Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

2016 Annual Performance Reports
F-61-R-21
Grant Number: F14AF00182

Jobs 1-14

Note: Jobs 5 and 7 have been completed

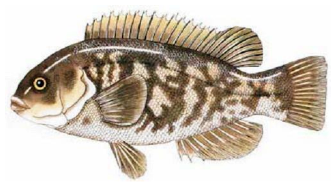
PERIOD: January 1, 2016 – December 31, 2016

Rhode Island Division of Fish and Wildlife

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

COASTAL FISHERY RESOURCE ASSESSMENT
TRAWL SURVEY
2016

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 2017

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, 2016 ï December 31, 2016.

PROJECT SUMMARY: Job 1, summary accomplished:
A: 153 twenty minute bottom trawl were successfully completed.
B: Data on weight, length, sex and numbers were gathered on 65 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 2016

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None
.
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 ï May)/ Fall (September ï October) 2016

PROJECT SUMMARY: Job 2, summary accomplished:
A: 44, twenty minute tows were successfully completed during the Spring 2016 survey (26 NB. ï 6 RIS ï 12 BIS).
B: 44, twenty minute tow were successfully completed during the Fall 2016 survey (26 NB. ï 6 RIS ï 12
C: Data on weight, length, sex and numbers were gathered on

64 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 2016.

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

JOBS 1 & 2

RECOMMENDATIONS: Continuation of both the Monthly and Seasonal Trawl surveys into 2017, 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: 153 tows were completed during 2016 Job 1 (Monthly survey). 65 species accounted for a combined weight of 6,856.2 kgs. and 229,061 length measurements being added to the existing Narragansett Bay monthly trawl data set
By contrast, 88 tows were completed during 2016 Job 2 (Seasonal survey) 64 species accounted for a combined weight of 5,235.4 kgs. and 167,221 length measurements added to the existing seasonal data set.

With the completion of the 2016 surveys, combined survey(s) Jobs (1&2) data now reflects the completion of 6,385 tows with data collected on 132 species.

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PREPARED BY: ________________________ ________________________
Scott D. Olszewski Date
Supervising Marine Fisheries Biologist
Principal Investigator

APPROVED BY: ________________________ ________________________
Jason McNamee Date
Chief, Marine Resources
RIDFW ï Marine Fisheries

Coastal Fishery Resource Assessment ï 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 ï 18.28
	5	13.5	18.28 ï 27.43
	6	9.75	>=27.43
Block Island Sound	7	3.50	<=9.14
	8	10.50	9.14 ï 18.28
	9	11.50	18.28 ï 27.43
	10	12.25	27.43 ï 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 4.5ò, 2 seam (40ô/ 55ô), the mesh size is 4.5ò and the sweep is 5/16ò chain, hung 12ò 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 50ô Wesmac hull, powered by a 3406 Caterpillar engine generating 700 hp.

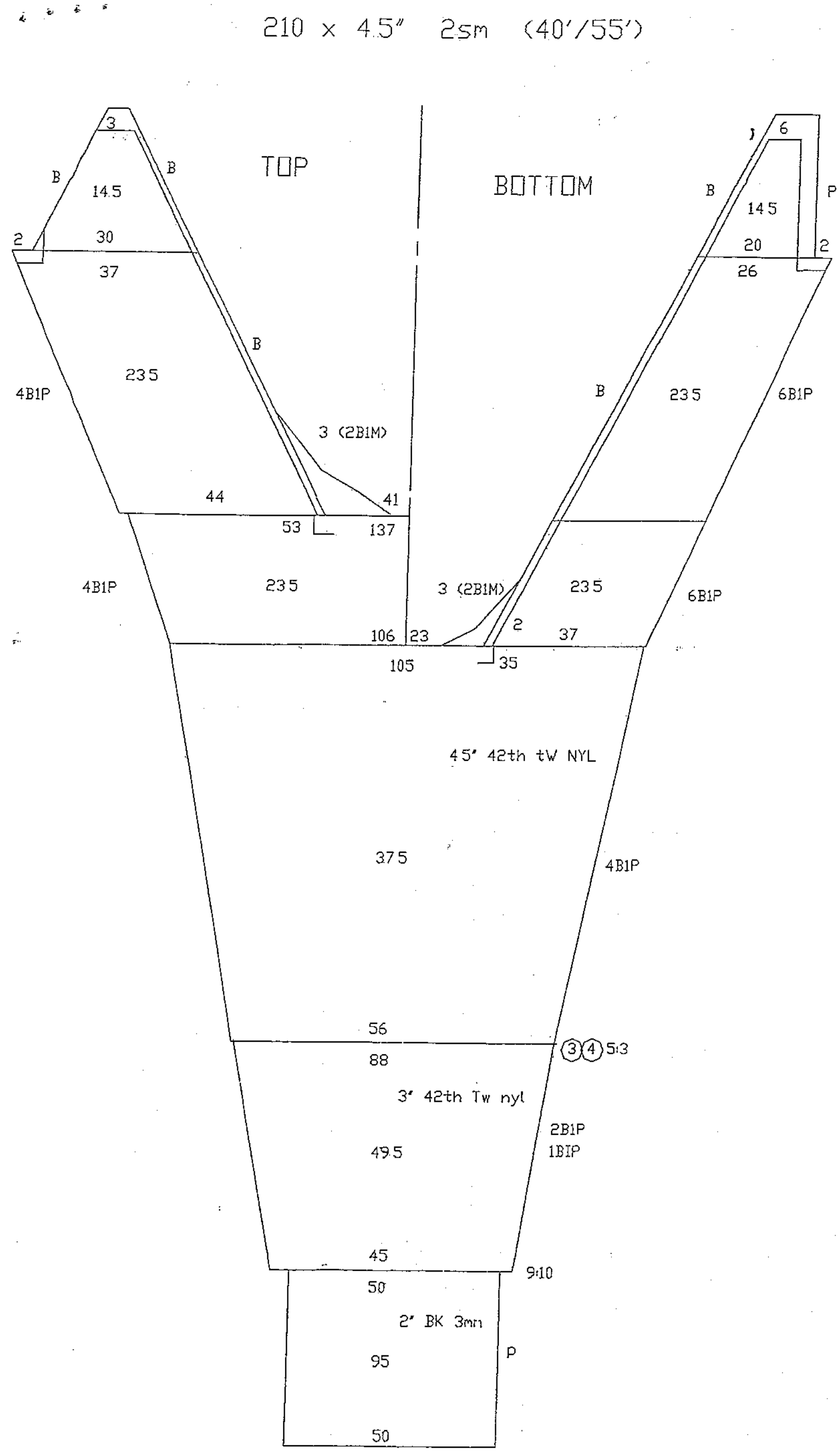
Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, Whelk lobster, blue crabs and horseshoe crabs.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

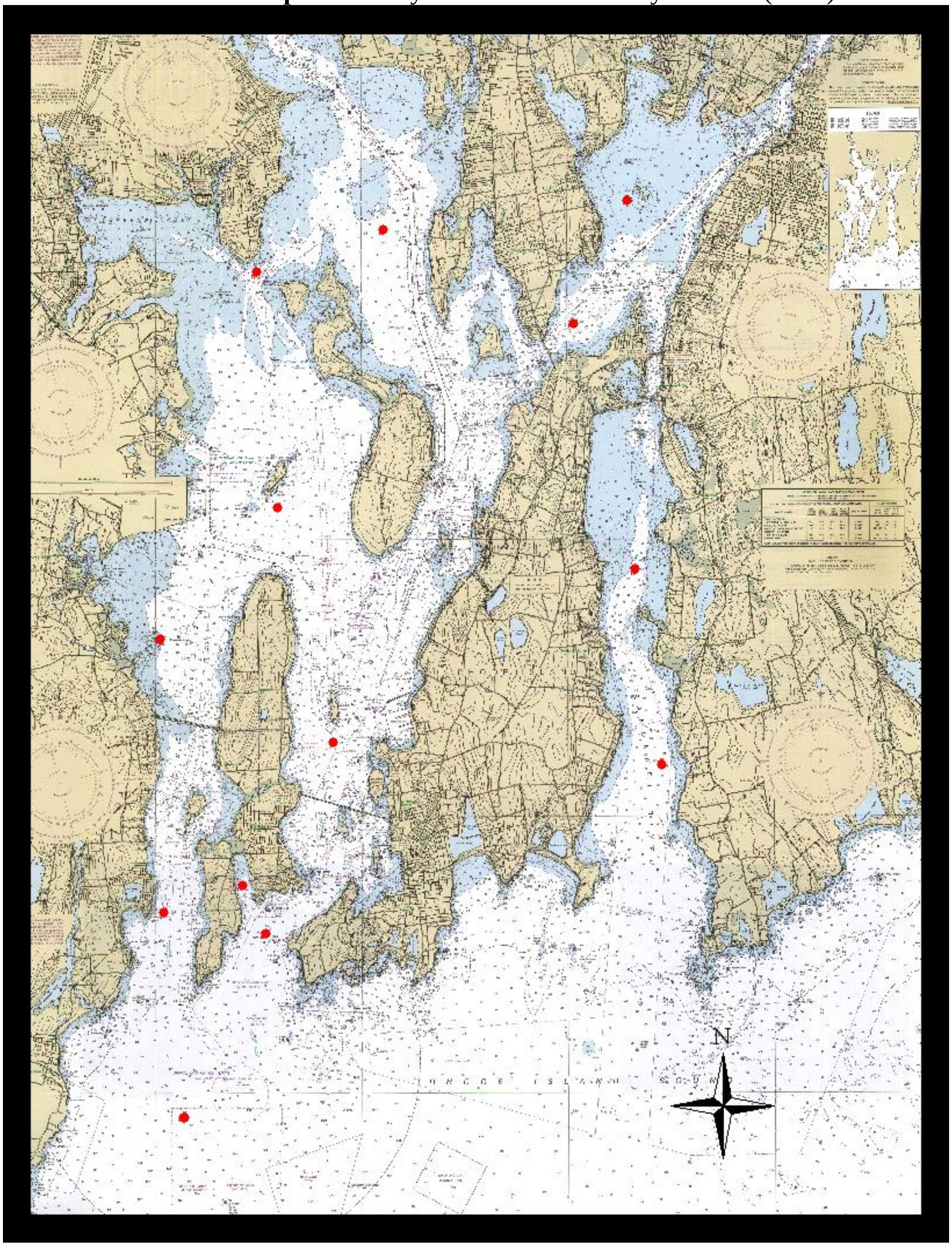
RIDEM R/V John H. Chafee

Acknowledgements:
Special thanks are again extended to Captain Richard Mello and Assistant Captain, Patrick Brown, Chris Parkins, Nichole Ares 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
P
14.5
20
2
26
B
235
6B1P
3 (2B1M)
235
6B1P
2
37
35
45' 42th tW NYL
375
4B1P
56
88
3 4 5:3
3' 42th Tw nyl
2B1P
1B1P
495
45
9:10
50
2' BK 3mn
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 65 species were observed and recorded during the 2016 Narragansett Bay Monthly Trawl Survey totaling 229,061 individuals or 1497.1 fish per tow. In weight, the catch accounted for 6,856.2 kg. or 44.8 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)

Fish Name	Scientific Name	Number
Scup	STENOTOMUS CHRYSOPS	85761
Atlantic Silverside	MENIDIA MENIDIA	32097
Atlantic Herring	CLUPEA HARENGUS	25900
Atlantic Menhaden	BREVOORTIA TYRANNUS	21192
Longfin Squid	LOLIGO PEALEI	18611
Bay Anchovy	ANCHOA MITCHILLI	18037
Butterfish	PEPRILUS TRIACANTHUS	10324
Alewife	ALOSA PSEUDOHARENGUS	7280
Weakfish	CYNOSCION REGALIS	2993
Blueback Herring	ALOSA AESTIVALIS	1416
Atlantic Moonfish	SELENE SETAPINNIS	1396
Little Skate	LEUCORAJA ERINACEA	578
Silver Hake	MERLUCCIUS BILINEARIS	369
American Lobster	HOMARUS AMERICANUS	315
Black Sea Bass	CENTROPRISTIS STRIATA	309
Northern Searobin	PRIONOTUS CAROLINUS	280
Winter Flounder	PLEURONECTES AMERICANUS	277
Spotted Hake	UROPHYCIS REGIA	276
Bluefish	POMATOMUS SALTATRIX	253
Rock Crab	CANCER IRRORATUS	241
Striped Searobin	PRIONOTUS EVOLANS	194
American Shad	ALOSA SAPIDISSIMA	157
Summer Flounder	PARALICHTHYS DENTATUS	149
Smooth Dogfish	MUSTELUS CANIS	107
Tautog	TAUTOGA ONITIS	100
Fourspot Flounder	PARALICHTHYS OBLONGUS	92
Red Hake	UROPHYCIS CHUSS	46
Windowpane Flounder	SCOPHTHALMUS AQUOSUS	40
Northern Kingfish	MENTICIRRHUS SAXATILIS	37
Blue Crab	CALLINECTES SAPIDUS	32

Channeled Whelk	BUSYCOTYPUS CANALICULATUS	32
Horseshoe Crab	LIMULUS POLYPHEMUS	24
Smallmouth Flounder	ETROPUS MICROSTOMUS	24
Clearnose Skate	RAJA EGLANTERIA	17
Rough Scad	TRACHURUS LATHAMI	13
Striped Bass	MORONE SAXATILIS	9
Inshore Lizardfish	SYNODUS FOETENS	8
Blue Runner	CARANX CRYSOS	7
Cunner	TAUTOGOLABRUS ADSPERSUS	7
Winter Skate	LEUCORAJA OCELLATA	6
Longhorn Sculpin	MYOXOCEPHALUS OCTODECEMSPINOS	6
Jonah Crab	CANCER BOREALIS	6
Goosefish	LOPHIUS AMERICANUS	5
Knobbed Whelk	BUSYCON CARICA	5
Atlantic Cod	GADUS MORHUA	5
Oyster Toadfish	OPSANUS TAU	3
Striped Anchovy	ANCHOA HEPSETUS	3
Northern Puffer	SPHOEROIDES MACULATUS	2
Haddock	MELANOGRAMMUS AEGLEFINUS	2
Mantis Shrimp	SQUILLA EMPUSA	2
Sea Lamprey	PETROMYZON MARINUS	2
Northern Pipefish	SYNGNATHUS FUSCUS	2
Spiny Dogfish	SQUALUS ACANTHIAS	1
Striped Burrfish	Chilomycterus schoepfi	1
Rainbow Smelt	OSMERUS MORDAX	1
Crevalle Jack	CARANX HIPPOS	1
Hogchoker	TRINECTES MACULATUS	1
African Pompano	ALECTIS CILIARIS	1
Round Herring	ETRUMEUS TERES	1
Bluespotted Cornetfish	FISTULARIA TABACARIA	1
Threespine Stickleback	GASTEROSTEUS ACULEATUS	1
American Sand Lance	AMMODYTES AMERICANUS	1
Pollock	POLLACHIUS VIRENS	1
Gobies	GOBIIDAE	1

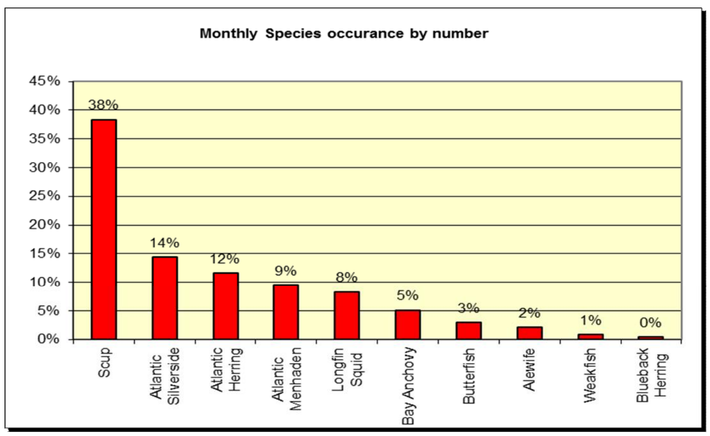
Figure 3 (Total Catch in Kilograms)

Fish Name	Scientific Name	Kg.
Scup	STENOTOMUS CHRYSOPS	3830.442
Atlantic Herring	CLUPEA HARENGUS	561.765
Butterfish	PEPRILUS TRIACANTHUS	448.415
Little Skate	LEUCORAJA ERINACEA	326.310
Longfin Squid	LOLIGO PEALEI	268.645
Tautog	TAUTOGA ONITIS	163.172
Black Sea Bass	CENTROPRISTIS STRIATA	159.345
Alewife	ALOSA PSEUDOHARENGUS	140.589
Summer Flounder	PARALICHTHYS DENTATUS	113.060
Smooth Dogfish	MUSTELUS CANIS	111.485
Atlantic Silverside	MENIDIA MENIDIA	103.830
American Lobster	HOMARUS AMERICANUS	94.450
Atlantic Menhaden	BREVOORTIA TYRANNUS	69.271
Bay Anchovy	ANCHOA MITCHILLI	51.625
Winter Flounder	PLEURONECTES AMERICANUS	47.010
Horseshoe Crab	LIMULUS POLYPHEMUS	46.560
Striped Searobin	PRIONOTUS EVOLANS	44.745
Northern Searobin	PRIONOTUS CAROLINUS	44.263
Weakfish	CYNOSCION REGALIS	42.950
Rock Crab	CANCER IRRORATUS	36.725
Clearnose Skate	RAJA EGLANTERIA	27.335
Fourspot Flounder	PARALICHTHYS OBLONGUS	19.470
Silver Hake	MERLUCCIUS BILINEARIS	14.824
Bluefish	POMATOMUS SALTATRIX	10.415
Winter Skate	LEUCORAJA OCELLATA	9.330
Blueback Herring	ALOSA AESTIVALIS	8.750
Striped Bass	MORONE SAXATILIS	8.280
Windowpane Flounder	SCOPHTHALMUS AQUOSUS	7.742
American Shad	ALOSA SAPIDISSIMA	6.480
Blue Crab	CALLINECTES SAPIDUS	5.600
Channeled Whelk	BUSYCOTYPUS CANALICULATUS	5.520
Spotted Hake	UROPHYCIS REGIA	5.423
Atlantic Moonfish	SELENE SETAPINNIS	3.945
Northern Kingfish	MENTICIRRHUS SAXATILIS	3.905
Red Hake	UROPHYCIS CHUSS	3.525
Spiny Dogfish	SQUALUS ACANTHIAS	2.100
Longhorn Sculpin	MYOXOCEPHALUS OCTODECEMSPINOS	1.950
Goosefish	LOPHIUS AMERICANUS	1.195
Oyster Toadfish	OPSANUS TAU	0.905

Knobbed Whelk	BUSYCON CARICA	0.865
Jonah Crab	CANCER BOREALIS	0.830
Blue Runner	CARANX CRYSOS	0.665
Cunner	TAUTOGOLABRUS ADSPERSUS	0.561
Inshore Lizardfish	SYNODUS FOETENS	0.470
Smallmouth Flounder	ETROPUS MICROSTOMUS	0.276
Rough Scad	TRACHURUS LATHAMI	0.231
Striped Burrfish	Chilomycterus schoepfi	0.205
Northern Puffer	SPHOEROIDES MACULATUS	0.160
Rainbow Smelt	OSMERUS MORDAX	0.100
Crevalle Jack	CARANX HIPPOS	0.095
Haddock	MELANOGRAMMUS AEGLEFINUS	0.090
Hogchoker	TRINECTES MACULATUS	0.065
Mantis Shrimp	SQUILLA EMPUSA	0.045
Striped Anchovy	ANCHOA HEPSETUS	0.035
Round Herring	ETRUMEUS TERES	0.025
African Pompano	ALECTIS CILIARIS	0.025
Bluespotted Cornetfish	FISTULARIA TABACARIA	0.015
Sea Lamprey	PETROMYZON MARINUS	0.015
Threespine Stickleback	GASTEROSTEUS ACULEATUS	0.010
Atlantic Cod	GADUS MORHUA	0.009
Northern Pipefish	SYNGNATHUS FUSCUS	0.006
American Sand Lance	AMMODYTES AMERICANUS	0.005
Pollock	POLLACHIUS VIRENS	0.001
Gobies	GOBIIDAE	0.001

Figure 4 Monthly Survey Top Ten Species Catch in Number

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	38%
Atlantic Silverside	MENIDIA MENIDIA	14%
Atlantic Herring	CLUPEA HARENGUS	12%
Atlantic Menhaden	BREVOORTIA TYRANNUS	9%
Longfin Squid	LOLIGO PEALEI	8%
Bay Anchovy	ANCHOA MITCHILLI	5%
Butterfish	PEPRILUS TRIACANTHUS	3%
Alewife	ALOSA PSEUDOHARENGUS	2%
Weakfish	CYNOSCION REGALIS	1%
Blueback Herring	ALOSA AESTIVALIS	0%



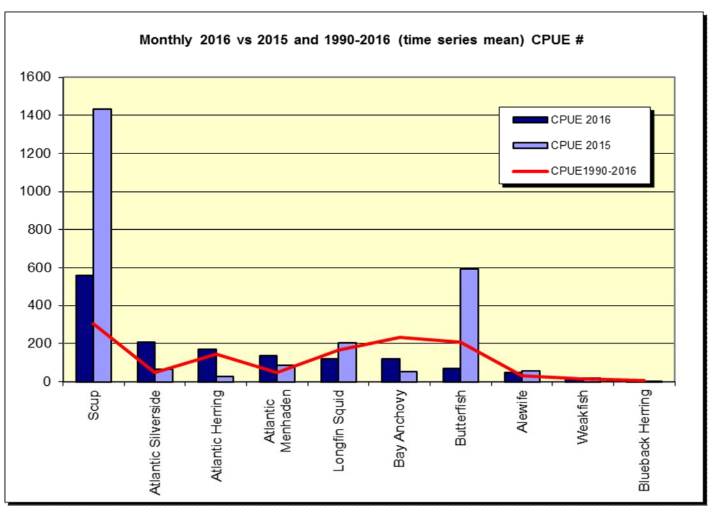
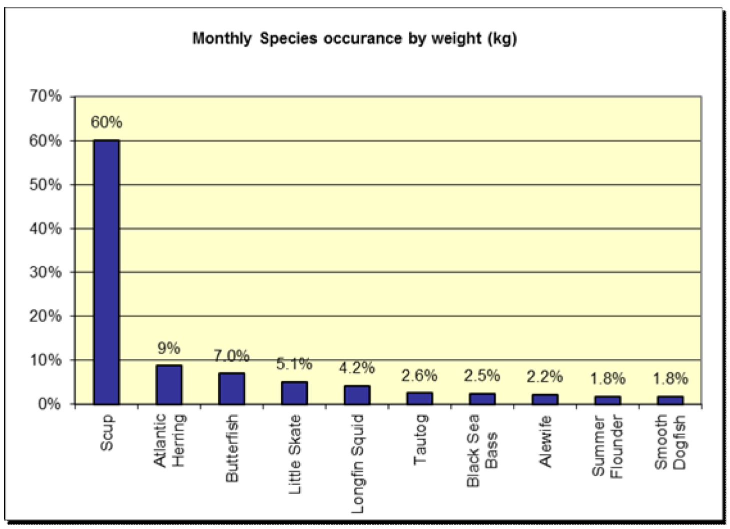
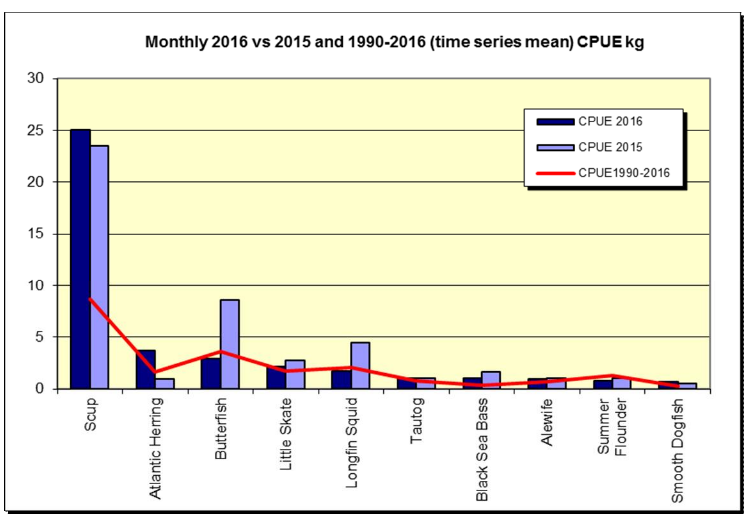


Figure 5 Top Ten Species Catch in Kilograms

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	60%
Atlantic Herring	CLUPEA HARENGUS	9%
Butterfish	PEPRILUS TRIACANTHUS	7.0%
Little Skate	LEUCORAJA ERINACEA	5.1%
Longfin Squid	LOLIGO PEALEI	4.2%
Tautog	TAUTOGA ONITIS	2.6%
Black Sea Bass	CENTROPRISTIS STRIATA	2.5%
Alewife	ALOSA PSEUDOHARENGUS	2.2%
Summer Flounder	PARALICHTHYS DENTATUS	1.8%
Smooth Dogfish	MUSTELUS CANIS	1.8%

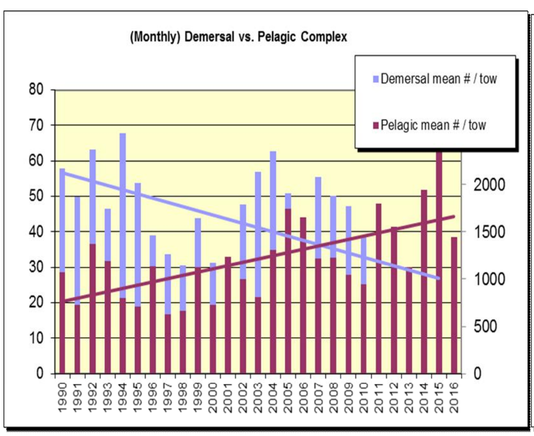


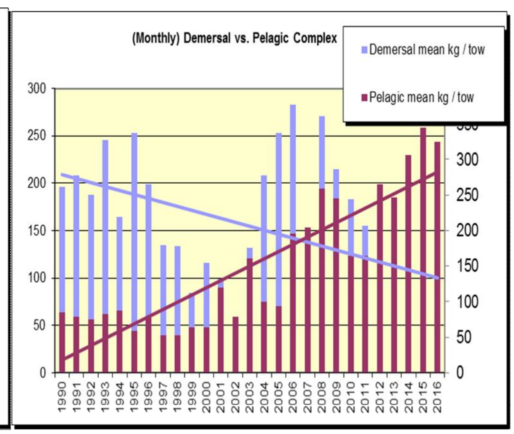


Demersal vs. Pelagic Species Complex

Demersal Species	**Pelagic/Multi-Habitat Species**
Cunner	Alewife
Four Spot Flounder	Atlantic Herring
Goosefish	Atlantic Moonfish
Hog Choker	Bay Anchovy
Lobster	Black Sea Bass
Longhorn Sculpin	Blueback Herring
Northern Searobin	Bluefish
Ocean Pout	Butterfish
Red Hake	Longfin Squid
Sea Raven	Menhaden
Silver Hake	Rainbow Smelt
Skates	Scup
Smooth Dogfish	Shad
Spiny Dogfish	Silverside
Spotted Hake	Striped Bass
Striped Searobin	Weakfish
Summer Flounder	
Tautog	
Windowpane Flounder	
Winter Flounder	

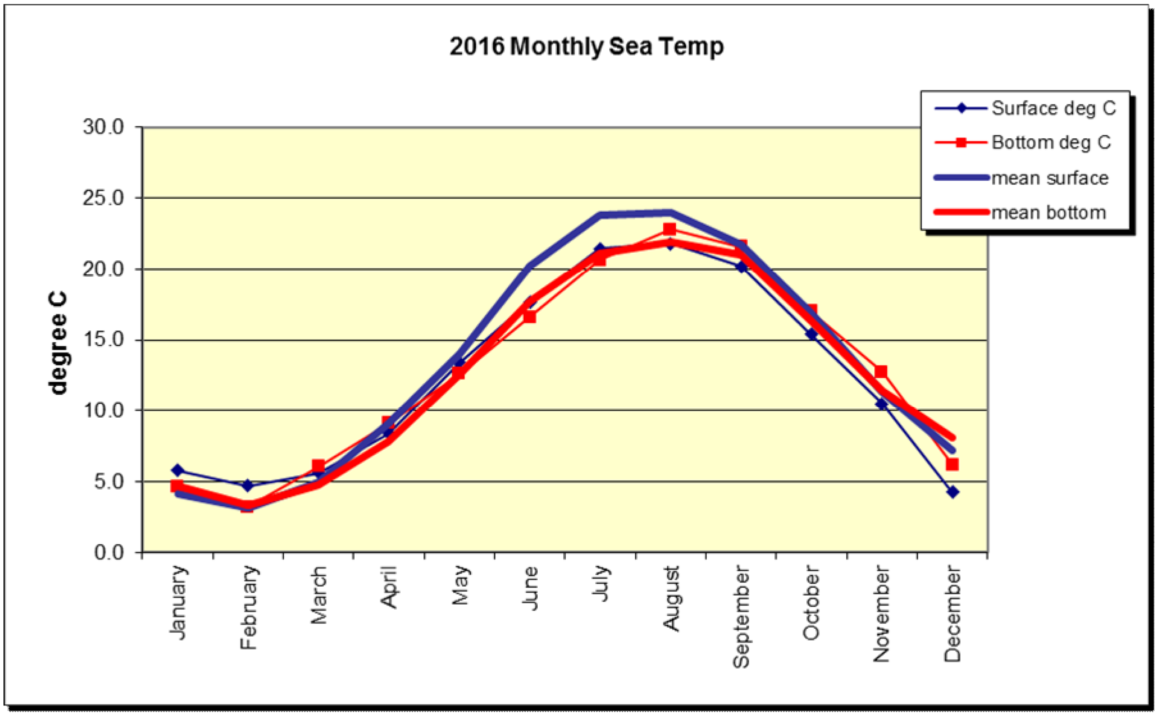
Figure 6 and 7

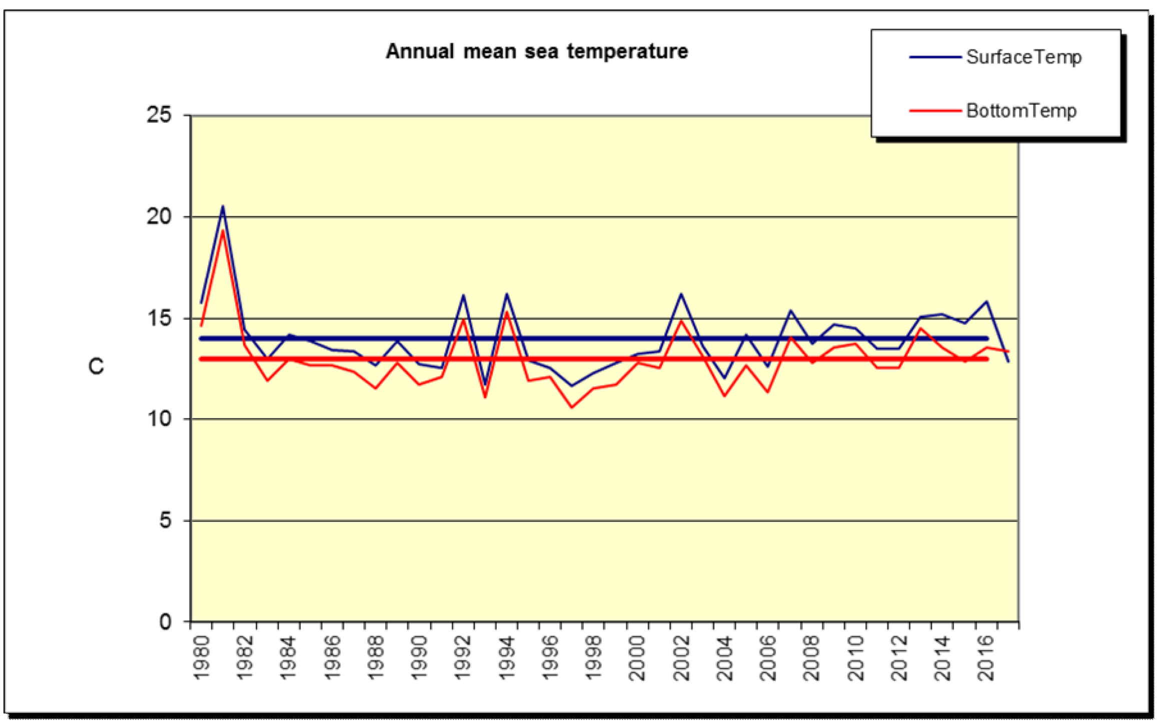




Survey Temperature Profile (Annual mean surface and bottom temperature)

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.
64 species were observed and recorded during the 2015 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)

Fish Name	Scientific Name	Number
Scup	STENOTOMUS CHRYSOPS	221613
Butterfish	PEPRILUS TRIACANTHUS	31804
Longfin Squid	LOLIGO PEALEI	19662
Bay Anchovy	ANCHOA MITCHILLI	6539
Atlantic Moonfish	SELENE SETAPINNIS	2271
Weakfish	CYNOSCION REGALIS	2003
Bluefish	POMATOMUS SALTATRIX	1195
Atlantic Herring	CLUPEA HARENGUS	1147
Atlantic Menhaden	BREVOORTIA TYRANNUS	1142
Little Skate	LEUCORAJA ERINACEA	810
Alewife	ALOSA PSEUDOHARENGUS	801
Atlantic Cod	GADUS MORHUA	267
Blueback Herring	ALOSA AESTIVALIS	251
Northern Kingfish	MENTICIRRHUS SAXATILIS	176
Summer Flounder	PARALICHTHYS DENTATUS	164
Winter Flounder	PLEURONECTES AMERICANUS	159
Rock Crab	CANCER IRRORATUS	141
Black Sea Bass	CENTROPRISTIS STRIATA	137
Striped Searobin	PRIONOTUS EVOLANS	133
Winter Skate	LEUCORAJA OCELLATA	88
Spotted Hake	UROPHYCIS REGIA	84
American Shad	ALOSA SAPIDISSIMA	76
Rough Scad	TRACHURUS LATHAMI	76
Atlantic Silverside	MENIDIA MENIDIA	68
American Sand Lance	AMMODYTES AMERICANUS	63
Smooth Dogfish	MUSTELUS CANIS	54
American Lobster	HOMARUS AMERICANUS	51
Red Hake	UROPHYCIS CHUSS	41
Windowpane Flounder	SCOPHTHALMUS AQUOSUS	39
Clearnose Skate	RAJA EGLANTERIA	37
Longhorn Sculpin	MYOXOCEPHALUS OCTODECEMSPINOS	29

Horseshoe Crab	LIMULUS POLYPHEMUS	28
Ocean Pout	MACROZOARCES AMERICANUS	26
Northern Puffer	SPHOEROIDES MACULATUS	24
Inshore Lizardfish	SYNODUS FOETENS	20
Channeled Whelk	BUSYCOTYPUS CANALICULATUS	19
Silver Hake	MERLUCCIUS BILINEARIS	19
Smallmouth Flounder	ETROPUS MICROSTOMUS	16
Tautog	TAUTOGA ONITIS	14
Knobbed Whelk	BUSYCON CARICA	11
Blue Crab	CALLINECTES SAPIDUS	7
Jonah Crab	CANCER BOREALIS	6
Fourspot Flounder	PARALICHTHYS OBLONGUS	6
Sea Scallop	PLACOPECTEN MAGELLANICUS	6
Striped Anchovy	ANCHOA HEPSETUS	5
Mantis Shrimp	SQUILLA EMPUSA	5
Yellowtail Flounder	LIMANDA FERRUGINEUS	4
Northern Pipefish	SYNGNATHUS FUSCUS	3
Cunner	TAUTOGOLABRUS ADSPERSUS	3
Northern Searobin	PRIONOTUS CAROLINUS	3
Grubby	MYOXOCEPHALUS AENAEUS	2
Bluespotted Cornetfish	FISTULARIA TABACARIA	2
Round Scad	DECAPTERUS PUNCTATUS	1
Sea Raven	HEMITRIPTERUS AMERICANUS	1
Blue Runner	CARANX CRYSOS	1
Atlantic Mackerel	SCOMBER SCOMBRUS	1
Striped Cusk Eel	OPHIDION MARGINATUM	1
Northern Sennet	SPHYRAENA BOREALIS	1
Rainbow Smelt	OSMERUS MORDAX	1
Crevalle Jack	CARANX HIPPOS	1
Haddock	MELANOGRAMMUS AEGLEFINUS	1
Bigeye	PRIACANTHUS ARENATUS	1
Goosefish	LOPHIUS AMERICANUS	1
Dwarf Goatfish	UPENEUS PARVUS	1

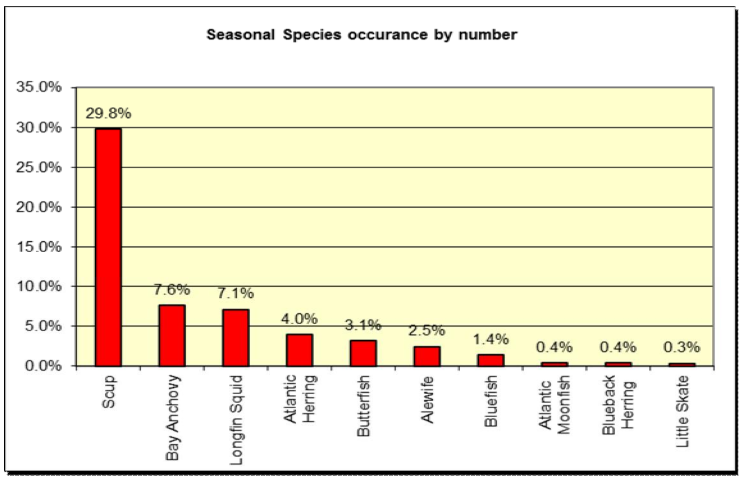
Figure 9 (Total Catch in Kilograms)

Fish Name	Scientific Name	Kg
Scup	STENOTOMUS CHRYSOPS	1842.040
Butterfish	PEPRILUS TRIACANTHUS	584.420
Longfin Squid	LOLIGO PEALEI	554.715
Little Skate	LEUCORAJA ERINACEA	468.095
Summer Flounder	PARALICHTHYS DENTATUS	123.750
Winter Skate	LEUCORAJA OCELLATA	88.520
Weakfish	CYNOSCION REGALIS	81.695
Black Sea Bass	CENTROPRISTIS STRIATA	69.287
Horseshoe Crab	LIMULUS POLYPHEMUS	59.045
Smooth Dogfish	MUSTELUS CANIS	58.985
Bluefish	POMATOMUS SALTATRIX	58.680
Clearnose Skate	RAJA EGLANTERIA	47.750
Winter Flounder	PLEURONECTES AMERICANUS	41.460
Striped Searobin	PRIONOTUS EVOLANS	36.250
Ocean Pout	MACROZOARCES AMERICANUS	24.235
Atlantic Moonfish	SELENE SETAPINNIS	17.906
Alewife	ALOSA PSEUDOHARENGUS	16.865
American Lobster	HOMARUS AMERICANUS	15.830
Rock Crab	CANCER IRRORATUS	13.208
Longhorn Sculpin	MYOXOCEPHALUS OCTODECEMSPINOS	12.885
Tautog	TAUTOGA ONITIS	11.420
Windowpane Flounder	SCOPHTHALMUS AQUOSUS	10.250
Northern Kingfish	MENTICIRRHUS SAXATILIS	9.965
Bay Anchovy	ANCHOA MITCHILLI	6.437
Atlantic Menhaden	BREVOORTIA TYRANNUS	5.841
Channeled Whelk	BUSYCOTYPUS CANALICULATUS	3.670
Blueback Herring	ALOSA AESTIVALIS	2.955
Knobbed Whelk	BUSYCON CARICA	2.745
Yellowtail Flounder	LIMANDA FERRUGINEUS	2.550
Spotted Hake	UROPHYCIS REGIA	2.518
Rough Scad	TRACHURUS LATHAMI	2.515
American Shad	ALOSA SAPIDISSIMA	2.315
Goosefish	LOPHIUS AMERICANUS	2.300
Inshore Lizardfish	SYNODUS FOETENS	2.010
Atlantic Herring	CLUPEA HARENGUS	2.003
Sea Raven	HEMITRIPTERUS AMERICANUS	1.590
Blue Crab	CALLINECTES SAPIDUS	1.125
Fourspot Flounder	PARALICHTHYS OBLONGUS	1.030
Cunner	TAUTOGOLABRUS ADSPERSUS	1.010
Red Hake	UROPHYCIS CHUSS	0.815
Jonah Crab	CANCER BOREALIS	0.775

Northern Puffer	SPHOEROIDES MACULATUS	0.645
Northern Searobin	PRIONOTUS CAROLINUS	0.570
Silver Hake	MERLUCCIUS BILINEARIS	0.490
Sea Scallop	PLACOPECTEN MAGELLANICUS	0.480
American Sand Lance	AMMODYTES AMERICANUS	0.476
Atlantic Silverside	MENIDIA MENIDIA	0.366
Mantis Shrimp	SQUILLA EMPUSA	0.220
Atlantic Cod	GADUS MORHUA	0.144
Blue Runner	CARANX CRYSOS	0.110
Northern Sennet	SPHYRAENA BOREALIS	0.105
Bluespotted Cornetfish	FISTULARIA TABACARIA	0.080
Smallmouth Flounder	ETROPUS MICROSTOMUS	0.079
Crevalle Jack	CARANX HIPPOS	0.070
Atlantic Mackerel	SCOMBER SCOMBRUS	0.065
Striped Anchovy	ANCHOA HEPSETUS	0.040
Dwarf Goatfish	UPENEUS PARVUS	0.035
Round Scad	DECAPTERUS PUNCTATUS	0.035
Haddock	MELANOGRAMMUS AEGLEFINUS	0.030
Bigeye	PRIACANTHUS ARENATUS	0.025
Striped Cusk Eel	OPHIDION MARGINATUM	0.025
Grubby	MYOXOCEPHALUS AENAEUS	0.018
Northern Pipefish	SYNGNATHUS FUSCUS	0.010
Rainbow Smelt	OSMERUS MORDAX	0.010

Figure 10 Top Ten Species Catch in Number

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	29.8%
Bay Anchovy	ANCHOA MITCHILLI	7.6%
Longfin Squid	LOLIGO PEALEI	7.1%
Atlantic Herring	CLUPEA HARENGUS	4.0%
Butterfish	PEPRILUS TRIACANTHUS	3.1%
Alewife	ALOSA PSEUDOHARENGUS	2.5%
Bluefish	POMATOMUS SALTATRIX	1.4%
Atlantic Moonfish	SELENE SETAPINNIS	0.4%
Blueback Herring	ALOSA AESTIVALIS	0.4%
Little Skate	LEUCORAJA ERINACEA	0.3%



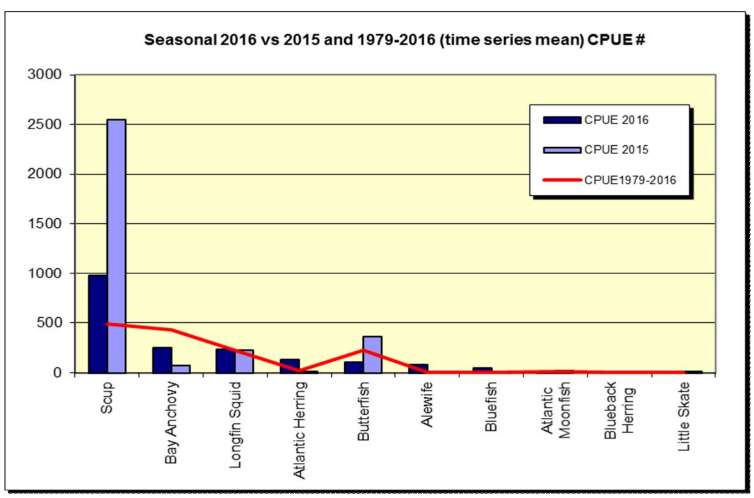
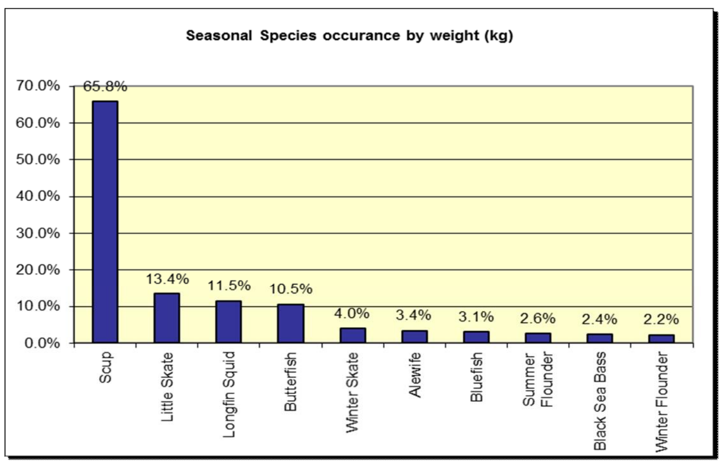
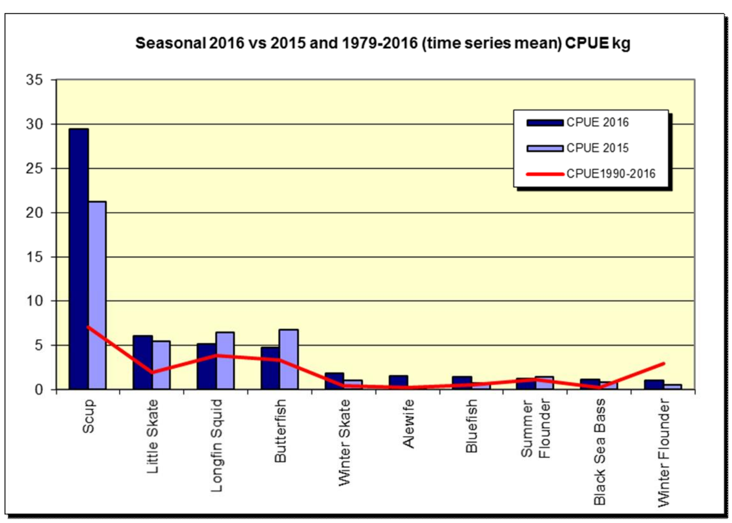


Figure 11 Top Ten Species Catch in Kilograms

Fish Name	Scientific Name	%
Scup	STENOTOMUS CHRYSOPS	65.8%
Little Skate	LEUCORAJA ERINACEA	13.4%
Longfin Squid	LOLIGO PEALEI	11.5%
Butterfish	PEPRILUS TRIACANTHUS	10.5%
Winter Skate	LEUCORAJA OCELLATA	4.0%
Alewife	ALOSA PSEUDOHARENGUS	3.4%
Bluefish	POMATOMUS SALTATRIX	3.1%
Summer Flounder	PARALICHTHYS DENTATUS	2.6%
Black Sea Bass	CENTROPRISTIS STRIATA	2.4%
Winter Flounder	PLEURONECTES AMERICANUS	2.2%

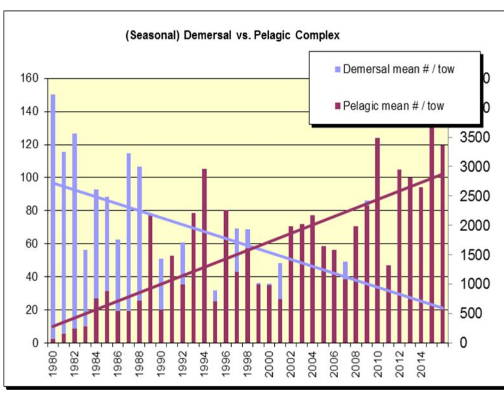


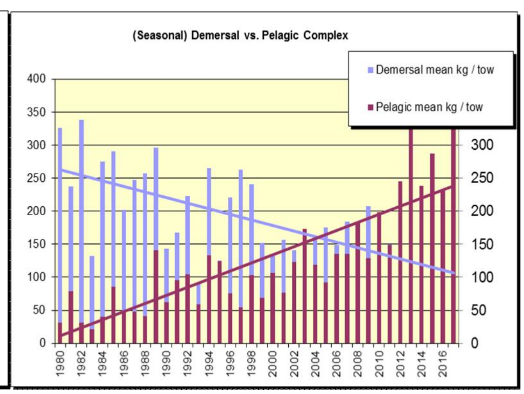


Demersal vs. Pelagic Species Complex

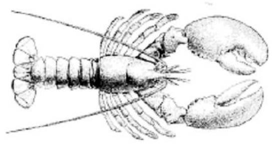
Demersal Species	**Pelagic/Multi-Habitat Species**
Cunner	Alewife
Four Spot Flounder	Atlantic Herring
Goosefish	Atlantic Moonfish
Hog Choker	Bay Anchovy
Lobster	Black Sea Bass
Longhorn Sculpin	Blueback Herring
Northern Searobin	Bluefish
Ocean Pout	Butterfish
Red Hake	Longfin Squid
Sea Raven	Menhaden
Silver Hake	Rainbow Smelt
Skates	Scup
Smooth Dogfish	Shad
Spiny Dogfish	Silverside
Spotted Hake	Striped Bass
Striped Searobin	Weakfish
Summer Flounder	
Tautog	
Windowpane Flounder	
Winter Flounder	

Figure 12 and 13



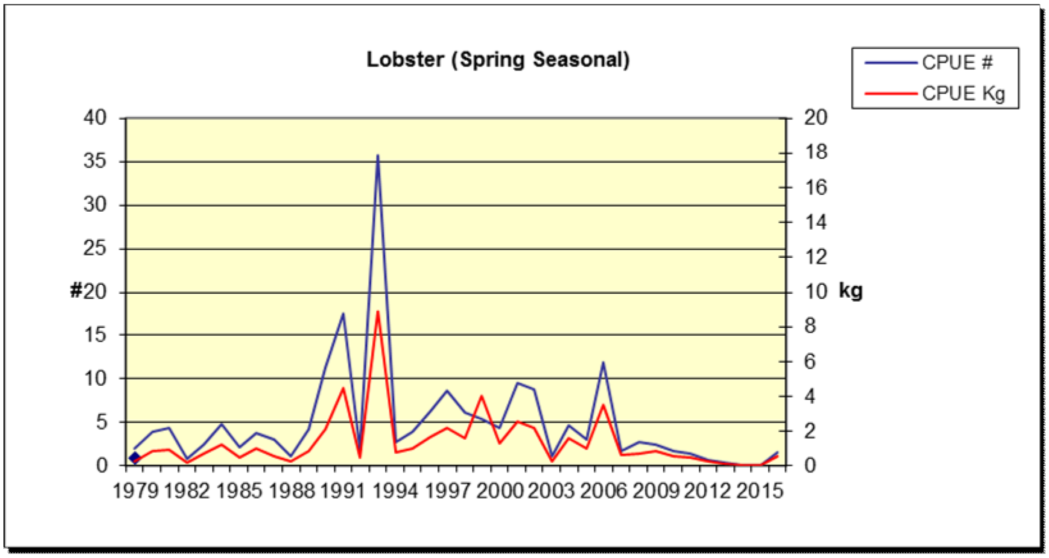


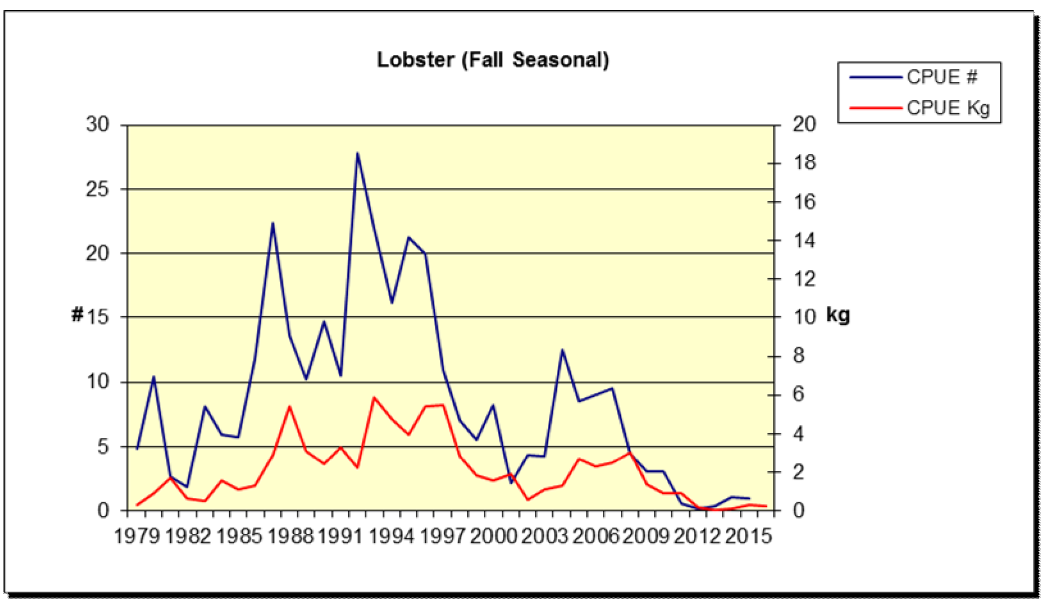
The following species represented are of high importance and are currently managed under fishery management plans through the Atlantic States Marine Fisheries Commission, New England Fishery Management Council, or the National Marine Fisheries Service. The seasonal portion of the Rhode Island Coastal 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***

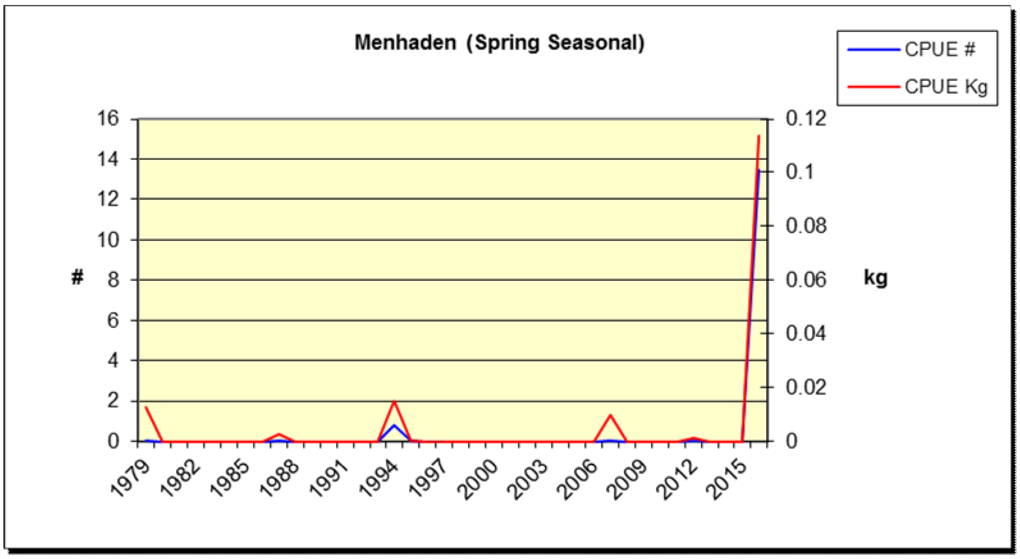
Stock Status: Southern New England Stock: overfished. Depleted Poor condition.
Management: ASMFC Amendment III, Addendum XXV

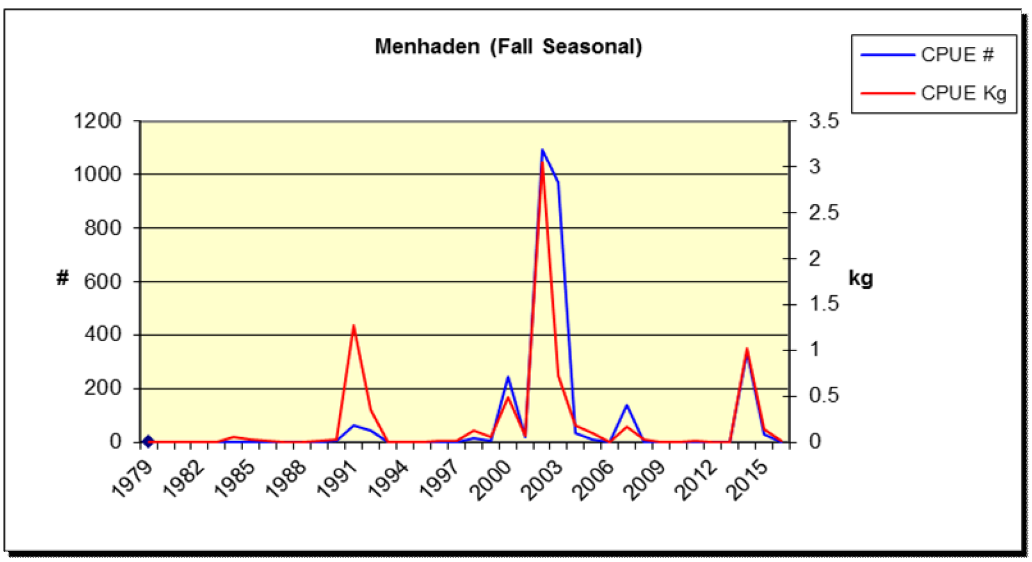




Atlantic Menhaden ***Brevoortia tyrannus***

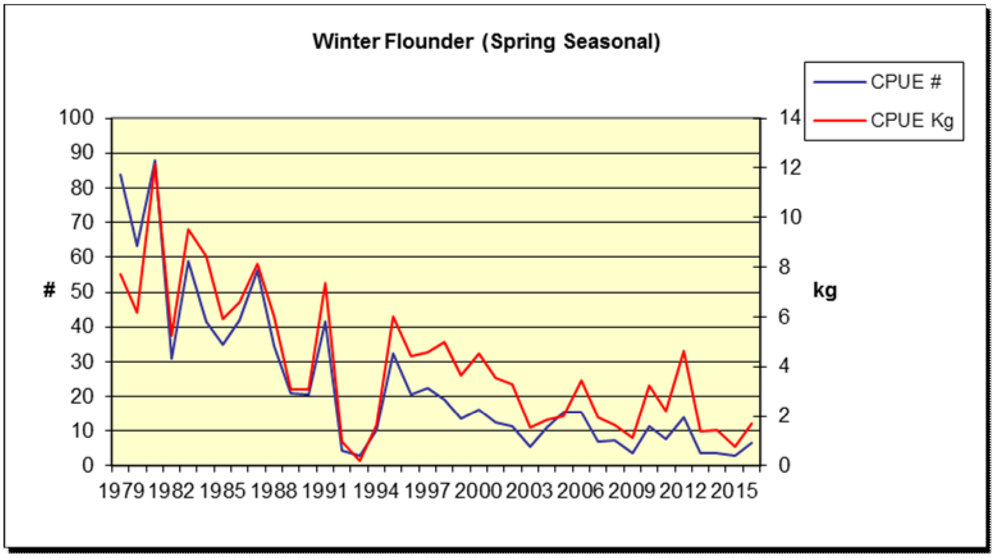
Stock Status: Not Overfished and overfishing is not occurring.
Management: ASMFC Amendment II, Addendum I

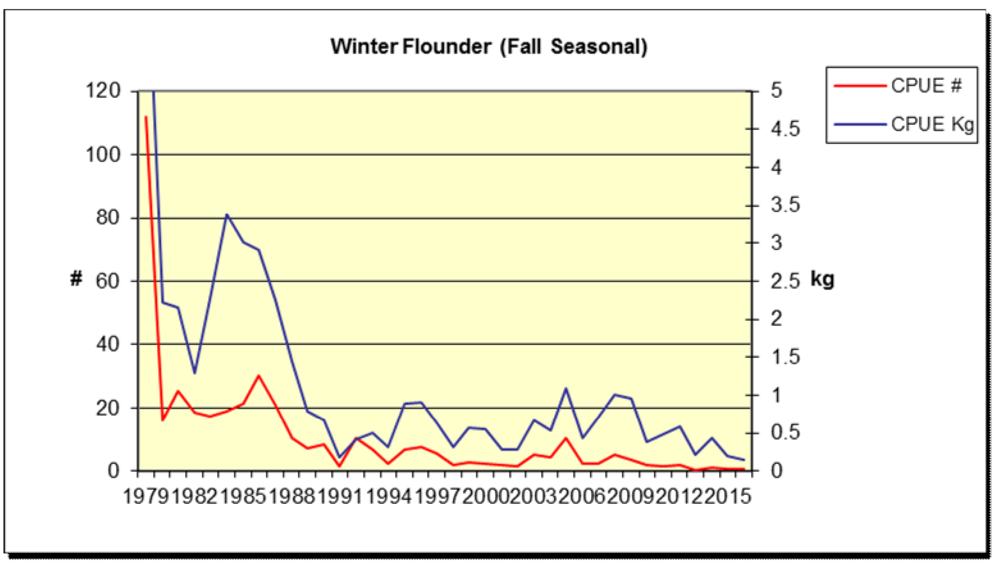


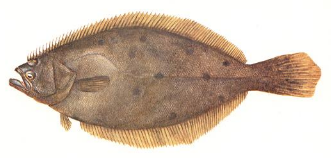


Winter Flounder ***Pleuronectes americanus***

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

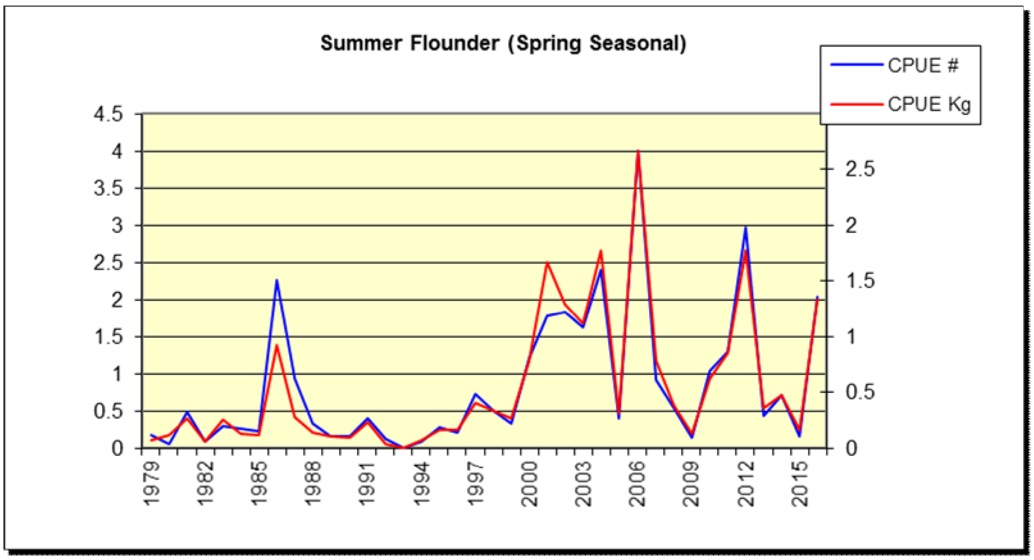


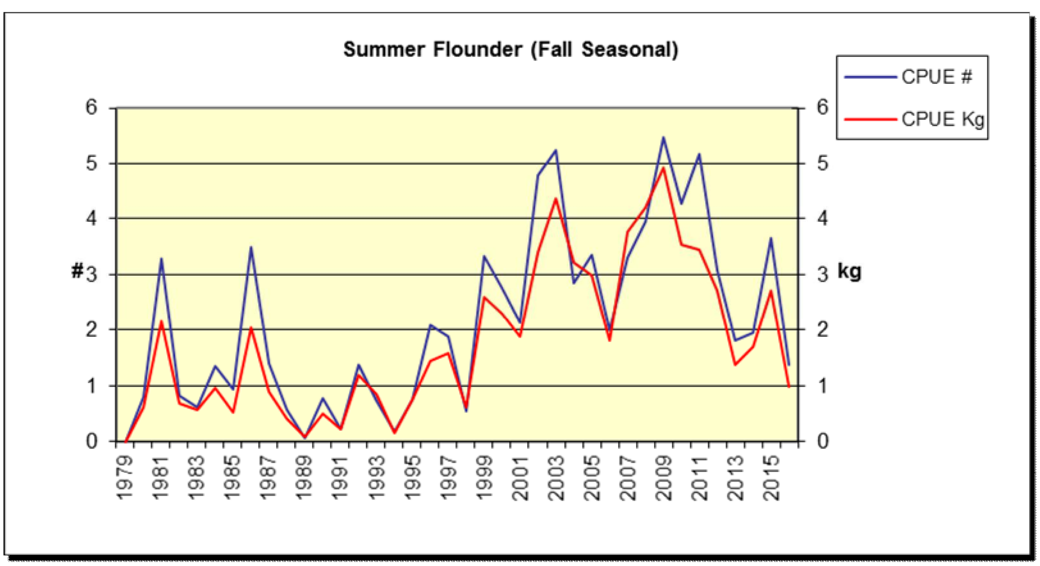


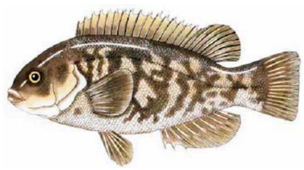


Summer Flounder ***Paralichthys dentatus***

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

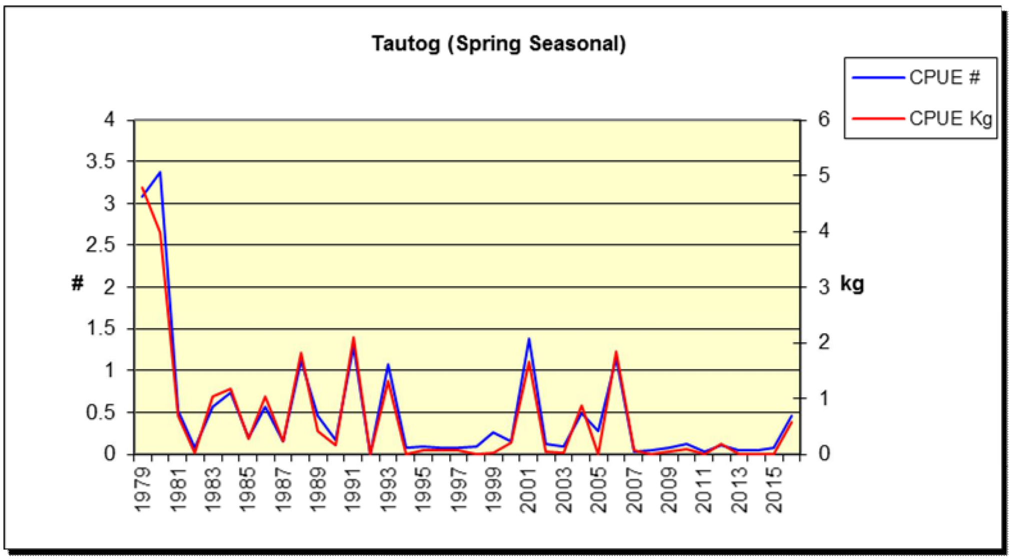


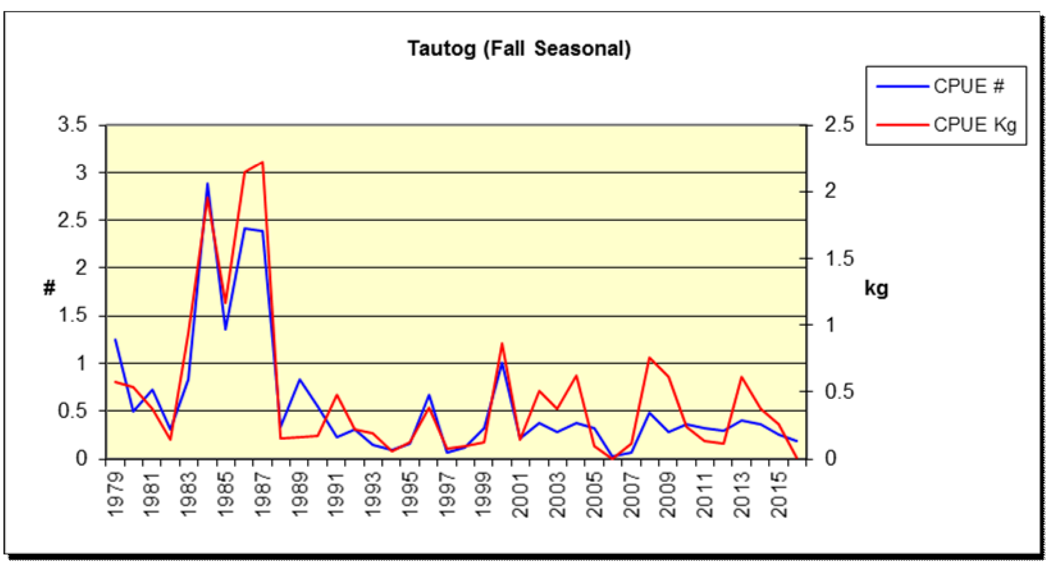


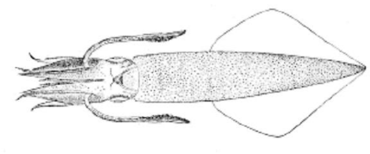


Tautog *Tautoga onitis*

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

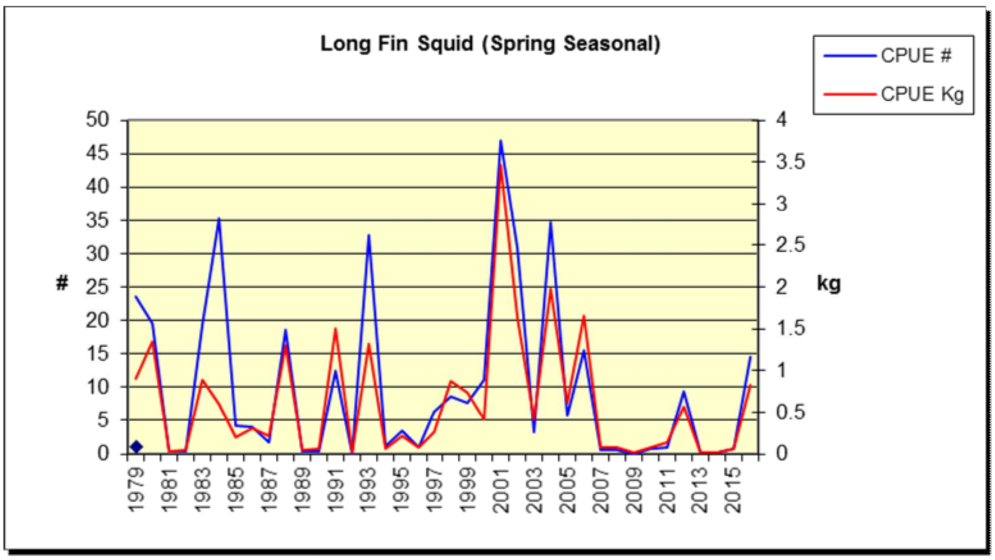


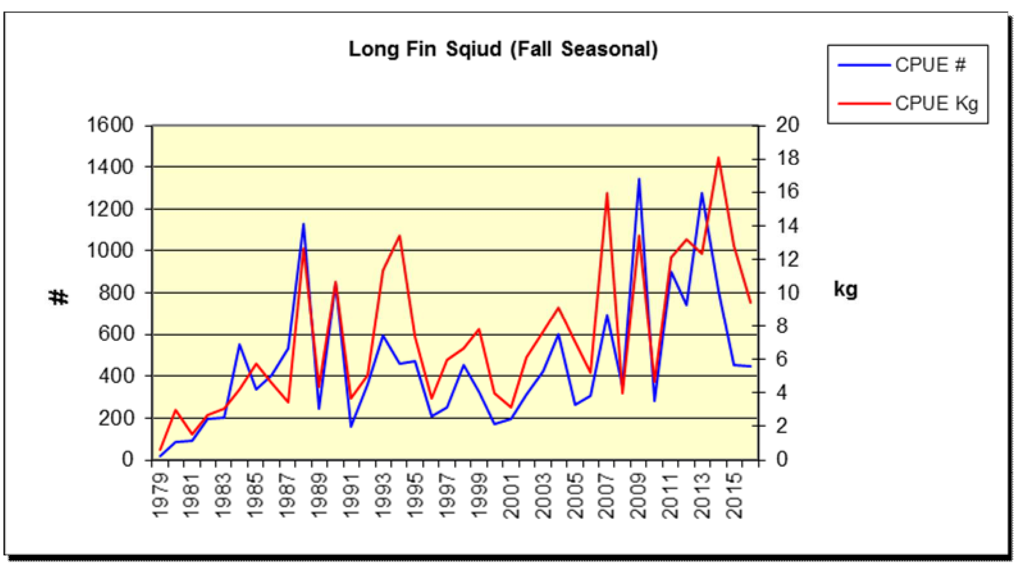




Longfin Squid ***Loligo pealei***

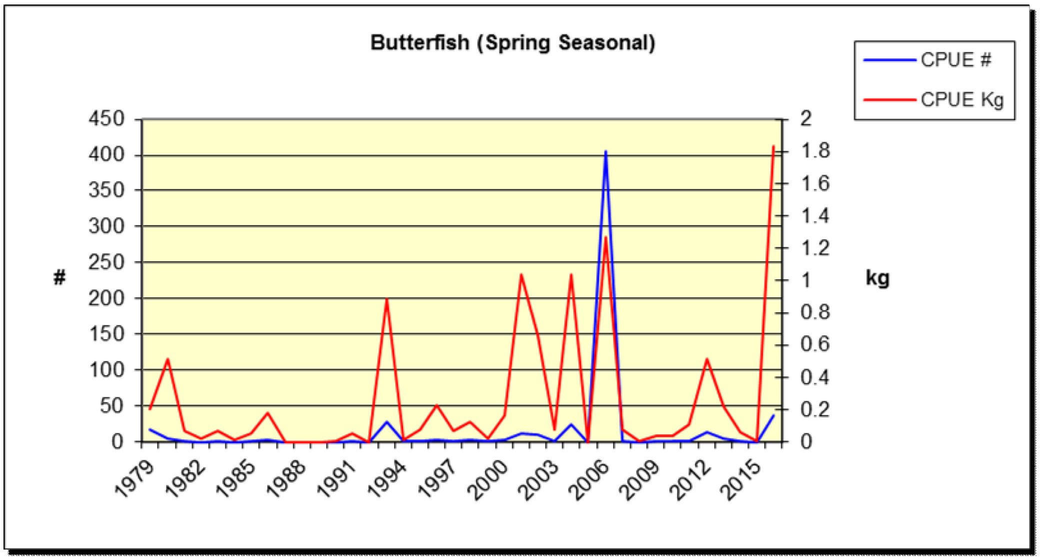
Stock Status: Overfishing undetermined not overfished
Management: NMFS, MAFMC, Atlantic Mackerel, Squid Butterfish FMP

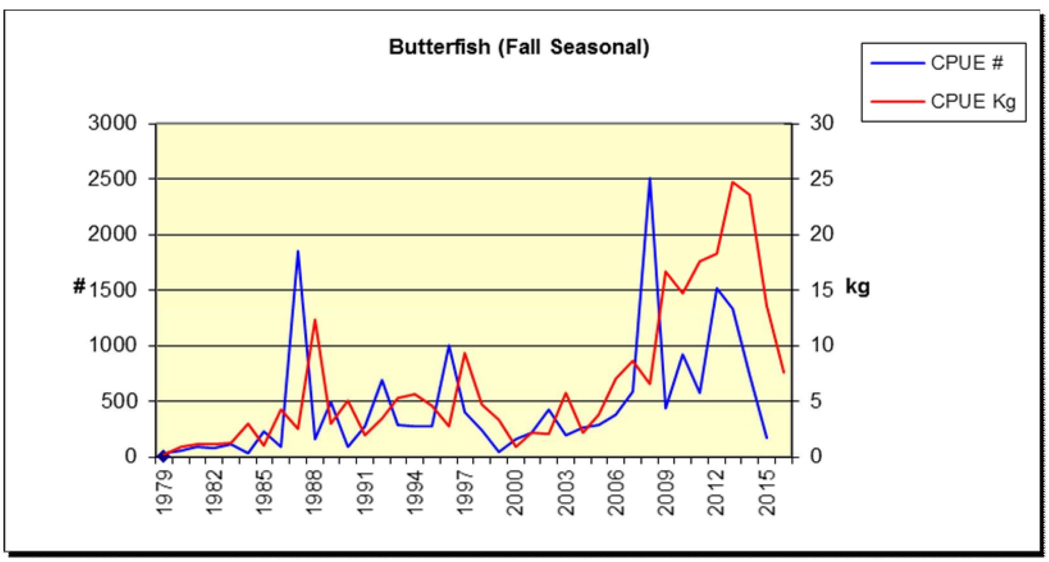


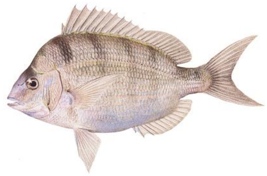


Butterfish ***Peprlilus triacanthus***

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

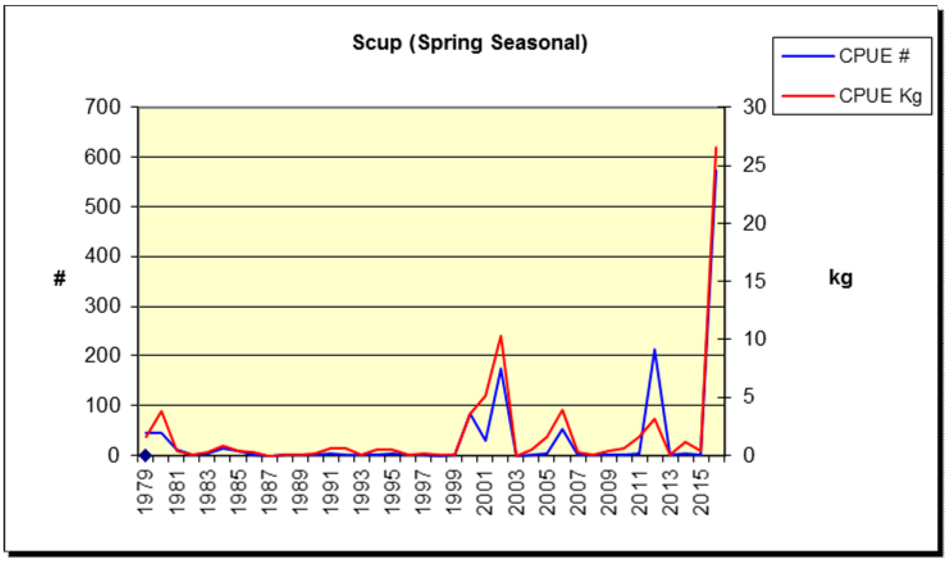


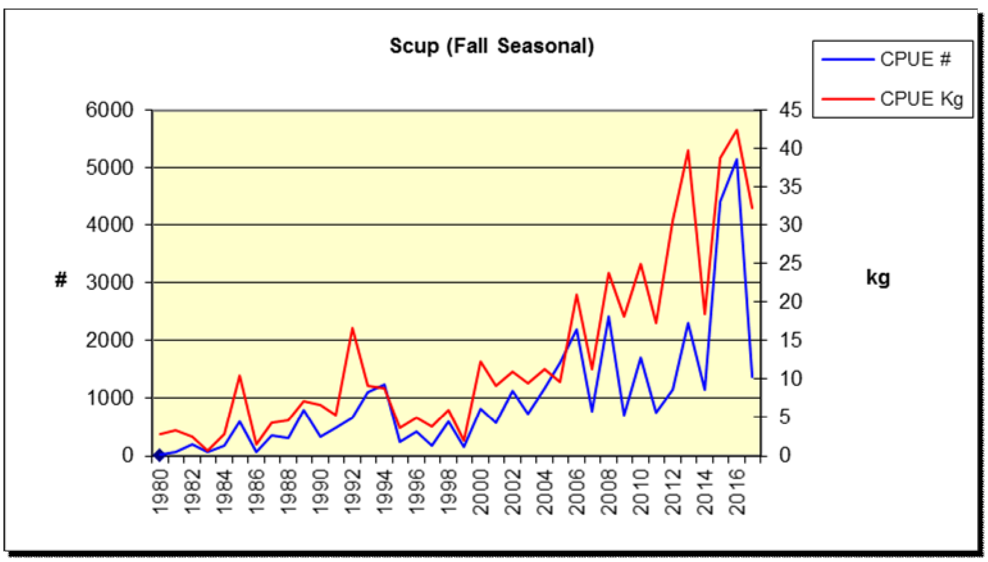


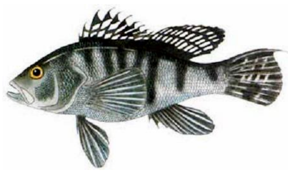


Scup ***Stenotomus chrysops***

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

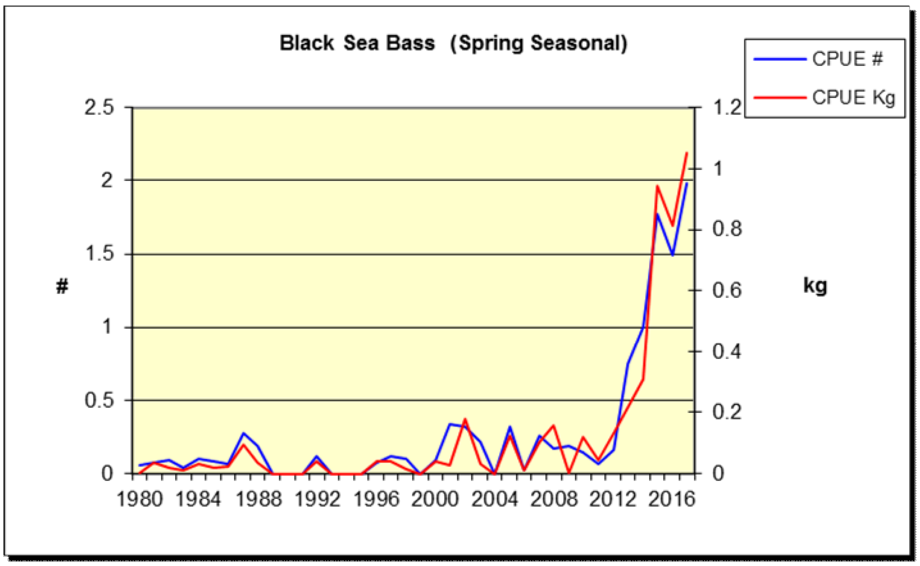


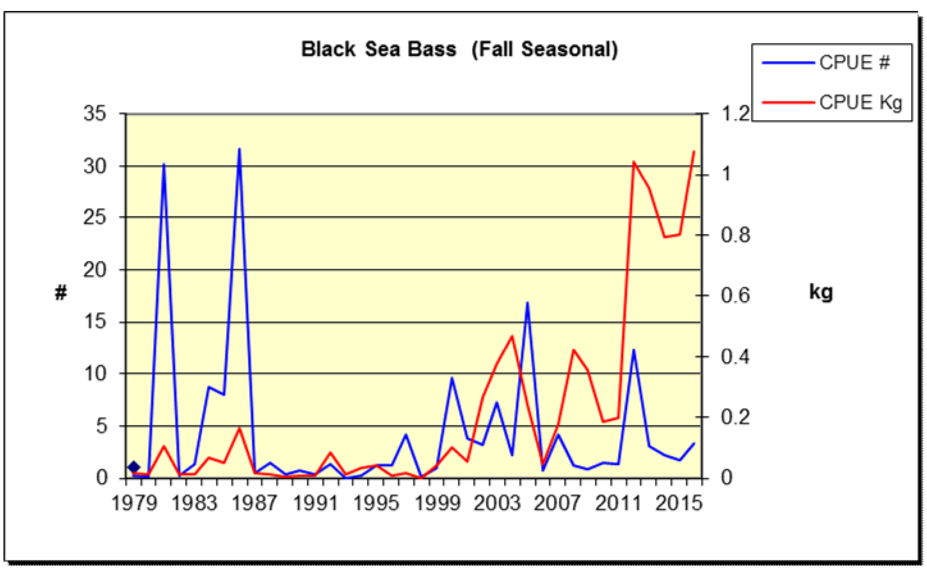




Black Sea Bass *Centropristis striata*

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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Federal Aid in Sportfish Restoration
F-61-R

Performance Report – Job#3 March 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: January 1, 2016 – December 31, 2016

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 2016, Investigators caught 51 species of finfish representing 36 families. This number is lower to the 55 species from 35 families that were collected during 2014. Additionally, the numbers of individuals caught in 2016 decreased from the 2015 survey; 16,166 collected in 2016 and 33,014 collected in 2015.

