Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

2017 Annual Performance Reports
F-61-R-21
Grant Number: F14AF00182

Jobs 1-14

Note: Jobs 5 and 7 have been completed

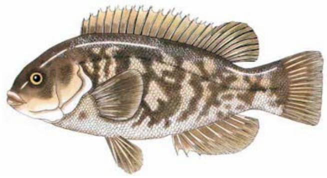
PERIOD: January 1, 2017 – December 31, 2017

Rhode Island Division of Marine Fisheries

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

COASTAL FISHERY RESOURCE ASSESSMENT TRAWL SURVEY
2017

PERFORMANCE REPORT
F-61-R SEGMENT 21
JOBS 1 AND 2



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Rhode Island Department of Environmental Management
Division of Fish and Wildlife
Marine Fisheries

March 2018

Annual Performance Report

STATE: Rhode Island PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

JOB NUMBER: 1
TITLE: Narragansett Bay Monthly Fishery Resource Assessment

JOB OBJECTIVE: To collect, summarize and analyze bottom trawl data for biological and fisheries management purposes.

PERIOD COVERED: January 1, 2017 – December 31, 2017.

PROJECT SUMMARY: Job 1, summary accomplished:

A: 156 twenty-minute bottom trawl were successfully completed.

B: Data on weight, length, sex and numbers were gathered on 61 species. Hydrographic data were gathered as well. Additionally, anecdotal notations were made on other plant and animal species. Although not previously discussed, these notations are in keeping with past practice.

TARGET DATE: December 2017

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

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JOB NUMBER: 2
TITLE: Seasonal Fishery Resource Assessment of Narragansett Bay, Rhode Island Sound and Block Island Sound

JOB OBJECTIVE: To collect, summarize and analyze bottom trawl data for biological and fisheries management purposes.

PERIOD COVERED: Spring (April – May)/ Fall (September – October) 2017

PROJECT SUMMARY: Job 2, summary accomplished:

A: 44, twenty-minute tows were successfully completed during the Spring 2017 survey (26 NB. – 6 RIS – 12 BIS).

B: 44, twenty-minute tow were successfully completed during the Fall 2017 survey (26 NB. – 6 RIS – 12 BIS)

C: Data on weight, length, sex and numbers were gathered on

61 species. Hydrographic data were gathered as well. Additionally, anecdotal notations were made on other plant and animal species. Although not previously discussed, these notations are in keeping with past practice.

TARGET DATE: DECEMBER 2017.

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

JOBS 1 & 2

RECOMMENDATIONS: Continuation of both the Monthly and Seasonal Trawl surveys into 2018, Data provided by these surveys is used extensively in the Atlantic States Marine Fisheries Commission Fishery Management process and Fishery Management Plans.

RESULTS AND DISCUSSION: 156 tows were completed during 2017 Job 1 (Monthly survey). 61 species accounted for a combined weight of 8323.4 kgs. and 305,398 length measurements being added to the existing Narragansett Bay monthly trawl data set
By contrast, 88 tows were completed during 2017 Job 2 (Seasonal survey) 61 species accounted for a combined weight of 3991.86 kgs. and 286,941 length measurements added to the existing seasonal data set.

With the completion of the 2017 surveys, combined survey(s) Jobs (1&2) data now reflects the completion of 6,716 tows with data collected on 147 species.

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PREPARED BY: ______________________ ______________________
Christopher J. Parkins Date
Principal Marine Biologist
Principal Investigator

APPROVED BY: ______________________ ______________________
Jason McNamee Date
Chief, Marine Resources
RIDFW – Marine Fisheries

Coastal Fishery Resource Assessment – Trawl Survey

Introduction:

The Rhode Island Division of Fish and Wildlife - Marine Fisheries Section, began monitoring finfish populations in Narragansett Bay in 1968, continuing through 1977. These data provided monthly identification of finfish and crustacean assemblages. As management strategies changed and focus turned to the near inshore waters, outside of Narragansett Bay, a comprehensive fishery resource assessment program was instituted in 1979. (Lynch T. R. Coastal Fishery Resource Assessment, 2007)

Since the inception of the Rhode Island Seasonal Trawl Survey (April 1979) and the Narragansett Bay Monthly Trawl Survey (January 1990), 6,385 tows have been conducted within Rhode Island territorial waters with data collected on 132 species. This performance report reflects the efforts of the 2016 survey year as it relates to the past 37 years. (Lynch T. R. Coastal Fishery Resource Assessment, 2007), (Olszewski S.D. Coastal Fishery Resource Assessment 2014)

Methods:

The methodology used in the allocation of sampling stations employs both random and fixed station allocation. Fixed station allocation began in 1988 in Rhode Island Sound and Block Island Sound. This was based on the frequency of replicate stations selected by depth stratum since 1979. With the addition of the Narragansett Bay monthly portion of the survey in 1990, an allocation system of fixed and randomly selected stations has been employed depending on the segment (Monthly vs. Seasonal) of the annual surveys.

Sampling stations were established by dividing Narragansett Bay into a grid of cells. The seasonal trawl survey is conducted in the spring and fall of each year. Usually 44 stations are sampled each season; however, this number has ranged from 26 to 72 over the survey time series due to mechanical and weather conditions. The stations sampled in Narragansett Bay are a combination of fixed and random sites. 13 fixed during the monthly portion and 26, (14 of which are randomly selected) during the seasonal portion. The random sites are randomly selected from a predefined grid. All stations sampled in Rhode Island and Block Island Sounds are fixed.

Depth Stratum Identification

Area	**Stratum**	**Area nm2**	**Depth Range (m)**
Narragansett Bay	1	15.50	<=6.09
	2	51.00	>=6.09
Rhode Island Sound	3	0.25	<=9.14
	4	2.25	9.14 – 18.28
	5	13.5	18.28 – 27.43
	6	9.75	>=27.43
Block Island Sound	7	3.50	<=9.14
	8	10.50	9.14 – 18.28
	9	11.50	18.28 – 27.43
	10	12.25	27.43 – 36.57
	11	4.00	>=36.57

At each station, an otter trawl equipped with a ¼ mesh inch liner is towed for twenty minutes. The Coastal Trawl survey net is 210 x 4.5”, 2 seam (40’ / 55’), the mesh size is 4.5” and the sweep is 5/16” chain, hung 12” spacing, 13 links per space. Figure 1 depicts the RI Coastal Trawl survey net plan.

The research vessel used in the Coastal Trawl Survey is the R/V John H. Chafee. Built in 2002, the Research Vessel is a 50’ Wesmac hull, powered by a 3406 Caterpillar engine generating 700 hp.

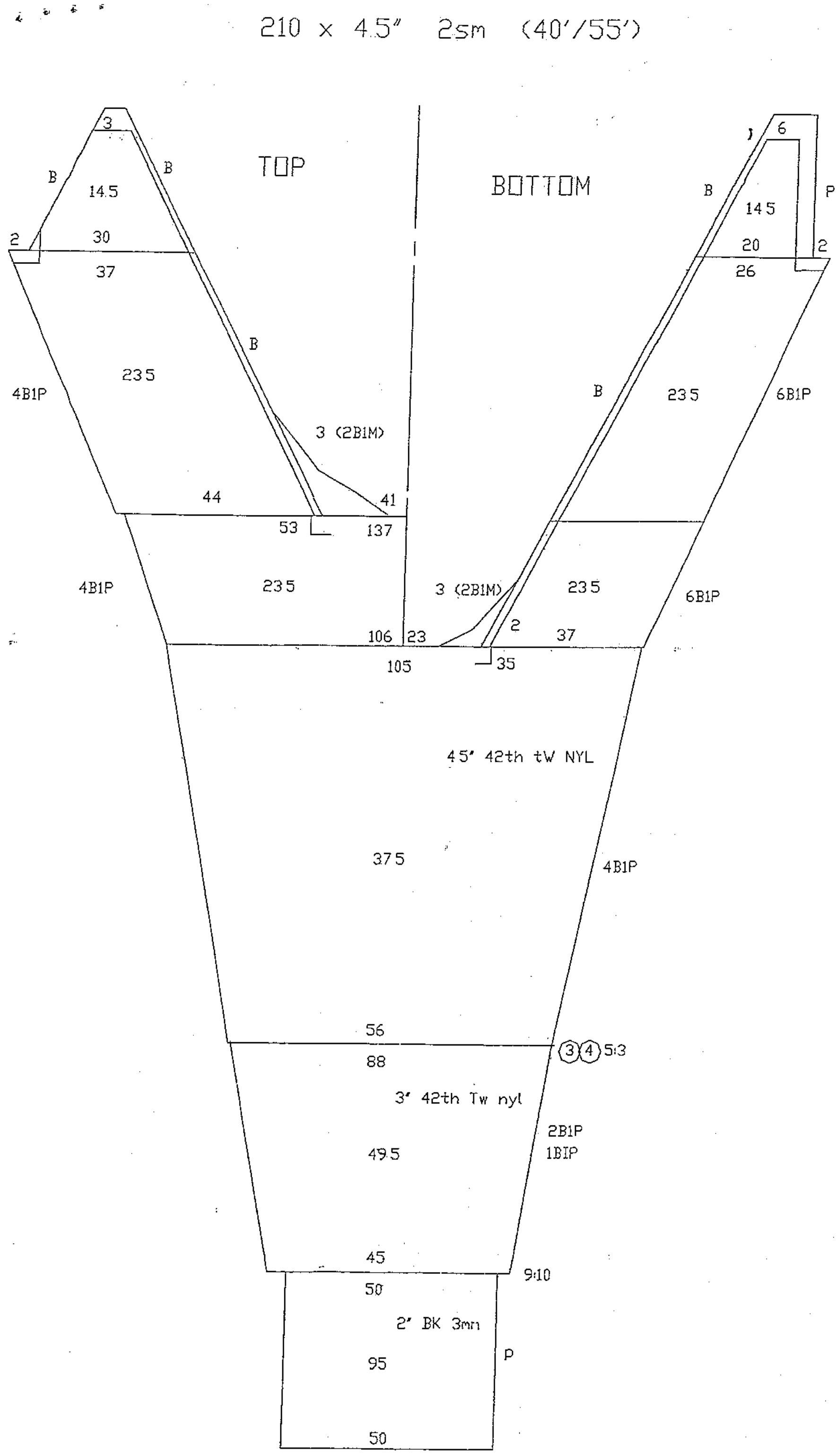
Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, Whelk lobster, blue crabs and horseshoe crabs. Similarly, weights (gm/kg) and number are recorded as well. Anecdotal information is also recorded for incidental plant and animal species.

Survey changes- Beginning January 2012 the Rhode Island Coastal Trawl Survey began using an updated set of trawl doors. Throughout 2012, a comparative gear calibration study was completed to determine if a significant change to the survey catch data is exists. The analysis of this calibration study was completed in 2013 and is available upon request.

RIDEM R/V John H. Chafee

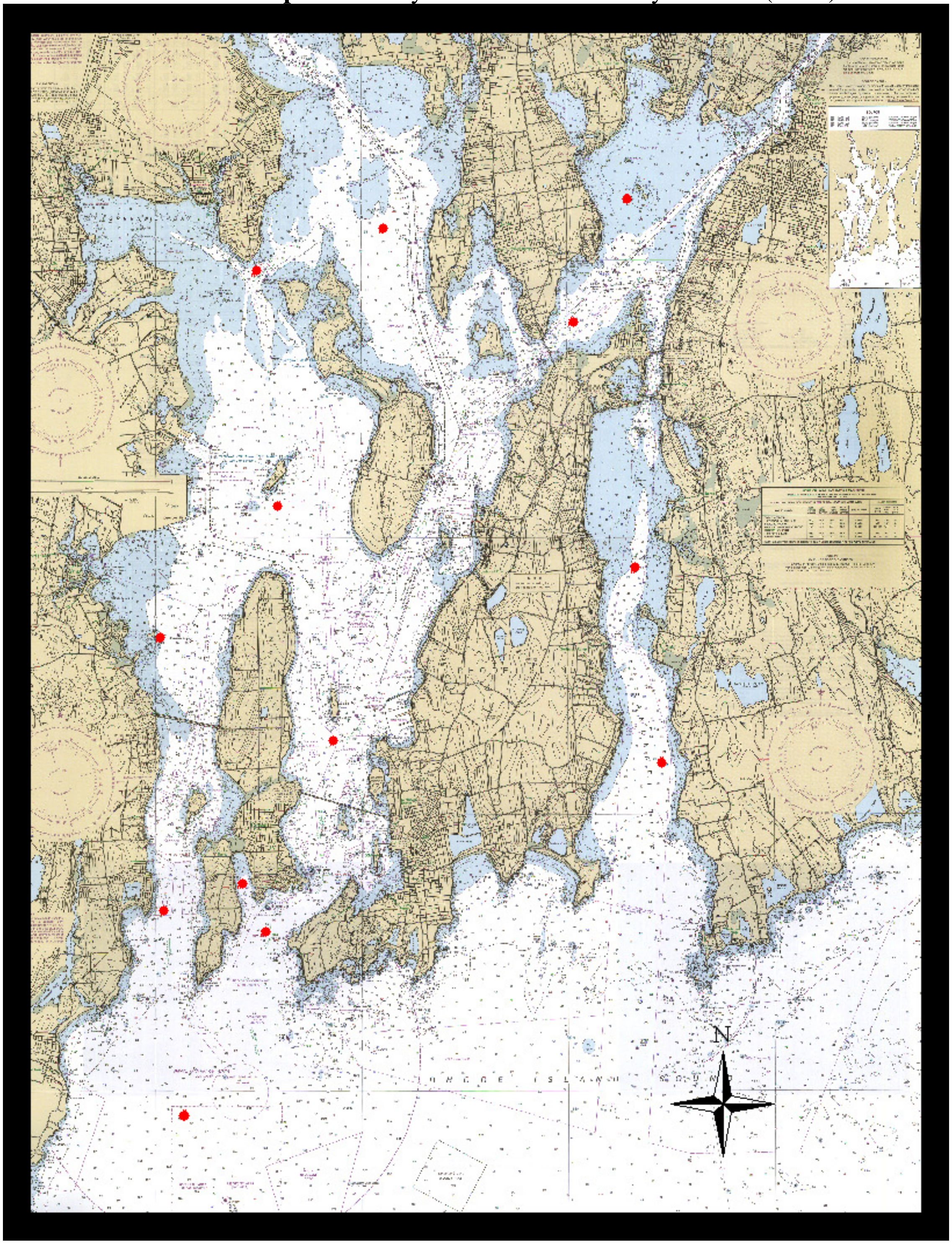
Acknowledgements:
Special thanks are again extended to Captain Richard Mello and Assistant Captain, Patrick Brown, Connor McManus and the entire seasonal staff and volunteers. The support given over the years has been greatly appreciated.

Figure 1



210 x 4.5" 2sm (40'/55')
TOP
BOTTOM
3
B
14.5
B
2
30
37
B
235
4B1P
3 (2B1M)
44
41
53
137
4B1P
235
106
23
105
6
B
145
P
20
2
26
B
235
6B1P
3 (2B1M)
235
6B1P
2
37
35
45' 42th tW NYL
375
4B1P
56
88
③④5:3
3' 42th Tw nyl
2B1P
1B1P
495
45
9:10
50
2" BK 3mm
95
P
50

Map 1 Monthly Coastal Trawl Survey Stations (fixed)



Results: Job 1. Monthly Coastal Trawl Survey; 12 fixed stations in Narragansett Bay and 1 in Rhode Island Sound.

A total of 61 species were observed and recorded during the 2017 Narragansett Bay Monthly Trawl Survey totaling 305,399 individuals or 1957.7 fish per tow. In weight, the catch accounted for 8323.4 kg. or 53.4 kg. per tow. (Figures 2 and 3) The top ten species by number and catch are represented in figures 4 and 5. The catch between demersal and pelagic species is represented in figures 6 and 7and shows a clear shift from demersal species to a more pelagic or multi-habitat species.

Figure 2 (Total Catch in Number)

Scientific Name	Common Name	total #
STENOTOMUS CHRYSOPS	Scup	80960
BREVOORTIA TYRANNUS	Atlantic Menhaden	66848
ANCHOA MITCHILLI	Bay Anchovy	40875
MENIDIA MENIDIA	Atlantic Silverside	35639
PEPRILUS TRIACANTHUS	Butterfish	27620
LOLIGO PEALEI	Longfin Squid	21016
CLUPEA HARENGUS	Atlantic Herring	16474
ALOSA PSEUDOHARENGUS	Alewife	7538
CYNOSCION REGALIS	Weakfish	1411
SELENE SETAPINNIS	Atlantic Moonfish	1374
MERLUCCIUS BILINEARIS	Silver Hake	1194
LEUCORAJA ERINACEA	Little Skate	458
ALOSA AESTIVALIS	Blueback Herring	453
CENTROPRISTIS STRIATA	Black Sea Bass	410
UROPHYCIS REGIA	Spotted hake	372
PRIONOTUS EVOLANS	Striped Sea Robin	348
POMATOMUS SALTATRIX	Bluefish	338
ALOSA SAPIDISSIMA	American Shad	308
GADUS MORHUA	Atlantic Cod	282
HOMARUS AMERICANUS	American Lobster	207
PLEURONECTES AMERICANUS	Winter Flounder	151
PARALICHTHYS DENTATUS	Summer Flounder	141
CANCER IRRORATUS	Rock Crab	138
PRIONOTUS CAROLINUS	Northern Sea Robin	137
UROPHYCIS CHUSS	Red Hake	126
ANCHOA HEPSETUS	Striped Anchovy	116
PARALICHTHYS OBLONGUS	Fourspot Flounder	73
TAUTOGA ONITIS	Tautog	59
MUSTELUS CANIS	Smooth Dogfish	57
MORONE SAXATILIS	Striped Bass	45

SCOPHTHALMUS AQUOSUS	Windowpane Flounder	32
ILLEX ILLECEBROSUS	Shortfin Squid	28
MENTICIRRHUS SAXATILIS	Northern Kingfish	27
LEIOSTOMUS XANTHURUS	Spot	23
LEUCORAJA OCELLATA	Winter Skate	21
RAJA EGLANTERIA	Clearnose Skate	17
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	15
ETROPUS MICROSTOMUS	Smallmouth Flounder	10
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	7
LIMULUS POLYPHEMUS	Horseshoe Crab	6
CANCER BOREALIS	Jonah Crab	5
BUSYCON CARICA	Knobbed Whelk	5
CALLINECTES SAPIDUS	Blue Crab	5
SYNGNATHUS FUSCUS	Northern Pipefish	4
SQUILLA EMPUSA	Mantis Shrimp	3
TRACHURUS LATHAMI	Rough Scad	3
CARANX CRYSOS	Blue Runner	3
SQUALUS ACANTHIAS	Spiny Dogfish	2
TRINECTES MACULATUS	Hogchoker	2
UPENEUS PARVUS	Dwarf Goatfish	2
GASTEROSTEUS ACULEATUS	Threespine Stickleback	1
TAUTOGOLABRUS ADSPERSUS	Cunner	1
LOPHIUS AMERICANUS	Goosefish	1
POLLACHIUS VIRENS	Pollock	1
DECAPTERUS PUNCTATUS	Round Scad	1
LAGODON RHOMBOIDES	Pinfish	1
SPHOEROIDES MACULATUS	Northern Puffer	1
ELOPS SAURUS	Ladyfish	1
EUTHYNNUS ALLETTERATUS	Little Tunny	1
SPHYRAENA BOREALIS	Northern Sennet	1
SCOMBER SCOMBRUS	Atlantic Mackerel	1

Figure 3 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight (kg)
STENOTOMUS CHRYSOPS	Scup	5257.962
PEPRILUS TRIACANTHUS	Butterfish	605.551
LOLIGO PEALEI	Longfin Squid	387.679
CLUPEA HARENGUS	Atlantic Herring	269.281
LEUCORAJA ERINACEA	Little Skate	266.720
BREVOORTIA TYRANNUS	Atlantic Menhaden	253.689
CENTROPRISTIS STRIATA	Black Sea Bass	184.179
ALOSA PSEUDOHARENGUS	Alewife	124.418
PARALICHTHYS DENTATUS	Summer Flounder	112.881
PRIONOTUS EVOLANS	Striped Sea Robin	109.135
MENIDIA MENIDIA	Atlantic Silverside	104.907
TAUTOGA ONITIS	Tautog	91.306
MUSTELUS CANIS	Smooth Dogfish	66.330
HOMARUS AMERICANUS	American Lobster	63.188
POMATOMUS SALTATRIX	Bluefish	60.515
MERLUCCIUS BILINEARIS	Silver Hake	41.711
PLEURONECTES AMERICANUS	Winter Flounder	41.702
ANCHOA MITCHILLI	Bay Anchovy	35.011
MORONE SAXATILIS	Striped Bass	27.053
UROPHYCIS REGIA	Spotted Hake	25.927
RAJA EGLANTERIA	Clearnose Skate	22.300
LEUCORAJA OCELLATA	Winter Skate	21.230
CANCER IRRORATUS	Rock Crab	21.028
CYNOSCION REGALIS	Weakfish	18.713
PRIONOTUS CAROLINUS	Northern Sea Robin	18.145
PARALICHTHYS OBLONGUS	Fourspot Flounder	16.720
ALOSA SAPIDISSIMA	American Shad	14.250
LIMULUS POLYPHEMUS	Horseshoe Crab	13.610
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	6.720
ALOSA AESTIVALIS	Blueback Herring	4.846
UROPHYCIS CHUSS	Red Hake	4.450
SELENE SETAPINNIS	Atlantic Moonfish	4.412
SQUALUS ACANTHIAS	Spiny Dogfish	3.720
EUTHYNNUS ALLETTERATUS	Little Tunny	3.700
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	2.919
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	2.505
MENTICIRRHUS SAXATILIS	Northern Kingfish	2.454
GADUS MORHUA	Atlantic Cod	2.055
LEIOSTOMUS XANTHURUS	Spot	2.050

LOPHIUS AMERICANUS	Goosefish	1.780
BUSYCON CARICA	Knobbed Whelk	1.445
CANCER BOREALIS	Jonah Crab	1.025
CALLINECTES SAPIDUS	Blue Crab	0.910
ANCHOA HEPSETUS	Striped Anchovy	0.888
CARANX CRYSOS	Blue Runner	0.525
SCOMBER SCOMBRUS	Atlantic Mackerel	0.35
ILLEX ILLECEBROSUS	Hortfin Squid	0.345
TAUTOGOLABRUS ADSPERSUS	Cunner	0.280
ELOPS SAURUS	Ladyfish	0.265
TRINECTES MACULATUS	Hogchoker	0.170
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.101
SQUILLA EMPUSA	Mantis Shrimp	0.090
TRACHURUS LATHAMI	Rough Scad	0.055
LAGODON RHOMBOIDES	Pinfish	0.050
POLLACHIUS VIRENS	Pollock	0.030
SPHYRAENA BOREALIS	Northern Sennet	0.022
SPHOEROIDES MACULATUS	Northern Puffer	0.020
UPENEUS PARVUS	Dwarf Goatfish	0.015
SYNGNATHUS FUSCUS	Northern Pipefish	0.013
GASTEROSTEUS ACULEATUS	Threespine Stickleback	0.005
DECAPTERUS PUNCTATUS	Round Scad	0.005

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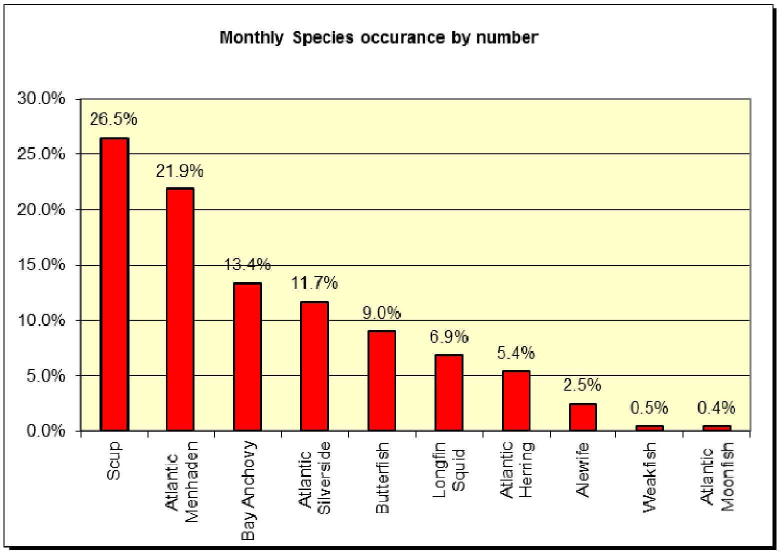
Figure 4 Monthly Survey Top Ten Species Catch in Number

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	26.5%
Atlantic Menhaden	BREVOORTIA TYRANNUS	21.9%
Bay Anchovy	ANCHOA MITCHILLI	13.4%
Atlantic Silverside	MENIDIA MENIDIA	11.7%
Butterfish	PEPRILUS TRIACANTHUS	9.0%
Longfin Squid	LOLIGO PEALEI	6.9%
Atlantic Herring	CLUPEA HARENGUS	5.4%
Alewife	ALOSA PSEUDOHARENGUS	2.5%
Weakfish	CYNOSCION REGALIS	0.5%
Atlantic Moonfish	SELENE SETAPINNIS	0.4%



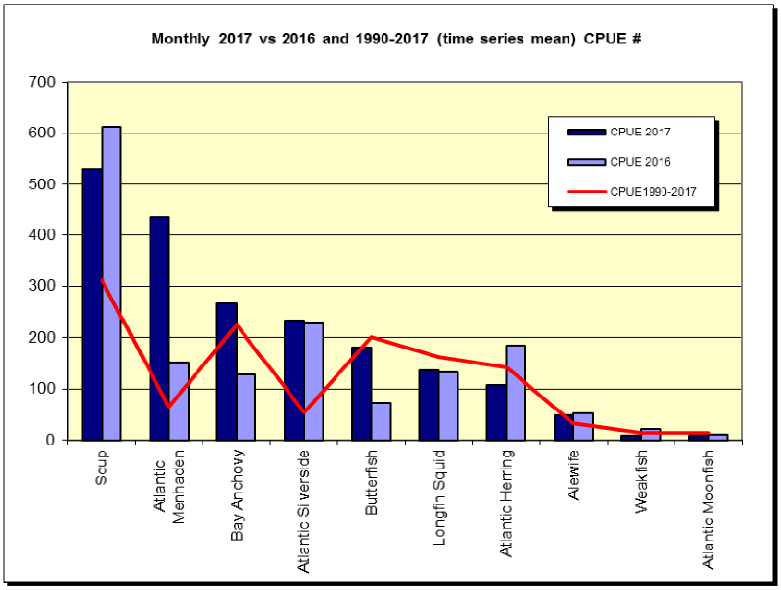
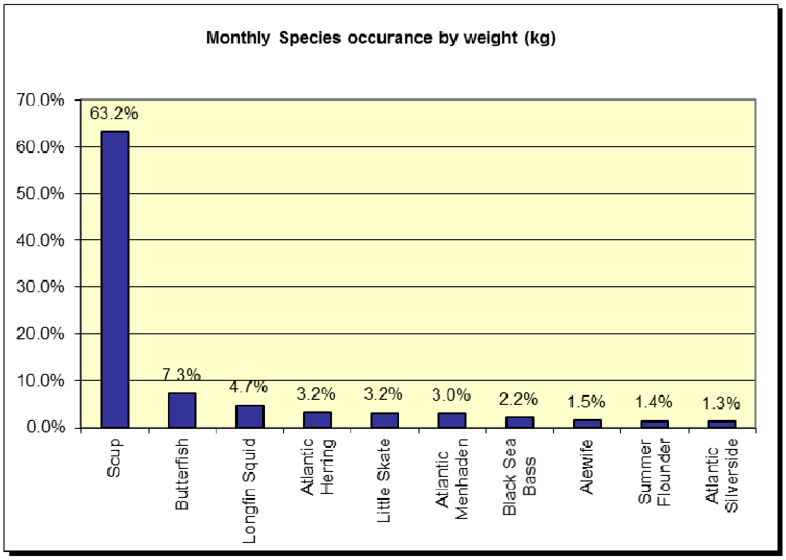
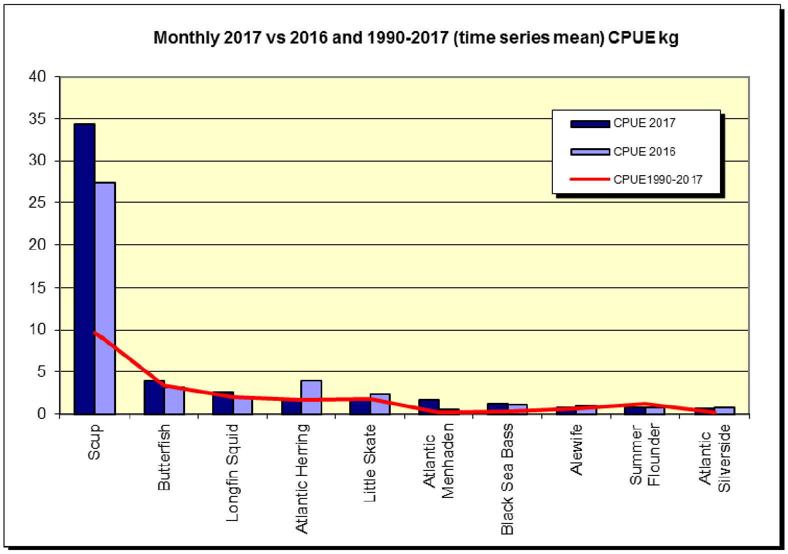


Figure 5 Top Ten Species Catch in Kilograms

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	63.2%
Butterfish	PEPRILUS TRIACANTHUS	7.3%
Longfin Squid	LOLIGO PEALEI	4.7%
Atlantic Herring	CLUPEA HARENGUS	3.2%
Little Skate	LEUCORAJA ERINACEA	3.2%
Atlantic Menhaden	BREVOORTIA TYRANNUS	3.0%
Black Sea Bass	CENTROPRISTIS STRIATA	2.2%
Alewife	ALOSA PSEUDOHARENGUS	1.5%
Summer Flounder	PARALICHTHYS DENTATUS	1.4%
Atlantic Silverside	MENIDIA MENIDIA	1.3%



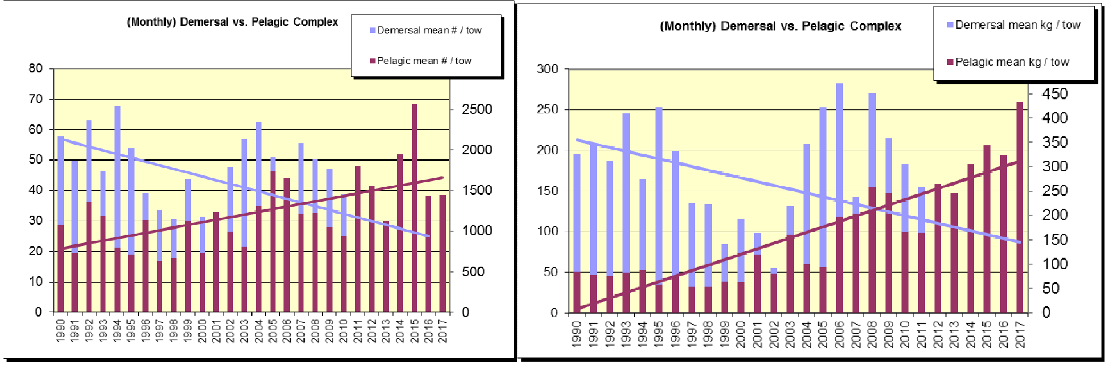


Demersal vs. Pelagic Species Complex

Demersal Species
Cunner
Four Spot Flounder
Goosefish
Hog Choker
Lobster
Longhorn Sculpin
Northern Searobin
Ocean Pout
Red Hake
Sea Raven
Silver Hake
Skates
Smooth Dogfish
Spiny Dogfish
Spotted Hake
Striped Searobin
Summer Flounder
Tautog
Windowpane Flounder
Winter Flounder

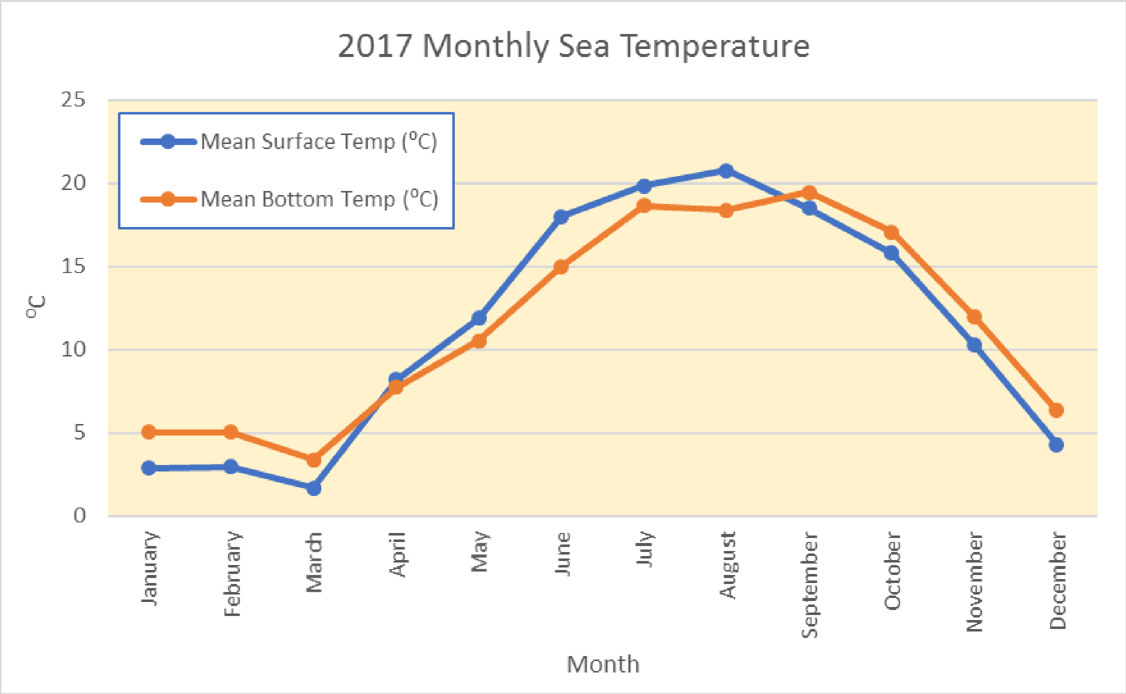
Pelagic/Multi-Habitat Species
Alewife
Atlantic Herring
Atlantic Moonfish
Bay Anchovy
Black Sea Bass
Blueback Herring
Bluefish
Butterfish
Longfin Squid
Menhaden
Rainbow Smelt
Scup
Shad
Silverside
Striped Bass
Weakfish

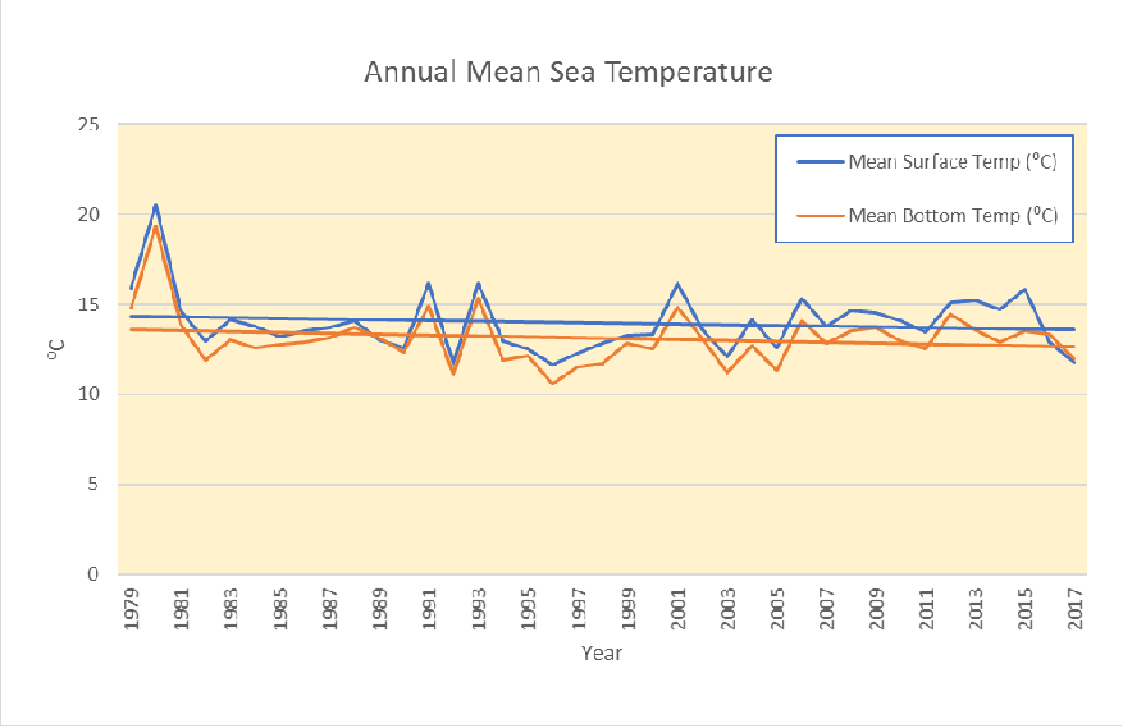
Figure 6 and 7



Survey Temperature Profile (Annual mean surface and bottom temperature)

Surface and bottom temperatures are collected at every station. The bottom temperature is collected by Niskin bottle at the average or maximum depth for each station.





Results: Job 2. The Seasonal Coastal Trawl Survey is defined by 12 fixed stations in Narragansett Bay, 14 random stations in Narragansett Bay, 6 fixed stations in Rhode Island Sound, 12 fixed stations in Block Island Sound.

61 species were observed and recorded during the 2017 Rhode Island Seasonal Trawl Survey, totaling 291,362 individuals or 3387.9 fish per tow. In weight, the catch accounted for 4295.6 kg. or 49.9 kg. per tow. (Figures 8 and 9) The top ten species by number and catch are represented in figures 10 and 11. The change between demersal and pelagic species is represented in figures 12 and 13 and shows a clear shift from demersal species to a more pelagic or multi-habitat species.

Figure 8 (Total Catch in Number)

Scientific Name	Common Name	Total #
ANCHOA MITCHILLI	Bay Anchovy	107123
STENOTOMUS CHRYSOPS	Scup	80177
BREVOORTIA TYRANNUS	Atlantic Menhaden	35821
LOLIGO PEALEI	Longfin Squid	24264
PEPRILUS TRIACANTHUS	Butterfish	19926
CLUPEA HARENGUS	Atlantic Herring	9330
ALOSA PSEUDOHARENGUS	Alewife	2211
SELENE SETAPINNIS	Atlantic Moonfish	1594
LEUCORAJA ERINACEA	Little Skate	1009
CYNOSCION REGALIS	Weakfish	963
POMATOMUS SALTATRIX	Bluefish	879
CENTROPRISTIS STRIATA	Black Sea Bass	463
GADUS MORHUA	Atlantic Cod	342
ALOSA SAPIDISSIMA	American Shad	297
UROPHYCIS REGIA	Spotted Hake	285
PLEURONECTES AMERICANUS	Winter Flounder	255
PRIONOTUS CAROLINUS	Northern Sea Robin	245
LEUCORAJA OCELLATA	Winter Skate	234
ALOSA AESTIVALIS	Blueback Herring	200
MERLUCCIUS BILINEARIS	Silver Hake	191
PARALICHTHYS DENTATUS	Summer Flounder	175
PRIONOTUS EVOLANS	Striped Sea Robin	174
CANCER IRRORATUS	Rock Crab	136
UROPHYCIS CHUSS	Red Hake	118
HOMARUS AMERICANUS	American Lobster	81
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	76
MUSTELUS CANIS	Smooth Dogfish	74
MENTICIRRHUS SAXATILIS	Northern Kingfish	60
MORONE SAXATILIS	Striped Bass	34
AMMODYTES AMERICANUS	American Sand Lance	26

PARALICHTHYS OBLONGUS	Fourspot Flounder	21
LEIOSTOMUS XANTHURUS	Spot	21
RAJA EGLANTERIA	Clearnose Skate	20
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	18
DECAPTERUS PUNCTATUS	Round Scad	13
TAUTOGA ONITIS	Tautog	12
LIMULUS POLYPHEMUS	Horseshoe Crab	10
ETROPUS MICROSTOMUS	Smallmouth Flounder	8
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	7
TRACHURUS LATHAMI	Rough Scad	6
TAUTOGOLABRUS ADSPERSUS	Cunner	5
ANCHOA HEPSETUS	Striped Anchovy	5
SPHOEROIDES MACULATUS	Northern Puffer	4
CALLINECTES SAPIDUS	Blue Crab	4
MENIDIA MENIDIA	Atlantic Silverside	3
CANCER BOREALIS	Jonah Crab	3
PLACOPECTEN MAGELLANICUS	Sea Scallop	3
MACROZOARCES AMERICANUS	Ocean Pout	3
DIPTURUS LAEVIS	Barndoor Skate	2
BUSYCON CARICA	Knobbed Whelk	2
OSMERUS MORDAX	Rainbow Smelt	1
SCOMBER SCOMBRUS	Atlantic Mackerel	1
SERIOLA ZONATA	Banded Rudderfish	1
TRINECTES MACULATUS	Hogchoker	1
UPENEUS PARVUS	Dwarf Goatfish	1
CARANX CRYSOS	Blue Runner	1
LAGODON RHOMBOIDES	Pinfish	1
SQUALUS ACANTHIAS	Spiny Dogfish	1
HEMITRIPTERUS AMERICANUS	Sea Raven	1
ETRUMEUS TERES	Round Herring	1
HIPPOCAMPUS ERECTUS	Seahorse	1

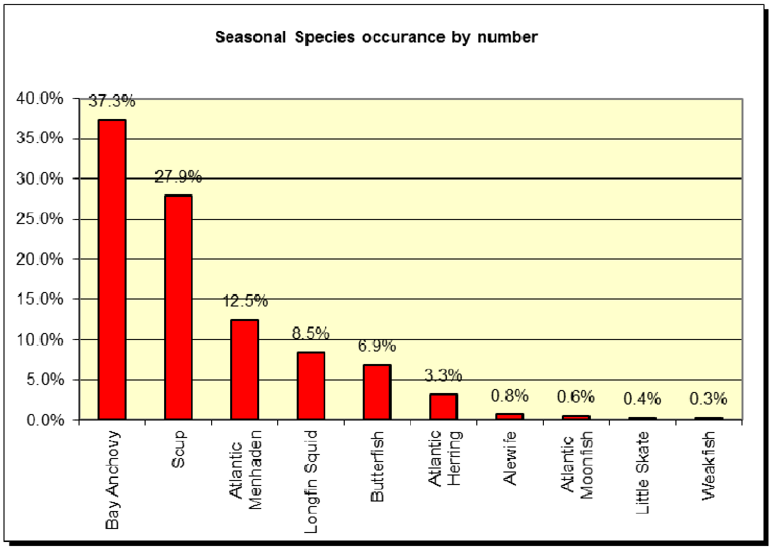
Figure 9 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight (kg)
STENOTOMUS CHRYSOPS	Scup	1397.361
LEUCORAJA ERINACEA	Little Skate	540.145
PEPRILUS TRIACANTHUS	Butterfish	374.1135
LEUCORAJA OCELLATA	Winter Skate	303.39
LOLIGO PEALEI	Longfin Squid	300.722
BREVOORTIA TYRANNUS	Atlantic Menhaden	149.32
PARALICHTHYS DENTATUS	Summer Flounder	116.0808
CLUPEA HARENGUS	Atlantic Herring	97.356
MUSTELUS CANIS	Smooth Dogfish	85.985
PLEURONECTES AMERICANUS	Winter Flounder	78.258
ANCHOA MITCHILLI	Bay Anchovy	77.947
CENTROPRISTIS STRIATA	Black Sea Bass	68.013
PRIONOTUS EVOLANS	Striped Sea Robin	63.365
ALOSA PSEUDOHARENGUS	Alewife	43.113
POMATOMUS SALTATRIX	Bluefish	38.4
RAJA EGLANTERIA	Clearnose Skate	31.105
PRIONOTUS CAROLINUS	Northern Sea Robin	25.28
HOMARUS AMERICANUS	American Lobster	23.785
LIMULUS POLYPHEMUS	Horseshoe Crab	22.44
CANCER IRRORATUS	Rock Crab	20.26
CYNOSCION REGALIS	Weakfish	19.495
UROPHYCIS REGIA	Spotted Hake	16.231
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	16.08
MORONE SAXATILIS	Striped Bass	15.523
ALOSA SAPIDISSIMA	American Shad	13.405
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	8.82
SELENE SETAPINNIS	Atlantic Moonfish	5.602
TAUTOGA ONITIS	Tautog	5.21
MACROZOARCES AMERICANUS	Ocean Pout	4.36
PARALICHTHYS OBLONGUS	Fourspot Flounder	3.85
MENTICIRRHUS SAXATILIS	Northern Kingfish	3.835
ALOSA AESTIVALIS	Blueback Herring	3.618
UROPHYCIS CHUSS	Red Hake	3.138
MERLUCCIUS BILINEARIS	Silver Hake	2.031
LEIOSTOMUS XANTHURUS	Spot	2.015
GADUS MORHUA	Atlantic Cod	2.004
HEMITRIPTERUS AMERICANUS	Sea Raven	1.99
DIPTURUS LAEVIS	Barndoor Skate	1.52

SQUALUS ACANTHIAS	Spiny Dogfish	1.45
CANCER BOREALIS	Jonah Crab	0.93
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	0.925
CALLINECTES SAPIDUS	Blue Crab	0.775
BUSYCON CARICA	Knobbed Whelk	0.56
TAUTOGOLABRUS ADSPERSUS	Cunner	0.45
SERIOLA ZONATA	Banded Rudderfish	0.425
SCOMBER SCOMBRUS	Atlantic Mackerel	0.24
TRACHURUS LATHAMI	Rough Scad	0.17
AMMODYTES AMERICANUS	American Sand Lance	0.144
DECAPTERUS PUNCTATUS	Round Scad	0.12
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.098
SPHOEROIDES MACULATUS	Northern Puffer	0.09
PLACOPECTEN MAGELLANICUS	Sea Scallop	0.07
TRINECTES MACULATUS	Hogchoker	0.065
LAGODON RHOMBOIDES	Pinfish	0.05
ANCHOA HEPSETUS	Striped Anchovy	0.035
UPENEUS PARVUS	Dwarf Goatfish	0.025
CARANX CRYSOS	Blue Runner	0.025
MENIDIA MENIDIA	Atlantic Silverside	0.023
ETRUMEUS TERES	Round Herring	0.02
OSMERUS MORDAX	Rainbow Smelt	0.007
HIPPOCAMPUS ERECTUS	Seahorse	0.005

Figure 10 Top Ten Species Catch in Number

Fish Name	Scientific Name	%
Bay Anchovy	ANCHOA MITCHILLI	37.3%
Scup	STENOTOMUS CHRYSOPS	27.9%
Atlantic Menhaden	BREVOORTIA TYRANNUS	12.5%
Longfin Squid	LOLIGO PEALEI	8.5%
Butterfish	PEPRILUS TRIACANTHUS	6.9%
Atlantic Herring	CLUPEA HARENGUS	3.3%
Alewife	ALOSA PSEUDOHARENGUS	0.8%
Atlantic Moonfish	SELENE SETAPINNIS	0.6%
Little Skate	LEUCORAJA ERINACEA	0.4%
Weakfish	CYNOSCION REGALIS	0.3%



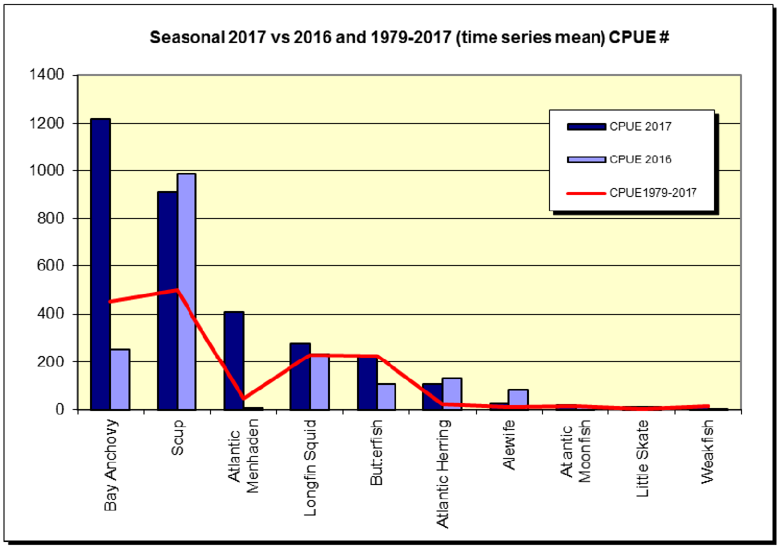
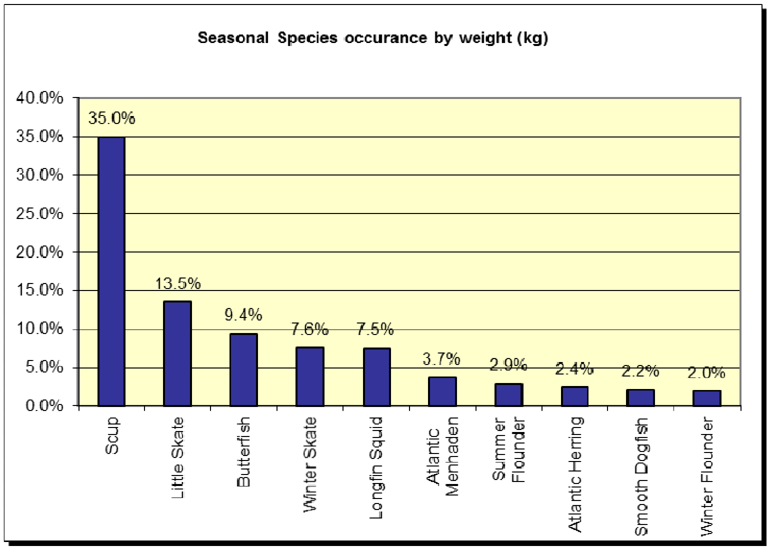
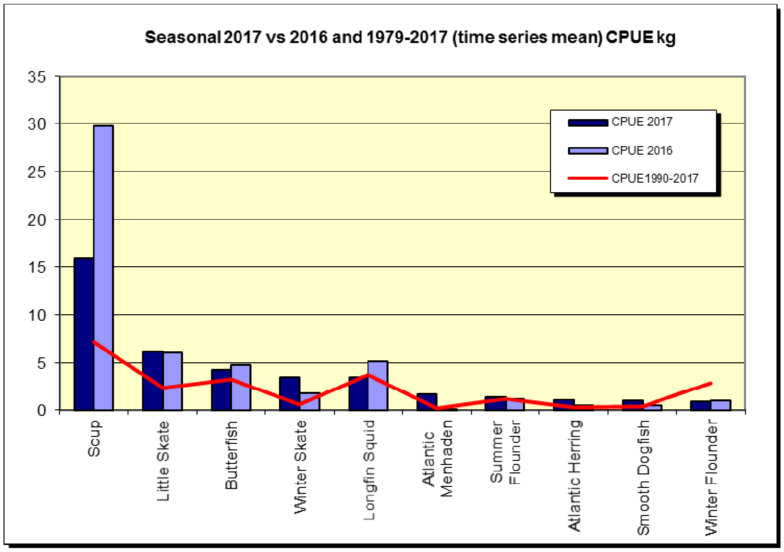


Figure 11 Top Ten Species Catch in Kilograms

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	35.0%
Little Skate	LEUCORAJA ERINACEA	13.5%
Butterfish	PEPRILUS TRIACANTHUS	9.4%
Winter Skate	LEUCORAJA OCELLATA	7.6%
Longfin Squid	LOLIGO PEALEI	7.5%
Atlantic Menhaden	BREVOORTIA TYRANNUS	3.7%
Summer Flounder	PARALICHTHYS DENTATUS	2.9%
Atlantic Herring	CLUPEA HARENGUS	2.4%
Smooth Dogfish	MUSTELUS CANIS	2.2%
Winter Flounder	PLEURONECTES AMERICANUS	2.0%



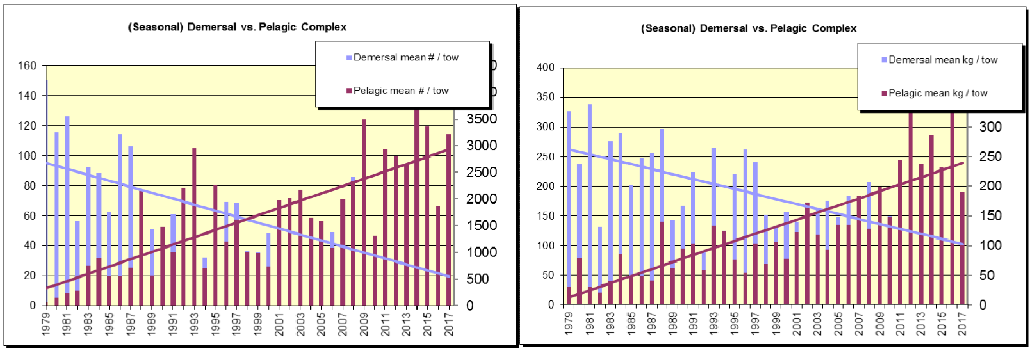


Demersal vs. Pelagic Species Complex

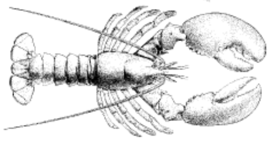
Demersal Species
Cunner
Four Spot Flounder
Goosefish
Hog Choker
Lobster
Longhorn Sculpin
Northern Searobin
Ocean Pout
Red Hake
Sea Raven
Silver Hake
Skates
Smooth Dogfish
Spiny Dogfish
Spotted Hake
Striped Searobin
Summer Flounder
Tautog
Windowpane Flounder
Winter Flounder

Pelagic/Multi-Habitat Species
Alewife
Atlantic Herring
Atlantic Moonfish
Bay Anchovy
Black Sea Bass
Blueback Herring
Bluefish
Butterfish
Longfin Squid
Menhaden
Rainbow Smelt
Scup
Shad
Silverside
Striped Bass
Weakfish

Figure 12 and 13

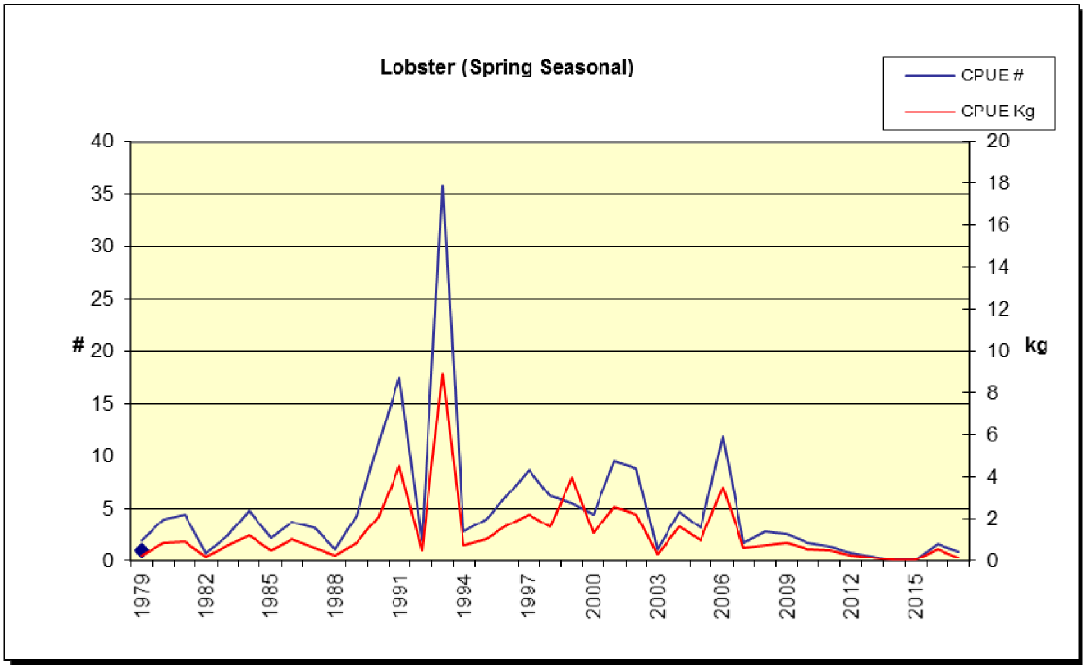


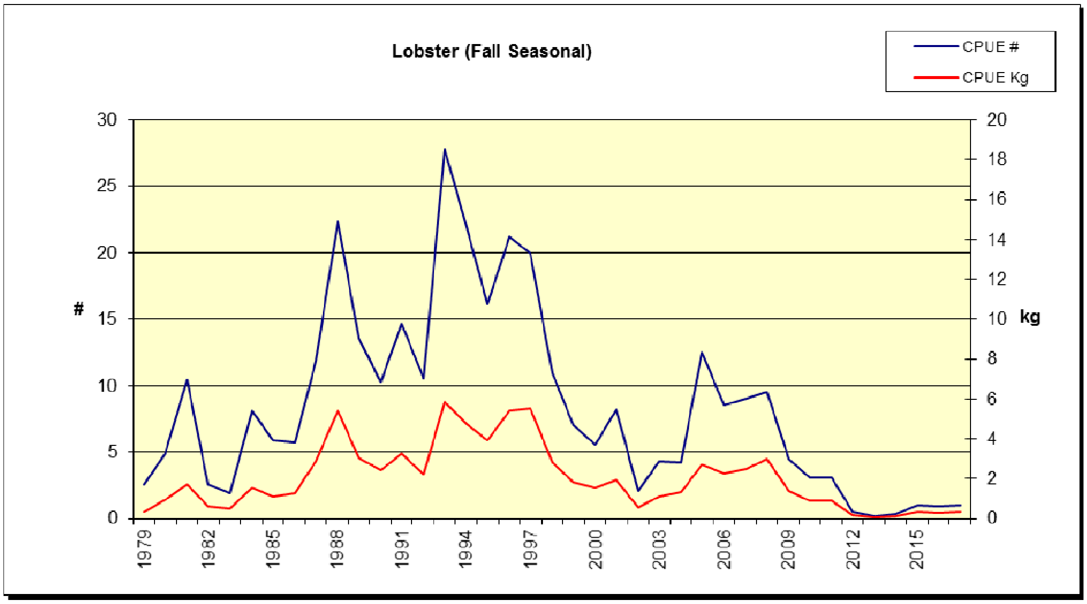
The following species represented are of high importance and are currently managed under fishery management plans through the Atlantic States Marine Fisheries Commission, New England Fishery Management Council, or the National Marine Fisheries Service. The seasonal portion of the Rhode Island Coastal Trawl Survey is an accurate indicator of relative abundance based on the biology and life history of a particular species. Values presented are expressed in either relative number or kilograms per tow. All data collected from both the Seasonal and Monthly Coastal Trawl Surveys are available upon request.



American Lobster ***Homarus americanus***

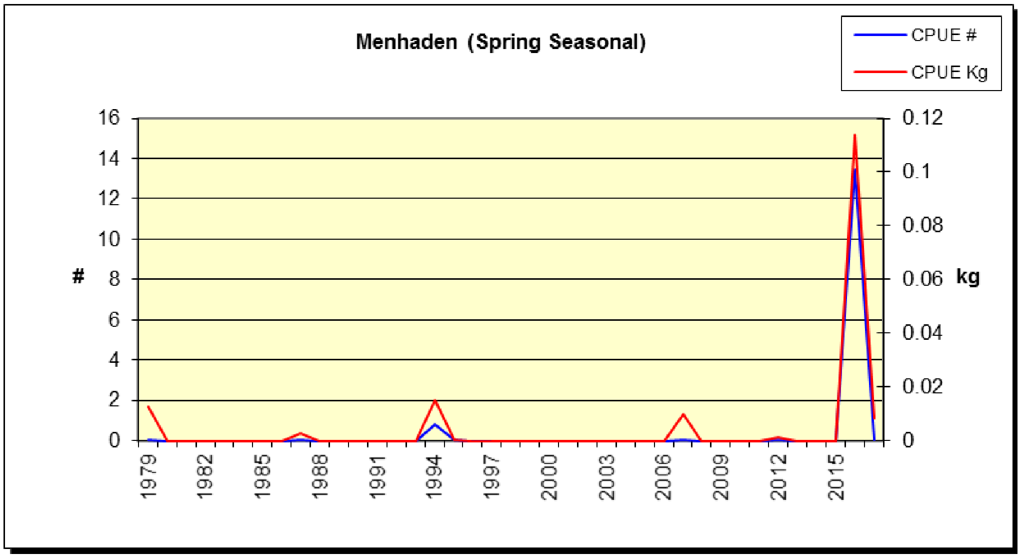
Stock Status: Southern New England Stock: overfished. Depleted Poor condition.
Management: ASMFC Amendment III, Addendum XXV

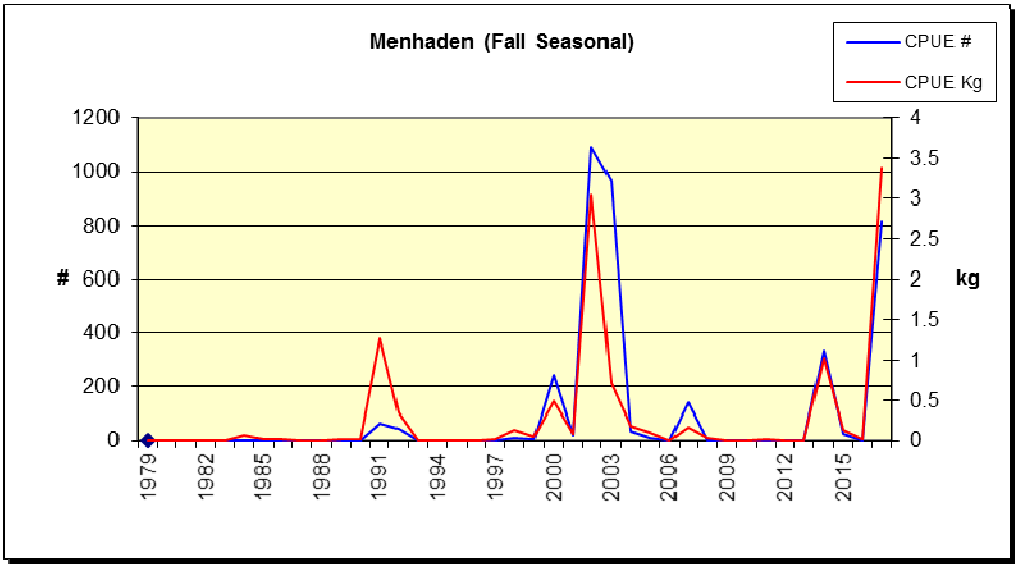




Atlantic Menhaden ***Brevoortia tyrannus***

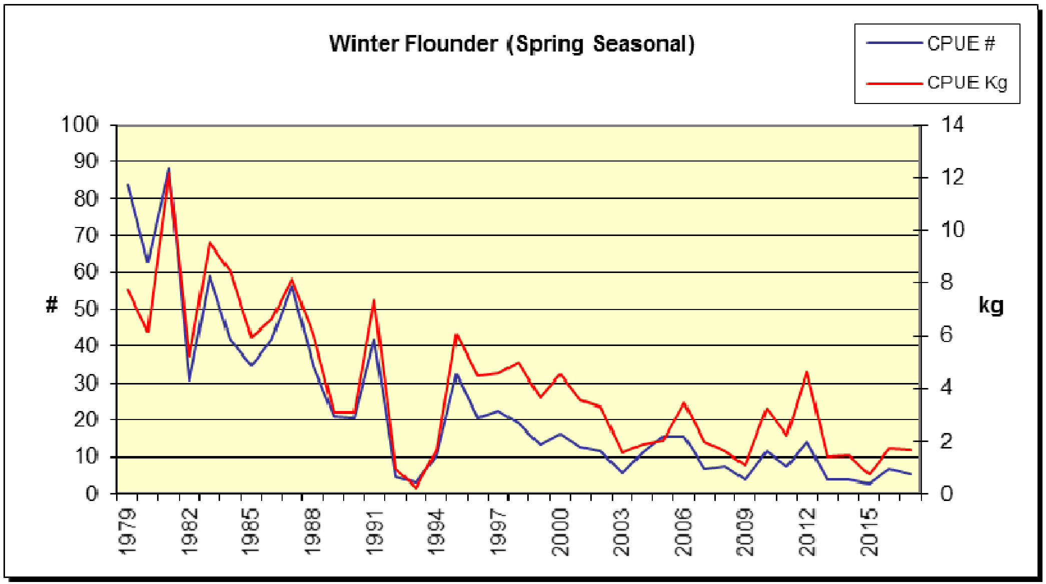
Stock Status: Not Overfished and overfishing is not occurring.
Management: ASMFC Amendment II, Addendum I

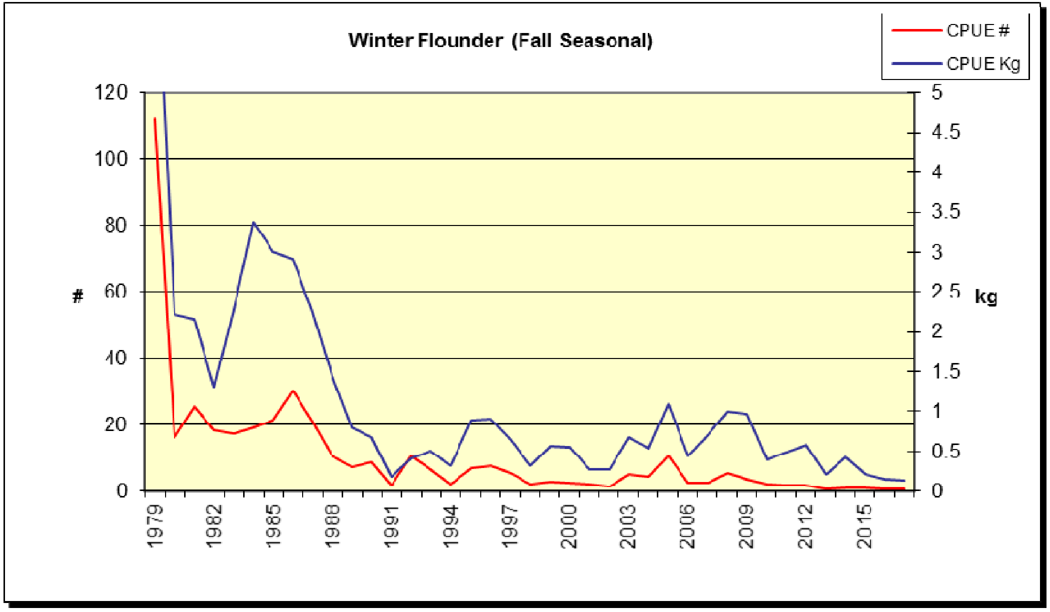


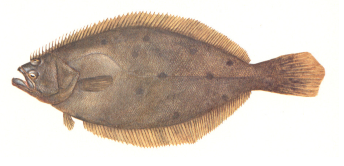


Winter Flounder ***Pleuronectes americanus***

Stock Status: Overfished but overfishing is not occurring.
Management: ASMFC Amendment I, Addendum III

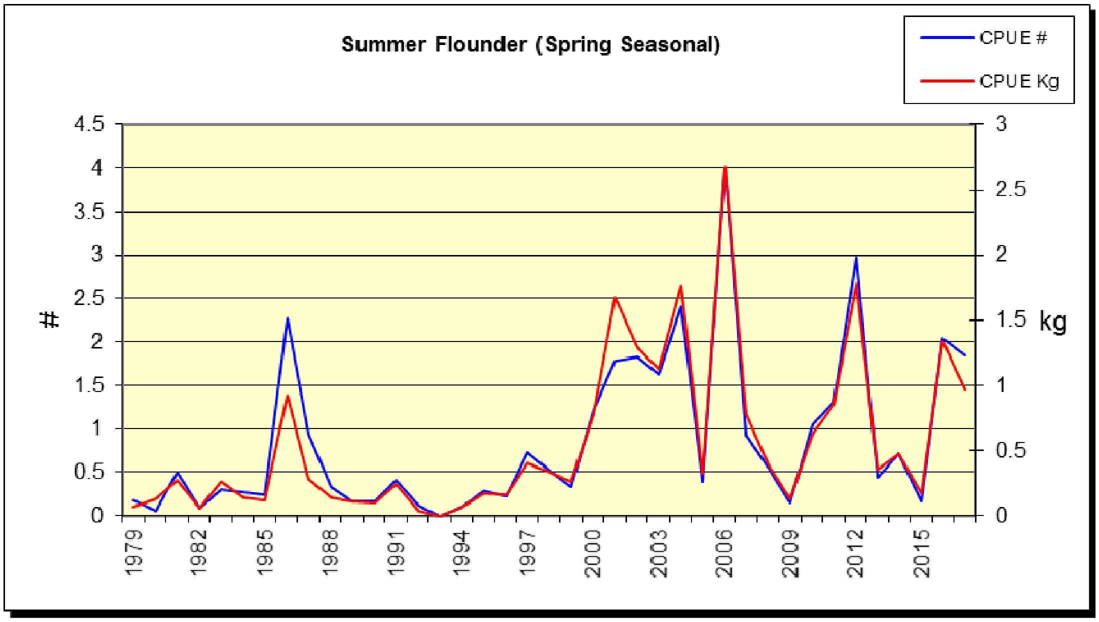


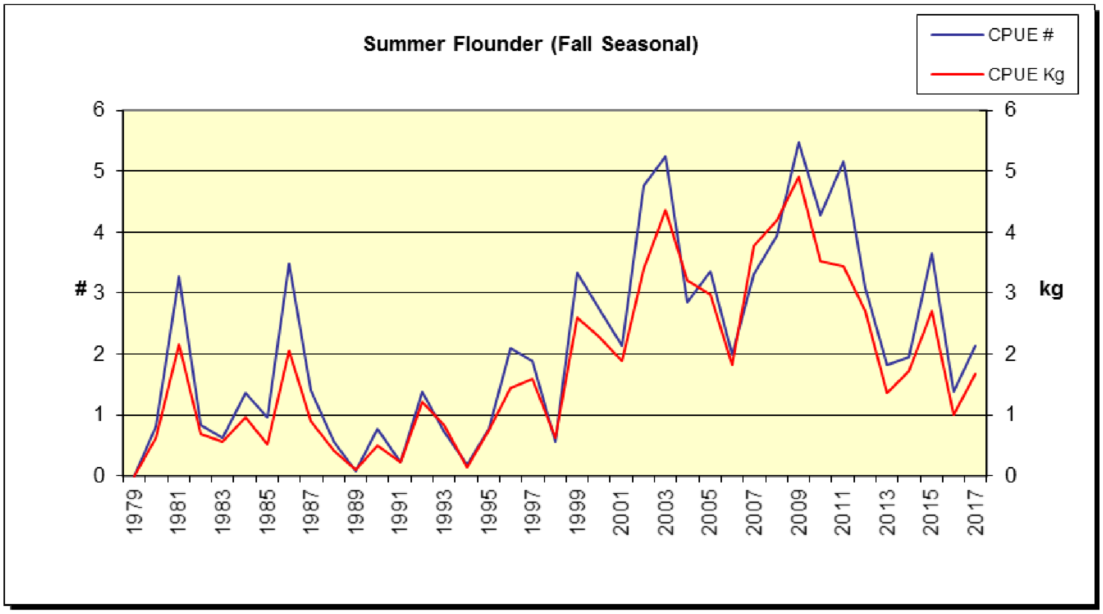


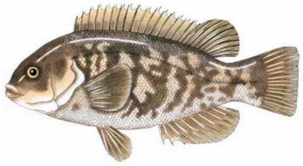


Summer Flounder ***Paralichthys dentatus***

Stock Status: Not overfished and overfishing is occurring.
Management: ASMFC Amendment XV Addendum XXV

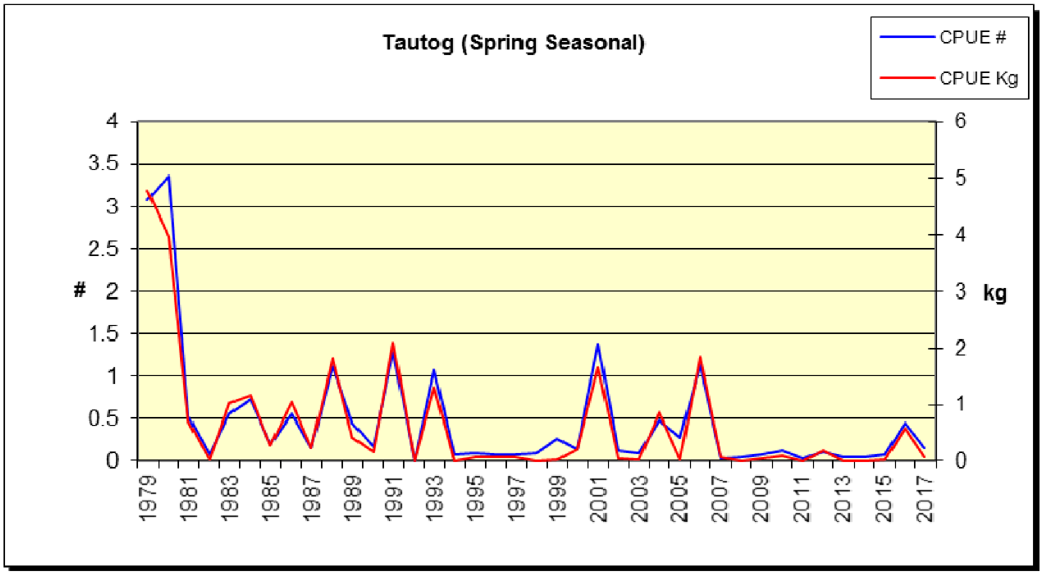


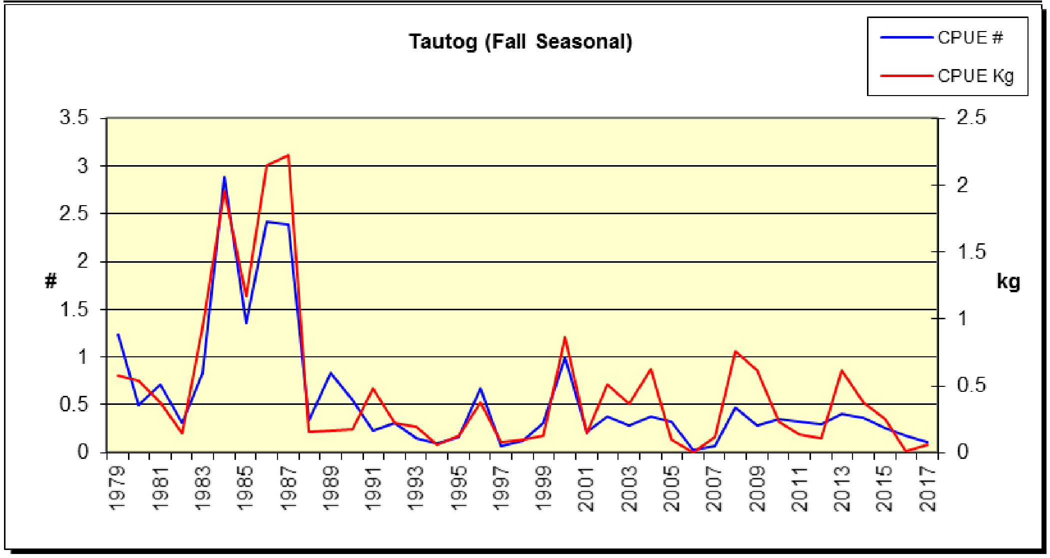


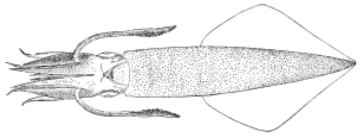


Tautog *__Tautoga onitis__*

Stock Status: Not Overfished and Overfishing is not occurring based on Regional (Rhode Island and Massachusetts) Stock Assessment
Management: ASMFC Amendment I, Addendum VI

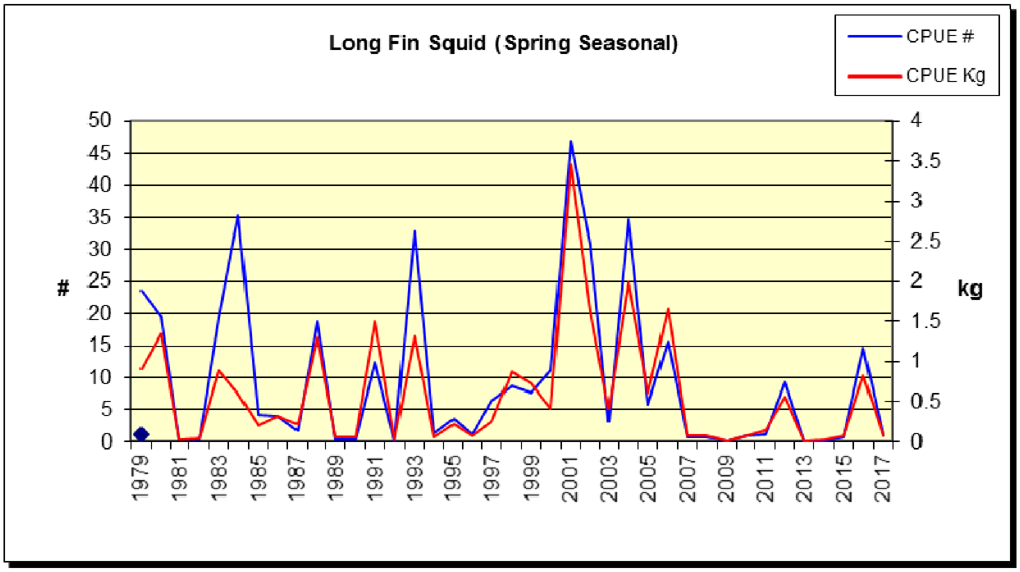


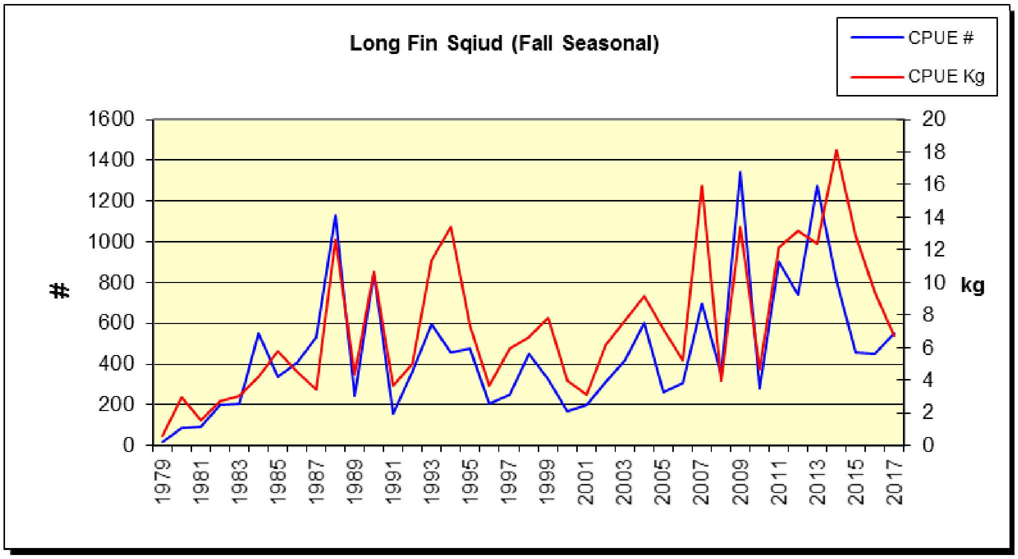


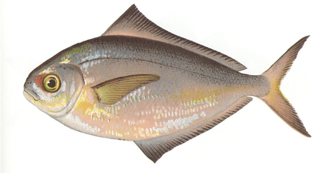


Longfin Squid ***Loligo pealei***

Stock Status: Overfishing undetermined not overfished
Management: NMFS, MAFMC, Atlantic Mackerel, Squid Butterfish FMP

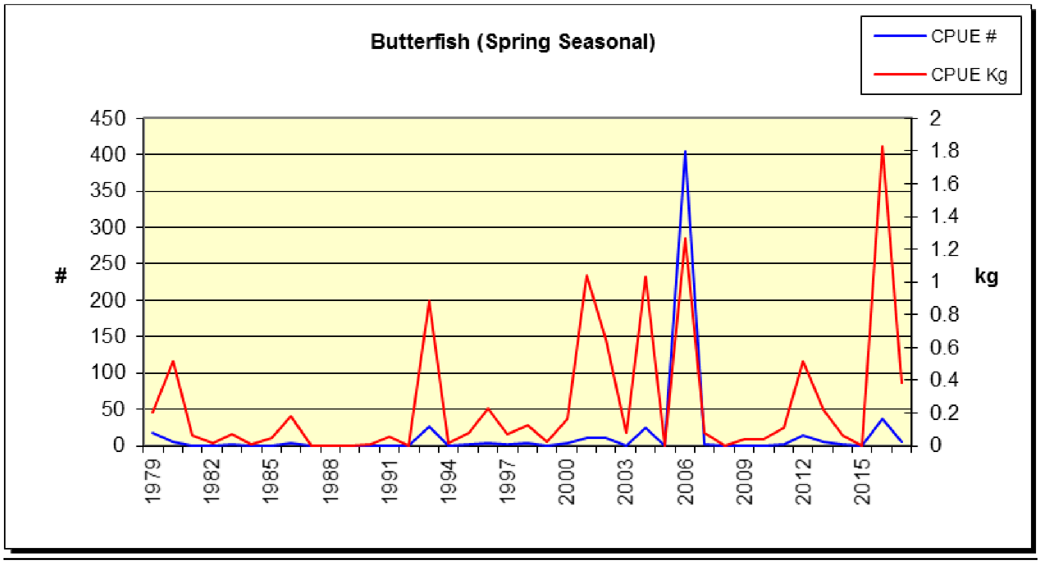


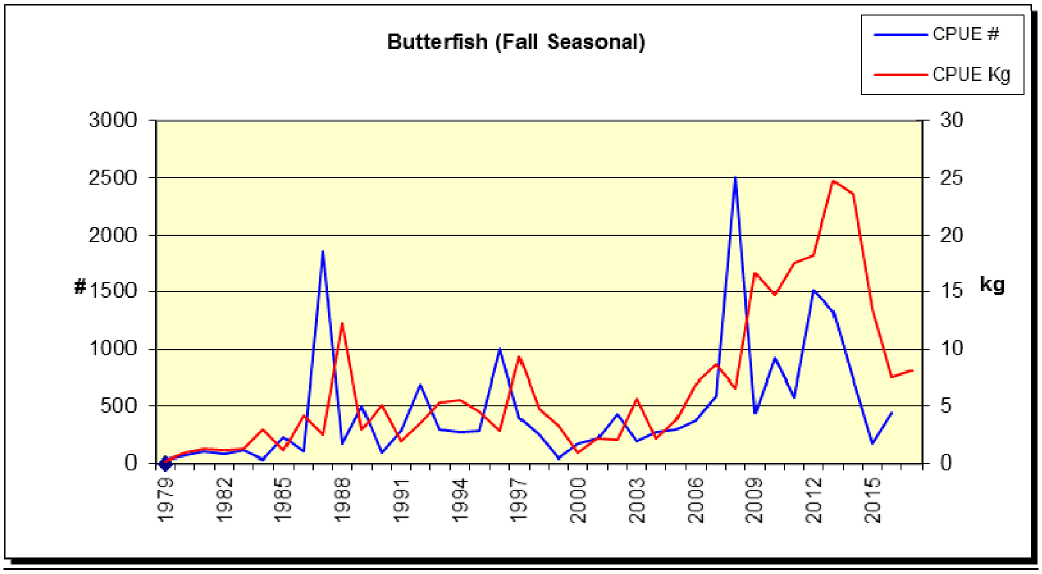


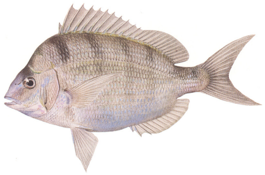


Butterfish ***Peprlilus triacanthus***

Stock Status: Variable / Uncertain
Management: Mid Atlantic Fishery Management Council, Atlantic Mackerel, Squid Butterfish FMP, ACL

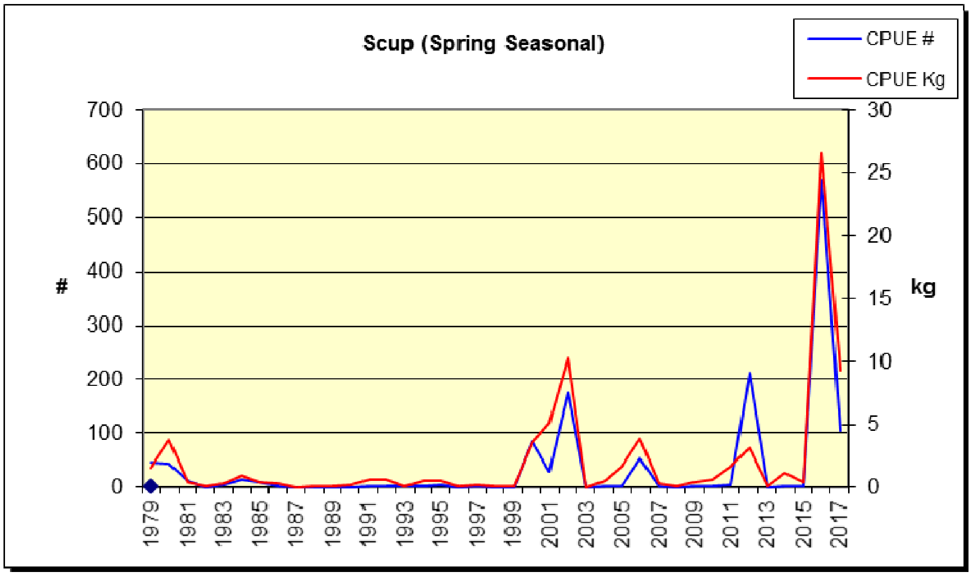


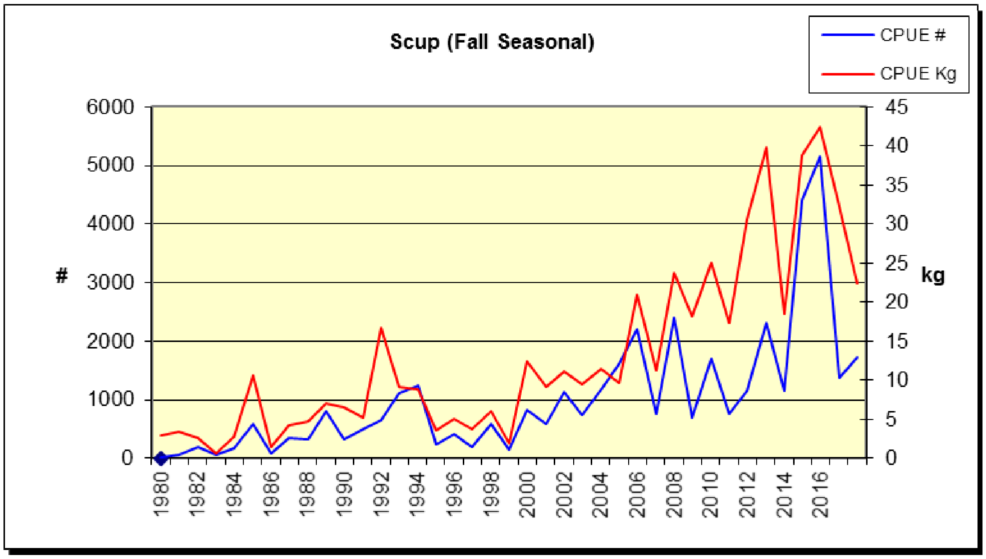


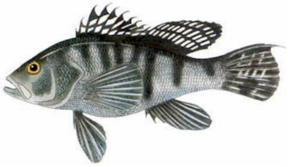


Scup *Stenotomus chrysops*

Stock Status: Rebuilt, not overfished and overfishing is not occurring
Management: ASMFC Amendment XIIV, Addendum XXII, Summer Flounder, Scup Black Sea Bass FMP

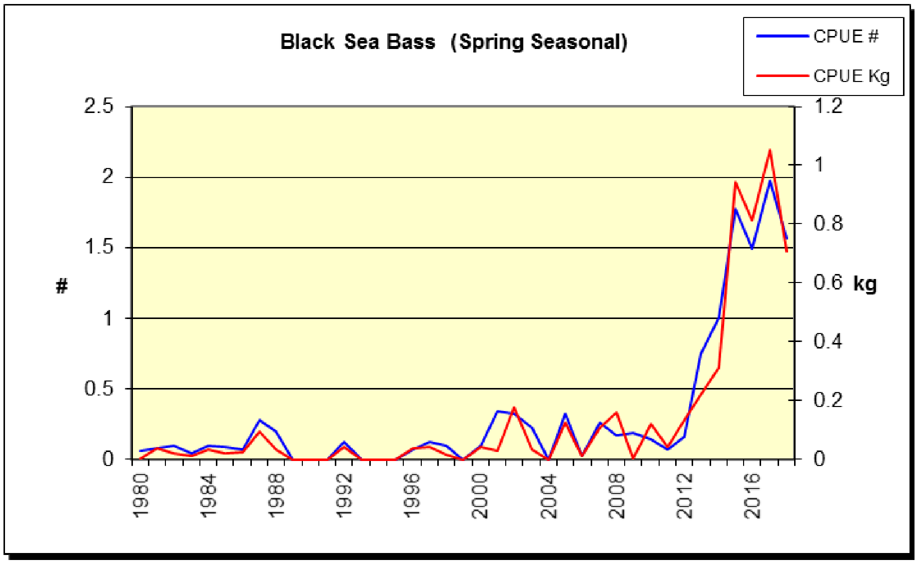


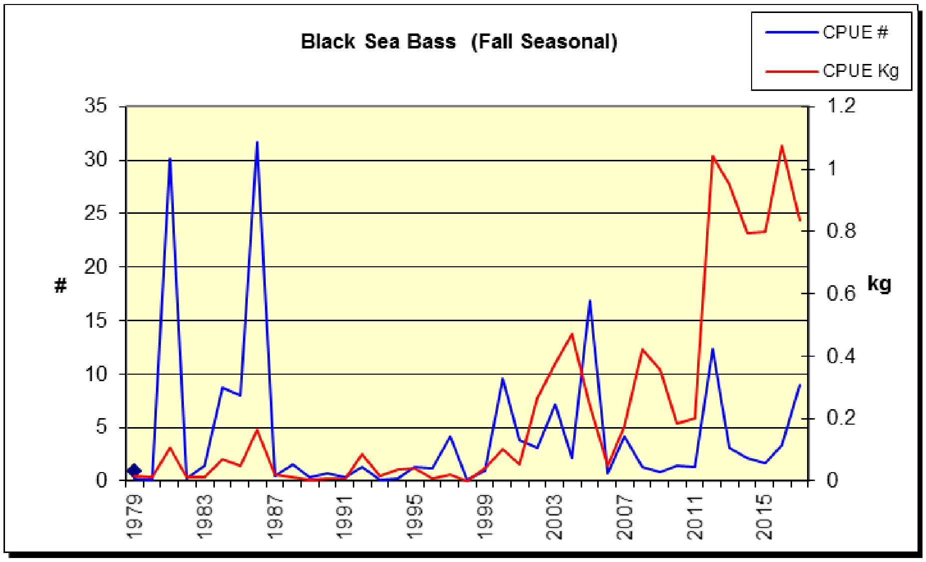




Black Sea Bass *Centropristis striata*

Stock Status: Rebuilt, not overfished overfishing is not occurring
Management: ASMFC Amendment XIIV, Addendum XXIII





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Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Ponds

Young of the Year Survey of Selected Rhode Island Coastal Ponds and Embayments

by
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Principal Biologist (Marine Fisheries)
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Division of Fish and Wildlife
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Jamestown, RI 02835

Federal Aid in Sportfish Restoration
F-61-R

Performance Report – Job#3a March 2018

Performance Report

State: Rhode Island

Project Number: F-61-R
Segment Number: 21

Project Title: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters.

Period Covered: January 1, 2017 – December 31, 2017

Job Number & Title: Job 3 – Young of the Year Survey of Selected Rhode Island Coastal Ponds and Embayment's

Job Objectives: To collect, analyze, and summarize beach seine survey data from Rhode Island's coastal ponds and estuaries, for the purpose of forecasting recruitment in relation to the spawning stock biomass of winter flounder and other recreationally important species.

Summary: In 2017, Investigators caught 50 species of finfish representing 35 families. This number is lower to the 51 species from 36 families that were collected during 2016. Additionally, the numbers of individuals caught in 2017 increased from the 2016 survey; 38,250 collected in 2017 and 16,166 collected in 2016.

Target Date: 2018

Status of Project: On Schedule

Significant Deviations: There were no significant deviations in 2017.

Recommendations: Continue into the next segment with the project as currently designed; continue at each of the 24 sample stations.

Remarks:

During 2017, Investigators sampled twenty four traditional stations in eight coastal ponds, Winnapaug Pond, Quonochontaug Pond, Charlestown Pond, Point Judith Pond, Green Hill Pond, Potter's Pond, Little Narragansett Bay and Narrow River (Figures 1-3). For consistency, the time series species indices for young of the year (YOY) winter flounder will not include the data taken from the new stations added in 2011 (PP 1-2, GH 1-2, PR 1-3, PJ4). The potential bias the new stations could introduce to the time series is unknown. This potential bias will be examined further when these samples have been sampled for a few more years. For the calculation of the annual catch per unit effort statistics for all other species data from all stations will be used.

Materials and Methods:

As in previous years, investigators attempted to perform all seining on an outgoing tide. To collect animals, investigators used a seine 130 ft. long (39.62m), 5.5 ft deep (1.67m) with ¼" mesh (6.4mm). The seine has a bag at its midpoint, a weighted footrope and floats on the head rope. Figure 4 describes the area covered by the seine net. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard powered 16' Polarkraft aluminum boat. The net is then hauled toward the beach by hand and the bag is emptied into a large water-filled tote. All animals collected are identified to species, measured, enumerated, and sub-samples were taken when appropriate. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station. Figure 1 shows the location of the subject coastal ponds and the Narrow River, while figures 2 - 3 indicate the location of the sampling stations within each pond.

Results and Discussion:

Winter Flounder (*Pseudopleuronectes americanus*)

Juvenile winter flounder were collected at 23 out of 24 stations over the course of the season. Winter flounder were not caught in Northern Potters pond (PP-2). Winter flounder ranked sixth in overall species abundance (n=1317) in 2017, with the highest mean abundance, fish/seine haul, occurring in June (Table 1). This is a month earlier than the usual expected pattern of highest index values occurring in July. 2017 is similar to 2016 with a peak occurring in June. Narrow river and Pawcatuck Rivers were the only two ponds that showed the typical July peak.

During 2017, 1317 winter flounder were collected, up from the 1119 collected in 2016. The juvenile winter flounder abundance index (YOY WFL index) for the survey measured using the mean fish/seine haul decreased slightly from 9.55 fish/seine haul in 2016 to 11.08 fish/seine haul in 2017. The 2017 index value remained relatively level compared to 2016, 2015 and 2014 but is still four years out from the lowest recorded since the surveys inception observed in 2013. For the purposes of consistency, the YOY WFL index is only calculated using fish < 12 cm from the long term stations of the survey. Data collected from the new stations added in 2011 (PP1-2, GH 1-2, PR1-3, PJ4) is not included in the index so as not to bias the results. A standardization methodology will be required to integrate this data into the overall YOY WFL index. Figure 5 displays the abundance indices, by pond, over the duration of the coastal pond survey. Table 2 and figure 6 display the mean catch per seine haul (CPUE) of winter flounder for each month by pond during the 2017 survey. Figure 8 displays the annual winter flounder abundance index plotted over time.

Narrow River and Charlestown Pond trended upward in 2017 from the lows observed in 2016. Winnipaug, Quononchontaug, and Point Judith ponds remained relatively level in comparison to last year’s index value. Green Hill and Potters pond had a show of YOY winter flounder in May (in Green Hill), June, and July (in Potter’s) of YOY WFL, no fish were observed after august (Green Hill) and September (Potter’s) in these ponds. The Lower Pawcatuck River is a more open system than the other ponds sampled in the survey. Instead of an inlet breaching a barrier beach there is only a mostly sub tidal sandbar separating the water body from the ocean. With the exception of august the water temperatures are cooler than the other pond temperatures (Table 13). YOY WFL were caught at all three stations in the Lower Pawcatuck River with station 1 catching the most consistent numbers (Table 1)(Figure 5).

Generally, the index values by pond peaked in June remained high in July. Narrow and Pawcatuck Rivers peaked in July. Generally the index values decreased significantly in August, September and October. Winnipaug Pond was the exception not showing a sharp decline until October (figure 6). Winter flounder catch per tow during October 2017 was up to 2.81 fish/tow from the low value of 0.03 fish/tow in 2016. These results are similar to 2014 and 2015 (~3.1 fish/tow) indicate that 2017 recruitment from the coastal ponds was below the time series average but rebounded from the last years low.

Two other RIDFW surveys target juvenile and adult winter flounder, the Narragansett Bay Spring Seasonal Trawl Survey and the Narragansett Bay Juvenile Survey. A comparison of the Coastal Pond Survey to these other projects reveals that despite some slight differences, they display similar trends (Figure 9). The downward YOY trend is mirrored in the Narragansett Bay Seine Survey. The low abundance in YOY WFL numbers was also observed in Narragansett Bay (McNamee Pers Comm) increasing slightly from 2016 to an index value of from 2.92 fish / tow to 4.07 fish / tow in 2017. The spring Trawl Survey WFL index remained relatively level decreasing slightly to a value of 5.25 fish/tow, not far removed from the low 2013, 2014, and 2015 values. Those low years were likely reflected regulations which changed ending the prohibition on possession of winter flounder in federal waters of Southern New England in 2012. Federal possession limits were either unlimited or set to 5,000 lbs per trip depending on the permit category of the vessel. It is believed that these high limits encourage a directed fishery for winter flounder in the spring. NOAA Fisheries has changed their procedures for administration of common pool possession limit restricting it to lower values during the year than allowed typically 2,000 lbs per day, in 2013. Possession limits remain 50 pounds in State waters.

The Narragansett Bay Seine Survey collects the most YOY WFL in June (McNamee Pers Comm). It should be noted that the Narragansett Bay Survey does not begin sampling until June and may miss those juvenile finfish which occur in May in the shallow coves etc. The Spring Trawl Survey collects the greatest number of winter flounder in April and May and is considered the best indicator for estimating local abundance especially for post spawn adults (Olszewski Pers Comm).

The time series of the survey shows that the ponds exhibit fluctuations of WFL abundance over time. One exception is Point Judith pond which has experienced a significant decline since 2000 and bottomed out at 0.89 fish/seine haul during 2010. Between 2011 and 2017 , the overall YOY WFL index in Point Judith pond increased slightly from the low 2010 value and as remained relatively level with index values averaging approximately 4 fish / tow (5.17 fish/tow in 2017). This trend in abundance might reflect the recent no possession rule in the pond as well as the former coast wide closure. The pond's winter flounder population has not rebounded to historic levels. It is important to note that, similar to the other ponds, the YOY WFL population in Point Judith Pond crashed in August and did not recover. Point Judith Pond is the only coastal pond where both a juvenile survey and an adult winter flounder survey occur annually. When relative abundance and number of WFL per seine haul of juvenile winter flounder are compared to the relative abundance and number of WFL per fyke net haul of the Adult Winter Flounder Tagging Survey, (Figure 10), a decline in relative abundance of winter flounder is observed in both surveys. The index value observed in the adult spawner survey was the lowest ever recorded at 0.8 WFL per net haul in 2014, recovering slightly in 2016 (1.1 fish /haul) and 2017 (2.7 fish / haul). The decline in adult spawner abundance and related decline in juvenile abundance does not support a fishery in the pond due to the lack of surplus production (Gibson, 2010). Given that winter flounder population shows an affinity for discrete spawning locations and the young of year tend to remain near the spawning location, the fish in this pond are in danger of depletion (Buckley et. al. 2008). A regulation was enacted 4/8/11 to close Point Judith Pond to both recreational and commercial fishing for winter flounder (RIMF Regulations Part 7 sec 8). Data from this survey and the Adult winter flounder spawning survey was the evidence used for justification of this regulation.

In 2017, juvenile winter flounder ranged in size from 2 to 31 cm, representing age groups 0-2+. The size range of animals collected is similar to those caught in previous years. Length frequency distributions indicate that the majority of individuals collected during sampling season were group 0 fish, less than 12 cm total length (Figure 7). During 2017, 95% of all winter flounder caught were <12 cm in length. The size ranges of these fish agree with ranges for young-of-the-year winter flounder in the literature (Able & Fahay 1998; Berry 1959; Berry et al. 1965). Mean monthly lengths for winter flounder are presented in Table 3.

Bluefish *(Pomatomus saltatrix)*

Forty nine bluefish were collected in July and August occurring in each of the coastal ponds except Potters Pond, Winnipaug Pond and Green Hill Pond in 2017. This is a decrease from the 55 fish caught in 2016 and less than the 124 individuals captured during 2015. The abundance index for 2017 was 0.34 fish/seine similar to the 2016 value of 0.39 fish/seine and less than the value of 0.86 fish/seine haul observed in 2015. Table 4 contains the abundance indices for the survey by month and pond. Bluefish ranged in size from 4 cm to 10 cm. No adult bluefish were caught in 2017. Figure 11 displays the annual abundance index of bluefish for all stations combined.

Tautog (*Tautoga onitis*)

Three hundred and fifty one tautog were collected between May and October in each of the ponds in 2017. This is higher than the 2016 catch of 299 individuals. The total survey 2017 abundance index was 2.13 fish/seine haul similar to the 2016 abundance index of 2.12 fish/seine haul. Table 5 contains the abundance indices for the survey by month and pond. The highest abundances in 2017 occurred in the Charlestown Pond. Tautog caught in 2017 ranged in size from 2 cm to 16 cm. Figure 12 displays the annual abundance index of tautog for all stations combined.

Black Sea Bass (*Centropristis striata*)

A total of 274 juvenile black sea bass were collected from May to October from each of the ponds except Potter's Pond and Green Hill Pond in 2017. This is more than the 202 fish that were caught in 2016 and less than the 348 fish collected in 2015. It is the fourth highest value recorded in the history of the survey. The highest abundances were found in Point Judith Pond. The total survey 2017 abundance index was 1.90 fish/seine haul up from the 2016 abundance index of 1.43 fish/seine haul but below the 2015 value of 2.41 fish/ seine haul. The population in the ponds continues trending upwards, the high BSB index value of 2017 represents another high value consistent with observations from other recent years. Black sea bass abundance throughout state waters was high again during 2017 (McNamee, pers comm.). Table 5 contains the abundance indices for the survey by month and pond. Black sea bass caught in 2016 ranged in size from 3 cm to 17 cm. Figure 13 displays the annual abundance index of black sea bass for all stations combined.

Scup *(Stenotomus chrysops)*

Five hundred and fifty eight scup were collected during the 2017 in August, September, and October in each of the ponds except Point Judith Pond and the Pawcatuck River. This is much higher than the 22 scup caught in 2016. The total survey abundance index was 3.88 fish per haul. Table 7 contains the abundance indices for the survey by month and pond. Scup caught in 2017 ranged in size from 2 cm to 12 cm. Figure 14 displays the annual abundance index of scup for all stations combined.

Clupeids:

In 2017 four species of clupeids were caught in the coastal pond survey, Atlantic menhaden (*Brevoortia tyrannus*), Atlantic herring (*Alosa harengus*), Blueback Herring (*Alosa Aestivalis)* and Alewife (*Alosa pseudoharengus*). Three hundred and fourty seven alewife were captured in 2017. The total survey abundance was 14.88 fish / seine haul. This high count continues an upward trend. Ten thousand seven hundred and eighty nine Atlantic menhaden were caught during 2017. The total survey abundance was 74.92 fish /seine haul. There were several schools of YOY menhaden captured in 2017. Two Atlantic herring were captured in 2017 and fourteen Blueback herring were caught in 2017. Table 8 contains the abundance indices for culpeids by month pooled across all 5 ponds. Figure 15 display the annual abundance index of clupeids for all stations combined. Menhaden are plotted on a separate axis for scale issues.

Baitfish Species:

Silversides *(Menidia sp.)*

Silversides had the highest abundance of all species with 13423 caught during the 2017 survey, up by half compared to the 7443 silversides collected in 2016. Silversides were collected in each of the ponds throughout the time period of the survey (May – October). The highest abundances were observed in Charlestown, Quononchontaug Potters, and Winnipaug ponds. The total survey abundance index was 93.22 fish / seine haul. Table 9 contains the abundance indices for the survey by month and pond. Atlantic silversides caught in 2017 ranged in size from 2 cm to 16 cm.

Striped Killifish *(Fundulus majalis)*

Striped killifish ranked third in species abundance with 3989 fish caught during 2017. This is higher than the 1959 fish caught during 2016. They occurred in each of the ponds and were caught each month during the survey. Winnipaug Pond had the highest abundance of striped killifish. The total survey abundance index was 27.70 fish / seine haul, trending lower from average levels. Table 10 contains the abundance indices for the survey by month and pond. Striped killifish caught in 2017 ranged in size from 2 cm to 12 cm.

Common Mummichog *(Fundulus heteroclitus)*

The mummichog was fourth in overall abundance in 2017 with 1963 individuals collected. This value is an increase from 1536 mummichogs collected in 2016. Mummichogs occurred in each of the ponds and were caught each month during the survey. Winnipaug Pond had the highest abundances of Mummichogs. The total 2017 survey abundance index was 13.63 fish / seine haul. It should be noted that although slightly down, this value continues to rebound from the lowest on record in 2013 of 2.09 fish/ seine haul. Table 11 contains the abundance indices for the survey by month and pond. Mummichogs caught in 2017 ranged in size from 2 cm to 10 cm.

Sheepshead Minnow *(Cyprinodon variegatus)*

The Sheepshead minnow ranked sixth in overall abundance with 1209 individuals collected. This is an increase from the 209 fish caught in 2016. Sheepshead minnow occurred in each of the ponds except Green hill Pond and Pawcatuck River and were caught between May and October. Winipaug Pond had the highest abundances of Sheepshead minnows. The total survey abundance index was 8.40 fish / seine haul. Table 12 contains the abundance indices for the survey by month and pond. Sheepshead minnow caught in 2017 ranged in size from 2 cm to 5 cm.

Figure 23 displays the annual abundance index of the baitfish species for all stations combined.

Physical and Chemical Data:

Physical and Chemical data for the 2017 Coastal Pond Survey is summarized in tables 13 – 15 and figure 15. Water temperature in 2017 averaged 21.4 ºC, with a range of 13.5ºC in October to 27.95 ºC in July. Salinity ranged from 15.1 ppt to 28.8 ppt, and averaged 24.8 ppt. Dissolved oxygen ranged from 5.6 mg/l to 10.35 mg/l with an average of 8.1 mg/l.

New Station Preliminary Data

This year was the fifth year of sampling the three additional ponds. On a whole the samples were consistent with 2011 -2016. A brief description of each pond follows.

