, NMFS will then be able to conduct a consultation under section 7 of the ESA.

While not protected under the ESA, several other species of marine mammals are present in Long Island Sound. These include several pinniped species, with the harbor seal (*Phoca vitulina*) and gray seal (*Halichoerus grypus*) being the most abundant. All marine mammals are protected under the Marine Mammal Protection Act of 1972 (MMPA). If it is felt that this project has the potential to take non-ESA listed marine mammals through injury, harassment, or mortality, then the applicants are responsible for obtaining an incidental take permit from NMFS. For more information about the permitting process, please visit http://www.nmfs.noaa.gov/pr/permits/.

We look forward to continued coordination with your office throughout the consultation process. Should you have any questions about this information, please contact Kristen Koyama at (978) 281-9300 ext. 6531.

Sincerely,

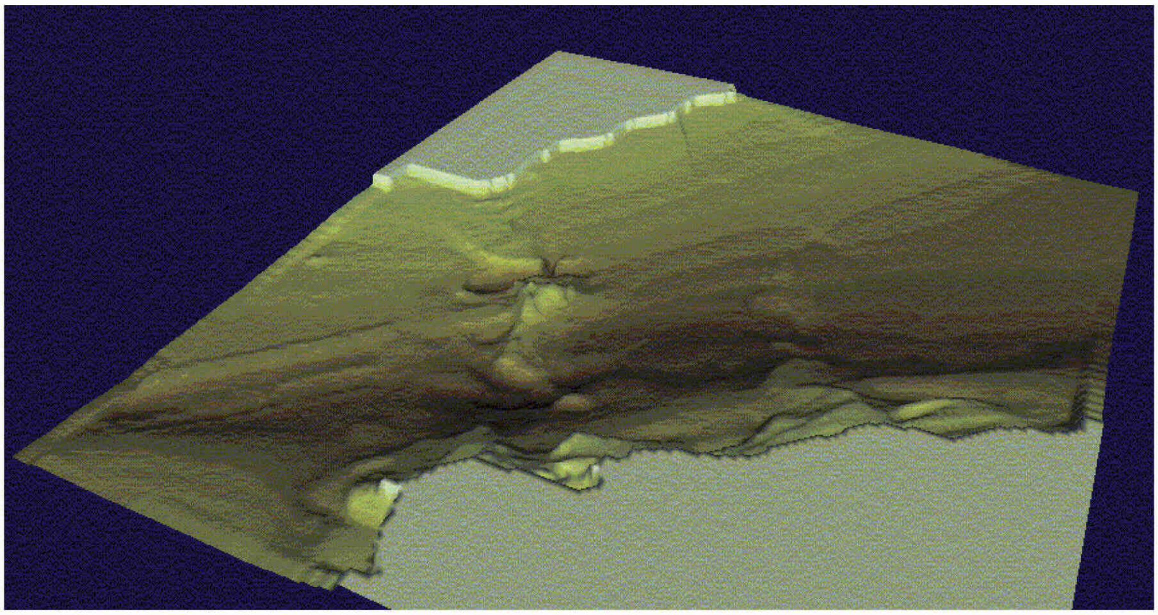
Mary A. Colligan
Assistant Regional Administrator
for Protected Resources

cc: Rusanowsky, F/NER4

File Code: 1514-05 (A) Species Presence – New York

APPENDIX G

SEDIMENT DEPOSITION RESULTING FROM CONSTRUCTION OF A NATURAL GAS PIPELINE TRENCH



Sediment Deposition Resulting From Construction of a Natural Gas Pipeline Trench

Report Prepared For
Ecology & Environment Inc.
And
Broadwater Energy

November 2005

HDR | LMS

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BW001646

Table of Contents

1.0	Introduction	3
2.0	Methodology	4
3.0	Results	5
4.0	References	11

1.0 Introduction

Broadwater Energy has proposed to place a natural gas pipeline in a trench that will be plowed or dredged into the bottom sediment of Long Island Sound. HDR|LMS was requested to calculate the depth of sediment that will be deposited as a result of excavating the trench. This report details the methodology utilized to address the question and the results of the analysis.

This report can be read as an addendum to the report "Water Quality/Sedimentation Modeling Report for a Project to Construct and Operate a Liquefied Natural Gas receiving Terminal in Long Island Sound, New York", prepared by HDR|LMS and Ecology and Environment in October 2005. The work contained in this report utilizes the same three dimensional hydrodynamic and water quality model as described in the previous report, and builds on the results of that modeling effort.

2.0 Methodology

As before the MIKE3 model of New York Harbor and Long Island Sound, developed for the Corps of Engineers, was used in this study. The model had been previously modified to perform calculations related to the transport and dispersion of solids that could be resuspended during the trenching operation.

The parameters specified during the previous calculation included the volume of sediment resuspended, and the settling velocity of the resuspended solids. As the MIKE3 model considers solids as a group, as opposed to a collection of individually sized particles, the specification of settling velocity is of primary importance when calculating the deposition of the resuspended solids.

The subject of in-situ settling velocities in tidal and non-tidal systems has been studied extensively for over a century. The complexities in the process include particle flocculation, coagulation, turbulence effects, bed chemical and physical characteristics, shear effects on single and coagulated or flocculated particles, and biological influences. The range of calculated and measured settling rates is large and there is no correct value. Any value chosen can be argued to be both too small and too large. After extensive literature review (only some of which are cited in the references at the end of this report), a value of 1 mm/s was chosen for use in the model.

The model was run in exactly the same manner as the previous calculation, except that now the mass of sediment deposited to the bottom was tracked. At the end of the simulation the total mass deposited is output. This is spatially varying.

It is more intuitive to convert areal mass deposition into a depth. This is achieved by dividing the areal mass by the bulk density of the deposited sediment. This calculation is as follows:

A = Areal mass = kg/m^2

B = Bulk density = kg/m^3

Depth, D = A/B = m (* 1000 mm/m) = mm

The bulk density is the estimated density of the deposited solids. To be conservative the porosity of the deposited solids was assumed to be 90%, an extremely high value. The density of the solids was assumed to be 2600 kg/m^3. The resulting bulk density is then:

Bulk density = porosity * density of water + (1-porosity)*density of solids
= 0.9 * 1000 kg/m^3 + (1-0.9) * 2600 kg/m^3
= 900 kg/m^3 + 260 kg/m^3
= 1160 kg/m^3

3.0 Results

The results of the calculation are shown in Figures 1 through 5. These are the computed deposition depths at the completion of all trenching work. These do not include the two cable crossings or the tie in to the Iroquois Gas Transmission System.