Target Date: 2017

Status of Project: On Schedule

Significant Deviations: Due to mechanical issues with the boat used for sampling the Pawcatuck River stations were not sampled in May of 2016.

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

Remarks:

During 2016, Investigators sampled twenty four traditional stations in four 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 incoming 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 had 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 was set in a semi-circle, away from the shoreline and back again using an outboard powered 16' Lund aluminum boat. The net was then hauled toward the beach by hand and the bag was emptied into a large water-filled tote. All animals collected were identified to species, measured, enumerated, and sub-samples were taken when appropriate. Water quality parameters temperature, salinity and dissolved oxygen, were 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 fourth in overall species abundance (n=1119) in 2016, 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. 2016 is similar to 2014 with a peak occurring in June. Narrow river and Pawcatuck Rivers were the only two ponds that showed the typical July peak.

During 2016, 1119 winter flounder were collected, down from the 1196 collected in 2015. The juvenile winter flounder abundance index (YOY WFL index) for the survey measured using the mean fish/seine haul decreased slightly from 10.99 fish/seine haul in 2015 to 9.55 fish/seine haul in 2016. The 2016 index value remained relatively level compared to 2015 and 2014 but is still three 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. Table 2 and figure 5b display the mean catch per seine haul (CPUE) of winter flounder for each month by pond during the 2016 survey. Figure 5a displays the abundance indices over the duration of the coastal pond survey. Figure 15 displays the annual abundance index for all stations combined.

Winnipaug and Point Judith Ponds trended upward in 2016. Narrow River and Charlestown Pond trended down below the average index value, in fact the lowest values observed in history the survey. This is concerning because these two water bodies historically represent the most abundant hauls of YOY winter flounder. Quononchontaug pond remained level at a lower than average index value. This low index value is particularly concerning because in years past high abundances of winter flounder have been observed consistently in Charlestown Pond. Green Hill and Potters pond had a show of YOY winter flounder in May, June, and July (in green hill) of YOY WFL, no fish were observed after august 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).

The index values by pond peaked in June remained high in July but with Winnipaug being an exception, were significantly reduced in August, September and October (figure 5b). Winter flounder catch per tow during October 2016 was 0.03 fish/tow similar to the low abundances seen in 2013 (0.58 fish/ tow) and down from 2014 (3.12 fish/tow) and 2015 (3.16 fish/tow). This value is well below the total survey index value (5.79 fish/tow). These results indicate that 2016 recruitment from the coastal ponds was poor and likey similar to 2013.

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 16). The downward YOY trend is mirrored in the Narragansett Bay Seine Survey. The continued low abundance in YOY WFL numbers was also observed in Narragansett Bay (McNamee Pers Comm) decreasing from 2015 to an index value of 2.92 fish / tow. The spring Trawl Survey WFL index did show some sign of improvement rising to a value of 6.70 fish/tow, but not far removed from the low 2013, 2014, and 2015 values. Those low years were likely a result of 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 in 2013. This year's high spring index value may reflect that change in management. 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 2016 , 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 (5.11 fish/tow in 2016). 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 17), a decline in relative abundance of winter flounder is observed in both surveys. The index value observed on the adult spawner survey was the lowest ever recorded at 0.8 WFL per net haul in 2014, recovering slightly in 2015 (4.0 fish /haul) but back down in 2016 to 1.1 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 2016, juvenile winter flounder ranged in size from 2 to 24 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 6). During 2016, 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. Length frequency distributions for coastal ponds by month are shown in Figures 7 -14. The WFL frequency histograms for each pond over time in years past have displayed two peaks in average size for YOY WFL suggesting two cohorts or a protracted spawning event. This result was not clearly observed in the Coastal Pond Survey during 2015 or 2016. Instead a more traditional one peaked histogram describes the size range of YOY WFL caught in the survey this year (figures 7 and 9).

Bluefish *(Pomatomus saltatrix)*

Fifty five bluefish were collected in July, August, September, and October occuring in each of the coastal ponds except Potters Pond and the Pawcatuck River in 2016. This is an decrease from the 124 fish caught in 2015 and similar to than the 53 individuals captured during 2014. The abundance index for 2016 was 0.39 fish/seine lower than the 2015 value of 0.86 fish/seine and similar to the value of 0.37 fish/seine haul observed in 2014. Table 4 contains the abundance indices for the survey by month and pond. Bluefish ranged in size from 4 cm to 18 cm. No adult bluefish were caught in 2016. Figure 18 displays the annual abundance index of bluefish for all stations combined.

Tautog (*Tautoga onitis*)

Two hundred and ninety nine tautog were collected between May and October in each of the ponds in 2016. This is higher than the 2015 catch of 219 individuals. The total survey 2016 abundance index was 2.12 fish/seine haul increased from the 2015 abundance index of 1.52 fish/seine haul. Table 5 contains the abundance indices for the survey by month and pond. The highest abundances in 2016 occurred in the Pawcatuck River. Tautog caught in 2016 ranged in size from 3 cm to 20 cm. Figure 19 displays the annual abundance index of tautog for all stations combined.

Black Sea Bass (*Centropristis striata*)

A total of 202 juvenile black sea bass were collected from August to October from each of the ponds except Green Hill Pond in 2016. This is less than the 348 fish that were caught in 2015 and more than the 175 fish collected in 2014. 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 2016 abundance index was 1.43 fish/seine haul down from the 2015 abundance index of 2.42 fish/seine haul and above the 2014 value of 1.22 fish/ seine haul. The population in the ponds continues trending upwards, the high BSB index value of 2016 represents another high value consistent with observations from other recent years. Black sea bass abundance throughout state waters was high again during 2016 (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 2 cm to 13 cm. Figure 20 displays the annual abundance index of black sea bass for all stations combined.

<u>Scup *(Stenotomus chrysops)*</u>

Twenty two scup were collected during the 2016 in July, August, September, and October in each of the ponds except Narrow River, Green Hill and Potter's ponds. This is lower than the 93 scup caught in 2015. The total survey abundance index was 0.16 fish per haul. Table 7 contains the abundance indices for the survey by month and pond. Scup caught in 2016 ranged in size from 3 cm to 11 cm. Figure 21 displays the annual abundance index of scup for all stations combined.

<u>Clupeids:</u>

In 2016 three species of clupeids were caught in the coastal pond survey, Atlantic menhaden (*Brevoortia tyrannus*), Atlantic herring (*Alosa harengus*) and Alewife (*Alosa pseudoharengus*). Thirteen alewife were captured in 2016. The total survey abundance was 0.09 fish / seine haul. This and the low 2015 count of 35 fish represents relative low values in an upward trend. Six hundred and thirty seven Atlantic menhaden were caught during 2016. The total survey abundance was 4.52 fish /seine haul. There were no large schools of YOY menhaden captured in 2016. Four Atlantic herring were captured in 2016 and zero Blueback herring were caught in 2016. Table 8 contains the abundance indices for culpeids by month pooled across all 5 ponds. Figures 22a and 22b display the annual abundance index of clupeids for all stations combined. Menhaden are plotted on a separate axis for scale issues.

<u>Baitfish Species:</u>

<u>Silversides *(Menidia sp.)*</u>

Silversides had the highest abundance of all species with 7443 caught during the 2016 survey, down by half compared to the 14220 silversides collected in 2015. Silversides were collected in each of the ponds throughout the time period of the survey (May – October). The highest abundances were observed in Charlestown, Potters, and Winnipaug ponds. The total survey abundance index was 52.79 fish / seine haul. Table 9 contains the abundance indices for the survey by month and pond. Atlantic silversides caught in 2016 ranged in size from 2 cm to 17 cm.

<u>Striped Killifish *(Fundulus majalis)*</u>

Striped killifish ranked second in species abundance with 1959 fish caught during 2016. This is lower than the 4063 fish caught during 2015. They occurred in each of the ponds and were caught each month during the survey. Point Judith Pond had the highest abundance of striped killifish. The total survey abundance index was 13.89 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 2016 ranged in size from 1 cm to 13 cm.

<u>Common Mummichog *(Fundulus heteroclitus)*</u>

The mummichog was third in overall abundance in 2016 with 1536 individuals collected. This value is an decrease from 2846 mummichogs collected in 2015. 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 2016 survey abundance index was 10.89 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 2016 ranged in size from 2 cm to 11 cm.

Sheepshead Minnow *(Cyprinodon variegatus)*

The Sheepshead minnow ranked tenth in overall abundance with 209 individuals collected. This is an increase from the 163 fish caught in 2015. Sheepshead minnow occurred in each of the ponds except Point Judith and were caught between July and October. Charlestown Pond had the highest abundances of Sheepshead minnows. The total survey abundance index was 1.48 fish / seine haul. Table 12 contains the abundance indices for the survey by month and pond. Sheepshead minnow caught in 2016 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 2015 Coastal Pond Survey is summarized in tables 13 – 15. Water temperature in 2016 averaged 22.53 ºC, with a range of 13.8ºC in May to 30.5 ºC in August. Salinity ranged from 12.1 ppt to 29.9 ppt, and averaged 26.6 ppt. Dissolved oxygen ranged from 4.17 mg/l to 15.4 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 -2014 with the exception of no winter flounder caught in Green Hill Pond. 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.

<u>Lower Pawcatuck River</u>: 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 five 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.

<u>Summary</u>

In 2016, Investigators caught 51 species of finfish representing 34 families. This number is less than the 55 species from 35 families that were collected during 2015. Additionally, the numbers of individuals landed in 2016 decreased from the 2015 survey; 16,166 collected in 2015 and 33,014 collected in 2015. Appendix 1 displays the frequency of all species caught by station during the 2015 Coastal Pond Survey. Additional data is available by request.

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Table 1: 2016 Coastal Pond Survey Winter Flounder Frequency by Station and Month

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
CP1	28	27	8	0	0	2	**65**	**10.83**	**13.24**
CP2	3	0	0	0	0	0	**3**	**0.50**	**1.22**
CP3	1	4	0	1	1	0	**7**	**1.17**	**1.47**
CP4	0	2	0	0	1	0	**3**	**0.50**	**0.84**
GH1	6	0	1	0	0	0	**7**	**1.17**	**2.40**
GH2	11	2	7	0	0	0	**20**	**3.33**	**4.63**
NR1	4	3	3	0	0	0	**10**	**1.67**	**1.86**
NR2	10	10	54	0	16	2	**92**	**15.33**	**19.83**
NR3	4	18	44	1	2	0	**69**	**11.50**	**17.25**
PJ1	1	2	0	0	0	0	**3**	**0.50**	**0.84**
PJ2	12	14	24	5	0	0	**55**	**9.17**	**9.35**
PJ3	3	26	4	1	0	0	**34**	**5.67**	**10.09**
PJ4	19	63	23	1	0	0	**106**	**17.67**	**24.44**
PP1	0	12	0	0	0	0	**12**	**2.00**	**4.90**
PP2	0	0	0	0	0	0	**0**	**0.00**	**0.00**
PR1	0	10	40	0	0	1	**51**	**8.50**	**15.92**
PR2	0	3	1	0	0	0	**4**	**0.67**	**1.21**
PR3	0	0	2	0	0	0	**2**	**0.33**	**0.82**
QP1	0	75	9	5	1	0	**90**	**15.00**	**29.60**
QP2	12	77	19	1	2	0	**111**	**18.50**	**29.62**
QP3	13	7	1	5	1	0	**27**	**4.50**	**4.97**
WP1	2	83	20	46	3	0	**154**	**25.67**	**33.06**
WP2	22	39	8	73	5	1	**148**	**24.67**	**27.47**
WP3	2	41	2	0	1	0	**46**	**7.67**	**16.35**
Totals	**153**	**518**	**270**	**139**	**33**	**6**			
Mean	**6.38**	**21.58**	**11.25**	**5.79**	**1.38**	**0.25**			
STD	**7.88**	**27.02**	**15.57**	**17.09**	**3.35**	**0.61**			

Table 2: 2016 Coastal Pond Survey winter flounder abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	8.0	8.3	2.0	0.3	0.5	0.5
Green Hill Pond	8.5	1.0	4.0	0.0	0.0	0.0
Narrow River	6.0	10.3	33.7	0.3	6.0	0.7
Point Judith Pond	8.8	26.3	12.8	1.8	0.0	0.0
Potter's Pond	0.0	6.0	0.0	0.0	0.0	0.0
Pawcatuck River		4.3	14.3	0.0	0.0	0.3
Quonochontaug Pond	8.3	53.0	9.7	3.7	1.3	0.0
Winnipaug Pond	8.7	54.3	10.0	39.7	3.0	0.3
Total	**7.3**	**21.6**	**11.3**	**5.8**	**1.4**	**0.3**

Table 3: 2016 Coastal Pond Survey average lengths (cm) of juvenile winter flounder by pond and month.

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	4.33	6.14	8.16	10.50	6.65	15.30
Green Hill Pond		5.34	6.44			
Narrow River	8.20	4.56	4.73	4.10	59.78	6.35
Point Judith Pond		4.65	5.96	7.34		
Potter's Pond		6.35				
Pawcatuck River		3.55	4.52			131.00
Quonochontaug Pond	8.80	5.14	5.70	6.39	6.63	
Winnipaug Pond	3.45	4.40	4.91	5.66	5.72	5.60

Table 4: 2016 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	0.00	0.00	1.50	0.25
Green Hill Pond	0.00	0.00	1.00	2.00	0.00	0.00
Narrow River	0.00	0.00	1.00	0.00	0.00	0.00
Point Judith Pond	0.00	0.75	0.50	1.00	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	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.33	0.33	0.00	0.00
Winnipaug Pond	0.00	0.00	0.00	0.00	0.00	2.33
Total pond index	**0.00**	**0.75**	**2.83**	**3.33**	**1.50**	**2.58**

Table 5: 2016 Coastal Pond Survey tautog abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	1.00	0.75	0.00	8.25	11.50	2.50
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	0.33	0.00
Point Judith Pond	0.00	0.25	2.25	1.75	2.00	0.00
Potter's Pond	0.00	0.00	0.00	2.50	0.00	1.50
Pawcatuck River	0.00	2.00	1.00	25.67	5.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	6.00	11.33	0.00
Winnipaug Pond	0.00	0.00	0.00	1.00	1.67	2.00
Total pond index	**0.17**	**0.38**	**0.41**	**5.65**	**3.98**	**0.81**

Table 6: 2016 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	3.00	4.25	1.00
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.00	0.00	7.33	0.00	0.33
Point Judith Pond	0.00	0.00	0.25	7.75	13.75	0.00
Potter's Pond	0.00	0.00	0.00	0.50	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	12.00	0.67	0.00
Winnipaug Pond	0.00	0.00	0.00	4.33	1.33	1.00
Total pond index	**0.00**	**0.00**	**0.03**	**4.36**	**2.50**	**0.29**

Table 7: 2016 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	1.00	0.00	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	0.00	0.00	0.00
Point Judith Pond	0.00	0.00	0.00	0.00	0.25	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	1.33	0.00	0.00
Quonochontaug Pond	0.00	0.00	1.67	0.33	0.00	0.00
Winnipaug Pond	0.00	0.00	0.00	2.33	0.00	0.00
Total pond index	**0.00**	**0.00**	**0.21**	**0.63**	**0.03**	**0.00**

Table 8: 2016 Coastal Pond Survey Clupeid abundance indices (fish/seine haul) by month

Species	May	Jun	Jul	Aug	Sep	Oct
Alewife	0	0.04	0.50	0	0	0
Atlantic Menhaden	0	0	0	26.08	0.17	0.29
Atlantic Herring	0	0.04	0.13	0	0	0
Blueback Herring	0	0	0	0	0	0

Table 9: 2016 Coastal Pond Survey Silverside abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	16.25	21.00	21.25	179.75	294.75	52.50
Green Hill Pond	0.00	23.00	12.50	18.00	5.50	27.00
Narrow River	14.33	9.67	14.33	54.33	13.67	22.67
Point Judith Pond	0.00	29.25	22.00	21.50	60.25	12.50
Potter's Pond	0.00	36.00	3.00	258.50	34.50	76.50
Pawcatuck River	0.00	16.67	14.67	127.33	18.67	23.33
Quonochontaug Pond	13.33	5.67	31.33	53.33	66.33	20.00
Winnipaug Pond	15.33	4.00	11.00	532.33	17.67	76.67
Total pond index	**7.41**	**18.16**	**16.26**	**155.64**	**63.92**	**38.90**

Table 10: 2016 Coastal Pond Survey Striped Killifish abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	11.50	15.25	16.25	30.00	19.25	3.50
Green Hill Pond	0.00	0.50	0.00	1.00	0.00	0.00
Narrow River	0.00	0.00	0.00	7.00	8.00	4.67
Point Judith Pond	0.00	15.25	126.00	50.00	6.00	13.00
Potter's Pond	0.00	9.00	0.00	0.00	0.00	0.50
Pawcatuck River	0.00	0.67	0.00	11.67	4.33	12.67
Quonochontaug Pond	0.00	0.00	0.33	14.33	2.00	12.33
Winnipaug Pond	1.67	2.33	15.00	36.00	97.67	7.00
Total pond index	**1.65**	**5.38**	**19.70**	**18.75**	**17.16**	**6.71**

Table 11: 2016 Coastal Pond Survey Mumichog abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	19.50	12.75	12.75	15.50	40.00	22.25
Green Hill Pond	0.00	36.00	18.00	11.00	7.50	2.00
Narrow River	10.67	8.33	23.67	4.00	5.67	0.33
Point Judith Pond	0.00	28.75	15.50	18.25	1.25	0.00
Potter's Pond	0.00	41.50	8.50	6.00	1.00	4.50
Pawcatuck River	0.00	1.67	0.67	1.67	0.00	7.00
Quonochontaug Pond	0.00	0.33	2.33	4.00	1.00	0.00
Winnipaug Pond	7.67	6.00	19.00	54.67	14.00	0.00
Total pond index	**4.73**	**16.92**	**12.55**	**14.39**	**8.80**	**4.51**

Table 12: 2016 Coastal Pond Survey Sheepshead Minnow abundance indices (fish/seine haul) by pond and month

Pond	May	Jun	Jul	Aug	Sep	Oct
Charlestown Pond	0.00	0.00	0.00	25.00	0.75	6.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.50	0.00
Narrow River	0.00	0.00	0.00	0.00	7.33	1.67
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	0.50
Potter's Pond	0.00	0.00	0.00	0.00	0.00	0.50
Pawcatuck River	0.00	0.00	0.00	0.00	0.00	3.67
Quonochontaug Pond	0.00	0.00	0.00	0.00	0.00	2.33
Winnipaug Pond	0.00	0.00	0.00	9.33	1.33	0.00
Total pond index	**0.00**	**0.00**	**0.00**	**4.29**	**1.24**	**2.13**

Table 13: 2016 Coastal Pond Survey average water temperature (degrees Celcius) by pond and month.

Station	May	June	July	August	September	October
Charlestown Pond	20.93	21.98	26.98	25.83	22.43	18.20
Green Hill Pond	25.35	27.00	28.45	30.10	26.10	16.75
Narrow River	20.23	22.07	26.00	24.87	23.03	17.83
Point Judith Pond	22.60	23.00	26.53	26.50	22.78	15.63
Potter's Pond	23.30	24.30	28.45	27.50	21.60	14.50
Pawcatuck River		20.30	23.37	23.45	22.20	17.07
Quonochontaug Pond	18.10	20.97	25.53	24.93	22.33	15.90
Winnipaug Pond	18.87	18.83	24.17	26.57	23.83	18.00
Average	21.34	22.31	26.18	26.22	23.04	16.73

Table 14: 2016 Coastal Pond Survey average salinity (ppt) by pond and month.

Station	May	June	July	August	September	October
Charlestown Pond	26.93	28.23	27.67	28.94	28.70	27.82
Green Hill Pond	21.91	21.45	18.01	24.51	24.53	24.37
Narrow River	22.40	22.17	19.53	26.95	25.25	25.35
Point Judith Pond	24.79	28.37	28.48	28.99	27.72	27.09
Potter's Pond	21.90	27.08	26.44	27.15	27.19	24.31
Pawcatuck River		26.19	25.71	27.12	26.66	26.67
Quonochontaug Pond	28.94	29.47	28.90	29.15	28.19	29.03
Winnipaug Pond	28.07	28.75	27.27	28.58		
Average	24.99	26.46	25.25	27.67	26.89	26.38

Table 15: 2016 Coastal Pond Survey average dissolved oxygen (mg/l) by pond and month.

Station	**May**	**June**	**July**	**August**	**September**	**October**
Charlestown Pond	7.82	8.83	7.68	7.67	8.46	8.44
Green Hill Pond	8.02	8.35	7.20	6.33	8.51	9.24
Narrow River	8.26	10.58	7.31	6.10	11.42	7.78
Point Judith Pond	8.59	8.00	6.90	7.10	9.09	9.21
Potter's Pond	9.04	8.22	7.19	6.21	6.94	8.75
Pawcatuck River		7.55	8.59	8.11	6.71	9.43
Quonochontaug Pond	8.67	8.39	6.51	5.82	5.92	7.98
Winnipaug Pond	8.26	8.41	6.56	6.96		
Average	8.38	8.54	7.24	6.79	8.15	8.69

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

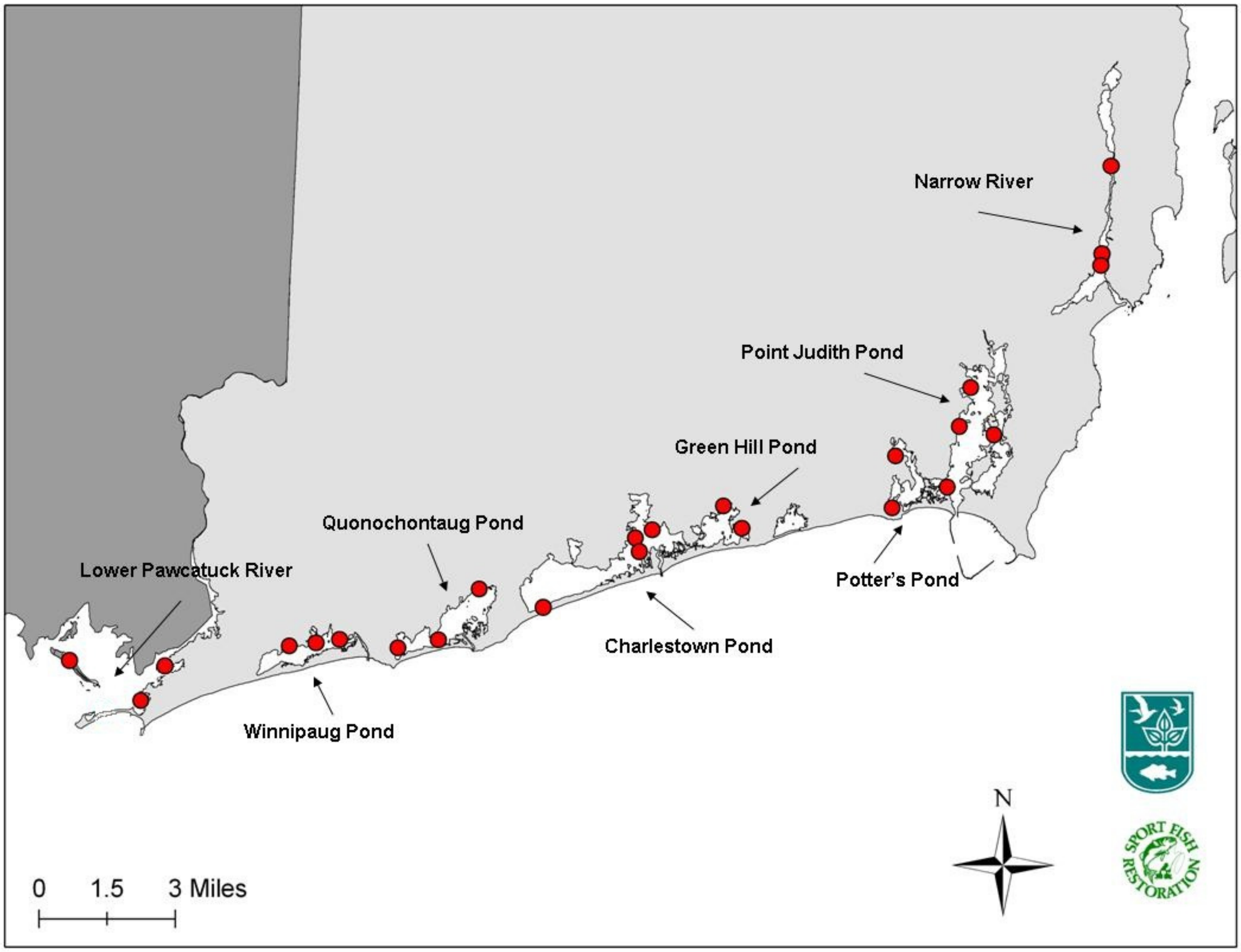


Figure 2: Coastal Pond Juvenile Finfish Survey station locations (western ponds).

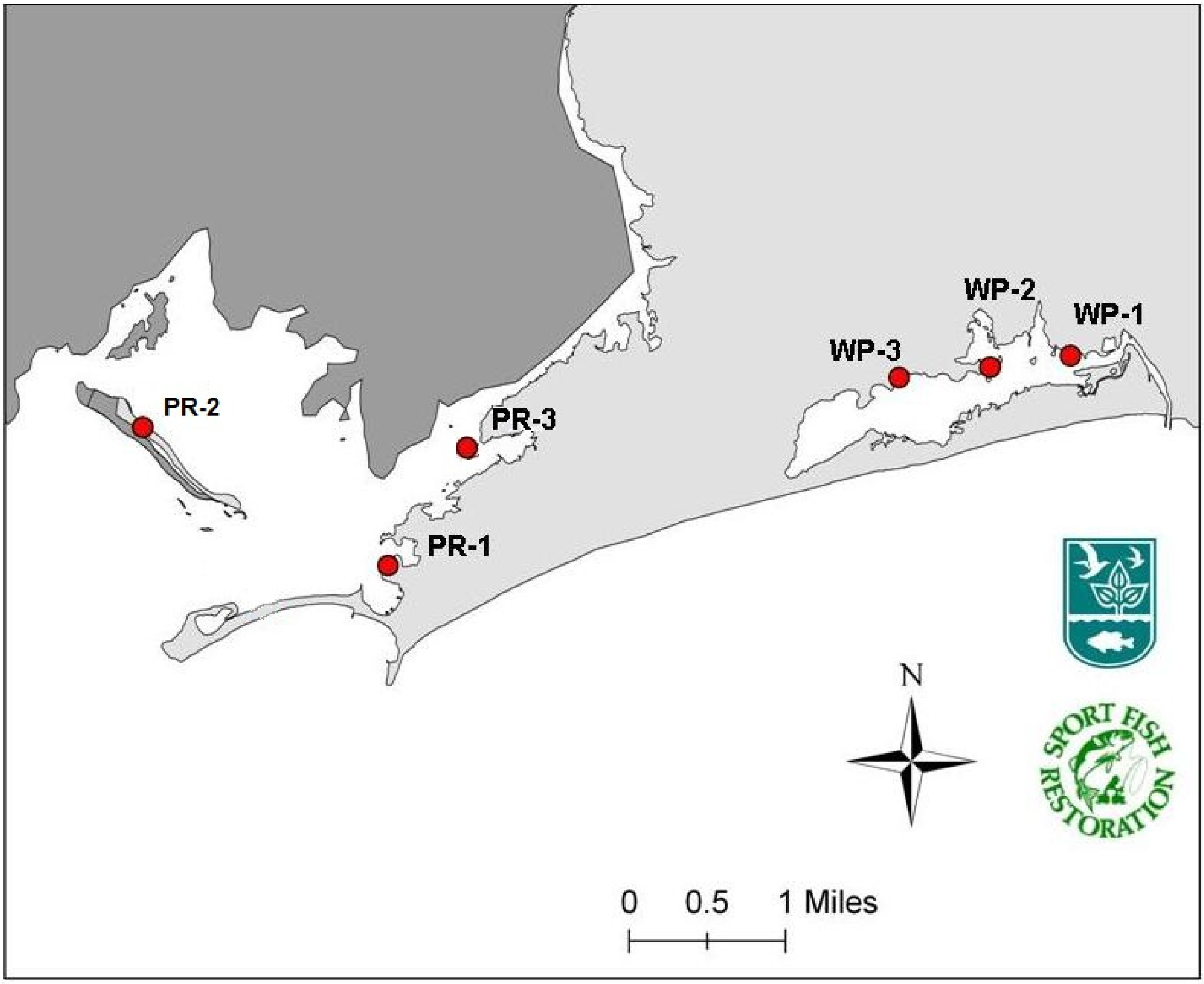


Figure 2 (cont): Coastal Pond Juvenile Finfish Survey station locations (western ponds).

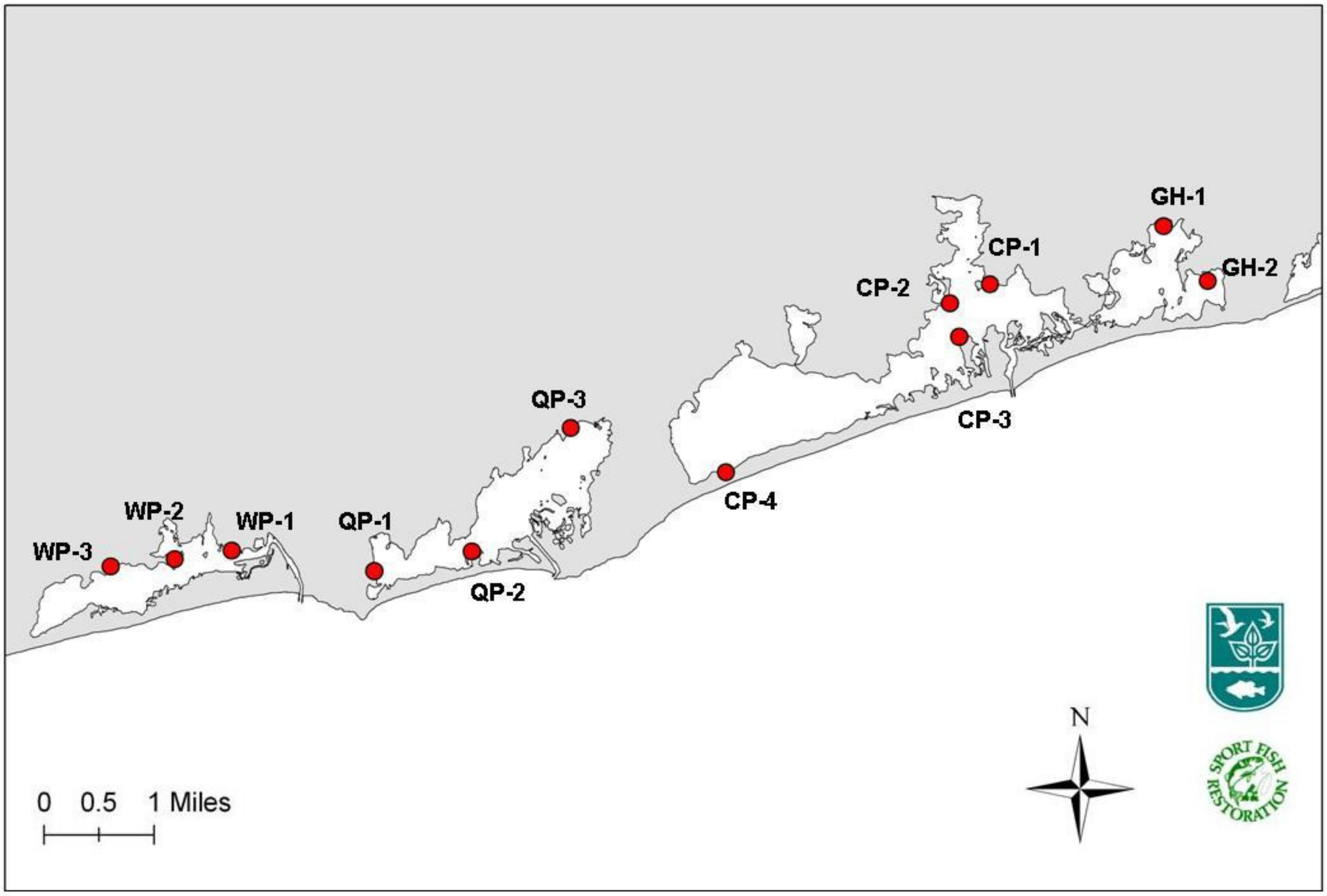


Figure 3: Coastal Pond Juvenile Finfish Survey station locations (eastern ponds).

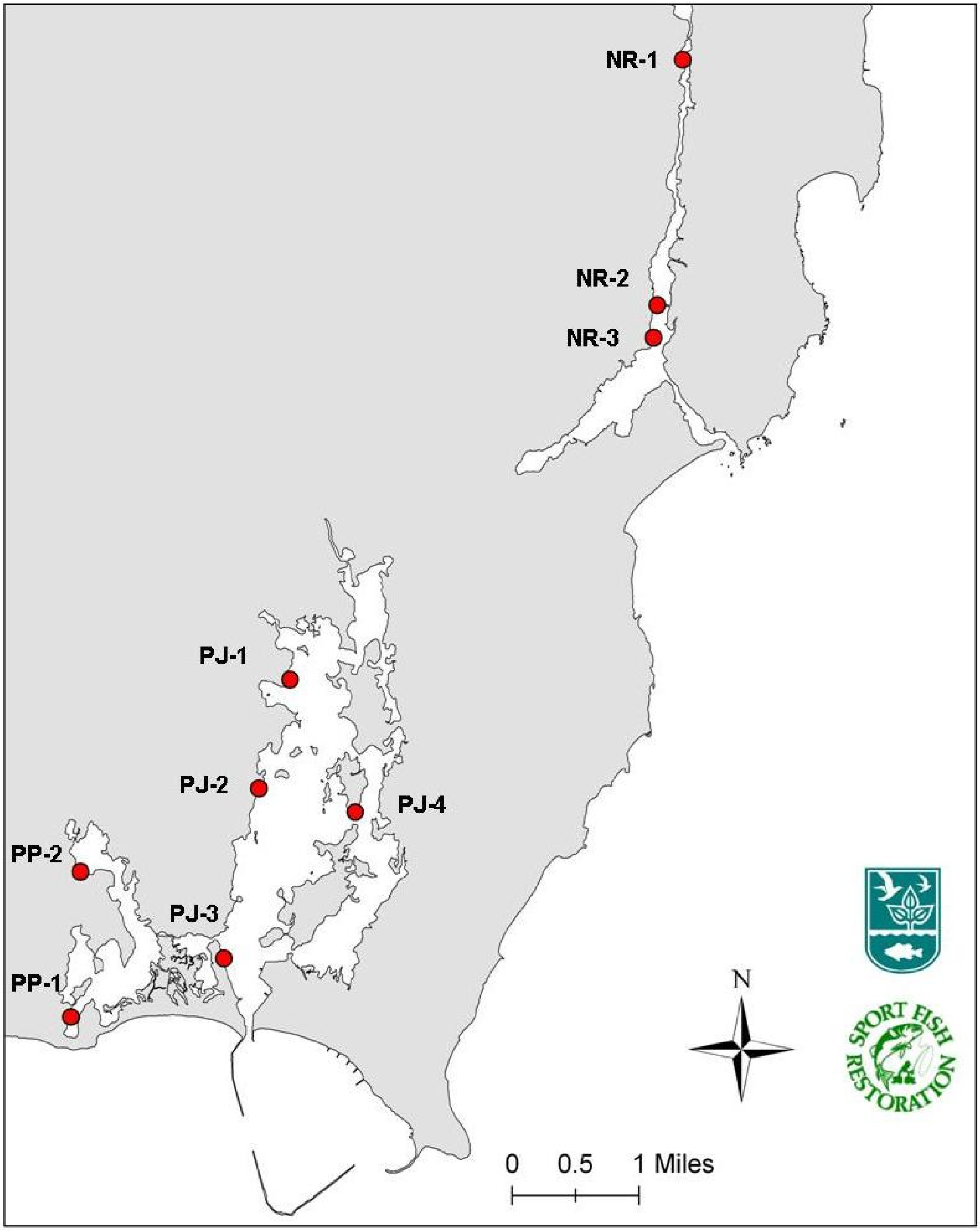


Figure 4
Coastal Pond Juvenile Finfish Survey

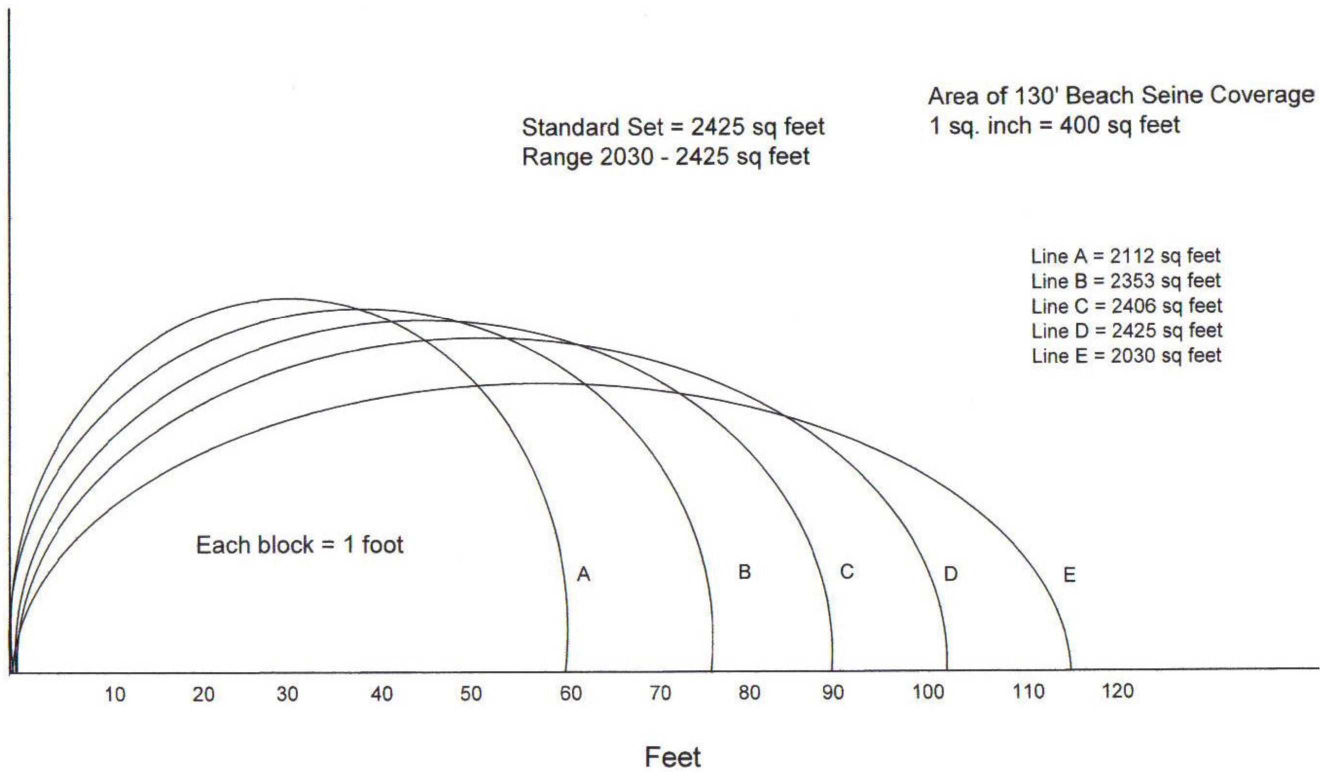


Figure 5a: Time series of abundance indices (fish/seine haul) for winter flounder YOY from each Coastal Pond in the survey.

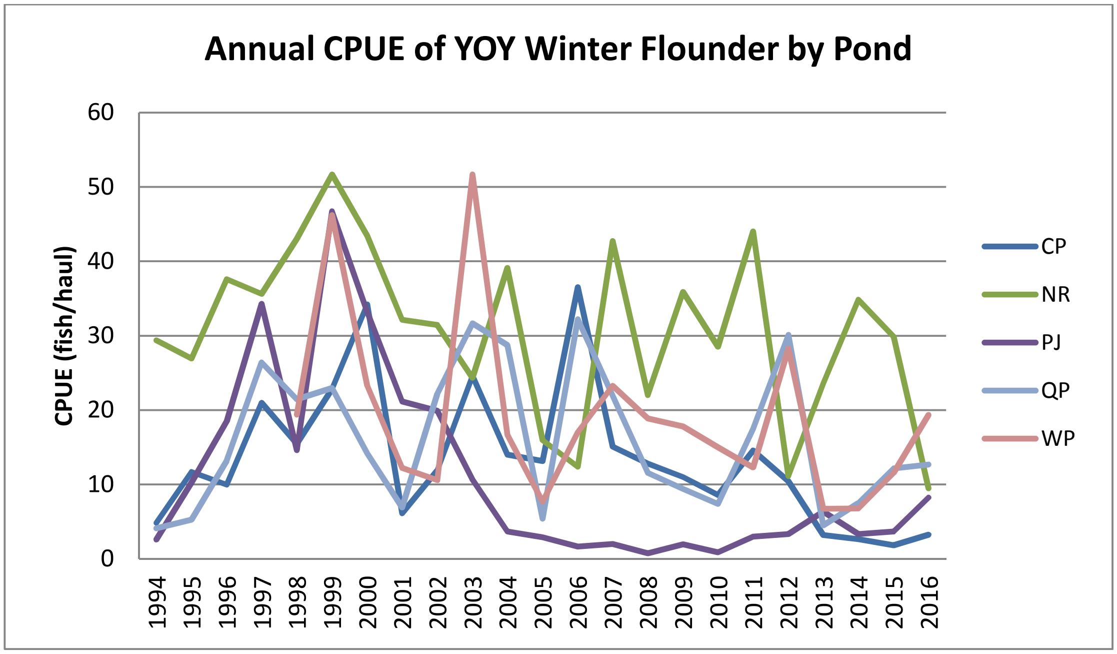


Figure 5b: 2016 time series of abundance indices (fish/seine haul) by month for winter flounder YOY for each Coastal Pond in the survey.

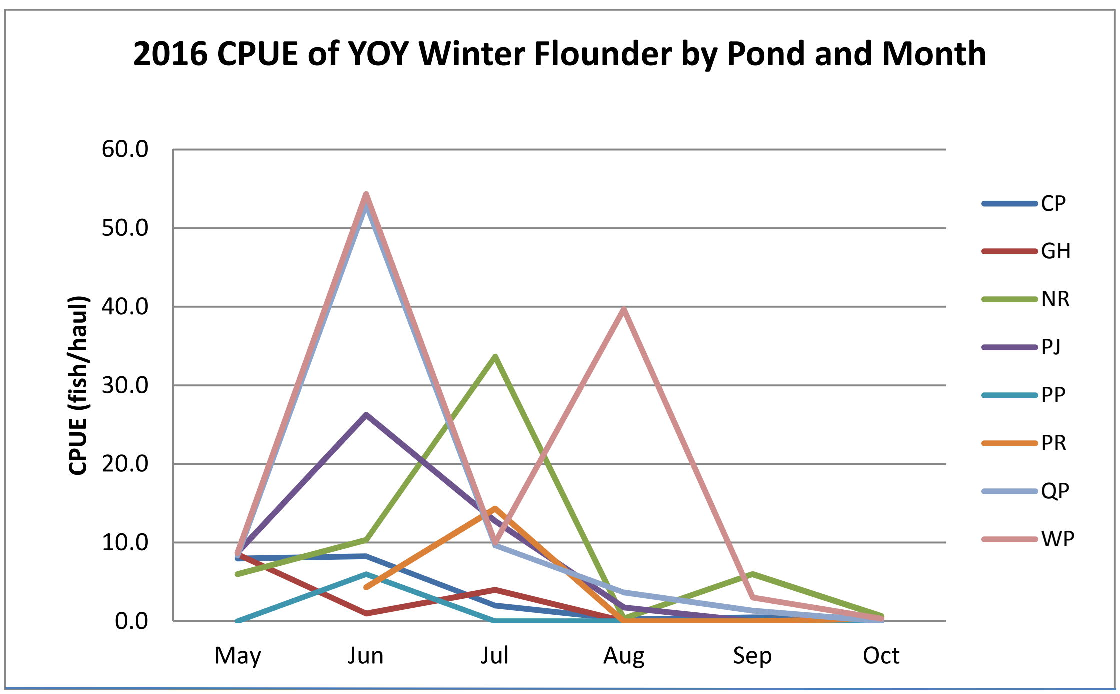


Figure 6: Length frequency of all winter flounder caught in Coastal Pond Survey during 2016.

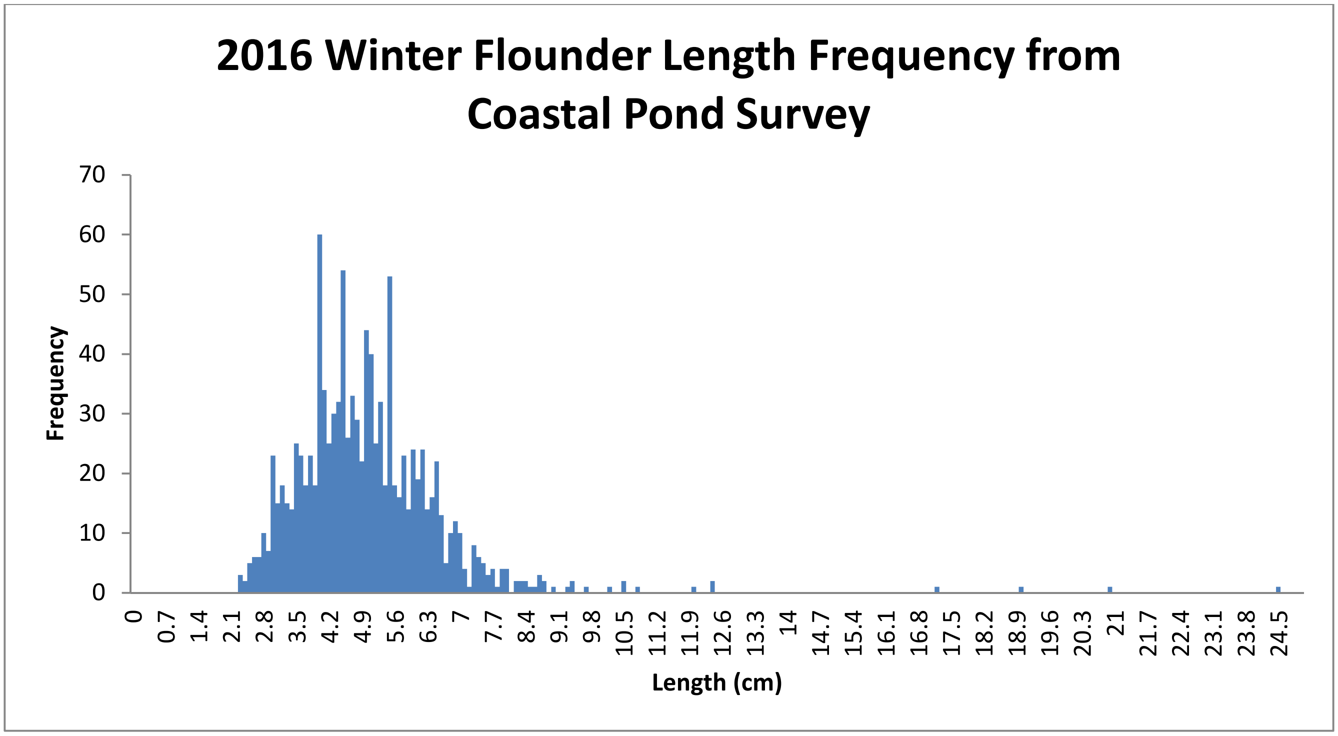


Figure 7: Monthly length frequency of winter flounder from Charlestown Pond, 2016.

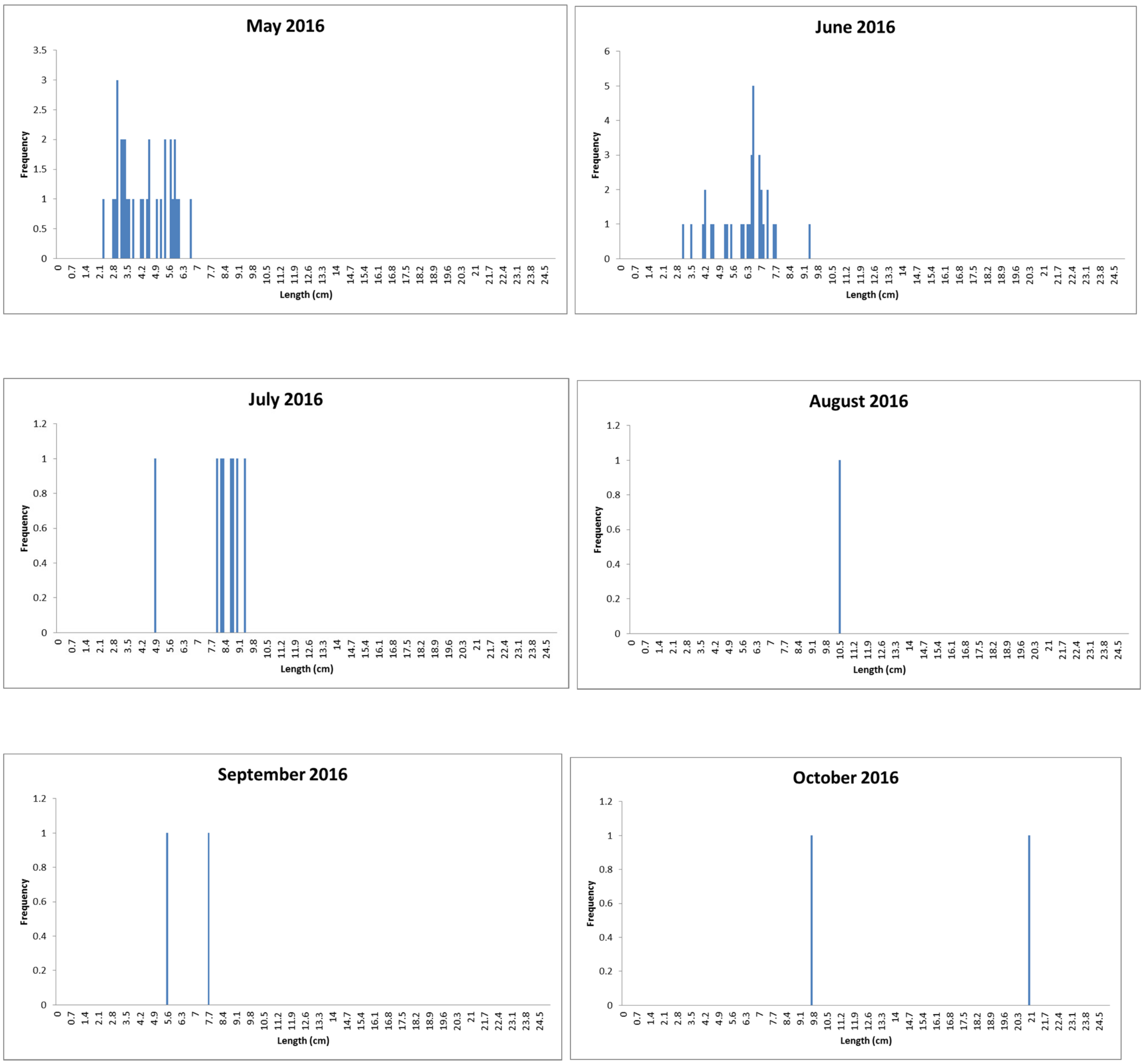


Figure 8: Monthly length frequency of winter flounder from Green Hill Pond, 2016.

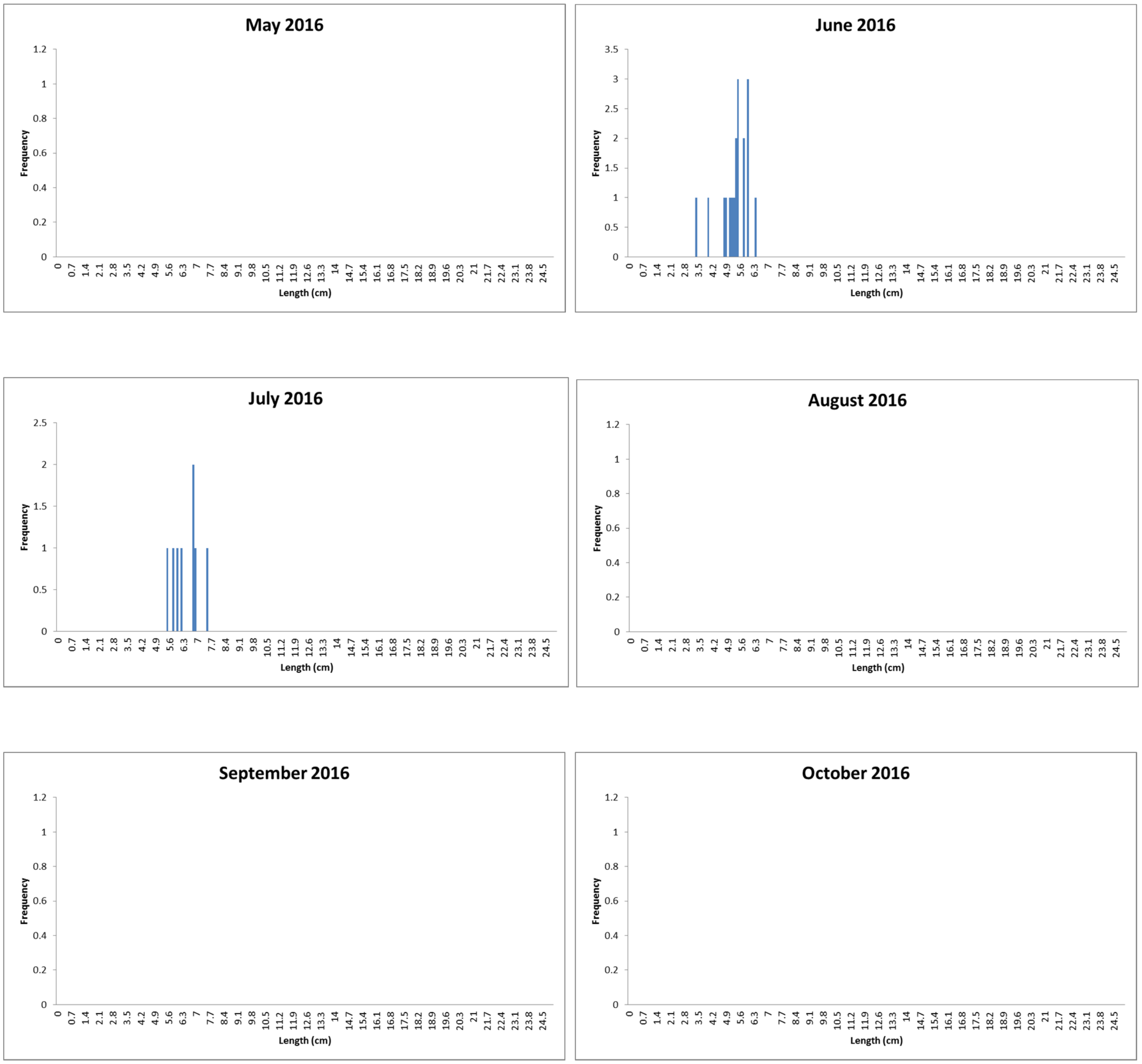


Figure 9: Monthly length frequency of winter flounder from Narrow River, 2016.

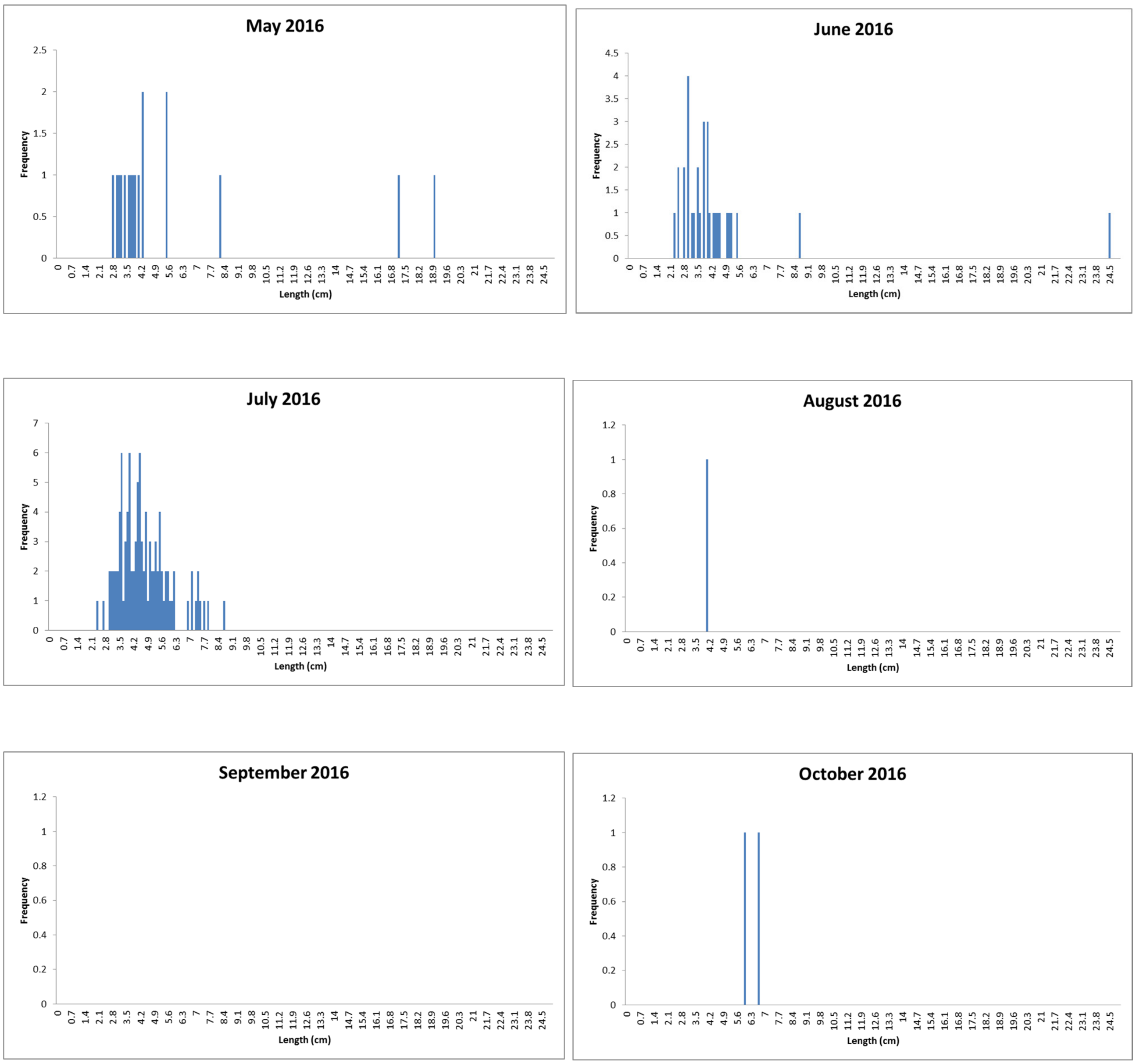


Figure 10: Monthly length frequency of winter flounder from Point Judith Pond, 2016.

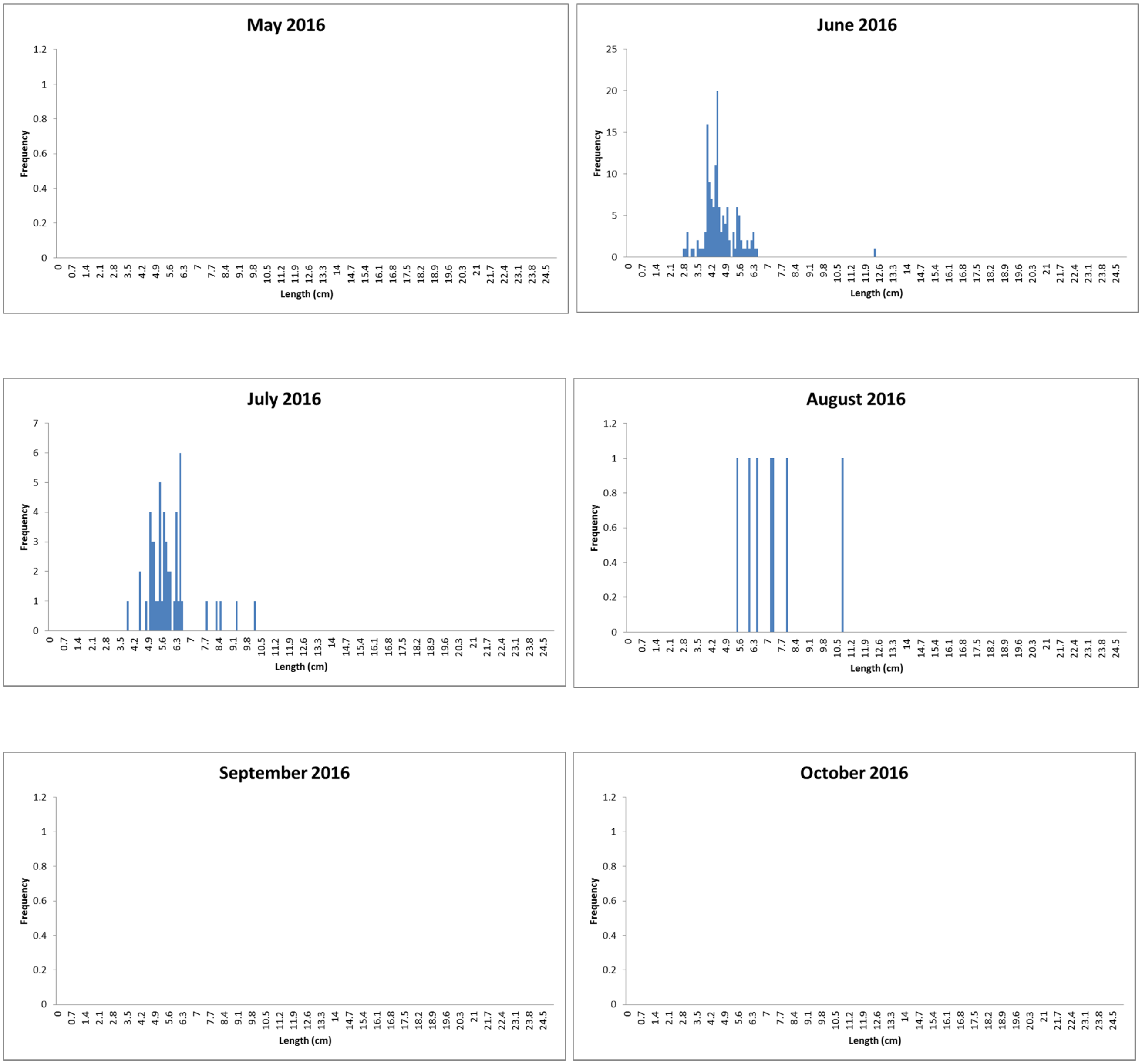


Figure 11: Monthly length frequency of winter flounder from Potter Pond, 2016.

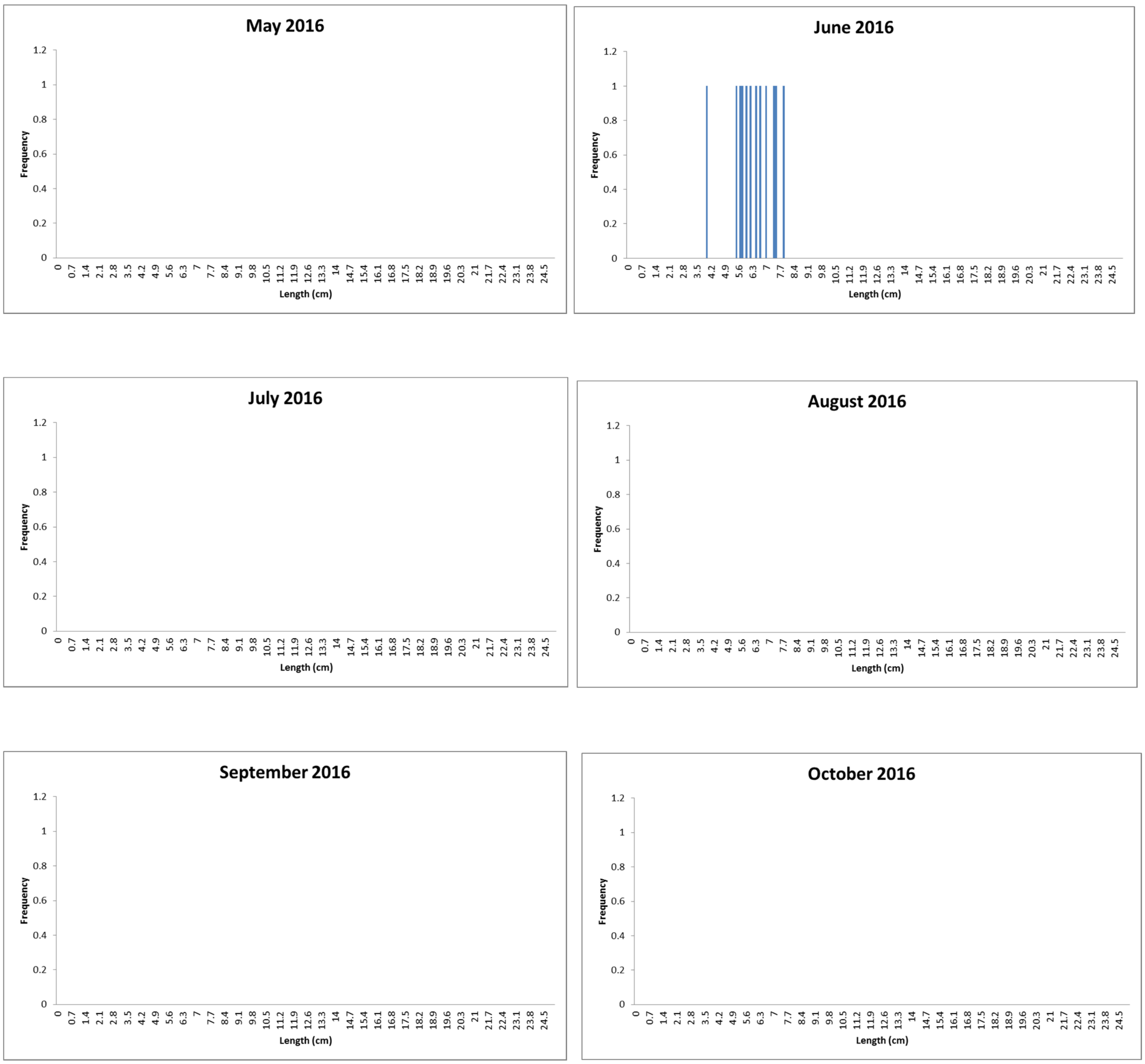


Figure 12: Monthly length frequency of winter flounder from Pawcatuck River, 2016.

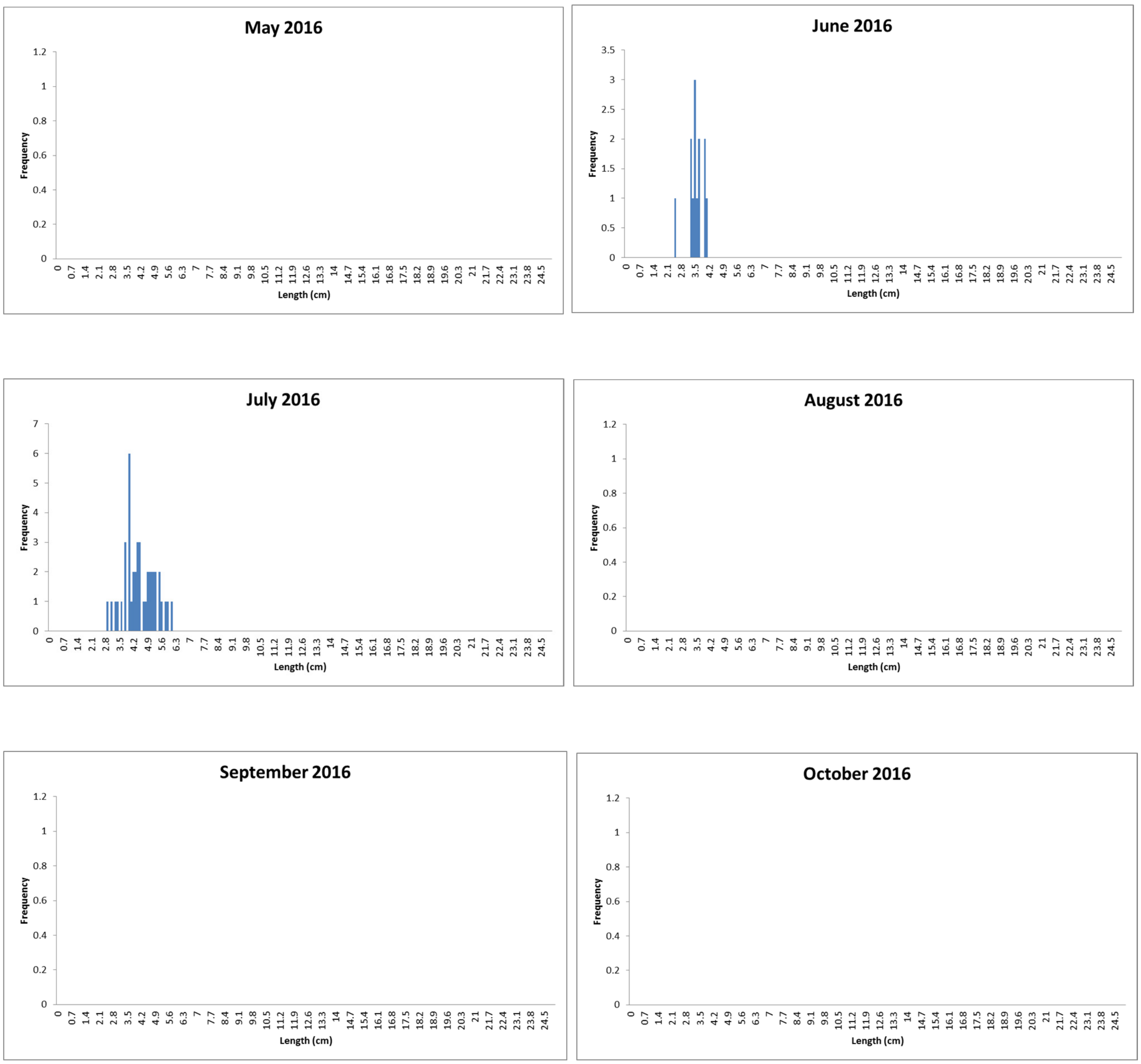


Figure 13: Monthly length frequency of winter flounder from Quonochontaug Pond, 2016.

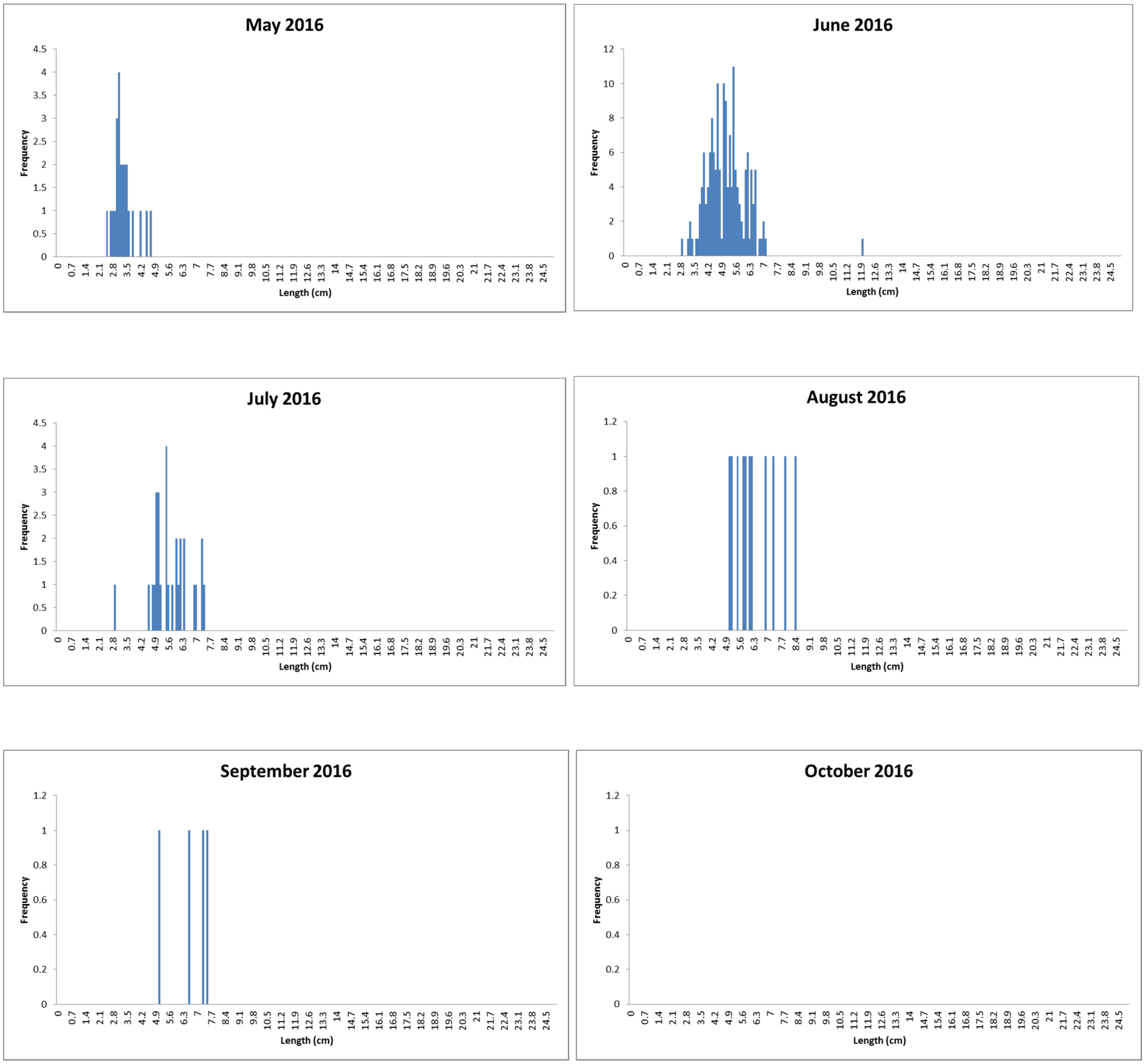


Figure 14: Monthly length frequency of winter flounder from Winnipaug Pond, 2016.