Green Hill Pond: Green Hill Pond is a small coastal pond located east of Charlestown Pond. It does not open directly to the ocean, instead its only inlet is via Charlestown Pond and is thus not well flushed. Green Hill pond has water quality issues including high summer temperatures, high nutrient load, and a permanent shellfish closure. GH – 1 is in the northeastern quadrant of the pond on a small island. The bottom substrate is mud with shell hash. GH – 2 is in the southeastern quadrant of the pond on a sand bar. The bottom substrate is muddy fine sand. WFL YOY have been caught in relatively high abundance in May suggesting spawning activity within the pond. The WFL YOY decreased in abundance at the stations in July and August when the water was warm and were not caught frequently after it had cooled in the fall. Other species frequently present in the pond are the baitfish species, naked goby, and blue crabs.

Potter Pond: Potter Pond is a small coastal pond located west of Point Judith Pond. Similarly to Green Hill Pond, it does not open directly to the ocean; instead its only inlet is via Point Judith Pond. The local geography is such that the tide flushes the pond more than in Green Hill. The inlet to Potter Pond is closer to the inlet to Point Judith Pond and its inlet is shorter. PP – 1 is in the southwestern quadrant of the pond in a shallow cove. The bottom substrate is mud. PP – 2 is in the northwestern quadrant of the pond adjacent to a deep (~25') glacial kettle hole. The bottom substrate is fine sand with some cobble. WFL YOY have been caught at both stations but only PP – 1 with high frequency. Similarly to the Green Hill during both stations WFL YOY are highest in May and decreased in abundance as the season progressed. The water temperature in Potter's Pond does not get as warm as Green Hill Pond but still may be a factor at station PP – 1. The geography of this station does not facilitate flushing and water quality may explain the lack of WFL YOY in mid-summer. Interestingly all three years had small catches of 1 year old flounder at station PP-1 during the late summer and early fall. Water temperatures are higher than the pond proper and dissolved oxygen was lower in that section of the pond. The rest of the pond does not have the same water quality issues. Other species frequently caught in the pond include the baitfish species, American eel, oyster toad fish, naked goby, tautog, and blue crabs.

Lower Pawcatuck River: The lower Pawcatuck River or Little Narragansett Bay is the mouth of a coastal estuary formed by the Pawcatuck River. It is different form the other stations on the survey in that it does not have a traditional barrier beach pierced by an inlet; instead it is relatively open to Block Island Sound. PR – 1 is a small protected beach in a small cove surrounded by large boulders. The bottom substrate is fine sand. This station had the most consistent catch of WFL YOY which were present during all months of the survey. PR – 2 is located on a sand bar island in the middle of Little Narragansett Bay on the protected side. This sand bar is all that is left of a larger barrier beach which existed prior to the 1938 hurricane. The bottom substrate is coarse sand. This station caught WFL YOY but at lower frequencies that PR – 1, the highest catch number was observed in October. PR – 3 was originally located in the southern part of Little Narragansett Bay on the protected side of Napatree Beach. After it was initially sampled in May 2011, the station was relocated because it was extremely shallow and a high wave energy area. PR – 3 is currently located in the northern section of Little Narragansett Bay at the mouth of the river near G. Willie Cove. The station is on a *Spartina spp*. covered bank at the head of G. Willie Cove. The bottom substrate is cobble. This station was selected to best characterize the species assemblage in the Lower Pawcatuck River as the majority of the shoreline consists of marsh grass covered banks. The station has been sampled in all 6 months since 2012. WFL YOY are not present in high frequencies at the station which is not unexpected due to the bottom substrate. Other species frequently caught in the river include the baitfish species, alewife, tomcod, menhaden, and bluefish.

<u>Point Judith Pond</u>: The new station PJ – 4 is located in the eastern section of the pond on Ram Island. The bottom substrate is silty sand with some large cobble. The station was selected because of its proximity to three fyke net stations sampled during the Adult Winter Flounder Spawner Survey. The station was added to better classify the species in the pond and to better document the decline of WFL YOY in the pond. The station had higher catch frequencies of WFL YOY than the other stations in the pond combined but still is low in comparison to the other ponds.

The first six years of sampling the new stations successfully collected target species, notably WFL YOY. It is recommended that these stations be sampled into the future so as to continue to provide species assemblage information from these coastal ponds. The additional catch frequencies and distributions of WFL YOY will provide a better understanding of the population, notably in areas where the fish only occur in the spring / early summer. Further analysis will be required to integrate data from these new stations into the traditional abundance indices. Until then the data will be presented separately for the time series indices but not for the annual information.

Summary

In 2017, Investigators caught 50 species of finfish representing 35 families. This number is less than the 51 species from 36 families that were collected during 2016. Additionally, the numbers of individuals landed in 2016 increased from the 2016 survey; 38,250 collected in 2017 and 16,166 collected in 2016. Appendix 1 displays the frequency of all species caught by station during the 2017 Coastal Pond Survey. Additional data is available by request.

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Table 1: 2017 Coastal Pond Survey Winter Flounder Frequency by Station and Month

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
CP1	3	26	11	16	4	3	**63**	**10.50**	**9.22**
CP2	0	5	1	0	1	1	**8**	**1.33**	**1.86**
CP3	0	12	5	3	6	5	**31**	**5.17**	**3.97**
CP4	2	0	0	0	2	1	**5**	**0.83**	**0.98**
GH1	8	0	0	0	0	0	**8**	**1.33**	**0.00**
GH2	1	1	0	0	0	0	**2**	**0.33**	**0.52**
NR1	14	0	8	0	0	1	**23**	**3.83**	**5.88**
NR2	5	37	63	35	58	7	**205**	**34.17**	**24.48**
NR3	0	26	20	2	8	10	**66**	**11.00**	**10.18**
PJ1	0	1	1	2	0	1	**5**	**0.83**	**0.75**
PJ2	2	16	7	3	0	3	**31**	**5.17**	**5.78**
PJ3	2	9	23	19	2	2	**57**	**9.50**	**9.40**
PJ4	0	32	14	7	0	4	**57**	**9.50**	**12.19**
PP1	0	7	12	2	0	3	**24**	**4.00**	**4.69**
PP2	0	0	0	0	0	0	**0**	**0.00**	**0.00**
PR1	7	58	66	18	3	0	**152**	**25.33**	**29.16**
PR2	3	2	0	3	0	0	**8**	**1.33**	**1.51**
PR3	0	0	2	0	0	0	**2**	**0.33**	**0.00**
QP1	1	8	7	9	1	9	**35**	**5.83**	**3.82**
QP2	4	65	46	22	6	6	**149**	**24.83**	**25.35**
QP3	8	16	4	3	0	3	**34**	**5.67**	**5.68**
WP1	5	27	39	20	6	8	**105**	**17.50**	**13.69**
WP2	18	78	27	60	42	4	**229**	**38.17**	**27.48**
WP3	2	0	3	2	11	0	**18**	**3.00**	**4.10**
Totals	**85**	**426**	**359**	**226**	**150**	**71**			
Mean	**3.54**	**17.75**	**14.96**	**9.42**	**6.25**	**2.96**			
STD	**4.65**	**22.33**	**19.70**	**14.30**	**14.02**	**3.10**			

Table 2: 2017 Coastal Pond Survey winter flounder abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	1.25	10.75	4.25	4.75	3.25	2.50
Green Hill Pond	4.50	0.50	0	0	0	0
Narrow River	6.33	21.00	30.33	12.33	22.00	6.00
Point Judith Pond	1.00	14.50	11.25	7.75	0.50	2.50
Potter's Pond	0	3.50	6.00	1.00	0	1.50
Pawcatuck River	3.33	20.00	22.67	7.00	1.00	0
Quonochontaug Pond	4.33	29.67	19.00	11.33	2.33	6.00
Winnipaug Pond	8.33	35.00	23.00	27.33	19.67	4.00
Total	**3.64**	**16.86**	**14.56**	**8.94**	**6.09**	**2.81**

Table 3: 2017 Coastal Pond Survey average lengths (cm) of juvenile winter flounder by pond and month.

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	3.76	4.84	5.74	6.46	7.25	8.57
Green Hill Pond	4.37	4.60				
Narrow River	3.61	3.41	4.72	5.16	5.98	10.06
Point Judith Pond	6.53	4.11	5.73	6.36	8.05	7.85
Potter's Pond		7.70	8.06	9.70		13.60
Pawcatuck River	2.95	3.67	8.83	4.94	4.43	
Quonochontaug Pond	4.70	3.71	4.87	5.86	5.29	7.15
Winnipaug Pond	3.85	3.34	4.70	5.58	5.60	4.97

Table 4: 2017 Coastal Pond Survey bluefish abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	0.00	0.00	0.25	0.00	0.00	0.00
Green Hill Pond	0.00	0.00	1.00	0.00	0.00	0.00
Narrow River	0.00	0.00	0.00	0.00	0.00	0.00
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	0.00
Potter's Pond	0.00	0.00	0.00	0.00	0.00	0.00
Pawcatuck River	0.00	0.00	0.00	1.67	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	13.33	0.00	0.00
Winnipaug Pond	0.00	0.00	0.00	0.00	0.00	0.00
Total pond index	**0.00**	**0.00**	**0.16**	**1.88**	**0.00**	**0.00**

Table 5: 2017 Coastal Pond Survey tautog abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	1.50	0.75	1.00	16.25	17.25	2.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.50
Narrow River	0.33	0.00	0.00	0.00	3.00	2.00
Point Judith Pond	0.50	1.75	1.00	3.75	0.00	0.50
Potter's Pond	0.00	0.00	0.00	0.00	0.50	0.00
Pawcatuck River	1.50	3.67	0.00	8.00	7.00	0.67
Quonochontaug Pond	0.67	0.00	0.00	8.67	9.67	7.00
Winnipaug Pond	0.33	0.00	0.33	1.00	1.00	0.00
Total pond index	**0.60**	**0.77**	**0.29**	**4.71**	**4.80**	**1.61**

Table 6: 2017 Coastal Pond Survey black sea bass abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	0.00	0.00	0.00	22.75	28.00	0.00
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.00	0.00	1.67	9.00	0.00
Point Judith Pond	0.00	0.00	0.00	1.25	0.00	0.00
Potter's Pond	0.00	0.00	0.00	0.00	0.00	0.00
Pawcatuck River	0.00	0.00	0.00	0.33	0.00	0.00
Quonochontaug Pond	0.33	0.33	0.00	1.33	6.33	0.67
Winnipaug Pond	0.00	0.00	0.00	0.67	1.33	0.00
Total pond index	**0.04**	**0.04**	**0.00**	**3.50**	**5.58**	**0.08**

Table 7: 2017 Coastal Pond Survey Scup abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	0.00	0.00	0.00	54.00	72.00	0.50
Green Hill Pond	0.00	0.00	0.00	0.00	0.50	0.50
Narrow River	0.00	0.00	0.00	5.00	9.33	0.00
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	0.00
Potter's Pond	0.00	0.00	0.00	1.00	0.00	0.00
Pawcatuck River	0.00	0.00	0.00	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	1.33	0.00	0.00
Winnipaug Pond	0.00	0.00	0.00	0.00	0.33	0.00
Total pond index	**0.00**	**0.00**	**0.00**	**7.67**	**10.27**	**0.13**

Table 8: 2017 Coastal Pond Survey Clupeid abundance indices (fish/seine haul) by month

Species	May	Jun	Jul	Aug	Sep	Oct
Alewife	0.00	7.54	5.25	1.50	0.17	0.00
Atlantic Menhaden	0.00	0.00	0.00	326.71	40.92	81.92
Atlantic Herring	0.04	0.00	0.04	0.00	0.00	0.00
Blueback Herring	0.00	0.54	0.00	0.04	0.00	0.00

Table 9: 2017 Coastal Pond Survey Silverside abundance indices (fish/seine haul) by pond and month

Pond	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Charlestown Pond	18.75	9.50	118.75	57.50	169.75	59.75
Green Hill Pond	0.50	1.50	10.00	42.00	70.00	26.50
Narrow River	3.33	0.33	2.67	29.00	97.00	166.00
Point Judith Pond	28.00	13.00	53.00	15.50	21.25	289.50
Potter's Pond	5.50	0.50	23.50	364.00	11.00	83.00
Pawcatuck River	0.50	1.67	2.33	26.33	413.00	31.33
Quonochontaug Pond	28.33	5.33	8.67	56.00	96.67	112.33
Winnipaug Pond	13.00	1.00	64.00	338.00	1391.00	22.33
Total pond index	**12.24**	**4.10**	**35.36**	**116.04**	**283.71**	**98.84**

Table 10: 2017 Coastal Pond Survey Striped Killifish abundance indices (fish/seine haul) by pond and month

Pond	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Charlestown Pond	0.50	0.00	1.00	47.00	87.25	10.50
Green Hill Pond	0.00	0.00	0.00	1.50	16.50	0.00
Narrow River	0.00	0.00	0.00	0.00	31.67	27.00
Point Judith Pond	1.00	1.00	0.25	25.50	5.00	49.75
Potter's Pond	0.00	0.50	0.50	24.00	1.50	5.00
Pawcatuck River	2.50	0.00	0.00	39.33	49.67	2.33
Quonochontaug Pond	0.00	0.00	0.00	0.67	0.00	87.33
Winnipaug Pond	0.00	0.00	87.00	186.00	95.00	384.00
Total pond index	**0.50**	**0.19**	**11.09**	**40.50**	**35.82**	**70.74**

Table 11: 2017 Coastal Pond Survey Mumichog abundance indices (fish/seine haul) by pond and month

Pond	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Charlestown Pond	19.25	0.75	9.50	10.75	61.25	29.25
Green Hill Pond	0.50	20.00	9.00	3.00	1.50	2.00
Narrow River	0.33	0.00	15.00	0.00	21.00	3.00
Point Judith Pond	2.00	3.75	29.25	1.50	0.00	0.50
Potter's Pond	1.00	8.50	30.00	8.50	0.00	13.00
Pawcatuck River	1.00	4.33	1.33	0.67	2.67	0.00
Quonochontaug Pond	0.00	0.00	0.33	3.33	1.33	2.67
Winnipaug Pond	3.67	0.00	95.00	153.33	48.33	9.00
Total pond index	**3.47**	**4.67**	**23.68**	**22.64**	**17.01**	**7.43**

Table 12: 2017 Coastal Pond Survey Sheepshead Minnow abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	0.25	0.25	2.00	0.50	0.00	25.50
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.00	1.67	0.00	2.67	0.00
Point Judith Pond	0.00	0.00	0.25	0.00	0.00	0.00
Potter's Pond	0.00	0.00	0.00	0.00	0.00	2.50
Pawcatuck River	0.00	0.00	0.00	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	0.00	0.00	3.00
Winnipaug Pond	0.00	0.00	2.67	85.67	46.67	220.67
Total pond index	**0.03**	**0.03**	**0.82**	**10.77**	**6.17**	**31.46**

Table 13: 2017 Coastal Pond Survey average water temperature (degrees Celcius) by pond and month.

Station	May	June	July	August	September	October
Charlestown Pond	18.35	23.55	26.00	24.23	22.25	17.20
Green Hill Pond	19.90	27.95	27.45	26.55	24.50	16.25
Narrow River	17.53	22.57	22.23	22.20	25.63	16.33
Point Judith Pond	18.48	21.63	24.72	22.65	21.00	17.20
Potter's Pond	18.90	21.75	25.33	23.60	21.60	17.20
Pawcatuck River	15.30	22.17	24.37	22.17	22.47	13.53
Quonochontaug Pond	17.73	21.47	24.57	23.43	23.53	16.30
Winnipaug Pond	21.23	20.53	23.23	23.48	23.10	16.13
Average	**18.43**	**22.70**	**24.74**	**23.54**	**23.01**	**16.27**

Table 14: 2017 Coastal Pond Survey average salinity (ppt) by pond and month.

Station	May	June	July	August	September	October
Charlestown Pond	25.83	27.11	26.06	27.84	26.79	27.26
Green Hill Pond	19.49	19.01	20.33	22.89	23.64	23.70
Narrow River	15.17	16.32	18.05	24.86	21.23	25.73
Point Judith Pond	23.92		26.82	28.30	28.56	27.60
Potter's Pond	22.59		26.52	25.98	26.58	25.88
Pawcatuck River	22.30		20.24	26.94	25.26	19.36
Quonochontaug Pond	27.96	28.61	28.09	28.59	28.33	28.87
Winnipaug Pond	27.84	27.78	21.99	28.67	27.88	28.18
Average	**23.14**	**23.76**	**23.51**	**26.76**	**26.03**	**25.82**

Table 15: 2017 Coastal Pond Survey average dissolved oxygen (mg/l) by pond and month.

Station	**May**	**June**	**July**	**August**	**September**	**October**
Charlestown Pond	9.04	9.15	7.78	8.86	6.90	8.64
Green Hill Pond	7.46	9.13	6.58	8.68	5.62	8.41
Narrow River	10.35	9.19	5.54	6.64	6.40	8.44
Point Judith Pond	10.01		8.35	7.55	7.98	8.18
Potter's Pond	8.86		7.53	6.91	7.26	6.64
Pawcatuck River	9.19		8.82	8.41	8.11	8.18
Quonochontaug Pond	8.56	8.80	7.66	7.83	7.33	9.09
Winnipaug Pond	7.93	8.29	6.61	8.33	7.68	7.83
Average	**8.92**	**8.91**	**7.36**	**7.90**	**7.16**	**8.18**

Figure 1: Location of coastal ponds sampled by the Coastal Pond Juvenile Finfish Survey in Southern Rhode Island.

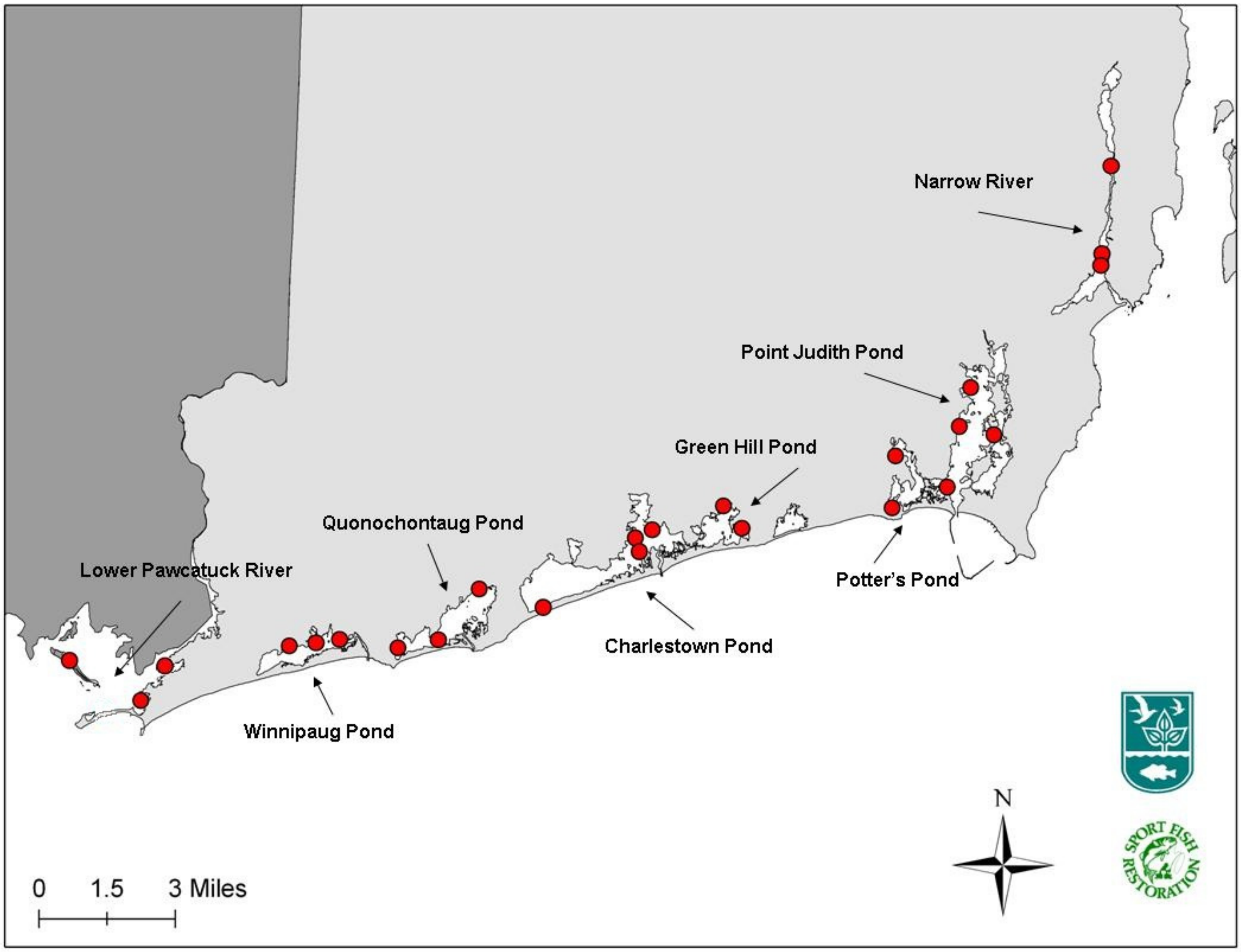


Figure 2: Coastal Pond Juvenile Finfish Survey station locations (western ponds).

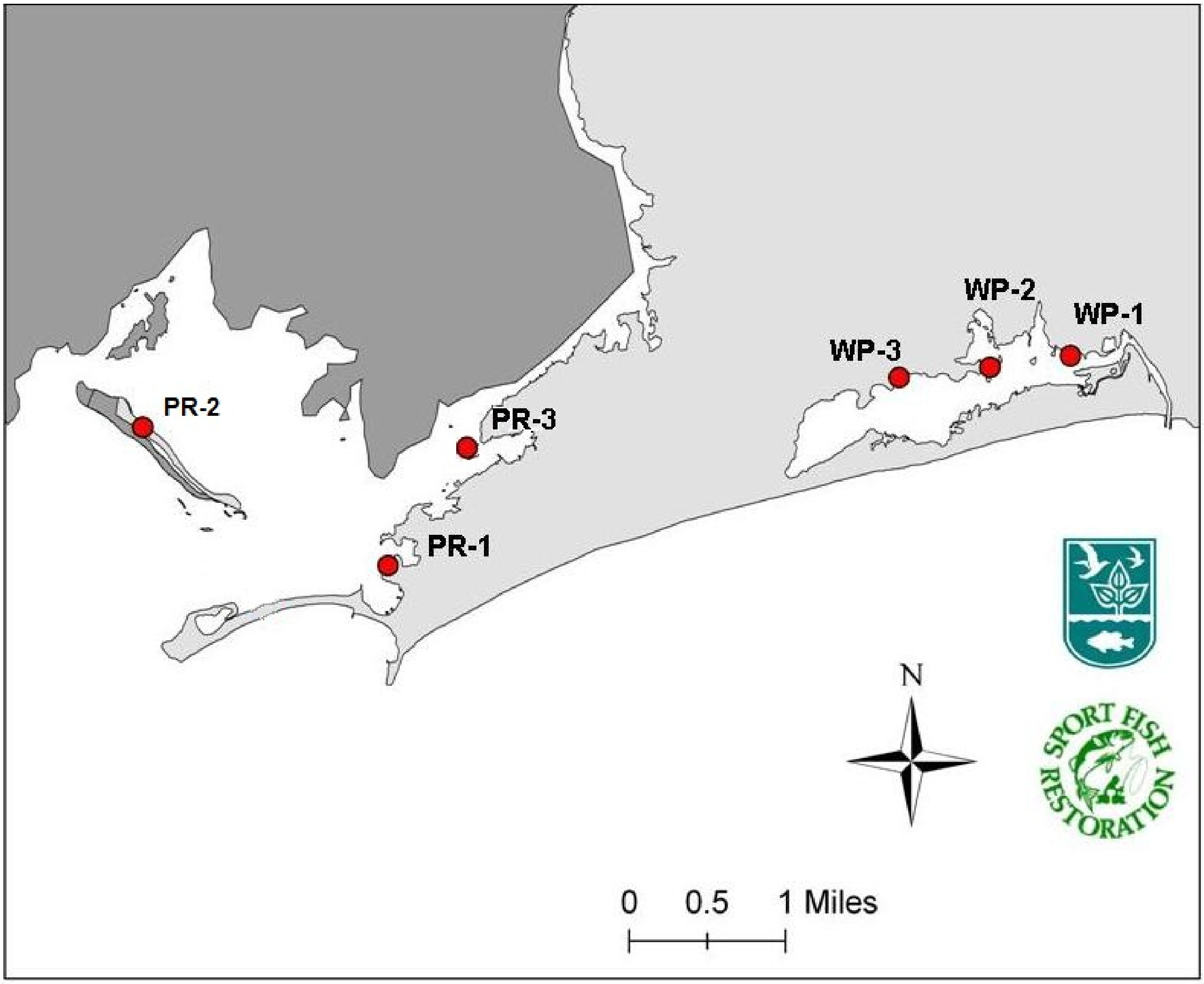


Figure 2 (cont): Coastal Pond Juvenile Finfish Survey station locations (western ponds).

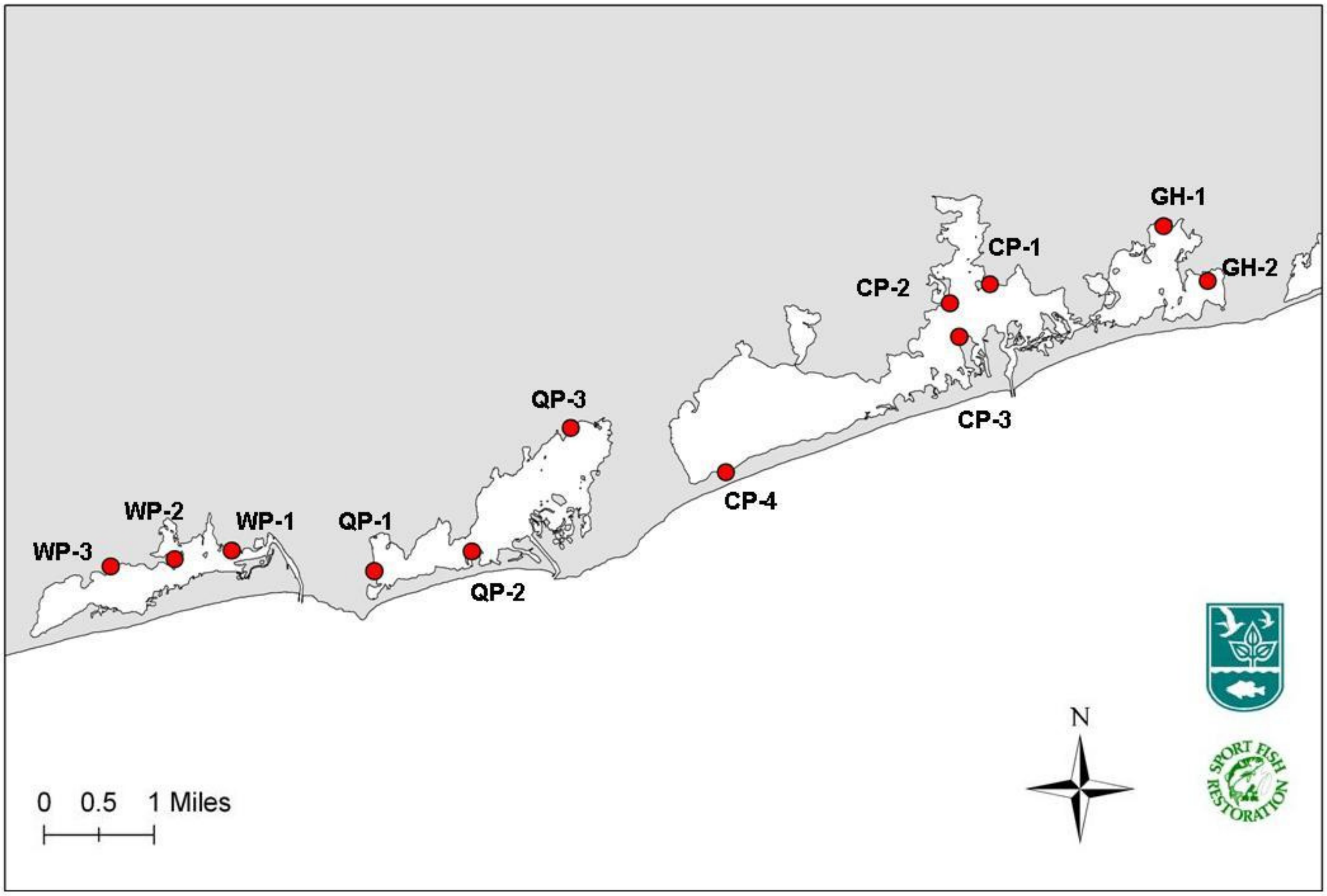


Figure 3: Coastal Pond Juvenile Finfish Survey station locations (eastern ponds).

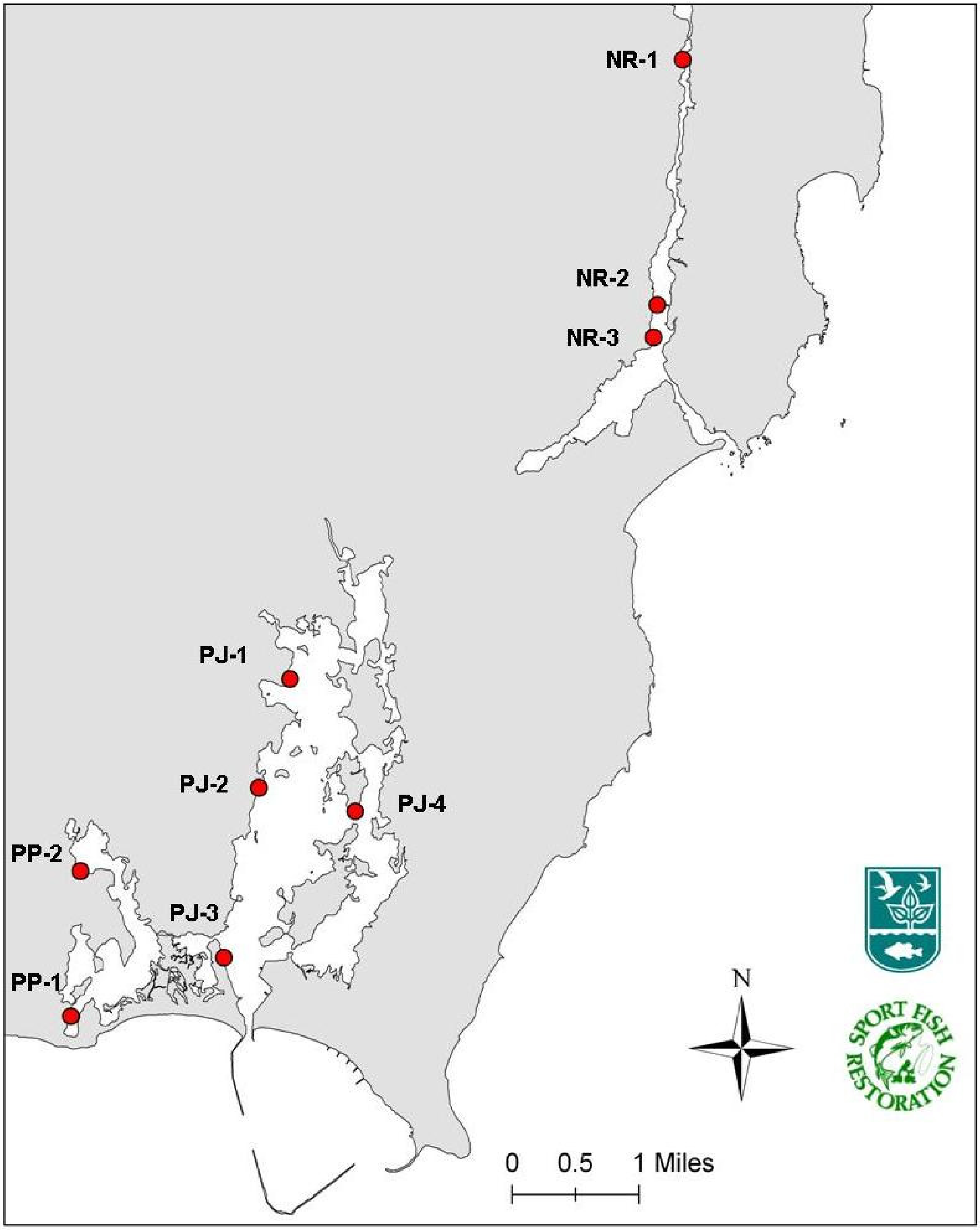


Figure 4
Coastal Pond Juvenile Finfish Survey

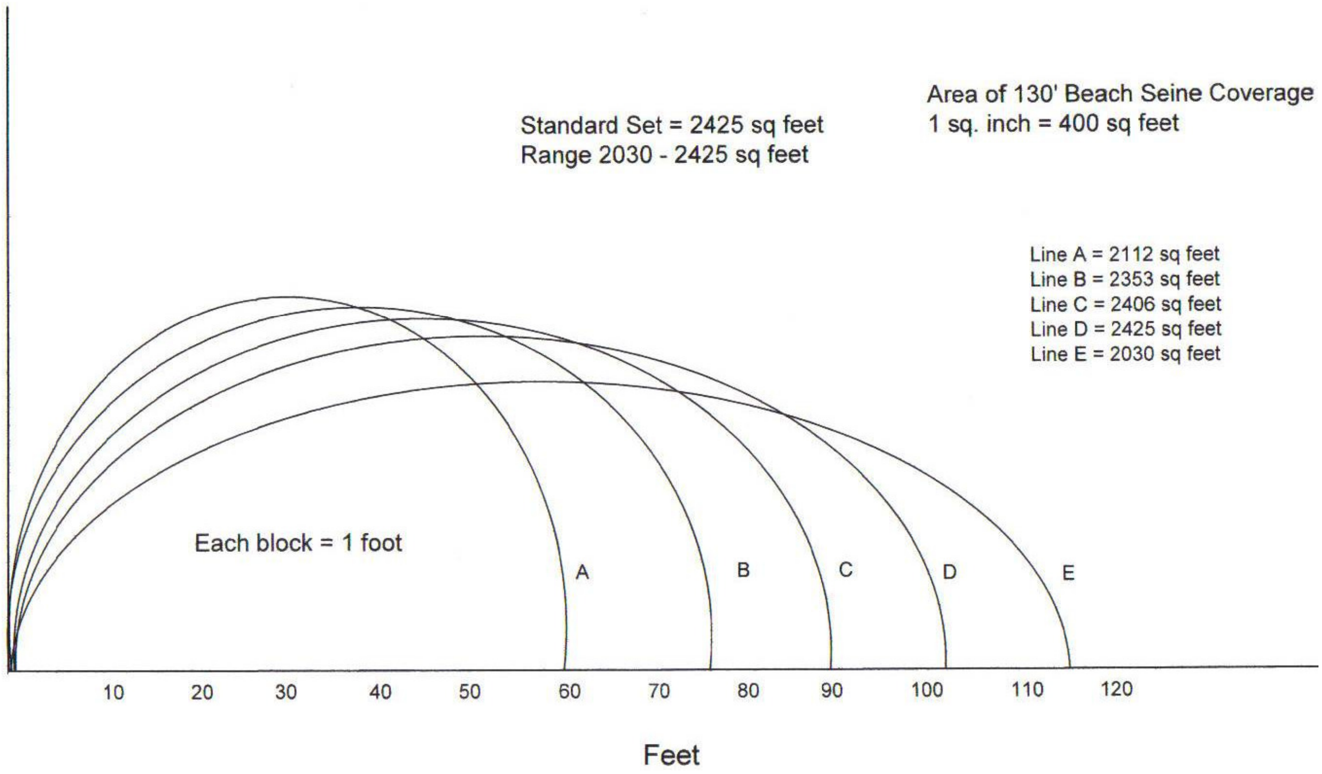


Figure 5: Time series of abundance indices (fish/seine haul) for winter flounder YOY from each Coastal Pond in the survey used for the index value.

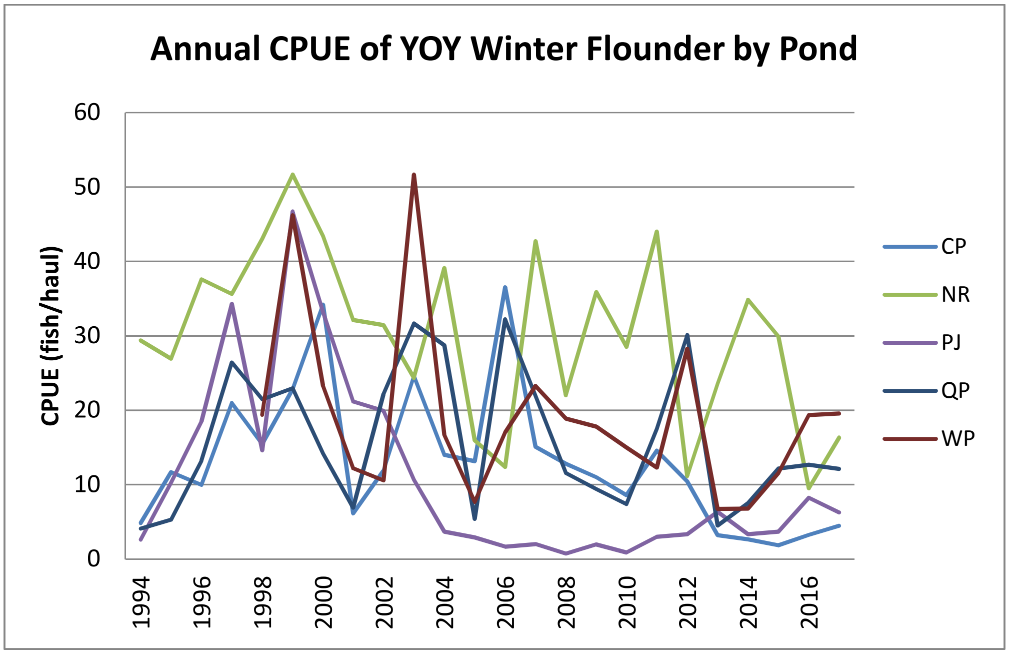


Figure 6: 2017 time series of abundance indices (fish/seine haul) by month for winter flounder YOY for each Coastal Pond in the survey.

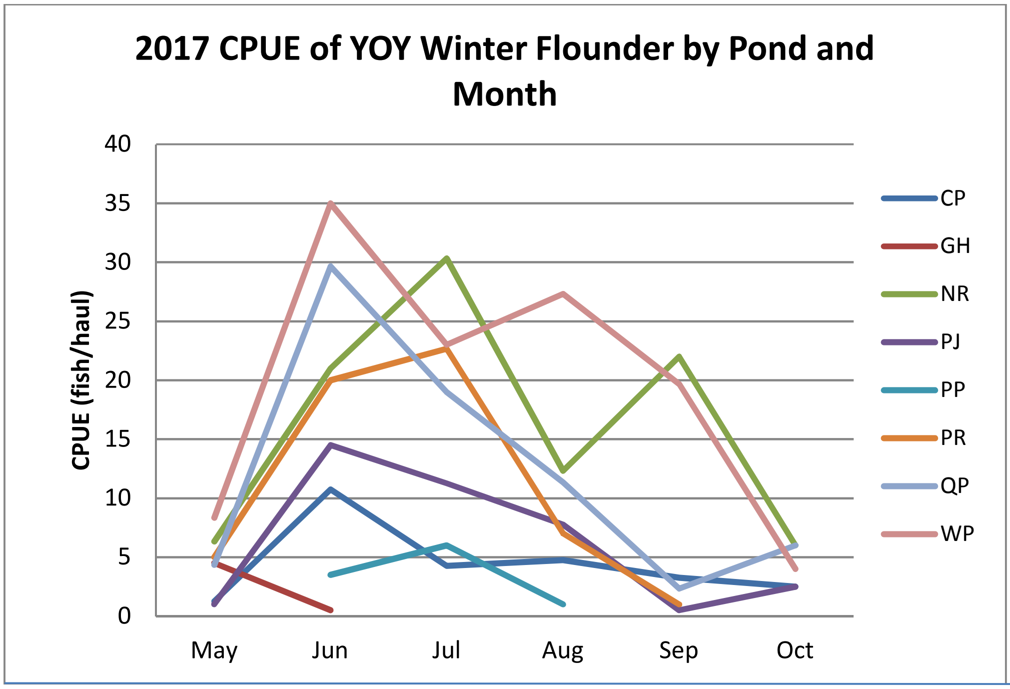


Figure 7: Length frequency of all winter flounder caught in Coastal Pond Survey during 2017.

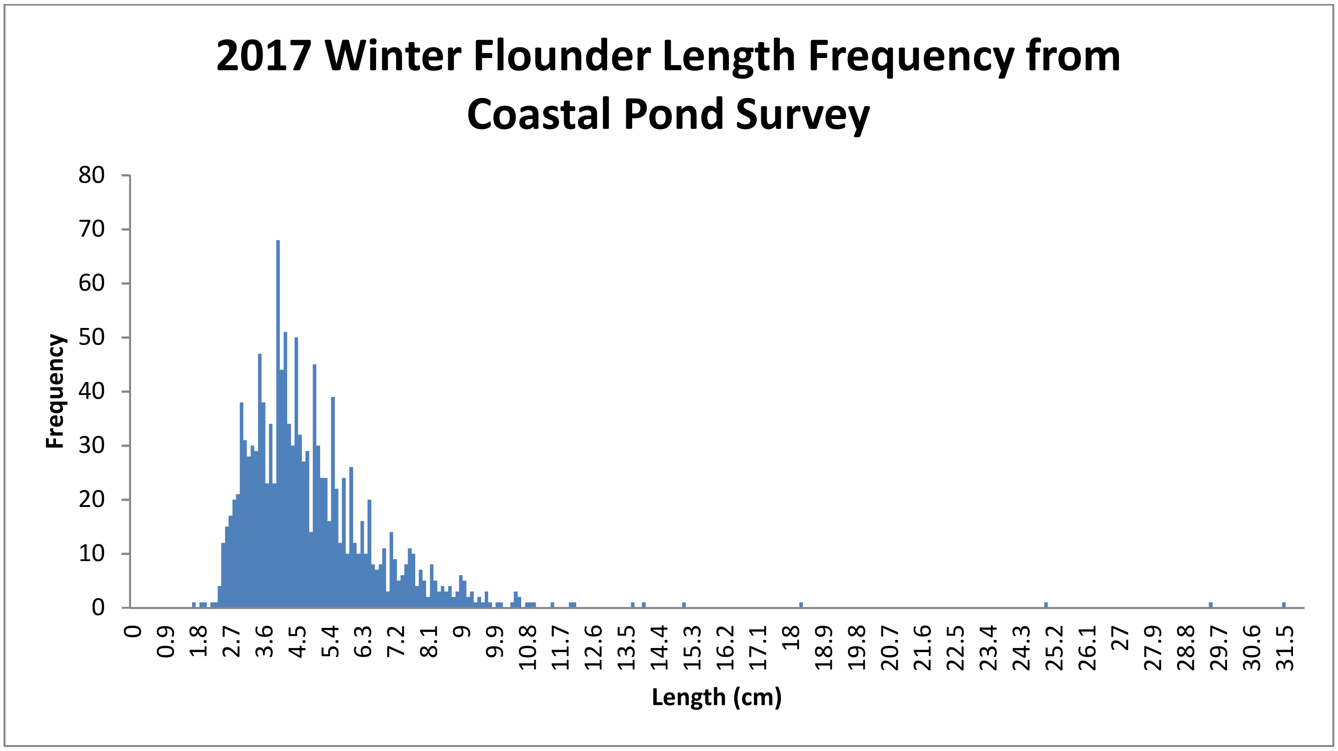


Figure 8: Time series of annual abundance indices for winter flounder YOY from the coastal pond survey.

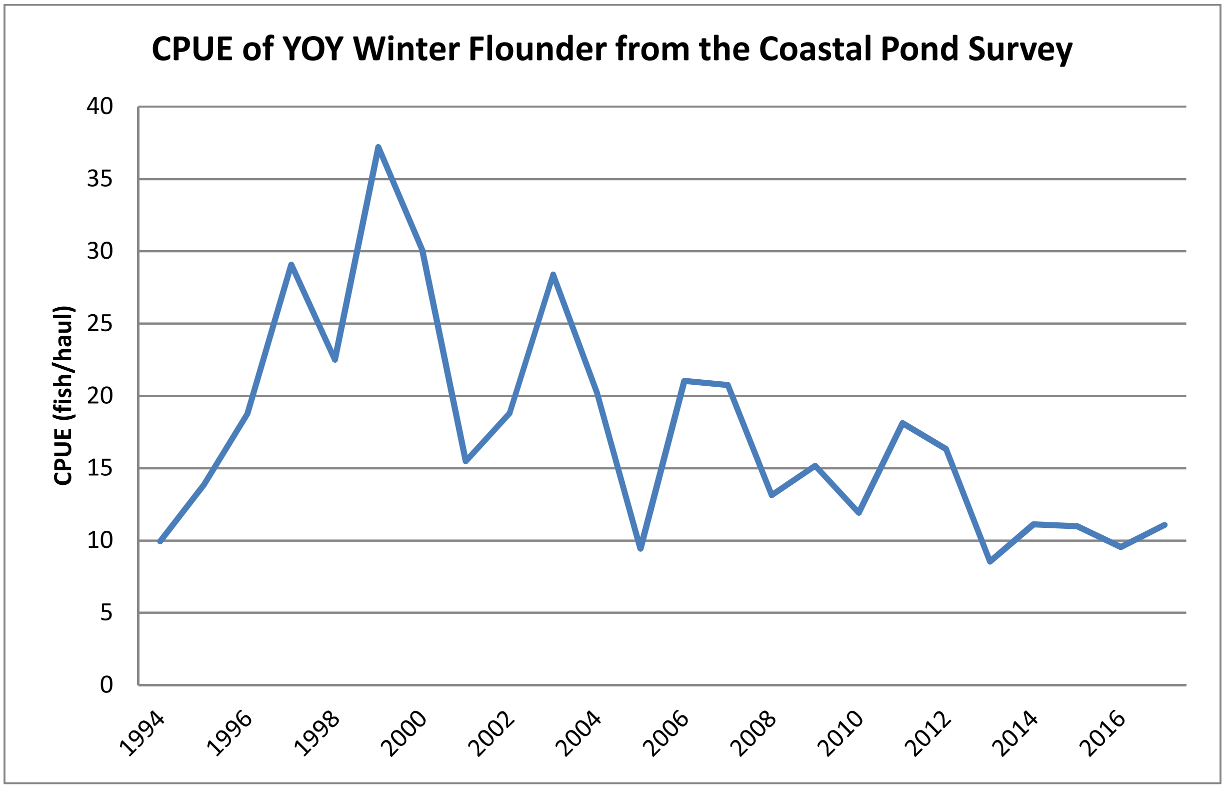


Figure 9: Abundance indices (fish/haul) from the Coastal Pond Survey, Narragansett Bay Seine Survey, and RIDFW Trawl Survey for winter flounder.

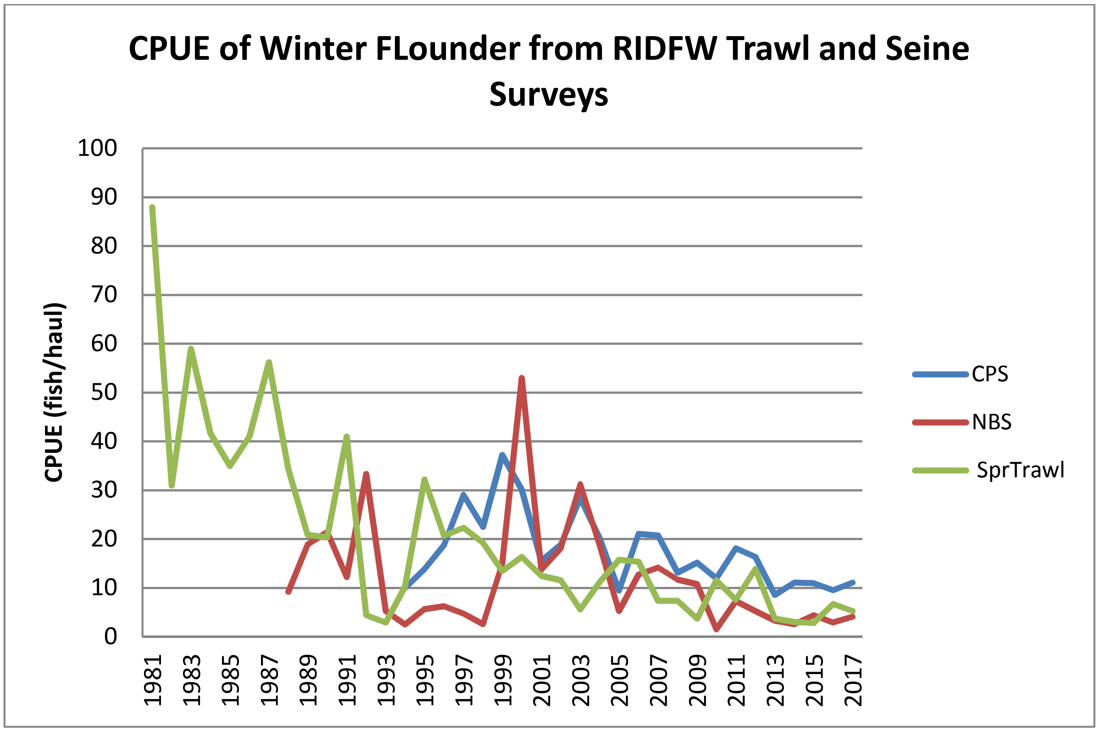


Figure 10: Abundance indices (fish/haul) from the Coastal Pond Survey and the Adult Winter Flounder Tagging Survey for winter flounder.

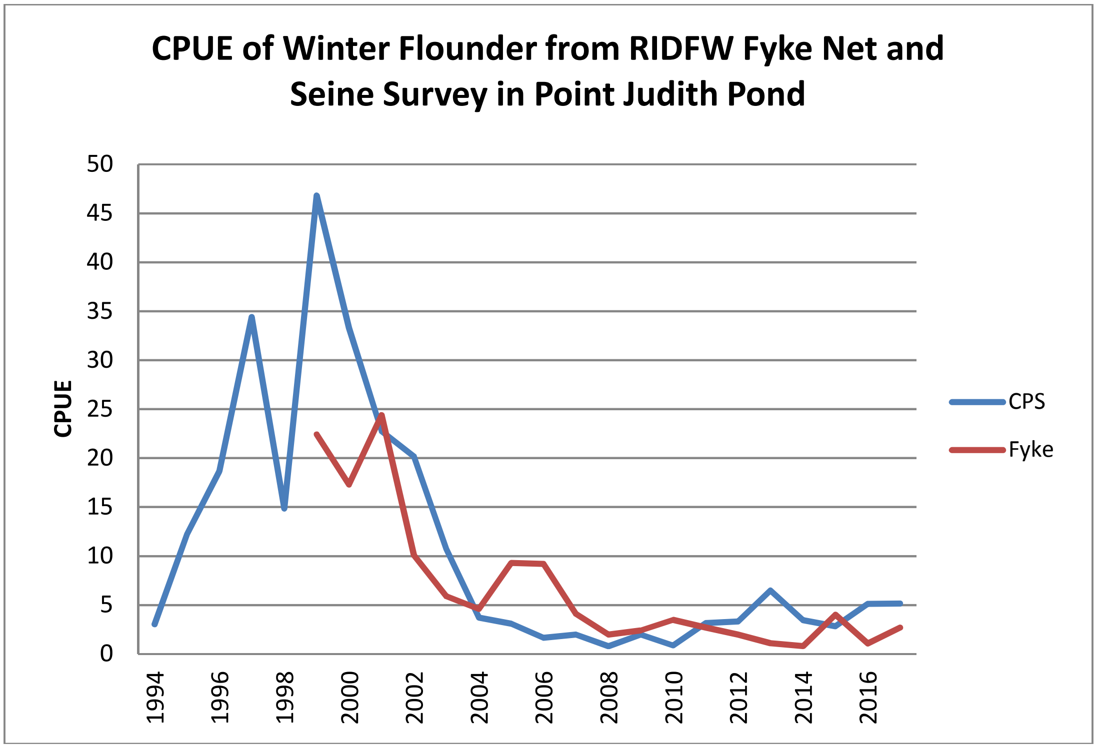


Figure 11. Time series of annual abundance indices for bluefish from the coastal pond survey.

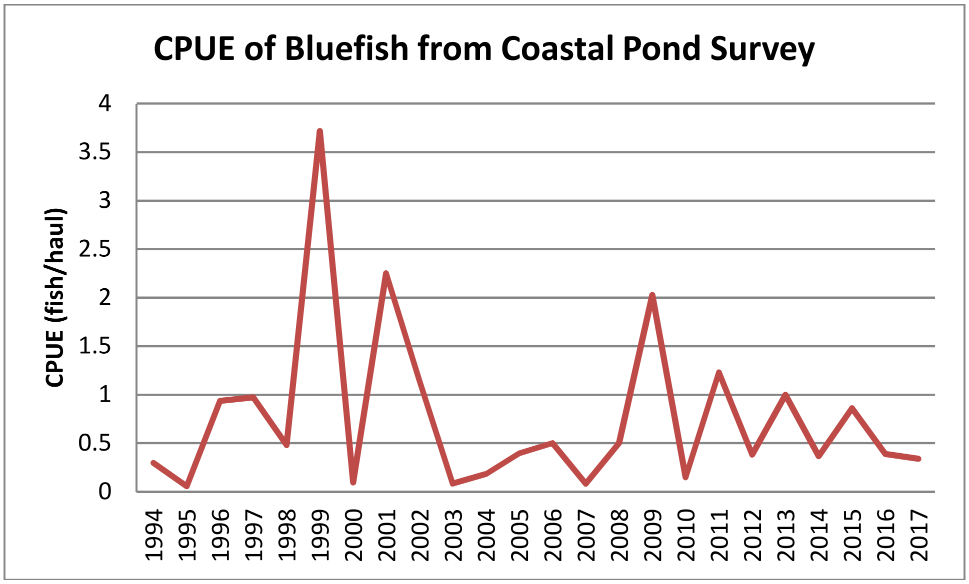


Figure 12. Time series of annual abundance indices for Tautog from the coastal pond survey.

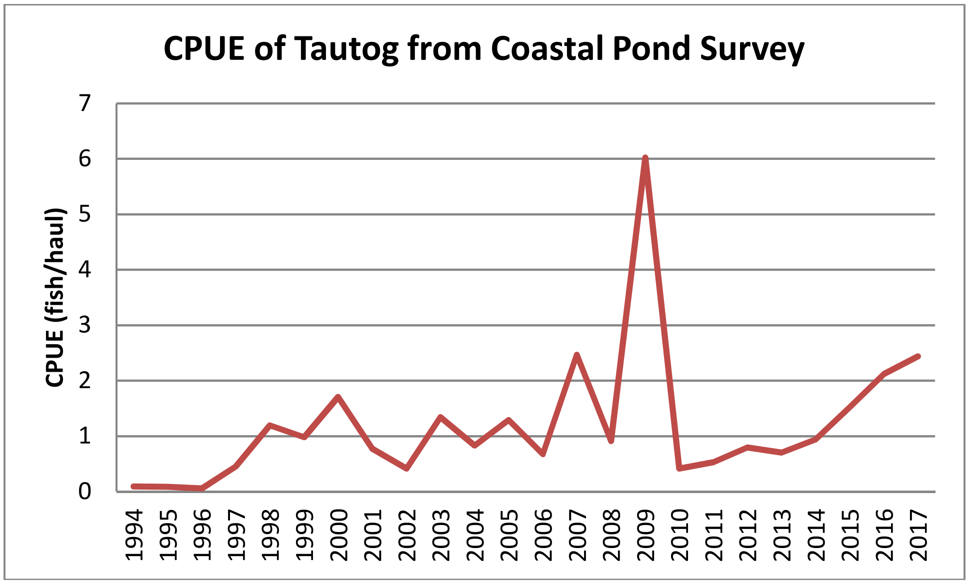


Figure 13. Time series of annual abundance indices for Black Sea Bass from the coastal pond survey.

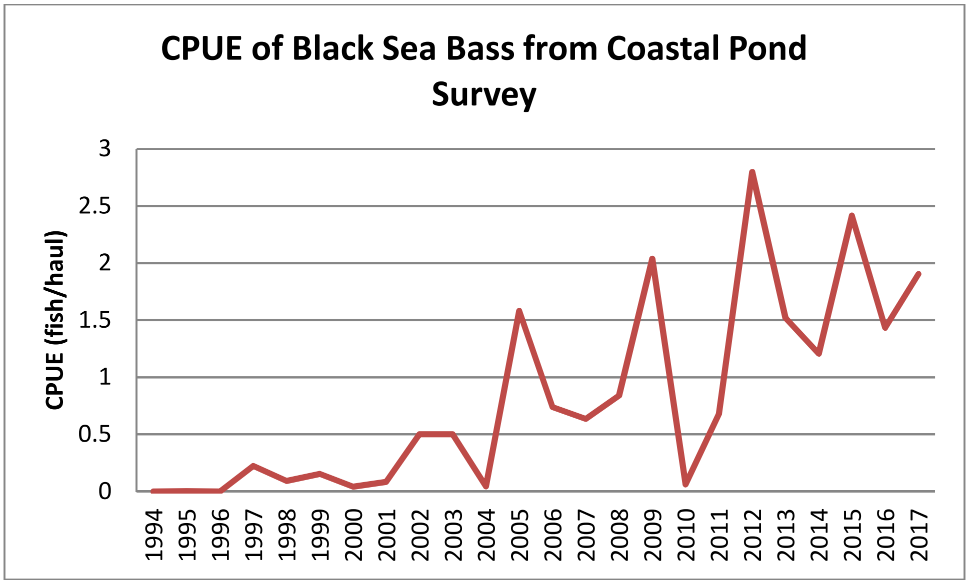


Figure 14. Time series of annual abundance indices for Scup from the coastal pond survey.

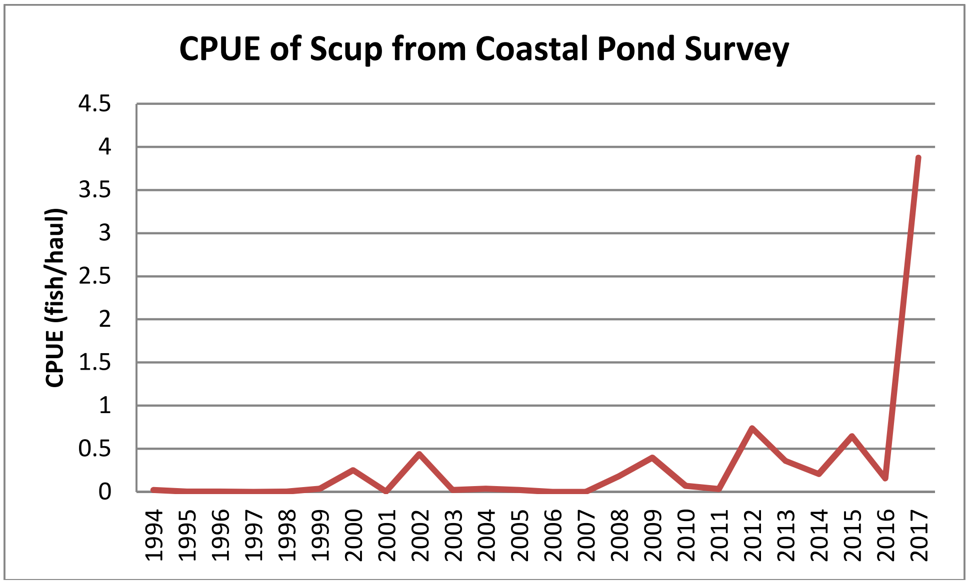


Figure 15. Time series of annual abundance indices for Clupeids from the coastal pond survey (menhaden on left y- axis)

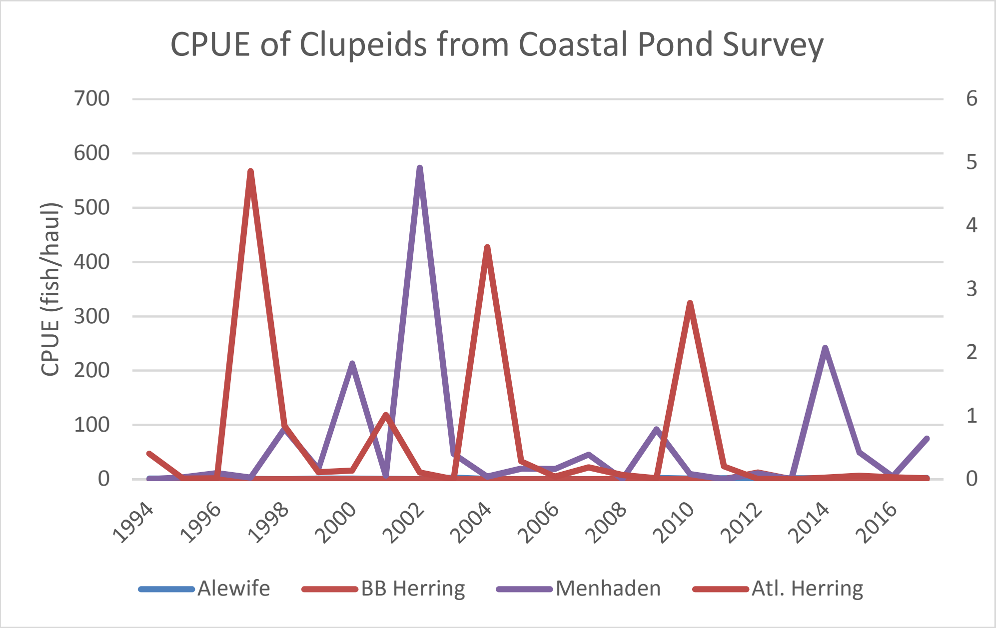


Figure 16. Time series of annual abundance indices for Baitfish from the coastal pond survey (silversides on left y- axis).

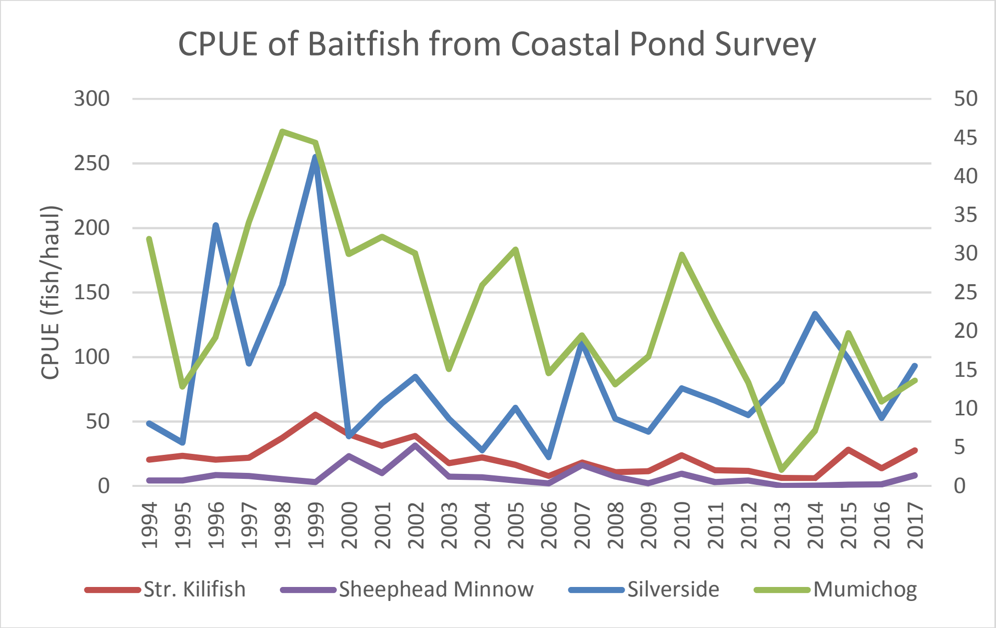
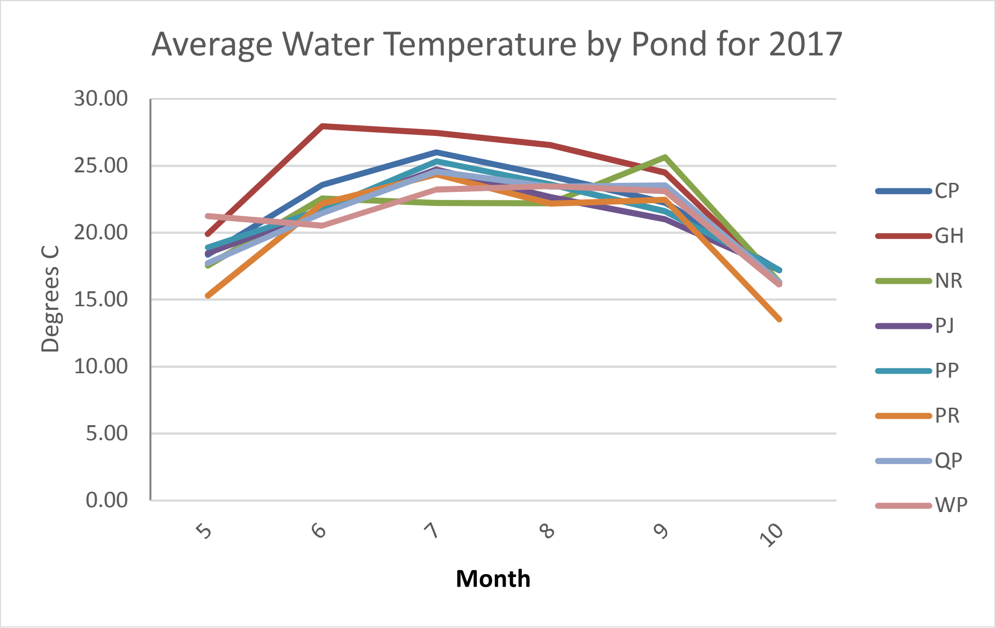


Figure 17. Average water temperature (Celcius) for coastal ponds.



Appendix 1a: Catch frequency of all species by station for 2017 Coastal Pond Survey original ponds.

Species	CP1	CP2	CP3	CP4	NR1	NR2	NR3	PJ1	PJ2	PJ3	PJ4	QP1	QP2	QP3	WP1	WP2	WP3
ALEWIFE (ALOSA PSEUDOHARENGUS)			33		3	4	24	199	68								
ANCHOVY BAY (ANCHOA MITCHILLI)			1		1245	2	1	1				5				10	
BASS STRIPED (MORONE SAXATILIS)					1							1					
BAY SCALLOP (ARGOPECTEN IRRADIANS)	1		4														
BLUE CRAB (CALLINECTES SAPIDIUS)					11	1		1			2						
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)		2		10	16	2	1	1				8				1	14
BLUE CRAB MALE (CALINECTES SAPIDIUS)	2	2	1	11	28	9			1		6	13	6	1			13
BLUEFISH (POMATOMUS SALTATRIX)		1			2		1					8		32			
COD ATLANTIC (GADUS MORHUA)										2							
CONGER EEL (CONGER OCEANICUS)							1										
CUNNER (TAUTOGOLABRUS ADSPERSUS)		2	4						4				3				
EEL AMERICAN (ANGUILLA ROSTRATA)		1	1														1
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)						1			2			1					
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)					1	1	2	1	3	1	1	1				1	2
FLOUNDER WINTER (PSEUDOPLEURONECTES AM	63	8	31	5	23	205	66	5	31	57	57	35	149	34	105	229	18
FLYING GURNARD (DACTYLOPTERUS VOLITANS)														1			
GOBY NAKED (GOBIOSOMA BOSC)				2	1	2	2	3	1		1	3		2			
GRUBBY (MYOXOCEPHALUS AENAEUS)	3	1	4						7		1	4	33	6	22	12	1
GUNNEL ROCK (PHOLIS GUNNELLUS)																	
HERRING ATLANTIC (CLUPEA HARENGUS)																	
HERRING BLUEBACK (ALOSA AESTIVALIS)						13											
HOGCHOKER (TRINECTES MACULATUS)																	
HORSESHOE CRAB (LIMULUS POLYPHEMUS)		1															
HORSESHOE CRAB FEMALE (LIMULUS POLYPHEMUS)			1									1	2	7		1	1
HORSESHOE CRAB MALE (LIMULUS POLYPHEMUS)			1									3	1	25			1
KILLIFISH STRIPED (FUNDULUS MAJALIS)	34	78	94	379		170	6	1	4	322	3	3	257	4	701	80	1475
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)						30					1						
LIZARDFISH INSHORE (SYNODUS FOETENS)						1			1		4						
MANTIS SHRIMP (SQUILLA MANTIS)																	
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)	1	1		1		2	4	1121		5		759	893	3	6592	437	52
MINNOW SHEEPSHEAD (CYPRINODON VARIEGAT	1	60	41	12		12	1	1					9		362	120	585
MULLET WHITE (MUGIL CUREMA)	18			1	1	82	9						36				16
MUMMICHOG (FUNDULUS HETEROCLITUS)	130	111	276	6	5	110	3	146		2		2	20	1	527	35	366
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)				5													
PERCH WHITE (MORONE AMERICANA)					6												
PINFISH (LAGODON RHOMBOIDES)								1	2								
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)	1	10	6		1	3	1	1	6		2		62	1		77	6
POLLOCK (POLLACHIUS VIRENS)			1													8	
PUFFER NORTHERN (SPHOEROIDES MACULATUS)	1			1		10	3		1		1	1		6		5	
RAINWATER KILLIFISH (LUCANIA PARVA)	75	358	173	4		1		42	2		2	15	1		3		42
SAND LANCE AMERICAN (AMMODYTES AMERICANUS)															1		
SCUP (STENOTOMUS CHRYSOPS)	83	3	45	375	30	1	12					3		1		1	
SEA BASS BLACK (CENTROPRISTIS STRIATA)	104	5	94			15	17		3		2		24	3	1	5	
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)	1													1		1	
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)	1															1	1
SEAROBIN STRIPED (PRIONOTUS EVOLANS)	2					25	4		3		3		1	1		7	1
SENNET NORTHERN (SPHYRAENA BOREALIS)		1															
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	264	796	274	402	94	553	248	151	277	500	753	103	202	617	575	4722	191
SNAKEFISH (TRACHINOCEPHALUS MYOPS)	3																
SNAPPER GRAY (LUTJANUS GRISEUS)		1															
SPOT (LEIOSTOMUS XANTHURUS)					15	1		1			2						
SQUID LONGFIN (LOLIGO PEALEI)			1													1	
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	6	173	154	2		8	4	4	3			1					57
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)			1			2											
TAUTOG (TAUTOGA ONITIS)	16	57	83			13	3	15	10		5	47	30	1	1	1	6
TOADFISH OYSTER (OPSANUS TAU)																	
TOMCOD ATLANTIC (MICROGADUS TOMCOD)													4	1			
WINDOWPANE (SCOPHTHALMUS AQUOSUS)			1														

Appendix 1b: Catch frequency of all species by station for 2017 Coastal Pond Survey (new ponds).

Spp	GH1	GH2	PP1	PP2	PR1	PR2	PR3
ALEWIFE (ALOSA PSEUDOHARENGUS)						7	9
ANCHOVY BAY (ANCHOA MITCHILLI)	2		5	23		76	2
BASS STRIPED (MORONE SAXATILIS)							
BAY SCALLOP (ARGOPECTEN IRRADIANS)			1				
BLUE CRAB (CALLINECTES SAPIDIUS)	1		6				
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)	9	3	8	2		2	3
BLUE CRAB MALE (CALINECTES SAPIDIUS)	17	12	17			1	4
BLUEFISH (POMATOMUS SALTATRIX)						4	1
COD ATLANTIC (GADUS MORHUA)			1				
CONGER EEL (CONGER OCEANICUS)							
CUNNER (TAUTOGOLABRUS ADSPERSUS)							
EEL AMERICAN (ANGUILLA ROSTRATA)	1	2	1	1			
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)							
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)	3		6				
FLOUNDER WINTER (PSEUDOPLEURONECTES AMERICANUS)	8	2	24		152	8	2
FLYING GURNARD (DACTYLOPTERUS VOLITANS)							
GOBY NAKED (GOBIOSOMA BOSC)	5		23	1			
GRUBBY (MYOXOCEPHALUS AENAEUS)			4		4	8	1
GUNNEL ROCK (PHOLIS GUNNELLUS)						1	
HERRING ATLANTIC (CLUPEA HARENGUS)				1		1	
HERRING BLUEBACK (ALOSA AESTIVALIS)	1						
HOGCHOKER (TRINECTES MACULATUS)	1						
HORSESHOE CRAB (LIMULUS POLYPHEMUS)							
HORSESHOE CRAB FEMALE (LIMULUS POLYPHEMUS)					2	1	
HORSESHOE CRAB MALE (LIMULUS POLYPHEMUS)			1		1	1	
KILLIFISH STRIPED (FUNDULUS MAJALIS)		36	11	52	135	143	1
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)							
LIZARDFISH INSHORE (SYNODUS FOETENS)							
MANTIS SHRIMP (SQUILLA MANTIS)			1				
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)			87	780		34	17
MINNOW SHEEPSHEAD (CYPRINODON VARIEGATUS)				5			
MULLET WHITE (MUGIL CUREMA)			11	6			
MUMMICHOG (FUNDULUS HETEROCLITUS)	69	3	35	87	3	8	18
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)	4				1		
PERCH WHITE (MORONE AMERICANA)							1
PINFISH (LAGODON RHOMBOIDES)		1					
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)	11	4	7	8	1	3	
POLLOCK (POLLACHIUS VIRENS)							
PUFFER NORTHERN (SPHOEROIDES MACULATUS)							
RAINWATER KILLIFISH (LUCANIA PARVA)	32	43	25	58		3	6
SAND LANCE AMERICAN (AMMODYTES AMERICANUS)							
SCUP (STENOTOMUS CHRYSOPS)	1	1	2				
SEA BASS BLACK (CENTROPRISTIS STRIATA)					1		
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)							
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)							
SEAROBIN STRIPED (PRIONOTUS EVOLANS)					2		
SENNET NORTHERN (SPHYRAENA BOREALIS)							
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	172	129	206	769	84	1027	314
SNAKEFISH (TRACHINOCEPHALUS MYOPS)							
SNAPPER GRAY (LUTJANUS GRISEUS)							
SPOT (LEIOSTOMUS XANTHURUS)	2				3		
SQUID LONGFIN (LOLIGO PEALEI)			3				
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	15	47	84	6		4	25
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)							
TAUTOG (TAUTOGA ONITIS)	1			1	4	10	47
TOADFISH OYSTER (OPSANUS TAU)		4		1			
TOMCOD ATLANTIC (MICROGADUS TOMCOD)					1		2
WINDOWPANE (SCOPHTHALMUS AQUOSUS)							

Assessment of Juvenile Finfish and Seasonal Dynamics in Great Salt Pond, Block Island, Rhode Island 2017

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Performance Report January 2018

Performance Report

State: Rhode Island

Project Title: Assessment of Juvenile Finfish and Seasonal Dynamics in Great Salt Pond, Block Island, Rhode Island 2017

Period Covered: May 19, 2017 – November 1, 2017

Job Objectives: To collect, analyze, and review beach seine survey data from Block Island (BI)'s coastal pond – Great Salt Pond (GSP) – for understanding recruitment relative to spawning stock biomass of Winter flounder and other important finfish species.

Summary: In 2017, TNC investigators caught 31 species of finfish representing 20 families in the GSP. The number of species logged for 2017 was considerably low in comparison to past seasons. The record high was recorded in 2015, with 49 species from 33 families. The total count of individuals collected during 2017 survey (totnum: 19,842) marked the highest overall record for the GSP time series. The species of highest frequency for 2017 in ranked descending order were: 1) Silversides spp. (n=16,021), 2) Striped killifish (n=2,765), 3) Winter flounder (n=159), 4) Scup (n=156), and 5) Tautog (n=142). High frequencies of Silversides spp. may be reflective of consecutive large catches recorded throughout the season.

Target Date: March 30, 2018

Status of Project: On schedule.

Significant Deviations: There were no significant deviations in 2017.

Recommendations: To continue next segment of the project as standardized. To continue sampling each of the 8 stations in the GSP. The 2018 season will mark the fifth year of juvenile fish sampling in the GSP.

Remarks: Investigators successfully sampled all index stations for each sampling event from May to October. The index value time series targets young of the year (YOY) Winter flounder (TL > 120mm). Data does not include sizes outside of this cohort (>120 mm) for consistent analyses. In addition, the time series species indices only include data points recorded from the 8 traditional stations. In past reports, investigators differentiated New World Silversides (Atlantic vs. Inland) in past GSP field collections and status reports. Going forward, all New World Silversides will be identified as *Atherinopsidae spp*. The master dataset was updated to modify this correction.

STUDY AREA

The GSP is a diverse body of water located in the center of BI. It is characterized as a coastal salt pond – a body of salt water surrounded by salt water (Hale 2000). The permanent breachway was constructed in 1896 (Hale 2000). This change had broad-reaching effects on the ecosystem (Olsen and Lee 1982; Katz 2000). The low flushing rate, absence of major freshwater aquifers, and relatively small size, creates a diverse mix of species and physical properties (Ketchum 1983; Shumway 2008). Rain falling on upland parts of the watershed also creates a salinity gradient between the fresh water coming into Harbor and Trims Pond (inner pond locations) in the southeast corner of the GSP (Shumway 2008).

Total acreage of GSP is approximately 800 acres at mean low tide[1]. Close to 50-percent of the area is less than 4m at MLW. Maximum depth in the heart of the GSP reaches 17m (reference NOAA chart 13205).

METHODS

Juvenile finfish were collected from 8 locations in the GSP between May and October 2017 (see map extent in Figure 1 for 8 traditional stations). Sampling events occurred once a month on the incoming tide. Stations GSP 1-8 were swept at fixed sites in shallow intertidal zone via 23-ft outboard vessel (Figure 3 illustrates area enclosed by net). Seine sites were less than 1.2m at mean low tide.

Fish were caught using a beach seine (39.6m x 2.2m; 6.9mm knotless diamond mesh; 1.3m x 1.3m midpoint pocket) with double weighted lead line footrope and head float line. The 23-ft outboard vessel was used to deploy net. Fish were identified, measured (TL; mm/cm), and counted (sub-sample recorded per species when number was greater than 20 individuals). Total length measurements were used as rationale for review of YOY cohort data. Water parameters were recorded for each seine event using Pro YSI meter (e.g., Water temperature, salinity and dissolved oxygen). Field notes also recorded other marine invertebrates yielded in catch.

Metrics and Rationale

Winter Flounder are defined as Species of Interest for the survey. Recreationally important species identified for this survey were Striped Bass (Pelagic, multi-habitat), Black Sea Bass (Pelagic, multi-habitat), Winter Flounder (Demersal), Tautog (Demersal), and Scup (Pelagic, multi-habitat). These species were targeted as species to quantify when discussing recreationally important fishes.

Additional Species of Interest by functional group

Bait: Killifish (Rainwater, Striped, Silversides, Mummichog).

Pelagic (multi-habitat): Menhaden, Spot, Herring (River Herring, Alewife, Bluefish, Pinfish, Mullet (White, Striped), Needlefish, Northern Sennet, Butterfish, Northern Kingfish, White Perch, Weakfish, Sand Tiger Shark, American Amberjack, Atlantic Croaker, Banded Rudderfish.

Demersal: Oyster Toadfish, Cunner, Striped Sea Robin, Sticklebacks (Threespine, Fourspine), American Eel (mostly demersal), Naked Goby, Northern Pipefish, Sculpins, Summer Flounder, Smooth Dogfish, Hogchoker.

Crustaceans (mobile invertebrates, shrimp): Sand Shrimp, Grass Shrimp, Spider Crab, Blue Crab, Green Crab, Mud Crab, Lady Crab, Rock Crab, Mantis Shrimp.

Frequency distributions of mean fish per seine haul are calculated according to station, month, and year. Size-frequency distribution is measured (TL) and numbered per bin (size distribution). Unit of measure used for Winter flounder is millimeters. All other finfish are measured in centimeters.

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[1] Acreage includes inner pond systems: Harbor Pond and Trims Pond. The number was estimated in ArcGIS online.

Juvenile cutoff sizes for Species of Interest were defined to compare species growth parameters. YOY Winter Flounder cutoff is TL < 120mm (accepted value)[2]. YOY Black Sea Bass is considered TL < 13cm[3]. YOY Scup range 5-10 cm fork length from June to November[4]. YOY Tautog cutoff is 10-15cm[5].

RESULTS AND DISCUSSION

Sampling Overview

Beach Seine Effort

In 2017, a total of 48 beach seine sets were made from May to October (Table 1). Block nets were calculated at the start of the first survey to enclose the seined area (Figure 3). A standard set ranged 2030-2425 ft^2.

Physical and Chemical Data

Environmental Conditions, 2017

Tidal Stage, Water Depth, and Water Transparency

Most of the sampling occurred at depths shallower than 2m of water (Table 2). Sampling dates were selected for tides that fell between 1.2 and 0.6m (+4 ft and +2 ft).

Water Chemistry, 2017

Water parameters measured by station and month for 2017 were summarized in table 3 and charted in figures 3-5. Measurements for water temperature, salinity and dissolved oxygen were recorded at each set[6]. Water temperature ranged between 12.9°C in May and 27.2°C in July. Dissolved oxygen ranged from 6.53 mg/L in August to 9.09 mg/L in October. Salinity ranged between 30.95 ppt in October to 33.09 ppt in September.

Biological Data

Time Series Comparisons

2017 Counts per Species

Investigators recorded 19,842 fish representing 31 different species from 20 families in 2017 (see Table 4 for species list and Table 6 for summary table of species measured and enumerated). This number was higher than previous survey counts: 2014 (n=6,464); 2015 (n=19,514); 2016 (n=14,703) (Appendix 1a, 1b, 1c).

Based on the geometric mean catch per seine haul, the most abundant finfish in descending rank order for 2017 were: 1) Silversides spp., 2) Striped killifish, 3) Winter flounder, 4) Scup, and 5) Tautog. Forage species comprised close to 95-percent of total catch for this year's survey.

The PCA ordination combined for top ranked bait fish species (Silversides=S1, Striped killifish=S2, Mummichog=S3) confirmed that Silversides comprised 83-percent of time series results grouped for bait fish. S1 axis explained or "extracted" almost ¾ of the variation in the entire data set. The second axis, S2, explained

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[2] Bigelow and Schroeder found that Winter flounder grow to 100mm within the first year in a RI study (1953c). Areas with higher growth than RI have documented 100-180mm within the first year (Witting 1995). Local conditions may be indicative of higher growth rates due to differing ecosystem functions related to migration patterns, and differing physical, chemical and biological factors (Packer et al. 1999).

[3] Size is highly dependent on temperature. BSB around this size are YOY to year-1. 21.0 cm are age 2 (ASMFC).

[4] Year-1 are 10-13cm and year-2 are >15.5cm (O'Brien et al. 1993). Ages for size classes were assigned based on seasonal mean sizes at age.

[5] Data was sourced from Atlantic Coastal Cooperative Statistics Program (starts at age 1 around 120cm, consistent with other sources).

[6] These readings are spot measures taken during time of beach seining using the ProYSI and are not a continuously measured record. Measurements are taken at 1m depth.

almost all the remaining variation. Axis 3, S3, only explained a trivial amount, and may not be worth further interpretation. Water parameters were included in analysis of this PCA.[7]

Silversides spp., Striped killifish, Mummichog and Winter flounder were caught at all stations (Table 5 species presence/absence). 9 out of 31 species were rarely encountered and occurred at a single station: American sand lance, Atlantic herring, Bluespotted cornetfish, Dwarf goatfish, Inshore lizardfish, Naked goby, Sand diver, Spotted Hake, and Striped Bass. See table in Appendix 1 for comprehensive list of species presence/absence compiled since 2014.

Trend analyses for number of individuals and number of species showed seasonal cycles that may be related to the nursery function of the estuary and to migratory activities. Overall, total abundance for individuals measured and counted were highest in September 2017. The greatest number of total individuals caught in 2017 happened during the October sampling. July and September sets (including all stations) were relatively close in overall counts for total individuals enumerated. In other words, sub-sample populations (i.e., Silversides and Striped killifish) skewed total abundance comparisons. In 2017, the comparison between monthly sampling events showed August and September to have slight differences in number of species.

2017 Counts per Station

Fish community composition may be related to physical characteristics according to site area in the Pond (Hart 1992; Maret 1997;). Habitat diversity influences the structure and composition of species assemblages, and is of interest for the greater context of this survey (Gebrekiros 2016).

In 2017, station GSP 7 had the lowest overall total for fish captured (n=967). This station also had the lowest number of different species recorded for the sampling season. In past surveys, GSP 1 had the lowest overall count amongst species both in 2014 (n=237) and 2015 (n=888). Whereas in 2016, GSP 6 held the record for lowest number for total individuals (n=802). GSP 3 had the highest total number of individuals for the time series: 2017 (n=6,484); 2016 (n=2,783); 2015 (n=4,635); 2015 (n=1,100).

Throughout the years, Silversides and Striped killifish tilted the scale for species of highest frequencies. Even further, the stations located closer to the cut of GSP showed more abundant catches of finfish, namely Silversides, Striped killifish and Scup in 2017. Stations near the breachway are GSP 2-5 (all within .6 nm of the cut). See Figure 2 to refer to colloquial names set by the fixed GSP stations.

GSP 3 is of interest for the time series station of overall highest frequencies. This site consistently showed the highest frequencies of species over the last four seasons. It is located off Beane Point, or the inner northwest corner shore of the Pond’s open channel. Between the bottom substrate (predominately sandy sediment with patches of macroalgae, coarse rock and shell fragments), sloped gradient, adjacent seagrass bed, and tidal flushing, brought on by the function of the breachway, may be contributing factors to the presence of schooling species in this area of the Pond (Briggs and O’Connor 1971; Lee 1980).

GSP 3 is also situated on the Pond’s shallow sandy delta that extends scores of meters to the north, connecting it to the salt marsh habitat where GSP 2 is located for the survey. Superimposed upon this sediment deposition process resulted in steep slopes just south of edges of the inlet delta. Here, the sandy barrier beach and connective salt marsh lies contiguous to the deepest portions of the GSP, creating an abrupt shoreline drop-off, and a possible indication for increased fish assemblages (Raposa 2002).

The widest range of species type occurred at GSP 6, with 19 different species in 2017. In 2016, GSP 5 had the highest diversity with 20 different species. Both GSP 5 and 6 were tied at 21 species for the 2015 season. Then again in 2014, GSP 6 also had the most diversity with 12 different species. The stations with lowest diversity were stations GSP 7 in 2017 (12 different species); GSP 8 in 2016 (11 different species); GSP 8 in 2015 (11 different species); and GSP 7 in 2014 (4 different species).

Stations GSP 5 and 6 are finger-like coves located on the western shores of the GSP. For the time series survey, these sites were marked as areas with greatest number of different species. GSP 5 and 6 may be conducive for various demersal and pelagic species during early life and juvenile phases to seek shelter, food

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[7] Most environmental factors can be included in this analysis, but for the bait fish comparison, bottom features, water depth were not included in the test.

and avoid predators according to speciation habits (Meng et al. 2000; Raposa 2002). Qualitatively speaking, these stations are relatively protected from prevailing SW winds during peak season months, they have varied substrates, contoured shorelines, fringing sloped depths, and direct sources of freshwater input coming from upper GSP watershed.

GSP 5, located in the western portion of Cormorant Cove and larger GSP area, is predominately dominated by sandy-mud substrates, shell fragments (e.g., mix of *Crepidula fornicata* and shellfish), macroalgae, and surrounded by larger rocks and boulders. Adjacent to GSP 5 is a gradient sloped from about 2m to 6 m in a relatively short distance of 30 m. While Sea robins sp., Black sea bass and Winter flounder have historically been the species of highest frequencies at this station, adult Striped bass were recorded at GSP 5 back in 2016, as well as large schools of American sand lance. Presence of both left-and-right flounder species have also been observed at GSP 5, including Summer flounder and Windowpane.

GSP 6, Bonnell Beach, is situated around the corner from Cormorant Cove. Bonnell Beach is one of the more secluded coves in the GSP. Between the riparian buffer that engulfs the small stretch of beach (measured slightly over 50m for distance)[8], denser patches of coastal shrubs and upland vegetation is more prominent around shoreline properties compared to other station sites found in the Pond. GSP 6 is mixed with coarse sand and gravel, mud, and peat bottom below initial bottom cover. It also is characterized by shell middens, various rocks and boulders, and algal mats. Together, these physical features may attract numerous forms of life, rich with benthos, marine invertebrates and finfish communities (Gebrekiros 2016).

Time Series Comparisons

Catch by Species, 2017

Winter Flounder (*Pseudopleuronectes americanus*)

Juvenile Winter flounder were collected at all 8 stations in 2017. Winter flounder ranked third in overall species abundance (n=159) (Table 7) for the 2017 survey, with increased CPUE (fish/seine haul) during the September sample (Figure 6). The total survey abundance index was 0.28 fish/seine haul for 2017. The 2017 count was slightly less than last year's count when 192 individuals were recorded in 2016. CPUE was also highest in September 2016. For the 2015 survey, investigators collected 188 Winter flounder, with greatest number of fish per haul spiked in both June and September. Then in 2014, 101 individuals were recorded for the season, also with increased CPUE in September (see summarized data displayed in Appendix 3 tables and illustrated in Appendix 4 figures).

The juvenile Winter flounder index (YOY WFL) measured populations by calculating mean fish abundance (mean ± SE) per seine haul[9]. Winter flounder were divided into two age groups for data analyses: age 0 to 12-months (TL < 120mm) and age 1+ (TL > 120mm). The YOY WFL included cohort fish sized <120mm.

The 2017 season recorded 36 individuals at GSP 5 for most YOY caught for one haul, with total of 70 Winter flounder enumerated for the season at this station. As for most individuals caught per month, September sampling event captured 54 Winter flounder, 6.75 ± 4.55 fish/seine haul.

The timing, site location and total number of individuals counted for peak abundance slightly fluctuated for GSP time series (see summary tables for time series data in Appendix 3). In 2014, the highest number of individuals were caught at GSP 5 (n=19) in September. During this month, a total of 44 YOY Winter flounder were recorded at all GSP stations, with 5.50 ± 2.27 fish/seine haul. Then again in 2015, the highest number of Winter flounder were also captured during the September sampling event (n=75), with 9.38 ± 3.01 fish/seine haul. GSP 5 had the greatest number recorded with 25 individuals in 2015. In 2016, the greatest number of individuals was caught at GSP 2 (n=45); and a total of 70 individuals recorded in September with 8.75 ± 1.96 fish/seine haul.

Based on existing age and size frequency data from GSP time series, YOY WF TL measurements represented age groups 0-1+ (see summary tables in Appendix 3: 3d-3e). In 2017, Winter flounder TL ranged from 30 to

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[8] The distance for Bonnell Beach's shoreline contour was measured in ESRI ArcGIS to provide rough estimate of the station found here, GSP 6. This station is noteworthy because of its consistent, diverse spread of species recorded thus far since baseline survey in 2014.

[9] Geometric means were calculated for the total survey abundance index for species commonly captured in the survey.

155mm. Table 12 summarizes mean length (mm) for individuals caught this past season by station and month for 2017.

For time series comparisons, Winter flounder TL ranged from 44 to 192mm in 2016, 26 to 196mm in 2015, and 31 to 170mm in 2014. The majority of YOY individuals collected during 2017 season represented 3 to 6-month age group distributed from 45 to 90mm, with the most frequent length range for YOY individuals between 60 to 70mm (n=52) (see length frequency histogram in Figure 9). The 3 to 6-month age group was distinguished as length of highest frequency for 2016 and 2015 seasons. No age 2+ Winter flounder (TL >200-250mm) have been caught thus far in GSP survey.

Silversides spp. (*Menidia spp.)*

Silversides spp. were the most abundant species for 2017 survey (n=16,021). This count marked the highest number of counted and measured individuals for species time series catalogue (2016 n=11,966; 2015 n=15,112; 2014 n=3,649). Silversides were most frequent at GSP 3 with large catches occurring in the August through October sampling events (see frequency data in Table 8). In contrast, highest frequencies were recorded at GSP 1 and 2 in 2016, predominately in May and June. The total survey abundance index was 31.93 fish/seine haul. TL ranged from 1 to 13 cm for the season.

Striped Killifish (*Fundulus majalis*)

Striped killifish ranked second for overall abundance in 2017 (n=2,765). This number is slightly higher than the 2015 abundance record (n=2,482). Table 9 shows frequency data according to month and station for 2017. Striped killifish were caught at all stations for each month. GSP 5 had the highest total recorded for the season in comparison to other stations (n=662). Large catches were hauled in August and September. Past surveys showed high abundance in September. Total survey abundance index was 6.48 fish/seine haul. TL ranged from 1 to 17 cm (time series maximum TL record for Striped killifish).

Scup (*Stenotomus chrysops*)

Scup ranked fourth in species abundance with 156 individuals caught in 2017. Scup counts were low for past surveys compared to other species in the time series catalogue. No individuals were caught in 2014; 46 individuals were counted in 2015; and 18 individuals were caught in 2016. The most recent frequency data shows Scup presence happened between June and August, with 87.4% of represented population caught in July. GSP 3 and 5 had similar numbers for increased frequency: 44 to 49 individuals recorded during season (Table 10). TL measurements ranged from 3 to 6 cm, indicating YOY presence in estuary (Bigelow and Schroeder 1953). Total survey abundance index was 0.20 fish/seine haul for 2017.

Tautog (*Tautoga onitis*)

One hundred and forty-two Tautog were caught between May and October in 2017. This value decreased from time series record, n=201 in 2015. In 2014, 23 individuals were measured, and then in 2016, 30 Tautog were measured. TL ranged between 3 and 11 cm in 2017. Length-at-age data showed 19 to 35 mm represents the YOY cohort for Tautog. August boasted the highest number of individuals caught for 2017. The greatest number of individuals was recorded at GSP 2. Table 11 breaks down frequency data by month and station. 2017 total survey abundance index was 0.17 fish/seine haul.

Herrings: Family Clupeidae

In 2017, two species of clupeids were caught in the GSP survey, Atlantic herring (*Alosa harengus*) and Atlantic menhaden (*Brevoortia tyrannus*). The total survey abundance was 0.39 fish/seine haul in 2017. One individual Atlantic herring was recorded at GSP 3 during June sampling in 2017. The only other time investigators caught Atlantic herring was at GSP 5 in June 2016 with a total of 2 individuals. As for Atlantic menhaden, 114 individuals were counted at stations GSP 3, 4, 5 and 7 in 2017. At GSP 3, 18 Atlantic menhaden were measured in September; at GSP 4, 27 were also measured in September; at GSP 5, 9 individuals were recorded in October; and at GSP 7, 46 menhaden were caught in October.

Mean abundance for *Clupeidae spp*. in 2016 was 0.13 fish/seine haul. In 2015, total survey abundance was 0.69 fish/seine haul, and in 2014, it was 0.63 fish/seine haul. From 2014 to 2016, investigators observed low counts of clupeids. Species included were Alewife, Atlantic herring, Atlantic menhaden and Blueback herring. Refer to annual abundance tables in Appendices 1 and 2 for specific counts per species.

Summary

In 2017, investigators caught 31 species of finfish representing 20 families in the GSP. This number is lower to the time series record: 49 species from 33 families collected in 2015. The overall counts are higher from past GSP surveys, 19,842 total individuals were recorded in 2017. In 2016, the total number of individuals caught was 14,703. The species of highest frequency for 2017 in ranked descending order were 1) Silversides spp. (n=16,021), 2) Striped killifish (n=2,765), 3) Winter flounder (n=159), 4) Scup (n=156), and 5) Tautog (n=142).

A critical characteristic of the long-term annual seine survey conducted in the GSP is the ability to identify year of below-average recruitment, which if persistent, serve as an early warning to managers of potential declines in Winter flounder standing stock biomass. The 2017 YOY WFL index was not significantly greater than the historic average for Rhode Island. Compared with historic averages, we did not observe significantly higher recruitment in the GSP in 2017. Continued evaluation of juvenile Winter flounder abundance is important in predicting recruitment to the commercial and recreational Winter flounder fisheries in Rhode Island and southern New England region.

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TABLES

Table 1. Summary of sampling effort for GSP survey, 2017.

Sampling dates	Number of sets
24-May	8
21-June	8
18-July	8
17-August	8
29-September	8
1-November	8
Total	**48**

Table 2. Water depth and transparency ranges, 2017.

Depth of area seined	
Maximum	2 meters
Minimum	0.3 meters
Average and 1 standard deviation (in parentheses)	1.04 (0.43) meters

Maximum	2 meters
Minimum	0.3 meters
Average and 1 standard deviation (in parentheses)	1.04 (0.43) meters

Table 3. Summary of water quality parameters recorded during 2017 sampling season.

2017 YSI Data										
Station	Month	Temp.(°C)	Sal. (ppt)	DO (mg/L)		Station	Month	Temp.(°C)	Sal. (ppt)	DO (mg/L)
GSP 1	May	12.9	32.09	8.86		GSP 5	May	14.4	31.46	8.29
	Jun	18.8	31.71	7.37			Jun	17.9	31.64	8.31
	Jul	23.4	32.01	8.66			Jul	23.9	31.79	7.25
	Aug	20.3	31.65	6.53			Aug	20.9	31.85	6.80
	Sep	20.6	32.48	7.32			Sep	20.1	32.67	7.72
	Oct	13.7	31.43	8.79			Oct	14.7	31.19	8.45
GSP 2	May	13.6	32.03	8.34		GSP 6	May	14.1	31.37	8.68
	Jun	18.3	31.62	7.46			Jun	18.3	31.72	7.58
	Jul	27.2	31.68	8.68			Jul	23.6	31.84	8.64
	Aug	20.6	31.67	7.09			Aug	20.7	31.84	7.15
	Sep	20.1	32.92	7.95			Sep	20.1	32.63	7.61
	Oct	13.9	31.50	8.51			Oct	14.2	31.96	8.84
GSP 3	May	14.1	31.64	8.66		GSP 7	May	13.8	31.68	8.91
	Jun	19.1	31.78	7.77			Jun	18.0	31.77	7.95
	Jul	24.8	31.70	7.69			Jul	23.1	31.84	7.89
	Aug	20.1	31.69	7.13			Aug	21.0	31.64	6.77
	Sep	20.2	33.09	8.15			Sep	20.0	32.64	8.82
	Oct	15.1	31.93	7.74			Oct	14.8	31.86	8.10
GSP 4	May	14.3	31.92	8.29		GSP 8	May	13.3	31.73	8.66
	Jun	18.4	31.79	7.76			Jun	17.4	31.75	8.22
	Jul	24.3	31.22	8.65			Jul	23.3	31.84	7.94
	Aug	20.8	32.91	7.54			Aug	20.2	31.42	6.72
	Sep	20.0	33.04	8.80			Sep	19.9	31.49	7.82
	Oct	15.1	32.00	7.84			Oct	13.9	30.95	9.09

Table 4. Catalogue of species, 2017. Bolded names were identified as Rhode Island Species of Greatest Conservation Need in 2015 Wildlife Action Plan (RI Team Taxa 2014).

2017		
Common Name	Scientific Name	Family
American Sand Lance	***Ammodytes americanus***	**Ammodytidae**
Atlantic Croaker	*Micropogonias undulatus*	Sciaenidae
Atlantic Herring	***Clupea harengus***	**Clupeidae**
Atlantic Menhaden	***Brevoortia tyrannus***	**Clupeidae**
Bighead Sea Robin	*Prionotus tribulus*	Triglidae
Black Sea Bass	***Centropristis striata***	**Serranidae**
Bluefish	***Pomatomus saltatrix***	**Pomatomidae**
Bluespotted Cornetfish	*Fistularia tabacaria*	Fistulariidae
Cunner	*Tautogolabrus adspersus*	Labridae
Dwarf Goatfish	*Upeneus parvus*	Mullidae
Grubby Sculpin	***Myoxocephalus aeneus***	**Cottidae**
Inshore Lizardfish	*Synodus foetens*	Synodontidae
Mummichog	***Fundulus heteroclitus***	**Cyprinodontidae**
Naked Goby	*Gobiosoma bosc*	Gobiidae
Northern Kingfish	*Menticirrhus saxatilis*	Sciaenidae
Northern Pipefish	*Syngnathus fuscus*	Syngnathidae
Northern Puffer	*Sphoeroides maculatus*	Tetraodontidae
Northern Sea Robin	***Prionotus carolinus***	**Triglidae**
Northern Sennet	*Sphyraena borealis*	Shyraenidae
Pinfish	*Lagodon rhomboides*	Sparidae
Round Herring	*Etrumeus sadina*	Clupeidae
Sand Diver	*Synodus intermedius*	Synodontidae
Scup	*Stenotomus chrysops*	Sparidae
Sheepshead Minnow	***Cyprinodon variegatus***	**Cyprinodontidae**
Silversides spp.	***Atherinopsidae spp.***	**Atherinopsidae**
Snakefish	*Trachinocephalus myops*	Synodontidae
Spotted Hake	*Urophycis regia*	Gadidae
Striped Bass	*Morone saxatilis*	Moronidae
Striped Killifish	***Fundulus majalis***	**Cyprinodontidae**
Tautog	***Tautoga onitis***	**Labridae**
Winter Flounder	***Pseudopleuronectes americanus***	**Pleuronectidae**

Table 5. Summary of species presence/absence for 2017. “1” represents present while blank slots represent absent.

2017	**Stations**							
Species	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
American Sand Lance								1
Atlantic Croaker		1				1		1
Atlantic Herring			1					
Atlantic Menhaden			1	1	1		1	1
Bighead Sea Robin		1			1	1	1	1
Black Sea Bass		1	1	1	1	1		
Bluefish	1	1	1	1			1	1
Bluespotted Cornetfish						1		
Cunner	1			1		1		
Dwarf Goatfish	1							
Grubby Sculpin	1	1		1		1		
Inshore Lizardfish			1					
Mummichog	1	1	1	1	1	1	1	1
Naked Goby		1						
Northern Kingfish		1	1			1	1	1
Northern Pipefish	1	1			1	1		
Northern Puffer				1	1	1		
Northern Sea Robin			1		1	1	1	
Northern Sennet		1	1					
Pinfish	1	1	1	1	1			
Round Herring		1				1		1
Sand Diver			1					
Scup	1	1	1	1	1	1	1	
Sheepshead Minnow		1		1	1	1		1
Silversides spp.	1	1	1	1	1	1	1	1
Snakefish			1				1	
Spotted Hake							1	
Striped Bass	1							
Striped Killifish	1	1	1	1	1	1	1	1
Tautog	1	1	1	1		1	1	1
Winter Flounder	1	1	1	1	1	1	1	1

Table 6. Breakdown of species measured and enumerated according to station, 2017. Total fish and number of different species identified per station is also included in this table.

2017		**Station**								
Common Name	**Scientific Name**	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	Total
American Sand Lance	***Ammodytes americanus***								11	11
Atlantic Croaker	*Micropogonias undulatus*		10				4		16	30
Atlantic Herring	***Clupea harengus***			1						1
Atlantic Menhaden	***Brevoortia tyrannus***			18	27	9		14	46	114
Bighead Sea Robin	*Prionotus tribulus*		12			4	18	13	4	51
Black Sea Bass	***Centropristis striata***		4	1	6	2	6			19
Bluefish	***Pomatomus saltatrix***	1	20	17	22			2	1	63
Bluespotted Cornetfish	*Fistularia tabacaria*						2			2
Cunner	*Tautogolabrus adspersus*	3			2		1			6
Dwarf Goatfish	*Upeneus parvus*	1								1
Grubby Sculpin	***Myoxocephalus aeneus***	1	1		1		2			5
Inshore Lizardfish	*Synodus foetens*			2						2
Mummichog	***Fundulus heteroclitus***	31	13	18	2	19	28	6	16	133
Naked Goby	*Gobiosoma bosc*		5							5
Northern Kingfish	*Menticirrhus saxatilis*		2	1			1	5	3	12
Northern Pipefish	*Syngnathus fuscus*	1	3			2	7			13
Northern Puffer	*Sphoeroides maculatus*				3	8	4			15
Northern Sea Robin	***Prionotus carolinus***			2		3	2	1		8
Northern Sennet	*Sphyraena borealis*		7	10						17
Pinfish	*Lagodon rhomboides*	17	10	3	2	1				33
Round Herring	*Etrumeus sadina*		12				16		4	32
Sand Diver	*Synodus intermedius*			5						5
Scup	*Stenotomus chrysops*	1	27	49	8	44	11	16		156
Sheepshead Minnow	***Cyprinodon variegatus***		1		1	11	1		3	17
Silversides spp.	***Atherinopsidae spp.***	850	2927	6106	1727	876	1803	741	991	16021
Snakefish	*Trachinocephalus myops*			1			1			2
Spotted Hake	*Urophycis regia*							1		1
Striped Bass	*Morone saxatilis*	1								1
Striped Killifish	***Fundulus majalis***	247	567	224	264	662	307	151	343	2765
Tautog	***Tautoga onitis***	32	48	11	1		2	15	33	142
Winter Flounder	***Pseudopleuronectes americanus***	14	11	15	12	70	22	2	13	159
Total		1200	3680	6484	2078	1711	2238	967	1484	**Total Fish**
Number of species		13	18	17	14	13	19	12	13	**19842**

Table 7. Winter flounder frequency by month and station, 2017.

Winter Flounder

2017	Month									
Station	May	Jun	July	Aug	Sep	Oct	**Total**	**Mean**	**SE±**	**SD**
GSP 1	0	2	8	0	2	2	14	2.33	1.20	2.94
GSP 2	2	3	3	0	0	3	11	1.83	0.60	1.47
GSP 3	0	11	1	0	0	3	15	2.50	1.77	4.32
GSP 4	2	1	1	7	1	0	12	2.00	1.03	2.53
GSP 5	2	18	2	9	36	3	70	11.67	5.48	13.43
GSP 6	0	1	3	3	15	0	22	3.67	2.33	5.72
GSP 7	0	2	0	0	0	0	2	0.33	0.33	0.82
GSP 8	0	2	0	0	0	11	13	2.17	1.80	4.40
Total	6	40	18	19	54	22				
Mean	0.75	5.00	2.25	2.38	6.75	2.75				
SE±	0.37	2.19	0.92	1.29	4.55	1.28				
SD	1.04	6.19	2.60	3.66	12.88	3.62				

Total Fish

159

Table 8. Silverside spp. frequency by month and station, 2017.

Silversides spp.

2017	Month									
Station	May	Jun	July	Aug	Sep	Oct	**Total**	**Mean**	**SE±**	**SD**
GSP 1	19	55	172	192	228	184	850	141.67	34.28	83.97
GSP 2	80	23	308	1947	427	142	2927	487.83	298.17	730.37
GSP 3	164	138	520	1820	2120	1344	6106	1017.67	351.93	862.04
GSP 4	252	319	241	347	347	221	1727	287.83	23.03	56.42
GSP 5	21	121	190	68	220	256	876	146.00	37.35	91.48
GSP 6	296	219	334	339	280	335	1803	300.50	19.04	46.64
GSP 7	147	18	134	181	179	82	741	123.50	25.76	63.09
GSP 8	0	123	281	244	132	211	991	165.17	41.59	101.87
Total	979	1016	2180	5138	3933	2775				
Mean	122.38	127.00	272.50	642.25	491.63	346.88				
SE±	39.42	36.20	42.98	272.96	234.97	144.89				
SD	111.50	102.39	121.57	772.05	664.60	409.81				

Total Fish

16021

Table 9. Striped killifish frequency by month and station, 2017.

