



Channel and Marina Dredging/Restoration of Bayside Sediment Processes

Sailors Haven Ecological Monitoring Report

Natural Resource Report NPS/FIIS/NRR—2019/1943



ON THE COVER

Gregory Greene and Garner Greene seining at Sailors Haven, Fire Island National Seashore.
KEITH BREWER /CASHIN ASSOCIATES, P.C.

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June 2019

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Landers, L., C. Soucier, K. Kuroiwa-Bazzan, K. Brewer, and K. Thyberg. 2019. Channel and marina dredging/restoration of bayside sediment processes: Sailors Haven ecological monitoring report. Natural Resource Report NPS/FIIS/NRR—2019/1943. National Park Service, Fort Collins, Colorado.

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Executive Summary

Ecological monitoring was conducted by Cashin Associates, P.C. (CA) to evaluate the impact of creating a feeder beach adjacent to Sailors Haven Marina (Fire Island, New York) on nearshore nekton community compositions and abundance. Tetra Tech provided oversight, management and technical support through GSA Contract No. GS-10F-0268K. A total of eight monitoring events were performed by CA from 2014 to 2017, two pre-construction (fall 2014 and fall 2015) and six post-construction events (spring, summer and fall of 2016 and 2017). Sampling was conducted by seining at triplicate random locations within each pre-defined project reach (transect) to characterize pre- and post- feeder beach finfish and invertebrate species composition and abundance.

Nearly 11,900 specimens were captured, measured, and released during the eight sampling events, consisting of 35 species of finfish, shrimp, and crab. The dominant finfish species captured was *Menidia menidia*, accounting for 50.8% of all finfish captured, followed by *Anchoa mitchilli* (44.1%). The species richness differed substantially by season, with the highest number of species captured in summer 2017. The data appeared to indicate that seasonal variability is a dominant factor in determining species richness and abundance.

Community composition and abundance were compared between years and among project reaches using the Analysis and Similarities (ANOSIM) procedure. Species composition and abundance were not found to differ significantly from pre-construction (2014, 2015) to post-construction years (2016, 2017), nor by sampling reach (transects extending east and west of the construction zone). Differences in abundance did exist between years, but there is no clear indication that these differences are a result of construction activities, particularly because no significant differences were observed from 2014 (pre-construction) to the post-construction years (2016, 2017), and significant differences were observed between post-construction years. ANOSIM analyses also indicated that significant differences in abundance were observed between seasons.

For pair-wise comparisons that were significant (i.e., communities were different) the proportion of the overall dissimilarity that was contributed by individual species was calculated using the Similarity Percentage analysis (SIMPER) procedure which utilizes the Bray-Curtis similarity measure. The species which contributed most to the dissimilarity for all significant year comparisons were *Menidia menidia*, *Crangon septemspinosa*, *Ovalipes ocellatus*, and *Anchoa mitchilli*. For season, *M. menidia*, *Anchoa mitchilli*, and *Crangon septemspinosa* contributed substantially to the seasonal dissimilarity.

Introduction

In September 2016, the National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, published a report (*Evaluation of the Effects of a Demonstration Project for Restoring Bayside Sediment Processes at Sailors Haven Marina*) to evaluate whether establishing a feeder beach to reinstate the sediment budget adjacent to a bulkhead at Sailor Haven, Fire Island, NY is a feasible solution for addressing future erosion problems along its sandy estuarine shore. The questions addressed in that report were (1) how fast does the new fill move out of the placement area; (2) how does the transported fill change coastal landforms downdrift; (3) are the volume and frequency of emplacement that are required for maintenance of landforms related to dredging needs; and (4) can the configuration of the fill mimic natural environments and minimize adverse environmental impacts? That report addressed the physical changes to the shore and suggested that a companion report will be produced to evaluate the impacts of those change on biota. This *Response of Nekton Community Composition and Abundance to Nourishment of an Estuarine Beach at Sailors Haven, NY* report represents that companion report.

The National Park Service, in cooperation with the Eastern Federal Lands Highway Division of the Federal Highway Administration and the U.S. Army Corps of Engineers, dredged the Sailors Haven Marina and Channel in November 2015. The dredged material was placed along the shoreline west of the marina. Ecological monitoring was performed pre-construction (pre-feeder beach) and post-construction (post-feeder beach) by Cashin Associates, P.C. (CA) at Sailors Haven from 2014 through 2017 (Appendix A: Location Map). Tetra Tech was the prime contractor (GS-10F-0268K) and managed the overall project. The purpose of the ecological monitoring was evaluate impacts to nekton community compositional and abundance from estuarine beach nourishment to create a feeder beach to restore sediment transport interrupted by dredging and hardened shoreline.

The presence of high quality beach sand in Sailors Haven Channel provided a ready sediment source of beachfront compatible material. Using sand obtained from the November 2015 dredging of the entrance channel, a feeder beach was created adjacent to Sailors Haven Marina along the western shoreline. The fill was placed along a 75 meter (m) length of upland and at height similar to the eroding bluff. The quantity of fill placed was measured at 1,747 m³ with a maximum shoreline advance of 20.7m.

Methods

Sampling Design

Ecological monitoring was conducted by CA over a four year period from 2014 through 2017. A total of eight monitoring events were conducted, as follows: two pre-construction events (fall 2014 and 2015); and six post-construction events (spring/summer/fall 2016, and spring/summer/fall 2017).

Previous monitoring efforts have produced an additional four years of data on the east side of the Sailors Haven Marina. These pre-feeder beach data are described in the 2011 Demonstration Project-Implementation Plan and are not discussed in this report.

Four sample areas were used for all sampling events (Figure 1):

- West Reach (nourishment area)
 - Transect 1: 0-200 meters west (direct impact)
 - Transect 2: 200-400 meters west (indirect impact)
- East Reach (control area)
 - Transect 3: 0-200 meters east (control)
 - Transect 4: 200-400 meters east (control)



Figure 1. The four sampling areas at Sailors Haven Marina, Fire Island, NY.

Nekton Sampling

In compliance with Project NY ERFO FIIS 3013-1(5) Sailors Haven Ecological Monitoring Statement of Work, nekton sampling was performed as random triplicate seine hauls within these four areas. Seining was conducted at triplicate random locations within each area by setting a 9.1 meter beach seine approximately 15 meters offshore and parallel to the shoreline and hauling the seine onto the beach at a constant rate. Replicate samples were conducted in sequence by area (i.e. each area was sampled once before repeating the sequence) with a random start.