The calculated maximum deposition depth anywhere along the route is just under 5 mm. The figures show that there are multiple points along the route where local maximums occur. These are most likely due to tidal effects and may coincide with slack water periods. In general it appears that depths greater than 1 mm only occur within 100m-200m from the route.

Given the limited spatial extent of deposition and the small resulting deposition depths it is unlikely that there would be any impact from the deposition of resuspended material from the trenching operation.

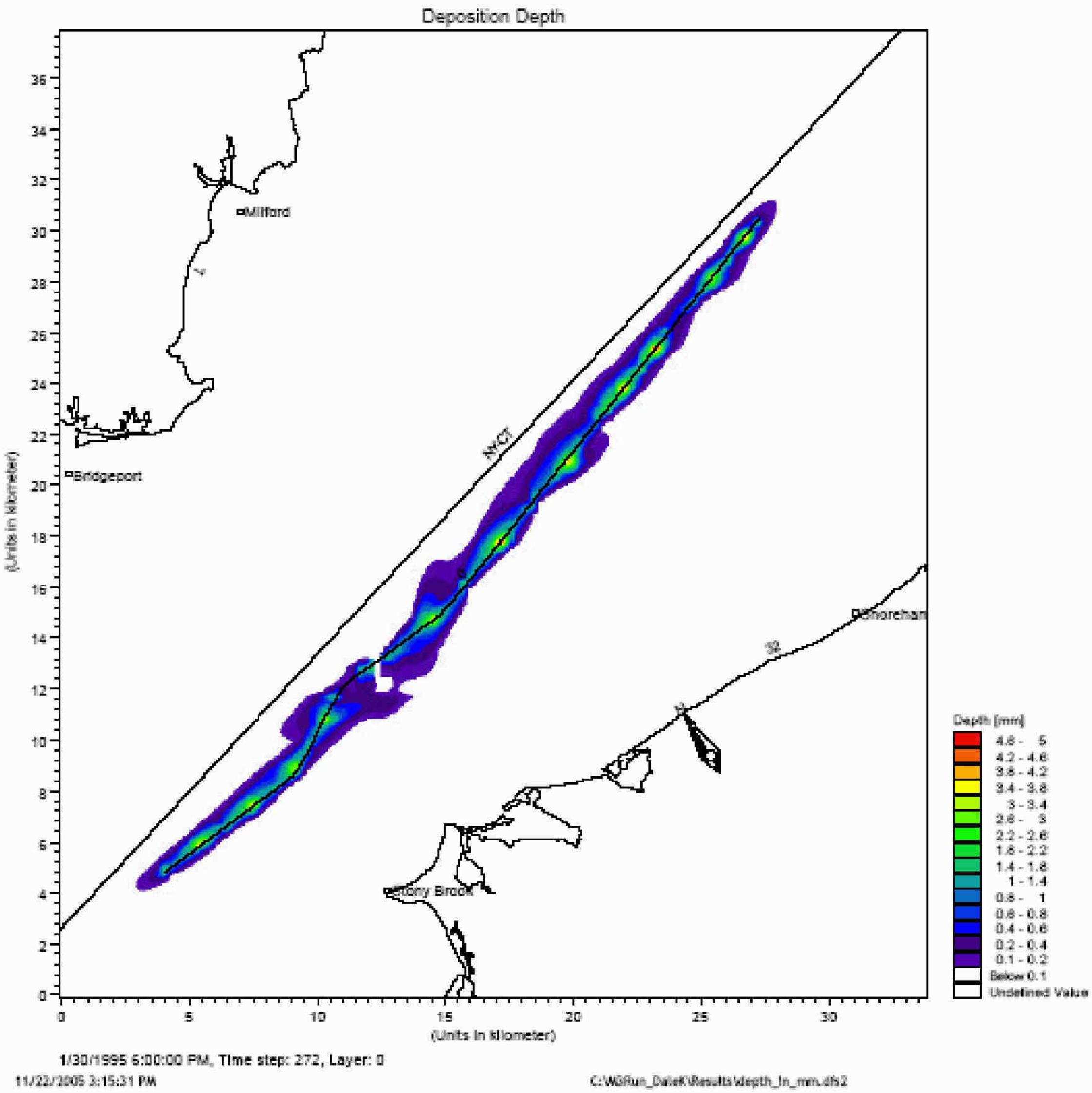

Figure 1. Deposition over entire route.