Striped Killifish

2017	Month									
Station	May	Jun	July	Aug	Sep	Oct	**Total**	**Mean**	**SE±**	**SD**
GSP 1	28	74	58	68	7	12	247	41.17	11.93	29.23
GSP 2	12	26	45	341	69	74	567	94.50	50.26	123.11
GSP 3	7	43	0	24	91	59	224	37.33	13.99	34.27
GSP 4	33	0	0	52	49	130	264	44.00	19.56	47.91
GSP 5	0	0	0	110	382	170	662	110.33	61.61	150.92
GSP 6	0	0	0	40	235	32	307	51.17	37.48	91.81
GSP 7	66	0	19	16	24	26	151	25.17	8.99	22.02
GSP 8	0	0	0	6	300	37	343	57.17	48.92	119.83
Total	146	143	122	657	1157	540				
Mean	18.25	17.88	15.25	82.13	144.63	67.50				
SE±	8.19	9.86	8.33	38.78	49.98	19.60				
SD	23.17	27.89	23.57	109.69	141.36	55.45				

Total Fish

2765

Table 10. Scup frequency by month and station, 2017.

	2017	Month									
	Station	May	Jun	July	Aug	Sep	Oct	**Total**	**Mean**	**SE±**	**SD**
Scup	GSP 1	0	1	0	0	0	0	1	0.17	0.17	0.41
	GSP 2	0	8	10	9	0	0	27	4.50	2.03	4.97
	GSP 3	0	27	22	0	0	0	49	8.17	5.21	12.75
	GSP 4	0	2	6	0	0	0	8	1.33	0.99	2.42
	GSP 5	0	3	28	13	0	0	44	7.33	4.62	11.31
	GSP 6	0	6	5	0	0	0	11	1.83	1.17	2.86
	GSP 7	0	0	16	0	0	0	16	2.67	2.67	6.53
	GSP 8	0	0	0	0	0	0	0	0.00	0.00	0.00
	Total	0	47	87	22	0	0				
	Mean	0.00	5.88	10.88	2.75	0.00	0.00				
	SE±	0.00	3.18	3.63	1.84	0.00	0.00				
	SD	0.00	9.00	10.27	5.20	0.00	0.00				

Total Fish

156

Table 11. Tautog frequency by month and station, 2017.

	2017	Month									
	Station	May	Jun	July	Aug	Sep	Oct	**Total**	**Mean**	**SE±**	**SD**
Tautog	GSP 1	1	1	0	20	9	1	32	5.33	3.23	7.92
	GSP 2	0	0	7	28	13	0	48	8.00	4.54	11.12
	GSP 3	0	0	0	0	11	0	11	1.83	1.83	4.49
	GSP 4	0	0	0	1	0	0	1	0.17	0.17	0.41
	GSP 5	0	0	0	0	0	0	0	0.00	0.00	0.00
	GSP 6	0	0	0	2	0	0	2	0.33	0.33	0.82
	GSP 7	0	0	0	0	15	0	15	2.50	2.50	6.12
	GSP 8	0	0	0	22	11	0	33	5.50	3.76	9.20
	Total	1	1	7	73	59	1				
	Mean	0.13	0.13	0.88	9.13	7.38	0.13				
	SE±	0.13	0.13	0.88	4.24	2.24	0.13				
	SD	0.35	0.35	2.47	11.99	6.35	0.35				

Total Fish

142

Table 12. Winter flounder mean length (mm) per station and month, 2017.

	2017	May	Jun	Jul	Aug	Sep	Oct
Winter Flounder	GSP 1	0.00	41.00	50.78	0.00	81.50	60.50
	GSP 2	118.50	81.33	47.67	0.00	0.00	76.00
	GSP 3	0.00	45.91	148.00	0.00	0.00	80.00
	GSP 4	113.50	36.00	49.00	58.71	88.00	0.00
	GSP 5	122.50	45.44	54.00	68.11	76.89	72.67
	GSP 6	0.00	37.00	41.00	66.00	60.93	0.00
	GSP 7	0.00	0.00	50.00	0.00	0.00	0.00
	GSP 8	0.00	38.50	0.00	0.00	0.00	89.00

FIGURES

Study Area

Figure 1. Extent map to show study area for GSP survey. The stations are marked by black circles and referred to as GSP 1-8. Map created in ArcGIS (2018).

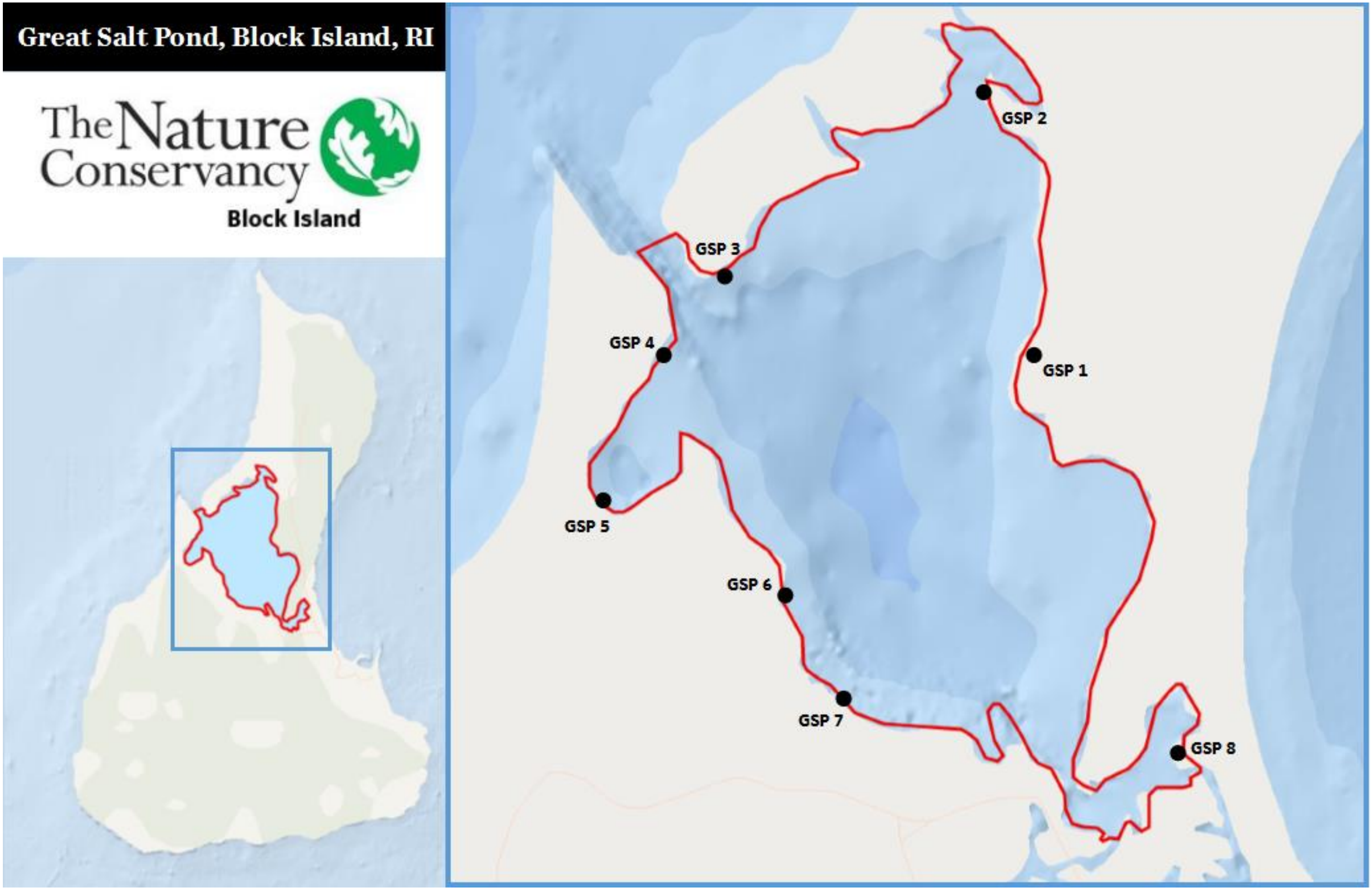
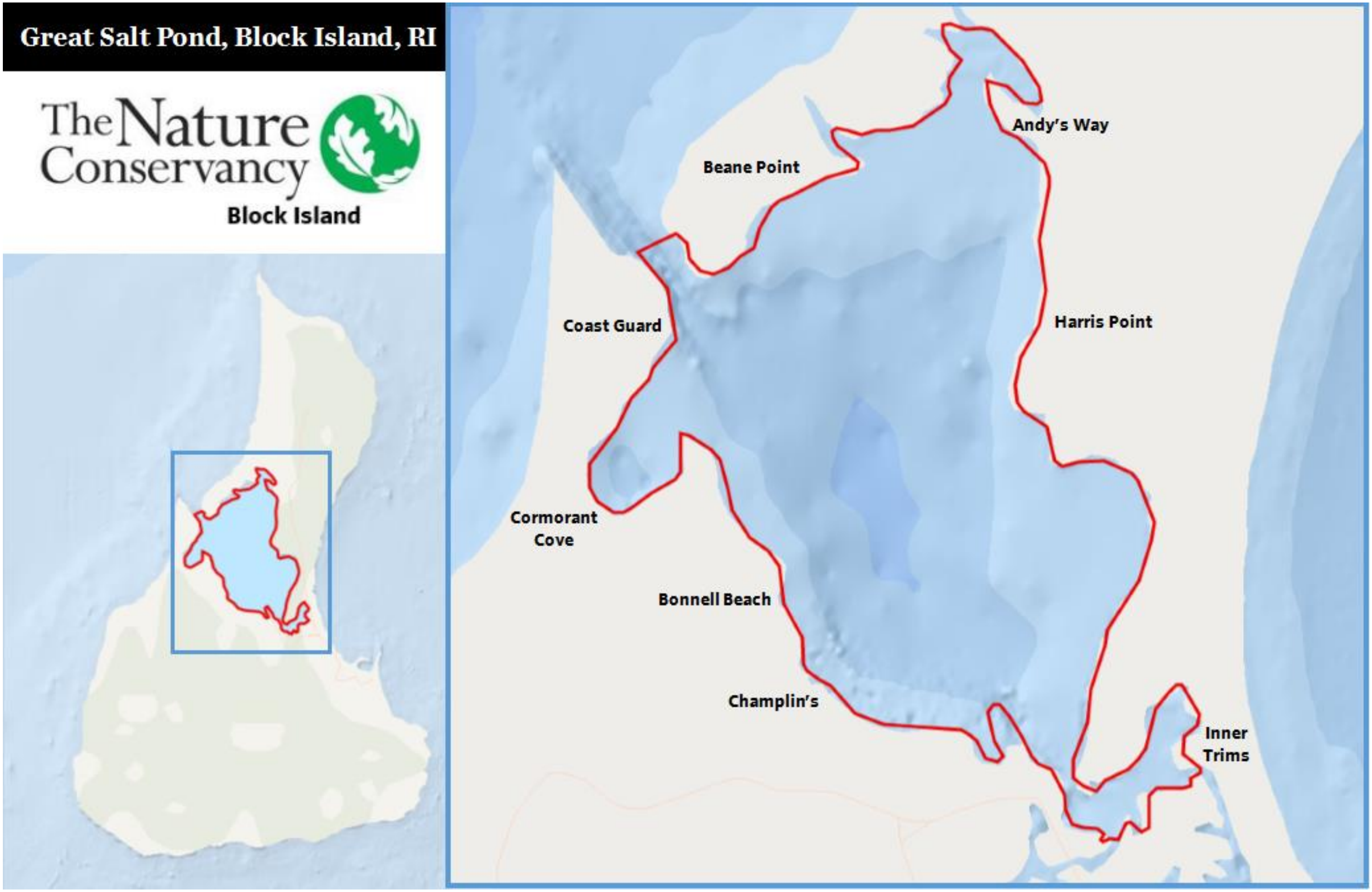


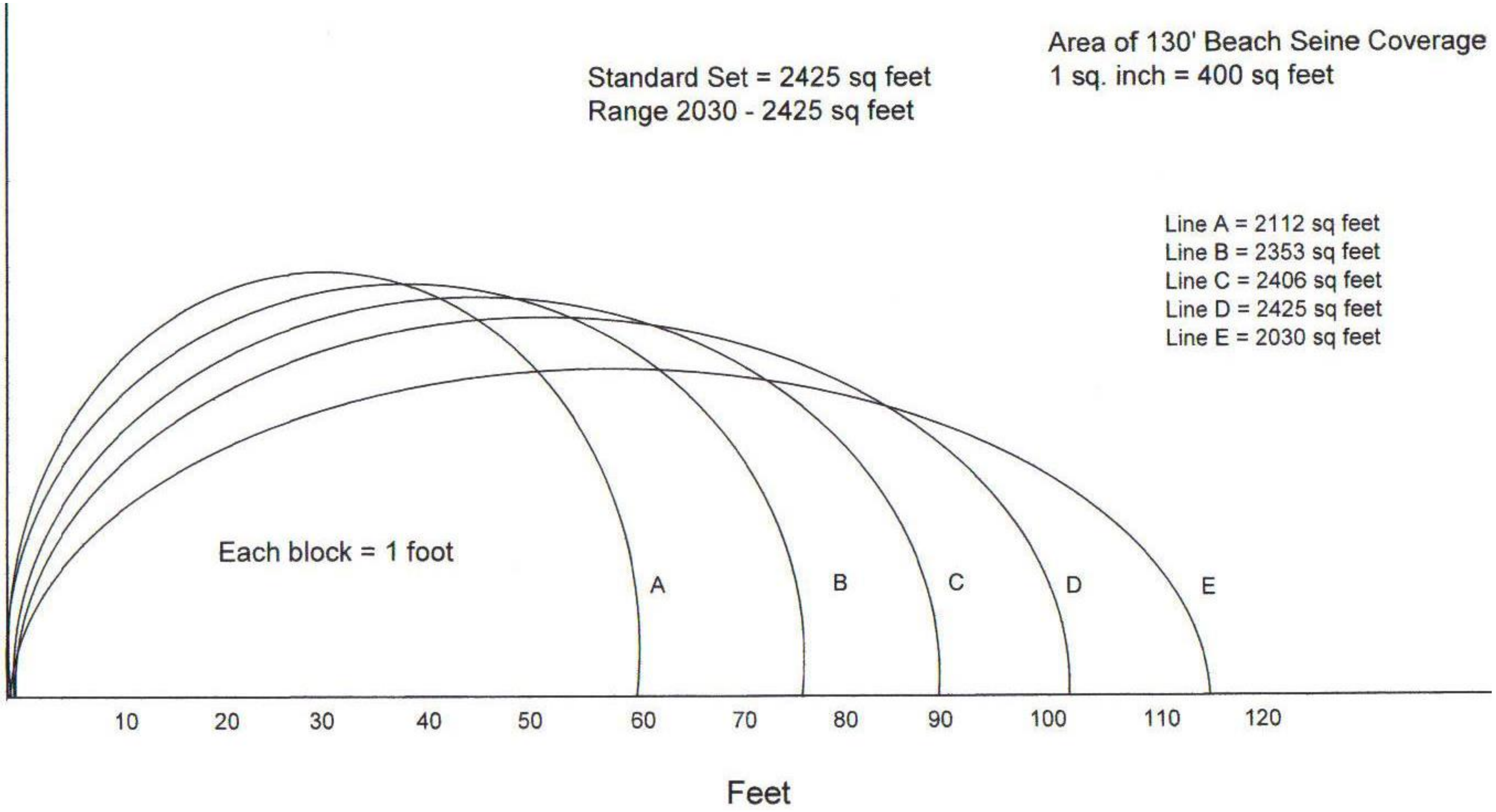
Figure 2. Reference for colloquial names of site areas for eight fixed stations, GSP 1-8.



Sampling Overview

Beach Seine Effort

Figure 3. Area covered by 130-ft seine net.



Physical and Chemical Data

Water Chemistry, 2017

Figure 3. Water temperature measurements taken at each station in 2017.

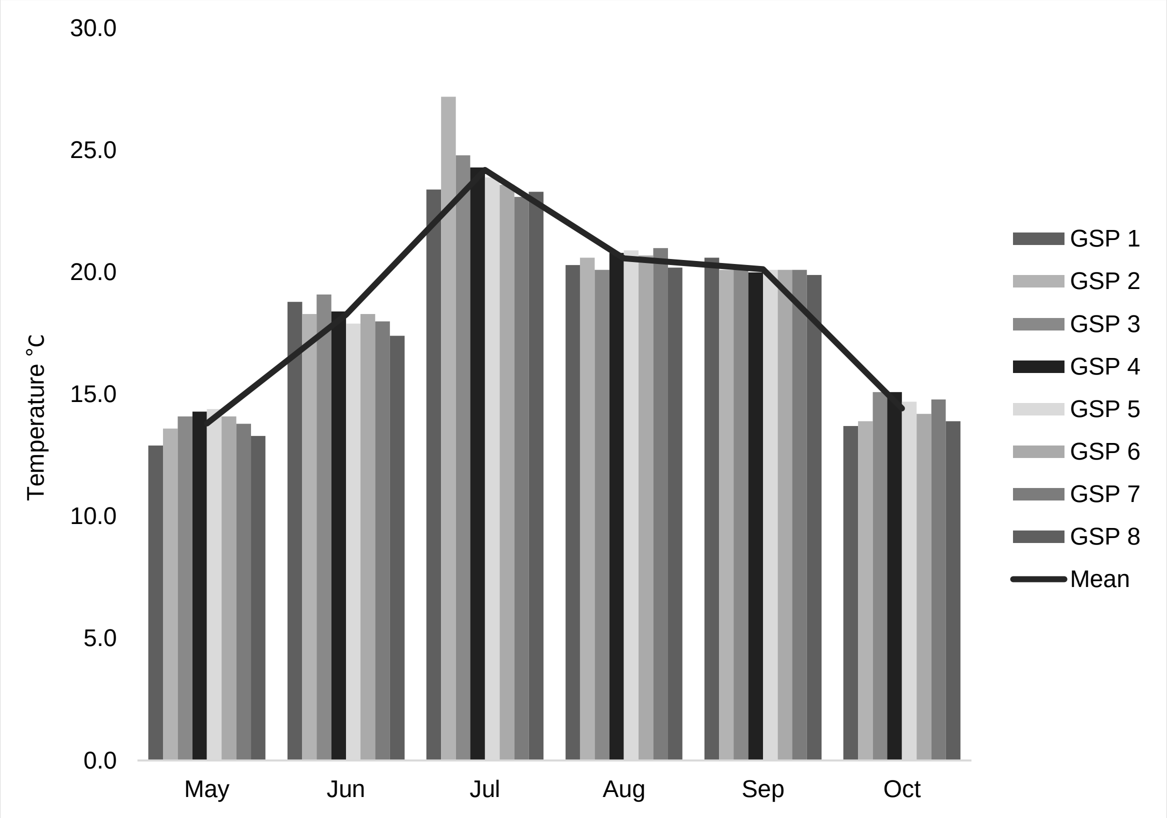


Figure 4. Dissolved oxygen measurements taken at each station in 2017.

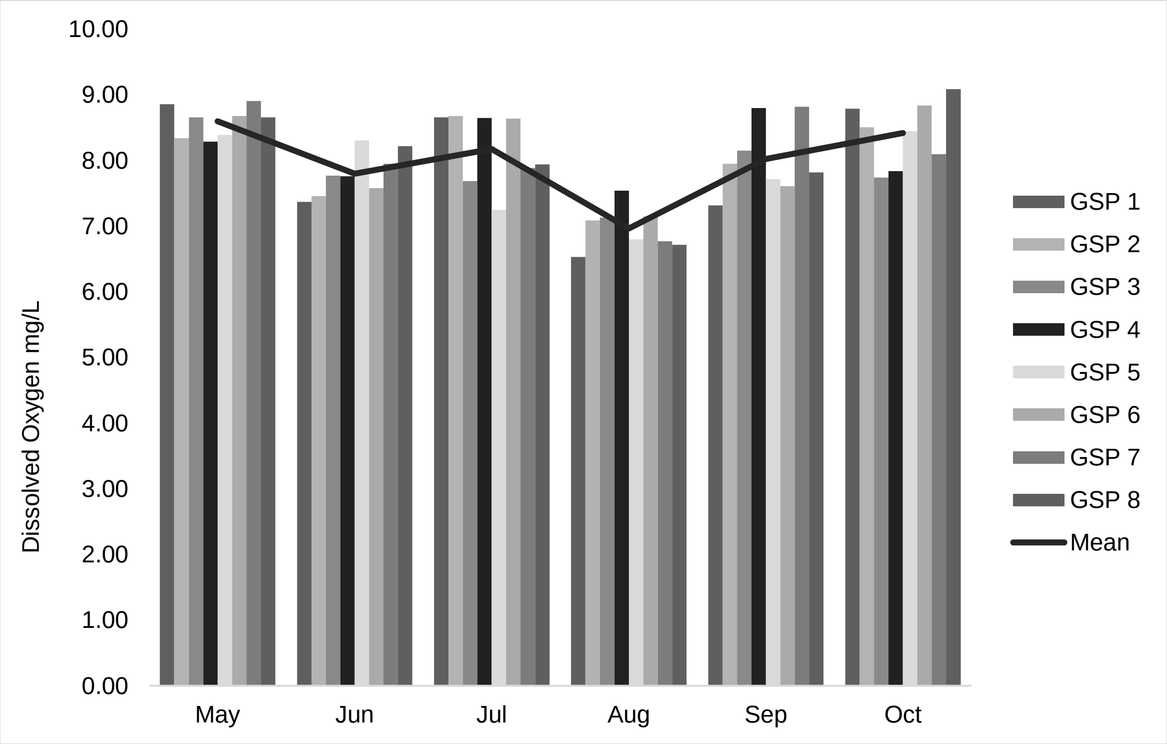
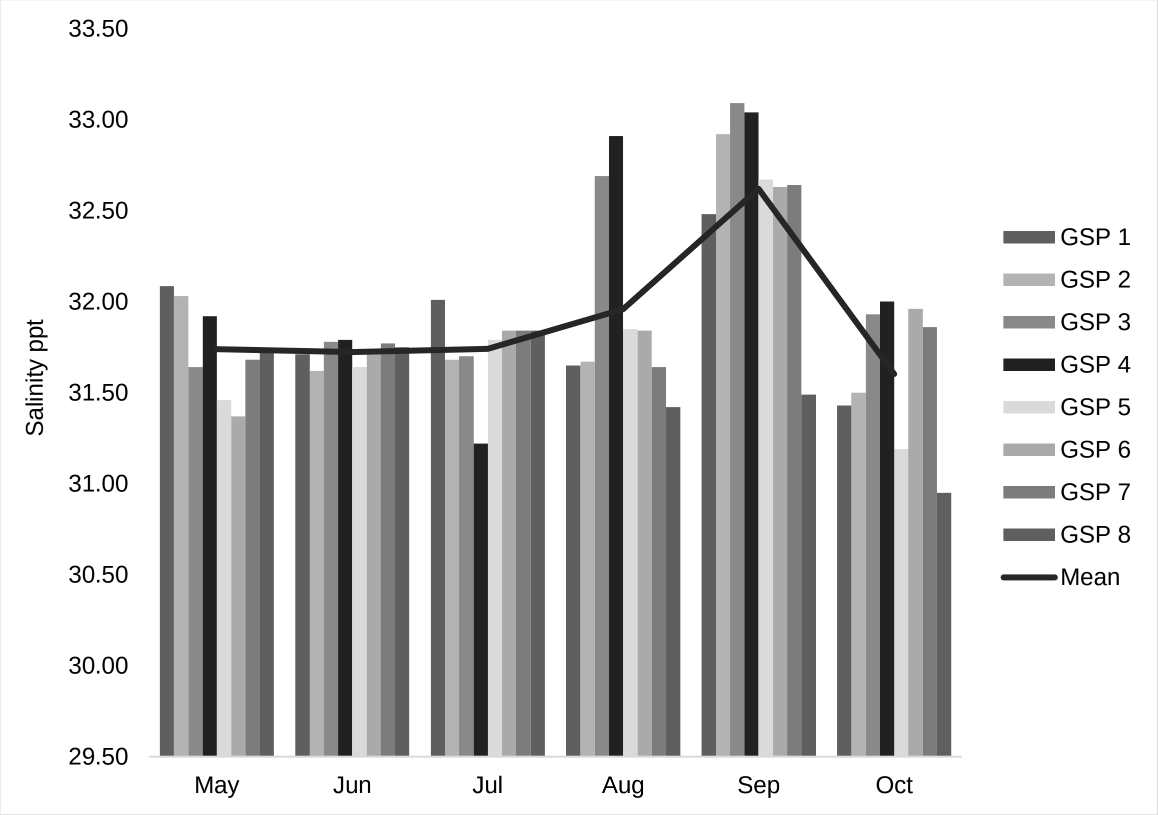


Figure 5. Salinity measurements taken at each station in 2017.



Biological Data

Catch by Species, 2017

Figure 6. Mean abundance ±SE (fish/seine haul) by month for Winter flounder, 2017.

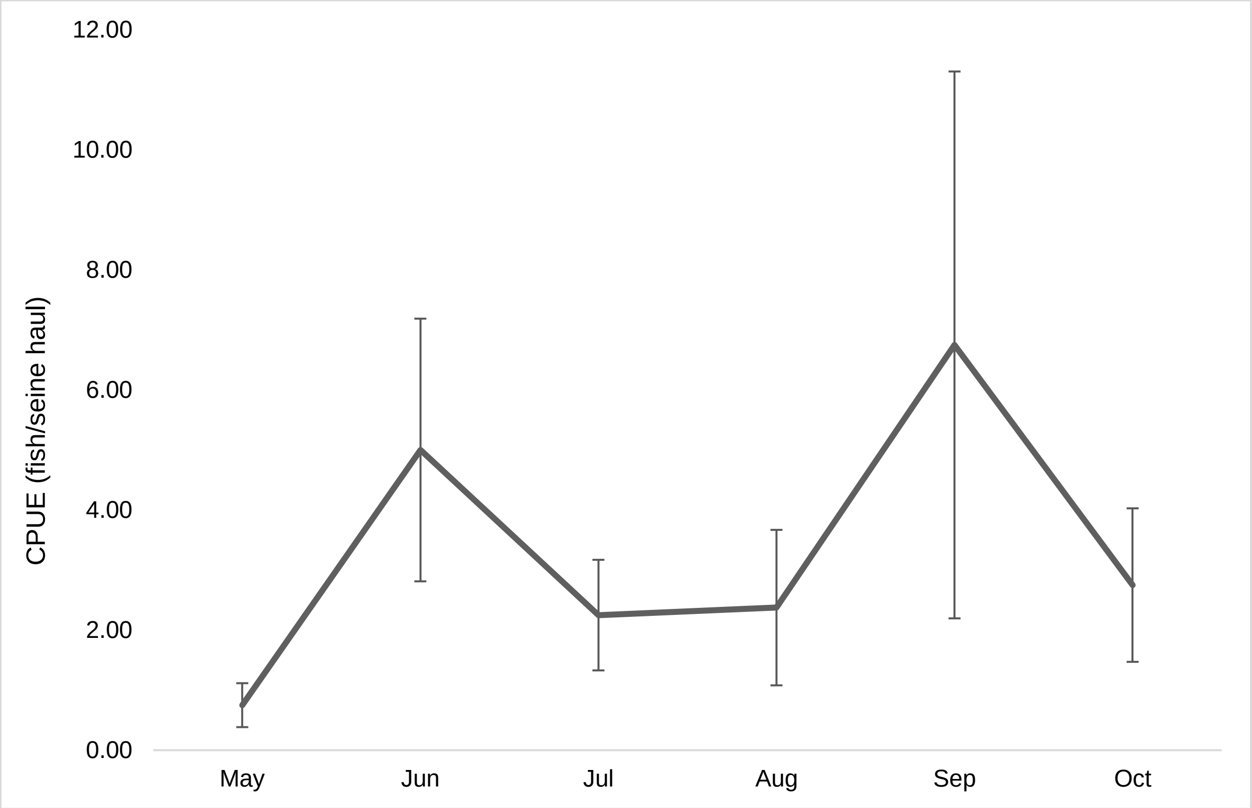


Figure 7. Mean abundance ±SE (fish/seine haul) by station for Winter flounder, 2017.

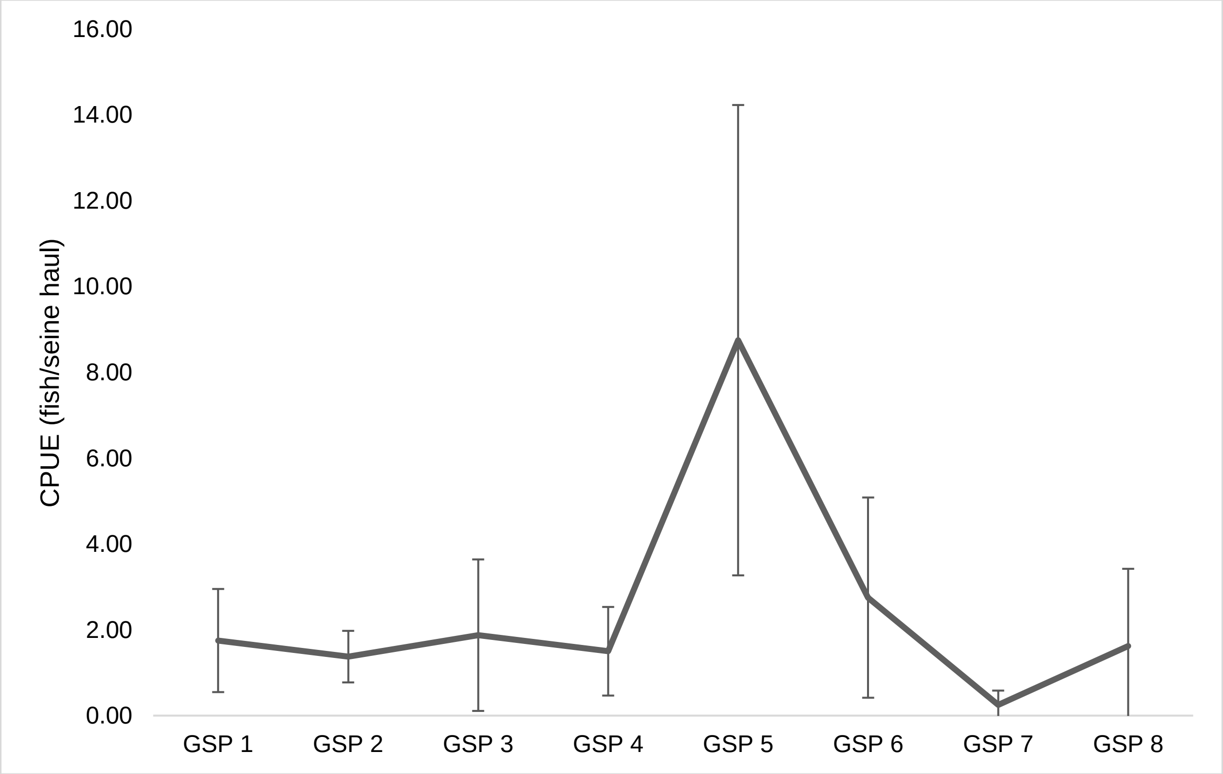


Figure 8. Abundance indices (fish/seine haul) by station and month for Winter flounder, 2017.

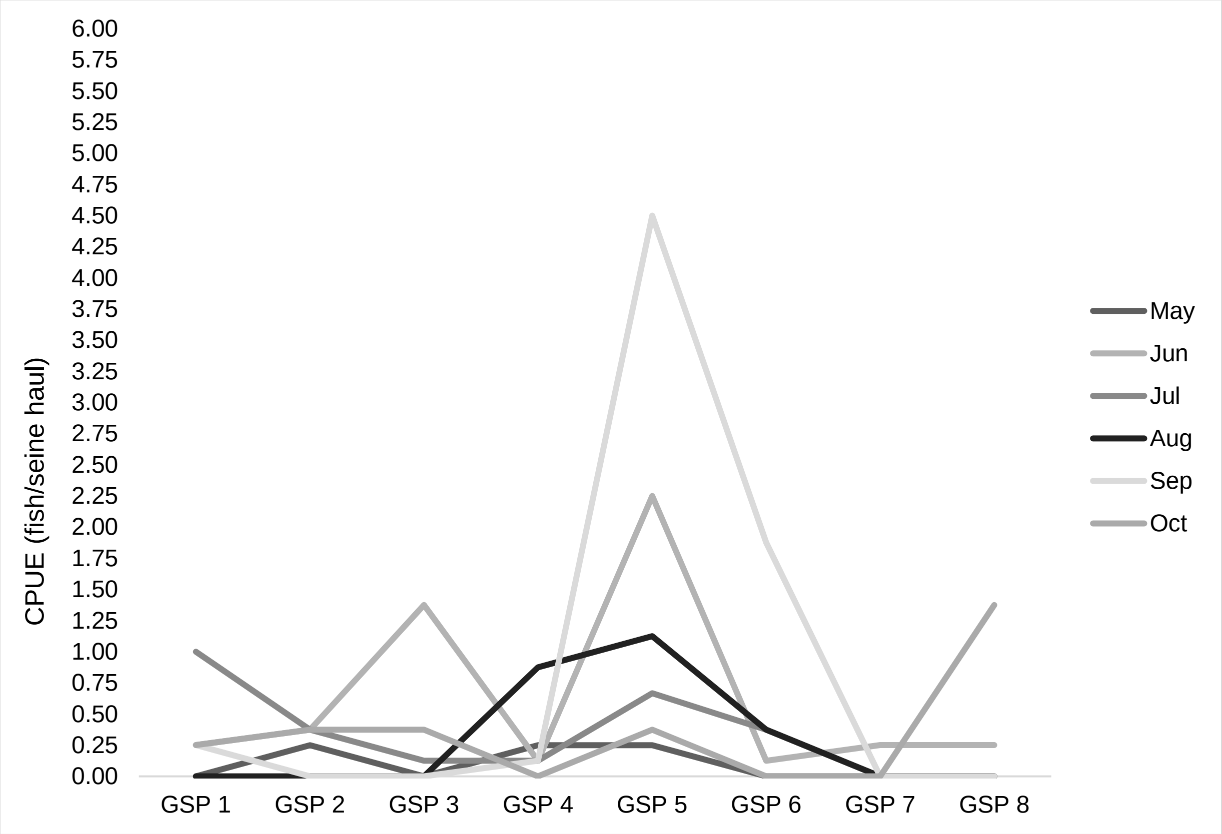


Figure 9. Length frequency distribution for all Winter flounder caught in 2017. YOY cutoff left of dotted line (TL>120 mm).

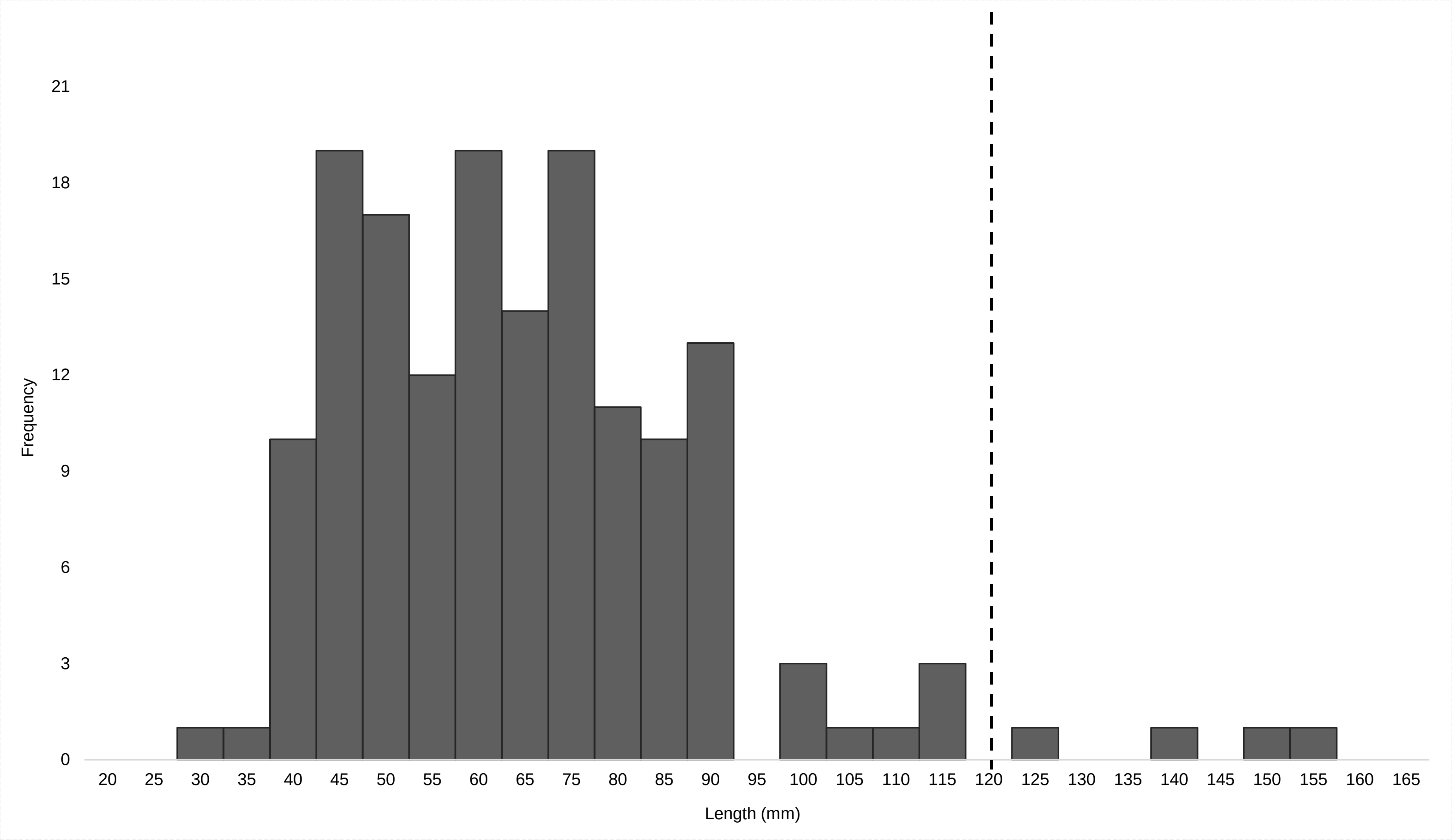
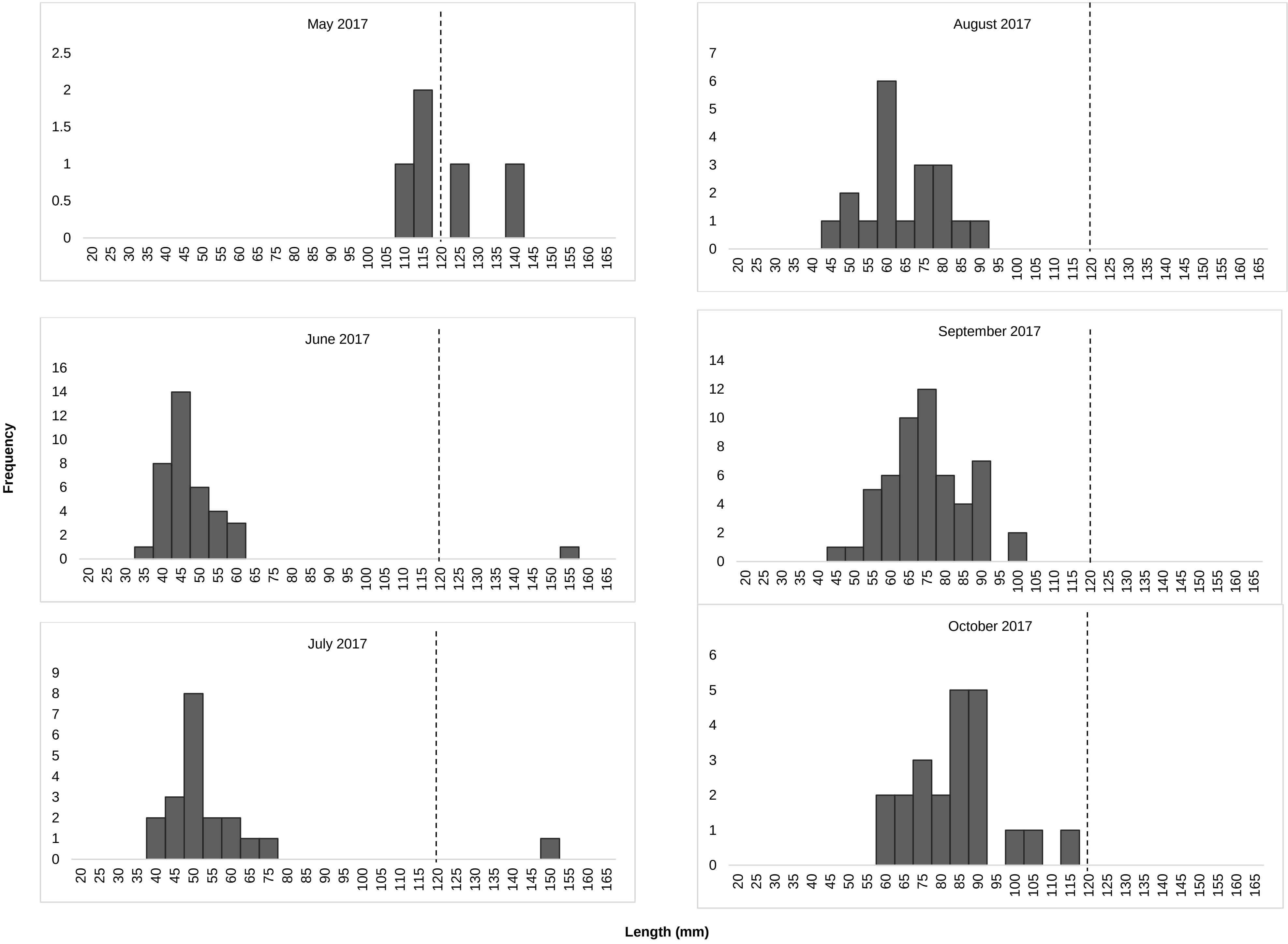


Figure 10. Histograms depicting monthly length frequency of Winter flounder from Great Salt Pond, 2017 (YOY cutoff left of dotted line <120 mm (TL)).



APPENDICES

Appendix 1

Time Series Tables, All Species

Appendix 1a. Presence/absence of species catalogued for each survey year, 2014-2017. “1” represents present while blank slots represent absent. Bolded names represent Rhode Island species of greatest conservation need identified by the RI Taxa Team in 2014.

Presence/Absence		Time Series			
Common Name	Scientific Name	2014	2015	2016	2017
Alewife	***Alosa pseudoharengus***	1	1		
American Sand Lance	***Ammodytes americanus***		1	1	1
Atlantic Cod	***Gadus morhua***		1	1	
Atlantic Croaker	*Micropogonias undulatus*	1	1	1	1
Atlantic Herring	***Clupea harengus***	1		1	1
Atlantic Lizardfish	*Synodus saurus*	1			
Atlantic Menhaden	***Brevoortia tyrannus***		1	1	1
Bay Anchovy	***Anchoa mitchilli***		1		
Bighead Sea Robin	*Prionotus tribulus*		1	1	1
Black Sea Bass	***Centropristis striata***	1	1	1	1
Blueback Herring	***Alosa aestivalis***		1		
Bluefish	***Pomatomus saltatrix***	1		1	1
Bluespotted Cornetfish	*Fistularia tabacaria*		1	1	1
Bonefish	*Albula vulpes*		1		
Butterfish	***Peprilus triacanthus***			1	
Crevalle Jack	*Caranx hippos*		1	1	
Cunner	*Tautogolabrus adspersus*		1	1	1
Dwarf Goatfish	*Upeneus parvus*		1		1
Fourspine Stickleback	*Apeltes quadracus*		1		
Fourspot Flounder	*Paralichthys oblongus*		1		
Grubby Sculpin	***Myoxocephalus aenaeus***		1	1	1
Grunt	*Haemulon spp*	1			
Inshore Lizardfish	*Synodus foetens*			1	1
Leopard Sea Robin	*Prionotus scitulus*		1		
Lined Seahorse	***Hippocampus erectus***	1			
Longfin Squid	*Loligo pealeii*		1		
Longhorn Cowfish	*Lactoria cornuta*	1			
Longhorn Sculpin	*Myoxocephalus octodecimspinosus*		1		
Mojarras spp.	*Gerreidae spp.*			1	
Mummichog	***Fundulus heteroclitus***	1	1	1	1
Naked Goby	*Gobiosoma bosc*		1		1
Ninespine Stickleback	***Pungitius pungitius***		1	1	
Northern Kingfish	*Menticirrhus saxatilis*		1	1	1
Northern Pipefish	*Syngnathus fuscus*	1	1	1	1
Northern Puffer	*Sphoeroides maculatus*	1	1	1	1
Northern Sea Robin	***Prionotus carolinus***	1	1	1	1
Northern Sennet	*Sphyraena borealis*		1	1	1
Orange Filefish	*Aluterus shoepfi*		1		
Pinfish	*Lagodon rhomboides*	1	1		1
Pollock	***Pollachius virens***			1	
Pompano spp.	*Trachinotus spp.*	1			
Rainwater Killifish	***Lacania parva***	1	1	1	
Round Herring	*Etrumeus sadina*				1

Sand Diver	*Synodus intermedius*			1	1
Sculpin spp.	***Myoxocephalus spp.***	1			
Scup	*Stenotomus chrysops*		1	1	1
Sheepshead Minnow	***Cyprinodon variegatus***	1	1	1	1
Shortfin Squid	*Illex illecebrosus*		1		
Shorthorn Sculpin	*Myoxocephalus scorpius*		1		
Silversides spp.	***Atherinopsidae spp.***	1	1	1	1
Smooth Trunkfish	*Rhinesomus triqueter*		1		
Snakefish	*Trachinocephalus myops*		1	1	1
Spot	*Leiostomus xanthurus*	1	1		
Spotfin Mojarra	*Eucinostomus argenteus*		1		
Spotted Hake	*Urophycis regia*				1
Spotted Whiff	*Citharichthys macrops*		1		
Striped Bass	*Morone saxatilis*	1		1	1
Striped Killifish	***Fundulus majalis***	1	1	1	1
Striped Sea Robin	*Prionotus evolans*		1	1	
Summer Flounder	*Paralichthys dentatus*		1	1	
Tautog	***Tautoga onitis***	1	1	1	1
Threespine Stickleback	***Gasterosteus aculeatus***		1	1	
Windowpane	***Scophthalmus aquosus***	1	1	1	
Winter Flounder	***Pseudopleuronectes americanus***	1	1	1	1

Appendix 1b. Catch frequency of all species by GSP 1-8 stations for 2016 GSP survey. Bolded names are species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team, 2014.

2016		**Station**								
Common Name	**Scientific Name**	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	Total
American Sand Lance	***Ammodytes americanus***				20	1				21
Atlantic Cod	***Gadus morhua***				2	1				3
Atlantic Croaker	*Micropogonias undulatus*	3	5			40	6	2		56
Atlantic Herring	***Clupea harengus***					1				1
Atlantic Menhaden	***Brevoortia tyrannus***			4					1	5
Bighead Sea Robin	*Prionotus tribulus*		4		1	2	3	1	2	13
Black Sea Bass	***Centropristis striata***	16	12	130	4	165	28	6		361
Bluefish	***Pomatomus saltatrix***								1	1
Bluespotted Cornetfish	*Fistularia tabacaria*						1			1
Butterfish	***Peprilus triacanthus***			2						2
Crevalle Jack	*Caranx hippos*	1	2							3
Cunner	*Tautogolabrus adspersus*	2	1							3
Grubby Sculpin	***Myoxocephalus aenaeus***							1		1
Inshore Lizardfish	*Synodus foetens*			1						1
Mojarras spp.	*Gerreidae spp.*					13				13
Mummichog	***Fundulus heteroclitus***	43				1		1	208	253
Ninespine Stickleback	***Pungitius pungitius***							2	1	3
Northern Kingfish	*Menticirrhus saxatilis*		1	1						2
Northern Pipefish	*Syngnathus fuscus*		3			1		2		6
Northern Puffer	*Sphoeroides maculatus*			1	2	1	1			5
Northern Sea Robin	***Prionotus carolinus***						2			2
Northern Sennet	*Sphyraena borealis*				1	3				4
Pollock	***Pollachius virens***	2		2	0			2		6
Rainwater Killifish	***Lacania parva***		2	1	16	5	10	21		55
Sand Diver	*Synodus intermedius*			3						3
Scup	*Stenotomus chrysops*				4	3	11			18
Sheepshead Minnow	***Archosargus probatocephalus***		35							35
Silversides spp.	***Atherinopsidae spp.***	961	2552	2454	371	304	654	2209	2461	11966
Snakefish	*Trachinocephalus myops*			1						1
Striped Bass	*Morone saxatilis*					1				1
Striped Killifish	***Fundulus majalis***	21	660	143	34	614	57	27	50	1606
Striped Sea Robin	*Prionotus evolans*					2				2
Summer Flounder	*Paralichthys dentatus*	1	3		1				2	7
Tautog	***Tautoga onitis***	4	2	3	5	6	4	5	1	30
Threespine Stickleback	***Gasterosteus aculeatus***	2							6	8
Windowpane	***Scophthalmus aquosus***			5	2	4	1	1		13
Winter Flounder	***Pseudopleuronectes americanus***	13	45	32	21	17	24	9	31	192
Total		1069	3327	2783	484	1185	802	2289	2764	**Total Fish**
Number of species		12	14	15	15	20	13	14	11	**14703**

Appendix 1c. Catch frequency of all species by GSP 1-8 stations for 2015 GSP survey. Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team, 2014.

2015		**Station**								
Common Name	**Scientific Name**	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	Total
Alewife	***Alosa pseudoharengus***		1	2		7	2			12
American Sand Lance	***Ammodytes americanus***				1		20			21
Atlantic Cod	***Gadus morhua***				1					1
Atlantic Croaker	*Micropogonias undulatus*	4	3			33	13			53
Atlantic Menhaden	***Brevoortia tyrannus***	20								20
Bay Anchovy	***Anchoa mitchilli***					1				1
Bighead Sea Robin	*Prionotus tribulus*		2			2	1	3	1	9
Black Sea Bass	***Centropristis striata***	21	7	23	112	453	218	64		898
Blueback Herring	***Alosa aestivalis***								1	1
Bluespotted Cornetfish	*Fistularia commersonii*						1			1
Bonefish	*Albula vulpes*		3							3
Crevalle Jack	*Caranx hippos*		2							2
Cunner	*Tautogolabrus adspersus*	22		3	2	4	5	21		57
Dwarf Goatfish	*Upeneus parvus*	1								1
Fourspine Stickleback	*Apeltes quadracus*	1								1
Fourspot Flounder	*Paralichthys oblongus*		2							2
Grubby Sculpin	***Myoxocephalus aenaeus***				3	1	6	1		11
Leopard Sea Robin	*Prionotus scitulus*					9				9
Longfin Squid	*Loligo pealeii*					1				1
Longhorn Sculpin	*Myoxocephalus octodecimspinosus*	2	3		2			2		9
Mummichog	***Fundulus heteroclitus***	38	12	32	6	27	9	29	46	199
Naked Goby	*Gobiosoma bosc*						2			2
Ninespine Stickleback	***Pungitius pungitius***								1	1
Northern Kingfish	*Menticirrhus saxatilis*		2					1	3	6
Northern Pipefish	*Syngnathus fuscus*	5			1	1	4	1		12
Northern Puffer	*Sphoeroides maculatus*				1	2				3
Northern Sea Robin	***Prionotus carolinus***						1			1
Northern Sennet	*Sphyraena borealis*		1							1
Orange Filefish	*Aluterus shoepfi*				1					1
Pinfish	*Lagodon rhomboides*	5	2				1	5	5	18
Rainwater Killifish	***Lacania parva***	18	1	6	6	14	5	7		57
Scup	*Stenotomus chrysops*	1				41		4		46
Sheepshead Minnow	***Cyprinodon variegatus***		20							20
Shortfin Squid	*Illex illecebrosus*	1								1
Shorthorn Sculpin	*Myoxocephalus scorpius*						4			4
Silversides spp.	***Atherinopsidae spp.***	621	948	4416	906	2804	2381	2562	474	15112
Smooth Trunkfish	*Rhinesomus triqueter*	1								1
Snakefish	*Trachinocephalus myops*			1						1
Spot	*Leiostomus xanthurus*			6						6
Spotfin Mojarra	*Eucinostomus argenteus*					20				20
Spotted Whiff	*Citharichthys macrops*	1				2				3
Striped Killifish	***Fundulus majalis***	8	1102	118	248	470	57	29	450	2482
Striped Sea Robin	*Prionotus evolans*						1			1
Summer Flounder	*Paralichthys dentatus*			1						1
Tautog	***Tautoga onitis***	105	8	5	20	6	21	35	1	201
Threespine Stickleback	***Gasterosteus aculeatus***	1							3	4
Windowpane	***Scophthalmus aquosus***			4	1	3	1			9
Winter Flounder	***Pseudopleuronectes americanus***	12	38	18	21	61	2	5	31	188
Total	Total	888	2157	4635	1332	3962	2755	2769	1016	**Total Fish**
Number of species	Number of species	20	18	13	16	21	21	15	11	**19514**

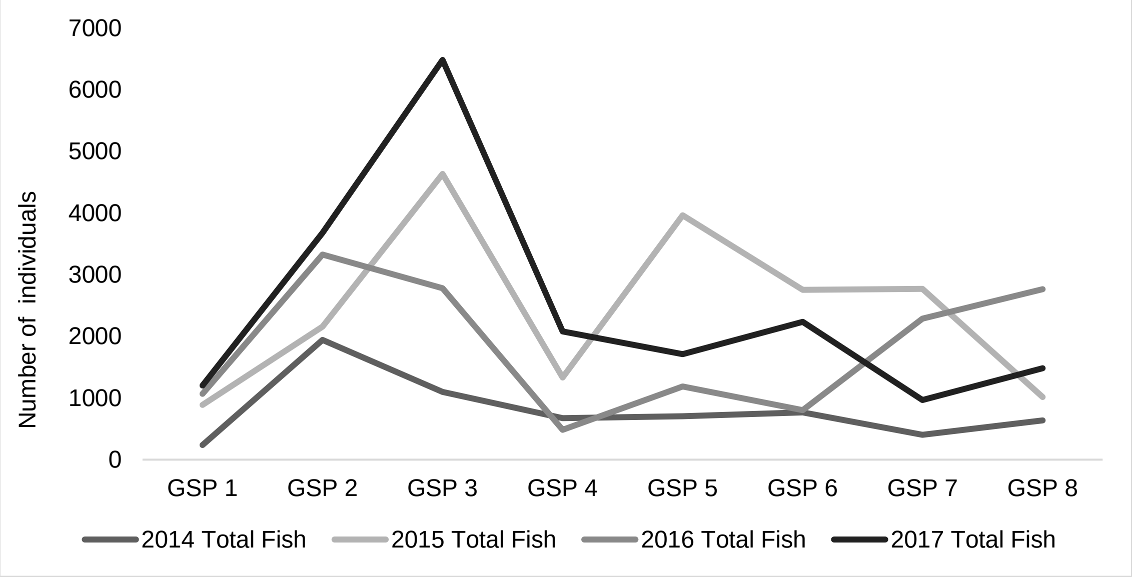
Appendix 1d. Catch frequency of all species by GSP 1-8 stations for 2014 GSP survey. Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team, 2014.

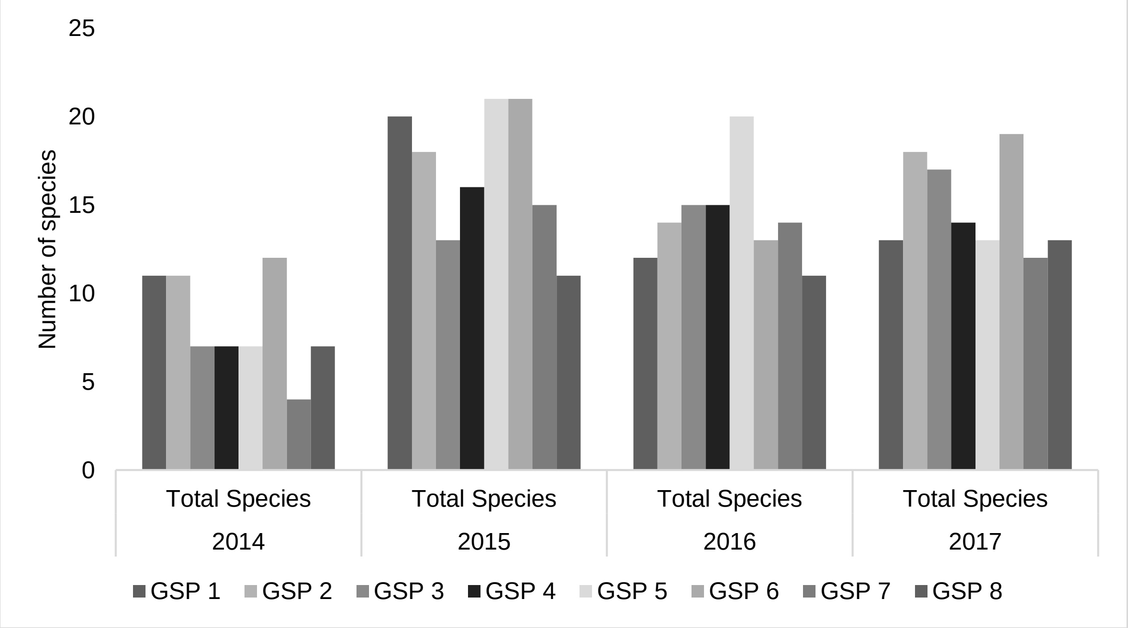
2014		**Station**								
Common Name	**Scientific Name**	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	Total
Alewife	***Alosa pseudoharengus***		1							1
Atlantic Croaker	*Micropogonias undulatus*		1							1
Atlantic Herring	***Clupea harengus***		2							2
Atantic Silverside	***Menidia menidia***	107	585	441	605	511	474	351	575	3649
Black Sea bass	***Centropristis striata***		4	4		4	12		1	25
Bluefish	***Pomatomus saltatrix***			1						1
Grunt	*Haemulon spp*	1								1
Atlantic Lizardfish	*Synodus saurus*			1						1
Longhorn Cowfish	*Lactoria cornuta*	1								1
Mummichog	***Fundulus heteroclitus***	11	2				7	2		22
Pinfish	*Lagodon rhomboides*		1							1
Pipefish	*Syngnathus fuscus*				1	1	1			3
Pompano spp.	*Trachinotus spp.*				1					1
Northern Pufferfish	*Sphoeroides maculatus*	1					1			2
Rainwater Killifsh	***Lucania parva***	32	1	2	25	23	52	30	5	170
Sculpin spp.	***Myoxocephalus spp***	3					4			7
Northern Sea Robin	***Prionotus carolinus***						3			3
Lined Seahorse	***Hippocampus erectus***						1			1
Sheapshead minnow	***Cyprinodon variegatus***	1			1					2
Spot	*Leiostomus xanthurus*								1	1
Striped Bass	*Morone saxatilis*					2				2
Striped Killifish	***Fundulus majalis***	61	1319	642	34	132	196	21	36	2441
Tautog	***Tautoga onitis***	13	9						1	23
Windowpane	***Scophthalmus aquosus***						2			2
Winter Flounder	***Pseudopleuronectes americanus***	6	17	9	6	29	14		20	101
Total		237	1942	1100	673	702	767	404	639	**Total Fish**
Number of species		11	11	7	7	7	12	4	7	**6464**

Appendix 2

Time Series Figures, All Species

Appendix 2a. Time series counts for total individuals recorded as well as species frequency per station and survey year, 2014-2017.





Appendix 3

Time Series Tables, Winter Flounder

Appendix 3a. Time series data for Winter flounder frequency, 2014-2017.

Winter Flounder

Time Series		Station											
	Month	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	**Total**	**Mean**	**SD**	**SE±**
2014	May	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	Jun	2	2	0	0	0	0	0	5	9	1.13	1.81	0.64
	Jul	0	7	0	4	4	0	1	7	23	2.88	3.04	1.08
	Aug	1	0	0	2	0	2	0	0	5	0.63	0.92	0.32
	Sep	2	8	9	0	19	4	0	2	44	5.50	6.41	2.27
	Oct	0	0	0	0	6	8	0	6	20	2.50	3.51	1.24
	Total	5	17	9	6	29	14	1	20				
	Mean	0.83	2.83	1.50	1.00	4.83	2.33	0.17	3.33		**Total Fish**		
	SD	0.98	3.71	3.67	1.67	7.39	3.20	0.41	3.08		**101**		
	SE±	0.40	1.51	1.50	0.68	3.02	1.31	0.17	1.26				
2015	May	0	0	0	0	3	0	0	0	3	0.38	1.06	0.38
	Jun	0	5	0	3	3	0	0	20	31	3.88	6.79	2.40
	Jul	3	3	1	0	3	1	0	1	12	1.50	1.31	0.46
	Aug	2	20	4	1	0	0	0	8	35	4.38	6.89	2.43
	Sep	6	10	12	17	25	1	4	0	75	9.38	8.52	3.01
	Oct	1	0	1	0	27	0	1	2	32	4.00	9.32	3.30
	Total	12	38	18	21	61	2	5	31				
	Mean	2.00	6.33	3.00	3.50	10.17	0.33	0.83	5.17		**Total Fish**		
	SD	2.28	7.66	4.65	6.72	12.34	0.52	1.60	7.86		**188**		
	SE±	0.93	3.13	1.90	2.74	5.04	0.21	0.65	3.21				
2016	May	0	3	0	1	1	0	0	13	18	2.25	4.46	1.58
	Jun	1	1	1	2	6	0	0	4	15	1.88	2.10	0.74
	Jul	3	9	2	7	0	5	0	1	27	3.38	3.34	1.18
	Aug	3	14	11	6	0	7	0	0	41	5.13	5.36	1.89
	Sep	5	17	16	3	4	12	5	8	70	8.75	5.55	1.96
	Oct	1	1	2	2	6	0	4	5	21	2.63	2.13	0.75
	Total	13	45	32	21	17	24	9	31				
	Mean	2.17	7.50	5.33	3.50	2.83	4.00	1.50	5.17		**Total Fish**		
	SD	1.83	6.92	6.56	2.43	2.86	4.94	2.35	4.79		**192**		
	SE±	0.75	2.83	2.68	0.99	1.17	2.02	0.96	1.96				
2017	May	0	2	0	2	2	0	0	0	6	0.75	1.04	0.37
	Jun	2	3	11	1	18	1	2	2	40	5.00	6.19	2.19
	Jul	8	3	1	1	2	3	0	0	18	2.25	2.60	0.92
	Aug	0	0	0	7	9	3	0	0	19	2.38	3.66	1.29
	Sep	2	0	0	1	36	15	0	0	54	6.75	12.88	4.55
	Oct	2	3	3	0	3	0	0	11	22	2.75	3.62	1.28
	Total	14	11	15	12	70	22	2	13				
	Mean	2.33	1.83	2.50	2.00	11.67	3.67	0.33	2.17		**Total Fish**		
	SD	2.94	1.47	4.32	2.53	13.43	5.72	0.82	4.40		**159**		
	SE±	1.20	0.60	1.77	1.03	5.48	2.33	0.33	1.80				

Appendix 3b. Summary table for time series data regarding Winter flounder CPUE (fish/seine haul) per month and station, 2014-2017.

Winter Flounder CPUE

Time Series		Station							
	Month	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
2014	May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jun	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.63
	Jul	0.00	0.88	0.00	0.50	0.50	0.00	0.13	0.88
	Aug	0.13	0.00	0.00	0.25	0.00	0.25	0.00	0.00
	Sep	0.25	1.00	1.13	0.00	2.38	0.50	0.00	0.25
	Oct	0.00	0.00	0.00	0.00	0.75	1.00	0.00	0.75
2015	May	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00
	Jun	0.00	0.63	0.00	0.38	0.38	0.00	0.00	2.50
	Jul	0.38	0.38	0.13	0.00	0.38	0.13	0.00	0.13
	Aug	0.25	2.50	0.50	0.13	0.00	0.00	0.00	1.00
	Sep	0.75	1.25	1.50	2.13	3.13	0.13	0.50	0.00
	Oct	0.13	0.00	0.13	0.00	3.38	0.00	0.13	0.25
2016	May	0.00	0.38	0.00	0.13	0.13	0.00	0.00	1.63
	Jun	0.13	0.13	0.13	0.25	0.75	0.00	0.00	0.50
	Jul	0.38	1.13	0.25	0.88	0.00	0.63	0.00	0.13
	Aug	0.38	1.75	1.38	0.75	0.00	0.88	0.00	0.00
	Sep	0.63	2.13	2.00	0.38	0.50	1.50	0.63	1.00
	Oct	0.13	0.13	0.25	0.25	0.75	0.00	0.50	0.63
2017	May	0.00	0.25	0.00	0.25	0.25	0.00	0.00	0.00
	Jun	0.25	0.38	1.38	0.13	2.25	0.13	0.25	0.25
	Jul	4.00	0.38	0.13	0.13	0.25	0.38	0.00	0.00
	Aug	0.00	0.00	0.00	0.88	1.13	0.38	0.00	0.00
	Sep	0.25	0.00	0.00	0.13	4.75	1.88	0.00	0.00
	Oct	0.25	0.38	0.38	0.00	0.38	0.00	0.00	1.38

Appendix 3c. The table below outlines the time series information regarding mean abundance ±SE *(fish/seine haul) for Winter flounder, 2014-2017. The total number of individuals recorded for each month were divided by total number of hauls for each sampling season (8 hauls=8 GSP stations).

Winter Flounder

Time Series	May	Jun	Jul	Aug	Sep	Oct
2014	0.00	1.13	2.88	0.63	5.50	2.50
2015	0.38	3.88	1.50	4.38	9.38	4.00
2016	2.25	1.88	3.38	5.13	8.75	2.63
2017	0.75	5.00	2.25	2.38	6.75	2.75

Appendix 3d. Winter flounder mean average length (mm) per station and month, 2014-2017.

	Time Series		May	Jun	Jul	Aug	Sep	Oct
Winter Flounder	2014	GSP 1	0.00	37.00	0.00	50.00	55.00	0.00
		GSP 2	0.00	121.00	69.43	0.00	72.00	0.00
		GSP 3	0.00	0.00	0.00	0.00	72.00	0.00
		GSP 4	0.00	0.00	69.25	64.50	0.00	0.00
		GSP 5	0.00	0.00	95.00	0.00	66.36	85.00
		GSP 6	0.00	0.00	0.00	44.50	66.75	76.25
		GSP 7	0.00	0.00	0.00	0.00	0.00	0.00
		GSP 8	0.00	44.80	55.00	0.00	69.50	77.17
	2015	GSP 1	0.00	0.00	59.33	97.00	60.33	59.00
		GSP 2	0.00	84.00	56.00	59.10	68.64	0.00
		GSP 3	0.00	0.00	41.00	63.50	90.67	68.00
		GSP 4	0.00	117.67	0.00	63.00	68.59	0.00
		GSP 5	88.00	42.33	50.67	0.00	69.72	72.96
		GSP 6	0.00	0.00	55.00	0.00	50.00	0.00
		GSP 7	0.00	0.00	0.00	0.00	129.50	142.00
		GSP 8	0.00	78.84	171.00	59.75	0.00	77.50
	2016	GSP 1	0.00	97.00	161.50	0.00	143.00	0.00
		GSP 2	106.75	104.75	134.00	0.00	0.00	0.00
		GSP 3	105.69	192.00	0.00	0.00	94.00	0.00
		GSP 4	0.00	0.00	0.00	65.40	0.00	71.00
		GSP 5	90.00	64.40	0.00	80.63	0.00	80.80
		GSP 6	119.00	45.00	0.00	0.00	73.50	0.00
		GSP 7	0.00	0.00	0.00	0.00	0.00	0.00
		GSP 8	120.00	56.00	0.00	0.00	0.00	87.00
	2017	GSP 1	0.00	41.00	51.29	0.00	81.50	60.50
		GSP 2	118.50	81.33	47.67	0.00	0.00	76.00
		GSP 3	0.00	45.91	148.00	0.00	0.00	80.00
		GSP 4	113.50	36.00	49.00	58.67	88.00	0.00
		GSP 5	122.50	45.27	54.00	66.75	72.40	72.67
		GSP 6	0.00	37.00	41.00	66.00	62.18	0.00
		GSP 7	0.00	0.00	50.00	0.00	0.00	0.00
		GSP 8	0.00	38.50	0.00	0.00	0.00	89.75

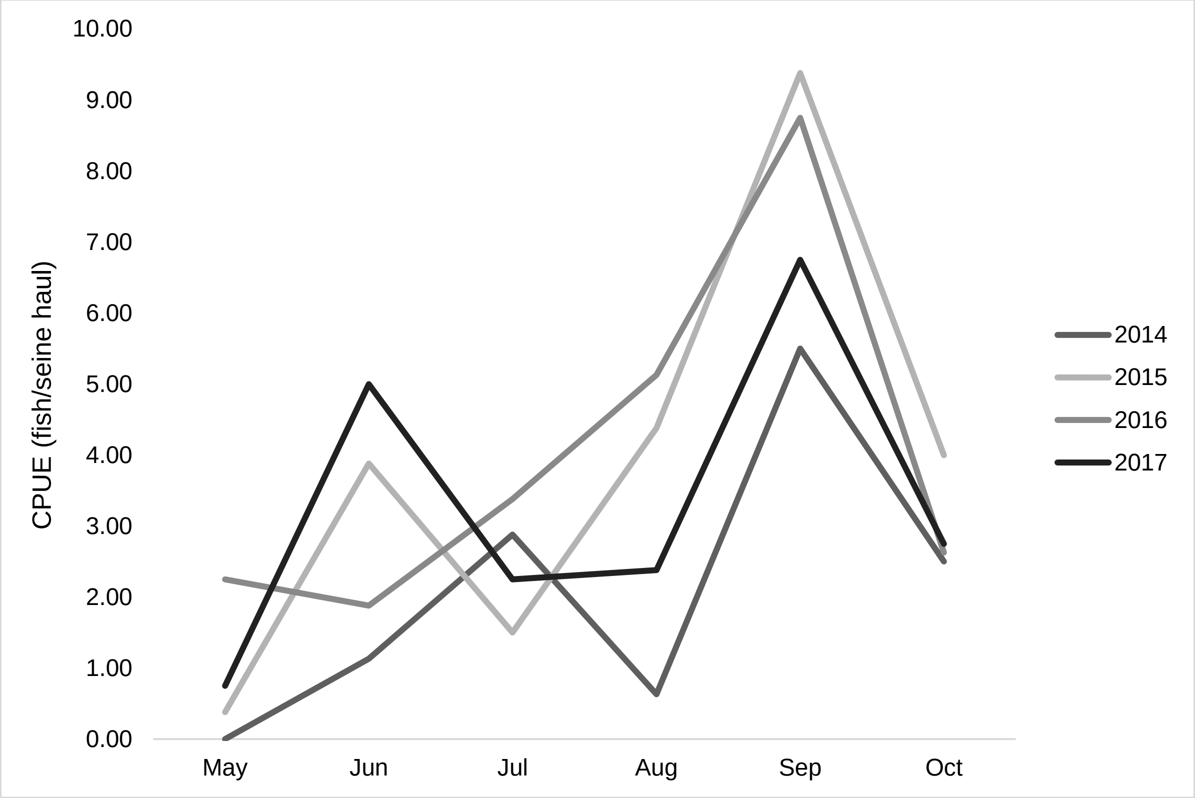
Appendix 3e. Summary table to show mean average lengths for Winter flounder (including individuals >120mm) per month, station and annual survey, 2014-2017.

			Station							
	Time Series		GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
Winter Flounder	2014	May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Jun	37.00	121.00	0.00	0.00	0.00	0.00	0.00	44.80
		Jul	0.00	69.42	0.00	69.25	95.00	0.00	0.00	55.00
		Aug	50.00	0.00	0.00	64.50	0.00	44.50	0.00	0.00
		Sep	55.00	72.00	72.00	0.00	66.41	66.75	0.00	69.50
		Oct	0.00	0.00	0.00	0.00	85.00	76.25	0.00	77.20
	2015	May	0.00	0.00	0.00	0.00	88.00	0.00	0.00	0.00
		Jun	0.00	84.00	0.00	117.67	42.33	0.00	0.00	78.84
		Jul	59.33	56.00	41.00	0.00	50.67	55.00	0.00	171.00
		Aug	97.00	59.10	63.50	63.00	0.00	0.00	0.00	59.75
		Sep	60.33	68.64	90.67	68.59	69.72	50.00	129.50	0.00
		Oct	59.00	0.00	68.00	0.00	72.96	0.00	142.00	77.50
	2016	May	0.00	106.75	105.69	0.00	90.00	119.00	0.00	120.00
		Jun	97.00	104.75	192.00	0.00	64.40	45.00	0.00	56.00
		Jul	161.50	134.00	0.00	0.00	0.00	0.00	0.00	0.00
		Aug	0.00	0.00	0.00	65.40	80.63	0.00	0.00	0.00
		Sep	143.00	0.00	94.00	0.00	0.00	73.50	0.00	0.00
		Oct	0.00	0.00	0.00	71.00	80.80	0.00	0.00	87.00
	2017	May	0.00	118.50	0.00	113.50	122.50	0.00	0.00	0.00
		Jun	41.00	81.33	45.91	36.00	45.44	37.00	0.00	38.50
		Jul	50.78	47.67	148.00	49.00	54.00	41.00	50.00	0.00
		Aug	0.00	0.00	0.00	58.71	68.11	66.00	0.00	0.00
		Sep	81.50	0.00	0.00	88.00	76.89	60.93	0.00	0.00
		Oct	60.50	76.00	80.00	0.00	72.67	0.00	0.00	89.00

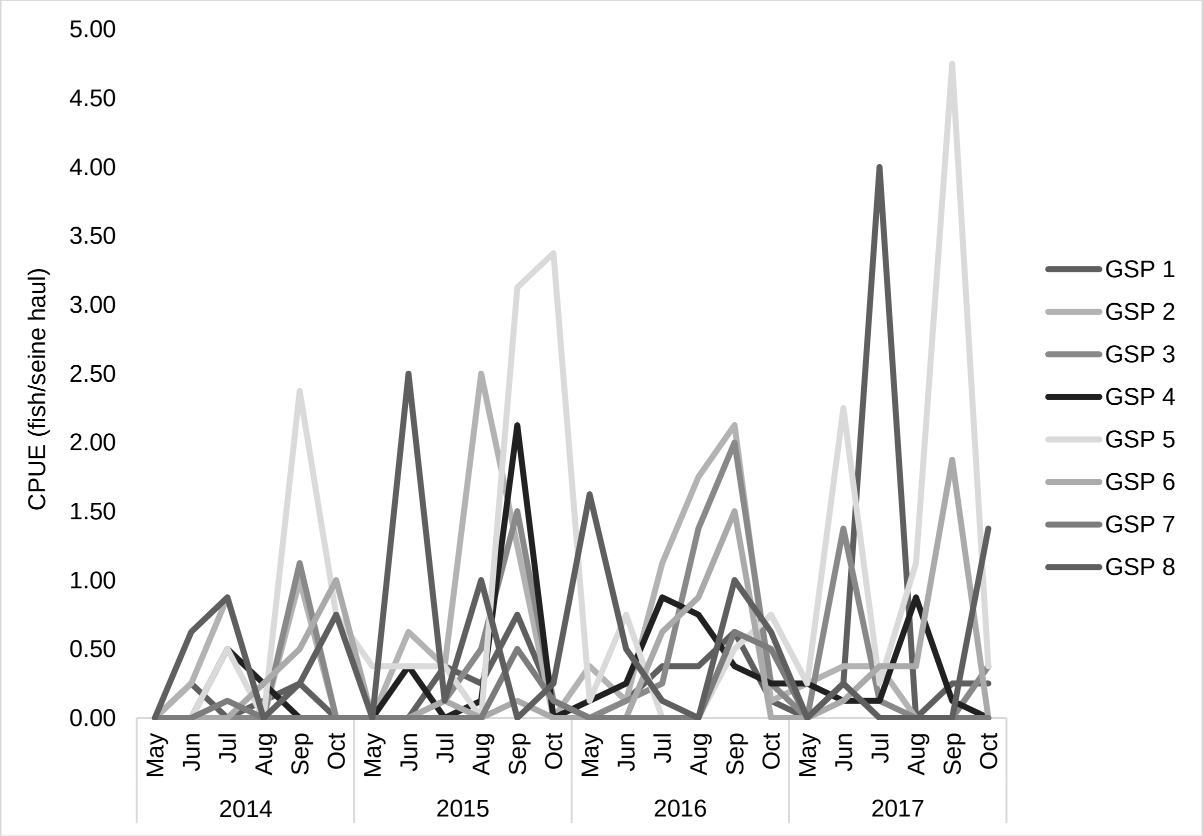
Appendix 4

Time Series Figures, Winter Flounder

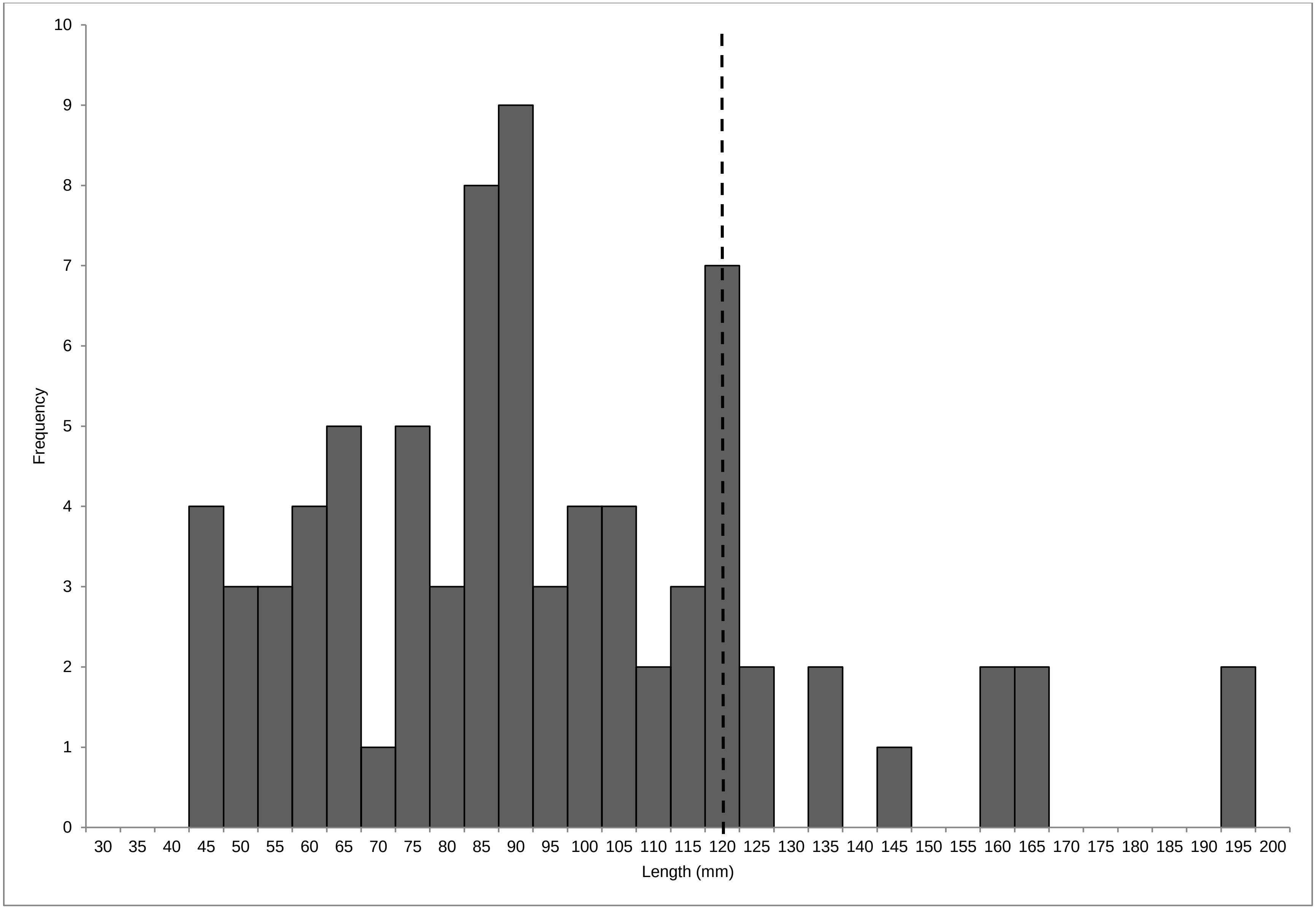
Appendix 4a. Time series abundance indices (CPUE (fish/seine haul)) for YOY Winter flounder for each month in the GSP survey.



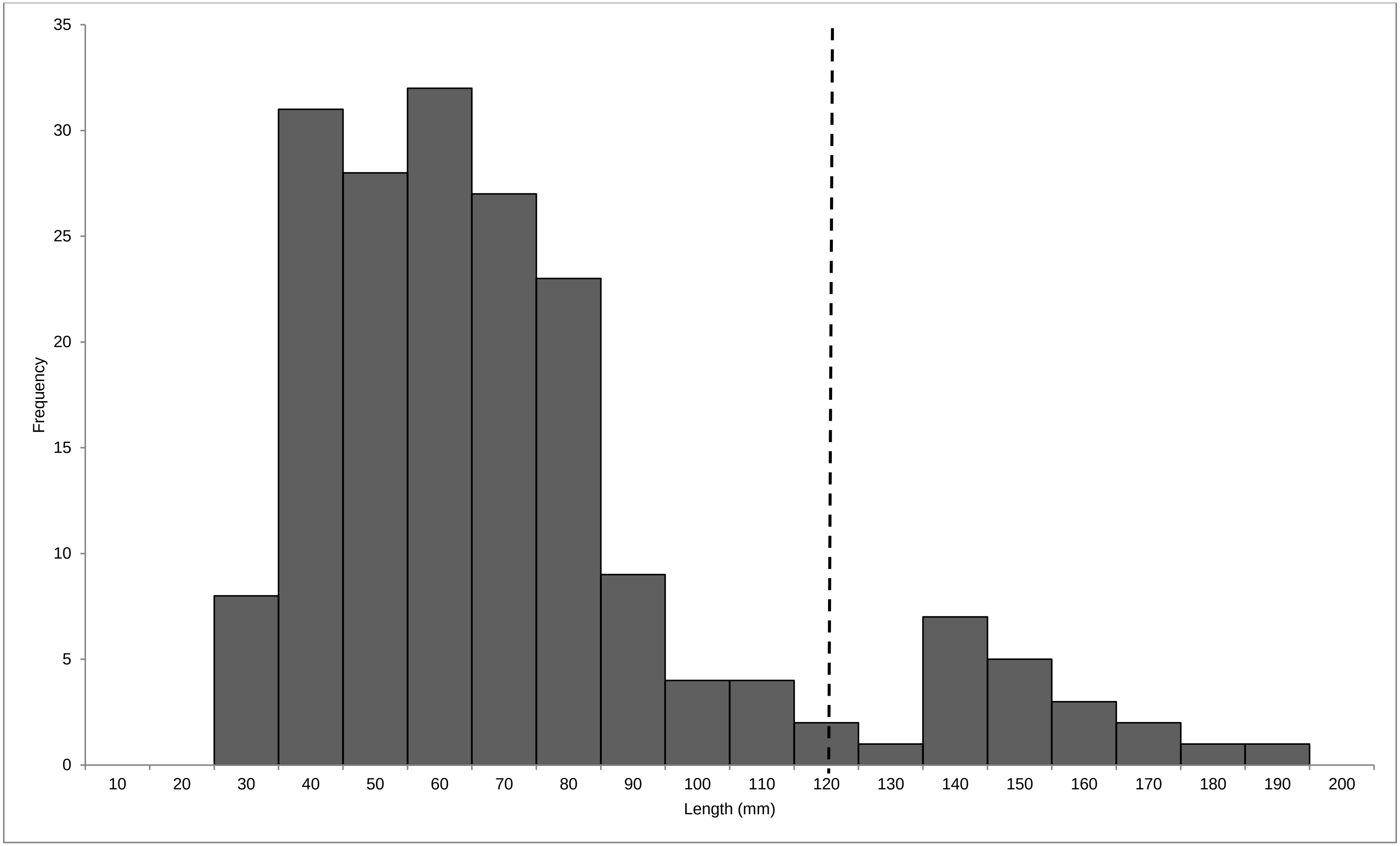
Appendix 4b. Time series abundance indices (fish/seine haul) for winter flounder YOY by month and station, 2014-2017.



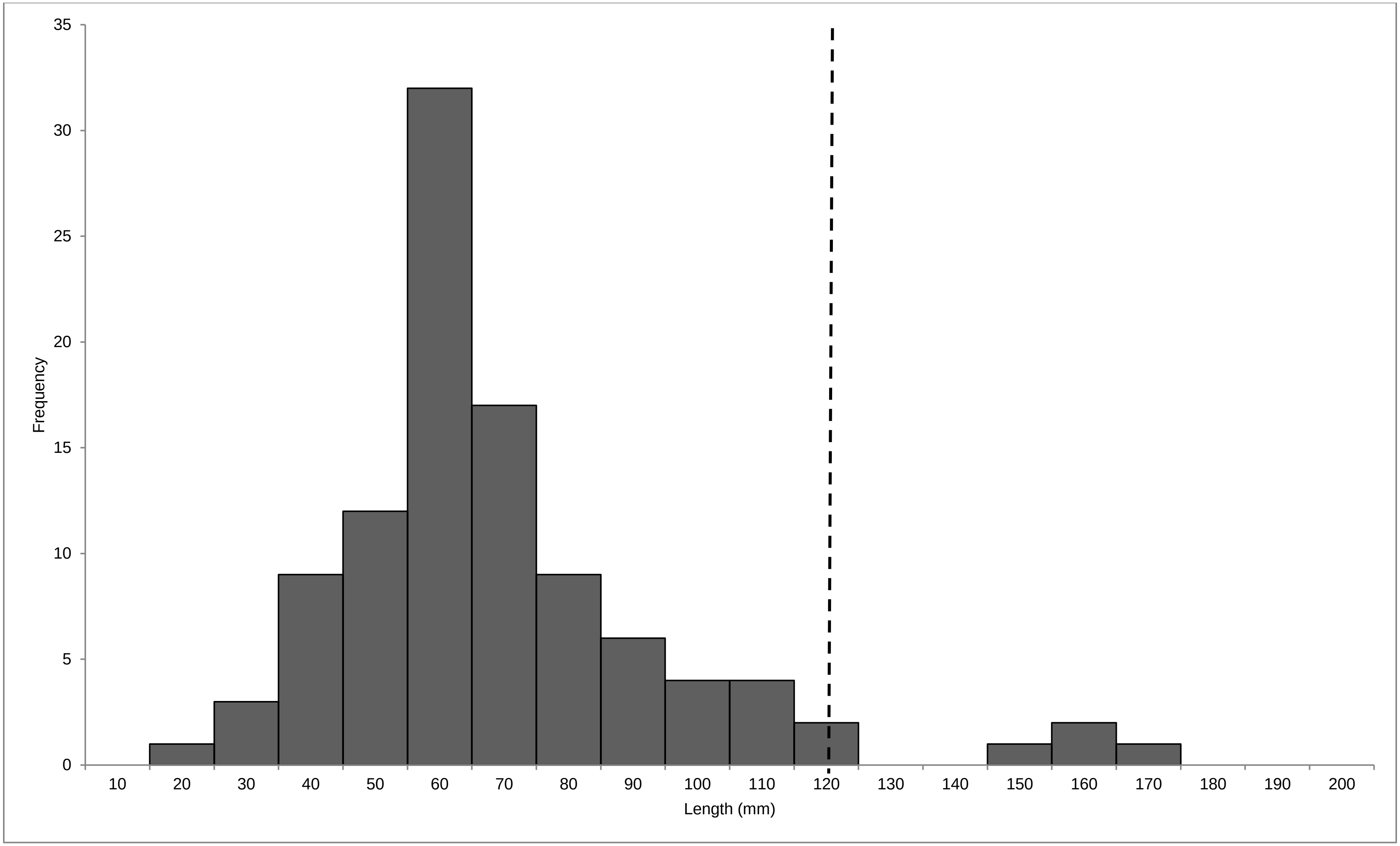
Appendix 4c. Length frequency distribution for all Winter flounder caught in 2016 (n=192). YOY cutoff left of dotted line (TL > 120mm).



Appendix 4d. Length frequency distribution for all Winter flounder caught in 2015 (n=188). YOY cutoff left of dotted line (T L> 120mm).



Appendix 4e. Length frequency distribution for all Winter flounder caught in 2014 (n=101). YOY cutoff left of dotted line (T L> 120mm).



ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

NARRAGANSETT BAY JUVENILE FINFISH SURVEY

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2017

PERFORMANCE REPORT

STATE: Rhode Island

PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters.

PERIOD COVERED: 1 January 2017 - 31 December 2017

JOB NUMBER AND TITLE: IV - Juvenile Marine Finfish Survey

JOB OBJECTIVE: To monitor the relative abundance and distribution of the juvenile life history stage of winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitis*), bluefish (*Pomatomus saltatrix*), scup (*Stenotomus crysops*), weakfish (*Cynocion regalis*), black sea bass (*Centropristis striata*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic herring (*Clupea harengus),* striped bass (*Morone saxatilis*), and other selected species of commercial and recreational importance in Narragansett Bay. To use these data to evaluate short and long term annual changes in juvenile population dynamics, to provide data for stock assessments, and for the development of Fishery Management Plans. To collect fish community data that is used to continue to identify, characterize, and map essential juvenile finfish habitat in Narragansett Bay.

SUMMARY: Eighteen fixed stations (Figure 1) around Narragansett Bay were sampled once a month from June through October 2017 with the standard 61 x 3.05 m beach seine. Adults and juveniles of sixty-eight species were collected during the 2017 survey. For comparison eighty species were collected in 2015, the highest number of species and families collected since the survey began. For the entire survey time series (1988 – 2016), all individuals of the target species: winter flounder, tautog, bluefish, weakfish, black sea bass, scup, river herring, sea herring, and menhaden were enumerated and measured. With few exceptions (noted) all individuals of these species that were collected in the survey were juveniles. Adult and juveniles of other species collected were not differentiated for data analysis or descriptive purposes prior to 2009. Presence and relative abundance (few, many, abundant) of three forage species: Atlantic silversides (*Menidia menidia*), common mummichog (*Fundulus heteroclitus*) and striped killifish (*Fundulus majalis*) had been noted until 2009. Since 2009 all finfish species caught were enumerated and measured. Invertebrate species were noted and enumerated using the relative abundance scale as noted above. Data on weather, water temperature, salinity, and dissolved oxygen were recorded at each station.

TARGET DATE: December 2017

SIGNIFICANT DEVIATIONS: There were no significant deviations to methodology in 2017.

RECOMMENDATIONS: Continue standard seine survey at all eighteen stations. Continue to provide comments and recommendations to other resource management and regulatory agencies regarding potential anthropogenic impacts to fisheries resources and habitat. Continue to analyze and provide data for use in fisheries stock assessments. A reassessment and characterization of the habitat at each station should be undertaken to see if any major changes have occurred since the original evaluation.

REMARKS: Abundance trends derived from adult data collected from the RIDFW seasonal trawl survey since 1979 indicate a declining abundance of demersal species and an increasing abundance for pelagic species in Rhode Island waters. It should be noted that the trawl survey samples both adult and juvenile fish and invertebrates. This trend has also been observed in other estuaries along the Atlantic coast. Reasons for these shifts are attributed to a number of factors but may not be limited to these factors. These include the effects of climate change, warming coastal waters, water quality, habitat degradation and loss, overexploitation of some species leading to niche replacement by other species, and trophic level changes and shifts associated with all of these factors. Anthropogenic affects and the synergy between factors have no doubt led to changes in fish communities along the coast (Kennish, 1992).

A non-parametric Mann-Kendall test for trend significance can be used to show annual abundance trends for species collected during this juvenile survey. Two iterations of this test were run on for a set of target species. The first iteration analyzed the entire dataset and then a second iteration of this non- parametric trend analysis was done using a shortened time period of 10 years. While no species have any significant long term, bluefish is showing a borderline decreasing trend (0.074 p-value, Table 1a). Tautog is showing a positive increasing trend in the shortened 10-year analysis (Table 1b). Other species such as winter flounder, river herring, striped bass, and menhaden show no abundance trend for either the full dataset or the past ten years (Table 1a, b).

Reductions and annual fluctuations in abundance of many species may be attributed to a number of factors outlined above. Any one or more of these factors and/or the synergy between them may be responsible for inhibiting populations of some species from returning to historic or in some cases sustainable levels. Continued monitoring of juvenile fish populations is necessary to document the abundance and distribution of important species as well as the interactions between species. Further, this data can be analyzed to evaluate the effectiveness of management actions, an example being a spawning closure enacted for tautog in 2006 and then lengthened in 2010. This spawning closure was in part supported by the data derived from this survey. Trends in abundance and shifts in fish community composition can also be evaluated with these data.

While the primary purpose for conducting this survey is to provide data for making informed fisheries management decisions, these data are also used when evaluating the adverse impacts of dredging and water dependent development projects.

METHODS, RESULTS & DISCUSSION: A 61m x 3.05m beach seine, deployed from a 22' boat, was used to sample the juvenile life stage of selected fish species in Narragansett Bay. Monthly seine collections were completed at the eighteen standard survey stations (Figure 1) from June through October 2017.

Number of individuals and lengths were recorded for all finfish species. While both juveniles and adults were represented in the collections for many species, individuals collected for the target species were predominately young-of-the-year juveniles (YOY). Species and number of individuals (both juveniles and adults) of invertebrate species collected were also recorded with the use of a relative index of abundance (abundant, many, few). Tables 3 - 7 show the species occurrence and number caught at each station for June through October. Table 8 is a summary table for all stations and species collected during the 2017 survey. Tables 9-13 provide the number of fish/seine haul for each station along with the station mean, monthly mean, and annual abundance index for each target species. Figures 2 – 10 show the annual abundance index trends for a number of important species for both the original and standardized indices. It should be noted when interpreting these data, that the survey began in 1986 with fifteen stations. The data represented in the graphs begins in 1988 as the period of time when the survey began using consistent methodology with the 15 stations. Station 16 (Dyer Is.) was added in June 1990, station 17 (Warren R.) was added in July of 1993, and station 18 (Wickford) was added in July of 1995. The addition of the stations is standardized in the analysis, see appendix A.

Table 15 provides bottom temperature, salinity, and dissolved oxygen data for each station by month.

Winter flounder

Juvenile winter flounder (*Pseudopleuronectes americanus*) were present in fifty-seven percent of the seine hauls for 2017. This is a small increase from 2016 when they were present in forty-one percent of the hauls. A total of 366 fish were collected in 2017 (all fish would be considered young-of-the-year (YOY) according to Table 2 winter flounder maximum size by month). This was an increase from the 263 individuals collected during the 2016 survey. They were present at all but one station (no presence at station 7), and were collected in all months (Table 9).

The 2017 juvenile winter flounder standardized abundance index was 4.07 ± 1.37 S.E. fish/seine haul; this is greater than the 2016 index of 2.92 ± 2.05 S.E. fish/seine haul. Figure 2 shows the standardized annual abundance indices since 1988. The Mann-Kendall test showed no significant abundance trend for this species for the full dataset, or in the last 10 years (Table 1a, b).

June had the highest mean monthly abundance of 11.17 ± 3.82 S.E. fish/seine haul. Spetacle Cove (Sta. 13) and Chepiwonoxet Pt (Sta. 3) had the highest mean station abundance of 18.60 ± 11.20 and 9.00 ± 4.24 S.E. respectively. Overall upper and mid bay stations continue to have higher abundances than lower bay stations. This is expected since the primary spawning area for this species is believed to be in the Providence River followed by a secondary spawning area in Greenwich Bay where Station 3 is located. Wickford (Sta. 18), located in the lower bay, also has an above median number of juveniles. This station is located just outside Wickford Harbor, an area believed to be an important winter flounder spawning area.

Winter flounder length frequency data from the 2017 survey indicate that all the winter flounder collected were young-of-the-year (YOY). The maximum lengths by month for YOY winter flounder used for this report are supported by growth rates in Rhode Island waters as reported in the literature (Delong et al, 2001; Meng et al, 2000; Meng et al, 2001; Meng et al, 2008). See Table 2 for maximum YOY lengths by month.

Figure 2 shows the 2017 abundance index continues to be lower than most years since 2000, the survey high. The Division of Fish and Wildlife's trawl survey data (sampling both adults and juveniles) saw a small decrease in winter flounder from 2016 to 2017. Over the course of the Narragansett Bay Juvenile Finfish Seine Survey the abundance index rose between 1995 and 2000, but then decreased with variability to 2017. The Mann-Kendall trend analysis shows no trend in the abundance of juvenile winter flounder in Narragansett Bay over the entire time series, and the declining trend indicated for the shortened 10-year time series in the terminal year of 2012 has dissipated, now showing no trend as we move away from the peak years of the early 2000's. The dramatic abundance fluctuations over the past ten years shown in Figure 2 and the declining trend over the last decade continue to be a concern to resource managers.

Tautog

During the 2017 survey 773 juvenile tautog (*Tautoga onitis*) were collected. This is an increase from the 2016 survey when 373 juveniles were collected. The 2017 abundance index was 8.59 ± 3.93 S.E. fish/seine haul, an increase from the 2016 index 4.14 ± 2.29 S.E. (Figure 3). As indicated in the introduction, based on this survey data, it can be concluded that the spawning closure enacted in 2006 and then extended in 2010 may be having an impact on the number of juveniles produced during the spring as there appears to be an increasing trend since this time period. It may take some time for a slow growing species such as tautog to recoup its spawning stock biomass to levels that will have significant impacts and major increases in biomass; therefore, we will continue to monitor this species closely in the coming years.

Juvenile tautog were collected in sixty-five percent of the seine hauls in 2017 (Table 10). This is an increase from 2016 when they were present in fifty-five percent of the seine hauls. September and August had the highest mean monthly abundances of 18.17 ± 9.14 S.E. and 14.00 ± 6.30 S.E. fish per seine haul, which corresponds to the majority of the survey time series data which indicates August as being the month with the highest abundance. Patience Island had the highest mean station abundance of 63.60 ± 32.55 S.E. which was driven by high sampling numbers in September (164 fish) and August (115 fish). Hog Island (Sta. 9) and Spectacle Cove (Sta. 13) had the next highest abundances with a mean station abundance of 18.80 ± 8.74 S. E and 18.40 ± 7.57 S. E fish/seine haul respectively. The Mann-Kendall test showed no long-term trend in juvenile abundance, but a short term increasing abundance trend for juvenile tautog is present for the 10-year series (Table 1a, b). It is plausible that the spawning closure is positively impacting the juvenile tautog population, and the increasing trend in the Mann-Kendall test supports this. It should be noted that this survey data was used as a young of the year index for the benchmark stock assessment for tautog by the Atlantic States Marine Fisheries Commission (ASMFC 2016).

Our Narragansett Bay trawl survey had a flat abundance trend for tautog for the past several years. There would be a lag in time between when juveniles are caught in the seine survey and when the cohort shows up in the trawl survey, but the trends are worth monitoring.

Bluefish

During the 2017 survey one-hundred sixty-five juvenile bluefish (*Pomatomus saltatrix*) were collected. This is significantly lower than the 1,430 juveniles collected in 2016. Juveniles were present in twenty percent of the seine hauls and were collected at twelve of the eighteen stations

(Table 11). They were present in all months, with the highest abundance occurring in July. October 2017 was more on par with what is typically seen, catching only 3 fish at a single station (Patience Island Sta.5), unlike October 2016 when 128 juveniles were caught. Since this survey began and prior to 2016, only one hundred forty-one juvenile bluefish have been collected in October, in seven different years (1990, 1997, 1999, 2005, 2011, 2012, and 2015), and only when water temperatures were 16 – 21° C.

The abundance index for 2017 was 1.83 ± 0.98 S.E. fish/seine haul. This is less than the 2016 abundance index of 15.89 ± 14.79 S.E. fish/seine haul (Figure 4). The Mann-Kendall test showed no long-term or 10-year abundance trend for this species (Table 1a, b).

July had the highest mean monthly abundance of 6.72 ± 3.24 S.E. fish/seine haul (Table 11). July and August are typically the months of highest juvenile abundance for this species. The only exception to this was in 2005 when September had the highest mean monthly abundance. This was probably due to the higher than normal water temperatures during September 2005.

In 2017, Potter's Cove (Sta. 8) had the highest mean station abundances of 15.20 ± 10.31 S.E. (Table 11). This is driven by July and September, the only 2 months the station caught bluefish.

Length frequency data for 2017 indicates that all juveniles collected were young-of-the-year individuals.

The spatial distribution and abundance of juvenile bluefish in Narragansett Bay is highly variable and is dependent on a number of factors: natural mortality, fishing mortality, size of offshore spawning stocks, spawning success, number of cohorts, success of juvenile immigration into the estuaries, and the availability of appropriate size prey species like Atlantic silversides (*Menidia menidia*) when juveniles enter the bay. The annual abundance indices since 1988 show dramatic fluctuations supporting a synergy of these factors affecting recruitment of this species to Narragansett Bay (Figure 4).

Striped Bass

During the 2017 survey 14 striped bass (*Morone saxatalis*) were collected. This is lower than the 36 fish collected in 2016. Striped bass were present in seven percent of the seine hauls and were collected at six of the eighteen stations (Table 14). They were present in June, July, and October.

The abundance index for 2017 was 0.16 ± 0.10 S.E. fish/seine haul. This is lower than in 2016, which had an abundance index of 0.40 ± 0.38 S.E. fish/seine haul (Figure 8). The Mann-Kendall test showed no abundance trend for this species for the entire dataset or for the shortened 10-year series (Table 1a, b).

June had the highest mean monthly abundance of 0.50 ± 0.27 S.E. fish/seine haul (Table 14). October had the second highest mean monthly abundance at 0.22 ± 0.17 fish/seine haul. September and October are usually the months with the highest abundance for the entire time series.

In 2017, striped bass were only present at 6 stations, Gaspee Point (Sta. 1), Dutch Island (Sta. 7), Potters Cove (Sta. 8), Kickimuit River (Sta. 11), Spar Island (Sta. 12), and Dyer Island (Sta. 16). The highest abundance was found at Spar Island with 0.80 ± 0.80 fish/seine haul, which was driven by a single catch of 4 fish in June. The station with the highest abundance each year is variable, though it does tend to be the lower bay stations in general for the entire time series.

Length frequency data for 2017 indicates that a mix of juveniles and adults were collected. This is normal for the seine survey. The spatial distribution and abundance of striped bass in Narragansett Bay is highly variable and is most likely highly dependent on the availability of appropriate size prey species like Atlantic silversides (*Menidia menidia*) and juvenile menhaden (*Brevoortia tyrannus*) when fish enter the bay. The annual abundance indices since 1988 show fluctuations in abundance from year to year (Figure 8), but generally appears to have had an increasing trend during the late 90s to early 2000s, but now appears to be on a downward trajectory since 2008, although in recent years there seems to be a very slight upward trend. The standardized index, which accounts for some of these factors, follows a similar trend year to year as the straight catch per unit effort (CPUE) index.

Clupeidae

Four species of clupeids are routinely collected during the survey. Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), collectively referred to as river herring, and Atlantic menhaden (*Brevoortia tyrannus*) are most common. Atlantic herring (*Clupea harengus*) have also been collected during the surveys time series but in very small numbers.

River Herring

Due to the large numbers of anadromous herring collected, and the difficulty of separating juvenile alewives from juvenile blueback herring without sacrificing them, both species are combined under the single category of river herring. Data collected from this survey and the Division of Fish and Wildlife's Anadromous Fish Restoration Project show alewives to be the predominate river herring species collected, although both species are present and have been stocked as part of the Division's restoration efforts.

River herring were present in twenty-seven percent of the seine hauls and were collected at sixteen of the eighteen stations during 2017, and were present in all months. A total of 3,593 juveniles were collected in 2017, an increase from the number collected in 2016 (1,324 fish).

The highest mean monthly abundance for 2017 occurred during August and was 115.89 ± 112.74 S.E. fish/seine haul. Pojac Point (Sta 4) and Fogland (Sta. 14) had the highest mean station abundance of 406.80 ± 406.30 S.E. and 101.60 ± 101.60 S.E., respectively (Table 13). Pojac Point experienced a single large catch in August (2,032 fish), and Fogland experienced a single large catch in July (508 fish) which drove their mean station abundances. Single large catches of these species are due to their schooling behavior and is the reason for the high standard error associated with the indices.

The standardized abundance index for 2017 was 39.32 ± 33.98 S.E. fish/seine haul (Figure 5). The annual abundance indices since 1988 show dramatic fluctuations as is a common occurrence with schooling clupeid species. Due to these fluctuations, there was no significant trend in the 10-year Mann-Kendall (Table 1b), and no long-term abundance trend for river herring (Table 1a).

Figure 6 shows the estimated spawning stock size of river herring as monitored by our Anadromous Fish Restoration Program at two fishways in Rhode Island. There may be some correlation between increasing numbers of returning adult fish (Figure 6) and the abundance index generated by this survey (Figure 5) as the recent small increases in juvenile abundance in the data corresponds to an increase in returning adults, and vise versa. Due to an extended period of low abundance of river herring in Rhode Island, the taking of either species of river herring is currently prohibited in all state waters.

Menhaden

One-hundred forty thousand five hundred-ninety-eight Atlantic menhaden (*Brevoortia tyrannus*) were collected during the 2017 survey, a large increase from 2016 when 2,177 fish were caught. The 2017 abundance is the highest is recent years; the last high abundance was 2007, when eight thousand two hundred fifty-three juveniles were collected. They were present in twenty-seven percent of the seine hauls and were collected at sixteen of the eighteen stations (Table 12).

The highest mean monthly abundance for 2017 occurred during September and was 7571.89 ± 7324.50 S.E. fish/seine haul. Chepiwanoxet (Sta. 3) had the highest mean station abundance of 26705.00 ± 26335.32 S.E. (Table 13) which was driven by a single large catch in September of 132,040 fish. Single large catches of these species are due to their schooling behavior and is the reason for the high standard error associated with the indices.

The standardized abundance index for 2017 was 1562.20 ± 1507.86 S.E. fish/seine haul. This is highest index since 2000 (3913.22 ± 3888.64 fish/seine haul, Figure 7). The standardized index indicates an increased abundance during the 2000s followed by lower numbers through the 2010s. In the most recent years an increasing abundance is evident. Our Narragansett Bay trawl survey showed a decrease in menhaden abundance from 2016 to 2017. The trawl survey catches juveniles as well as some age one fish. The Mann-Kendall test showed no long-term or short-term abundance trend for this species (Table 1a, b).