Nekton were collected, identified to species or lowest practical taxonomic level, measured, and released. For each seine haul, up to 50 individuals of each species of nekton were measured to the nearest millimeter. In some instances where a very large abundance of specimens were captured, 50 individuals were measured and the rest were counted for a total count (these instances are noted in the results). For finfish, the maximum total length (tip of snout to the tip of the longer lobe of the caudal fin with lobes compressed along the midline) were measured to the nearest millimeter. For shrimp, the length (inside of the eye socket to the tip of the tail) were measured to the nearest millimeter. For crabs, the maximum carapace width was also measured to the nearest millimeter. Voucher specimens were collected only when field identification was not possible.

Water quality parameters, including dissolved oxygen, temperature and salinity, was measured with a YSI-85 meter (or equivalent) prior to the start of each seine haul. All instrumentation was calibrated to ensure accurate field measurements.

Sampling data were then analyzed. Species richness (total number of species captured) was first determined for finfish and invertebrates. Abundance, expressed in catch per unit effort (CPUE), was also determined. Next, community composition and abundance were compared between years and among project reach using the Analysis and Similarities (ANOSIM) procedure in the PRIMER statistical package (version 7.0). ANOSIM is a non-parametric, multivariate permutation procedure that analyses both species composition and abundance and is considered a non-parametric analog to MANOVA. Assumptions of normality can generally not be satisfied with community datasets, and thus, MANOVA is not an appropriate analysis method.

The ANOSIM procedure calculates a similarity measure and a similarity matrix that allows for the objective identification of samples that have similar (or dissimilar) communities in term of species composition and abundance. The Bray Curtis similarity metric was then used to create similarity matrices from the untransformed abundance data. Pair-wise comparisons were made using Clark's R (Global R) that compares between-group to within-group dissimilarities. Monte Carlo permutation tests were run 99,999 times and were used to derive p-values for comparisons between groups of samples.

For pair-wise comparisons that were significant (i.e., communities were different) the proportion of the overall dissimilarity that was contributed by individual species was calculated using Similarity Percentage analysis (SIMPER) procedure which utilizes the Bray-Curtis similarity measure. The SIMPER procedure generates a list of species ranked in order by their percent contribution to the dissimilarity between significant pair-wise comparisons.

Statistical Analysis

Abundance and Composition Overview

Dominant Species

A total of 11,858 specimens were captured, measured, and released during all eight sampling events, representing 35 finfish, shrimp, and crab species (Table 1 and Appendix B). A total of 10,767 finfish specimens were captured, representing 26 finfish species. The most dominant finfish species was *Menidia menidia* (5,466 specimens), accounting for 50.8% of all finfish captured. The second most dominant finfish species was *Anchoa mitchilli* (4,746 specimens), accounting for 44.1% of all finfish captured. Therefore, these two species accounted for nearly 95% of all finfish captured. The other finfish species captured were observed in relatively small frequencies.

A total of 495 crab specimens were captured, representing seven crab species. The most dominant crab species was *Callinectes sapidus* (286 specimens), accounting for 57.8% of all crabs captured. The second most dominant crab species was *Pagurus* spp. (108 specimens), followed by *Emerita talopoida* (46 specimens), and *Ovalipes ocellatus* (30 specimens). A total of 596 shrimp specimens were captured, consisting of two shrimp species. 69.8% of shrimp captured were *Crangon septemspinosa* and 30.2% were *Hippolyte* spp. It can be concluded that although 35 species were captured overall, a majority of the catch consisted of six species that were observed in high abundance (*Menidia menidia*, *Anchoa mitchilli*, *Callinectes sapidu*, *Emerita talopoida*, *Crangon septemspinosa*, and *Palaemonetes* spp.).

Catch per Unit Effort

Table 1 shows the abundance in terms of Catch per Unit Effort (CPUE) for all sampling events. The CPUE represents the total number of each species caught divided by the total number of seine trawls (12 total trawls per event over 8 events which totals to 96 trawls). The CPUE across all events for finfish, crabs, and shrimp was 123.52 (112.16 for finfish, 5.16 for crabs, and 6.21 for shrimp). The species with the highest CPUE was *M. menidia* (56.94), followed by *Anchoa mitchilli* (49.44). The CPUE for all other finfish and invertebrate species was small.

Table 1. Species Abundance and Composition: All Sampling, at Sailors Haven Marina, Fire Island, NY. N = total number of specimens captured; %N = percent of either total finfish, crabs, or shrimp; CPUE = catch per unit effort.

Taxa	Species	Common Name	N	%N	CPUE
Finfish	<i>Menidia menidia</i>	Atlantic silverside	5,466	50.77	56.94
	<i>Anchoa mitchilli</i>	bay anchovy	4,746	44.12	49.44
	<i>Pomatomus saltatrix</i>	bluefish	176	1.64	1.83
	<i>Ammodytes hexapterus</i>	sand lance	139	1.29	1.45
	<i>Syngnathus fuscus</i>	northern pipefish	86	0.80	0.90

Table 1 (continued). Species Abundance and Composition: All Sampling, at Sailors Haven Marina, Fire Island, NY. N = total number of specimens captured; %N = percent of either total finfish, crabs, or shrimp; CPUE = catch per unit effort.

Taxa	Species	Common Name	N	%N	CPUE
Finfish (continued)	<i>Mugil cephalus</i>	striped mullet	32	0.30	0.33
	<i>Fundulus majalis</i>	striped killifish	25	0.23	0.26
	<i>Brevoortia tyrannus</i>	Atlantic menhaden	15	0.14	0.16
	<i>Stenotinus chrysops</i>	scup	12	0.11	0.13
	<i>Menticirrhus saxatilis</i>	northern kingfish	12	0.11	0.13
	<i>Cyprinodon variegatus</i>	sheepshead minnow	12	0.11	0.13
	<i>Alosa</i> spp.	herring	9	0.08	0.09
	<i>Anchoa hepsetus</i>	broad striped anchovy	8	0.07	0.08
	<i>Trachinotus falcatus</i>	permit	7	0.07	0.07
	<i>Fundulus heteroclitus</i>	mummichog	5	0.05	0.05
	<i>Fistularia tabacaria</i>	tobacco pipefish	3	0.03	0.03
	<i>Paralichthys dentatus</i>	summer flounder	2	0.02	0.02
	<i>Strogylura marina</i>	Atlantic needlefish	2	0.02	0.02
	<i>Apeltes quadracus</i>	fourspine stickleback	2	0.02	0.02
	<i>Anguila rostrata</i>	American eel	2	0.02	0.02
	<i>Pseudopleuronectes americanus</i>	winter flounder	1	0.01	0.01
	<i>Sphoeroides maculatus</i>	northern puffer	1	0.01	0.01
	<i>Tauatoga onitis</i>	blackfish	1	0.01	0.01
	<i>Tautoglabrus adspersus</i>	bergall	1	0.01	0.01
	<i>Trachurus lathami</i>	rough scad	1	0.01	0.01
	<i>Opsanus tau</i>	oyster toadfish	1	0.01	0.01
Finfish Total	–	–	10,767	–	112.16
Crabs	<i>Callinectes sapidus</i>	blue crab	286	57.78	2.98
	<i>Pagurus</i> spp.	hermit crab	109	22.02	1.14
	<i>Emerita talpoida</i>	mole crab	46	9.29	0.48
	<i>Ovalipes ocellatus</i>	lady crab	30	6.06	0.31
	<i>Panopeus</i> spp.	mud crab	12	2.42	0.13
	<i>Carcinus maenas</i>	green crab	10	2.02	0.10
	<i>Libinia emarginata</i>	portly spider crab	2	0.40	0.02
Crabs Total	–	–	495	–	5.16
Shrimp	<i>Crangon septemspinosa</i>	sand shrimp	416	69.80	4.33
	<i>Palaemonetes</i> spp.	grass shrimp	180	30.20	1.88
Shrimp Total	–	–	596	–	6.21
Total Finfish, Crabs, Shrimp	–	–	11,858	–	123.43