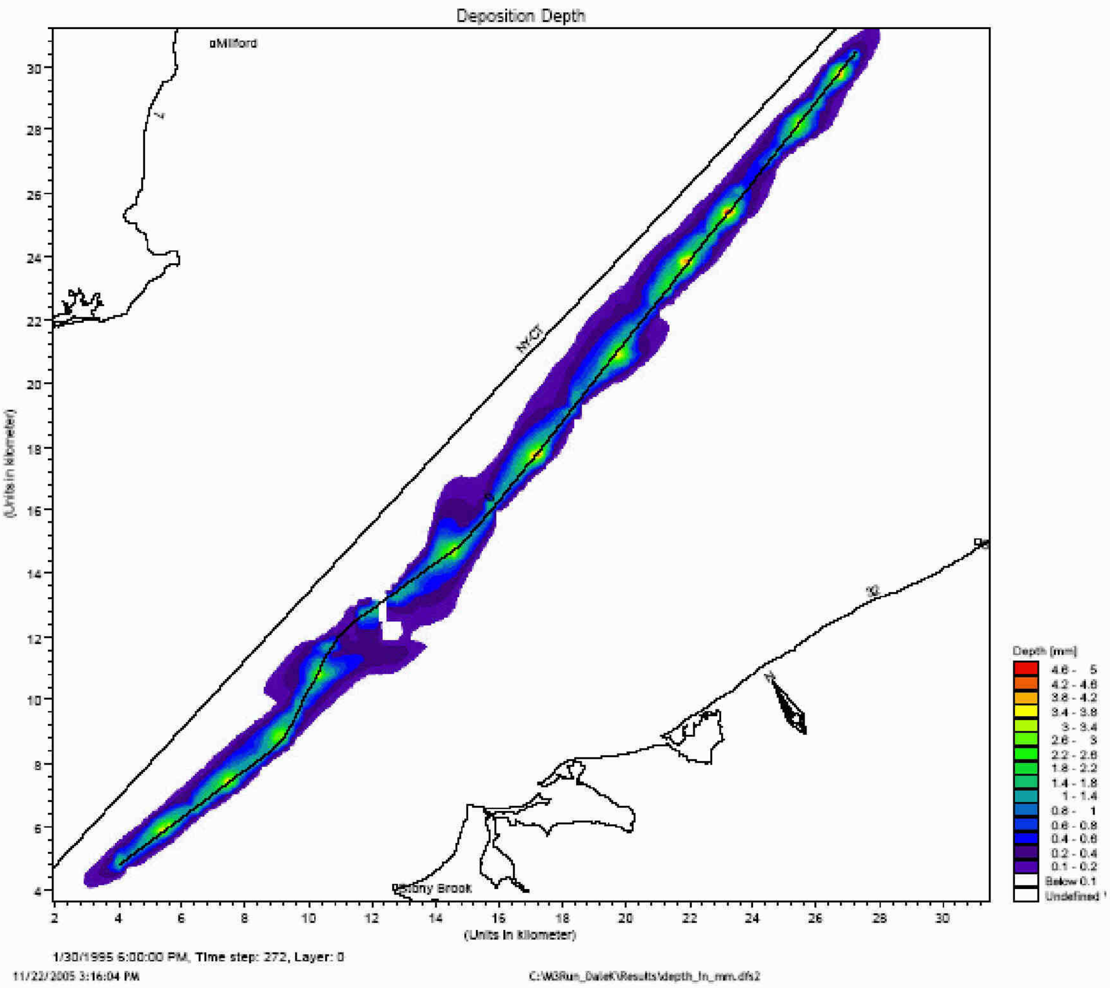

Figure 2. Closer view of deposition over entire route.

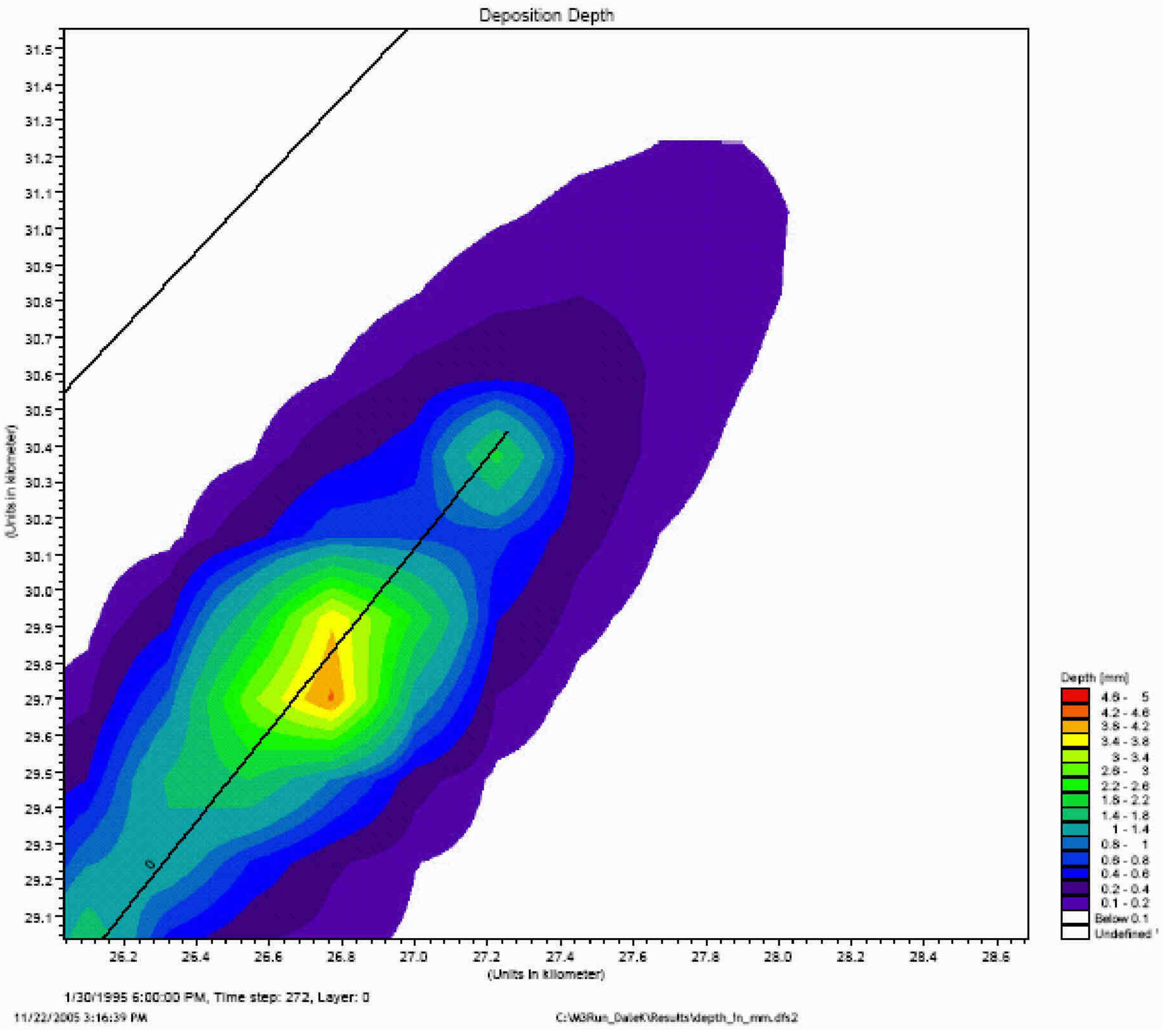

Figure 3. Deposition at start of route.