Similar to river herring, juvenile menhaden were also observed in very large schools around Narragansett Bay and as discussed earlier, this behavior often results in single large catches resulting in a high abundance index and large standard error. This schooling behavior also contributes to the variability of their spatial and temporal abundance from year to year. Because of these characteristics it is difficult to develop an abundance index that will accurately reflect the number of juveniles actually observed in the field rather than the number represented in the samples. The standardization techniques used for analysis this year are an effort to take in to account this variability and high percentage of zero catches through the use of a delta lognormal model (Appendix A).

Weakfish

Four weakfish, *Cynocion regalis,* were collected during the 2017 survey. Weakfish were collected at Pojac Point (Sta. 4) and Spectacle Cove (Sta. 13). Station 3 in Greenwich Bay and

Station 4 at the mouth of the Potowomut River, immediately south of Greenwich Bay, are the stations where this species is collected most frequently.

The abundance trend over the past several years indicate the juvenile population of this species in Narragansett Bay fluctuates dramatically, a trend also reflected in our trawl survey. There, have been 10 years since 1988 where no fish have been caught. Six of the 10 total zero catch years occur after 2004. Possible reasons for this high variability in abundance, other than fishing pressure, may be environmental and anthropogenic factors that affect spawning and nursery habitat. Survival rate at each life history stage may also be influenced by these factors. The literature indicates this species spawns in calm coves within the estuary and juveniles move up the estuary to nursery areas of lower salinity. These are the same areas of the bay where anthropogenic impacts are high, often resulting in hypoxic and/or anoxic events that may increase mortality of the early life history stages of this species.

With the limited and sporadic juvenile data generated by this survey a juvenile population trend analysis is difficult. A nominal index was developed, but due to the sparse nature of the data, the index generated should be viewed with caution.

Black Sea Bass

Fifty-nine black sea bass (*Centropristis striata*) were caught in 2017, a small increase from the 20 fish that were collected in 2016. The number of black sea bass has been highly variable from year to year during the time series of this survey, but the 2012 and 2015 numbers stand out as unique. Black sea bass were caught in sixty -five percent of the seine hauls in 2017.

The highest mean monthly abundances for 2017 occurred during August and September at 1.56 ± 0.72 S.E. fish/seine haul and 1.44 ± 0.51 fish/seine haul respectively. Black sea bass were caught at 13 of the 18 stations; Warren River (Sta. 17) and Third Beach (Sta. 15) had the highest mean station abundances of 2.60 ± 1.60 S.E. and 2.00 ± 2.00 fish/seine haul respectively (Table 13).

The abundance index for 2017 was 0.66 ± 0.28 S.E. fish/seine haul. This was higher than the 2016 index 0.22 ± 0.20 S.E. (Figure 10). Our Narragansett Bay trawl survey had a small decrease in the abundance of black sea bass from 2016 to 2017 in the spring seasonal survey, however, the abundance was still much greater than it has been since the survey began in 1979. The fall index dropped down from the high values in 2012 and 2013, but did show a small increase in abundance from 2016 to 2017. This recruitment signal in recent years was seen not only in RI waters, but all along the Northern Atlantic coast.

Both the trawl survey and the coastal pond survey seem to be better indicators for local abundances of black sea bass. The Narragansett Bay seine survey does not catch them in any consistent manner leading one to believe that they may be using deeper water and or the coastal ponds as their preferred nursery areas. There are no indications that there are any problems with the local abundance of black sea bass, information that is also corroborated by the coastwide stock assessment for black sea bass, which indicates no overfishing and a rebuilt stock (NEFSC 2016).

Other important species

Juveniles of other commercial or recreationally important species were also collected during the 2016 survey. These juveniles included scup (*Stenotomus chrysops*), and Northern kingfish (*Menticirrhus saxatilis*).

Three-hundred-thirty-three juvenile scup were collected in 2017 during July, August, and September, an increase from 2016 when 66 scup were collected. Five hundred ninety-nine Northern kingfish were collected in 2017, and were present in the greatest numbers on July and August. This is an increase from 2016 when 168 Northern kingfish were caught. Two summer flounder were collected in 2017 in July. Six smallmouth flounder were caught in 2017. Relative to the sixty-eight smallmouth flounder that were caught in 2011, and the thirty-three that were caught in 2010, the decrease in abundance continued in 2017. This species will have to be monitored in future years to see if, due to changing habitat conditions or possible vacant niches, it is increasing its residency in the Bay. No juvenile Haddock were caught in 2017, unlike June 2016 when 44 juvenile haddock were caught, or June 2015 when 27 were caught. They were caught primarily in the lower portion of the bay. 2015 was the first recorded observance of juvenile Haddock in the history of the survey, this species will continue to be monitored in future years to see if there is an increasing abundance over time in Narragansett Bay. See Tables 3-8 for additional survey data on these species.

Physical & Chemical Data

Previous to 2010 a YSI 85 was used to collect water temperature, salinity and dissolved oxygen data from the bottom water at all stations on each sampling date. This meter was upgraded in 2010 to a YSI Professional Plus Multiparameter instrument 6050000. The instrument collects the same suite of information as the YSI 85, but is an improved meter with better functionality. The water quality data collected are shown in Table 15.

Water temperatures during the 2017 survey ranged from a low of 15.4°C at Rose Island (Sta. 10) in June to a high of 25.7°C at Chepiwanoxset (Sta. 3) in August.

Salinities ranged from 10.6 *ppt* at Dyer Island (Sta. 16) in July to 29.0 *ppt* at Rose Island (Sta. 10) in October.

SUMMARY: In summary, data from the 2017 Juvenile Finfish Survey continue to show that a number of commercial and recreationally important species utilize Narragansett Bay as an important nursery area. Using the Mann Kendall test, winter flounder, tautog, river herring, menhaden, striped bass, and bluefish showed no long-term abundance trends. For some species abundance trends from this survey agree with those from our coastal pond survey and/or trawl survey, in some instances they do not. This outcome is probably influenced by the species specific use of habitat and looking at appropriate data lags between the juvenile life stages and the adult stages. Hopefully, juvenile survey abundance indices will be reflected later in the abundance of adults in the trawl survey, but this is not always the case.

Sixty-eight species, both vertebrates and invertebrates, were collected in 2017. This is slightly higher than, the survey mean for the past twenty-five years of sixty species. An initial audit of the earlier time series and information contained on the field logs was undertaken to determine if some of the species diversity was missing from the earlier time series. Some issues were resolved from this analysis, however there are still some unresolved issues contained in the historical field logs. These final issues will be addressed over the coming year.

During 2017 three tropical and subtropical species were collected during the survey. While tropical and subtropical species are collected during this survey every year, the number of species and individuals is dependent upon the course of the Gulf Stream, the number of streamers and warm core rings it generates, and the proximity of these features to southern New England.

The survival and recruitment of juvenile finfish to the Rhode Island fishery is controlled by many factors: over-fishing of adult stocks, spawning and nursery habitat degradation and loss, water quality changes, and ecosystem changes that effect fish community structure. Any one of these factors, or a combination of them, may adversely impact juvenile survival and/or recruitment in any given year.

An ongoing effort to increase populations of important species must embrace a comprehensive approach that takes into account the above factors, their synergy and the changing fish community in the Bay. A continued effort to identify and protect essential fish habitat (EFH) and improve water quality is essential to this effort. The Division through our permit review program does represent the interests of fish and habitat preservation and protection. As well, properly informed management decisions are tantamount to preserving spawning stock biomass in order to create and maintain sustainable populations. This survey’s dataset is used to inform the statistical catch at age models for both a regional tautog assessment as well as the coastwide menhaden assessment. In addition to the direct usage of the data in fisheries models, the other information collected by the survey helps to identify ancillary information such as abundances of forage species and habitat parameters, all important information for making good informed management decisions. These activities will all continue to be an important component of this project.

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FIGURES

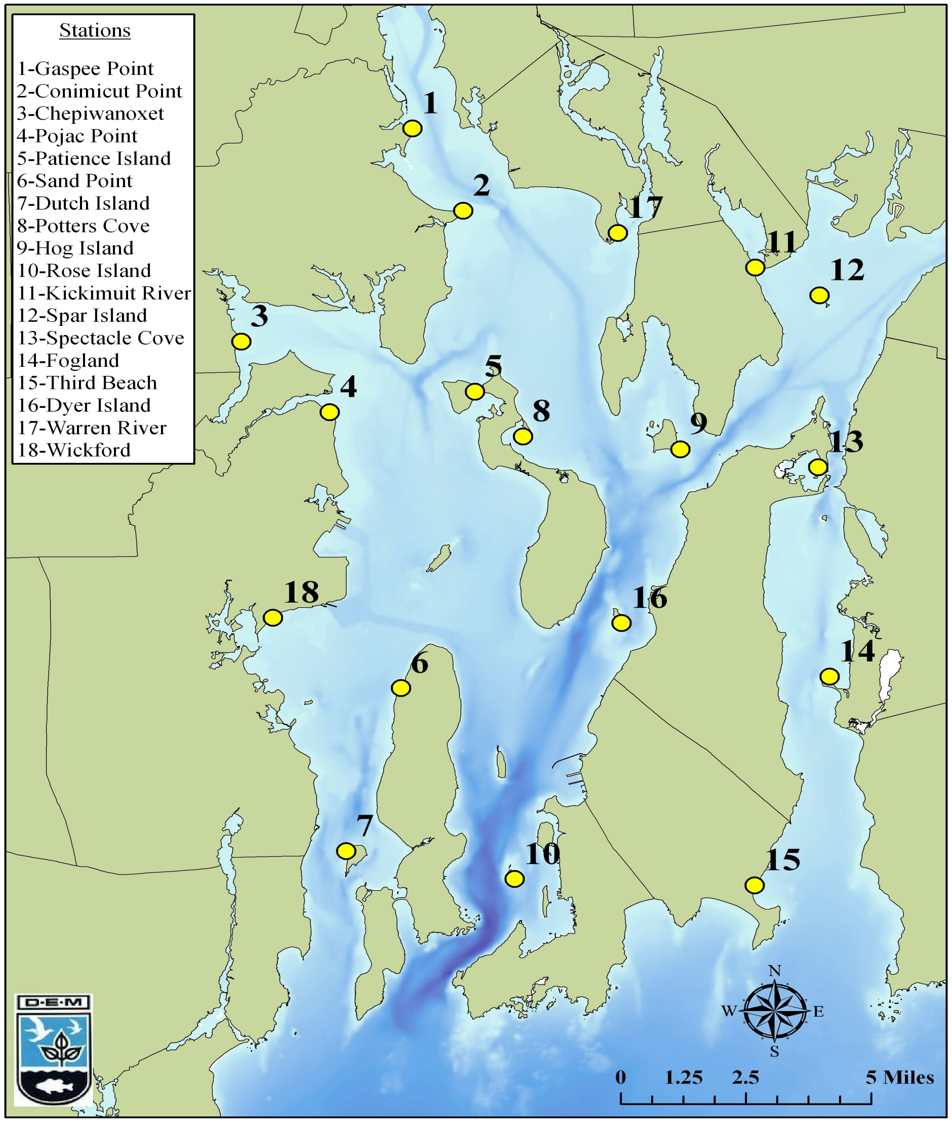


Figure 1. Survey station location map.

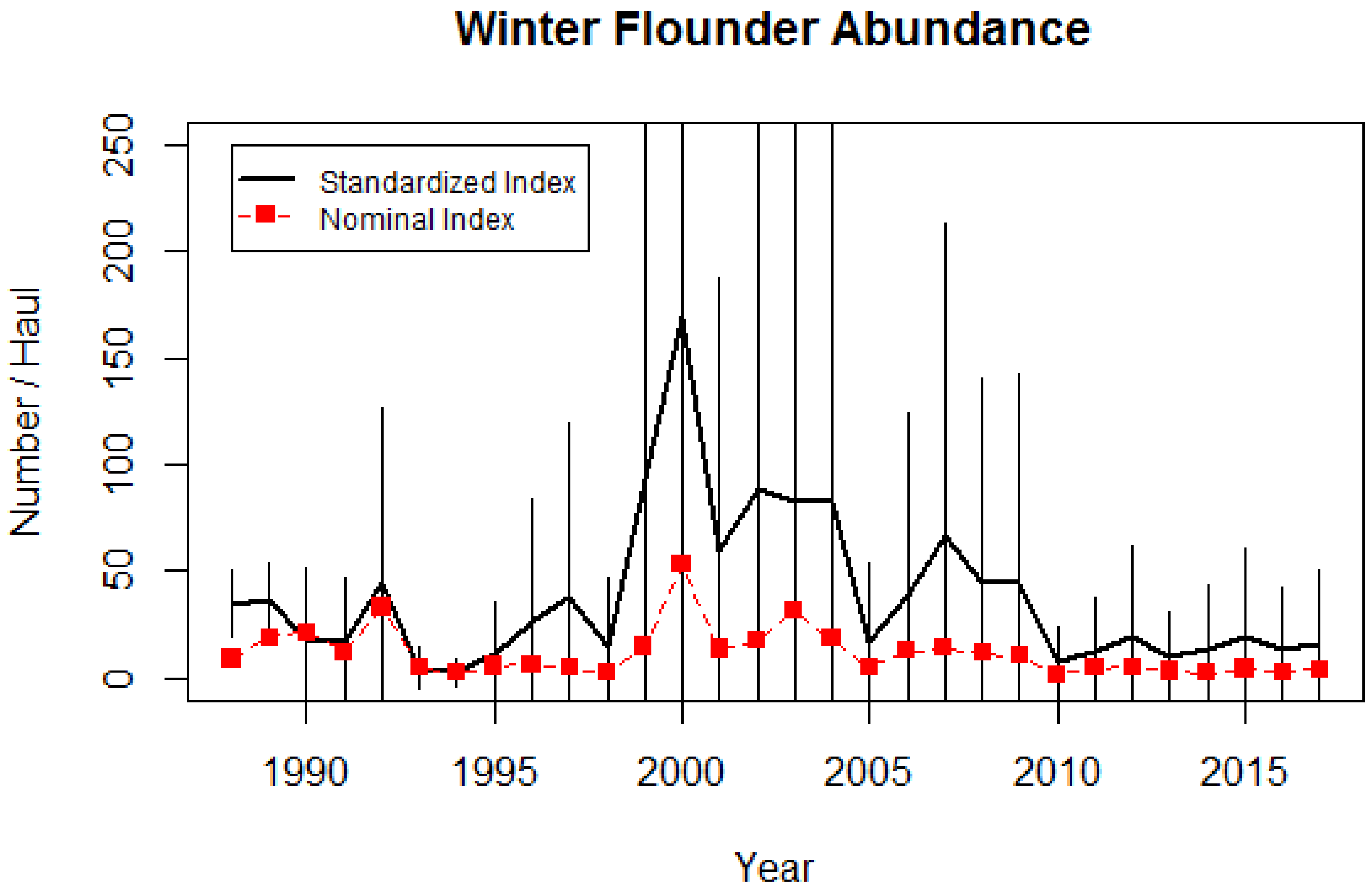


Figure 2. Juvenile winter flounder standardized abundance index 1988 – 2017 (see appendix A for standardization methodology).

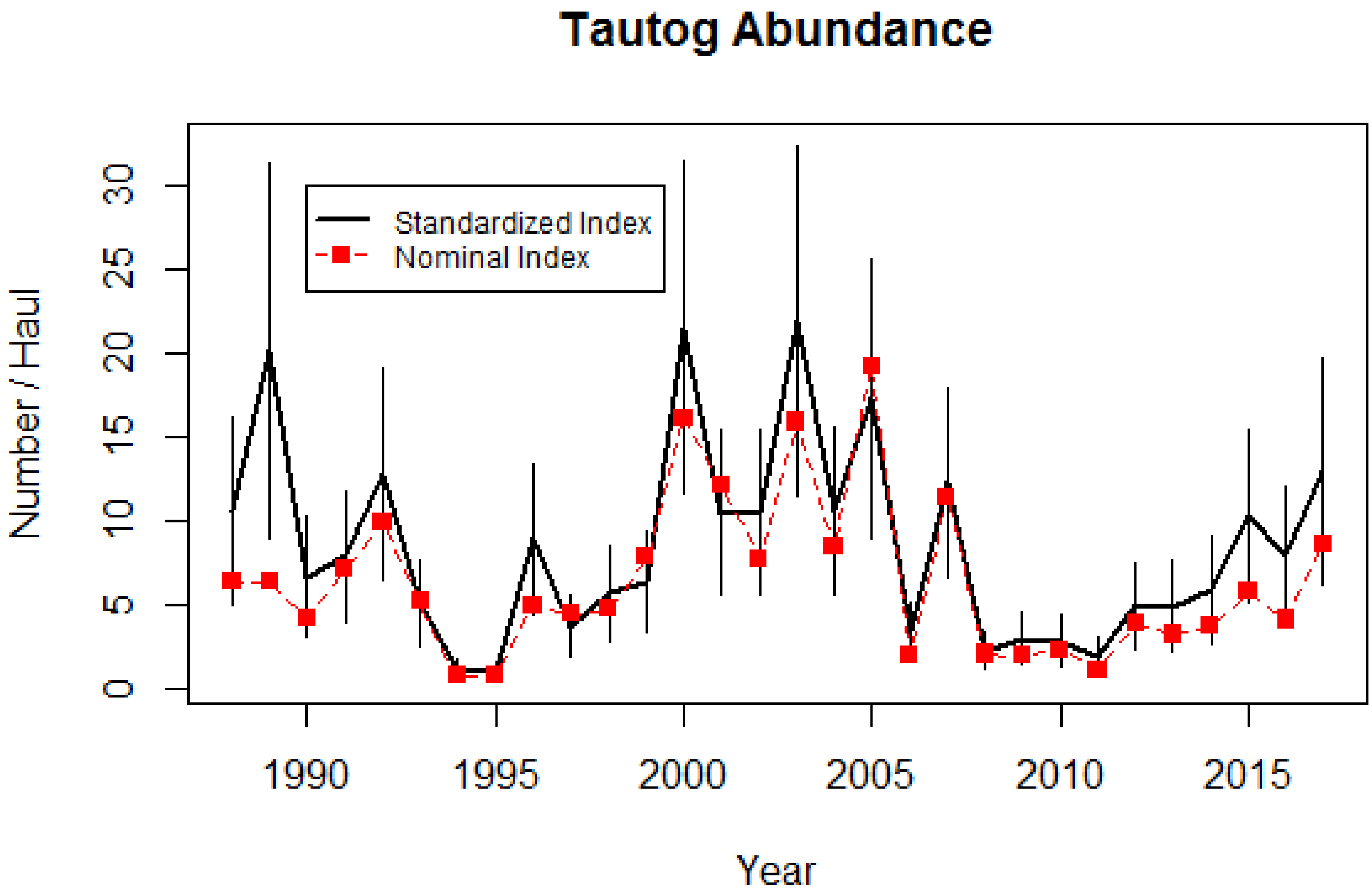


Figure 3. Juvenile tautog standardized annual abundance index 1988 – 2017 (see appendix A for standardization methodology).

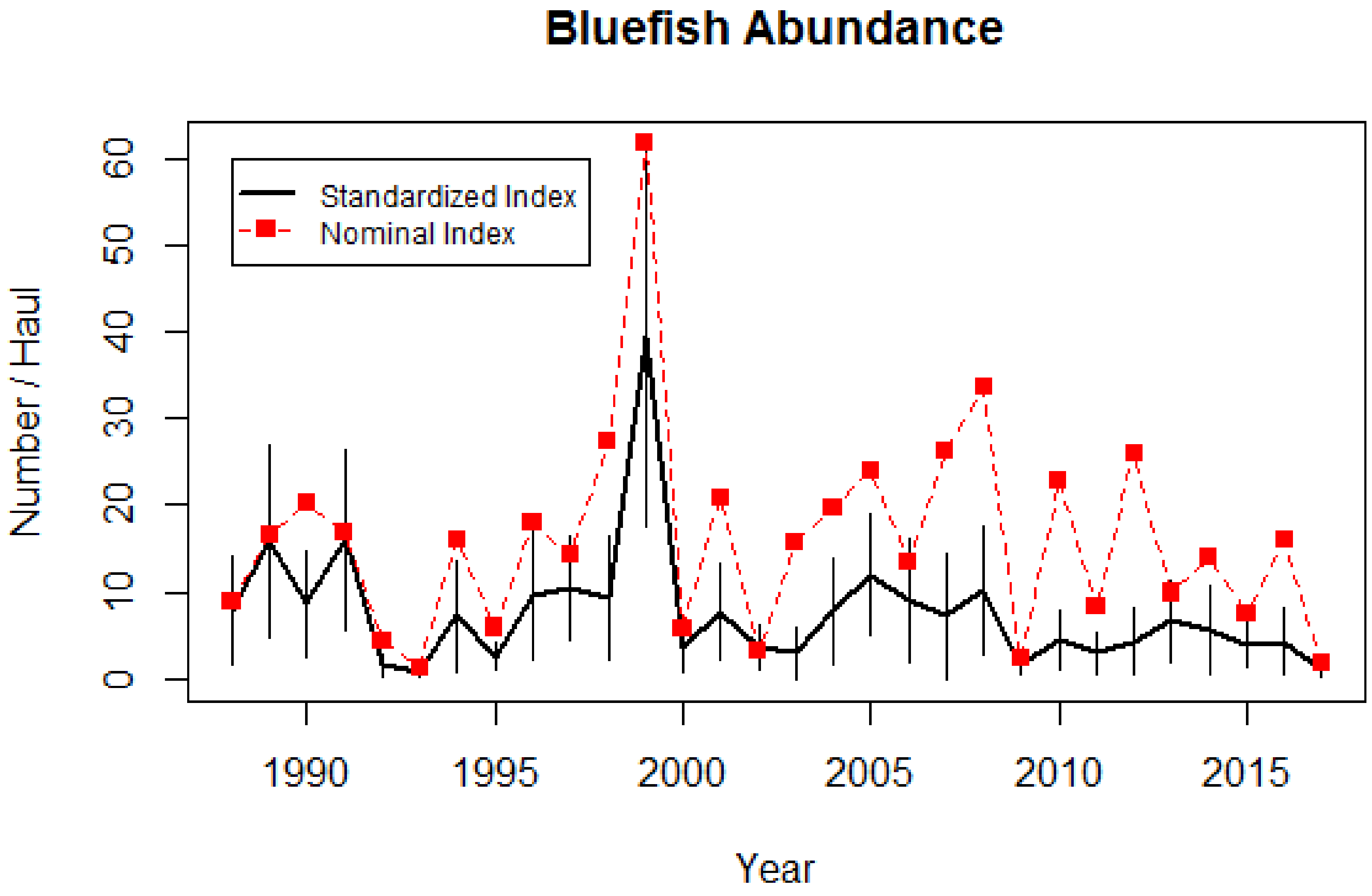


Figure 4. Juvenile bluefish standardized annual abundance index 1988 – 2017 (see appendix A for standardization methodology).

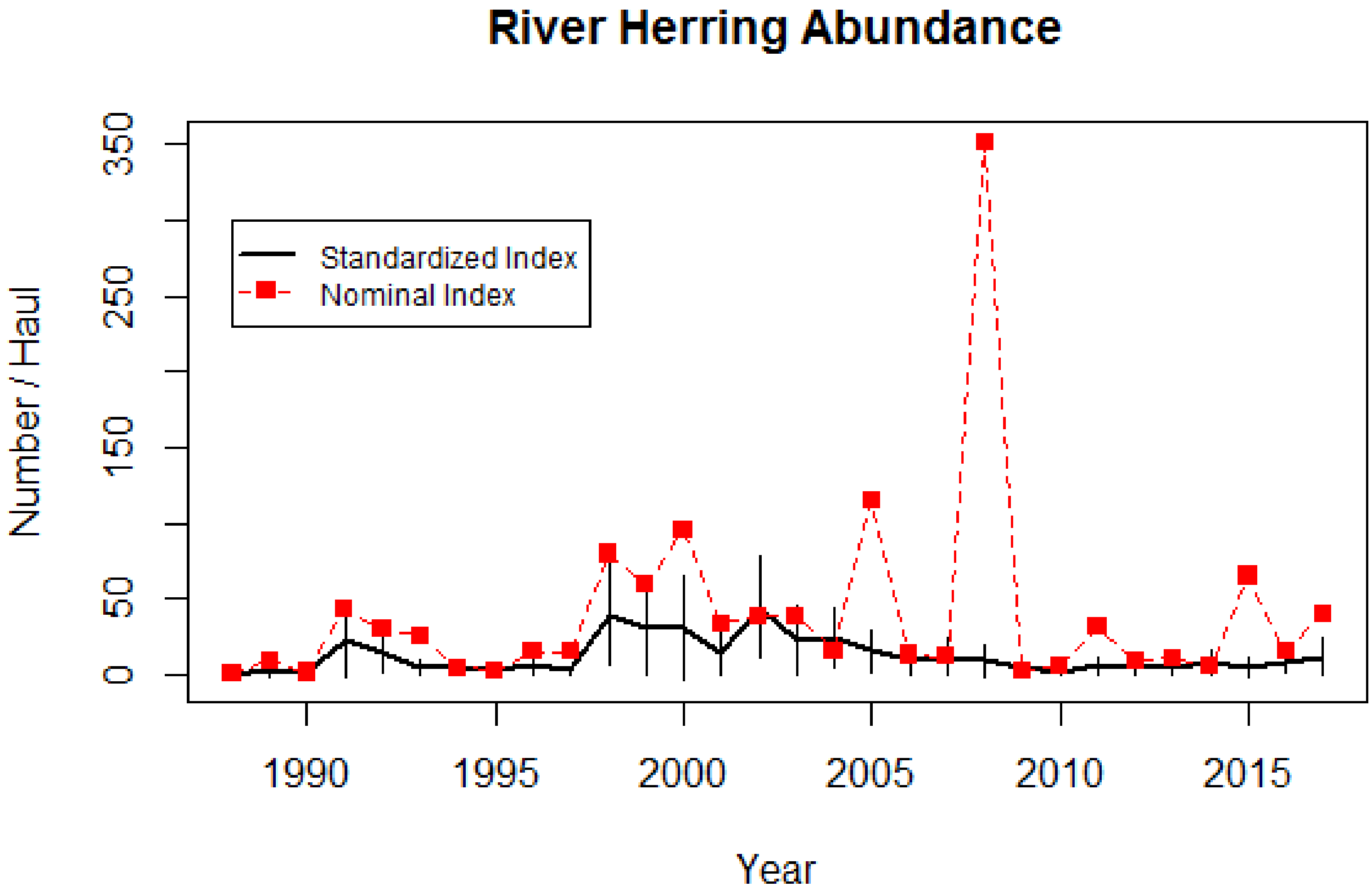
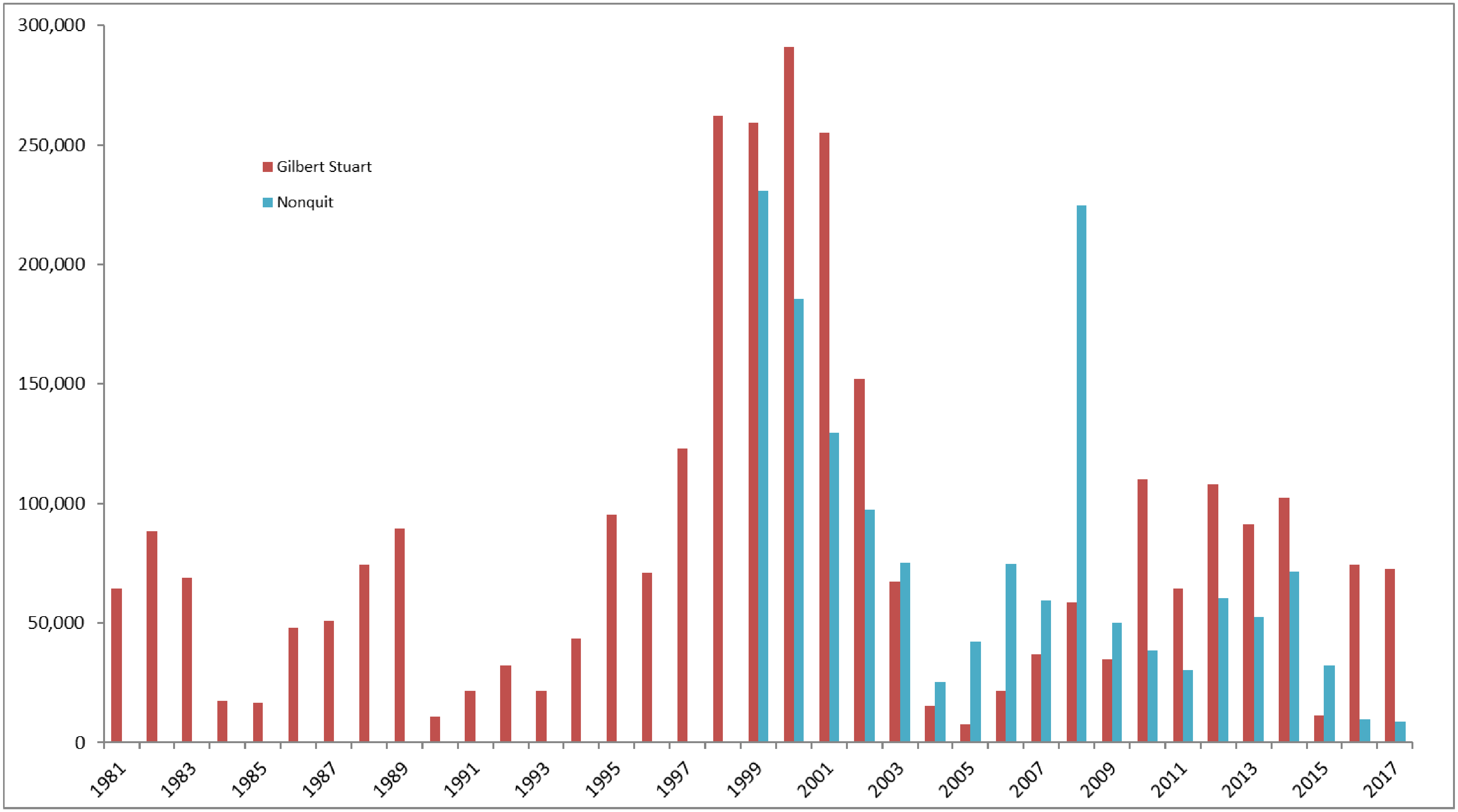


Figure 5. Juvenile river herring standardized annual abundance index 1988 – 2017 (see appendix A for standardization methodology).



Courtesy - Phil Edwards, RIF&W Anadromous Fish Restoration Program

Figure 6. River herring spawning stock size from monitoring at two locations 1999 – 2017.

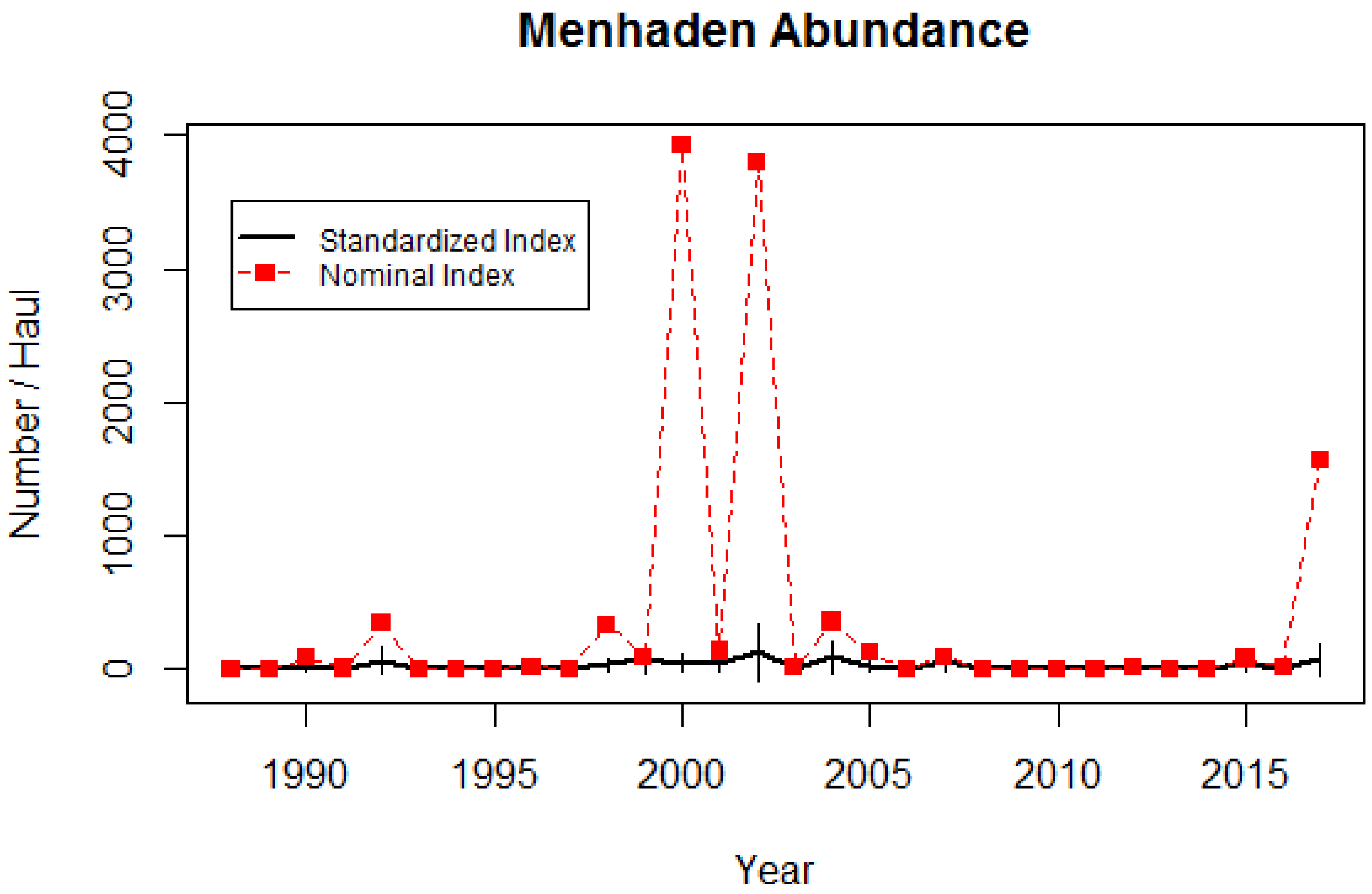


Figure 7. Juvenile menhaden standardized annual abundance index 1988 – 2017 (see appendix A for standardization methodology).

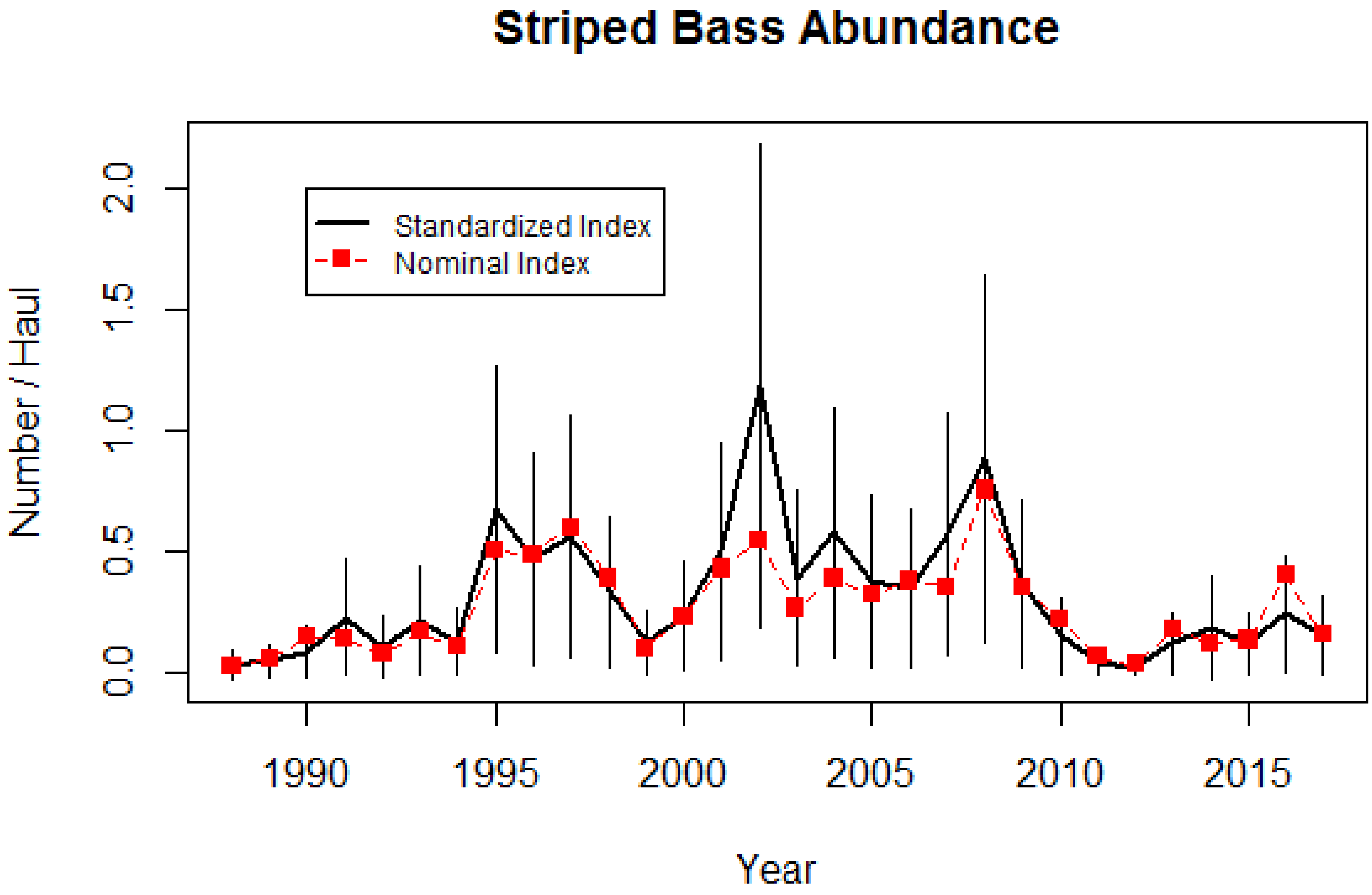


Figure 8. Striped bass standardized annual abundance index 1988 – 2017 (see appendix A for standardization methodology).

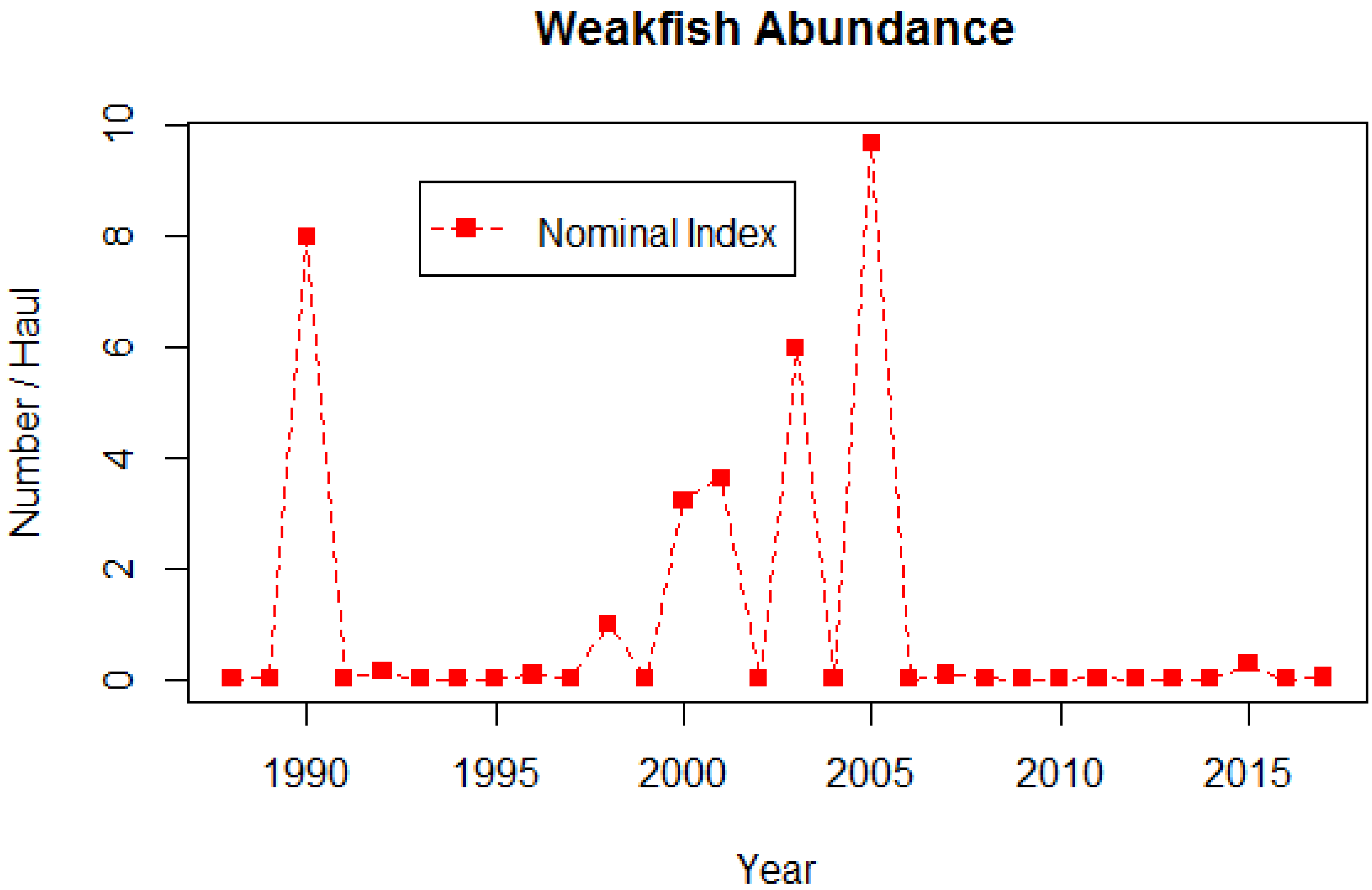


Figure 9. Weakfish annual abundance index 1988 – 2017.

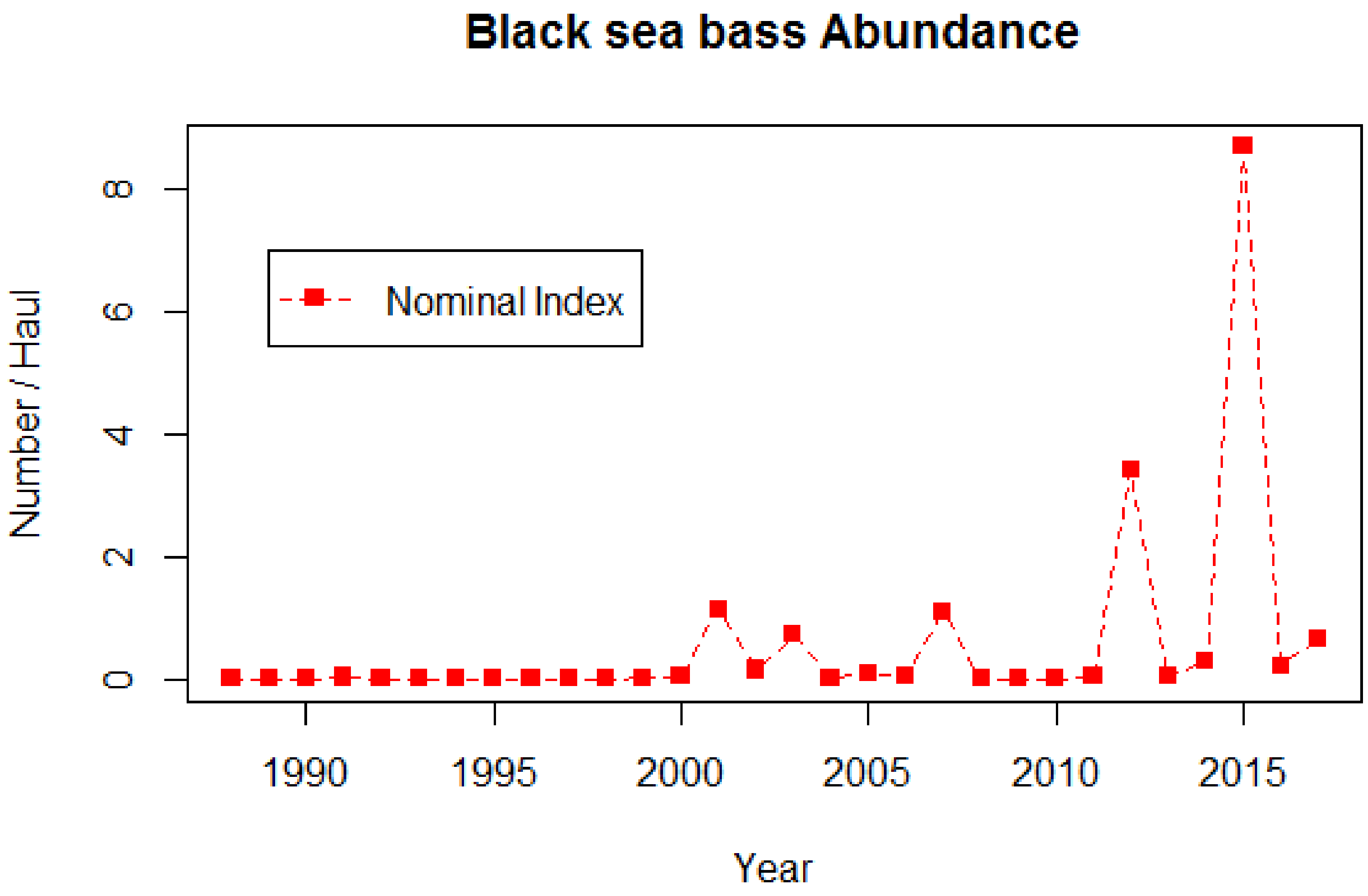


Figure 10. Black sea bass annual abundance index 1988 – 2017.

TABLES

Table 1a. Mann-Kendall test for target species abundance trend analysis (Full dataset; 1988 - 2017).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-39	-25	-101	13	47	23
n Observations	30	30	30	30	30	30
Variance	3141	3141	3141	3141	3141	3141
Tau	-0.0897	-0.0575	-0.232	0.0299	0.108	0.052
2-sided p value	0.4978	0.668	0.074	0.83	0.411	0.694
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	No	Borderline ↓	No	No	No

Table 1b. Mann-Kendall test for target species abundance trend analysis (2008 - 2017).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-5	33	-11	17	19	-5
n Observations	10	10	10	10	10	10
Variance	125	125	125	125	125	125
Tau	-0.111	0.733	-0.244	0.378	0.422	-0.111
2-sided p value	0.721	0.004	0.371	0.152	0.101	0.721
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	Yes ↑	No	No	No	No

Table 2. Young-of-the-Year (YOY) winter flounder - maximum total length for each month. *

Month	July	August	September	October
Max. YOY length (TL)	100 mm	107 mm	109 mm	115 mm

* data provided by L. Buckley, National Marine Fisheries Service, Narragansett Laboratory, Narragansett, R.I.

Table 3. Species presence by station for June 2017.

JUNE	**Station**																		
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1		1						1										3
Amphipoda order															1				1
Anchoa mitchilli	1																		1
Anguilla rostrata					1														1
Calinectes sapidus	1		1										1				1		4
Carcinus maenus					1						1	1	1						4
Crangon septemspinosa		1		1	1				1	1	1							1	7
Crepidula fornicata					1		1									1			3
Etropus microstomus																		1	1
Fundulus heteroclitus	1		1	1	1	1					1	1	1			1			9
Fundulus majalis	1	1	1			1			1		1		1	1					8
Gadus morhua										1						1			2
Gobiosoma bosc												1							1
Libinia emarginata			1	1					1				1				1		5
Limulus polyphemus		1	1					1	1									1	5
Menidia menidia	1	1	1	1		1		1	1		1		1	1		1	1	1	13
Menticirrhus saxatilis		1																	1
Microgadus tomcod	1	1			1					1		1	1			1	1		8
Morone saxatilis							1	1			1	1							4
Myoxocephalus aenaeus						1	1				1		1			1			5
Nassarius obsoletus			1	1		1						1		1					5
Neanthes succinea					1														1
Opsanus tau					1								1						2
Pagurus spp	1	1	1	1		1		1	1						1		1	1	10
Palaemonetes vulgaris	1	1		1		1					1	1	1	1	1	1	1	1	12
Panopeus spp	1		1		1	1			1		1		1	1	1				9
Pomatomus saltatrix																	1		1
Prionotus evolans				1													1		2
Pseudopleuronectes americanus	1	1	1	1	1			1	1		1		1		1		1	1	12
Scophthalmus aquosus															1				1
Sphoeroides maculatus		1				1													2
Syngnathus fuscus	1		1	1	1														4
Tautoga onitis		1		1	1	1				1		1	1			1	1		9
Tautogolabrus adspersus					1					1		1				1			4
Tunicata		1		1															2
Urophycis chuss										1						1		1	3
Urophycis regia						1				1				1	1				4

Table 4. Species presence by station for July 2017.

JULY	**Station**																		
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1		1				1	1			1		1	1	1		1	1	10
Amphipoda order										1									1
Anchoa mitchilli	1	1																	2
Anguilla rostrata					1														1
Brevoortia tyrannus													1						1
Busycotypus canaliculatus					1														1
Calinectes sapidus	1	1	1	1			1						1				1		7
Carcinus maenus		1			1				1							1			4
Centropristus striata														1					1
Clupea harengus						1													1
Crangon septemspinosa														1					1
Crassostrea virginica	1																		1
Ctenophora phylum		1						1					1			1	1		5
Cynoscion regalis													1						1
Cyprinodon variegatus																		1	1
Fundulus heteroclitus			1		1				1		1		1				1	1	7
Fundulus majalis	1	1	1	1		1		1	1		1		1	1	1		1	1	13
Gasterosteus aculeatus	1		1																2
Gobiosoma bosc		1	1																2
Hemigrapsus sanguineus						1													1
Lagodon Rhomoides													1						1
Leiostomus xanthurus																		1	1
Libinia emarginata			1	1			1	1	1						1		1		7
Limulus polyphemus													1				1		2
Menidia menidia	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	16
Menticirrhus saxatilis			1								1	1		1	1			1	6
Microgadus tomcod	1															1			2
Morone saxatilis	1																		1
Myoxocephalus aenaeus							1						1						2
Nassarius obsoletus		1	1	1	1								1	1			1		7
Pagurus spp	1	1						1	1		1				1		1	1	8
Palaemonetes vulgaris	1		1	1	1			1	1	1			1	1		1		1	11
Panopeus spp	1		1	1	1				1								1		6
Paralichthys dentatus	1			1															2
Peprilus triacanthus															1				1
Pomatomus saltatrix	1	1	1					1	1		1						1	1	8
Prionotus evolans	1															1		1	3
Pseudopleuronectes americanus	1	1	1	1	1				1		1		1	1	1	1	1		12
Sphoeroides maculatus	1	1				1	1				1		1	1	1			1	9
Stenotomus chrysops								1			1	1	1	1					5
Strongylura marina	1																	1	2
Syngnathus fuscus		1								1	1		1				1		5
Tautoga onitis	1				1	1	1		1	1		1	1	1		1	1		11
Tautogolabrus adspersus							1			1			1				1		4
Trachinotus falcatus															1				1

Table 5. Species presence by station for August 2017.

AUGUST	Station																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus		1		1				1			1								4
Anguilla rostrata					1														1
Brevoortia tyrannus			1	1						1									3
Busycon carica												1							1
Calinectes sapidus	1			1													1		3
Carcinus maenus					1					1			1				1		4
Centropristus striata								1				1	1	1	1		1		6
Crangon septemspinosa		1																	1
Crepidula fornicata									1										1
Cynoscion regalis				1															1
Cyprinodon variegatus									1					1					2
Etropus microstomus															1				1
Fundulus heteroclitus	1	1	1		1			1	1		1		1	1		1	1	1	12
Fundulus majalis	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	17
Gobiosoma bosc													1						1
Hippocampus genus												1							1
Isopoda order															1				1
Libinia emarginata		1			1											1			3
Limulus polyphemus																1			1
Loligo pealei											1								1
Lucania parva														1					1
Menidia menidia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Menticirrhus saxatilis	1	1		1	1			1				1			1		1	1	9
Microgadus tomcod													1						1
Mugil curema																		1	1
Myoxocephalus aenaeus						1			1				1				1		4
Nassarius obsoletus	1		1		1							1	1	1					6
Opsanus tau					1												1		2
Ovalipes ocellatus			1																1
Pagurus spp	1	1	1	1	1	1	1	1		1				1	1	1		1	13
Palaemonetes vulgaris			1	1	1	1			1		1	1	1	1			1		10
Panopeus spp	1		1		1			1			1				1		1		7
Pollachius virens										1									1
Pomatomus saltatrix															1			1	2
Prionotus carolinus															1				1
Prionotus evolans	1	1	1	1														1	5
Pseudopleuronectes americanus	1	1	1		1	1			1				1	1				1	9
Sphoeroides maculatus						1		1	1		1				1			1	6
Stenotomus chrysops	1		1	1	1		1		1		1				1		1	1	10
Strongylura marina																	1	1	2
Syngnathus fuscus	1	1			1					1	1	1					1		7
Tautoga onitis		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	16
Tautogolabrus adspersus						1			1					1		1	1		5

Table 6. Species presence by station for September 2017.

SEPTEMBER	**Station**																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1	1					1			1									4
Anguilla rostrata					1														1
Brevoortia tyrannus	1	1	1	1		1	1	1	1			1	1	1		1	1		13
Busycotypus canaliculatus												1							1
Calinectes sapidus		1	1																2
Carcinus maenus	1		1				1		1		1		1				1		7
Centropristus striata	1	1			1				1	1	1	1	1				1		9
Crangon septemspinosa													1						1
Ctenophora phylum						1	1			1	1	1		1					6
Cyprinodon variegatus									1		1					1			3
Etropus microstomus				1															1
Fundulus heteroclitus	1		1		1				1		1		1	1		1	1	1	10
Fundulus majalis	1	1	1	1	1	1		1	1		1		1	1		1	1	1	14
Gobiosoma bosc									1								1		2
Libinia emarginata	1												1		1				3
Limulus polyphemus																	1		1
Menidia menidia	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	17
Menticirrhus saxatilis	1	1	1						1	1	1	1						1	8
Mugil curema								1										1	2
Myoxocephalus aenaeus					1				1				1						3
Nassarius obsoletus			1	1				1			1		1	1					6
Opsanus tau					1														1
Ovalipes ocellatus												1							1
Pagurus spp		1		1				1	1		1	1	1					1	8
Palaemonetes vulgaris	1	1		1		1			1		1					1		1	8
Panopeus spp			1	1		1		1	1				1				1		7
Pholis gunnellus	1																		1
Pomatomus saltatrix		1	1				1	1	1							1			6
Prionotus carolinus		1																	1
Prionotus evolans	1			1														1	3
Pseudopleuronectes americanus	1	1		1	1				1	1	1	1	1				1	1	11
Sphoeroides maculatus						1						1							2
Stenotomus chrysops	1	1		1			1		1		1	1					1	1	9
Syngnathus fuscus				1	1				1			1	1						5
Tautoga onitis	1	1		1	1	1	1		1		1	1	1	1		1	1		13
Tautogolabrus adspersus					1		1		1			1				1	1		6
Urosalpinx cinerea									1										1

Table 7. Species presence by station for October 2017.

OCTOBER	**Station**																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1			1	1											1			4
Anchoa mitchilli					1			1								1			3
Apeltes quadracus			1										1						2
Brevoortia tyrannus				1	1						1	1	1	1		1	1		8
Carcinus maenus	1		1	1	1			1	1		1	1	1	1			1		11
Centropristus striata					1					1		1							3
Clupea harengus					1											1			2
Crangon septemspinosa	1		1	1											1	1			5
Crassostrea virginica									1										1
Crepidula fornicata									1						1				2
Ctenophora phylum						1		1		1		1	1	1			1	1	8
Cyprinodon variegatus		1	1						1		1			1			1		6
Etropus microstomus											1								1
Fundulus heteroclitus	1	1	1	1		1			1		1					1	1		9
Fundulus majalis	1	1	1	1	1	1		1	1	1	1		1	1	1	1	1		15
Gobiosoma bosc									1										1
Libinia emarginata												1				1			2
Menidia menidia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Menticirrhus saxatilis															1			1	2
Mercenaria mercenaria									1										1
Microgadus tomcod					1					1									2
Morone saxatilis								1								1			2
Myoxocephalus aenaeus		1			1	1						1							4
Nassarius obsoletus		1	1								1	1		1					5
Ovalipes ocellatus									1									1	2
Pagurus spp						1				1	1								3
Palaemonetes vulgaris		1	1		1	1					1		1	1		1			8
Panopeus spp		1	1	1	1			1	1				1						7
Pomatomus saltatrix					1														1
Prionotus carolinus																		1	1
Prionotus evolans																		1	1
Pseudopleuronectes americanus	1	1	1	1	1	1								1				1	8
Sphyraena borealis										1									1
Syngnathus fuscus		1		1						1			1			1			5
Tautoga onitis		1	1		1	1		1	1	1		1				1	1	1	11
Tautogolabrus adspersus					1	1			1	1						1	1	1	7

Table 8. Summary of species occurrence by station in 2017.

ALL MONTHS	**Station**																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	16
Amphipoda order										1					1				2
Anchoa mitchilli	1	1			1			1								1			5
Anguilla rostrata					1														1
Apeltes quadracus			1										1						2
Brevoortia tyrannus	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1		16
Busycon carica												1							1
Busycotypus canaliculatus					1							1							2
Calinectes sapidus	1	1	1	1			1						1				1		7
Carcinus maenus	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1		15
Centropristus striata	1	1			1			1	1	1	1	1	1	1	1		1		12
Clupea harengus					1	1										1			3
Crangon septemspinosa	1	1	1	1	1				1	1	1		1	1	1	1		1	13
Crassostrea virginica	1								1										2
Crepidula fornicata					1		1		1						1	1			5
Ctenophora phylum		1				1	1	1		1	1	1	1	1		1	1	1	12
Cynoscion regalis				1									1						2
Cyprinodon variegatus		1	1						1		1			1		1	1	1	8
Etropus microstomus				1							1				1			1	4
Fundulus heteroclitus	1	1	1	1	1	1		1	1		1	1	1	1		1	1	1	15
Fundulus majalis	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	17
Gadus morhua										1						1			2
Gasterosteus aculeatus	1		1																2
Gobiosoma bosc		1	1						1			1	1				1		6
Hemigrapsus sanguineus						1													1
Hippocampus genus												1							1
Isopoda order															1				1
Lagodon Rhomoides													1						1
Leiostomus xanthurus																		1	1
Libinia emarginata	1	1	1	1	1		1	1	1			1	1		1	1	1		13
Limulus polyphemus		1	1					1	1				1			1	1	1	8
Loligo pealei											1								1
Lucania parva														1					1
Menidia menidia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Menticirrhus saxatilis	1	1	1	1	1			1	1	1	1	1		1	1		1	1	14
Mercenaria mercenaria									1										1
Microgadus tomcod	1	1			1					1		1	1			1	1		8
Morone saxatilis	1						1	1			1	1				1			6
Mugil curema								1										1	2
Myoxocephalus aenaeus		1			1	1	1		1		1	1	1			1	1		10
Nassarius obsoletus	1	1	1	1	1	1		1			1	1	1	1			1		12
Neanthes succinea					1														1
Opsanus tau					1								1				1		3
Ovalipes ocellatus			1						1			1						1	4
Pagurus spp	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Palaemonetes vulgaris	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	17
Panopeus spp	1	1	1	1	1	1		1	1		1		1	1	1		1		13
Paralichthys dentatus	1			1															2
Peprilus triacanthus															1				1
Pholis gunnellus	1																		1
Pollachius virens										1									1
Pomatomus saltatrix	1	1	1		1		1	1	1		1				1	1	1	1	12
Prionotus carolinus		1													1			1	3
Prionotus evolans	1	1	1	1												1	1	1	7
Pseudopleuronectes americanus	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	17
Scophthalmus aquosus															1				1
Sphoeroides maculatus	1	1				1	1	1	1		1	1	1	1	1			1	12
Sphyraena borealis										1									1
Stenotomus chrysops	1	1	1	1	1		1	1	1		1	1	1	1	1		1	1	15
Strongylura marina	1																1	1	3
Syngnathus fuscus	1	1	1	1	1				1	1	1	1	1			1	1		12
Tautoga onitis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Tautogolabrus adspersus					1	1	1		1	1		1	1	1		1	1	1	11
Trachinotus falcatus															1				1
Tunicata		1		1															2
Urophycis chuss										1						1		1	3
Urophycis regia						1				1				1	1				4
Urosalpinx cinerea									1										1

* The units are number of times present at each station (maximum would be 18 times present for a species at all stations for the year).

Table 9. Numbers of juvenile winter flounder per seine haul in 2017.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	27	19	22	10	6	0	0	1	5	0	37	0	59	0	1	0	4	10	11.17	16.19	3.82
JUL	4	5	16	5	3	0	0	0	6	0	6	0	27	2	2	1	8	0	4.72	6.88	1.62
AUG	5	1	3	0	5	3	0	0	5	0	0	0	5	1	0	0	0	5	1.83	2.23	0.53
SEP	3	1	0	3	4	0	0	0	10	1	1	3	2	0	0	0	1	2	1.72	2.44	0.58
OCT	1	1	4	3	2	1	0	0	0	0	0	0	0	1	0	0	0	3	0.89	1.28	0.30
Mean	8.00	5.40	9.00	4.20	4.00	0.80	0.00	0.20	5.20	0.20	8.80	0.60	18.60	0.80	0.60	0.20	2.60	4.00			
St Dev	10.72	7.80	9.49	3.70	1.58	1.30	0.00	0.45	3.56	0.45	15.96	1.34	25.05	0.84	0.89	0.45	3.44	3.81		Total Fish	
SE	4.80	3.49	4.24	1.66	0.71	0.58	0.00	0.20	1.59	0.20	7.14	0.60	11.20	0.37	0.40	0.20	1.54	1.70		366	
Number	40	27	45	21	20	4	0	1	26	1	44	3	93	4	3	1	13	20			

Table 10. Numbers of juvenile tautog per seine haul in 2017.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	5	0	1	9	2	0	0	0	5	0	7	3	0	0	6	0	0	2.11	2.97	0.70
JUL	1	0	0	0	1	1	9	0	4	6	0	2	32	2	0	1	8	0	3.72	7.61	1.79
AUG	0	5	8	3	115	4	3	0	30	1	3	5	19	12	1	4	27	12	14.00	26.73	6.30
SEP	3	12	0	1	164	8	9	0	47	0	1	9	38	1	0	16	18	0	18.17	38.78	9.14
OCT	0	1	3	0	24	8	0	1	13	2	0	3	0	0	0	18	12	4	4.94	7.18	1.69
Mean	0.80	4.60	2.20	1.00	62.60	4.60	4.20	0.20	18.80	2.80	0.80	5.20	18.40	3.00	0.20	9.00	13.00	3.20			
St Dev	1.30	4.72	3.49	1.22	72.78	3.29	4.55	0.45	19.54	2.59	1.30	2.86	16.92	5.10	0.45	7.55	10.20	5.22		Total Fish	
SE	0.58	2.11	1.56	0.55	32.55	1.47	2.03	0.20	8.74	1.16	0.58	1.28	7.57	2.28	0.20	3.38	4.56	2.33		773	
Number	4	23	11	5	313	23	21	1	94	14	4	26	92	15	1	45	65	16			

Table 11. Numbers of juvenile bluefish per seine haul in 2017.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.06	0.24	0.06
JUL	1	13	22	0	0	0	0	52	6	0	1	0	0	0	0	0	1	25	6.72	13.74	3.24
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.11	0.32	0.08
SEP	0	3	1	0	0	0	1	24	3	0	0	0	0	0	0	6	0	0	2.11	5.70	1.34
OCT	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.71	0.17
Mean	0.20	3.20	4.60	0.00	0.60	0.00	0.20	15.20	1.80	0.00	0.20	0.00	0.00	0.00	0.20	1.20	0.40	5.20			
St Dev	0.45	5.63	9.74	0.00	1.34	0.00	0.45	23.05	2.68	0.00	0.45	0.00	0.00	0.00	0.45	2.68	0.55	11.08		Total Fish	
SE	0.20	2.52	4.35	0.00	0.60	0.00	0.20	10.31	1.20	0.00	0.20	0.00	0.00	0.00	0.20	1.20	0.24	4.95		165	
Number	1	16	23	0	3	0	1	76	9	0	1	0	0	0	1	6	2	26			

Table 12. Numbers of juvenile menhaden per seine haul in 2017.

	Station																			
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.06	0.24	0.06
AUG	0	0	1485	400	0	0	0	0	0	1	0	0	0	0	0	0	0	0	104.78	357.08	84.16
SEP	9	3	132040	1	0	1	3696	3	378	0	0	149	1	1	0	11	1	0	7571.89	31075.23	7324.50
OCT	0	0	0	5	2	0	0	0	0	0	43	1	7	3	0	2	2354	0	134.28	554.06	130.59
Mean	1.80	0.60	26705.00	81.20	0.40	0.20	739.20	0.60	75.60	0.20	8.60	30.00	1.80	0.80	0.00	2.60	471.00	0.00			
St Dev	4.02	1.34	58887.57	178.23	0.89	0.45	1652.90	1.34	169.05	0.45	19.23	66.52	2.95	1.30	0.00	4.77	1052.63	0.00		Total Fish	
SE	1.80	0.60	26335.32	79.71	0.40	0.20	739.20	0.60	75.60	0.20	8.60	29.75	1.32	0.58	0.00	2.14	470.75	0.00		140,598	
Number	9	3	133525	406	2	1	3696	3	378	1	43	150	9	4	0	13	2355	0			

Table 13. Numbers of juvenile river herring per seine haul in 2017.

	Station																			
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0.17	0.38	0.09
JUL	67	0	4	0	0	0	2	276	0	0	106	0	1	508	1	0	24	6	55.28	131.86	31.08
AUG	0	42	0	2032	0	0	0	1	0	0	11	0	0	0	0	0	0	0	115.89	478.30	112.74
SEP	4	4	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0.67	1.37	0.32
OCT	1	0	0	2	463	0	0	0	0	0	0	0	0	0	0	31	0	0	27.61	108.90	25.67
Mean	14.60	9.20	1.00	406.80	92.60	0.00	0.80	55.40	0.20	0.40	23.40	0.00	0.20	101.60	0.20	6.20	4.80	1.20			
St Dev	29.33	18.42	1.73	908.51	207.06	0.00	1.10	123.32	0.45	0.89	46.42	0.00	0.45	227.18	0.45	13.86	10.73	2.68		Total Fish	
SE	13.12	8.24	0.77	406.30	92.60	0.00	0.49	55.15	0.20	0.40	20.76	0.00	0.20	101.60	0.20	6.20	4.80	1.20		3593	
Number	73	46	5	2034	463	0	4	277	1	2	117	0	1	508	1	31	24	6			

Table 14. Numbers of striped bass per seine haul in 2017.

	Station																			
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	0	0	0	0	0	1	1	0	0	3	4	0	0	0	0	0	0	0.50	1.15	0.27
JUL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0.24	0.06
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
SEP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
OCT	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0.22	0.73	0.17
Mean	0.20	0.00	0.00	0.00	0.00	0.00	0.20	0.40	0.00	0.00	0.60	0.80	0.00	0.00	0.00	0.60	0.00	0.00			
St Dev	0.45	0.00	0.00	0.00	0.00	0.00	0.45	0.55	0.00	0.00	1.34	1.79	0.00	0.00	0.00	1.34	0.00	0.00		Total Fish	
SE	0.20	0.00	0.00	0.00	0.00	0.00	0.20	0.24	0.00	0.00	0.60	0.80	0.00	0.00	0.00	0.60	0.00	0.00		14	
Number	1	0	0	0	0	0	1	2	0	0	3	4	0	0	0	3	0	0			

Table 15. Temperature, salinity, and dissolved oxygen by station and month – 2017 (NA indicates a day where batteries failed on YSI).

		Month					
Station		**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**Total Average**
1	Temperature (C)	21.8	20.8	23.8	21.7	17.6	21.14
	Salinity	16	15.2	22.4	25.8	26.8	21.24
	Dissolved Oxygen	9.1	6.14	7.32	9.15	8.1	7.96
2	Temperature (C)	22.6	21.2	23.8	21.6	16.8	21.20
	Salinity	18.3	18.9	23.3	26.4	26.6	22.70
	Dissolved Oxygen	12.58	5.89	6.86	10.4	9.03	8.95
3	Temperature (C)	23.3	20.4	25.7	21.6	17.1	21.62
	Salinity	24.9	20.5	25.8	26.9	26.4	24.90
	Dissolved Oxygen	8.67	6.8	6.42	5.77	7.15	6.96
4	Temperature (C)	23.6	24.1	25.4	21	16.5	22.12
	Salinity	23.6	24.8	25.6	27.5	26	25.50
	Dissolved Oxygen	9.9	5.25	7.39	7.38	7.42	7.47
5	Temperature (C)	22.5	21.3	23.8	20.1	20.1	21.56
	Salinity	24.9	1.1	27.1	27.4	28.2	21.74
	Dissolved Oxygen	7.08	6.16	6.11	8.5	5.81	6.73
6	Temperature (C)	19.7	22.7	21.6	19.8	20	20.76
	Salinity	26.6	26.7	27.7	28.2	28.6	27.56
	Dissolved Oxygen	9.93	8.58	7.4	6.44	8.35	8.14
7	Temperature (C)	18.6	21.3	21.1	20.4	20.2	20.32
	Salinity	27.5	27.2	28	28.5	28.7	27.98
	Dissolved Oxygen	8.3	7.56	8.06	7.88	9.11	8.18
8	Temperature (C)	19.5	25.5	23.2	22	20.3	22.10
	Salinity	26	25.1	26.6	27.5	28.1	26.66
	Dissolved Oxygen	9.22	5.9	6.93	9.4	6.67	7.62
9	Temperature (C)	19.3	24.1	22.8	20.8	19.7	21.34
	Salinity	26.1	26.2	27	27.8	28.3	27.08
	Dissolved Oxygen	10.5	7.09	7.39	7.71	6.87	7.91
10	Temperature (C)	15.4	19.8	19	21.4	18.6	18.84
	Salinity	28.4	27.8	28.5	27	29	28.14
	Dissolved Oxygen	8.58	6.91	8.05	7.54	6.39	7.49
11	Temperature (C)	20.7	24.7	24.5	22.9	17.6	22.08
	Salinity	23.2	24.4	25.9	27.4	26.6	25.50
	Dissolved Oxygen	7.77	6.02	8.4	7.23	8.01	7.49
12	Temperature (C)	21.2	24.3	23.6	20.9	16.5	21.30
	Salinity	23.2	24.9	25.9	27.2	27.7	25.78
	Dissolved Oxygen	10.54	8.73	5.63	7.82	7.34	8.01
13	Temperature (C)	20.7	22.1	25.4	21.6	NA	22.45
	Salinity	26.8	26.9	27.2	27.9	NA	27.20
	Dissolved Oxygen	7.77	7.75	9.35	6.62	NA	7.87
14	Temperature (C)	20.3	22	23.3	20.5	NA	21.53
	Salinity	27.7	27.6	27.8	28.2	NA	27.83
	Dissolved Oxygen	9.03	7.65	7.61	8.61	NA	8.23
15	Temperature (C)	19.5	20.2	21.5	NA	NA	20.40
	Salinity	28	28.1	28.3	NA	NA	28.13
	Dissolved Oxygen	8.83	6.75	7.37	NA	NA	7.65
16	Temperature (C)	17.1	22.4	20.9	19.9	19.1	19.88
	Salinity	27	11.6	27.5	28.2	28.8	24.62
	Dissolved Oxygen	10.07	8.21	7.08	3.51	7.35	7.24
17	Temperature (C)	22.9	25.6	23.8	20.4	20.6	22.66
	Salinity	23.5	22.6	26	27.3	27.7	25.42
	Dissolved Oxygen	9.56	6.63	6.55	8.1	6.86	7.54
18	Temperature (C)	19.7	22	21.9	19.8	20.6	20.80
	Salinity	26.8	26.5	27.4	28	28.7	27.48
	Dissolved Oxygen	8.41	6.9	6.67	6.22	7.33	7.11

APPENDIX A

Standardized Index Development – Delta Lognormal

Menhaden, Bluefish, River Herring

The standardized indices for 2 of the main target species of the survey considered five factors as possible influences on the indices of abundance, which are summarized below:

Factor	**Levels**	**Value**
Year	30	1988-2017
Month	5	June - October
Temperature (°C)	Continuous	
Salinity (ppt)	Continuous	
Station	18	18 fixed stations throughout bay

The delta lognormal model approach (Lo et al., 1992) was used to develop standardized indices of abundance for the seine survey data. This method combines separate generalized linear model (GLM) analyses of the proportion of successful hauls (i.e. hauls that caught winter flounder) and the catch rates on successful hauls to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure in the R statistical software package (dglm function see: http://www.sefsc.noaa.gov/sedar/download/SEDAR17-RD16%20User%20Guide%20Delta-GLM%20function%20for%20R%20languageenvironment%20(Ver.%201.7.2,%2007-06-2006).pdf?id=DOCUMENT).

For each GLM procedure of proportion positive trips, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a model assuming lognormal error distribution was examined.

The final models for the analysis of catch rates on successful trips, in all cases were:

Ln(catch) = Year + Month + Station + Temperature + Salinity

The final models for the analysis of the proportion of successful hauls, in all cases including menhaden, were:

Success = Year + Month + Station + Temperature + Salinity

Standardized Index Development – Negative Binomial Generalized Linear Model

Winter Flounder, Tautog, Striped Bass

The standardized indices for 3 of the main target species of the survey considered up to six factors as possible influences on the indices of abundance, which are summarized below:

Species	Factor	Levels	Value
Winter Flounder	Year	30	1988-2017
	Station Periods	4	Stations were added to the survey on 3 separate occasions (station 16 added June 1990, station 17 added July 1993, station 18 added July 1995)
	Temperature (°C)	Continuous	
	Salinity (ppt)	Continuous	
	Station	18	18 fixed stations throughout bay
Tautog	Year	30	1988-2017
	Station Periods	4	Stations were added to the survey on 3 separate occasions (station 16 added June 1990, station 17 added July 1993, station 18 added July 1995)
	Station	18	18 fixed stations throughout bay
Striped Bass	Year	30	1988-2017
	Station Periods	4	Stations were added to the survey on 3 separate occasions (station 16 added June 1990, station 17 added July 1993, station 18 added July 1995)
	Temperature (°C)	Continuous	
	Salinity (ppt)	Continuous	
	Station	18	18 fixed stations throughout bay
	Month	5	June - October

The negative binomial generalized linear model approach was used to develop standardized indices of abundance for the seine survey data. This method produces a generalized linear model (GLM) for the catch rates on all hauls to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure in the R statistical software package, the code of which was modified from Nelson and Coreia of the Northeast Fishery Science Center (personal communication).

During the analysis of catch rates on hauls, a model assuming a negative binomial error distribution was examined. The linking function selected was "log", and the response variable was abundance (count) for each individual haul where one of the three species was caught.

A stepwise approach was used to quantify the relative importance of the factors. First a GLM model was fit on year. These results reflect the distribution of the nominal data. Next, each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$). This model then became the base model, and the process was repeated, adding factors individually until no factor met the criteria for incorporation into the final model.

The final models for the analysis of catch rates were:

Winter Flounder: Abundance = Year + Temperature + Station + Station Periods
Tautog: Abundance = Year + Temperature + Station + Salinity
Striped Bass: Abundance = Year + Station

Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Waters

2017 Annual Performance Report for Job VI, Part A:

Assessment, Protection, and Enhancement of Fish Habitat to Sustain Coastal and Marine Ecosystems and Healthy Stocks of Recreationally Important Finfish:

Assessing, Monitoring, and Minimizing Impacts to Marine Habitat

Prepared by: Eric G. Schneider and Patrick D. Barrett (RI DEM Div. of Marine Fisheries Principal Marine Fisheries Biologist and Fisheries Specialist, respectively),

Reporting elements related to Objective 1 prepared by: William Helt and Heather Kinney (TNC RI Chapter, Coastal Restoration Scientist and Coastal Restoration Science Technician, respectively)

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Division of Fish and Wildlife, Marine Fisheries
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Federal Aid in Sportfish Restoration
F-61-R

2017 Performance Report for Job VI, Part A March 27, 2017

PERFORMANCE REPORT

STATE: Rhode Island

PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 21

PROJECT TITLE: Assessing, Monitoring, and Minimizing Impacts to Marine Habitat

PERIOD COVERED: January 1, 2017 - December 31, 2017

JOB NUMBER AND TITLE: VI, Part A: Assessment, Protection, and Enhancement of Fish Habitat to Sustain Coastal and Marine Ecosystems and Healthy Stocks of Recreationally Important Finfish: initial project area Providence-Seekonk Tidal Estuaries (head of Narragansett Bay)

STAFF: Eric G. Schneider and Patrick D. Barrett (RI DEM Div. of Marine Fisheries Principal Marine Fisheries Biologist and Fisheries Specialist, respectively)

Note: Reporting elements related to Objective 1 provided by: William Helt and Heather Kinney (TNC RI Chapter, Coastal Restoration Scientist and Coastal Restoration Science Technician, respectively)

JOB OBJECTIVE: The goal of this project is to assess, protect, enhance, and restore important marine habitat to support healthy marine ecosystems and stocks of recreationally important finfish. We will obtain this goal by addressing the following objectives:

(1) Identify, assess, and monitor sensitive and important marine habitat in Rhode Island (RI) waters in concert with developing a RI Marine Habitat Management and Restoration Plan through a regional approach, starting at the Head of Narragansett Bay.
(2) Provide a comprehensive review of permit applications for projects that occur in RI waters and may directly or indirectly impact coastal and marine resources and their habitat, including economic development projects, such as energy, infrastructure, dredging, and dredge spoil disposal projects, as well as aquaculture and habitat restoration projects.
(3) Respond to major fish kills and assess habitat conditions, and in the event of a significant environmental incident, coordinate hazard mitigation, assessment of natural resource damages, and resulting habitat restoration.

SUMMARY: This report summarizes all work conducted for this project between January 1 and December 31, 2017. During this period, we focused on aspects related to the three aforementioned objectives.

To address Objective 1, a total of 72 seines were hauled across 12 sites resulting in the identification of 40 distinct species (see Appendix). Of the five target species in this study, four were caught in the seines: scup, summer flounder, tautog, and winter flounder.
In addition, a total of 20 successful video transects were completed. Both a qualitative whole-video review (QWVR) and a quantitative analysis using the Coastal and Marine Ecological

Classification Standard (CMECS) (FGDC 2012) were used to evaluate the video footage. Video analysis is currently underway. HOBO Salt Water Conductivity/Salinity Data Loggers were placed at all 12 sites, while HOBO Dissolved Oxygen Data Loggers were placed at three sites (Pawtucket Boat Ramp, Sabin Point, and Gaspee Point). A total of 33,235 instances were recorded, containing temperature (°C), salinity (ppt), and dissolved oxygen (mg/L). The location for the fish pot sites were determined and deployed 14 times during the months of August-October to test feasibility and sampling protocol. A total of nine species were caught in the pots during this time including 26 finfish and 63 invertebrates.

To address Objective 2, the DMF reviewed 51 projects and applications as part of its Environmental Review program during the 2016 calendar year, excluding aquaculture application reviews, which are reported separately. Verbal comment was provided on all general permit reviews through the monthly general permit meeting at the RI Coastal Resource Management Council (CRMC) with the U.S. Army Corps of Engineers (USACE). We reviewed and responded to all dredging project applications and provided dredge windows for all projects, as well as comments on specific habitat-related concerns (e.g., requested a max dredge depth of 6' to avoid a "dead flushing" zone that would exacerbate hypoxia in summer months). Applications for residential dock permits were largely new requests and did not encroach on known eelgrass beds or critical habitat.

This past year, the DMF participated in and formulated responses for 13 preliminary determination meetings with aquaculture applicants. The meetings are designed to allow participants to voice any concerns, including those related to fish and fish habitat. We also provided formal, written responses for over 10 public noticed lease applications, and held RI Marine Fishery Council (RIMFC) Advisory Panel meetings to gain input from industry on aquaculture sites for the RIMFC and to provide scientific opinion to the Council regarding the sites. We coordinated all responses with RI DEM Fish and Wildlife Program for waterfowl habitat and hunting concerns, and drafted DMF official response letters related to fish habitat impacts that were identified through a detailed review of applications for new and modifications to aquaculture leases starting in Jan 2017.

As a result of frequent concerns with protecting fish habitat, the DMF developed the state's first spatial database of all active and proposed aquaculture sites in state waters. This database is and will be used, along with other spatial use layers, by the DMF to better understand potential habitat and public use conflicts with newly proposed aquaculture locations. The Division has made the active sites layer public via an interactive map on the Department's website: http://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=8beb98d758f14265a84d69758d96742f. This interactive map features mapping tools for future applicants to aid in the site selection process and help them avoid areas of public use or historic eelgrass habitat.

To address Objective 3, RI DMF participated in the initial phases of developing Geographic Response Plans (GRPs) for the Blackstone and Pawtuxet Rivers in RI. GRPs are response plans tailored to protect specific sensitive areas from oil spill impacts. They show first responders where sensitive areas are located and where to place oil spill protection resources to protect those areas. RI DMF responded to one reported fish kill (scup) during May of 2017. It was determined that this event was related to fishery discards and not related to environmental aspects.

TARGET DATE: December 31, 2017

DEVIATIONS: There were no significant deviations from the timeline proposed in the current grant.

RECOMMENDATIONS: We recommend continuing to work closely with TNC through the ongoing cooperative agreement to assess the waters at the Head of the Bay in summer 2018, characterize the fish communities and habitat conditions in this formerly highly polluted area, and highlight areas that may be conducive to habitat restoration or enhancement opportunities. We also recommend continuing to collaborate with Dr. Giancarlo Cicchetti of EPA AED and Dr. Emily Shumchenia on work that is presently funded by EPA under Biological Condition Gradient efforts with local National Estuary Programs, including the NBEP based on the supposition that the they may be interested in a collaborative effort to complete a SPI survey at the Head of the Bay.

We recommend continued sampling of beach seines, benthic video survey, and water quality data loggers at the 12 designated sites. We also recommend fully implementing the fish pot survey during the 2018 sampling season.

Specific to the Benthic Video Survey, although QWVR is a time-consuming process, it is an important contribution to the overall site analysis. It may also make it easier to highlight important qualitative differences between sites or the upper and lower reaches of the Providence River Estuary. The QWVR also provides the potential to identify faster-moving animals and rare items that may not be caught in the CMECS snapshots, but could include important insight on site suitability and possible restoration methods.

Specific to the water quality data loggers, we recommend standardizing data logger depth within the water column. Some variation in results across sites from the 2017 sampling season may be attributed to the different placements of data loggers within the water column.

Specific to the beach seine, three of the target species were caught at minimal numbers or not at all (black sea bass, scup, and summer flounder). We recommend investigating whether the current sampling method is adequately capturing the abundance of these species. If not, we suggest additional sampling techniques be considered.

INTRODUCTION

Healthy and resilient coastal and marine ecosystems depend on the careful stewardship of both the living marine resources and the habitats upon which they depend. The importance of fish habitat to the sustainability of healthy fisheries was formally recognized with the advent of the Essential Fish Habitat (EFH) component of the Sustainable Fisheries Act (1996). Site specific baseline information detailing the condition of the habitat (e.g., water column conditions for Salinity, Temperature, Dissolved oxygen (D.O.), chlorophyll (chl *a*)); submerged aquatic vegetation (SAV); and the benthic structural habitat and epifauna) is required for several important fishery management tasks, including identifying areas of important habitat that should be protected, documenting the spatial distribution and condition of habitat in case of an environmental disaster, assessing changes over time due to impacts from climate change or other anthropogenic factors, as well as minimizing impacts from development activities.

In Rhode Island (RI) most of the habitat-related survey work is conducted via collaborative projects that are often coordinated by non-regulatory partners and do not have consistent funding sources. Although the information collected by these projects is usually beneficial to managers, there is not an overarching plan or vision regarding how RI's marine habitat should be assessed, monitored, and managed. Thus, there is a clear need for a Marine Habitat Management and Restoration Plan that provides guidance for current (on-going) projects and establishes priorities for future work. This type of plan would also be a vital resource when establishing goals and objectives of cooperative projects and when seeking funds via a competitive grant process. Because such a plan requires extensive filling of data gaps, we will be taking a regional approach to developing a statewide habitat plan, starting with the Providence-Seekonk tidal rivers (Head of Narragansett Bay) during 2016 and 2017.

APPROACH

The approach for each objective is described separately below.

Objective 1 - OVERVIEW

The purpose and scope of this objective is to focus on a regional approach to developing a Habitat Management and Restoration Plan by filling serious habitat data gaps for critical marine areas where very little recent habitat data are available. This approach will allow us to evaluate and develop recommendations for restoration and enhancement techniques that can be rapidly deployed as part of a state-wide plan. It will also allow us to make positive improvements to fishery habitat and resources more quickly, while increasing the knowledge base for the state-wide plan. For the next 1-2 years we will continue to concentrate on the urban marine waters at the Head of the Bay where substantial water quality improvements have been recorded.

This work is being conducted under a multi-year cooperative agreement with The Nature Conservancy (TNC) and Rhode Island Department of Environmental Management (DEM), Division of Marine Fisheries (DMF). The agreement addresses the following tasks:

Task I. Identify and study locations of degraded coastal habitat in Rhode Island estuaries that have the greatest potential to benefit from shoreline and sub-tidal restoration techniques and improved fish production.

Task II. Identify relevant and cost-effective coastal fishery habitat enhancement practices that have the potential to make the greatest improvements to the degraded fish habitat sites selected for the study.

Task III. Design pilot studies and obtain permitting necessary to begin evaluating fish habitat restoration techniques

Overall, fish populations and habitats in these urban areas have been rarely investigated, but the few research studies available suggest that these populations may be significant for important recreational species like juvenile winter flounder due to the high primary production found here. In 2018, we will continue efforts to assess the fish assemblages and present fish habitat and water column conditions at the Head of Narragansett Bay. We will continue the work begun in 2016 that focuses on gathering information on present fish habitat using seasonal video transects, as well as characterizing the fish assemblages at 12 sites (8 in Providence tidal River and 4 in the Seekonk tidal River) using beach seines and fish pots on a monthly basis. Results of this work will lead to the development of a fish habitat restoration and enhancement action plan (2018-2019) for this area. Future grant years will entail implementing components of the plan that are feasible with the funds available, as well as applying for additional funds through grant opportunities pertinent to fish habitat restoration.

Objective 1 - METHODS

Beach Seine

All 12 sites were sampled at monthly intervals from May through October. At each site a 130' long, 5.5'deep, ¼" mesh net beach seine was used. This net was also outfitted with a bag at its midpoint for fish collection, a weighted footrope, and a floated headrope, all consistent with the net used in the Young of the Year Survey of Selected RI Coastal Ponds and Embayments (conducted as part of F-61-R-23, Job #3). For sampling, the net was deployed along the shoreline in a semicircle by boat. The net was then hauled onto shore from both ends toward the beach by hand. Animals caught were then emptied from the bag and transferred into a water-filled tote. All collected animals were then identified to genus or species and measured to the nearest centimeter (except winter flounder which were measured to the nearest millimeter). When appropriate, species were subsampled by measuring the first 30 individuals identified then enumerating the remainder. Upon completion, all animals were discarded back into the water at the collection site. While at the sampling site, temperature (°C), salinity (ppt), and dissolved oxygen (mg/L) were recorded with a Professional Plus series handheld YSI multiparameter meter.

Though future reports will include more robust data analysis after an additional sampling season at the selected sites, a preliminary comparison across sites was conducted. Mean Shannon diversity and species richness were both compared by 1-way ANOVAs (Shannon Diversity ~ Site; Richness ~ Site). Diversity was calculated using the "Shannon Index" (Shannon 1948), and richness was defined as the total number species caught. Diversity and richness were calculated for each haul and the mean values per haul were determined for each site sampled during the 2017 season.

Catch per haul for target species has been compared across Providence River seine sites, and future reports will incorporate the Young of the Year Survey of Selected RI Coastal Ponds and Embayments beach seine results to compare across other water bodies. Comparisons of catch per haul will be made using a generalized linear model, inputting site, month, temperature, salinity, dissolved oxygen, and tidal stage after additional replicates are sampled.

Benthic Video Survey

During the 2017 field season, video transects were collected at the 12 sites with the same PVC benthic sled used in 2016. The sled included a HD digital video camera (SeaViewer), two green laser lights separated by ~15cm (14.85cm) for measuring fauna during video analysis (Figure 2), and two LED lights to increase visibility at deeper transects or overcast days. In addition, the Eureka Manta 2 WQ Sonde was attached to the rear crossbar for measuring salinity (ppt), temperature (°C), D.O. (mg/L) and Chl. a (µg/L) (Figure 1).

Before each video transect, the lasers were calibrated to a 15cm ruler on the datasheet. The sled was then lowered to the bottom and pulled ~15 meters behind the boat at ~1knot. Where possible, transects were recorded perpendicular to the shore. At the two northernmost sites (Pawtucket Boat Ramp and Bishop Point) tracks were taken parallel to the shore due to the narrow river width. The sled tracks were recorded from the stern of the boat with a handheld Garmin GPS to estimate transect locations.

The open-source media player VLC was used along with Windows Photo Viewer to analyze the benthic videos and video snapshots taken for analysis. The brightness, contrast, and saturation were altered when necessary to gain the clearest image of the seafloor. Snapshots were taken every 60 seconds starting from the beginning of the transect.

There were two analysis methods used to evaluate the video: a qualitative whole-video review (QWVR) and a quantitative analysis using the Coastal and Marine Ecological Classification Standard (CMECS) (FGDC 2012). Video quality was also documented, as recommended by a Narragansett Bay Commission scientist, on a range on 1-5 where 1 represented very poor visibility and 5 represented excellent visibility (Moore pers. comm.; Figure 3; Table 1). These ranges were later used during analysis to determine the level at which the CMECS framework could be documented accurately.

Qualitative Whole-Video Review (QWVR)

During QWVR each video transect was viewed from start to finish, and any rare occurrences (presence of nekton, large epifauna, anthropogenic materials, etc.) were noted, and corresponding timestamps were recorded. Videos were viewed at half-speed to properly analyze the data.

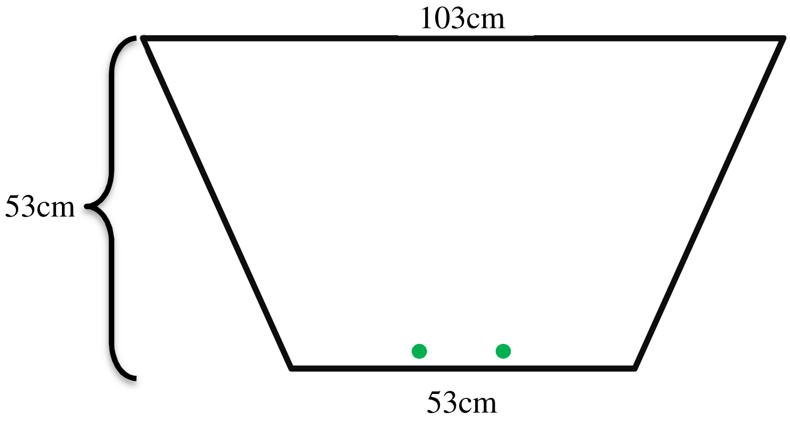
Quantitative analysis using CMECS

This report considered two of the four CMECS components: Substrate and Biotic.
Other biological, physiochemical, and spatial CMECS modifiers were used to provide additional information about the ecosystem. The following CMECS modifiers were used to convert numerical values to categorical units based on data gathered from the Eureka Manta 2: Temperature Category, Salinity Regime (Table 6), Benthic Depth Zone Values, Oxygen Regime Values (Table 7), and Productivity (Table 8; FGDC 2012).

Together, this information will be utilized to identify biotopes within the Providence River Estuary based on guidelines set up in the CMECS framework. These biotopes, along with the beach seine, data-logger, and fish pot data, will help determine locations of future restoration work that will have the greatest impact on selected degraded areas. In addition, the CMECS framework will allow the results to be more comparable with other studies, in this area and throughout the rest of Narragansett Bay, that have used the same framework for previous biotope evaluation (Shumchenia, Guarinello, and King 2016).

The angle of the camera created a slightly skewed field of view (shown below) which was taken into consideration during the analysis (CMECS is a spatially based classification system so the field of view impacts the percent-cover analysis).

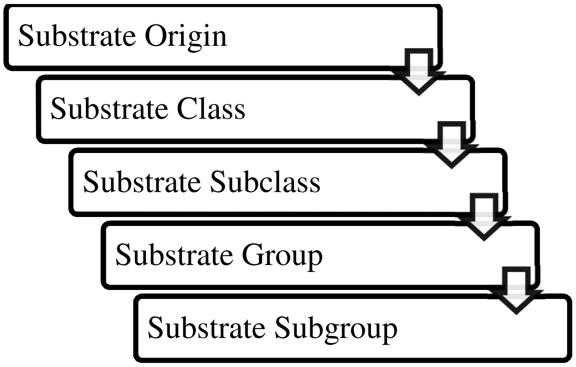
Field of view:



*Note: green laser lights not to scale

Substrate Components:

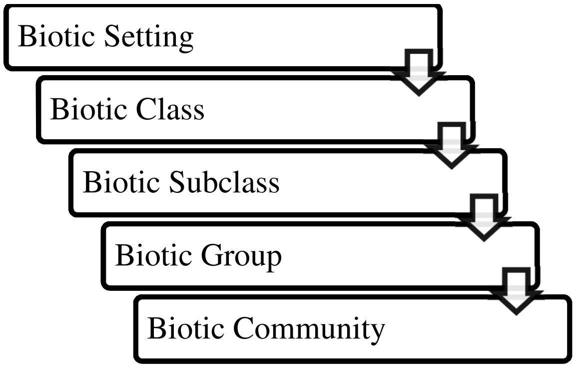
CMECS separates substrate components into five hierarchical levels:



Substrate components were analyzed to the most specific level possible without sacrificing the integrity of the data. Video samples, regardless of rating, were analyzed to the Substrate Class and video samples with ratings ≥3 were analyzed down to the Substrate Group level (Figure 4). Co-occurring elements were also used to identify non-dominant substrate types and were expressed using the Percent Cover Modifier: Coarse Percent Cover Values from CMECS (Table 2). A few modifications were made to the Coarse Percent Cover Values to better represent the data. These modifications change the trace and sparse values to <10% and 10-<30% respectively, and the moderate value to two separate values: moderate low (30-<50%) and moderate high (50-<70%) (Table 2). These changes were based on a recommendation from the Narragansett Bay Commission scientists working on similar research (Moore pers. comm.).

Biotic Components:

CMECS separates biotic components into five hierarchical levels:



Biotic components were analyzed down to the most specific level possible without sacrificing the integrity of the data. Video samples, regardless of rating, were analyzed to the Biotic Class, and video samples with ratings ≥3 were analyzed down to the Biotic Group, and to the Biotic Community when possible (Figure 5). Non-dominant biota, associated taxa, and community successional stage were also noted. Associated taxa represent biota that do not fall into a

CMECS classification unit, and community successional stage was determined based off the CMECS modifier on videos with quality grades ≥3 (FGDC 2012).

Water Quality Data Loggers

HOBO Salt Water Conductivity/Salinity Data Loggers (Part # U24-002-C) were placed at all 12 sites, while HOBO Dissolved Oxygen Data Loggers (Part # U25-001) were placed at three sites (Pawtucket Boat Ramp, Sabin Point, and Gaspee Point) during the 2017 sampling season. The data loggers were housed within specially-designed PVC enclosures for protection while still allowing water flow, then attached at mid-water to up and down lines anchored within each site. The data loggers recorded temperature (°F), conductivity (uS/cm), and dissolved oxygen (mg/L) every 30 minutes. Data from the data loggers were uploaded monthly by hauling them to the surface, connecting to a HOBO Waterproof Shuttle (Part # U-DTW-1) to upload information, and resyncing the internal clock. Any fouling to the housing was scrubbed with a brush, then redeployed.

In this report, a brief time period is extracted and sites are compared in terms of mean water quality and variability to demonstrate how this dataset can be applied in future analysis once an additional season of monitoring is recorded. Temperature, salinity, and D.O. will be compared across sites as well as evaluated individually by site to gauge suitability for target species.

Fish Pots

Fish pots were deployed at all 12 sites to test sampling feasibility and finalize a sampling design for the following season. Black Sea Bass pots, with dimensions 43.5” length, 23” width, 16” height, and 1.5”x1.5” coated wire mesh, were used. The pots also contained a single mesh entry head and single mesh inverted parlor nozzle consistent with the Black Sea Bass Pots used in the Narragansett Bay Ventless Pot, Multispecies Monitoring and Assessment Program (conducted as part of F-61-R-23, Job #12). Two fish pots were deployed by boat at each site and left to soak for ~96 hours, unbaited. The pots were then hauled, all animals were identified to genus or species, measured to the nearest centimeter by fork length, enumerated, then discarded back into the water. Data collected from the fish pot survey will be analyzed in next year’s annual report after a full season of sampling has been completed.

Approach - Objective 2

To address Objective 2, the Division provides a comprehensive review of any project or activity, including economic development projects (e.g. energy and infrastructure), dredging and dredge spoil disposal projects, as well as other activities (e.g. recreational and commercial fishing, aquaculture, habitat restoration, etc.) that are proposed for Rhode Island waters and could pose potential direct or indirect impacts to coastal and marine resources and their habitat. Reviews include all available data and provided important information to permitting agencies to allow for more informed permitting decisions.

As part of this effort, RI DMF attends a monthly meeting of upcoming General Permit activities with the Army Corps and the RI CRMC every first Thursday of the month. During that meeting, applications for pier expansions, new piers, dredging projects, as well as aquaculture leases and any concerns over natural resource impacts were discussed by the agencies. Depending on the size, scope, and location of the proposed project or activity the review process sometimes involves determining the living and non-living resources present at or near the project site and evaluating the potential direct and indirect adverse effects of the proposed project or activity on fishery resources and marine habitat. More specifically, this process often requires a site visit and a review of fishery resource data and marine habitat data, including EFH, that were collected at or near the project site or in similar habitat conditions. These data may include data collected by RI DMF finfish surveys funded by the USFWS Sport Fish Restoration Program (e.g. Narragansett Bay Monthly and Seasonal Fishery Resource Assessment, Winter Flounder Spawning Stock Biomass Survey, Young of the Year Survey of Selected RI Coastal Ponds and Embayments, and the Juvenile Marine Finfish Survey) and surveys related to finfish, shellfish, and ichthyoplankton conducted by RI DMF pursuant to other funding sources or other originations and institutions (e.g. MA DMF, NEMAP, NEFSC, URI GSO, etc.). Habitat data, including EFH data, may require leveraging data collected previously by RI DMF or other organizations and institutions.

In cases where site-specific habitat and marine resource data is limited, dated, or absent new data may be collected, analyzed, and summarized. When possible, this work takes advantage of collaborative efforts with other agencies. Collection of marine habitat and resource (finfish) data has required use of a vehicle, boat, research vessel, field equipment including but not limited to habitat surveying tools, such as submersible high-resolution digital cameras (video and still-shot), bottom samplers (benthic dredge/sled), water quality data sondes, meters, and associated equipment, and marine resource survey tools, including nets (bongo, seine), measuring boards, and foul weather gear. Data is assimilated and analyzed using statistical software, databases, imaging processing software, and GIS mapping and processing technologies where applicable.
Where necessary, RI DMF staff testify at RI CRMC hearings for permits where there is a significant objection by the Division.

As the aquaculture industry continues to expand, there is an increasing concern about additional user conflicts arising from the leasing of marine waters for aquaculture, which may limit certain public uses (e.g., fishing & waterfowl hunting). The DMF has been active in reviewing aquaculture permits to ensure prospective sites do not pose a threat to marine fish and their habitats. The most frequent concern with aquaculture applications is the spatial overlap with recent (e.g., last 3-4 years) or historic presence of eelgrass within the footprint of the proposed lease site. Additional fish habitat concerns include certain bottom substrates that impact foraging or spawning activities, or those located in areas of high recreational fishing activity.

Approach - Objective 3

The Division has the duty to provide available scientific information on sudden mass-die-off events such as fish kills in marine waters, and identify important recreational fish habitat and pre-impact conditions in the event of a significant environmental incident classified as a Category 3 major environmental disaster incident (e.g., > 10,000 gal oil spill or wide coastal environmental impact likely). In addition, the DMF provides a staff member with recreational fishery habitat expertise for coordination of DMF responses related to assisting the Office of Emergency Response Incident Command in assessing any significant environmental impacts of a major oil spill or incident on recreational habitat and biota in Rhode Island marine waters. For moderate incidents such as fish kills, the staff will follow the “Bay Response Team” (BART) protocols. We have been responding to all moderate and large kills and investigating habitat conditions to ascertain the role of severe hypoxia/anoxia in fish kills (the typical cause in summer months) in RI marine habitats.

RESULTS

Objective 1

Beach Seine

For the 2017 field sampling season, a total of 72 seines were hauled across the selected sites. 38,028 finfish were identified and enumerated, and 4,859 of those were measured (see Appendix for station map and catch data summary). Catch data is presented as mean catch per haul ± the standard error. A total of 40 species were caught in the beach seines this season (Table 3). Aside from the list of species caught, all figures and analyses include only finfish. All invertebrates were removed to focus on the fish assemblage alone.

Results of the 1-way ANOVA testing the effect of site on species diversity was not significant. Results of the 1-way ANOVA testing for the effect of site on species richness was partially significant (p-value <0.1), suggesting that richness may vary by site despite a stable Shannon diversity index (1-way ANOVAs; Site ~ Diversity: p = 0.573; Site ~ Richness: p = 0.0867; Figure 6). Species richness was log-transformed to satisfy assumptions of the ANOVA.

On average, 528.18 ± 155.60 finfish were caught per haul. Catch per haul was greatest at Bishop Point 1,422.00 ± 1365.34 while finfish were least abundant at Conimicut Point (98.17 ± 32.84 SE; Figure 7). These results were somewhat confounded by large abundances of juvenile Atlantic menhaden (3,500+ individuals) caught in September and October at Bishop Point, Pawtucket Boat Ramp, Butler, and Fields Point. The highest catch per haul was in September at 1431.17 ± 740.01, while the lowest was in June at 67.67 ± 16.69 (Figure 8).

Of the five target species in this study, four were caught in the seines: scup, summer flounder, tautog, and winter flounder (Figure 9). Winter flounder and tautog were the most abundant target finfish caught across all seine sites at a catch per haul of 3.40 ± 0.82 and 0.79 ± 0.36, respectively. Scup and summer flounder were caught at a catch per haul of 0.07 ± 0.05 and 0.22 ± 0.13, respectively.

Of the total 245 winter flounder caught in 2017 seines, 244 were young of the year. The year-1 individual measured 129mm and was caught in May, suggesting it had recruited the year prior, based on previous age at length studies (Able and Fahay 1998; Berry et al. 1965). Winter flounder were caught at 11 of the 12 sites; they were not caught at Mussachuck Creek. The most abundant site for winter flounder was Sabin Point at a catch per haul of 8.33 ± 4.78 . The most abundant month for winter flounder was June at a catch per haul of 8.58 ± 3.14 (Figure 10).

A total of 57 tautog were caught in 2017 beach seines ranging in size from 4cm to 17cm. Tautog were caught at 7 of the 12 sites: Conimicut Point, Fields Point, Gaspee Point, Mussachuck Creek, Narragansett Terrace, Sabin Point, and Stillhouse Cove. Of the seven sites they were caught, tautog were most abundant at Fields Point, a catch per haul of 7.67 ± 3.40. The most individuals were caught in June, totaling 23 (all caught at Fields Point; Figure 11).

Benthic Video Survey

In 2017, a total of 20 successful video transects were completed across all sites in the Providence River Estuary in June (nine transects), August (six transects), and September (five transects) (Table 4). The average transect length was 0.8 km and the average video length was ~16 minutes. Video quality varied significantly between transects and was dependent on water turbidity, boat speed, and video settings (720p vs 1080p). The average video quality rating among analyzed video across all transects was three (Table 1). Analysis of video is still underway. The final report will include QWVR and CMECS analyses of data collected from 2016-2018.

Qualitative Whole-Video Review (QWVR)

A total of six videos from 2017 have been analyzed so far from start to finish including all sites sampled in September (Bishop Point, Stillhouse Cove, Pawtuxet Cove, Omega Dam, and Butler), and one site sampled in August (Sabin Point). Rare occurrences identified through video analysis thus far were grouped into six categories: large crustaceans, gastropod aggregations, dead fauna, anthropogenic material, air bubbles, school of fish (Table 5).

Anthropogenic Material was found in different quantities at Bishop Point, Omega Dam, Butler, and Sabin Point, which ranged from large items such as tires, to small pieces of plastic wrappers and bottles. Blue crabs and horseshoe crabs were among the most common crustaceans found along the transects. The presence of blue crabs was common in the Seekonk sites. Horseshoe crabs were identified at Pawtuxet Cove (6), Butler (2), and Omega (1). There was a large aggregation of Nassariidae (estimated N >800 animals in one snapshot) found at Omega Dam, and a few occurrences of air bubbles being released from the sediment at Bishop Point. In conjunction with the air bubbles, were ~12 dead menhaden carcasses, and 1 blue crab carcass spread out along the Bishop Point transect. Water quality data assessed in CMECS identified a hypoxic zone along this same transect. Small schools of juvenile menhaden ~ 4-6cm were often seen swimming with the sled at Sabin Point, Omega Dam, Butler, and early in the Bishop Point video (before the hypoxic zone).

Quantitative analysis using CMECS

A total of nine videos have been analyzed for substrate components so far in 2017. The following section describes only the results of these sites. Three of 13 distinct substrate classes were identified throughout these sites: anthropogenic wood, shell substrate, and unconsolidated mineral substrate (Figure 12). Samples with video quality too poor to positively categorize were placed in the ‘undetermined’ category.

Unconsolidated mineral substrate was the dominant substrate class at all sites except Pawtuxet, which had a greater number of samples with shell substrate as the dominant class. The anthropogenic wood was dominant in only one snapshot at Bishop Point. The unconsolidated mineral substrate and shell substrate were also broken down into their more specific Substrate Groups (Figure 13).

There were five distinct unconsolidated substrate groups (out of eight) identified throughout all the sites: mud, sandy-mud, muddy-sand, sand, and slightly gravelly. Most sites had the highest number of snapshots identified as mud or muddy sand. Mussachuck Creek was the only site analyzed so far that had more than 50% of the snapshots identified as sand (Figure 13).
The shell substrate was also broken down into distinct groups. Sabin Point, Pawtuxet Cove and Conimicut Point were the only three sites so far that had snapshots with shell substrate as the dominant component. Sabin and Conimicut Point's snapshots showed Crepudila reef as the dominant shell, while Pawtuxet Cove was a combination of clam shell of different sizes (Figure 14).