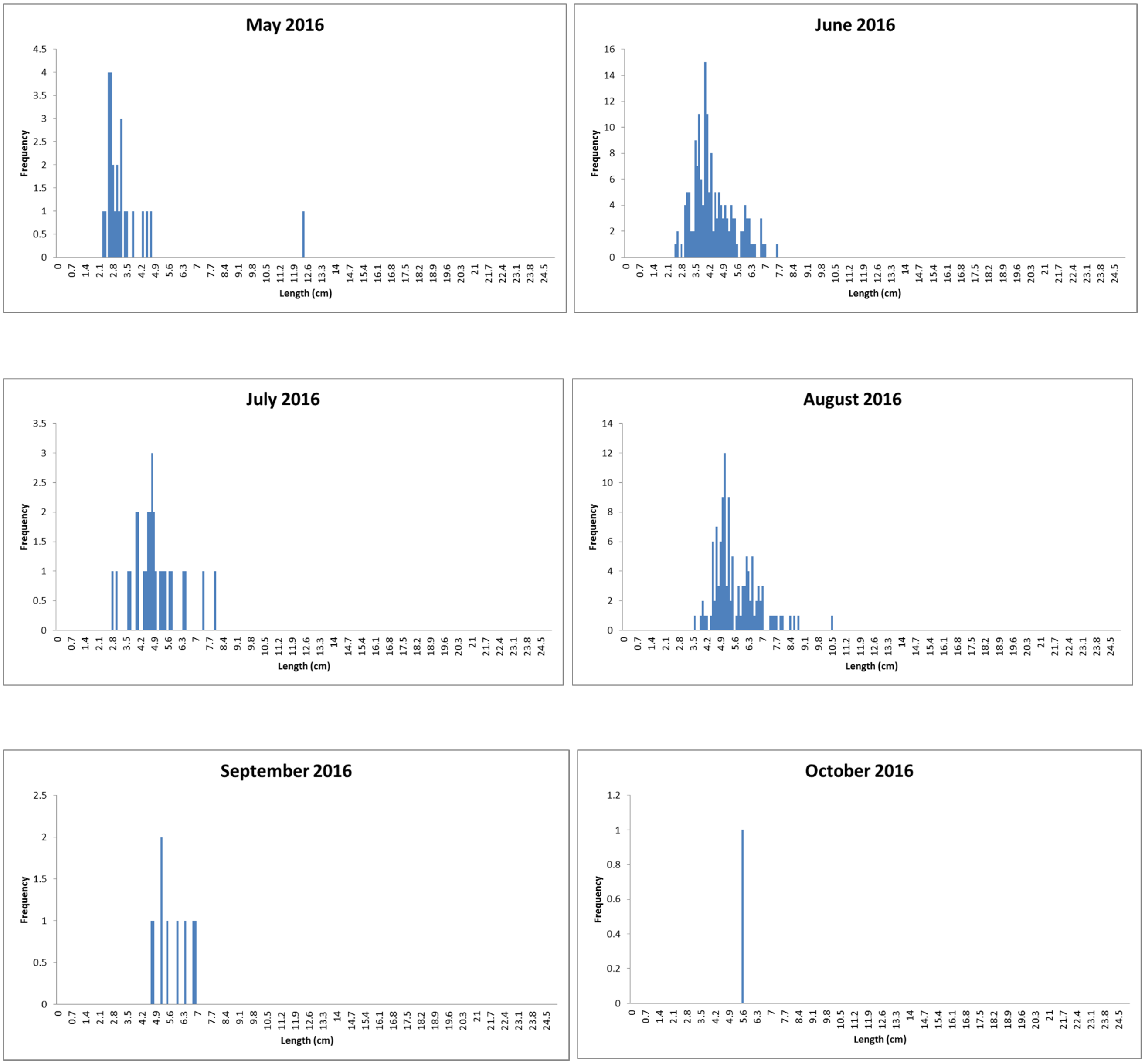


Figure 15: Time series of annual abundance indices for winter flounder YOY from the coastal pond survey.

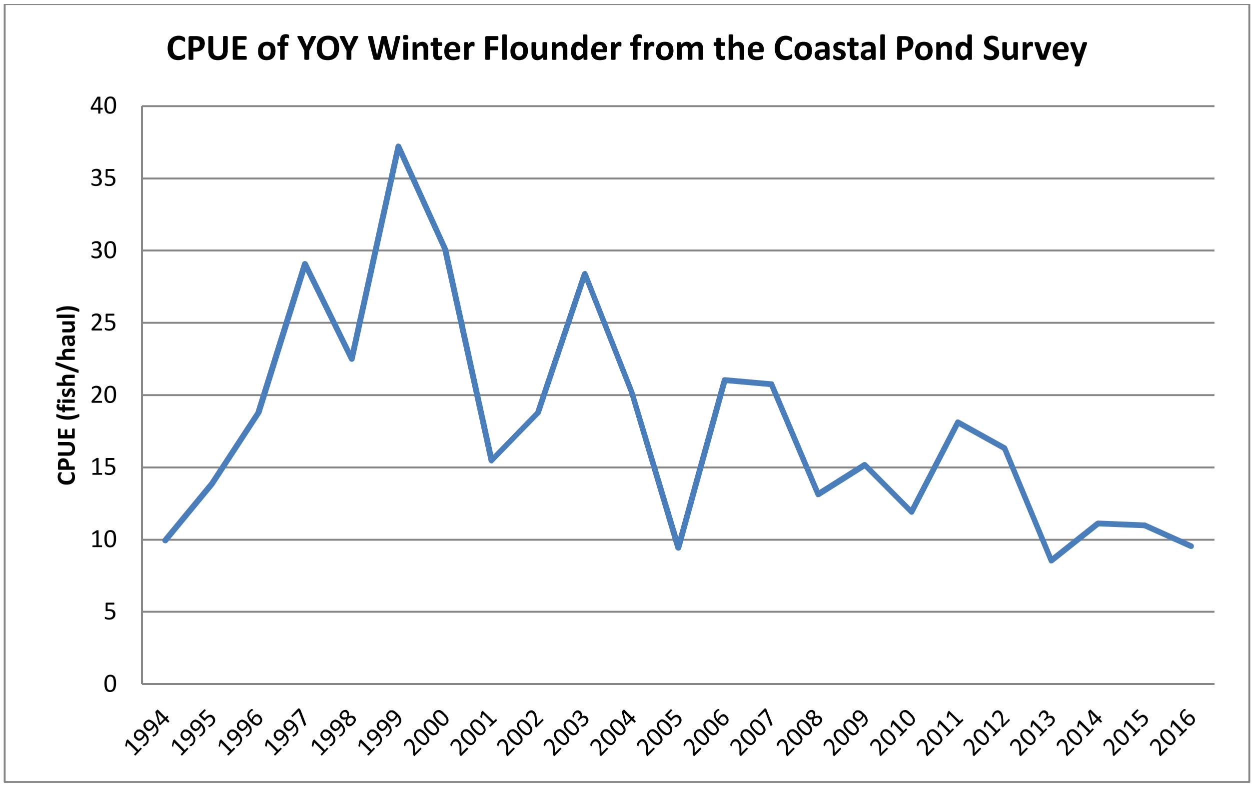


Figure 16: Abundance indices (fish/haul) from the Coastal Pond Survey, Narragansett Bay Seine Survey, and RIDFW Trawl Survey for winter flounder.

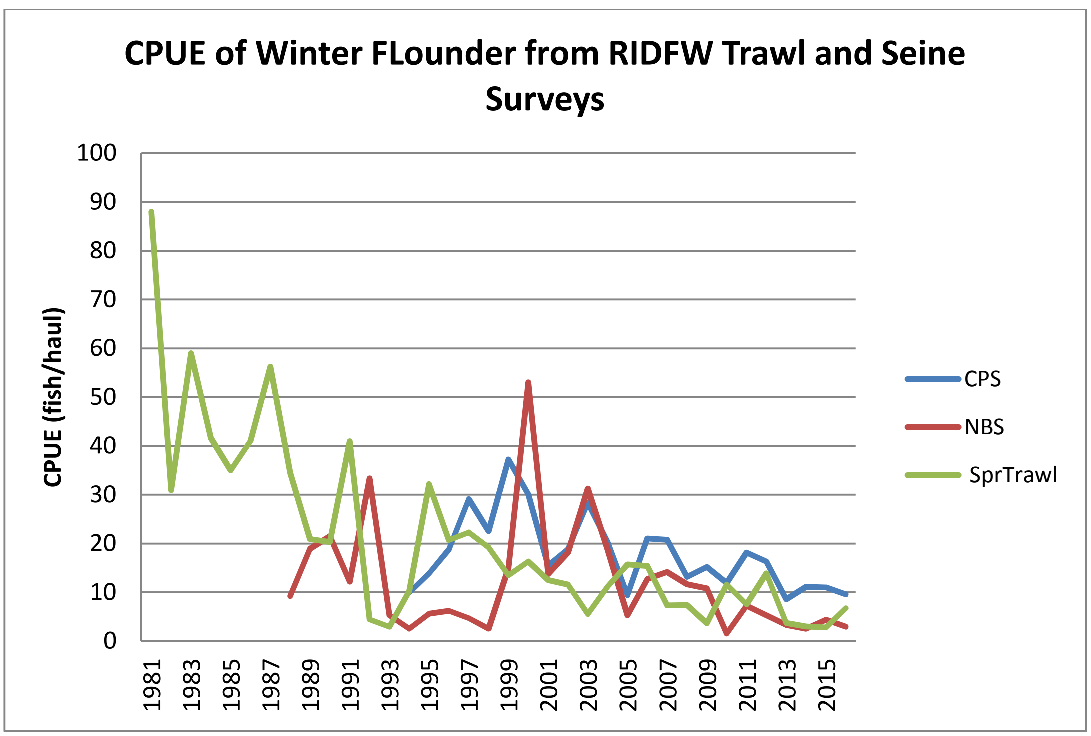


Figure 17: Abundance indices (fish/haul) from the Coastal Pond Survey and the Adult Winter Flounder Tagging Survey for winter flounder.

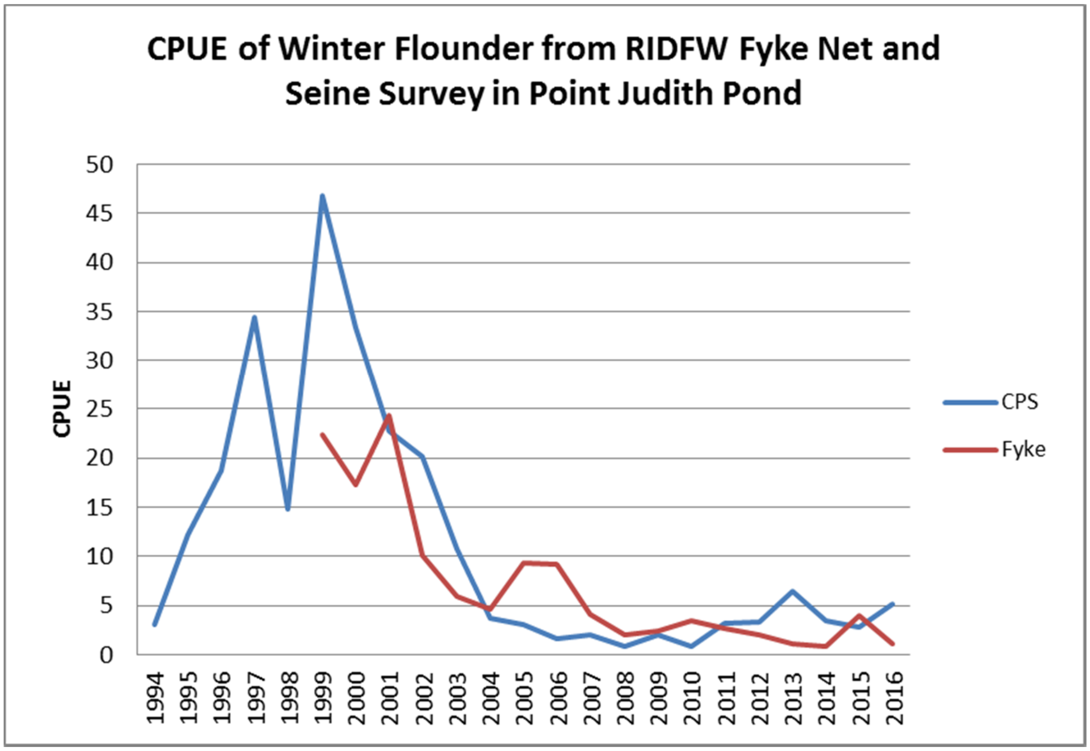


Figure 18. Time series of annual abundance indices for bluefish from the coastal pond survey.

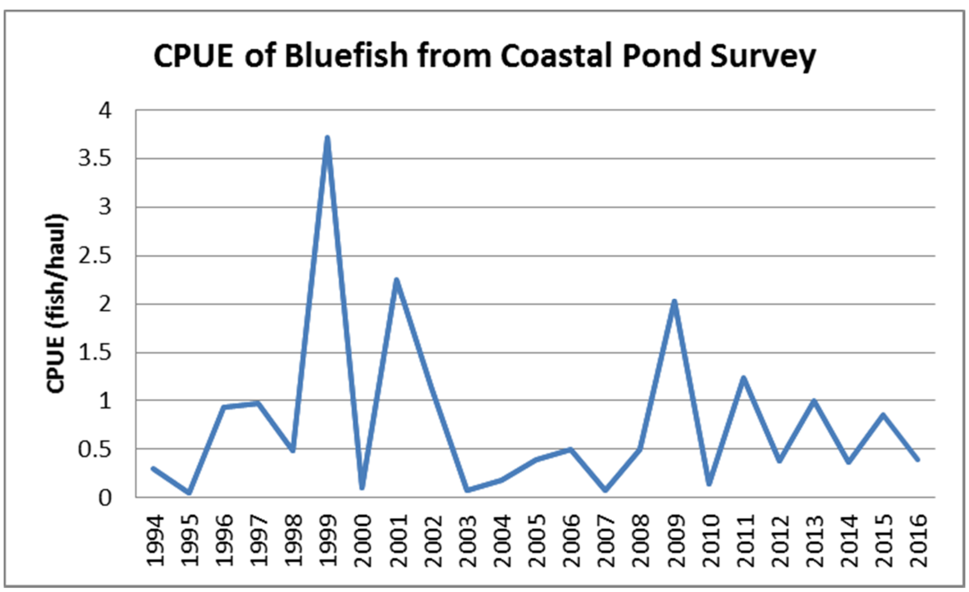


Figure 19. Time series of annual abundance indices for Tautog from the coastal pond survey.

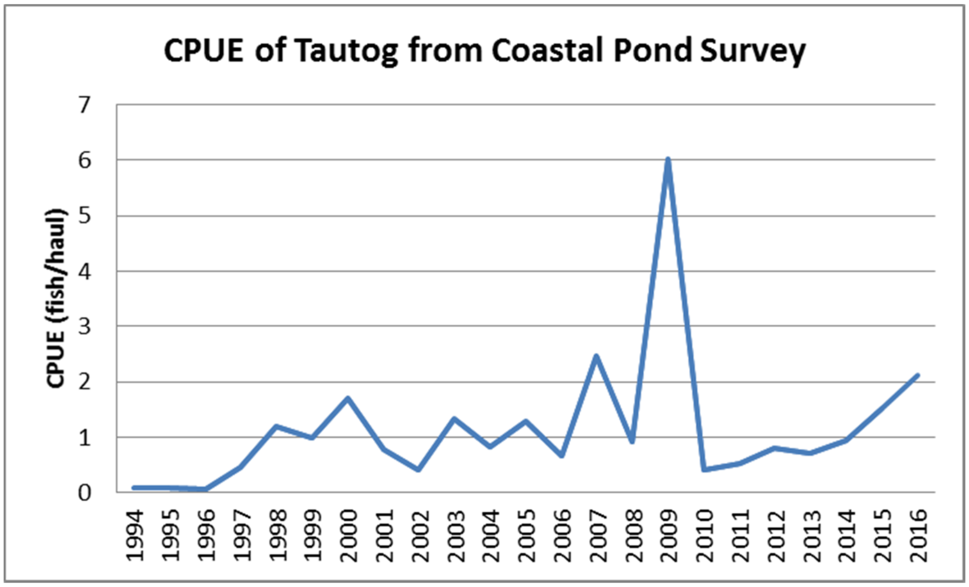


Figure 20. Time series of annual abundance indices for Black Sea Bass from the coastal pond survey.

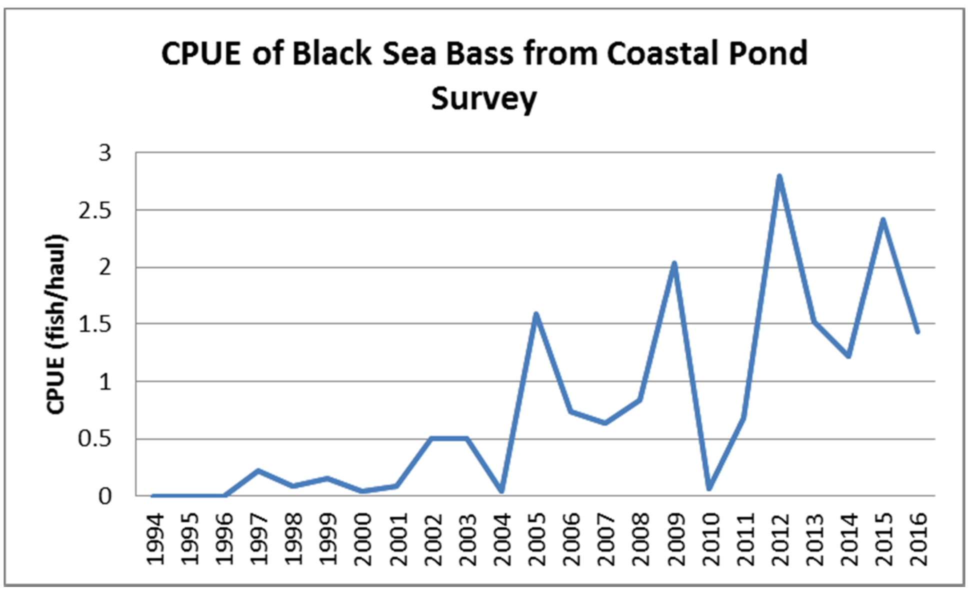


Figure 21. Time series of annual abundance indices for Scup from the coastal pond survey.

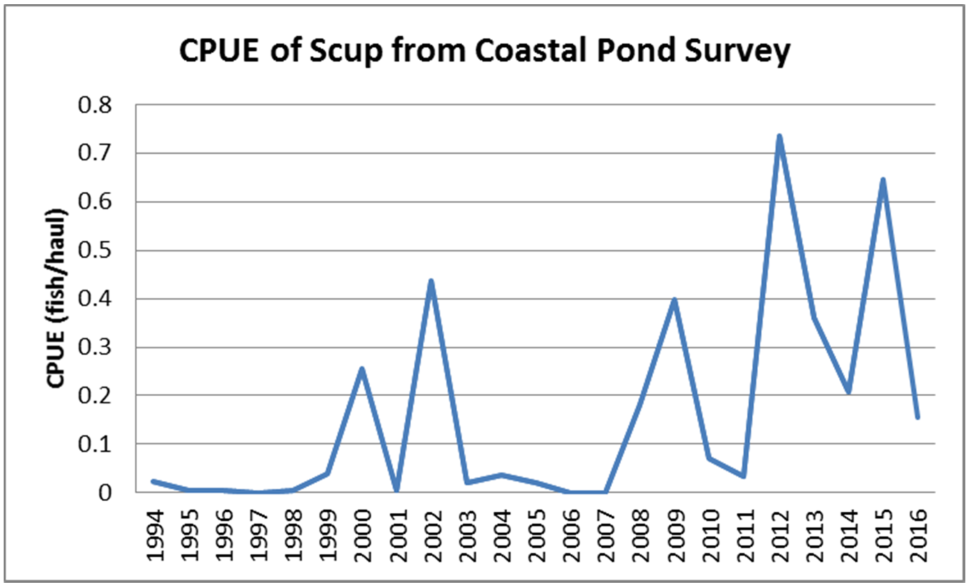


Figure 22. Time series of annual abundance indices for Clupeids from the coastal pond survey (menhaden on right y- axis)

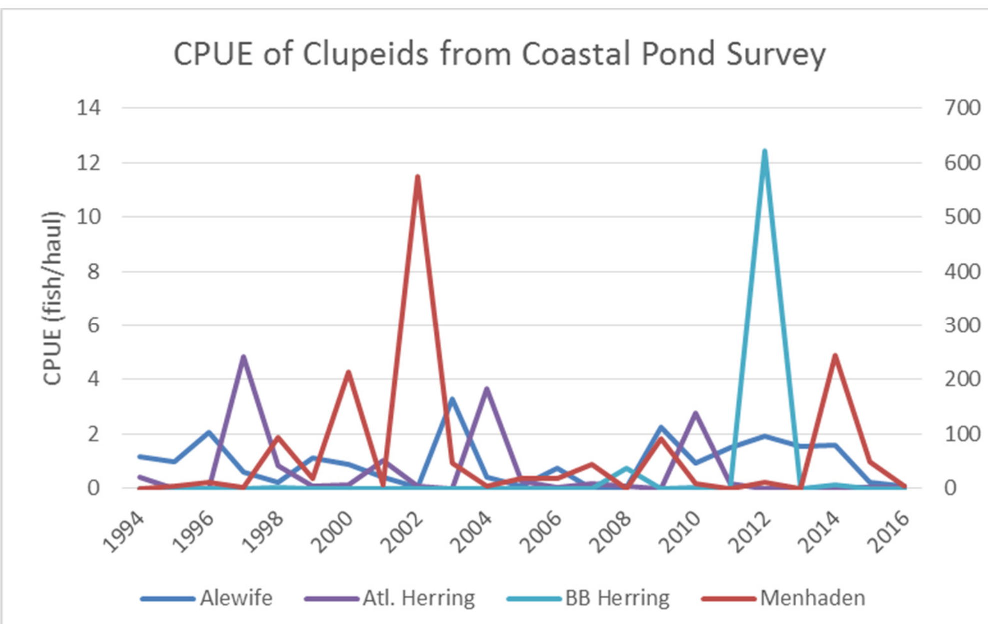
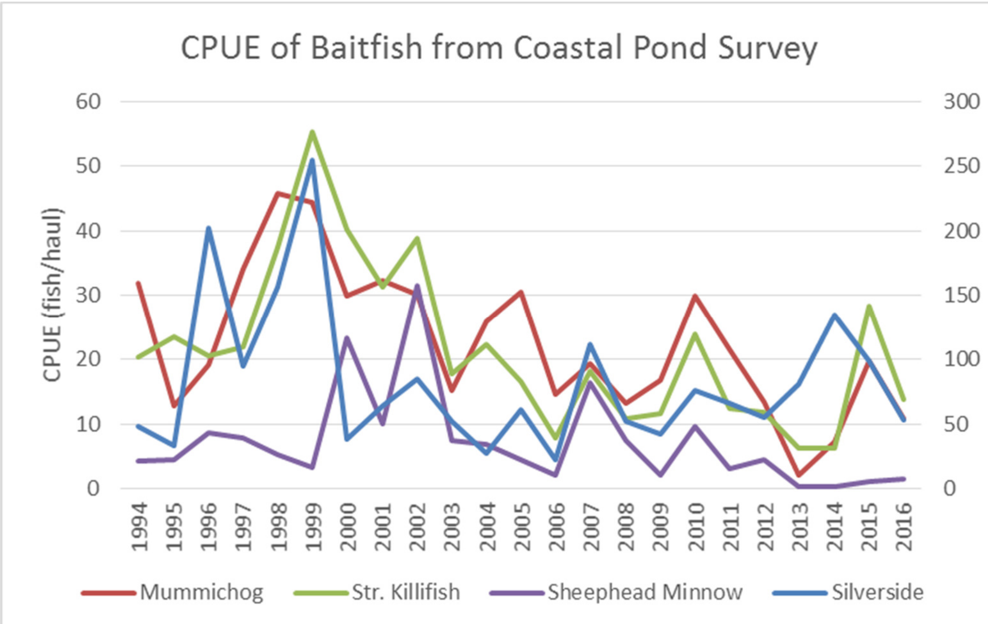


Figure 23. Time series of annual abundance indices for Baitfish from the coastal pond survey (silversides on right y- axis).



Appendix 1a: Catch frequency of all species by station for 2016 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)					10			1									
ANCHOVY BAY (ANCHOA MITCHILLI)			1		3			3			11						
BASS STRIPED (MORONE SAXATILIS)							2										
BAY SCALLOP (ARGOPECTEN IRRADIANS)	2	1	10									1	4				
BLUE CRAB (CALLINECTES SAPIDIUS)				21	1	1		1				8					1
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)		3	1	9	24	2	2	3	2		21	4	3	1		1	11
BLUE CRAB MALE (CALINECTES SAPIDIUS)	2	2	1	8	19		4	7	3		25	5	2	2		1	21
BLUEFISH (POMATOMUS SALTATRIX)		6	1					8			1	1		1			7
CUNNER (TAUTOGOLABRUS ADSPERSUS)	1		14										3				
EEL AMERICAN (ANGUILLA ROSTRATA)		1	2		1		1										
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)			1	2		3	1					3					9
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)		1			2		1		2		3				4		
FLOUNDER WINTER (PSEUDOPLEURONECTES AMERICANUS)	65	3	7	3	10	92	69	3	55	34	106	90	111	27	154	148	46
GOBY NAKED (GOBIOSOMA BOSC)				6	5			3	2		10	1					1
GRUBBY (MYOXOCEPHALUS AENAEUS)							2									20	
GUNNEL ROCK (PHOLIS GUNNELLUS)																	
HERRING ATLANTIC (CLUPEA HARENGUS)									1		2		1				
HOGCHOKER (TRINECTES MACULATUS)					1												
HORSESHOE CRAB (LIMULUS POLYPHEMUS)	2			2		2	1	1				3		5			
JACK CREVALLE (CARANX HIPPOS)														1			
KILLIFISH STRIPED (FUNDULUS MAJALIS)	32	117	114	120	6	53		59	95	633	54	14	49	24	332	20	127
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)						1	1		1			7					
LIZARDFISH INSHORE (SYNODUS FOETENS)					3	1			19		22					4	
MANTIS SHRIMP (SQUILLA MANTIS)											1						
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)		2		1	4	4				374		1				5	
MINNOW SHEEPSHEAD (CYPRINODON VARIEGATUS)	2	123	3		2	24	1			2			7		31		1
MOJARRA SPOTFIN (EUCINOSTOMUS ARGENTEUS)		1				20						1					
MULLET WHITE (MUGIL CUREMA)				16	11												1
MUMMICHOG (FUNDULUS HETEROCLITUS)	25	248	157	61	33	77	48	132	41	52	30	3	14	6	215	17	72
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)			1	1				2			1		1				
PERCH WHITE (MORONE AMERICANA)					7												
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)	2	10	12		3	3		11	14		8	5	3	3	5	4	3
PUFFER NORTHERN (SPHOEROIDES MACULATUS)		1	1		1	1	1		3			3	1	9		5	
RAINWATER KILLIFISH (LUCANIA PARVA)	32	44	132	9	1	1		14	1		1	12			5	1	11
SCUP (STENOTOMUS CHRYSOPS)			4								1			6		7	
SEA BASS BLACK (CENTROPRISTIS STRIATA)	20	2	11			2	21	22	20		45	3	31	4	4	16	
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)													1				
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)	1		1		1				2		1					4	1
SEAROBIN STRIPED (PRIONOTUS EVOLANS)					3	3	1		4		2		2			24	
SENNET NORTHERN (SPHYRAENA BOREALIS)																2	
SHEEPSHEAD (ARCHOSARGUS PROBATOCEPHALUS)	1		6	6		4	1	1			1		1				6
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	85	523	839	895	80	125	182	72	271	111	128	161	246	163	150	1547	274
SNAKEFISH (TRACHINOCEPHALUS MYOPS)	1																
SPOT (LEIOSTOMUS XANTHURUS)																	
SQUID LONGFIN (LOLIGO PEALEI)												1	1				
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	5	82	93	12		4	16	13	2		1						24
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)	1	1															
TAUTOG (TAUTOGA ONITIS)	14	4	78		1	1		7	16		2	34	17	1	1	3	10
TOADFISH OYSTER (OPSANUS TAU)		1	1		1	1		1			3						1
TOMCOD ATLANTIC (MICROGADUS TOMCOD)			1														
WINDOWPANE (SCOPHTHALMUS AQUOSUS)																	

Appendix 1b: Catch frequency of all species by station for 2016 Coastal Pond Survey (new ponds).

Species	GH1	GH2	PP1	PP2	PR1	PR2	PR3
ALEWIFE (ALOSA PSEUDOHARENGUS)							2
ANCHOVY BAY (ANCHOA MITCHILLI)			19	955			1
BASS STRIPED (MORONE SAXATILIS)	1						
BAY SCALLOP (ARGOPECTEN IRRADIANS)							
BLUE CRAB (CALLINECTES SAPIDIUS)		1					
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)	2	2	7				1
BLUE CRAB MALE (CALINECTES SAPIDIUS)	4	4	11	2	1	2	3
BLUEFISH (POMATOMUS SALTATRIX)					5	5	20
CUNNER (TAUTOGOLABRUS ADSPERSUS)							1
EEL AMERICAN (ANGUILLA ROSTRATA)		2	2	4			
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)							
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)	1		2				
FLOUNDER WINTER (PSEUDOPLEURONECTES AMERICANUS)	7	20	12		51	4	2
GOBY NAKED (GOBIOSOMA BOSC)	5		47	3			
GRUBBY (MYOXOCEPHALUS AENAEUS)					1		
GUNNEL ROCK (PHOLIS GUNNELLUS)					1		
HERRING ATLANTIC (CLUPEA HARENGUS)							
HOGCHOKER (TRINECTES MACULATUS)							
HORSESHOE CRAB (LIMULUS POLYPHEMUS)		2			1	1	
JACK CREVALLE (CARANX HIPPOS)			2				
KILLIFISH STRIPED (FUNDULUS MAJALIS)	1	2	16	3	32	56	
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)				4	1		
LIZARDFISH INSHORE (SYNODUS FOETENS)					3		
MANTIS SHRIMP (SQUILLA MANTIS)			1				
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)			235	6		5	
MINNOW SHEEPSHEAD (CYPRINODON VARIEGATUS)		1		1	8		3
MOJARRA SPOTFIN (EUCINOSTOMUS ARGENTEUS)							
MULLET WHITE (MUGIL CUREMA)			5				
MUMMICHOG (FUNDULUS HETEROCLITUS)	100	49	64	59		3	30
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)	3	1					
PERCH WHITE (MORONE AMERICANA)		1					
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)	7	5	4	6	1		1
PUFFER NORTHERN (SPHOEROIDES MACULATUS)					3		
RAINWATER KILLIFISH (LUCANIA PARVA)	18	59	45	59			7
SCUP (STENOTOMUS CHRYSOPS)					4		
SEA BASS BLACK (CENTROPRISTIS STRIATA)				1			
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)							
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)					1	1	
SEAROBIN STRIPED (PRIONOTUS EVOLANS)			1		3		
SENNET NORTHERN (SPHYRAENA BOREALIS)							
SHEEPSHEAD (ARCHOSARGUS PROBATOCEPHALUS)		4		1			
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	48	124	358	459	181	251	170
SNAKEFISH (TRACHINOCEPHALUS MYOPS)							
SPOT (LEIOSTOMUS XANTHURUS)			1				
SQUID LONGFIN (LOLIGO PEALEI)							
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	5	40	13	1		2	18
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)							
TAUTOG (TAUTOGA ONITIS)		1		8	3	1	97
TOADFISH OYSTER (OPSANUS TAU)		2	17	2	1		
TOMCOD ATLANTIC (MICROGADUS TOMCOD)							
WINDOWPANE (SCOPHTHALMUS AQUOSUS)					1		

Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Ponds

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

by
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Federal Aid in Sportfish Restoration
F-61-R

Performance Report – Job#3b March 2017

Assessment of Juvenile Finfish and Seasonal
Dynamics in Great Salt Pond, Block Island, Rhode Island 2016

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Performance Report January 2017

erformance eport

State Rhode Island

ro ect Title Assessment of Juvenile Finfish and Seasonal Dynamics in Great Salt Pond, Block Island, Rhode Island 2016

eriod o ered May 17, 2016 – October 6, 2016

o ecti es To collect, analyze, and review beach seine survey data from Block Island's (BI) coastal pond – Great Salt Pond (GSP) – for the purpose of understanding recruitment relative to spawning stock biomass of winter flounder and other important species.

Summar In 2016, The Nature Conservancy (TNC) investigators caught 38 species of finfish representing 21 families in the GSP. Though overall counts are lower from 2015 (49 species of finfish from 33 families), 14,703 total individuals were recorded during the 2016 sampling season. In 2015, the total number of individuals caught was 19,514. For the 2014 sampling season, 25 species from 24 families were recorded. These increases in number of fish caught during 2015 and 2016 seasons are reflective of high frequencies of Atlantic silversides, striped killifish, and black sea bass, particularly with consecutive large catches in September and October.

Target ate March 30, 2017

Status of ro ect On schedule.

Significant e iations There were no significant deviations in 2016.

ecommendations Continue next segment of the project as currently standardized; continue sampling at each of the 8 sample stations in the GSP.

emarks Investigators successfully sampled all eight stations for each sampling event from May to October. For the purposes of this report, the index value time series for young of the year (YOY) winter flounder will not include data from the stations sampled in Old Harbor (OH). For consistency, the time series species indices will also only include the 8 traditional stations used in the past. The potential bias is unknown if OH data was included; however, the information is readily available upon request.

Stud rea

The GSP is BI's interior marine environment, a body of salt water within an island surrounded by salt water[1], with an approximate surface area of 800 acres at mean low tide[2]. The GSP watershed comprises most of Block Island, with the pond occupying less than 10-percent of the total area (Hale, 2000).

The GSP separates the northern and southern regions of the island. The permanent channel on the northwestern shore of the island connects the pond to Block Island Sound. In 1895, a breachway was constructed to allow open access into the Pond (Hale, 2000). Channel depth ranges from 2.1 m to 4.6 m and maximum depth in the pond reaches up to 20m (Figure 1). The size of the channel affects the salinity of the pond[3], as well as low (tidal) flushing rate, absence of major freshwater aquifers, and relatively small size of the Great Salt Pond watershed[4] (Olsen & Lee, 1982; Katz, 2000).

According to Hale (2000), this breachway has broad-reaching ecological effects on the GSP as it allows for fluctuating synergies of species and environmental conditions. The mix of species changes with the salinity and water temperature (Shumway, 2008). Rain falling on upland parts of the island also creates a salinity gradient between the fresh water coming into inner pond systems of the GSP (Hale, 2014).

Materials and Methods

The beach seine net was used to sample in shallow intertidal areas along the shoreline of the GSP. Juvenile finfish were sampled at 8 traditional stations in the Pond (Figure 2). Stations are referred to as GSP 1-8. The fixed areas for seining are typically less than four feet deep (1.2m) at mean high tide, and have relatively homogeneous habitat features (water depth, substrate, and vegetation). Field collections occurred on a monthly basis from May to October 2016. One beach seine set was made at each site per sampling day. The seine sets were hauled on an incoming tide.

To collect fish, investigators used a seine 130-foot (39.62 m) long by 7.2-foot (2.20 m) by 0.27-inch (7.0mm) knotless diamond mesh with a double weighted lead line footrope, float line on the head rope, and 6-foot (1.83 m) by 6-foot (1.83 m) pocket in the middle of the net. Figure 3 illustrates the area enclosed by the seine net. The net was set in "round haul" fashion by fixing one end of the net on the beach while the other end was deployed from 23-foot outboard powered boat, fed out of a container, and then returned to the shoreline in a semi-circle. Both ends of the net were retrieved and emptied into a bucket of sea water, yielding a catch.

At each draw of the net, the first twenty fish of each species were measured before release. Additional fish were counted and released. For abundant species, the number measured was much less than the overall number captured (Tables in appendix 1a-1b). The size of juvenile fish was characterized by

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[1] *Coastal salt pond* defined in the following source:
Hale, S.S. 2000. Marine Bottom Communities of Block Island Waters. In P.W. Paton, L.L. Gould, P.V. August & A.O. Frost (Ed.), *The Ecology of Block Island* (pp. 131-149). Kingston, RI: The Rhode Island Natural History Survey.

[2] This area includes the tributary ponds, Harbor Pond and Trims Pond as part of the Great Salt Pond and was calculated using ArcGIS.

[3] According to Olsen & Lee (1982), reduced salinity influences suitability of the pond for fish populations and habitat.

[4] The Great Salt Pond watershed drains about 1700 acres, or 27-percent of Block Island according to RIGIS. Database online, 2014. The most convenient way to define the watershed is to use surface topography, and assume the drainage patterns of surface and groundwater follow the same flow patterns. Groundwater gradients may differ somewhat from surface topography.

measuring total length (TL). All finfish were measured in centimeters, except for winter flounder measured in millimeters. The date and time of each seine set was recorded, as well as, several physical habitat parameters associated with each set, including water temperature, salinity and dissolved oxygen. These parameters were measured using YSI Pro Water Quality Meter.

esults and iscussion

Sampling Overview

Beach Seine ffort

The GSP sampling effort in 2016 consisted of 48 beach seine sets made during May through October (Table 1). Average beach seine set area ranges 2030-2445 square meters (Figure 3).

n ironmental onditions during Beach Seine Sampling

Tidal Stage, Water Depth, and Water Transparency

The majority of beach seine sampling occurred at depths slightly shallower than one meter of water (Table 2). Sampling dates were selected for tides that fell between +4 and +2.

Physical and Chemical Data:

Physical and Chemical data for the 2016 survey are summarized in figures 4a, 4b, 4c. For each date, measurements for salinity, water temperature, and dissolved oxygen were recorded at each set, and then averaged for that day. These YSI measurements are not spot measures taken during the time of beach seining and are not a continuously measured record. They are likely insufficient for determining whether the monthly pattern of salinity for the GSP varies as a function of overall Block Island Sound salinity, which is known to be influenced by freshwater sources from the Pond’s watershed (Hale, 2014).

Water temperature in 2016 averaged 19.4°C, with a range of 12.7°C in May to 26.1°C in August. Salinity ranged from 29.79 ppt to 35.10 ppt and averaged 32.54 ppt. Dissolved oxygen averaged 7.86 mg/L, and ranged from 5.30 mg/L in August to 9.86 mg/L in October. Comparison graphs for 2015 and 2016 average measurements are displayed in figures 4d, 4e, 4f, as well as table 3.

HOBO data logger measurements were used to calibrate YSI readings. The data loggers are fixed at three different locations to provide full coverage of the pond. Data logger #1 is situated at Hog Pen dock (SW Great Salt Pond); Data Logger #2 is located at Block Island Club (E Great Salt Pond); Data logger #3 is set at Coast Guard House (NW Great Salt Pond) (Figure 5). These loggers measure salinity, temperature and water conductivity 365-days a year every 30-minutes. Water temperature in GSP nearshore showed an overall seasonal increase from May through August.

These loggers calibrate data points taken by the YSI. The intention is to enhance long term water quality research for the Pond. Figures 6a-6r pinpoint the date and time investigators were in close proximity to the data loggers during the survey for May through October 2016. The graphs display average salinity (µS/cm) and temperature (ºC).

_atch _ Species

We recorded 14,703 fish representing 38 different species throughout the 2016 sampling season (Table 4; appendix 1a). This number is lower than the previous year (Appendix 1b), but significantly higher compared to 2014 (Appendix 1c). Of the 38 species identified and counted in 2016, 745 individuals were measured for total length (TL). Based on geometric mean catch per seine haul, the most abundant finfish in 2016 survey were ranked at: (1) Inland silversides, (2) striped killifish, (3) Atlantic silversides, (4) black sea bass and (5) mummichog. Forage species comprised 97-percent of total catch, with Atlantic and inland silversides composing 83-percent of total catch. The remaining 36 species accounted for 17-percent of the total catch (Figure 7).

Forage fish species, specifically Atlantic and inland silversides, striped killifish and mummichogs were captured at all stations (Appendix 1a). 20 out of 38 total species were rarely encountered and occurred at a single station. Such species included: Atlantic cod, Atlantic herring, Atlantic menhaden, bluefish, bluespotted cornetfish, butterfish, crevalle jack, ninespine stickleback, northern kingfish, northern pipefish, northern puffer, northern searobin, northern sennet, pollock, sand diver, snakefish, striped bass, striped searobin, summer flounder and threespine stickleback.

In 2016, station GSP 8 has the lowest overall species abundance with 462 fish captured. GSP 8 also had the lowest diversity with 6 different species. This same station had the lowest species abundance and diversity in 2015. In 2014, station GSP 7 has the lowest overall species abundance with 314 fish captured, but the third highest diversity with 8 different species. For 2016, station GSP 4 has the highest abundance of species with 16 different species recorded; whereas in 2015, the most individual species caught at a site was station GSP 3 with 14 different species recorded. Stations GSP 3 and 4 are located on either side of the Pond’s channel; interesting to note since the channel functions ecologically as a passage for forage species and pelagic species.

The most diverse site for 2016 was station GSP 6 with 16 different species recorded. In 2015, GSP 5 and 6 were the most diverse and had 21 different species recorded at each station. In 2014, GSP 6 was also the most diverse site and had 14 different species recorded at the station. For three consecutive sampling seasons, Bonnell Beach, or station GSP 6, serves as the most diverse site in the GSP Survey (Table 5a and 5b compare 2015 and 2016 numbers for total individuals and species diversity by station). Water quality data and bottom habitat characterization help explain why this site may be riddled with life. The sandy/rock substrate and boulder outcroppings create complexity for a number of species; tributary system connecting to this site could be adding to the mixing of water and species; and this site is well buffered by vegetation and tucked away as a cove in the contours of the Pond. Out of all of the stations, GSP 6 is the most protected (Figures 8 and 9 show visual comparisons for abundance and diversity results for 2015 and 2016 surveys).

Species abundance was highest in September. Most species abundance numbers peaked in September and then showed slight declines during the October sampling. Possible explanations to these trends, as seen in previous sampling seasons as well, may be indicative of falling trends for finfish species (Bigelow and Shroeder, 2002).

Winter Flounder *Pseudopleuronectes americanus*

Juvenile winter flounder were collected at all 8 stations during the sampling season. Winter flounder ranked sixth in overall species abundance (n=192) in 2016, with the highest mean abundance (fish/seine haul) occurring in September (Table 5; Figure 10). In 2015, winter flounder was also ranked sixth in overall abundance (n=188) with the highest mean abundance occurring in June (Table 6; Figure 11); and in 2014, the species ranked in fourth place (n=96) (Figure 12). Mean abundance indices showed different trends for each sampling year in the GSP (Table 7); peaks vary according to month and catch (Bigelow and Shroeder, 2002). The timing of peak abundance trends differed between 2015 and 2016 (Figure 13). This year, September had a higher mean abundance of winter flounder in the GSP and June had a higher mean abundance of winter flounder in the Pond. The greatest number of winter flounder surveyed in one seine haul came from station GSP 2 in September 2016 (17 individuals measured) (Table 6). In 2015, the greatest number of winter flounder caught in one seine haul happened in October at GSP 5 with 27 individuals measured (Table 7). These differences may indicate separate spawning events (Pentilla *et al.,* 1989; Bigelow and Shroeder, 2002).

One hundred and one winter flounder were collected during the 2014 survey. The juvenile winter flounder abundance index (YOY WFL index) measured populations using the mean fish/seine haul. It increased from 2.08 fish/seine hail in 2014 to 3.48 fish/seine haul in 2015. Mean abundance increased again this year (2016) to 4.00 fish/seine haul. For the purposes of consistency, the YOY WFL index only takes into account fish less than 120 mm TL. The standardized methodology was integrated into the dataset to calculate the overall YOY WFL index.

When comparing spawning of winter flounder in GSP to previous year data, June is typically the peak time for surveyed winter flounder populations (Figure 13). This sequence may be related to the general timing of larvae concentrations occurring in March and April for this region of the northern Atlantic coast (Howe and Coates, 1975; Klein-MacPhee *et al.,* 2012). Winter flounder are documented breed in the winter and early spring, spawning from January through May in New England, and spawning events beginning earlier in southern portions of its range (Pentilla and Dery, 1988; Bigelow and Shroeder, 2002). No significant correlations can be statistically supported for this claim; however, the inference is important to note for the purposes of this time series survey.

YOY WFL index was calculated using fish < 120 mm from the traditional GSP stations. In 2016, winter flounder ranged in size from 44 mm to 192 mm, representing age groups 0-1+ (Bigelow and Shroeder, 2002). Table 9 shows 2016 data for average lengths of winter flounder by month and station. In comparison, the size of winter flounder ranged from 26 mm to 196 mm in 2015. 2016 average TL sizes were longest in July and shortest in October (Table 10 and figure 14). This trend is different from last year's mean averages (Table 11). Table 12 and figure 15 compare average lengths for populations measured in 2015 and 2016.

The majority of individuals collected during the sampling season (89%) were grouped in the 3-6-month age range (Figure 16), since each was less than 120 mm. For YOY WFL index, the most frequent sizes encountered were between 80-90 mm (25 individuals) (Figure 17). No adult winter flounder (age 2+, >200-250 mm) were caught during the GSP 2016 Survey. Monthly length frequency histograms for winter flounder suggested reoccurring spawning events (Figure 18). Figure 19 shows the monthly length frequencies of winter flounder from the 2015 survey.

nland Sil erside *Menidia beryllina*

Inland silverside had the highest abundance of all species: 10,488 individuals caught in the 2016 survey. We did not identify this species in previous sampling seasons[5]. Inland silversides were collected at each station from May to October. The highest abundances were observed in September (Table 13).

Spawning and reproductive ecology is much less studied than that of *M. menidia* (Bigelow and Shroeder, 2002). North of New England region, *M. beryllina* are documented to spawn during the summer months of June and July (Bengston, 1984). Although there is also evidence for twice annual

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[5] *Important note:* At the start of the season, our team carefully keyed out Inland and Atlantic silverside species to more accurately decipher and determine subtle differences between the two (or in the very least, do our best). At the start of sampling season, it was clear we were catching two silverside species. After careful consideration, we are confident in our ability to interpret inland versus Atlantic silverside (i.e, counting fin rays, head-to-eye ratio). Though we may not get it right every time, we have a better handle on key differences.

spawning for inland silverside south and west of Cape Hatteras, there is no current evidence that this occurs in southern New England (Bigelow and Shroeder, 2002). Inland silversides are known to spawn in shallow waters of the intertidal zone of the upper estuary at high tide (Bengston, 1984). Station GSP 8 was the most abundant site for the species throughout the season, with peak numbers recorded in June, September and October. This particular site is characterized as upper estuary zone. The total GSP 1-8 survey index was 27.3 fish/seine haul in 2016 (Table 14). Inland silversides caught in 2016 ranged in size from 5 to 14 cm.

Striped illifish *Fundulus majalis*

Striped killifish ranked second in most abundant species with 1,606 fish caught in 2016. In 2016, striped killifish also came in second for the overall abundance species list (n=2,122). Table 15 contains frequency data according to month and station for 2016. Table 16 lays out the frequency data for 2015. Striped killifish were caught during all sampling events excluding the month of July. In September and October, this species was caught at each station, and station GSP 2 sampled the higher numbers, which is similar to the previous year's results. They were most abundant in September for both 2015 and 2016. Total survey index was 4.2 fish/seine haul for 2016 and it was 6.48 fish/seine haul in 2015 (Table 17). Striped killifish ranged in size from 3 cm to 12 cm in 2016; similar to 2015 range of 4 cm to 12 cm.

tlantic Sil erside *Menidia menidia*

A total of 1,478 were collected from May to October in 2016. This count is significantly less than numbers caught in 2015 (n=15,112) and in 2014 (n=3,649). As previously mentioned, the two species were keyed out a number of times to make sure field investigators were accurately identifying species in this family. Atlantic silversides were most frequently caught at stations GSP 1 and 2, predominantly in May and June 2016 (Table 18). In contrast to 2015, the highest abundances were observed in September (Table 19). Atlantic silversides were ranked the top most abundant species for the 2015 GSP Survey. The total GSP 1-8 survey index was 3.8 fish/seine haul in 2016 compared to 40.9 fish/seine in 2015 (Table 20). TL ranged from 1 cm to 10 cm in 2016; whereas, in 2015, TL ranged from 3 cm to 15 cm.

While *M. menidia* abundances show remarkably different numbers for the past three sampling seasons, this species was consistently ranked in the top most abundant species list since the inception of the GSP Survey. Investigators observe the astronomic volume of Atlantic silversides throughout the year, especially during late summer to fall months. This may be indicative of the winter spawning events happening because of the resident population overwintering in the Pond. Bigelow and Shroeder (2002) confirm shifting patterns of spawning events for this species, particularly in NE region, depending on available food sources and the context of the ecosystem. More research is needed to study food supply in the GSP. Investigators began a plankton study in the GSP to start identifying phyto and/or zooplankton occurring in the Pond. The intention of this study is to link interactions for species caught in this juvenile fish survey as well as other biological surveys.

Black Sea Bass *Centropristis striata*

Black sea bass ranked fourth overall in 2016 with 361 individuals collected. Last year, 897 individuals were collected. Both of these numbers are significantly greater than the number caught in 2014 (n=25). The highest abundances were observed in October this year at station GSP 5 (Table 21); whereas, September was the most abundant event for black sea bass collected in 2015 (Table 22). Interestingly enough, station GSP 5 was also the site to support the greatest catch of black sea bass in both 2014 and 2015 (Table 22). This station is located in Cormorant Cove, adjacent to the channel, where black sea bass populations (of all life stages) are especially known to congregate and move through this corridor. The species' preferred habitat features and environmental conditions align well to this area of the GSP: (1) varying depths and slope gradients; (2) rocky bottom; (3) inshore area;

and (4) higher-salinity conditions (particularly ideal for juvenile phases) (Mercer, 1989; Bigelow and Shroeder, 2002; McNamee, per comm.).

Overall, the abundance index for this season was lower than the last: 0.9 fish/seine haul in 2016 and 2.34 fish/seine haul in 2015 (Table 23). Size ranged from 3 cm to 7 cm in 2016, similar to 2015 range of 2 cm to 7 cm.

Mummichog *Fundulus heteroclitus*

Two hundred and fifty-three mummichogs were collected between May and October 2016. Mummichogs occurred at stations GSP 1, 5 and 8, and were most abundant at GSP 8 (Table 24). In 2015, 201 individuals were collected and were caught at each station in every month sampling event except in June (Table 25). They were also most abundant at stations GSP 3 and 7 in 2015. The 2014 catch yielded a total of 24 individuals (appendix 1c). The abundance index in 2016 was slightly higher 0.7 fish/seine haul compared to 2015's 0.47 fish/seine haul (Table 26). Mummichogs measured in 2016 ranged in size from 5 cm to 11 cm. In 2015, species size ranged from 3 cm to 9 cm.

Summar

This year marked the third sampling season for the GSP Survey. In 2016, investigators caught 38 species of finfish representing 21 families in the GSP. This number is comparatively lower than 2015 records (49 species from 33 families), but comparatively higher than 2014 (25 species from 24 families). Shifting water quality conditions and different influx of species are two of the many available factors that may influence such changes. It is also important to note that these factors may be influenced by (1) different seine net design (pocket added in 2015 survey), (2) proficiency in identification methods, (3) species identifications possibly lumped together in previous survey years (namely 2014), and (4) higher frequencies of forage fish species occurring in the GSP system, specifically, silversides, black sea bass and striped killifish. The time series dataset will project these trends over time.

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Ta les

Ta le . Summary of beach seine effort (number of sets) at Great Salt Pond and Old Harbor, 2016.

Sampling effort num er of each seine sets	
Sampling dates	**reat Salt ond sets**
17-May	8
13-June	8
11-July	8
16-August	8
13-September	8
6-October	8
Total	

Ta le . Water depth and water transparency during beach seine sampling at Great Salt Pond sites in 2016.

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

epth of ater transparenc Secchi disc	
Maximum	2 meters
Minimum	0.3 meters
Average and 1 standard deviation (in parentheses)	1.04 (0.43) meters

Ta le Comparing 2015 and 2016 water quality parameters.

erages for ater temperature dissol ed o gen and salinit s		
Water temperature (°C)	18.3	19.4
Salinity (ppt)	32.87	32.54
Dissolved oxygen (mg/L)	8.26	7.86

Ta le   2016 catalogue of species. Names in bold are fish species considered of greatest conservation need of Rhode Island according to RI WAP Fish Taxa Team 2014.

Fish Species			
ommon ame	**Scientific ame**	**ommon ame**	**Scientific ame**
American sand lance	***Ammodytes americanus***	Northern kingfish	*Menticirrhus saxatilis*
Atlantic cod	***Gadus morhua***	Northern pipefish	*Syngnathus fuscus*
Atlantic croaker	*Micropogonias undulatus*	Northern puffer	*Sphoeroides maculatus*
Atlantic herring	***Clupea harengus***	**Northern searobin**	***Prionotus carolinus***
Atlantic menhaden	***Brevoortia tyrannus***	Northern sennet	*Sphyraena borealis*
Atlantic silverside	***Menidia menidia***	**Pollock**	***Pollachius virens***
Bighead searobin	*Prionotus tribulus*	**Rainwater killifish**	***Lacania parva***
Black sea bass	***Centropristis striata***	Sand diver	*Synodus intermedius*
Bluefish	***Pomatomus saltatrix***	Scup	*Stenotomus chrysops*
Bluespotted cornetfish	*Fistularia tabacaria*	**Sheepshead minnow**	***Archosargus probatocephalus***
Butterfish	***Peprilus triacanthus***	Snakefish	*Trachinocephalus myops*
Crevalle jack	*Caranx hippos*	Striped bass	*Morone saxatilis*
Cunner	*Tautogolabrus adspersus*	**Striped killifish**	***Fundulus majalis***
Grubby	***Myoxocephalus aenaeus***	Striped searobin	*Prionotus evolans*
Inland silverside	***Menidia beryllina***	Summer flounder	*Paralichthys dentatus*
Inshore lizardfish	*Synodus foetens*	**Tautoga onitis**	***Tautog***
Mojarras sp.	*Gerreidae spp.*	**Threespine stickleback**	***Gasterosteus aculeatus***
Mummichog	***Fundulus heteroclitus***	**Windowpane**	***Scophthalmus aquosus***
Ninespine stickleback	***Pungitius pungitius***	**Winter flounder**	***Pseudopleuronectes americanus***

Ta le a Total number of individuals collected and species diversity by station for GSP Survey 2016.

	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
Total # individuals	1006	2442	2766	4327	824	2651	349	338
Species diversity #	9	7	8	10	12	16	8	6

Ta le Total number of individuals collected and species diversity by station for GSP Survey 2015.

	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
Total # individuals	940	2214	5236	1259	3769	2954	2803	702
Species diversity #	18	17	14	16	21	21	15	10

Ta le Winter flounder frequency by station and month GSP Survey 2016.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	1	3	3	5	1	**13**	**2.17**	**1.83**
GSP-2	3	1	9	14	17	1	**45**	**7.50**	**6.92**
GSP-3	0	1	2	11	16	2	**32**	**5.33**	**6.56**
GSP-4	1	2	7	6	3	2	**21**	**3.50**	**2.43**
GSP-5	1	6	0	0	4	6	**17**	**2.83**	**2.86**
GSP-6	0	0	5	7	12	0	**24**	**4.00**	**4.94**
GSP-7	0	0	0	0	5	4	**9**	**1.50**	**2.35**
GSP-8	13	4	1	0	8	5	**31**	**5.17**	**4.79**
Totals	**18**	**15**	**27**	**41**	**70**	**21**			
Mean	**2.25**	**1.88**	**3.38**	**5.13**	**8.75**	**2.63**			
STD	**4.46**	**2.10**	**3.34**	**5.36**	**5.55**	**2.13**			

Ta le Great Salt Pond Survey 2015 winter flounder frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	0	34	12	6	1	**53**	**8.83**	**13.18**
GSP-2	2	73	33	47	10	5	**170**	**28.33**	**28.07**
GSP-3	0	0	1	6	12	2	**21**	**3.50**	**4.72**
GSP-4	0	3	0	7	17	0	**27**	**4.50**	**6.72**
GSP-5	3	3	3	0	25	27	**61**	**10.17**	**12.34**
GSP-6	0	0	2	0	6	0	**8**	**1.33**	**2.42**
GSP-7	0	0	0	0	4	1	**5**	**0.83**	**1.60**
GSP-8	0	37	1	8	1	2	**49**	**8.17**	**14.41**
Totals	**5**	**116**	**74**	**80**	**81**	**38**			
Mean	**0.63**	**14.50**	**9.25**	**10.00**	**10.13**	**4.75**			
STD	**1.19**	**26.82**	**15.00**	**15.59**	**7.81**	**9.13**			

Ta le Mean abundance indices (fish/seine haul) for winter flounder by site area and month. Values show the total survey index for 2015 and 2016.

	May	Jun	Jul	Aug	Sep	Oct
Pond index 2015	0.5	11.6	7.7	8.0	8.1	3.8
Pond index 2016	2.25	1.88	3.38	5.13	8.75	2.63

Ta le 2016 GSP Survey winter flounder average lengths (mm) by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct
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

Ta le Mean average lengths (mm) for winter flounder by month for GSP Survey 2016.

	May	Jun	Jul	Aug	Sep	Oct
Mean average lengths (mm)	105.52	83.77	152.33	74.77	88.5	81.33

Ta le 2015 GSP Survey winter flounder average lengths (mm) by station and month.

Station	18-May	17-Jun	15-Jul	11-Aug	15-Sep	13-Oct
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

Ta le Mean average lengths (mm) of winter flounder by month for both 2015 and 2016 surveys.

	2015	**2016**
May	88.00	105.52
Jun	82.35	83.77
Jul	64.64	152.33

Aug	62.54	74.77
Sep	74.76	88.50
Oct	74.81	81.33

Ta le 2016 GSP Survey inland silverside frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	61	109	0	280	5	**455**	**75.83**	**109.11**
GSP-2	76	233	382	0	1201	21	**1913**	**318.83**	**455.83**
GSP-3	0	336	0	6	55	1975	**2372**	**395.33**	**784.71**
GSP-4	0	0	0	6	184	50	**240**	**40.00**	**73.20**
GSP-5	0	0	0	1	282	21	**304**	**50.67**	**113.63**
GSP-6	0	0	14	0	177	429	**620**	**103.33**	**174.07**
GSP-7	0	0	0	0	27	2134	**2161**	**360.17**	**869.06**
GSP-8	0	987	0	0	1349	87	**2423**	**403.83**	**603.83**
Totals	**76**	**1617**	**505**	**13**	**3555**	**4722**			
Mean	**9.50**	**202.13**	**63.13**	**1.63**	**444.38**	**590.25**			
STD	**26.87**	**341.89**	**134.23**	**2.72**	**522.26**	**915.15**			

Ta le 2016 GSP Survey inland silverside abundance index (fish/seine haul) by site and month.

	May	Jun	Jul	Aug	Sep	Oct
Pond index	9.50	202.13	63.13	1.63	444.38	590.25

Ta le 2016 GSP Survey striped killifish frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	2	4	0	9	1	5	**21**	**3.50**	**3.27**
GSP-2	8	10	0	20	603	19	**660**	**110.00**	**241.63**
GSP-3	0	12	0	20	93	18	**143**	**23.83**	**34.95**
GSP-4	0	0	0	4	20	10	**34**	**5.67**	**8.04**
GSP-5	0	0	0	21	525	68	**614**	**102.33**	**208.74**
GSP-6	0	0	0	7	21	29	**57**	**9.50**	**12.57**
GSP-7	0	0	0	4	6	17	**27**	**4.50**	**6.63**
GSP-8	0	0	0	20	20	10	**50**	**8.33**	**9.83**
Totals	**10**	**26**	**0**	**105**	**1289**	**176**			
Mean	**1.25**	**3.25**	**0.00**	**13.13**	**161.13**	**22.00**			
STD	**2.82**	**5.01**	**0.00**	**7.79**	**251.13**	**19.97**			

Ta le 2015 Great Salt Pond Survey striped killifish frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD

GSP-1	0	0	3	0	5	0	**8**	**1.33**	**2.16**
GSP-2	0	0	2	83	1012	5	**1102**	**183.67**	**407.10**
GSP-3	0	0	0	33	85	0	**118**	**19.67**	**34.62**
GSP-4	0	0	0	11	108	129	**248**	**41.33**	**60.29**
GSP-5	0	0	0	27	72	371	**470**	**78.33**	**146.11**
GSP-6	0	0	0	3	43	11	**57**	**9.50**	**16.96**
GSP-7	0	0	1	1	6	21	**29**	**4.83**	**8.23**
GSP-8	0	0	0	68	382	0	**450**	**75.00**	**152.84**
OH-1	0	0	0	0	0	0	**0**	**0.00**	**0.00**
OH-2	0	0	0	0	0	6	**6**	**1.00**	**2.45**
Totals	**0**	**0**	**6**	**226**	**1713**	**543**			
Mean	**0.00**	**0.00**	**0.60**	**22.60**	**171.30**	**54.30**			
STD	**0.00**	**0.00**	**1.07**	**30.47**	**316.69**	**118.05**			

Ta le 2015 and 2016 GSP Survey striped killifish abundance index (fish/seine haul) by site and month.

	May	Jun	Jul	Aug	Sep	Oct
Pond index 2015	0.00	0.00	0.75	28.25	214.13	67.88
Pond index 2016	1.25	3.25	0.00	13.13	161.13	22.00

Ta le 2016 GSP Survey Atlantic silverside frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	92	332	29	34	9	10	**506**	**84.33**	**125.05**
GSP-2	451	44	0	144	0	0	**639**	**106.50**	**177.77**
GSP-3	0	63	0	0	0	0	**63**	**10.50**	**25.72**
GSP-4	0	86	0	0	45	0	**131**	**21.83**	**36.22**
GSP-5	0	0	0	0	0	0	**0**	**0.00**	**0.00**
GSP-6	0	0	34	0	0	0	**34**	**5.67**	**13.88**
GSP-7	48	0	0	0	0	0	**48**	**8.00**	**19.60**
GSP-8	57	0	0	0	0	0	**57**	**9.50**	**23.27**
Totals	**648**	**525**	**63**	**178**	**54**	**10**			
Mean	**81.00**	**65.63**	**7.88**	**22.25**	**6.75**	**1.25**			
STD	**153.50**	**112.80**	**14.64**	**50.61**	**15.77**	**3.54**			

Ta le 2015 GSP Survey Atlantic silverside frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	0	26	24	533	38	**621**	**103.50**	**210.96**
GSP-2	0	73	154	15	23	683	**948**	**158.00**	**263.25**
GSP-3	0	20	5	169	389	4434	**5017**	**836.17**	**1768.93**
GSP-4	28	7	14	6	722	129	**906**	**151.00**	**283.61**

GSP-5	0	1	0	57	2176	570	**2804**	**467.33**	**866.34**
GSP-6	20	0	0	37	1936	388	**2381**	**396.83**	**768.84**
GSP-7	0	0	0	27	2158	377	**2562**	**427.00**	**860.91**
GSP-8	0	19	3	24	382	46	**474**	**79.00**	**149.36**
OH-1	51	2	78	19	76	748	**974**	**162.33**	**288.52**
OH-2	0	0	0	272	583	119	**974**	**162.33**	**232.35**
Totals	**99**	**122**	**280**	**650**	**8978**	**7532**			
Mean	**9.90**	**12.20**	**28.00**	**65.00**	**897.80**	**753.20**			
STD	**17.65**	**22.74**	**50.41**	**86.55**	**851.69**	**1319.31**			

Ta le 2015 and 2016 GSP Survey Atlantic silverside abundance index (fish/seine haul) by site and month.

	May	Jun	Jul	Aug	Sep	Oct
Pond index 2015	5.00	15.00	25.25	44.88	1039.88	833.13
Pond index 2016	81.00	65.63	7.88	22.25	6.75	1.25

Ta le 2016 GSP Survey black sea bass frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	0	0	4	12	0	**16**	**2.67**	**4.84**
GSP-2	0	0	0	0	2	10	**12**	**2.00**	**4.00**
GSP-3	0	0	0	40	28	62	**130**	**21.67**	**26.12**
GSP-4	0	0	0	2	1	1	**4**	**0.67**	**0.82**
GSP-5	0	0	0	25	32	108	**165**	**27.50**	**41.89**
GSP-6	0	0	0	19	6	3	**28**	**4.67**	**7.42**
GSP-7	0	0	0	6	0	0	**6**	**1.00**	**2.45**
GSP-8	0	0	0	0	0	0	**0**	**0.00**	**0.00**
Totals	**0**	**0**	**0**	**96**	**81**	**184**			
Mean	**0.00**	**0.00**	**0.00**	**12.00**	**10.13**	**23.00**			
STD	**0.00**	**0.00**	**0.00**	**14.59**	**12.94**	**40.33**			

Ta le 2015 GSP Survey black sea bass frequency by station and month.

Station	May	Jun	Jul	Aug	Sep	Oct	Totals	Mean	STD
GSP-1	0	0	0	2	19	0	**21**	**3.50**	**7.64**
GSP-2	0	0	0	6	1	0	**7**	**1.17**	**2.40**
GSP-3	0	0	0	0	21	2	**23**	**3.83**	**8.45**
GSP-4	0	0	0	0	93	19	**112**	**18.67**	**37.20**
GSP-5	0	0	0	0	65	388	**453**	**75.50**	**155.29**
GSP-6	0	0	0	25	183	10	**218**	**36.33**	**72.52**
GSP-7	0	0	0	3	59	2	**64**	**10.67**	**23.71**
GSP-8	0	0	0	0	0	0	**0**	**0.00**	**0.00**

OH-1	0	0	0	0	1	0	**1**	**0.17**	**0.41**
OH-2	0	0	0	0	0	0	**0**	**0.00**	**0.00**
Totals	**0.00**	**0.00**	**0.00**	**36.00**	**442.00**	**421.00**			
Mean	**0.00**	**0.00**	**0.00**	**6.55**	**44.20**	**42.10**			
STD	**0.00**	**0.00**	**0.00**	**12.24**	**58.79**	**121.70**			

Ta le 2015 and 2016 GSP Survey black sea bass abundance index (fish/seine haul) by site and month.

	May	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Pond index 2015	0.00	0.00	0.00	4.50	55.13	52.63
Pond index 2016	0.00	0.00	0.00	12.00	10.13	23.00

Ta le 2016 GSP Survey mummichog frequency by station and month.

Station	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Totals**	**Mean**	**STD**
GSP-1	22	0	20	0	0	1	**43**	**7.17**	**10.74**
GSP-2	0	0	0	0	0	0	**0**	**0.00**	**0.00**
GSP-3	0	0	0	0	0	0	**0**	**0.00**	**0.00**
GSP-4	0	0	0	0	0	0	**0**	**0.00**	**0.00**
GSP-5	0	0	0	0	0	1	**1**	**0.17**	**0.41**
GSP-6	0	0	0	0	0	0	**0**	**0.00**	**0.00**
GSP-7	0	0	0	1	0	0	**1**	**0.17**	**0.41**
GSP-8	0	0	0	103	71	34	**208**	**34.67**	**43.81**
Totals	**22**	**0**	**20**	**104**	**71**	**36**			
Mean	**2.75**	**0.00**	**2.50**	**13.00**	**8.88**	**4.50**			
STD	**7.78**	**0.00**	**7.07**	**36.37**	**25.10**	**11.93**			

Ta le 2015 GSP Survey mummichog frequency by month and station.

Station	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Totals**	**Mean**	**STD**
GSP-1	0	0	0	25	80	0	**105**	**17.50**	**32.21**
GSP-2	0	0	0	7	0	1	**8**	**1.33**	**2.80**
GSP-3	0	0	0	1	3	1	**5**	**0.83**	**1.17**
GSP-4	0	0	0	0	20	0	**20**	**3.33**	**8.16**
GSP-5	0	0	0	0	6	0	**6**	**1.00**	**2.45**
GSP-6	0	0	0	1	20	0	**21**	**3.50**	**8.09**
GSP-7	0	1	6	7	21	0	**35**	**5.83**	**8.04**
GSP-8	0	0	0	0	1	0	**1**	**0.17**	**0.41**
OH-1	0	0	1	18	3	0	**22**	**3.67**	**7.12**
OH-2	0	0	0	4	0	0	**4**	**0.67**	**1.63**
Totals	**0**	**1**	**7**	**63**	**154**	**2**			
Mean	**0.00**	**0.10**	**0.70**	**6.30**	**15.40**	**0.36**			

STD	**0.00**	**0.32**	**1.89**	**8.62**	**24.32**	**0.42**			

Ta le 2016 and 2015 GSP Survey mummichog abundance index (fish/seine haul) by site and month.

	May	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Pond index 2015	0	0.13	0.75	5.13	18.88	0.25
Pond index 2016	2.75	0.00	2.50	13.00	8.88	4.50

Figures

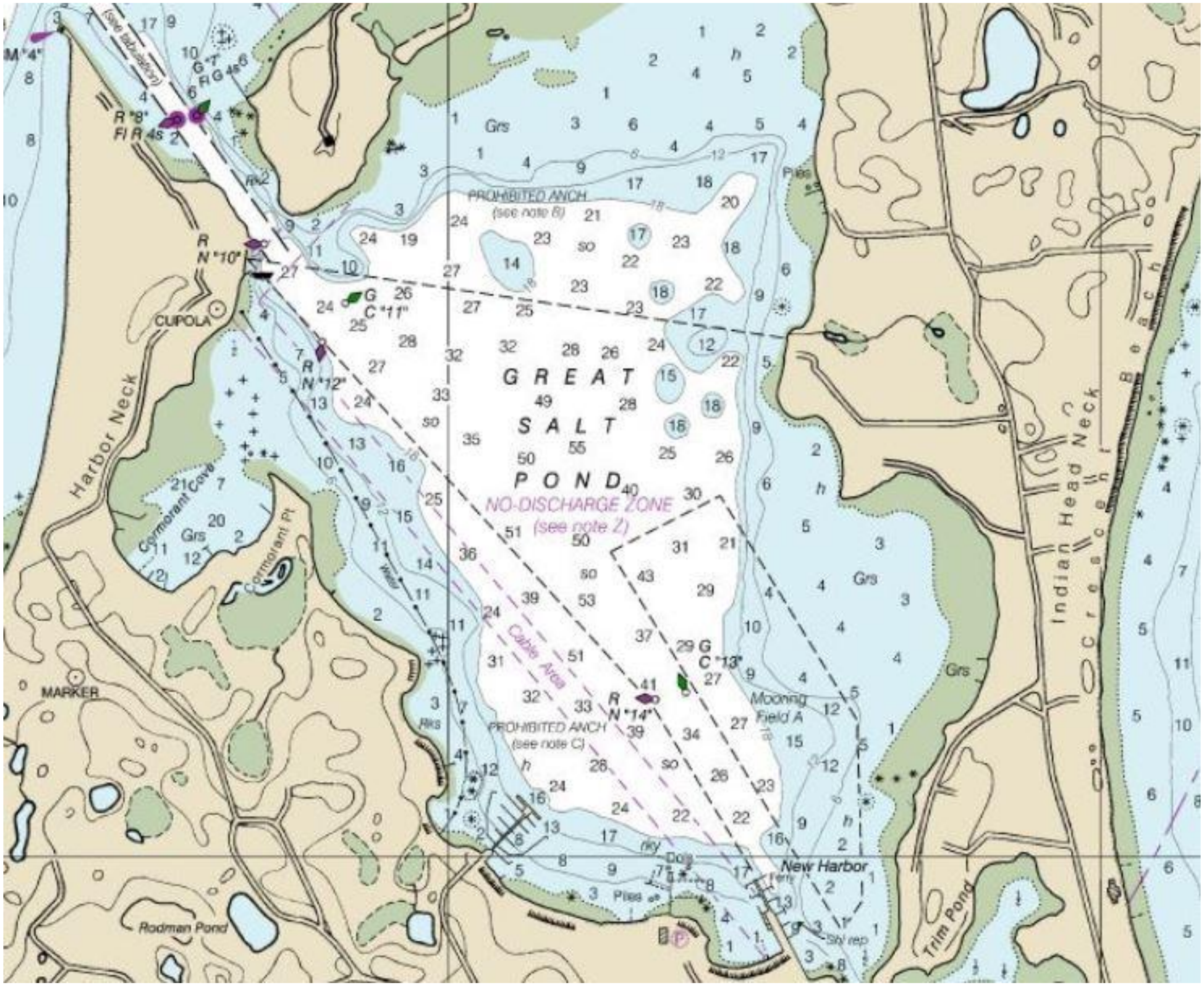

Figure NOAA Office of Coastal Survey, Nautical Chart 13217, Great Salt Pond, Block Island.

Figure Locations for sample stations in the GSP. White circles represent GSP 1-8 sites. Map created in Google Earth.

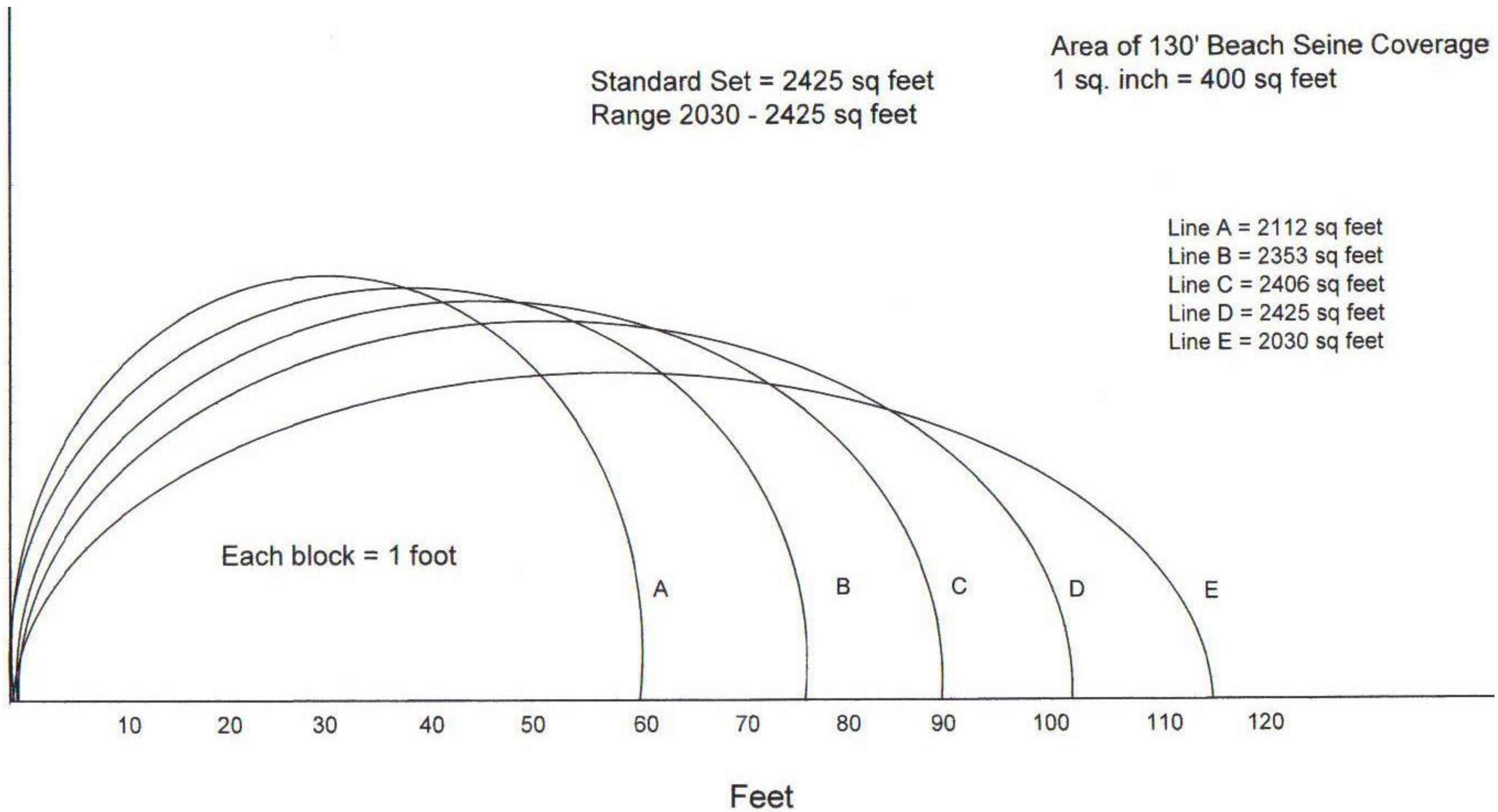

Figure . Area covered by seine net in GSP juvenile fish survey.

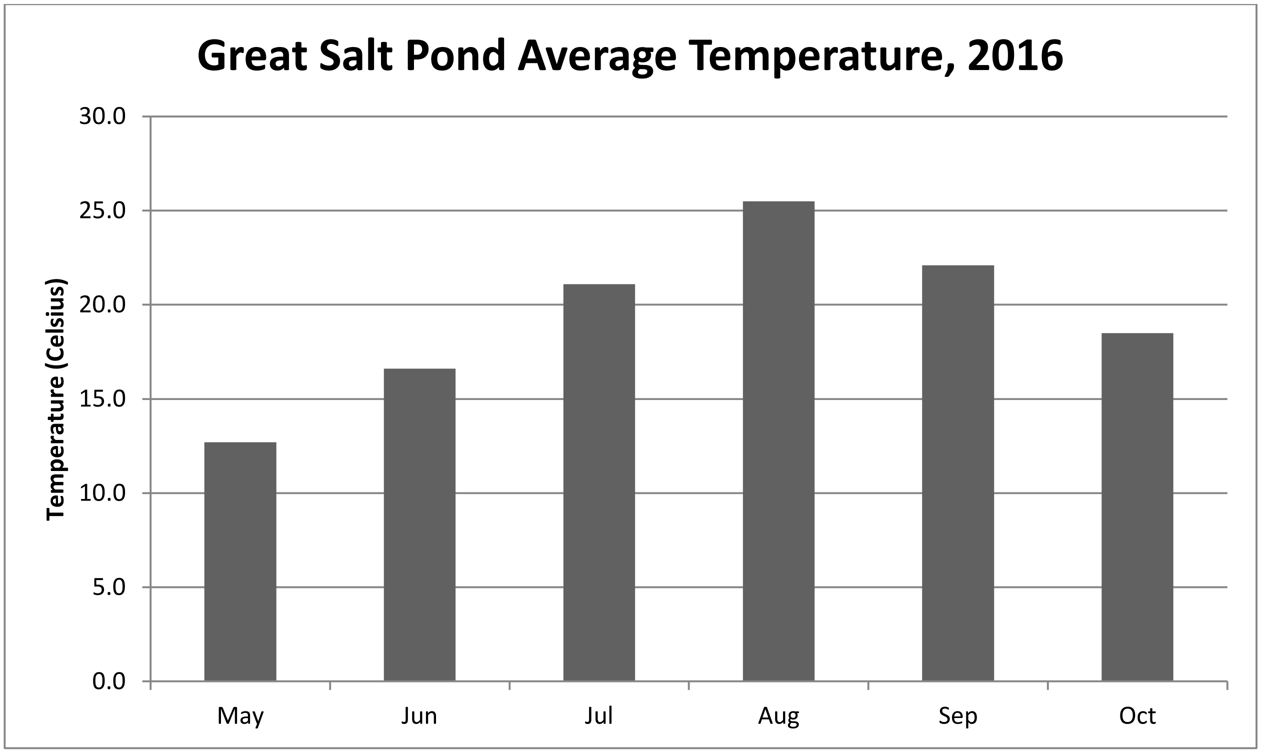

Figure a Average water temperature at GSP sites during the time of beach seining in 2016.