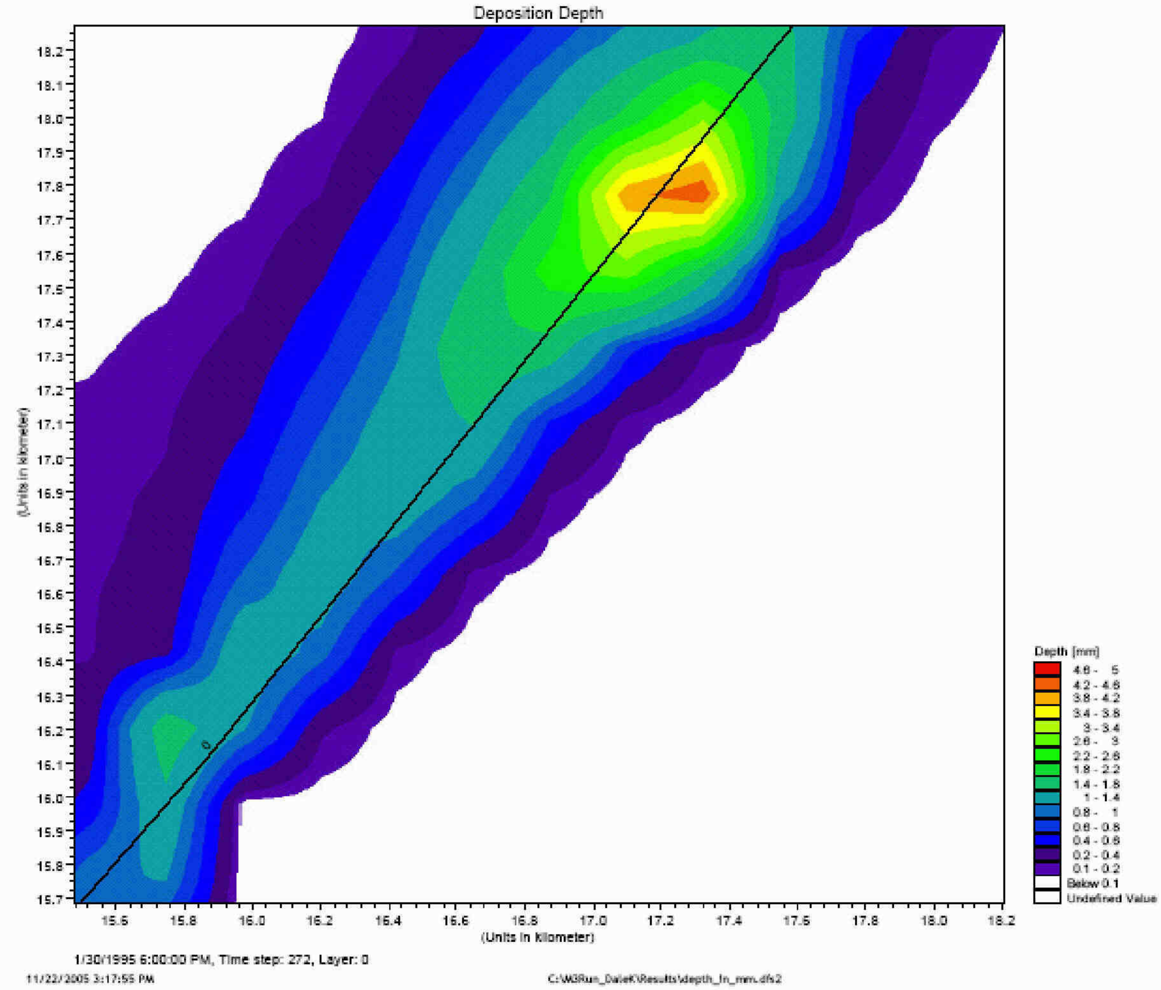

Figure 4. Deposition at middle of route.

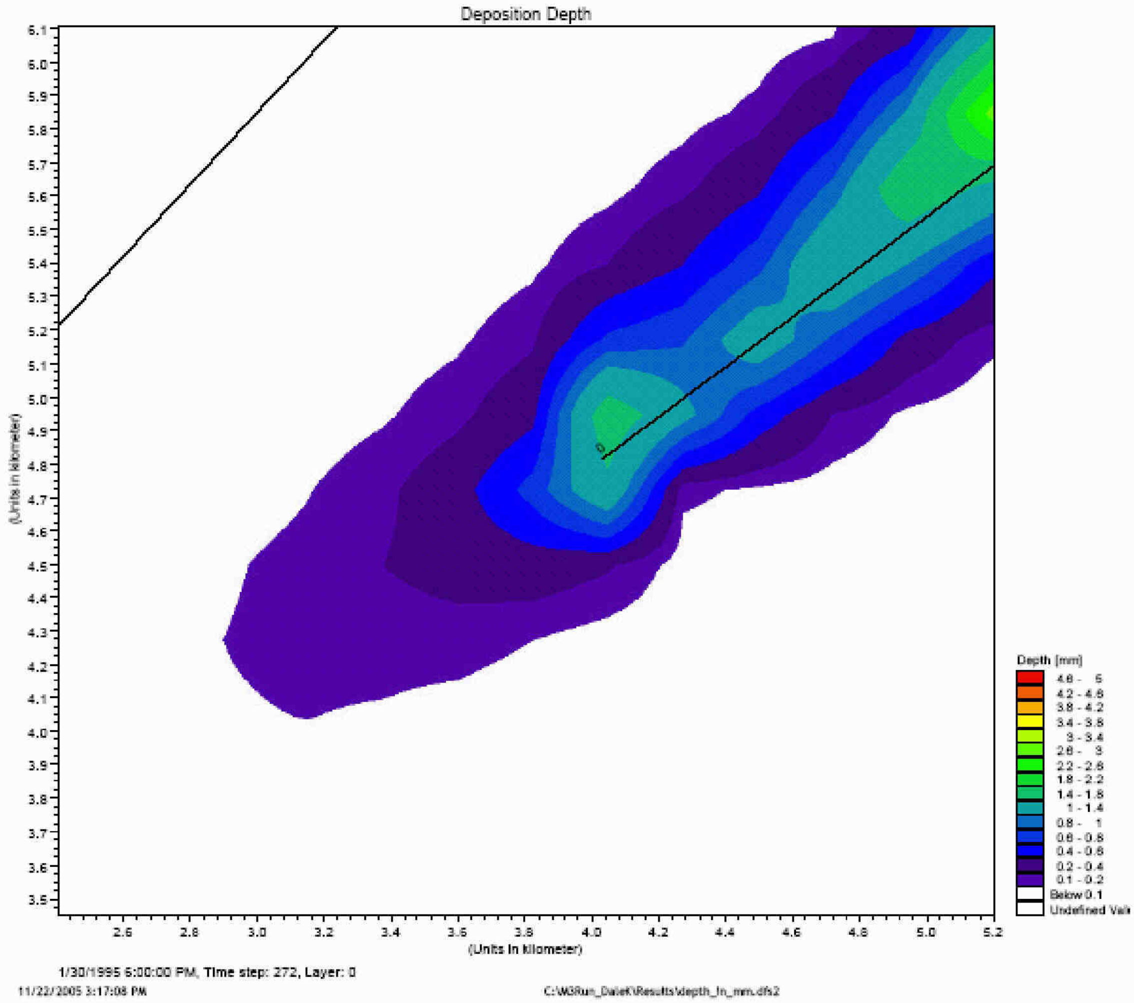

Figure 5. Deposition at end of route.