A total of seven videos have been analyzed for biotic components so far in 2017. The following section describes only the results of these sites. Four of eight distinct Biotic Classes were identified throughout these sites: Reef Biota, Faunal Bed, Aquatic Vegetation Bed, Microbial Communities (Figure 15). Samples with video quality too poor to positively categorize were placed in the 'undetermined' category.

The only site with identified Reef Biota so far has been Sabin Point (1/11 snapshots). The Reef Biota was more specifically identified as Crepidula Reef (level: Biotic Community). Snapshots identifying Aquatic Vegetation Bed as the dominant biota were at every site except Butler, and in only 1/26 snapshots at Omega (Butler's neighboring site; Figure 15).

The three Seekonk sites analyzed so far (Bishop Point, Butler, and Omega Dam) have the greatest percentage of snapshots with Microbial Communities identified as the dominant biota. The Microbial Communities were more specifically identified as *Beggiatoa* Communities, commonly found in the upper reaches of the Seekonk.

Faunal Beds were made up of Soft Sediment Fauna (e.g. Nassariid Beds, Small Surface-Burrowing Fauna (e.g. polychaetes) Tunneling Megafauna (e.g. Squilla Beds) and Inferred Fauna (e.g. Gastropod Trails; see Figure 6 for a complete list). Faunal Beds made up around 25-55% of transect snapshots except for Sabin Point and Pawtuxet Cove which had the greatest number of snapshots identified as Aquatic Vegetation Bed (excluding Undetermined snapshots; Figure 15).

CMECS modifiers were also used to evaluate different water column components including salinity (Table 6), D.O. (Table 7), and phytoplankton productivity (Table 8). The sites were not differentiated by month; however, they will be separated in the future as some factors may be more seasonally dependent.

A total of nine videos have been analyzed for water column components so far in 2017. The following section describes only the results of these sites. The sites within the Upper Seekonk had a greater percentage of snapshots with lower salinity values. All Providence River sites were identified as upper polyhaline water (25 to <30 ppt; Figure 16). Bishop Point and Sabin Point were the only two sites so far in which hypoxic (2 to <4 mg/L) or severely hypoxic levels (<2 mg/L) were identified during a video transect. Phytoplankton productivity was measured by presence of Chlorophyll a with the CMECS Phytoplankton Productivity Modifier. There have been no Eutrophic (≥50 µg/L) snapshots analyzed yet, and most snapshots have fallen into the Mesotrophic category (5 to <50 µg/L). The sites from the Seekonk River have the highest percentage of snapshots falling within the Oligotrophic category (<5 µg/L).

Water Quality Data Loggers

A total of 33,235 instances were recorded across all 12 sites containing temperature, salinity, and DO for the 2017 sampling season, from 7/15 to 11/15. We extracted and plotted temperature and salinity data points recorded 7/19-7/27 in 2017 to demonstrate how the sites compare to each other during the same time period. Mean temperatures during this period ranged from 73.26 °F at Fields Point to 74.66 °F at Narragansett Terrace across sites (Figure 19; Table 9). The maximum temperature recorded was 85.95 °F at Omega Pond.

Mean Salinities during this time period ranged from 11.68 ppt at Pawtuxet Cove to 23.93 ppt at Mussachuck Creek (Table 10). The sites experienced vast differences in salinity range during this period, from 5.58 to 22.58 ppt. The sites with the lowest recorded salinities are all located within the Seekonk River, averaging 1.84 ppt across the four sites, while Pawtuxet Cove recorded the lowest salinity within the Providence River at 5.64 ppt.

Given the above results that reveal the broad range of salinities occurring at a site within a short period of time, researchers decided to overlay tidal height to determine whether tidal flow is correlated with salinity (Figure 21). Upon visual examination of the overlaid data, it appears that salinity and tidal height are closely correlated. Sites that displayed this correlation were: Bishop Point, Butler, Omega Dam, Pawtucket Boat Ramp, and Pawtuxet Cove.

Though all three sampled sites recorded hypoxic D.O. levels (<2 mg/L), the proportion of instances varied (Figure 22). 22.35 % of Sabin Point's recordings were below the hypoxia threshold, while Gaspee Point and Pawtucket boat ramp revealed 2.52% & 0.69%, respectively between 9/12/17 and 10/25/17 (Figure 23).

Fish Pots

Coordinates were determined for fish pot placement based on the following factors: proximity to beach seine sites, depth, ease of access, and location of channel (Table 11). Appropriate locations and sampling methods were established to ensure a feasible and more complete study in 2018. Fish pots were deployed 14 times during the months of August-October. A total of 9 species were caught in the pots during this time, including 26 finfish and 63 invertebrates (Table 12).

Results - Objective 2 (Review of permit applications)

As part of its environmental review program the DMF reviewed permits applications that contained approximately 137 separate potential impacts and concerns related to activities that may affect marine resources during the 2017 calendar year (Table 13). Verbal comment was provided on all general permit reviews through the monthly general permit meeting at the RI CRMC with the US Army Corps. Most residential dock permits were modifications requests and only a few were in proximity to eelgrass requiring further assessment to avoid impacts. DMF continued to participate in the Manchester Street Power Station 316(b) review process, as well several additional large-scale (potential) projects. For example, the DMF reviewed and provided comments on a proposal to create a temporary breach in the barrier beach and/or conduct maintenance dredging to increase circulation in Green Hill Pond. We also reviewed and provided comments on a proposal by the Town of Swansea to modify the salinity discharge limits of their desalination plant into the Palmer River. In addition, we reviewed, commented on, and worked closely with stakeholders and applicants to revise large-scale restoration projects focused on conducting maintenance dredging for the purpose of saltmarsh and eelgrass restoration, beach nourishment, and navigation channel maintenance.

The DMF also actively participated in updating and reauthorizing of the USACE RI General Permit. In short, the RI General Permit streamlines the review and permitting process by identifying required protections and authorizing specific predetermined activities that have no more than minimal individual and cumulative adverse environmental effects. Some of the changes enacted to the General Permit exempt fish habitat enhancement and restoration work from USACE review, providing General Permit standards are met and work in conducted in partnership with DMF.

This past year, the DMF participated in and formulated responses for 13 preliminary determination meetings with aquaculture applicants. The meetings are designed to allow participants to voice any concerns, including those related to fish and fish habitat. We also provided formal, written responses for over 10 public noticed lease applications, and held RI Marine Fishery Council (RIMFC) Advisory Panel meetings to gain input from industry on aquaculture sites for the RIMFC and to provide scientific opinion to the Council regarding the sites. We coordinated all responses with RI DEM Fish and Wildlife Program for waterfowl habitat and hunting concerns, and drafted DMF official response letters related to fish habitat impacts that were identified through a detailed review of applications for new and modifications to aquaculture leases starting in Jan 2017.

As a result of frequent concerns with protecting fish habitat, the DMF developed the state's first spatial database of all active and proposed aquaculture sites in state waters. This database is and will be used, along with other spatial use layers, by the DMF to better understand potential habitat and public use conflicts with newly proposed aquaculture locations. The Division has made the active sites layer public via an interactive map on the Department's website: http://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=8beb98d758f14265a84d69758d96742f. This interactive map features mapping tools for future applicants to aid in the site selection process and help them avoid areas of public use or historic eelgrass habitat.

Results - Objective 3 (response to a significant environmental incident)

RI DMF participated in the initial phases of developing Geographic Response Plans (GRPs) for the Blackstone and Pawtuxet Rivers in RI. GRPs are response plans tailored to protect specific sensitive areas from oil spill impacts. They show first responders where sensitive areas are located and where to place oil spill protection resources to protect those areas. RI DMF responded to one reported fish kill (scup) during May of 2017. It was determined that this event was related to fishery discards and not related to environmental aspects.

DISCUSSION

Objective 1

Beach Seine

Though Shannon Diversity and species richness did not yield significant differences by site, perhaps additional yearly replicates will allow for analysis to account for monthly variations. Mean finfish abundance appeared to vary greatly across sites and sampling months. The data may be confounded somewhat by large abundances of juvenile Atlantic menhaden (3,500+ individuals) in September and October at Bishop Point, Pawtucket Boat Ramp, Butler, and Fields Point. Since this species is not a target species and appears to show little site fidelity, we suggest that future abundance and diversity analyses omit Atlantic menhaden.

Though four of the five target species were caught in the 2017 beach seines, scup and summer flounder were caught in minimal numbers. Investigators should determine whether this gear type selects for juveniles of these target species. If it does not, additional sampling methods should be considered to better-sample these species.

11 of 12 sites appear to support winter flounder, and abundance varied by site. Winter flounder were predominantly caught in June, July, and August, consistent with other beach seine surveys in this region (Young of the Year Survey of Selected RI Coastal Ponds and Embayments & Narragansett Bay Juvenile Fish Survey). If winter flounder are targeted in habitat restoration projects within this study area, investigators should consider suitable habitat connectivity, allowing for migration of these recruits into more suitable waters as the season progresses (Neumann 1993). Tautog were caught in all sampling months, predominantly at Fields Point. It is expected that future analysis combining water quality, benthic substrate, and fish assemblage will explain some variability in target species abundances. For example, juvenile winter flounder and tautog habitat preferences are well known and qualitatively explain some disparity across sampling sites. Juvenile tautog prefer rocky habitat and algal mats provided at Field’s Point (Dorf and Powell 1997). Though juvenile winter flounder habitat preferences appear to vary by waterbody, they can generally be found in sandy/muddy habitats within estuaries (Neumann 1993). In addition to the benthic substrate monitoring, it is recommended that categorical parameters describing the habitat setting be added to complement current descriptors, for example adjacent aquatic and intertidal/upland habitat types.

Benthic Video Survey

Video analysis will continue into the following year. The completed report will include an analysis of the video collected from 2016-2018 to incorporate three years of transects from the 12 sites within the Providence River Estuary. The average transect length was greater than the intended average of 0.5 Km. This result is most likely due to the Omega Dam and Butler sites. These sites are opposite each other along the Seekonk River, and transects were often taken directly from Omega Dam across the channel to Butler and vice versa, resulting in a very long transect. The video quality was also lower than the desired average of at least four impacting the CMECS analysis. In the future, a higher resolution setting and slower boat speed may help to alleviate this issue. However, other impacts like water turbidity and loose substrate may still have a negative impact on the clarity of the video clips.

Qualitative Whole-Video Review (QWVR)

As more videos are reviewed using this method, a more detailed comparison will be possible across all sites. So far, the Omega Dam site shows some of the impacts of hypoxia occurring across the channel in the Seekonk River. The identified air bubbles, dead menhaden, and low dissolved oxygen values (discussed in following CMECS sections) are all strong indicators of severe hypoxia occurring in the area during the month of September. The video clip selection method used in the CMECS analysis did not provide clips showing the dead menhaden or gas bubbles at Omega Dam. This supports the need to continue with QWVR in conjunction with CMECS as each provides important data for habitat quality evaluation.

Another interesting occurrence was the presence of juvenile menhaden that could be seen swimming along with the sled. A potential explanation is that the lights and/or lasers attached to the sled that may have attracted them. This is important to note for future tows and something to take into consideration during data analysis.

The presence of anthropogenic material was not surprising in any of these areas. In the future, items like tires and large pieces of debris may be separated into their own category as they provide some level of structure to certain species like blue crabs and other invertebrates commonly found in the area. For example, some tires were seen with blue crabs foraging off them. It will also be important to take note of areas that have higher volumes of garbage found along the transect as this could be an indicator of lower site suitability.

Quantitative analysis using CMECS

The high percentage of unconsolidated mineral substrate is not surprising across all sites, and is relatively consistent with a similar ongoing study conducted by the Narragansett Bay Commission (Moore pers. comm.). Sites that contain a high percentage of snapshots (>75%) identified as mud (Butler Point, Omega Dam, and Pawtuxet Cove) also exhibit organisms that thrive in these areas including Nassariidae, and *Beggiatoa*. At Sabin Point, both the Substrate and Biotic Groups identify the presence of *Crepidula*. It is highly probable this will also be the case for Conimicut Point because of the similar dominant substrate of *Crepidula* shells. On the other-hand the Biotic Groups identified at Pawtuxet Cove did not include presence of clam reefs, even though the substrate component was dominantly clam shell. It is important to note that, in this case, the lack of clam reefs as a dominant Biotic Group was most likely not depicted in Pawtuxet Cove because of the high volume of aquatic vegetation, (which often impedes the view of other biota) rather than an absence of the live biota altogether. There is no way to know for certain without a direct sample of the area or additional video transects. This may be important as existence of a high density of shell substrate with the absence of live organisms could indicate reduced water quality, and/or an unsuitable habitat for that species at that site. The issue of aquatic vegetation (especially sheet algal species like *Ulva*) is currently unavoidable using this CMECS strategy, however, an increased number of transects at varying times during the season may be able to provide a more comprehensive picture.

Within the upper Seekonk transects, higher percentages of *Beggiatoa* communities were identified. This presence is consistent with the 2016 report. In the future, it will be interesting to evaluate potential changes in the microbial community's scope over time by comparing the results to Shumchenia, Guarinello, and King's (2010) study describing it presence in 2008 and 1988.

Overall, it can be hypothesized that Butler and Omega Dam have similar substrate compositions because of their relative proximity to one another. However, Omega Dam does have a direct input of freshwater coming into the area potentially impacting the epifauna and aquatic vegetation composition. More research on these freshwater inputs and their impacts on different species is underway. It will also be interesting to compare the difference in biotic composition of these two sites as the data analysis and sample size becomes more saturated.

The salinity data is also consistent with the flow of the river as the data shows a shift from Upper Polyhaline (25 to <30 ppt) to Lower Polyhaline (18 to <25 ppt) toward the head of the river where freshwater inputs are greater. This data may differ from the dataloggers because of the varying depths each instrument was used to sample at, or the time of sampling. Both Bishop Point and Sabin Point revealed hypoxic values. Sabin Point is well known for its large accumulations and blooms of *Ulva* which although initially increase the dissolved oxygen levels, often create a hypoxic event shortly afterward as the accumulations begin to decay. At Bishop Point the transect ran parallel to shore and along the channel. This area is often hypoxic because of the higher temperatures and shallow area surrounding the channel limiting turnover and flushing of the water column. Phytoplankton productivity will be addressed in more detail as more data is analyzed. In addition, the CMECS Phytoplankton Productivity Modifier may be adapted to help create greater separation between the Mesotrophic (5 to <50 µg/L) and Oligotrophic (<5 µg/L) values. The Oligotrophic levels found in the Seekonk, and at Sabin and Conimicut Point indicate areas of low productivity resulting in reduced food availability for filter feeders like shellfish species. This may be important when determining site suitability for shellfish restoration depending on different species caloric needs.

Continued analysis of existing transects, and those to be completed in 2018 will be used to create CMECS biotopes, evaluate the identified site's suitability for different restoration methods, and add to quantitative and standardized classification of the Providence River Estuary.

Water Quality Data Loggers

While mean temperatures were similar across sites (73.26-74.66 °F), it is important to examine the maximum temperatures during the summer sampling period where warmest temperature by site varied by 6.7°F. Warm summer temperatures are known to negatively impact certain fishes. For example, Nichols observed a massive die-off of winter flounder that were trapped in shallow enclosed bays when temperatures rose to about 86°F (Nichols 1918). Furthermore, observations made in Great South Bay, Long Island reported that winter flounder became inactive at 73.4°F (Olla et al. 1969). Though individuals of this species have been known to bury themselves to avoid heat, that technique may only offset a few degrees of temperature. Given that winter flounder were caught in relative abundance at sites prior to temperatures that exceeded their tolerance threshold and very few were caught in the months following, maximum water temperatures should be considered in future restoration sites. Investigators should also consider suitable adjacent habitats that allow for emigration of individuals from a site that may become unsuitable during warmer months.

We acknowledge that our findings are limited to one sampling season, and future monitoring will determine whether the 2017 season provided exceptionally warm waters in the estuary or temperatures such as the ones recorded are typical for the season. We also recommend that investigators note the specific placement of the dataloggers within the water column, because variability in this placement could affect water quality comparisons across sites.

Mean salinities appeared to vary greatly by site. The two driving factors in salinity at these sites are tidal flow and precipitation, which appear to affect our sites at different magnitudes. Salinity at the four sites in the Seekonk River (Pawtucket Boat Ramp, Bishop Point, Butler, and Omega Dam) as well as Pawtuxet Cove varied greatly with tidal stage, while the remaining sites showed little correlation with tide. This finding is important, because juvenile finfish residing at the sites where salinity varies with tide will experience significant fluctuations in salinity depending on whether the tide is incoming or outgoing. Species must be able to endure frequent and rapid salinity changes. At times, water was fresh enough at these sites to record freshwater species (e.g. bluegill). We recommend that investigators consider whether target species can endure these variable and at times low saline habitats.

To address the effect of precipitation on salinity at these sites, we recommend that investigators identify the major freshwater inputs into the study area and contributing watersheds. Combining salinity data with precipitation data in this area should explain variations in salinity, especially at sites where salinity does not depend on tidal flow.

Though dissolved oxygen readings below 2 mg/L were measured at all three sampled sites, the frequency and intensity of these hypoxic recordings varied. Interestingly, Sabin Point appeared to have the most frequent and intense hypoxic readings, likely resulting from the dense mats of algae found at this site. Given that demersal species such as winter flounder, by nature of being restricted to the bottom surface, can be most impacted by hypoxic events, a site’s dissolved oxygen levels should be considered when selecting a restoration site. Previous studies have caught winter flounder in significantly lower numbers when D.O. concentration was 2.0-2.2 mg/L and showed reduced lengths at concentrations higher than 2.0 mg/L (Howell and Simpson

1994). Supporting these findings Bejda et al. performed mesocosm experiments determining that growth rates of YOY winter flounder were significantly lower in constant low (2.2 mg/L) dissolved oxygen levels than diurnally fluctuating (2.5-6.5 mg/L), which were then significantly lower than those in constant high dissolved oxygen levels (Bejda et al. 1992). This research highlights the impact of dissolved oxygen on winter flounder growth and survival. We recommend that investigators research and consider the effects of low dissolved oxygen concentrations on individual target species by frequency, magnitude, and duration to inform restoration practices. Investigators should also consider the availability of adjacent suitable habitat when conditions do become unsuitable for these species. The initial findings from these dissolved oxygen dataloggers highlight the need for continued monitoring of these sites, as these hypoxic events are rarely recorded by YSI instruments at the time of seine. We plan to implement D.O. data loggers at all 12 sites for the 2018 sampling season.

Fish Pots

The depth at the fish pot locations varies by site, especially in the upper estuary. This is simply due to limited depth in the Seekonk River. Pots were placed within ~0.25 km of the beach seine locations where possible to remain consistent with the original site selection. In the Seekonk, pots were placed closer to the channel to provide enough water for the pot to be submerged at mean low tide. Finally, to create a feasible study some locations were adjusted to improve ease of access, and to limit impacts to other users of the area. For example, the original fish pot location was adjusted at the Pawtuxet cove site to avoid the channel and main marina access. Due to setbacks in purchasing the fish pots and finalizing sampling design, the survey was not fully implemented in the 2017 season. However, the initial sample did include some of the target species.

Results from continued implementation of the fish pot survey may also be compared with the previously mentioned F-61-R-23, Job #12 ongoing study of the Narragansett Bay. It is expected that a full season of sampling will occur in 2018.

Objective 2

The DMF's ability to protect marine resources and their habitat from adverse anthropogenic impact is largely dependent upon the quality and extent of the data available. Therefore, the DMF strives to use high quality, quantitative information to develop science-based recommendations for regulations and permits. These efforts are reflected in the comments provided on large-scale projects (e.g., Green Hill Pond proposed dredging and breaching, Town of Swansea Desalination Discharge alteration, Manchester Street Power Station 316(b) review process, Winnapaug Pond Dredging and Beach Restoration Project, etc.). Utilizing a quantitative, science-based approach has resulted in DMF recommendations typically being adopted into permit requirements, resulting in applicants seeking to meet with DMF during project scoping and design so that DMF-related concerns can be considered and addressed prior to permit submission (e.g., Winnapaug Pond Dredging and Beach Restoration Project).

CONCLUSION

During 2017, DMF in partnership with TNC successfully completed field and analytical work related to Objective 1. This information will be critical for developing a Habitat Management and Restoration Plan for urban marine waters at the Head of the Narragansett Bay. Relative to the year prior (i.e., 2016), the FHE team made substantial gains by completing all of the seining and benthic video work, developing a quantitative protocol for analyzing video, and evaluated techniques for incorporating fish pots into the survey. In regard to all permit review and responses to significant environmental incidents (i.e., Objectives 2 and 3), DMF will continue to improve data collection and engage in planning processes in order to protect the important recreational fishery resources of the state.

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Table 1. Description of video quality determination with associated rating and grade.

Video Quality Grade	Rating	Description
5	Excellent	Video exhibits perfect to almost perfect visibility. Image snapshot able to be identified down to Substrate and Biotic Group without help from video. Fauna >2mm can be quantified.
4	Great	Video exhibits great to very good visibility. Image snapshot able to be identified down to Substrate and Biotic Group with some help from video. Fauna >5mm can be quantified.
3	Good	Video exhibits good visibility. Image snapshot able to be identified down to Substrate and Biotic Group with much help from video. Fauna >1cm can be quantified.
2	Poor	Video exhibits poor visibility. Image snapshot able to be identified down to only Substrate Class, and Biotic Class where possible with help from video. Fauna >2cm can be quantified.
1	Very Poor	Video exhibits very poor to no visibility. Image snapshot able to be identified down to only Substrate and Biotic Class with much help from video, and in some cases not at all. Fauna are not able to be quantified.

Table 2. Adapted CMECS percent cover modifier.

Coarse Percent Cover Values	Percent Cover Range (%)
Trace	0 – 9
Sparse	10 – 29
Moderate Low	30 – 49
Moderate High	50 – 69
Dense	70 – 89
Complete	90 - 100

Table 3. Common and scientific names of all species collected in beach seines during 2017.

Common Name	**Scientific Name**
Atlantic Menhaden	*Brevoortia tyrannus*
Silverside	*Menidia spp.*
Striped Killifish	*Fundulus majalis*
Common Mummichog	*Fundulus heteroclitus*
River Herring	*Alosa spp.*
Winter Flounder	*Pseudopleuronectes americanus*
White Perch	*Morone americana*
Northern Kingfish	*Menticirrhus saxatilis*
Bluefish	*Pomatomus saltatrix*
Blue Crab	*Callinectes sapidus*
Tautog	*Tautoga onitis*
Gizzard Shad	*Dorosoma cepedianum*
Atlantic Tomcod	*Microgadus tomcod*
Cunner	*Tautogolabrus adspersus*
Sheepshead Minnow	*Cyprinodon variegatus*
Searobin	*Prionotus spp.*
4-Spine Stickleback	*Apeltes quadracus*
Green Crab	*Carcinus maenas*
Summer Flounder	*Paralichthys dentatus*
Bluegill	*Lepomis macrochirus*
Hogchoker	*Trinectes maculatus*
Spot	*Leiostomus xanthurus*
Northern Pipefish	*Syngnathus fuscus*
Striped Bass	*Morone saxatilis*
Atlantic Needlefish	*Strongylura marina*
American Eel	*Anguilla rostrata*
Weakfish	*Cynoscion regalis*
Scup	*Stenotomus chrysops*
Largemouth Bass	*Micropterus salmoides*
Naked Goby	*Gobiosoma bosc*
Lady Crab	*Ovalipes ocellatus*
White Mullet	*Mugil curema*
Golden Shiner	*Notemigonus crysoleucas*
Horseshoe Crab	*Limulus polyphemus*
Japanese Shore Crab	*Hemigrapsus sanguineus*
Longhorn Sculpin	*Myoxocephalus octodecemspinosus*
Northern Puffer	*Sphoeroides maculatus*
Oyster Toadfish	*Opsanus tau*
Rainwater Killifish	*Lucania parva*
Smallmouth Flounder	*Nematops microstoma*

Table 4. Overview of sampling frequency from 2017. * = incomplete GPS transect data; this value was not included in calculating the average transect length.

Site	Month	Transect length (km)	Total Video Time (min)	Average video quality
Pawtucket Ramp	6	-	3:24	-
Bishop Point	6	-	14:08	-
Butler	6	-	21:08	-
Omega Pond	6	-	16:12	-
Stillhouse Cove	6	-	16:16	-
Pawtuxet Cove	6	-	7:37	-
Gaspee Point	6	-	22:05	-
Conimicut Point	6	0.75	21:18	-
Mussachuck Creek	6	0.44	20:01	-
Field Point	8	0.66	1:04	3
Sabin Point	8	-	10:16	2
Narragansett Terrace	8	0.41	24:10	2
Gaspee Point	8	0.58	15:35	3
Conimicut Point	8	0.59	15:28	3
Mussachuck Creek	8	0.86	7:02	3
Bishop Point	9	1.29	30:52	2
Butler	9	0.96	19:58	3
Omega Pond	9	1.47	25:59	3
Stillhouse Cove	9	0.7	16:48	2
Pawtuxet Cove	9	*0.07	11:00	4

Table 5. Description of rare occurrences by category. NOTE: Categories are still being developed as more video is analyzed, and therefore are not limited to this list in the future.

Category	Specific Description of Occurrences
Large Crustaceans	blue crabs, horseshoe crabs
Gastropod Aggregations	mud snail aggregation
Dead Fauna	dead adult menhaden
Anthropogenic Material	plastic, aluminum cans, glass bottles, rubber gloves, tires, other
Air Bubbles	air bubbles released from substrate
School of Fish	school of juvenile menhaden

Table 6. CMECS salinity modifier used for water quality analysis (FGDC 2012).

Salinity Regime Values	Salinity (Practical Salinity Scale)
Oligohaline	< 5
Mesohaline	5 to < 18
Lower Polyhaline	18 to < 25
Upper Polyhaline	25 to < 30
Euhaline	30 to < 40
Hyperhaline	≥ 40

Table 7. CMECS oxygen modifier used for water quality analysis (FGDC 2012).

Oxygen Regime Values	Oxygen Concentration (mg/L)
Anoxic	0 to < 0.1
Severely Hypoxic	0.1 to < 2
Oxic	2 to < 4
Highly Oxic	4 to < 8
Very Oxic	≥ 12

Table 8. CMECS productivity modifier used for water quality analysis (FGDC 2012).

Phytoplankton Productivity Values	Chlorophyll a Level (µg/L)
Oligotrophic	< 5
Mesotrophic	5 to < 50
Eutrophic	≥ 50

Table 9. Mean, minimum, and maximum temperature (°F) at sites during 7/19/17 - 7/27/17.

Site	Mean	SE	Min	Max
Bishop	73.62	0.17	68.43	79.52
Butler	73.56	0.22	65.79	84.29
Conimicut	73.81	0.25	67.62	83.35
Fields	73.26	0.18	68.20	79.95
Gaspee	73.88	0.24	67.10	82.99
Mussachuck	74.41	0.26	68.14	84.47
Narr. Terr.	74.66	0.25	67.62	83.64
Omega	73.80	0.23	65.70	85.95
Pawtucket	73.96	0.18	68.38	79.45
Pawtuxet	74.58	0.28	66.13	82.78
Sabin	74.02	0.22	67.96	83.98
Stillhouse	73.64	0.19	67.77	79.30

Table 10. Mean, minimum, and maximum salinity (ppt) at sites during 7/19/17 - 7/27/17.

Site	Mean	SE	Min	Max
Bishop	13.99	0.32	2.31	21.55
Butler	17.02	0.32	2.27	24.85
Conimicut	21.85	0.10	17.99	24.64
Fields	19.15	0.09	15.85	21.43
Gaspee	20.62	0.11	16.94	24.04
Mussachuck	23.93	0.11	20.08	26.31
Narr. Terr.	19.48	0.09	15.64	21.54
Omega	15.75	0.30	1.31	22.62
Pawtucket	12.58	0.32	1.48	20.51
Pawtuxet	11.68	0.29	5.64	24.49
Sabin	21.28	0.11	15.89	23.84
Stillhouse	17.56	0.19	8.93	20.69

Table 11. Geographic coordinates for fish pot placement.

Site	Latitude	Longitude
Bishop	41.86248	-71.37877
Butler	41.83940	-71.37800
Conimicut	41.71958	-71.35960
Fields	41.78682	-71.37958
Gaspee	41.74703	-71.37400
Mussachuck	41.72781	-71.34311
Narr. Terr.	41.75224	-71.36497
Omega	41.83687	-71.37222
Pawtucket	41.87102	-71.38249
Pawtuxet	41.75909	-71.38544
Sabin	41.76319	-71.36695
Stillhouse	41.77256	-71.38607

Table 12. Common and scientific names of all species collected in fish pots during 2017 sampling season.

Common Name	Scientific Name
Scup	*Stenotomus chrysops*
Summer Flounder	*Paralichthys dentatus*
Black Sea Bass	*Centropristis striata*
White Perch	*Morone americana*
Tautog	*Tautoga onitis*
Oyster Toadfish	*Opsanus Tau*
Spider Crab	*Libinia sp.*
Blue Crab	*Callinectes sapidus*
Green Crab	*Carcinus maenas*

Table 13. Activities and potential impacts identified as part of the permit review process performed in 2017 by RI DMF (not including aquaculture reviews).

Activities & Potential Impacts - 2017 Permits	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Potential Impacts to SAV or Benthic Habitat	1	1		1						1	1		5
Saltmarsh Restoration			1			1						1	3
Eelgrass Restoration			1										1
Coastal Restoration (other)			2			1			1			1	5
Maintenance Dredging	1	1	2	1	2	1		6	1		2		17
New Dredging		1	1										2
New Marina													0
Marina Expansion or Reconfiguration		1					1						2
Restoration of Tidal Flow to Coastal Pond		1					1						2
Residential Docks (new)													0
Residential Docks (modification)	4	3	4	6	7	2	1	3	2	2	3	2	39
Commercial/Municipal Piers or Docks	1	2	1	1				1	2	2	3		13
Commercial/Municipal Mooring expansion													0
Salt Marsh or Coastal Wetland Impacts	1	1	2	2				2	2	2	2	2	16
Beach Nourishment or Coastal Feature Restoration												1	1
Waterfront Bulkhead/Riprap	1			1	2	2		2		1	1	1	11
Waterfront Development													0
Public Works or Utility												1	1
Fish Passage													0
Potential Shellfish Impacts		1	1					2					4
Channel Maintenance	1		1	1				1	1				5
Boat Ramp (New or Repair)	1		1										2
Oyster Restoration									2				2
Conflict with Recreational Use													0
Impacts from Discharge	1	1		1					1	1		1	6
Total	12	13	17	14	11	7	3	17	12	9	12	10	137

Figure 1. Photo depicting benthic sled configuration. A) Eureka Manta 2; B) SeaView Camera; C) Lasers; D) LED lights.

Figure 2. Benthic video snapshot #4 from Butler depicting green laser lights calibrated ~15cm apart in field of view. Video quality: 5, Substrate Class: Unconsolidated Mineral Substrate, Substrate Group: Mud. Biotic Class: Faunal Bed, Biotic Group: Small Surface-Burrowing Fauna, Co-occurring Elements: Tracks and Trails (Sparse), Bacterial Mat/Film (Moderately Low), Nassariid Bed (Trace).

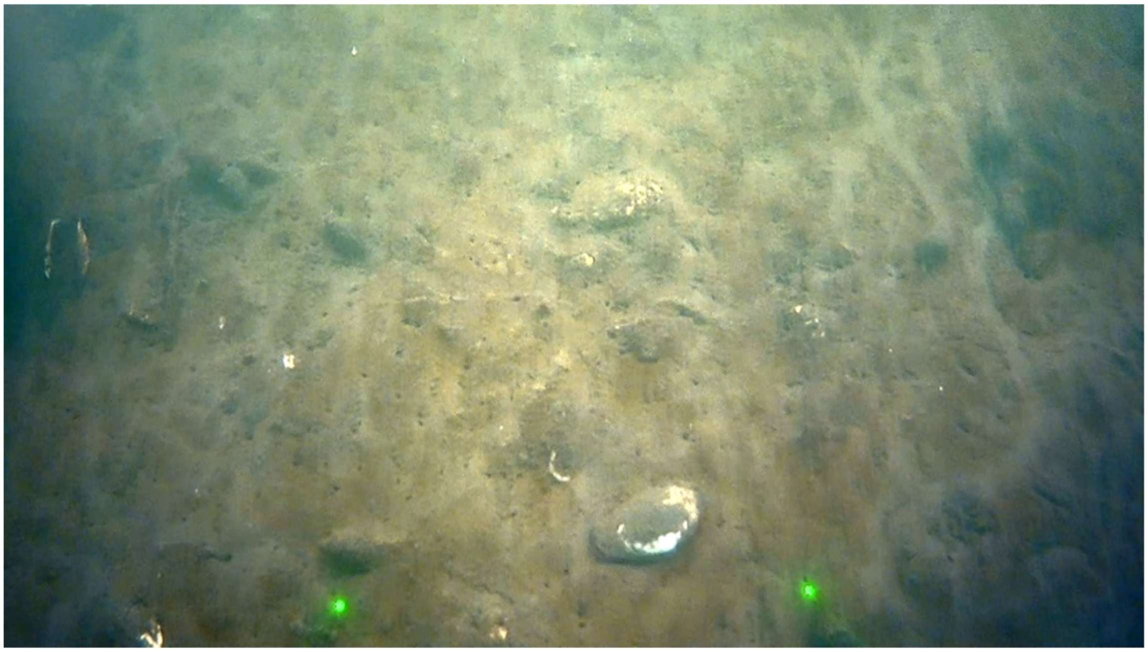


Figure 3. Video quality scale. Video snapshots taken from Gaspee Point. A video snapshot with grade ≥3 was used to identify Substrate and Biotic Components down to the Group level, when possible. See Table 1 for more detailed description of video quality determination.

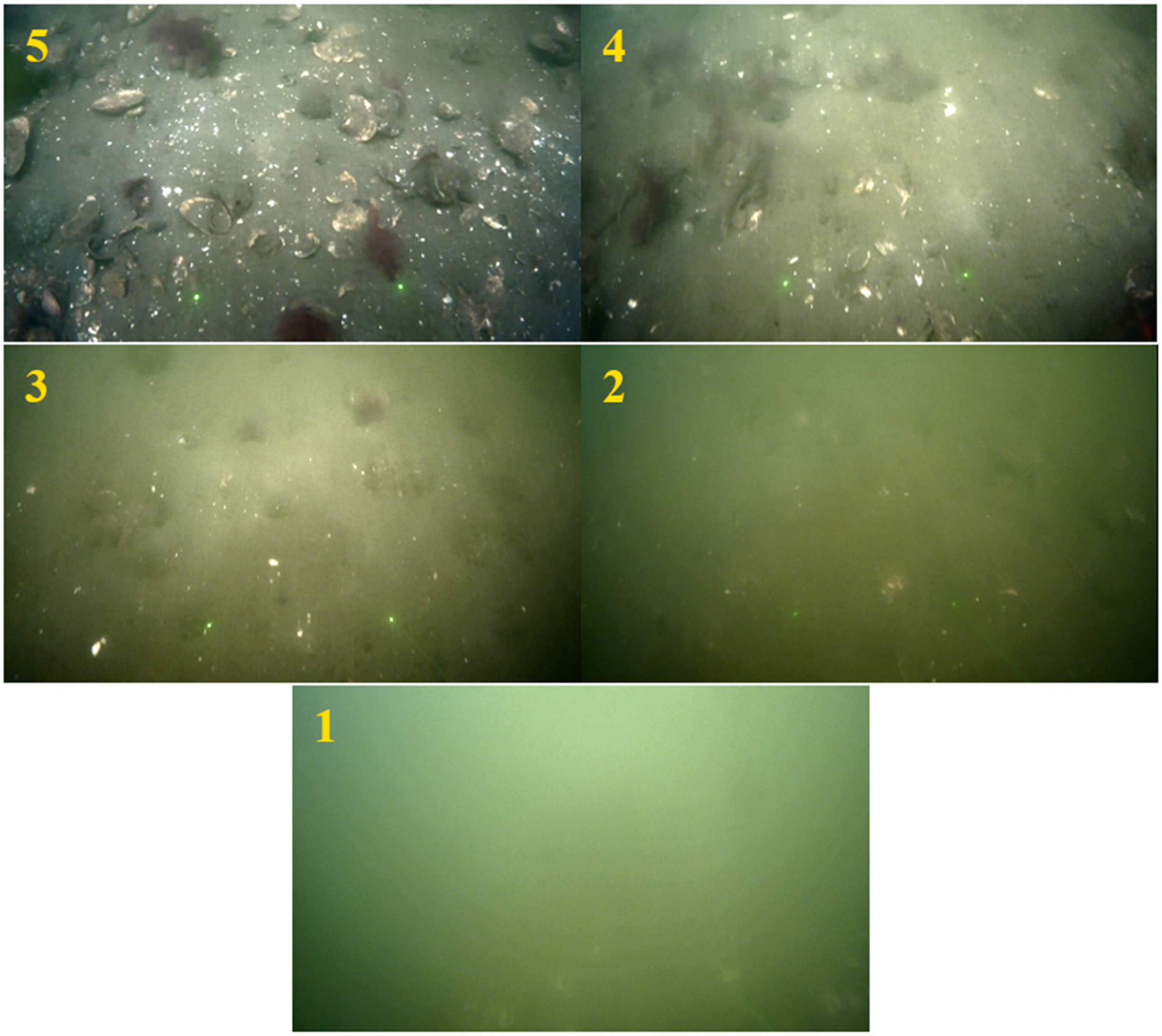


Figure 4. Flowchart of CMECS substrate components used in video analysis thus far.

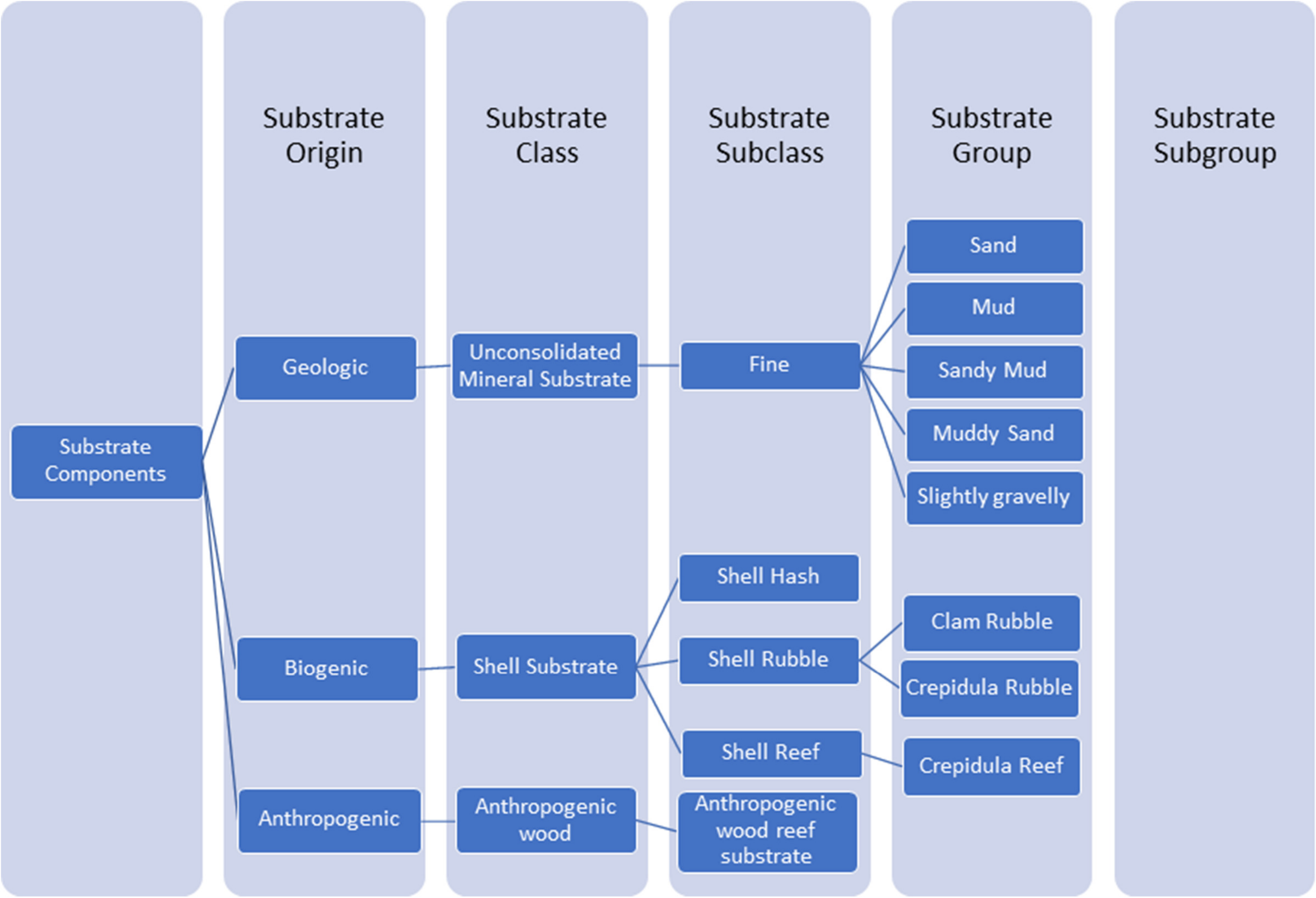


Figure 5. Flowchart of CMECS biotic components used in video analysis thus far.

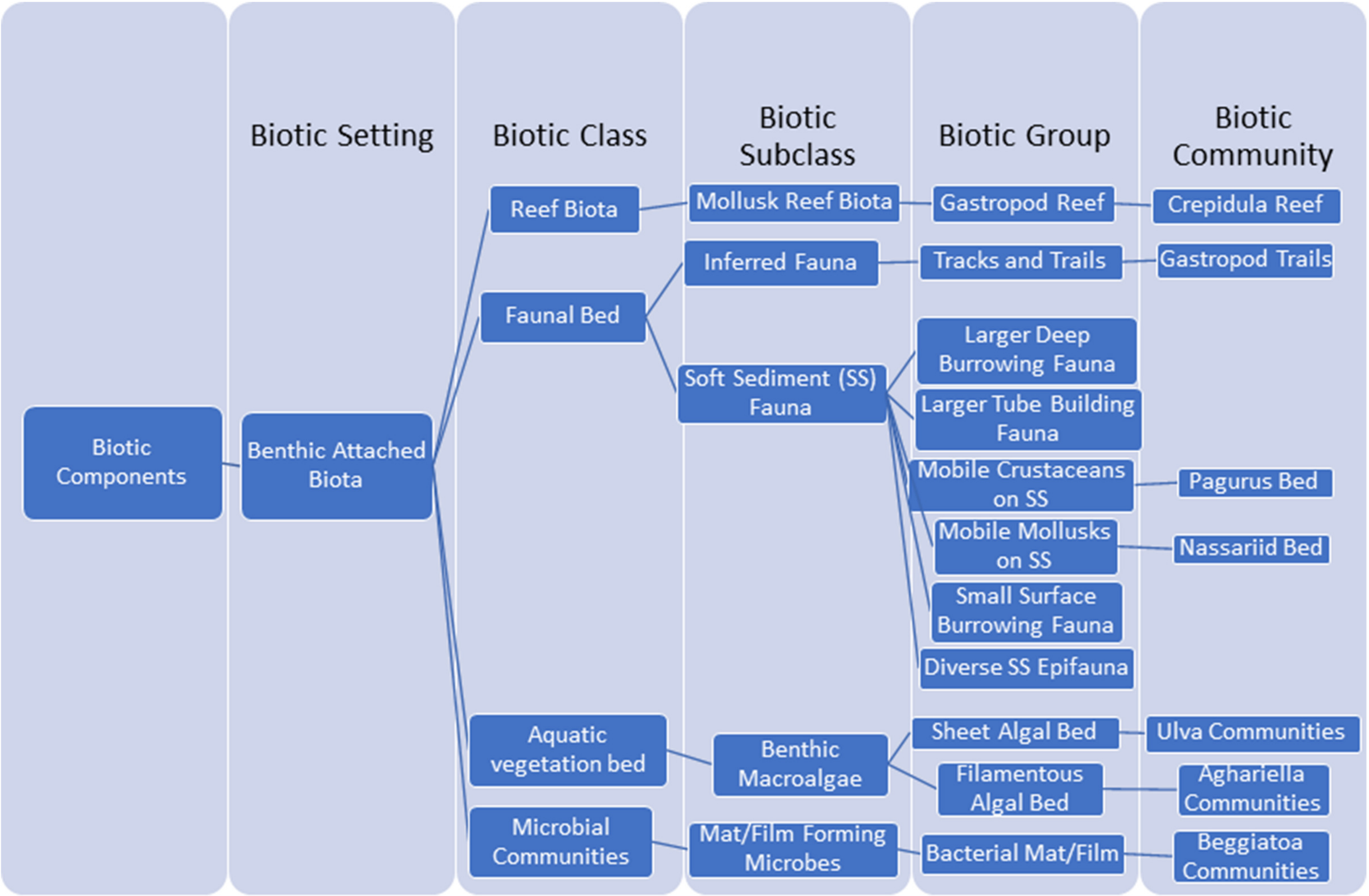


Figure 6. Mean Shannon diversity and species richness across sites in 2017 beach seines.

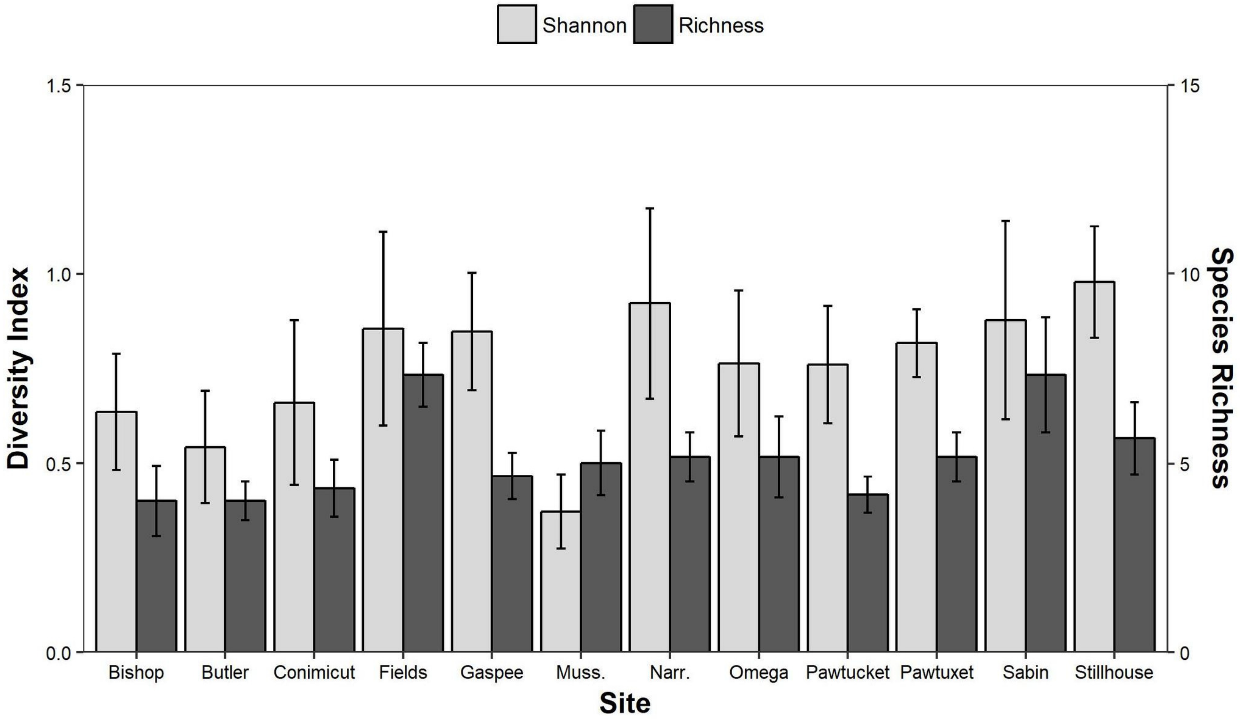


Figure 7. Mean abundance of finfish across sites in 2017 beach seines.

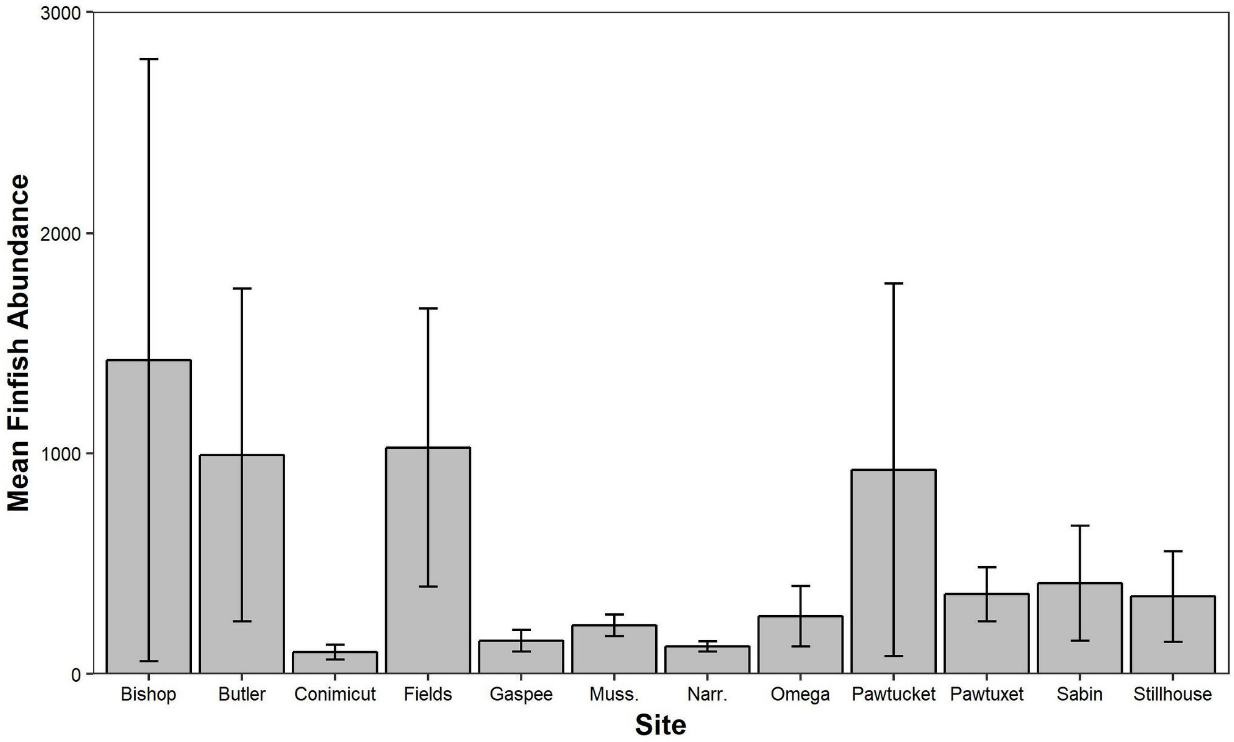


Figure 8. Mean abundance finfish caught each month in 2017 beach seines.

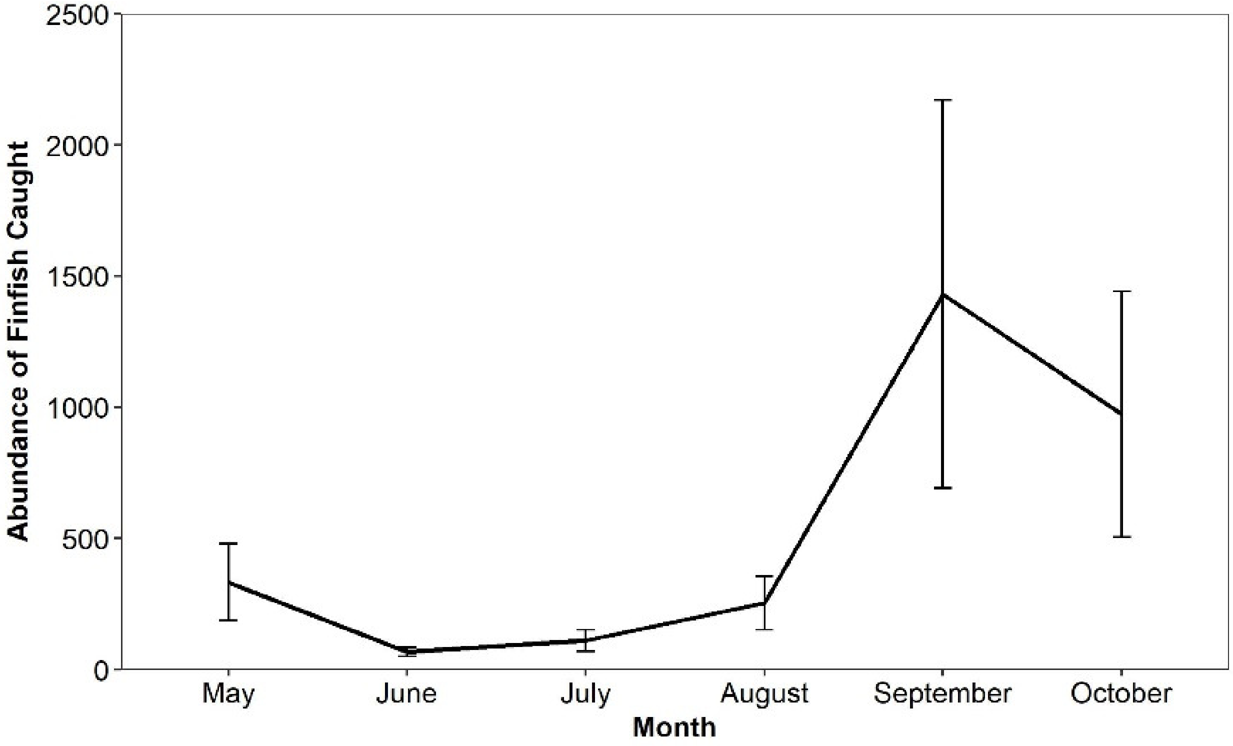


Figure 9. Mean abundance of target finfish caught across sites in 2017 beach seines.

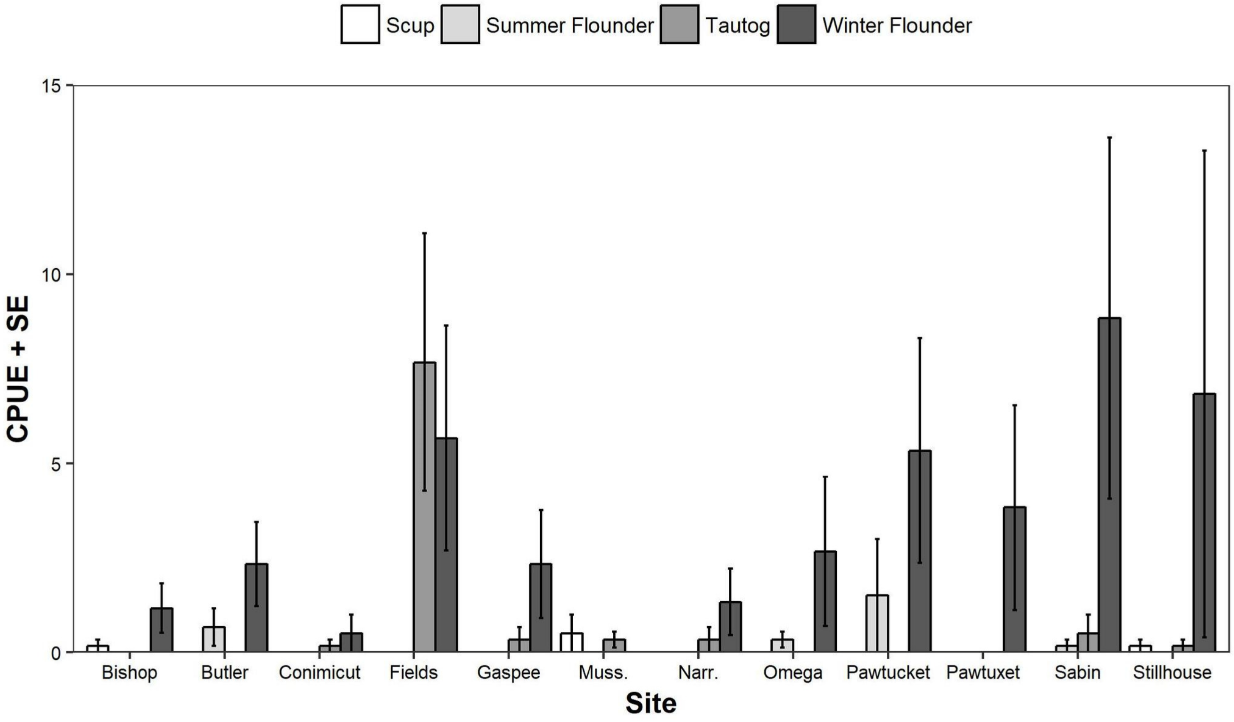


Figure 10. Mean winter flounder per seine haul (± SE) plotted for each month sampled during the 2017 field season.

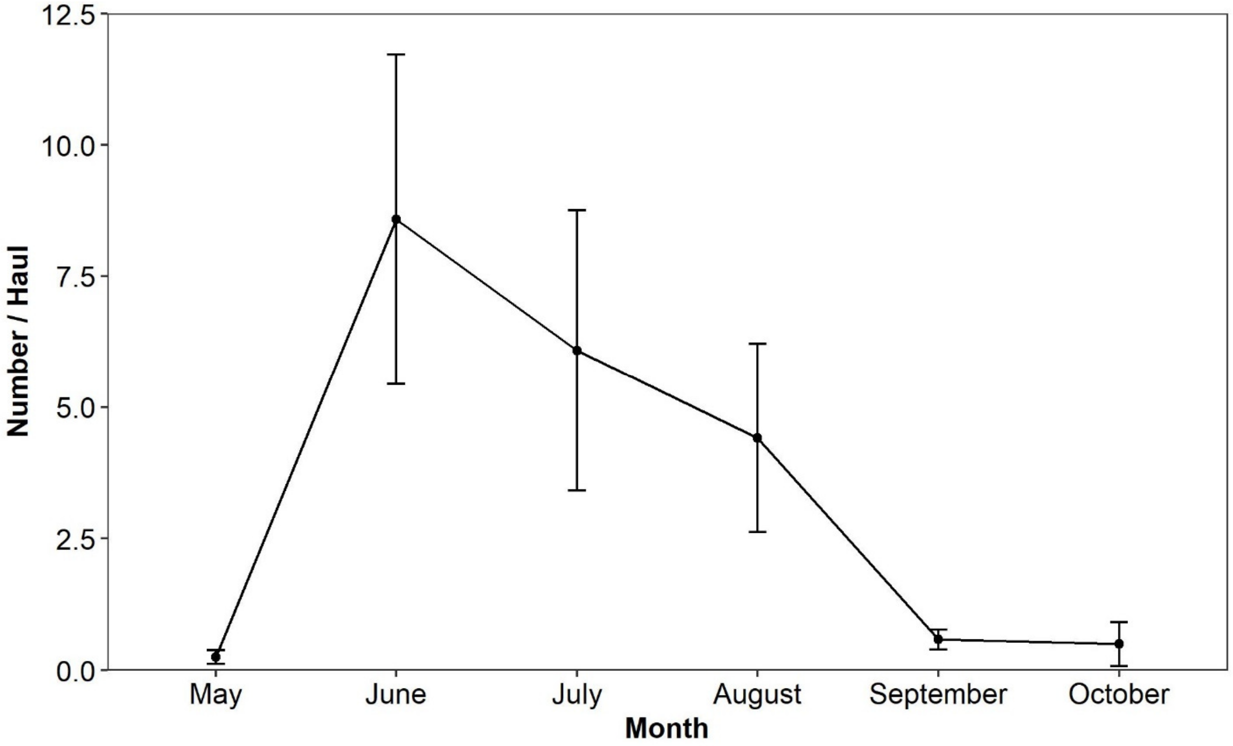


Figure 11. Mean tautog per seine haul (± SE) plotted for each month sampled during the 2017 field season.

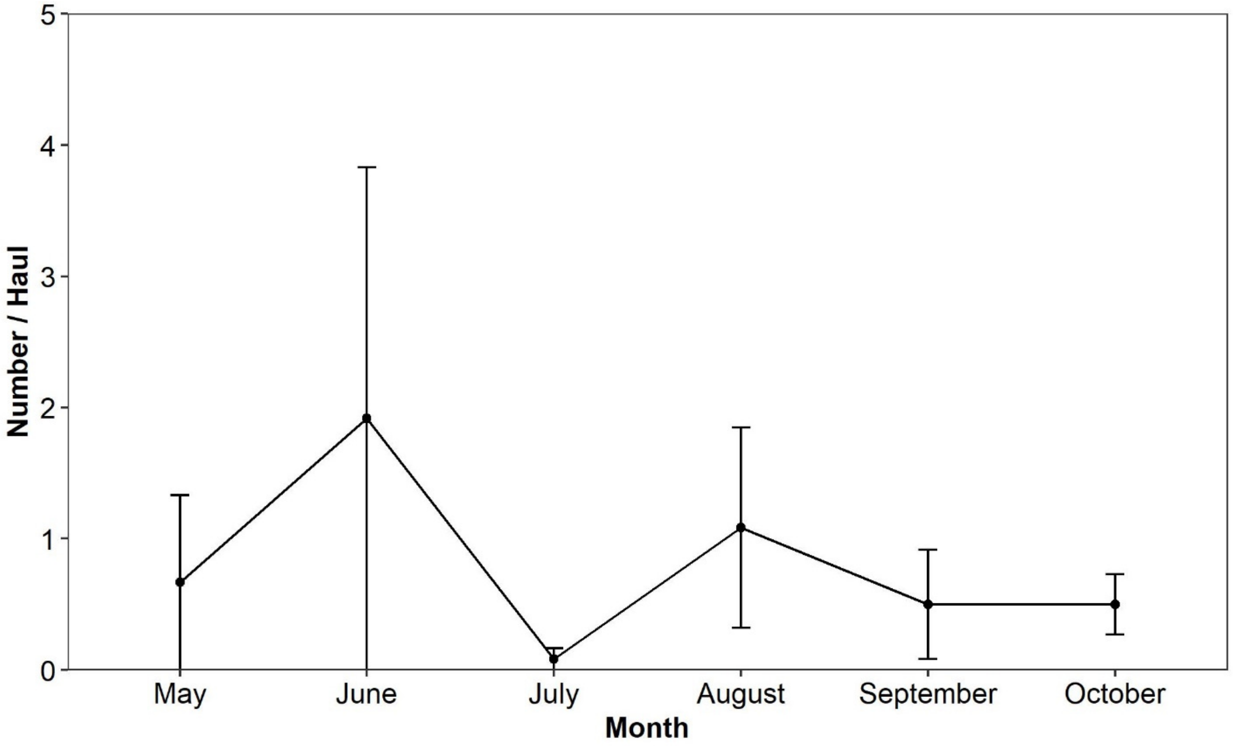


Figure 12. Identified Substrate Class across analyzed sites in 2017 (Figure 4). Percent values indicate the number of snapshots identified as that substrate. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column (e.g. the Bishop transect contained 32 total snapshots). Sites are listed by latitude starting from the northernmost to the southernmost site.

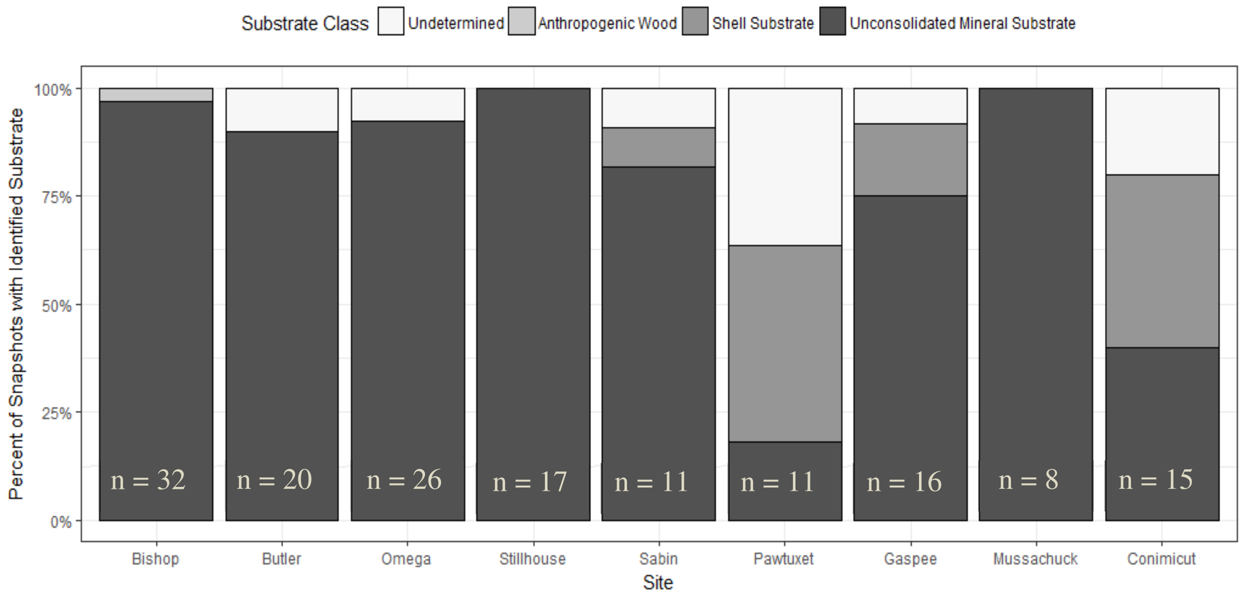


Figure 13. Unconsolidated Mineral Substrate broken down into Substrate Group with video quality ≥3 across analyzed sites in 2017 (Figure 4). Percent values indicate the number of snapshots identified as that substrate. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

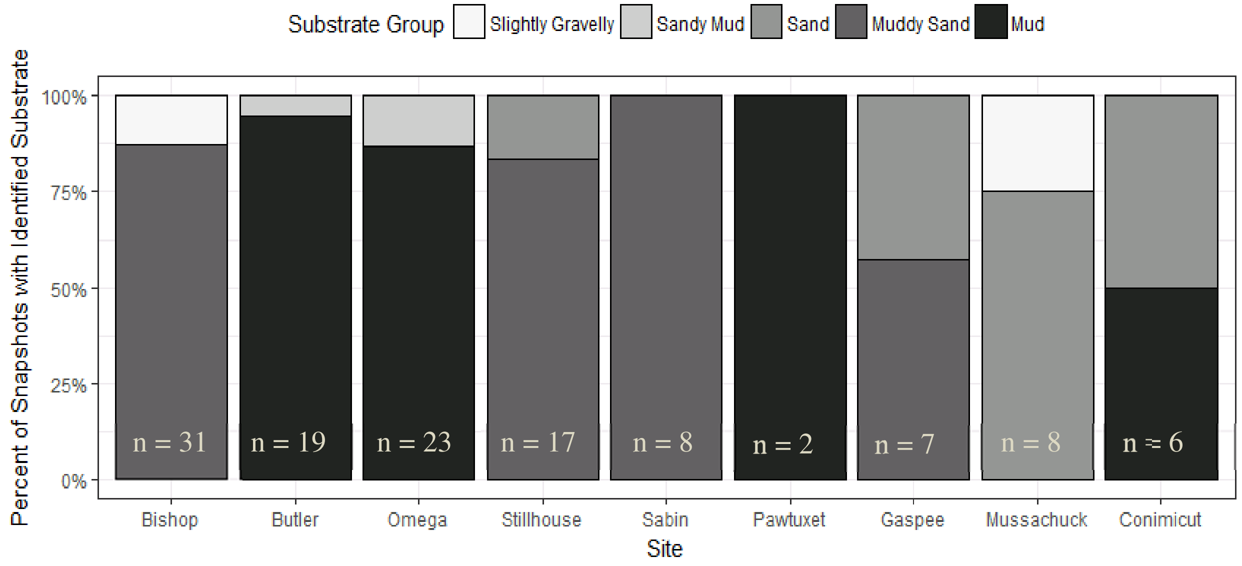


Figure 14. Shell Substrate broken down into Substrate Group with video quality ≥3 across analyzed sites in 2017 (Figure 4). Percent values indicate the number of snapshots identified as that substrate. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

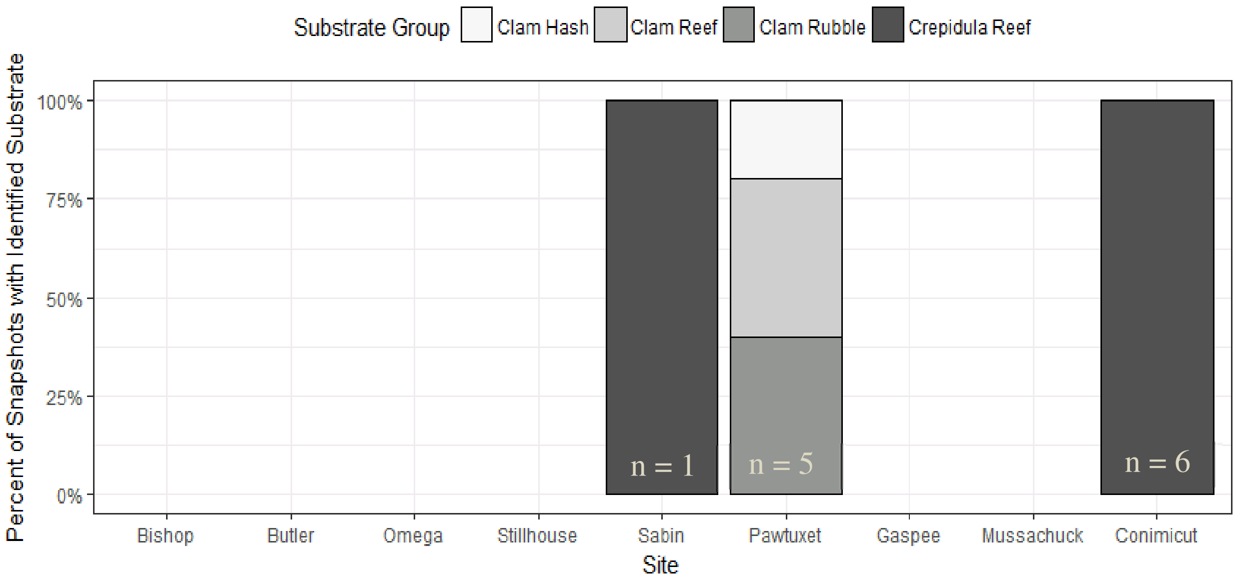


Figure 15. Identified Biotic Class across analyzed sites in 2017 (Figure 5). Percent values indicate the number of snapshots identified as that substrate. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

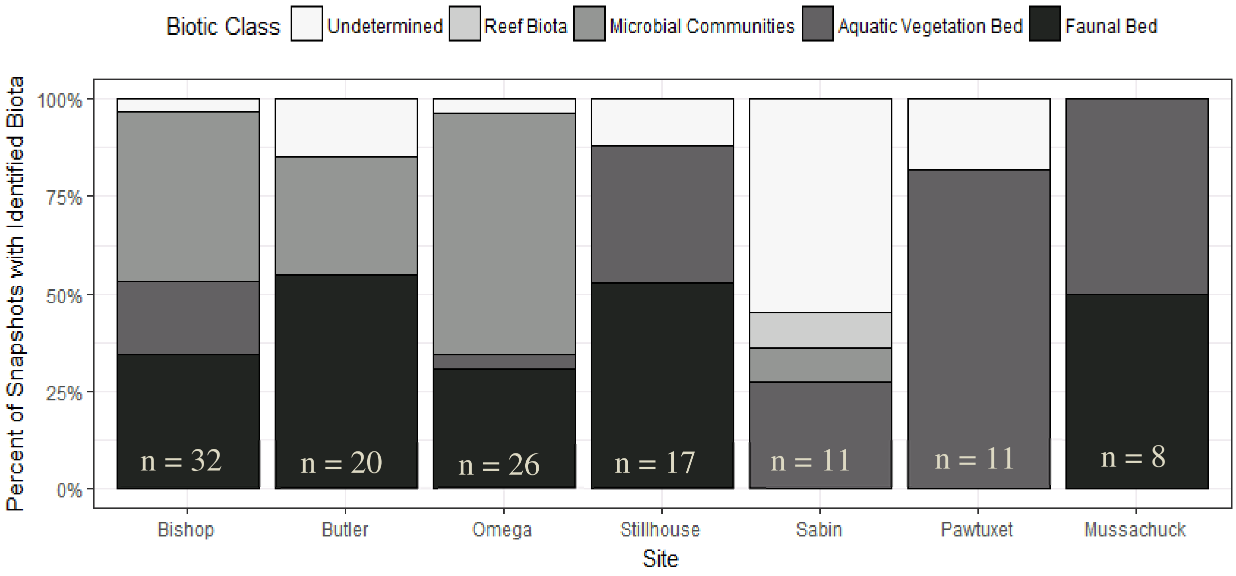


Figure 16. Identified salinity regime using CMECS Salinity Regime Modifier (FGDC 2012; Table 6). Percent values indicate the number of snapshots within each value range. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

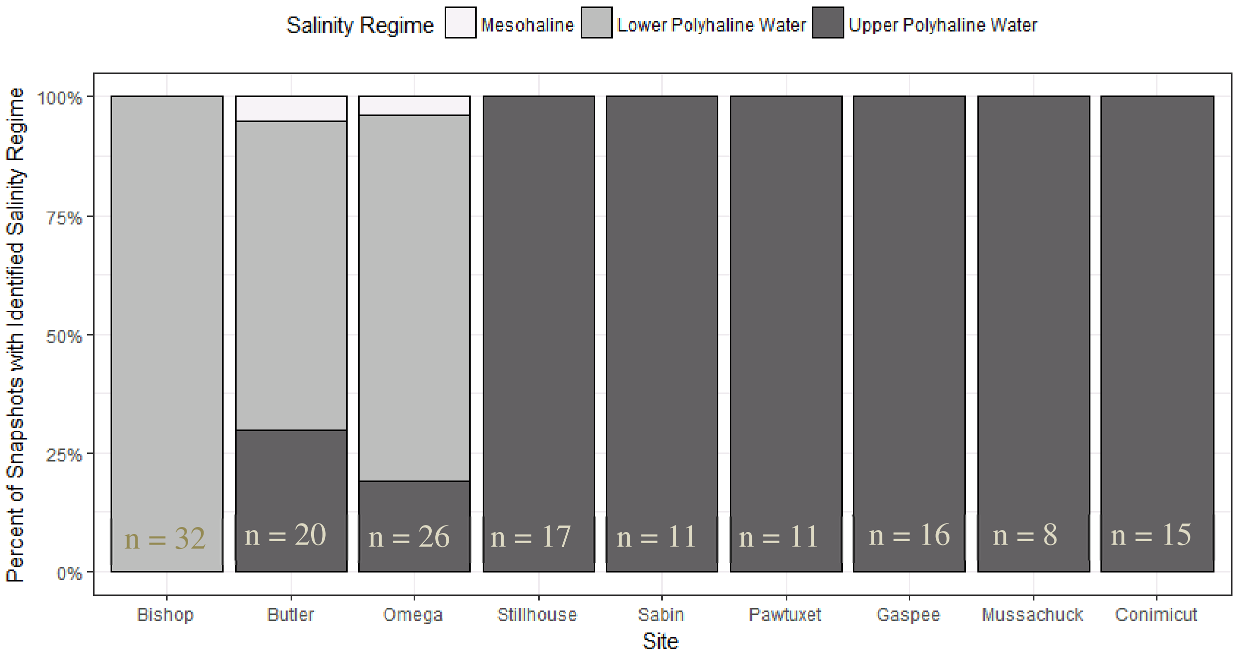


Figure 17. Identified dissolved oxygen regime using CMECS Oxygen Regime Modifier (FGDC 2012; Table 7) Percent values indicate the number of snapshots within each value range. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

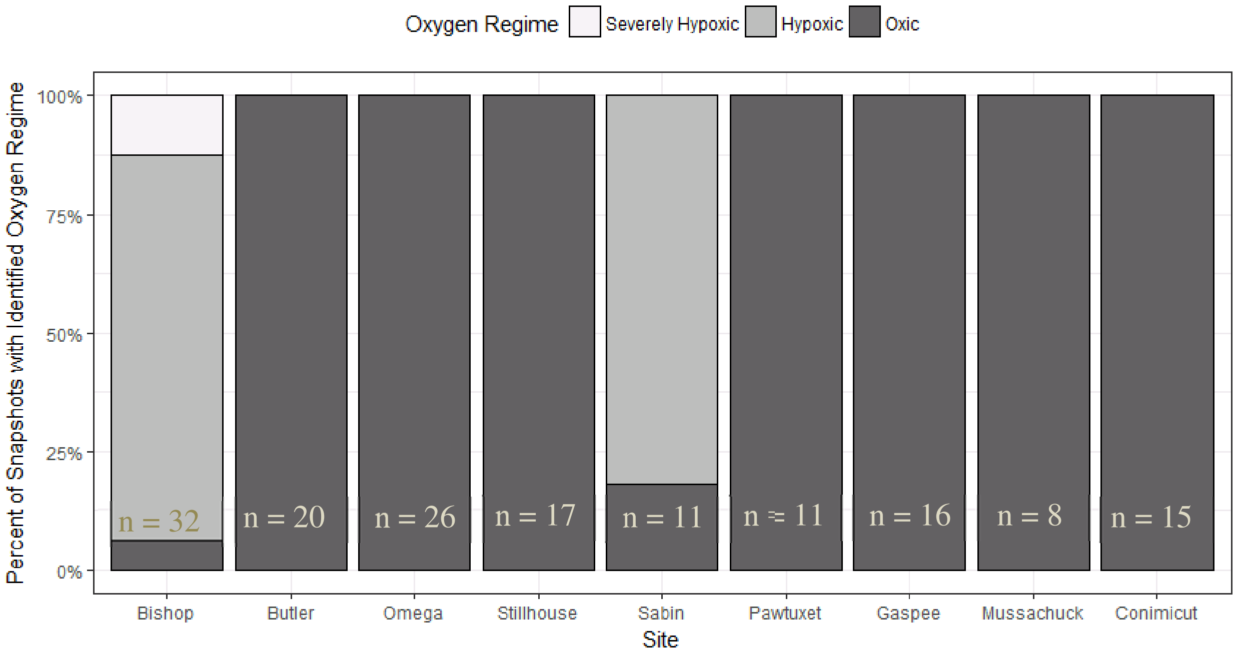


Figure 18. Identified phytoplankton productivity regime using CMECS Phytoplankton Productivity Modifier (FGDC 2012; Table 8). Percent values indicate the number of snapshots within each value range. Sites contain varying numbers of total snapshots analyzed, and are indicated by the number within the column. Sites are listed by latitude starting from the northernmost to the southernmost site.

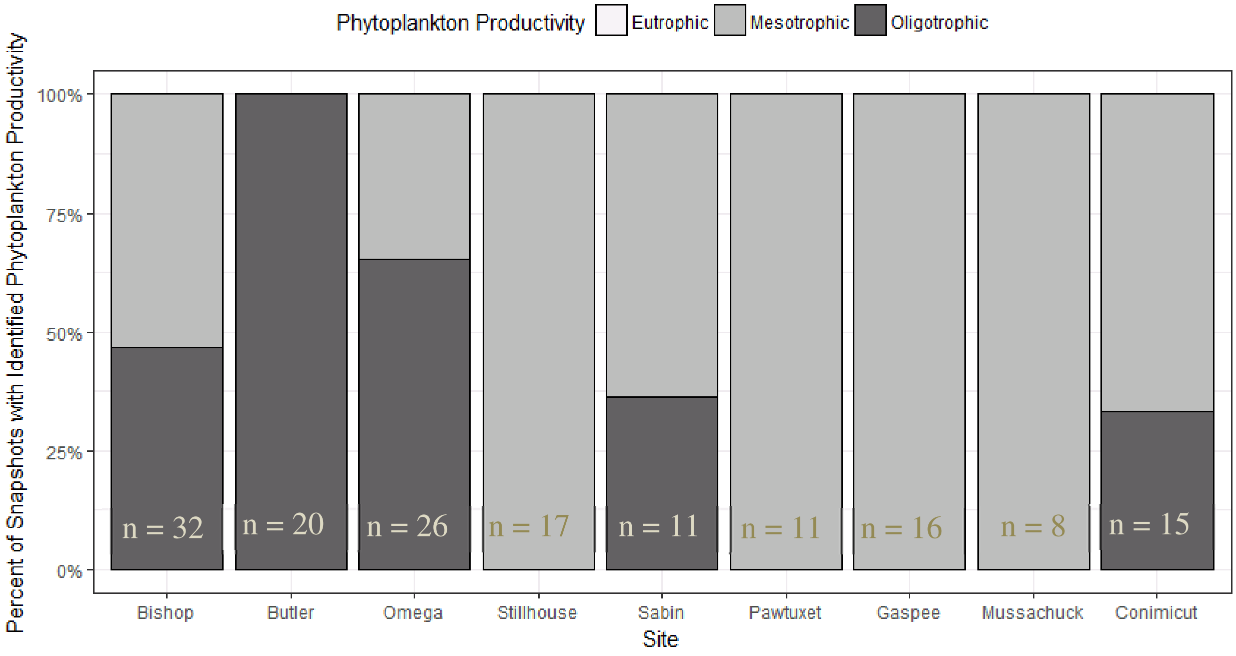


Figure 19. Boxplots of temperature (°F) at sites during 7/19/17 – 7/27/17 with center points representing mean values.

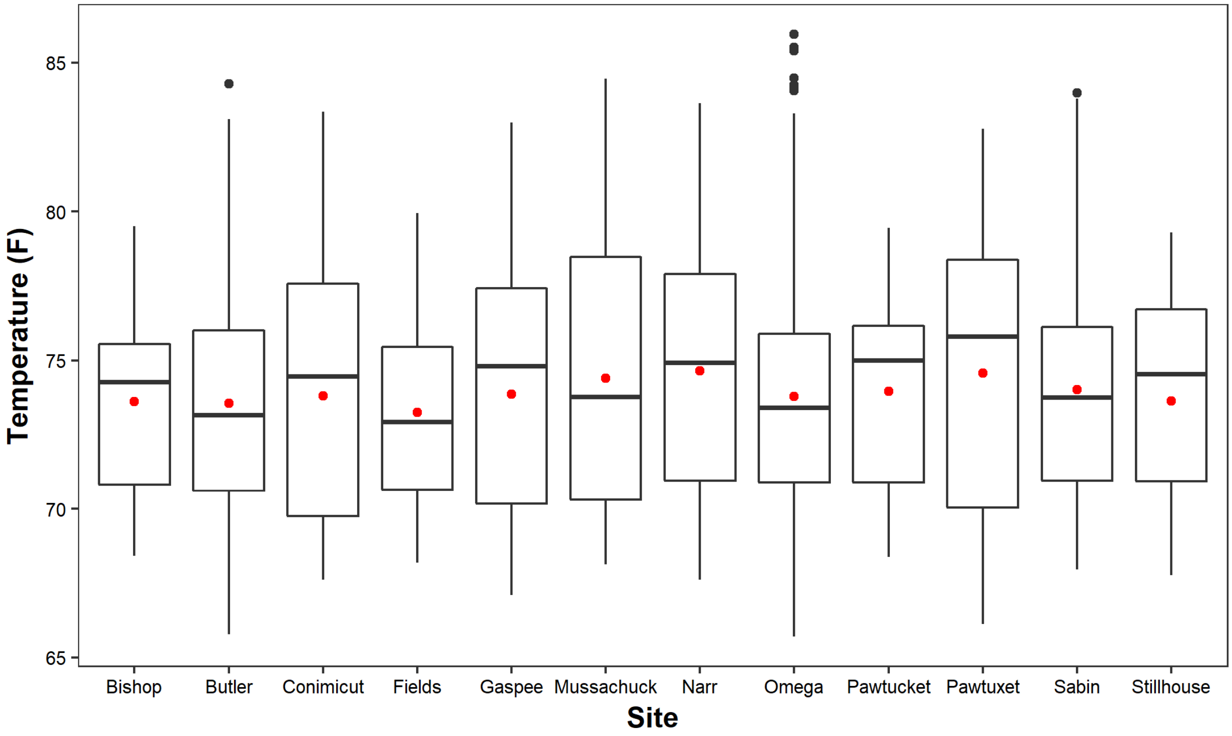


Figure 20. Boxplots of salinity (ppt) at sites during 7/19/17 – 7/27/17, with center points representing mean values.

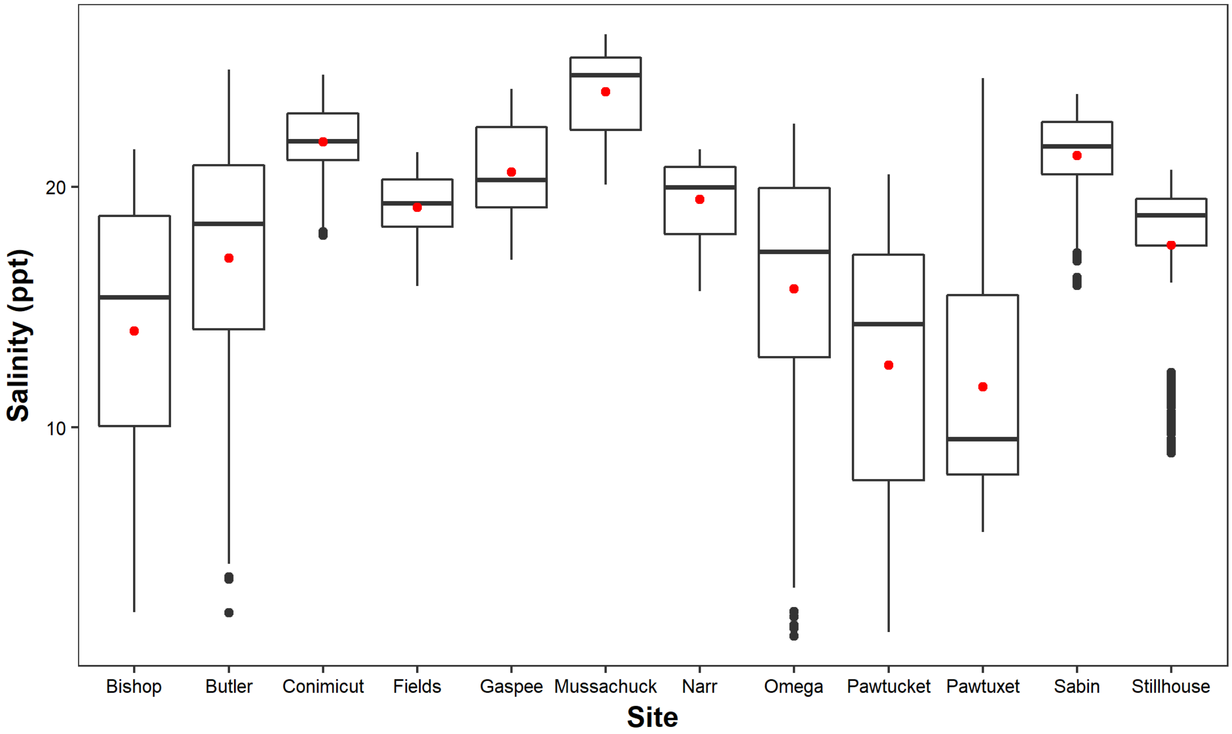


Figure 21. Line graph showing salinity from the Pawtuxet Cove water quality datalogger and tidal height from the NOAA Pawtuxet Cove site during 7/15/17 – 8/18/17.

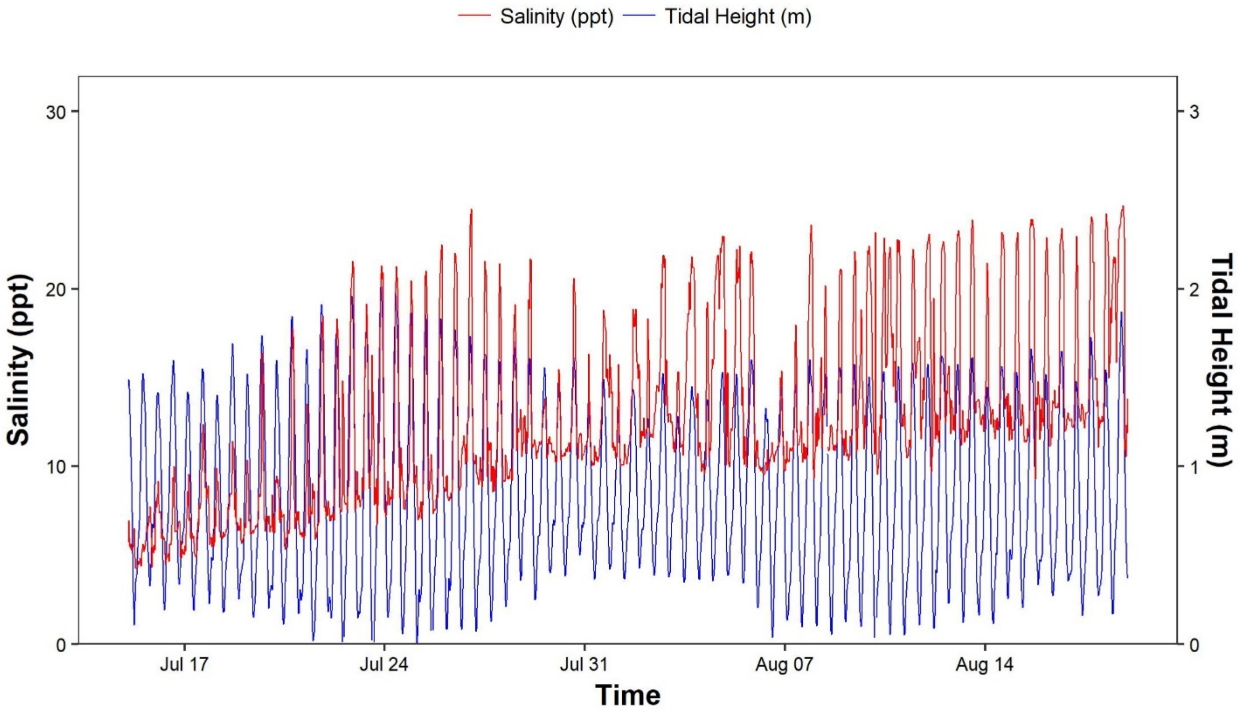


Figure 22. Histogram displaying frequency of instances for D.O. at (top left) Gaspee Point, (top right) Pawtucket Boat Ramp, and (bottom left) Sabin Point for 9/12/17 – 10/25/17. Red line represents hypoxia (D.O. < 2 mg/L)

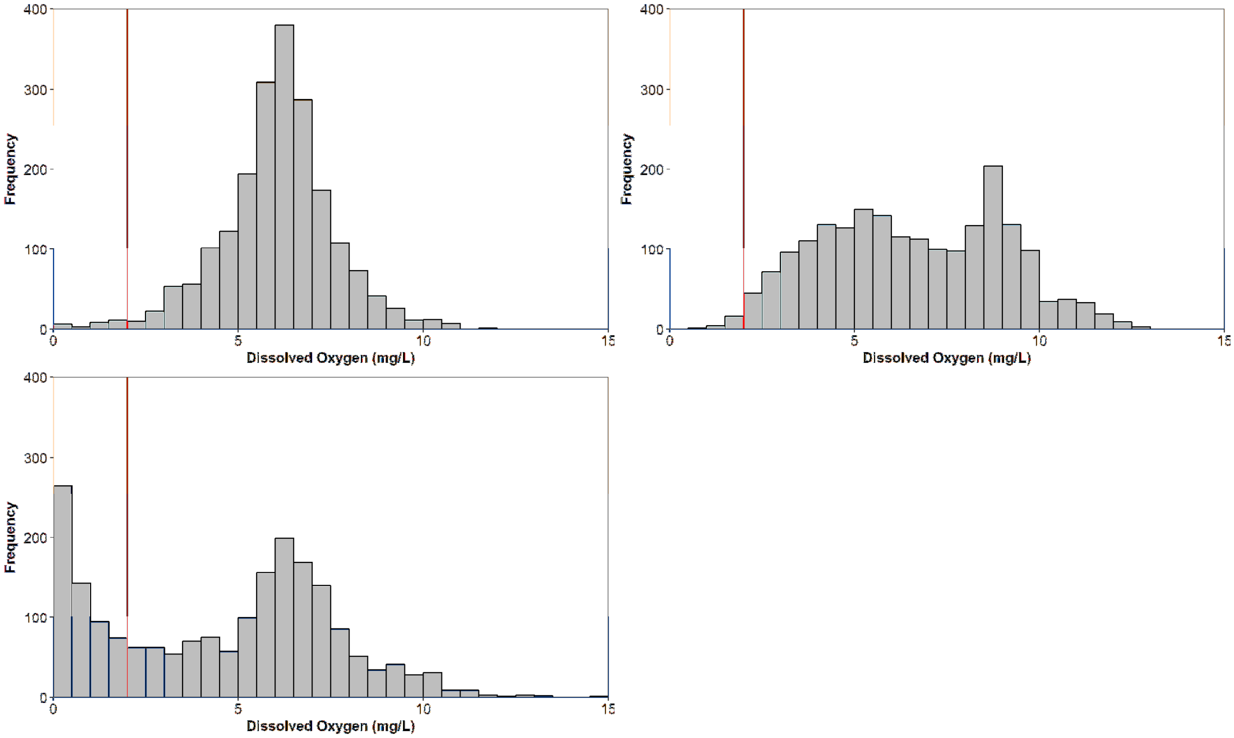
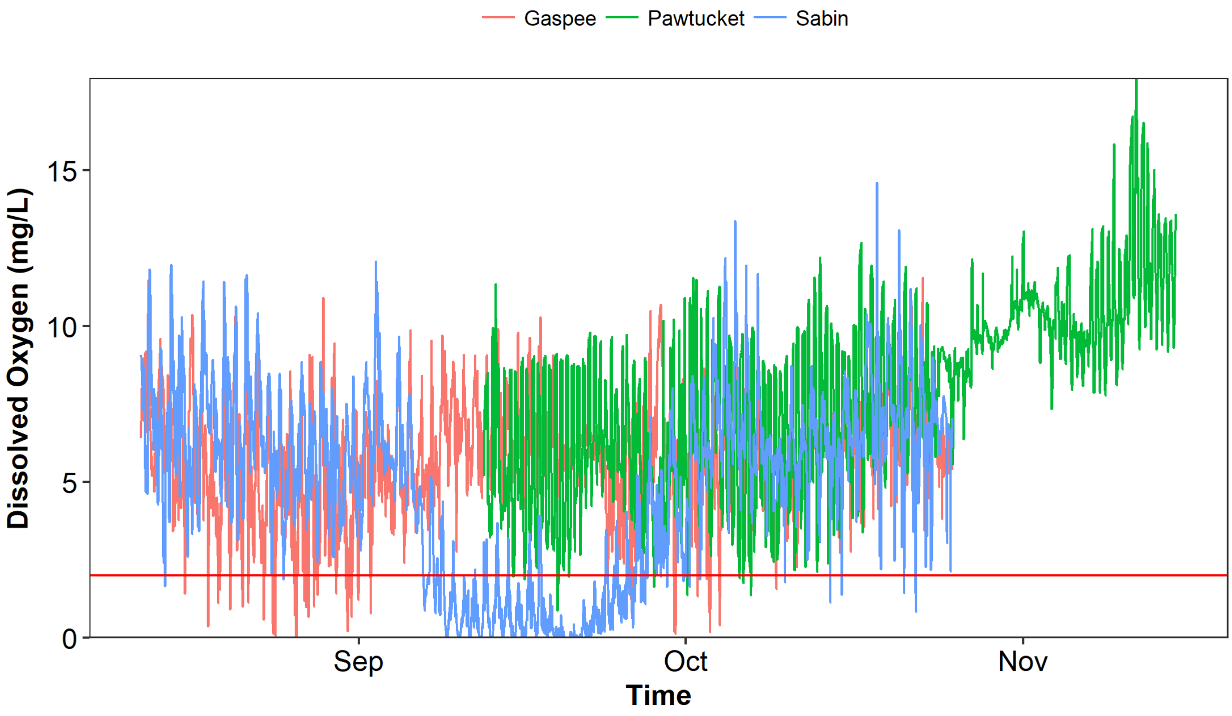


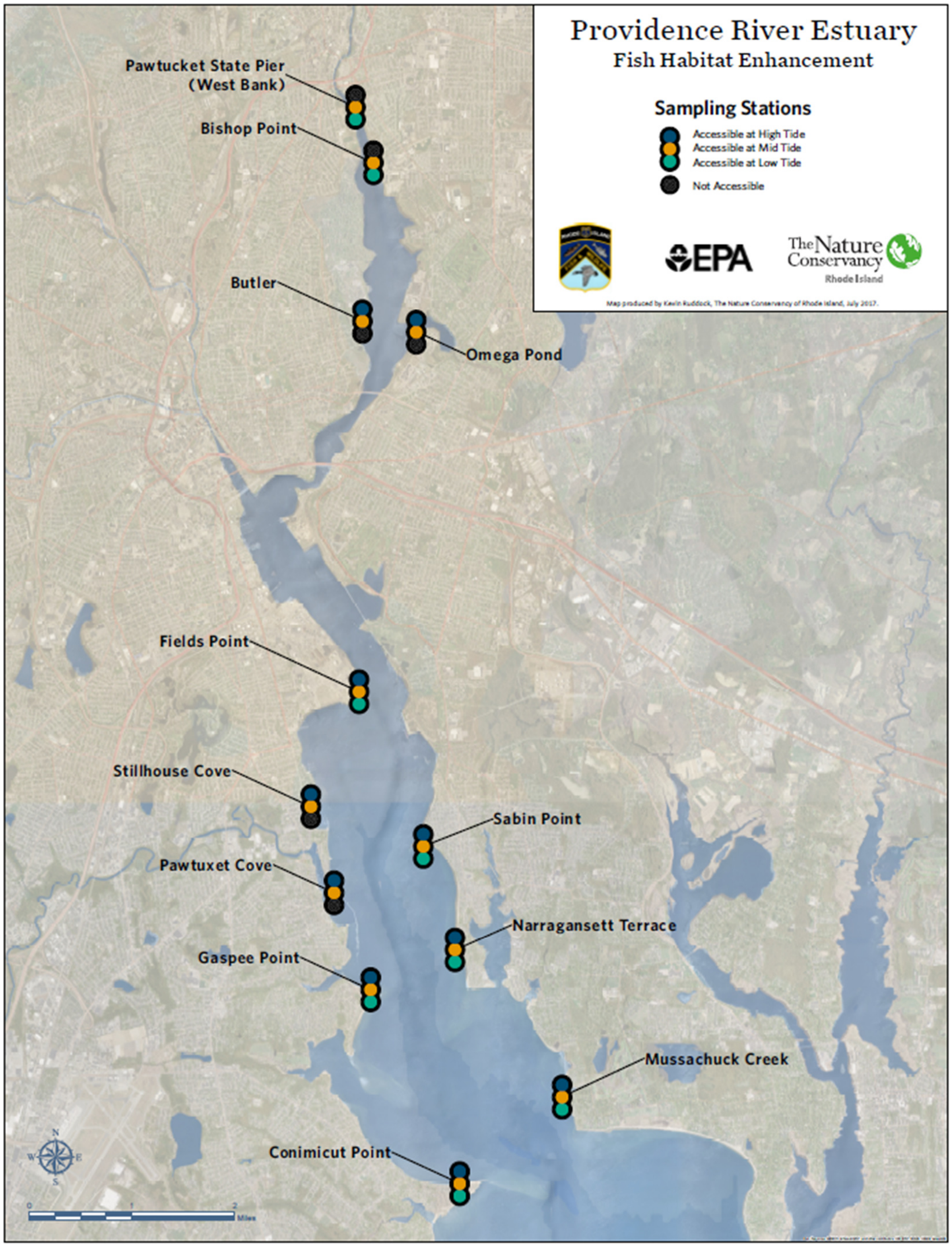
Figure 23. Line graph showing D.O. through time at Gaspee Point, Pawtucket Boat Ramp, and Sabin Point. Red line represents hypoxia (D.O. < 2 mg/L).



Appendix

Station map and catch data summary for fish assemblage and habit assessments conducted in the Providence River tidal estuaries under Objective 1

Map depicting sampling site locations within the Providence River Estuary.



Species presence by site for May 2017 beach seines.

MAY	**Site**												
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1		1	1	1	**11**
4-Spine Stickleback	1			1				1		1			**4**
American Eel	1								1				**2**
Atlantic Tomcod	1						1						**2**
Common Mummichog	1	1		1				1	1	1		1	**7**
Cunner							1						**1**
Hogchoker									1				**1**
Northern Pipefish											1		**1**
Rainwater Killifish										1			**1**
River Herring								1					**1**
Scup	1												**1**
Striped Killifish	1	1	1	1	1	1		1		1	1	1	**10**
Tautog				1									**1**
Winter Flounder	1								1		1		**3**

Species presence by site for June 2017 beach seines.

JUNE	**Site**												
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1		1	1	1	**11**
4-Spine Stickleback				1						1		1	**3**
American Eel												1	**1**
Atlantic Tomcod			1	1		1	1					1	**5**
Common Mummichog			1	1	1			1	1	1		1	**7**
Cunner				1		1					1		**3**
Northern Pipefish			1	1			1				1		**4**
River Herring								1			1		**2**
Smallmouth Flounder			1										**1**
Spot												1	**1**
Striped Bass								1					**1**
Striped Killifish		1		1	1							1	**4**
Summer Flounder		1						1					**2**
Tautog				1									**1**
White Perch								1					**1**
Winter Flounder	1	1	1	1	1		1	1	1	1	1	1	**11**

Species presence by site for July 2017 beach seines.

JULY	**Site**												
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1		**11**
Atlantic Menhaden		1				1					1		**3**
Atlantic Tomcod							1						**1**
Bluefish			1	1	1	1	1						**5**
Common Mummichog				1		1					1	1	**4**
Hogchoker									1				**1**
Largemouth Bass									1				**1**
Northern Kingfish						1						1	**2**
Northern Puffer			1										**1**
River Herring			1		1	1	1				1	1	**6**
Spot											1		**1**
Striped Bass										1			**1**
Striped Killifish	1				1	1				1	1		**5**
Summer Flounder									1		1		**2**
Tautog				1									**1**
White Perch											1		**1**
Winter Flounder		1		1	1		1	1	1		1	1	**8**

Species presence by site for August 2017 beach seines.

AUGUST	**Site**											
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
American Eel				1									**1**
Atlantic Menhaden											1		**1**
Atlantic Needlefish											1		**1**
Bluefish							1						**1**
Common Mummichog		1	1	1		1	1		1	1	1	1	**9**
Cunner				1							1		**2**
Hogchoker	1								1				**2**
Longhorn Sculpin					1								**1**
Naked Goby									1		1		**2**
Northern Kingfish			1	1	1	1	1			1	1	1	**8**
Northern Pipefish											1		**1**
Oyster Toadfish				1									**1**
River Herring	1	1				1	1				1		**5**
Scup						1							**1**
Sheepshead Minnow										1			**1**
Spot											1	1	**2**
Striped Killifish		1	1	1	1	1	1			1	1	1	**9**
Striped Searobin				1	1		1				1		**4**
Summer Flounder		1											**1**
Tautog				1		1					1		**3**
Weakfish								1					**1**
White Perch								1		1			**2**
Winter Flounder	1	1		1	1				1	1	1		**7**

Species presence by site for September 2017 beach seines.

SEPTEMBER	**Site**												
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Atlantic Menhaden	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Atlantic Needlefish					1								**1**
Bluefish	1		1	1			1					1	**5**
Bluegill										1			**1**
Common Mummichog			1	1		1	1			1	1	1	**7**
Cunner				1									**1**
Northern Kingfish			1								1	1	**3**
River Herring	1					1	1					1	**4**
Scup												1	**1**
Searobins					1								**1**
Sheepshead Minnow										1			**1**
Striped Killifish	1		1		1	1	1	1		1	1	1	**9**
Striped Searobin				1									**1**
Tautog			1	1									**2**
White Mullet											1		**1**
White Perch							1	1	1				**3**
Winter Flounder		1		1					1	1	1	1	**6**

Species presence by site for October 2017 beach seines.

OCTOBER	Site												
Species	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Total**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
4-Spine Stickleback								1					**1**
American Eel										1			**1**
Atlantic Menhaden	1	1		1	1	1		1	1		1	1	**9**
Bluegill						1		1	1	1			**4**
Common Mummichog		1	1	1	1		1			1	1	1	**8**
Cunner				1		1							**2**
Gizzard Shad				1									**1**
Golden Shiner								1					**1**
Hogchoker									1				**1**
Naked Goby		1			1								**2**
River Herring							1						**1**
Striped Killifish		1	1	1	1	1	1	1		1	1	1	**10**
Summer Flounder								1					**1**
Tautog					1	1	1					1	**4**
White Mullet								1					**1**
White Perch	1							1	1				**3**
Winter Flounder				1							1		**2**

Abundances of winter flounder and summer flounder in 2017 beach seines.

		Site														
	Month	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Mean**	**SD**	**SE**
Winter Flounder	**May**	1	0	0	0	0	0	0	0	1	0	1	0	0.25	0.45	0.13
	June	2	7	3	16	9	0	3	4	1	4	15	39	8.58	10.88	3.14
	July	0	4	0	2	2	0	5	12	17	0	30	1	6.08	9.24	2.67
	August	4	2	0	14	3	0	0	0	12	17	1	0	4.42	6.22	1.79
	September	0	1	0	1	0	0	0	0	1	2	1	1	0.58	0.67	0.19
	October	0	0	0	1	0	0	0	0	0	0	5	0	0.50	1.45	0.42
	Mean	1.17	2.33	0.50	5.67	2.33	0.00	1.33	2.67	5.33	3.83	8.83	6.83		Total Fish	
	SD	1.60	2.73	1.22	7.28	3.50	0.00	2.16	4.84	7.28	6.65	11.70	15.77			
	SE	0.65	1.12	0.50	2.97	1.43	0.00	0.88	1.98	2.97	2.71	4.78	6.44		245	
	Total	7	14	3	34	14	0	8	16	32	23	53	41			
Summer Flounder	**May**	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	0.000
	June	0	3	0	0	0	0	0	1	0	0	0	0	0.333	0.888	0.256
	July	0	0	0	0	0	0	0	0	9	0	1	0	0.833	2.588	0.747
	August	0	1	0	0	0	0	0	0	0	0	0	0	0.083	0.289	0.083
	September	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	0.000
	October	0	0	0	0	0	0	0	1	0	0	0	0	0.083	0.289	0.083
	Mean	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.33	1.50	0.00	0.17	0.00		Total Fish	
	SD	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.52	3.67	0.00	0.41	0.00			
	SE	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.21	1.50	0.00	0.17	0.00		16	
	Total	0	4	0	0	0	0	0	2	9	0	1	0			

Abundances of tautog and scup in 2017 beach seines.