Species Richness and Number of Specimens Captured

Table 2 shows the total number of specimens captured and the number of species observed by sampling event (defined by year and season). The sampling event with the greatest number of specimens collected was summer 2017 (4,944 specimens), followed by fall 2017 (2,700 specimens), and summer 2016 (1,453 specimens). The sampling event with the fewest number of specimens collected was fall 2015 (129 specimens). The mean number of specimens caught per season differed substantially by season, with 978 specimens captured in fall, 772 captured in spring, and 3,199 captured in summer.

Table 2. Number of specimens captured and species abundance by sampling event at Sailors Haven Marina, Fire Island, NY. N = total number of specimens captured.

Event / Total N Across All Transects and Replicates	Transect ¹	Total Species Count	# Replicates	Total N Across 3 Transect Replicates
Fall 2014 / 534	1	13	3	142
	2	15	3	76
	3	18	3	183
	4	13	3	133
Fall 2015 / 129	1	13	3	71
	2	6	3	17
	3	5	3	14
	4	4	3	27
Spring 2016 / 560	1	17	3	115
	2	10	3	78
	3	15	3	38
	4	16	3	329
Summer 2016 / 1,453	1	14	3	169
	2	16	3	241
	3	22	3	786
	4	18	3	257
Fall 2016 / 546	1	16	3	106
	2	10	3	78
	3	12	3	33
	4	16	3	329

¹ Transects are numbered as follows:

Transect 1 - 0-200 meters west (direct impact)

Transect 2 - 200-400 meters west (indirect impact)

Transect 3 - 0-200 meters east (control)

Transect 4 - 200-400 meters east (control)

Table 2 (continued). Number of specimens captured and species abundance by sampling event at Sailors Haven Marina, Fire Island, NY. N = total number of specimens captured.

Event / Total N Across All Transects and Replicates	Transect ¹	Total Species Count	# Replicates	Total N Across 3 Transect Replicates
Spring 2017 / 992	1	13	3	73
	2	14	3	96
	3	15	3	551
	4	12	3	272
Summer 2017 / 4,944	1	29	3	714
	2	23	3	523
	3	27	3	1,614
	4	19	3	2,093
Fall 2017 / 2,700	1	9	3	1,694
	2	11	3	223
	3	13	3	487
	4	9	3	296

¹ Transects are numbered as follows:

Transect 1 - 0-200 meters west (direct impact)

Transect 2 - 200-400 meters west (indirect impact)

Transect 3 - 0-200 meters east (control)

Transect 4 - 200-400 meters east (control)

Table 3 shows the average species richness (number of species captured) per replicate by project reach (transect) and sampling event. On average, the greatest number of species were observed during the summer 2017 event (8.2 species), followed by summer 2016 (5.8 species), and fall 2014 (4.9 species). On average, the fewest number of species were observed during the fall 2015 event (2.3 species). The average species richness differed substantially by season, with 3.8 species captured in fall, 4.6 captured in spring, and 7.0 captured in summer.

Table 3. Mean number of species captured by project reach and event at Sailors Haven Marina, Fire Island, NY.

Event / Average Number of Species per Event	Transect ¹	Average Number of Species per Transect
Fall 2014 / 4.9	1	4.3
	2	5.0
	3	6.0
	4	4.3
Fall 2015 / 2.3	1	4.3
	2	2.0
	3	1.7
	4	1.3
Spring 2016 / 4.8	1	5.3
	2	3.3
	3	5.0
	4	5.3
Summer 2016 / 5.8	1	4.7
	2	5.3
	3	7.3
	4	6.0
Fall 2016 / 4.5	1	5.3
	2	3.3
	3	4.0
	4	5.3
Spring 2017 / 4.5	1	4.3
	2	4.7
	3	5.0
	4	4.0
Summer 2017 / 8.2	1	9.7
	2	7.7
	3	9.0
	4	6.3
Fall 2017 / 3.5	1	3.0
	2	3.7
	3	4.3
	4	3.0

¹ 3 replicates were conducted for each transect. Transects are numbered as follows:

Transect 1 - 0-200 meters west (direct impact)

Transect 2 - 200-400 meters west (indirect impact)

Transect 3 - 0-200 meters east (control)

Transect 4 - 200-400 meters east (control)

The total number of specimens captured and the species richness was also examined per transect. Average species richness and number of individual specimens per transect were as follows:

- *Transect 1* - richness: 5.2, specimens: 3,084
- *Transect 2* - richness: 4.4, specimens: 1,332
- *Transect 3* - richness: 5.3, specimens: 3,706
- *Transect 4* - richness: 4.5, specimens: 3,736

All transects had similar average species richness. Transect 3 had the highest average species richness and number of specimens captured, and transect 2 the lowest. The number of specimens captured in transect 2 was considerably less than the other three transects.

Specimen Length

Table 4 provides a summary of the length data collected as part of the monitoring effort. The maximum total length of up to 50 individuals of each species of finfish, crab, and shrimp were measured to the nearest millimeter. In some instances, more than 50 specimens were measured if the species was observed in large abundance. The table shows the total number of specimens of each species measured and counted per monitoring event, as well as the average, minimum and maximum length recorded. Note that the ordering of species listed in the table is based on the abundance of the species across all sampling events (consistent with Table 1).

Table 4. Mean length of specimens captured at Sailors Haven Marina, Fire Island, NY.