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APPENDIX H

NATURAL BACKFILLING OF NATURAL GAS PIPELINE TRENCH

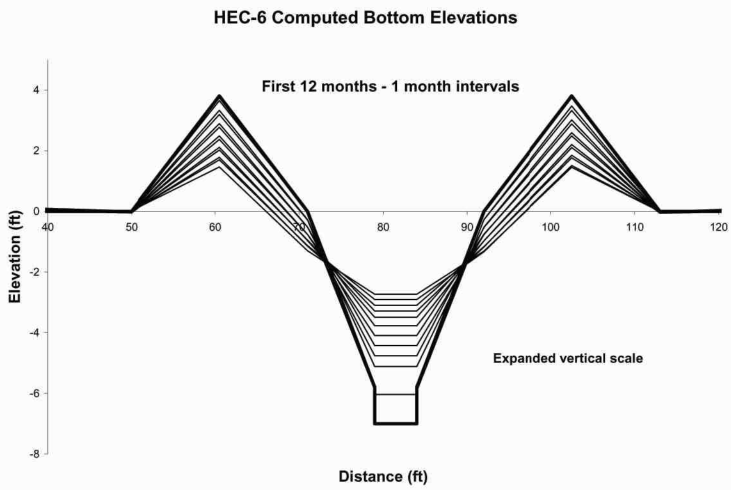

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Table of Contents

1.0 Introduction 3

2.0 Methodology 4
2.1 Corps of Engineers HEC-6 Model 5
2.2 Model Set Up 6
2.3 Model Sediment Input Data 8
2.3.1 Suspended Sediment 8
2.3.2 Bed Sediment 9
2.3.2.1 Clay 9
2.3.2.2 Silt 9
2.3.2.3 Sand 9

3.0 Results 10
3.1 Stratford Shoals 12

4.0 References 13

1.0 Introduction

Broadwater Energy has proposed to place a natural gas pipeline in a trench that will be plowed or dredged into the bottom sediment of Long Island Sound. HDR|LMS was requested to calculate how long it would take this trench to backfill by natural sedimentation and sediment transport processes. This report details the methodology utilized to address the question and the results of the analysis.

2.0 Methodology

A typical cross section of the trench is shown in Figure 1. This cross section is used as the basis of the model calculations.

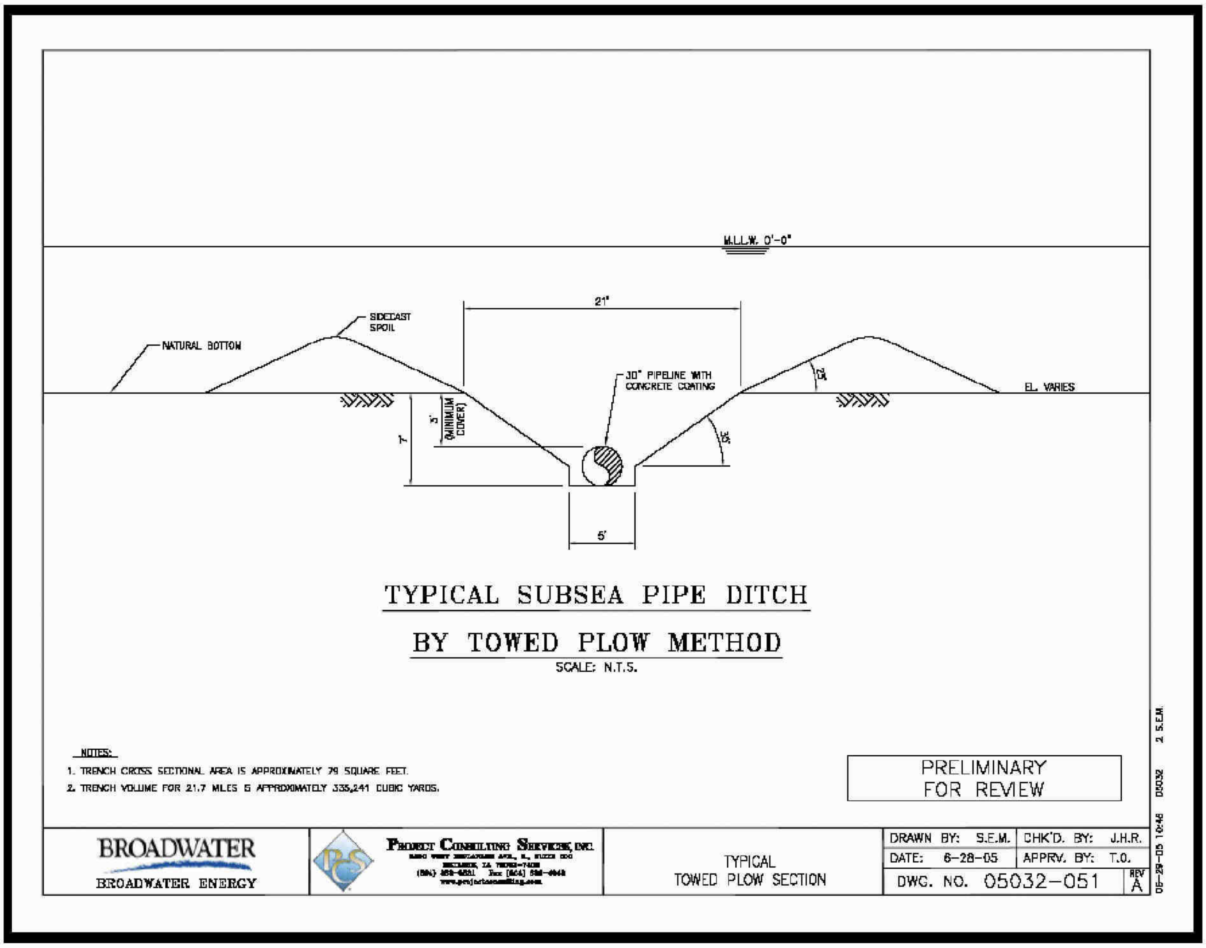

Figure 1. Typical trench cross section.

There are two processes that will act to fill the trench in:

1. Deposition from suspended solids in the water column
2. Transport of sediment adjacent to the trench into the trench

To enable the estimation of these processes, the Corps of Engineers HEC-6 model was chosen.