		Site														
	Month	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Mean**	**SD**	**SE**
Tautog	**May**	0	0	0	8	0	0	0	0	0	0	0	0	0.67	2.31	0.67
	June	0	0	0	23	0	0	0	0	0	0	0	0	1.92	6.64	1.92
	July	0	0	0	1	0	0	0	0	0	0	0	0	0.08	0.29	0.08
	August	0	0	0	9	0	1	0	0	0	0	3	0	1.08	2.64	0.76
	September	0	0	1	5	0	0	0	0	0	0	0	0	0.50	1.45	0.42
	October	0	0	0	0	2	1	2	0	0	0	0	1	0.50	0.80	0.23
	Mean	0.00	0.00	0.17	7.67	0.33	0.33	0.33	0.00	0.00	0.00	0.50	0.17		Total Fish	
	SD	0.00	0.00	0.41	8.33	0.82	0.52	0.82	0.00	0.00	0.00	1.22	0.41			
	SE	0.00	0.00	0.17	3.40	0.33	0.21	0.33	0.00	0.00	0.00	0.50	0.17		57	
	Total	0	0	1	46	2	2	2	0	0	0	3	1			
Scup	**May**	1	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0.1
	June	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	July	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	August	0	0	0	0	0	3	0	0	0	0	0	0	0.3	0.9	0.3
	September	0	0	0	0	0	0	0	0	0	0	0	1	0.1	0.3	0.1
	October	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	Mean	0.17	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.17		Total Fish	
	SD	0.41	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.41			
	SE	0.17	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.17		5	
	Total	1	0	0	0	0	3	0	0	0	0	0	1			

Abundances of bluefish and Atlantic menhaden in 2017 beach seines.

		Site														
	Month	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Mean**	**SD**	**SE**
Bluefish	**May**	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	June	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	July	0	0	2	4	2	6	2	0	0	0	0	0	1.33	1.97	0.57
	August	0	0	0	0	0	0	11	0	0	0	0	0	0.92	3.18	0.92
	September	1	0	3	47	0	0	6	0	0	0	0	1	4.83	13.40	3.87
	October	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	Mean	0.17	0.00	0.83	8.50	0.33	1.00	3.17	0.00	0.00	0.00	0.00	0.17		Total Fish	
	SD	0.41	0.00	1.33	18.93	0.82	2.45	4.49	0.00	0.00	0.00	0.00	0.41			
	SE	0.17	0.00	0.54	7.73	0.33	1.00	1.83	0.00	0.00	0.00	0.00	0.17		85	
	Total	1	0	5	51	2	6	19	0	0	0	0	1			
Atlantic Menhaden	**May**	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	June	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
	July	0	58	0	0	0	5	0	0	0	0	401	0	38.7	115.3	33.3
	August	0	0	0	0	0	0	0	0	0	0	1	0	0.1	0.3	0.1
	September	7500	750	3	3	3	6	10	750	5000	621	4	3	1221.1	2428.4	701.0
	October	3	4635	0	3759	186	1	0	9	73	0	1527	19	851.0	1631.9	471.1
	Mean	1250.5	907.2	0.5	627.0	31.5	2.0	1.7	126.5	845.5	103.5	322.2	3.7		Total Fish	
	SD	3061.6	1849.9	1.2	1534.4	75.7	2.8	4.1	305.5	2035.5	253.5	611.5	7.6			
	SE	1249.9	755.2	0.5	626.4	30.9	1.1	1.7	124.7	831.0	103.5	249.7	3.1		25330	
	Total	7503	5443	3	3762	189	12	10	759	5073	621	1933	22			

Abundances of River Herring in 2017 beach seines.

Site

River Herring

Month	Bishop Pt.	Butler	Conimicut Pt.	Fields Pt.	Gaspee Pt.	Mussachuck Creek	Narragansett Terrace	Omega Pond	Pawtucket State Pier	Pawtuxet Cove	Sabin Pt.	Stillhouse Cove	**Mean**	**SD**	**SE**
May	0	0	0	0	0	0	0	5	0	0	0	0	0.42	1.44	0.42
June	0	0	0	0	0	0	0	13	0	0	1	0	1.17	3.74	1.08
July	0	0	4	0	11	243	1	0	0	0	8	9	23.00	69.40	20.03
August	3	1	0	0	0	2	1	0	0	0	1	0	0.67	0.98	0.28
September	6	0	0	0	0	1	7	0	0	0	0	1	1.25	2.49	0.72
October	0	0	0	0	0	0	1	0	0	0	0	0	0.08	0.29	0.08
Mean	1.50	0.17	0.67	0.00	1.83	41.00	1.67	3.00	0.00	0.00	1.67	1.67		Total Fish	
SD	2.51	0.41	1.63	0.00	4.49	98.96	2.66	5.29	0.00	0.00	3.14	3.61			
SE	1.02	0.17	0.67	0.00	1.83	40.40	1.09	2.16	0.00	0.00	1.28	1.48		319	
Total	9	1	4	0	11	246	10	18	0	0	10	10			

Temperature, salinity, and dissolved oxygen by site and month during 2017 beach seines (NA indicates when YSI device failed).

Site	Month	Temp. (°C)	Sal. (ppt)	DO (mg/L)	Site	Month	Temp. (°C)	Sal. (ppt)	DO (mg/L)
Pawtucket State Pier	May	13.4	14.4	12.0	Sabin Pt.	May	14.4	16.0	10.5
	June	17.0	1.2	12.6		June	17.1	14.9	NA
	July	24.2	2.1	5.8		July	NA	NA	NA
	August	22.5	7.4	6.6		August	22.8	26.9	4.7
	September	20.9	15.1	2.6		September	20.6	28.9	7.2
	October	16.1	0.9	12.0		October	15.6	17.6	10.2
Bishop Pt.	May	NA	NA	NA	Pawtuxet Cove	May	16.6	4.0	10.1
	June	17.0	1.2	12.6		June	17.6	3.5	9.4
	July	24.1	3.7	6.1		July	24.3	8.1	8.9
	August	22.8	10.3	4.9		August	21.7	10.3	7.5
	September	21.2	17.9	NA		September	19.6	13.9	7.3
	October	16.2	1.0	12.6		October	13.1	1.1	11.4
Butler	May	13.2	1.6	13.9	Narragansett Terrace	May	15.9	27.0	NA
	June	19.1	4.7	11.0		June	16.7	22.6	11.9
	July	25.2	5.4	5.0		July	24.4	24.6	6.0
	August	24.5	13.3	5.0		August	22.6	27.3	5.0
	September	21.2	19.4	4.7		September	19.9	28.1	7.2
	October	16.2	4.8	9.7		October	15.1	14.9	10.1
Omega Pond	May	13.7	2.1	10.3	Gaspee Pt.	May	15.1	20.0	11.9
	June	19.8	3.0	8.0		June	17.3	17.4	8.8
	July	23.3	15.4	3.5		July	24.3	22.1	8.0
	August	23.2	17.7	4.0		August	24.1	22.5	11.3
	September	21.3	17.9	4.5		September	21.1	27.4	7.2
	October	15.3	1.4	11.1		October	14.6	11.4	10.3
Fields Pt.	May	12.3	21.8	11.4	Mussachuck Creek	May	12.3	23.3	9.6
	June	17.8	18.0	10.8		June	15.9	27.0	NA
	July	25.5	18.2	9.1		July	23.4	26.5	5.4
	August	24.5	23.3	10.8		August	23.5	26.7	8.6
	September	21.2	28.0	6.4		September	19.0	28.7	6.5
	October	15.3	15.7	9.0		October	14.6	15.2	10.2
Stillhouse Cove	May	15.1	21.0	12.7	Conimicut Pt.	May	15.6	NA	12.3
	June	16.7	20.3	8.8		June	16.2	17.9	11.0
	July	25.5	19.7	10.7		July	23.2	25.4	6.9
	August	22.5	23.0	9.5		August	23.2	25.5	9.2
	September	20.9	28.5	7.0		September	21.2	28.4	8.6
	October	17.4	24.0	9.4		October	17.0	26.2	11.4

Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Waters

2017 Annual Performance Report for Job VI, Part B:

Assessment, Protection, and Enhancement of Fish Habitat to Sustain Coastal and Marine Ecosystems and Healthy Stocks of Recreationally Important Finfish:

Investigating techniques to enhance degraded marine habitats to improve recreational fisheries

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Federal Aid in Sportfish Restoration
F-61-R

PERFORMANCE REPORT

STATE: Rhode Island

PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 21

PROJECT TITLE: Investigating techniques to enhance degraded marine habitats to improve recreational fisheries

PERIOD COVERED: January 1, 2017 - December 31, 2017

JOB NUMBER AND TITLE: VI, Part B: Assessment, Protection, and Enhancement of Fish Habitat to Sustain Coastal and Marine Ecosystems and Healthy Stocks of Recreationally Important Finfish

STAFF: Eric Schneider (Principal Marine Fisheries Biologist) and Pat Barrett (Fisheries Specialist), RI DEM, Div. of Marine Fisheries, and William Helt (Coastal Restoration Scientist), The Nature Conservancy Rhode Island Chapter

JOB OBJECTIVE: This project aims to positively affect local fish populations by improving degraded marine habitat. Specifically, the goal is to determine if oyster reef construction can be used to improve productivity of early-life stages of recreationally important fishes such as black sea bass (*Centropristis striata*), tautog (*Tautoga onitis*), scup (*Stenotomus chrysops)*, summer flounder (*Paralichthys dentatus*), and winter flounder (*Pseudopleuronectes americanus*).

This goal will be addressed with the following objectives:
(1) Determine the appropriate location for reef establishment, considering oyster suitability modeling, present habitat quality and value, and connectivity to adjacent fish habitat;
(2) Create and establish oyster reefs in selected coastal ponds; and
(3) Conduct pre- and post-enhancement evaluation of study sites and controls to establish baselines and determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish.

SUMMARY: This report summarizes all work conducted for this project between January 1 and December 31, 2017. During this period, we: (1) completed the fish habitat enhancement (FHE) reef construction in Quonochontaug Pond, (2) conducted Year-2 of post-enhancement fish and reef monitoring of FHE reef sites in Ninigret Pond as well as Year-1 of post-enhancement fish and reef monitoring of FHE reef sites in Quonochontaug Pond, (3) determined the locations and experimental design of reef habitats to be constructed in Pt. Judith Pond.

Although there was a delay in obtaining the required permits, the planning, reef construction, and fish and reef monitoring for the FHE reefs in Quonochontaug Pond and fish and reef monitoring for the FHE reefs in Ninigret Pond went well (Table 1). More specifically, we created three reefs across three sites, for a total of nine fish habitat reefs in Quonochontaug Pond during May 2017. We also continued to conduct post-enhancement fish monitoring in both Quonochontaug and Ninigret Ponds. To date under this project, three years of monitoring has been conducted consisting of 792 and 717 hauls of fish sampling gear in Ninigret and Quonochontaug Ponds, respectively. The most frequently captured species in Ninigret Pond and Quonochontaug Pond were killifish, menhaden, and striped bass (Table 2a) and black sea bass, striped bass, and spot (Table 2b), respectively.

Overall, preliminary analyses suggest more fish were observed at FHE sites during the post-enhancement monitoring (i.e. after reef construction) compared with the pre-enhancement baseline and specific reef-dwelling species, such as tautog and black sea bass, were observed more frequently at FHE reefs sites compared to controls (Table 2 and 3). However, additional data will be needed to properly evaluate the success of these FHE reefs over time. Reef habitat monitoring showed the overall health of the FHE reefs in both Ninigret Pond and Quonochontaug Pond was good, with high survival of juvenile oysters on the FHE reefs.

We anticipate obtaining the required permits for the FHE reefs to be created in Pt. Judith Pond in April 2018, with construction of these reefs is expected to begin in October 2018. In addition to the current fish monitoring survey work, we will also investigate whether additional monitoring should be implemented, such as collecting biomass measurements, utilizing habitat trays, drop net sampling, or video sampling, which would allow for calculations of fish density and productivity estimates.

TARGET DATE: December 2017

SIGNIFICANT DEVIATIONS: Due to unforeseen challenges with obtaining the required permits for fish habitat enhancement (FHE) reef construction in Quonochontaug Pond, the construction of the FHE reefs was delayed from October of 2016 to May of 2017. This delay resulted in the need to overwinter the seed oysters until FHE reef creation was completed in the spring of 2017. Supplemental monitoring efforts were introduced to ensure the overwintering process would not impact the growth or survival of these oysters. Efforts included collecting oyster length and proportion living data at three different time intervals surrounding the extended time in which the oysters would be maintained in submerged winter storage units. The three monitoring events took place in the fall of 2016 before over-wintering began, the spring of 2017 at the time of the seed was being deployed, and, 6 months post reef construction in the fall of 2017.

RECOMMENDATIONS: Given that permit acquisition took longer than anticipated and delayed the Quonochontaug Pond fish habitat enhancement (FHE) reef construction, we will re-evaluate our timeline for permit submission to buffer any unforeseen delays in the application process for the Point Judith reef construction. A revised timeline will be finalized in the spring of 2018 and construction of the reefs is expected in the fall of 2018 (Table 1). We will also investigate whether additional monitoring should be implemented, such as collecting biomass measurements, or utilizing habitat trays and drop net sampling, which will allow us to estimate density and productivity.

Additional assistance from a DMF contract employee, as well as DMF and TNC seasonal staff was crucial in completing all necessary reef construction and monitoring in 2017. We have determined that this increased level of staffing will be required to complete fish habitat monitoring in 2018. These aspects will be assessed during 2018 and revisions to the grant will be requested, if necessary.

INTRODUCTION

Alteration and loss of coastal habitats, such as saltmarshes, eelgrass, and oyster reefs, is believed to be one of the most important factors contributing to declines in populations of marine finfish (Deegan & Bucshbaum 2005). For example, more than 70% of Rhode Island's recreationally and commercially important finfish spend part of their lives in coastal waters, usually when they are young (Meng & Powell, 1999). The shallow water, salt marshes, sea grasses, and oyster reefs provide excellent foraging and feeding areas as well as protection from larger, open-water predators. Juvenile finfish show a high degree of site fidelity, rarely moving far from shallow-water nursery habitats until either water cools in the late fall or resources are insufficient (Saucerman and Deegan 1991). Habitats known to be important to early life stages of finfish include unvegetated soft sediments or tidal flats, submerged aquatic vegetation, and complex shellfish and oyster reefs (ASMFC 2007). It is broadly accepted that habitat restoration and enhancement improves coastal ecosystems; however, it remains unclear if coastal habitat restoration practices conducted here in RI would benefit the survival and growth of early life stages of finfish as in the mid-Atlantic.

In Rhode Island, complex shellfish reefs formed by oysters (*Crassostrea virginica*) and ribbed mussels (*Geukensia demissa*) are found in intertidal and shallow subtidal waters of coastal ponds and bays. Recent decades have witnessed declines in this habitat. For example, Beck *et al.* (2011) estimated that shellfish reefs are at less than 10% of their prior abundance and that ~85% of reefs have been lost globally. The decrease in oyster reef extent and condition has coincided with decreases in water quality and clarity, and loss of important nursery habitat for finfish and crustaceans (zu Ermgassen et al. 2013).

Numerous studies completed in the mid-Atlantic have identified shellfish reefs as essential fish habitat (EFH) for resident and transient finfish (Breitburg 1999, Coen et al. 1999). Similarly, Wells (1961) collected 303 different species of marine life that utilized oyster reef habitat. Reef-dwelling organisms are then consumed by transient finfish of recreational and commercial importance (Grabowski *et al.* 2005; Grabowski and Peterson, 2007). Harding and Mann (2001) suggested that oyster reefs may provide a higher diversity and availability of food or a greater amount of higher quality food compared to other marine habitats. Grabowski et al. (2005) found that oyster reefs constructed in soft sediments increased the abundance of juvenile fish such as the black sea bass *Centropristis striata*. Studies in the Mid-Atlantic and Gulf of Mexico have also shown that oyster reefs can increase the growth and survival of juvenile finfish (e.g., Peterson et al. 2003, zu Emgassen et al. 2016), as well as fish and invertebrate biomass (e.g., Humphries and La Peyre 2015) compared to unenhanced habitats. Despite these successes, this approach has not yet been evaluated in a temperate region of the Northwest Atlantic.

The growing recognition of the ecological and economic importance of complex benthic habitat has led to an increase in the efforts to construct oyster reefs (Coen and Luckenback 2000, Brumbaugh et al. 2006, Scyphers et al. 2011). In North Carolina, recreational fisherman value constructed oyster reefs as a place to find a large number and variety of fish. Grabowski and

Peterson (2007) estimated that an acre of oyster reef sanctuary will result in ~$40,000 in additional value of commercial finfish and crustacean fisheries. Note that Grabowski and Peterson (2007) suggested that the recreational sector, like the commercial sector, would be positively affected by an oyster reef sanctuary; however, there was not a clear and convenient value metric for the recreational sector for assessment (i.e., value of landings for commercial species was used to assess commercial value).

APPROACH

Under a cooperative agreement between the Division of Marine Fisheries (DMF) and The Nature Conservancy (TNC), we will collaborate to examine the practice of establishing oyster reefs in shallow coastal waters as a tool to improve populations of recreationally important fishes. The project is broken into four components described in Table 1. In general, we aim to construct up to 4 acres of oyster reef habitat (up to 1 acre per pond per year starting in 2015) to evaluate reef habitat function and services related to local fish populations. The project will be completed in four stages: (1) identify optimal project locations, and if not already in place promulgate regulatory protections for the "to be created resource", and submit permit applications; (2) construct oyster reefs; (3) monitor reefs and evaluate fish use and productivity; and (4) develop public outreach materials and reports.

This project will be completed in the coastal ponds of South County, Rhode Island (Figure 1). The coastal pond ecosystems provide refuge and spawning areas for numerous estuarine and marine finfish and are popular fishing areas for recreational anglers. A thorough analysis of oyster and finfish habitat suitability will be completed prior to reef construction. This will be done at the pond and site-level scale to identify areas with appropriate physical and biological characteristics. We will use TNC's oyster restoration suitability model along with DEM's juvenile fisheries data to evaluate not only suitability but the likelihood of recruitment of juvenile fishes. Geospatial data developed in our suitability analysis will greatly inform this project and future fish habitat restoration projects in coastal pond ecosystems.

Reef construction will take place in state-designated Shellfish Management Areas, within which the DMF has authority to conserve and enhance shellfish resources with appropriate management strategies including transplanting, area closures, establishment of spawner sanctuaries, and daily possession limits. If needed, the DMF will promulgate regulations to protect the "to be created" resource prior to placing shell in the water for reef creation. These rules and regulations are promulgated pursuant to Chapter 42-17.1, §20-1-4, §§20-2.1 and Public Laws Chapter 02-047, in accordance with §42-35 of the Rhode Island General Laws of 1956, as amended.

ACTIVITIES

This report summarizes all work conducted for this project between January 1 and December 31, 2017. During this period, we (1) completed the fish habitat enhancement (FHE) reef construction in Quonochontaug Pond, (2) conducted Year-2 of post-enhancement fish and reef monitoring of FHE reefs sites in Ninigret Pond, as well as Year-1 of post-enhancement fish and reef monitoring of FHE reefs sites in Quonochontaug Pond, (3) determined the locations and experimental design of reef habitats to be constructed in Pt. Judith Pond.

FHE reef construction

Aside from the delayed start date due to permitting issues (see Significant Deviations Section above), the construction of the FHE reefs in Quonochontaug Pond went as planned. Quonochontaug Pond, which spans the towns of Westerly and Charlestown, was selected for the second phase of oyster reef construction in 2016. There is a pond-wide oyster harvest moratorium, that allowed for more potential sites to be considered for the experimental FHE plots compared to Ninigret Pond. Three study sites were chosen after taking into account TNC's Oyster Habitat Suitability Index, depth, subaqueous soil types, user conflicts, and ease of access. All three study sites are located within large boulder fields consisting of Napatree sand. Maps depicting the FHE study sites for Ninigret and Quonochontaug have been updated and are included in Figures 1-5. Potential locations for Pt. Judith Pond reef sites are included in Figure 6.

In an attempt to create reef habitat that will provide quality habitat for fish and require minimal long-term maintenance, we are collaborating with Drs. Jon Grabowski and Randall Hughes of Northeastern University to implement an experimental design that includes four distinct treatments. The goal is to identify whether specific genetic lines (lineage) of oysters contain desirable traits for both fish habitat and reef longevity, such as disease resistance and high fecundity. To evaluate this effect, we used two 'wild' linage of oysters, spawned from adults collected from existing populations that will be compared against a commercial strain of oysters (eyed larvae purchased from Aquaculture Research Corporation in Dennis, Massachusetts) commonly used in oyster reef restoration and enhanced projects in RI and used in the Ninigret Pond FHE reefs in 2015. The experimental design included creating three reefs, each seeded with one oyster linage, and a bare control plot at three sites (replicates). In total, there are a 12 experimental reef plots, which is consistent with Ninigret Pond; however, we've reduced the number of replicates from four to three.

Pre- and Post-enhancement monitoring and analysis

Oyster reef monitoring

Oysters were monitored in Ninigret Pond during May and October and during October in Quonochontaug Pond using the Rhode Island Oyster Restoration Minimum Monitoring Metrics and Assessment Protocols (Griffin et al. 2012). Longest possible length (N-S) and width (W-E) were measured to estimate total reef area. At each reef, a 0.25m^2 quadrat was haphazardly placed six times. Using standard cover practices, the percent cover of macroalgae was estimated, then all algae was brushed away to allow for percent cover estimation of benthic substrate. Reef height was measured and then all oysters and dead shell were excavated from the quadrat. Live oysters were measured and enumerated, as well as any recently dead oysters. All material was then returned to the sampling location so as not to disturb the reef. In addition to the standard oyster sampling, sub-samples of oysters were collected during reef construction in Quonochontaug Pond in May to assess average length and percent alive/dead at the time of reef seeding.

Fish assemblage monitoring

We continued the Year-2 post-enhancement fish monitoring of the FHE reef sites in Ninigret and began Year-1 of post-enhancement monitoring in Quonochontaug Pond starting in May and June, respectively. Monitoring in Quonochontaug Pond began in June rather than May, because reef construction occurred during the month of May. Each month, we conducted fish survey work using eel pots, minnow traps, and gillnets in both ponds. Fish pot sampling consisted of setting 2 eel pots and 3 minnow pots connected on a trot line at each site twice per month. The pots were soaked (i.e., fished) for 6 and 24 hours before hauling. At each site gillnets were typically set between 18:00 or 19:00 and soaked for 12 hours. Gillnets consisted of two 15' long by 4' tall panels, with one panel made of 3.8cm (1.5") and the other panel made of 7.6cm (3") stretch mesh (monofilament). Fish captured with the aforementioned gears were identified, measured to the nearest millimeter, counted, and released alive whenever possible.

Environmental data such as temperature, salinity, and dissolved oxygen are collected using YSI Professional Plus Multiparameter instrument during every oyster monitoring session, as well as at least once a month at each sampling station during either the gillnet or eel pot hauls, and sometimes both. Mean temperature (C°), salinity (ppt), and dissolved oxygen (mg/L) per month are summarized for Ninigret and Quonochontaug Pond (Tables 6 and 7, respectively).

Statistical Analyses – General Approach

Prior to analysis, all data were tested for homogeneity of variance and conformance to a normal distribution using a Levene's test and Shapiro Wilks, respectively (Levene's $p > 0.05$, Shapiro Wilks $p < 0.05$). Data was not transformed for analyses, except for oyster data, which was log transformed prior to analysis. After log transformation, mean density, proportion living, and proportion with boring sponge data met assumption of homogeneity of variance, but still failed to meet the assumption of normality. Considering that ANOVAs are a robust test against the normality assumption (Zar 1999) and capable of overcoming small violations in normality that are typical to quadrat sampling data (Underwood 1981), we decided to continue with the parametric ANOVA despite this small normality infraction. Precedent has been set to continue with parametric ANOVAs in cases specific to oyster quadrat sampling (e.g., density of living oysters per quadrat in Scyphers et al. 2011).

We present values as mean ± one standard error and set level of significance for all tests at $p < 0.05$, unless stated otherwise. All significant differences between the ANOVA factors were denoted using letters derived from Tukey's post hoc tests on the ANOVA models.

Statistical Analyses – Oyster Reef Monitoring

Oyster density (#/m^2), and mean length (mm), per quadrat were used to calculate a mean oyster density and length value for each reef. To evaluate if oyster density and length differed by treatment, between ponds, or over time we used a two-way ANOVAs testing the effect of factors such as Time (monitoring event) and Site (pond location; includes one of each reef treatment type), or Site and Seed (Treatment; Control, Unseeded, ARC, Green Hill Pond, Narrow River).

One-way ANOVAs were used to test for the difference in mean oyster length during the pre- and post- overwinter storage period in Quonochontaug pond.

Length frequency histograms and Kernel Density Estimation plots were used to visualize the changes in oyster size distributions through time for the ARC seeded reefs in Ninigret Pond, as well as by site in Quonochontaug Pond. Bin lengths have been set to 5 mm. Using kernel density estimation, distributions were converted to relative distribution density and plotted by length (mm) to better visualize how these distributions overlap with one another. Bandwidths for the Kernel density plots were calculated using the rule of thumb “ndr0” method of the density estimation function included in the R “stats” package (R Core Team, 2013).

Survival of oysters between monitoring events was analyzed by comparing the mean proportion of living oysters per reef (*n* = 6-8 quadrats) using two-way ANOVAs to test for significant differences between sites over time in Ninigret Pond. Lines were used to note significant main effects as well as interactive effects that monitoring event and site have on proportion of living oysters and proportion of oysters with boring sponge respectively. In Quonochontaug, where each site contains multiple seeded reefs, mean proportion of living oysters per reef were averaged across reefs for each site in order to test the effect of site on proportion of living oysters and those with boring sponge 6 months after reef construction (e.g., Fall Year 0). Significant interactive effects of the main factors of the ANOVA factors were denoted using solid lines.

Statistical Analysis - Fish Monitoring Analyses

A Before-After-Control-Impact (BACI) approach was used to determine how reef construction can impact the fish assemblage, relative species abundance, and juvenile length distributions in the coastal ponds. We specifically assessed how species diversity and relative species abundance changed over time between our baseline surveys to 1 and 2 years post reef construction, by month (sampling event), and by habitat enhancement treatment (Control, Unseeded, Seed lineage (i.e, Ninigret = ARC (only); Quonochontaug = ARC, Green Hill, and Narrow River)).

The proportion of species caught by each gear type was calculated for all years in each pond respectively (Tables 4 - 5). Species diversity was calculated using the Shannon Index of Species diversity (SHDI, Shannon & Weaver, 1949).

$$H = -\sum_{i=1}^{R} pi \ \cdot lnpi$$

Where *pi* is the proportion of individuals of species *i,* and *R* is the total number of species caught, or richness, per haul. Mean Shannon diversity (H) for each haul were averaged by month for each treatment (Seed) replicate. These monthly treatment means were used in all comparisons that use two-way ANOVAs testing difference between treatments before and after impact. Species abundance was calculated for young of the year (YOY) sized fish only.

To ensure only YOY fish where included, we implemented a maximum length (mm) per month as follows:

Species	June	July	Aug	Sept	Oct	Nov
Black sea bass[1]	*NA*	*NA*	*NA*	*NA*	*NA*	130
Scup[2]	50	*NA*	*NA*	*NA*	*NA*	100
Tautog[3]	100	107	109	115	*NA*	*NA*
Winter flounder[4]	*NA*	*NA*	*NA*	*NA*	*NA*	120

1 J. E. McNamee, personal communication (2018).
2 O'Brien, Loretta, Jay Burnett, and Ralph K. Mayo. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990.US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, (1993).
3 data provided by L. Buckley, National Marine Fisheries Service, Narragansett Laboratory, Narragansett, R.
4 Bigelow, A., and Shroeder, W. 2002. Bigelow and Shroeder's Fishes of the Gulf of Maine (3rdEd.).

After removing all non-YOY sized fish, mean catch per haul was then averaged by month for each treatment per replicate for each year. Mean catch per haul was plotted by year and grouped by treatment as well as by month grouped by treatment for each year fished. Abundance for Ninigret and Quonochontaug Ponds were analyzed separately for each species, except winter flounder due to insufficient catch in Ninigret Pond (*n* = 3 winter flounder). Summer flounder was not tested in either pond due to insufficient catch (*n* = 7 both ponds combined). Mean catch per haul are summed by year and seed, and by month and seed for each year. Catch data was non-normal and are currently being fit to generalized linear models to better understand how factors such as year, month, site, and reef treatment, influence the distributions of the species of interest in the coastal ponds.

Length frequency distributions and kernel density estimations were generated using the total catch of each species regardless of trap method in order to visualize the size distributions of the fish caught between the different reef treatments. Both length frequency bins and kernel density bandwidths were set to 5mm. YOY max cutoff lines were added to both plots in order to clarify size class specific trends in YOY vs Year 1+ aggregations among the different seeded treatments and control plots in each pond.

Site selection and experimental design for 2018 FHE reef creation

Pt Judith Pond in South Kingstown was chosen for the location for the third phase of oyster reef construction. The northern portion of Pt. Judith is within a duly promulgated Shellfish Management Area wherein shellfishing is prohibited. Three study sites were chosen after taking into account TNC's Oyster Habitat Suitability Index, depth, subaqueous soil types, user conflicts, and ease of access. All three study sites are located along the shore adjacent to saltmarsh with varying proportions of Anguilla mucky sand and pishagqua muck silt loam. The soil characterizations for each research site are as follows:

RS-1: Anguilla mucky sand (sandy and gravelly marine/estuarine deposits)
RS-2: part Pishagqua mucky silt loam (fluid silty estuarine deposits (thick)) and part Anguilla mucky sand
RS-3: Anguilla mucky sand (sandy and gravelly marine/estuarine deposits)

In an attempt to create reef habitat that will provide quality habitat for fish and require the minimum long-term maintenance we are collaborating with Drs. Jon Grabowski and Randall Hughes of Northeastern University to implement an experimental design that now includes five distinct treatments. Our goal is to identify whether specific oyster lineage(s) contain desirable traits for both fish habitat and reef longevity, such as disease resistance and high fecundity. To evaluate this effect, we are using two ‘wild’ lineages of oysters, spawned from adults collected from existing populations (i.e., Narrow River and Green Hill Pond) that will be compared against a commercial lineage known as ARC (purchased from Aquaculture Research Corporation in Dennis, Massachusetts) as well as a poly treatment consisting of all three lines. In summary, at each study site there will be four reefs, each seeded with one of the lineages, including one poly reef, and a bare control plot. The total number of experimental reefs will be 15, which is three more than both Ninigret and Quonochontaug Pond. This allows us to keep the same number of replicates as Quonochontaug Pond, while introducing an extra treatment factor (five rather than four).

RESULTS

Oyster Reef Monitoring - Density, Proportion Living, and Boring Sponge

In each pond we tested for difference between oyster density amongst our seeded reef treatments. In Ninigret Pond, oyster density differed by year and site (Figures 7A and 7C). During this time mean oyster density dropped from 409 ± 129 oysters/m^2 at time 1 (spring 2016), to 156 ± 30, 128 ±31, and 130 ± 38 oysters/m^2 over the next three monitoring events (Figure 7C). These differences suggest mortality was highest during the first six months after seeding the reefs and then leveled off from there on out.

In Quonochontaug Pond, oyster lineage had a partial effect on the density of oysters six months prior to reef construction, with the wild Green Hill Pond (571 ± 154 oyster/m^2) and Narrow River (407 ± 131 oysters/m^2) lineages being 75.8% and 69.1% more dense than the commercial ARC lineage (182 ± 56 oysters/m^2) (Figure 7D). These results suggest that the Green Hill Pond lineage had higher densities compared to the ARC commercial lineage, 6 months post reef creation (Figure 7D).

To better understand the dynamics behind changing oyster density through time we tested for differences in mean proportion living, as well as mean proportion with boring sponge in both ponds. In Ninigret the two-way ANOVA revealed that both time and site have strong effects on proportion living (p-value <0.01), and that there is significant interactive effect of time and reef site on the proportion with boring sponge (Figure 8A). More specifically, Site 3 (SW) (95.08 ± 0.80 %) significantly differed from Sites 4 (SE) (90.04 ± 1.96 %) and Site 2 (NE) (89.79 ± 1.18 %). Although proportion living varied between site, all sites exhibited a fairly steady ~3-4 % decrease in proportion living over time (Time 1 = 0.96 ± 0.005); Time 2 = 0.93 ± 0.008; Time 3 = 0.89 ± 0.014; Time 4 =0.86 ± 0.021). The proportion with boring sponge remained low for the first year and then increased from 0 to ~0.2 for Sites 1-3 during the spring and fall year 1 monitoring events, whereas Site 4 (SW) remained lower than 0.1 during all four monitoring events despite having the lowest proportion of living oysters (Figure 8A). These results suggest that survival has declined steadily over the first 2 years of monitoring in Ninigret Pond and that there may be some site-specific factors that are either influencing oyster survival and boring sponge presence.

Proportion living did not differ between oyster lineage or site in Quonochontaug Pond, and boring sponge was not detected (Figure 8B). These results suggest there are no site-specific differences in proportion living between the east and west basin of Quonochontaug Pond after the first 6 months post reef creation or between oyster lineages. The results also show that 6 months post seeding may not be sufficient time to become infected with boring sponge.

During the Quonochontaug Pond over winter storage monitoring we found that the proportion of living of oysters decreased from .889 to .834 between the monitoring events that bookended the overwintering period (Figure 9). Oysters that survived the winter continued to show a proportion living (after 6 months) of 92.1%, which is roughly equivalent to the survival observed on the Ninigret reefs 6 months prior to deployment (91.6%) suggesting that the over winter storage of seed on shell in Quonochontaug had no impact on oyster survival to age 1.

Oyster Reef Monitoring - Oyster Length

Oyster length was used to measure oyster growth over time, as well as site and seed lineage specific trends. In Ninigret Pond the ANOVA on mean oyster length per quadrat revealed that time and site had independent effects on mean oyster length (mm) per quadrat, where each time was greater than the next (Time 1 = 28.86 ± 0.48 mm; Time 2 = 53.66 ± 1.55 mm; Time 3 = 63.69 ± 1.96 mm; Time 4 = 79.21 ± 3.21 mm). These results show oysters maintained steady growth between monitoring events; growing as much as 24.8 mm during the first summer period and almost 80 mm during the first two years (Figure 10a).

In Quonochontaug pond, mean length was compared by site and seed lineage. The results suggest that reef site and has a partial effect on oyster length ($p\text{-value} < 0.1$). Furthermore, post-hoc results indicated that Site 1 in the west basin of Quonochontaug Pond was significantly different than Site 3 located in the east basin of the pond. This result suggested that the oysters at Site 1 (41.09 ± 1.25 mm) are ~19.71% percent larger than those at Site 3 (34.49 ± 1.65 mm) regardless of the oyster's lineage 6 months post reef construction (Figure 10B).

The over winter analysis on Quonochontaug Pond showed that seed source was a significant factor on oyster length. The results suggest that length of oyster differed by seed lineage in both the Fall of 2016 (oysters on lease) and Spring of 2017 (time of reef seeding), but did not differ 6 months post construction in the spring of 2017 (Fall 2017). The results of the ANOVAs suggest that the ARC lineage exhibited a higher increase in length after being seeded on their respective leases. The ARC lineage grew approximately ~116% (17.87 ±0.37 to 38.68 ±0.67 mm), which was much larger compared to the Narrow River (23.57 ± 0.45 to 39.18 ±0.52 mm) and Green Hill Pond (21.14 ±0.45 to 34.84 ±0.52 mm) lineages that only grew in length by ~66% and ~64% respectively (Figure 10).

Despite the initial differences of mean length per shell observed between lineages in Quonochontaug Pond, the mean oyster length of the ARC lineage exhibited a similar response as the oysters in Ninigret Pond (89.13%, or 25.28 mm) over the first summer season increasing by

~116.41 % or 20.80 mm. By comparing the growth of the ARC lineage between ponds, it suggests that the additional overwintering stage in Quonochontaug Pond did not impact the oysters ability to grow to the expected length by the end of the first growing season. The results of the overwintering monitoring efforts for Quonochontaug Pond are shown in Figure 9.

Fish Monitoring - Species Diversity

The proportion of species caught by each gear type by year in Ninigret and Quonochontaug Pond is shown in Tables 2 and 3, respectively. Proportioning total catch by species provides insight into the species captured by gear type and suggests that there is little overlap between the minnow traps and eel pots, and the gillnets. As expected, the gillnets caught more highly migratory and pelagic species such as Striped Bass, Menhaden, and Herring, whereas the eel pots caught more, structure-oriented species like tautog, cunner, and oyster toadfish. The minnow traps caught juvenile sized fish (i.e., Black Sea Bass, Tautog, Winter Flounder) in addition to several bait species such as silversides, killifish, and mummichog, which were rare in in the other gear types (Table 2 and 3).

Upon a further quantitative evaluation of species diversity in each pond, we found that diversity in Ninigret Pond increased 1.78-fold from 2015 (0.61 ± 0.098) to 2016 (1.09 ± 0.044). The same analysis run for Quonochontaug Pond revealed no significant differences of diversity amongst sites. These results show that Ninigret Pond diversity increased with the addition of oyster reefs but diversity remained unchanged in Quonochontaug Pond after reef enhancement (Figure 11). The mean Shannon H index of Ninigret in 2017 (1.24 ± 0.050), 2 years post reef enhancement, approached that of Quonochontaug pond (2016; 1.30 ± 0.065), 2017; 1.46 ± 0.058) but still remained slightly lower. These results suggest that Quonochontaug Pond had a naturally higher diversity than Ninigret before enhancement and Ninigret Pond benefited more from reef enhancement in terms of species diversity.

Fish Monitoring - Mean Catch per Haul, Length Frequency, and Kernel Density

Black Sea Bass

In Ninigret Pond, black sea bass were most abundant in 2016 across all treatments (0.72 ± 0.35 per haul). In 2016, 54 black sea bass were caught compared to only 23 in 2017 (a 50% decrease). In 2016, mean black sea bass caught per seeded reef (1.45 ±1.02) was 2.48 and 7.58 times greater than the mean catch at the unseeded and control sites, respectively (Figure 12 top left). Additionally, during the month of September of 2017 when abundance was highest, mean black sea bass caught per haul was 8.75 ± 5.18 on seeded reefs, compared to 2.75 ± 1.37 and 1.25 ± 0.47 on unseeded and control plots respectively (Figure 12 middle left). In Quonochontaug Pond black sea bass were caught in higher abundance at the wild oyster lineages over ARC and the control plots in Quonochontaug Pond (Figure 12 middle right). Despite these differences, it appears that YOY sized black sea bass were simply more abundant in 2016 across the ponds and additional years of sampling will be required to more fully assess the effect of FHE reefs.

Length distributions by year and treatment confirm that sea bass caught in 2016 were almost all young of the year. In 2017 the distributions shift from YOY dominance to Year 1 sized sea bass and show site selectivity based on size. It appears that smaller sea bass are aggregating closer to the seeded and unseeded reefs than control plots (Figure 12 bottom left). The distribution of black sea bass in Quonochontaug was relatively unchanged by the introduction of reefs (Figure 12 bottom right). It'll be interesting if this distribution changes as the reef matures and undergoes successional changes.

Scup

In 2017 mean YOY catch per haul was highest in Ninigret Pond (Figure 13 top left), however mean YOY catch per haul was never greater than 1 and showed no preference for treatments. Length distributions by year and treatment suggest that Scup caught in 2016 were almost all Year 1 sized Scup. In 2017 the distributions shift from year 1 sized scup back to YOY suggesting the 2016 scup had moved on from the ponds and new YOY have settled in their place (Figure 13 bottom left). This trend was observed in both ponds, but Ninigret has a much stronger agreement.

Tautog

In 2017 we caught 46 tautog in Quonochontaug Pond, which far surpassed the 2-fish caught in 2016. Mean YOY tautog caught per haul post reef creation (2017) shows that tautog have a tendency to aggregate near the wild lineages over ARC and the control plots (Figure 14). During September of 2017 when tautog abundance was highest, we caught an average of ~2.17 ±1.33 at Green Hill Pond Reefs, compared to 1.16 ±0.79 and 0.667 ± 0.49 tautog per haul at the Narrow River and ARC reef sites respectively (Figure 14 middle right).

Length frequency (Figure 14 top right) and kernel density estimated length distributions (Figure 14 bottom right) post construction by year and treatment suggest that there may be site selectivity of YOY tautog favoring reefs, whereas the year 1+ sized tautog had a more even distribution between reef and control sites.

Winter Flounder

A total of 3 winter flounder were caught in Ninigret pond compared to 118 in Quonochontaug Pond. In Quonochontaug Pond, mean winter flounder caught per haul was highest in 2017 (Figure 15 top left). Mean catch per hour by month and lineage during the 1^{st} year post impact shows that Winter Flounder have a tendency to aggregate near control plots in Quonochontaug Pond and have a slight tendency to aggregate near the ARC lineage over the wild (Figure 15 bottom left). During July of 2017, peak winter flounder abundance, mean YOY winter flounder was 5.83 ± 3.13 at the control sites compared to 5.16 ± 2.82, 3.5 ± 3, and 2.16 ± 1.94 at Narrow River, ARC, and Green Hill reef sites respectively (Figure 15 Bottom left)
The length frequency (Figure 14 top right) and kernel density estimated length distributions (Figure 15 bottom right) for the first-year post enhancement by year and treatment do not differ. All flounder were YOY sized fish and the length distributions separated by treatment revealed no size difference between the flounder caught at either treatment (Figure 15 top right and bottom right).

DISCUSSION

Reef Habitat

Before we could evaluate whether oyster reef construction can be used to improve productivity of early-life stages of recreationally, we first needed to create functional oyster reef habitat. Results from oyster reef monitoring suggest our reef establishment approaches have thus far been successful in both Ninigret and Quonochontaug Ponds. In Ninigret Pond where there was only a single lineage of oysters seeded (e.g., commercial ARC) oyster density decreased over the first 6-months but has since stabilized. In Quonochontaug Pond, the density of oysters 6 months after construction differed by oyster lineage, where the wild Green Hill Pond and Narrow River lineages were 75.8% and 69.1% more dense than the commercial ARC. Overall, the level of survival and general stability in density is promising and allows these reefs to function and provide habitat for fish, as well as some level of associated ecosystem services.

We were also pleased that reefs in both ponds continue to exhibit increased growth between successive monitoring events. In Quonochontaug Pond, the ARC lineage was the smallest of all the three linages at the time of reef establishment; however, after one growing season, all lineages were equal in mean length, suggesting the ARC line grows more quickly during the first 6 months on the reefs. Additional oyster pathology monitoring and future survival analysis, combined with fish monitoring at these sites, will help determine which lineages present a better option for FHE reef establishment and long-term FHE functions.

Fish Abundance and Species Diversity

Providing the health of these reefs are maintained, the quality of habitat provided should increase over time in response to successional changes on these reefs. That said, it's generally agreed that oyster reefs provide some level of enhancement to fish habitat beginning at time of reef creation. Consistent with this expectation, we observed that abundance of fish increased across sites after reef creation, in comparison to preconstruction baseline monitoring. We also observed an increase in targeted species, such as black sea bass, tautog, and winter flounder.

Upon a further quantitative evaluation of species diversity in each pond, we found that diversity in Ninigret Pond increased 1.78-fold from 2015 to 2016. The same analysis run for Quonochontaug Pond revealed no significant differences of diversity amongst sites. These results show that Ninigret Pond diversity increased with the addition of oyster reefs, but diversity remained unchanged in Quonochontaug Pond one-year after reef enhancement (Figure 11). Two years after reef enhancement in Ninigret Pond (i.e., 2017) the mean Shannon H index (1.24 ± 0.05) , approached but still remained slightly lower that of Quonochontaug Pond (2016 = 1.30 ± 0.07; 2017 = 1.46 ± 0.056). These results suggest that Quonochontaug Pond may have had a naturally higher diversity than Ninigret before enhancement and Ninigret Pond benefited more from reef enhancement in terms of species diversity.

Preliminary quantitative analysis of the mean catch per haul and length frequency distributions are showing promise and providing information on how juvenile fish such as black sea bass, scup, tautog, and winter flounder are utilizing enhanced reef. Consistent with studies conducted in the mid-Atlantic (i.e, zu Ermgassen 2016; Grabowski, 2005), results to date for this work suggest that black sea bass are utilizing oyster reef sites post enhancement. For example, in Ninigret Pond YOY black sea bass were observed more often on seeded reefs compared to unseeded reefs and control mud flat plots. Although this result is not shocking, due in part to black sea bass's affinity for structure, we were surprised to see that in some years YOY black sea bass almost exclusively utilized reef habitat, whereas older fish more likely to use both reef and fringe habitat. It's possible that a strong 2016-year class may be contributing to these results, but if so additional sampling will resolve year-specific influences.

Tautog saw an increase in YOY abundance on reefs that most likely related to increased enhancement, which like black sea bass was anticipated for structure-oriented species like tautog. Young-of-year sized tautog were observed most often during our 2017 monitoring season, represented by Ninigret Pond 2nd and Quonochontaug 1st year post-reef enhancement. In Quonochontaug pond the abundance of YOY size tautog increased from 0 to 46 between the baseline and year post construction. Tautog observations peaked in September of 2017 where tautog were found to be two times higher than at reefs sites during peak tautog abundance. In addition to higher YOY abundance we also found that that the length distribution of fish caught on the reefs was smaller than those caught off the reef. With time and additional techniques, we hope to tease out whether these habitats are increasing YOY survival.

Winter Flounder were more abundant post reef enhancement in Quonochontaug Pond; however, greater abundances were observed at adjacent control sites (off reefs) compared to the reefs themselves. Although this could be a year-class effect, it may also suggest that winter flounder are benefiting from reef enhancement as a secondary or fringe habitat. Previous work has shown that other flounder species benefited from reef habitat that was adjacent to their more preferred seagrass or mud flat nursery habitats (e.g., Grabowski et al. 2005).

Aspects of work for 2018 and thereafter

Permit applications for reef construction in Pt. Judith Pond will be submitted to the CRMC during the spring of 2018. If the permit applications are approved, we will be on schedule for reef construction, which will begin October of 2018. In addition to FHE reef construction in 2018, we plan to conduct the pre-enhancement monitoring in Pt. Judith Pond, as well as Year-3 and Year-2 of post-enhancement monthly fish monitoring and seasonal oyster monitoring on the FHE reefs in Ninigret and Quonochontaug Ponds, respectively. We will also investigate whether additional monitoring should be implemented, such as collecting biomass measurements, or utilizing habitat trays, which will allow us to estimate density and productivity.

CONCLUSION

With exception for the delay in Quonochontaug reef construction from October 2016 to May 2017, all other tasks were completed as expected. We completed the Year-2 post-enhancement fish and habitat (reef) monitoring of FHE reefs sites in Ninigret Pond, constructed the second round of fish habitat enhancement reefs in Quonochontaug Pond, conducted Year-1 post-enhancement fish and habitat (reef) monitoring of FHE sites in Quonochontaug, determined the locations and experimental design of reef habitats to be constructed in Pt. Judith Pond, and began planning for the 2018 season including discussions regarding the inclusion of additional sampling techniques.

Overall, a qualitative assessment appears to show more fish species were observed at FHE reefs during the post-enhancement monitoring (i.e. after reef construction) compared with the pre-enhancement baseline. However, additional data will be needed to properly evaluate the success of these FHE reefs over time. Reef habitat monitoring showed the overall health of the FHE reefs in both Ninigret Pond and Quonochontaug Pond was good, with high survival of juvenile oysters on the FHE reefs.

We believe conducting video work, in addition to the current fish monitoring survey work, will confirm that the targeted fish species utilizing the FHE sites are being captured by our sampling gear, as well as provide insight into fish behavior, such as residence time and reef utilization. We will also investigate whether additional monitoring should be implemented, such as collecting biomass measurements, or utilizing habitat trays and drop net sampling, which will allow us to estimate density and productivity.

The additional assistance from the DMF contract employee, as well as DMF and TNC seasonal staff was crucial in completing all necessary reef construction and monitoring in 2017. We have determined that this additional staffing will be required once again to complete fish habitat monitoring in 2018.

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Table 1. Summary of project specific activities, timelines, and status through December 2017.

Component	Activity	Timeline Proposed in original grant	Site 1: Ninigret Pond	Site 2: Quonochontaug Pond	Site 3: Pt. Judith Pond
I. Site Identification & Permits	Evaluate pond & sanctuary suitability	May-14	Completed	Completed	Completed
	Incorporate fisheries data into suitability models	June-14	Completed	Completed	Completed
	Identify reef & control sites	June-14	Completed	Completed	To Be Completed February 2018
	Complete baseline surveys	Annually, June	Completed	Completed	Scheduled for May 2018
	Submit permit applications	Annually, July	Completed	Completed	Scheduled for March 2018
II. Oyster Reef Construction	Host volunteer workdays to bag shell	Annually, May	Completed	Completed	To Be Scheduled
	Secure contracts for reef construction	Annually, May	Completed	Completed	Scheduled for Spring 2018
	Deliver shell bags to hatchery	Annually, July	Completed	Completed	Scheduled for May 2018
	Grow seed in cages prior to deployment	Annually, July to September	Completed	Completed	Scheduled for July 2018
	Delineate, construct & seed reefs	Annually, October	Completed	Completed	Scheduled for October 2018
III. Monitoring, Evaluation, & Analysis	Post-enhancement bathymetry & elevation	Annually, *post-enhancement*	On going	On going	Start Date May 2019
	Evaluate reef stability & succession	Seasonally, post-enhancement	On going	On going	Start Date May 2019
	Evaluate fish & invert community structure	Seasonally, post-enhancement	On going	On going	Start Date May 2019
IV. Submit Reports	Analyze data & submit reports	December 2014 - 2018	Completed for 2017	Completed for 2017	Completed for 2017

Table 2a. Summary of species caught by year in Ninigret Pond, summed across sites and months. Species of interest are highlighted in yellow.

Niniget Pond	Year			Species
Species	2015	2016	2017	Total
RAINWATER KILLIFISH	11	488	77	576
MENHADEN ATLANTIC	35	98	161	294
BLUE CRAB	20	107	81	208
BASS STRIPED	0	65	73	138
SPIDER CRAB	3	71	47	121
RIVER HERRING	0	0	88	88
BLUEFISH	14	52	18	84
SEA BASS BLACK	0	54	23	77
MUMMICHOG	1	54	11	66
PINFISH	1	0	40	41
SCUP	0	20	15	35
SEAROBIN STRIPED	4	27	2	33
SPOT	0	1	30	31
MUD CRAB	0	13	17	30
SILVERSIDE ATLANTIC	0	0	26	26
TOADFISH OYSTER	4	3	15	22
MULLET WHITE	0	18	0	18
NEEDLEFISH ATLANTIC	0	4	13	17
TAUTOG	0	3	14	17
STICKLEBACK THREESPINE	11	5	0	16
KILLIFISH STRIPED	1	11	3	15
CUNNER	0	3	11	14
GOBY NAKED	0	5	7	12
EEL AMERICAN	4	0	5	9
SENNET NORTHERN	0	5	3	8
BUTTERFISH	0	3	4	7
PIPEFISH NORTHERN	1	2	4	7
STICKLEBACK FOURSPINE	0	0	7	7
HORSESHOE CRAB	0	2	3	5
TOMCOD ATLANTIC	0	0	5	5
FLOUNDER SUMMER	0	2	1	3
FLOUNDER WINTER	0	0	3	3
ALEWIFE	0	0	1	1
AMBERJACK GREATER	0	0	1	1
HERRING ATLANTIC	0	0	1	1
HOGCHOKER	0	0	1	1
KINGFISH NORTHERN	0	0	1	1
LADY CRAB	0	0	1	1
PERCH WHITE	0	1	0	1
SCULPINS	0	0	1	1
SMOOTH DOGFISH	0	0	1	1
CROAKER ATLANTIC	0	0	0	0
GREEN CRAB	0	0	0	0
MANTIS SHRIMP	0	0	0	0
MULLET STRIPED	0	0	0	0
ROCK CRAB	0	0	0	0
RUDDERFISH BANDED	0	0	0	0
SAND TIGER SHARK	0	0	0	0
SCULPIN SHORTHORN	0	0	0	0
WEAKFISH	0	0	0	0
Grand Total	110	1117	815	2042

Table 2b. Summary of species caught by year in Quonochontaug Pond, summed across sites and months. Species of interest are highlighted in yellow.

Quonochontaug Pond	Year		Species
Species	2016	2017	Total
SEA BASS BLACK	79	144	223
BASS STRIPED	86	125	211
SPOT	42	164	206
SPIDER CRAB	108	84	192
MENHADEN ATLANTIC	132	19	151
FLOUNDER WINTER	7	109	116
RIVER HERRING	36	63	99
RAINWATER KILLIFISH	0	96	96
BLUEFISH	57	32	89
GREEN CRAB	27	43	70
SILVERSIDE ATLANTIC	21	38	59
BLUE CRAB	30	21	51
TAUTOG	2	46	48
LADY CRAB	30	11	41
CUNNER	2	21	23
MUD CRAB	6	17	23
SCUP	16	6	22
TOADFISH OYSTER	1	21	22
PINFISH	1	18	19
EEL AMERICAN	0	15	15
MULLET WHITE	12	0	12
MUMMICHOG	8	4	12
ROCK CRAB	0	10	10
PIPEFISH NORTHERN	4	5	9
GOBY NAKED	3	4	7
HORSESHOE CRAB	0	7	7
MANTIS SHRIMP	5	1	6
STICKLEBACK FOURSPINE	0	6	6
SCULPIN SHORTHORN	0	5	5
FLOUNDER SUMMER	2	2	4
NEEDLEFISH ATLANTIC	3	1	4
SCULPINS	0	4	4
SMOOTH DOGFISH	0	4	4
KILLIFISH STRIPED	1	2	3
KINGFISH NORTHERN	3	0	3
PERCH WHITE	2	0	2
TOMCOD ATLANTIC	0	2	2
CROAKER ATLANTIC	1	0	1
HERRING ATLANTIC	1	0	1
MULLET STRIPED	1	0	1
RUDDERFISH BANDED	1	0	1
SAND TIGER SHARK	1	0	1
SEAROBIN STRIPED	0	1	1
STICKLEBACK THREESPINE	0	1	1
WEAKFISH	1	0	1
AMBERJACK GREATER	0	0	0
BUTTERFISH	0	0	0
HOGCHOKER	0	0	0
SENNET NORTHERN	0	0	0
ALEWIFE	0	0	0
Grand Total	732	1152	1884

Table 3a. Summary of species caught by treatment in Ninigret Pond, summed across sites and months by treatment. Species observed in higher abundances at sites post enhancement are highlighted in yellow and those bolded were specially increased at reef sites.

Ninigret Pond	2015				2016				2017				Grand
Common Name	Control	Unseeded	ARC	Total	Control	Unseeded	ARC	Total	Control	Unseeded	ARC	Total	Total
ALEWIFE	0	0	0	0	0	0	0	0	0	1	0	1	1
AMBERJACK GREATER	0	0	0	0	0	0	0	0	1	0	0	1	1
BASS STRIPED	0	0	0	0	27	21	17	65	35	17	21	73	138
BLUE CRAB	8	4	8	20	66	26	15	107	25	32	24	81	208
BLUEFISH	2	4	8	14	18	18	16	52	10	7	1	18	84
BUTTERFISH	0	0	0	0	1	2	0	3	3	1	0	4	7
CROAKER ATLANTIC	0	0	0	0	0	0	0	0	0	0	0	0	0
CUNNER	0	0	0	0	0	2	1	3	0	4	7	11	14
EEL AMERICAN	1	1	2	4	0	0	0	0	2	0	3	5	9
FLOUNDER SUMMER	0	0	0	0	2	0	0	2	1	0	0	1	3
FLOUNDER WINTER	0	0	0	0	0	0	0	0	0	1	2	3	3
GOBY NAKED	0	0	0	0	1	3	1	5	2	1	4	7	12
GREEN CRAB	0	0	0	0	0	0	0	0	0	0	0	0	0
HERRING ATLANTIC	0	0	0	0	0	0	0	0	0	0	1	1	1
HOGCHOKER	0	0	0	0	0	0	0	0	0	0	1	1	1
HORSESHOE CRAB	0	0	0	0	1	0	1	2	1	0	2	3	5
KILLIFISH STRIPED	0	0	1	1	11	0	0	11	3	0	0	3	15
KINGFISH NORTHERN	0	0	0	0	0	0	0	0	1	0	0	1	1
LADY CRAB	0	0	0	0	0	0	0	0	0	1	0	1	1
MANTIS SHRIMP	0	0	0	0	0	0	0	0	0	0	0	0	0
MENHADEN ATLANTIC	6	4	25	35	19	44	35	98	76	44	41	161	294
MUD CRAB	0	0	0	0	1	3	9	13	4	6	7	17	30
MULLET STRIPED	0	0	0	0	0	0	0	0	0	0	0	0	0
MULLET WHITE	0	0	0	0	9	1	8	18	0	0	0	0	18
MUMMICHOG	0	0	1	1	35	12	7	54	3	5	3	11	66
NEEDLEFISH ATLANTIC	0	0	0	0	2	1	1	4	3	5	5	13	17
PERCH WHITE	0	0	0	0	1	0	0	1	0	0	0	0	1
PINFISH	0	0	1	1	0	0	0	0	20	4	16	40	41
PIPEFISH NORTHERN	0	0	1	1	0	1	1	2	0	3	1	4	7
RAINWATER KILLIFISH	1	7	3	11	170	136	182	488	21	40	16	77	576
RIVER HERRING	0	0	0	0	0	0	0	0	40	25	23	88	88
ROCK CRAB	0	0	0	0	0	0	0	0	0	0	0	0	0
RUDDERFISH BANDED	0	0	0	0	0	0	0	0	0	0	0	0	0
SAND TIGER SHARK	0	0	0	0	0	0	0	0	0	0	0	0	0
SCULPIN SHORTHORN	0	0	0	0	0	0	0	0	0	0	0	0	0
SCULPINS	0	0	0	0	0	0	0	0	0	1	0	1	1
SCUP	0	0	0	0	5	7	8	20	6	5	4	15	35
SEA BASS BLACK	0	0	0	0	5	14	35	54	4	6	13	23	77
SEAROBIN STRIPED	1	2	1	4	6	8	13	27	1	0	1	2	33
SENNET NORTHERN	0	0	0	0	5	0	0	5	3	0	0	3	8
SILVERSIDE ATLANTIC	0	0	0	0	0	0	0	0	8	10	8	26	26
SMOOTH DOGFISH	0	0	0	0	0	0	0	0	0	0	1	1	1
SPIDER CRAB	1	1	1	3	39	26	6	71	25	11	11	47	121
SPOT	0	0	0	0	1	0	0	1	19	6	5	30	31
STICKLEBACK FOURSPINE	0	0	0	0	0	0	0	0	1	4	2	7	7
STICKLEBACK THREESPINE	4	4	3	11	5	0	0	5	0	0	0	0	16
TAUTOG	0	0	0	0	0	0	3	3	1	8	5	14	17
TOADFISH OYSTER	2	2	0	4	1	2	0	3	4	6	5	15	22
TOMCOD ATLANTIC	0	0	0	0	0	0	0	0	3	2	0	5	5
WEAKFISH	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	26	29	55	110	431	327	359	1117	326	256	233	815	2042

Table 3b. Summary of species caught by treatment in Quonochontaug Pond, summed across sites and months by treatment. Species observed in higher abundances at sites post enhancement are highlighted in yellow and those bolded were specifically increased at reef sites.

Quonochontaug Pond	2016					2017					Grand
Common Name	Control	ARC	GHP	NR	Total	Control	ARC	GHP	NR	Total	Total
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
AMBERJACK GREATER	0	0	0	0	0	0	0	0	0	0	0
BASS STRIPED	36	13	17	20	86	33	32	29	31	125	211
BLUE CRAB	10	9	6	5	30	9	4	6	2	21	51
BLUEFISH	12	13	18	14	57	11	4	8	9	32	89
BUTTERFISH	0	0	0	0	0	0	0	0	0	0	0
CRANGON SHRIMP	0	0	0	4	4	51	163	55	71	340	344
CROAKER ATLANTIC	0	1	0	0	1	0	0	0	0	0	1
CUNNER	0	0	1	1	2	4	7	3	7	21	23
EEL AMERICAN	0	0	0	0	0	9	2	3	1	15	15
FLOUNDER SUMMER	0	2	0	0	2	1	0	1	0	2	4
FLOUNDER WINTER	0	0	5	2	7	38	25	15	31	109	116
GOBY NAKED	1	1	0	1	3	1	0	2	1	4	7
GRASS / SHORE SHRIMP	10	15	0	27	52	0	3	0	0	3	55
GREEN CRAB	14	6	4	3	27	6	6	20	11	43	70
HERRING ATLANTIC	1	0	0	0	1	0	0	0	0	0	1
HOGCHOKER	0	0	0	0	0	0	0	0	0	0	0
HORSESHOE CRAB	0	0	0	0	0	4	3	0	0	7	7
KILLIFISH STRIPED	0	0	1	0	1	0	0	0	2	2	3
KINGFISH NORTHERN	1	0	2	0	3	0	0	0	0	0	3
LADY CRAB	9	5	11	5	30	5	3	1	2	11	41
MANTIS SHRIMP	0	3	1	1	5	0	0	1	0	1	6
MENHADEN ATLANTIC	37	18	44	33	132	3	3	8	5	19	151
MUD CRAB	1	1	2	2	6	1	8	0	8	17	23
MULLET STRIPED	1	0	0	0	1	0	0	0	0	0	1
MULLET WHITE	2	5	4	1	12	0	0	0	0	0	12
MUMMICHOG	0	2	1	5	8	0	0	1	3	4	12
NEEDLEFISH ATLANTIC	0	0	2	1	3	1	0	0	0	1	4
PERCH WHITE	0	0	0	2	2	0	0	0	0	0	2
PINFISH	0	0	1	0	1	10	2	2	4	18	19
PIPEFISH NORTHERN	0	1	0	3	4	2	3	0	0	5	9
RAINWATER KILLIFISH	0	0	0	0	0	11	7	25	53	96	96
RIVER HERRING	8	7	7	14	36	20	12	19	12	63	99
ROCK CRAB	0	0	0	0	0	2	1	7	0	10	10
RUDDERFISH BANDED	1	0	0	0	1	0	0	0	0	0	1
SAND TIGER SHARK	0	0	0	1	1	0	0	0	0	0	1
SCULPIN SHORTHORN	0	0	0	0	0	1	0	1	3	5	5
SCULPINS	0	0	0	0	0	2	1	1	0	4	4
SCUP	3	3	6	4	16	2	1	3	0	6	22
SEA BASS BLACK	30	14	10	25	79	32	27	40	45	144	223
SEAROBIN STRIPED	0	0	0	0	0	1	0	0	0	1	1
SENNET NORTHERN	0	0	0	0	0	0	0	0	0	0	0
SILVERSIDE ATLANTIC	3	13	4	1	21	15	12	7	4	38	59
SMOOTH DOGFISH	0	0	0	0	0	0	2	0	2	4	4
SPIDER CRAB	29	40	12	27	108	53	9	12	10	84	192
SPOT	10	12	6	14	42	28	55	23	58	164	206
STICKLEBACK FOURSPINE	0	0	0	0	0	0	5	1	0	6	6
STICKLEBACK THREESPINE	0	0	0	0	0	1	0	0	0	1	1
TAUTOG	0	0	2	0	2	8	8	20	10	46	48
TOADFISH OYSTER	0	0	0	1	1	4	5	7	5	21	22
TOMCOD ATLANTIC	0	0	0	0	0	1	0	1	0	2	2
WEAKFISH	0	1	0	0	1	0	0	0	0	0	1
Grand Total	219	185	167	217	788	370	413	322	390	1495	2283

Table 4a. Summary of species caught by gillnets in Ninigret Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
MENHADEN ATLANTIC	285	0.265	Gillnet
BLUE CRAB	190	0.177	Gillnet
BASS STRIPED	132	0.123	Gillnet
SPIDER CRAB	112	0.104	Gillnet
RIVER HERRING	88	0.082	Gillnet
BLUEFISH	81	0.075	Gillnet
PINFISH	35	0.033	Gillnet
SEAROBIN STRIPED	33	0.031	Gillnet
SCUP	24	0.022	Gillnet
SPOT	21	0.02	Gillnet
NEEDLEFISH ATLANTIC	17	0.016	Gillnet
MULLET WHITE	16	0.015	Gillnet
BUTTERFISH	7	0.007	Gillnet
SENNET NORTHERN	6	0.006	Gillnet
HORSESHOE CRAB	4	0.004	Gillnet
TAUTOG	4	0.004	Gillnet
TOADFISH OYSTER	4	0.004	Gillnet
SEA BASS BLACK	3	0.003	Gillnet
FLOUNDER SUMMER	2	0.002	Gillnet
TOMCOD ATLANTIC	2	0.002	Gillnet
ALEWIFE	1	0.001	Gillnet
AMBERJACK GREATER	1	0.001	Gillnet
FLOUNDER WINTER	1	0.001	Gillnet
HERRING ATLANTIC	1	0.001	Gillnet
HOGCHOKER	1	0.001	Gillnet
KINGFISH NORTHERN	1	0.001	Gillnet
LADY CRAB	1	0.001	Gillnet
PERCH WHITE	1	0.001	Gillnet
SMOOTH DOGFISH	1	0.001	Gillnet

Table 4b. Summary of species caught by eel pots in Ninigret Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
SEA BASS BLACK	67	0.387	Eel Pot
TOADFISH OYSTER	16	0.092	Eel Pot
BLUE CRAB	12	0.069	Eel Pot
TAUTOG	12	0.069	Eel Pot
CUNNER	10	0.058	Eel Pot
MUMMICHOG	10	0.058	Eel Pot
EEL AMERICAN	9	0.052	Eel Pot
MUD CRAB	8	0.046	Eel Pot
SCUP	7	0.04	Eel Pot
PINFISH	6	0.035	Eel Pot
CRANGON SHRIMP	3	0.017	Eel Pot
GRASS / SHORE SHRIMP	3	0.017	Eel Pot
GOBY NAKED	2	0.012	Eel Pot
PIPEFISH NORTHERN	2	0.012	Eel Pot
SPIDER CRAB	2	0.012	Eel Pot
FLOUNDER SUMMER	1	0.006	Eel Pot
FLOUNDER WINTER	1	0.006	Eel Pot
STICKLEBACK FOURSPINE	1	0.006	Eel Pot
TOMCOD ATLANTIC	1	0.006	Eel Pot

Table 4c. Summary of species caught by minnow traps in Ninigret Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
GRASS / SHORE SHRIMP	959	0.388	Minnow Trap
SAND / CRANGON SHRIMP	737	0.298	Minnow Trap
RAINWATER KILLIFISH	576	0.233	Minnow Trap
MUMMICHOG	56	0.023	Minnow Trap
SILVERSIDE ATLANTIC	26	0.011	Minnow Trap
MUD CRAB	22	0.009	Minnow Trap
STICKLEBACK THREESPINE	16	0.006	Minnow Trap
KILLIFISH STRIPED	15	0.006	Minnow Trap
GOBY NAKED	10	0.004	Minnow Trap
SPOT	10	0.004	Minnow Trap
SEA BASS BLACK	7	0.003	Minnow Trap
SPIDER CRAB	6	0.002	Minnow Trap
STICKLEBACK FOURSPINE	6	0.002	Minnow Trap
PIPEFISH NORTHERN	5	0.002	Minnow Trap
BLUE CRAB	4	0.002	Minnow Trap
CUNNER	4	0.002	Minnow Trap
SCUP	4	0.002	Minnow Trap
TOADFISH OYSTER	2	0.001	Minnow Trap
TOMCOD ATLANTIC	2	0.001	Minnow Trap
FLOUNDER WINTER	1	0	Minnow Trap
SCULPINS	1	0	Minnow Trap
TAUTOG	1	0	Minnow Trap

Table 5a. Summary of species caught by gillnets in Quonochontaug Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
BASS STRIPED	210	0.182	Gillnet
SPOT	205	0.177	Gillnet
SPIDER CRAB	188	0.163	Gillnet
MENHADEN ATLANTIC	151	0.131	Gillnet
RIVER HERRING	96	0.083	Gillnet
BLUEFISH	89	0.077	Gillnet
BLUE CRAB	44	0.038	Gillnet
LADY CRAB	41	0.035	Gillnet
GREEN CRAB	29	0.025	Gillnet
SCUP	17	0.015	Gillnet
MULLET WHITE	12	0.01	Gillnet
PINFISH	10	0.009	Gillnet
ROCK CRAB	9	0.008	Gillnet
SEA BASS BLACK	8	0.007	Gillnet
TAUTOG	8	0.007	Gillnet
HORSESHOE CRAB	7	0.006	Gillnet
MANTIS SHRIMP	6	0.005	Gillnet
CUNNER	4	0.003	Gillnet
NEEDLEFISH ATLANTIC	4	0.003	Gillnet
SMOOTH DOGFISH	4	0.003	Gillnet
KINGFISH NORTHERN	3	0.003	Gillnet
PERCH WHITE	2	0.002	Gillnet
CROAKER ATLANTIC	1	0.001	Gillnet
FLOUNDER SUMMER	1	0.001	Gillnet
HERRING ATLANTIC	1	0.001	Gillnet
MULLET STRIPED	1	0.001	Gillnet
PIPEFISH NORTHERN	1	0.001	Gillnet
SAND TIGER SHARK	1	0.001	Gillnet
SEAROBIN STRIPED	1	0.001	Gillnet
WEAKFISH	1	0.001	Gillnet

Table 5b. Summary of species caught by eel pots in Quonochontaug Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
SEA BASS BLACK	142	0.498	Eel Pot
GREEN CRAB	39	0.137	Eel Pot
TAUTOG	26	0.091	Eel Pot
TOADFISH OYSTER	14	0.049	Eel Pot
EEL AMERICAN	13	0.046	Eel Pot
FLOUNDER WINTER	8	0.028	Eel Pot
BLUE CRAB	7	0.025	Eel Pot
CUNNER	6	0.021	Eel Pot
PINFISH	6	0.021	Eel Pot
MUD CRAB	5	0.018	Eel Pot
SPIDER CRAB	4	0.014	Eel Pot
MUMMICHOG	3	0.011	Eel Pot
SCUP	3	0.011	Eel Pot
TOMCOD ATLANTIC	2	0.007	Eel Pot
FLOUNDER SUMMER	1	0.004	Eel Pot
GRASS / SHORE SHRIMP	1	0.004	Eel Pot
PIPEFISH NORTHERN	1	0.004	Eel Pot
RIVER HERRING	1	0.004	Eel Pot
ROCK CRAB	1	0.004	Eel Pot
RUDDERFISH BANDED	1	0.004	Eel Pot
SPOT	1	0.004	Eel Pot

Table 5c. Summary of species caught by minnow traps in Quonochontaug Pond, summed across sites, months, and years. Species of interest are highlighted in yellow.

Common Name	Number	Prop	Gear Type
CRANGON SHRIMP	344	0.41	Minnow Trap
FLOUNDER WINTER	108	0.129	Minnow Trap
RAINWATER KILLIFISH	96	0.114	Minnow Trap
SEA BASS BLACK	73	0.087	Minnow Trap
SILVERSIDE ATLANTIC	59	0.07	Minnow Trap
GRASS / SHORE SHRIMP	54	0.064	Minnow Trap
MUD CRAB	17	0.02	Minnow Trap
TAUTOG	14	0.017	Minnow Trap
CUNNER	13	0.015	Minnow Trap
MUMMICHOG	9	0.011	Minnow Trap
TOADFISH OYSTER	8	0.01	Minnow Trap
GOBY NAKED	7	0.008	Minnow Trap
PIPEFISH NORTHERN	7	0.008	Minnow Trap
STICKLEBACK FOURSPINE	6	0.007	Minnow Trap
SCULPIN SHORTHORN	5	0.006	Minnow Trap
SCULPINS	4	0.005	Minnow Trap
KILLIFISH STRIPED	3	0.004	Minnow Trap
PINFISH	3	0.004	Minnow Trap
EEL AMERICAN	2	0.002	Minnow Trap
FLOUNDER SUMMER	2	0.002	Minnow Trap
GREEN CRAB	2	0.002	Minnow Trap
SCUP	2	0.002	Minnow Trap
RIVER HERRING	1	0.001	Minnow Trap
STICKLEBACK THREESPINE	1	0.001	Minnow Trap

Table 6. Mean water quality data from fish sampling days in Ninigret Pond during 2017

Pond	Month	Site	Temperature (C°)	Temp.SE	Salinity (ppt)	Sal.SE	Dissolved Oxygen (mg/L)	DO.SE
Ninigret Pond	May	1	19.6	0.1	27.65	0.04	8.69	0.28
Ninigret Pond	May	2	20.033	0.26	27.42	0.15	8.72	0.17
Ninigret Pond	May	3	19.3	0.1	27.59	0	8.42	0.15
Ninigret Pond	May	4	19.3	0.15	27.6	0.03	9.67	1.27
Ninigret Pond	June	1	25.4	0.06	27.8	0.08	7.67	0.1
Ninigret Pond	June	2	25.47	0.13	27.54	0.03	7.74	0.29
Ninigret Pond	June	3	26.4	0.15	28.37	0.01	8.54	0.25
Ninigret Pond	June	4	26.3	0.2	28.37	0.01	9.12	0.43
Ninigret Pond	July	1	22.9	0	29.28	0.02	6.28	0.13
Ninigret Pond	July	2	23.03	0.09	29.19	0.04	7.18	0.7
Ninigret Pond	July	3	22.47	0.07	29.15	0.28	8.45	0.46
Ninigret Pond	July	4	22.3	0.15	29.57	0	7.82	0.14
Ninigret Pond	August	1	25.58	0.03	29.84	0.02	6.45	0.07
Ninigret Pond	August	2	25.65	0.06	29.8	0.01	6.33	0.1
Ninigret Pond	August	3	26.43	0.02	29.99	0	7.68	0.16
Ninigret Pond	August	4	26.37	0.03	30.01	0	7.56	0.26
Ninigret Pond	September	1	20.2	0.16	28.15	0.03	9.12	0.17
Ninigret Pond	September	2	20.6	0.31	27.31	0.81	9.76	0.47
Ninigret Pond	September	3	18.73	0.03	29.49	0	8.13	0.29
Ninigret Pond	September	4	18.57	0.06	29.45	0	8.41	0.18
Ninigret Pond	October	1	12.83	0.02	26.13	0.02	10.05	0.19
Ninigret Pond	October	2	13.1	0.05	25.97	0.07	9.81	0.02
Ninigret Pond	October	3	14.93	0.06	26.21	0.01	9.96	0.05
Ninigret Pond	October	4	14.92	0.03	26.24	0.03	9.98	0.14

Table 7. Mean water quality data from fish sampling days in Quonochontaug Pond during 2017.

Pond	Month	Site	Temperature (C°)	Temp.SE	Salinity (ppt)	Sal.SE	Dissolved Oxygen (mg/L)	DO.SE
Quonochontaug Pond	June	2	13.8	0.1	31.32	0.04	6.67	NA
Quonochontaug Pond	June	3	13.75	0.06	31.38	0.09	7.6	0.46
Quonochontaug Pond	July	1	26.85	0.12	30.49	0.04	6.68	0.13
Quonochontaug Pond	July	2	26.99	0.72	30.68	0.07	7.2	0.33
Quonochontaug Pond	July	3	28.38	0.2	30.4	0.08	6.84	0.1
Quonochontaug Pond	August	1	25.35	0.25	28.44	0.1	9.17	0.29
Quonochontaug Pond	August	2	23.01	0.36	29.48	0.57	8.61	0.38
Quonochontaug Pond	August	3	22.68	0.11	29.56	0.13	9.21	0.25
Quonochontaug Pond	September	1	23.13	0.08	31.74	0.03	6.91	0.13
Quonochontaug Pond	September	2	21.8	0.22	31.96	0.03	7.36	0.17
Quonochontaug Pond	September	3	21.78	0.01	31.96	0.07	8.56	0.18
Quonochontaug Pond	October	1	17.01	0.06	31.77	0.01	9.04	0.08
Quonochontaug Pond	October	2	17.25	0.12	31.97	0.09	10.21	0.43
Quonochontaug Pond	October	3	16.54	0.1	31.74	0.06	11.77	0.24

Figure 1. Coastal ponds located in Southern Rhode Island including constructed and proposed Fish Habitat Enhancement sites.

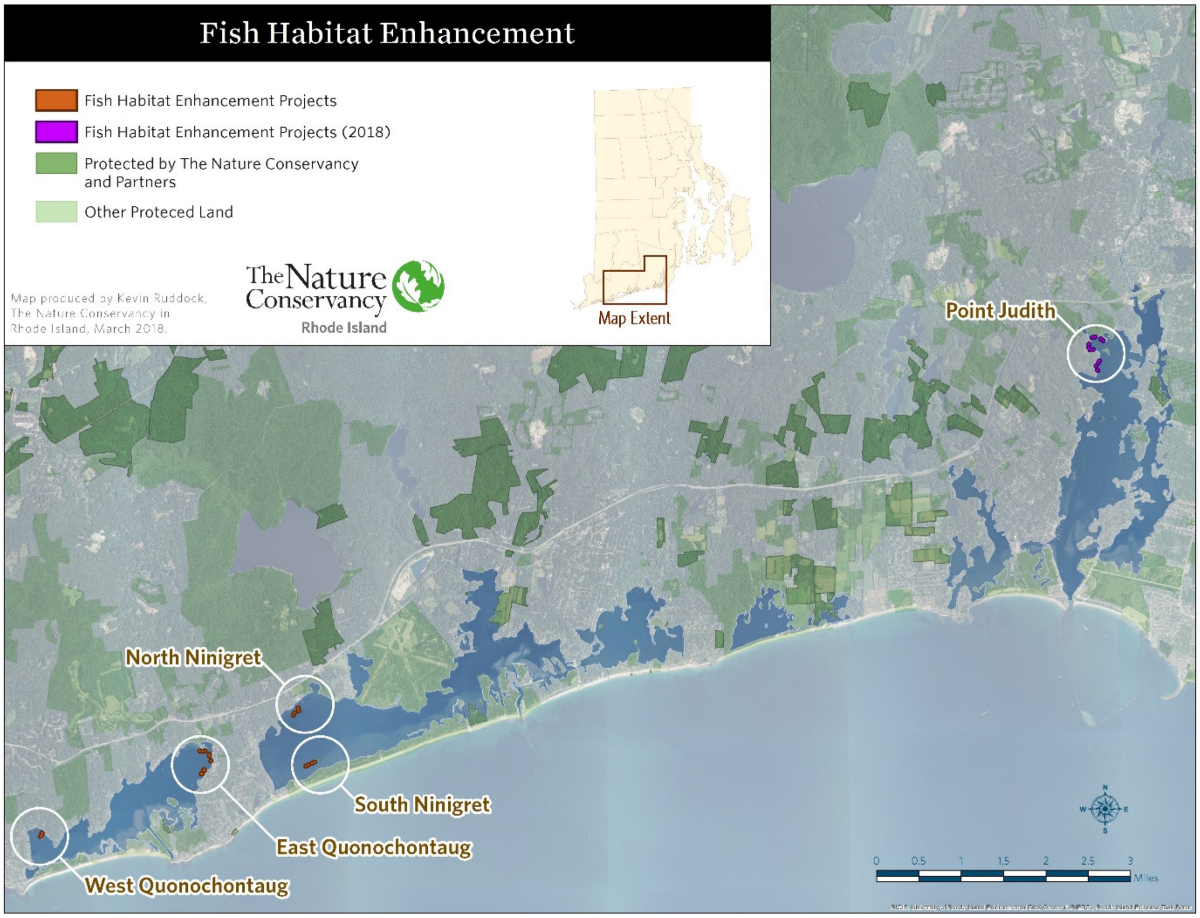
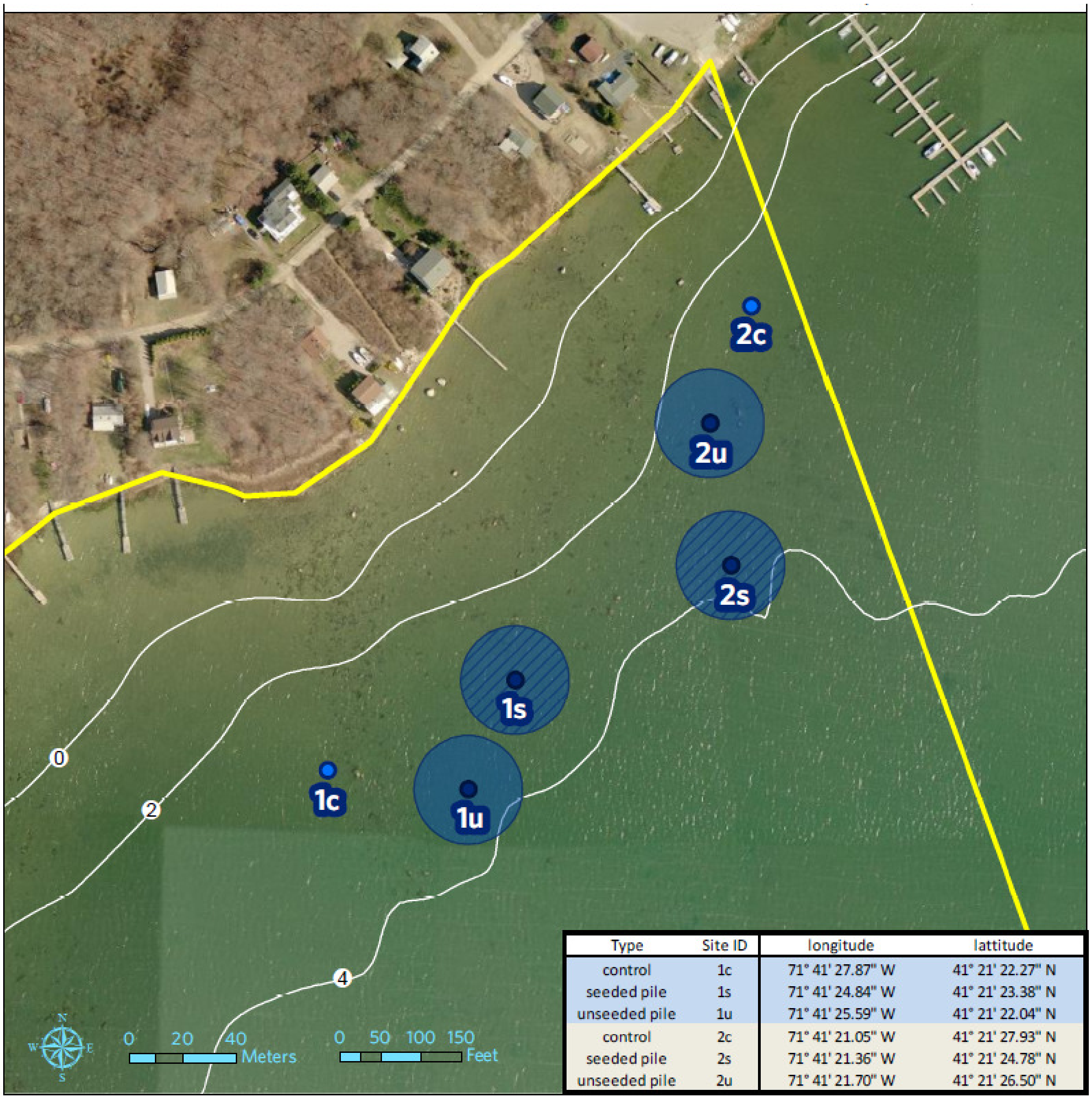
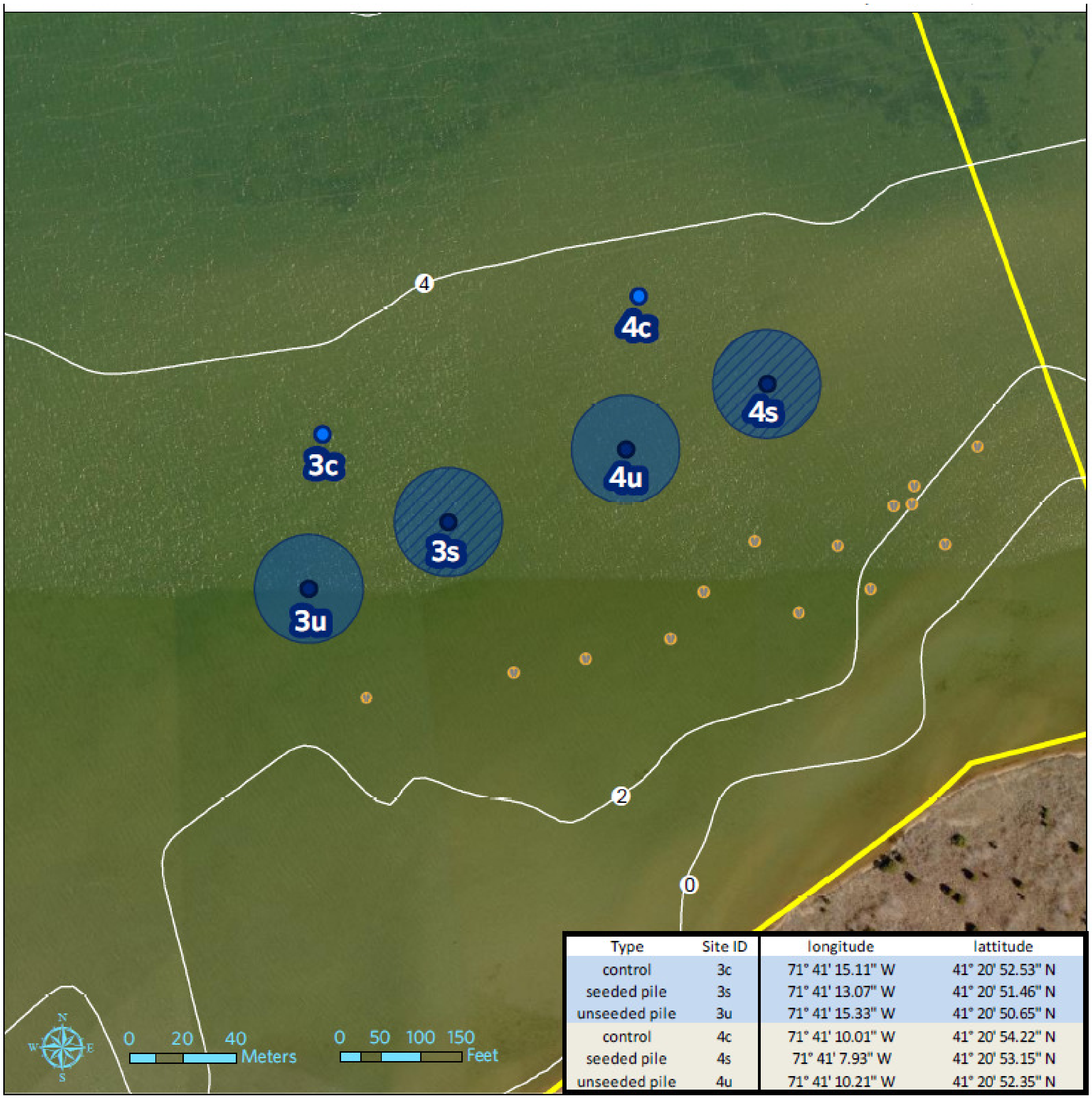


Figure 2. Fish Habitat Enhancement sites in the northern portion of Ninigret Pond. The RI DMF management closure (i.e., Shellfish Spawner Sanctuary) is depicted by the yellow outline. Map produced by Kevin Ruddock (TNC).



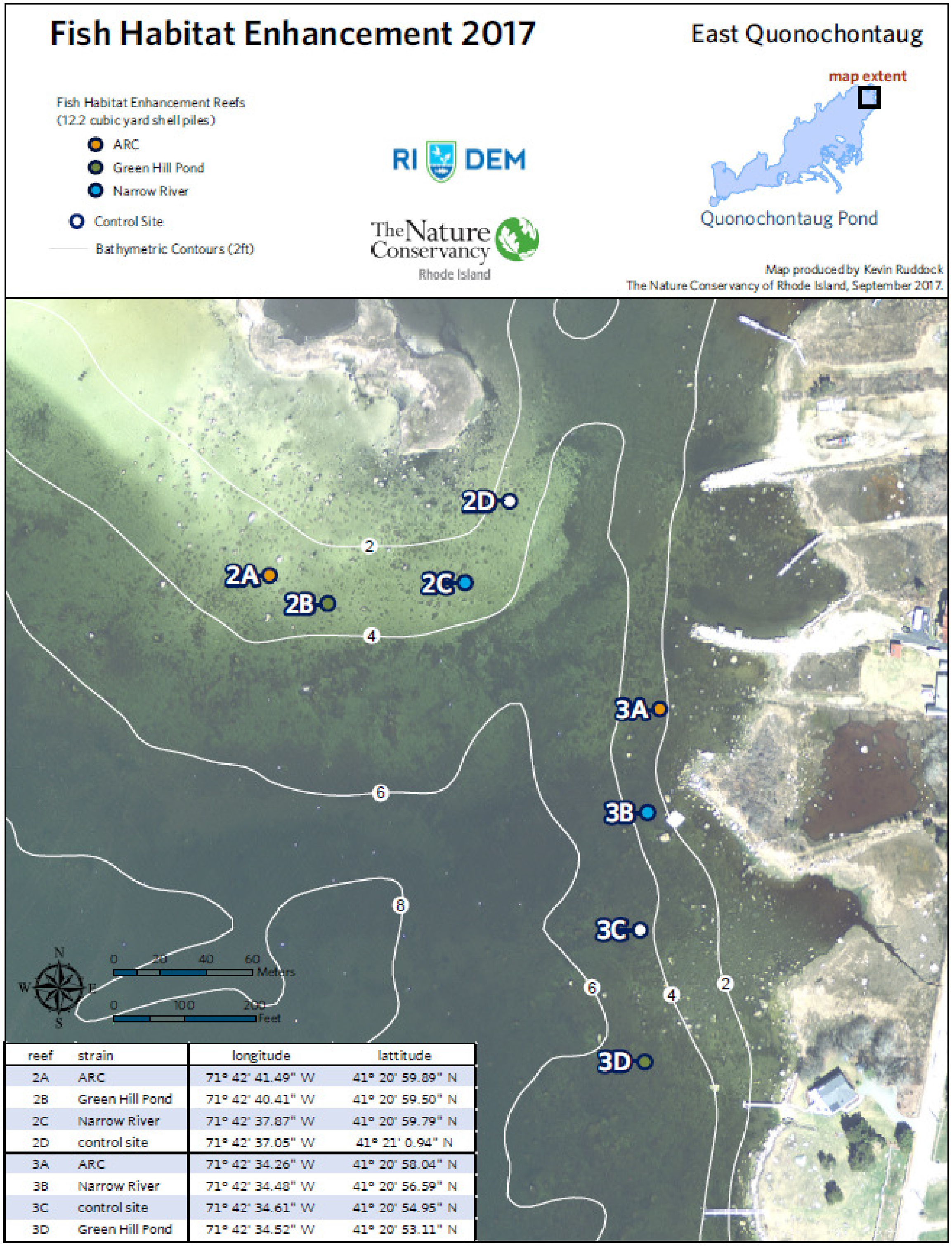
Type	Site ID	longitude	lattitude
control	1c	71° 41' 27.87" W	41° 21' 22.27" N
seeded pile	1s	71° 41' 24.84" W	41° 21' 23.38" N
unseeded pile	1u	71° 41' 25.59" W	41° 21' 22.04" N
control	2c	71° 41' 21.05" W	41° 21' 27.93" N
seeded pile	2s	71° 41' 21.36" W	41° 21' 24.78" N
unseeded pile	2u	71° 41' 21.70" W	41° 21' 26.50" N

Figure 3. Fish Habitat Enhancement sites in the southern portion of Ninigret Pond. The RI DMF management closure (i.e., Shellfish Spawner Sanctuary) is depicted by the yellow outline. Points marked to the south of our reefs are restored oyster reefs created by the NRCS EQIP Program between 2008 and 2010.   Map produced by Kevin Ruddock (TNC).



Type	Site ID	longitude	lattitude
control	3c	71° 41' 15.11" W	41° 20' 52.53" N
seeded pile	3s	71° 41' 13.07" W	41° 20' 51.46" N
unseeded pile	3u	71° 41' 15.33" W	41° 20' 50.65" N
control	4c	71° 41' 10.01" W	41° 20' 54.22" N
seeded pile	4s	71° 41' 7.93" W	41° 20' 53.15" N
unseeded pile	4u	71° 41' 10.21" W	41° 20' 52.35" N

Figure 4. Configuration for Fish Habitat Enhancement sites (i.e., research plot #2 and #3) located in the eastern end of Quonochontaug Pond, Charlestown, RI. Each research plot contains 3 experimental reefs and 1 control. Map produced by Kevin Ruddock (TNC).

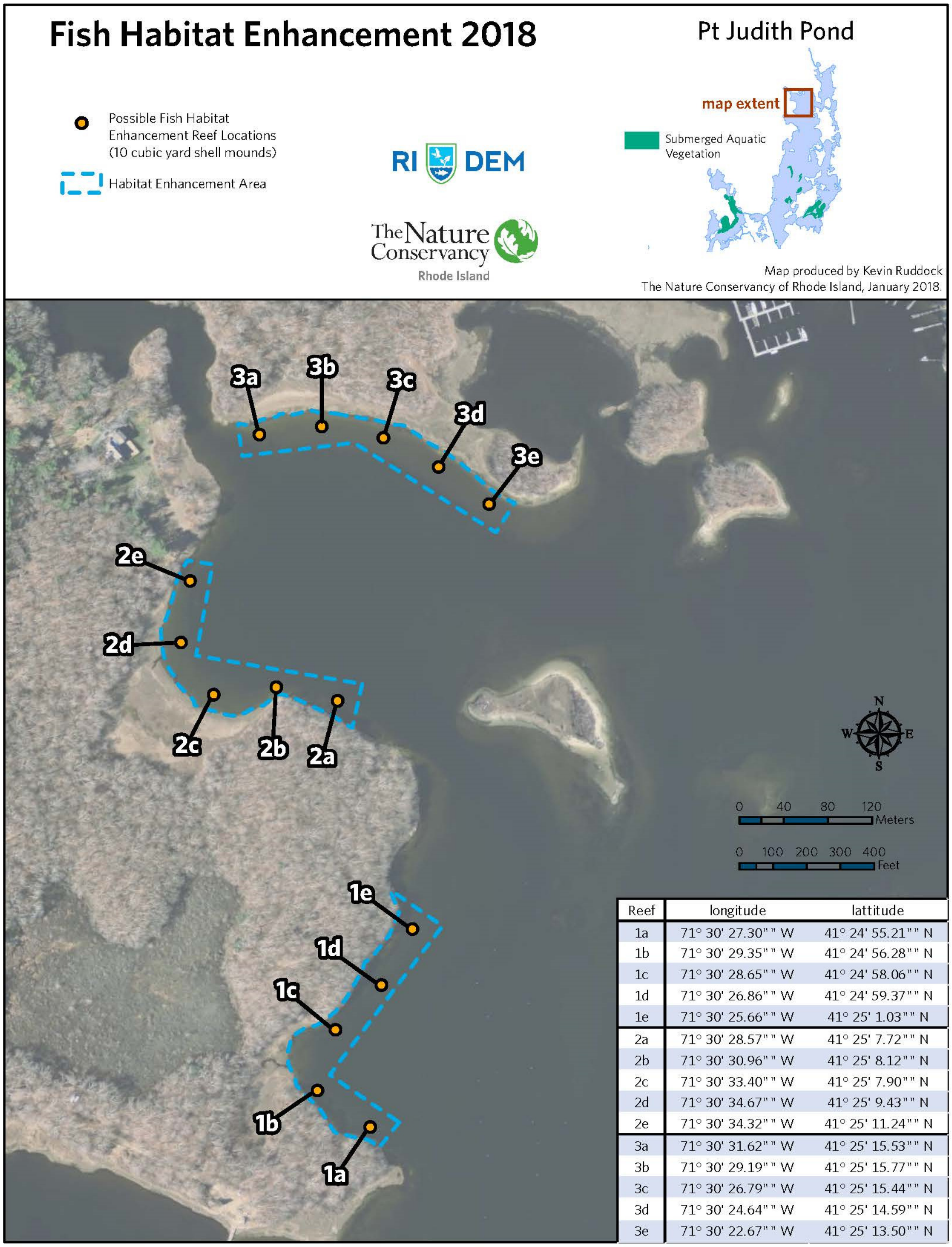


reef	strain	longitude	lattitude
2A	ARC	71° 42' 41.49" W	41° 20' 59.89" N
2B	Green Hill Pond	71° 42' 40.41" W	41° 20' 59.50" N
2C	Narrow River	71° 42' 37.87" W	41° 20' 59.79" N
2D	control site	71° 42' 37.05" W	41° 21' 0.94" N
3A	ARC	71° 42' 34.26" W	41° 20' 58.04" N
3B	Narrow River	71° 42' 34.48" W	41° 20' 56.59" N
3C	control site	71° 42' 34.61" W	41° 20' 54.95" N
3D	Green Hill Pond	71° 42' 34.52" W	41° 20' 53.11" N

Figure 5. Configuration for Fish Habitat Enhancement sites (i.e., research plot #1) located in the western end of Quonochontaug Pond, Westerly, RI. Each research plot contains 3 experimental reefs and 1 control. Map produced by Kevin Ruddock (TNC).

reef	strain	longitude	lattitude
1A	control site	71° 44' 51.89" W	41° 20' 9.93" N
1B	ARC	71° 44' 51.68" W	41° 20' 8.65" N
1C	Narrow River	71° 44' 52.40" W	41° 20' 7.62" N
1D	Green Hill Pond	71° 44' 52.89" W	41° 20' 6.37" N

Figure 6. Potential configuration for Fish Habitat Enhancement sites (i.e., research plots #1-3) to be located in the northwestern portion of Pt. Judith Pond, South Kingstown, RI. Each research plot contains 4 experimental reefs and 1 control. Map produced by Kevin Ruddock (TNC).



Reef	longitude	lattitude
1a	71° 30' 27.30"" W	41° 24' 55.21"" N
1b	71° 30' 29.35"" W	41° 24' 56.28"" N
1c	71° 30' 28.65"" W	41° 24' 58.06"" N
1d	71° 30' 26.86"" W	41° 24' 59.37"" N
1e	71° 30' 25.66"" W	41° 25' 1.03"" N
2a	71° 30' 28.57"" W	41° 25' 7.72"" N
2b	71° 30' 30.96"" W	41° 25' 8.12"" N
2c	71° 30' 33.40"" W	41° 25' 7.90"" N
2d	71° 30' 34.67"" W	41° 25' 9.43"" N
2e	71° 30' 34.32"" W	41° 25' 11.24"" N
3a	71° 30' 31.62"" W	41° 25' 15.53"" N
3b	71° 30' 29.19"" W	41° 25' 15.77"" N
3c	71° 30' 26.79"" W	41° 25' 15.44"" N
3d	71° 30' 24.64"" W	41° 25' 14.59"" N
3e	71° 30' 22.67"" W	41° 25' 13.50"" N

Figure 7. Two-way ANOVAs of Mean Density per Quadrat by Year and Site for Ninigret Pond (A) and by Site and Seed in Quonochontaug Pond (B). One-way ANOVAs of Mean Density per Quadrat by Year and Site for Ninigret Pond (C) and Quonochontaug Pond (D) respectively; letters denote significant differences (p-value <0.05) from Tukey's post hoc test (C), and periods denote partial significance from ANOVA (p-value <.01, *n* = *9*)) (D).

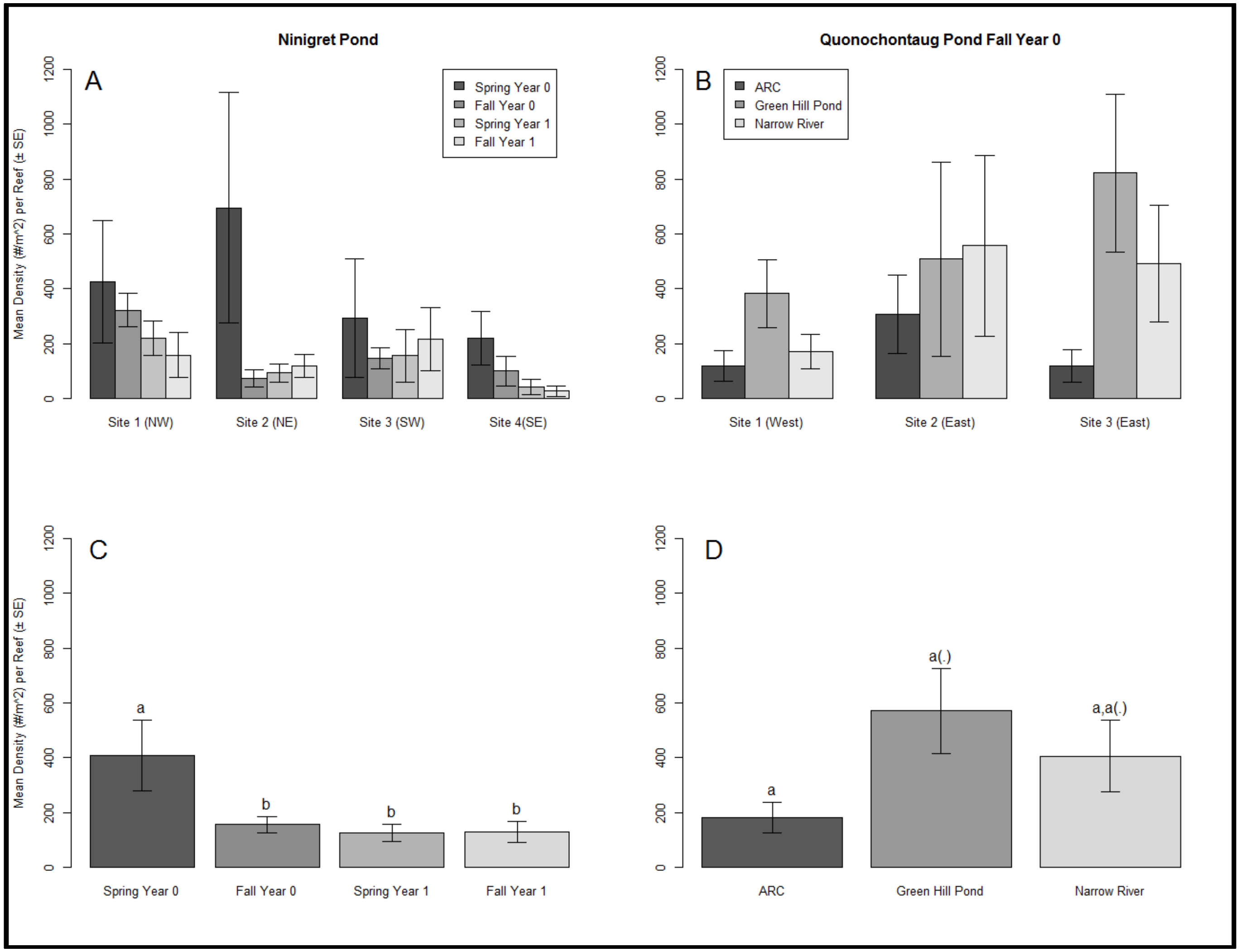


Figure 8. Two-way ANOVAs of mean proportion living (circles) and mean proportion with boring sponges (triangles) per quadrat by time (monitoring event) and site in Ninigret Pond (A), and by site and seed in Quonochontaug Ponds (B); lines denote significant main factors of time and site on proportion living (A; circles) as well as a significant interactive effect of the two main factors time and site on with boring sponge respectively (A; triangles). Oyster density per quadrat by quadrat relief (height above pond floor) for Ninigret (C) and Quonochontaug Ponds (D).

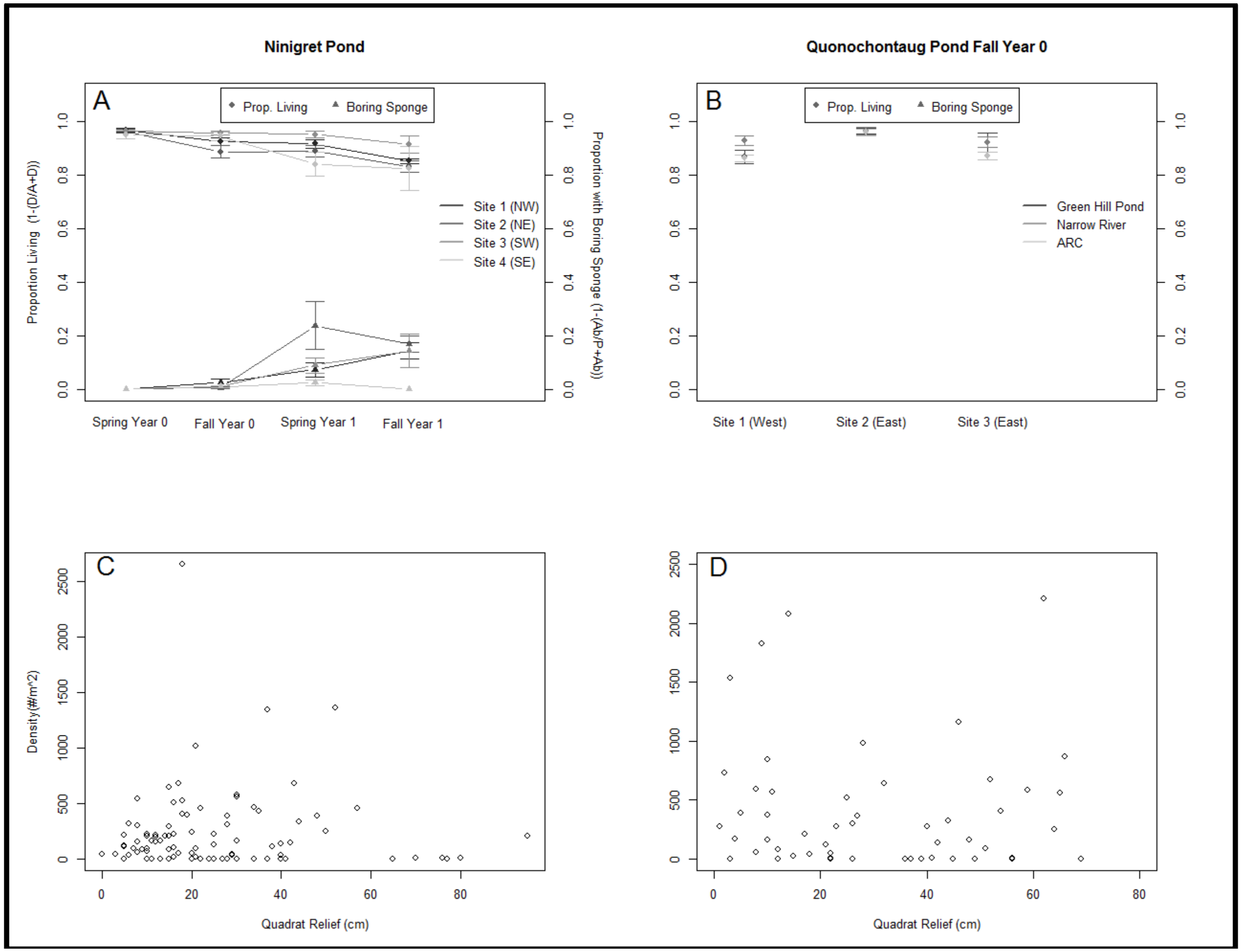


Figure 9. Mean length per quadrat by oyster linage for the three over wintering monitoring events conducted for the Quonochontaug oyster (top row). Mean proportion living by strain and monitoring event (bottom row).