Taxa	Species	Common Name	Fall 2014	Fall 2015	Spring 2016	Summer 2016	Fall 2016	Spring 2017	Summer 2017	Fall 2017
			M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)
Finfish	<i>Menidia menidia</i>	Atlantic silverside	72 (163)	49 (91)	73 (87)	55 (481)	67 (5)	91 (83)	60 (283)	64 (470)
	<i>Anchoa mitchilli</i>	bay anchovy	35 (49)	47 (13)	–	36 (16)	46 (15)	31 (196)	29 (550)	35 (37)
	<i>Pomatomus saltatrix</i>	bluefish	13 (1)	–	–	–	127 (15)	–	104 (86)	–
	<i>Ammodytes hexapterus</i>	sand lance	–	–	–	–	–	39 (111)	–	–
	<i>Syngnathus fuscus</i>	northern pipefish	14 (8)	44 (1)	74 (1)	86 (23)	45 (1)	153 (4)	118 (45)	137 (1)
	<i>Mugil cephalus</i>	striped mullet	–	–	–	92 (29)	–	–	134 (2)	99 (1)
	<i>Fundulus majalis</i>	striped killifish	26 (1)	27 (2)	84 (35)	109 (17)	38 (3)	–	52 (1)	62 (2)
	<i>Brevoortia tyrannus</i>	Atlantic menhaden	–	–	–	–	–	–	49 (15)	–
	<i>Stenotinus chrysops</i>	scup	–	–	–	–	–	–	115 (11)	135 (1)
	<i>Menticirrhus saxatilis</i>	northern kingfish	12 (6)	–	–	–	–	–	140 (6)	–
	<i>Cyprinodon variegatus</i>	sheepshead minnow	–	–	30 (4)	–	36 (6)	–	–	–
	<i>Alsos</i> spp.	herring	–	–	32 (9)	–	–	–	–	–
	<i>Anchoa hepsetus</i>	broad striped anchovy	–	–	–	–	27 (4)	–	–	–
	<i>Trachinotus falcatus</i>	permit	67 (4)	–	–	–	–	–	–	174 (3)
	<i>Fundulus heteroclitus</i>	mummichog	–	38 (1)	48 (1)	33 (1)	–	43 (2)	–	69 (1)
	<i>Fistularia tabacaria</i>	tobacco pipefish	–	–	–	138 (4)	–	–	–	–
	<i>Paralichthys dentatus</i>	summer flounder	–	–	–	–	–	–	233 (2)	–
	<i>Strogylura marina</i>	Atlantic needlefish	–	–	–	–	–	–	155 (3)	–
	<i>Apeltes quadracus</i>	fourspine stickleback	–	–	–	–	–	–	36 (2)	–
	<i>Anguila rostrata</i>	American eel	–	–	–	–	–	55 (2)	–	–
	<i>P. americanus</i>	winter flounder	–	–	–	–	–	–	71 (1)	–
	<i>Sphoeroides maculatus</i>	northern puffer	–	–	–	79 (1)	–	–	–	–
	<i>Tauatoga onitis</i>	blackfish	76 (1)	–	–	–	–	–	–	–

¹ M = Mean length

² N = number of specimens measured. In cases where more than 50 specimens per tow were captured, only 50 were measured to determine mean length.

Table 4 (continued). Mean length of specimens captured at Sailors Haven Marina, Fire Island, NY.

Taxa	Species	Common Name	Fall 2014	Fall 2015	Spring 2016	Summer 2016	Fall 2016	Spring 2017	Summer 2017	Fall 2017
			M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)	M ¹ (N ²)
Finfish (cont'd)	<i>Tautoglabrus adspersus</i>	bergall	46 (1)	–	–	–	–	–	–	–
	<i>Opsanus tau</i>	oyster toadfish	–	–	–	33 (1)	–	–	–	–
Crabs	<i>Callinectes sapidus</i>	blue crab	15 (12)	–	11 (3)	47 (49)	19 (25)	10 (2)	20 (171)	14 (1)
	<i>Pagurus</i> spp.	hermit crab	11 (20)	12 (1)	13 (120)	18 (14)	14 (21)	16 (17)	18 (6)	15 (18)
	<i>Emerita talpoida</i>	mole crab	–	13 (16)	–	–	–	11 (18)	10 (8)	–
	<i>Ovalipes ocellatus</i>	lady crab	–	–	–	74 (5)	63 (3)	–	84 (2)	–
	<i>Panopeus</i> spp.	mud crab	–	–	11 (2)	–	–	–	6 (3)	–
	<i>Carcinus maenas</i>	green crab	–	–	–	–	13 (5)	–	–	–
	<i>Libinia emarginata</i>	portly spider crab	–	–	71 (7)	–	–	–	–	–
Shrimp	<i>Crangon septemspinosa</i>	sand shrimp	–	–	35 (11)	29 (76)	29 (39)	43 (93)	23 (43)	30 (24)
	<i>Palaemonetes</i> spp.	grass shrimp	–	34 (4)	–	34 (18)	29 (15)	31 (40)	27 (52)	32 (4)

¹ M = Mean length

² N = number of specimens measured. In cases where more than 50 specimens per tow were captured, only 50 were measured to determine mean length.

Abundance and Composition by Year, Season, and Project Reach: ANOSIM and SIMPER Analysis

Species composition and abundance were compared between assigned groups using the non-parametric ANOSIM method. ANOSIM was used to test differences in species composition and abundance among the following: (1) year of survey; (2) season of survey; and (3) transect. The null hypothesis tested using ANOSIM is that similarity between groups is greater than or equal to the similarity within groups (essentially stating that there is no difference between members of the groups). If the assigned groups are meaningful, samples within groups should be more similar than samples from different groups and the null hypothesis should be rejected.

A Bray-Curtis similarity measure and similarity matrix was generated to identify samples that had similar communities in terms of species composition and abundance. Pair-wise comparisons were made using Clark's R that compares between-group to within-group dissimilarities. The test statistic, R, can range in value from -1 to 1, where positive numbers indicate more similarity within groups, and values close to zero represent no difference between groups and within groups. Negative R values indicate more similarity between groups than within groups.

To test for significance and generate p-values, the ranked similarity within and between groups was compared with the similarity that would be generated by random chance. Essentially, the samples are randomly assigned to groups 99,999 times with R calculated for each permutation. The observed R value is then compared against the random distribution to evaluate if it is significantly different from that which could occur at random. If the value of R is significant, it can be concluded that there is evidence that the samples within groups are more similar than would be expected by random chance.

Year

Species composition and abundance were compared between assigned groups using the non-parametric ANOSIM method. ANOSIM was used to test differences in species composition and abundance among the following: (1) year of survey; (2) season of survey; and (3) transect. The null hypothesis tested using ANOSIM is that similarity between groups is greater than or equal to the similarity within groups (essentially stating that there is no difference between members of the groups). If the assigned groups are meaningful, samples within groups should be more similar than samples from different groups and the null hypothesis should be rejected.