2.1 Corps of Engineers HEC-6 Model

The HEC-6 model contains all of the computational elements necessary to do sediment transport calculations but it is designed for use in rivers. There is no equivalent model available for estuarine situations, that is, a robust sediment transport that can be set up and run in a reasonable time frame. Therefore the HEC-6 model was set up and run in a manner that can be used to simulate the tidal conditions present in Long Island Sound. These set up and run details are described below.

HEC-6 is a one-dimensional movable boundary open channel flow numerical model designed to simulate and predict changes in river profiles resulting from scour and/or deposition over moderate time periods. A continuous flow record is partitioned into a series of steady flows of variable discharges and durations. For each flow a water surface profile is calculated thereby providing energy slope, velocity, depth, etc. at each cross section. Potential sediment transport rates are then computed at each section. These rates, combined with the duration of the flow, permit a volumetric accounting of sediment transport and bed sediment within each reach. The amount of scour or deposition at each section is then computed and the cross section adjusted accordingly. The computations then proceed to the next flow in the sequence and the cycle is repeated beginning with the updated geometry. The sediment calculations are performed by grain size fraction thereby allowing the simulation of hydraulic sorting and armoring.

2.2 Model Set Up

The model was set up to simulate a 500ft wide section of trench, as shown below in Figure 2. The flow is set perpendicular to the trench and the length of the section is 2000 ft. The length and width are arbitrary and were chosen to ensure that boundary effects are not an issue around the area of interest, i.e., the trench.

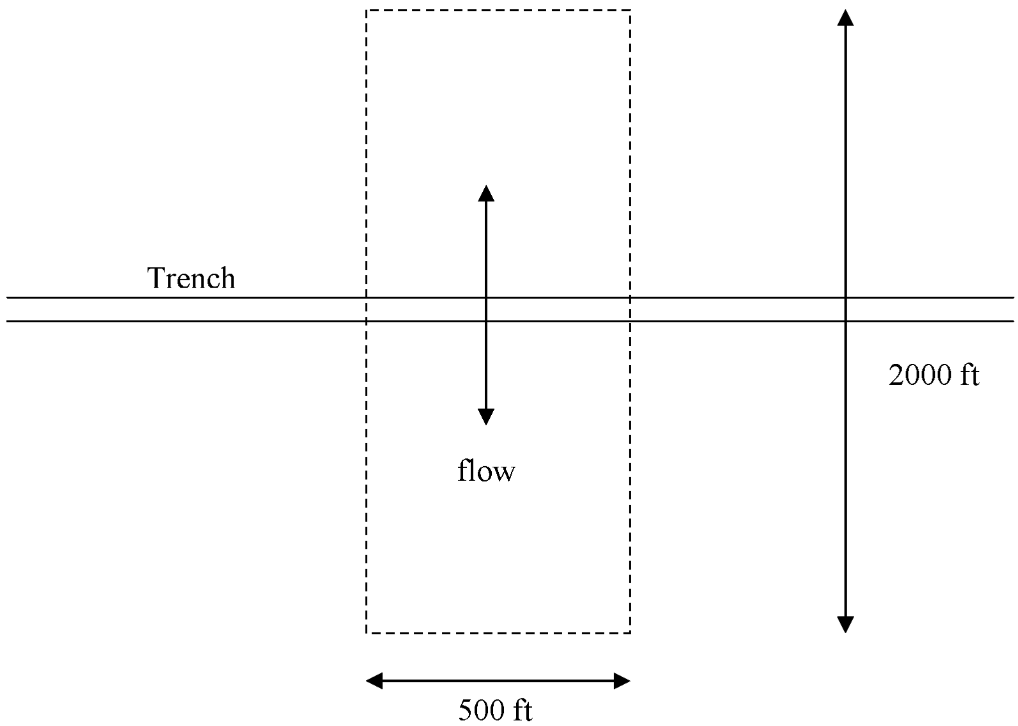

Figure 2. Schematic of HEC-6 model set up.

The trench profile is defined as shown in Figure 1 and includes both the excavated trench and the adjacent spoil piles.

The actual prevailing tidal direction crosses the trench at an angle that is less than the ninety degrees used in the model. The approximation to use a perpendicular flow significantly simplifies the modeling procedure and allows the geometry to be symmetrical when the flow direction is changed.

The model depth is based on the average depth at the locations of the three Acoustic Doppler Current Profiler (ADCP) units that were placed along the route. This depth is 72.9 feet. Over the course of the 22 mile long pipeline route, the depth varies from around 45ft at the Stratford Shoal to just over 100ft mid way along the route, with the average depth being close to that used in the model.

As the depths along the route are large compared to the details being modeled in the trench, (spoil piles only 3.8 ft high) any change in depth, from say 70 ft to 80ft, produces only a small change in model results.

The model water temperature is set to 50^{o} F.

The model simulates the tidal motion by using time varying flow. The model uses a 1 hour time step. The ADCP data showed velocities varying from zero at slack water up to a maximum of around 2.5 ft/s. The velocities vary in the typical sinusoidal pattern associated with tidal systems. The model velocities were set to vary between zero and 1.5 ft/s. The upper value, 1.5 ft/s represents an average of the peak flood and peak ebb velocities during each tidal cycle measured by the three ADCP units.

Even though the prevailing currents are not at ninety degrees to the trench, as in the model set up, it is not appropriate to simply reduce the velocities geometrically (that is, consider only the component perpendicular to the trench). As the bottom sediments will be exposed to the full range of tidal velocities, these are used in the model. The approximation is that where particles scoured in the model will move perpendicular into the trench, or away from the trench, in reality they will move at an angle into, or away from, the trench. As such the net effect should be the same.

HEC-6, being designed for unidirectional river flows, can only simulate flow in one direction during any model run. In order to change the direction of flow, as occurs during a tidal cycle, each model run needs to stop at the end of every six hours, before the flow changes direction. The computed sediment profiles are then used as inputs for a new model run that has the flow coming from the opposite direction.

As the process of naturally backfilling the trench was expected to occur over a period of years, stopping and starting the model every six hours would be extremely time consuming. Some sensitivity tests were performed and the model was run for 30 days of temporally-varying flow in one direction and then the same magnitude of flow was reversed. During each run the flow continues to vary in a half-sinusoidal manner so the effect of varying velocity is still captured.