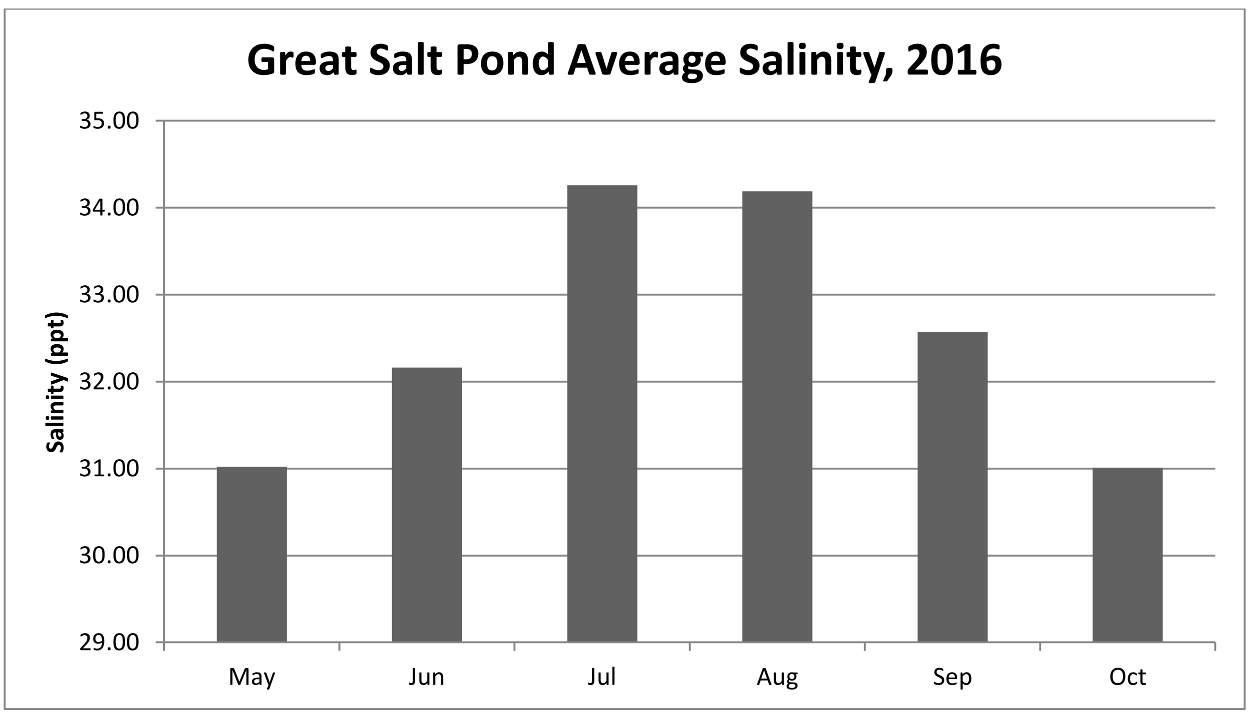

Figure Average salinity at GSP sites during the time of the beach seining in 2016.

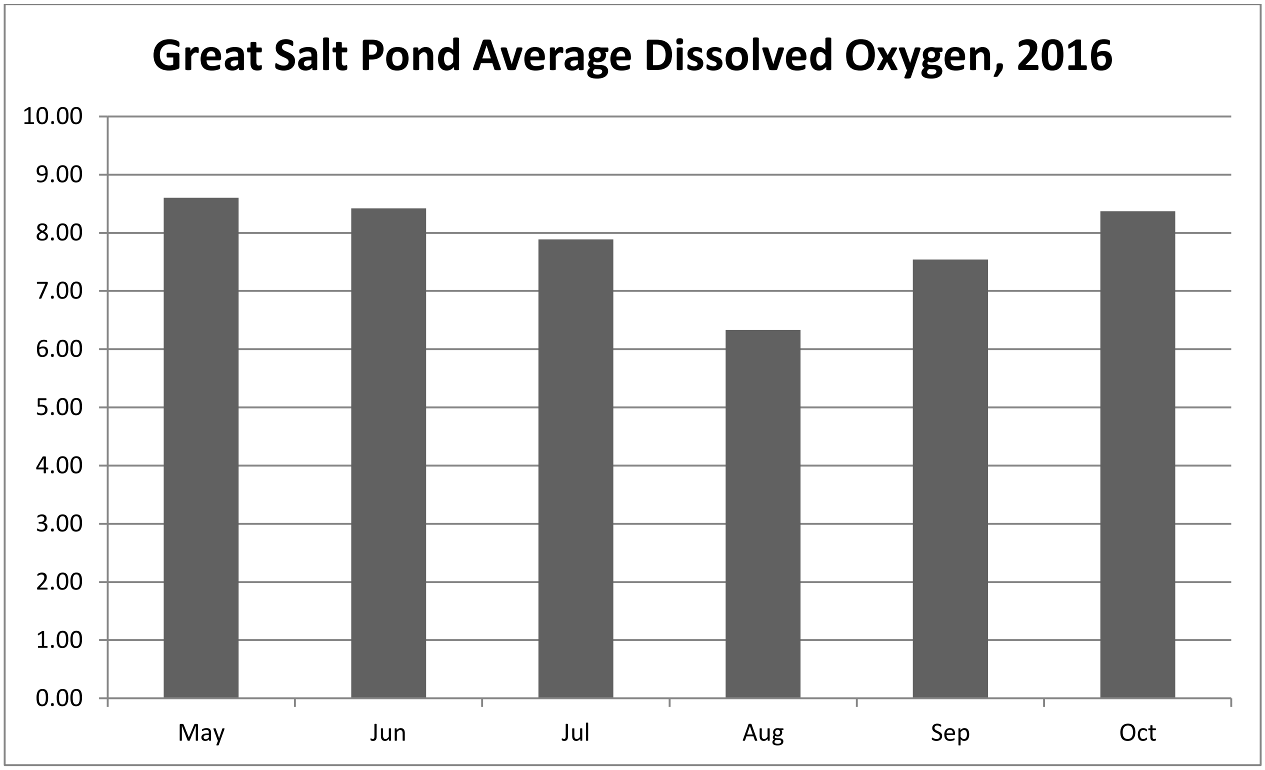

Figure c Average dissolved oxygen at GSP sites during the time of the beach seining in 2016.

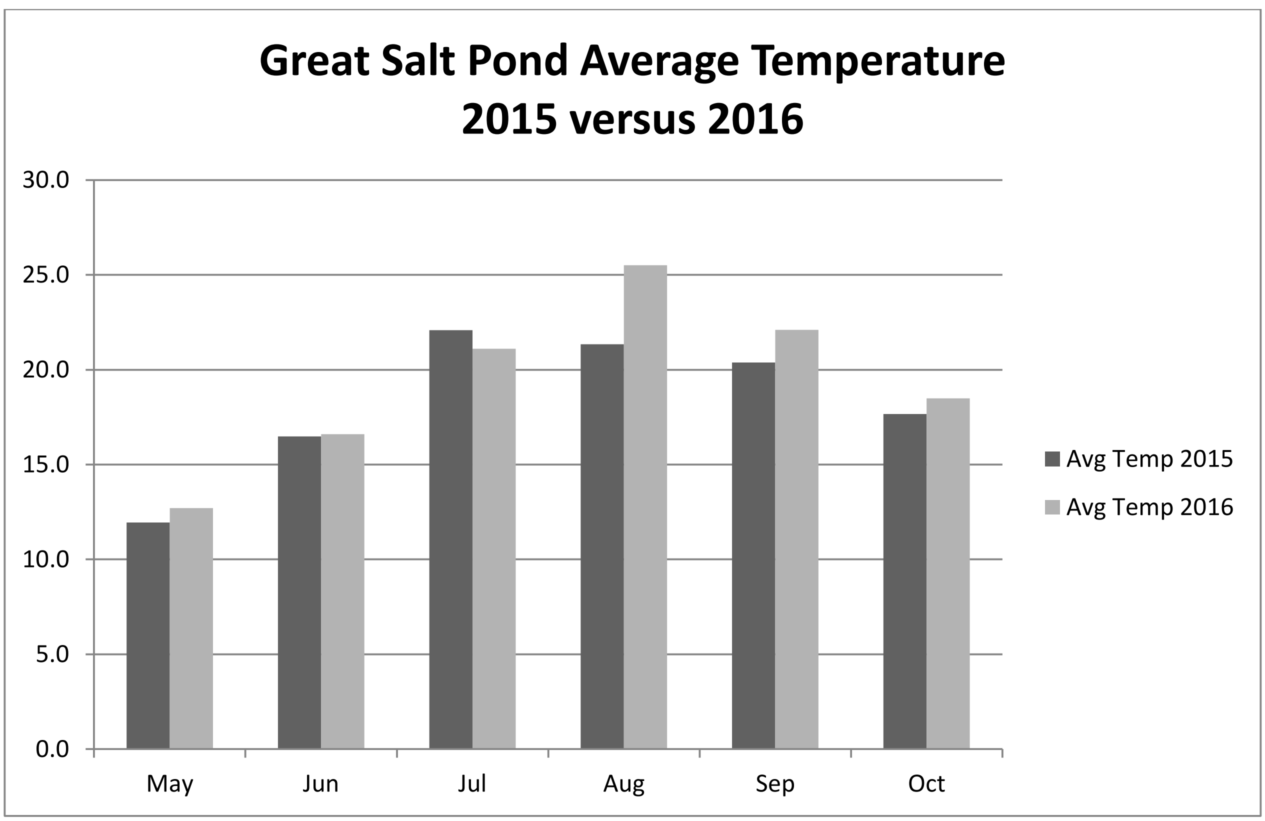

Figure d 2015 vs. 2016 average water temperature comparison.

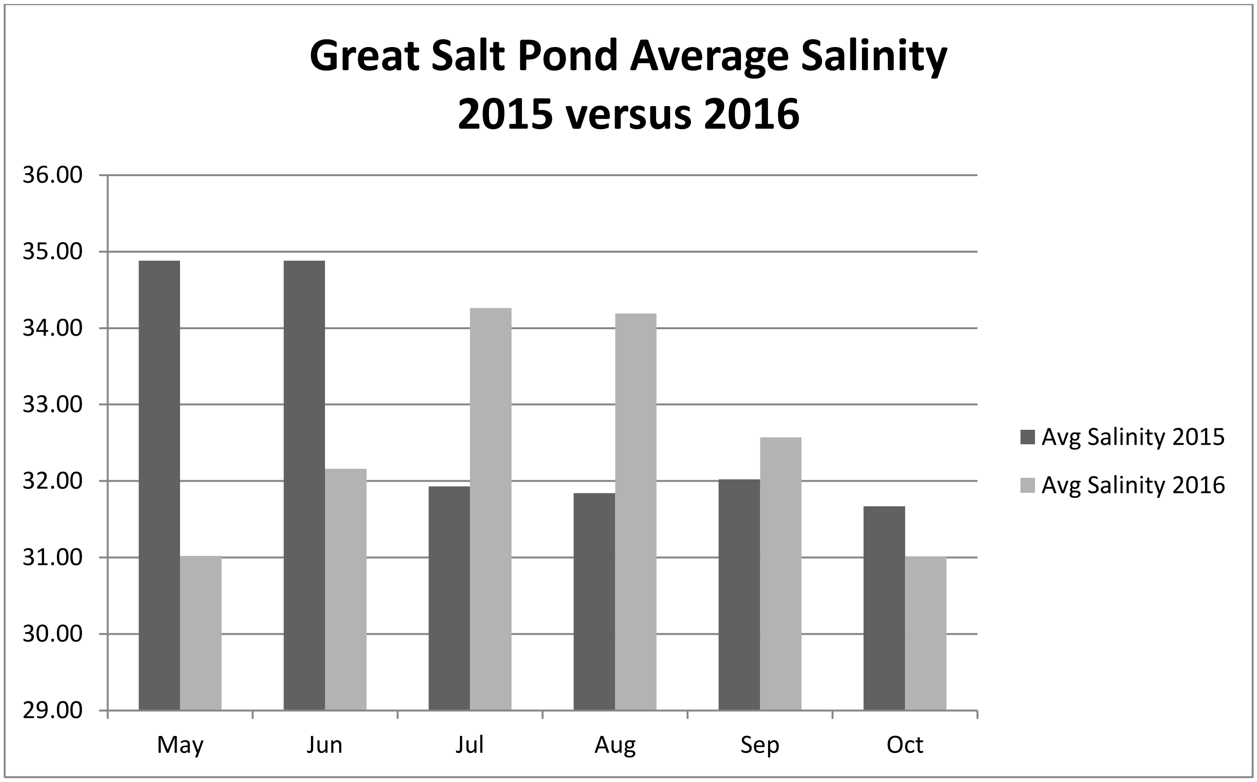

Figure e 2015 vs. 2016 average salinity comparison.

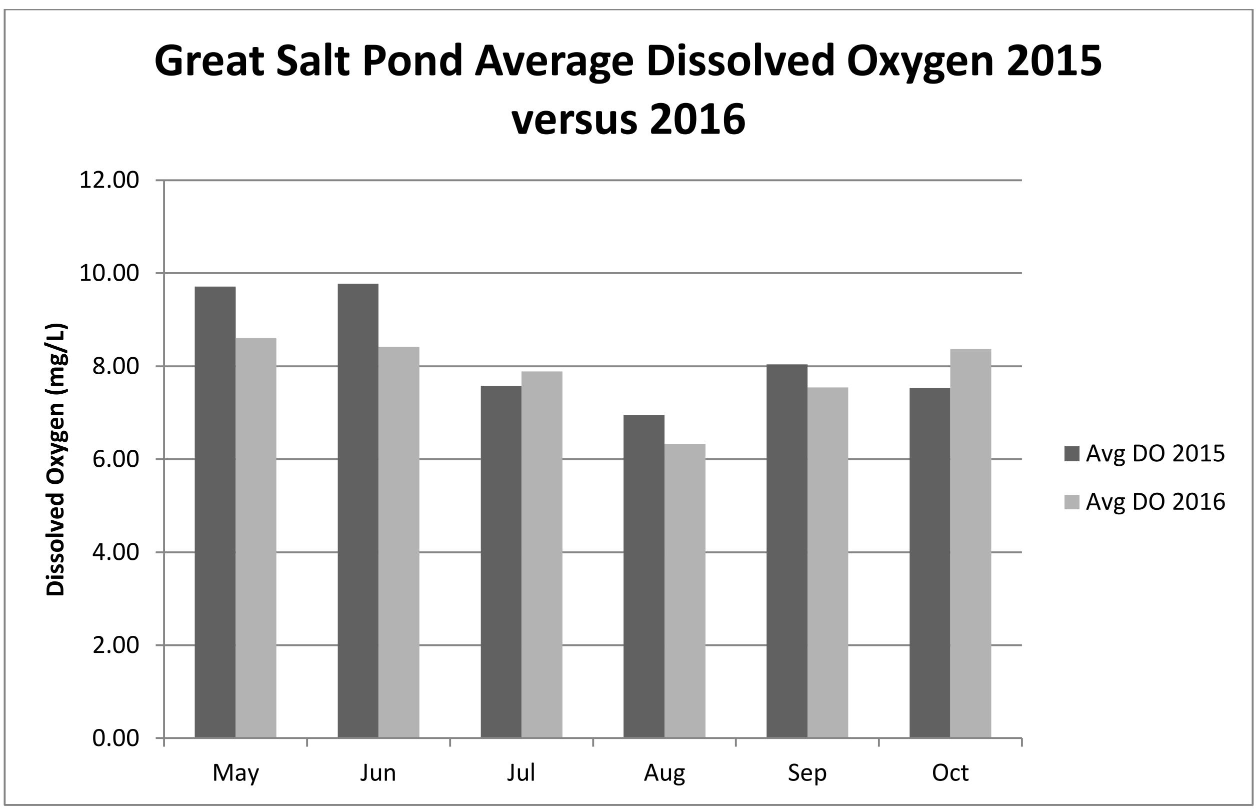

Figure f 2015 vs. 2016 average dissolved oxygen comparison.

Figure Locations for HOBO data loggers in Great Salt Pond in relation to stations GSP 1-8.

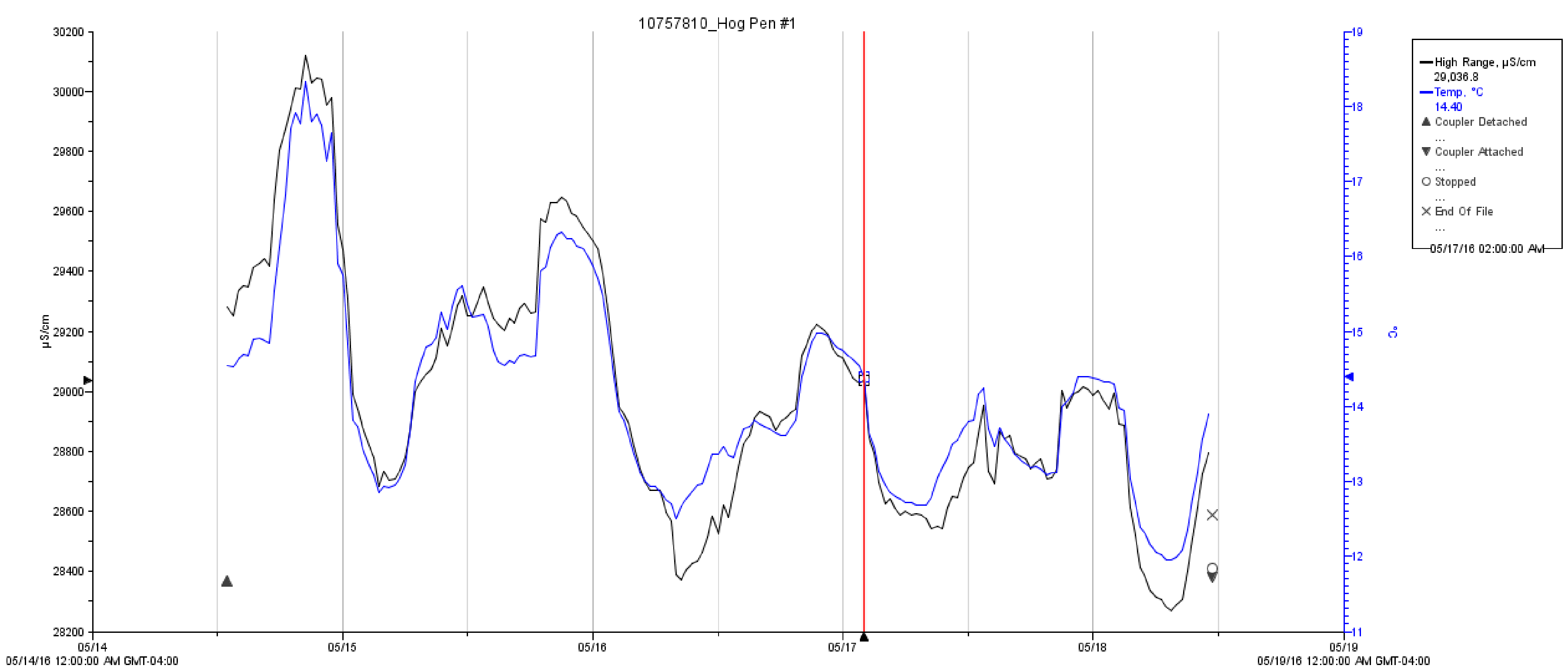

Figure a Data logger #1 located at Hog Pen dock on May 17, 2016 at 13:00 showing salinity and temperature data points.

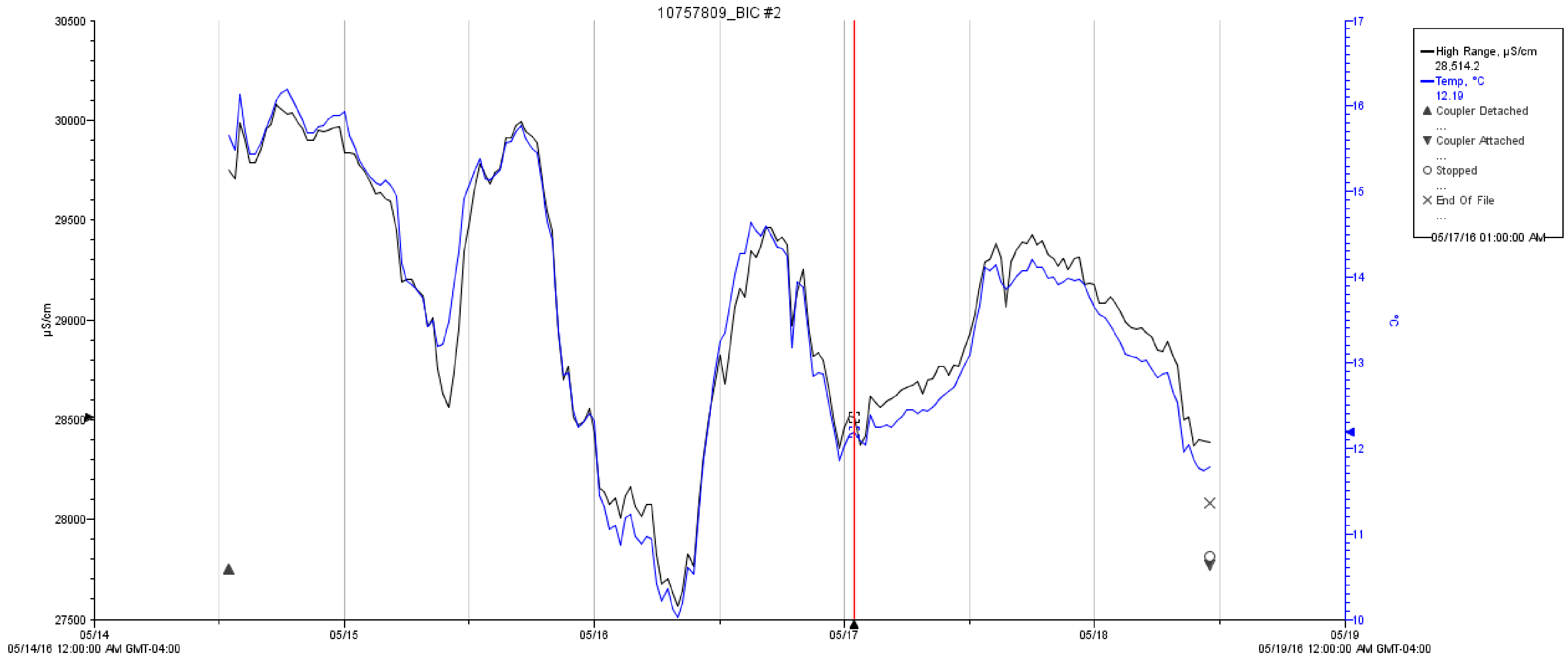

Figure Data logger #2 located at BIC on May 17, 2016 at 13:00 showing salinity and temperature data points.

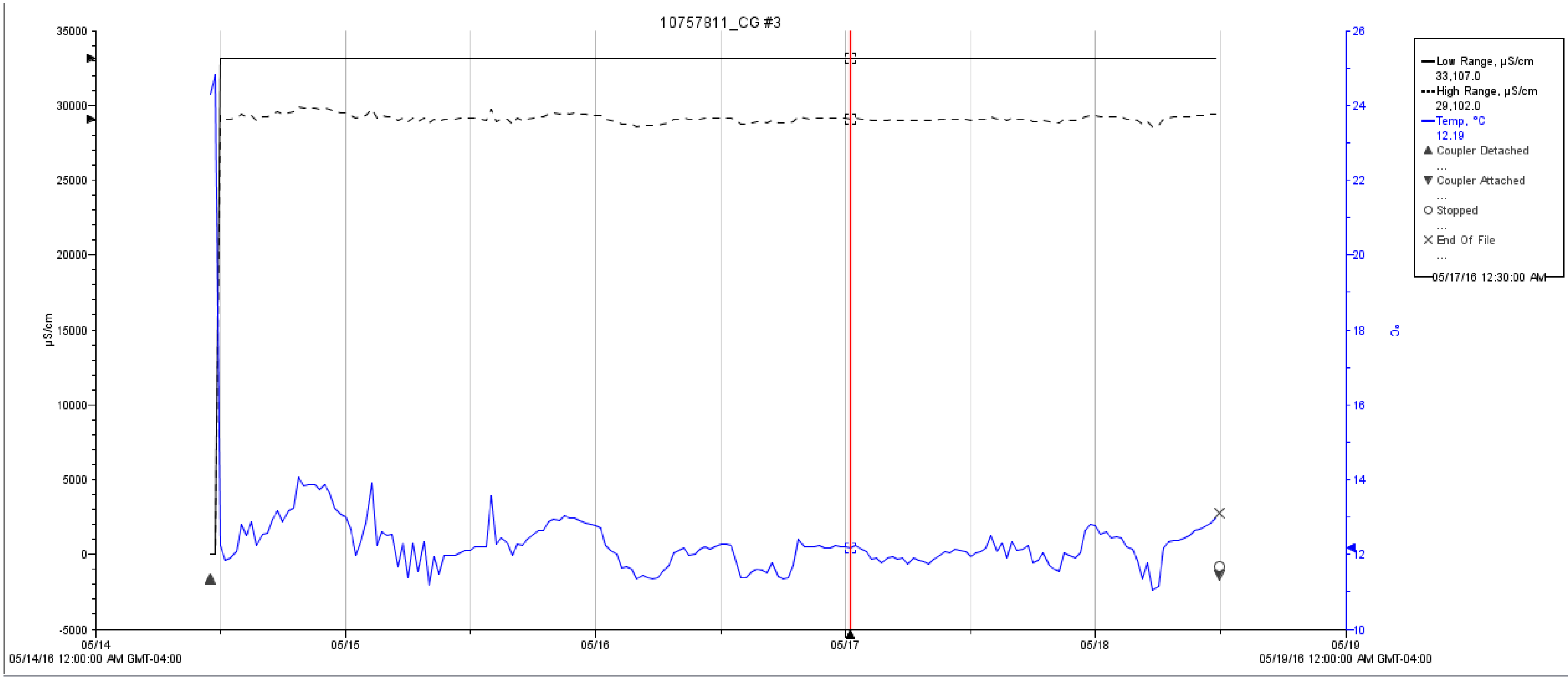

Figure c Data logger #3 located at Coast Guard on May 17, 2016 at 13:00 showing salinity and temperature data points.

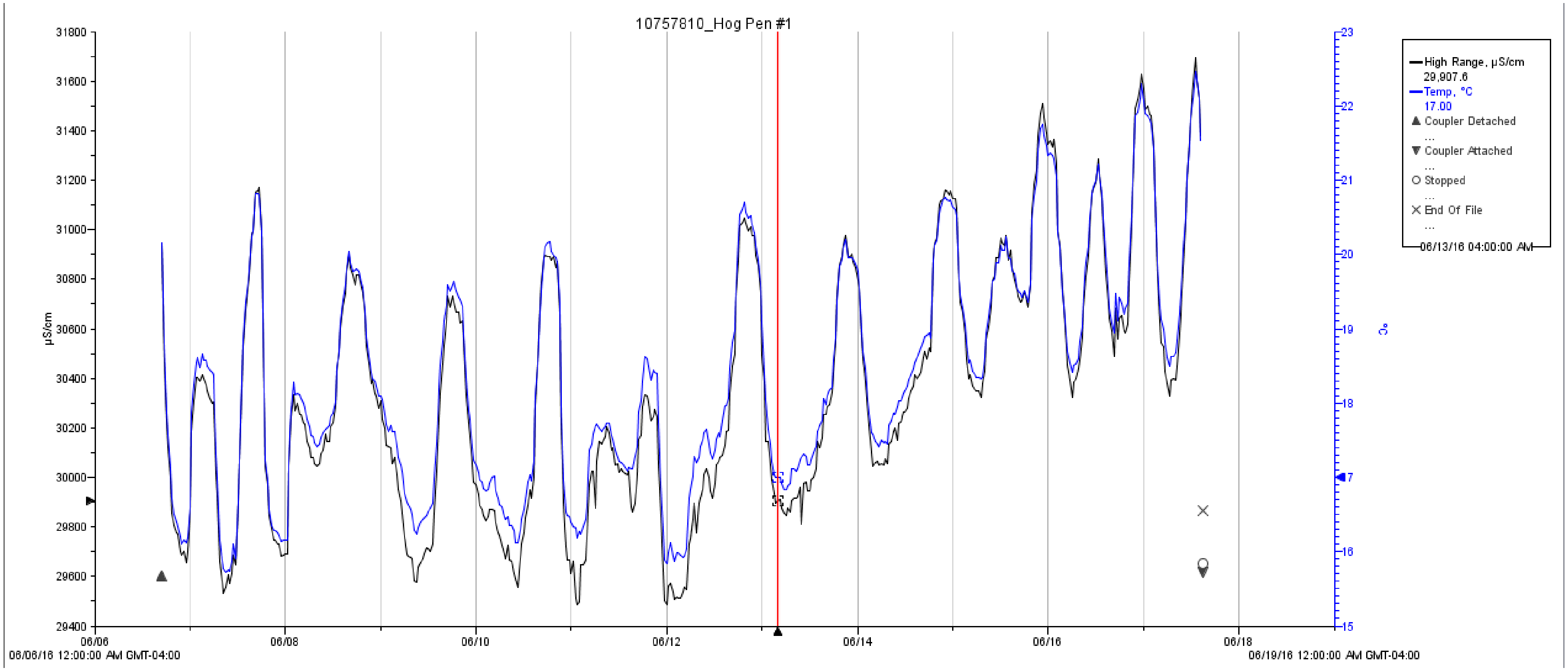

Figure d. Data logger #1 located at Hog Pen on June 13, 2016 at 16:00 showing salinity and temperature data points.

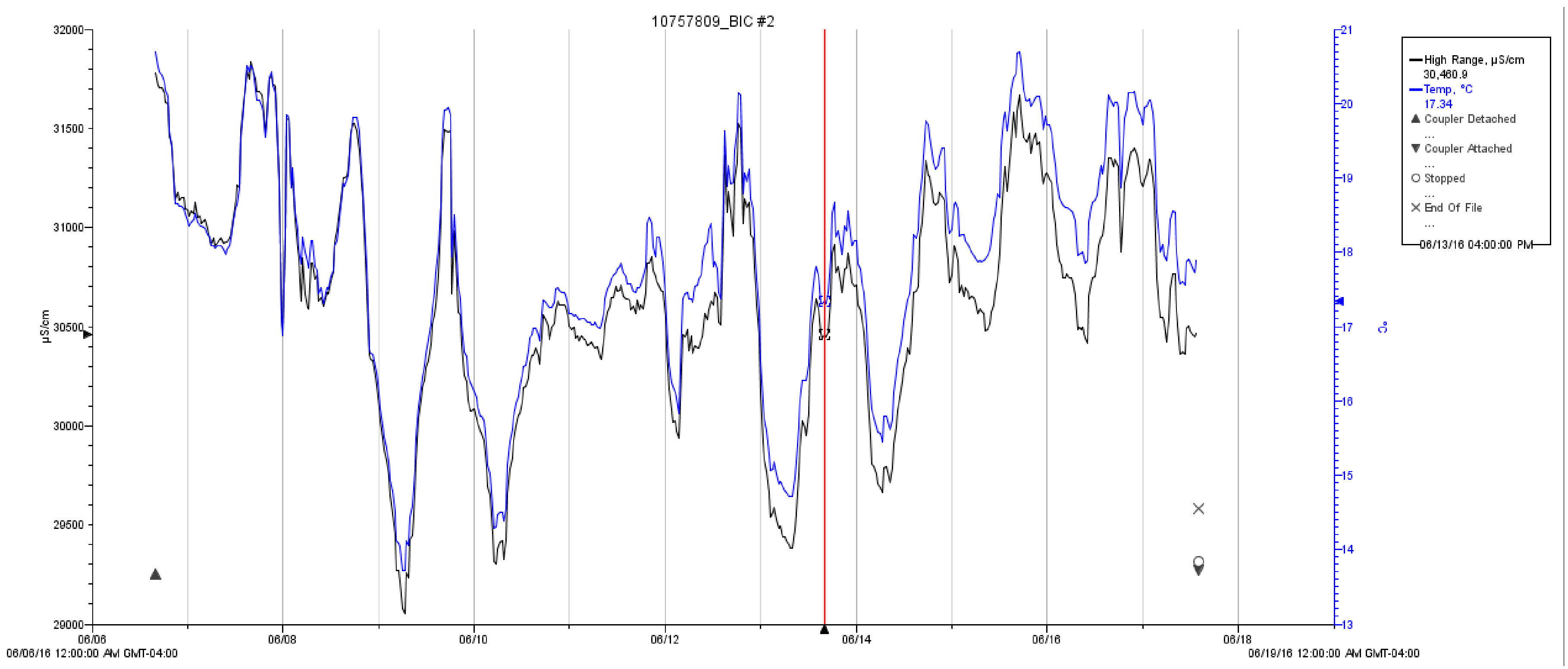

Figure e Data logger #2 located at BIC on June 13, 2016 at 16:00 showing salinity and temperature data points.

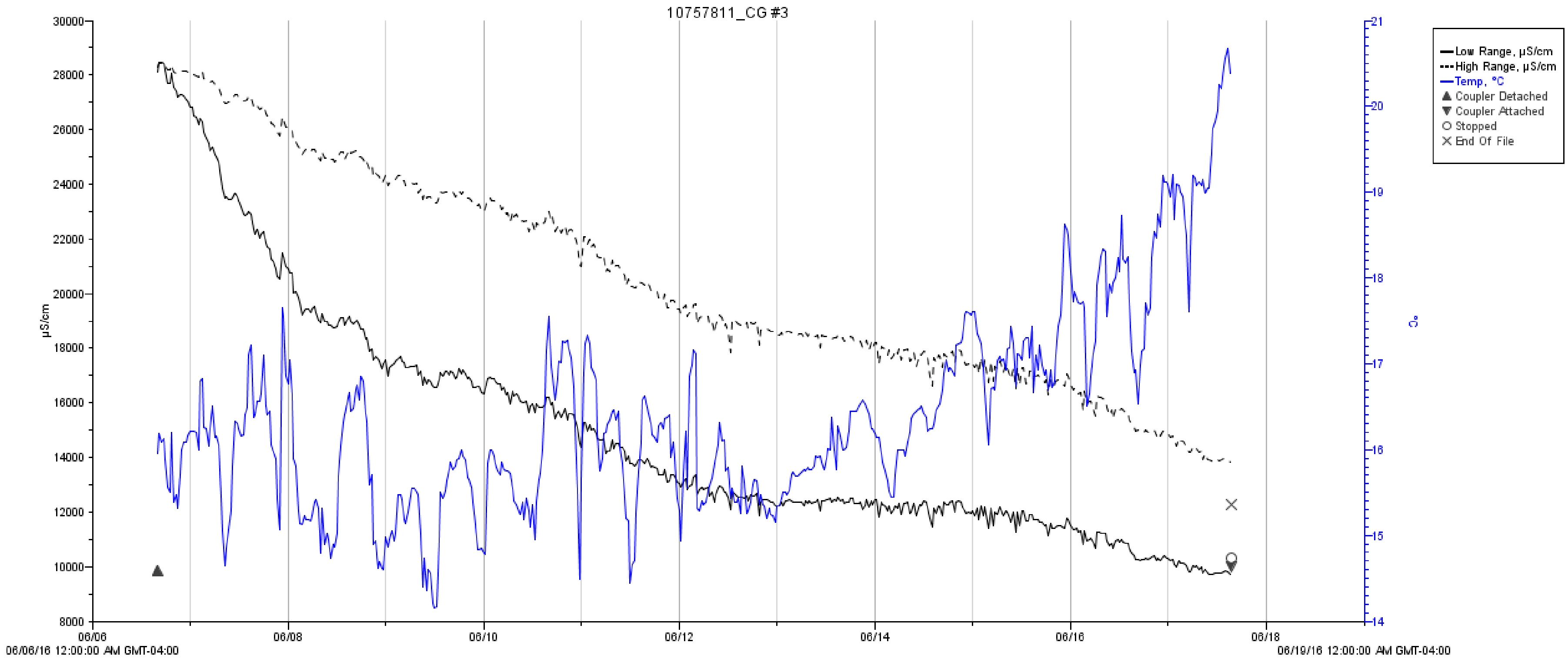

Figure f Data logger #3 located at Coast Guard on June 13, 2016 at 16:00 showing salinity and temperature data points.

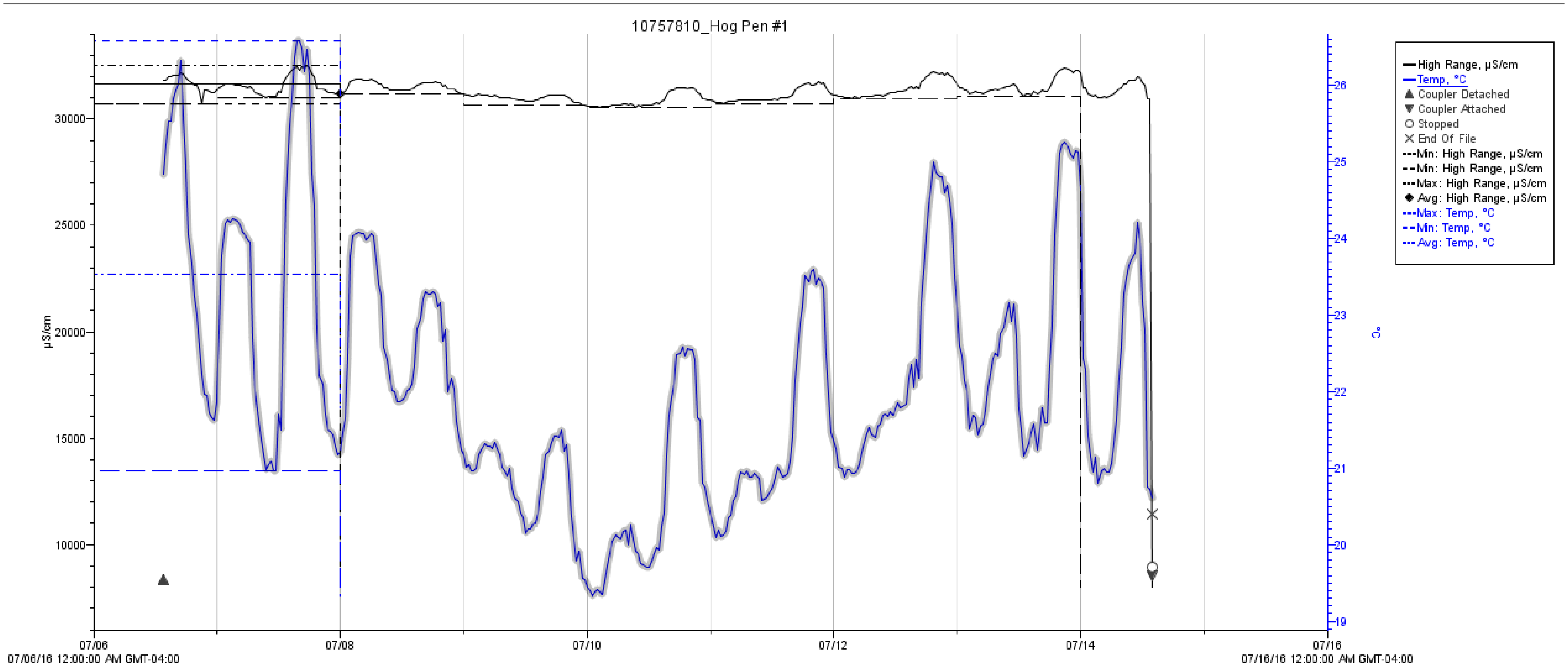

Figure g Data logger #1 located at Hog Pen on July 11, 2016 at 14:00 showing salinity and temperature data points.

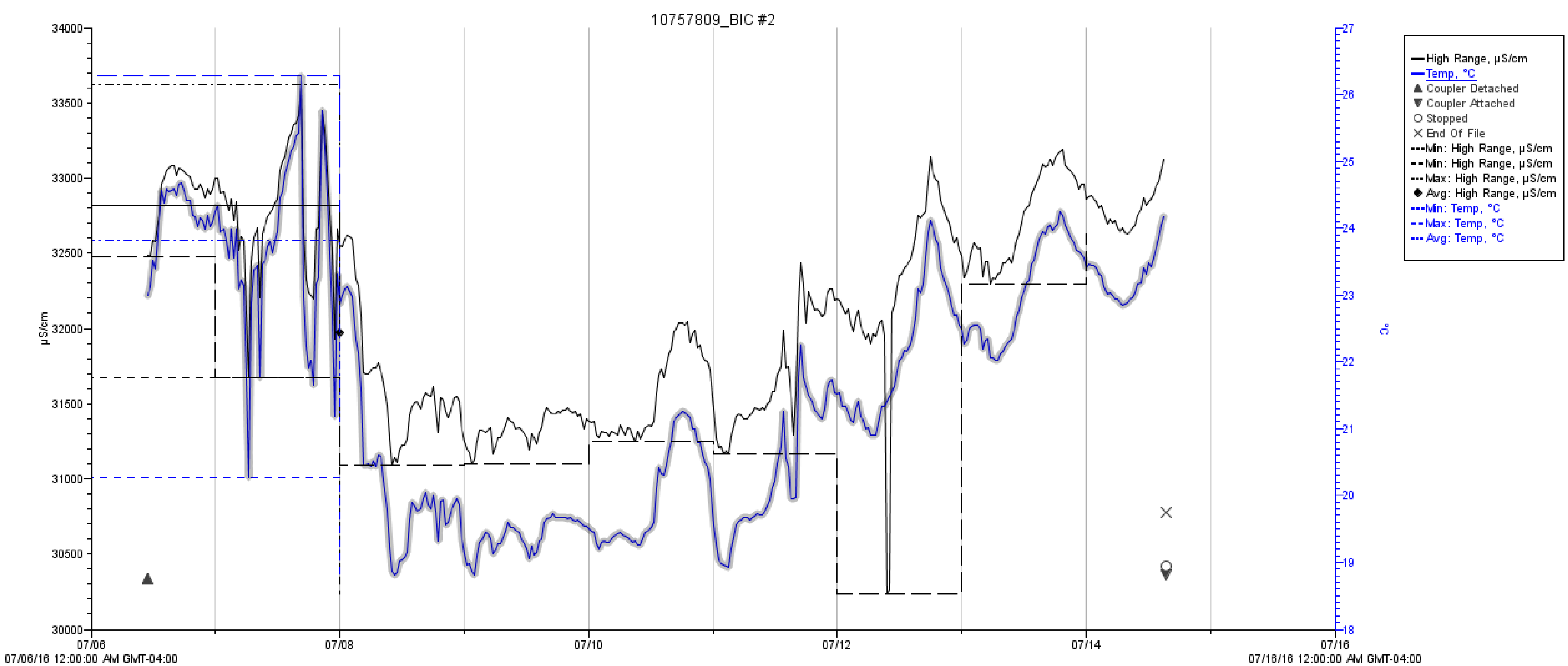

Figure h Data logger #2 located at BIC on July 11, 2016 at 14:00 showing salinity and temperature data points.

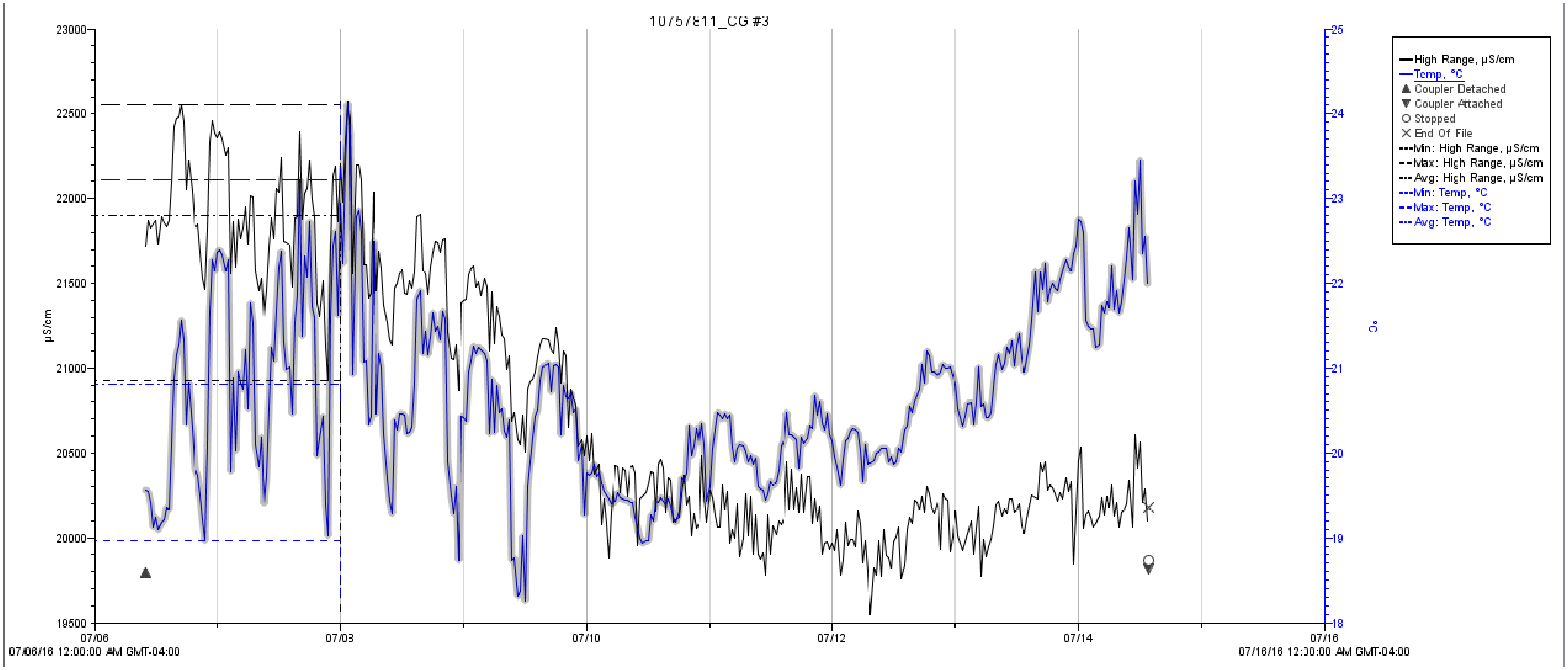

Figure i Data logger #3 at Coast Guard on July 11, 2016 at 14:00 showing salinity and temperature data points.

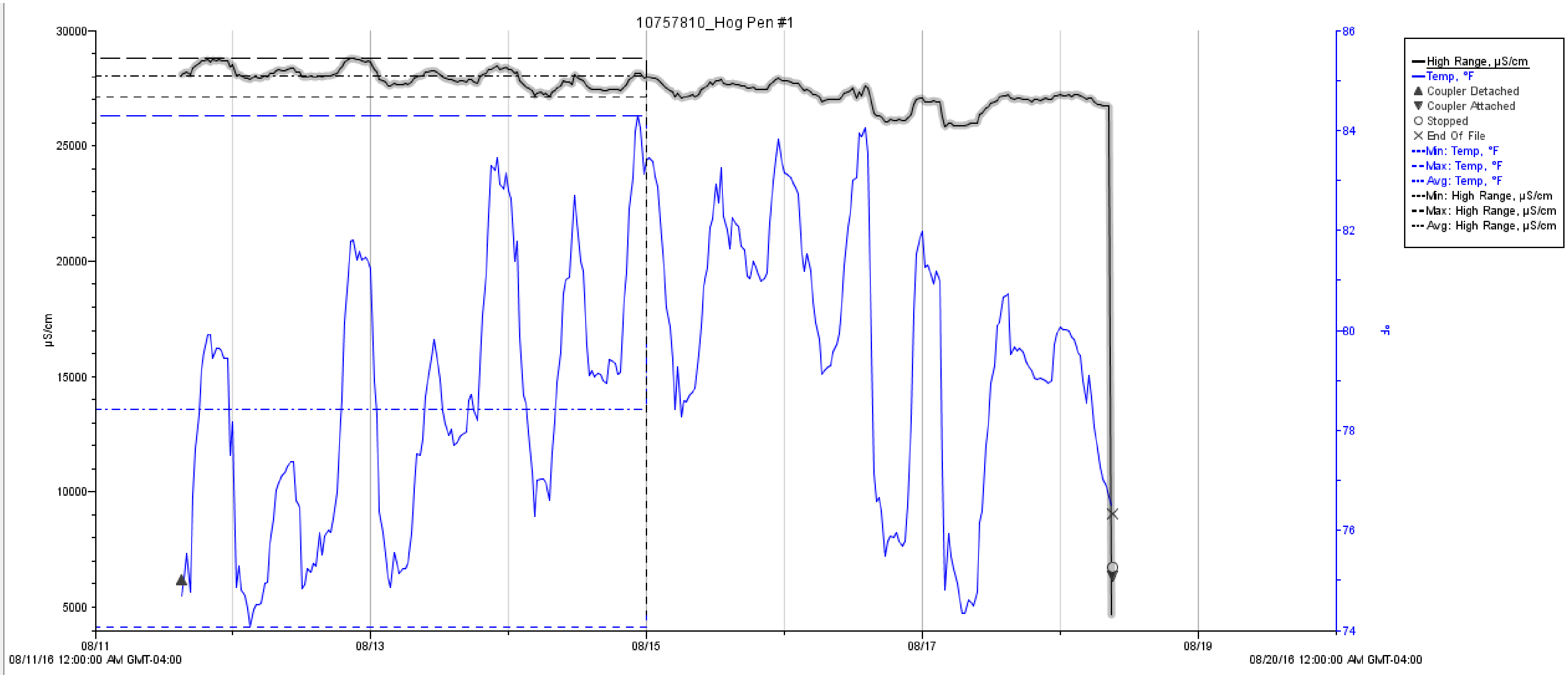

Figure Data logger #1 located at Hog Pen on August 16, 2016 at 10:30 showing salinity and temperature data points.

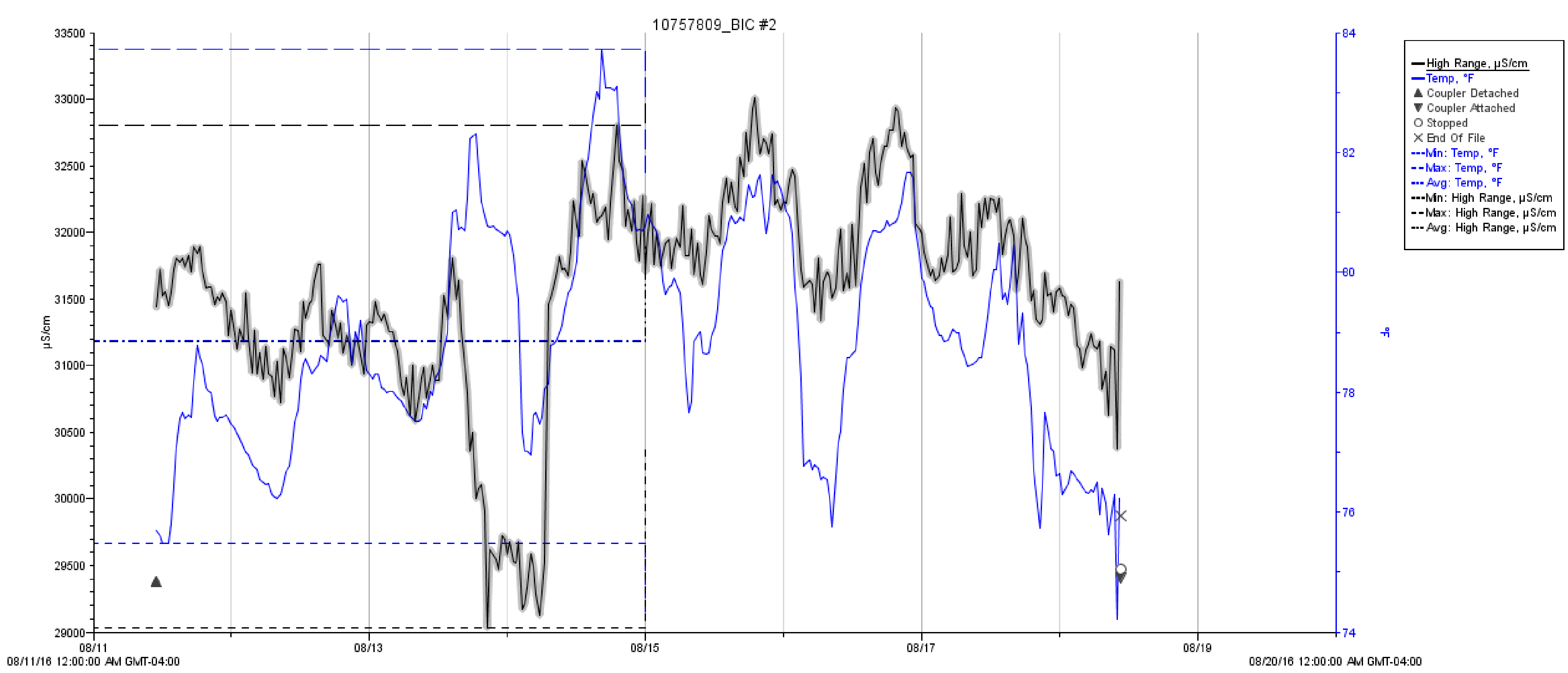

Figure k Data logger #2 located at BIC on August 16, 2016 at 10:30 showing salinity and temperature data points.

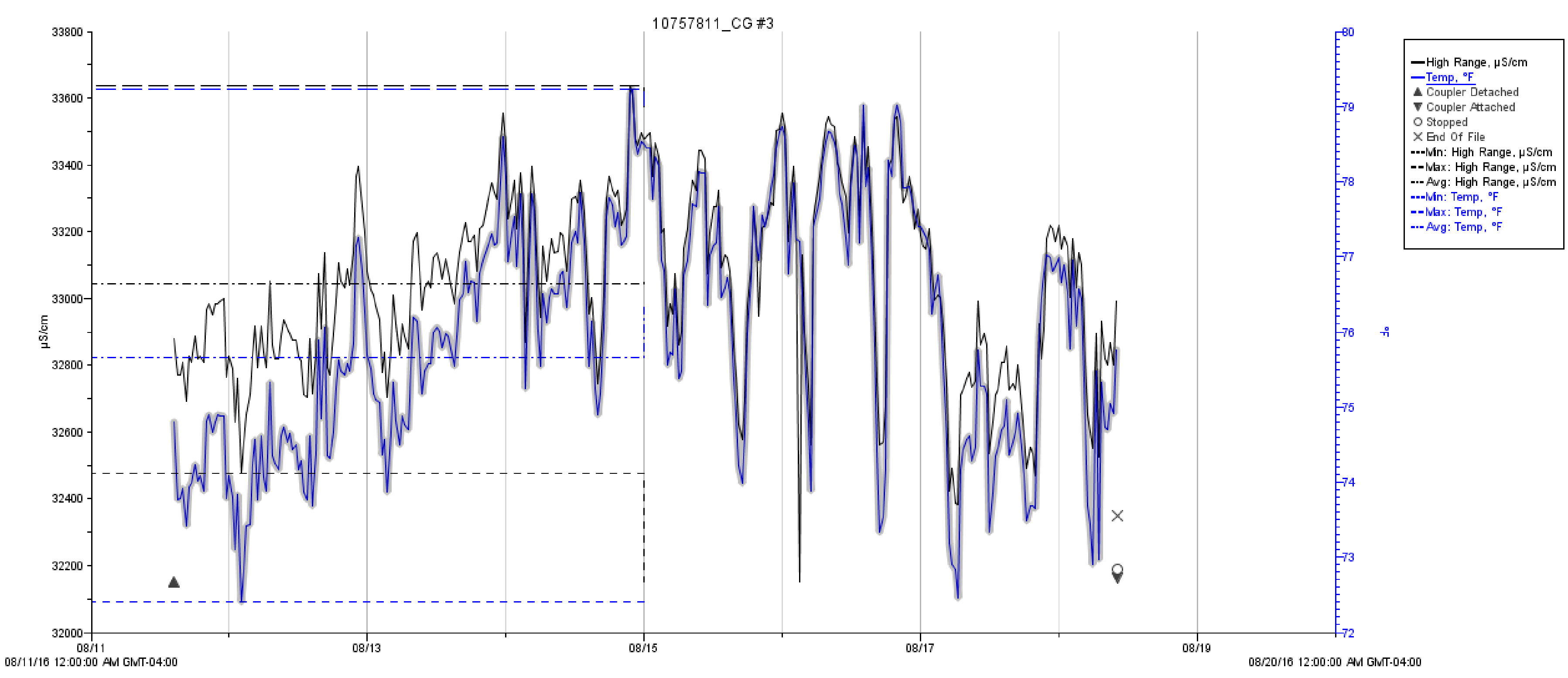

Figure I. Data logger #3 located at Coast Guard on August 16, 2016 at 10:30 showing salinity and temperature data points.

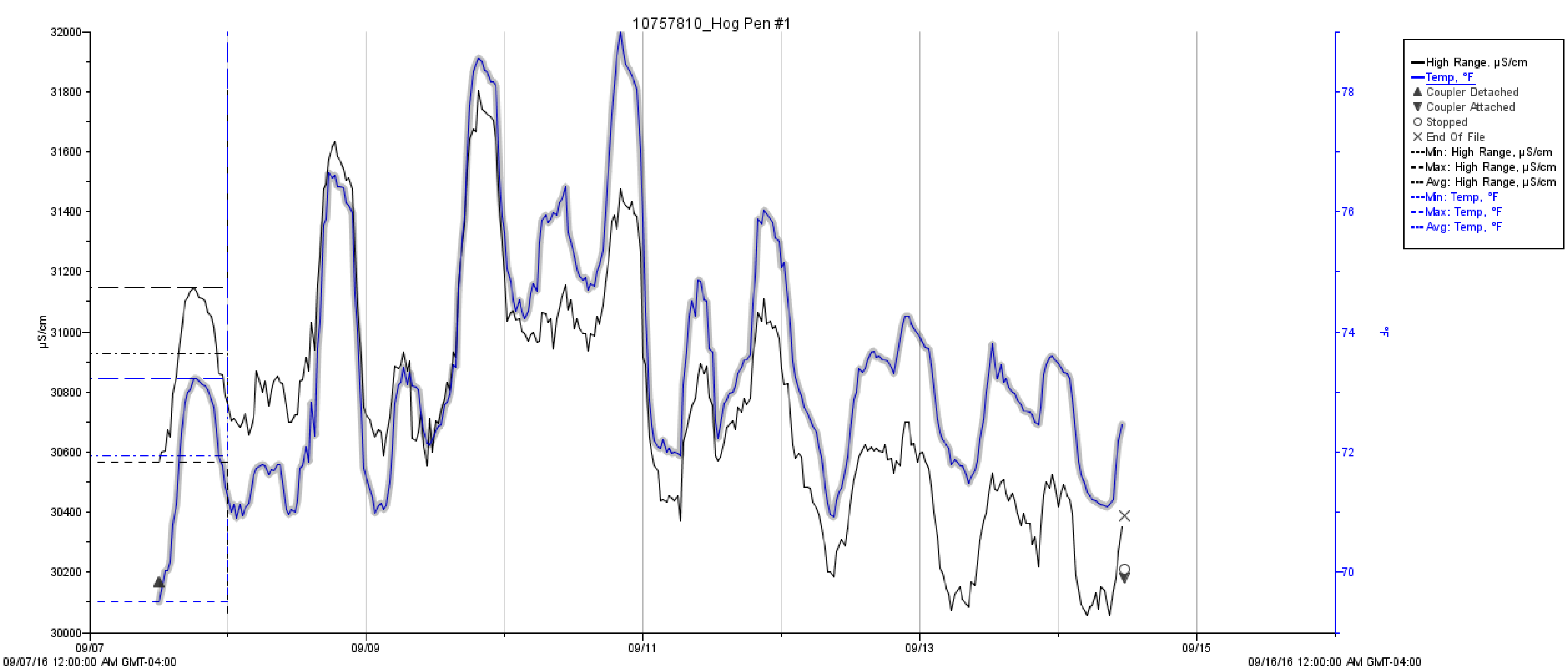

Figure m Data logger #1 at Hog Pen on September 13, 2016 at 8:00 showing salinity and temperature data points.

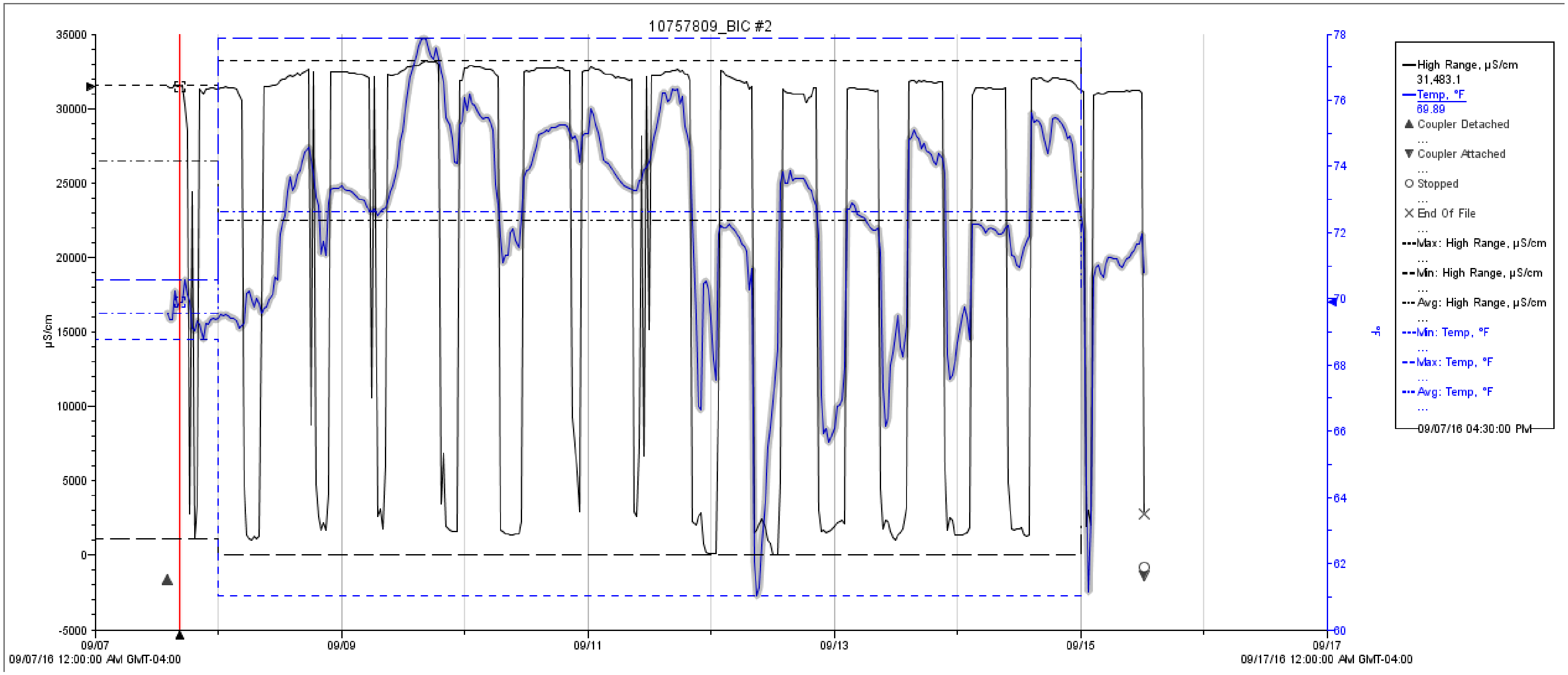

Figure n Data logger #2 located at BIC on September 13, 2016 at 8:00 showing salinity and temperature data points.

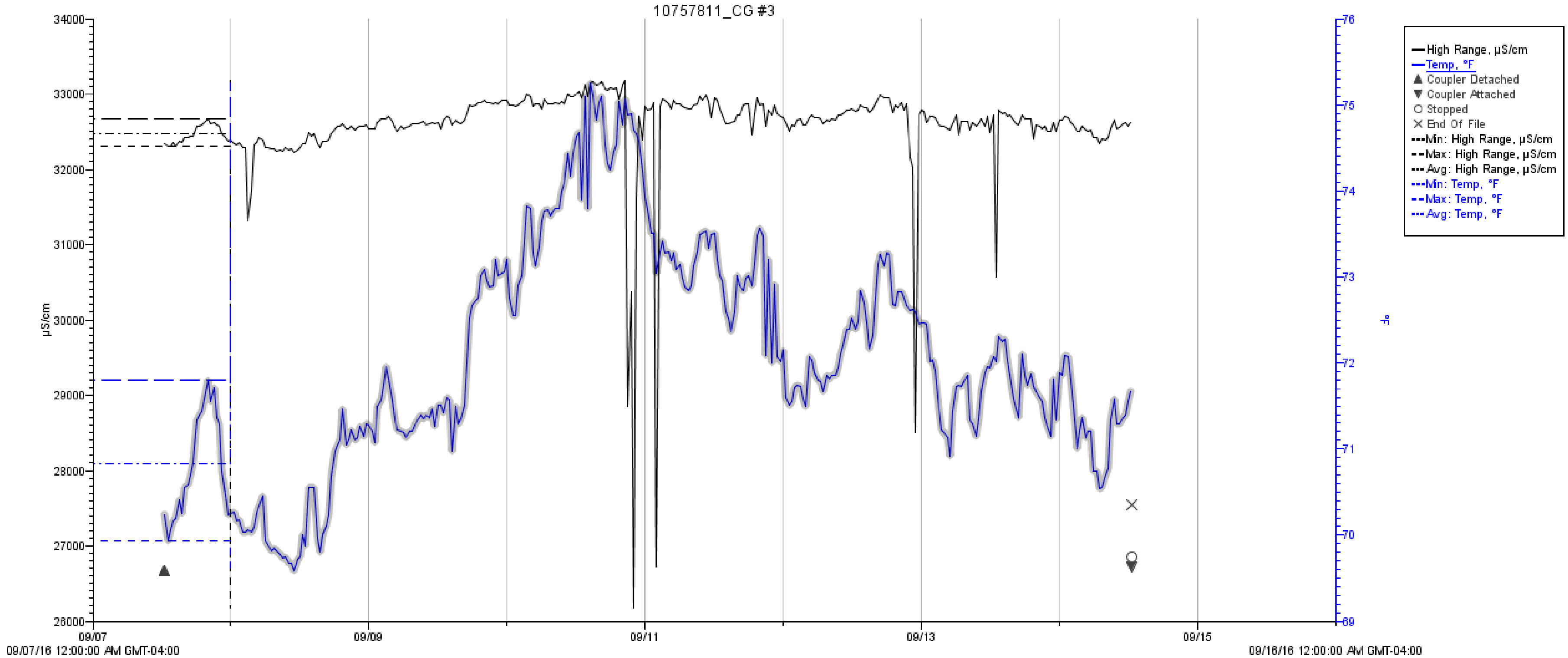

Figure o Data logger #3 at Coast Guard on September 13, 2016 at 8:00 showing salinity and temperature data points.

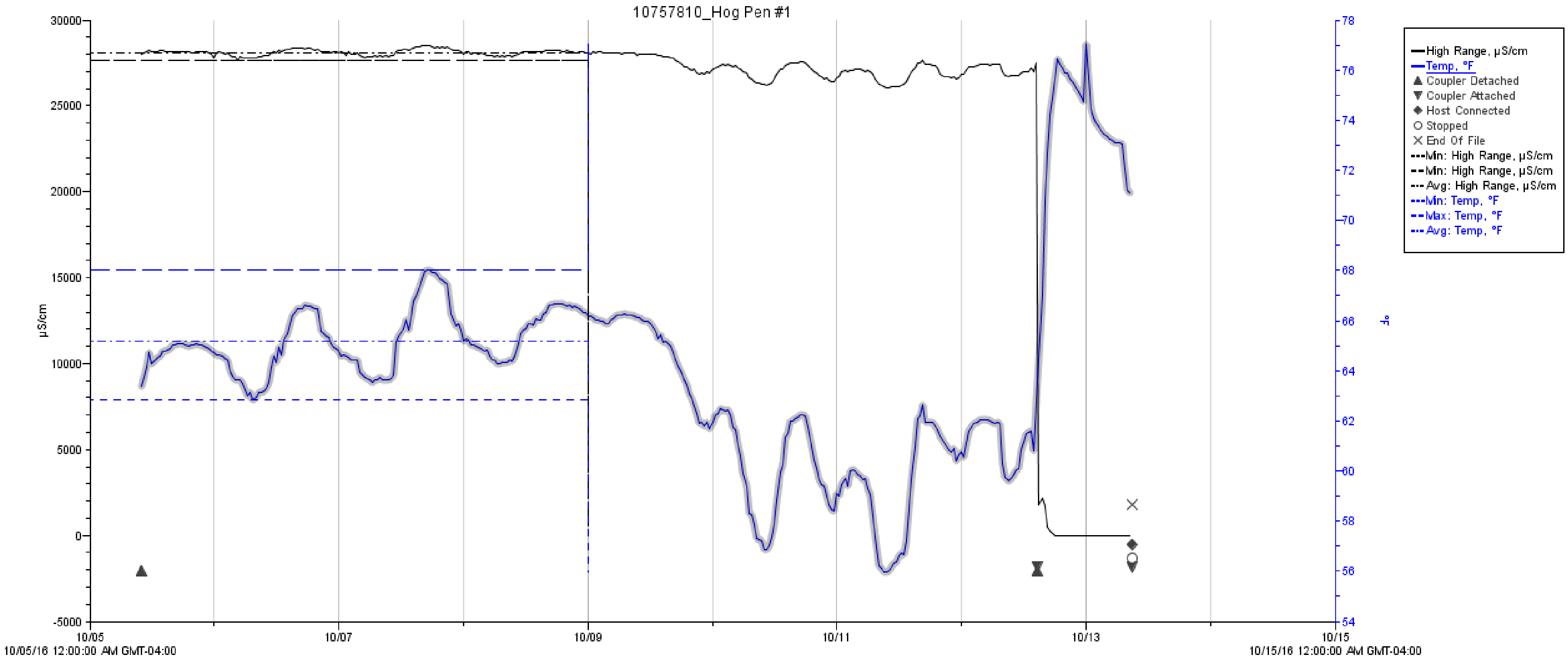

Figure p Data logger #1 located at Hog Pen on October 6, 2016 at 13:30 showing salinity and temperature data points.

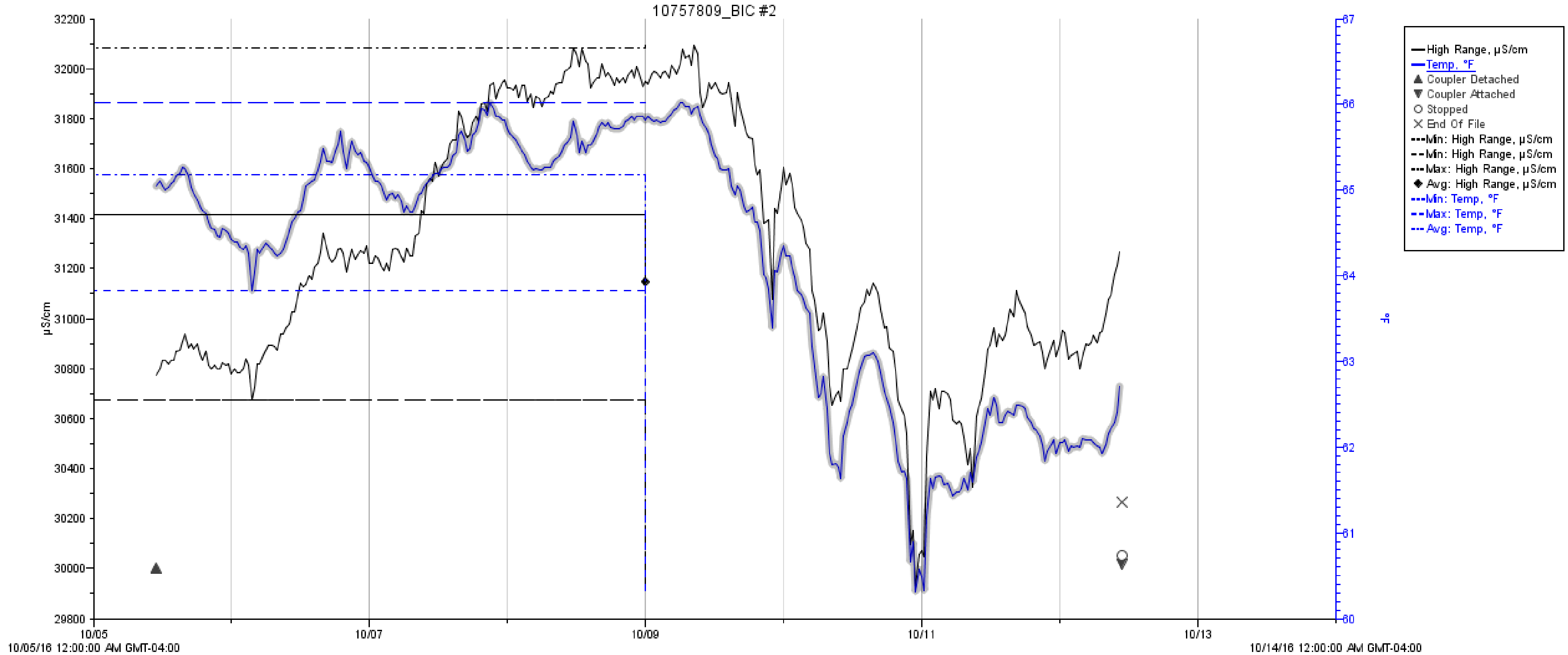

Figure Data logger #2 located at BIC on October 6, 2016 at 13:30 showing salinity and temperature data points.

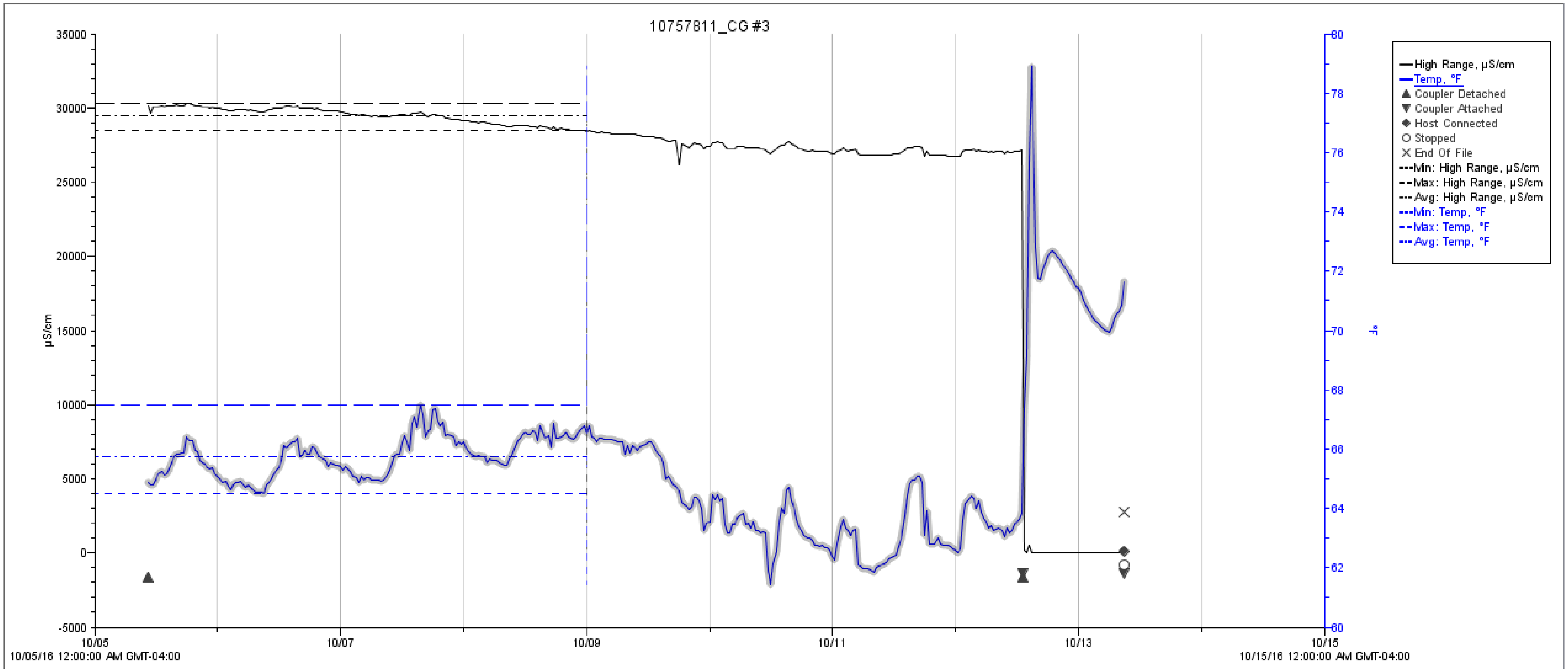

Figure r Data logger #3 located at Coast Guard on October 6, 2016 at 13:30 showing salinity and temperature data points.