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To test for significance and generate p-values, the ranked similarity within and between groups was compared with the similarity that would be generated by random chance. Essentially, the samples are randomly assigned to groups 99,999 times with R calculated for each permutation. The observed R value is then compared against the random distribution to evaluate if it is significantly different from

that which could occur at random. If the value of R is significant, it can be concluded that there is evidence that the samples within groups are more similar than would be expected by random chance.

Species composition and abundance was also examined separately between project years for post-construction sampling events only (2016, 2017). These events were conducted during all three seasons (spring, summer, fall) for each year. Note that sampling was conducted during the fall season only for pre-construction (2014, 2015) sampling events. Significant differences in abundance were observed between years 2016 and 2017 (ANOSIM, $R = 0.13$, $p < 0.05$), thus indicating that the null hypothesis can be rejected. These results support those found in the overall year analysis (Table 5), as the 2016/2017 pairwise comparison was found to be significant in that comparison as well. So, differences in abundance between 2016 and 2017 can be concluded.

Table 5. ANOSIM Analysis Results: Year, at Sailors Haven Marina, Fire Island, NY.

Groups	R Statistic	Significance Level
Unordered Year Groups	0.171	0.00001*
2014, 2015	0.344	0.00009*
2014, 2016	0.009	0.413
2014, 2017	0.086	0.107
2015, 2016	0.313	0.0001*
2015, 2017	0.327	0.00003*
2016, 2017	0.130	0.0004*

*p value significant at the 0.05 level

Season

Species composition and abundance were also compared between seasons (fall, spring, summer). Significant differences in abundance were observed between seasons (ANOSIM, $R = 0.157$, $p < 0.05$), thus indicating that the null hypothesis can be rejected (Table 6). Therefore, differences in abundance were observed between seasons. When examining pairwise comparisons between seasons (comparing every combination of two groups), significant differences between seasons was observed for all seasonal comparisons. R values for these pairwise comparisons were: fall/spring-0.100; fall/summer-0.143; and spring/summer-0.324, with p values all being less than 0.05 (Table 6). All R values were greater than 0, indicating some divergence in community structure by season. However, they were all less than 0.5, suggesting that a high level of species overlap within seasonal communities also exists.

Table 6. ANOSIM Analysis Results: Season, at Sailors Haven Marina, Fire Island, NY.

Groups	R Statistic	Significance Level
Unordered Season Groups	0.157	0.00001*
Fall, Spring	0.100	0.015*
Fall, Summer	0.143	0.004*
Spring, Summer	0.324	0.00001*

*p value significant at the 0.05 level

Reach

Species composition and abundance were compared between project reach (transects 1, 2, 3, and 4). No significant differences in abundance were observed between transects (ANOSIM, $R = 0.002$, $p > 0.05$), thus indicating that the null hypothesis cannot be rejected (Table 7). Therefore, no differences between transects can be concluded. All of the R values for pairwise comparisons were very close to 0, indicating no difference between groups and within groups.

Table 7. ANOSIM Analysis Results: Reach, at Sailors Haven Marina, Fire Island, NY.

Groups	R Statistic	Significance Level
Unordered Transect Groups	0.002	0.394
1, 2	-0.012	0.624
1, 3	0.005	0.353
1, 4	0	0.423
2, 3	0.034	0.113
2, 4	0.012	0.279
3, 4	-0.024	0.814

*p value significant at the 0.05 level

Significant Pair-Wise Comparisons: SIMPER Analysis

For pair-wise comparisons that were significant (i.e., communities were different), the proportion of the overall dissimilarity that was contributed by individual species was calculated using Similarity Percentage analysis (SIMPER) methodology which utilizes the Bray-Curtis similarity measure. The SIMPER procedure generates a list of species ranked in order by their percent contribution to the dissimilarity between significant pair-wise comparisons.

Table 8 provides a summary of the SIMPER analysis for year and shows the percent contribution of species to the dissimilarity values for high contributing variables. Average dissimilarity for the significant pairwise comparisons for year ranged from 81.81 to 89.29. *Menidia menidia* contributed most to the dissimilarity for all significant year comparisons. Other species contributing substantially to the dissimilarity were: *Crangon septemspinosa*, *Ovalipes ocellatus*, and *Anchoa mitchilli*.

Table 8. SIMPER Analysis Results: Year, at Sailors Haven Marina, Fire Island, NY.

Group, Average Dissimilarity	Species	% Contribution to Dissimilarity
2014 and 2015, 84.17	<i>Menidia menidia</i>	43.45
	<i>Crangon septemspinosa</i>	21.80
	<i>Ovalipes ocellatus</i>	6.39
2015 and 2016, 83.69	<i>Menidia menidia</i>	53.29
	<i>Crangon septemspinosa</i>	10.74
	<i>Anchoa mitchilli</i>	6.15
2015 and 2017, 89.29	<i>Menidia menidia</i>	35.92
	<i>Anchoa mitchilli</i>	35.65
2016 and 2017, 81.81	<i>Menidia menidia</i>	42.08
	<i>Anchoa mitchilli</i>	33.24

Table 9 provides a summary of the SIMPER analysis for season and shows the percent contribution of species to the dissimilarity values for high contributing variables. Average dissimilarity for the significant pairwise comparisons for season ranged from 81.99 to 84.24. *Menidia menidia* contributed most to the dissimilarity for the fall/spring and fall/summer comparisons. *Anchoa mitchilli* contributed most for the spring/summer comparison. *Crangon septemspinosa* also contributed substantially to the dissimilarity.

Table 9. SIMPER Analysis Results: Season, at Sailors Haven Marina, Fire Island, NY.

Group, Average Dissimilarity	Species	% Contribution to Dissimilarity
Fall and Spring, 82.06	<i>Menidia menidia</i>	44.65
	<i>Anchoa mitchilli</i>	15.21
	<i>Crangon septemspinosa</i>	12.27
Fall and Summer, 81.99	<i>Menidia menidia</i>	41.67
	<i>Anchoa mitchilli</i>	37.55
Spring and Summer, 84.24	<i>Anchoa mitchilli</i>	39.84
	<i>Menidia menidia</i>	37.30

Discussion

Analyses indicated that significant differences in abundance were observed between years for all year pairwise comparisons, except for 2014/2016 and 2014/2017. Therefore, it appears that differences in abundance do exist between years, but there is no clear indication that these differences are a result of construction activities, particularly because no significant differences were observed from 2014 (pre-construction) to the post-construction years (2016, 2017), and significant differences were observed between post-construction years. Annual differences in abundance may result from other factors, such as environmental conditions (e.g., weather). The species which contributed most to the dissimilarity for all significant year comparisons were *Menidia menidia*, *Crangon septemspinosa*, *Ovalipes ocellatus*, and *Anchoa mitchilli*. The year analysis did indicate that although significant community differences do exist between years, there also is a high level of species overlap across annual communities as well.