2.3 Model Sediment Input Data

2.3.1 Suspended Sediment

Based on typical data for Long Island Sound a suspended solids concentration of 25 mg/L was used. The particle size distribution of suspended solids in the Sound are not known, so the distribution was based on reported literature values for estuarine systems. These include works by Wolanski and Gibbs (1995), Hamblin (1989), Orton and Kineke(2001) and Gartner et al. (2001). HEC-6 has predefined sediment classes as shown in Table 1.

Table 1. HEC-6 Sediment Classes

HEC-6 Size Class		Material	Grain Diameter (mm)
Clay	1	Clay	0.002-0.004
Silt	1	Very Fine Silt	0.004-0.008
	2	Fine Silt	0.008-0.016
	3	Medium Silt	0.016-0.032
	4	Coarse Silt	0.032-0.0625
Sand	1	Very Fine Sand	0.0625-0.125
	2	Fine Sand	0.125-0.25
	3	Medium Sand	0.25-0.30
	4	Coarse Sand	0.5-1.0
	5	Very Coarse Sand	1-2
	6	Very Fine Gravel	2-4
	7	Fine Gravel	4-8
	8	Medium Gravel	8-16
	9	Coarse Gravel	16-32
	10	Very Coarse Gravel	32-64
	11	Small Cobbles	64-128
	12	Large Cobbles	128-256
	13	Small Boulders	256-512
	14	Medium Boulders	512-1024
	15	Large Boulders	1024-2028

The distribution used in the model for the suspended solids was 25% clay (0.002- 0.004 mm diameter), 25% very fine silt (0.004 – 0.008 mm), 20% fine silt (0.008 – 0.016 mm), 10% medium silt (0.016 – 0.032 mm), 10% coarse silt (0.032 – 0.0625 mm) and 10% very fine sand (0.0625 – 0.125 mm).

The fall velocity of the suspended sediment is calculated in the model by using the Federal Interagency Sedimentation Project method (Williams 1980).

2.3.2 Bed Sediment

The particle size distribution of the solids in the bed sediment was based on data collected by Broadwater along the proposed pipeline route. The model bed sediment particle size distribution is shown below in Table 2.

Table 2. Model Bed sediment Particle Size Distribution

Mean Particle Diameter (mm)	Percent Less Than
8.0	100.0
4.0	99.0
2.0	97.0
1.0	96.0
0.5	95.1
0.25	79.7
0.125	63.0
0.062	48.0
0.031	33.0
0.016	18.0
0.008	0.0

The properties of the clay, silt and sand that comprise the suspended solids and bed sediment are detailed below:

2.3.2.1 Clay

The model calculates deposition of clay using the settling velocity but erosion of cohesive sediment is not allowed. The specific gravity of clay is set at 2.65. The shear threshold for clay deposition is set at 0.02 lb/ft^2 . This number is obtained from Bureau of Reclamation (BOR) Tables as presented by Lowe (2003). The unit weight of compacted clay is assumed to be 78 lb/ft^3 , also given by the BOR. Uncompacted clay is set at 30 lb/ft^3. The compaction coefficient is 16 lb/ft^3 per year.

2.3.2.2 Silt

The model calculates the deposition and erosion of silt. The specific gravity of silt is set at 2.65. The shear threshold for clay deposition is set at 0.02 lb/ft^2 . This number is obtained from Bureau of Reclamation (BOR) Tables as presented by Lowe (2005). The unit weight of compacted silt is assumed to be 82 lb/ft^3 , also given by the BOR. The unit weight of freshly deposited silt is set at 65 lb/ft^3. The compaction coefficient is 5.7 lb/ft^3 per year.

2.3.2.3 Sand

Sand transport is computed using Toffaleti's (1966) transport function. The specific gravity of sand is set to 2.65. The grain shape factor is set to 0.667. The exponent in the surface area exposed function calculation is 0.5. The Einstein bed load parameter is 30. The unit weight of settling sand is 93 lb/ft^3.

3.0 Results

The results of the initial HEC-6 runs indicated that while the model was calculating erosion and deposition, the model was not allowing the material eroded from the spoil piles adjacent to the trench to actually deposit into the trench. Instead the material would be evenly deposited along the 1000 ft downstream portion of the segment. Some sensitivity tests showed that the large depth, nearly 73 ft, had effectively damped the geometry effect of the trench. Based on our extensive experience with dredged channels, we know that the highest sedimentation rates occur in the deepest areas and that much of the material deposited in the trench will remain there – hence the well documented problems that dredged channels experience with siltation.

In order to correct this issue an adjustment was made when the model was restarted at the end of each 30 day period. It was assumed that the material scoured from the upstream spoil pile would be deposited in the trench. Material scoured from the downstream spoil pile was assumed to have been moved away from the trench. The bottom elevation of the trench was then recomputed using the volume of the spoil piles that were scoured, and this elevation was used as input for the next run. The calculation includes an allowance for the fact that the trench geometry is not uniform with depth. For example at depths below 5.8 ft the trench is only 5 ft wide and tends to fill rapidly. As the depth decreases, the trench width increases, and hence the trench will fill at a slower rate. The volume of the trench that is occupied by the pipe itself is also considered when recomputing the new bottom elevations.

When the trench is deep it can be assumed that all of the material that settles there is trapped. As the trench fills in the trapping efficiency will decrease. It was assumed that at depths greater than 4 ft below the bed, the trapping efficiency is 1.0, i.e. 100%. Between depths 3-4 ft, the trapping efficiency is reduced to 0.9. From 2 to 3 ft, the efficiency is 0.8; and at depths less than 2 ft, the efficiency is 0.7.

The model computed bottom elevations are shown in Figure 3. This figure shows the first 12 months of the simulation in 30 day (approximately 1 month) increments. Figure 4 shows the model computed bottom elevations for months 12 to 36 in 180 day (approximately 6 month) increments. By the end of 36 months the trench is essentially filled.

The pipe itself is covered by around day 200.

The model is also conservative in that no storm events that would cause increased bottom velocities, hence increased sediment transport, are considered. Storms were not considered because they are randomly occurring events, of varying magnitudes, directions and durations. There were also no data showing the effect of storms on bottom velocities in the vicinity of the trench. It is known however that storms are responsible for significant amounts of bed sediment movement and could deposit a large volume into the trench over a short period of time.

Over a three year period one would expect that Long Island Sound would experience several large storms that would contribute to filling the trench. Hence the model calculated time frame can be considered conservative.