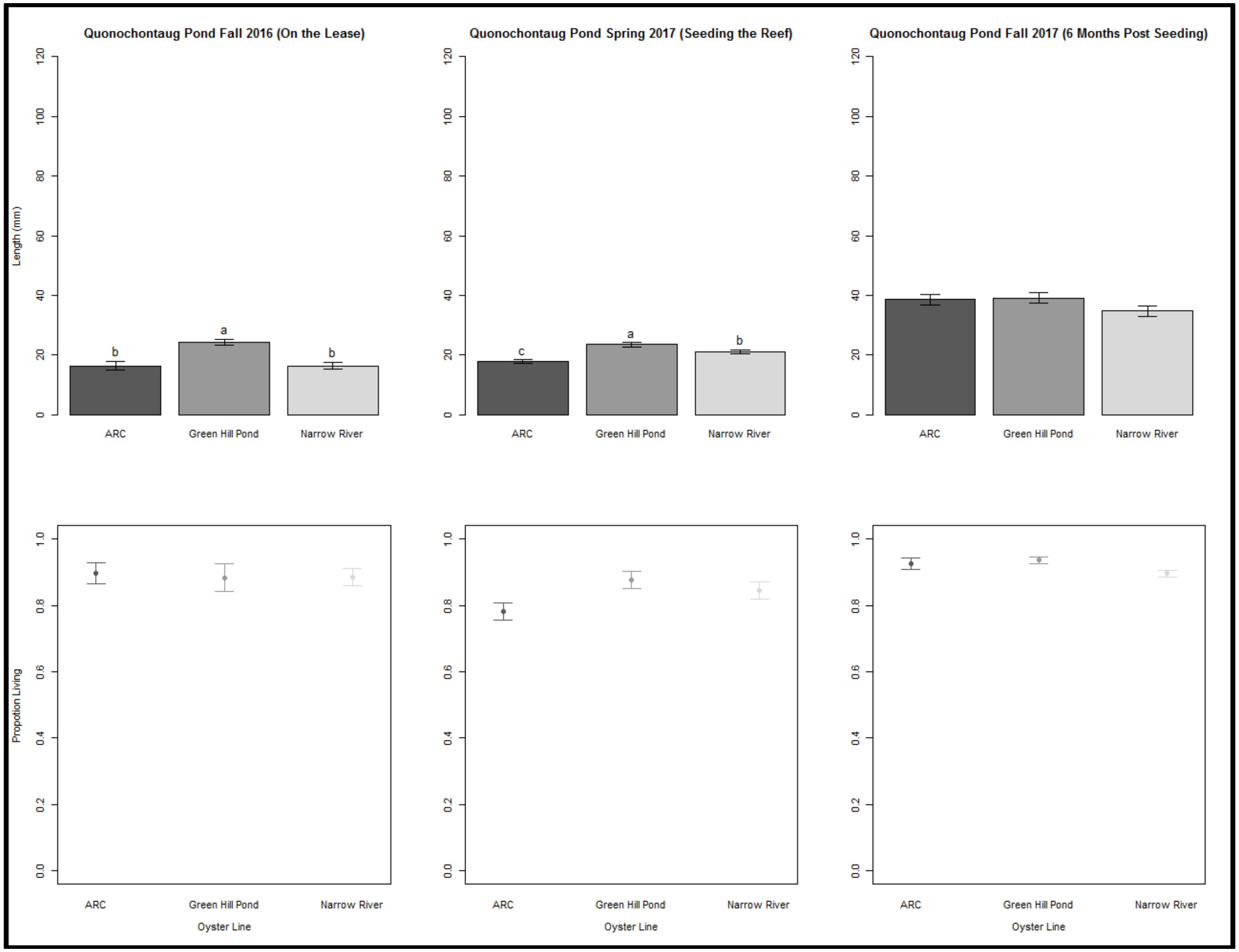


Figure 10. Two-way ANOVAs of Mean Oyster Length per Quadrat by Time (Monitoring Event, *n* = 3), Site (*n* = 3), and the interaction (Time:Site, *n* = 9) in Ninigret Pond (A). Two-way ANOVAs of Mean Oyster Length per Quadrat by Site (*n* = 3), Seed (*n* = 3), and the interaction (Site:Seed, *n* = 9) in Quonochontaug Pond (B), letters denote significant differences in Tukey's post hoc test. Length frequency by Year (C) and by Site (D) for Ninigret and Quonochontaug Ponds respectively; bins are set to 5mm. Kernel density estimation of length by Year (E) and Site (F) for Ninigret and Quonochontaug Ponds respectively; bandwidths were calculated using the rule of thumb "ndr0" method included in density function of the "stats" program in R.

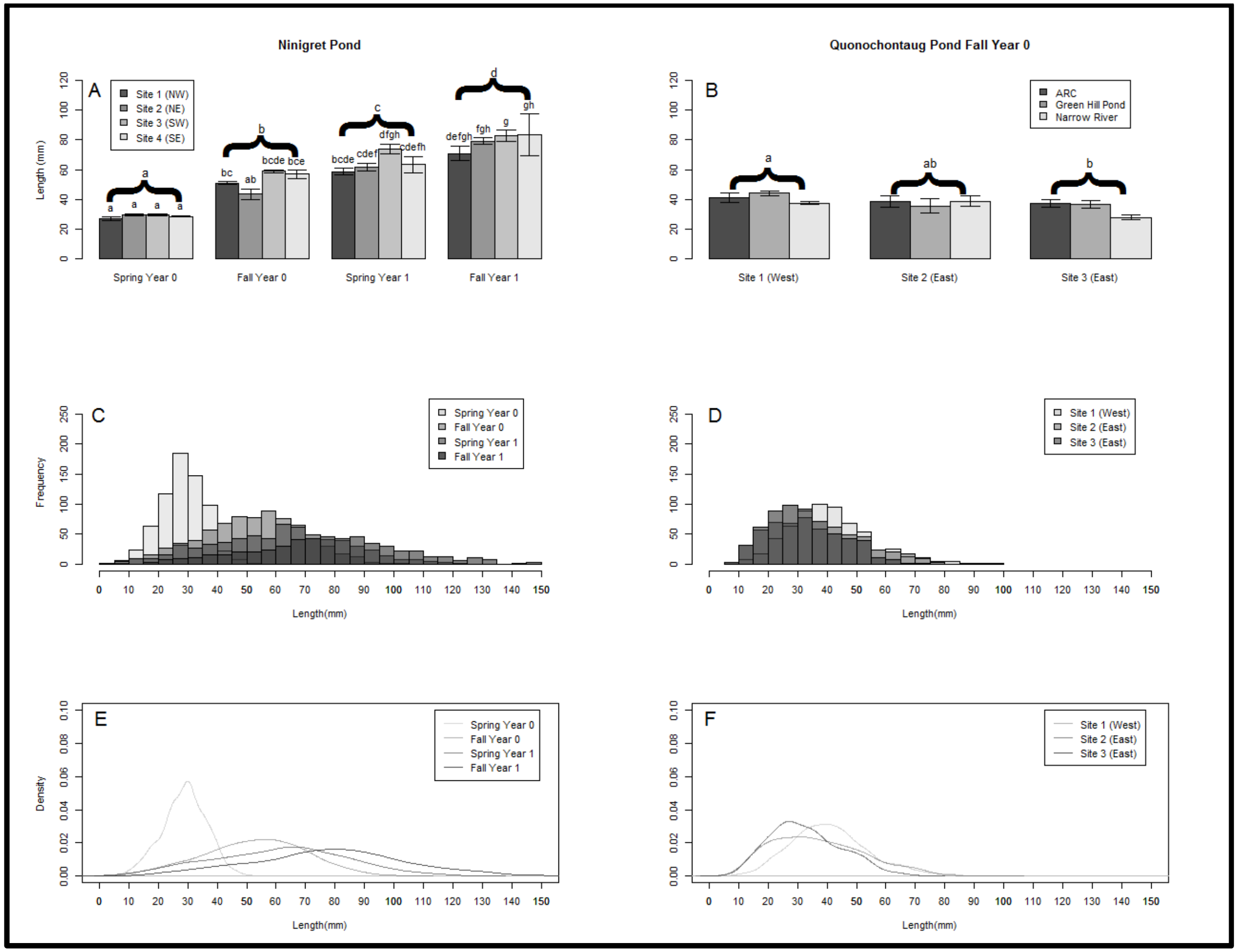


Figure 11. Mean Shannons Diversity Index (H) by year and seed (treatment) for all Ninigret Pond (Top Left) and Quonochontaug Pond (Top Right) finfish surveys. Mean Shannons Diversity Index (H) by year for (treatment) for all Ninigret Pond (Bottom Left) and Quonochontaug Pond (Bottom Right) finfish surveys.

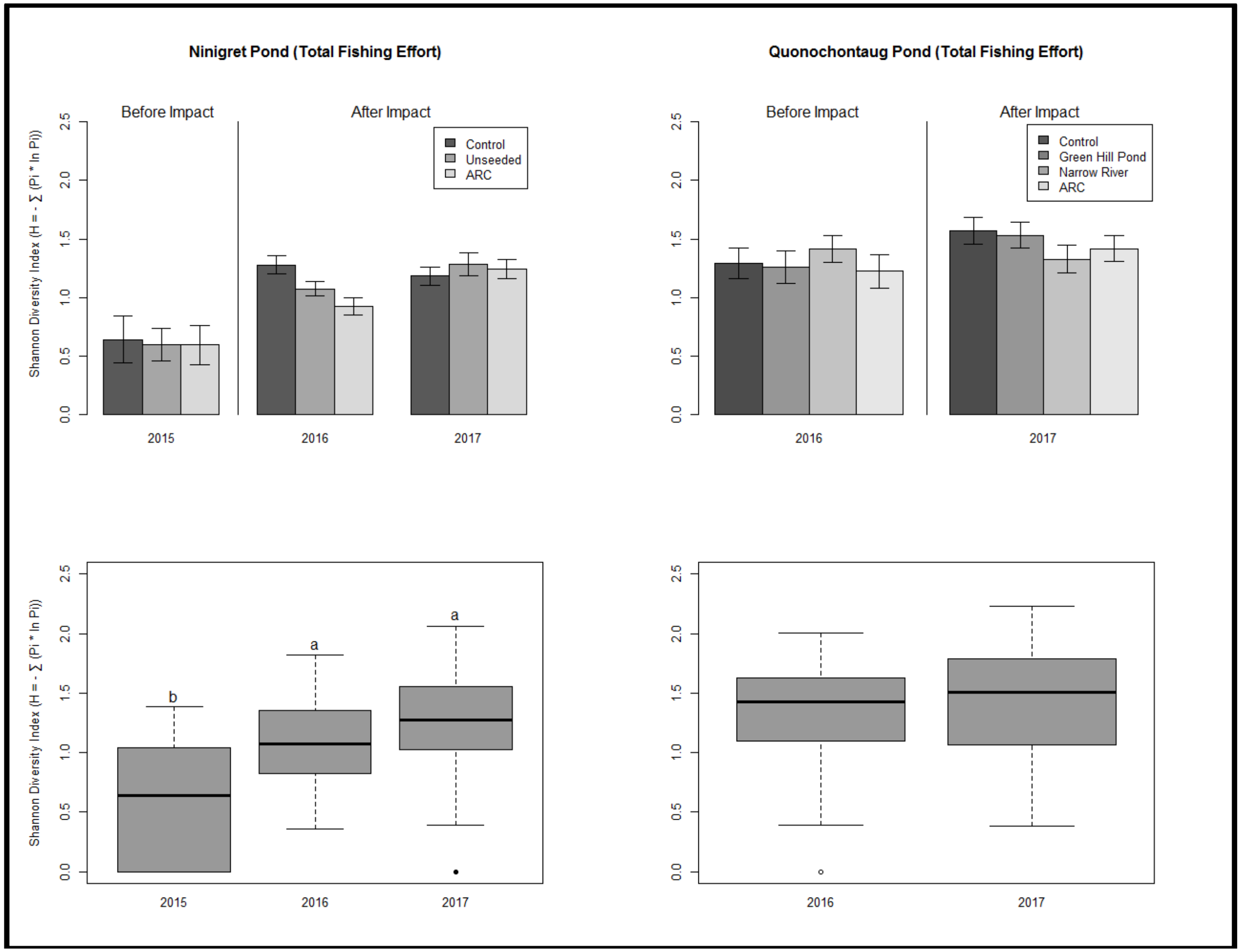


Figure 12. Black Sea Bass Analysis: Mean catch per haul (± SE) by year and seed (top), Mean catch per haul (± SE) by month and seed (middle), Kernel Density Estimation based on year and seed (bottom).

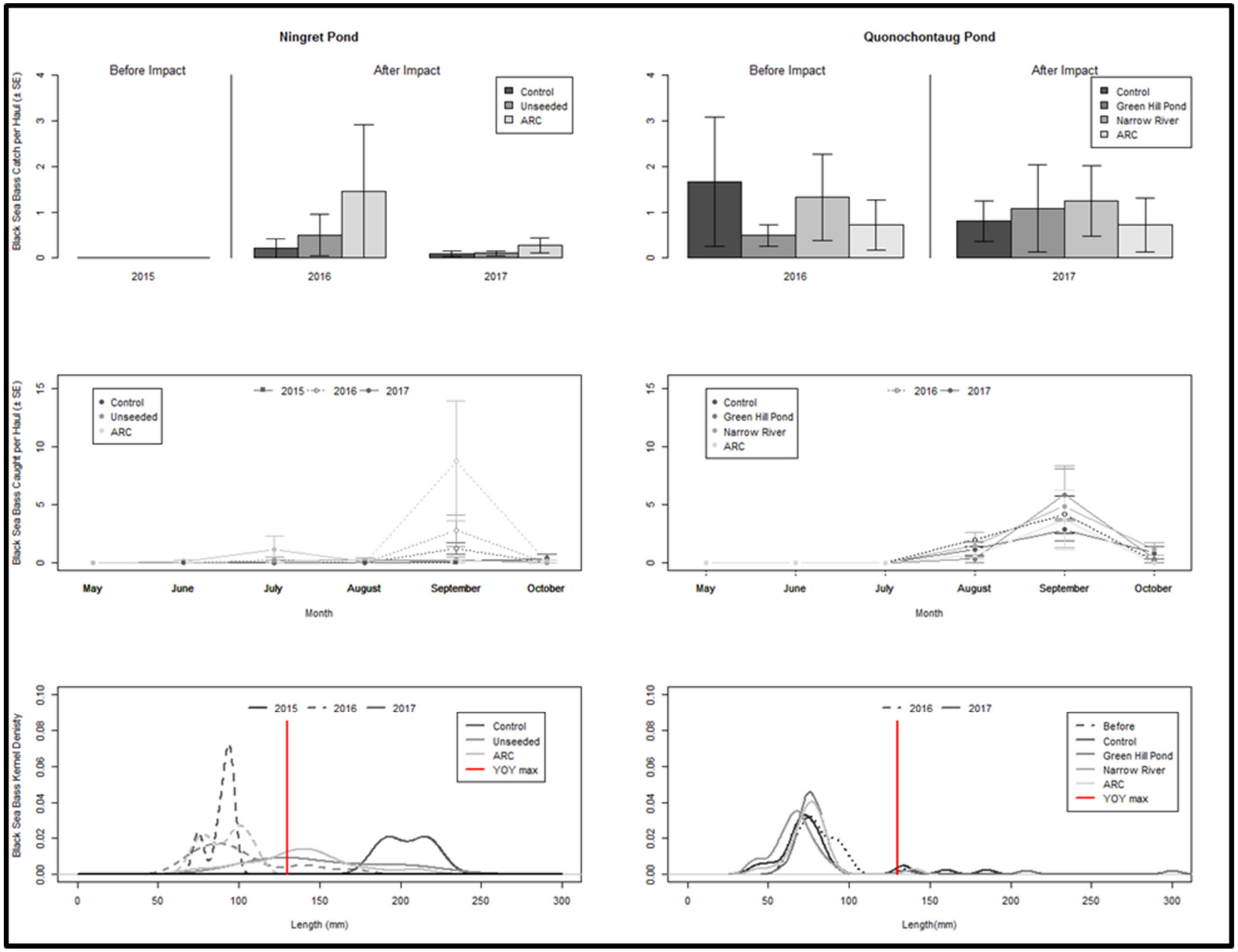


Figure 13. Scup Analysis: Mean catch per haul (± SE) by year and seed (top), Mean catch haul (± SE) by month and seed (middle), Kernel Density Estimation based on year and seed (bottom).

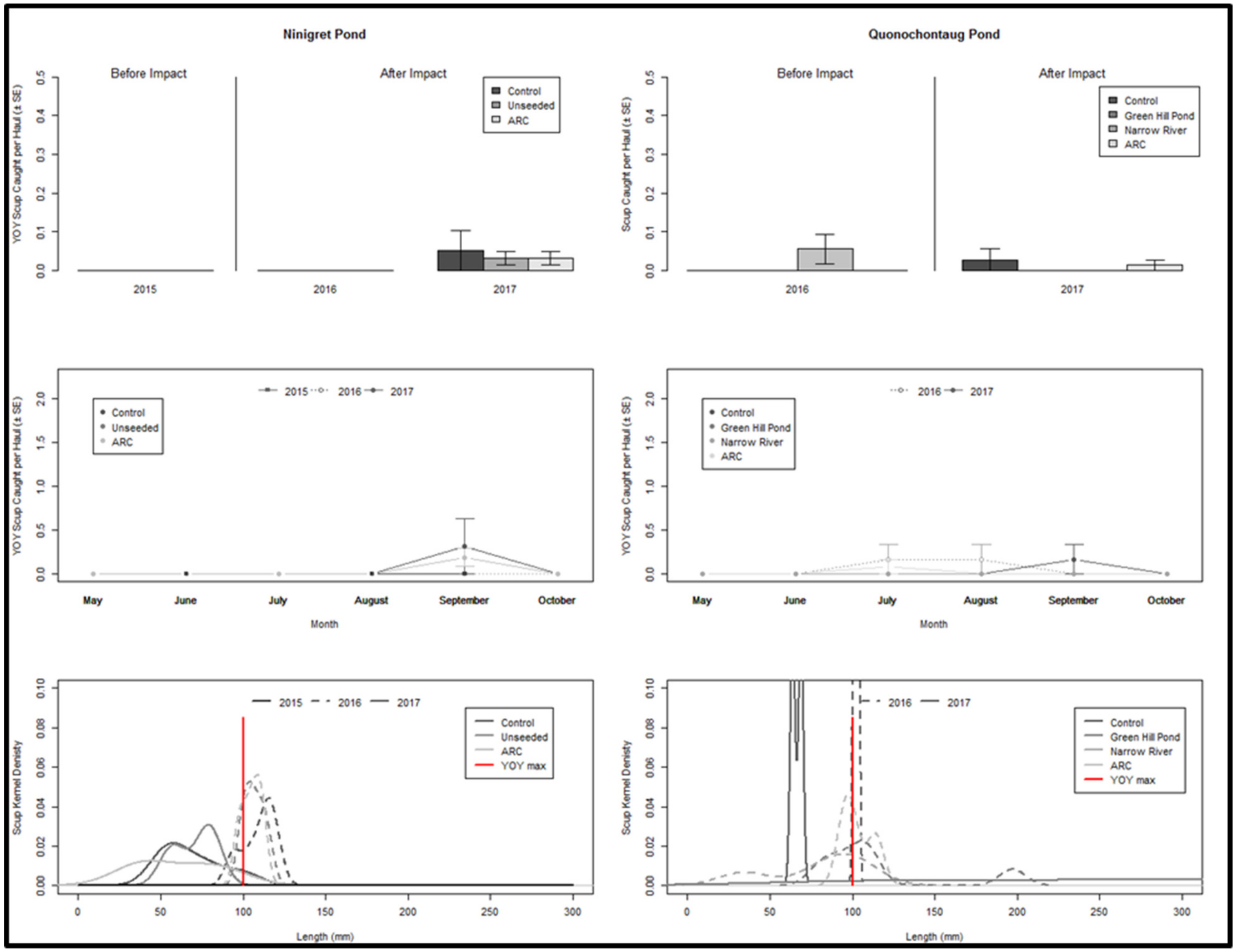


Figure 14. Tautog Analysis (Quonochontaug Pond): Mean catch per haul (± SE) by year and seed (top left), Mean catch per haul (± SE) by month and seed (top right), length frequency by control or reef post impact (bottom left), and Kernel Density Estimation based on year and treatment (bottom right).

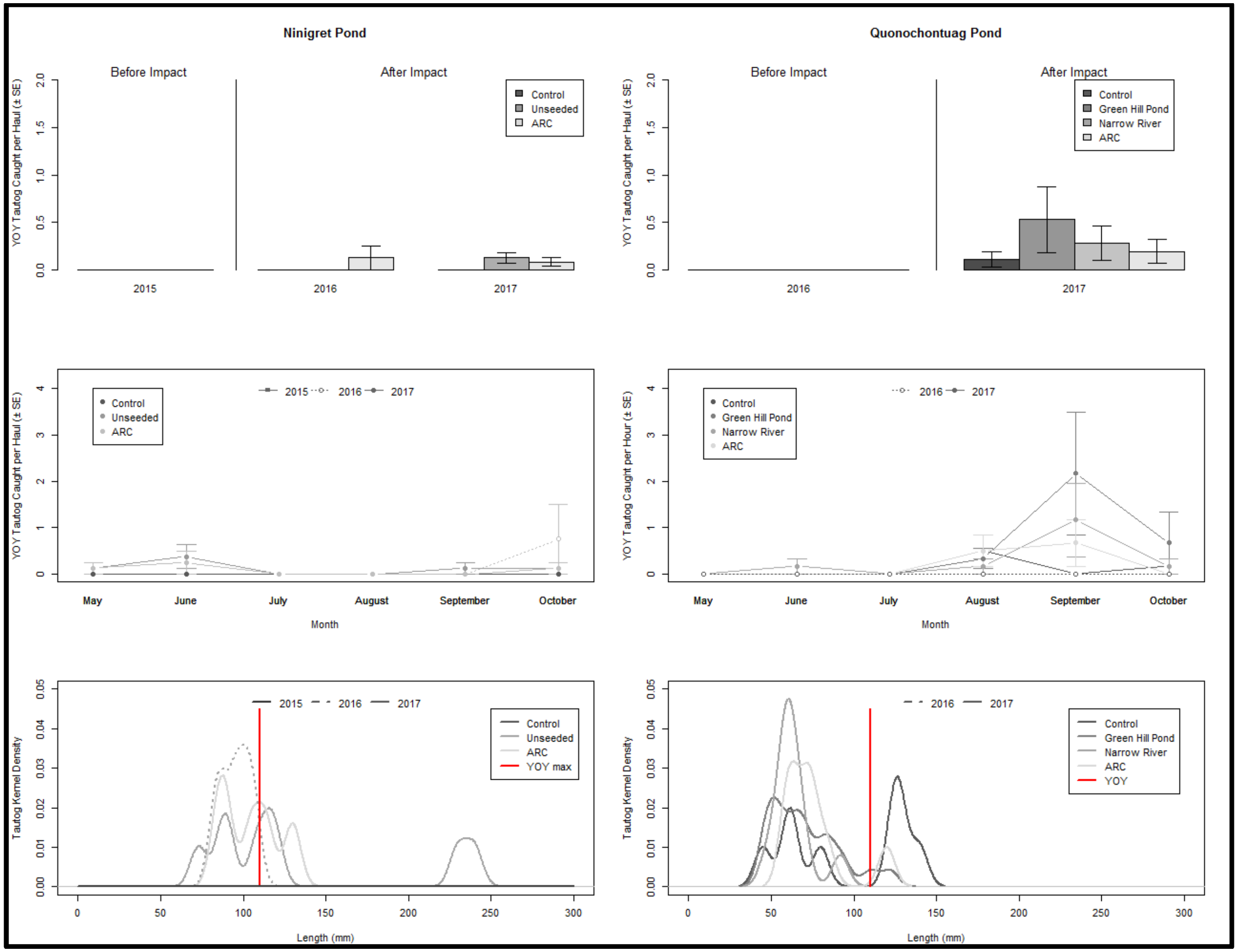


Figure 15. Winter Flounder Analysis (Quonochontaug Pond): Mean catch per haul (± SE) by year and seed (top left), Mean catch per haul (± SE) by month and seed (bottom left), length frequency by control or reef post impact (top right), and Kernel Density Estimation based on year and treatment (bottom right).

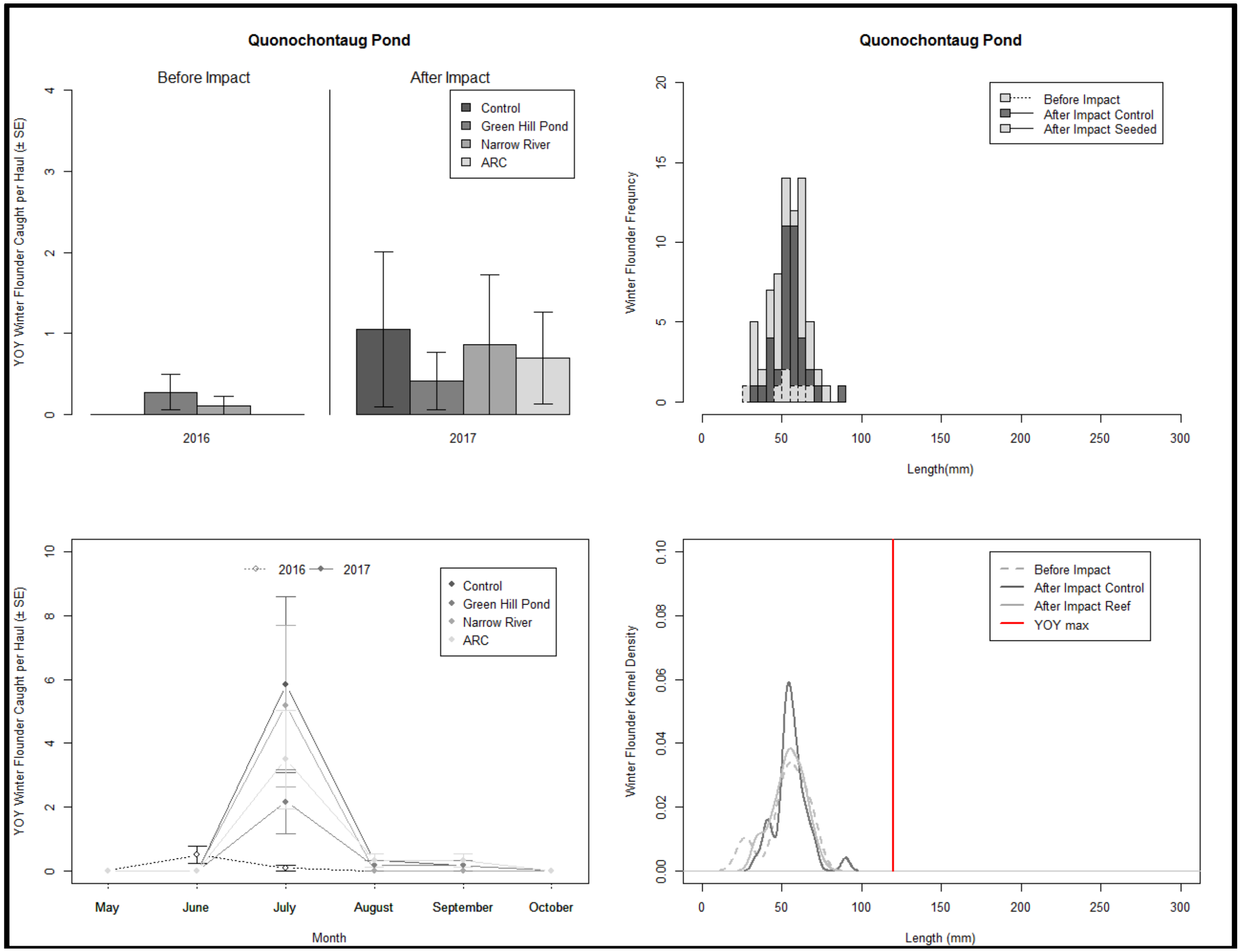


Figure 16. Photograph of DMF and TNC employees sampling gillnets for post-enhancement of reefs in Ninigret Pond.

Figure 17. Photograph of a seeded FHE reef in Ninigret Pond taken during FHE habitat monitoring.

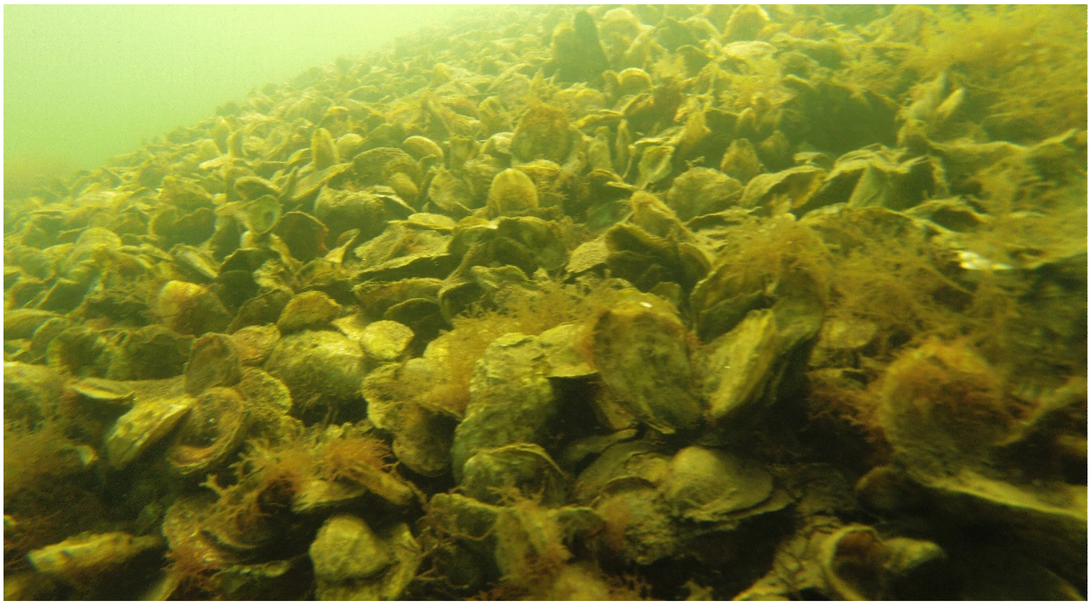


Figure 18. Photograph of black sea bass caught and measured in an eel pot during sampling.

Figure 19. Photograph of black sea bass being measured during sampling.

- End of Report -

Sportfish Assessment and Management in Rhode Island Waters

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STATE: Rhode Island

PROJECT NUMBER: F-61-R

SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

PERIOD COVERED: January 1, 2017 – December 31, 2017

JOB NUMBER 8 TITLE: Sportfish Assessment and Management in Rhode Island Waters
During this segment, four fish stock assessments were completed that included a menhaden update stock assessment, a winter flounder operational assessment, an Atlantic mackerel benchmark assessment, and a tautog update assessment. In addition to completed stock assessments, there are two other stock assessments that have been initiated and are in progress including a striped bass benchmark stock assessment, and a summer flounder benchmark assessment. RI also contributes local small scale stock assessments to help inform local management decisions, and these often rely on survey information that is derived from surveys funded by the sportfish restoration grant. Scientific advice to fisheries managers emerged from these assessments, particularly during the deliberations of the state's licensing provisions for 2017, which has impacts to recreational fisheries, as well as in the process for setting the recreational management plans for 2018. The project leaders participated at the Atlantic States Marine Fisheries Commission's meetings relative to the management of recreationally important coastal stocks. They also participated in the National Marine Fisheries Service (NMFS) stock assessment meetings for species under their jurisdiction. Other project staff participated at fish stock assessment trainings conducted through ASMFC and NOAA. The status of the most important recreationally caught species in Rhode Island were presented in the finfish sector management plan which was submitted for public review and input for establishing management strategies for 2018 (Finfish Sector Management Plan 2017, see: http://www.dem.ri.gov/pubs/regs/regs/fishwild/mpfinfsh.pdf). The following is a summary of the activities that took place in 2017.

1. SUMMER FLOUNDER

Beginning when the new statistical catch at age stock assessment (ASAP = age structured assessment program) was introduced and peer reviewed in 2008, an annual update has been performed for the coastwide stock for summer flounder. These updates are less time consuming than full benchmark assessments, but still require some work to be able to perform the update. In 2013, a full benchmark assessment was performed and was peer reviewed at the SAW57 meeting (http://www.nefsc.noaa.gov/saw/saw57/Agenda-SAWSARC57-Rev%207242013.pdf). This assessment passed peer review and was updated for management use in 2014 and 2015. The summer flounder assessment will be benchmarked in 2018, and will include multiple modeling frameworks such as sex specific and state-space models. The main tasks are to gather both catch and fishery independent information from the previous year, and stratify that information by age based on aging information from the NMFS trawl survey. RI contributes its Division of Fish and Wildlife trawl survey data (see job number 2 from this grant) to the assessment. Staff collects the information and age stratifies it for the assessment. Staff also participates in several meetings where the assessment information is released, and staff are active members of the benchmark stock assessment working group.

2. ATLANTIC MENHADEN

The ASMFC began a benchmark assessment in 2013 for the coastwide stock for Atlantic menhaden. The Atlantic menhaden stock is assessed with a statistical catch at age model called BAM (Beaufort Assessment Model). This was a full benchmark assessment, therefore is more time consuming than an update assessment, so while it was begun in 2013, it concluded in 2015. This model was updated in 2017 (http://www.asmfc.org/uploads/file/59832ee0MenhadenStockAssessmentUpdate_Aug2017.pdf). The main tasks were to gather both catch and fishery independent information from the previous year, and stratify that information by age based on aging information from the NMFS menhaden sampling program, which RI contributed locally caught samples to. RI contributed its Division of Fish and Wildlife seine survey data (see job number 4 from this grant) to the assessment and contributed the RI trawl survey data (jobs 1 and 2 from this report) to the assessment data elements for the update assessment. Staff collected the information and processed it for the assessment. Staff also participated in meetings where the assessment information was reviewed and were active members of the stock assessment sub-committee. A new benchmark is planned for 2018 - 2019.

3. STRIPED BASS

The ASMFC began a benchmark assessment in 2013 for the coastwide stock for striped bass. The Atlantic striped bass stock is assessed with a statistical catch at age model called SCAM (Statistical Catch-at-age Assessment Model), though different model configurations were tested for the benchmark. A full benchmark assessment was performed and was peer reviewed at the SAW57 meeting (http://www.nefsc.noaa.gov/saw/saw57/Agenda-SAWSARC57-Rev%207242013.pdf), along with summer flounder. This assessment passed peer review in 2013 and was used for fisheries management in 2014, 2015, and 2016 through update assessments. The striped bass stock assessment will be benchmarked in 2018, and the work towards that benchmark began in 2017. Several modeling platforms will be tested, and reference points will be evaluated. The main tasks are to gather both catch and fishery independent information from the previous year, and stratify that information by age based on aging information from various sources, which RI contributed locally caught samples to. RI has again attempted to contribute its Division of Fish and Wildlife seine survey data (see job number 4 from this grant) to the assessment. Staff collected the information and processed it for the assessment. Staff will also participate in meetings where the assessment information is reviewed.

4. TAUTOG

The ASMFC began a benchmark assessment in 2013 for the tautog stock. The tautog stock had been assessed with a Virtual Population Analysis, but for the benchmark several other data rich and data poor models were tested. This was a full benchmark assessment, therefore is more time consuming than an update. In addition, the stock assessment has progressed from a coastwide assessment to a regional set of assessments. RI is in a region with Massachusetts. This benchmark assessment was approved in 2015, and was updated in 2016, with finalization occurring in 2017. The main tasks were to gather both catch and fishery independent information from the previous years, and stratify that information by age based on aging information that was collected in each state, and which RI contributed locally caught samples to. RI contributed its Division of Fish and Wildlife seine survey data (see job number 4 from this grant), trawl survey data (see jobs 1 and 2 from this document), and hopes to contribute the new ventless pot survey info in the future to the assessment. Staff collected the information and processed it for the assessment. Staff also participated in several meetings where the assessment information was reviewed and were active members of the stock assessment sub-committee.

5. WINTER FLOUNDER

Beginning when the new statistical catch at age stock assessment (ASAP = age structured assessment program) was introduced and peer reviewed in 2010, an updates and operational assessments has been performed for the coastwide stock for winter flounder. These updates are less time consuming than full benchmark assessments, but still require some work to be able to perform the update. In 2011, a full benchmark assessment was performed and was peer reviewed at the SAW52 meeting (http://www.asmfc.org/uploads/file/56d762c711-004_2011WinterFlounderStockAssessment[1].pdf). This assessment passed peer review and was updated through an operational assessment for management use in 2015 and 2017. The main tasks were to gather both catch and fishery independent information from the previous year, and stratify that information by age based on aging information from the NMFS trawl survey. RI contributed its Division of Fish and Wildlife trawl survey data (see job number 2 from this grant) as well as seine survey data (see job number 4 from this grant) to the assessment. Staff collected the information and age stratified it for the assessment. Staff also participated in several meetings where the assessment information was released, and staff were active members of New England Fisheries Management Council (NEFMC) Scientific and Statistical Committee that reviewed all of the update stock assessment information including data and research on winter flounder.

6. 2018 SCHEDULE

As previously noted, several stock assessments were initiated in 2017, and are scheduled to conclude in 2018 and 2019. Many assessments for recreationally important species will go through operational updates in 2018 and 2019. These updates stem from the recalibration of the Marine Recreational Information Program effort and intercept data. RI assessment staff will be active participants in all of these assessments.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

Age and Growth Study

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March 2018

PERFORMANCE REPORT

STATE: Rhode Island **PROJECT NUMBER:** F-61-R

SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Coastal Waters

PERIOD COVERED: January 1, 2017 – December 31, 2017

JOB NUMBER AND TITLE: 9, Age and Growth Study

JOB OBJECTIVE: To collect age, growth, diet composition, and maturity data on recreationally and ecologically important finfish in Narragansett Bay for management purposes. Data collected in this study will be used in state, regional and coast-wide fisheries management.

SUMMARY: Investigators collected lengths, weights, and age structures from target species of recreationally important finfish. The type of age structure collected and the number of samples collected varied by species. Investigators were able to collect, or exceed, the target sample numbers for black sea bass, menhaden, scup, summer flounder, tautog, and weakfish, however fell short on target sample numbers for bluefish (97/100) and striped bass (190/300). Ageing structures were also collected for spiny dogfish and winter flounder although they are not target species for ageing. Investigators had difficulty in obtaining samples for certain species due to the dynamics of the fisheries and the availability of fish. Work to age the primary ageing structures collected in 2017 is complete.

In addition to age and growth data collected in 2017, investigators continued the collection of stomach content, sex, and maturity stage data from target species in 2017. This data was collected through collaboration with investigators on the RIDMF monthly and seasonal trawl survey (Jobs 1 and 2), fish pot survey (Job 13), commercial floating fish trap operations, commercial gillnetters, and fish donated by recreational hook and line fishers.

TARGET DATE: Ongoing

STATUS OF PROJECT: On schedule

SIGNIFICANT DEVIATIONS: No significant deviations occurred in 2017. Investigators achieved, or exceeded, sampling targets for six species (black sea bass, menhaden, scup, summer flounder, tautog, and weakfish), but fell short on the sampling targets for the remaining two species (bluefish and striped bass). This was due to the dynamics of the fisheries as well as the availability of fish.

RECOMMENDATIONS: Move into the next grant award period and project segment and continue data collection in 2018.

REMARKS: In the future and to better describe the natural diet, stomach content analysis will not utilize fish caught in baited fish pots (i.e. scup pots). Through the Atlantic States Marine Fisheries Commission (ASMFC), a full-time contracted Fisheries Specialist I was hired in 2017 that will assist on this project to ensure that all sampling targets are met.

INTRODUCTION

Age and growth information is essential in estimating the age-structure of a fish population. Understanding the age-structure of a population allows scientists to make informed management decisions regarding acceptable harvest levels for a species. In recent years, diet composition of finfish has become increasingly important in understanding the age and growth of a population. Diet composition of a species may help to inform managers on whether an observed change in a population may be due to prey availability. Understanding predator –prey dynamics can also allow managers to utilize a multi-species modeling approach by which they can better understand not only the population dynamics of one particular target species, but other choke or prey species that may be associated with the target species. Work is currently underway at ASMFC through the Biological Ecological Reference Points (BERP) working group, to develop an ecosystem based approach for assessing Atlantic menhaden. The data collected in this study will help contribute to the aforementioned efforts.

This study is aimed to characterize the age-structure and diet composition of stocks whose ranges extend into Narragansett Bay and will supplement data collected in the Northeast Fisheries Science Center (NEFSC) spring and fall surveys as well as the NorthEast Area Monitoring and Assessment Program (NEAMAP), which do not sample within Narragansett Bay. Data collected in this study is already used in several stock assessments and we expect that number to increase each year as benchmark stock assessments are conducted and ecosystem based modeling approaches are further developed. Additionally, this study satisfies the requirements of ASMFC Fishery Management Plans (FMP's) for tautog, bluefish, menhaden and weakfish which require the state of Rhode Island to collect a minimum number of age and growth samples annually for stock assessment purposes. This study has also been designed to use other jobs in this grant as a platform for obtaining biological samples.

Collection of stomach content, sex, and maturity stage data for the species listed above was initiated in 2014. This task also included collection of both scale and otolith samples for ageing from most species, except for weakfish and bluefish for which only otolith samples were taken. For tautog, opercula and otoliths were collected (no scales). Additionally, and beginning in 2017, the first anal spine of tautog and the dorsal spine array (nine spines) of striped bass were collected for use in ageing.

METHODS, RESULTS & DISCUSSION

Seasonal port sampling of nine species of finfish considered to be extremely important to the recreational fishing community was conducted primarily from May through December of 2017. Data collected included lengths, weights and the appropriate age structure for the specific species (i.e. scale, otolith, operculum, and anal or dorsal spine). The number of samples and age structures collected varied depending on the species (Table 1). Investigators focused on obtaining samples from various locations throughout the state from various finfish dealers, recreational anglers, commercial floating fish trap companies, commercial gillnetters, and Rhode Island Division of Marine Fisheries (RIDMF) surveys (otter trawl and fish pot) (Table 2).

Diet composition data was collected for high priority species by excising fish stomachs from fish collected during the RIDMF seasonal and monthly bottom trawl surveys, RIDMF Fish Pot survey, or from fish racks and whole fish collected during port sampling, purchased from dealers, or which were donated. For each species, the target number of stomachs to be examined is 40 (Table 3). Additional data collected from these samples included length, weight (if whole fish available), sex, maturity, and age structures. Once stomachs were removed, they were analyzed in the laboratory by sorting and identifying prey to the lowest taxonomic level possible and recording the wet mass for each taxon. All collected data were entered and stored in a Microsoft Access database.

Black sea bass

A total of 931 black sea bass age samples were collected from multiple sources including hook and line, RIDMF otter trawl, RIDMF fish pots, and commercial lobster pots in 2017. In 2017, RIDMF collaborated with the Commercial Fisheries Research Foundation (CFRF) on a proposal that would allow RIDMF to collect our required samples and provide additional data for stock assessment purposes. This resulted in our target number of samples (100) being exceeded in 2017.

Currently the use of scales is an acceptable ageing technique for black sea bass, however otoliths remain the preferred method when they are available for extraction. While scales are the primary age structure collected by project staff, when available, otoliths are collected as well. Black sea bass samples collected ranged in size from 3.3-22.4 inches (8.3-57.0 cm) total length. Age samples have been sent to the Virginia Institute of Marine Science (VIMS) and Massachusetts Division of Marine Fisheries (MADMF) for processing and ageing. This was primarily due to the fact that VIMS and MADMF will be collecting additional information as part of other ongoing research projects. Stomach content and maturity stage data was collected from 739 black sea bass. Stomach contents included prey items from 12 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Black sea bass stomach contents were dominated by crustaceans (29%) and cephalopod molluscs (26%), followed by finfish (10%) and bivalve molluscs (9%); “unidentifiable” contents accounted for 24%. Removal of “unidentifiable” contents from the analysis resulted in crustaceans accounting for 38% and cephalopod molluscs for 34%, followed by finfish (13%) and bivalve molluscs (11%) (Figure 10, Table 5).

Combined 2014-2017 data ("unidentifiable" contents removed) shows stomach contents dominated by crustaceans (41%) and cephalopod molluscs (31%), followed by finfish (13%) and bivalve molluscs (11%) (Figure 11, Table 6).

Bluefish

The ASMFC requires that a minimum of 100 bluefish age samples be collected annually by the state of Rhode Island. Due to the assistance of commercial gillnetters, recreational hook and line fishers, and the RIDMF otter trawl, staff successfully collected 97 bluefish otolith samples in 2017. Bluefish samples ranged in fork length from 14.8-34.9 inches (37.7-88.7 cm) and 2-11 years old (Figure 1). Stomach content and maturity stage data was collected from 44 bluefish. Stomach contents included prey items from 2 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Of the bluefish stomachs examined in 2017, stomach contents were dominated by finfish (88%), with a small amount of cephalopod molluscs (0.03%) comprising identifiable stomach contents encountered; "unidentifiable" contents accounted for 12%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being made up nearly completely of finfish (99.96%) (Figure 10, Table 5). Combined 2014-2017 data ("unidentifiable" contents removed) shows stomach contents dominated by finfish (83%) and cephalopod molluscs (17%) (Figure 11, Table 6).

Menhaden

A total of 120 Atlantic menhaden age samples (scales and otoliths) were collected in 2017 from 2 floating fish trap operations and the RIDMF otter trawl. Typically, additional samples are collected from commercial purse seine operations when they are actively fishing in Narragansett Bay. In 2017, purse seine fishing in Narragansett Bay was short-lived due to the short duration of time during which a high biomass of menhaden was present in the bay and therefore no samples were collected. Menhaden samples ranged in fork length from 9.8-12.2 inches (24.9-31.1 cm) and age from 1-6 years old (Figure 2). Only maturity stage data was collected from all 120 menhaden. Due to the fact that menhaden are filter feeders, all stomach contents encountered in previous years of this study were liquefied, with prey item(s) unable to be identified and classified. Due to this, no menhaden stomachs were examined in 2017. Generally, menhaden stomach contents should reflect the dominant planktonic species present at the time of sample collection.

Scup

Scup age samples were collected in 2017 from multiple sources including commercial otter trawls, the RIDMF otter trawl, and RIDMF fish pot survey. Investigators successfully collected scales and otoliths from 100 scup ranging in fork length from 5.9-14.2 inches (15.1-36.1 cm) and age from 2-13 years old (Figure 3). Stomach content and maturity stage data was collected from 40 scup. Stomach contents included prey items from 3 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents were dominated by bivalve molluscs (21%) and polychaetes (19%), with a small quantity of crustaceans (3%); "unidentifiable" contents accounted for 57%. Removal of "unidentifiable" data from the analysis resulted in stomach contents being dominated by bivalve molluscs (50%) and polychaetes (44%), followed by crustaceans (7%) (Figure 10, Table 5). Combined 2014-2017 data ("unidentifiable" contents removed) shows stomach contents dominated by crustaceans (43%) and polychaetes (32%), followed by bivalve molluscs (14%) (Figure 11, Table 6).

Spiny Dogfish

For 2017, only 1 spiny dogfish was obtained from the RIDMF otter trawl survey. Ageing structures collected included a section of several vertebrae and both dorsal spines. The sole spiny dogfish sampled had a fork length of 25.9 inches (65.8 cm) and has not been aged yet as staff have to learn this new protocol for vertebrae. There were no identifiable stomach contents in the sample.

Striped Bass

A total of 200 striped bass scale and otolith samples and 7 sets of dorsal spine arrays (9 spines per array) were collected and aged in 2017. Each year investigators set a sampling target of 150 samples from floating fish traps and 150 samples from the general category fishery. Floating fish traps have a minimum size of 26" while the commercial general category fishery has a minimum size of 34". Sampling from both of these operations allows us to sample a wider size range of striped bass. In 2017 there were a very limited number of floating fish traps fishing for striped bass making obtaining samples from this fishery difficult. Staff supplemented traditional sampling by collecting 19 striped bass age samples from the RIDMF otter trawl and 1 age sample from RIDMF gillnets. These samples were well below legal minimum size(s) and helped to round out the length frequency distribution sampled. Striped bass sampled ranged from 10.7-47.6 inches fork length (27.2-121.0 cm) and 2-17 years old (Figure 4). Stomach contents included prey items from 8 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (60%) and cephalopod molluscs (15%), with a small quantity of crustaceans (2%) also encountered; "unidentifiable" contents accounted for 21%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by finfish (76%), followed by cephalopod molluscs (18%), and crustaceans (3%) (Figure 10, Table 5). Combined 2014-2017 data ("unidentifiable" contents removed) shows stomach contents dominated by finfish (86%), followed by cephalopod molluscs (6%) and crustaceans (6%) (Figure 11, Table 6).

Summer Flounder

A total of 115 summer flounder scale and otolith samples were collected in 2017. The majority of these samples (n=107) were collected by RIDMF staff on board our RIDMF otter trawl and fish pot surveys (Jobs 1, 2, and 13); 4 samples came from the commercial hook and line fishery, 1 sample from a finfish dealer with an unknown gear type, and 1 sample from the University of Rhode Island/Graduate School of Oceanography (URI/GSO) otter trawl survey. Summer flounder samples collected varied in size from 8.2-30.7 inches (20.8-78.0 cm) total length and 0-17 years old (Figure 5). Stomach content and maturity stage data was collected from 47 summer flounder. Stomach contents included prey items from 6 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents were dominated by cephalopod molluscs (29%) and finfish (27%), followed by crustaceans (16%); “unidentifiable” contents accounted for 28%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being dominated by cephalopod molluscs (40%) and finfish (37%), followed by crustaceans (22%) (Figure 10, Table 5). Combined 2014-2017 data (“unidentifiable” contents removed) shows stomach contents dominated by cephalopod molluscs (40%) and finfish (38%), followed by crustaceans (21%) (Figure 11, Table 6).

Tautog

A total of 329 tautog operculum and otolith samples were collected in 2017 from the recreational hook and line fishery (n=303), RIDMF fish pot survey (n=10), RIDMF otter trawl survey (n=5), and recreational spear fishery (n=11). Tautog samples are typically collected in the fall months when the party and charter boat vessels are targeting them. The ability to obtain samples during this period of time can be quite variable due to weather conditions such as strong winds and high seas. Tautog samples collected ranged from 8.3-23.7 inches (21.0-60.1 cm) total length and 1-19 years old (Figure 6). Stomach content and maturity stage data was collected from 61 tautog. Stomach contents included prey items from 6 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Identifiable tautog diet was primarily comprised of crustaceans (32%) and bivalve molluscs (31%), with smaller quantities of gastropod molluscs (4%), algae (3%), and echinoderms (1%) also observed; “unidentifiable” contents accounted for 29%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being dominated by crustaceans (46%) and bivalve molluscs (43%), with minor contributions from gastropod molluscs (5%) and algae (4%) (Figure 10, Table 5). Combined 2014-2017 data (“unidentifiable” contents removed) shows stomach contents dominated by crustaceans (65%), followed by bivalve molluscs (16%) and gastropod molluscs (13%), with monor contributions from algae (2%) and echinoderms (1%) (Figure 11, Table 6).

In 2017 staff began to explore a new, non-lethal ageing technique for tautog. This new technique uses a cross-section of a pectoral (anal) spine for age determination. Staff received training at a workshop held in April 2017 and will be able to utilize this new method which will aid in achieving our sampling targets in 2017, as samples can now be collected from live fish.

Weakfish

Rhode Island is required by the ASMFC to collect three age structures per metric ton of weakfish landed commercially in the state. In 2017, this would have resulted in a sampling target of 23 fish. In recent years, weakfish have become scarce in RI, which has resulted in extreme difficulty in obtaining samples. Investigators now purchase fish directly from seafood dealers at market value to ensure that they can obtain samples, however strong market demand and limited supply during 2017 prevented the availability of this species for sampling. In 2017, a total of 68 weakfish otolith samples were collected. Weakfish collected by the RIDMF otter trawl (n=67) were almost entirely sub-legal sized fish (n=66 sub-legal); one (1) legal-sized fish was provided by the recreational hook and line fishery. Weakfish sampled ranged from 2.4-23.0 inches (6.0-58.3 cm) total length and were 1-2 years old (Figure 7). Stomach content and maturity stage data was collected from 42 weakfish. Stomach contents included prey items from 2 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Of the weakfish stomachs examined in 2017, stomach contents were dominated by finfish (63%), with a small amount of crustaceans (6%) comprising identifiable stomach contents encountered; “unidentifiable” contents accounted for 31%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being made up nearly completely of finfish (92%), with a minor contribution from crustaceans (8%) (Figure 10, Table 5). Combined 2014-2017 data (“unidentifiable” contents removed) shows stomach contents dominated by finfish (67%), followed nearly equally by cephalopod (14%) and bivalve (13%) molluscs, and a minor contribution from crustaceans (4%) (Figure 11, Table 6).

In 2018, staff will continue to collect more weakfish samples from the RIDMF trawl survey to ensure our sampling targets are met, although these are usually small YOY and age 1 fish.

Winter Flounder

A total of 49 winter flounder scale and otolith samples were collected in 2017. These samples were collected entirely by RIDMF staff on board our RIDMF otter trawl survey (n=49) (Jobs 1 and 2). Winter flounder samples collected varied in size from 7.4-14.6 inches (18.8-37.1 cm) total length and 1-4 years old (Figure 19). Stomach content and maturity stage data was collected from 49 winter flounder. Stomach contents included prey items from 8 taxonomic groups (Tables 3 and 4). The proportional contribution of all stomach contents encountered in 2017 is shown in Figure 9 and summarized in Table 4. Of the winter flounder stomachs examined in 2017, stomach contents were dominated by cnidarians (50%) and polychaetes (11%), with small amounts of crustaceans (4%), nemerteans (4%), and bivalve molluscs (2%) comprising identifiable stomach contents encountered; “unidentifiable” contents accounted for 27%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being dominated by cnidarians (69%) and polychaetes (15%), with minor contributions from crustaceans (6%), nemerteans (5%), and bivalve molluscs (3%) (Figure 10, Table 5). Combined 2014-2017 data (“unidentifiable” contents removed) shows stomach contents dominated nearly equally by cnidarians and polychaetes (41% each), with minor contributions from crustaceans (7%), nemerteans (4%), algae (3%), and bivalve molluscs (2%) (Figure 11, Table 6).

SUMMARY

In 2017 investigators were able to collect, or exceed, the target sample numbers for most species, while under-achieving target sample numbers for bluefish (97/100) and striped bass (190/300). In the cases where the sample targets were not achieved, this was due to dynamics of the fisheries, inclement weather, and availability of fish. Processing and ageing of all hard parts is complete for 2017 and staff completed an ageing precision exercise. The ageing precision exercise involved staff reading samples collected in 2015 and 2016 to double check their ageing precision. A minimum of 10% of samples went through a second reading and all precision estimates had a level of agreement of 90% or greater. In 2018, staff will continue reaching out to additional seafood dealers and the recreational community to ensure that the target number of samples is met for each species. A full-time contracted fisheries specialist was hired by RIDMF in 2017 to assist in the collection and processing of biological samples and to ensure that project goals are met. Staff participated in a quality assurance and quality control ageing workshop in 2017. This workshop brought together agers from along the Atlantic coast to review current methods for ageing and ensure that all agers are being consistent in their methodology. Additionally, staff have been working on the ASMFC ageing sub-committee to help draft a Gulf and Atlantic coasts ageing manual. Staff will continue to participate in ASMFC ageing workshops as they occur in 2018.

FIGURES

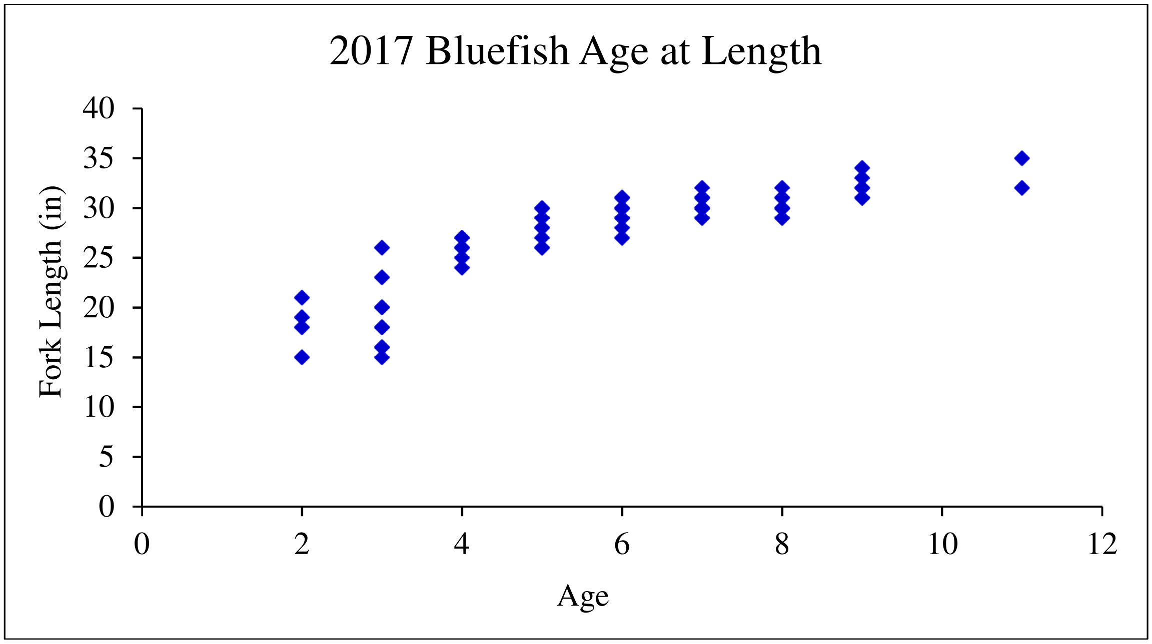


Figure 1. Bluefish age at length.

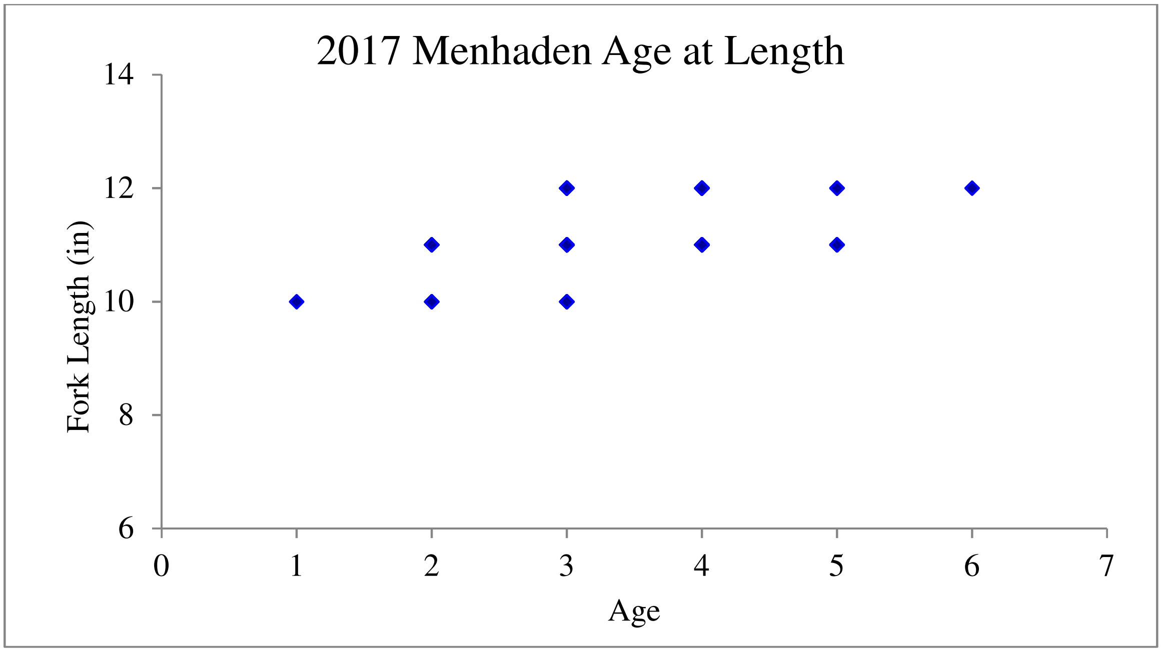


Figure 2. Menhaden age at length.

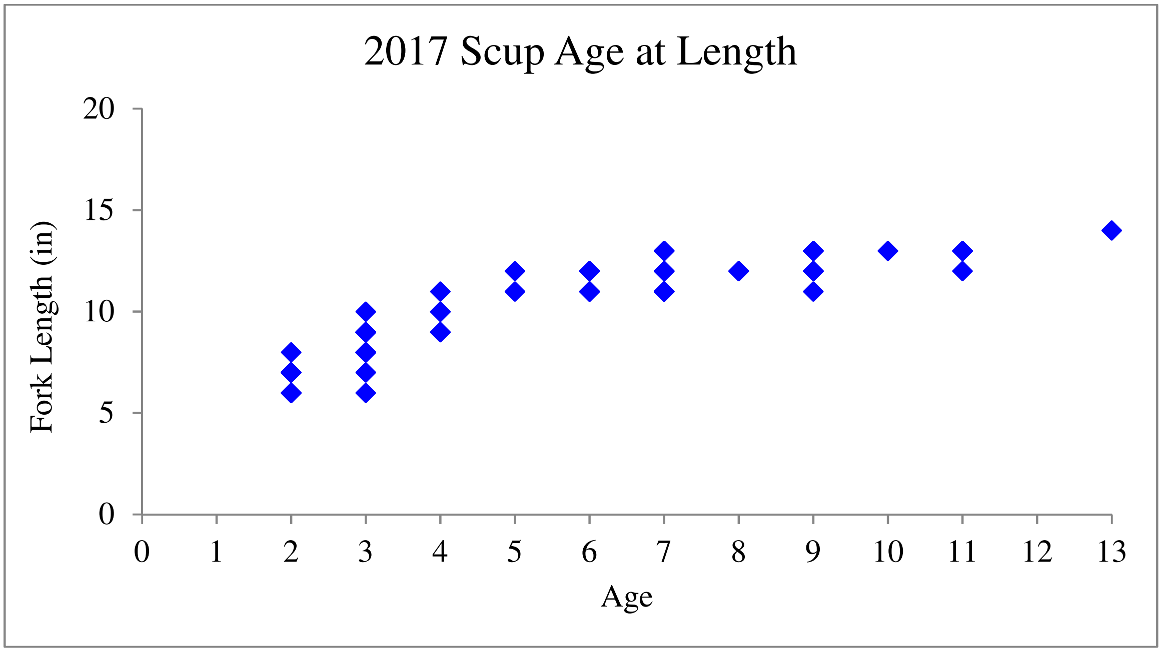


Figure 3. Scup age at length.

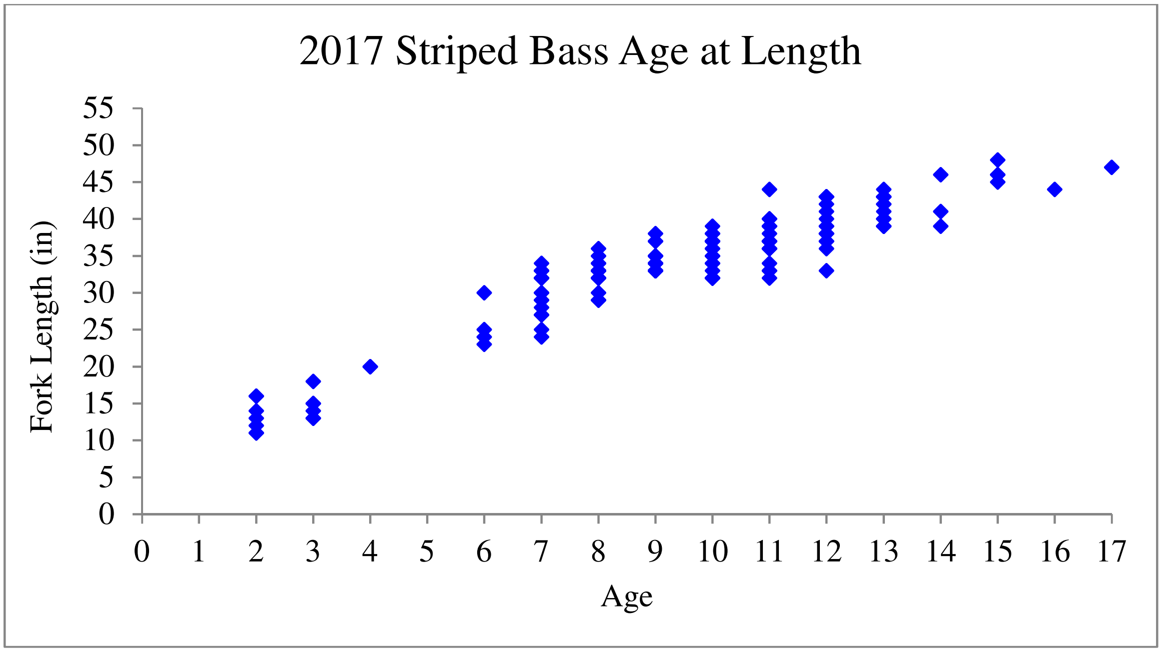


Figure 4. Striped bass age at length.

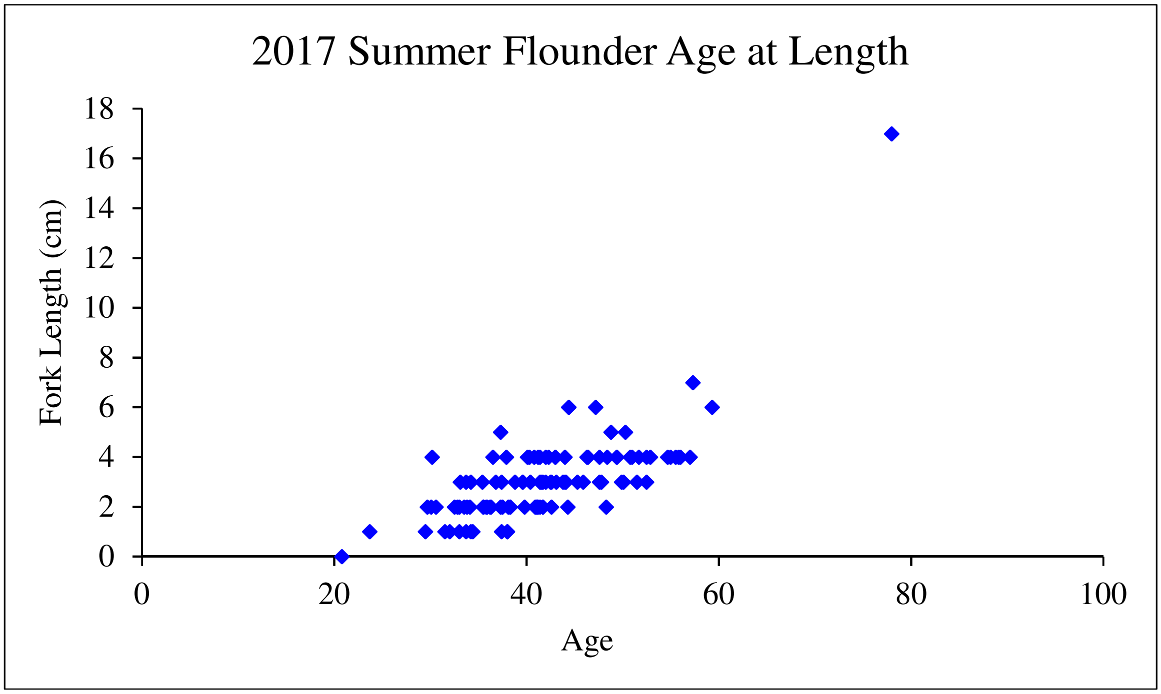


Figure 5. Summer flounder age at length.

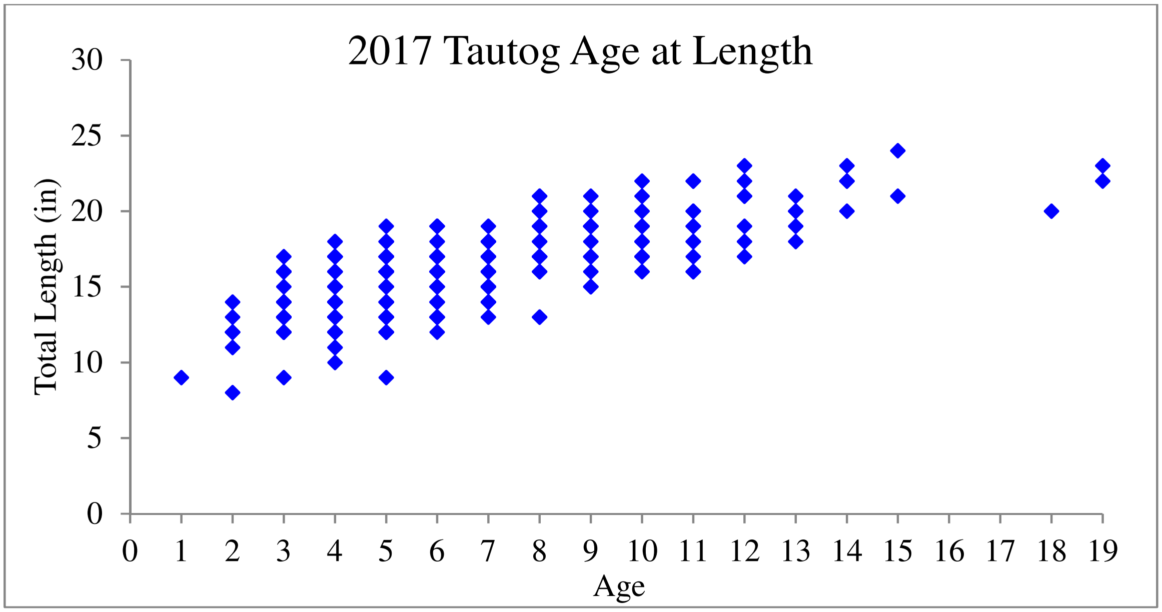


Figure 6. Tautog age at length.

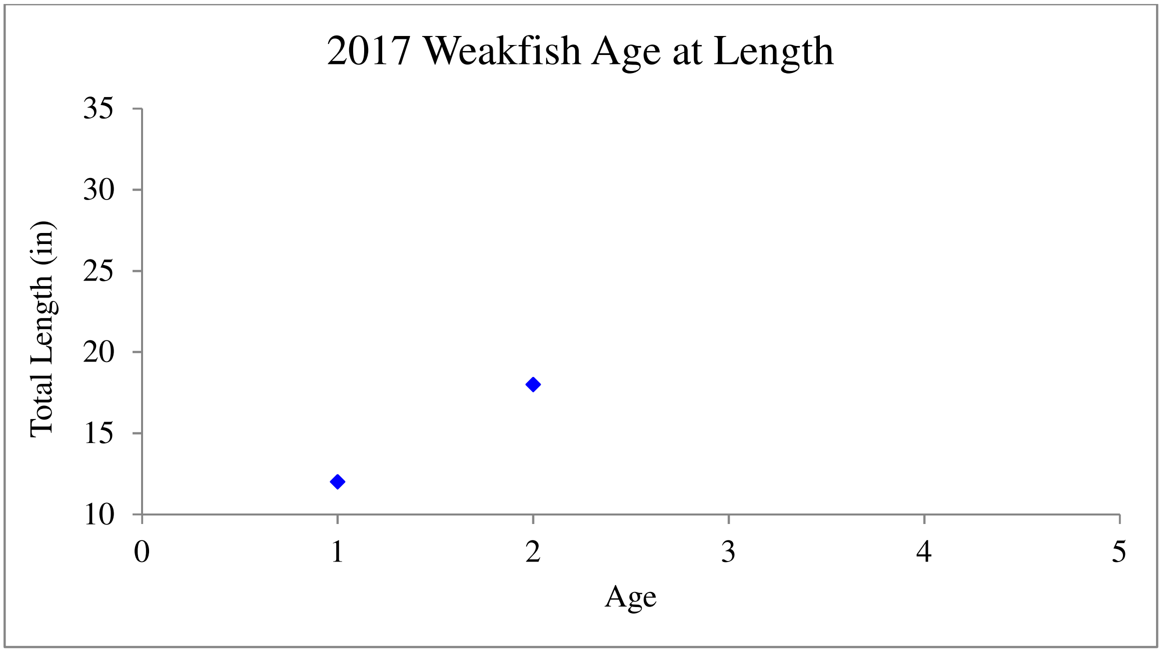


Figure 7. Weakfish age at length.

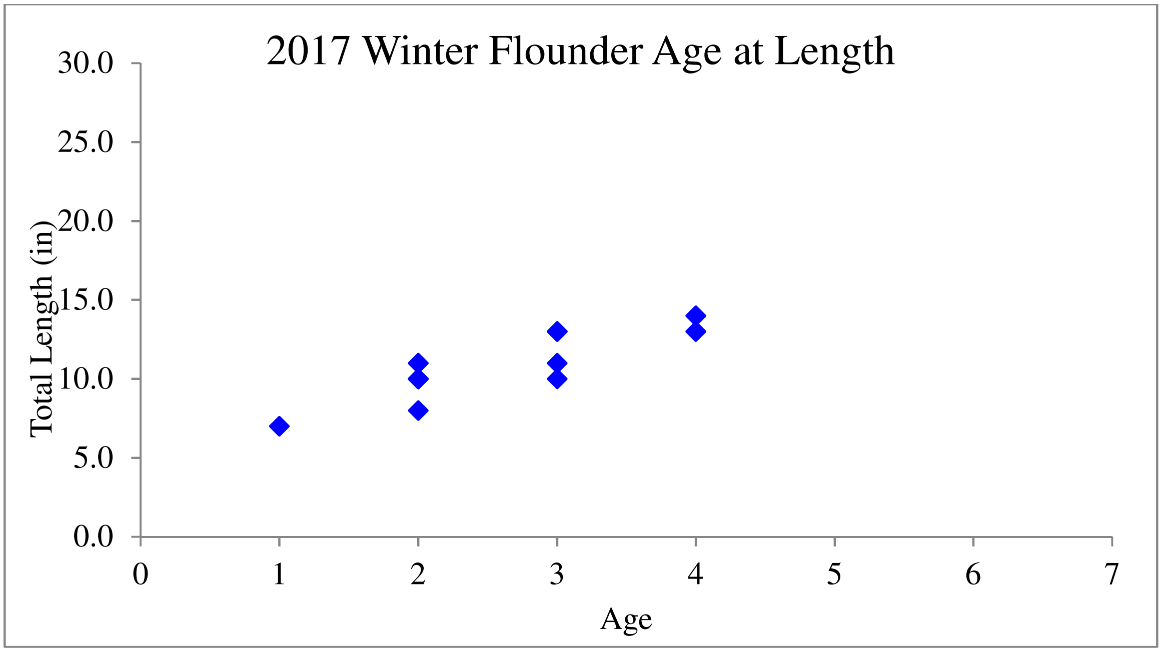


Figure 8. Winter flounder age at length.

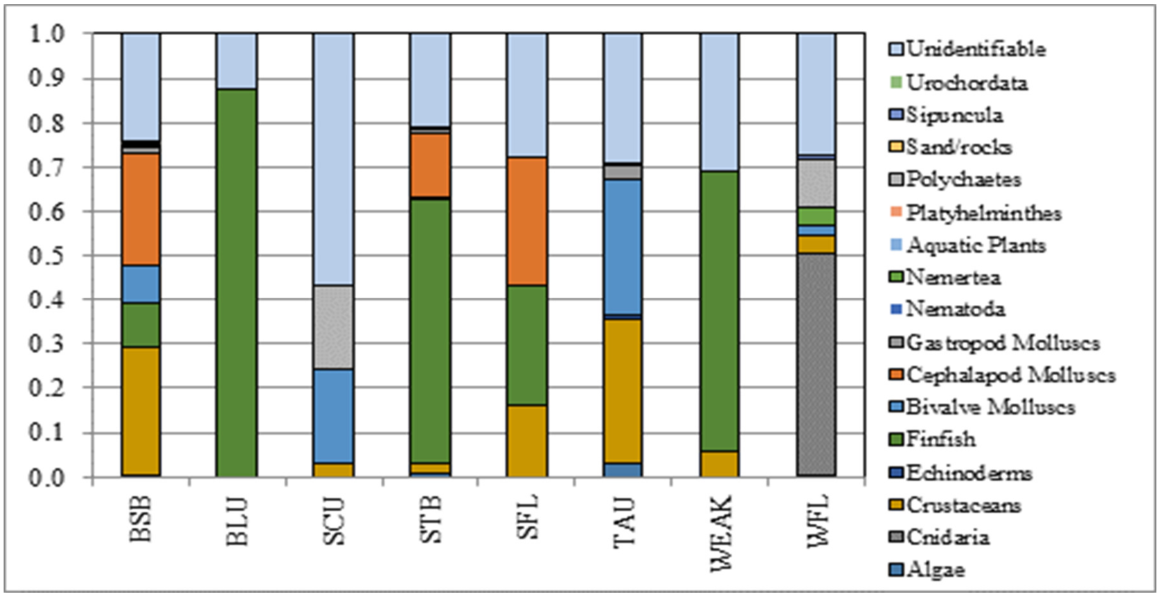


Figure 9. 2017 Proportional contribution of **all** stomach content types by species.

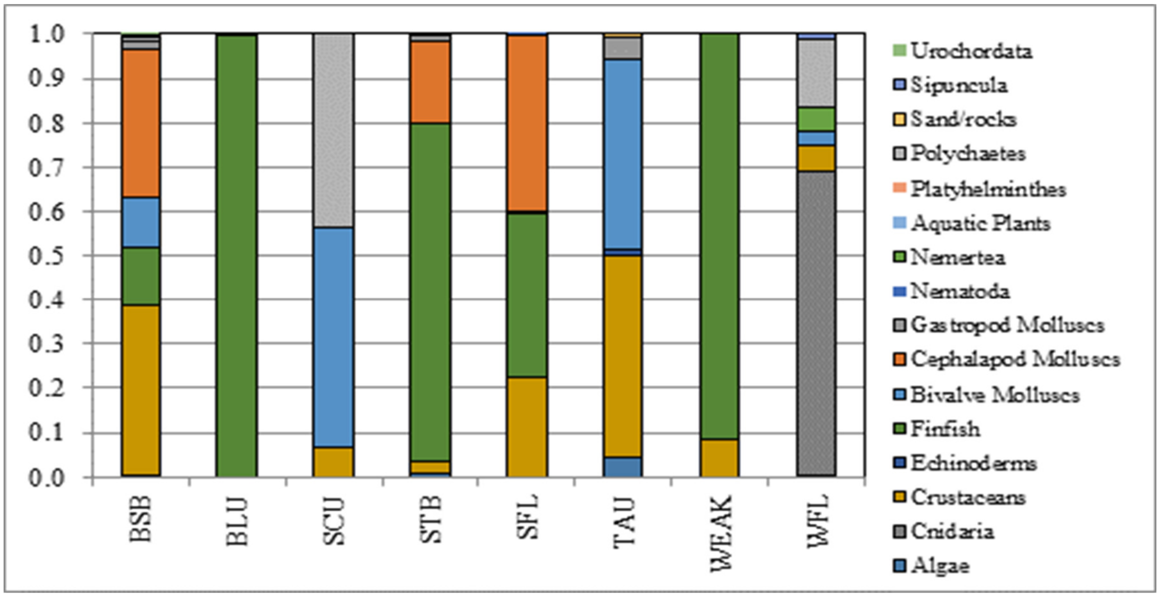


Figure 10. 2017 Proportional contribution of stomach content types by species; "unidentifiable" contents not included.

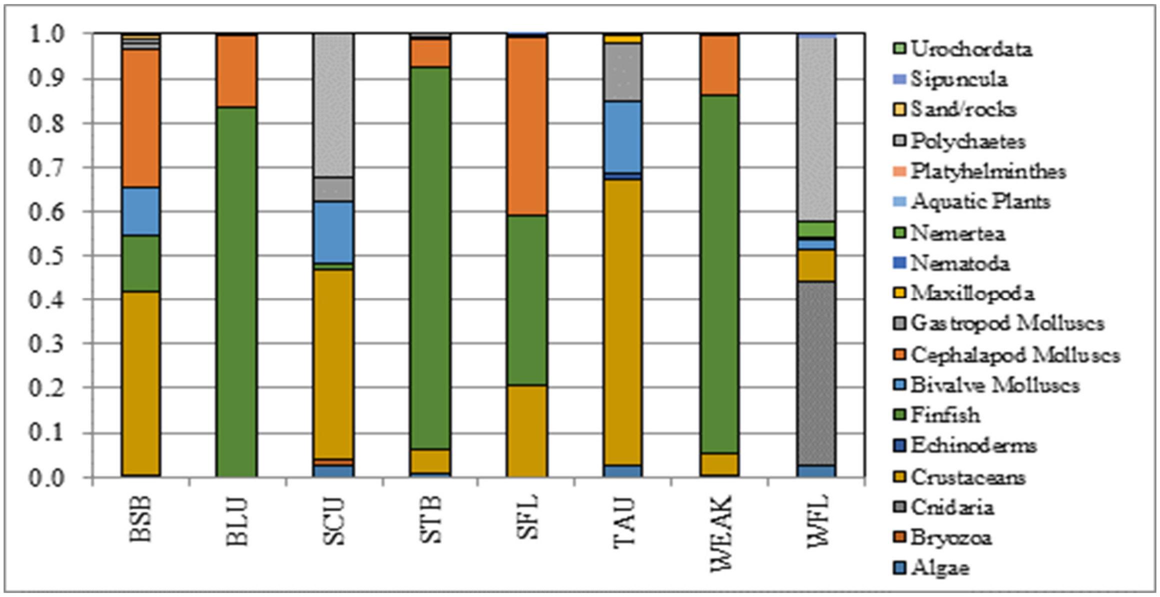


Figure 11. 2014-2017 Proportional contribution of stomach content types by species; "unidentifiable" contents not included.

TABLES

Table 1. Species, ageing structures collected, and number of fish sampled in 2017.

Common name	Ageing structure(s)	Target number of ageing structures	Number of ageing structures collected
Black sea bass	Scale, Otolith	100	931 scale, 931 otolith
Bluefish***	Otolith	100	97
Menhaden***	Scale, Otolith	100	120 scale, 120 otolith

Scup	Scale, Otolith	100	100 scale, 100 otolith
Spiny Dogfish	Vertebrae, Dorsal spines	NA	1 vertebrae array, 2 dorsal spines
Striped bass	Scale, Otolith, Dorsal spines	150 fish/gear type**	200 scale, 200 otolith, 7 dorsal spine arrays
Summer Flounder	Scale, Otolith	100	115 scale, 115 otolith
Tautog***	Operculum, Otolith, 1st anal spine	200	329 operculum, 329 otolith, 314 anal spine
Weakfish***	Otolith	3 fish aged per metric ton landed*	68
Winter Flounder	Scale, Otolith	NA	49 scale, 49 otolith

*Per ASMFC FMP requirements, 23 ages required for 2017

**Gear types include floating fish trap and general category

***Required by ASMFC

Table 2. Gear type sampled for each species collected in 2017 (FFT=Floating Fish trap).

Common name	**Gear Type**
Black sea bass	Hook and Line, Fish Pot, Otter Trawl, Lobster Pot
Bluefish	Gillnet, Hook and Line, Otter Trawl
Menhaden	FFT, Otter Trawl
Scup	Fish Pot, Otter Trawl
Spiny Dogfish	Otter Trawl
Striped bass	FFT, Hook and Line, Otter Trawl, Gillnet
Summer Flounder	Otter Trawl, Hook and Line, Fish Pot
Tautog	Hook and Line, Fish Pot, Otter Trawl, Spear
Weakfish	Otter Trawl
Winter Flounder	Otter Trawl

Table 3. 2017 Summary of stomach content sampling by species (* Sand/rocks and "unidentifiable" stomach contents not included in number of prey taxa).

SPECIES	Target # Stomachs	# Stomachs sampled	# PREY TAXA*
Black Sea Bass	40	739	12
Bluefish	40	44	2
Scup	40	40	3
Spiny Dogfish	40	1	0
Striped Bass	40	30	8
Summer Flounder	40	47	6
Tautog	40	61	6
Weakfish	40	42	2
Winter Flounder	40	49	8

Table 4. 2017 Proportional contribution of **all** stomach content types by species (see Figure 9).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL

Algae	0.0003	0	0	0.0061	0	0.0311	0	0.0027
Aquatic Plants	0.00001	0	0	0.0008	0	0	0	0
Bryozoa	0	0	0	0	0	0	0	0
Cnidaria	0.0029	0	0	0	0	0	0	0.5003
Crustaceans	0.2903	0	0.0290	0.0231	0.1612	0.3233	0.0570	0.0425
Echinoderms	0	0	0	0	0	0.0094	0	0
Finfish	0.0970	0.8775	0	0.5996	0.2711	0.0004	0.6312	0
Bivalve Molluscs	0.0861	0	0.2148	0.0006	0.0002	0.3059	0	0.0231
Cephalopod Molluscs	0.2552	0.0003	0	0.1456	0.2887	0	0	0.0001
Gastropod Molluscs	0.0108	0	0	0.0109	0.0022	0.0355	0	0
Maxillopoda	0	0	0	0	0	0	0	0
Nematoda	0.00003	0	0	0	0.0002	0	0	0
Nemertea	0	0	0	0	0	0	0	0.0385
Platyhelminthes	0.00006	0	0	0	0	0	0	0
Polychaetes	0.0074	0	0.1881	0.0010	0	0	0	0.1111
Sand/rocks *	0.0058	0	0	0.0003	0	0.0042	0	0
Sipuncula	0	0	0	0	0	0	0	0.0089
Urochordata	0.00014	0	0	0	0	0	0	0
Unidentifiable *	0.2442	0.1222	0.5681	0.2120	0.2763	0.2902	0.3119	0.2727

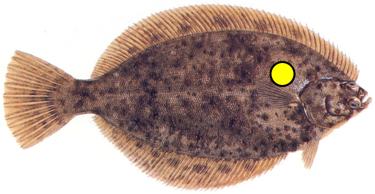
Table 5. 2017 Proportional contribution of stomach content types by species; “unidentifiable” stomach contents not included (see Figure 10).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL
Algae	0.0004	0	0	0.0077	0	0.0438	0	0.0037
Aquatic Plants	0.00001	0	0	0.0010	0	0	0	0
Bryozoa	0	0	0	0	0	0	0	0
Cnidaria	0.0038	0	0	0	0	0	0	0.6880
Crustaceans	0.3840	0	0.0671	0.0293	0.2228	0.4555	0.0828	0.0585
Echinoderms	0	0	0	0	0	0.0133	0	0
Finfish	0.1283	0.9996	0	0.7609	0.3747	0.0005	0.9172	0
Bivalve Molluscs	0.1139	0	0.4974	0.0008	0.0003	0.4310	0	0.0317
Cephalopod Molluscs	0.3376	0.0004	0	0.1848	0.3989	0	0	0.0002
Gastropod Molluscs	0.0143	0	0	0.0138	0.0030	0.0499	0	0
Maxillopoda	0	0	0	0	0	0	0	0
Nematoda	0.00004	0	0	0	0.0003	0	0	0
Nemertea	0	0	0	0	0	0	0	0.0529
Platyhelminthes	0.0001	0	0	0	0	0	0	0
Polychaetes	0.0097	0	0.4355	0.0013	0	0	0	0.1528
Sand/rocks *	0.0076	0	0	0.0003	0	0.0059	0	0
Sipuncula	0	0	0	0	0	0	0	0.0123
Urochordata	0.0002	0	0	0	0	0	0	0

Table 6. 2014-2017 Proportional contribution of stomach content type by species; “unidentifiable” stomach contents not included (see Figure 11).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL

Algae	0.0004	0.00004	0.0262	0.0057	0	0.0238	0.0020	0.0197
Aquatic Plants	0	0.00006	0	0.0025	0	0	0	0
Bryozoa	0	0	0.0112	0	0	0.0005	0	0
Cnidaria	0.0035	0	0	0	0	0	0	0.3015
Crustaceans	0.4136	0	0.4332	0.0554	0.2081	0.6490	0.0409	0.0795
Echinoderms	0	0	0	0	0	0.0139	0.0121	0
Finfish	0.1293	0.8331	0.0112	0.8646	0.3822	0.0002	0.6746	0
Bivalve Molluscs	0.1053	0	0.1423	0.0001	0.0002	0.1630	0.1343	0.0198
Cephalopod Molluscs	0.3137	0.1667	0	0.0627	0.4046	0	0.1358	0.0001
Gastropod Molluscs	0.0136	0	0.0542	0.0024	0.0048	0.1282	0	0.0043
Maxillopoda	0	0	0	0	0	0.0185	0	0
Nematoda	0	0	0	0	0.0002	0	0	0
Nemertea	0	0	0	0	0	0	0	0.0329
Platyhelminthes	0.0001	0	0	0	0	0	0	0
Polychaetes	0.0107	0	0.3216	0.0067	0	0.0001	0.0003	0.5352
Sand/rocks	0.0070	0.00016	0	0.0001	0	0.0029	0	0.0016
Sipuncula	0.0026	0	0	0	0	0	0	0.0054
Urochordata	0.0002	0	0	0	0	0	0	0



Assessment of Recreationally Important Finfish Stocks in Rhode Island Coastal Waters

Winter Flounder Spawning Stock Biomass Survey in Pt. Judith Pond ,RI

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Rhode Island Department of Environmental Management
Federal Aid in Sportfish Restoration
F-61-21

Performance Report March, 2018

State: Rhode Island Project Number: F-61-R-21

Project Title: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

Period Covered: January 1, 2017 – December 31, 2017

Job Number and Title: Job III - Spawning Stock Biomass (SSB) in Rhode Island Coastal Ponds.

Job Objective: To support a seasonal Young of the Year Winter flounder survey by providing data on the dynamics and abundance of the spawning population of winter flounder in Rhode Island coastal ponds.

Significant Deviations: Staff limitations are leading to a shorten sampling period

Summary: In 1999 the Rhode Island Coastal Ponds Project was expanded to support an adult winter flounder monitoring and tagging project. This winter phase of the seasonal coastal pond juvenile flounder work was an opportunity to collect data on the adult spawning populations of winter flounder in the south shore coastal ponds. An experimental winter flounder tagging study and monitoring project could be conducted with little additional funding or manpower. A commercial fisherman who had historically fished for winter flounder in the coastal ponds agreed to assist the RI Marine Fisheries staff and get the survey off the ground.

The research project runs from January - May annually. Fishing gear is deployed depending on ice cover in the ponds and the gear is generally hauled on three to seven-night sets. There is a total of eight stations where data exists, all found in the Pt. Judith Pond system including Potters Pond. (NOAA Nautical Chart 13219) These two ponds use the same breach to connect to Block Island and Rhode Island Sounds.

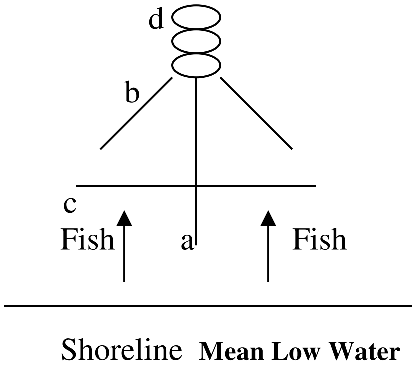
Additional Research: In 2012 an additional coastal pond system was added to the survey. As adult winter flounder abundance in the Point Judith system declined to all-time lows, an adjacent pond, Charlestown Pond, also known as Ninigret Pond (NOAA Nautical Chart 13205) was surveyed during the same time period and continued during the 2014 sampling year. Rhode Island Coastal Trawl Survey data (Spring Survey) shows a sharp increase in relative abundance in the Block Island Sound area. This appears to be a similar trend in the Charlestown Pond system. If, through this continuation of the multiple sampling areas, Point Judith continues to experience low abundance and recruitment while other area surveys show a diverging trend then the assumption would be that the Point Judith system is having localized winter flounder depletion from sources other than fishing mortality. Commercial fishing activity in Block Island Sound is also returning valuable tag recapture information from the Charlestown Pond sampling, that which is now missing from the Point Judith Pond survey due to the inability to catch enough fish to tag. The Environmental Protection Agency partnered in this project on Charlestown Pond and currently has collected data during three winter survey seasons. In the future this data set will be added to the current Adult Winter Flounder time series which was existed since 1999.

Methods and Materials:

Fyke Nets are a passive fixed fishing gear, attached perpendicular to the shoreline at mean low water. A vertical section of net wall or leader directs fish toward the body of the net where the catch is funneled through a series of parlors, eventually being retained in the terminal parlor. The wings of the net accomplish further direction of the catch.

Net dimensions:
a. Leader - 100'
b. Wings - 25'
c. Spreader Bar - 15'
d. Net parlors – 2.5’
Mesh size - 2.5" throughout

Station water profile:
Depth / turbidity - feet
Dissolved oxygen - mg/l
Salinity - ppt
Temperature - degree C



Fieldwork:

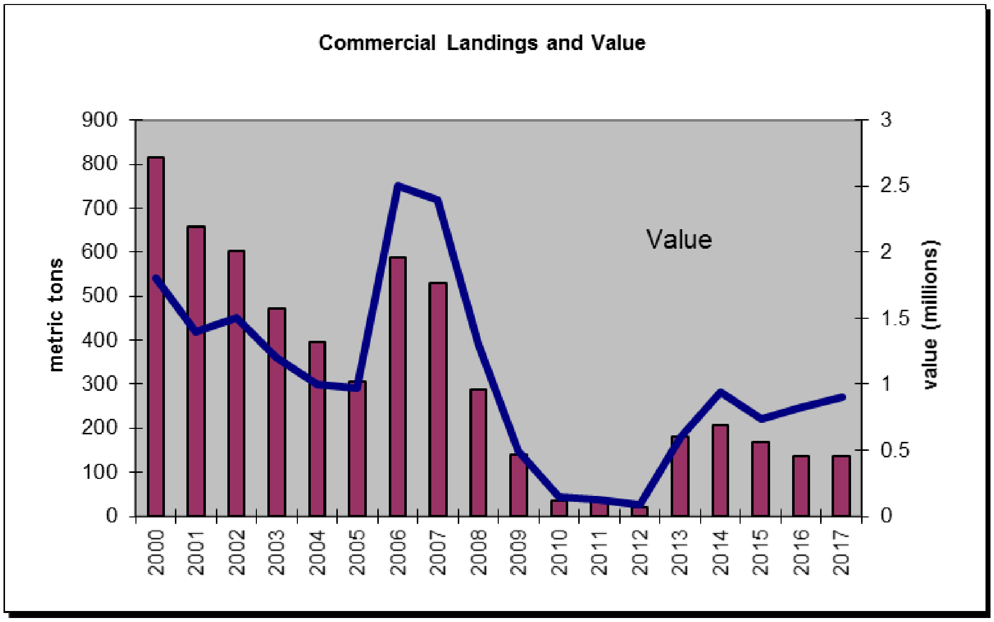
Three fyke nets were set at three fixed stations in Pt. Judith and Potter Ponds during January and April in 1999 - 2001 and two nets were set at four fixed stations from 2002 to present. The nets are fixed at mean low water and set perpendicular to the shoreline. Fyke nets are a passive fishing gear and allow the catch to be retained alive for a short period of time. Nets are tended from two to seven days depending on the size of the catch and weather conditions. Higher catches increase density inside the net and attract predators such as cormorants, seals and otters thus increasing survey-induced mortality.

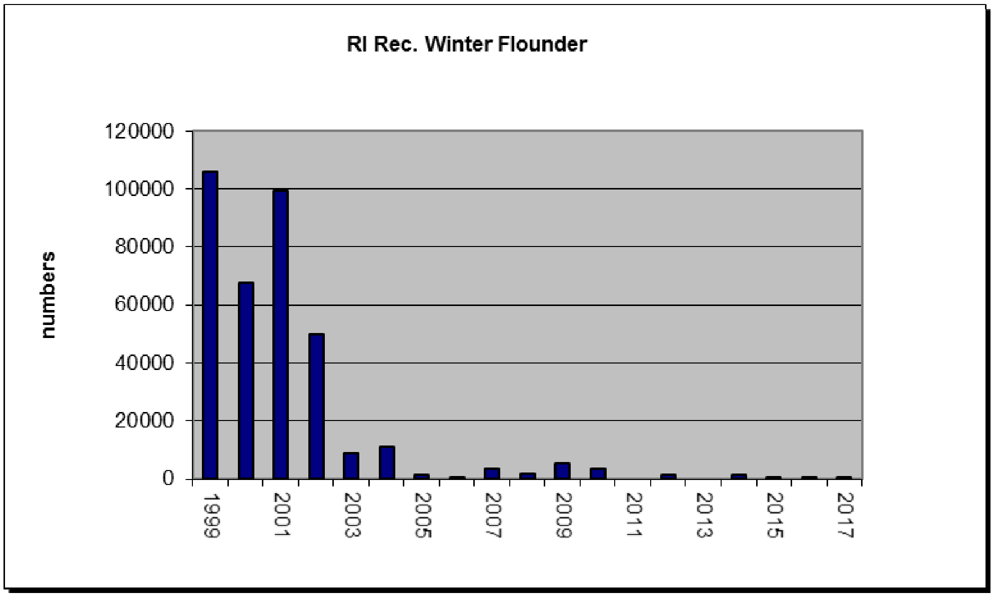
All fish captured are measured, sexed, enumerated and categorized to describe spawning stage. Spawning stage is defined as ripe (pre-spawn), ripe/running (active spawn), spent (post-spawn), resting (non-active spawn) and immature. These data illustrate how the spawning activity of flounder advances throughout the duration of the survey season. This is useful in determining the potential impacts of coastal zone activities such as harbor and breach way dredging and pier construction.

Fish of legal size, 30.48 cm or recruits to the fishery are tagged and released away from the capture area.

Fisheries:

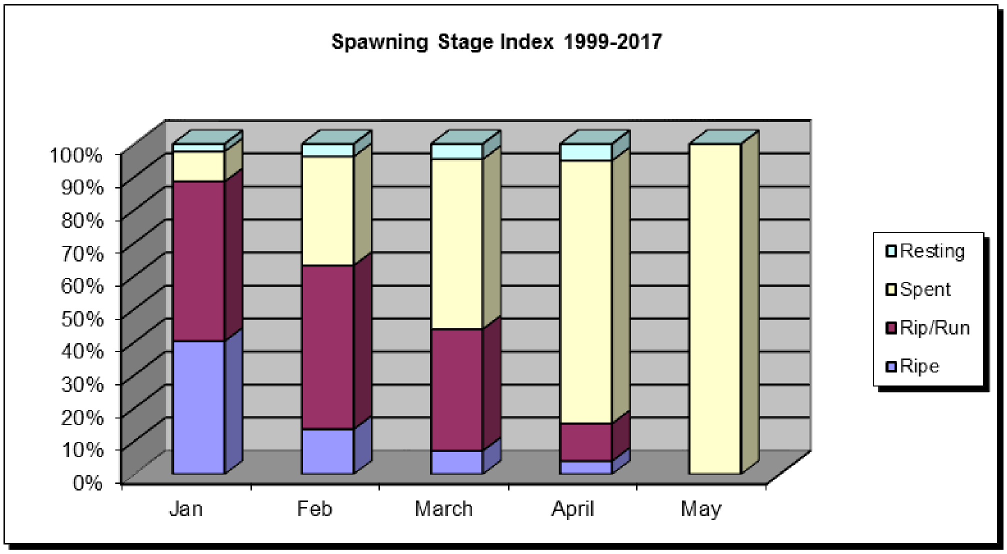
Winter Flounder (***Pseudopleuronectes americanus***) are both a commercially and recreationally important species to the State of Rhode Island. From 1999 - 2017 commercial landings of winter flounder in Rhode Island averaged over 300 metric tons and an average value of one million dollars annually. Recreational landings have declined rapidly throughout the period and remain low through 2017. (NMFS. 2017 Commercial landings query and MRFSS database)





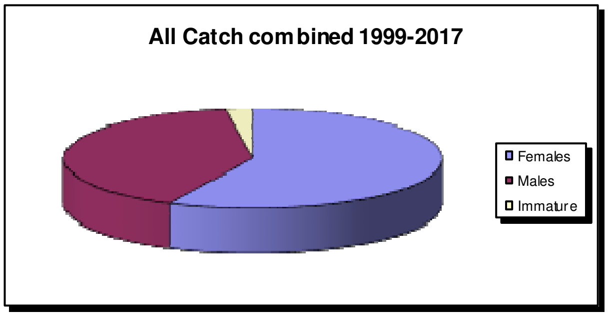
Spawning Behavior: Pt Judith / Potters Pond System

Winter Flounder enter the south shore coastal pond systems in Rhode Island to spawn in the early part of winter (November) and engage in spawning activity from January through May annually. Spawning and egg deposition takes place on sandy bottoms and algal accumulations. Winter Flounder eggs are non-buoyant and clump together on these substrates. Survey data indicate that peak-spawning activity takes place during the month of February, however this appears to vary annually in relation to average water temperatures.



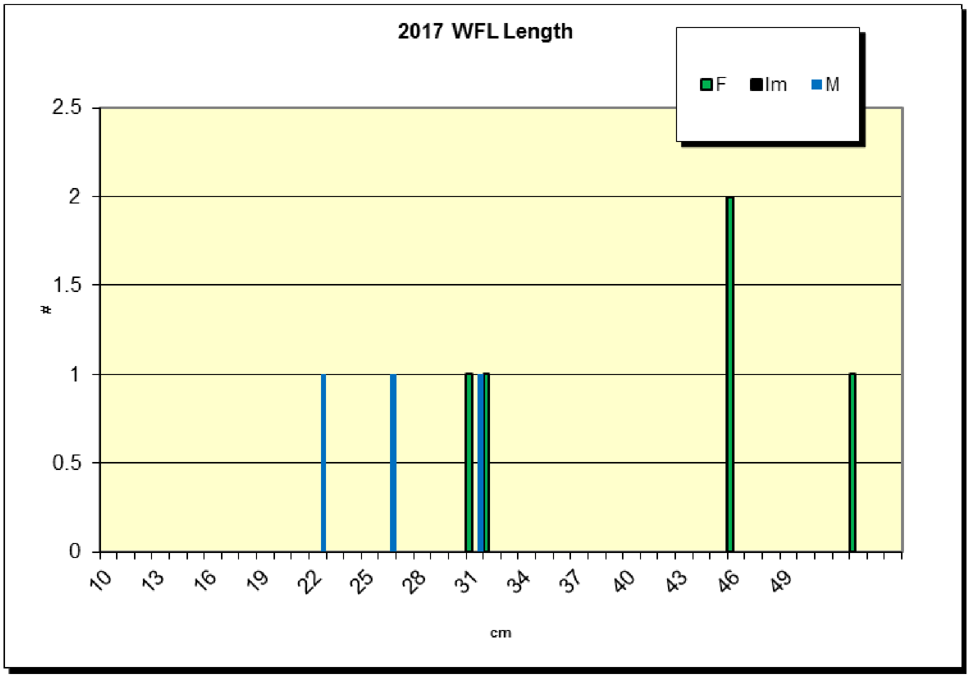
Spawning occurs in inshore waters at close to seasonal minimal water temperatures of 0 - 1.7 degrees C and in estuarine salinities as low as 11.4 ppt. (Bigelow and Schroeder 2002) Salinity was not available during the 2016 sampling season. With the shortened sampling period which occurred in 2017, Temperature and Salinity data are not available.

Sex ratios throughout the time series tend to favor females. Similar observations were made in Green Hill Pond, a neighboring coastal pond (Saila 1961), and in Narragansett Bay (Saila 1962).



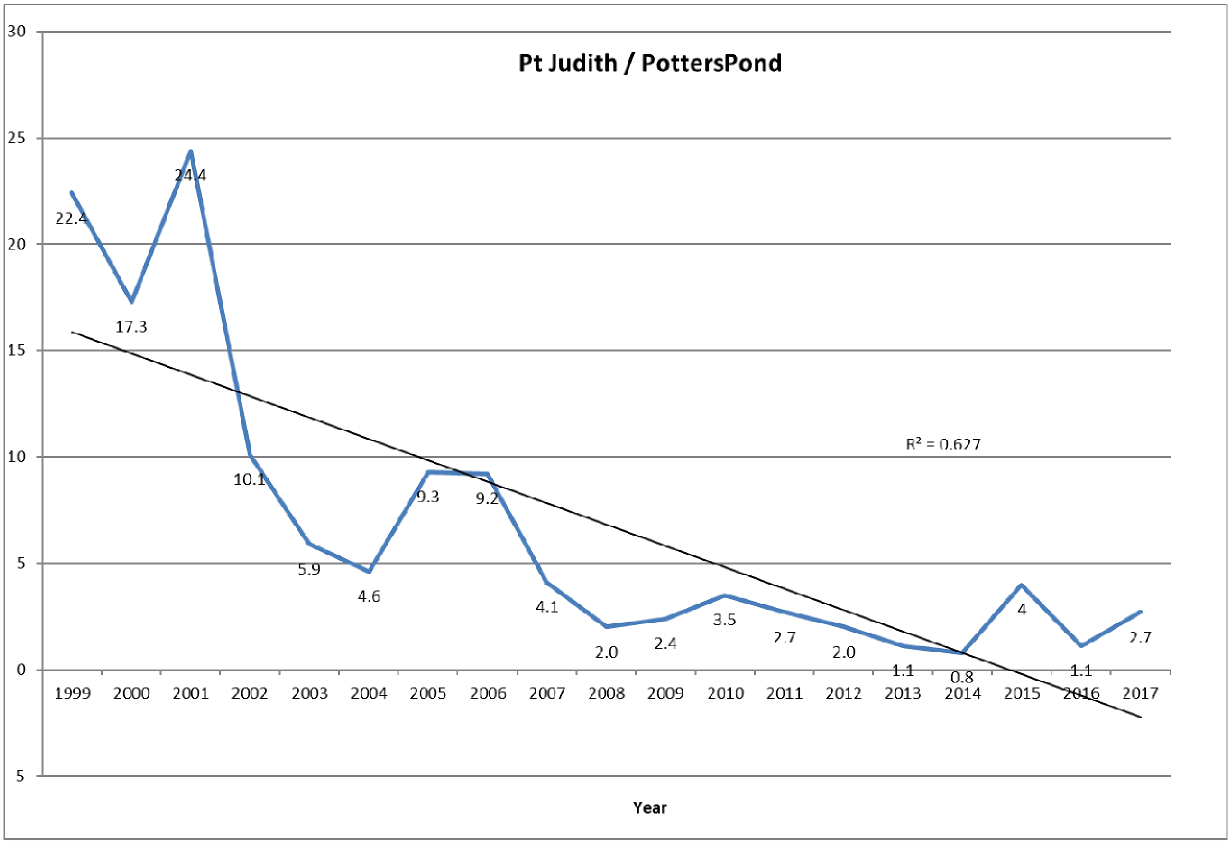
Size Distribution: Pt Judith / Potters Pond System

The total number of winter flounder sampled during the 2016 survey was 14. This was a 75% decrease from the 2015 survey. Sizes ranged from 14cm to 38cm. The mean size sampled was 25.8 cm.



Results:

2017 Adult winter flounder CPUE in Pt Judith Pond increased to 2.7 fish per net haul. A increase from the 2016 value of 1.1 fish per net haul. This value is well below the time series high of 24.4 in 2001. The catch rates have showed a downward trend throughout the time series with the 2014 CPUE being the lowest data point every recorded.