In addition to year, differences in abundance were also analyzed by season and were found to be significant. So, seasonal variability was found to be a dominant factor in determining abundance at the study site. Considerable differences in abundance were observed between all three seasons when sampling occurred (fall, spring, summer). The species which contributed most to the dissimilarity for all significant season comparisons were *Menidia menidia*, *Anchoa mitchilli*, and *Crangon septemspinosa*. The summer, on average, had the highest species richness, as well as the highest number of individual specimens, compared to the fall and spring. Some species overlap was observed across seasonal communities as well.

Transect did not have a significant effect on species composition and abundance. This suggests that the indirect and direct effects of the creation of a feeder beach did not impact abundance to the east or west of the marina. Although some differences in community structure across transects was observed, the transect communities were not found to be significantly different in terms of abundance and, in general, the communities strongly overlapped.

Physical water quality parameters were also collected and the average recording for each location is depicted in Table 10. Parameters recorded were temperature (°C), pH, dissolved oxygen (mg/l), and salinity (ppt). The data appears to indicate that there is no significant difference in the average water quality by transect that would suggest any differential effect on species composition or abundance.

Table 10. Depicts average physical water quality parameter recorded for each location at Sailors Haven Marina, Fire Island, NY.

Site	Temperature (°C)	pH	DO (mg/l)	Salinity (ppt)
0-200 East	22.21	8.40	6.64	27.45
200-400 East	21.95	8.43	6.94	27.56
0-200 West	22.00	8.26	6.32	26.22
200-400 West	22.19	8.42	6.18	27.08

Conclusions

Ecological monitoring was conducted from 2014 to 2017 to evaluate impacts to nekton community composition and abundance from estuarine beach nourishment to create a feeder beach to restore sediment transport interrupted by dredging and hardened shoreline. The ecological monitoring was performed to characterize species composition and abundance related to pre- and post- feeder beach construction activities. Species composition and abundance were not found to differ significantly from pre-construction to post-construction years, nor by sampling reach (control transects extending east and feeder beach transects extending to the west). Other factors not dependent on construction activities, such as year and season, were found to lead to significant differences in species abundance and composition.

Appendix A. Location Map at Sailors Haven Marina, Fire Island, NY.



Appendix B. Data Summaries: Detailed Species Abundance by Sampling Event and Transect

Table B-1. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		F14T1-1	F14T1-2	F14T1-3	F14T2-1	F14T2-2	F14T2-3	F14T3-1	F14T3-2	F14T3-3	F14T4-1
Finfish	<i>Menidia menidia</i>	23	28	3	6	—	32	123	2	16	106
	<i>Anchoa mitchilli</i>	1	—	—	—	—	—	—	—	—	—
	<i>Pomatomus saltatrix</i>	—	—	—	—	—	—	1	—	—	—
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	—	—	1	1	1	1	—	4	—	—
	<i>Mugil cephalus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	—	—	—	1	—	—	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	1	2	1	—	—	—	2
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Alsos</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	1
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tauatoga onitis</i>	—	—	—	—	—	—	—	1	—	—
	<i>Tautogolabrus adspersus</i>	—	—	—	—	—	—	—	1	—	—
	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	4	4	1	—	—	—	—	—	—	2
	<i>Pagurus</i> spp.	3	5	—	4	3	—	1	—	2	2
	<i>Emerita talpoida</i>	—	—	—	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	2	2	—	4	4	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	9	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	2	—	—
Shrimp	<i>Crangon septemspinosa</i>	33	24	12	16	—	3	3	2	3	3
	<i>Palaemonetes</i> spp.	—	—	—	—	—	—	—	4	1	1

Table B-2. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		F14T4-2	F14T4-3	F15T1-1	F15T1-2	F15T1-3	F15T2-1	F15T2-2	F15T2-3	F15T3-1	F15T3-2
Finfish	<i>Menidia menidia</i>	–	1	6	32	11	5	1	7	10	1
	<i>Anchoa mitchilli</i>	–	–	5	4	3	–	–	–	–	–
	<i>Pomatomus saltatrix</i>	–	–	–	–	–	–	–	–	–	–
	<i>Ammodytes hexapterus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Syngnathus fuscus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Mugil cephalus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Fundulus majalis</i>	–	–	–	1	1	–	–	–	–	–
	<i>Brevoortia tyrannus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Stenotinus chrysops</i>	–	–	–	–	–	–	–	–	–	–
	<i>Menticirrhus saxatilis</i>	–	–	–	–	–	–	–	–	–	–
	<i>Cyprinodon variegatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Alsos</i> spp.	–	–	–	–	–	–	–	–	–	–
	<i>Anchoa hepsetus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Trachinotus falcatus</i>	–	3	–	–	–	–	–	–	–	–
	<i>Fundulus heteroclitus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Fistularia tabacaria</i>	–	–	–	–	–	–	–	–	–	–
	<i>Paralichthys dentatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Strogylura marina</i>	–	–	–	–	–	–	–	–	–	–
	<i>Apeltes quadracus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Anguila rostrata</i>	–	–	–	–	–	–	–	–	–	–
	<i>P. americanus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Sphoeroides maculatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Tauatoga onitis</i>	–	–	–	–	–	–	–	–	–	–
	<i>Tautoglabrus adspersus</i>	–	–	–	–	–	–	–	–	–	–

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	1	—	—	—	—	—	1	—	—	—
	<i>Pagurus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Emerita talpoida</i>	—	—	2	1	3	—	—	1	—	—
	<i>Ovalipes ocellatus</i>	5	—	—	—	—	—	—	—	—	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	5	—	—	—	—	—	—	—	—	—
	<i>Palaemonetes</i> spp.	—	1	1	—	1	2	—	—	—	—