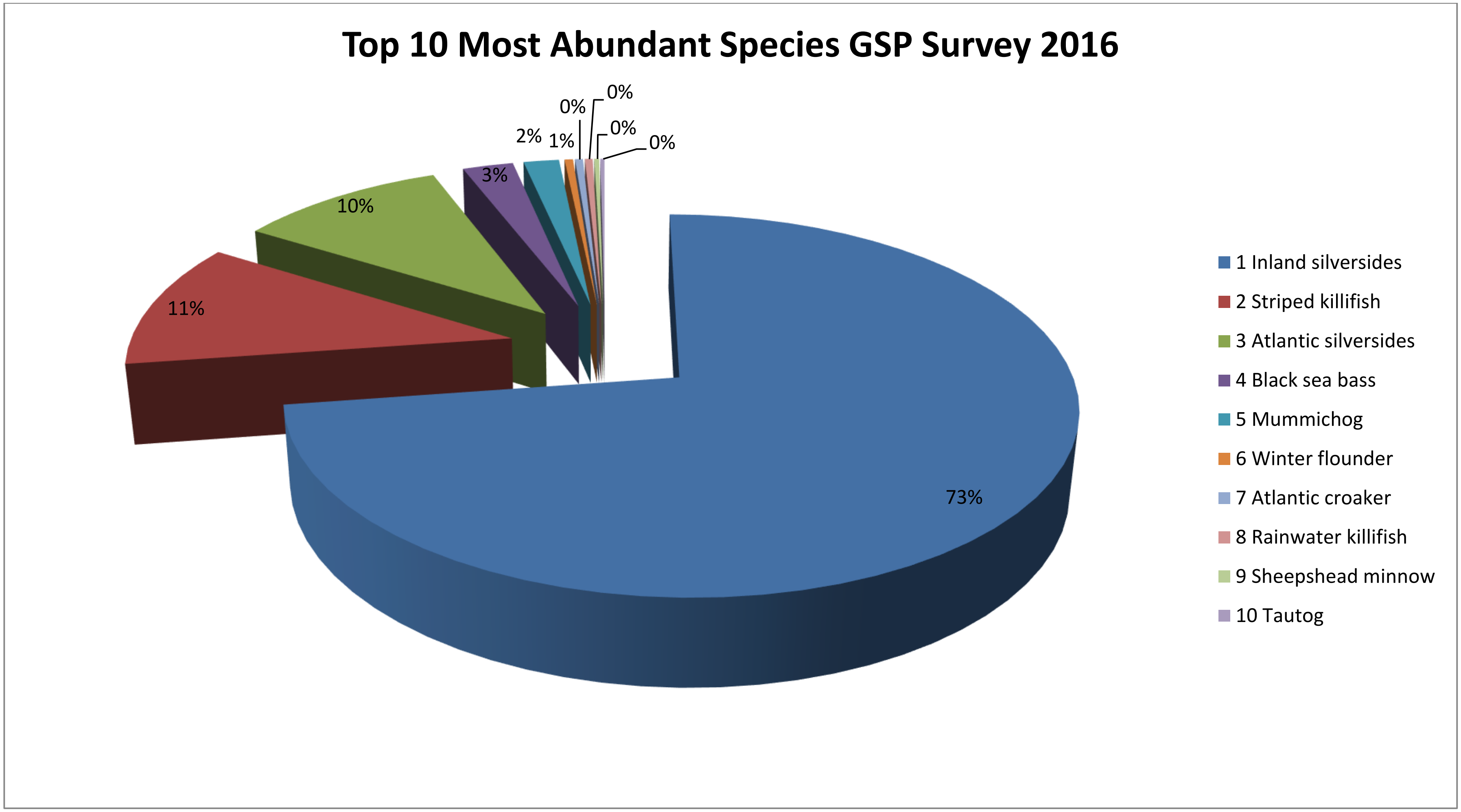

Figure Top 10 most abundant species collected during 2016 survey. Rank 1 represents the highest frequency of total number of species collected, measured and counted.

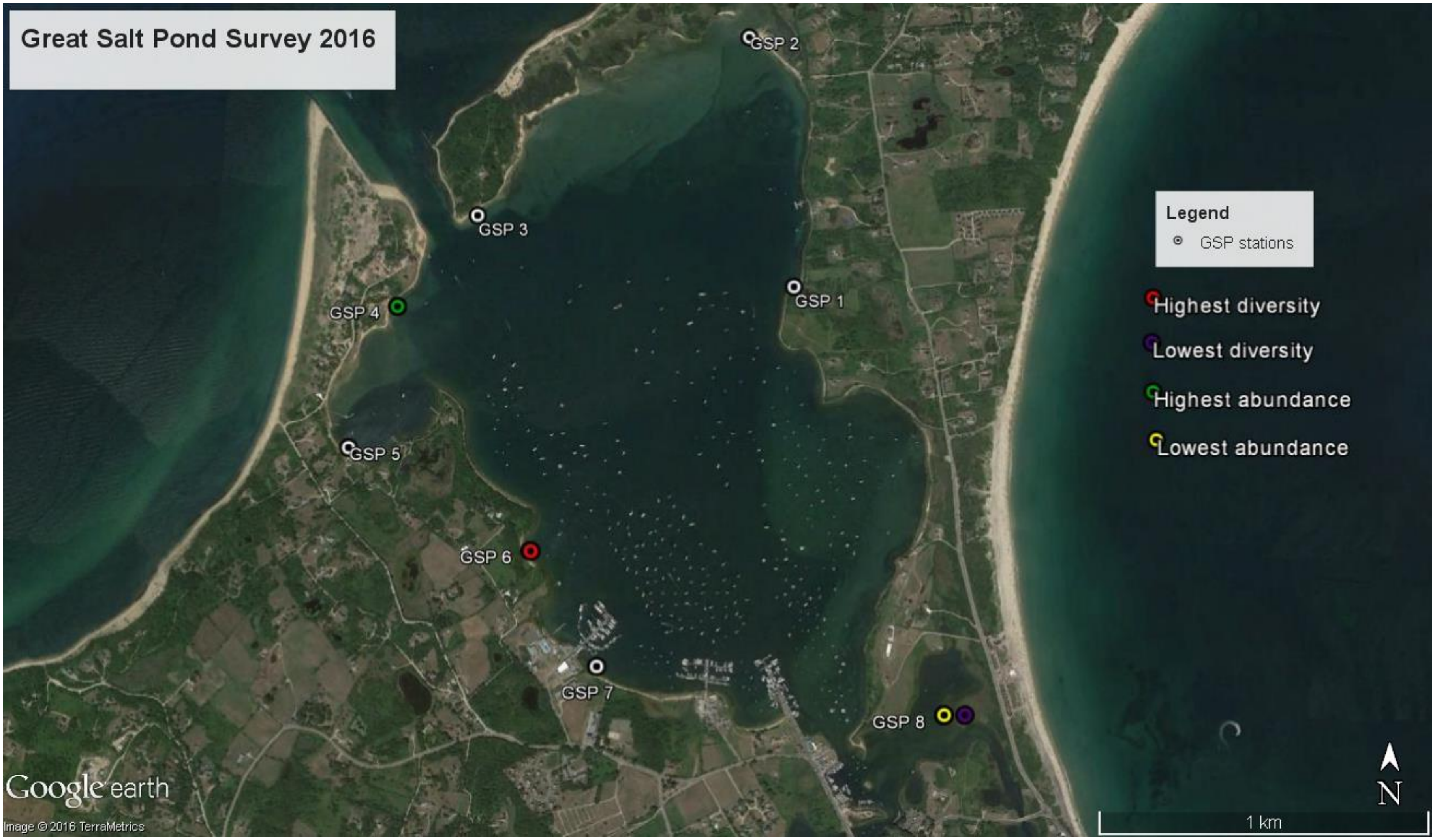

Figure Visual representation to compare sites based on abundance and diversity results. This map shows the results for 2016.

Figure Comparing abundance and diversity results amongst stations for the GSP Survey 2015.

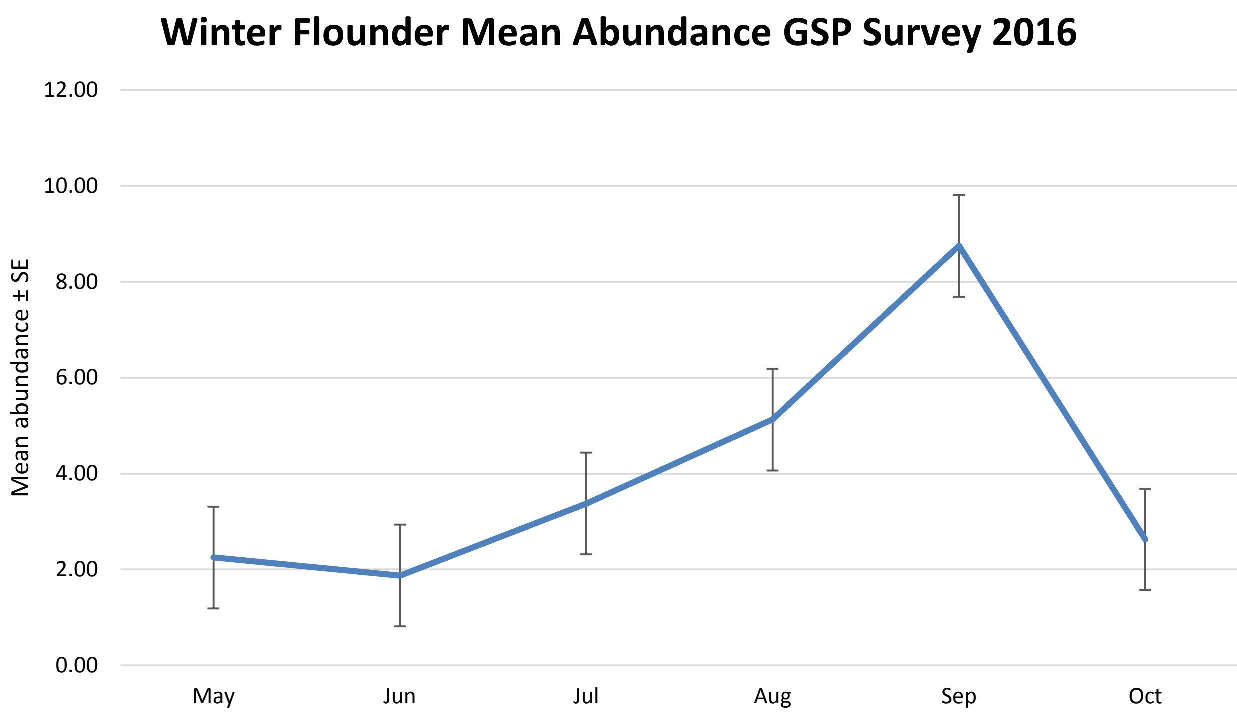

Figure Winter flounder abundance indices (fish/seine haul) ± SE from GSP Survey 2016.

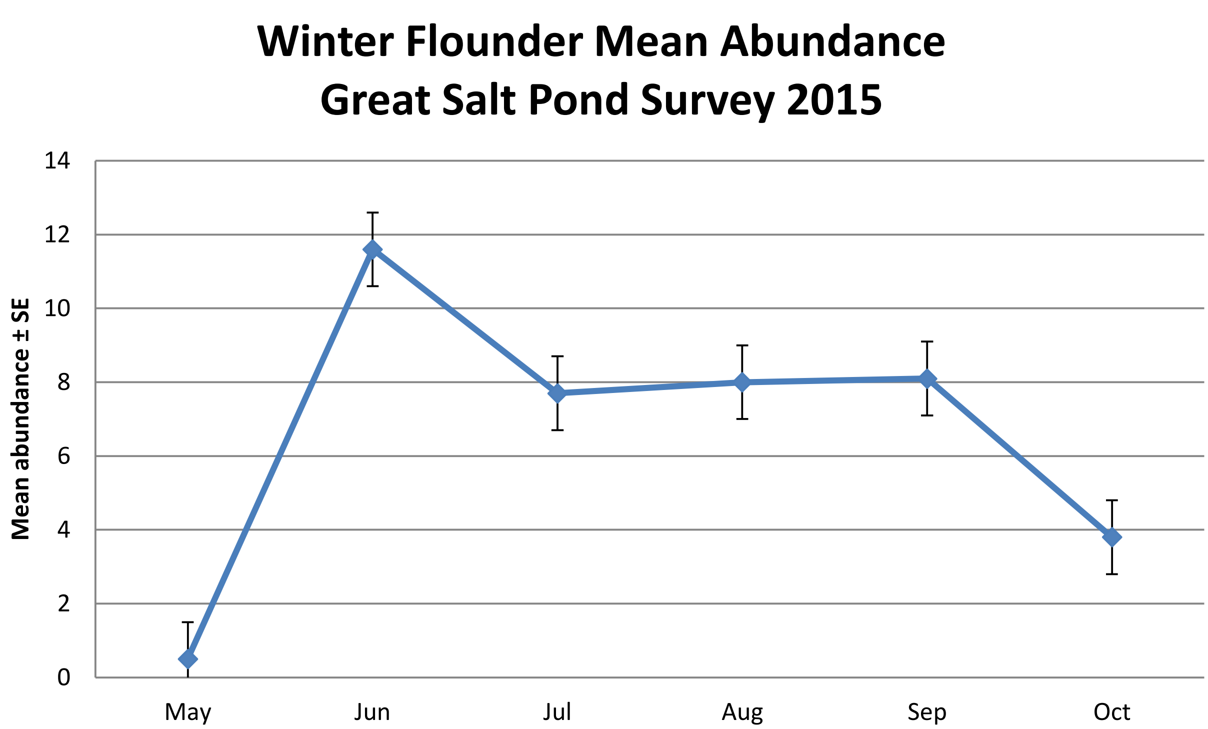

Figure . Winter flounder abundance indices (fish/seine haul) ±SE from GSP Survey 2015.

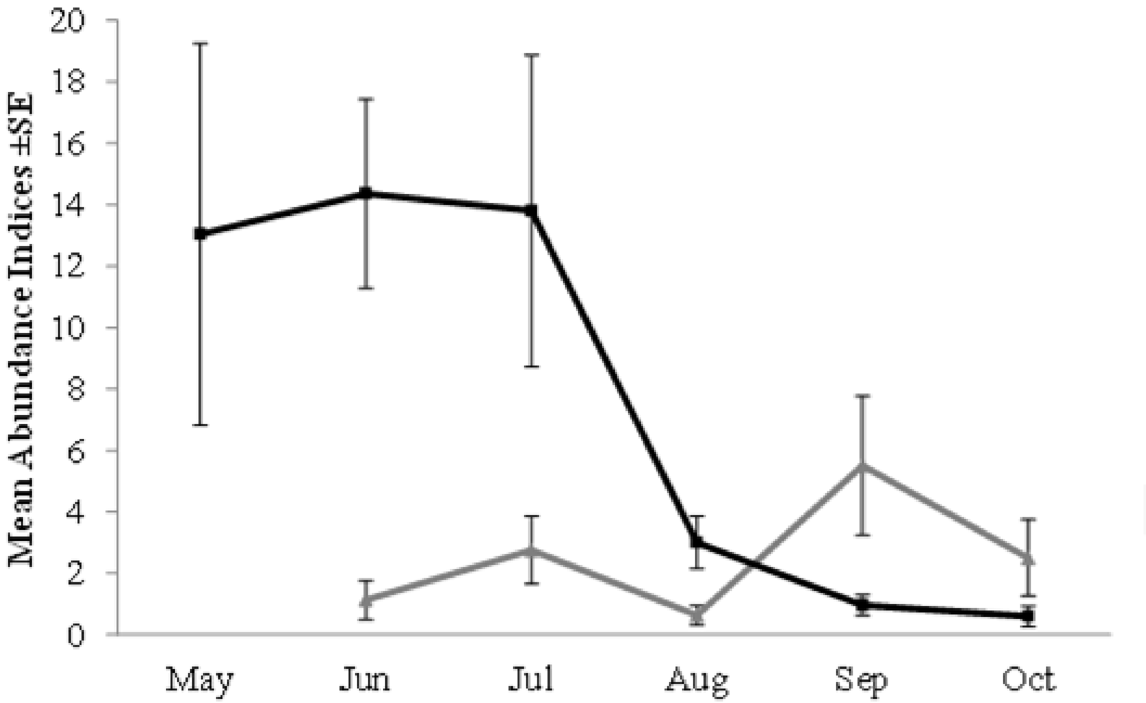

Figure 12. Comparison of mean winter flounder abundance indices (fish/seine haul) ±SE, from mainland Coastal Pond Survey 2013 (black line) to Great Salt Pond Survey, Block Island 2014 (grey line).

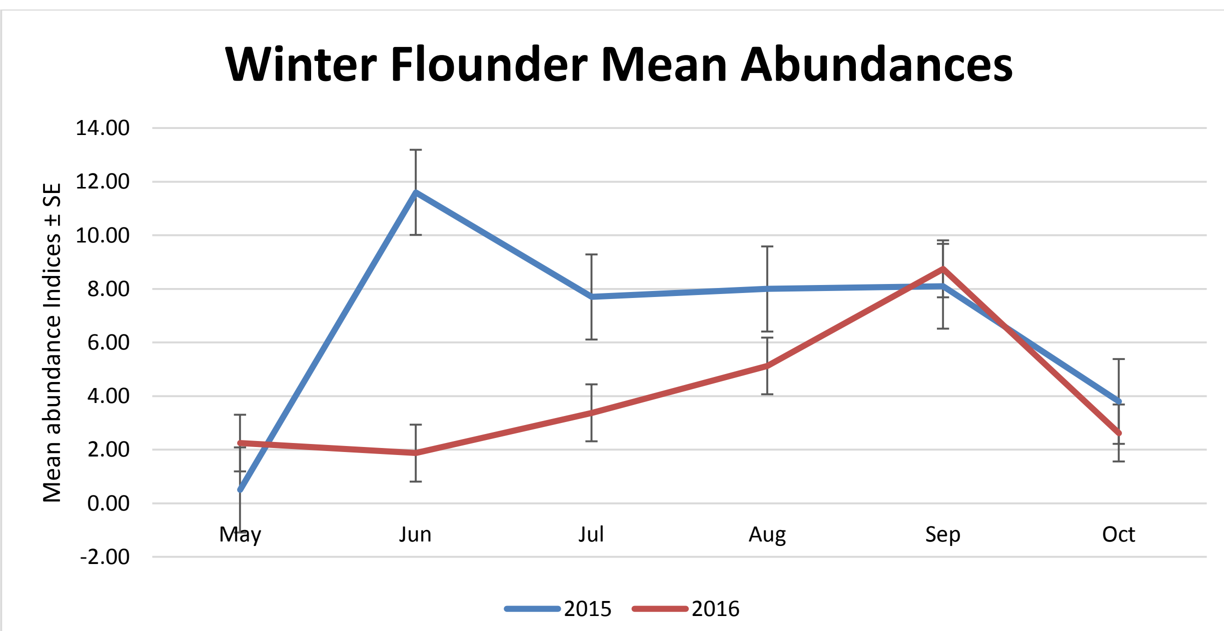

Figure 13. Comparison of mean winter flounder abundance indices (fish/seine haul) ± SE from GSP Survey 2015 (blue line) and 2016 (red line).

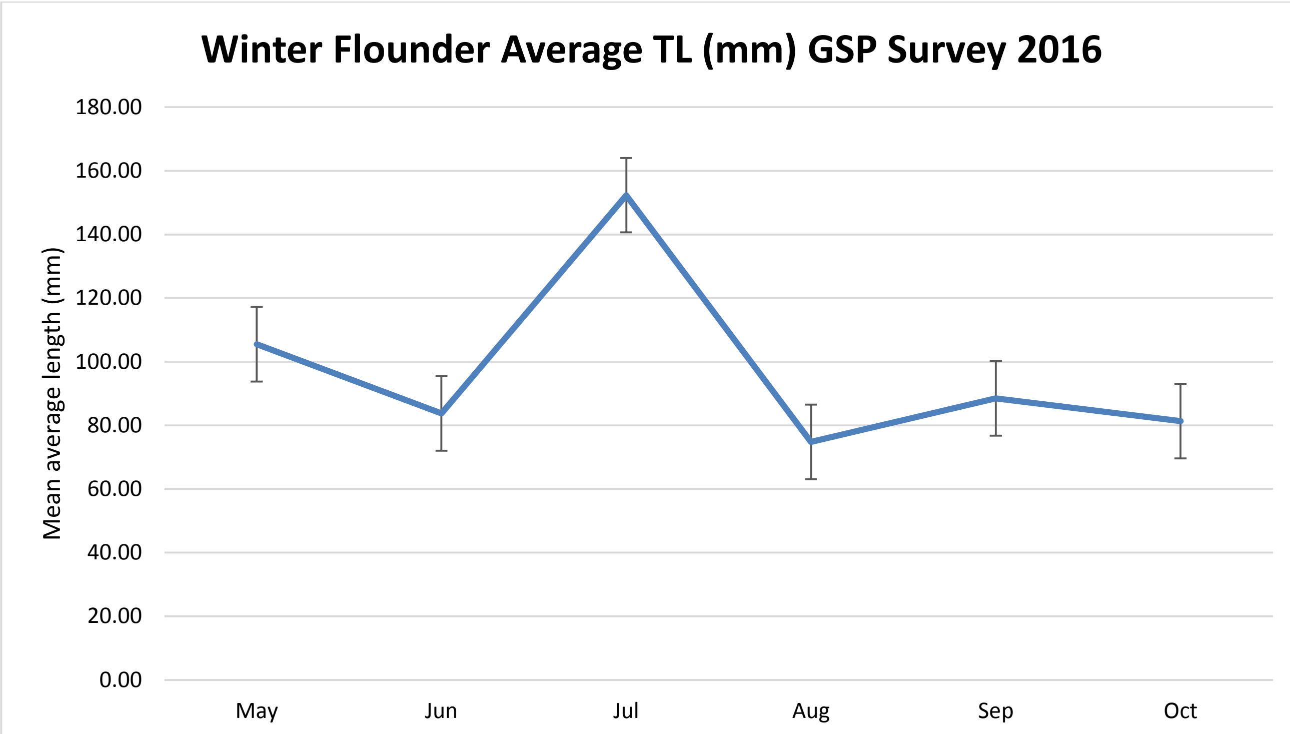

Figure Mean average length (mm) for winter flounder organized by total number collected at each station by month.

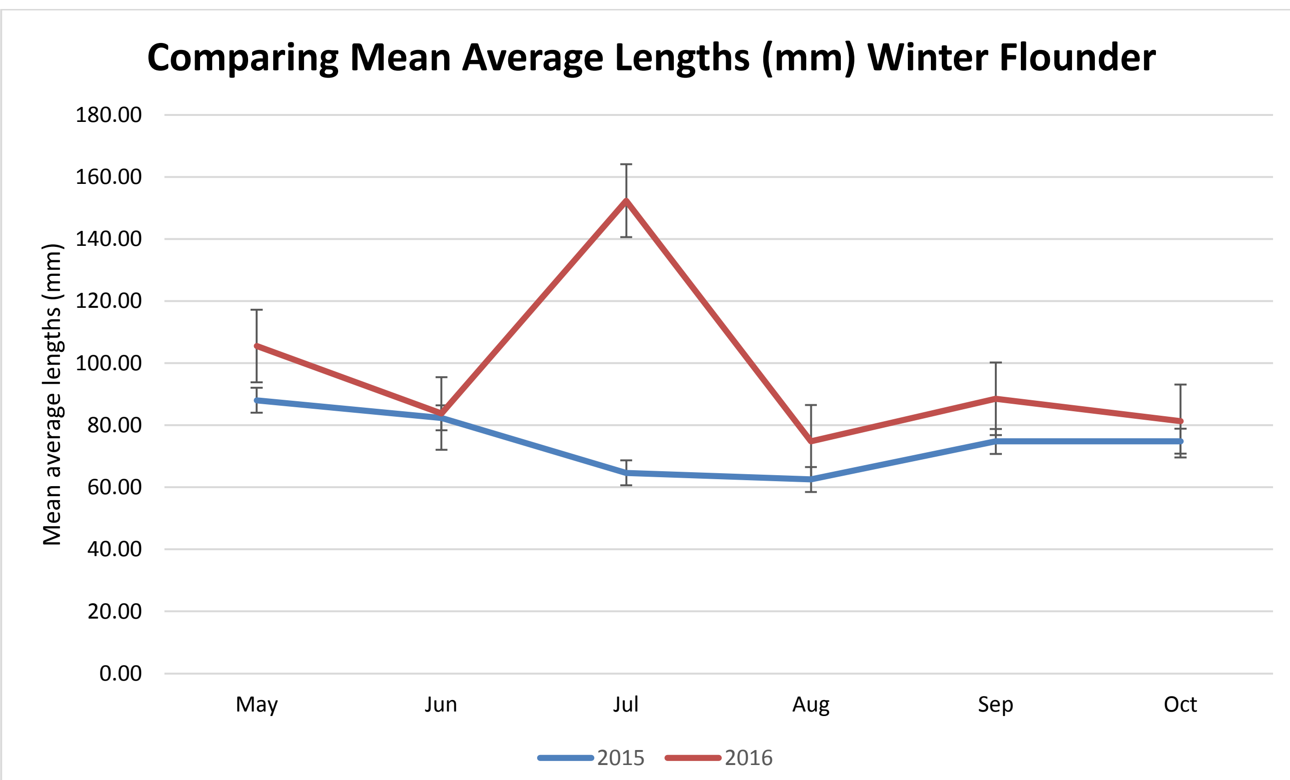

Figure Comparing mean average lengths (mm) for winter flounder surveyed in 2015 and 2016.

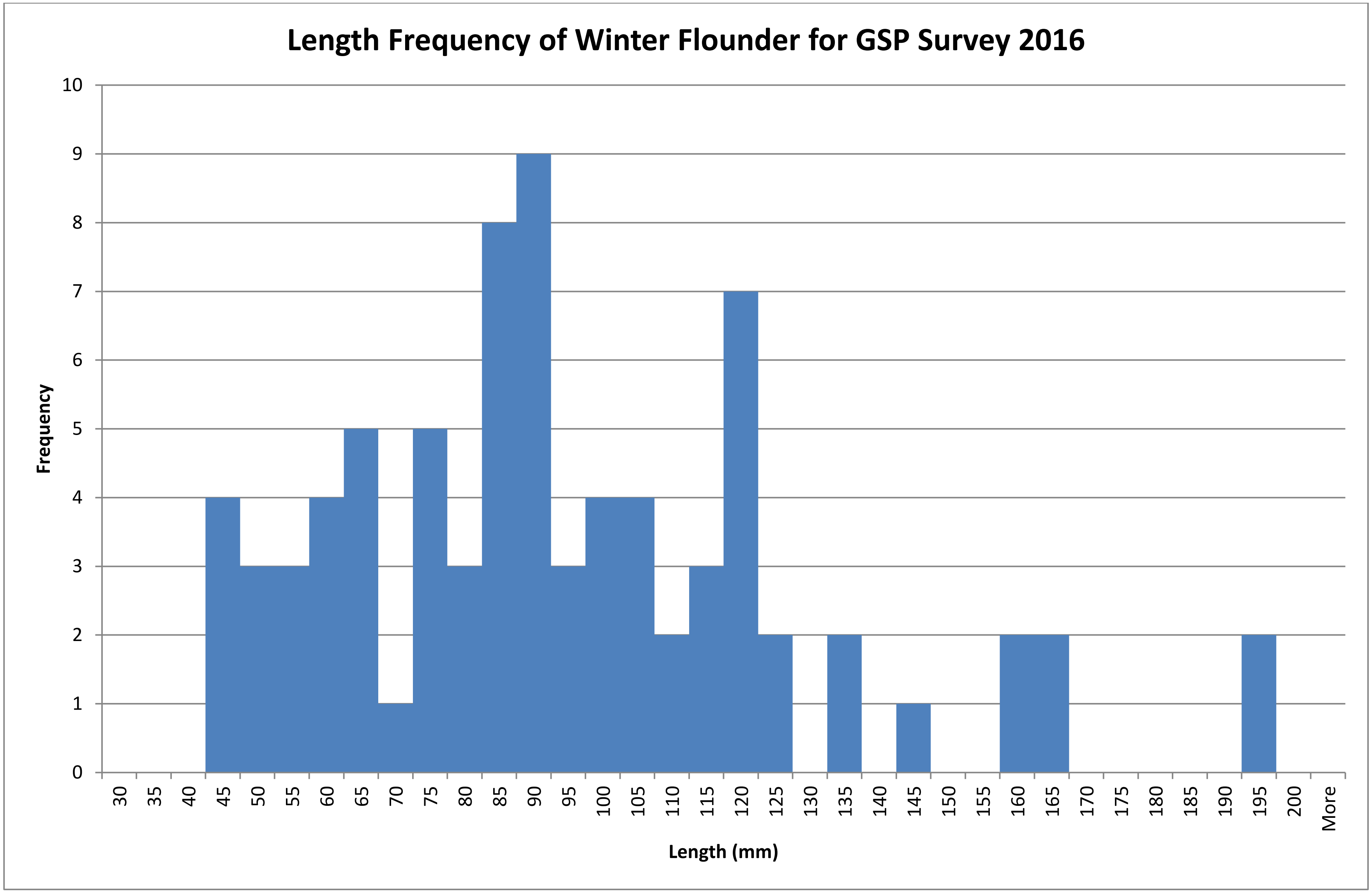

Figure Length frequency histogram showing the range of size and frequency for winter flounder measured in the GSP Survey 2016.

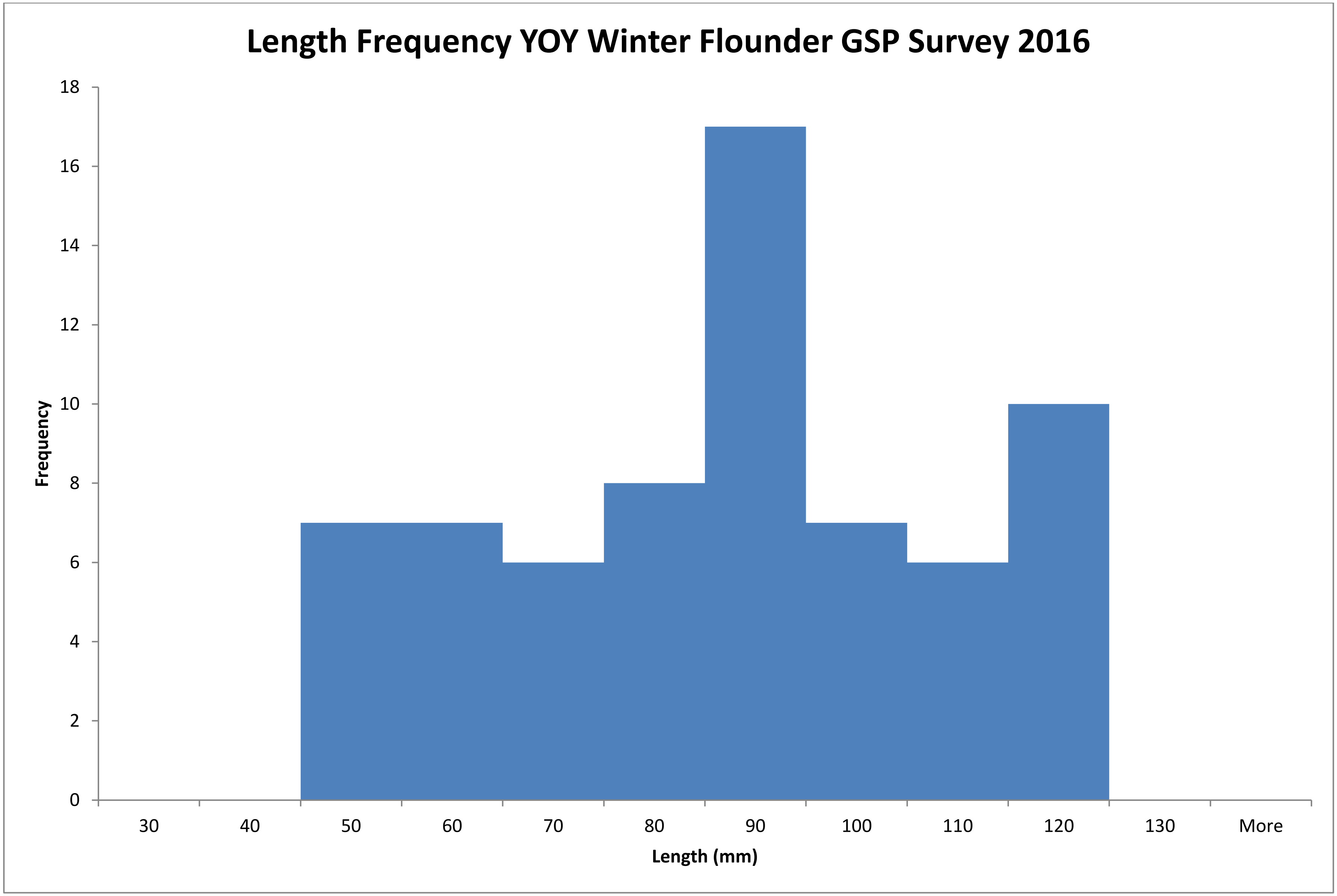

Figure Length frequency histogram displaying the size ranges for winter flounder measured in the 2016 survey.

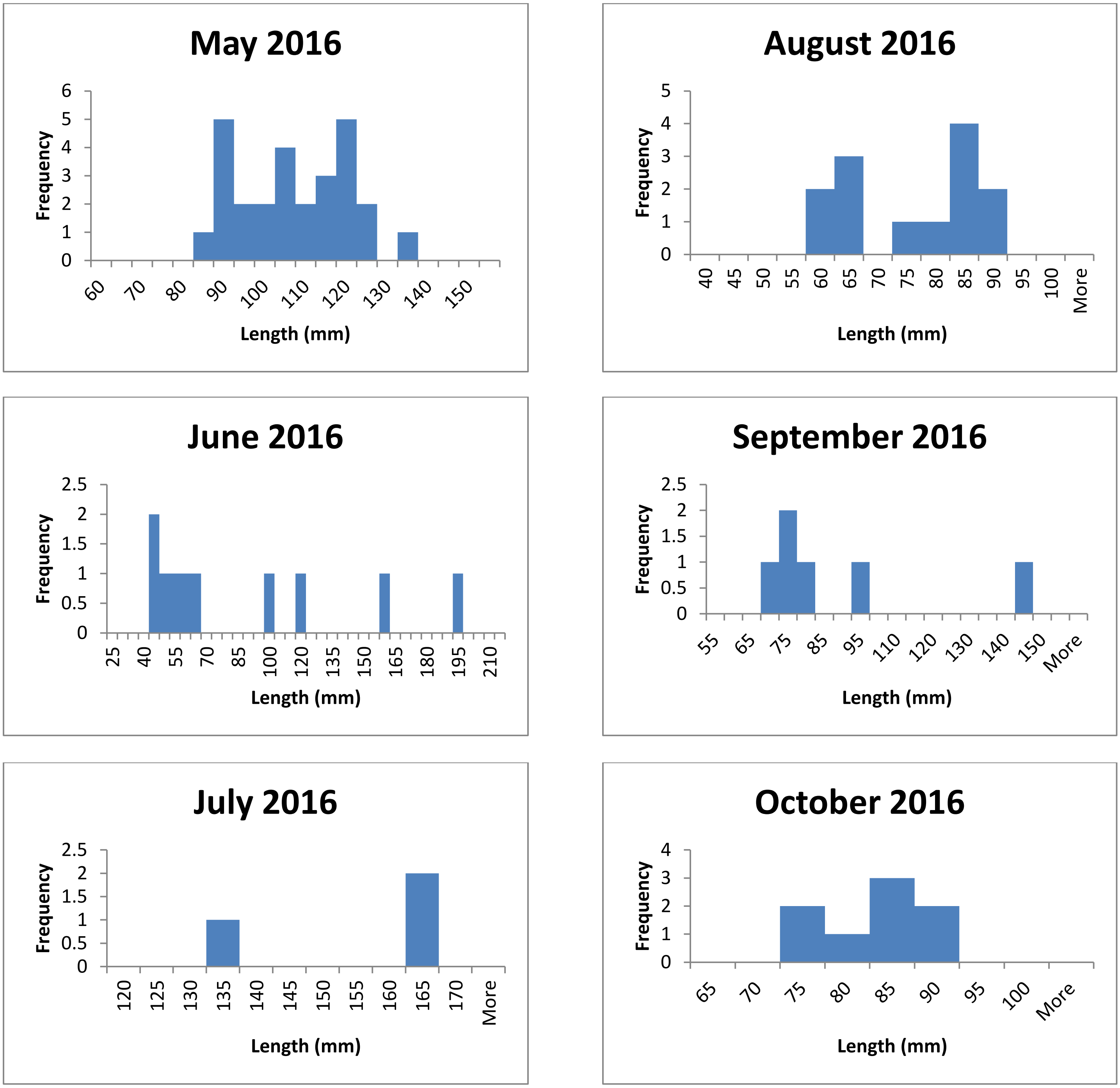

Figure Monthly length frequencies for 2016.

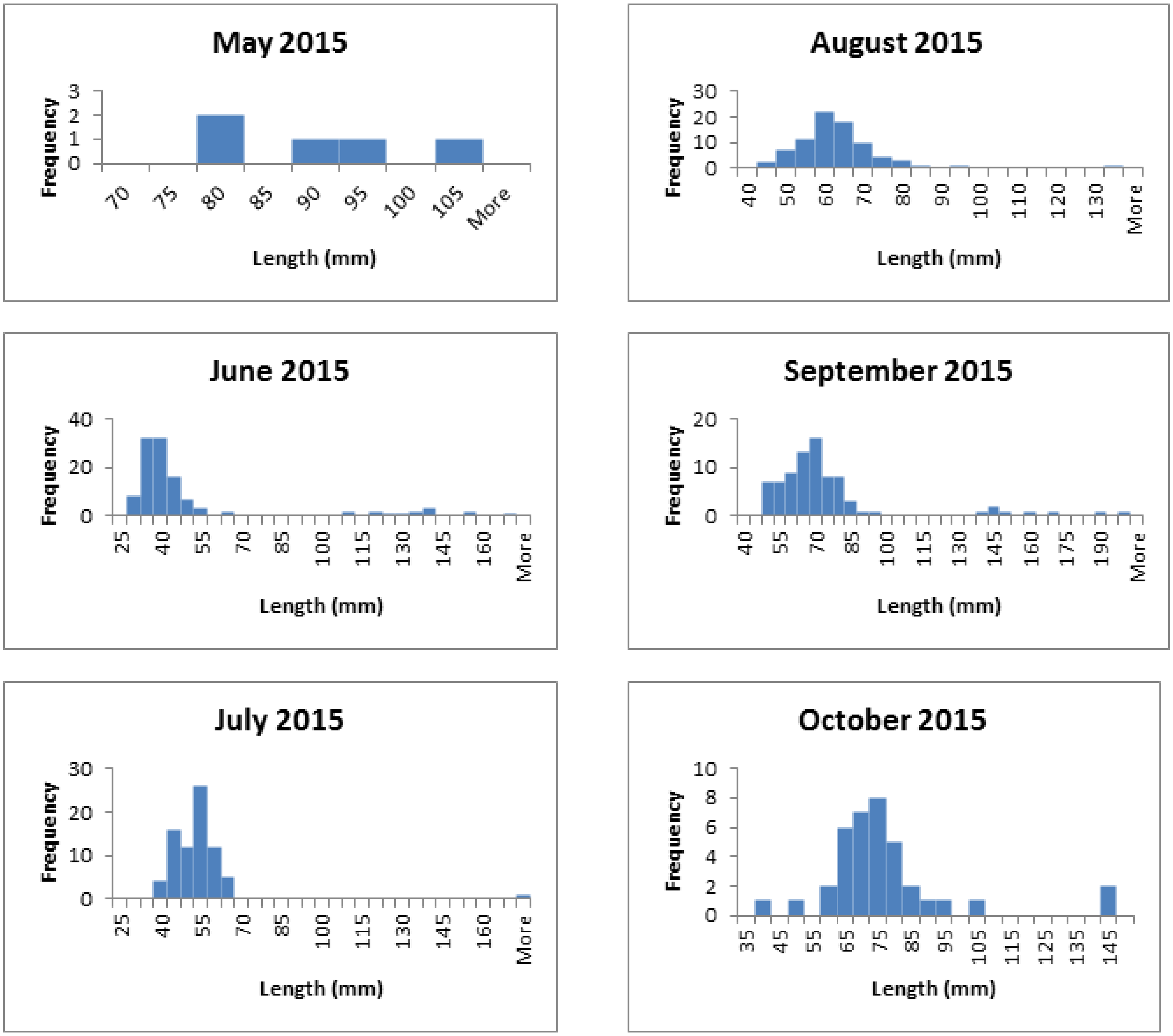

Figure Monthly length frequency of winter flounder from 2015 GSP Survey.

ppendi a Catch frequency of all species by traditional GSP 1-8 stations for 2016 GSP Survey. Species highlighted were the most abundant this sampling season.

Common name	Scientific name	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	Total measured	Total counted	Total measured+counted
American sand lance	***Ammodytes americanus***	0	0	0	20	1	0	0	0	21	0	21
Atlantic cod	***Gadus morhua***	0	0	0	2	1	0	0	0	3	0	3
Atlantic croaker	*Micropogonias undulatus*	3	5	0	0	40	6	2	0	56	0	56
Atlantic herring	***Clupea harengus***	0	0	0	0	1	0	0	0	1	0	1
Atlantic menhaden	***Brevoortia tyrannus***	0	0	4	0	0	0	0	1	5	0	5
Atlantic silverside	***Menidia menidia***	20	78	53	46	17	48	33	63	100	1378	1478
Bighead searobin	*Prionotus tribulus*	0	4	0	1	2	3	1	2	13	0	13
Black sea bass	***Centropristis striata***	0	1	2	8	21	34	6	0	20	341	361
Bluefish	***Pomatomus saltatrix***	0	0	0	0	0	0	0	1	1	0	1
Bluespotted cornetfish	*Fistularia tabacaria*	0	0	0	0	0	1	0	0	1	0	1
Butterfish	***Peprilus triacanthus***	0	0	2	0	0	0	0	0	2	0	2
Crevalle jack	*Caranx hippos*	1	2	0	0	0	0	0	0	3	0	3
Cunner	*Tautogolabrus adspersus*	2	1	0	0	0	0	0	0	3	0	3
Grubby	***Myoxocephalus aenaeus***	0	0	0	0	0	0	1	0	1	0	1
Inland silverside	***Menidia beryllina***	20	74	62	27	0	42	41	58	140	10348	10488
Inshore lizardfish	*Synodus foetens*	0	0	1	0	0	0	0	0	1	0	1
Mojarras sp.	*Gerreidae spp.*	0	0	0	0	13	0	0	0	13	0	13
Mummichog	***Fundulus heteroclitus***	20	0	0	0	1	0	1	20	20	233	253
Ninespine stickleback	***Pungitius pungitius***	0	0	0	0	0	0	2	1	3	0	3
Northern kingfish	*Menticirrhus saxatilis*	0	1	1	0	0	0	0	0	2	0	2
Northern pipefish	*Syngnathus fuscus*	0	3	0	0	1	0	2	0	6	0	6
Northern puffer	*Sphoeroides maculatus*	0	0	1	2	1	1	0	0	5	0	5
Northern searobin	***Prionotus carolinus***	0	0	0	0	0	2	0	0	2	0	2
Northern sennet	*Sphyraena borealis*	0	0	0	1	3	0	0	0	4	0	4
Pollock	***Pollachius virens***	2	0	2	0	0	0	2	0	6	0	6
Rainwater killifish	***Lacania parva***	0	2	1	16	5	10	21	0	55	0	55
Sand diver	*Synodus intermedius*	0	0	3	0	0	0	0	0	3	0	3
Scup	*Stenotomus chrysops*	0	0	0	4	3	11	0	0	18	0	18
Sheepshead minnow	***Archosargus probatocephalus***	0	35	0	0	0	0	0	0	35	0	35
Snakefish	*Trachinocephalus myops*	0	0	1	0	0	0	0	0	1	0	1

Striped bass	*Morone saxatilis*	0	0	0	0	1	0	0	0	1	0	1
Striped killifish	***Fundulus majalis***	0	60	58	42	69	45	10	53	80	1526	1606
Striped searobin	*Prionotus evolans*	0	0	0	0	2	0	0	0	2	0	2
Summer flounder	*Paralichthys dentatus*	1	3	0	1	0	0	0	2	7	0	7
Tautoga onitis	***Tautog***	4	2	3	5	6	4	5	1	30	0	30
Threespine stickleback	***Gasterosteus aculeatus***	2	0	0	0	0	0	0	6	8	0	8
Windowpane	***Scophthalmus aquosus***	0	0	5	2	4	1	1	0	13	0	13
Winter flounder	***Pseudopleuronectes americanus***	13	45	32	21	17	24	9	31	192	0	192

*Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team 2014.

ppendi Catch frequency of all species by station (GSP and OH sites) for 2015 Great Salt Pond Survey.

Common name	Scientific name	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	OH 1	OH 2	Total # measured GSP	Total # measured OH	Total (measured+ counted)
Alewife	***Alosa pseudoharengus***	0	1	2	0	7	2	0	0	13	2	12	15	27
American sand lance	***Ammodytes americanus***	0	0	0	1	0	20	0	0	0	0	21	0	128
Atlantic cod	***Gadus morhua***	0	0	0	1	0	0	0	0	0	0	1	0	1
Atlantic croaker	*Micropogonias undulatus*	4	3	0	0	33	13	0	0	0	0	53	0	73
Atlantic menhaden	*Brevoortia tyrannus*	20	0	0	0	0	0	0	0	20	20	20	40	252
Atlantic silverside	***Menidia menidia***	80	95	85	87	61	80	58	82	100	59	628	159	17037
Bay anchovy	***Anchoa mitchilli***	0	0	0	0	1	0	0	0	0	0	1	0	1
Bighead searobin	*Prionotus tribulus*	0	2	0	0	2	1	3	1	0	8	9	8	17
Black sea bass	***Centropristis striata***	21	7	21	39	40	50	25	0	1	0	203	1	898
Blueback herring	***Alosa aestivalis***	0	0	0	0	0	0	0	0	1	0	0	1	1
Bluespotted cornetfish	*Fistularia commersonii*	0	0	0	0	0	1	0	0	0	0	1	0	1
Bonefish	*Albula vulpes*	0	3	0	0	0	0	0	0	0	0	3	0	3
Crevalle jack	*Caranx hippos*	0	2	0	0	0	0	0	0	0	0	2	0	2
Cunner	*Tautogolabrus adspersus*	22	0	3	2	4	5	21	0	24	0	57	24	120
Dwarf goatfish	*Upeneus parvus*	0	0	0	0	0	0	0	0	1	0	0	1	1
Fourspine stickleback	***Apeltes quadracus***	0	0	0	0	0	0	0	0	1	0	0	1	1
Fourspot flounder	*Paralichthys oblongus*	0	0	0	0	0	0	0	0	0	1	0	1	1
Grubby sculpin	***Myoxocephalus aenaeus***	0	0	0	3	1	6	1	0	1	0	11	1	12
Inshore lizardfish	*Synodus foetens*	0	0	1	0	0	0	0	0	0	0	1	0	1
Leopard searobin	*Prionotus scitulus*	0	0	0	0	9	0	0	0	0	0	9	0	9
Longfin squid	*Loligo pealeii*	0	0	0	0	1	0	0	0	0	0	1	0	1
Longhorn sculpin	*Myoxocephalus octodecimspinosus*	2	3	0	2	0	0	2	0	10	0	9	10	19
Mummichog	***Fundulus heteroclitus***	38	12	32	6	27	9	29	29	9	3	182	12	214
Naked goby	*Gobiosoma bosc*	0	0	0	0	0	2	0	0	0	0	2	0	2
Ninespine stickleback	***Pungitius pungitius***	0	0	0	0	0	0	0	1	2	1	1	3	4
Northern kingfish	*Menticirrhus saxatilis*	0	2	0	0	0	0	1	3	0	0	6	0	6
Northern pipefish	*Syngnathus fuscus*	5	0	0	1	1	4	1	0	0	1	12	1	13
Northern puffer	*Sphoeroides maculatus*	0	0	0	1	2	0	0	0	0	1	3	1	4
Northern searobin	***Prionotus carolinus***	0	0	0	0	0	1	0	0	0	0	1	0	1
Northern sennate	*Sphyraena borealis*	0	1	0	0	0	0	0	0	1	0	1	1	2
Orange filefish	*Aluterus shoepfi*	0	0	0	1	0	0	0	0	0	0	1	0	1
Pinfish	*Lagodon rhomboides*	5	2	0	0	0	1	5	5	9	4	18	13	31
Rainwater killifish	***Lacania parva***	18	1	6	6	14	5	7	0	0	0	57	0	57

Scup	*Stenotomus chrysops*	1	0	0	0	41	0	4	0	0	0	46	0	184
Sheepshead minnow	***Cyprinodon variegatus***	0	20	0	0	0	0	0	0	2	1	20	3	46
Shortfin squid	*Illex illecebrosus*	1	0	0	0	0	0	0	0	0	0	1	0	1
Shorthorn sculpin	*Myoxocephalus scorpius*	0	0	0	0	0	4	0	0	1	5	4	6	10
Smooth trunkfish	*Rhinesomus triqueter*	1	0	0	0	0	0	0	0	0	0	1	0	1
Snakefish	*Trachinocephalus myops*	0	0	1	0	0	0	0	0	0	0	1	0	1
Spot	*Leiostomus xanthurus*	0	0	6	0	0	0	0	0	0	0	6	0	6
Spotfin mojarra	*Eucinostomus argenteus*	0	0	0	0	20	0	0	0	0	9	20	9	29
Spotted whiff	*Citharichthys macrops*	1	0	0	0	2	0	0	0	0	0	3	0	3
Striped killifish	***Fundulus majalis***	8	47	40	51	60	25	28	40	0	6	299	6	2128
Striped searobin	*Prionotus evolans*	0	0	0	0	0	1	0	0	0	0	1	0	1
Summer flounder	*Paralichthys dentatus*	0	0	1	0	0	0	0	0	0	0	1	0	1
Tautog	*Tautoga onitis*	40	8	5	20	6	21	27	8	22	4	135	26	227
Threespine stickleback	***Gasterosteus aculeatus***	1	0	0	0	0	0	0	3	2	0	4	2	6
Windowpane	***Scophthalmus aquosus***	0	0	4	1	3	1	0	0	2	0	9	2	11
Winter flounder	***Pseudopleuronectes americanus***	12	38	18	21	61	2	5	31	138	71	188	209	397

*Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team 2014.

ppendi c Catch frequency of all species by station for 2014 Great Salt Pond Survey.

Common name	Scientific name	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
Alewife	***Alosa pseudoharengus***		1						
Atlantic croaker	*Micropogonias undulatus*		1						
Atlantic herring	***Clupea harengus***		2						
Atantic silverside	***Menidia menidia***	107	585	441	605	511	474	351	575
Black sea bass	***Centropristis striata***		4	4		4	12		1
Bluefish	***Pomatomus saltatrix***			1					
Grunt	*Haemulon spp*	1							
Lizard fish	*Synodus saurus*			1					
Longhorn cowfish	*Lactoria cornuta*	1							
Mummichog	***Fundulus heteroclitus***	11	2				7	2	
Pinfish	*Lagodon rhomboides*		1						
Pipefish	*Syngnathus fuscus*				1	1	1		
Pompano	*Trachinotus spp*				1				
Northern pufferfish	*Sphoeroides maculatus*	1					1		
Rainwater killifsh	***Lucania parva***	32	1	2	25	23	52	30	5
Sculpin	***Myoxocephalus spp***	3					4		
Sea robin	*Prionotus carolinus*						3		
Seahorse	*Hippocampus erectus*						1		
Sheapshead minnow	***Cyprinodon variegatus***	1			1				
Spot	*Leiostomus xanthurus*								1
Striped bass	*Morone saxatilis*					2			
Striped killifish	***Fundulus majalis***	61	1319	642	34	132	196	21	36
Tautog	***Tautoga onitis***	13	9						1
Windowpane	***Scophthalmus aquosus***						2		
Winter flounder	***Pseudopleuronectes americanus***	6	17	9	6	29	14		20

*Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team 2014.

ppendi c Catch frequency of all species by station for 2014 GSP Survey.

Common name	Scientific name	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8
Alewife	***Alosa pseudoharengus***		1						
Atlantic croaker	*Micropogonias undulatus*		1						
Atlantic herring	***Clupea harengus***		2						
Atantic silverside	***Menidia menidia***	107	585	441	605	511	474	351	575
Black sea bass	***Centropristis striata***		4	4		4	12		1
Bluefish	***Pomatomus saltatrix***			1					
Grunt	*Haemulon spp*	1							
Lizard fish	*Synodus saurus*			1					
Longhorn cowfish	*Lactoria cornuta*	1							
Mummichog	***Fundulus heteroclitus***	11	2				7	2	
Pinfish	*Lagodon rhomboides*		1						
Pipefish	*Syngnathus fuscus*				1	1	1		
Pompano	*Trachinotus spp*				1				
Northern pufferfish	*Sphoeroides maculatus*	1					1		
Rainwater killifish	***Lucania parva***	32	1	2	25	23	52	30	5
Sculpin	***Myoxocephalus spp***	3					4		
Sea robin	*Prionotus carolinus*						3		
Seahorse	*Hippocampus erectus*						1		
Sheepshead minnow	***Cyprinodon variegatus***	1			1				
Spot	*Leiostomus xanthurus*								1
Striped bass	*Morone saxatilis*					2			
Striped killifish	***Fundulus majalis***	61	1319	642	34	132	196	21	36
Tautog	***Tautoga onitis***	13	9						1
Windowpane	***Scophthalmus aquosus***						2		
Winter flounder	***Pseudopleuronectes americanus***	6	17	9	6	29	14		20

*Names in bold are fish species considered of greatest conservation need for Rhode Island according to RI WAP Fish Taxa Team 2014.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

NARRAGANSETT BAY JUVENILE FINFISH SURVEY

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2016

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 2016 - 31 December 2016

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 2016 with the standard 61 x 3.05 m beach seine. Adults and juveniles of fifty-eight species were collected during the 2016 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 ï 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 2016

SIGNIFICANT DEVIATIONS: There were no significant deviations to methodology in 2016.

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 trend in abundance, striped bass has previously shown significant trends of decreasing abundance during the past 10 years, although the trend has subsided in recent years. The other species such as juvenile bluefish, winter flounder, and tautog show no abundance trend for either the full dataset or the past ten years (Table 1a, b). The data in Table 1a all indicate trends or lack thereof for the entire survey data series going back to 1988.

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 22ô 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 2016.

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 2016 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 ï 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 forty-one percent of the seine hauls for 2016. This is a small decrease from 2015 when they were present in forty-six percent of the hauls. A total of 263 fish were collected in 2016 (all fish would be considered young-of-the-year (YOY) according to Table 2 winter flounder maximum size by month). This was a decrease from the 394 individuals collected during the 2015 survey. They were present at all but three stations (no presence at stations 7, 10, and 14), and were collected in all months (Table 9).

The 2016 juvenile winter flounder standardized abundance index was 2.92 ± 2.05 S.E. fish/seine haul; this is less than the 2015 index of 4.38 ± 2.26 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 7.61 ± 3.78 S.E. fish/seine haul. Chepiwonoxet Pt (Sta. 3) and Kikimuit River (Sta. 11) had the highest mean station abundance of 19.60 ± 12.92 and 13.60 ± 12.62 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 high numbers 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 2016 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 2012 abundance index continues to be lower than most years since 2000, the survey high. The Division of Fish and Wildlifeôs trawl survey data (sampling both adults and juveniles) saw a small increase in winter flounder from 2015 to 2016. 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 2016. 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 in 2016, now showing no trend as we move away from the peak years of the early 2000ôs. 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 2016 survey 373 juvenile tautog (*Tautoga onitis*) were collected. This is a decrease from the 2015 survey when 521 juveniles were collected. The 2016 abundance index was 4.14 ± 2.29 S.E. fish/seine haul, a decrease from the 2015 index 5.78 ± 2.26 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 fifty-five percent of the seine hauls in 2016 (Table 10). This is a slight increase from 2015 when they were present in fifty-four percent of the seine hauls. October and August had the highest mean monthly abundances of 5.89 ± 4.47 and 5.17 ± 1.64 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. The high mean monthly abundance in October was driven by a single high abundance at Patience Island (Sta. 5), in fact, Patience Island had the highest mean station abundance of 23.80 ± 14.71 S.E. followed by Dyer Island (Sta. 16) and Hog Island (Sta. 9) with a mean station abundance of 7.40 ± 2.68 S.E and 7.40 ± 3.47 S.E fish/seine haul respectively. The Mann-Kendall test showed no long-term or short term abundance trend for juvenile tautog (Table 1a, b). 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 from 2015 to 2016. 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 2016 survey 1,430 juvenile bluefish (*Pomatomus saltatrix*) were collected. This is higher than the six-hundred seventy-one juveniles collected in 2015. Juveniles were present in thirty-four percent of the seine hauls and were collected at seventeen of the eighteen stations

(Table 11). They were present in all months except for June, with the highest abundance occurring in August. In October in 2016, 128 juvenile bluefish were caught, a majority caught at Gaspee Point (Sta. 1) and Hog Island (Sta. 9). It should be noted that 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 ï 21° C.

The abundance index for 2016 was 15.89 ± 14.79 S.E. fish/seine haul. This is greater than the 2015 abundance index of 7.46 ± 4.73 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).

August had the highest mean monthly abundance of 68.17 ± 37.58 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 2016, Spar Island (Sta. 12) and Third Beach (Sta. 15) had the highest mean station abundances of 107.60 ± 107.60 S.E. and 91.00 ± 90.00 S.E. fish/seine haul (Table 11). Both of these high mean monthly abundances were due to a single high catch of bluefish at this station in August.

Length frequency data for 2016 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).

<u>Striped Bass</u>
During the 2016 survey 36 striped bass (*Morone saxatalis*) were collected. This is higher than the 12 fish collected in 2015. Striped bass were present in five percent of the seine hauls and were collected at three of the eighteen stations (Table 14). They were present in July, August, and October.

The abundance index for 2016 was 0.40 ± 0.38 S.E. fish/seine haul. This is higher than in 2015, which had an abundance index of 0.133 ± 0.08 S.E fish/seine haul (Figure 8). The Mann-Kendall test showed no abundance trend for this species for the entire dataset. A decreasing trend for the truncated 10 year dataset was present last year, but has subsided with the addition of the 2016 abundance (Table 1a, b).

July had the highest mean monthly abundance of 1.78 ± 1.72 S.E. fish/seine haul (Table 14), this was largely driven by a high catch (31 fish) at Warren River (Sta. 17). September and October are usually the months with the highest abundance for the entire time series.

In 2016, striped bass were only present at 3 stations, Warren River (Sta. 17), Third Beach (Sta. 15), and Spar Island (Sta. 12) with mean station abundances of 6.20 ± 6.20 S.E., 0.60 ± 0.40 S.E., and 0.40 ± 0.24 S.E. respectively (Table 14). 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 2016 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.

<u>Clupeidae</u>

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.

<u>River Herring</u>

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 Divisionǒs 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 Divisionǒs restoration efforts.

River herring were present in thirty percent of the seine hauls and were collected at fourteen of the eighteen stations during 2016. River herring were present in June, July, August, and September in 2016. A total of 1,324 juveniles were collected in 2016, a decrease from the number collected in 2015 (5,865 fish).

The highest mean monthly abundance for 2016 occurred during July and was 27.22 ± 18.43 S.E. fish/seine haul. Warren River (Sta. 17) and Hog Island (Sta. 9) had the highest mean station abundance of 96.20 ± 92.96 S.E. and 67.40 ± 67.15 S.E., respectively (Table 13). Warren River experienced a single high catch in June (468 fish), while Hog Island experienced a single high catch in July (336 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 2016 was 14.71 ± 13.87 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

Two-thousand one-hundred seventy-seven Atlantic menhaden (*Brevoortia tyrannus*) were collected during the 2016 survey, a decrease from 2015 when 7,356 fish were caught. The 2015 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 twelve percent of the seine hauls and were collected at eight of the eighteen stations (Table 12).

The highest mean monthly abundance for 2016 occurred during July and was 121.53 ± 117.98 S.E. fish/seine haul. Kikemuit River (Sta. 18) had the highest mean station abundance of 418.80 ± 411.34 S.E. (Table 13). 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 2016 was 24.38 ± 23.85 S.E. fish/seine haul. This is slightly higher than recent years (excluding 2015) but lower than 2007 (Figure 7). The standardized index indicates an increased abundance during the 2000s. In the most recent years a increasing abundance is evident. Our Narragansett Bay trawl survey showed an increase in menhaden abundance from 2015 to 2016. 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.

Weakfish
No weakfish, *Cynocion regalis,* were collected during the 2016 survey. 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 were no fish caught in 2016, no fish have been caught in 9 other years since 1988. 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
Twenty black sea bass (*Centropristis striata*) were caught in 2016, a dramatic decrease from the 783 fish that were collected in 2015, which represents a high recruitment event in Narragansett Bay. 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 twelve percent of the seine hauls in 2016.

The highest mean monthly abundances for 2016 occurred during September and July at 0.50 ± 0.23 S.E. fish/seine haul and 0.44 ± 0.17 fish/seine haul respectively. Warren River (Sta. 17) had the highest mean station abundance of 1.00 ± 0.77 S.E. (Table 13). Many stations that caught black sea bass in 2015 did not yield any catch in 2016, in fact only half (9) of the 18 stations yielded a catch of black sea bass in 2016, compared to 14 of the 18 stations yielding a catch in 2015.

The abundance index for 2016 was 0.22 ± 0.20 S.E. fish/seine haul. This was lower than the 2015 index of 8.70 ± 3.70 S.E (Figure 10). Our Narragansett Bay trawl survey had a small decrease in the abundance of black sea bass from 2015 to 2016, 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. 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*).

Sixty-six juvenile scup were collected in 2016 during July, August, and September. One hundred sixty-eight Northern kingfish were collected in 2016 with the majority (83%) collected in August. Four summer flounder were collected in 2016 in June and July. No smallmouth flounder were caught in 2016. 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 for 2015 continued in 2016. 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. Additionally, 44 juvenile haddock were caught in June 2016, an increase from 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 2016 survey ranged from a low of 15.5°C at Kikimuit River (Sta. 11) in October to a high of 27.2°C at Kikemuit River (Sta. 11) in August.

Salinities ranged from 20.0 *ppt* at Patience Island (Sta. 5) in August to 29.6 *ppt* at Rose Island (Sta. 10) in October.

SUMMARY: In summary, data from the 2016 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.

Fifty-eight species, both vertebrates and invertebrates, were collected in 2016. This is slightly lower 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 2016 one 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

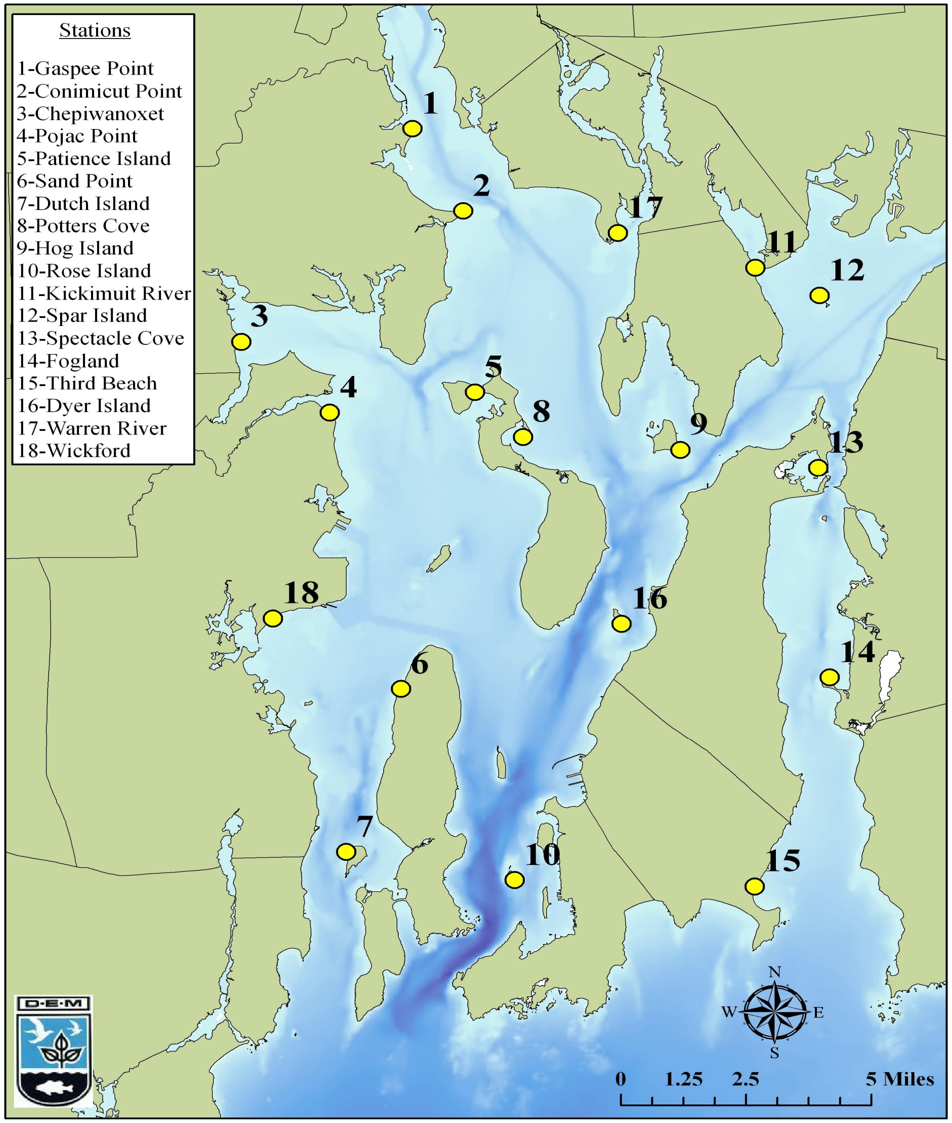


Figure 1. Survey station location map.

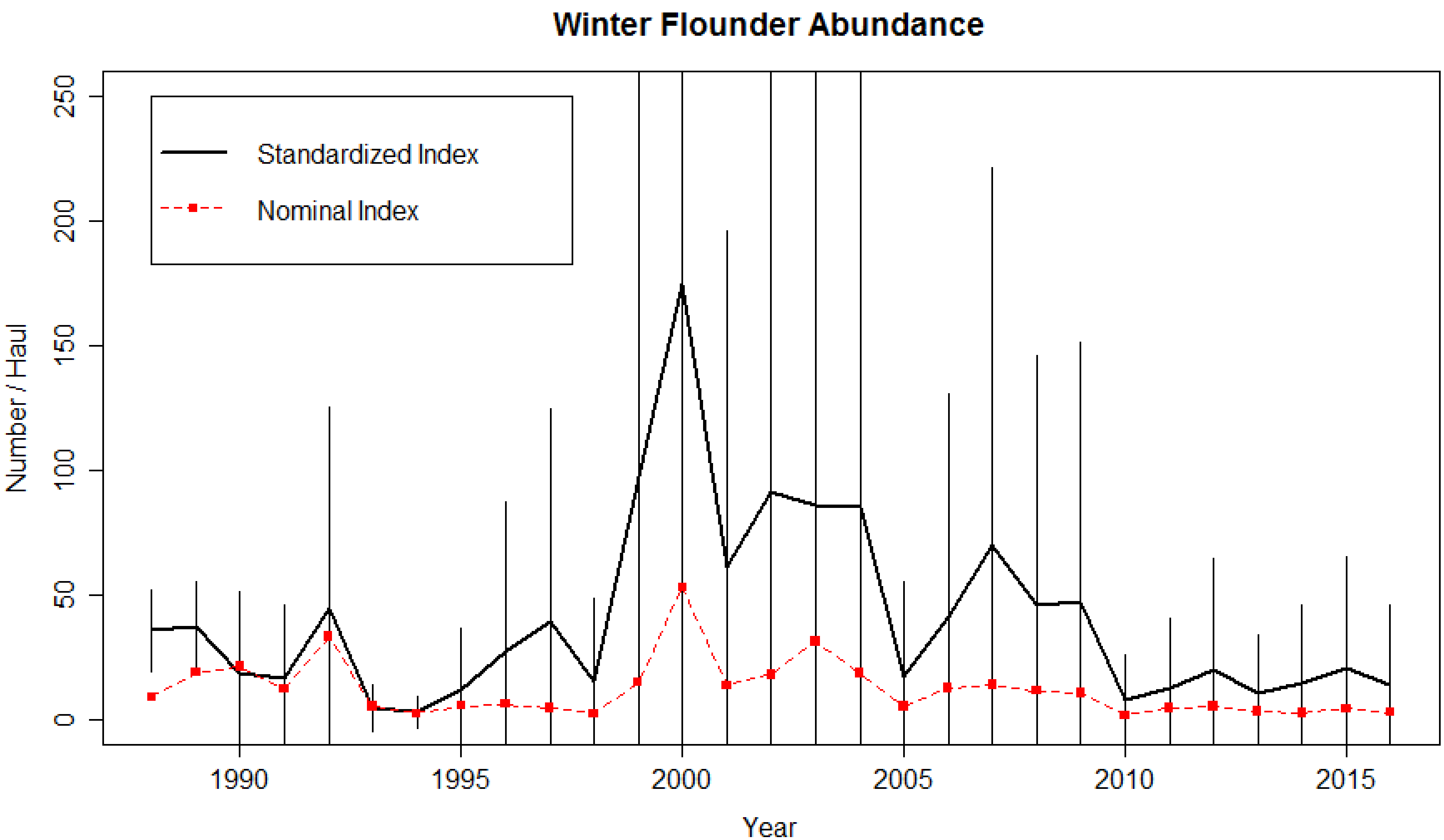


Figure 2. Juvenile winter flounder standardized abundance index 1988 ï 2016 (see appendix A for standardization methodology).

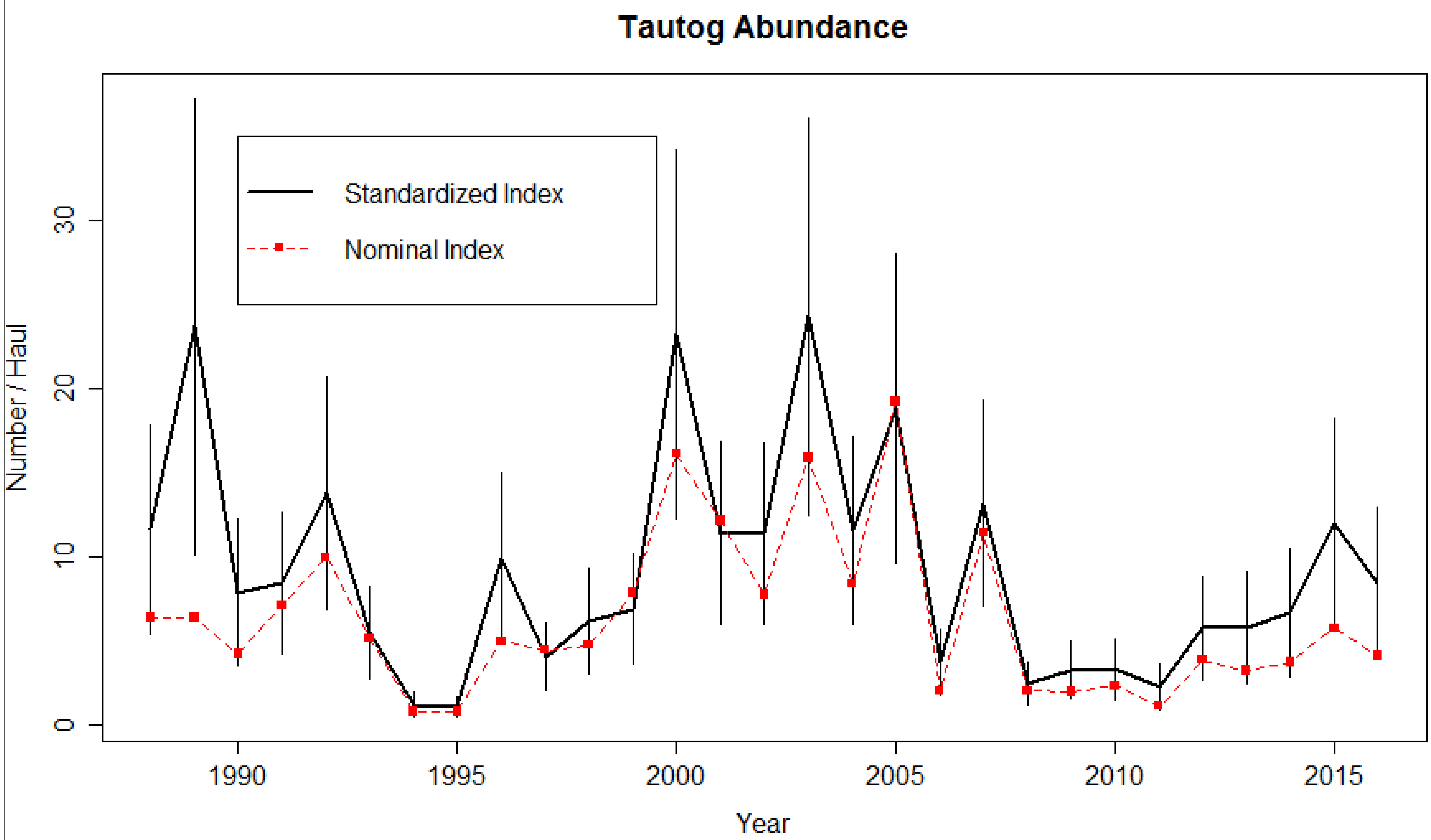


Figure 3. Juvenile tautog standardized annual abundance index 1988 ï 2016 (see appendix A for standardization methodology).

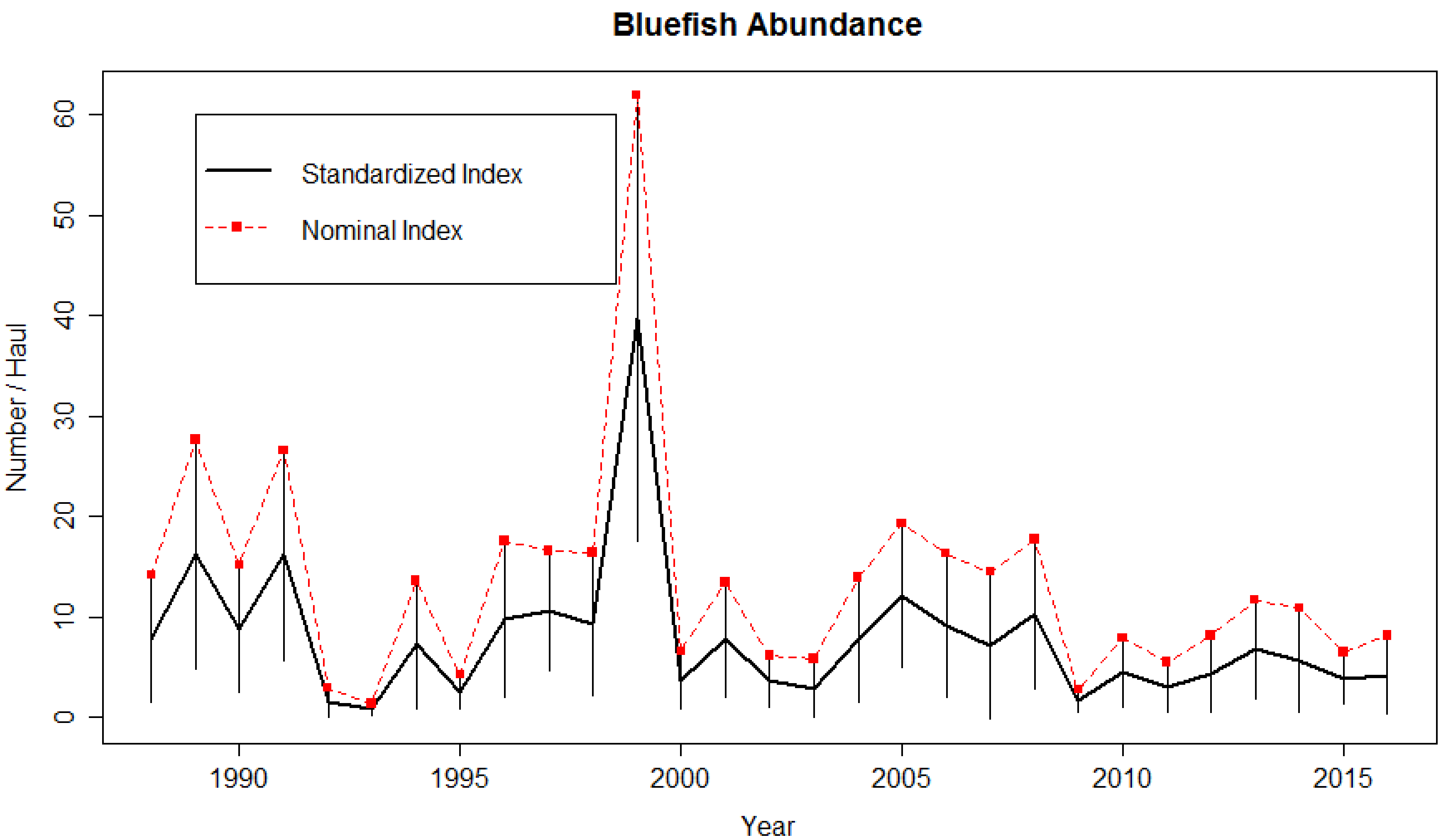


Figure 4. Juvenile bluefish standardized annual abundance index 1988 ï 2016 (see appendix A for standardization methodology).