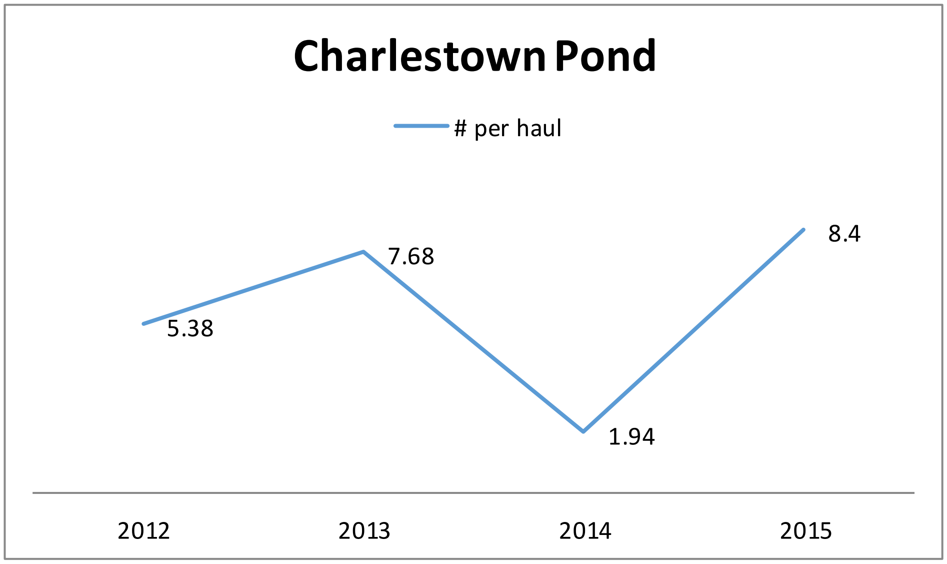


Table 1 Mark / recapture data 1999 - 2017 (Pt Judith / Potter Pond system)

Year	Number	Number	Number recaptured
1999	1301	332	31
2000	417	208	31
2001	538	358	70
2002	265	182	18
2003	160	87	6
2004	102	64	14
2005	252	115	7
2006	416	91	9
2007	120	35	6
2008	42	14	2
2009	63	0	0
2010	85	19	0
2011	68	11	0
2012	41	15	0
2013	22	5	0
2014	14	3	0
2015	56	14	0
2016	14	2	0
2017	8	2	0
Total	3984	1557	194

Table 2 Mark recapture in subsequent years (Survey and Fishing Recaptures) (Pt Judith system)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total	% recap
1999	31	8	10	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	51	0.1536145
2000		23	17	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0.2211538
2001			43	11	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0.1592179
2002				1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.0274725
2003					1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0.045977
2004						9	1	2	0	0	0	0	0	0	0	0	0	0	0	12	0.1875
2005							4	4	2	1	0	0	0	0	0	0	0	0	0	11	0.0956522
2006								3	2	0	0	0	0	0	0	0	0	0	0	5	0.0549451
2007									2	1	0	0	0	0	0	0	0	0	0	3	0.0857143
2008										0	0	0	0	0	0	0	0	0	0	0	0
2009											0	0	0	0	0	0	0	0	0	0	0
2010												0	0	0	0	0	0	0	0	0	0
2011													0	0	0	0	0	0	0	0	0
2012														0	0	0	0	0	0	0	0
2013															0	0	0	0	0	0	0
2014																0	0	0	0	0	0
2015																	0	0	0	0	0
2016																		0	0	0	0
Total	31	31	70	18	6	14	7	9	6	2	0	0	0	0	0	0	0	0	0	194	1.0312472

Table 3 Mark recapture in subsequent years (Fishing Recaptures Only) (Pt Judith system)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016		Total	% recap
1999	26	6	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	39	0.1174699
2000		18	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0.1346154
2001			39	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0.122905
2002				1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.0274725
2003					1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0.045977
2004						9	1	2	0	0	0	0	0	0	0	0	0	0	0	12	0.1875
2005							1	3	2	1	0	0	0	0	0	0	0	0	0	7	0.0608696
2006								1	1	0	0	0	0	0	0	0	0	0	0	2	0.021978
2007									2	1	0	0	0	0	0	0	0	0	0	3	0.0857143
2008										0	0	0	0	0	0	0	0	0	0	0	0
2009											0	0	0	0	0	0	0	0	0	0	0
2010												0	0	0	0	0	0	0	0	0	0
2011													0	0	0	0	0	0	0	0	0
2012														0	0	0	0	0	0	0	0
2013															0	0	0	0	0	0	0
2014															0	0	0	0	0	0	0
2015																	0	0	0	0	0
2016																		0	0	0	0
2017																			0	0	0
Total	26	24	54	3	6	14	4	6	5	2	0	0	0	0	0	0	0	0	0	144	0.8045017

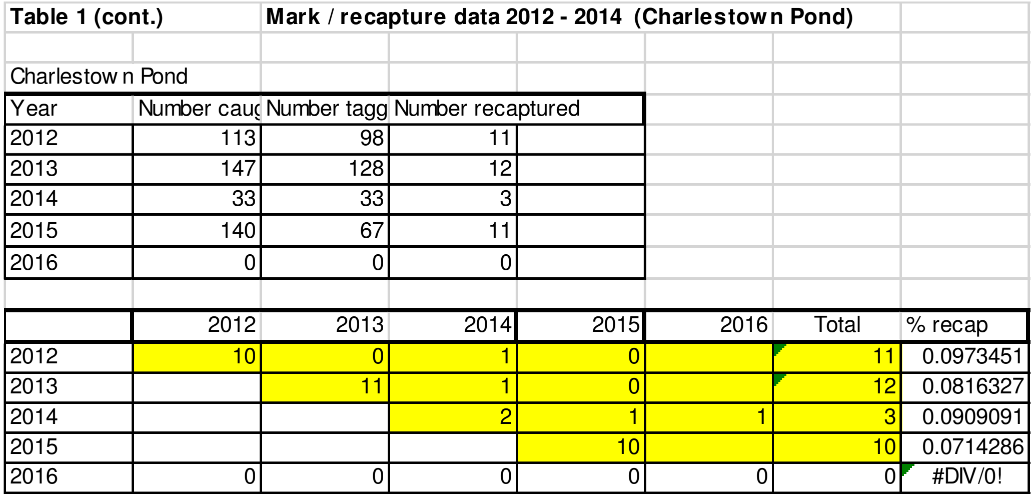


Table 1 (cont.) **Mark / recapture data 2012 - 2014 (Charlestown Pond)**

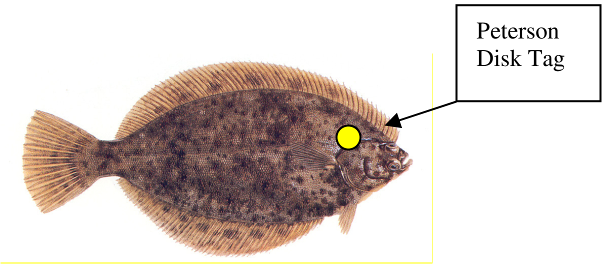
Charlestown Pond

Year	Number cau	Number tagg	Number recaptured
2012	113	98	11
2013	147	128	12
2014	33	33	3
2015	140	67	11
2016	0	0	0

	2012	2013	2014	2015	2016	Total	% recap
2012	10	0	1	0		11	0.0973451
2013		11	1	0		12	0.0816327
2014			2	1	1	3	0.0909091
2015				10		10	0.0714286
2016	0	0	0	0	0	0	#DIV/0!

Discussion: Much lower catch rates are being observed in the later years of the adult coastal pond survey. For some time, the data indicated that the problems found in nearby Narragansett Bay, were not as obvious in the south shore coastal ponds and that possibly, there were lower fishing mortality rates exhibited on the stocks that inhabit theses ponds and Block Island Sound.

Tag / Recapture data gives accurate estimations on population size and year class structure. These estimations depend on additional years and recapture data and therefore show the need for a more long-term approach to adult winter flounder assessments in Rhode Island south shore coastal ponds. Tag return rates for the survey time series are between 8 and 9 %. In past years almost, the entire set of tag returns come from the recreational fishery which has now been closed since 2012. The offshore trawl fleet has been the source of tag returns in the recent years along with survey recaptures indicating the increased willingness of the offshore commercial trawler fleet to supply information on flounder movements and mortality rates.



<u>Recommendations:</u> Continuation of all adult winter flounder work statewide in order to make accurate connections between coastal pond, Narragansett Bay and Rhode Island/Block Island Sounds winter flounder stocks. Continuation of the Charlestown Pond System to track local adult winter flounder abundance and use the catch as a source of tag able animals to gain information on population size, mortality and year class structure. Stress the importance of returning tag data from commercial trawl fleet in Rhode Island Sound and Block Island Sound. Addition of dedicated staff should be investigated as current staff limitations are part of the reason for shortened sampling season.

Additional Species captured:

Winter Flounder ***Pseudopleuronectes americanus***
Summer Flounder ***Paralicthes detatus***
Striped Bass ***Morone saxatilis***
White Perch ***Morone americana***
Atlantic Tomcod ***Microgadus tomcod***
Tautog ***Tautoga onitis***
Alewife ***Alosa pseudoharengus***
Atlantic Menhaden ***Brevortia tyrannus***
American Eel ***Anguilla rostrata***
Horseshoe Crab ***Limulus polyphemus***
American Lobster ***Homarus americanis***
Green Crab ***Carcinus maenas***
Atlantic Rock Crab ***Cancer irroratus***
Blue Crab ***Callinectes sapidus***
Longnose Spider Crab ***Libinia dubia***
Portly Spider Crab ***Libinia emarginata***

References:

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Saila, S. B. 1961. The contribution of estuaries to the offshore winter flounder fishery in Rhode Island. Proc. Gulf Carib. Fish. Inst.

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Narragansett Bay Atlantic Menhaden Monitoring Program

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STATE: Rhode Island

PROJECT NUMBER: F-61-R

SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

PERIOD COVERED: January 1, 2017 – December 31, 2017

JOB NUMBER 11 TITLE: Narragansett Bay Atlantic Menhaden Monitoring Program

JOB OBJECTIVE: Continue administering an Atlantic menhaden monitoring program in Narragansett Bay that will use sentinel fishery observations (information of landings from floating fish traps), abundance information from spotter flights (both with a trained spotter and independent flights), removal information by tracking fishery landings, and a mathematical model (Depletion Model for Open Systems; see Gibson, 2007) to monitor the abundance of menhaden in Narragansett Bay in close to real-time and adjust access to the fishery as necessary through a dynamic regulatory framework.

SUMMARY: Atlantic menhaden (menhaden) undergo large coastwide migrations each year. After aggregating in the offshore waters of the Mid Atlantic region during the winter, menhaden migrate west and north stratifying by size and age the further north they migrate (Arenholz, 1991). Menhaden arrive in RI coastal waters beginning in the early spring, and in some years, enter Narragansett Bay in large numbers, where they can reside for varying amounts of time until they begin their southward migration in the fall. During the period when they reside in Narragansett Bay, a number of user groups compete for the resource. Commercial bait companies begin to fish on the schools of menhaden and provide bait for both recreational fishing interests and for the lobster fishery. As well, recreational fishermen access the schools of menhaden directly and use the resource as bait for catching larger sport fish such as striped bass and bluefish. Large numbers of sport fishermen can be seen in their boats surrounding large schools of menhaden throughout the spring and summer using various methods to harvest them (snagging lures, cast nets, dip nets). The migration of menhaden to the north is also one factor which brings these larger sport fish to northern areas, as they are an important food resource for these species (Arenholz, 1991; ASMFC, 2017). During the period when the menhaden resource is within Narragansett Bay and multiple user groups are accessing it, user group conflicts are an inevitable outcome. These conflicts were further exacerbated in 2013 with the implementation of Technical Addendum I and Amendment 2 to the Interstate Fishery Management Plan for Atlantic menhaden. Amendment 2 established coast-wide state quotas for Atlantic menhaden while Technical Addendum I established an Episodic Event Set Aside program. Both of these management measures resulted in increased resource conflicts due to a very low quota allocated to the state. In November of 2017, Amendment 3 to the Interstate Fishery Management Plan for Atlantic menhaden was approved by the Atlantic menhaden management board and will be implemented in 2018. Amendment 3 maintained many of the measures from Amendment 2 but additionally gave Rhode Island a significant increase in our state quota allocation. Investigators expect that due to the increased quota and high availability

of fish in the spring in summer in Narragansett Bay, user conflicts will persist and may worsen in 2018. This makes it important now more than ever for RI to accurately monitor the Atlantic menhaden resource in Narragansett Bay.

To help assuage some of these conflicts, to allow for an amount of the menhaden resource to remain unharvested by commercial interests for use by the recreational community, and to allow a portion of the menhaden resource to remain in Narragansett Bay to provide ecological services, the RI Division of Marine Fisheries (Division) administers a menhaden monitoring program in Narragansett Bay. The program collectively uses sentinel fishery observations (floating fish trap data), spotter flight information both with a trained spotter pilot and from independent helicopter flights, fishery landings information, computer modeling, and biological sampling information to open, keep track of, and close the fisheries on menhaden as conditions dictate.

TARGET DATE: December 2017

SIGNIFICANT DEVIATIONS: In 2017, Division staff were no longer able to utilize the state helicopter as a resource for this monitoring program to conduct independent school counts due to changes that occurred at the RI Airport Corporation. Investigators will continue to request use of the state helicopter in the future.

RECOMMENDATIONS: Continue spotter flights and data collection to create the estimate of Narragansett Bay Atlantic menhaden biomass. Continue to analyze and provide data for use in the RI menhaden fishery management program. Continue development of the assessment model and continue to move from a Microsoft excel framework in to a more advanced statistical program such as ADMB.

REMARKS: Abundance estimates derived from the menhaden monitoring program have been used to open and close the Narragansett Bay menhaden fishery. The management is performed to accommodate the recreational sportfish fishery that depends on menhaden as a source of bait for striped bass, bluefish, and weakfish, popular sportfish species in Narragansett Bay. In addition, the maintenance of a standing stock of menhaden biomass in Narragansett Bay meets other ecological services that this species performs.

The management structure maintains a biomass threshold of 1.5 million pounds in the Bay, which provides forage for the predatory species of striped bass and bluefish. Prior to the commencement of commercial fishing, the biomass needs to reach 2 million pounds to provide a body of fish for the fishery to remove without dropping below the 1.5 million pound threshold. Once fishing is authorized, the commercial fishery is allowed to remove 50% of the biomass above the 1.5 million pound threshold, leaving the rest for ecological services and for use as bait by recreational fishermen. If the biomass estimates based on the spotter flights drop below the 1.5 million pound threshold, the fishery will close. In addition, if landings by the commercial fishery reach the 50% cap, the fishery closes. Beginning in 2015, DEM adopted a regulation that opens the fishery annually on September 1st in the lower portion of Narragansett Bay at a reduced possession limit, despite the level of biomass present in the Bay. This opening is contingent upon the state having unharvested state quota remaining or having opted into the Episodic Event Set Aside program through ASMFC.

METHODS, RESULTS & DISCUSSION: The program in 2017 consisted of three main elements: collection of fishery landing information through call in requirements, computer modeling work, and field work (spotter fights and biological sampling). DEM regulations require that purse seine vessels fishing for menhaden in Narragansett Bay report their catches to Division staff. The commercial fishery interests also agree to carry a Division observer on the fishing vessel upon request, or allow a port sample to occur while the catch is being offloaded. In 2017, port samples were undertaken where Division biologists sampled the catch and recorded the weight of catch offloaded for floating fish traps. Catch sampling includes length frequencies, body weights, and collecting scales for age determination (see Age and Growth Study, Job 9 of this F-61R grant progress report). The Division staff also contracted a trained spotter pilot to make abundance estimates of menhaden in Narragansett Bay. When in the air, the pilot records counts of menhaden schools observed, the estimated weight within the schools, and the location of the schools. All RI licensed commercial harvesters, including floating fish trap and purse seine operators, were required to file logbook reports monthly with the Division that detailed daily fishing activities. The fixed gear floating fish trap fishery is useful as sentinels, documenting the arrival and movements of menhaden in state waters. Other information on menhaden abundance and movements were obtained from scientific staff on Division research cruises and a network of fishers working in Narragansett Bay. Collectively, these sources of information were analyzed using the theory of depletion estimation as applied to open populations. All of the aforementioned information was centrally collected and used in a computer modeling approach that allows the Division to monitor the abundance of menhaden in Narragansett Bay. The existing regulatory framework governing state waters allows the Division to use the output from the mathematical modeling approach to set a number of fishing activity parameters including a static amount of fish that need to be present to allow commercial fishing to commence, thus protecting recreational and ecological interests if only a small population enters the Bay, allows for only half of the standing population present in Narragansett Bay above the initial threshold amount to be harvested, thus maintaining an amount of unharvested fish even when commercial fishing has commenced, and subsequently allows the Division to close the fishery when the standing population of menhaden in Narragansett Bay drops back below the threshold level of fish, again maintaining a portion of the population for recreational fishermen and ecological services. This program also allows the Division to accurately track the newly implemented state quota and provides justification for Rhode Island to participate in the Episodic Event Set Aside Program as it has annually since 2013.

2017 Fishery Data

In 2017, the RI commercial bait fishery operating under the RI state quota closed on May 14, 2017, as it was determined that the entire RI state quota had been harvested. During this closure a bycatch allowance of 6,000 pounds/vessel/day was permitted for cast netters and floating fish traps.

As a result of exhausting our RI state quota but still having a large biomass of fish residing in state waters, RI applied for inclusion in the Atlantic menhaden episodic event set aside program administered by the ASMFC. On May 21, 2017, after being allowed access to the episodic event set aside program, the commercial bait fishery for vessels landing in RI was re-opened at a possession limit of 120,000 pounds/vessel/day. RI state waters inside and outside of the management area remained open through July 6, 2017, when the episodic events set aside quota was exhausted. The management area remained open to possession of menhaden until July 13, 2017, when it closed as a result of hitting the biomass threshold. Biomass levels in the Bay remained below the threshold until August when the management area was re-opened to possession on August 10, 2017. The management area stayed open to possession until September 8, 2017, when a biomass threshold was hit. In 2017, over 1.5 million lbs of menhaden were landed in the state of RI.

In 2017 the landings cap was not exceeded and a total of 26 spotter flights (Table 1) were accomplished. The flights were spread throughout the season to make sure there were estimates that occurred before, during, and after the fishery occurred. This was done to achieve an accurate sense of the migratory patterns of this important species in to RI waters. Over time, these estimates could be used to improve the predictive power of the model.

The model estimated a harvest cap of 4,825,000 pounds in 2017. This was driven by a large observation in the spring where over 11 million pounds of menhaden was estimated to be in Narragansett Bay at the end of May. This high level of biomass dropped steadily until July when biomass levels dropped to below 0.5 million pounds (Figure 1).

SUMMARY: The menhaden monitoring program in Narragansett Bay opened in May. There were several in season closures and subsequent re-openings throughout the year due to biomass thresholds and the episodic event set-aside program. Biomass estimates continued regularly throughout the season and ended in October. In total 26 spotter flights (Table 1) were taken giving ample data to use in the depletion model. Upon review, it was found that the harvest cap was not exceeded, therefore the program can be considered a success in 2017.

The RI State menhaden quota was exhausted, and thus the state waters fishery closed in May in 2017. Upon application to, and permission from the ASMFC to participate in the Atlantic menhaden episodic event set aside program, RI state waters re-opened to the landing of menhaden and remained open until July 6, 2017. The management area had a brief re-opening to possession only from August to September.

Table 1. Dates of contractor spotter flights and associated estimates of menhaden biomass.

Date	**Biomass Estimate**
5/16/2017	7,400,000
5/21/2017	11,205,000
5/27/2017	7,290,000
6/4/2017	9,700,000
6/8/2017	7,295,000
6/15/2017	5,030,000
6/22/2017	4,290,000
6/27/2017	2,660,000
7/4/2017	1,925,000
7/9/2017	410,000
7/20/2017	492,000
7/26/2017	1,324,000
7/31/2017	1,945,000
8/7/2017	3,768,000
8/14/2017	3,510,000
8/24/2017	1,765,000
9/2/2017	1,127,000
9/8/2017	810,000
9/16/2017	1,180,000
9/24/2017	747,000
9/29/2017	735,000
10/3/2017	270,000

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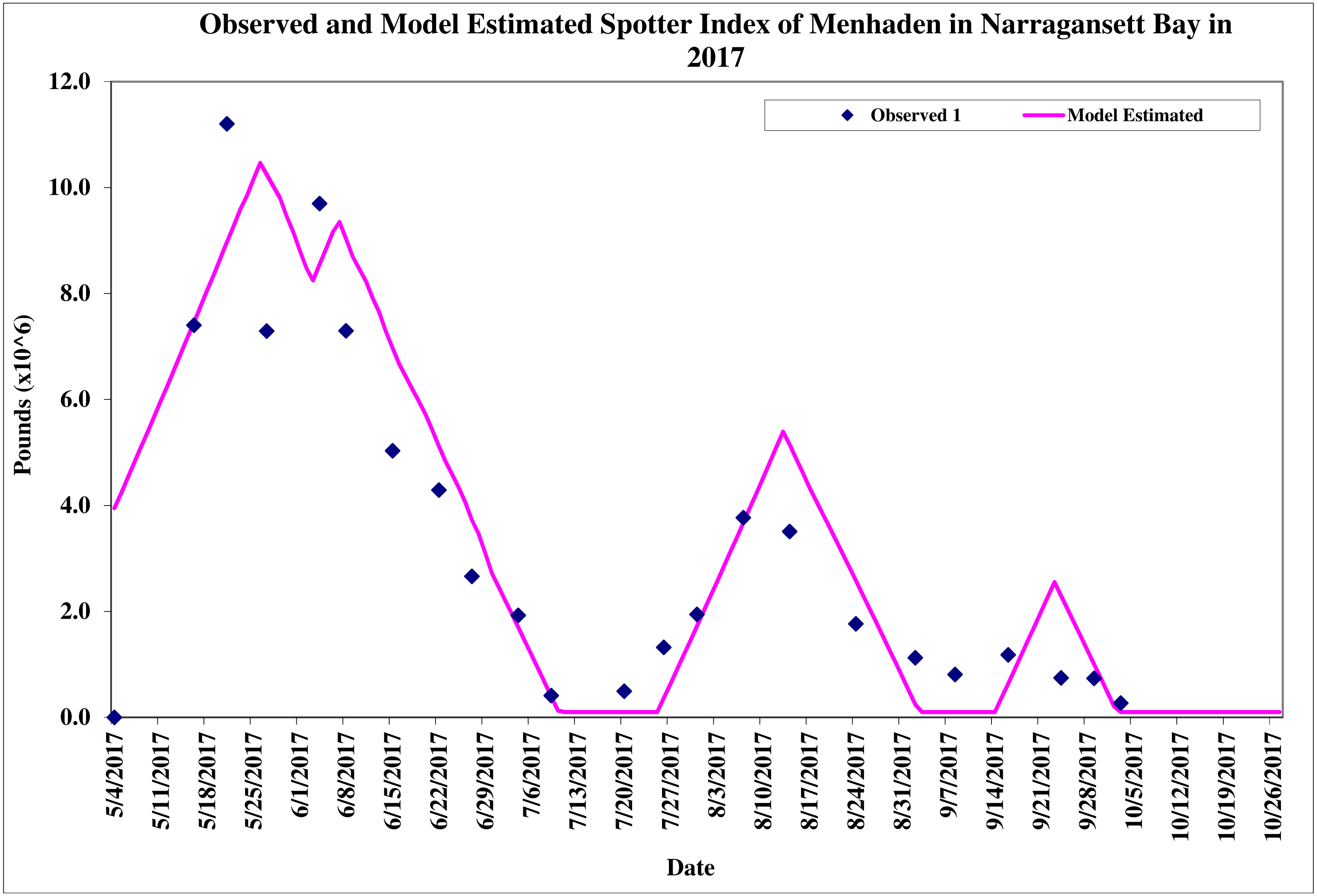

Figure 1. Predicted spotter pilot estimates and observed biomass in Narragansett Bay in 2017.

Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program

By
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Rhode Island Department of Environmental Management
Division of Marine Fisheries

Performance Report - Job - 12 - 21 March 2018

PERFORMANCE REPORT

State: Rhode Island Project Number: F-61-R

Project Type: Resource Monitoring

Project Title: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

Period Covered: January 1, 2017 to December 31, 2017

Job Number & Title: 12- 21 Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program

Job Objective: The goal of this project is to assess and standardize a time series of relative abundance for structure oriented finfish (scup, black sea bass, and Tautog) in Narragansett Bay. Investigators will also collect age and weight at length information for these species, as well as collect data on other biological characteristics while they're in RI state waters. Abundance data will be integrated into both local and coast wide stock assessments for the target species.

Summary: Vessel service needs in spring 2017 delayed the vessels operation until June. Additionally, due to continuing vessel issues, we were forced to curtail sampling after several weeks, Table 1. And subsequently were unable to get the vessel back into service until the end of September at which time it was determined that the sampling season and opportunity had passed. Investigators are confident that this project is working properly as designed and getting the desired results. In 2017, we caught 1,120 Scup, 150 Black Sea Bass, 67 Tautog, as well as four other species of finfish and four species of shellfish Table 2.

Target Date: 2018

Status of Project: Behind Schedule

Significant Deviations: Investigators were unable to complete sampling during the entire sampling season due to vessel problems and project staff which were on sick leave until the middle of May.

Recommendations: Continue on into the next segment.

Remarks: In 2017, Investigators began sampling in June, due to the Principal Investigator having undergone a left knee revision in February and remained on sick leave until the middle of May. We spent the remainder of May getting the vessel ready for the water and launching it. Sampling began in June, in the West Passage and the Providence River, launching and hauling Black Sea Bass trawls, and scup pots, Table 1. However, while in the process of setting scup pots in the Providence River, the vessel began to overheat and required a tow back to base. Staff attempted to rectify the situation in house to no avail, the raw water in the system appeared clear, however the vessel still overheated after a few minutes. We were unable to find service for the vessel and were unable get out contracted service people to haul the vessel and fix it until the end of August. The Vessel was returned nearly a month suspended later at the end of September near end of the sampling season. It was decided to suspend the rest of the season and save the money it would cost to launch, re-haul and block the vessel.

In the month of June, we set and hauled ten Black Sea Bass Trawls, two in the each of the five sampling areas, see Figure 1. We were also able to set ten scup pots in the West Passage and two in the Providence River before losing the vessel. The Division has specked out a new Down East Lobster vessel and awarded to bid unfortunately due to production limitations, the Division may have to wait up to two years for the new vessel, in the meantime the project will have to make due with the Privateer.

In spite of the issues in 2017, investigators captured and measured 1341 individual fish representing seven species, Table 2, and 31 invertebrates representing four species, Table 2a. Additionally, we sampled 208 Spider crabs, *Libinia spp*., 3 Green crabs, *Carcinus maenus*, 29 Rock crab, *Cancer irroratus*, 1 Hermit crabs, *Pagurus spp*. These aforementioned species are of little or no commercial or recreational importance and were merely counted and released without measurement. However, we caught and measured the following invertebrates which are of commercial or recreational significance, two Jonah crabs, Cancer Borealis which currently is covered by an ASMFC fisheries management plan. Additionally, we measured 11 channeled whelk, *Busycotypus canaliculatus*, 12 knobbed whelk, *Busycon carica*.

In 2017, the Division again utilized the King side scan maps, PDF's and computer images of Narragansett Bay for selection of stations as they refer to structure, non-structure. As more data is gathered, Investigators will perform data analysis on the efficacy of the changes.

Personnel worked with staff from our age and growth project in order to obtain scales, otoliths, and weights from fishes. Additionally, Black Sea Bass samples were brought back to the lab for stomach analysis as well as Tautog, between 17 and 38 cm, were brought back to the lab for later operculum removal, weighting, etc.

Introduction: Working groups such as the Northeast Data Poor Stocks Working Group (2008), have reported that size classes of many species may be under represented in their assessments, particularly scup, black sea bass, and Tautog. All three of these species tend to associate with bottom structure for a major portion of the year and as a result tend to be unavailable to traditional trawl surveys.

Furthermore, this survey is an attempt to employ an alternative survey gear type for these species, e.g. fish traps, as recommended by Shepherd (2008) and Terceiro (2008) in order to attempt to index the abundance of older scup (ages 3 and older).

Methods: Narragansett Bay was divided into five sampling areas, The Providence/lower Seekonk River including portions of the Upper Bay/Greenwich Bay, West

Passage, East Passage, Mount Hope Bay including portions of the Upper Bay, and the Sakonnet River including the area from Land's End to Sakonnet Point (Figure 1). Each area was subdivided into 0.5 deg. of latitude and longitude squares and numbered. These numbered boxes were referred to as stations. Investigators then located areas of hard bottom, shipwreck, major bridge abutments, or pilings, etc., in each station. The areas of structure were noted in the stations containing structural elements and the goal for each month was to randomly sample half of the replicates in areas of known structure and half in areas without known structure.

All sampling stations were selected randomly. In order to maintain a consistent methodology with the URI/Sea Grant projects, investigators adopted the following sampling schedule which they anticipate will take approximately two to three weeks.

A monthly survey was conducted in the Narragansett Bay from June, July, September, and part of October. The unvented scup pots (2'x2'x2') are constructed of 1.5" x 1.5" coated wire mesh. The unvented Black Sea Bass Pots (43.5" L, 23" W, and 16" H) are also constructed of 1.5" x 1.5" coated wire mesh, single mesh entry head, and single mesh inverted parlor nozzle.

> Beginning on Thursday or Monday, investigators set black sea bass pots in five (5) pot trawls at two (2) randomly selected stations in two separate sampling areas. One trawl will be set on structured bottom and one on bottom without structure. These traps will be unbaited and allowed to fish for 96+/- 1 hr. After the four days, the traps will be hauled, the catch processed and the trawls held for 24 hours then moved to a new areas and allowed reset. This will be repeated until there are ten set in total for Narragansett Bay.
>
> In the intervening time, Investigators set scup pots at ten (10) randomly selected stations, five on structured bottom and five on bottom without structure, in one of the five sampling areas and left to soak for **24+/- 1 hr**. All pots were baited with sea clams. After 24 hrs. the pots set were hauled, the catch processed and gear either reset or removed from the water so investigators could tend trawls. This continues until 50 sets have been made throughout Narragansett Bay.

Upon hauling all gear types, the catch was sorted by species. Finfish were measured to the nearest centimeter, fork length (FL) or total length (TL). Invertebrates were measured using a species specific appropriate metric or counted. Personnel from the age and growth project have accompanied us in order to obtain scale samples and fish specimens from which to obtain stomach samples, otoliths and/or opercula. Going forward, it appears that this could become a normal part of this project. Project personnel collected data on water temperatures, salinities, dissolved oxygen, air temperature at each sampling station using a Eureka Systems Manta 2 Multiprobe.

Results/Discussion:

Due to the Principal Investigator on sick Leave until Mid May, we didn't begin sampling until June, Staff set the Black sea Bass Trawls 10 times in all five areas. We set the Scup Pots 10 times in the West Passage and two times in the Providence River, however, while in the process of setting scup pots in the Providence River/Upper Bay, the vessel began to overheat and required a tow back to Jamestown. Staff attempted to rectify the situation in house to no avail, the raw water in the system appeared clear, however the vessel still overheated after a few minutes. We were unable to find any Professionals willing to service the vessel and were unable get out contracted service people to haul the vessel and fix it until the end of August. The Vessel was returned after nearly a month at the end of September. A decision was made to suspend the sampling season and to have the vessel put on blocks.

Table 2 enumerates the finfish species caught and the percentage of total catch, while Table 2 a, enumerates the shellfish caught. From this table, it is obvious that these gear types are very efficient at catching the target species. This table shows that scup dominated the catch with 1120 individuals which comprised 83.52% of the total catch. However, only 150 black sea bass were caught which equaled 11.19%. In 2017, 67 Tautog were caught which equaled 5% of the total catch. Length frequency histograms for Black Sea Bass, Scup, and Tautog along with length at age graphs for each species are presented in figures 2, 2a, 3,3a,4,4a, respectively.

Figures 2 a, depicts the frequency of black sea bass captured in June 2017, where they ranged from 20 cm to 55 cm. Figures 3, represents the length frequencies of the scup captured and processed in 2017. The scup ranged in size from 13 cm to 34 cm in length. Figure 4, shows the various size classes of Tautog that were caught in June 2017. We caught 67 Tautog, ranging in size from 19 cm to 53 cm.

Temperature, Salinity, and Dissolved Oxygen:

Surface water temperatures varied only slightly from station to station but rose constantly and ranged from a low of 16.19 ℃ on June 9 to as High of 29.03 ℃ on June 21. This constant rise was probably attributable to the air temperatures which were intermittent throughout the time and ranged from 19.14℃ to 26.7 ℃. Bottom temperatures ranged from 14.09 ℃ on June 08 to a high of 20.16 ℃ on June 22. Surface salinities ranged from 16.29‰ to 32.21‰ and surface dissolved oxygen ranged from 7.11 mg/L to 10.28 mg/L. Bottom salinities ranged from 28.71‰ to 32.2‰ and dissolved oxygen ranged from 5.43 mg/L to 10.32 mg/L.

Prepared by: ________________	Approved by: ____________________
Richard J. Satchwill	Jason McNamee
Principal Biologist, Marine Fisheries	Chief, Marine Fisheries

References:

Shepherd, G. 2008. Black Sea Bass. Northeast Data Poor Stocks Working Group Meeting. Dec 8-12. National Marine Fisheries Service. Northeast Fisheries Science Center. 166 Water St., Woods Hole, MA 02543

Terceiro, M. 2008. Scup: Stock Assessment and Biological Reference Points for 2008. Northeast Data Poor Stocks Working Group Meeting. Dec. 8-12. Northeast Fisheries Science Center, 166 Water St. Woods Hole, MA 02543.

Working Group Report. 2008. The Northeast Data Poor Stocks. Dec 8-12. Northeast Fisheries Science Center Reference Document 09-02A & B. Northeast Fisheries Science Center. 166 Water St., Woods Hole, MA 02543

Table 1

Number and Type of Traps set Each Month during 2016

Trap Type	Apr	May	Jun	Jul	Aug	Sept	Oct
BSB Trawls	0	0	10	0	0	0	0
Scup Pots	0	0	12	0	0	0	0
Total	0	0	22	0	0	0	0

TABLE 2

Ranking by Abundance of all Finfish Species Collected in Fish Traps in Narragansett Bay, R. I.

(Apr 2016 - Sept 2016)

Scientific Name	Common Name	Number	% Catch
Stenotomus chrysops	Scup	1,120	83.52
Centropristis striata	Sea Bass Black	150	11.19
Tautoga onitis	Tautog	67	5.00
Opsanus tau	Toadfish Oyster	1	0.07
Paralichthys dentatus	Flounder Summer	1	0.07
Prionotus evolans	Searobin Striped	1	0.07
Tautogolabrus adspersus	*Cunner*	1	0.07

TABLE 2a

Ranking by Abundance of all Shellfish Species Collected in Fish Traps in Narragansett Bay, R. I.

(Apr 2016 - Sept 2016)

Scientific Name	Common Name	Number	% Catch
Busycon carica	Knobbed Whelk	12	38.71
Busycotypus canaliculatus	Channeled Whelk	11	35.48
Homarus americanus	American Lobster	6	19.35
Cancer borealis	Jonah Crab	2	6.45

Figure 1. – Chart of Narragansett Bay with Colregs line of demarcation and Location of Five Sampling Areas.

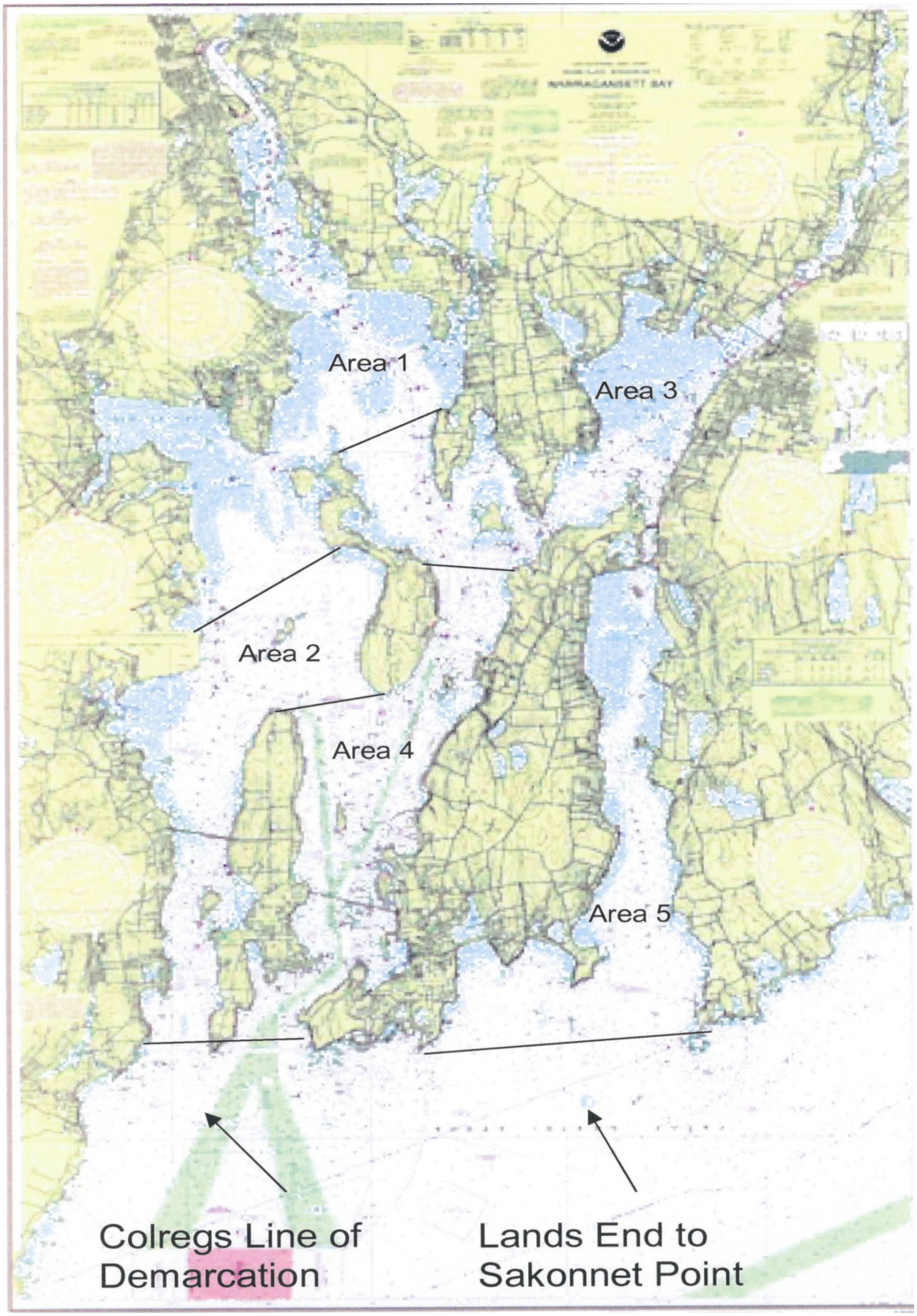


Figure 2a... Length Frequency Histogram for Black Sea Bass.

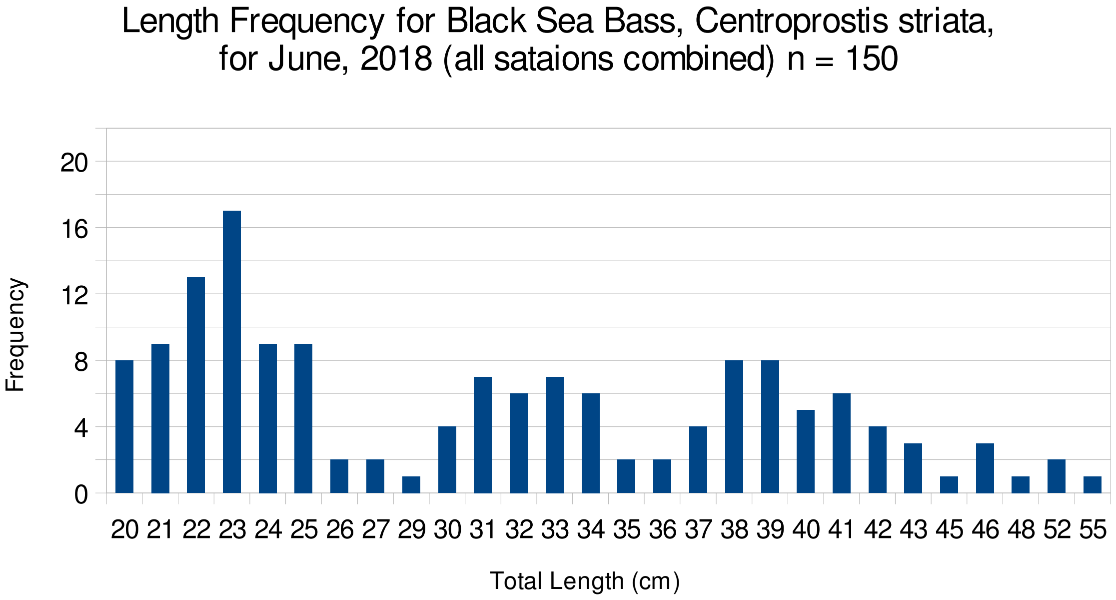


Figure 2b. Length at Age graph for Black Sea Bass

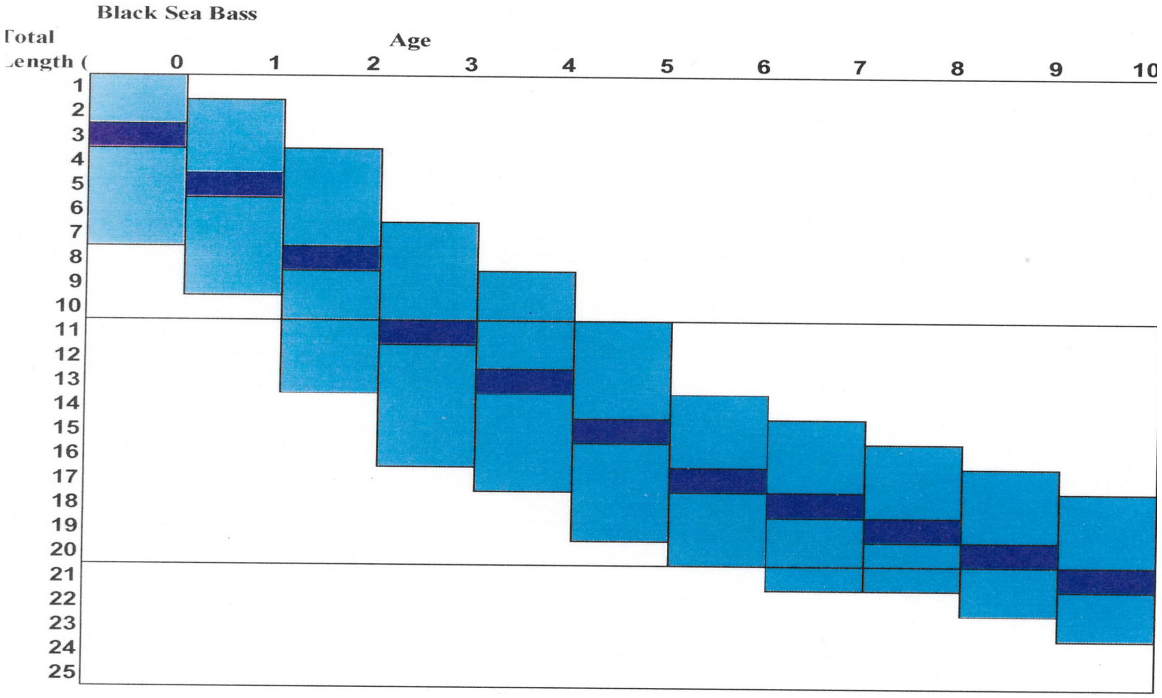


Figure 4 a. Length Frequency Histogram for Scup.

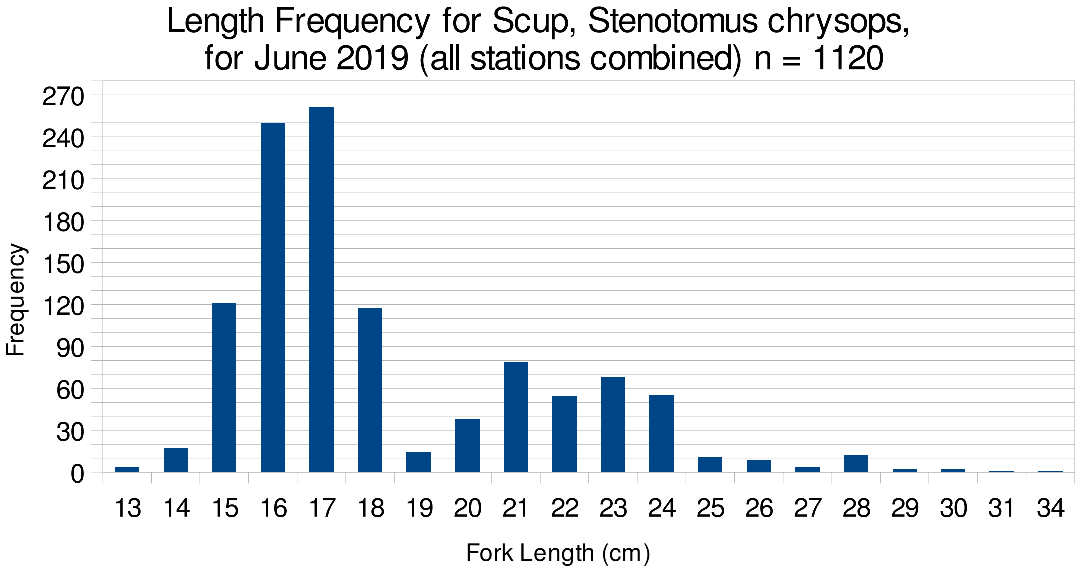


Figure 4b. Length at age graph for scup

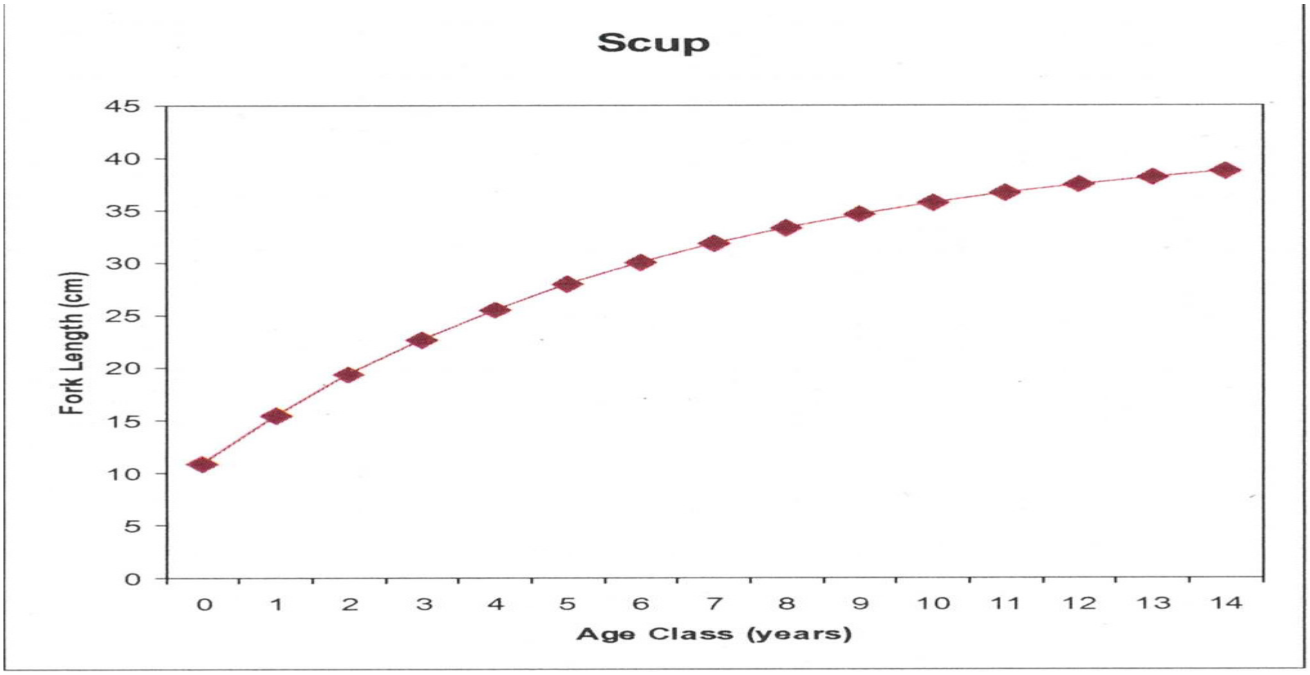


Figure 5 a. Length Frequency Histogram for Tautog.

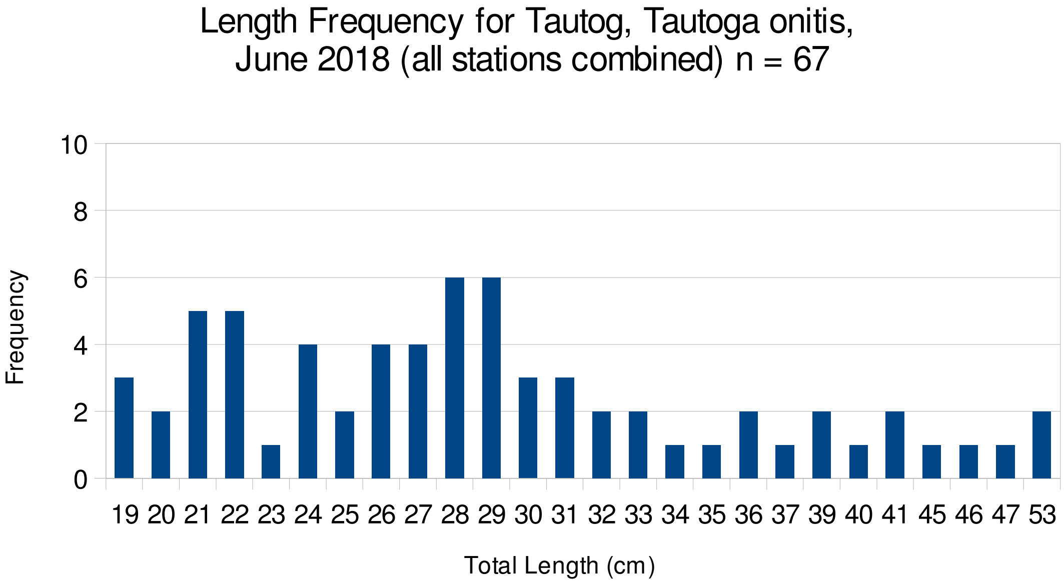
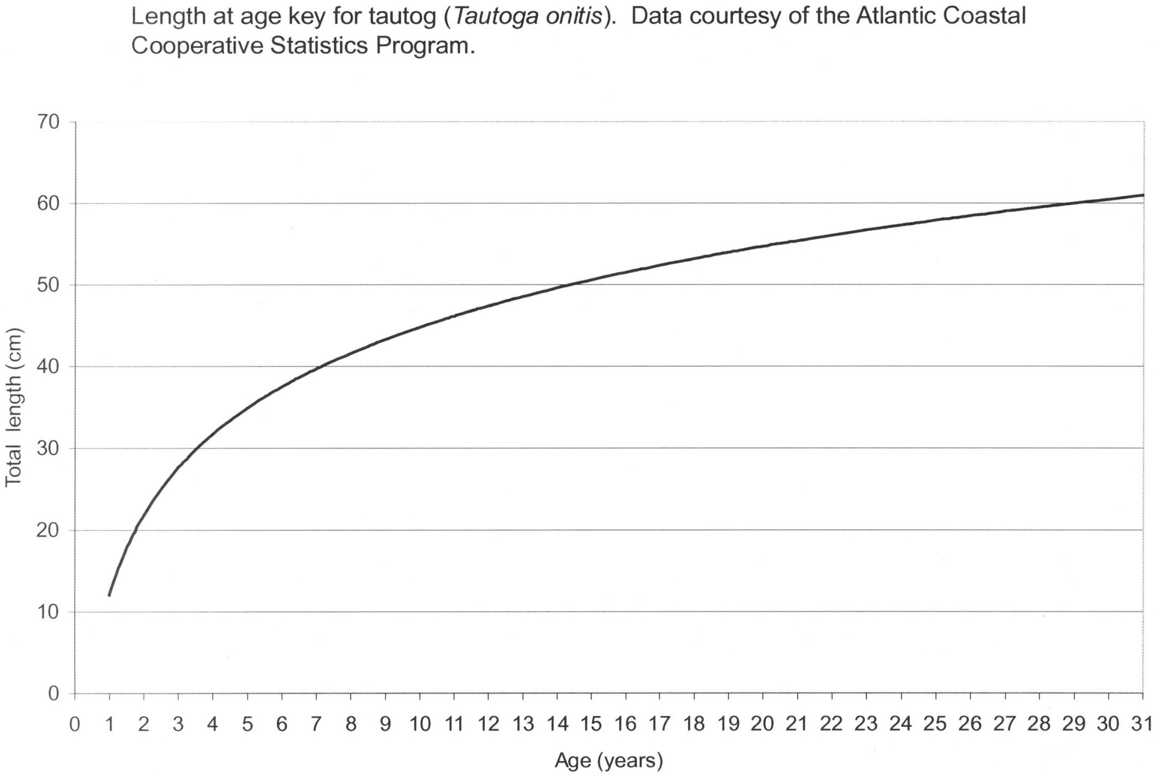


Figure 5 b. Length at age graph for Tautog



ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

2017 ANNUAL PERFORMANCE REPORT

Federal Aid in Sportfish Restoration
F-61-R
SEGMENT 21, JOB 13

MARINE FISHES OF RHODE ISLAND

by
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Rhode Island Department of Environmental Management
Division of Marine Fisheries
3 Fort Wetherill Road
Jamestown, RI 02835

March 2018

STATE: Rhode Island

PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 21

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Coastal Waters

JOB NUMBER: 13

JOB TITLE: Marine Fishes of Rhode Island

PERIOD COVERED: January 1, 2017 – December 31, 2017

JOB OBJECTIVE:

The goal of this project is to produce a manuscript which will act as a reference for recreational fishermen, commercial fishermen, and fisheries scientists alike. The finished product will summarize existing knowledge on the occurrence and distribution of fish species observed within Rhode Island marine waters, based on information collected through several field surveys conducted by RIDMF. The information will be presented systematically and the manuscript will include scientific illustrations of fish species encountered occasionally to commonly in RIDMF surveys; rare species will not be illustrated. This work is designed to be a stand-alone manuscript, but also to be compatible with and be a companion volume to the Fresh Water Fishes of Rhode Island book produced in 2013.

SUMMARY:

A significant amount of progress was made on this job during 2017. The basic foundation of the book was laid out, including the following sections: glossary, introduction, description of the data sources (field surveys) that collected the data with maps of survey sampling locations, lists of species observed in RIDMF surveys (surveys combined and by individual survey) and species observed historically with life history classification and historic status, family descriptions, species descriptions (scientific and common name(s), species identification, distribution, current management (where applicable)), current RI sportfish and all-tackle (worldwide) records (where applicable), references used, and an index.

To date, the following sections and portions of the book are near completion or have been completed: cover page, glossary, introduction, data sources (field sampling surveys), tables of lists of species caught in recent RIDMF surveys (surveys combined and by individual survey), scientific and common names, information on RI sportfish records and all-tackle (worldwide) records (where applicable), references, and index. Family descriptions for 5 families have been prepared (Acipenseridae, Albulidae, Clupeidae, Engraulidae, and Serranidae). Species descriptions (scientific and common name(s), species identification, distribution, current management) for 7 species have been prepared (bonefish, blueback herring, hickory shad, alewife, American shad, rock sea bass, and black sea bass).

Species distribution maps are in the process of being compiled from GPS sampling location data for each species by each RIDMF survey.

There have been 3 meetings with the illustrator (Robert Jon Golder) since submission of the last performance report (March 2017). At the last meeting in January 2018, a contract was developed that included a schedule for the illustrations to be completed over the next 2.5 - 3 years. Illustrations for 39 of the marine species for which illustrations will be used have already been completed as part of the "Inland Fishes of Rhode Island" book. There is a minimum of 50 and a maximum of 65 species remaining to have illustrations prepared.

TARGET DATE: December 31, 2018 and continuing into the next grant cycle

SIGNIFICANT DEVIATIONS:

There was little progress made on this job in previous years (2016) due to issues described in last year's performance report. There has been a delay in putting the illustrator's contract in place due to the recent death (February 2018) of the illustrator's wife. It is anticipated that the contract will be signed and in place by the end of March 2018.

RECOMMENDATIONS: Continue into the next grant cycle/segment

REMARKS:

While this job has fallen behind schedule, it is the intent and goal of staff currently assigned to this job (Thomas Angell) to have it completed prior to the end of the next grant cycle (i.e. within 5 years).

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

University of Rhode Island
Graduate School of Oceanography
Weekly Fish Trawl
2017

PERFORMANCE REPORT
F-61-R SEGMENT 21
JOB 14

Jeremy Collie, PhD
Professor of Oceanography
March 2017

Annual Performance Report

STATE: Rhode Island PROJECT NUMBER: F-61-R
SEGMENT NUMBER: 22

PROJECT TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

JOB NUMBER: 14

TITLE: University of Rhode Island Graduate School of Oceanography Weekly Fish Trawl

JOB OBJECTIVE: To collect, summarize and analyze bottom trawl data for biological and fisheries management purposes.

PERIOD COVERED: January 1, 2017 – December 31, 2017.

TARGET DATE: December 2017

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

RECOMMENDATIONS: Continuation of the weekly trawl survey into 2018; data provided by the survey are used extensively in the Atlantic States Marine Fisheries Commission and NOAA Fisheries fish stock assessments and fishery management plans.

Introduction:

The University of Rhode Island, Graduate School of Oceanography, began monitoring finfish populations in Narragansett Bay in 1959, and has continued through 2017. These data provide weekly identification of finfish and crustacean assemblages. Since the inception of the weekly fish trawl, survey tows have been conducted within Rhode Island territorial waters at two stations, one representing habitat of Narragansett Bay and one representing more open-water type habitats, characteristic of Rhode Island Sound. The weekly time step of this survey and its long duration are two unique characteristics of this survey. The short duration time step (weekly) has enough definition to capture migration periods and patterns of important finfish species and the length of the time series allows for the characterization of these patterns back into periods of time that may represent different productivity or climate regimes for many of these species. This performance report reflects the efforts of the 2017 survey year as it relates to the past 58 years.

Methods:

A weekly trawl survey is conducted on the URI research vessel Cap'n Bert. Two stations are sampled each week: one off Wickford represents conditions in mid Narragansett Bay (Fox Island) and one at the mouth of Narragansett Bay represents conditions in Rhode Island Sound (Whale Rock). A hydrographic profile at each station measures temperature, salinity and dissolved oxygen. The same otter trawl net design has been used for the past 57 years. A half-hour tow is made at each station at a speed of 2 knots. All species are counted and weighed with an electronic balance. Winter flounder are routinely measured and sexed. When present on board, an undergraduate intern measures all other species with an electronic measuring board.

The following are the station locations for the survey:

Site	Location	Coordinates	Depth Range at Low Tide (North to South Along Tow Line)	Bottom Substrate
Fox Island	Adjacent to Quonset Point and Wickford	41°34.5' N, 71°24.3' W	20 feet (6.1 meters) to 26 feet (7.9 meters)	Soft mud and shell debris
Whale Rock	Mouth of West Passage	41°26.3' N, 71°25.4' W	65 feet (19.8 meters) to 85 feet (25.9 meters)	Coarse mud/fine sand

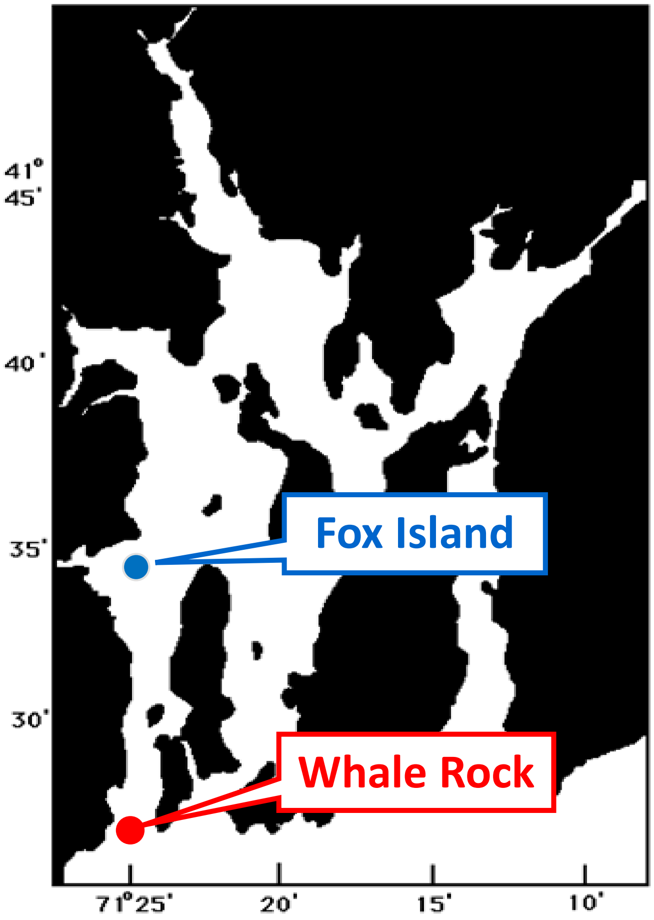


Figure 1. Location of trawl stations in Narragansett Bay.

The gear dimensions of the net are as follows:

Net type	2-seam with bag
Length of headrope	39 feet (11.9 meters)
Otter boards	steel, 24 inches tall, 48 inches long (61 centimeters by 1.24 meters)
Distance from otter boards to net	60 feet (18.3 meters)
Mesh size: net	3 inches (7.6 centimeters)
Mesh size: codend	2 inches (5.1 centimeters)
Distance between otter boards while fishing	52 feet (15.8 meters) at Fox Island 64.5 feet (19.7 meters) at Whale Rock

(For more information about the GSO fish trawl go https://web.uri.edu/fishtrawl/)

Results:

38 and 37 weekly tows were made at the bay (Fox Island) and sound (Whale Rock) stations respectively. A large sampling gap occurred from January 1 – May 1, 2017 due boat safety and master complications. For this report, monthly average proportions from the previous 8 years were applied to the expected total for each species to replace missing values. More in-depth approaches to model missing values are being explored for a long-term solution.

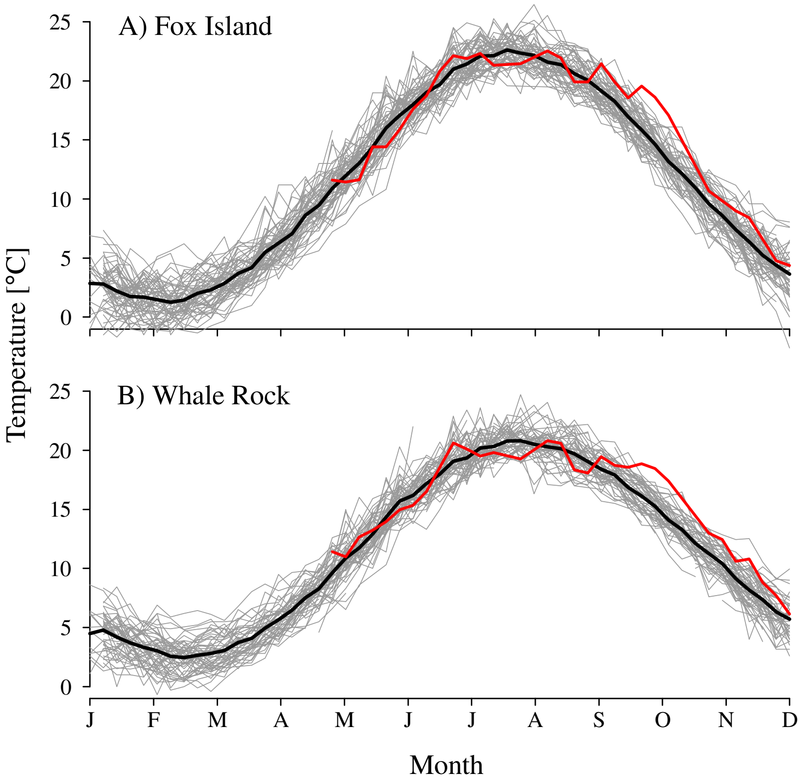


Figure 2. Weekly sea surface temperature of Narragansett Bay at each sampling station. The gray lines represent the seasonal temperature cycle for each previous year. The black line is the average temperature over all years. The most recent year, 2017, is labeled red.

Environmental conditions

Weekly water temperatures at both stations remained consistent with the historic average during late spring and summer of 2017 (Fig. 2). The year began warmer than average coming off of the strong El Niño year in 2016. September and October temperatures were well above average indicating delayed cooling.

Summary catch statistics

Table 1. Total catch by species at Fox Island (FI) and Whale Rock (WR) for the top 25 species.

Species	**FI**	**WR**	**Total**
SCUP (*Stenotomus chrysops*)	19994	7168	27162
ROCK CRAB (*Cancer irroratus*)	107	2950	3057
BUTTERFISH (*Peprilus triancanthus*)	287	2517	2804
LITTLE SKATE (*leucoraja erinacea*)	94	1457	1551
SQUID (*Loligo pealii*)	412	856	1268
SUMMER FLOUNDER (*Paralichthys dentatus*)	293	511	804
STRIPED SEAROBIN *(Prionotus evolans*)	272	516	788
NORTHERN SEAROBIN (*Prionotus carolinus*)	215	493	708
HERMIT CRABS	594	35	629
CONCH (*Busycon canaliculatum* & B. carica)	462	17	479
SPIDER CRAB *(Libinia emarginata*)	311	155	466
SAND FLOUNDER (*Scophthalmus aquosus*)	15	379	394
FOURSPOT FLOUNDER (*Paralichthys oblongus*)	12	370	382
SILVER HAKE (*Merluccius bilinearis*)	7	323	330
SPOTTED HAKE (*Urophycis regia*)	36	273	309
WINTER FLOUNDER (*Pseudopleuronectes americanus*)	51	128	179
MOONFISH (*Selene setapinnis*)	109	60	169
CLEARNOSE SKATE (*Raja eglanteria*)	52	113	165
SMALLMOUTH FLOUNDER (*Etropus microstomus*)	15	141	156
COCKLE	152	0	152
SPONGE (*Suberites* spp)	121	0	121
LOBSTER (*Homarus americanus*)	2	117	119
MANTIS SHRIMP (*Squilla empusa*)	71	35	106
MENHADEN (*Brevootia tyrannus*)	62	30	92
SMOOTH DOGFISH (*Mustelus canis*)	77	10	87
Total	**23823**	**18654**	**42477**

The top 10 species caught in 2017 (and the station where they were most numerous) were: Scup (FI), Rock crabs (WR), Butterfish (WR), Little skate (WR), Squid (WR), Summer flounder (WR), Striped searobin (WR), Northern searobin (WR), Hermit crabs (FI), and Conch (FI).

A number of species of recreational importance were collected during 2017 by the URI Fish trawl survey. Represented below are a number of important species and their abundance trends throughout the time series of this survey. On each graph, the species abundance at the two stations is represented separately for each station.

Winter flounder

Winter flounder are one of the target species for the survey. The population of winter flounder has declined dramatically since the mid 1980s with some of the lowest estimates on record for both stations occurring in the last decade (Figure 3). Winter flounder was historically more abundant at the Bay Station (Fox Island), but the abundance of this subpopulation has declined. A slight increase at Whale Rock was observed in 2016, due to an increase in the number of age-1 winter flounder. This increase was not sustained in 2017. The survey information is used during the stock assessment process for winter flounder.

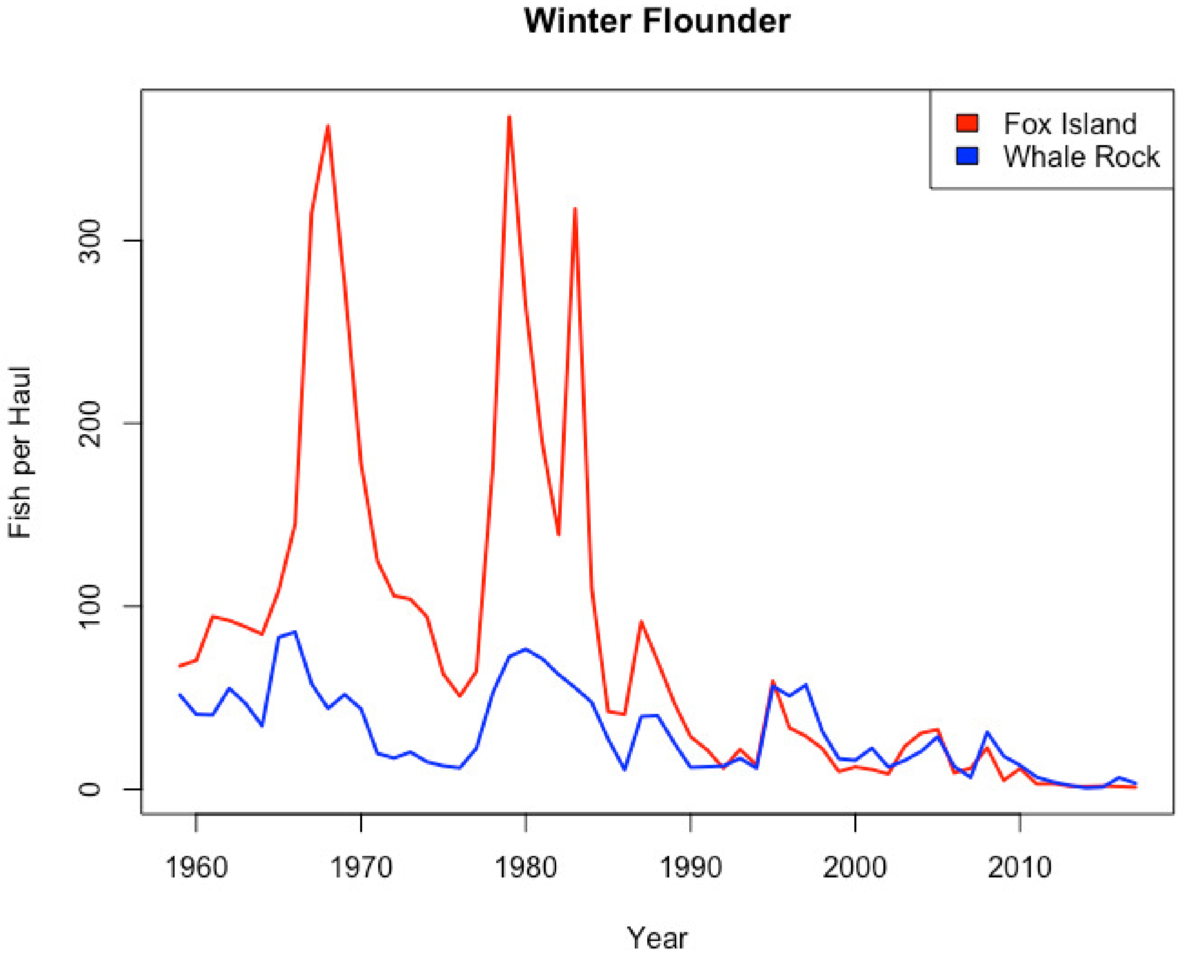


Figure 3 – Survey data for entire time series for winter flounder at both sampling stations (Fox Island and Whale Rock).

Tautog

Tautog are another important recreational species caught by the survey. The population of tautog was historically more abundant in Narragansett Bay before the mid1980s. It declined dramatically during the time period of the survey, but does show some improvement in the most recent period of time (Figure 4). Despite the improvement, the population according to the survey has not rebounded to former levels. Tautog are mainly caught at the Fox Island station, with only random and infrequent catches occurring at Whale Rock. The survey information was reviewed during the stock assessment process for tautog.

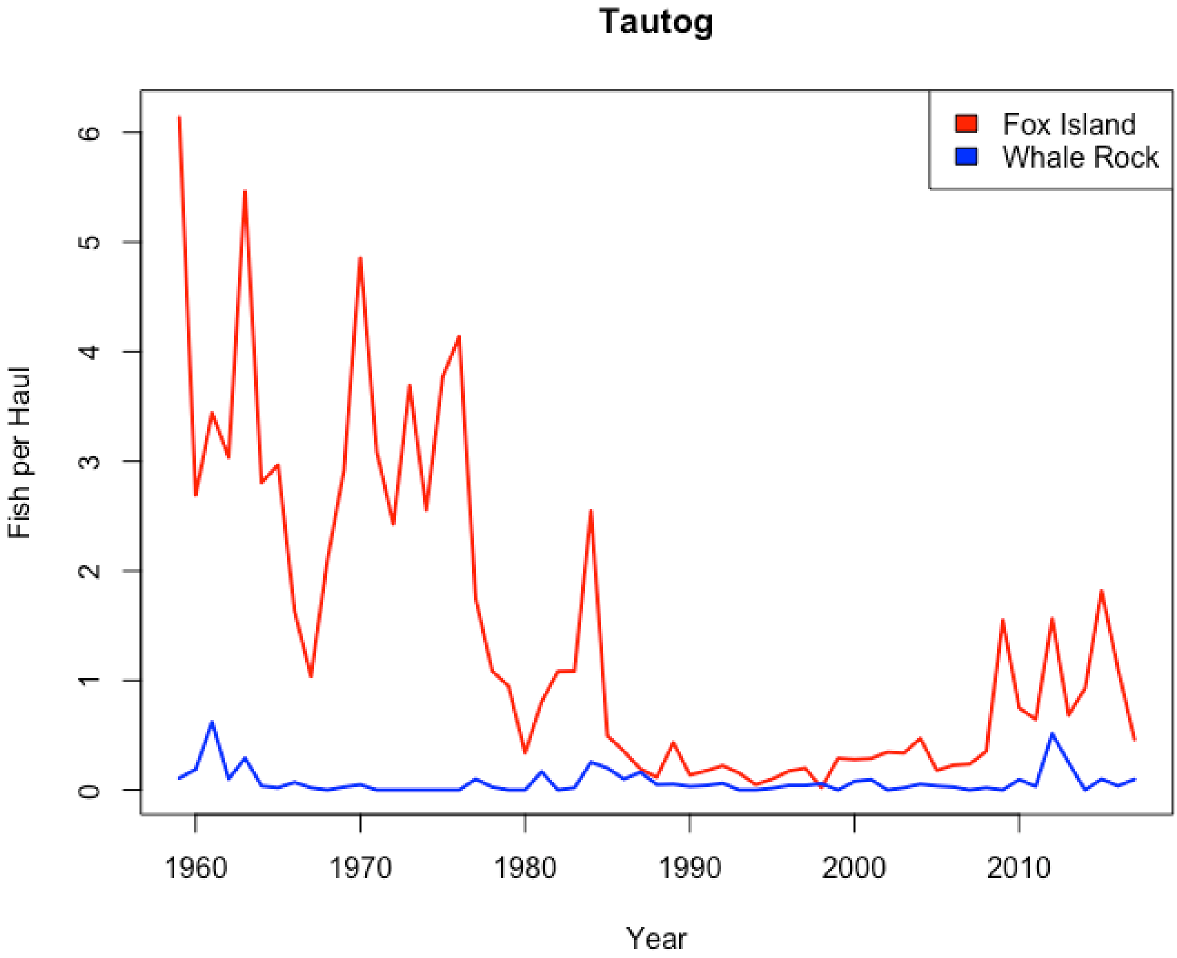


Figure 4 – Survey data for entire time series for tautog at both sampling stations (Fox Island and Whale Rock).

Summer Flounder

Summer flounder are another important recreational species caught by the survey. The population of summer flounder has increased dramatically during the time period of the survey, but does showing a fair amount of variability in the most recent time period (Figure 5). Summer flounder are caught at both sampling stations pretty consistently, though abundance has increased at Whale Rock relative to Fox Island. Both stations are capturing the seasonal migration patterns of summer flounder. The survey information was reviewed during the stock assessment process for summer flounder, and the trends indicated by the survey are similar to those indicated by the overall population trends.

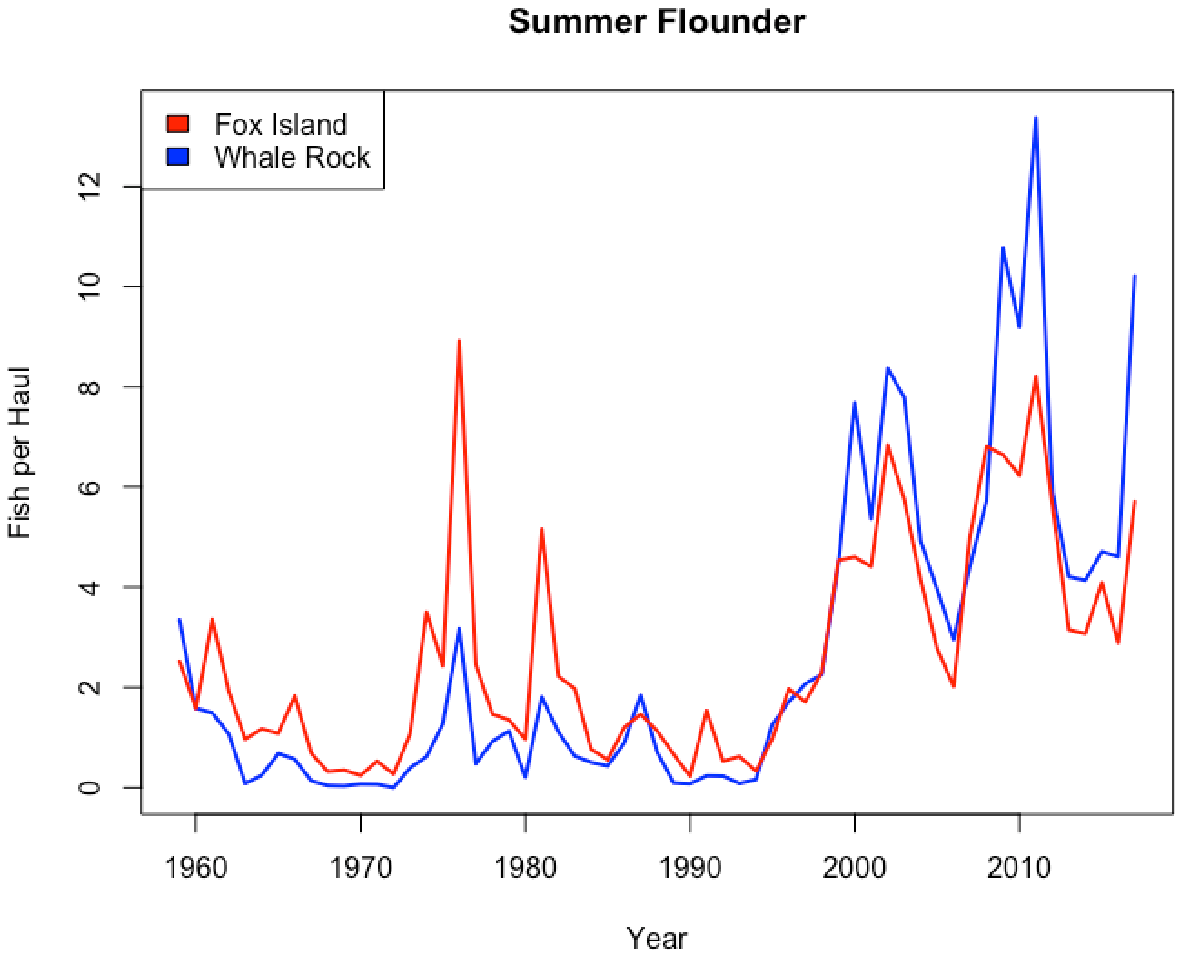


Figure 5 – Survey data for entire time series for summer flounder at both sampling stations (Fox Island and Whale Rock).

Black Sea Bass

Black sea bass are another important recreational species caught consistently by the survey. The population of black sea bass has increased dramatically since the mid 1990s, much like summer flounder, and also shows a fair amount of variability in the most recent time period (Figure 6). Black sea bass are caught at both sampling stations pretty consistently.

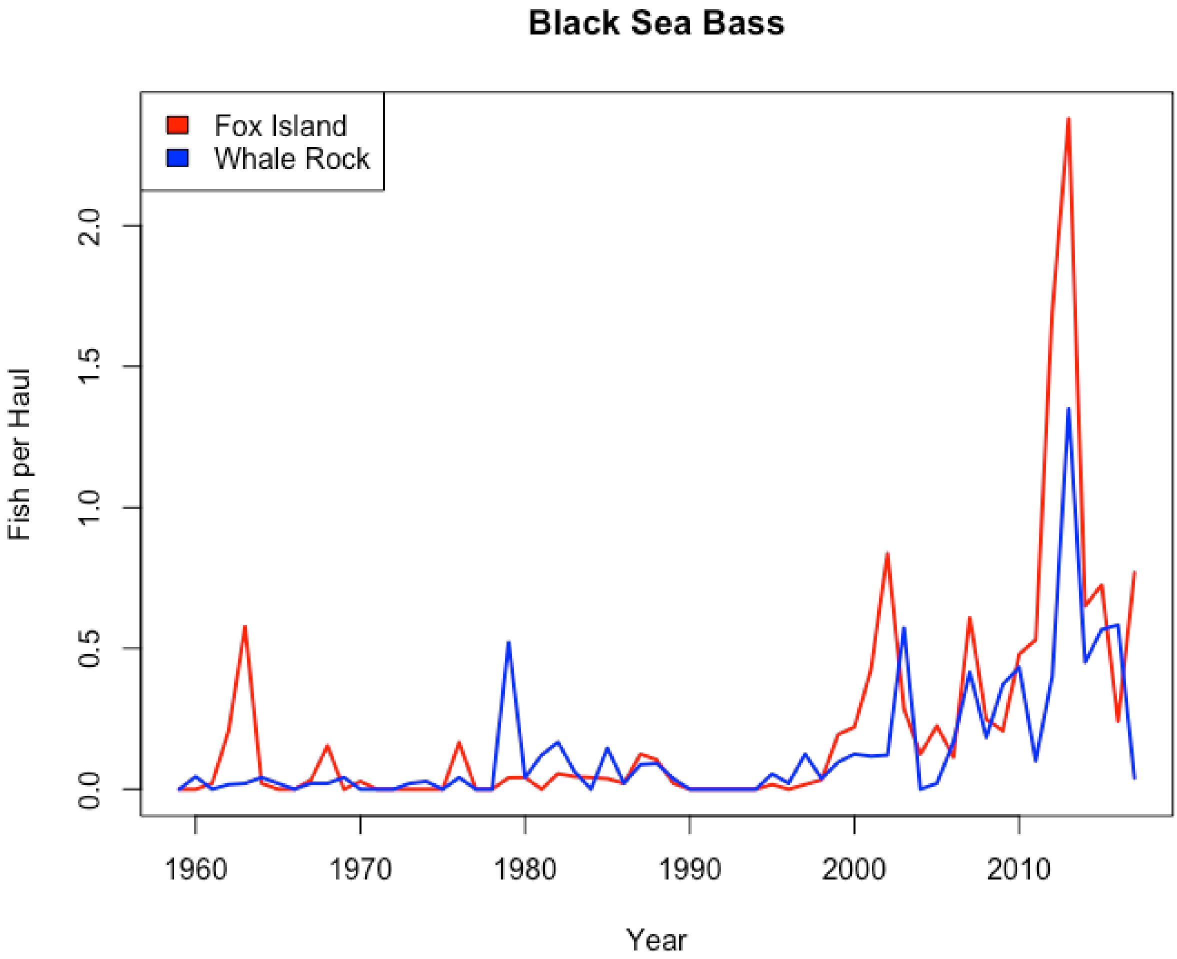
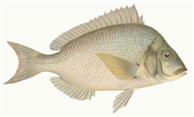


Figure 6 – Survey data for entire time series for black sea bass at both sampling stations (Fox Island and Whale Rock).



Scup

Scup is another of the Mid-Atlantic species caught consistently by the survey, along with summer flounder, black sea bass, bluefish, and menhaden. The population of scup has increased dramatically during the time period of the survey, much like summer flounder and black sea bass, but starting in the mid 1970s (Figure 7). Scup are caught at both sampling stations pretty consistently, though the Fox Island station catches a much higher magnitude than does the Whale Rock station. Though caught in large numbers, scup catches have a high degree of variability. Some of this variability and magnitude difference for scup is driven by high recruitment events, the young of the year recruits being susceptible to the trawl gear. The 2017 survey year produced the 2nd highest catch per unit effort for scup ever recorded in the survey. The survey information was reviewed during the stock assessment process for scup.

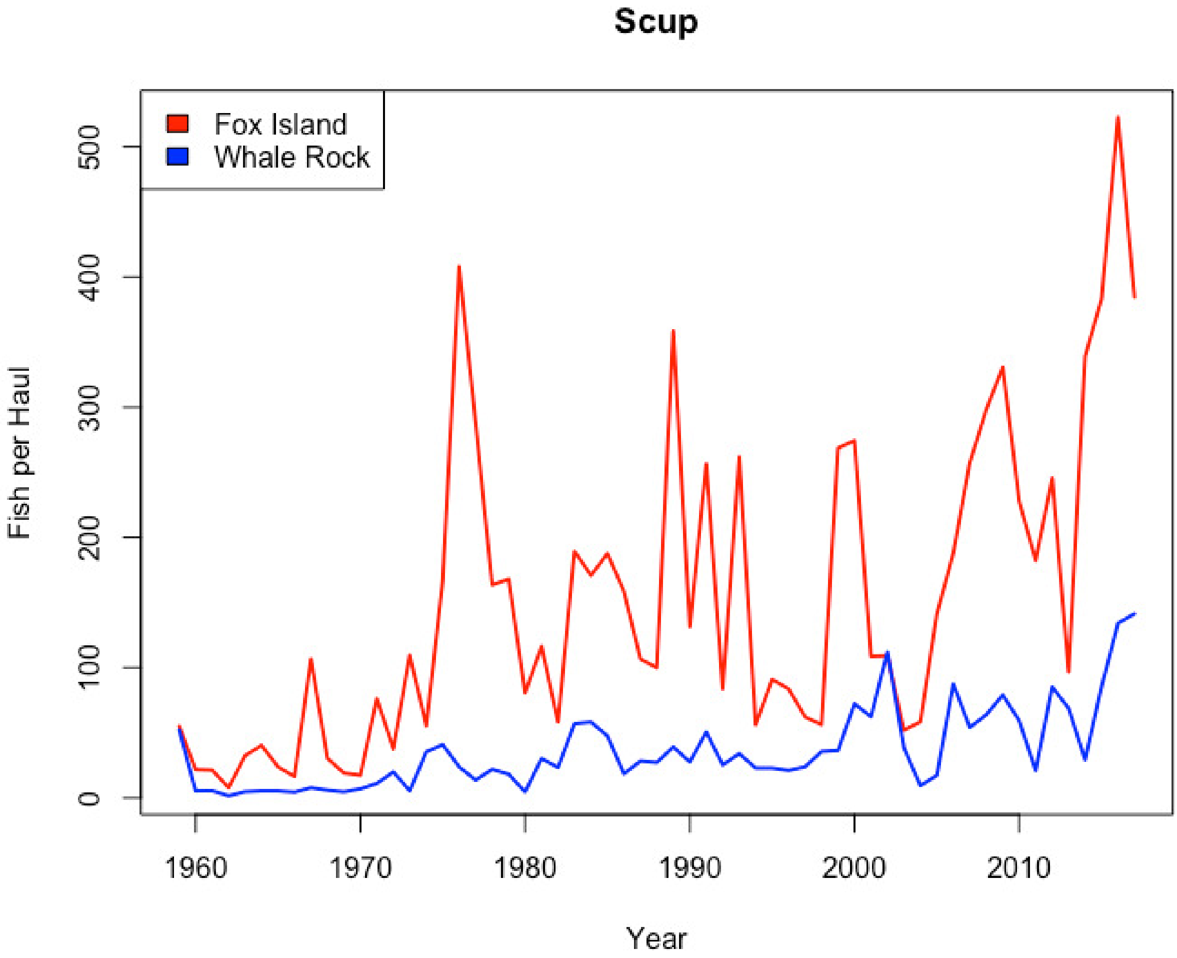


Figure 7 – Survey data for entire time series for scup at both sampling stations (Fox Island and Whale Rock).

Bluefish

Bluefish is another of the Mid-Atlantic species caught consistently by the survey. The population of bluefish peaked during the mid 1990s, but has since declined, with some potential improvement in recent years. There is high variability for this species in the survey data, again mainly due to catching young of the year bluefish as opposed to adults (Figure 8). Bluefish are caught at both sampling stations pretty consistently.

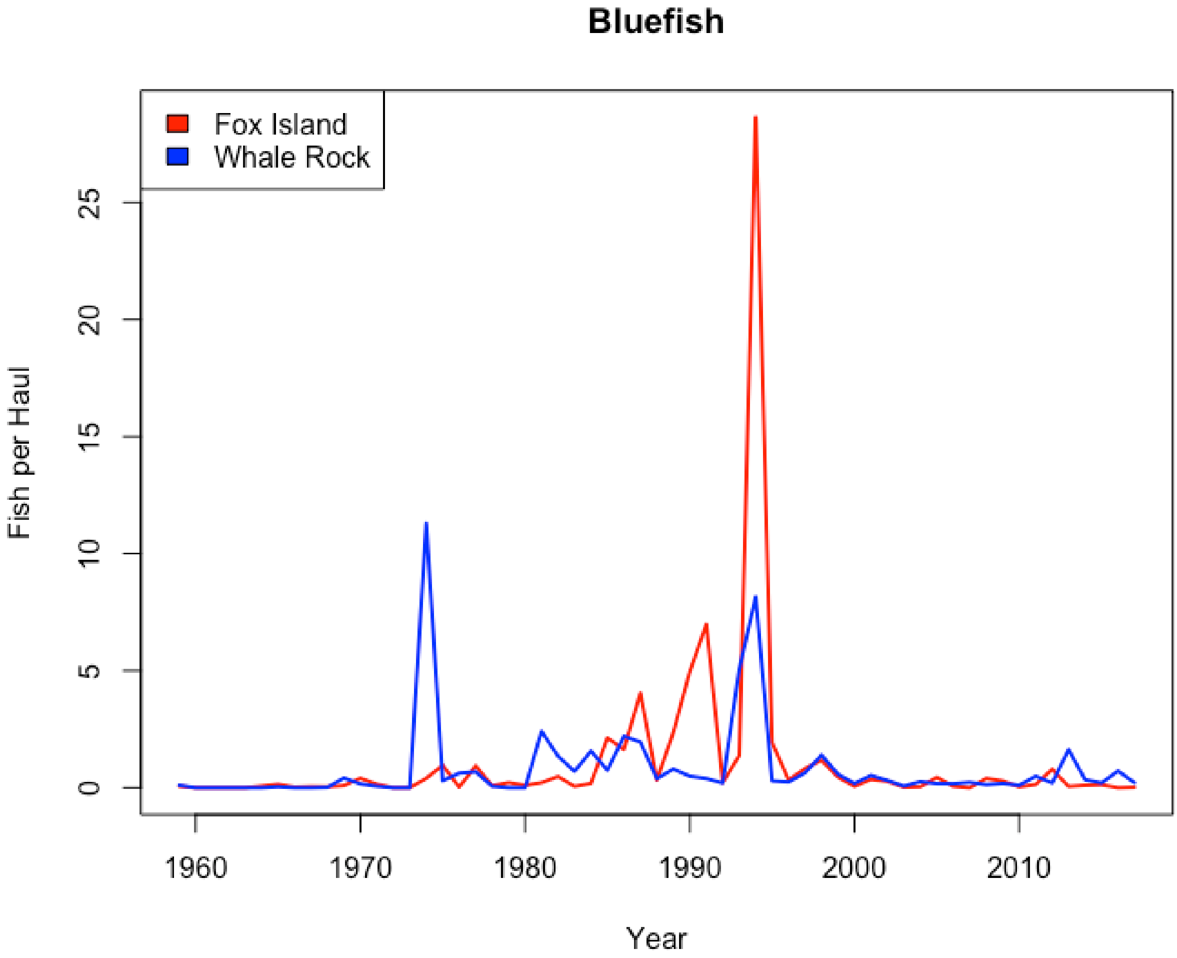
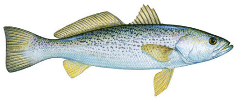


Figure 8 – Survey data for entire time series for bluefish at both sampling stations (Fox Island and Whale Rock).



Weakfish

Weakfish is another of the Mid-Atlantic species caught consistently by the survey, as weakfish use Narragansett Bay as a nursery habitat. The population of weakfish has been variable through the time period of the survey with periods of high abundance in the 1970s and 1990s and periods of very low abundance. There is high variability for this species in the survey data, again mainly due to catching young of the year weakfish as opposed to adults (Figure 9), so this survey is probably a better indicator of recruitment than adult population size. Weakfish are caught at both sampling stations pretty consistently.

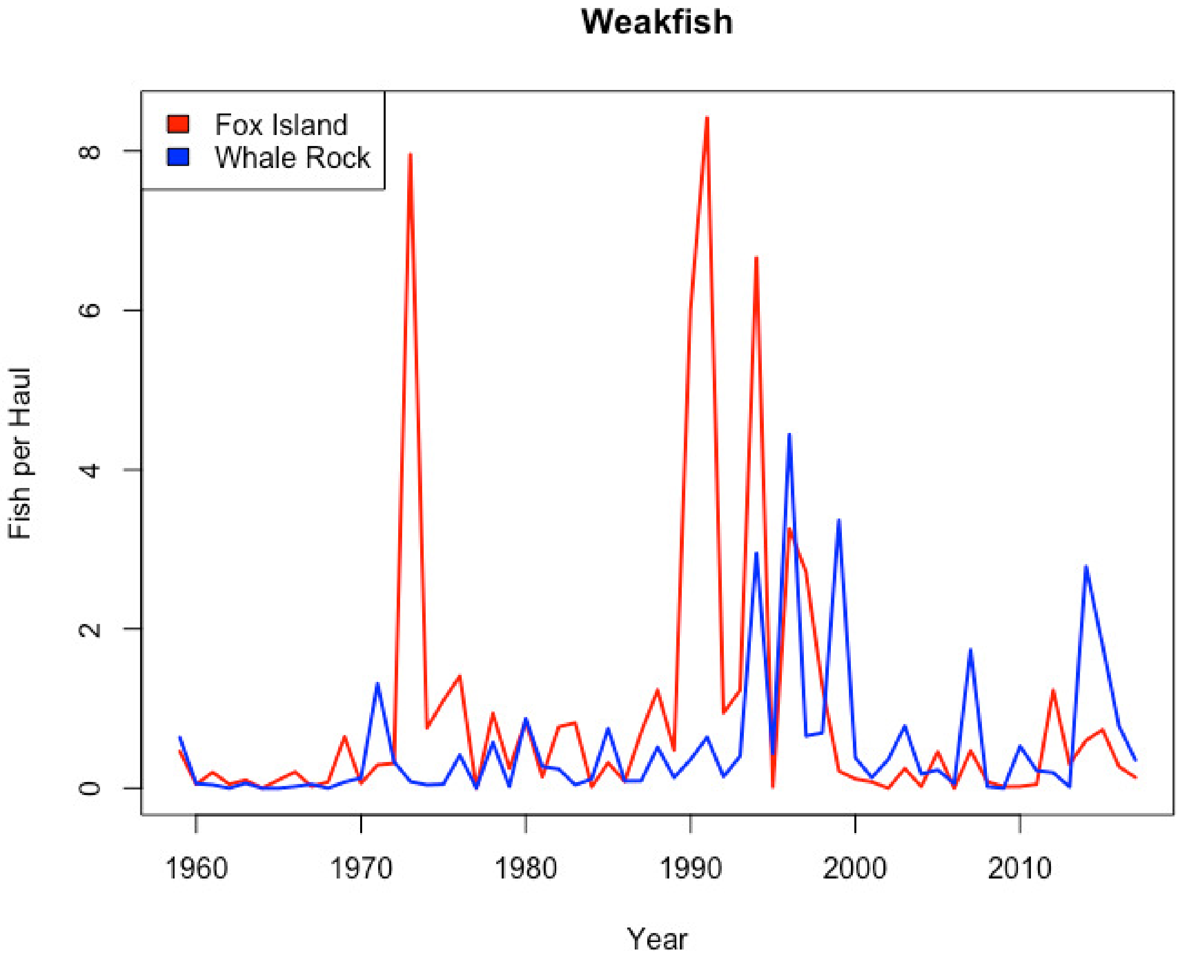


Figure 9 – Survey data for entire time series for weakfish at both sampling stations (Fox Island and Whale Rock).

Striped Bass

Striped bass is probably the premier recreational species caught by the survey. The catch of striped bass has been variable throughout the time period of the survey. Striped bass were rarely caught before 1990, especially during the period of low coast-wide abundance in the 1980s. Frequencies were higher 1990 and 2010. There is high variability for this species in the survey data, but the survey catches both juveniles and adults (Figure 10). Striped bass are caught in greater abundance and frequency at Fox Island than at Whale Rock.

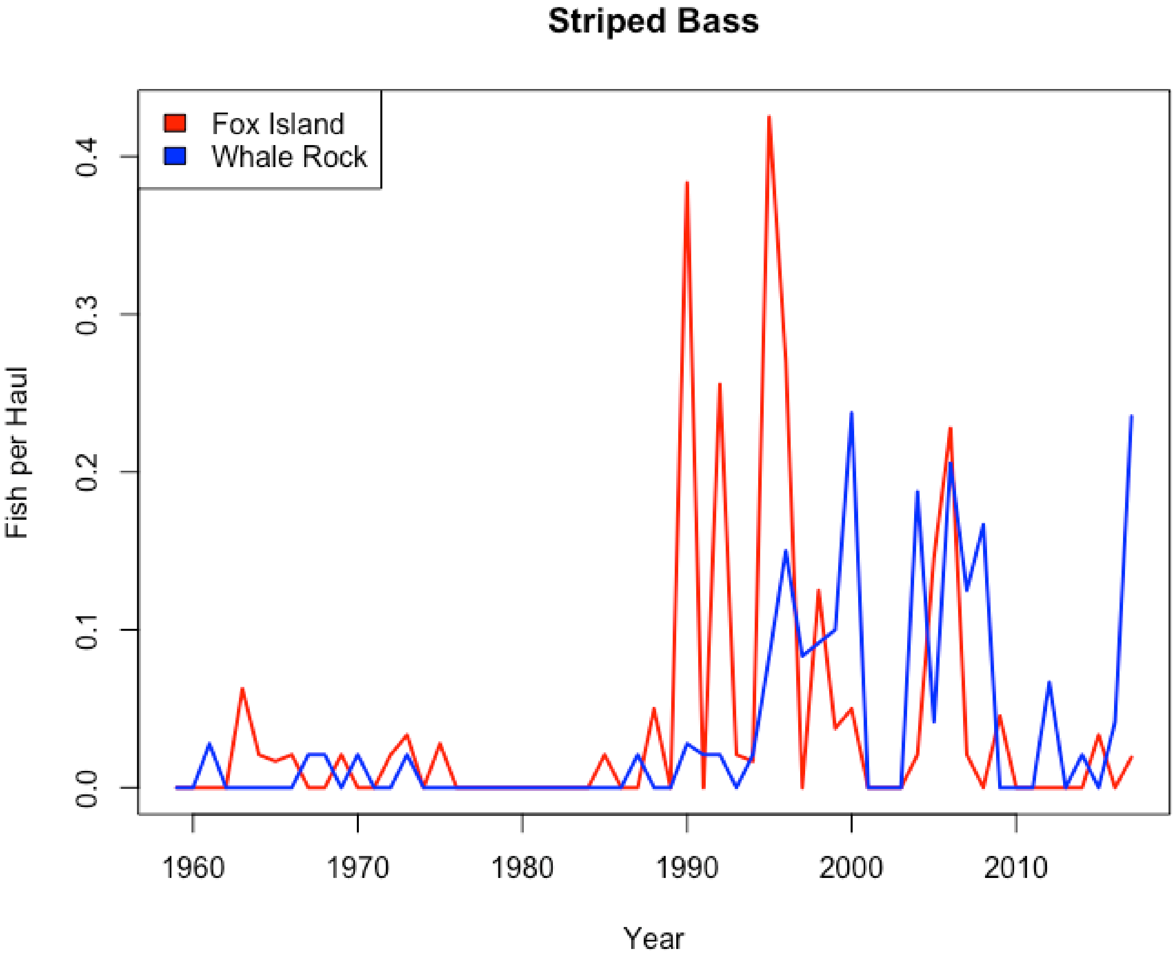


Figure 10 – Survey data for entire time series for striped bass at both sampling stations (Fox Island and Whale Rock).

Menhaden

Menhaden is another of the Mid-Atlantic species caught consistently by the survey. The catch of menhaden has been variable throughout the time period of the survey, mainly due to the schooling pelagic nature of this species. Menhaden were rarely caught prior to 1985 and have been caught in higher numbers since then. There is high variability for this species in the survey data, but the survey mainly catches juveniles (Figure 11). Menhaden are caught in greater abundance and frequency at Fox Island than at Whale Rock. The survey information was reviewed during the stock assessment process for menhaden.

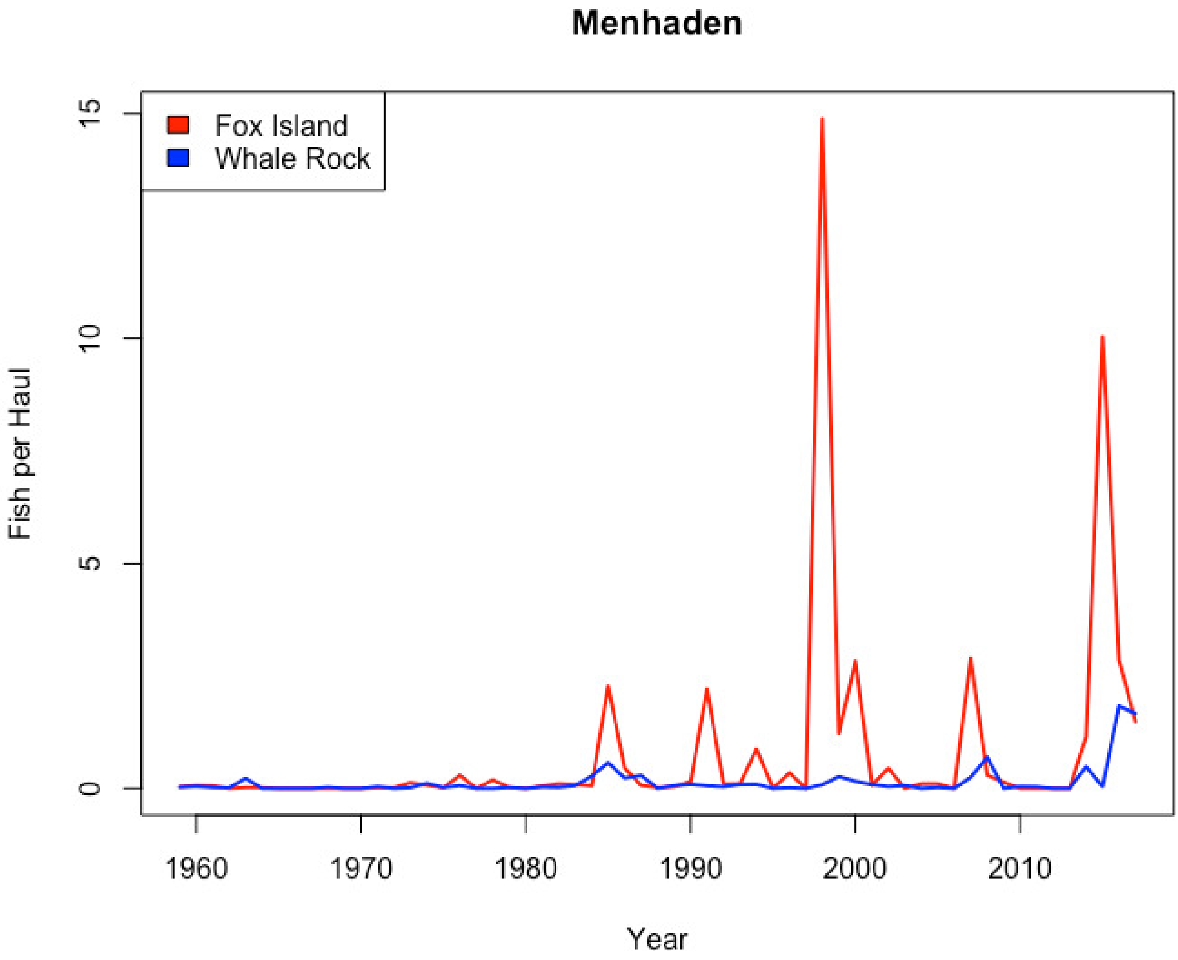


Figure 11 – Survey data for entire time series for menhaden at both sampling stations (Fox Island and Whale Rock)

In general, the abundance trends measured by the GSO/URI trawl survey are consistent with other coast-wide abundance trends for the same species. In addition to measuring the local abundance in Narragansett Bay, this survey contributes to the coast-wide assessment of migratory fish species. It not only extends the time series to almost 60 years, but also provides weekly time resolution.

Special Projects

Summer Flounder Research

A special project on summer flounder was started in 2016 by summer student Adena Schonfeld. Summer flounder collected by the fish trawl were analyzed for sex ratio and stomach contents. This sampling continued through 2017 and was augmented with summer flounder collected on the DEM trawl surveys. This work was presented at the Flatfish Symposium and is being submitted for presentation at the American Fisheries Society 2018 Annual Meeting. A paper is being prepared for publication; the abstract is included below.

Evaluating Summer Flounder (*Paralichthys dentatus)* Sexual Dimorphism in Spatial Distribution in a Southern New England Estuary

Langan, JA, A Schonfeld, MC McManus, C Truesdale, & JS Collie

The summer flounder (*Paralichthys dentatus*) is one of the most commercially- and recreationally-significant finfish on the United States Atlantic coast. Documented sexual dimorphism and recent evidence of spatial patterns in the sex ratio of landings have raised new questions for management of the fishery. In an effort to evaluate and characterize coastal sex-specific habitat preferences, 1328 summer flounder were collected and sexed by visual inspection of the gonad from fishery-independent from the survey between May and October of 2016 and 2017. Statistical analyses of these data revealed that sex ratios among survey stations varied widely as a function of both water depth and season. Here, females were found to prefer shallower habitats and exhibited a longer seasonal residence of inshore habitats than their male counterparts. Validation of the fitted logistic regression model demonstrated that it had high accuracy in predicting spatiotemporal differences in summer flounder sex ratios and could serve as a valuable tool in evaluating spatial considerations in management of the fishery in the future.

Phenology of the Fish Community

The weekly trawl data are being used to investigate how the seasonal residence times (phenology) of fish in Narragansett Bay have changed in response to warming sea temperatures. This study is being prepared for publication.

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