Table B-3. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		F15T3-3	F154T4-1	F15T4-2	F15T4-3	S16T1-1	S16T1-2	S16T1-3	S16T2-1	S16T2-2	S16T2-3
Finfish	<i>Menidia menidia</i>	—	5	2	11	1	6	45	1	43	9
	<i>Anchoa mitchilli</i>	1	—	—	—	—	—	—	—	—	—
	<i>Pomatomus saltatrix</i>	—	—	—	—	1	—	2	—	11	1
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	1	—	—	—	—	—	—	—	—	—
	<i>Mugil cephalus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	5	—	—	—	—	—
	<i>Alsos</i> spp.	—	—	—	—	—	—	9	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus heteroclitus</i>	1	—	—	—	—	—	—	—	—	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tauatoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	—	—	—	—	2	—	7	1	—	—
	<i>Pagurus</i> spp.	—	—	—	—	1	4	3	3	4	—
	<i>Emerita talpoida</i>	—	—	9	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	1	—	—	—	—	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	—	—	—	—	7	—	14	4	—	1
	<i>Palaemonetes</i> spp.	—	—	—	—	—	—	6	—	—	—

Table B-4. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		S16T3-1	S16T3-2	S16T3-3	16T4-1	S16T4-2	S16T4-3	SU16T1-1	SU16T1-2	SU16T1-3	S16T2-1
Finfish	<i>Menidia menidia</i>	—	—	1	—	284	9	81	8	52	83
	<i>Anchoa mitchilli</i>	—	—	15	—	—	—	—	—	—	—
	<i>Pomatomus saltatrix</i>	—	—	—	—	—	—	—	—	2	1
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	—	—	—	—	—	1	—	—	—	—
	<i>Mugil cephalus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	2	1	—	—	—	—	—	4	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	1	—	—	—	—	—
	<i>Alsos spp.</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	1	—	2	—	—	—	—	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	1	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	1	—	—	1
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tauatoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	2	—	1	3	4	5	—	1	3	1
	<i>Pagurus</i> spp.	3	1	—	—	1	1	—	1	—	—
	<i>Emerita talpoida</i>	—	—	—	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	2	—	—	—	2
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	5	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	4	1	2	2	3	1	—	5	1	—
	<i>Palaemonetes</i> spp.	1	2	1	5	—	—	—	7	2	—

Table B-5. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		SU16T2-2	SU16T2-3	SU16T3-1	SU16T3-2	SU16T3-3	SU16T4-1	SU16T4-2	SU16T4-2	F16T1-1	F16T1-2
Finfish	<i>Menidia menidia</i>	25	94	275	232	190	109	22	26	1	6
	<i>Anchoa mitchilli</i>	—	—	6	8	—	2	—	—	—	—
	<i>Pomatomus saltatrix</i>	—	—	1	—	—	—	—	—	1	—
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	—	1	4	1	3	1	13	—	—	—
	<i>Mugil cephalus</i>	—	—	2	—	25	—	—	2	—	—
	<i>Fundulus majalis</i>	—	7	—	—	3	—	2	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	—	—	5	—
	<i>Alsos</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	—	—	—	1
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fistularia tabacaria</i>	1	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	1	—	—	—	—	—	—	—	—
	<i>Tauatoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	1	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	—	1	3	1	7	—	31	1	2	—
	<i>Pagurus</i> spp.	1	—	2	1	3	1	—	3	1	4
	<i>Emerita talpoida</i>	—	—	—	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	2	—	—	—	1	—	—	1	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	1	19	2	5	11	2	30	—	7	—
	<i>Palaemonetes</i> spp.	—	—	—	—	—	3	4	2	—	—

Table B-6. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		F16T1-3	F16T2-1	F16T2-2	F16T2-3	F16T3-1	F16T3-2	F16T3-3	F16T4-1	F16T4-2	F16T4-3
Finfish	<i>Menidia menidia</i>	45	1	43	9	—	—	—	—	284	9
	<i>Anchoa mitchilli</i>	—	—	—	—	—	—	15	—	—	—
	<i>Pomatomus saltatrix</i>	2	—	11	1	—	—	—	—	—	—
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	—	—	—	—	—	—	—	—	—	1
	<i>Mugil cephalus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	—	—	1	—
	<i>Alsos spp.</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	1	—	2	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	7	1	—	—	2	1	1	3	4	5
	<i>Pagurus</i> spp.	3	3	4	—	1	—	—	—	1	1
	<i>Emerita talpoida</i>	—	—	—	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	—	—	—	—	2
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	5	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	14	4	—	1	4	1	2	2	3	1
	<i>Palaemonetes</i> spp.	6	—	—	—	2	2	1	5	—	—

Table B-7. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		S17T1-1	S17T1-2	S17T1-3	S17T2-1	S17T2-2	S17T2-3	S17T3-1	S17T3-2	S17T3-3	S17T4-1
Finfish	<i>Menidia menidia</i>	1	—	1	—	1	39	26	16	—	—
	<i>Anchoa mitchilli</i>	—	—	—	—	1	—	353	44	1	83
	<i>Pomatomus saltatrix</i>	—	—	—	—	—	—	—	—	—	—
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	78	2	—	17
	<i>Syngnathus fuscus</i>	1	—	2	—	—	—	1	—	—	—
	<i>Mugil cephalus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	—	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Alsos</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	2	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	2	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	—	—	1	—	—	1	—	—	—	—
	<i>Pagurus</i> spp.	2	—	—	1	1	—	—	—	3	1
	<i>Emerita talpoida</i>	—	—	—	9	9	4	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	12	29	2	9	3	6	5	13	4	—
	<i>Palaemonetes</i> spp.	4	13	3	6	—	6	1	2	—	—

Table B-8. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		S17T4-2	S17T4-3	SU17T1-1	SU17T1-2	SU17T1-3	SU17T2-1	SU17T2-2	SU17T2-3	SU17T3-1	SU17T3-2
Finfish	<i>Menidia menidia</i>	–	–	3	22	52	7	12	9	50	19
	<i>Anchoa mitchilli</i>	113	–	320	88	58	242	62	138	850	120
	<i>Pomatomus saltatrix</i>	–	1	–	4	3	–	2	2	8	105
	<i>Ammodytes hexapterus</i>	41	–	–	–	–	–	–	–	–	–
	<i>Syngnathus fuscus</i>	–	–	1	2	2	1	–	1	2	5
	<i>Mugil cephalus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Fundulus majalis</i>	–	–	–	–	1	–	–	–	–	–
	<i>Brevoortia tyrannus</i>	–	–	6	4	–	3	–	1	1	–
	<i>Stenotinus chrysops</i>	–	–	1	–	–	–	–	–	4	2
	<i>Menticirrhus saxatilis</i>	–	–	2	–	–	–	–	–	1	3
	<i>Cyprinodon variegatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Alsos spp.</i>	–	–	–	–	–	–	–	–	–	–
	<i>Anchoa hepsetus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Trachinotus falcatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Fundulus heteroclitus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Fistularia tabacaria</i>	–	–	–	–	–	–	–	–	–	–
	<i>Paralichthys dentatus</i>	–	–	1	–	–	1	–	–	–	–
	<i>Strogylura marina</i>	–	–	–	–	1	–	–	–	–	1
	<i>Apeltes quadracus</i>	–	–	–	–	–	–	–	–	–	1
	<i>Anguila rostrata</i>	–	–	–	–	–	–	–	–	–	–
	<i>P. americanus</i>	–	–	1	–	–	–	–	–	–	–
	<i>Sphoeroides maculatus</i>	–	–	–	–	–	–	–	–	–	–
	<i>Tauatoga onitis</i>	–	–	–	–	–	–	–	–	–	–
	<i>Tautoglabrus adspersus</i>	–	–	–	–	–	–	–	–	–	–