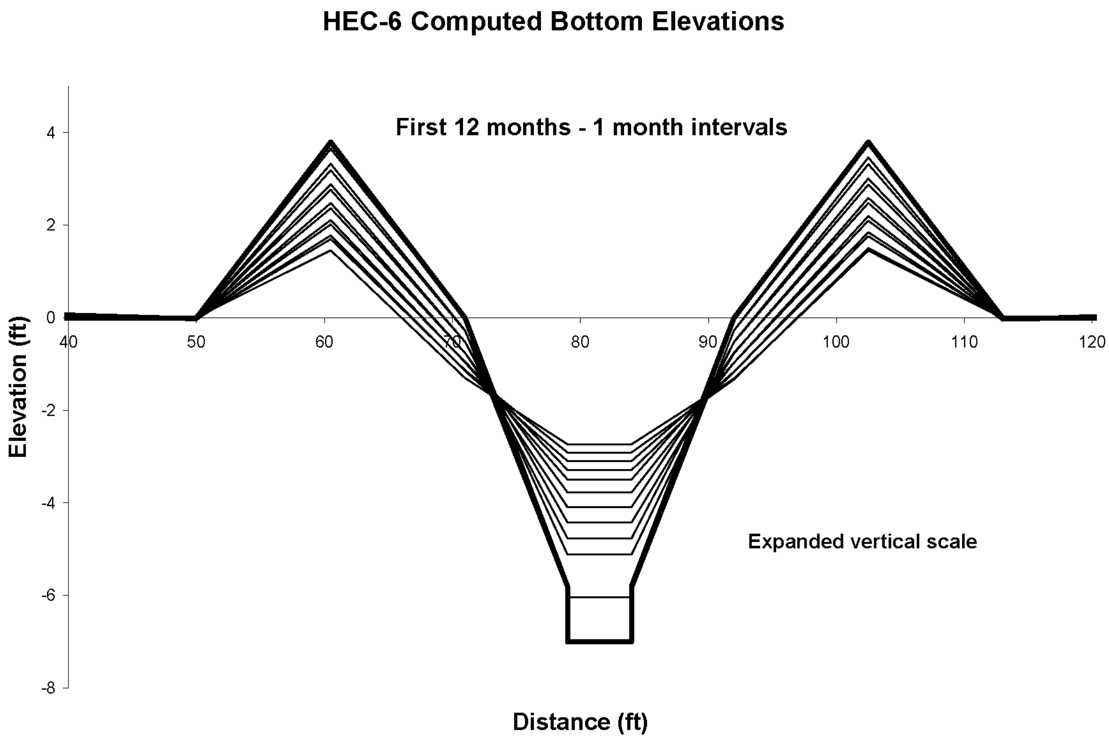

Figure 3. Computed bottom elevations for first 12 months.

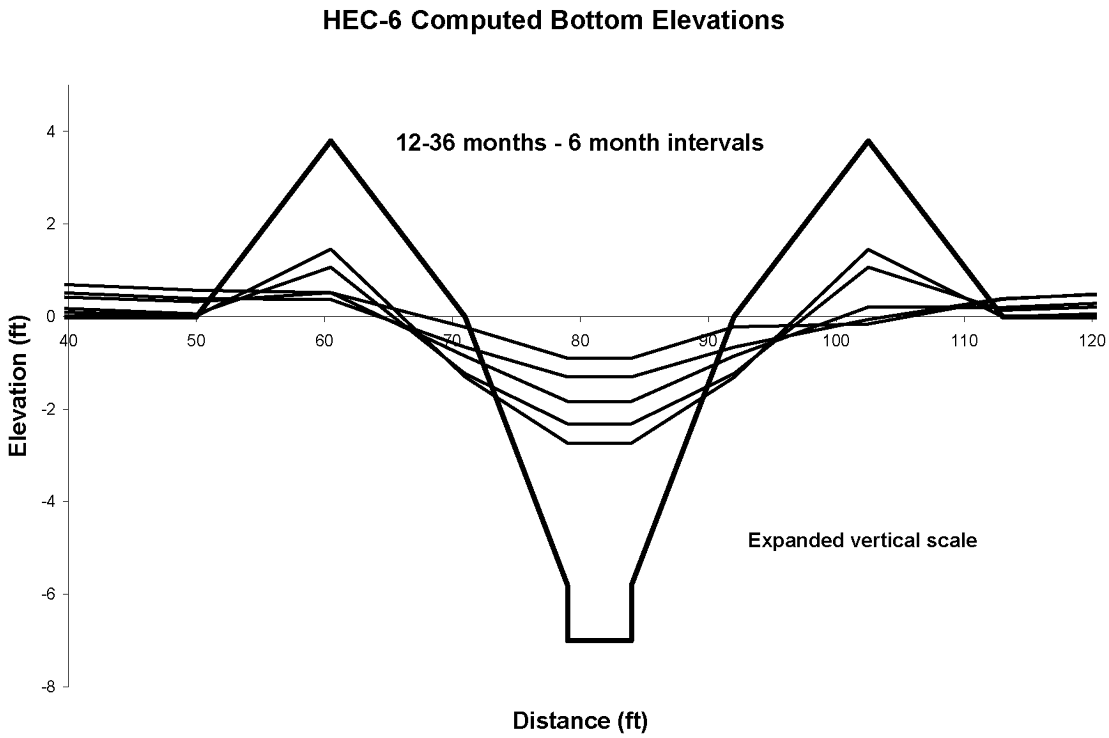

Figure 4. Computed bottom elevations for months 12 to 36.

3.1 Stratford Shoals

The model results described above can be considered indicative of what would occur along most of the route, where the sediment is a mixture of clay, silt and sand. In the area of the Stratford Shoals the sediment composition is primarily sand, or sand and gravel. No modeling was done specifically of the Stratford Shoals This section comprises approximately one mile of the 22 mile route.

Even though the ADCP located on the shoal showed maximum tidal velocities in the 2.5 ft/s range, these velocities are only likely to move small amounts of the heavy sand and gravel, that comprises the sediment of the shoals, into the trench. The shallow depth of the shoal (around 45 ft), and its prominent vertical relief indicate that high bottom velocities will occur during storm events. It is these storm-induced velocities that will be responsible for most of the sediment transport that will fill in the trench.

As mentioned previously, storms are random events in terms of occurrence, duration, strength and direction. For this reason no attempt is made to predict the timeframe over which the trench in the vicinity of the Stratford Shoals will be filled.

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