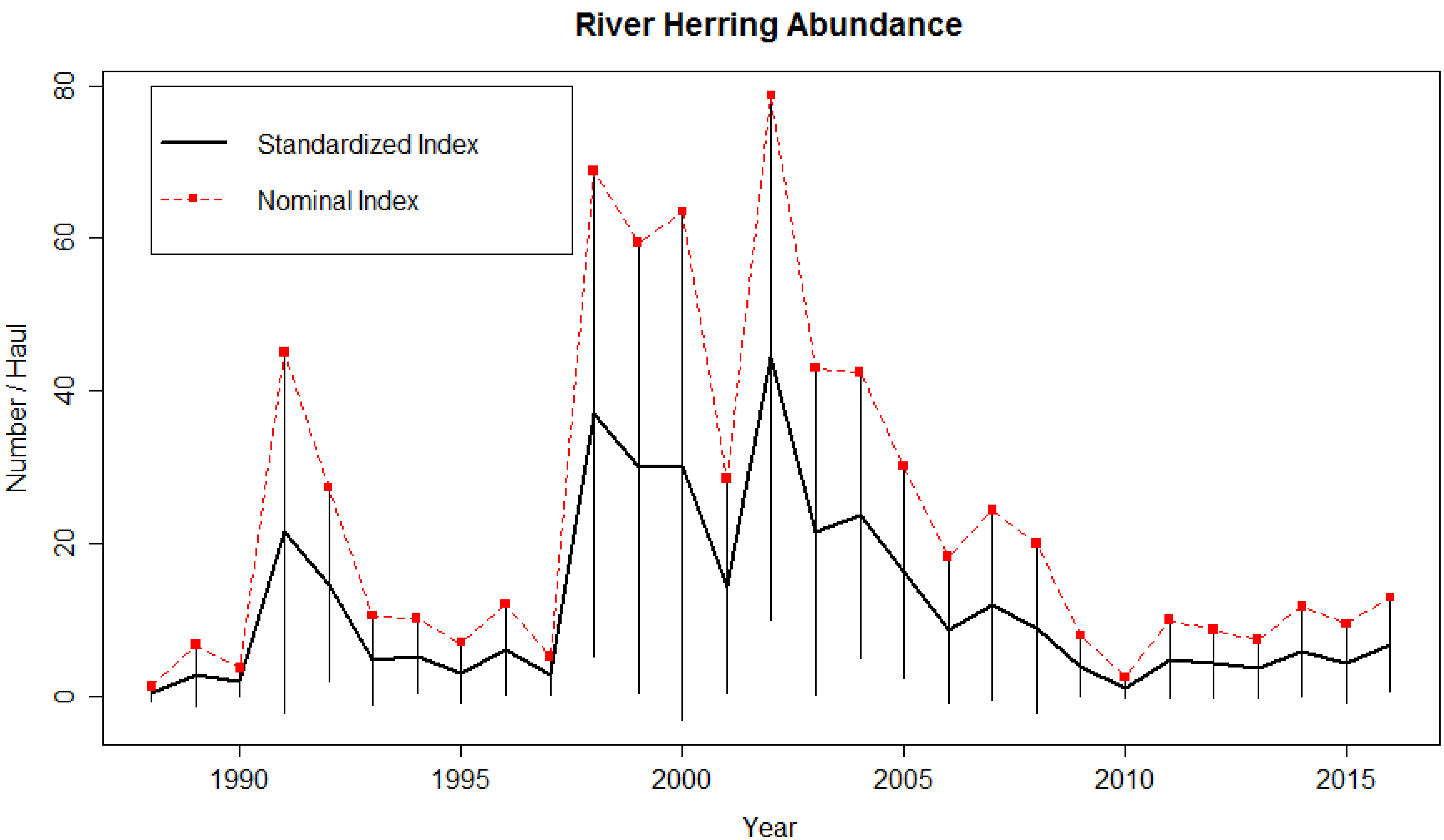
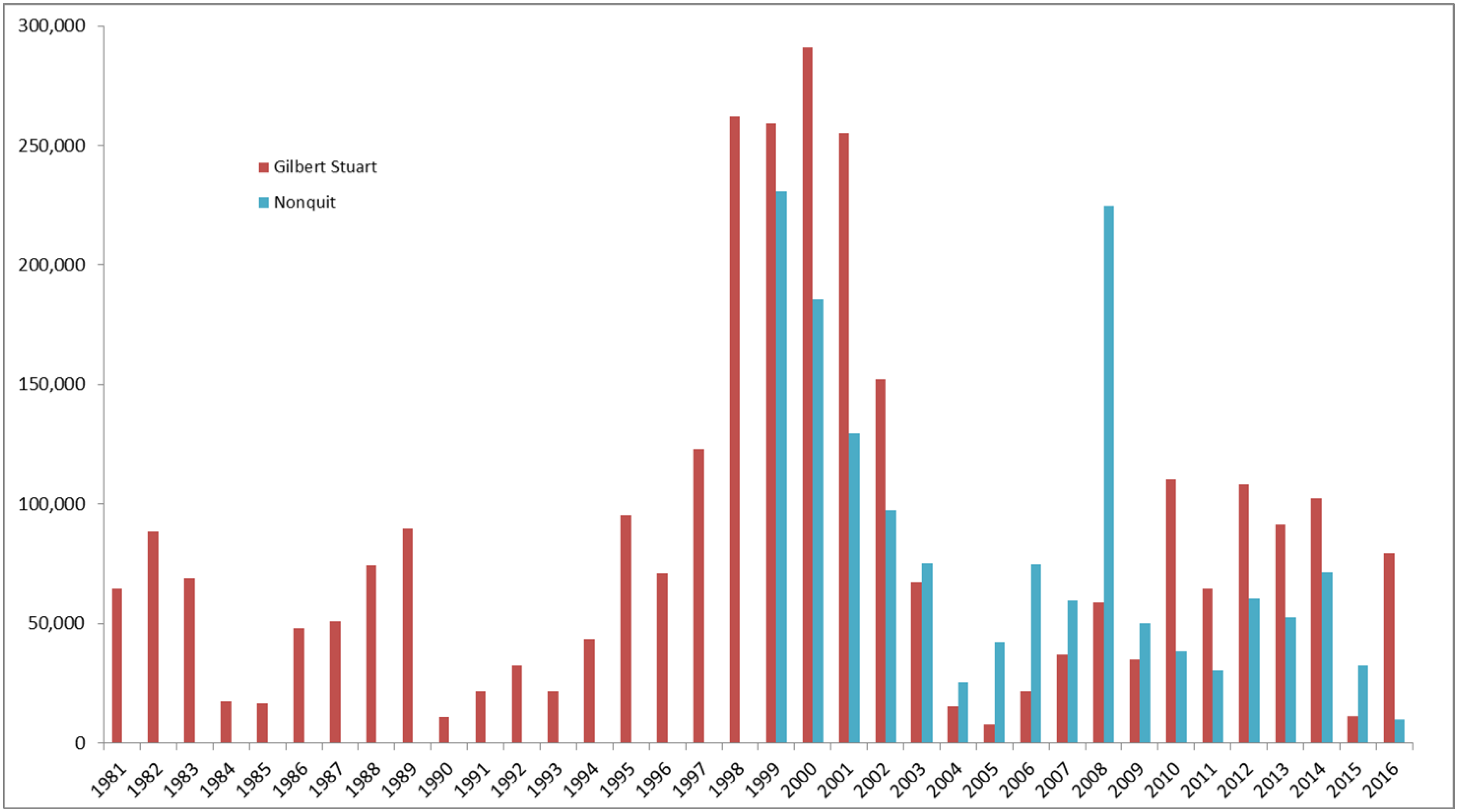


Figure 5. Juvenile river herring standardized annual abundance index 1988 ï 2016 (see appendix A for standardization methodology).



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

Figure 6. River herring spawning stock size from monitoring at two locations 1999 ï 2016.

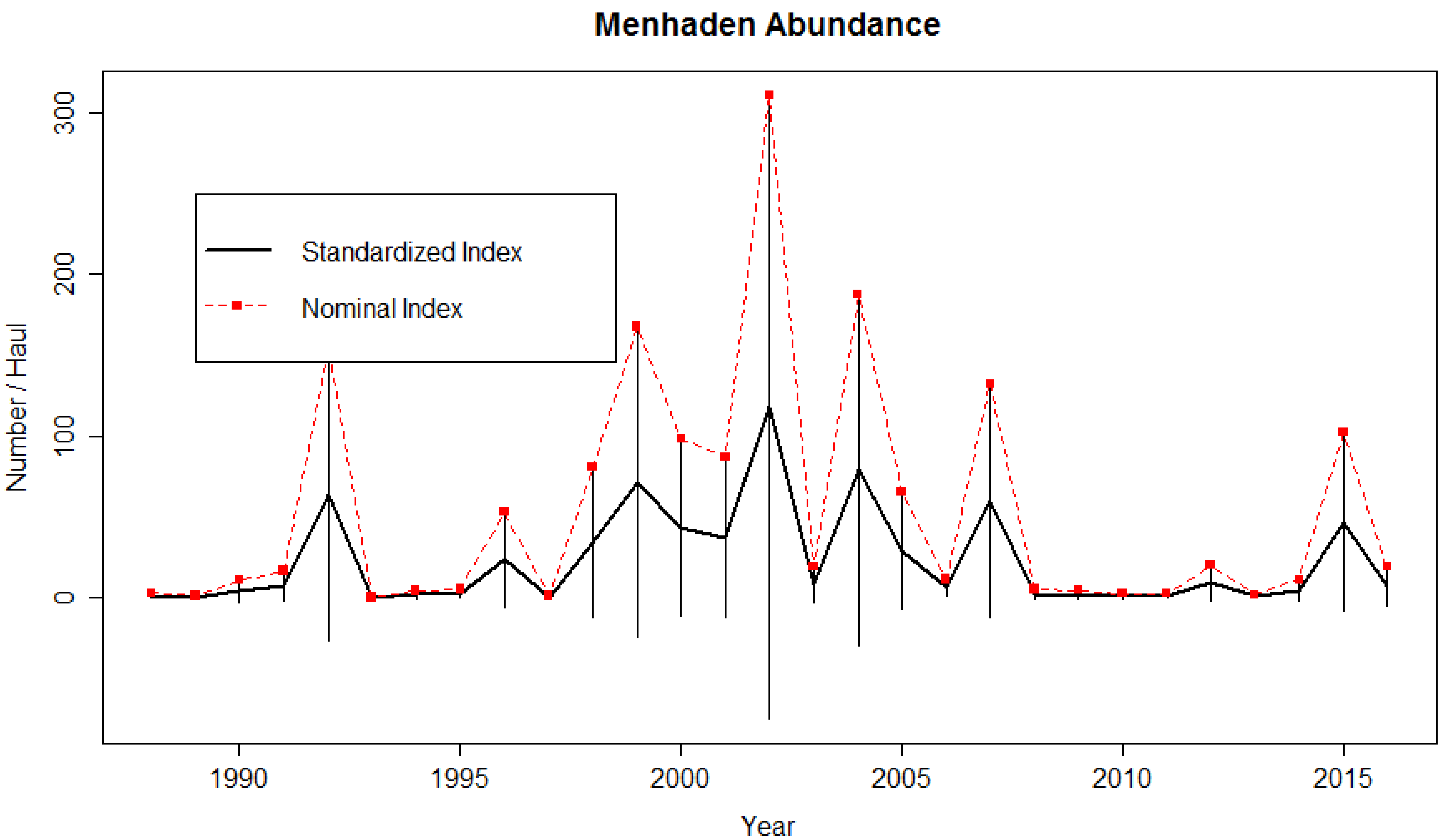


Figure 7. Juvenile menhaden standardized annual abundance index 1988 ï 2016 (see appendix A for standardization methodology).

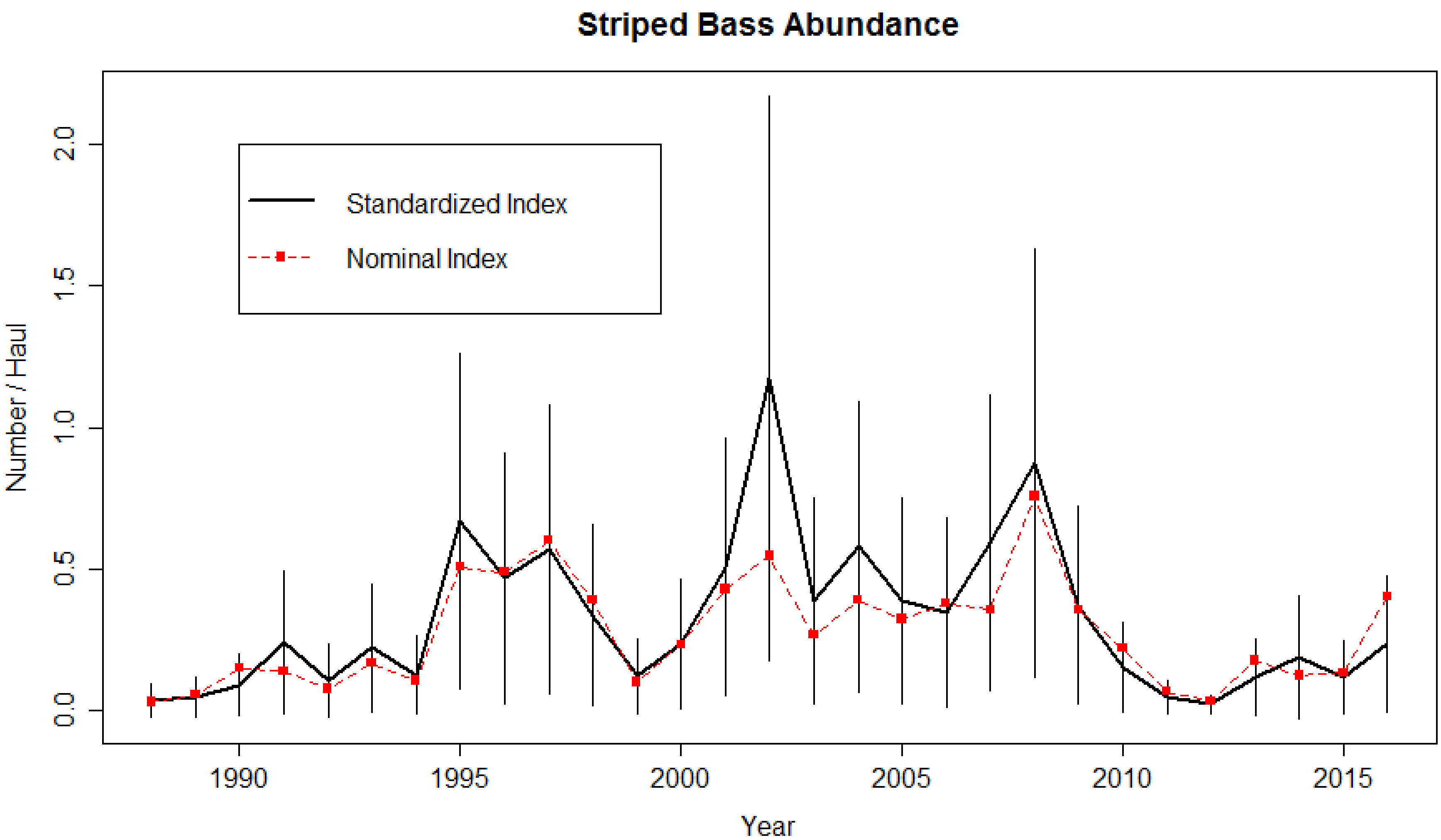


Figure 8. Striped bass standardized annual abundance index 1988 ï 2016 (see appendix A for standardization methodology).

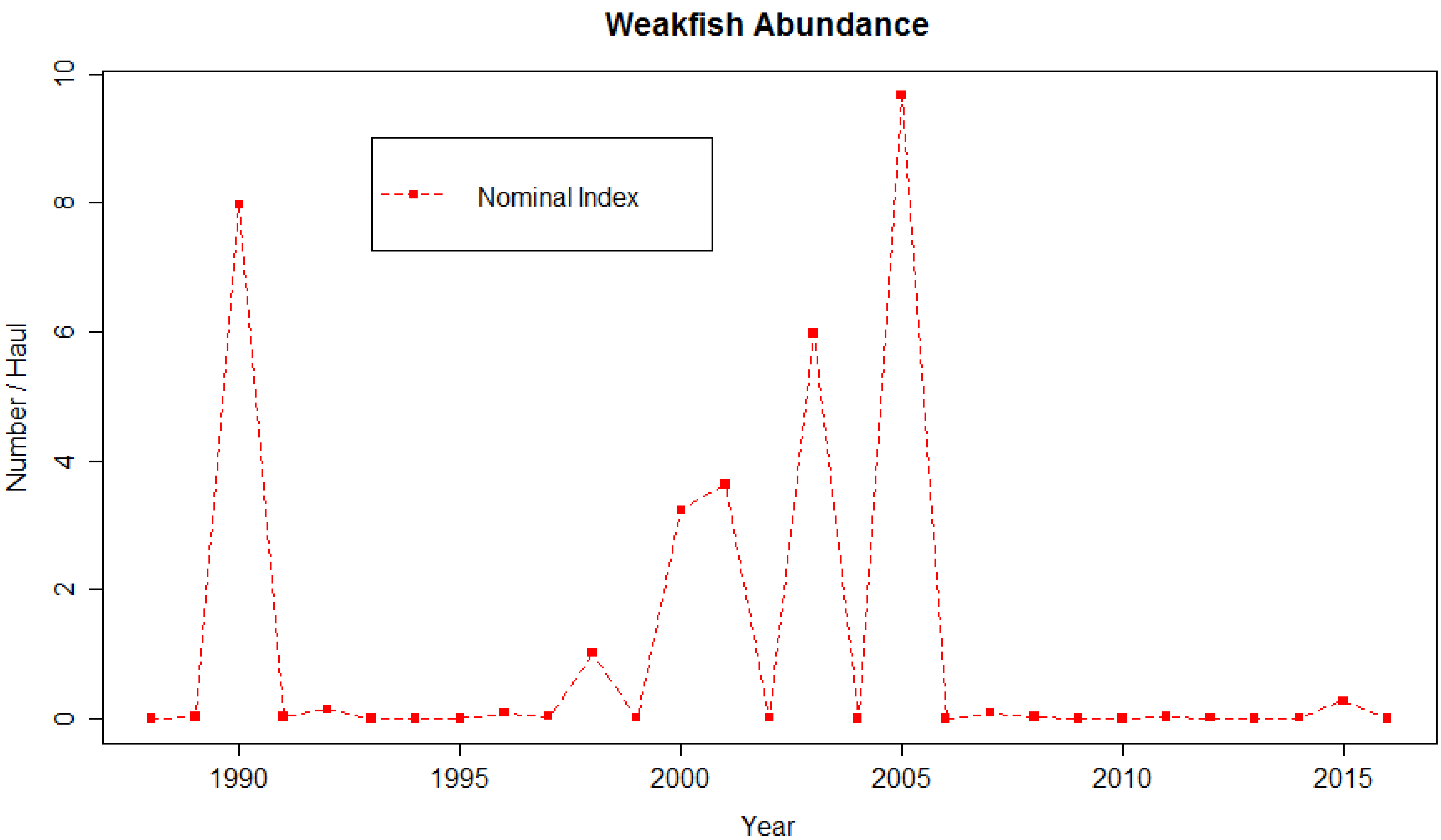


Figure 9. Weakfish annual abundance index 1988 ï 2016.

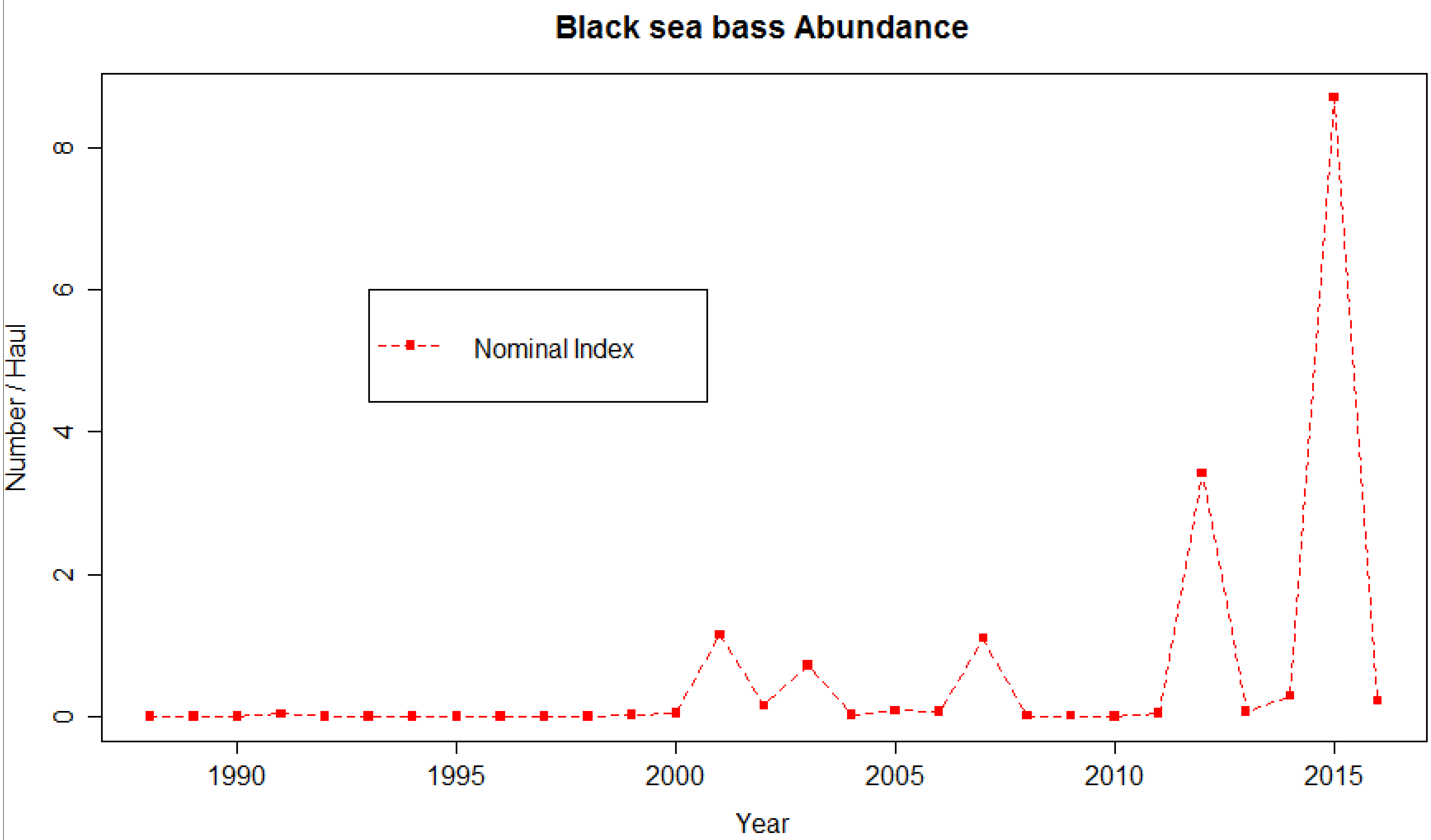


Figure 10. Black sea bass annual abundance index 1988 ï 2016.

TABLES

Table 1a. Mann-Kendall test for target species abundance trend analysis (Full dataset; 1988 - 2016).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-22	-36	-76	-4	22	26
n Observations	29	29	29	29	29	29
Variance	2842	2842	2842	2842	2842	2842
Tau	-0.054	-0.0887	-0.187	-0.010	0.054	0.064
2-sided p value	0.694	0.512	0.159	0.955	0.694	0.639
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	No	No	No	No	No

Table 1b. Mann-Kendall test for target species abundance trend analysis (2007 - 2016).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-13	19	-9	-3	1	-15
n Observations	10	10	10	10	10	10
Variance	125	125	125	125	125	125
Tau	-0.289	0.422	-0.200	-0.067	0.022	-0.333
2-sided p value	0.283	0.107	0.474	0.858	1	0.211
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	No	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 2016.

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				1	1		1		1				1		8
Amphipoda order							1												1
Anchoa mitchilli	1										1				1				3
Brevoortia tyrannus											1								1
Calinectes sapidus	1		1	1							1						1		5
Carcinus maenus			1		1								1	1					4
Crangon septemspinosa	1	1	1		1						1	1	1		1			1	9
Crepidula fornicata					1				1										2
Ctenophora phylum				1				1	1		1	1	1				1		7
Emerita talpoida															1				1
Farfantepenaeus aztecus					1							1							2
Fundulus heteroclitus	1		1		1			1					1				1		6
Fundulus majalis	1	1	1						1				1						5
Gobiosoma bosc	1		1						1		1	1							5
Hemigrapsus sanguineus								1							1		1		3
Libinia emarginata			1		1				1		1		1				1		6
Limulus polyphemus																	1	1	2
Littorina littorea																		1	1
Melanogrammus aeglefinus							1			1		1			1				4
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
Microgadus tomcod												1				1			2
Myoxocephalus aenaeus						1					1		1			1			4
Nassarius obsoletus	1			1	1	1							1					1	6
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			1	1	1	11
Panopeus spp					1						1		1						3
Paralichthys dentatus											1								1
Prionotus evolans				1															1
Pseudopleuronectes americanus	1		1	1					1		1		1		1		1	1	9
Syngnathus fuscus	1		1	1	1				1				1			1			7
Tautoga onitis					1	1	1		1	1		1	1	1		1	1		10
Tautogolabrus adspersus					1					1						1			3
Urophycis regia																1			1

Table 4. Species presence by station for July 2016.

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
Anguilla rostrata				1															1
Apeltes quadracus	1																		1
Brevoortia tyrannus											1			1					2
Calinectes sapidus	1		1	1										1			1		5
Carcinus maenus		1						1	1				1	1			1		6
Centropristus striata														1					1
Crangon septemspinosa									1				1					1	3
Crepidula fornicata					1		1						1						3
Ctenophora phylum	1	1			1		1	1	1	1		1		1	1	1	1	1	13
Cyprinodon variegatus								1								1			2
Fundulus heteroclitus	1	1	1	1		1			1		1		1	1		1	1		11
Fundulus majalis	1	1	1	1		1	1	1	1		1		1	1			1	1	13
Leiostomus xanthurus			1																1
Libinia emarginata			1	1	1			1	1				1	1		1	1		9
Limulus polyphemus					1				1								1		3
Littorina littorea														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	4
Microgadus tomcod										1				1					2
Morone saxatilis												1					1		2
Myoxocephalus aenaeus													1			1			2
Nassarius obsoletus	1	1		1	1	1								1					6
Ovalipes ocellatus		1	1												1				3
Pagurus spp				1				1	1				1		1			1	6
Palaemonetes vulgaris				1		1			1				1					1	5
Panopeus spp	1			1	1			1					1			1			6
Paralichthys dentatus	1								1		1								3
Pomatomus saltatrix				1	1		1							1	1			1	6
Prionotus carolinus														1					1
Prionotus evolans									1										1
Pseudopleuronectes americanus	1	1	1	1	1						1	1	1		1	1	1	1	12
Sphoeroides maculatus	1	1			1	1							1					1	6
Stenotomus chrysops									1					1			1	1	4
Strongylura marina																		1	1
Syngnathus fuscus		1		1	1										1		1		5
Tautoga onitis		1		1	1	1	1		1	1				1		1	1		10
Tautogolabrus adspersus					1											1			2
Urophycis chuss																1			1

Table 5. Species presence by station for August 2016.

AUGUST	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		6
Anchoa mitchilli								1											1
Brevoortia tyrannus	1	1	1								1								4
Calinectes sapidus		1	1	1									1						4
Caranx hippos															1				1
Carcinus maenus	1		1		1				1										4
Centropristus striata											1	1			1		1		4
Crangon septemspinosa												1	1		1				3
Crepidula fornicata								1											1
Ctenophora phylum		1	1	1		1	1	1		1	1	1	1			1	1	1	13
Cyprinodon variegatus																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	16
Libinia emarginata		1	1		1			1	1		1	1	1				1		9
Limulus polyphemus		1						1	1								1		4
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	10
Morone saxatilis												1			1				2
Mugil curema																	1		1
Myoxocephalus aenaeus									1	1			1		1				4
Opsanus tau			1		1														2
Ovalipes ocellatus		1													1				2
Pagurus spp	1	1	1	1	1	1		1	1	1			1		1		1		12
Palaemonetes vulgaris		1	1		1	1			1		1					1		1	8
Panopeus spp	1				1	1			1				1					1	6
Pomatomus saltatrix	1		1	1	1	1	1					1			1	1	1	1	11
Prionotus evolans		1	1	1															3
Pseudopleuronectes americanus			1	1	1	1			1				1						6
Sphoeroides maculatus		1			1	1	1				1	1	1						7
Sphyraena borealis							1												1
Squilla empusa													1						1
Stenotomus chrysops							1								1		1	1	4
Strongylura marina	1										1		1				1	1	5
Syngnathus fuscus					1														1
Synodus foetens	1								1										2
Tautoga onitis		1	1		1	1	1	1	1		1	1	1	1		1	1	1	14
Tautogolabrus adspersus					1	1	1		1	1						1	1		7

Table 6. Species presence by station for September 2016.

SEPTEMBER	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
Apeltes quadracus	1																		1
Brevoortia tyrannus								1	1										2
Calinectes sapidus			1			1								1				1	4
Carcinus maenus						1		1	1		1					1			5
Centropristus striata						1	1				1						1		4
Crangon septemspinosa	1				1														2
Ctenophora phylum	1				1	1	1	1		1	1	1	1	1	1	1	1	1	14
Fundulus heteroclitus	1	1	1	1				1	1		1					1			8
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		1			1	1		1								6
Limulus polyphemus												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								1	1		1		1		6
Mugil curema								1							1				2
Myoxocephalus aenaeus									1	1									2
Nassarius obsoletus							1							1					2
Opsanus tau					1				1										2
Ovalipes ocellatus	1																1	1	3
Pagurus spp	1	1	1	1	1	1	1	1	1	1		1	1	1	1			1	15
Palaemonetes vulgaris	1	1	1	1	1				1		1		1						8
Panopeus spp				1	1				1	1						1			5
Pomatomus saltatrix	1	1		1			1	1	1	1	1		1						9
Pseudopleuronectes americanus					1			1	1						1			1	5
Sphoeroides maculatus		1							1				1			1	1		5
Stenotomus chrysops					1		1	1							1		1		5
Strongylura marina	1																	1	2
Syngnathus fuscus				1	1		1									1			4
Synodus foetens								1						1			1	1	4
Tautoga onitis		1	1		1	1	1		1	1	1	1				1	1		11
Tautogolabrus adspersus							1		1	1						1	1		5
Urophycis chuss																		1	1

Table 7. Species presence by station for October 2016.

OCTOBER	Station																		
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa sapidissima						1													1
Brevoortia tyrannus	1					1													2
Busycon carica			1														1		2
Carcinus maenus	1	1			1				1		1		1				1		7
Centropristus striata					1					1									2
Crangon septemspinosa			1	1															2
Crepidula fornicata								1											1
Ctenophora phylum	1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	15
Cyanea capillata									1										1
Cyprinodon variegatus			1																1
Elops Saurus						1													1
Farfantepenaeus aztecus					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	1	1	1	1	1	18
Gobiosoma bosc					1														1
Libinia emarginata			1		1												1		3
Limulus polyphemus			1																1
Littorina littorea													1	1					2
Lunatia heros										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															2
Microgadus tomcod							1												1
Morone saxatilis															1				1
Mugil curema															1				1
Nassarius obsoletus								1	1					1				1	4
Ovalipes ocellatus	1		1						1										3
Pagurus spp	1	1	1	1	1			1	1			1	1	1			1	1	12
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	1				1				1		1				6
Pseudopleuronectes americanus			1	1		1			1									1	5
Strongylura marina	1					1							1						3
Syngnathus fuscus															1	1		1	3
Tautoga onitis					1	1	1		1	1				1		1			7
Tautogolabrus adspersus					1		1		1	1						1			5

Table 8. Summary of species occurrence by station in 2016.

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		14
Alosa sapidissima						1													1
Amphipoda order							1												1
Anchoa mitchilli	1							1			1				1				4
Anguilla rostrata				1															1
Apeltes quadracus	1																		1
Brevoortia tyrannus	1	1	1			1		1	1		1			1					8
Busycon carica			1														1		2
Calinectes sapidus	1	1	1	1		1					1		1	1			1	1	10
Caranx hippos															1				1
Carcinus maenus	1	1	1		1	1		1	1		1		1	1		1	1		12
Centropristus striata					1	1	1			1	1	1		1	1		1		9
Crangon septemspinosa	1	1	1	1	1				1		1	1	1		1			1	11
Crepidula fornicata					1		1	1	1				1						5
Ctenophora phylum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Cyanea capillata									1										1
Cyprinodon variegatus			1					1								1			3
Elops Saurus						1													1
Emerita talpoida															1				1
Farfantepenaeus aztecus					1							1							2
Fundulus heteroclitus	1	1	1	1	1	1		1	1		1		1	1		1	1	1	14
Fundulus majalis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Gobiosoma bosc	1		1		1				1		1	1							6
Hemigrapsus sanguineus								1							1		1		3
Leiostomus xanthurus			1																1
Libinia emarginata		1	1	1	1			1	1		1	1	1	1		1	1		12
Limulus polyphemus		1	1		1			1	1			1					1	1	8
Littorina littorea													1	1				1	3
Lunatia heros										1									1
Melanogrammus aeglefinus							1			1		1			1				4
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	12
Microgadus tomcod							1			1		1		1		1			5
Morone saxatilis												1			1		1		3
Mugil curema								1							1		1		3
Myoxocephalus aenaeus						1			1	1	1		1		1	1			7
Nassarius obsoletus	1	1		1	1	1	1	1	1				1	1				1	11
Opsanus tau			1		1				1										3
Ovalipes ocellatus	1	1	1						1						1		1	1	7
Pagurus spp	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	1	16
Palaemonetes vulgaris	1	1	1	1	1	1			1	1	1	1	1			1	1	1	14
Panopeus spp	1		1	1	1	1	1	1	1	1	1		1	1		1		1	14
Paralichthys dentatus	1								1		1								3
Pomatomus saltatrix	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
Prionotus carolinus														1					1
Prionotus evolans		1	1	1					1										4
Pseudopleuronectes americanus	1	1	1	1	1	1		1	1		1	1	1		1	1	1	1	15
Sphoeroides maculatus	1	1			1	1	1		1		1	1	1			1	1	1	12
Sphyraena borealis							1												1
Squilla empusa													1						1
Stenotomus chrysops					1		1	1	1					1	1		1	1	8
Strongylura marina	1					1					1		1				1	1	6
Syngnathus fuscus	1	1	1	1	1		1		1				1		1	1	1	1	12
Synodus foetens	1							1	1					1			1	1	6
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						1	1		7
Urophycis chuss																1		1	2
Urophycis regia																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 2016.

	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	7	0	30	3	0	0	0	0	4	0	64	0	17	0	3	0	4	5	7.61	16.03	3.78
JUL	3	1	66	3	4	0	0	0	0	0	4	3	5	0	8	1	1	3	5.67	15.22	3.59
AUG	0	0	1	3	1	1	0	0	1	0	0	0	6	0	0	0	0	0	0.72	1.53	0.36
SEP	0	0	0	0	1	0	0	2	1	0	0	0	0	0	1	0	0	1	0.33	0.59	0.14
OCT	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0.28	0.46	0.11
Mean	2.00	0.20	19.60	2.00	1.20	0.40	0.00	0.40	1.40	0.00	13.60	0.60	5.60	0.00	2.40	0.20	1.00	2.00			
St Dev	3.08	0.45	28.88	1.41	1.64	0.55	0.00	0.89	1.52	0.00	28.23	1.34	6.95	0.00	3.36	0.45	1.73	2.00		Total Fish	
SE	1.38	0.20	12.92	0.63	0.73	0.24	0.00	0.40	0.68	0.00	12.62	0.60	3.11	0.00	1.50	0.20	0.77	0.89		263	
Number	10	1	98	10	6	2	0	2	7	0	68	3	28	0	12	1	5	10			

Table 10. Numbers of juvenile tautog per seine haul in 2016.

	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	22	2	7	0	2	2	0	3	1	3	0	6	3	0	2.83	5.23	1.23
JUL	0	1	0	11	7	2	7	0	5	1	0	0	0	1	0	13	1	0	2.72	4.11	0.97
AUG	0	6	5	0	1	22	8	1	21	0	2	12	9	0	0	0	5	1	5.17	6.97	1.64
SEP	0	6	1	0	8	6	3	0	6	13	1	2	0	0	0	14	14	0	4.11	5.11	1.20
OCT	0	0	0	0	81	2	2	0	3	12	0	0	0	2	0	4	0	0	5.89	18.97	4.47
Mean	0.00	2.60	1.20	2.20	23.80	6.80	5.40	0.20	7.40	5.60	0.60	3.40	2.00	1.20	0.00	7.40	4.60	0.20			
St Dev	0.00	3.13	2.17	4.92	32.89	8.67	2.70	0.45	7.77	6.35	0.89	4.98	3.94	1.30	0.00	5.98	5.59	0.45		Total Fish	
SE	0.00	1.40	0.97	2.20	14.71	3.88	1.21	0.20	3.47	2.84	0.40	2.23	1.76	0.58	0.00	2.68	2.50	0.20		373	
Number	0	13	6	11	119	34	27	1	37	28	3	17	10	6	0	37	23	1			

Table 11. Numbers of juvenile bluefish per seine haul in 2016.

	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	0	0
JUL	0	0		1	4	0	10	0	0	0	0	0	0	3	3	0	0	2	1.35	2.60	0.61
AUG	26	0	2	4	1	31	144	0	0	0	0	538	0	0	451	0	20	10	68.17	159.43	37.58
SEP	3	2	0	1	0	0	19	1	10	3	3	0	10	0	0	0	0	0	2.89	5.11	1.20
OCT	49	0	0	3	1	0	0	0	64	0	0	0	10	0	1	0	0	0	7.11	18.31	4.32
Mean	15.60	0.40	0.50	1.80	1.20	6.20	34.60	0.20	14.80	0.60	0.60	107.60	4.00	0.60	91.00	0.00	4.00	2.40			
St Dev	21.62	0.89	1.00	1.64	1.64	13.86	61.67	0.45	27.84	1.34	1.34	240.60	5.48	1.34	201.25	0.00	8.94	4.34		Total Fish	
SE	9.67	0.40	0.45	0.73	0.73	6.20	27.58	0.20	12.45	0.60	0.60	107.60	2.45	0.60	90.00	0.00	4.00	1.94		1430	
Number	78	2	2	9	6	31	173	1	74	3	3	538	20	3	455	0	20	12			

Table 12. Numbers of juvenile menhaden per seine haul in 2016.

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	1	0	0	0	0	0	0	0	0.06	0.24	0.06
JUL	0	0	0	0	0	0	0	0	0	0	2064	0	0	2	0	0	0	0	121.53	500.56	117.98
AUG	1	5	67	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	5.67	16.76	3.95
SEP	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0.17	0.51	0.12
OCT	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.96	0.23
Mean	1.00	1.00	16.75	0.00	0.00	0.20	0.00	0.40	0.20	0.00	418.80	0.00	0.00	0.40	0.00	0.00	0.00	0.00			
St Dev	1.73	2.24	33.50	0.00	0.00	0.45	0.00	0.89	0.45	0.00	919.78	0.00	0.00	0.89	0.00	0.00	0.00	0.00		Total Fish	
SE	0.77	1.00	14.98	0.00	0.00	0.20	0.00	0.40	0.20	0.00	411.34	0.00	0.00	0.40	0.00	0.00	0.00	0.00		2177	
Number	5	5	67	0	0	1	0	2	1	0	2094	0	0	2	0	0	0	0			

Table 13. Numbers of juvenile river herring per seine haul in 2016.

	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	2	0	1	3	0	0	0	1	1	0	4	0	1	0	0	0	468	0	26.72	110.13	25.96
JUL	2	34	0	0	0	0	3	1	336	0	17	0	17	37	0	35	8	0	27.22	78.20	18.43
AUG	1	0	0	0	0	0	37	0	0	9	0	0	0	0	1	297	5	0	19.44	69.82	16.46
SEP	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0.17	0.38	0.09
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	1.00	6.80	0.20	0.60	0.00	0.00	8.00	0.40	67.40	2.00	4.40	0.00	3.80	7.40	0.20	66.40	96.20	0.00			
St Dev	1.00	15.21	0.45	1.34	0.00	0.00	16.26	0.55	150.15	3.94	7.23	0.00	7.40	16.55	0.45	129.80	207.87	0.00		Total Fish	
SE	0.45	6.80	0.20	0.60	0.00	0.00	7.27	0.24	67.15	1.76	3.23	0.00	3.31	7.40	0.20	58.05	92.96	0.00		1324	
Number	5	34	1	3	0	0	40	2	337	10	22	0	19	37	1	332	481	0			

Table 14. Numbers of striped bass per seine haul in 2016.

	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	1	0	0	0	0	31	0	1.78	7.30	1.72
AUG	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0.17	0.51	0.12
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	0	0	0	0	0	0	0	1	0	0	0	0.06	0.24	0.06
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.60	0.00	6.20	0.00			
St Dev	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.89	0.00	13.86	0.00		Total Fish	
SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.40	0.00	6.20	0.00		36	
Number	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	31	0			

Table 15. Temperature, salinity, and dissolved oxygen by station and month ï 2016 (NA indicates a day where batteries failed on YSI).

		Month					
Station		**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**Total Average**
1	Salinity	20.7	25.4	NA	26.1	26	24.55
	Temperature (C)	20.7	24.4	20	23	18	21.22
	Dissolved Oxygen	8.89	6.25	NA	7.14	4.65	6.73
2	Salinity	22.6	26.2	NA	27.6	26.4	25.70
	Temperature (C)	20.7	24.2	20	23.2	18.3	21.28
	Dissolved Oxygen	8.97	5.25	NA	8.5	4.92	6.91
3	Salinity	27	27.3	27.6	27.6	27.6	27.42
	Temperature (C)	20.8	26.2	26.5	24.4	17.1	23.00
	Dissolved Oxygen	6.14	6.67	7.59	8.32	7.77	7.30
4	Salinity	27	27.6	28	27.5	24.2	26.86
	Temperature (C)	20.1	26.6	25.4	24.3	18.8	23.04
	Dissolved Oxygen	8.08	7.41	6.88	11.5	5.46	7.87
5	Salinity	26.8	27.9	20	28.7	28.5	26.38
	Temperature (C)	21.2	24.3	26.1	23.7	17.6	22.58
	Dissolved Oxygen	9.8	5.94	9.1	9.71	8.56	8.62
6	Salinity	27.9	27.7	28.5	28.8	28.9	28.36
	Temperature (C)	18.4	22.3	22.9	21.6	18.1	20.66
	Dissolved Oxygen	7.59	10.03	6.14	7.59	8.25	7.92
7	Salinity	28.5	28.3	28.8	22.3	29	27.38
	Temperature (C)	16.8	21.8	22.8	21.8	17.8	20.20
	Dissolved Oxygen	7.22	7.29	6.84	7.41	8.56	7.46
8	Salinity	27.2	27.5	27.9	28.5	28.4	27.90
	Temperature (C)	19.4	23.5	24	24.6	18.8	22.06
	Dissolved Oxygen	6.82	6.67	6.67	10.52	5.64	7.26
9	Salinity	27.3	27.7	28.2	28.7	28.9	28.16
	Temperature (C)	18.2	22.6	23.2	23.4	18.3	21.14
	Dissolved Oxygen	7.34	6.95	6.37	8.47	5.25	6.88
10	Salinity	27.6	28.7	29	29.1	29.6	28.80
	Temperature (C)	15.7	18.4	21.7	21.4	19.2	19.28
	Dissolved Oxygen	8.97	7.8	6.6	7.56	9.17	8.02
11	Salinity	25.9	27.1	NA	28.6	27.7	27.33
	Temperature (C)	20.9	23.6	27.2	20.2	15.5	21.48
	Dissolved Oxygen	6.8	7.04	NA	5.24	7.2	6.57
12	Salinity	24.5	27.2	27.7	28.6	28	27.20
	Temperature (C)	19.7	22.5	25.6	23	18.6	21.88
	Dissolved Oxygen	8.75	7.88	7.84	5.96	7.11	7.51
13	Salinity	27.1	28	28.3	28.8	28.9	28.22
	Temperature (C)	19.3	22.6	25.4	22.7	18.8	21.76
	Dissolved Oxygen	7.31	6.7	6.48	5.74	8.25	6.90
14	Salinity	27.6	28.3	28.6	29	29	28.50
	Temperature (C)	18.6	23.5	25.3	22.4	18.1	21.58
	Dissolved Oxygen	7.13	8.86	8.45	6.53	10.88	8.37
15	Salinity	28.5	28.5	28.9	28.5	29.2	28.72
	Temperature (C)	17.3	21.3	24.2	21.4	17.5	20.34
	Dissolved Oxygen	8.14	8.25	7.11	6.46	7.66	7.52
16	Salinity	28	28.1	28.6	29.3	29.2	28.64
	Temperature (C)	16.6	21.3	22.2	21.8	17.3	19.84
	Dissolved Oxygen	8.16	6.73	6.07	7.04	9.14	7.43
17	Salinity	25.5	27.1	27.6	28.7	28.3	27.44
	Temperature (C)	20.4	24.1	24.3	23.8	18.3	22.18
	Dissolved Oxygen	6.61	5.71	5.7	7.6	8.5	6.82
18	Salinity	27.9	27.9	28.3	29	28.5	28.32
	Temperature (C)	19.1	22.6	24.4	21.2	17.8	21.02
	Dissolved Oxygen	7.44	9.52	6.81	6.65	8.89	7.86

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	27	1988-2016
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	27	1988-2016
	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	25	1988-2012
	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	25	1988-2012
	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 ñlogò, 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

<u>2016 Annual Performance Report for Job VI, Part A:</u>

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

By
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(Supervising Environmental Scientist) and
Eric Schneider
(Principal Marine Fisheries Biologist)

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Federal Aid in Sportfish Restoration
F-61-R

2016 Performance Report for Job VI, Part A March 30, 2016

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, 2016 - December 31, 2016

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: Chris Deacutis, PhD (Supervising Environmental Scientist) and
Eric Schneider (Principal Marine Fisheries Biologist)
Note: Scott Comings, Kevin Ruddock and John OôBrien of TNC prepared aspects of the Providence ï Seekonk Project Information associated with the RIDEM-TNC Annual Report

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, 2016. During this period we focused on aspects related to the three aforementioned objectives.

To address Objective 1 we initiated a collaborative project with The Nature Conservancy (TNC) to assess fish habitat in the Providence-Seekonk tidal Rivers in upper Narragansett Bay (Head of the Bay). We developed GIS maps in 2016 that summarize key aspects of datasets we gathered in 2015 concerning physical characteristics of the habitat (e.g., percent total organic carbon wet weight (TOC%), frequency of hypoxia, depth of hypoxic zone) and biological data from two old datasets: one from a year-long study of the fish assemblages by Division of Fish and Wildlife,

Marine Fisheries (DFW) in 1996, and a second study investigating benthic juvenile fish in this area in summer 2002-2003 by the US Environmental Protection Agency (EPA), Atlantic Ecology Division Laboratory (AED) in Narragansett, RI, using a special benthic sled equipped with a trawl net and video camera. We initially designed our study plan to use the same benthic sled system used by EPA AED (loaned to DFW for 2016) to repeat a subset of the stations previously sampled by EPA AED in 2002-03. However, early fish monitoring results from tows conducted using the EPA AED sled in summer 2016 indicated it was inadequate for our sampling needs, because despite capturing demersal species, it was poor at capturing pelagics and needed to be towed at a speed too fast for adequate video-based habitat assessment. Thus, we decided to use a 130ô long by 5.5ô tall seine net with ¼ ñ mesh and bag that replicates the seine survey in the Salt Ponds (conducted as part of F-61-R-23, Job #3, Young of the Year Survey of Selected RI Coastal Ponds and Embayments). We purchased and utilized the beach seine to sample fish assemblages and used a PVC benthic sled to perform the video transects to assess habitat type and quality. Based on the new sampling techniques, we designed a sampling plan that included 8 stations in the Providence River and 6 in the Seekonk, which were seine-able and had differing shoreline habitat (e.g., sandy beach, fringe salt marsh and creek mouth, cobble beach, etc.). Both sampling techniques worked well and we were able to sample all stations at least once in summer 2016. Overall, results indicated certain areas of this Providence-Seekonk estuary are highly diverse and productive. We expect to complete monthly seines and fish pot deployments from May through Oct 2017, in addition to seasonal video transects to more fully characterize the area. We also expect to add monthly fish pot sampling as the technique to further assess fish assemblages in the Head of the Bay. We plan to finalize the fish pot survey design during the spring of 2017.

We have also continued meeting with a group of scientists at EPA AED who are attempting to apply the ñBiological Condition Gradientò technique to various National Estuary Programs, including the Narragansett Bay Estuary Program (NBEP) for assessment of present water quality conditions in relation to past (e.g., clean) conditions, with a goal towards identifying achievable improvements in water quality through management decisions. There is consensus amongst participants, including DFW, that repeating the Sediment Profile Imaging (SPI) techniques during 2018 at stations that were covered by SPI in 1988 and 2008 to assess changes in marine habitat conditions in relation to changes in water quality gradients and pollution loads to this area (e.g., toxics, bacteria, and nutrient loads to this area have all been lowered substantially). The NBEP continues to discuss possible collaborative opportunities to use SPI in the Providence ï Seekonk estuary for benthic habitat assessments during 2018. They have also become interested in our Providence-Seekonk Rivers project. Chris Deacutis will be presenting results from the 2016 fish monitoring (e.g., beach seines and video assessment) to the NBEP Management Committee and at a scientific society meeting New England Estuarine Research Society (NEERS) in spring of 2017.

To address Objective 2, the DFW 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 6ô to avoid a ñdead flushingò 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. A number of dredge applications came in very late (Oct-Nov) this year, which is after the start of the window when dredging can be conducted. This caused problems with scheduling the assessments of natural resources that are conducted prior to commenting on dredge permits. We expect to have meetings with RI CRMC in 2017 regarding the timelines afforded to review and respond to late-season applications.

Also during 2016, the DFW participated in and formulated responses for approximately 42 preliminary determinations 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 40 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. We coordinated all responses with RI DEM Wildlife Program for waterfowl habitat and hunting concerns, and drafted DFW 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 2016.

In previous years, the DFW was involved in portions of the permit review that focused on impacts to recreationally important fish species and their habitat from the proposed Block Island Wind Farm (BIWF) as part of this job. The DFW obtained funding from Deep Water Wind in 2015 for a contract employee that would focus on monitoring and impact assessment of the nationôs first offshore wind farm. Since obtaining this funding, impact assessment of the BIWF is no longer part of this job (i.e., F-61 R-21, Job VI-A), and therefore specifics are no longer contained within this report. However, considering the DFW is engaged in assessing potential impacts to recreationally important fish species and their habitat from wind energy, at large, a status update on the BIWF project is contained as an appendix (see Appendix VI.A.II).

To address Objective 3, the RI DFW responded to 1 fish kill (adult menhaden) during the summer of 2016. Overall, 2016 had far fewer kill incidents compared with summer 2015. The single fish kill reported (Greenwich Cove) was investigated and found to be caused by low dissolved oxygen (D.O.), despite that it was late in the season (Oct. 2016). The investigation report to this fish kill is provided in Appendix.VI.A.1).

TARGET DATE: December 31, 2016

DEVIATIONS: There were no significant deviations from the timeline proposed in the current grant. We revised Objective-1 from the original Job-VI, Part A in June 2015 to shift from a comprehensive synoptic 5-yr Restoration Plan covering all marine waters to a regional approach. This change was, in part, due to the significant data needs that were uncovered in the 2014-15 efforts to develop a state-wide Plan development. We are now addressing this need in a geographically segmented process, starting with the Head of the Bay, where significant water quality improvements are thought to have positively shifted the quality of habitat. The improvements in water quality and likely marine habitat is allowing for greater collaborative opportunities with TNC for fish habitat enhancement and restoration.

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 2017, 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 NBEP may be interested in a collaborative effort to complete a SPI survey at the Head of the Bay.

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 RIȏs 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 anticipated approach for each objective is described separately below.

Approach - Objective 1

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. We are taking a regional approach to adequately fill in data gaps in areas where very little recent habitat data is 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 also allows us to more quickly make positive improvements to fishery habitat, and hopefully fishery resources while increasing the knowledge base for the state-wide plan. In the next 2-3 years we will 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 in collaboration with The Nature Conservancy (TNC) under a multi-year cooperative agreement between TNC and the Rhode Island (RI) Department of Environmental Management (DEM), Division of Fish and Wildlife, Marine Fisheries (DFW). The agreement addresses the following tasks:

> Task I. Identifying and studying locations of degraded coastal habitat in Rhode Island estuaries that have the greatest potential to benefit from shoreline and sub-tidal restoration techniques and improve fish production.
>
> Task II. Identify relevant and cost effective coastal fishery habitat enhancement practices that have potential to make the greatest improvements to the degraded fish habitat sites that are selected for the study.
>
> Task III. Design pilot studies and obtain permitting necessary to begin evaluating fish habitat restoration techniques.

Overall, fish populations and habitat in these urban areas have been rarely investigated, but the few research studies available suggest that the populations in these areas may be significant for important recreational species like winter flounder (juveniles) due to the high primary production found here. In 2017 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 14 stations (8 in Providence tidal River and 6 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 that are pertinent to fish habitat restoration.

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 DFW 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 F&W 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 F&W 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 F&W 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 DFW staff testify at RI CRMC hearings for permits where there is a significant objection by the Division.

As the aquaculture industry continues to expand (see Figure VI.A.10), 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 DFW 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.

In previous years, the DFW was involved in portions of the permit review that focused on impacts to recreationally important fish species and their habitat from the proposed Block Island Wind Farm (BIWF) as part of this job. The DFW obtained funding from Deep Water Wind in 2015 for a contract employee that would focus on monitoring and impact assessment of the nationœs first offshore wind farm. Since obtaining this funding, impact assessment of the BIWF is no longer part of this job (i.e., F-61 R-21, Job VI-A), and therefore specifics are no longer contained within this report. However, considering the DFW is engaged in assessing potential impacts to recreationally important fish species and their habitat from wind energy, at large, a status update on the BIWF project is contained as an appendix (Appendix VI.A.II).

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 DFW provides a staff member with recreational fishery habitat expertise for coordination of DFW 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 ñBay Response Teamò (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

Results - Objective 1 (rRegional assessment the Head of Bay waters, as part of development of a Comprehensive Marine Habitat Management and Restoration Plan)

Given the extensive positive water quality changes to the areas in upper Narragansett Bay due to toxics pretreatment and nutrient treatment requirements in major Waste Water treatment Facilities (WWTF) permits, we initiated work in 2016 to assess an area of the Bay that was ñwritten offò as poor habitat in the past due to what seemed in the past to be intractable pollution sources. These areas were once some of the most productive areas of the Bay (Oviatt et al. 2003). In a number of cases, productivity is still high for certain species such as juvenile winter flounder, *Pseudopleuronectes americanus,* in these urban parts of the estuary (Meng et al. 2005). This program has begun (2016) to assess habitat conditions in these once ñseverely degradedò areas at the Head of the Bay, and investigate potential opportunities to restore or enhance recreational fish habitat. Specifically, our efforts have focused on the Providence-Seekonk tidal river mesohaline waters at the Head of Narragansett Bay, which include tidal marine locations in Providence, East Providence, Pawtucket, Cranston, and Warwick RI.

Historical Biological and Physical Data Compilation and Initial Mapping

The DFW decided that waters at the Head of the Bay would be the focus of a DFW - TNC collaborative project to examine degraded coastal and estuarine habitat and identify areas for potential juvenile fish habitat restoration and enhancement efforts. A location map of the area is contained in Figure 1 . In 2016, the approach to the work was threefold: 1) Historic map and aerial review of the area; 2) Review of existing scientific data of the area; 3) Preliminary field investigation of sites and techniques to determine the exact locations and methods for future fish habitat survey work and potential habitat improvement.

Historic Map Review

Methods

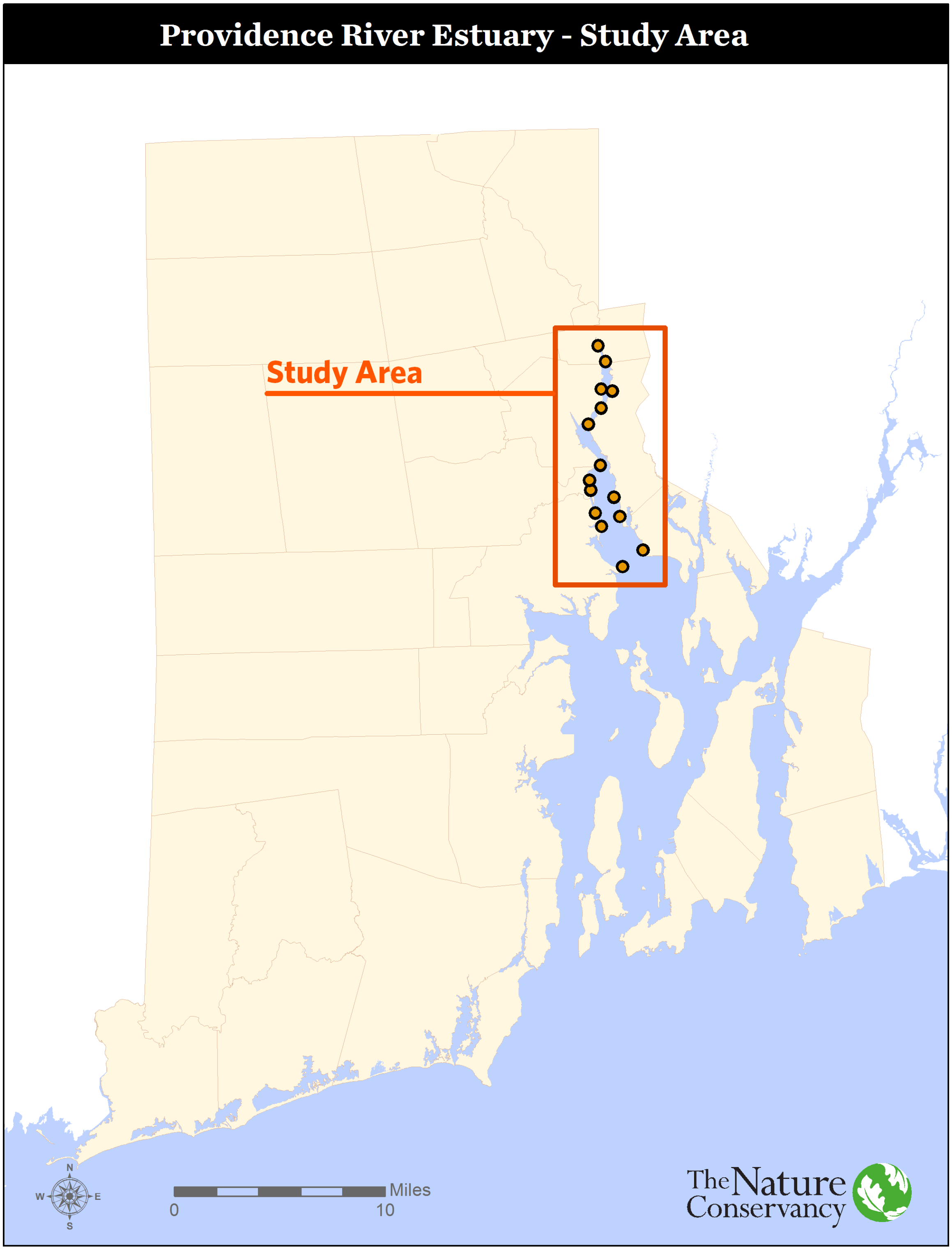
After extensive review of the literature it became clear that an analysis of the amount of historic salt marsh specifically in the study area had never been completed. Thus, it was decided by TNC and DFW to conduct a qualitative assessment of the historic salt marsh in the study area. The first step was to identify and review all known historic maps of the focus area. If the map considered accurate and yielded additional information, the image was digitized. The search identified maps from 1770 on with specific ones from 1770, 1777, 1798 and 1823. In total nine maps were identified that provided additional information about the study area. Aerial photography starting in 1939 was also reviewed.

Results

The results showed that there was extensive salt marsh in the study area pre-degradation. Should the decision be made by the team to do additional work in this area, the next step would be to process the maps by identifying reference points which would quantify the total amount of historic salt marsh.

Prior to field sampling, the project team sought to gather existing scientific data collected in the Providence River Estuary and Upper Narragansett Bay. To map the quality and character of the Providence River Estuary water quality, sampling data were acquired from the Brown University ñInsomniacsò program (Prell et al. 2006). These data include measurements of salinity, temperature, D.O., and chl-a at half-meter depth increments from the surface to the bottom throughout Narragansett Bay. These data were collected in the months of June, July, August, and September from 2005 through 2014. This study only used the northernmost thirty sampling stations necessary to evaluate the Providence Estuary. Each of the water quality variables were analyzed and mapped. The focus of this project is primarily in DO values taken near the bottom to help determine the likelihood of hypoxic conditions unfavorable to fish survival. The following method describes how to map bottom DO estimates.

Figure VI.A.1. Location map of the study area. Map produced by Kevin Ruddock, TNC.



Review of Existing Scientific Data

Methods

This method intends to visualize the lowest bottom DO value that has been shown to reoccur at a moderately regular interval. To achieve this, a continuous raster surface was created that represents the DO value (in mg/L) for which 20% of measurements are lower. To restate, we can predict that 1 in 5 measurements at a given location will fall below the mapped value.

Techniques that interpolate across bottom values with different depths may not capture the effects of vertical stratification that have been observed in the bay. To factor this phenomenon into the interpolation, a method was developed that uses bathymetry in combination with horizontal interpolation at multiple depths. The first step in this method was to combine the half-meter samples into two-meter depth bins (0-2m, 2-4m, 4-6m, 6-8m, 8-10m, and >10m). A database was created containing the average DO value for each sample day for each station within each depth bin. All average DO sample values for each station and depth zone were evaluated to determine the value representing the threshold below which 20% of the values fall.

Each depth zone was then interpolated using the ñ20% thresholdò. The interpolation was done with Arcmap 10.3.1 Geostatistical Analyst. To respect barriers to water movement and best model the nature of water movement through the estuary *Diffusion Interpolation with Barriers* was used. This method uses a kernel that is based on heat diffusion and treats the coastline as an impassable barrier. This method results in six interpolated surfaces, one for each depth zone. These values are then assigned to a final grid based on the underlying bathymetry such that the depth zones correlate with depth.

Mapping Results

Figures 2-4 show the interpolation of the water quality data; sediment grain size; organic carbon content; salt marsh migration zones; shoreline hardening; bathometry; and general landscape context. To better display this data, it was separated into three figures. Areas that had the lowest recurring DO values seemed to follow the deeper channels in the Providence and Seekonk Rivers. In the Upper Bay, the southernmost extent of the maps, DO values rarely consistently fell below 2mg/L. The shallow areas closest to shore appear to have the highest DO readings. Review of these maps by TNC and DFW aided in site selection of initial field inventory locations.

Figure VI.A.2. Seekonk River section of water quality data interpolated by depth strata. Map produced by Kevin Ruddock, TNC.

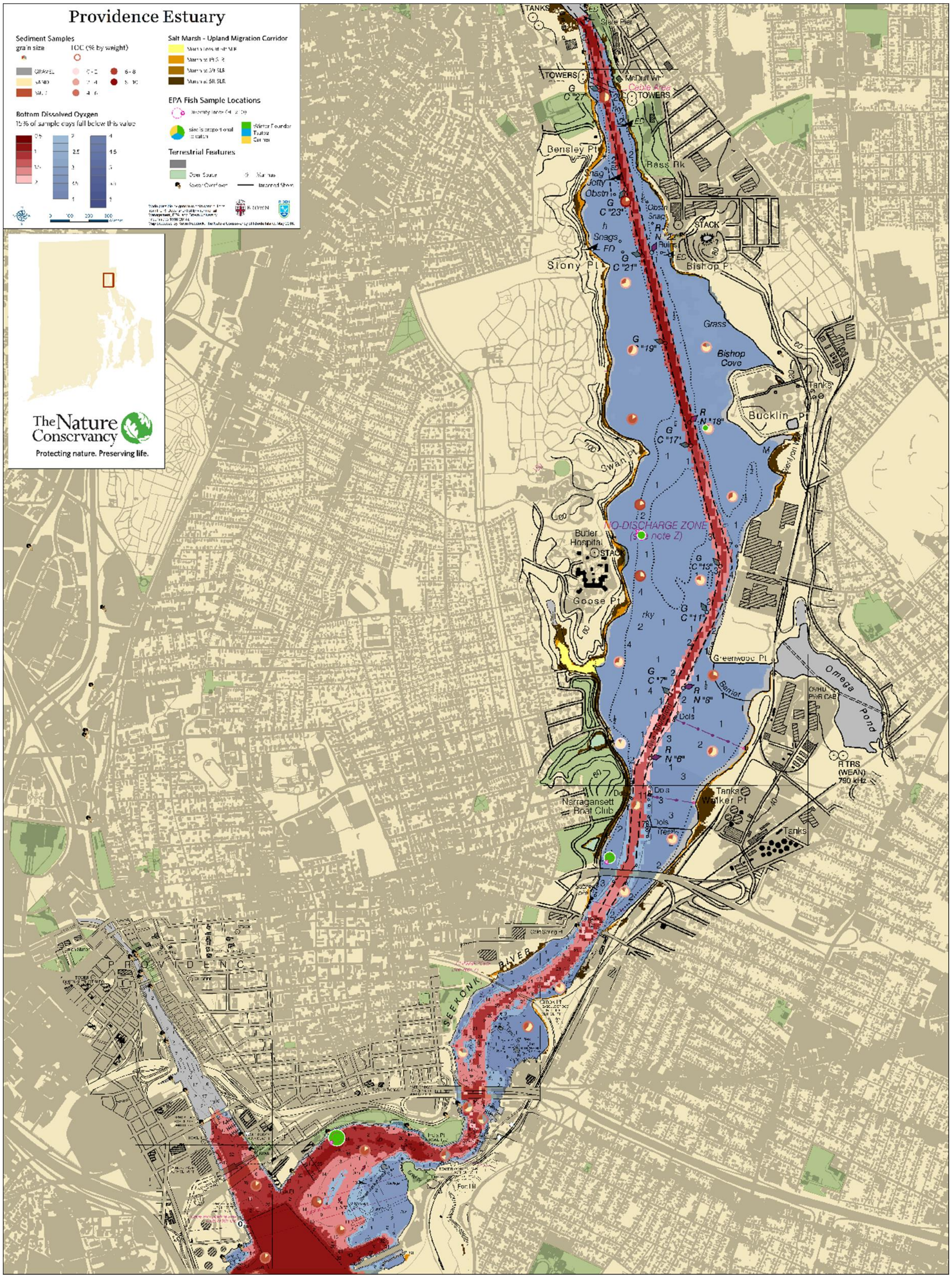


Figure VI.A.3.Providence River section of water quality data interpolated by depth strata. Map produced by Kevin Ruddock, TNC.

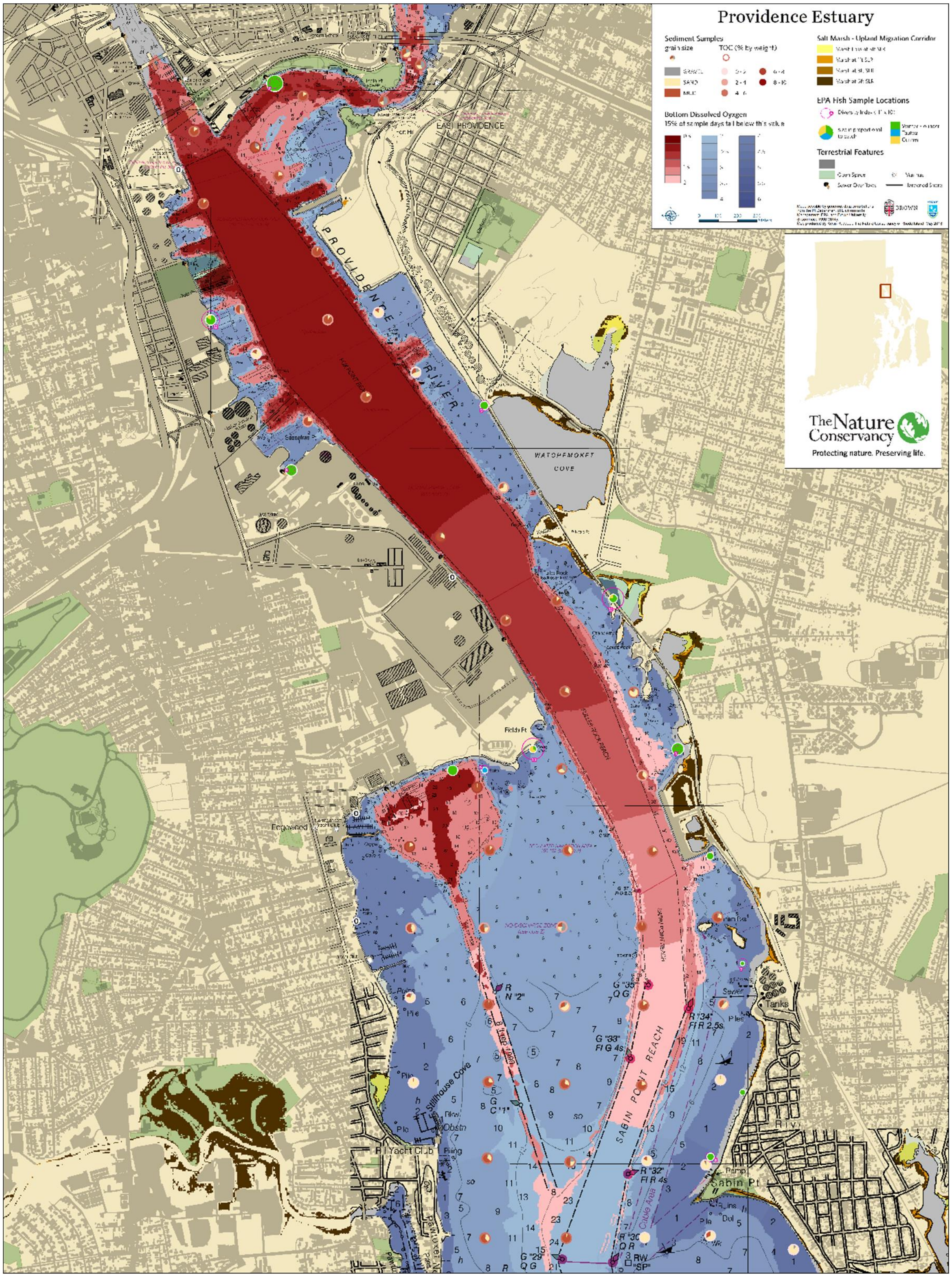
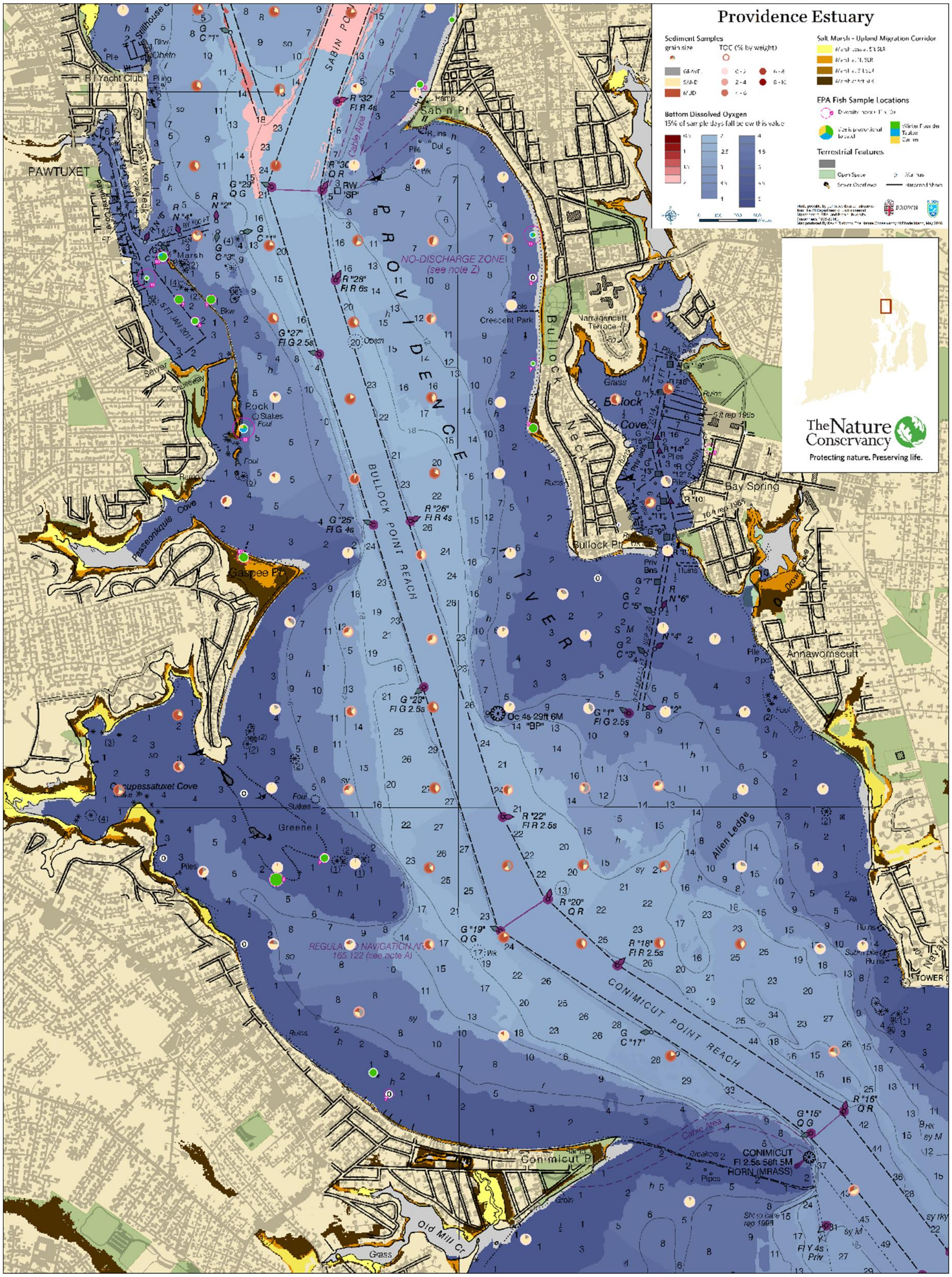


Figure VI.A.4. Upper Bay section of water quality data interpolated by depth strata. Map produced by Kevin Ruddock, TNC.

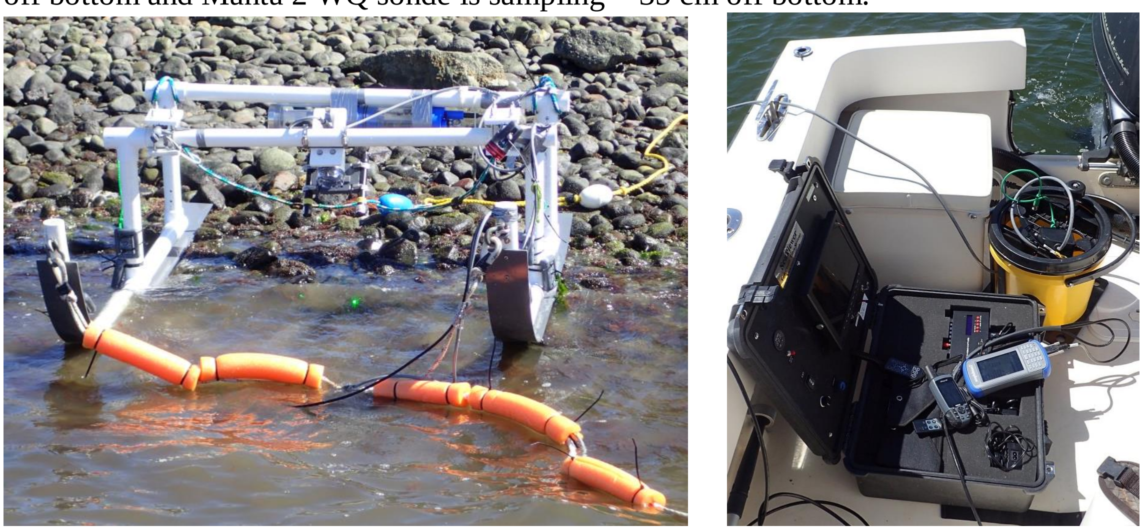


Beach Seining Results

In 2016, we used sampling gear and equipment designed for shallow estuarine waters, including water quality sampling equipment (Eureka Manta 2) and fish sampling gear that duplicates previous survey work. Although we initially (June 2016) tried using the benthic sled and net system used by the US EPA in 2002-03, we found it had serious drawbacks. It captured juvenile winter flounder and other demersal species, but was poor at capturing pelagics, and had to be towed too fast for adequate video.

We therefore purchased and utilized a a 130ô long by 5.5ô tall beach seine with ¼ò mesh that duplicates the sampling technique used in the F-61-R-23, Job #3, Young of the Year Survey of Selected RI Coastal Ponds and Embayments). For the video transects, we used an HD digital video camera (SeaViewer) attached to a PVC benthic sled and taped the Manta 2 WQ sonde onto the cross bar to measure salinity, temperature, D.O., and chl a (Fig. VI.A.5. see below).

Fig VI.A.5. (Left) Video Sled with HD Video Cameras + Manta 2 WQ Sonde. (Right) Video DVR + monitor + WQ Manta 2 logger and GPS for transect tracking. Video camera is ~ 30 cm off bottom and Manta 2 WQ sonde is sampling ~ 35 cm off bottom.



Sampling with the new seine began in July 2016. Prior to actually deploying the seine there were several reconnaissance excursions during the month of June that were conducted throughout the estuary to ground-truth potential seine sampling locations and to become more familiar with the coastline, tidal range, currents, and substrates of the study area. The boundaries of the Providence Estuary study area was established and the study area extended from Conimicut Point located in Upper Narragansett Bay north to Pawtucket Falls, where the Blackstone River empties into the Seekonk River Estuary. Along this gradient, a number of shoreline locations were evaluated to determine if a beach seine would work effectively. Depth, grade, substrate, the impact of current, the ability to beach the seine, and the effect of tidal range were all taken into consideration.

A total of 17 potential locations were identified. Efforts were made to insure that stations would be evenly distributed from the southernmost portion of the Providence Estuary to the discharge of the Blackstone River in Pawtucket. Two of the stations, Gaspee Pt. and Conimucut Pt., actually overlap with the ongoing DEM Narragansett Bay juvenile fish seine survey. Beginning in July 2016 the seine was deployed at potential sampling locations on randomly selected dates, at different stages of the tide. This continued through the months of August, September, and November 2016. There were 9 different sampling dates where stations were successfully seined. There were several different sampling dates where stations were evaluated and sampling was unsuccessful. These are not listed in the summary. The sampling program seined 17 different locations, which was eventually reduced to 14 different sampling stations identified in FigureVI.A.6 (e.g., 6 in the Seekonk and 8 in the Providence River). Each station was chosen based on proper depth, substrate (clean bottom), landing or beach area, and lack of current.

A total of 28 successful seine hauls were completed during the 2016 reconnaissance work, resulting in the capture of 20 different (mostly pelagic) species of fish (See Table VI.A.1). All fish collected by seine were transferred to the boat where they were identified and enumerated. A subsample of approximately 25-30 individuals were measured from each species observed. Water quality data for beach seines were recorded using a handheld YSI ProPlus meter or a refractometer and thermometer.

Table VI.A.2. lists a summary of the different seine stations with dates sampled and the abundance of species and Fig.VI.A.8. compares station results for common species. The most abundant fish found in the seine surveys were forage species such as silversides, *Menidia* sp. and striped killifish. Of note was the presence of river herring *Alosa* sp. at 5 locations in late July and August, most likely progeny from the recent fish passage restoration efforts in the Ten Mile River and the Woonasquatucket River. A substantial decrease in the numbers of fish captured at each location sampled during in the beginning of November supports the terminating the sampling schedule in the month of October (Fig.VI.A.8).

Based on the physical configuration (depth, substrate, current, beach area) of each site and the location of each site within the estuary, 14 locations were chosen as potential future sampling sites. These sites included Conimicut Point; Mussachuck Creek; Gaspee Point; Narragansett Terrace; Sabin Point; Pawtuxet Cove; Stillhouse Cove; Save the Bay; Bold Pt.; Waterman Grille East; Butler; Omega Dam; Bishop Point; and Pawtucket West of State Pier depicted in Fig. VI.A.6. Each of these sites will be sampled (seined) monthly May through October in 2017. In order to obtain water access to each station and be able to beach the seine properly, stations in the Seekonk River Estuary will require careful timing with tidal cycles. Stations in the lower part of the estuary can be sampled at any stage of the tide. Data from these sampling sites will provide information for characterizing the juvenile fish populations utilizing the estuary and assessing changes in species composition and relative abundance compared with the previous studies in this area.

We completed 16 beach seines and 14 video benthic sled transects at the 14 stations were selected for future work in summer 2016 honing sampling techniques for these urban waterways. Based on experience from 2016, we will be adding scup fish pots to the monthly fish sampling in summer 2017 to better characterize some of the larger benthic-structure associated fish species in the area. We will be using these data to characterize the area and compare results with the two previous studies completed ~ 15 and 20 years ago.