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	1
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	—	—	21	9	26	7	15	4	10	—
	<i>Pagurus</i> spp.	1	2	1	—	1	—	—	—	1	2
	<i>Emerita talpoida</i>	—	—	—	—	—	—	5	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	1	1	—	—	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	2	—	—	1
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	5	3	30	—	6	—	4	—	—	—
	<i>Palaemonetes</i> spp.	1	4	25	12	11	1	2	—	—	25

Table B-9. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate.

Taxa	Species	Sampling Event / Transect/ Replicate									
		SU17T3-3	SU17T4-1	SU17T4-2	SU17T4-3	F17T1-1	F17T1-2	F17T1-3	F17T2-1	F17T2-2	F17T2-3
Finfish	<i>Menidia menidia</i>	46	11	31	89	720	890	47	157	45	7
	<i>Anchoa mitchilli</i>	335	1,490	120	230	13	3	18	1	2	—
	<i>Pomatomus saltatrix</i>	7	—	8	2	—	—	—	—	—	—
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Syngnathus fuscus</i>	3	—	20	10	—	—	—	—	—	—
	<i>Mugil cephalus</i>	—	2	—	—	—	—	—	—	—	—
	<i>Fundulus majalis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Stenotinus chrysops</i>	—	—	—	4	—	—	—	—	—	—
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Alsos spp.</i>	—	—	—	—	—	—	—	—	—	—
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	—	—	—	3
	<i>Fundulus heteroclitus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	—	—	—	—
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Strogylura marina</i>	—	—	—	—	—	—	—	—	—	—
	<i>Apeltes quadracus</i>	—	—	1	—	—	—	—	—	—	—
	<i>Anguila rostrata</i>	—	—	—	—	—	—	—	—	—	—
	<i>P. americanus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tauatoga onitis</i>	—	—	—	—	—	—	—	—	—	—
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	—	—	—	—

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	—	—	—	—
	<i>Opsanus tau</i>	—	—	—	—	—	—	—	—	—	—
Crabs	<i>Callinectes sapidus</i>	10	7	44	18	—	1	—	—	—	—
	<i>Pagurus</i> spp.	1	—	—	—	—	—	—	1	1	—
	<i>Emerita talpoida</i>	—	3	—	—	—	—	—	—	—	—
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	—	—	—	—	—
	<i>Panopeus</i> spp.	—	—	—	—	—	—	—	—	—	—
	<i>Carcinus maenas</i>	—	—	—	—	—	—	—	—	—	—
	<i>Libinia emarginata</i>	—	—	—	—	—	—	—	—	—	—
Shrimp	<i>Crangon septemspinosa</i>	—	—	1	2	1	1	—	—	4	1
	<i>Palaemonetes</i> spp.	—	—	—	—	—	—	—	—	1	—

Table B-10. Detailed Species Abundance by Sampling Event and Transect. Sampling event nomenclature is interpreted as follows: First Letter represents season, followed by two numbers which represent year, followed by letter and number which represents transect, followed by number which represents replicate. SUM = total number of individuals for all transects and replicates.

Taxa	Species	Sampling Event / Transect/ Replicate						
		F17T3-1	F17T3-2	F17T3-3	F17T4-1	F17T4-2	F17T4-3	SUM
Finfish	<i>Menidia menidia</i>	50	386	28	186	88	3	5,466
	<i>Anchoa mitchilli</i>	—	—	—	—	—	—	4,746
	<i>Pomatomus saltatrix</i>	—	—	—	—	—	—	176
	<i>Ammodytes hexapterus</i>	—	—	—	—	—	—	139
	<i>Syngnathus fuscus</i>	—	1	—	—	—	—	86
	<i>Mugil cephalus</i>	—	—	1	—	—	—	32
	<i>Fundulus majalis</i>	1	—	1	—	—	—	25
	<i>Brevoortia tyrannus</i>	—	—	—	—	—	—	15
	<i>Stenotinus chrysops</i>	—	1	—	—	—	—	12
	<i>Menticirrhus saxatilis</i>	—	—	—	—	—	—	12
	<i>Cyprinodon variegatus</i>	—	—	—	—	—	—	12
	<i>Alsos</i> spp.	—	—	—	—	—	—	9
	<i>Anchoa hepsetus</i>	—	—	—	—	—	—	8
	<i>Trachinotus falcatus</i>	—	—	—	—	—	—	7
	<i>Fundulus heteroclitus</i>	—	—	1	—	—	—	5
	<i>Fistularia tabacaria</i>	—	—	—	—	—	—	3
	<i>Paralichthys dentatus</i>	—	—	—	—	—	—	2
	<i>Strogylura marina</i>	—	—	—	—	—	—	2
	<i>Apeltes quadracus</i>	—	—	—	—	—	—	2
	<i>Anguila rostrata</i>	—	—	—	—	—	—	2
	<i>P. americanus</i>	—	—	—	—	—	—	1
	<i>Sphoeroides maculatus</i>	—	—	—	—	—	—	1
	<i>Tautoga onitis</i>	—	—	—	—	—	—	1
	<i>Tautoglabrus adspersus</i>	—	—	—	—	—	—	1

Finfish (cont'd)	<i>Trachurus lathami</i>	—	—	—	—	—	—	1
	<i>Opsanus tau</i>	—	—	—	—	—	—	1
Crabs	<i>Callinectes sapidus</i>	—	—	—	—	—	—	286
	<i>Pagurus</i> spp.	—	4	8	1	—	3	109
	<i>Emerita talpoida</i>	—	—	—	—	—	—	46
	<i>Ovalipes ocellatus</i>	—	—	—	—	—	—	30
	<i>Panopeus</i> spp.	—	—	—	—	—	—	12
	<i>Carcinus maenas</i>	—	—	—	—	—	—	10
	<i>Libinia emarginata</i>	—	—	—	—	—	—	2
Shrimp	<i>Crangon septemspinosa</i>	—	—	3	1	5	8	416
	<i>Palaemonetes</i> spp.	—	—	2	1	—	—	180

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NPS 615/154321, June 2019

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