There were 19 successful video tows conducted throughout the season in the study area (Table VI.A.3). Initial video analysis included viewing footage and annotating each clip. Preliminary viewing shows a variety of bottom types, including sand, shell hash, cobbles, large aggregations of *Crepidula* sp., and thick algal mats. Video analysis has also distinguished many burrows, perhaps belonging to *Squilla* sp. (mantis shrimp). Some transects move directly over crabs and some areas north of Fields Point contain white Beggiatoa bacterial mats, suggesting very low D.O. at the sediment-water interface. Most video transects moved too slowly (<1 kn) to observe mobile fish along the bottom since they easily avoided the clearly observable sled, but we were still able to record a summer flounder (North Conimicut transect, 10-6-16) and a sea robin (Edgewood Turning Basin transect, 9-13-16) which came into field to check out the disturbance due to the sled. A project team meeting is planned for mid-March 2017 to discuss how to further analyze the videos and apply a standard classification such as the Coastal and Marine Ecological Classification Standard (CMECS) to evaluate and interpret the results.

Fig. VI.A.6. Beach seine and video transect stations on the Providence River (n=8) and Seekonk River (n=6)

Table VI.A.1. Fish species collected in seine net surveys during 2016 sampling.

Atlantic croaker (*Micropogonias undulatus*)	Northern puffer (*Sphoeroides maculatus*)
Atlantic needlefish (*Strongylura marina*)	Rainwater killifish (*Lucania parva*)
Bluefish (*Pomatomus saltatrix*)	River herring (*Alosa* sp.)
Cunner (*Tautogolabrus adspersus*)	Scup (*Stenotomus chrysops*)
Four-spined stickleback (*Apeltes quadracus*)	Silverside (*Menidia* sp.)
Hogchoker (*Trinectes maculatus*)	Striped killifish (*Fundulus majalis*)
Menhaden (*Brevoortia tyrannus*)	Striped sea robin (*Prionotus evolans*)
Mummichog (*Fundulus heteroclitus*)	Summer flounder (*Paralichthys dentatus*)
Northern kingfish (*Menticirrhus saxatilis*)	Tautog (*Tautoga onitis*)
Northern pipefish (*Syngnathus fuscus*)	Winter founder (*Pseudopleuronectes americanus*)

Discussion - Objective 1

Observations from this past summer produced several expected and some unexpected results. We confirmed that certain areas of the Seekonk and the upper Providence River continue to experience poor benthic habitat quality due to severe hypoxia (e.g., turning basin just south of Fields Point and upper area of Seekonk). Video from these hypoxic zones exhibited beggiatoa bacterial film on the sediment surface (an indicator of very low D.O.) and in some cases, dead juvenile menhaden (e.g., upper Seekonk). We also found that dissolved oxygen conditions are improved compared to the historically poor conditions in the lower Providence River, likely associated with the decreased loading of total nitrogen from the major WWTFs under new permit limits. Results show the lower Providence River has good D.O. levels as well as good fish habitat (seen in videos), while the Port Edgewood turning basin and the Pawtucket upper Seekonk station have low hypoxic D.O. levels. Based on video results, these lower Providence river areas exhibited good benthic fish habitat at least during the transect visits (good benthic habitat structure: sand; shell hash; Crepidula shell ñreefò; and macroalgae in reasonable levels as refuge).

Table VI.A.2. Beach Seine Sampling dates, locations, species and total caught in Providence-Seekonk Rivers 2016.

Date	Station	Silverside	Striped killifish	Blue crab	Menhaden	River herring	Kingfish	Bluefish	Needlefish	Striped sea robin	N. Pufferfish	Mummichog	Summer flounder	Tautog	Winter flounder	N. Pipefish	Green crab	Four spine stickleback	Hogchoker	Lady Crab	Scup	Cunner	Rainwater killifish	Croaker
8/5/2016	Bishop Point	96		2				1																
11/2/2016	Bold Point N	3			1																			
8/5/2016	Bold Point S	6	42	1		1			1			70			1									
11/2/2016	Conimicut	3	4																					
7/21/2016	Conimicut N	244	435	1		2	11	1			1	5			5					1				
7/21/2016	Conimicut S	327	21				3					9									8	2		
7/21/2016	Gaspee Point	629	45			1	2				1	20												
8/19/2016	Gaspee Point	250	153				3		2	1	2													
11/2/2016	Gaspee Point	1	8																					
9/28/2016	Mussachuck Creek	153	17			1																		
11/2/2016	Mussachuck Creek	27														1								
7/26/2016	Narragansett Terrace	247	23	1								36												
8/11/2016	Narragansett Terrace	80									1	1	1	1										
11/2/2016	Omega Dam		3									2												
7/14/2016	Pawtuxet Cove Inside																		1					
8/2/2016	Sabin Point	208	190				14					10												
9/28/2016	Sabin Point	102	160	1				4				4												
11/2/2016	Sabin Point	3	1									1					2							
8/19/2016	Save the Bay	31	6	7	91	90	3	2				4												
11/2/2016	Save the Bay	19	6									1		1				2						
8/5/2016	South of Goose Point (Butler)	404	14	1			3					3			1									
8/5/2016	South of Omega Dam	15	33						3			572											82	
7/26/2016	Stillhouse Cove	39	135	7								112			1									
11/2/2016	Stillhouse Cove	7																						
7/26/2016	Stillhouse Cove N	54	32	10		9	98			1	9	15			10				1					1
8/2/2016	Stillhouse Cove N	327				22	11		23		11													
8/11/2016	Stillhouse Cove N	81	1				20		1			8		1										
9/28/2016	Waterman Grille (East)	201	15		13			1				3												

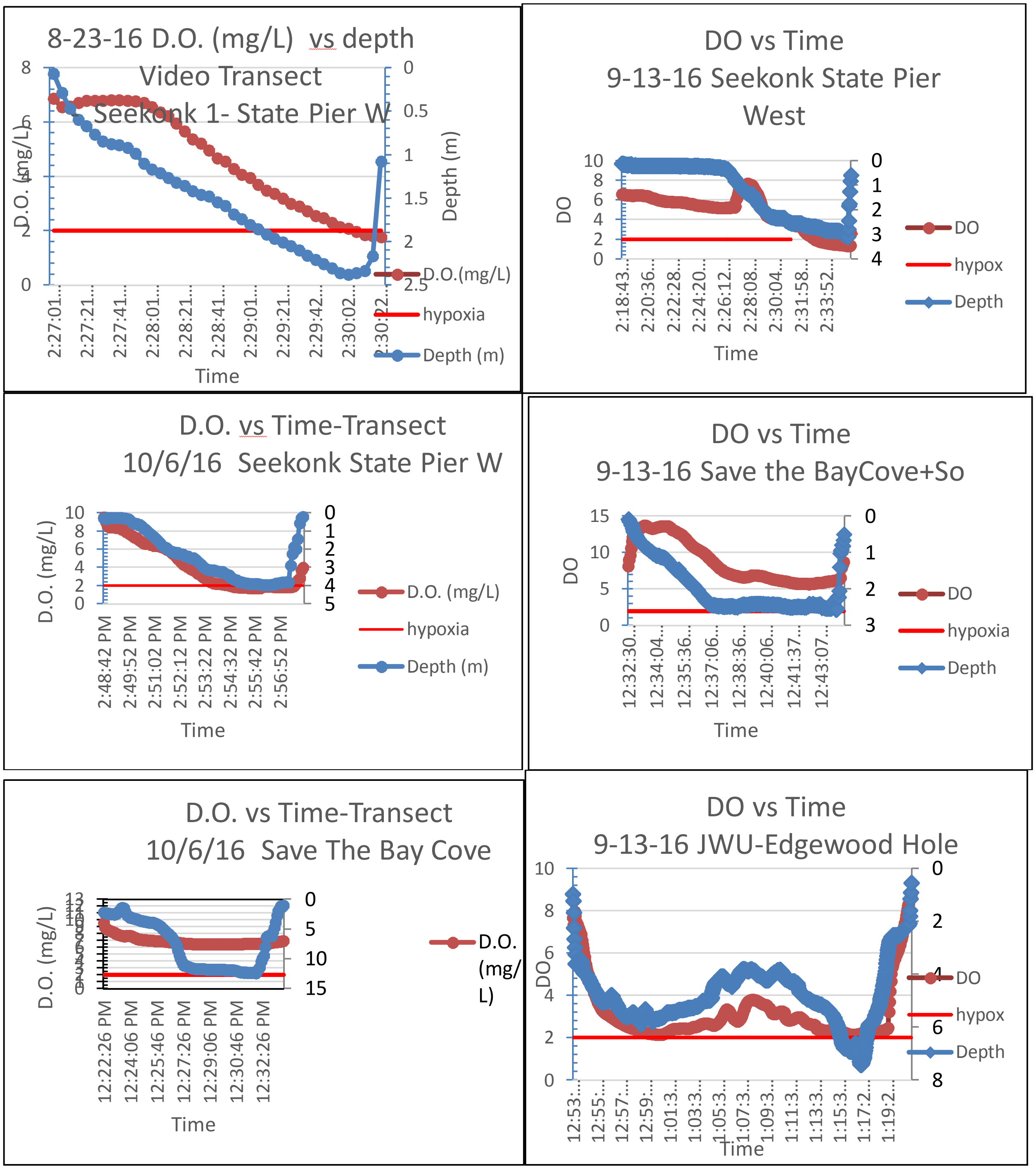
Table VI.A.3. Dates and locations of video tow sampling

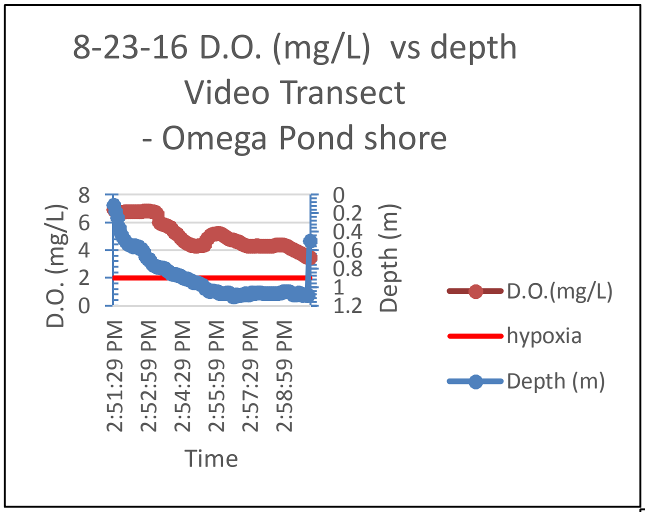
Station	lat	long	8/23/16*	9/13/2016	10/6/2016
Pawcatuck State Pier	41° 52' 10.24" N	71° 22' 54.58" W	X	x	x
Butler	41° 50' 22.46" N	71° 22' 45.07" W			x
Omega Pond	41° 50' 17.81" N	71° 22' 8.64" W	X		x
Waterman Grille (East Bank)	41° 49' 36.05" N	71° 22' 45.33" W			
Bold Point	41° 48' 56.57" N	71° 23' 27.89" W			x
Fields Point / Save the Bay	41° 47' 13.82" N	71° 22' 47.42" W	X	x	x
Edgewood Marina	41° 46' 37.12" N	71° 23' 24.70" W		x	
Sabin Point	41° 45' 54.45" N	71° 22' 3.06" W		x	
Pawtuxet Cove	41° 45' 15.77" N	71° 23' 4.40" W			
Narragansett Terrace	41° 44' 59.96" N	71° 21' 41.33" W			
Mussachuck Creek / Nyatt Point	41° 43' 44.24" N	71° 20' 27.67" W		x	
Conimicut Point	41° 43' 3.63" N	71° 21' 34.86" W	X	x	x

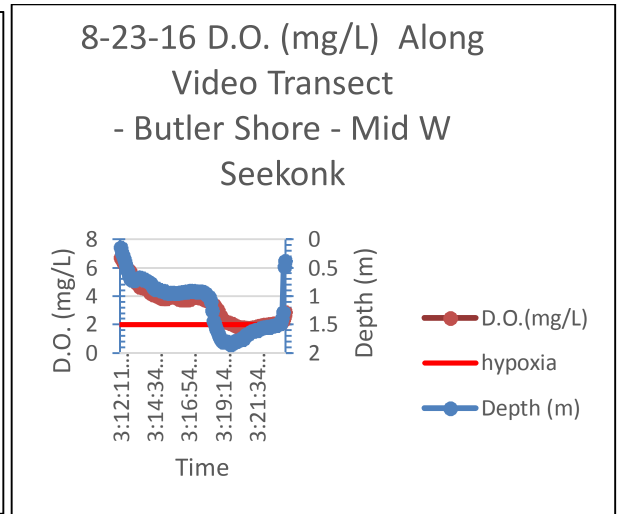
Two surprising positive results were discovered during our sampling efforts. The upper Seekonk shallow mud shoals (< 3ô depth), despite their position adjacent to low oxygen bottom water areas (≥ 5-6ô depth), had extraordinarily high numbers of juvenile young-of-year (YOY) winter flounder (25 and 26 captured in 2 test seines with a small 50ô net in June 2015). This high juvenile winter flounder density was confirmed by Dr. Dave Taylor of Roger Williams University, who seined nearby areas and found very high densities of YOY winter flounder in the same period. We suspect this area may provide a refugia for the early summer. However, we are concerned that the severe hypoxia which usually sets in around end of June to early July may lead to high mortality of these fish as they move deeper when the water warms. These fish disappeared at the end of June 2015.

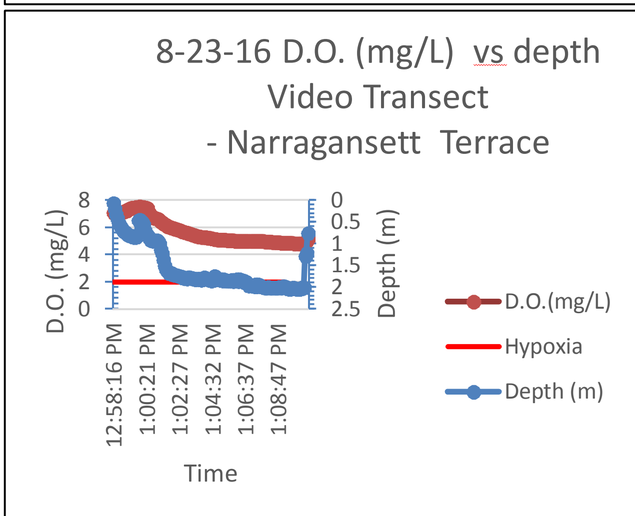
The second surprise was a station halfway up the Providence River (Stillhouse Cove) that had high diversity, with many species in numbers we did not see elsewhere (e.g., 98 juvenile northern kingfish) despite its location near another hypoxic zone. We will be looking at this zone carefully with the video in 2017. Such areas may provide refugia for juvenile fish if they can remain in the oxygenated zone. The figures below show the D.O. levels recorded during video transect stations as well as a comparison of stations using results of beach seines.

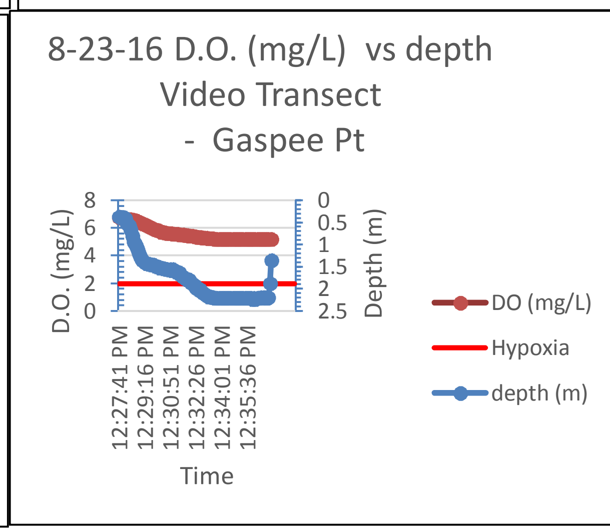
Fig. VI.A.7. Dissolved oxygen (mg/L, red line) and depth (m, blue line) for each video transect from Manta 2 log (~ 30 cm off bottom). Thin red bar indicates 2.0 mg/L severe hypoxia line.




8-23-16 D.O. (mg/L) vs depth
Video Transect
- Omega Pond shore
D.O. (mg/L)
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
Depth (m)
2:51:29 PM
2:52:59 PM
2:54:29 PM
2:55:59 PM
2:57:29 PM
2:58:59 PM
Time
D.O.(mg/L)
hypoxia
Depth (m)


8-23-16 D.O. (mg/L) Along
Video Transect
- Butler Shore - Mid W
Seekonk
D.O. (mg/L)
8
6
4
2
0
0
0.5
1
1.5
2
Depth (m)
3:12:11...
3:14:34...
3:16:54...
3:19:14...
3:21:34...
Time
D.O.(mg/L)
hypoxia
Depth (m)


8-23-16 D.O. (mg/L) vs depth
Video Transect
- Narragansett Terrace
D.O. (mg/L)
8
6
4
2
0
0
0.5
1
1.5
2
2.5
Depth (m)
12:58:16 PM
1:00:21 PM
1:02:27 PM
1:04:32 PM
1:06:37 PM
1:08:47 PM
Time
D.O.(mg/L)
Hypoxia
Depth (m)


8-23-16 D.O. (mg/L) vs depth
Video Transect
- Gaspee Pt
D.O. (mg/L)
8
6
4
2
0
0
0.5
1
1.5
2
2.5
Depth (m)
12:27:41 PM
12:29:16 PM
12:30:51 PM
12:32:26 PM
12:34:01 PM
12:35:36 PM
Time
DO (mg/L)
Hypoxia
depth (m)

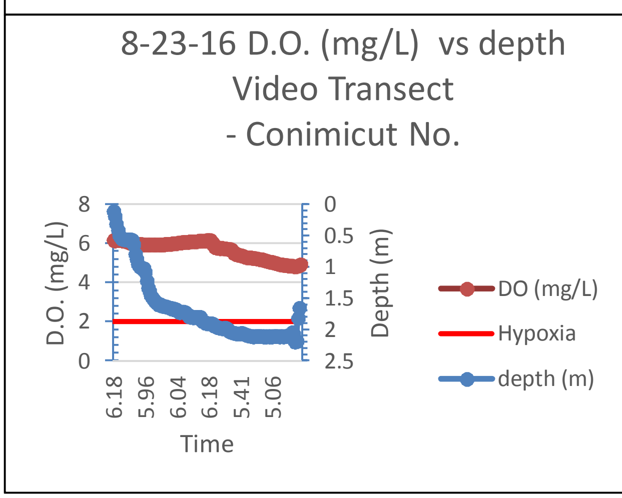
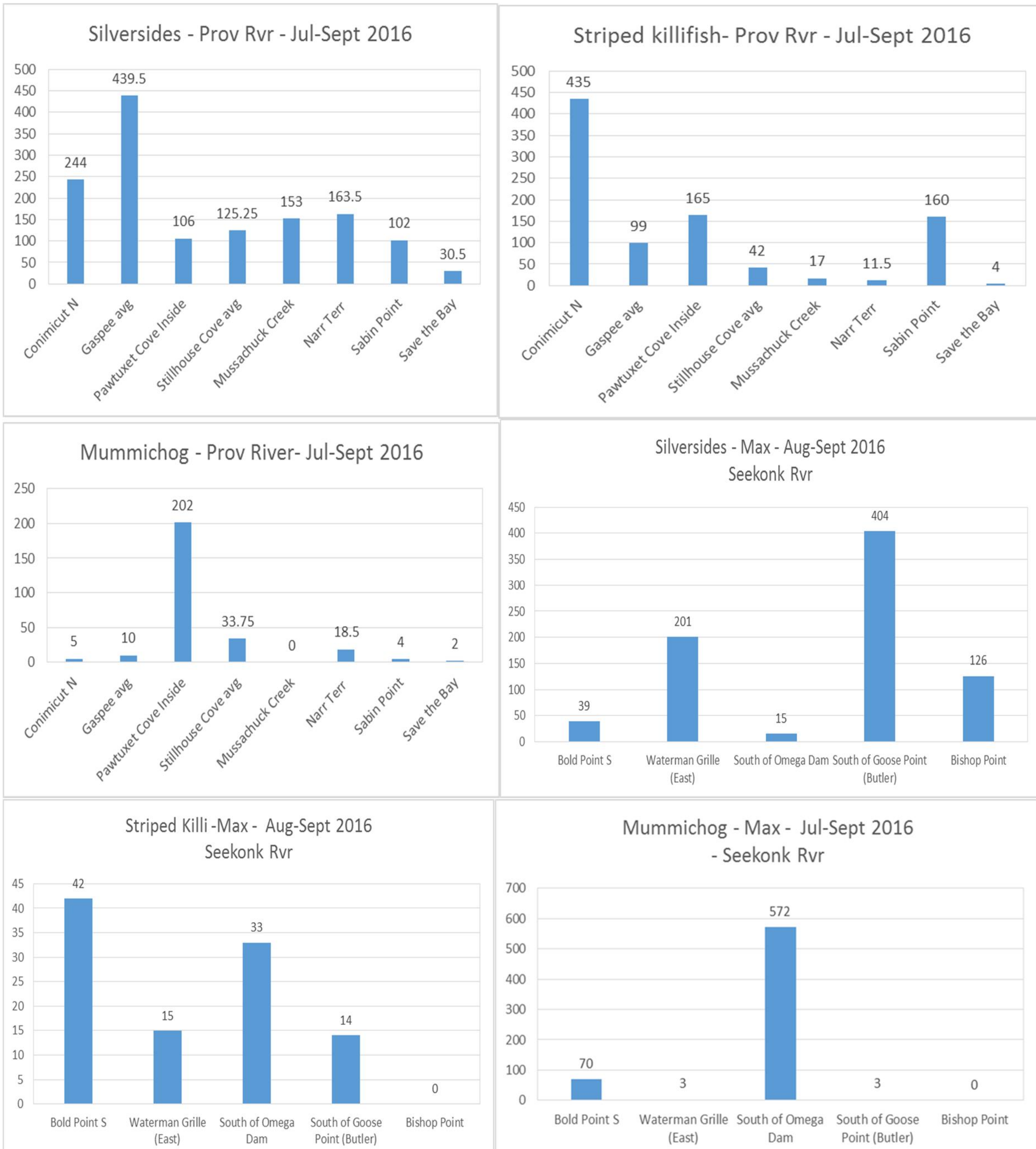
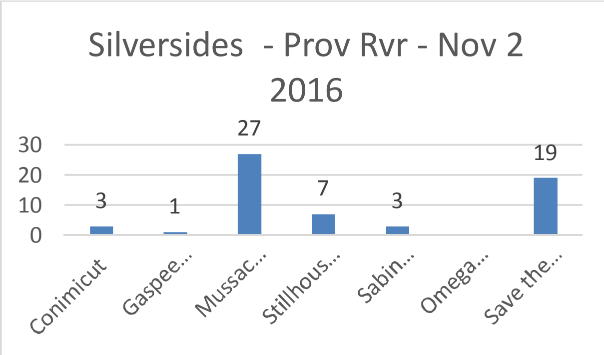
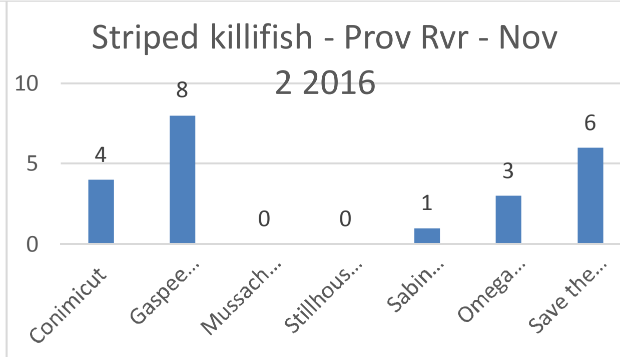
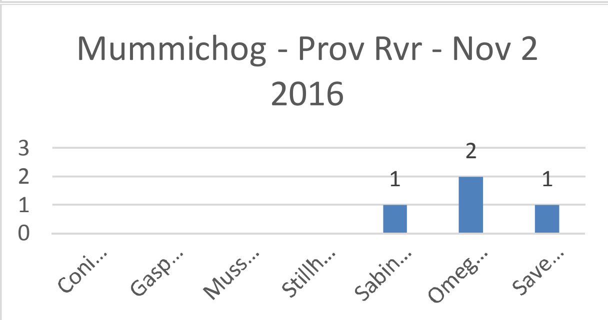

8-23-16 D.O. (mg/L) vs depth
Video Transect
- Conimicut No.
D.O. (mg/L)
8
6
4
2
0
0
0.5
1
1.5
2
2.5
Depth (m)
6.18
5.96
6.04
6.18
5.41
5.06
Time
DO (mg/L)
Hypoxia
depth (m)

Fig VI A.8. Results for beach seines 2016 for the three dominant fish species at each station.







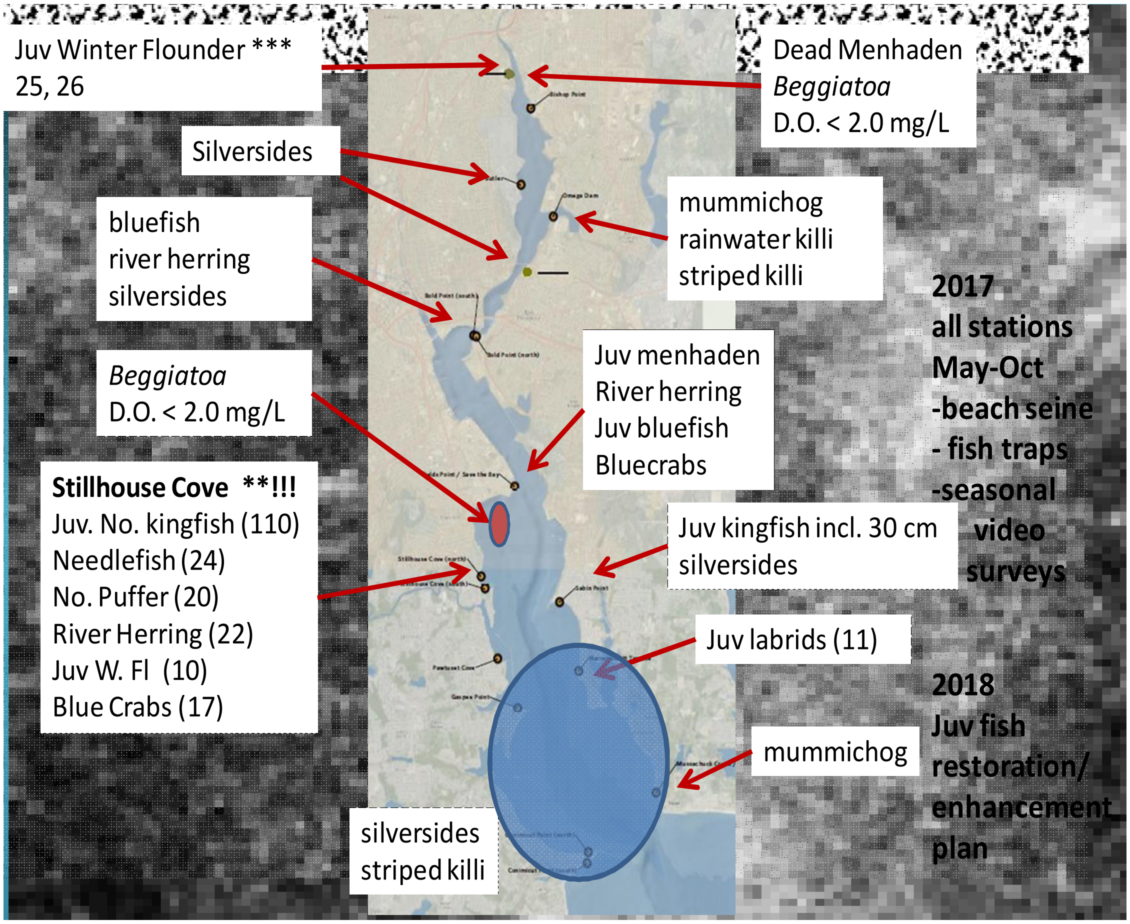


Works Cited - Objective 1

Meng, L., G. Cicchetti, and S. Raciti. 2005. Relationships between Juvenile Winter Flounder and Multiple-Scale Habitat Variation in Narragansett Bay, Rhode Island. Trans. Am. Fish Soc. 134:1509-1519

Prell, W., Murray, D., Deacutis, C., 2006. Summer-Season survey of dissolved oxygen in upper Narragansett Bay beginning in 2005. Data available via the following link: http://www.geo.brown.edu/georesearch/insomniacs

Fig. VI.A.9. Dominant species found at specific stations for in beach seines conducted during 2016, and high diversity results for Stillhouse Cove station, Providence River.

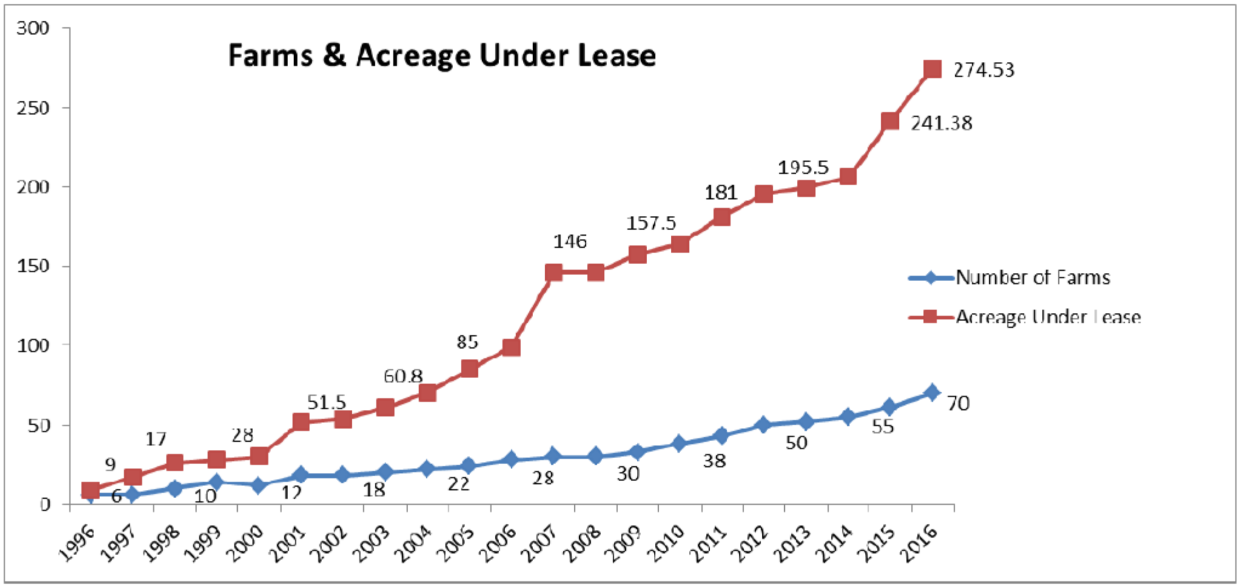


Results - Objective 2 (Review of permit applications)

The DFW reviewed 51 dredging projects and dock permit applications as part of its Environmental Review program during the 2016 calendar year. All permit reviews are detailed in Table VI.A.4 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 new requests and did not encroach on known eelgrass beds or other critical fish habitat. The DFW staff were also involved in site visits to a marina maintenance dredging project in Greenwich Cove, Warwick.

Also during 2016, the DFW participated in and formulated responses for approximately 42 preliminary determinations 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 40 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. We coordinated all responses with RI DEM Wildlife Program for waterfowl habitat and hunting concerns, and drafted DFW 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 2016

Figure VI.A.10. Number of Aquaculture Farms and acreage in RI waters (source, RICRMC 2016 Annual Status Report on Aquaculture in Rhode Island).



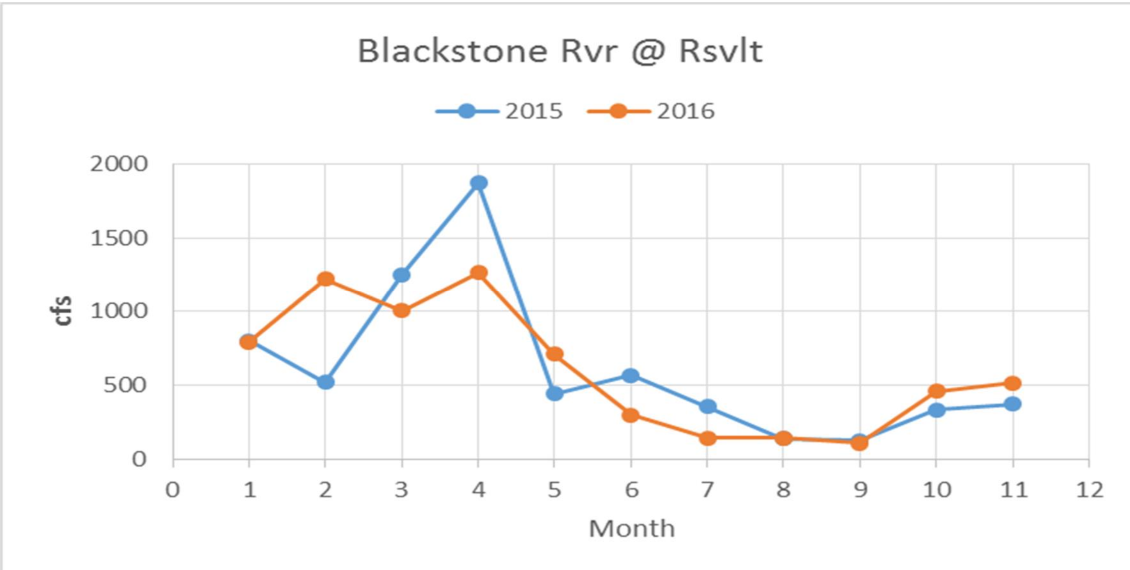
Discussion – Objective 2

The DFW'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 DFW strives to use high quality, quantitative information to develop science-based recommendations for regulations and permits. The number of activities and types reviewed are listed in Table VI.A.4. We provided DFW comments to the RIDEM Div. Water Resources for all dredge applications that require a WQ Certification, and reviewed and verbally commented on a number of dredging projects. A special meeting is being planned for early 2017 because a number of very late marina maintenance dredging applications were submitted in Oct-Nov 2016 due to the sudden availability of a clamshell dredge and barge that marinas decided to share for projects. Normally these applications come in around June, allowing the Division to do these assessments without disrupting ongoing field work and other tasks. This surge in late applications required review including determination of natural resource habitat usage assessments under difficult time constraints for the DEM DMF. We expect to have meetings with RI CRMC in 2017 regarding the timelines afforded to review and respond to late-season applications.

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

Summer 2016 had far fewer kill incidents compared with summer 2015. Part of this may be due to the lower duration of menhaden schools frequenting the upper Bay area's subject to hypoxia, and part is likely due to the slightly drier summer months compared with 2015 (Fig. VI.A.11). April 2015 was much rainier, and June + July were slightly wetter in 2015. Wet summers are known to increase duration and severity of hypoxia in the upper areas of Narragansett Bay due to increased nutrient load + increased stratification.

Fig. VI A.11. Monthly river flows for the Blackstone River to Narragansett Bay/ Seekonk River in 2015 and 2016.



Conclusion

The DFWôs 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 DFW strives to use high quality, quantitative information to develop science-based recommendations for regulations and permits. We will continue to improve data collection and the review process in order to protect the important recreational fishery resources of the state.

Table VI.A.4. General Permit Reviews performed in 2016 by RI DFW (not including aquaculture reviews).

2016 permit Reviews	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2016
Potential Impacts to SAV or Benthic Habitat		cancelled	1[a]				cancelled						
SaltMarsh Restoration										1[j]		1[r]	1
Eelgrass Restoration													
Coastal Restoration (other)													
Maintenance Dredging	3[o]				1[n]			1[q]		3[j]	2[k]		10
New Dredging													
New Marina													
Marina Expansion or Reconfiguration								1[g]	1[h]	1[i]			3
Restoration of Tidal Flow to Coastal Pond													
Residential Docks (new)	3			2	4	2		7	2	1		2	
Residential Docks (modification)			1	1	3			2					
Commercial and muni Piers or Docks											1[l]		
Commercial and Muni Mooring expansion	1			1[c]	1[m]			1[d]			1[m]		
Salt Marsh or Coastal Wetland Impacts													
Beach Nourishment or Coastal Feature Restoration								1[f]		2[j]			
Waterfront Bulkhead/Riprap			1[b]			1[e]							
Waterfront Development													
Public Works or Utility					1[p]								
Fish Passage													
Potential Shellfish Impacts													
Channel Maintenance													
Boat Ramp (New or Repair)													
Oyster Restoration													
Conflict with Recreational Use													
Impacts from Discharge													
- Total Number of Activities and Potential Impacts Identified	7		1	4	9	3		13		8	4	2	51

*Note- aquaculture permit applications are also reviewed but dealt with in this report in a separate section

a existing pier with eelgrass around it to be replaced by pier extension and T-pier JamestownRI

b 16' x 20' riprap splash pad - Seekonk River urban area

c install 10 additional moorings E Passage -Conanicut YC and move older mooring out of eelgrass - no impact to SAV w/ new moorings

d Pre-app meeting with Chevron on proposed site-remediation along Providence River / East Prov. -will not use soft living shoreline salt marsh restoration due concern over erosion.

e Chevron follow up discussions of remediation plans for "Brownfields" site of former tank farm - plan indicates they would put concrete structures out as "living shoreline" fish habitat - RIDEM and Save the Bay do not accept these structures as legitimate lving shoreline fish habitat (essentially parking curbstones as wave breaks)

f SAV survey completed- moved existing moorings in SAV offshore

g Wickford Marina fill-reconfigure - CRMC requiring public access to float for fishing

h Trims Pond area B.I. incr. capacity by 5 boats - no new structures

i Expand exising marina + establish Marina Perimeter Limits - E Providence - Prov. River

j maint dredge - (1+2)Jim's dock+Corrogan dock- Pt.Judith Pond breachway S.Kingstown/Narragansett 3800+3500cy to Matunuck Nr Shorebeach renourish -concern due to SAV that will be dredged with no mitigation (RICRMC policy for existing marina with SAV regrowth w/in MPL) ; (3) Brewer's Cowessett Marina 8940 cy to CAD- performed site visit with USACE

k Pawtuxet Cove Marina 900 cy to CAD; Greenwich Bay Enterprises 41,700 cy to CAD

l NE Boatworks Portsmouth - 2 piers for 200 ton travellift

m Clark Boat Yard add 20 moorings to existing 65 - incl conservation moorings at existing mooring w/ SAV

n Block Island Maintenance Dredging by USACE - Currituck -at Great Salt Pond and BI Harbor of Refuge - GSP sediments to be placed nearshore adjacent to Sachem Pond Harbor of Refuge sediments to be placed nearshore off Crescent Beach

o Bela Vista Marina 930 cy Warwick Cove to CAD; RIYC 3,380 cy Stillhouse Cove to CAD - permit limited depth to -6' (wanted-9') due to hypoxia issues with no sill Silver Spring Marina maintenance dredge ~800 cy - onsite disposal

p Mod to RIDOT WQCert on I-195 relocation - mods included Prov. River pedestrian bridge / bicycle pathway and newly restored riverwall and riverwalks in the area.

q RI Mooring Services, 4,000 cy Little Allen Harbor N.K. - upland disposal

r Meeting at US Navy Newport on eelgrass restoration as part of US EPA mitigation in response to violation of dredging turbidity monitoring requirements 2016

Appendix I –

Fish Kill Incident Reports 2016

Compilation Summaries of Investigations of Fish and Other Biological Kills 2016

<u>Overview</u>

Summer 2016 had much fewer incidents of fish kills, probably due to the drier summer months vs 2015. Increased river flows are clearly associated with increased hypoxic events in Narragansett Bay. A second aspect of the lower kill numbers seems to be the fact that menhaden were not as plentiful this summer comparted with summer and Fall 2015.

There was a small kill of adult menhaden (<12) late in the season (October) at the mouth of a tidal creek in Greenwich Cove, an area which has severe hypoxia problems, and the D.O. was < 1.0 mg/L on the bottom in the deepest area of the creek.

We ran into a juvenile menhaden kill in August 2016 while studying the upper Seekonk tidal River using video transects. The kill was small there also (~ dozens). The latter kill was not written up because we had full evidence of the cause and have the data within our dataset for the Seekonk river study. Low bottom water dissolved oxygen (<2.0mg/L) was also the cause of this kill, and it too was in an area plagued with sever hypoxia because of the nutrient loads to the area + strong stratification (end of the Blackstone river-salt wedge area).

<u>Description of Kill</u>

Observed ~150 Fish swimming in school right at surface. Approx. 6 dead adult fish seen on bottom. Low D.O. appears to be cause of kill. Extreme high and low tides occurred in recent days. FW flow has been low. Oxygen levels were very low in the bottom waters (2-4ô) even in sunny daytime hours with photosynthesis occurring. Oxygen levels likely decrease significantly in the evening when photosynthesis is no longer occurring. The bottom waters may be high salinity- low DO water sloshing back and forth in this deeper area of the creek bed. Many of the fish had significant #ôs of parasitic copepods *Lernaeenicus radiates*, suggesting poor health conditions in these fish.

FISH KILL INVESTIGATION REPORT FORM

1 Date:

10-18-16

2 Time of Arrival: **11:48 AM**

Total Time spent at site: ~ **20 min**

3. Waterbody Location: **Greenwich Cove in creek coming out of train trestle**

4. Person reporting:
Name: J OòConnor ï Anthony Esposito Div Law Enforce
Phone:
Address: Affiliation:RIDEM

5. # of fish Killed: _____
Incident Size:
Minor <100 X
Moderate 100-1000 Ĭ
Major >1000 Ĭ

6. Dimensions of fish kill:
__________ by __________ ~ 150 adult menhaden swimming creek - ~ 6 dead

7. Fish Species Affected: **Fish Size**
1. __adult menhaden______________________ Same Ĭ Different Ĭ Range ____ to ____ in.
2. _____________________________________ Same Ĭ Different Ĭ Range ____ to ____ in.
3. _____________________________________ Same Ĭ Different Ĭ Range ____ to ____ in.
4. _____________________________________ Same Ĭ Different Ĭ Range ____ to ____ in
5. _____________________________________ Same Ĭ Different Ĭ Range ____ to ____ in.
6. _____________________________________ Same Ĭ Different Ĭ Range ____ to ____ in.

7a. **Other Species Affected:**
1, _____none______________________________ Dead Ĭ Dying Ĭ Lethargic Ĭ Live Ĭ
2. _______________________________________ Dead Ĭ Dying Ĭ Lethargic Ĭ Live Ĭ
3. _______________________________________ Dead Ĭ Dying Ĭ Lethargic Ĭ Live Ĭ
4. _______________________________________ Dead Ĭ Dying Ĭ Lethargic Ĭ Live Ĭ

8. Fish Species Not Affected
____
____
____
____
____

9. Weather
Temp (F) air = 19.3 °C
Cloud Cover (%) 0
Precipitation (%) 0
Wind Speed (mph) 6-8 Knt
Wind direction SSW ï no wind at creek

10. Water Quality:
Temp (C): ___17.3 °C _
pH: ________________
DO: ___3.9 mg surf____ - 2-0.8 mg bottom_______
Conductivity: _________
Salinity: _____________
Chlorine: _____________
Alkalinity: ____________

11. Water Condition:
Turbid X
Sediment Loading Ĭ
Colored: __________ Ĭ
Odor: ____________ Ĭ
Tidal Stage: ___________
SAV/ macroalgae ______ Ĭ

12. Fish Condition:

Dying	Ĭ	Discoloration	Ĭ	Increased respiration	X	Emaciated	Ĭ
Gills flared	Ĭ	Odd fin position	Ĭ	Eyes sunken in	Ĭ	Spasms, convulsions	Ĭ
Red/pink gills	Ĭ	Swimming at surface	Ĭ	Eyes bulging	Ĭ	Erratic Swimming	Ĭ
Gill clubbing	Ĭ	Equilibrium loss	Ĭ	Bloated	Ĭ	Lethargy	Ĭ
Excessive mucus	Ĭ	Trying to get out of water	Ĭ	Mouth agape	X	Hemorrhaging	Ĭ
Lesions	Ĭ			Hypersensitivity	Ĭ	Spine curved	Ĭ

Other ___________________________________ Run samples for:______________________________

13. Symptoms/Conditions	Possible Cause	Possible Source	Source present?	
• Fish coming to surface gulping for air X • Low dissolved oxygen X	Oxygen depletion ï Definite Cause	Sewage Treatment Plan	Yes Ĭ	No Ĭ
		Livestock Feedlot	Yes Ĭ	No Ĭ
		Irrigation/De-icing Runoff	Yes Ĭ	No Ĭ
		Decaying Plant Matter	Yes Ĭ	No Ĭ
		Dying Algal Bloom	Yes Ĭ	No Ĭ
• Fish coming to surface gulping for air X • Adequate dissolved oxygen Ĭ	Early oxygen depletion with slow re-oxygenation	Ammonia Chemicals	Yes Ĭ	No Ĭ
		Livestock Feedlot	Yes Ĭ	No Ĭ
• Fish swimming erratically Ĭ • Fish moving upstream to avoid something in water Ĭ	Chemical pollution	Heavy Metal Plant	Yes Ĭ	No Ĭ
		Chemical Waste Facility	Yes Ĭ	No Ĭ
		Sewage Treatment Plant	Yes Ĭ	No Ĭ
• Fish dying or dead after heavy rain Ĭ	Pesticide, herbicide washed out/runoff	Farms, Crop fields	Yes Ĭ	No Ĭ
		Aerial Crop Sprayer	Yes Ĭ	No Ĭ
		Man/mechanical Sprayer	Yes Ĭ	No Ĭ
• Fish coming to surface gulping for air Ĭ	Oxygen depletion	Dredging/ Marina activity	Yes Ĭ	No Ĭ
• Low pH Ĭ Good clarity Ĭ Orange Discoloration Ĭ	Acid	Coal/Strip Mining	Yes Ĭ	No Ĭ
• Fish dying below a dam or industrial plant Ĭ	Turbines or thermal shock	Heated water	Yes Ĭ	No Ĭ

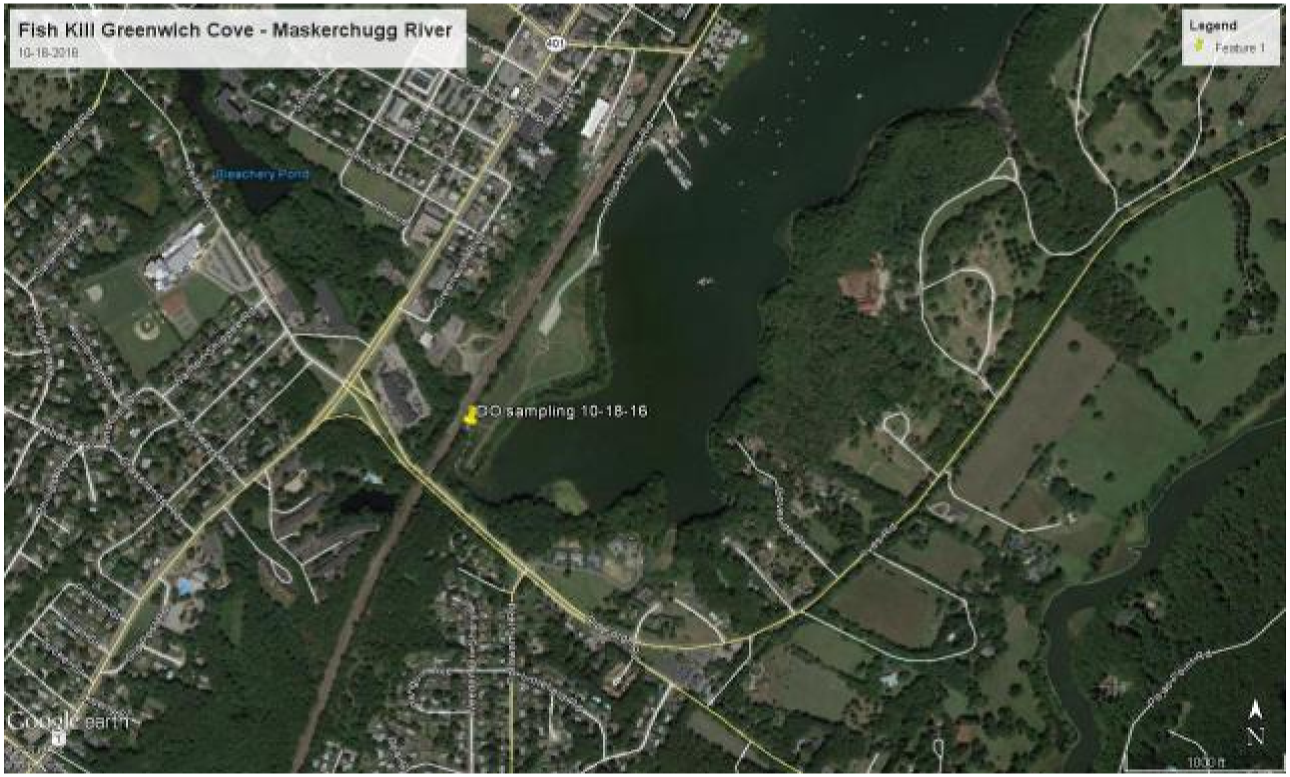
• Kill restricted to one species or size class Ĭ	Spawning stress, disease	Pathogens, WQ poor	Yes Ĭ	No Ĭ

14. **Documentation and Samples**: Photos taken X Water samples Ĭ Number: ______________ Sent to: ______________________ Tested For: _____________________ Fish Samples Ĭ Number: ______________ Sent to: ______________________ Tested For: _____________________	15. **Prepared By**: Chris Deacutis, RIDEM F&W

<u>Small school of adult menhaden at this area next to the trestle culvert ~ 150 adults</u>

AIR TEMP 19.3 °

Depth	**D.O.Mg/.L**	**Temp °C**	**Time**
Surf	**3.9**	**16.8**	
~1'	**2.3**	**17.2**	**11:48 AM– 12:03PM**
~2'	**1.2**	**17.2**	
~4'	**0.8**	**17.3**	


Fish Kill Greenwich Cove - Maskerchugg River
10-18-2016
Legend
Feature 1
Bleachery Pond
DO sampling 10-18-16
401
Google earth
1000 ft
N

App.I. Fig.1. Location of DO samples Maskerchugg River at Train Trestle-
SW side of Scalloptown Park East Greenwich RI

App.I.Fig2. Looking downstream in river from site.

App.I.Fig. 3. Dead adult menhaden from this site. Note parasitic copepod *Lernaeenicus radiates* (white and white-red stringy objects on fishôs side). Their presence suggests poor health of these fish.

App.I.Fig.4. schooling adult menhaden and several dead menhaden on bottom of Maskerchugg River at Train Trestle

Appendix II –

Status Update: Construction of the nationôs first offshore wind farm, the Block Island Wind Farm

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Note: *the work described in this Appendix (II) is currently funded through a separate funding source and thus, not being conducted as part of this job (i.e., F-61 R-21, Job VI-A). However, considering the DFW is engaged in assessing potential impacts to recreationally important fish species and their habitat from potential impacts from wind energy, at large, we have decided to include a status update on the BIWF project*

Block Island Wind Farm Impact Evaluation

Introduction

Construction of the nationôs first offshore wind farm, the Block Island Wind Farm (BIWF), is complete and all turbines are now online. The 5-turbine wind farm is situated entirely in Rhode Island state waters, approximately three miles southeast of Block Island. The farmôs electricity transmission cable extends from state waters off Block Island into federal waters, and back into Rhode Island state waters at Scarborough State Beach. Project siting was orchestrated through the 2010 Rhode Island Ocean Special Area Management Plan (Ocean SAMP) stakeholder engagement process, facilitated by the Rhode Island Coastal Resources Center on behalf of the Rhode Island Coastal Resources Management Council.[i] The BIWF will supply more than enough energy to meet Block Islandôs needs; excess energy will enter the mainland electrical grid through the submarine electricity cable.[ii]

Approach

The ecological and fishery impacts of offshore wind development in the Northwest Atlantic are largely unknown, as no commercial offshore wind development projects have occurred in North America prior to the BIWF. The BIWF is located within essential fish habitat for over 20 species of interest to the region.[iii]. There is concern that several recreationally important species such as striped bass, winter flounder, black seabass, tautaug, scup, summer flounder, and bluefish may be directly or indirectly impacted by this work. The presence of wind turbine foundations will increase the amount of hard substrate in the area and may serve as an artificial reef.[iv] However, negative impacts to marine species are also possible. Past offshore wind research endeavors have addressed the effects of construction noise on the behavior of marine mammals and fish,[v,vi] habitat loss,[vii] the influences of electricity generation and electromagnetic field disruption,[viii,ix,x,xi,xii] and the dispersion of sediment,[xiii] but a knowledge gap exists regarding potential changes in the local community structure or species abundances during and after the construction of offshore wind farms. The study of the BIWF has been designed to help fill these gaps concerning possible changes to the local environment as a result of fixed turbine foundation construction and operation.

The Rhode Island Department of Environmental Management (RI DEM) Division of Fish and Wildlife, Marine Fisheries Section (RI DFW) are monitoring the ecological impacts of the wind farm on the marine environment. Through the RI DEMÕs 2014 issuance of dredge and water quality permits for the BIWF, the state required that the developer (Deepwater Wind, LLC.) conduct impact assessment surveys and analysis. Data are collected monthly by Deepwater Wind consultants at the area of potential impact (near the wind farm construction site) and at control sites through a trawl survey and a ventless lobster survey; the trawl survey is conducted year-round, while the lobster survey takes place six months per year. These data are being collected as part of a before-after-control-impact (BACI) study to evaluate the marine system effects of offshore wind development in the Northeast to inform possible development of larger wind energy projects in the region and to minimize potential environmental impacts. Staff at the RI DFW are provided with all raw data from the two surveys to conduct independent impact assessment analysis.

Results

Baseline analyses (from the two years prior to construction) have illustrated preexisting differences between impact and control sites, which will be used for comparison with construction and post-construction phase data. Thus, project specific data will be used in conjunction with the RI DFW survey datasets (trawl and ventless lobster surveys) to parse out what changes may be attributed to wind farm development, as opposed to larger regional trends. Data from Deepwater Wind-funded surveys for the first complete year of construction were received by RI DEM staff on March 13th, 2017. Construction-phase impact analyses are now underway.

Future BIWF impact research aims to address questions about possible effects on recreational fishing, for example: 1) Have abundances of recreationally important species changed as the result of the wind farm? 2) Has the proportion of legally harvestable fish changed? 3) How has the ecological community structure changed, if at all? 4) Has recreational catch near the wind farm changed?

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[i] State of Rhode Island (2010). Coastal Resources Management Council. The Rhode Island Ocean Special Area Management Plan, V. I and II. Rhode Island: Narragansett. Print and web.

[ii] "Resilient Rhode Island Act of 2014." Accessed July 3, 2014. http://blogs.law.columbia.edu/climatechange/2014/07/22/resilient-rhode-island-act-of-2014-sets-85-carbon-emissions-reduction-goal-by-2050-strongest-in-the-united-states/#sthash.Z7jhHJiZ.dpuf

[iii] State of Rhode Island (2010).

[iv] Inger, R., Attrill, M. J., Bearhop, S., Broderick, A. C., James Grecian, W., Hodgson, D. J., Mills, C., Sheehan, E., Votier, S. C., Witt, M. J. and Godley, B. J. (2009), Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology, 46: 1145–1153. doi:10.1111/j.1365-2664.2009.01697.x

[v] Horowitz, C. and M. Jasny. 2007. Precautionary management of noise: lessons from the U.S. Marine Mammal Protection Act. Journal of International Wildlife Law & Policy, 10:225–232. doi: DOI: 10.1080/13880290701769288

[vi] Dolman, S.J., Green, M. & Simmonds, M.P. 2007. Marine Renewable Energy and Cetaceans. Submission to the Scientific Committee of the IWC SC/59/E10/.

[vii] Inger et al. 2009

[viii] Walker, T.I. 2001. Review of Impacts of High Voltage Direct Current Sea Cables and Electrodes on Chondrichthyan Fauna and Other Marine Life. Basslink Supporting Study No. 29. Marine and Freshwater Resources Institute, Queenscliff, Australia.

[ix] Gill, A.B. 2005. Offshore renewable energy: ecological implications of generating electricity in the coastal zone. Journal of Applied Ecology, 42:605–615.

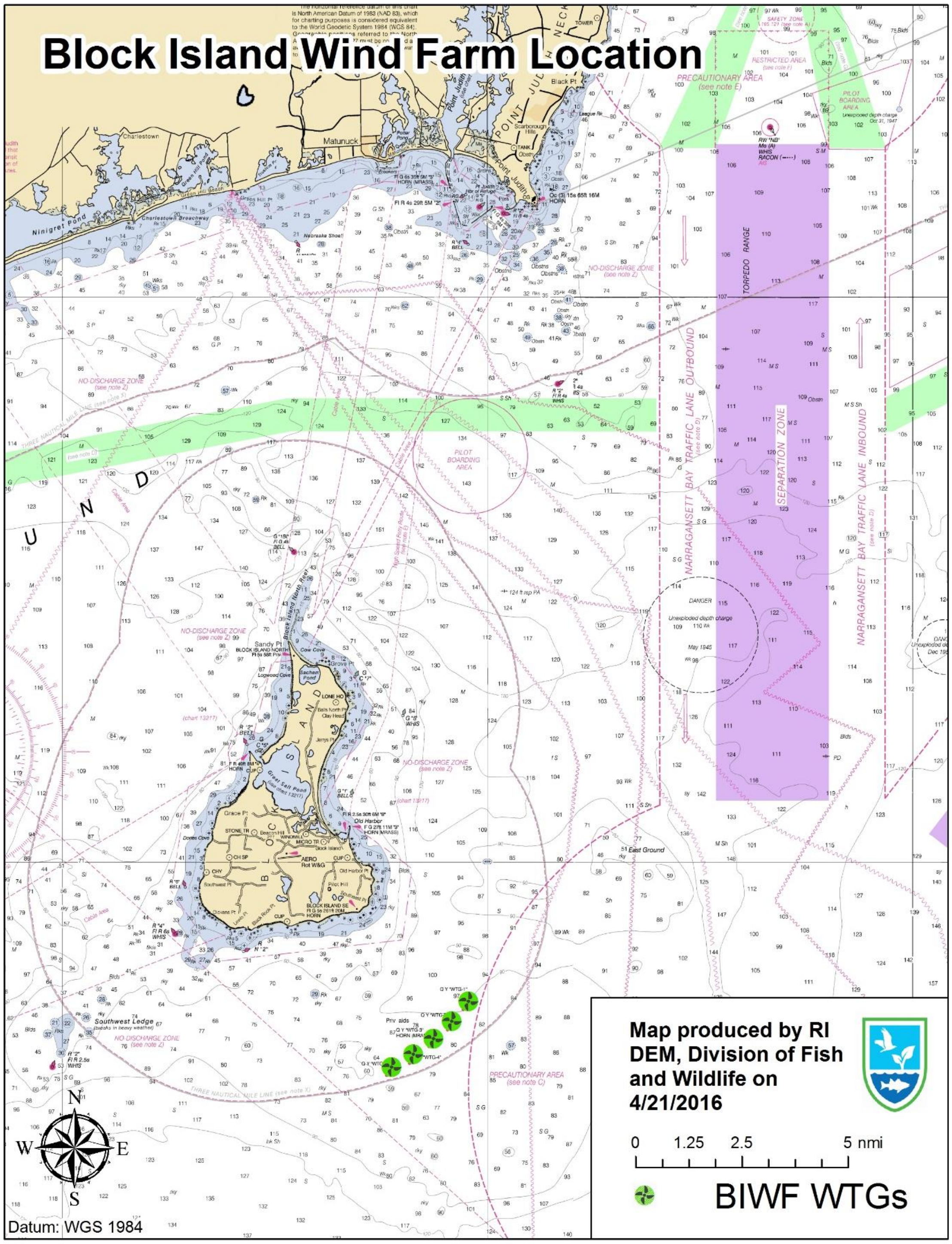
[x] Gill, A.B. and J. Kimber. 2005. The potential for cooperative management of elasmobranchs and offshore renewable energy developments in UK waters. Journal of the Marine Biological Association of the United Kingdom, 85:1075–1081.

[xi] Gill, A.B., I. Gloyne-Phillips, K.J. Neal, and J. A. Kimber. 2005. The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms – A Review. Cowrie Report COWRIE-EM FIELD 2-06-2004.

[xii] Bailey, H., K. L. Brookes, and P. M. Thompson. 2014. Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. Aquatic Biosystems, 10:8.

[xiii] Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N. Å. Capetillo, and D. Wilhelmsson. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environmental Research Letters, 9:034012.

Map showing the location of the Block Island Wild Farm.



Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Waters

2016 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

By

Eric Schneider and Will Helt
Rhode Island Department of Environmental Management
Division of Fish and Wildlife, Marine Fisheries
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3 Fort Wetherill Road
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&

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Federal Aid in Sportfish Restoration
F-61-R

2016 Performance Report for Job VI, Part B March 30, 2017

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, 2016 - December 31, 2016

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 Will Helt (Fisheries Specialist), RI DEM, Div. of Fish and Wildlife, Marine Fisheries, and Sara Coleman (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 growth and survival (i.e., 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, 2016. During this period, we (1) conducted Year-1 of post-enhancement fish and habitat (reef) monitoring of FHE reefs sites in Ninigret Pond, (2) determined the locations and experimental design of reef habitats to be constructed in Quonochontaug Pond, (3) submitted the required permit applications for the proposed FHE work in Quonochontaug Pond, (4) conducted pre-enhancement fish and habitat monitoring in Quonochontaug Pond at the proposed FHE sites, (4) installed salinity and temperature data loggers at FHE sites in Ninigret and Quonochontaug Pond, (5) prepared the juvenile oysters (i.e., seed-on-shell) that will be used to populate the FHE reef construction in Quonochontaug Pond, and (6) began planning for the 2017 and 2018 seasons, including discussions regarding the siting of the third series of FHE reefs for 2018.

With exception for the delay in permitting, planning and field work for 2016 went well. 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 (i.e., before reef construction) baseline monitoring; however, additional data will be needed to properly evaluate the success of these FHE reefs. Reef habitat monitoring showed the overall health of the FHE reefs in Ninigret was good, with excellent survival (91.6%) of juvenile oysters on the FHE reefs. In addition to the current fish monitoring survey work, we believe that conducting video work at the FHE reef sites will confirm that the targeted fish species are being captured by our sampling gear, as well as provide insight into fish behavior, such as residence time and reef utilization. We anticipate obtaining the required permits for the FHE reefs to be created in Quonochontaug Pond in February of 2017 and construction of these reefs is expected to begin in May 2017.

TARGET DATE: December 2016

SIGNIFICANT DEVIATIONS: Due to unforeseen challenges with obtaining the required permits for fish habitat enhancement (FHE) reef construction in Quonochontaug Pond, the construction of these FHE reefs was delayed from October of 2016 to April/May of 2017. This delay resulted in the need to overwinter the seed oysters until FHE reef creation in the spring of 2017. Deviations are shown in Table 1.

RECOMMENDATIONS: Given that permit acquisition took longer than anticipated, which delayed the Quonochontaug Pond FHE reef construction, we will re-evaluate our timeline for permit submission in order to buffer any unforeseen delays in the application process. Although a revised timeline will be finalized in the spring of 2017, itõs likely that the third series of FHE reefs will be scoped in 2017 and constructed in the fall of 2018.

Based on a review of the 2016 fish monitoring data, we believe conducting video work, in addition to the current fish monitoring survey work, is warranted to ensure that the sampling gear is adequately capturing the specie assemblage, across size classes, present at the reefs. In addition to confirming that the targeted fish species utilizing the sites are being captured by our sampling gear, these video surveys will also provide insight into fish behavior, such as residence time and reef utilization.

We also appear to have underestimated the level of staffing required to complete the fish and habitat monitoring, as well as the cost of these conducting these surveys and FHE reef construction in general. As a stop-gap, additional assistance is being provided by a DFW contract employee, as well as DFW and TNC seasonal staff. These aspects will be assessed during 2017 and revisions to the grant will be requested, if determined 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 Islandõs 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 growth and survival of juveniles fishes such as the black sea bass *Centropristis striata*.

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). 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 Fish and Wildlife (DFW) 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 will 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 ñto be createdò 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 TNCôs oyster restoration suitability model along with DEMôs juvenile fisheries data (Figure 1) 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 DFW 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 DFW will promulgate regulations to protect the ñto be createdò 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, 2016 (see Table 1 for a summary of specific activities, timelines, and status). During this period, we (1) conducted Year-1 of post-enhancement fish and habitat (reef) monitoring of FHE reefs sites in Ninigret Pond (Figures 2, 3), (2) determined the locations and experimental design of reef habitats to be constructed in Quonochontaug Pond (Figures 4, 5), (3) submitted the required permit applications for the proposed FHE work in Quonochontaug Pond (see Appendix I for applications), (4) conducted pre-enhancement fish and habitat monitoring in Quonochontaug Pond at the proposed FHE sites, (4) installed salinity and temperature data loggers at FHE sites in Ninigret and Quonochontaug Pond, (5) prepared the juvenile oysters (i.e., seed-on-shell) that will be used to populate the FHE reef construction in Quonochontaug Pond, and (6) began planning for the 2017 and 2018 seasons, including discussions regarding the siting of the third series of FHE reefs for 2018.

Pre- and Post-enhancement monitoring

We continued the post-enhancement fish and habitat monitoring of the FHE reef sites in Ninigret and began pre-enhancement monitoring in Quonochontaug Pond starting in May and June, respectively. Each month, we conducted fish survey work using fish traps and gillnets in both ponds. Fish pot sampling consisted of setting 2 eel pots and 3 minnow pots connected on a trot line per site. The pots were soaked (i.e., fished) for 6 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 15ô long by 4ô tall panels, with one panel made of 3.8cm (1.5ò) stretch mesh (monofilament) and the other panel made of 7.6cm (3ò) stretch mesh (monofilament). Fish captured with all of the aforementioned gears were identified, measured, counted, and released alive whenever possible.

In May and October, oysters were monitored in Ninigret Pond following 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 boxes. All material was then returned to the sampling location so as not to disturb the reef.

Site selection and experimental design for the second FHE reef

Quonochontaug Pond in Charlestown was chosen for the second round of oyster reef construction. There is a pond-wide oyster harvest moratorium in Quonochontaug Pond, allowing more potential sites to be considered for siting the experimental FHE plots compared to Ninigret Pond. Three study sites were chosen after taking into account TNCôs Oyster Habitat Suitability Index, depth, subaqueous soil types, user conflicts, and ease of access (Figures 4 & 5). All three study sites are located within large boulder fields consisting of Napatree sand and in close proximity to RI DEM Coastal Pond Juvenile Finfish Survey stations (conducted as part of F-61-R-23, Job #3; stations are shown in Figure 1), which will contribute to the post-enhancement monitoring of the FHE reefs.

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 includes four distinct treatments. The goal is to identify whether specific genetic lines of oysters contain desirable traits for both fish habitat and reef longevity, such as disease resistance and high fecundity. To evaluate this we are using two ówildô strains of oysters, spawned from adults collected from existing populations that will be compared against a commercial strain of spat (purchased from Aquaculture Research Corporation in Dennis, Massachusetts) used in the FHE reefs in Ninigret Pond during 2015. In summary, at each study site there will be three reefs, each seeded with one of the lines of oyster spat, and a bare control plot. The total number of experimental plots will be 12, the same as Ninigret Pond, but there will be fewer replicates (three rather than four).

Seed-on-shell preparation

In early spring 2016, 300 oyster shell bags (approximately 5.6yd^3) were prepared to be sent to the hatchery for juvenile oyster settlement. Oysters from Narrow River and Green Hill Pond were chosen to create the wild strain of spat, since these locations have some of the only persistent natural reefs in Rhode Island. In May and June, adult oysters were collected from Green Hill Pond and Narrow River and transported to Roger Williams University (RWU) in Bristol, Rhode Island, to condition for spawning. The shell bags were also transported to RWU to provide a substrate for oyster larvae settlement post spawn. Staff at the RWU hatchery spawned the adult wild oysters, along with adults from ARC, and then maintained the newly settled recruits in separate outdoor tanks. On July 11 and July 14, DFW and TNC staff retrieved the oyster shell bags from RWU and delivered them to Jim Arnoux, an aquaculturist with a lease in Quonochontaug Pond, to grow out the seed on shell until late November. Seed on shell was then removed from Mr. Arnouxôs lease, placed in aquaculture grow-out cage, and moved to a winter storage location on the eastern end of Quonochontaug Pond. The cages are in 2-3m of water and each genetic line was kept separate throughout the transfer process. The juvenile oysters will stay in the cages over the winter until the reefs are built in the spring (i.e. once the required permits are obtained).

Reef Construction

Permits for the Quonochontaug reefs were submitted to the Coastal Resources Management Council (CRMC) in June 2016. In late September, the CRMC received a letter of objection from several homeowners on the pond. A CRMC public hearing is scheduled for February 27, 2017 to review and this proposed work. Thus, reef construction has been placed on hold until such conflicts can be resolved with tentative construction now scheduled for mid-May.

Results

Year-1 Post-enhancement monitoring in Ninigret Pond

Sampling occurred monthly from May through October, which is more frequent than in 2015. In 2015, gillnets with only a single panel of 7.6cm (3ò) stretch mesh (poly-cotton) were used and menhaden was the most abundant fish species. In 2016, two 15ft. panels, one panel made of 3.8cm (1.5ò) stretch mesh (monofilament) and the other panel made of 7.6cm (3ò) stretch mesh (monofilament) were used and captured a over 400 animals from 18 different species (Tables 2-5). The most abundant species collected was blue crab, followed by menhaden. Most of these animals were caught in control plots. The traps deployed in 2016 were identical to those used in 2015. This year, eleven different species were caught in eel pots, the most abundant being black sea bass. Minnow traps collected 12 different species, with grass shrimp and rainwater killifish being the most plentiful. Pooling the trap data, just over half of the individuals collected were fishes. Several American eels were collected in eel pots in 2015, but no eels were caught in 2016. Overall, a qualitative assessment appears to show that more fish species were observed at FHE reefs during the post-enhancement monitoring (i.e., after reef construction) compared with the pre-enhancement (i.e., pre-enhancement) baseline; however, additional data will be needed to properly evaluate the successfulness of these FHE reefs.

Year-1 FHE Reef Habitat Monitoring in Ninigret Pond

Oyster monitoring in the spring (May) and fall (October) showed high survival rate of juvenile oysters across all seeded reefs. An estimate based on comparing the ratio of live to recently dead oysters suggests a mean survival rate of oysters one year post-enhancement to be about 91.6% across all sites. The mean oyster length across seeded reefs during the fall sampling was 46.9mm (Figure 6). Only one site (1U) revealed recruitment of juvenile oysters; however, it was at a negligible rate. Overall, the health of the FHE reefs in Ninigret was good, with excellent survival (91.6%) of juvenile oysters.

Pre-enhancement monitoring in Quonochontaug Pond

The baseline sampling in Quonochontaug Pond was consistent with the post-enhancement sampling in Ninigret, except sampling did not begin until June of 2016. Monthly fish trap sampling took place from June through October. Similar to Ninigret, black sea bass was the most plentiful species caught in eel pots and grass shrimp was the most abundant species caught in minnow traps. Gillnet sampling also occurred monthly but was not completed in October due to inclement weather. Twenty-two different species were found in gillnets, the most abundant being menhaden. Almost 40% of the individuals collected in gillnets were found in Site 2 (Figure 5).

Discussion

Aspects of work for 2017 and thereafter

The permit applications for reef construction in Quonochontaug Pond will be presented to the CRMC Council for decision at a meeting scheduled February 28, 2017. If the permit applications are approved, we will begin planning the logistics for reef construction. We're optimistic that the permits will be approved and we'll begin construction of the FHE reefs on May 8, 2017.

In addition to FHE reef construction in 2017, we plan to conduct Year-2 of post-enhancement monthly fish monitoring on the FHE reefs in Ninigret Pond in May and continue until October. As mentioned earlier, we plan to add a video monitoring component to this work. Reef habitat monitoring to assess reef and oyster health will be conducted in May and October in Ninigret Pond. In Quonochontaug Pond we plan to begin Year-1 of post-enhancement monthly fish monitoring on the FHE reefs (estimated to be constructed in May 2017) beginning in June and continuing until October. Reef habitat monitoring to assess reef and oyster health will be conducted in October in Quonochontaug Pond.

We will continue determining the location and design for the third FHE reefs. Currently, we are reviewing Winnapaug Pond and Pt. Judith Pond as potential locations. Further analysis will consider the suitability of a site for oyster restoration work, including the substrate, water quality, salinity, status of previous oyster restoration work, knowledge of the current marine resources present, as well as the general quality of and type of fish habitat present, and connectivity to other habitats. We will also solicit of feedback from the RI Shellfish Restoration

Working Group. Once potential sites are identified, we will then groundtruth the locations. Once the third FHE reef locations are finalized, we will begin pre-enhancement monthly fish monitoring, which will begin in May of 2018 and continue until October 2018. The TNC shell recycling program will continue in 2017, and weathered shell from the program will be used to construct future reefs.

Conclusion

With exception for the delay in permitting, planning and field work for 2016 went well. We completed all of the Year-1 of post-enhancement fish and habitat (reef) monitoring of FHE reefs sites in Ninigret Pond, determined the locations and experimental design of reef habitats to be constructed in Quonochontaug Pond, submitted the required permit applications for the proposed FHE work in Quonochontaug Pond, conducted pre-enhancement fish and habitat monitoring in Quonochontaug Pond at the proposed FHE sites, installed salinity and temperature data loggers at FHE sites in Ninigret and Quonochontaug Ponds, prepared the juvenile oysters (i.e., seed-on-shell) that will be used to populate the FHE reef construction in Quonochontaug Pond, and began planning for the 2017 and 2018 seasons, including discussions regarding the siting of the third series of FHE reefs for 2018.

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 (i.e., pre-enhancement) baseline; however, additional data will be needed to properly evaluate the successfulness of these FHE reefs. Reef habitat monitoring showed the overall health of the FHE reefs in Ninigret Pond was good, with excellent survival (91.6%) of juvenile oysters on the FHE reefs. We anticipate obtaining the required permits for the FHE reefs to be created in Quonochontaug Pond in February of 2017 and construction of these reefs is expected to begin in May 2017. 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 also appear to have underestimated the level of staffing required to complete the fish and habitat monitoring, as well as the cost of these conducting these surveys and FHE reef construction in general. As a stop-gap, additional assistance is being provided by a DFW contract employee, as well as DFW and TNC seasonal staff. These aspects will be assessed during 2017 and revisions to the grant will be requested, if determined necessary.

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Table 1. Summary of project specific activities, timelines, and status through December 2016.

Component	Activity	Timeline Proposed in original grant	Site 1: Ninigret Pond	Site 2: Quonochontaug Pond
I. Site Identification & Permits	Evaluate pond & sanctuary suitability	May-14	Completed	Completed
	Incorporate fisheries data into suitability models	June-14	Completed	Completed
	Identify reef & control sites	June-14	Completed	Completed
	Complete baseline surveys	Annually, June	Completed	Completed
	Submit permit applications	Annually, July	Completed	Completed
II. Oyster Reef Construction	Host volunteer workdays to bag shell	Annually, May	Completed	Completed
	Secure contracts for reef construction	Annually, May	Completed	Completed
	Deliver shell bags to hatchery	Annually, July	Completed	Completed
	Grow seed in cages prior to deployment	Annually, July to September	Completed	Completed. Seed is being overwintered until reefs are constructed (see next activity)
	Delineate, construct & seed reefs	Annually, October	Completed	Delayed until permits are obtained. Revised timeline: May 2017
III. Monitoring, Evaluation, & Analysis	Post-enhancement bathymetry & elevation	Annually, *post-enhancement*	On going	On Hold until reef creation
	Evaluate reef stability & succession	Seasonally, post-enhancement	On going	On Hold until reef creation
	Evaluate fish & invert community structure	Seasonally, post-enhancement	On going	On Hold until reef creation
IV. Submit Reports	Analyze data & submit reports	December 2014 - 2018	Completed for 2015	Completed for 2016

Table 2: Summary of presence (shown as ñ1ò) and absence (shown as ñ0ò) of species caught by month in Ninigret Pond, summed across gear types. Species of interest are highlighted in yellow.

Species	May	June	July	Aug	Sept	Oct	Total
American shad	1	0	0	0	0	0	1
Black sea bass	0	0	1	0	1	0	2
Blue crab	1	1	1	1	1	1	6
Bluefish	0	0	0	1	1	0	2
Butterfish	1	0	0	0	1	1	3
Cunner	0	0	1	0	0	1	2
Grass shrimp	0	1	1	1	1	1	5
Horseshoe crab	1	1	0	0	0	0	2
Menhaden	1	0	1	1	1	1	5
Mud crab	0	0	1	0	1	1	3
Mummichog	0	1	1	1	1	1	5
N. pipefish	0	0	1	0	0	0	1
Naked goby	0	1	0	0	0	1	2
Needlefish	0	1	0	0	0	1	2
Oyster toadfish	1	0	0	1	0	0	2
Rainwater killifish	0	1	1	1	1	1	5
Sand shrimp	0	0	1	0	0	0	1
Scup	0	0	0	0	1	1	2
Sea robin	0	0	0	1	1	1	3
Sennet	0	0	0	0	0	1	1
Spider crab	1	1	0	1	1	1	5
Spot	0	0	0	1	0	0	1
Striped bass	1	1	1	1	0	1	5
Striped killifish	0	0	0	0	1	0	1
Summer flounder	0	0	1	1	0	0	2
Tautog	0	0	0	0	0	1	1
3-spine stickleback	1	1	0	0	0	0	2
White mullet	0	0	0	0	1	0	1
White perch	0	0	0	1	0	0	1
Total	9	10	12	13	14	16	74

Table 3: Summary of presence (shown as ñ1ò) and absence (shown as ñ0ò) of species caught by month in Quonochontaug Pond, summed across gear types. Species of interest are highlighted in yellow.

Species	June	July	Aug	Sept	Oct	Total
Banded rudderfish	0	1	0	0	0	1
Black sea bass	0	1	1	1	1	4
Blue crab	1	1	1	1	0	4
Bluefish	0	1	1	1	0	3
Croaker	0	1	0	0	0	1
Cunner	0	0	0	1	1	2
Grass shrimp	1	1	1	1	1	5
Green crab	1	1	0	1	1	4
Kingfish	0	0	1	0	0	1
Lady crab	1	1	1	1	1	5
Mantis shrimp	0	0	1	1	0	2
Menhaden	1	1	1	1	0	4
Mud crab	0	0	1	1	1	3
Mummichog	1	1	1	1	1	5
N. Kingfish	0	0	0	1	0	1
Naked goby	1	0	0	1	1	3
Needlefish	0	0	1	0	0	1
Oyster toadfish	1	0	0	0	0	1
Pinfish	0	0	1	0	0	1
Pipefish	0	1	1	1	0	3
River herring	1	0	0	1	0	2
Sand shrimp	0	0	1	0	0	1
Sand tiger shark	0	1	0	0	0	1
Scup	0	1	1	1	0	3
Silverside	0	1	1	1	0	3
Spider crab	1	1	0	1	1	4
Spot	0	1	0	0	0	1
Striped bass	1	1	1	1	1	5
Striped killifish	0	0	0	0	1	1
Striped mullet	0	0	0	0	1	1
Summer flounder	1	0	0	0	0	1
Tautog	0	1	0	0	1	2
Weakfish	0	1	0	0	0	1
White mullet	0	0	1	1	0	2
White perch	0	0	1	0	0	1
Winter flounder	1	1	0	0	0	2
Total	13	20	19	20	13	85

Table 4: Summary of black sea bass caught per hour fished in minnow traps and eel pots at each sampling site.

Ninigret Pond										
Site	May	June	July	Aug.	Sept.	Oct.	Mean	Std. Dev	SE	Total
1C	0	0	0	0	0	0	0	0	0	0
1S	0	0	0	0	0.68	0	0.11	0.28	0.11	0.68
1U	0	0	0	0	1.07	0	0.18	0.44	0.18	1.07
2C	0	0	0	0	0.35	0	0.06	0.14	0.06	0.35
2S	0	0	0	0	4.07	0	0.68	1.66	0.68	4.07
2U	0	0	0	0	0.17	0	0.03	0.07	0.03	0.17
3C	0	0	0	0	0.15	0	0.03	0.06	0.03	0.15
3S	0	0	0	0	0.91	0	0.15	0.37	0.15	0.91
3U	0	0	0.18	0	0.60	0	0.13	0.24	0.10	0.79
4C	0	0	0	0	0.30	0	0.05	0.12	0.05	0.30
4S	0	0	0	0	0.15	0	0.03	0.06	0.03	0.15
4U	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0.02	0	0.70	0				
Std. Dev	0	0	0.05	0	1.11	0				
SE	0	0	0.02	0	0.32	0				
Total	0	0	0.18	0	8.46	0				
Quonochontaug Pond										
Site	May	June	July	Aug.	Sept.	Oct.	Mean	Std. Dev	SE	Total
1A	N/A	0	0	0	0	0	0	0	0	0
1B	N/A	0	0	0	0	0	0	0	0	0
1C	N/A	0	0	0	0	0	0	0	0	0
1D	N/A	0	0	0.17	0	0	0.03	0.07	0.03	0.17
2A	N/A	0	0	0.82	0.17	0	0.20	0.36	0.16	0.99
2B	N/A	0	0	0.33	0	0	0.07	0.15	0.07	0.33
2C	N/A	0	0	0.18	1.20	0	0.28	0.52	0.23	1.38
2D	N/A	0	0	0.18	1.77	0	0.39	0.78	0.35	1.95
3A	N/A	0	0	0.89	0.38	0	0.25	0.39	0.17	1.27
3B	N/A	0	0	1.05	2.12	0	0.63	0.95	0.42	3.16
3C	N/A	0	0	0.53	3.19	0	0.74	1.39	0.62	3.72
3D	N/A	0	0	0	0.74	0.33	0.21	0.33	0.15	1.07
Mean	N/A	0	0	0.35	0.80	0.03				
Std. Dev	N/A	0	0	0.38	1.06	0.09				
SE	N/A	0	0	0.11	0.31	0.03				
Total	N/A	0	0	4.14	9.57	0.33				

Table 5: Summary of scup caught per hour fished in gillnets at each sampling site.

Ninigret Pond										
Site	May	June	July	Aug.	Sept.	Oct.	Mean	Std. Dev	SE	Total
1C	0	0	0	0	0	0	0	0	0	0
1S	0	0	0	0	0	0	0	0	0	0
1U	0	0	0	0	0.16	0	0.03	0.06	0.03	0.16
2C	0	0	0	0	0	0	0	0	0	0
2S	0	0	0	0	0	0.08	0.01	0.03	0.01	0.08
2U	0	0	0	0	0	0	0	0	0	0
3C	0	0	0	0	0.08	0	0.01	0.03	0.01	0.08
3S	0	0	0	0	0.25	0	0.04	0.10	0.04	0.25
3U	0	0	0	0	0.27	0	0.04	0.11	0.04	0.27
4C	0	0	0	0	0.25	0.08	0.06	0.10	0.04	0.33
4S	0	0	0	0	0.26	0.08	0.06	0.10	0.04	0.34
4U	0	0	0	0	0.17	0.08	0.04	0.07	0.03	0.25
Mean	0	0	0	0	0.12	0.03				
Std. Dev	0	0	0	0	0.12	0.04				
SE	0	0	0	0	0.03	0.01				
Total	0	0	0	0	1.43	0.33				
Quonochontaug Pond										
Site	May	June	July	Aug.	Sept.	Oct.	Mean	Std. Dev	SE	Total
1A	N/A	0	0	0	0	0	0	0	0	0
1B	N/A	0	0	0	0	0	0	0	0	0
1C	N/A	0	0	0	0	0	0	0	0	0
1D	N/A	0	0	0	0	0	0	0	0	0
2A	N/A	0	0	0	0.15	0	0.04	0.08	0.04	0.15
2B	N/A	0	0	0	0.30	0	0.08	0.15	0.08	0.30
2C	N/A	0	0	0	0.14	0	0.04	0.07	0.04	0.14
2D	N/A	0	0	0	0	0	0	0	0	0
3A	N/A	0	0	0	0.07	0	0.01	0.03	0.01	0.07
3B	N/A	0	0	0	0	0	0	0	0	0
3C	N/A	0	0	0	0.22	0	0.04	0.10	0.04	0.22
3D	N/A	0	0	0	0.15	0	0.03	0.06	0.03	0.15
Mean	N/A	0	0	0	0.09	0				
Std. Dev	N/A	0	0	0	0.10	0				
SE	N/A	0	0	0	0.03	0				
Total	N/A	0	0	0	1.03	0				

Table 6: Water quality data from fish sampling days in Ninigret Pond during 2016.

Date	Site	Temp. (C)	Sal. (ppt)	DO (mg/L)	pH
5/12	3U	16.2	28.15	7.65	-
5/12	4S	16.4	28.17	7.82	-
6/20	4U	23.4	30.28	-	8.13
7/13	1S	24.7	30.65	4.64	8.06
7/13	1C	24.7	30.60	5.23	8.10
7/13	2S	24.7	30.56	5.10	7.80
7/13	2U	24.8	30.53	4.75	7.93

Table 7: Water quality data from fish sampling days in Quonochontaug Pond during 2016.

Date	Site	Temp. (C)	Sal. (ppt)	DO (mg/L)	pH
6/22	1	20.7	31.43	-	7.87
6/23	2	19.9	31.45	-	7.85
7/26	2	23.3	31.70	-	7.80
7/28	3	25.6	31.75	-	7.80

Figure 1. Coastal ponds located in Southern Rhode Island, as well as the Lower Pawcatuck River system. Red circles indicate sites sampled by the RI DEM Division of Fish and Wildlife Coastal Pond Juvenile Finfish Survey. The coastal ponds, which excludes the Lower Pawcatuck River, present potential areas for Fish Habitat Enhancement work under this project.

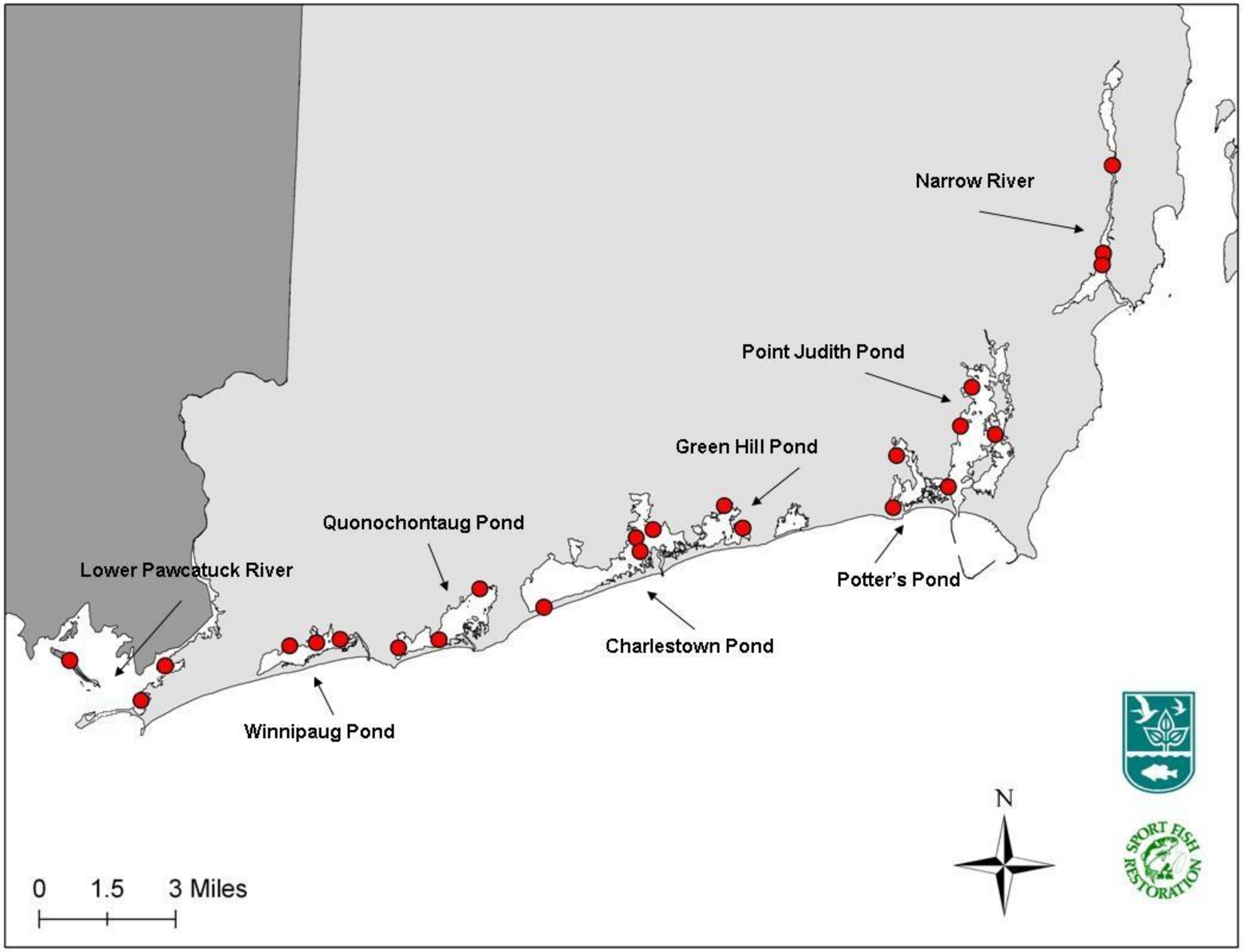
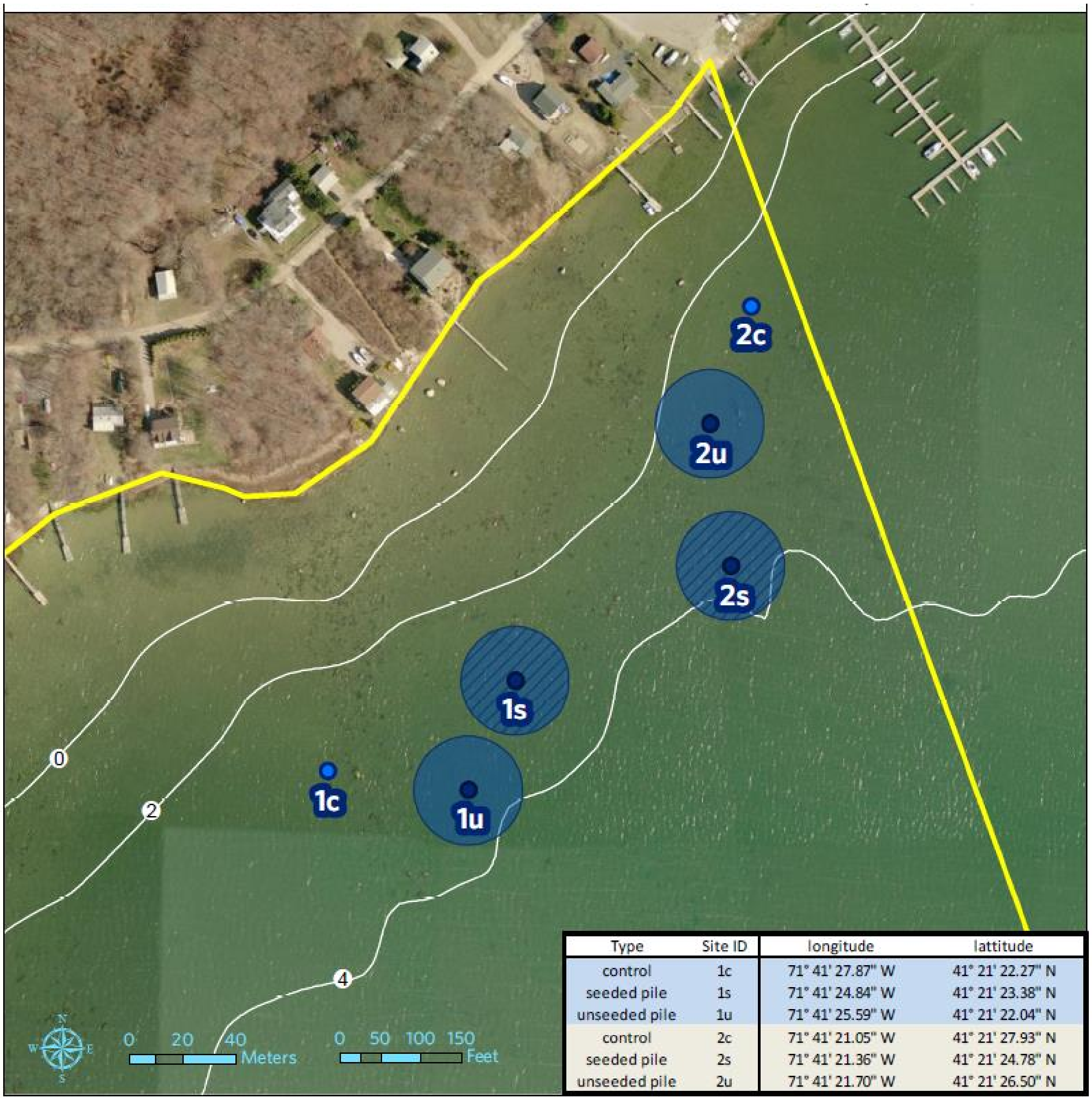
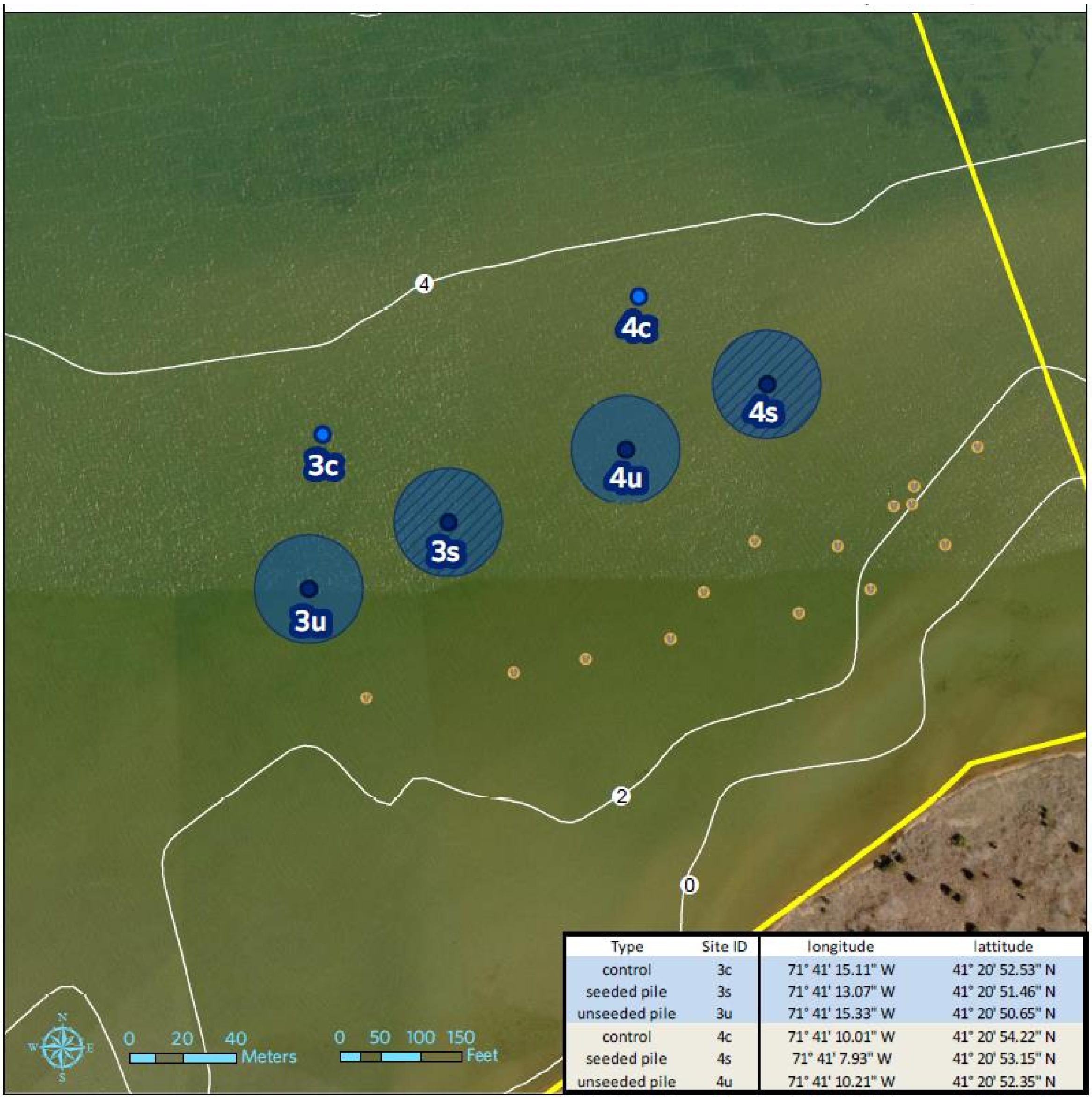


Figure 2. Fish Habitat Enhancement sites in the northern portion of Ninigret Pond. The RI Div. of Fish and Wildlife Marine Fishery management closure (i.e., Shellfish Spawner Sanctuary) is depicted by the yellow outline. Map produced by Kevin Ruddock.



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 Div. of Fish and Wildlife Marine Fishery 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.



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. Proposed configuration for Fish Habitat Enhancement sites (i.e., research plot #1), which contains experimental reefs (3) and control (1) in the western end of Quonochontaug Pond, Westerly, RI**.**

Figure 5. Proposed configuration for Fish Habitat Enhancement sites (i.e., research plot #2 and #3), which contain experimental reefs (3) and control (1) in each site located in the eastern end of Quonochontaug Pond, Charlestown, RI**.**

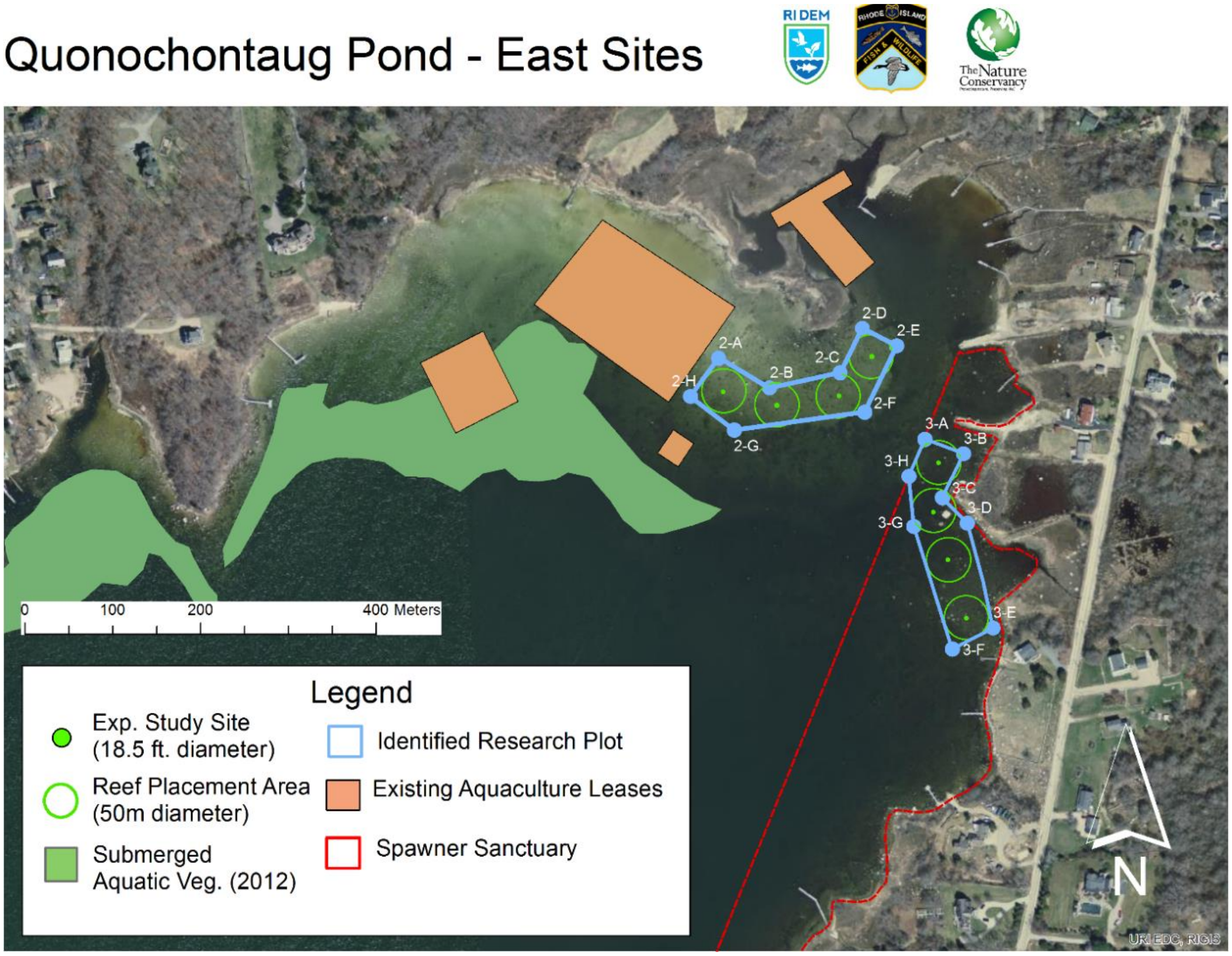


Figure 6. Histograms depicting live oysters length distribution grouped by 5mm bins for seeded reef in Ninigret Pond.

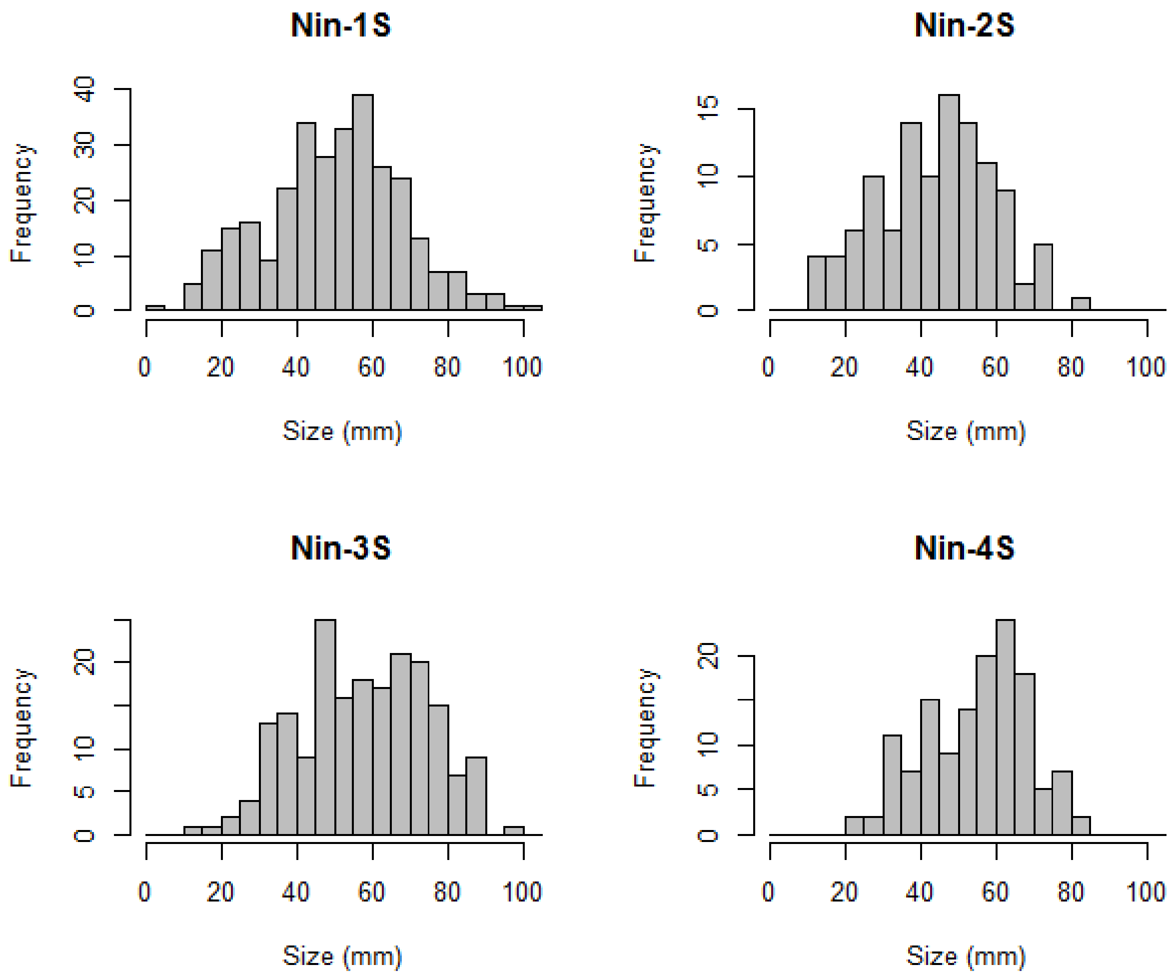


Figure 7. Photograph of DEM and TNC employees sampling gillnets for post-enhancement of reefs in Ninigret Pond.

Figure 8. Photograph of a seeded FHE reef in Ninigret Pond taken during FHE habitat monitoring to assess reef health.

Figure 9. Photograph of black sea bass caught in an eel pot during sampling during 2016.

Appendix I –

2016 Permit Applications for *investigating techniques to enhance degraded marine habitats to improve recreational fisheries*

PERMIT APPLICATION
REQUEST 2016

Proposed Work: Scientific research to assess if enhancing fish habitat by creating oyster reefs increases the growth and survival of fish populations

Water Body Name: Quonochontaug Pond

City/State/ Zip: Charlestown & Westerly, Rhode Island

Site Location: A research plot (Plot #1) will be established within the western portion of the current Shellfish Management Area of Quonochontaug Pond, Westerly, RI. The latitude and longitude for the corner points of the research plot are presented in Table 1 and Figures 1 & 2.

Applicant(s):

Rhode Island Department of Environmental Management
Division of Fish and Wildlife, Marine Fisheries Section
Fort Wetherill Marine Laboratory, 3 Fort Wetherill Road
Jamestown, Rhode Island 02835

Primary Investigators: Jason McNamee (Chief of Marine Resource Management), & Eric Schneider (Principal Marine Fisheries Biologist)
Contact: Eric.Schneider@dem.ri.gov ƀ Phone: 401-423-1933

RI Chapter of The Nature Conservancy (TNC) *
159 Waterman Street
Providence, RI 02906
Primary Investigators: Sara Coleman (Coastal Restoration Scientist)
*TNC is the co-applicant

Date Submitted: ____________

PERMIT APPLICATION
REQUEST 2016

Summary

The Rhode Island Department of Environmental Management (RI DEM) Division of Fish & Wildlife Marine Fisheries Section (RI DFW) in collaboration with The Nature Conservancy (TNC) is evaluating techniques to improve fisheries habitat in the coastal ponds along the south shore of RI. The scientific research outlined in this permit application is the pilot project of a multi-year, collaborative research program to determine if the practice of establishing oyster reefs in shallow coastal waters can be used as a tool to improve populations of recreationally important sportfish. Previous work in the mid-Atlantic has shown these techniques to be successful, resulting in a significant increase in growth and survival of recreationally important species (e.g. Grabowski et al. 2005); however, these techniques have not yet been evaluated in a temperate region of the Atlantic.

Specific to this permit application is scientific research to determine if construction of oyster reefs (using oyster and surf clam shell) can be used to improve growth and survival (i.e. productivity) of early-life stages of recreationally important fishes such as black sea bass, tautog, scup, summer flounder, and winter flounder. The experimental design is discussed in the Approach section below. This permit application is applicable to one of the three research plots in the pond. Specifically in this permit, we propose to create a research plot in the western end (Figure 1) of Quonochontaug Pond with an area of 2.92 acres, which is intended to designate an area where oyster restoration will occur while still allowing the harvest of other species. The entire pond is an established Shellfish Management Area and there is a pond-wide probation of oyster harvest until September 15, 2021, which will protect the oyster reefs and the fish habitat they provide. Within each study there will be 3 experimental reefs, seeded with oyster spat on shell, and 1 control site (Figure 1). Each reef has a footprint of ~ 269 ft^2 and is comprised of no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint in the research plot will be ~807 ft^2 (0.019 acres) and consist of a volume of shell estimated at no more than 45 y^3. Oyster seed-on-shell will be placed on these reefs according to the experimental design (See Approach; Figure 2). Fish and habitat survey work will be conducted at the 3 experimental reef sites as well as at the control site prior to reef creation to determine the baseline conditions. These sites will also be monitored for 3-years post reef creation to determine if the abundance, diversity, growth, and survival of fish at these reefs are different than at the control sites (i.e. does enhancing these sites by creating oyster reefs increase the productivity of recreationally important fish species) as well as the success of the oyster reef creation techniques.

We are requesting an Army Corps of Engineers (ACOE) Category II permit, RI DEM Water Quality Certification (WQC), and a Rhode Island Coastal Resource Management Council (CRMC) Letter of Authorization. We highlight that we are only returning shell to marine waters and seeding this shell with live oysters. We emphasize that this work is proposed within a duly promulgated RI DEM Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). The pond-wide probation of oyster harvest will protect the oyster reefs and the fish habitat they provide.

We also emphasize that this research is conducted by a public entity and serves a compelling public purpose by providing benefits to public trust resources (e.g. the Quonochontaug Pond ecosystem and local fish stocks). Since this work consists of only returning substrate (shell) to waters of the state and placing oyster seed in areas that historically supported oysters or is suitable for oyster reef construction, we expect the impacts will be beneficial, with no negative effects.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

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 Islandõs 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).

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 lagoons 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 have identified shellfish reefs as critical and essential fish habitat (EFH) for resident and transient finfish (Breitburg, 1999; Coen et al., 1999, ASMFC 2007). For example, Wells (1961) collected 303 different species of marine organisms 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 growth and survival of juvenile fishes such as the black sea bass (*Centropristis striata)*.

The growing recognition of the ecological and economic importance of complex benthic habitat has caused an increase in the efforts to construct oyster reefs (Coen and Luckenback, 2000; Brumbaugh et al., 2006). Although broadly accepted that habitat restoration and enhancement improves coastal ecosystems, it remains unclear if coastal habitat enhancement practices conducted here in RI would benefit the survival and growth of early life stages of finfish as in the mid-Atlantic.

Objectives

Specifically, the goal of the proposed research is to determine if oyster reef construction can be used to improve growth and survival (i.e., 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*). We will obtain this goal by addressing 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) Conduct pre-enhancement evaluation of the experimental sites and associated control sites to establish baselines

(3) Create and establish oyster reefs at the experimental sites, consistent with the experimental design; and

(4) Conduct post-enhancement evaluation of the experimental and control sites to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques.

Approach

Experimental Design

Although this research will be expanded to other coastal ponds in future years, the 2016 research will occur within a duly promulgated Shellfish Management Area (RI General Law § 20-3-4) and in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). Harvest of oysters is prohibited in such areas until at least September, 2021 to support this and other research/restoration. This prohibition on harvest allows for oyster propagation and growth and protects the oyster reefs and the fish habitat they provide. The experimental design for this research consists of 3 research plots, one (Area 1) in the western end (Figure 1) and a pair (Areas 2 & 3) in the eastern end of the Quonochontaug Pond. **This permit application pertains to only research plot #1. Approval for research plots #2 & 3 will be sought in a separate application.** Within each research plot there will be 3 experimental reefs, seeded with oysters, and 1 control site that will remain untouched and with no shell or alterations (Figures 1 and 2). By having study sites in the same geographical areas, we can ensure that these sites experience similar environmental conditions. In addition, by having research plots in areas with different types of fish habitat (boulder vs. barren sand), we can investigate how adjacent habitats influence the fishery response.

Site Selection and Characteristics

The DFW and TNC completed a site suitability analysis using available geospatial and fisheries data, including TNC oyster restoration suitability modeling results, marine sediment data, fish habitat data, and DFW seine survey data combined with visual underwater inspections to determine potential suitable locations for establishing oyster reef habitat in Quonochontaug Pond. From the 16 *potential* experimental research plots, we selected 3 plots that minimize impacts to other known uses occurring in these coastal ponds.

The experimental research plot (#1) relevant to this permit application (Figure 1) is located in a back cove, which is not typically used for navigation and does not have moorings. This area is suitable habitat for oyster restoration and is uniquely located adjacent to habitat that could be high quality fish habitat. However, based on preliminary observations, this area appears to be underutilized by targeted fish species. The sediment at this plot consists of Napatree sand (i.e. loamy marine and estuarine deposits over till).

Reef Construction

Shell used in this project will consist of disarticulated oyster and surf clam shell that has been seasoned for six months following Busheck et al. (2004) or steam-shucked and thus, possessing no viable biological material. Shell will be inspected by CRMC staff for residual tissue prior to use. Reef construction will occur as follows: Shell will be loaded into fish totes and transported by barge (16 x 16 ft^2 sectional) to each reef site. Shell will be deposited, by hand, along transects established by RI DFW and TNC. Each transect will mark the exact locations where shell will be deposited and the experimental reef will be created. Each reef will be round and have a footprint of ~ 269 ft^2 and comprised no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint pertinent to this application is ~807 ft^2 (0.019 acres) and volume of shell estimated at no more than 45 y^3 (Figure 2).

Research has shown that reef height, or vertical relief from the bottom, significantly affects oyster larval survival and after one growing season, larval densities can be an order of magnitude greater on high versus low vertical relief reefs (Brown, DS. 2013). At our experimental reef sites we aim to achieve sufficient relief to reduce impacts from predators and microalgae by deploying not more than 15 cubic yards of shell to create a round reef with an initial reef height of at least 18 inches and not more than 30 inches from the bottom. This ñbuiltò height accounts for future reef subsidence (up to 6ò at some sites), general compression, and wave scour that will likely reduce the final reef height by as much as 6-12 inches. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site. We anticipate the top of each reef will be at minimum 12 inches below the surface of the water and typically 12-30 inches below mean low water depending on the site and given tide. This is generally consistent with the amount of water over oyster reefs at restoration sites located in the western Spawner Sanctuary of Ninigret Pond where Fish Habitat Enhancement reefs were established in 2015 as well as various other restoration projects conducted by DEM-NRCS and DEM-TNC.

Construction will occur during early to mid-October 2016. Live oyster seed-on-shell at a density of at least 1,000 oysters/m^2 will placed on reefs between mid-October and early November. Live

oyster seed-on-shell will be contained in biodegradable mesh bags and placed on reefs as shown in Figure 4. These sites will be marked according to RI DFW and RI CRMC requirements.

Monitoring

Monitoring of fish habitat and assemblage will be conducted pre-reef construction at both experimental reef sites and adjacent control sites to establish baselines. Monitoring of fish habitat, fish assemblages, and oyster reefs will be conducted at both experimental reef sites and adjacent control sites (except controls will not have reefs, thus no reef monitoring) post-reef creation to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques. This monitoring will be conducted 3 times annually (May, July, and September) over 4 years (1-year pre- and 3-years post-reef creation) across sites. Pre-reef construction monitoring (i.e. baseline) begins in 2016; post-construction monitoring will begin in 2017 and continue until at least 2019.

To assess fish assemblages we will use a combination of standard fisheries sampling techniques, including deploying minnow pots, modified eel pots, and gill nets at each study plot. Gillnets will be 10m long, consisting of two different mesh sizes. We will also evaluate the use of video sampling to target the resident fishes on the reefs. To determine the health of the oyster reefs and evaluate the success of reef creation techniques, each reef will be monitored using techniques consistent with those outlined in the ñEssential Monitoringò requirements established by the Rhode Island Shellfish Technical Working Group and documented in the Monitoring Outline (pg 22) of the RI Oyster Restoration Minimum Monitoring Metric and Assessment Protocols (Griffin et al. 2012). We will assess whether recruitment monitoring using artificial spat collectors is needed based on other monitoring projects being conducted within the Shellfish Spawner Sanctuary.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design, monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

Potential Impacts

We do not anticipate any negative impacts from the proposed restoration work. As part of the site selection process and baseline monitoring, the research plot was surveyed using underwater video, snorkel, and SCUBA to evaluate benthic habitat and eelgrass presence. Based on our findings, the proposed reef locations are not located on eelgrass or areas mapped as containing eelgrass and will not impact eelgrass or benthic habitat. We note that any shellfish located within the reef footprint will be relocated prior to reef construction, thus there will be no impacts to current shellfish stocks located within the Shellfish Spawner Sanctuary. Furthermore, all reef sites are located within large boulder fields and not in areas that are navigable or used for navigation by local homeowners.

We emphasize that this research is conducted by a public entity and serves a compelling public purpose by providing benefits to public trust resources (e.g. the Quonochontaug ecosystem and local fish stocks). We also highlight that this work is proposed within a duly promulgated RI DEM Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). The current pond-wide probation of oyster harvest will protect the oyster reefs and the fish habitat they provide. Since this work consists of only returning substrate (shell) to waters of the state and placing oyster seed in areas that historically supported oysters or is suitable for oyster reef construction, we expect the impacts will be beneficial, with no negative effects.

Potential Limitations on Success

Challenges to the establishment of these oyster reefs and the associated enhanced habitat they provide for recreationally important fish species include natural variation in oyster larval supply and recruitment success, predation, and physical disturbance, including sediment burial, wave impact, and scouring. Unlike most research and habitat enhancement projects, we have the ability to assess the success of these reefs and conduct maintenance seeding in future years if deemed necessary and appropriate.

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Table 1. Coordinates for the corner points of research plot #1

Site ID	Longitude	Latitude
1-A	-71.74786	41.33642
1-B	-71.74741	41.33643
1-C	-71.74728	41.33547
1-D	-71.74800	41.33498
1-E	-71.74833	41.33519
1-F	-71.74777	41.33563

Figure 1. Proposed configuration for research plot #1 and associated experimental reefs (3) and control (1) in the western end of Quonochontaug Pond, Westerly, RI**.**

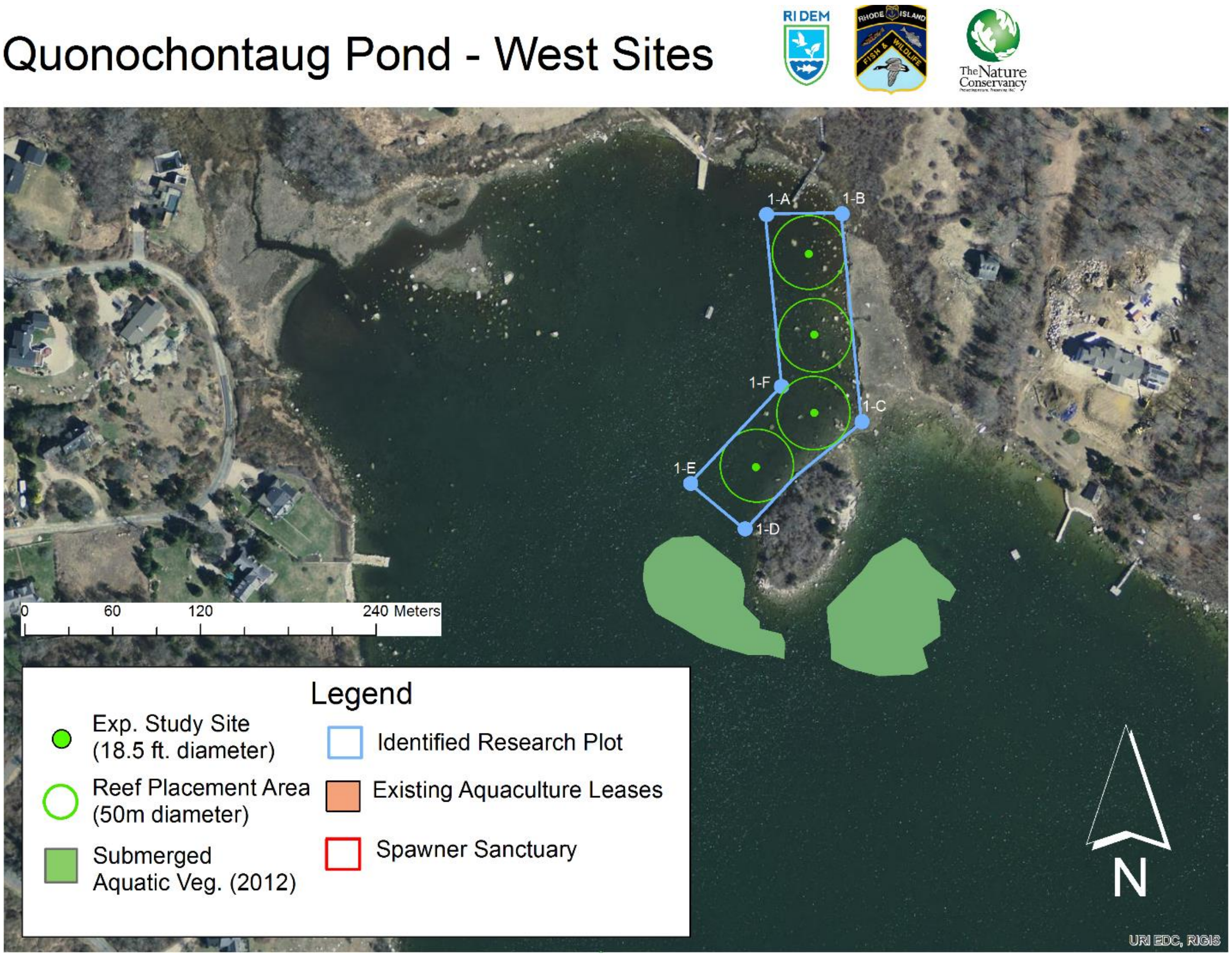
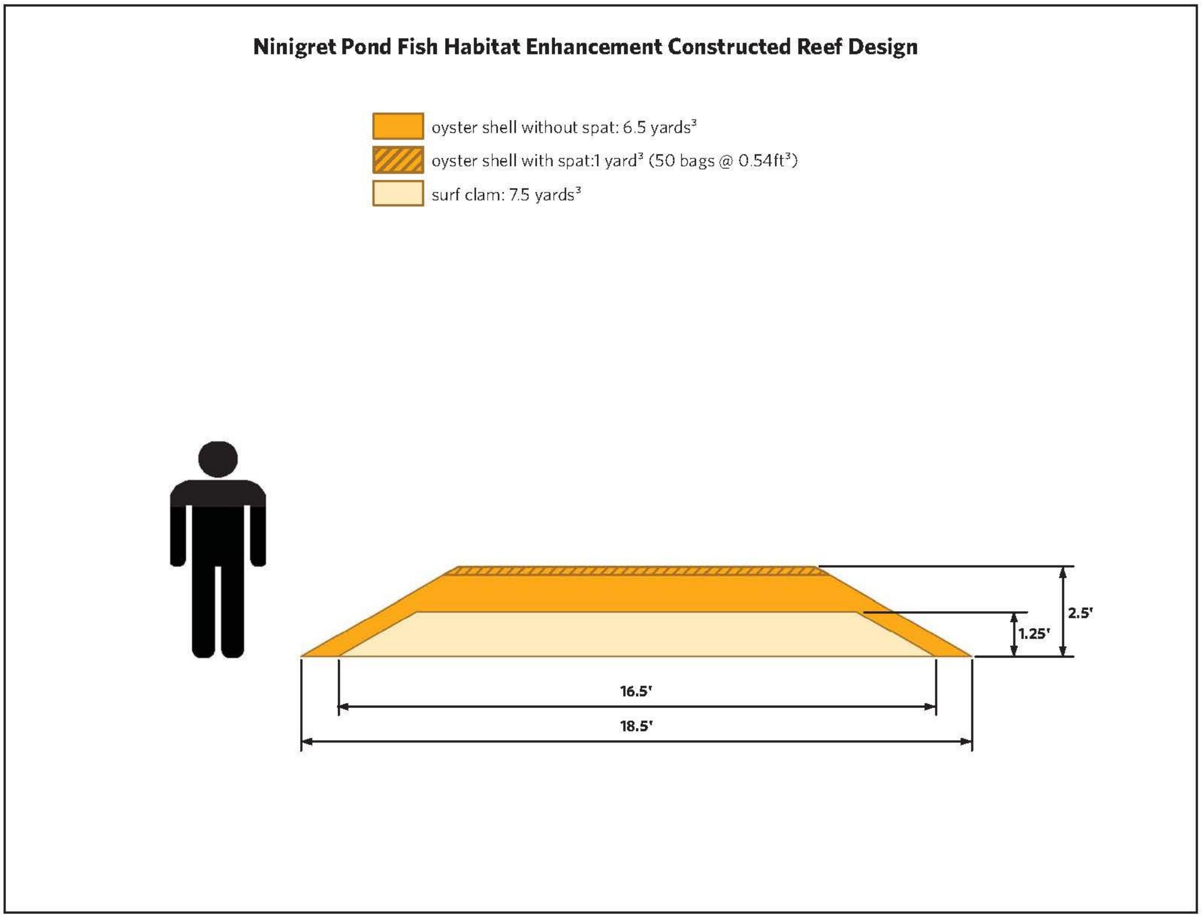


Figure 2. Side profile of an experimental reef showing the maximum ñbuiltò height immediately following reef creation. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site, as well as expected effects from reef subsidence. Each reef will be round extending 18.5 feet from the center, have a total footprint of ~ 269 ft^2, and comprised not more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell. We anticipate the top of each reef will be typically 12-30 inches below mean low water depending on the site and given tide.



--- End of Permit Application Request ---

PERMIT APPLICATION
REQUEST 2016

Proposed Work: Scientific research to assess if enhancing fish habitat by creating oyster reefs increases the growth and survival of fish populations

Water Body Name: Quonochontaug Pond

City/State/ Zip: Charlestown & Westerly, Rhode Island

Site Location: A research plot (Plot #2) will be established within the eastern portion of the current Shellfish Management Area of Quonochontaug Pond, Charlestown, RI. The latitude and longitude for the corner points of the research plot are presented in Table 1 and Figures 1 & 2.

Applicant(s):

Rhode Island Department of Environmental Management
Division of Fish and Wildlife, Marine Fisheries Section
Fort Wetherill Marine Laboratory, 3 Fort Wetherill Road
Jamestown, Rhode Island 02835

Primary Investigators: Jason McNamee (Chief of Marine Resource Management), & Eric Schneider (Principal Marine Fisheries Biologist)
Contact: Eric.Schneider@dem.ri.gov ƀ Phone: 401-423-1933

RI Chapter of The Nature Conservancy (TNC) *
159 Waterman Street
Providence, RI 02906
Primary Investigators: Sara Coleman (Coastal Restoration Scientist)
*TNC is the co-applicant

Date Submitted: _____________

PERMIT APPLICATION
REQUEST 2016

Summary

The Rhode Island Department of Environmental Management (RI DEM) Division of Fish & Wildlife Marine Fisheries Section (RI DFW) in collaboration with The Nature Conservancy (TNC) is evaluating techniques to improve fisheries habitat in the coastal ponds along the south shore of RI. The scientific research outlined in this permit application is the pilot project of a multi-year, collaborative research program to determine if the practice of establishing oyster reefs in shallow coastal waters can be used as a tool to improve populations of recreationally important sportfish. Previous work in the mid-Atlantic has shown these techniques to be successful, resulting in a significant increase in growth and survival of recreationally important species (e.g. Grabowski et al. 2005); however, these techniques have not yet been evaluated in a temperate region of the Atlantic.

Specific to this permit application is scientific research to determine if construction of oyster reefs (using oyster and surf clam shell) can be used to improve growth and survival (i.e. productivity) of early-life stages of recreationally important fishes such as black sea bass, tautog, scup, summer flounder, and winter flounder. The experimental design is discussed in the Approach section below. This permit application is applicable to one of the three research plots in the pond. Specifically in this permit, we propose to create a research plot in the eastern end (Figure 1) of Quonochontaug Pond with an area of 2.94 acres, which is intended to designate an area where oyster restoration will occur while still allowing the harvest of other species. The entire pond is an established Shellfish Management Area and there is a pond-wide probation of oyster harvest until September 15, 2021, which will protect the oyster reefs and the fish habitat they provide. Within each study there will be 3 experimental reefs, seeded with oyster spat on shell, and 1 control site (Figure 1). Each reef has a footprint of ~ 269 ft^2 and is comprised of no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint in the research plot will be ~807 ft^2 (0.019 acres) and consist of a volume of shell estimated at no more than 45 y^3. Oyster seed-on-shell will be placed on these reefs according to the experimental design (See Approach; Figure 2). Fish and habitat survey work will be conducted at the 3 experimental reef sites as well as at the control site prior to reef creation to determine the baseline conditions. These sites will also be monitored for 3-years post reef creation to determine if the abundance, diversity, growth, and survival of fish at these reefs are different than at the control sites (i.e. does enhancing these sites by creating oyster reefs increase the productivity of recreationally important fish species) as well as the success of the oyster reef creation techniques.

We are requesting an Army Corps of Engineers (ACOE) Category II permit, RI DEM Water Quality Certification (WQC), and a Rhode Island Coastal Resource Management Council (CRMC) Letter of Authorization. We highlight that we are only returning shell to marine waters and seeding this shell with live oysters. We emphasize that this work is proposed within a duly promulgated RI DEM Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). The pond-wide probation of oyster harvest will protect the oyster reefs and the fish habitat they provide.

We also emphasize that this research is conducted by a public entity and serves a compelling public purpose by providing benefits to public trust resources (e.g. the Quonochontaug Pond ecosystem and local fish stocks). Since this work consists of only returning substrate (shell) to waters of the state and placing oyster seed in areas that historically supported oysters or is suitable for oyster reef construction, we expect the impacts will be beneficial, with no negative effects.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

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 Islandô 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).

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 lagoons 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 have identified shellfish reefs as critical and essential fish habitat (EFH) for resident and transient finfish (Breitburg, 1999; Coen et al., 1999, ASMFC 2007). For example, Wells (1961) collected 303 different species of marine organisms 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 growth and survival of juvenile fishes such as the black sea bass (*Centropristis striata)*.

The growing recognition of the ecological and economic importance of complex benthic habitat has caused an increase in the efforts to construct oyster reefs (Coen and Luckenback, 2000; Brumbaugh et al., 2006). Although broadly accepted that habitat restoration and enhancement improves coastal ecosystems, it remains unclear if coastal habitat enhancement practices conducted here in RI would benefit the survival and growth of early life stages of finfish as in the mid-Atlantic.

Objectives

Specifically, the goal of the proposed research is to determine if oyster reef construction can be used to improve growth and survival (i.e., 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*). We will obtain this goal by addressing 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) Conduct pre-enhancement evaluation of the experimental sites and associated control sites to establish baselines

(3) Create and establish oyster reefs at the experimental sites, consistent with the experimental design; and

(4) Conduct post-enhancement evaluation of the experimental and control sites to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques.

Approach

Experimental Design

Although this research will be expanded to other coastal ponds in future years, the 2016 research will occur within a duly promulgated Shellfish Management Area (RI General Law § 20-3-4) and in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). Harvest of oysters is prohibited in such areas until at least September, 2021 to support this and other research/restoration. This prohibition on harvest allows for oyster propagation and growth and protects the oyster reefs and the fish habitat they provide. The experimental design for this research consists of 3 research plots, one (Area 1) in the western end and a pair (Areas 2 & 3) (Figure 1) in the eastern end of the Quonochontaug Pond. **This permit application pertains to only research plot #2. Approval for research plots #1 & 3 will be sought in a separate application.** Within each research plot there will be 3 experimental reefs, seeded with oysters, and 1 control site that will remain untouched and with no shell or alterations (Figures 1 and 2). By having study sites in the same geographical areas, we can ensure that these sites experience similar environmental conditions. In addition, by having research plots in areas with different types of fish habitat (boulder vs. barren sand), we can investigate how adjacent habitats influence the fishery response.

Site Selection and Characteristics
The DFW and TNC completed a site suitability analysis using available geospatial and fisheries data, including TNC oyster restoration suitability modeling results, marine sediment data, fish habitat data, and DFW seine survey data combined with visual underwater inspections to determine potential suitable locations for establishing oyster reef habitat in Quonochontaug Pond. From the 16 *potential* experimental research plots, we selected 3 plots that minimize impacts to other known uses occurring in these coastal ponds.

The experimental research plot (#2) relevant to this permit application (Figure 1) is located on a sandy-rocky shoal strewn with boulders and rocks. It is generally considered not navigable and does not have moorings. This area is suitable habitat for oyster restoration and is uniquely located adjacent to habitat that could be high quality fish habitat. However, based on preliminary observations, this area appears to be underutilized by targeted fish species. The sediment at this plot consists of Napatree sand (i.e. loamy marine and estuarine deposits over till).

Reef Construction
Shell used in this project will consist of disarticulated oyster and surf clam shell that has been seasoned for six months following Busheck et al. (2004) or steam-shucked and thus, possessing no viable biological material. Shell will be inspected by CRMC staff for residual tissue prior to use. Reef construction will occur as follows: Shell will be loaded into fish totes and transported by barge (16 x 16 ft^2 sectional) to each reef site. Shell will be deposited, by hand, along transects established by RI DFW and TNC. Each transect will mark the exact locations where shell will be deposited and the experimental reef will be created. Each reef will be round and have a footprint of ~ 269 ft^2 and comprised no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint pertinent to this application is ~807 ft^2 (0.019 acres) and volume of shell estimated at no more than 45 y^3 (Figure 2).

Research has shown that reef height, or vertical relief from the bottom, significantly affects oyster larval survival and after one growing season, larval densities can be an order of magnitude greater on high versus low vertical relief reefs (Brown, DS. 2013). At our experimental reef sites we aim to achieve sufficient relief to reduce impacts from predators and microalgae by deploying not more than 15 cubic yards of shell to create a round reef with an initial reef height of at least 18 inches and not more than 30 inches from the bottom. This ñbuiltò height accounts for future reef subsidence (up to 6ò at some sites), general compression, and wave scour that will likely reduce the final reef height by as much as 6-12 inches. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site. We anticipate the top of each reef will be at minimum 12 inches below the surface of the water and typically 12-30 inches below mean low water depending on the site and given tide. This is generally consistent with the amount of water over oyster reefs at restoration sites located in the western Spawner Sanctuary of Ninigret Pond where Fish Habitat Enhancement reefs were established in 2015 as well as various other restoration projects conducted by DEM-NRCS and DEM-TNC.

Construction will occur during early to mid-October 2016. Live oyster seed-on-shell at a density of at least 1,000 oysters/m^2 will placed on reefs between mid-October and early November. Live

oyster seed-on-shell will be contained in biodegradable mesh bags and placed on reefs as shown in Figure 4. These sites will be marked according to RI DFW and RI CRMC requirements.

Monitoring

Monitoring of fish habitat and assemblage will be conducted pre-reef construction at both experimental reef sites and adjacent control sites to establish baselines. Monitoring of fish habitat, fish assemblages, and oyster reefs will be conducted at both experimental reef sites and adjacent control sites (except controls will not have reefs, thus no reef monitoring) post-reef creation to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques. This monitoring will be conducted 3 times annually (May, July, and September) over 4 years (1-year pre- and 3-years post-reef creation) across sites. Pre-reef construction monitoring (i.e. baseline) begins in 2016; post-construction monitoring will begin in 2017 and continue until at least 2019.

To assess fish assemblages we will use a combination of standard fisheries sampling techniques, including deploying minnow pots, modified eel pots, and gill nets at each study plot. Gillnets will be 10m long, consisting of two different mesh sizes. We will also evaluate the use of video sampling to target the resident fishes on the reefs. To determine the health of the oyster reefs and evaluate the success of reef creation techniques, each reef will be monitored using techniques consistent with those outlined in the ñEssential Monitoringò requirements established by the Rhode Island Shellfish Technical Working Group and documented in the Monitoring Outline (pg 22) of the RI Oyster Restoration Minimum Monitoring Metric and Assessment Protocols (Griffin et al. 2012). We will assess whether recruitment monitoring using artificial spat collectors is needed based on other monitoring projects being conducted within the Shellfish Spawner Sanctuary.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design, monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

Potential Impacts

We do not anticipate any negative impacts from the proposed restoration work. As part of the site selection process and baseline monitoring, the research plot was surveyed using underwater video, snorkel, and SCUBA to evaluate benthic habitat and eelgrass presence. Based on our findings, the proposed reef locations are not located on eelgrass or areas mapped as containing eelgrass and will not impact eelgrass or benthic habitat. We note that any shellfish located within the reef footprint will be relocated prior to reef construction, thus there will be no impacts to current shellfish stocks located within the Shellfish Spawner Sanctuary. Furthermore, all reef sites are located within large boulder fields and not in areas that are navigable or used for navigation by local homeowners.

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Table 1. Coordinates for the corner points of research plot #2

Site ID	Longitude	Latitude
2-A	-71.71176	41.35025
2-B	-71.71125	41.35002
2-C	-71.71052	41.35013
2-D	-71.71029	41.35047
2-E	-71.70994	41.35034
2-F	-71.71027	41.34983
2-G	-71.71160	41.34969
2-H	-71.71206	41.34995

Figure 1. Proposed configuration for research plot #2 and associated experimental reefs (3) and control (1) in the eastern end of Quonochontaug Pond, Charlestown RI**.**

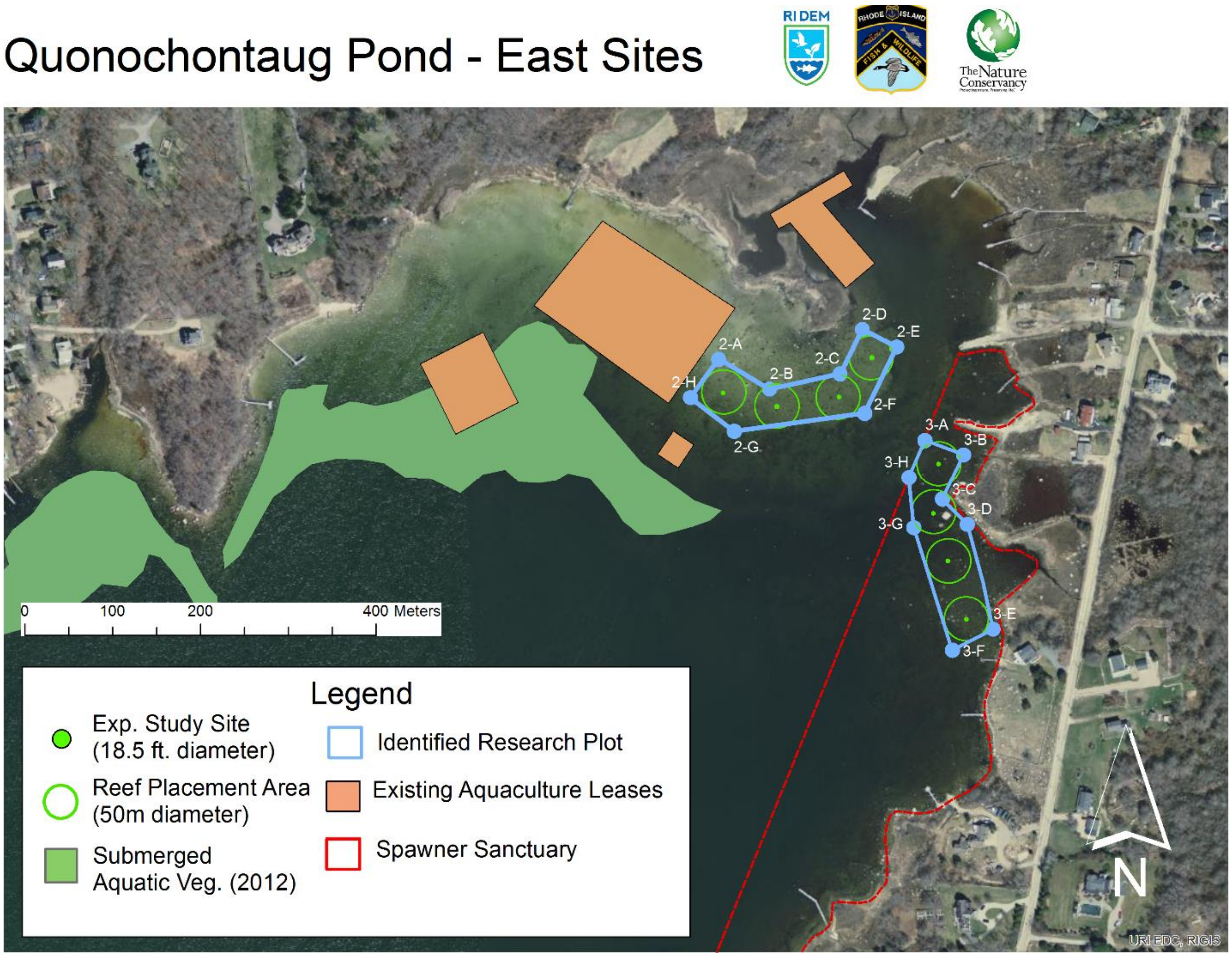
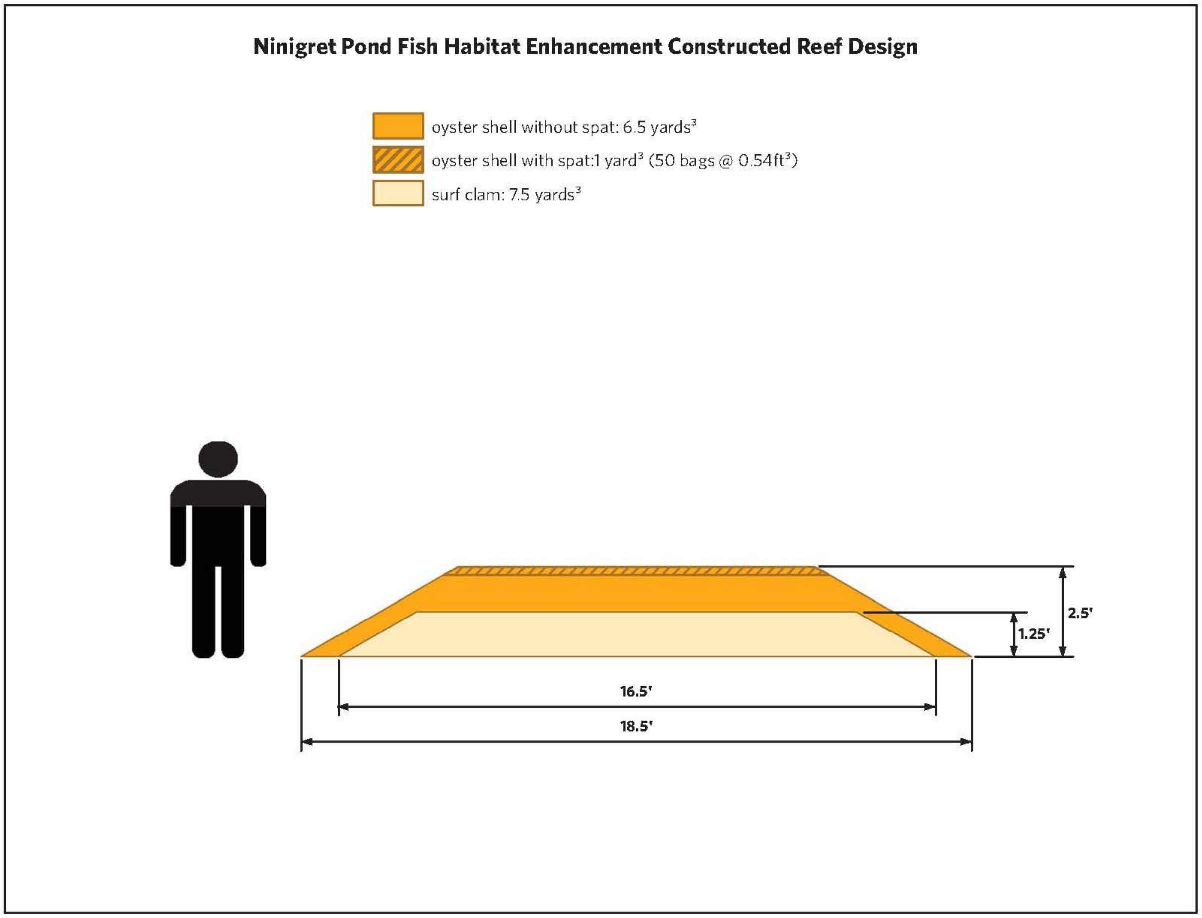


Figure 2. Side profile of an experimental reef showing the maximum ñbuiltò height immediately following reef creation. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site, as well as expected effects from reef subsidence. Each reef will be round extending 18.5 feet from the center, have a total footprint of ~ 269 ft^2, and comprised not more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell. We anticipate the top of each reef will be typically 12-30 inches below mean low water depending on the site and given tide.



--- End of Permit Application Request ---

PERMIT APPLICATION
REQUEST 2016

Proposed Work: Scientific research to assess if enhancing fish habitat by creating oyster reefs increases the growth and survival of fish populations

Water Body Name: Quonochontaug Pond

City/State/ Zip: Charlestown & Westerly, Rhode Island

Site Location: A research plot (Plot #3) will be established within the eastern portion of the current Shellfish Management Area of Quonochontaug Pond, Charlestown, RI. The latitude and longitude for the corner points of the research plot are presented in Table 1 and Figures 1 & 2.

Applicant(s):

Rhode Island Department of Environmental Management
Division of Fish and Wildlife, Marine Fisheries Section
Fort Wetherill Marine Laboratory, 3 Fort Wetherill Road
Jamestown, Rhode Island 02835

Primary Investigators: Jason McNamee (Chief of Marine Resource Management), & Eric Schneider (Principal Marine Fisheries Biologist)
Contact: Eric.Schneider@dem.ri.gov ƀ Phone: 401-423-1933

RI Chapter of The Nature Conservancy (TNC) *
159 Waterman Street
Providence, RI 02906
Primary Investigators: Sara Coleman (Coastal Restoration Scientist)
*TNC is the co-applicant

Date Submitted: ____________

PERMIT APPLICATION
REQUEST 2016

Summary

The Rhode Island Department of Environmental Management (RI DEM) Division of Fish & Wildlife Marine Fisheries Section (RI DFW) in collaboration with The Nature Conservancy (TNC) is evaluating techniques to improve fisheries habitat in the coastal ponds along the south shore of RI. The scientific research outlined in this permit application is the pilot project of a multi-year, collaborative research program to determine if the practice of establishing oyster reefs in shallow coastal waters can be used as a tool to improve populations of recreationally important sportfish. Previous work in the mid-Atlantic has shown these techniques to be successful, resulting in a significant increase in growth and survival of recreationally important species (e.g. Grabowski et al. 2005); however, these techniques have not yet been evaluated in a temperate region of the Atlantic.

Specific to this permit application is scientific research to determine if construction of oyster reefs (using oyster and surf clam shell) can be used to improve growth and survival (i.e. productivity) of early-life stages of recreationally important fishes such as black sea bass, tautog, scup, summer flounder, and winter flounder. The experimental design is discussed in the Approach section below. This permit application is applicable to one of the three research plots in the pond. Specifically in this permit, we propose to create a research plot in the eastern end (Figure 1) of Quonochontaug Pond with an area of 2.95 acres, which is intended to designate an area where oyster restoration will occur while still allowing the harvest of other species. The entire pond is an established Shellfish Management Area and there is a pond-wide probation of oyster harvest until September 15, 2021, which will protect the oyster reefs and the fish habitat they provide. Within each study there will be 3 experimental reefs, seeded with oyster spat on shell, and 1 control site (Figure 1). Each reef has a footprint of ~ 269 ft^2 and is comprised of no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint in the research plot will be ~807 ft^2 (0.019 acres) and consist of a volume of shell estimated at no more than 45 y^3. Oyster seed-on-shell will be placed on these reefs according to the experimental design (See Approach; Figure 2). Fish and habitat survey work will be conducted at the 3 experimental reef sites as well as at the control site prior to reef creation to determine the baseline conditions. These sites will also be monitored for 3-years post reef creation to determine if the abundance, diversity, growth, and survival of fish at these reefs are different than at the control sites (i.e. does enhancing these sites by creating oyster reefs increase the productivity of recreationally important fish species) as well as the success of the oyster reef creation techniques.

We are requesting an Army Corps of Engineers (ACOE) Category II permit, RI DEM Water Quality Certification (WQC), and a Rhode Island Coastal Resource Management Council (CRMC) Letter of Authorization. We highlight that we are only returning shell to marine waters and seeding this shell with live oysters. We emphasize that this work is proposed within a duly promulgated RI DEM Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug

Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). The pond-wide probation of oyster harvest will protect the oyster reefs and the fish habitat they provide.

We also emphasize that this research is conducted by a public entity and serves a compelling public purpose by providing benefits to public trust resources (e.g. the Quonochontaug Pond ecosystem and local fish stocks). Since this work consists of only returning substrate (shell) to waters of the state and placing oyster seed in areas that historically supported oysters or suitable for oyster reef construction, we expect the impacts will be beneficial, with no negative effects.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

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 Islandôs 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).

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 lagoons 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 have identified shellfish reefs as critical and essential fish habitat (EFH) for resident and transient finfish (Breitburg, 1999; Coen et al., 1999, ASMFC 2007). For example, Wells (1961) collected 303 different species of marine organisms 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 growth and survival of juvenile fishes such as the black sea bass (*Centropristis striata)*.

The growing recognition of the ecological and economic importance of complex benthic habitat has caused an increase in the efforts to construct oyster reefs (Coen and Luckenback, 2000; Brumbaugh et al., 2006). Although broadly accepted that habitat restoration and enhancement improves coastal ecosystems, it remains unclear if coastal habitat enhancement practices conducted here in RI would benefit the survival and growth of early life stages of finfish as in the mid-Atlantic.

Objectives

Specifically, the goal of the proposed research is to determine if oyster reef construction can be used to improve growth and survival (i.e., 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*). We will obtain this goal by addressing 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) Conduct pre-enhancement evaluation of the experimental sites and associated control sites to establish baselines

(3) Create and establish oyster reefs at the experimental sites, consistent with the experimental design; and

(4) Conduct post-enhancement evaluation of the experimental and control sites to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques.

Approach

Experimental Design

Although this research will be expanded to other coastal ponds in future years, the 2016 research will occur within a duly promulgated Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). Harvest of oysters is prohibited in such areas until at least September, 2021 to support this and other research/restoration. This prohibition on harvest allows for oyster propagation and growth and protects the oyster reefs and the fish habitat they provide. The experimental design for this research consists of 3 research plots, one (Area 1) in the western end and a pair (Areas 2 & 3) (Figure 1) in the eastern end of the Quonochontaug Pond. **This permit application pertains to only research plot #3. Approval for research plots # 1 & 2 will be sought in a separate application.** Within each research plot there will be 3 experimental reefs, seeded with oysters, and 1 control site that will remain untouched and with no shell or alterations (Figures 1 and 2). By having study sites in the same geographical areas, we can ensure that these sites experience similar environmental conditions. In addition, by having research plots in areas with different types of fish habitat (boulder vs. barren sand), we can investigate how adjacent habitats influence the fishery response.

Site Selection and Characteristics

The DFW and TNC completed a site suitability analysis using available geospatial and fisheries data, including TNC oyster restoration suitability modeling results, marine sediment data, fish habitat data, and DFW seine survey data combined with visual underwater inspections to determine potential suitable locations for establishing oyster reef habitat in Quonochontaug Pond. From the 16 *potential* experimental research plots, we selected 3 plots that minimize impacts to other known uses occurring in these coastal ponds.

The experimental research plot (#3) relevant to this permit application (Figure 1) is located in a boulder field that is typically not traversed by boat traffic and contains no moorings. This area is suitable habitat for oyster restoration and is uniquely located adjacent to habitat that could be high quality fish habitat. However, based on preliminary observations, this area appears to be underutilized by targeted fish species. The sediment at this plot consists of Napatree sand (i.e. loamy marine and estuarine deposits over till).

Reef Construction

Shell used in this project will consist of disarticulated oyster and surf clam shell that has been seasoned for six months following Busheck et al. (2004) or steam-shucked and thus, possessing no viable biological material. Shell will be inspected by CRMC staff for residual tissue prior to use. Reef construction will occur as follows: Shell will be loaded into fish totes and transported by barge (16 x 16 ft^2 sectional) to each reef site. Shell will be deposited, by hand, along transects established by RI DFW and TNC. Each transect will mark the exact locations where shell will be deposited and the experimental reef will be created. Each reef will be round and have a footprint of ~ 269 ft^2 and comprised no more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell (Table 1, Figure 2). The total oyster reef footprint pertinent to this application is ~807 ft^2 (0.019 acres) and volume of shell estimated at no more than 45 y^3 (Figure 2).

Research has shown that reef height, or vertical relief from the bottom, significantly affects oyster larval survival and after one growing season, larval densities can be an order of magnitude greater on high versus low vertical relief reefs (Brown, DS. 2013). At our experimental reef sites we aim to achieve sufficient relief to reduce impacts from predators and microalgae by deploying not more than 15 cubic yards of shell to create a round reef with an initial reef height of at least 18 inches and not more than 30 inches from the bottom. This ñbuiltò height accounts for future reef subsidence (up to 6ò at some sites), general compression, and wave scour that will likely reduce the final reef height by as much as 6-12 inches. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site. We anticipate the top of each reef will be at minimum 12 inches below the surface of the water and typically 12-30 inches below mean low water depending on the site and given tide. This is generally consistent with the amount of water over oyster reefs at restoration sites located in the western Spawner Sanctuary of Ninigret Pond where Fish Habitat Enhancement reefs were established in 2015 as well as various other restoration projects conducted by DEM-NRCS and DEM-TNC.

Construction will occur during early to mid-October 2016. Live oyster seed-on-shell at a density of at least 1,000 oysters/m^2 will placed on reefs between mid-October and early November. Live

oyster seed-on-shell will be contained in biodegradable mesh bags and placed on reefs as shown in Figure 4. These sites will be marked according to RI DFW and RI CRMC requirements.

Monitoring

Monitoring of fish habitat and assemblage will be conducted pre-reef construction at both experimental reef sites and adjacent control sites to establish baselines. Monitoring of fish habitat, fish assemblages, and oyster reefs will be conducted at both experimental reef sites and adjacent control sites (except controls will not have reefs, thus no reef monitoring) post-reef creation to determine if there are changes in fish productivity, such as changes in recruitment and survival of early life stages of recreationally important fish, and the effectiveness of the oyster reef construction techniques. This monitoring will be conducted 3 times annually (May, July, and September) over 4 years (1-year pre- and 3-years post-reef creation) across sites. Pre-reef construction monitoring (i.e. baseline) begins in 2016; post-construction monitoring will begin in 2017 and continue until at least 2019.

To assess fish assemblages we will use a combination of standard fisheries sampling techniques, including deploying minnow pots, modified eel pots, and gill nets at each study plot. Gillnets will be 10m long, consisting of two different mesh sizes. We will also evaluate the use of video sampling to target the resident fishes on the reefs. To determine the health of the oyster reefs and evaluate the success of reef creation techniques, each reef will be monitored using techniques consistent with those outlined in the ñEssential Monitoringò requirements established by the Rhode Island Shellfish Technical Working Group and documented in the Monitoring Outline (pg 22) of the RI Oyster Restoration Minimum Monitoring Metric and Assessment Protocols (Griffin et al. 2012). We will assess whether recruitment monitoring using artificial spat collectors is needed based on other monitoring projects being conducted within the Shellfish Spawner Sanctuary.

It is important to recognize that in addition to expertise provided by RI DFW and TNC, Dr. Jon Grabowski of Northeastern University is assisting with aspects including the experimental design, monitoring design, and subsequent analyses of the data. We note that RI DFW and TNC have pooled their financial resources to help fund this work, with additional funding provided by a grant awarded to the RI DFW under the US FWS Sportfish Restoration Program.

Potential Impacts

We do not anticipate any negative impacts from the proposed restoration work. As part of the site selection process and baseline monitoring, the research plot was surveyed using underwater video, snorkel, and SCUBA to evaluate benthic habitat and eelgrass presence. Based on our findings, the proposed reef locations are not located on eelgrass or areas mapped as containing eelgrass and will not impact eelgrass or benthic habitat. We note that any shellfish located within the reef footprint will be relocated prior to reef construction, thus there will be no impacts to current shellfish stocks located within the Shellfish Spawner Sanctuary. Furthermore, all reef sites are located within large boulder fields and not in areas that are navigable or used for navigation by local homeowners.

We emphasize that this research is conducted by a public entity and serves a compelling public purpose by providing benefits to public trust resources (e.g. the Quonochontaug ecosystem and local fish stocks). We also highlight that this work is proposed within a duly promulgated RI DEM Shellfish Management Area (RI General Law § 20-3-4) in Quonochontaug Pond (RI DEM Marine Fisheries Regulations, Shellfish Section, 13.17.1). The current pond-wide probation of oyster harvest will protect the oyster reefs and the fish habitat they provide. Since this work consists of only returning substrate (shell) to waters of the state and placing oyster seed in areas that historically supported oysters or is suitable for oyster reef construction, we expect the impacts will be beneficial, with no negative effects.

Potential Limitations on Success

Challenges to the establishment of these oyster reefs and the associated enhanced habitat they provide for recreationally important fish species include natural variation in oyster larval supply and recruitment success, predation, and physical disturbance, including sediment burial, wave impact, and scouring. Unlike most research and habitat enhancement projects, we have the ability to assess the success of these reefs and conduct maintenance seeding in future years if deemed necessary and appropriate.

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Table 1. Coordinates for the corner points of research plot #3.

Site ID	Longitude	Latitude
3-A	-71.70965	41.34963
3-B	-71.70926	41.34951
3-C	-71.70947	41.34917
3-D	-71.70922	41.34898
3-E	-71.70896	41.34817
3-F	-71.70937	41.34801
3-G	-71.70977	41.34895
3-H	-71.70981	41.34934

Figure 1. Proposed configuration for research plot #3 and associated experimental reefs (3) and control (1) in the eastern end of Quonochontaug Pond, Charlestown, RI**.**

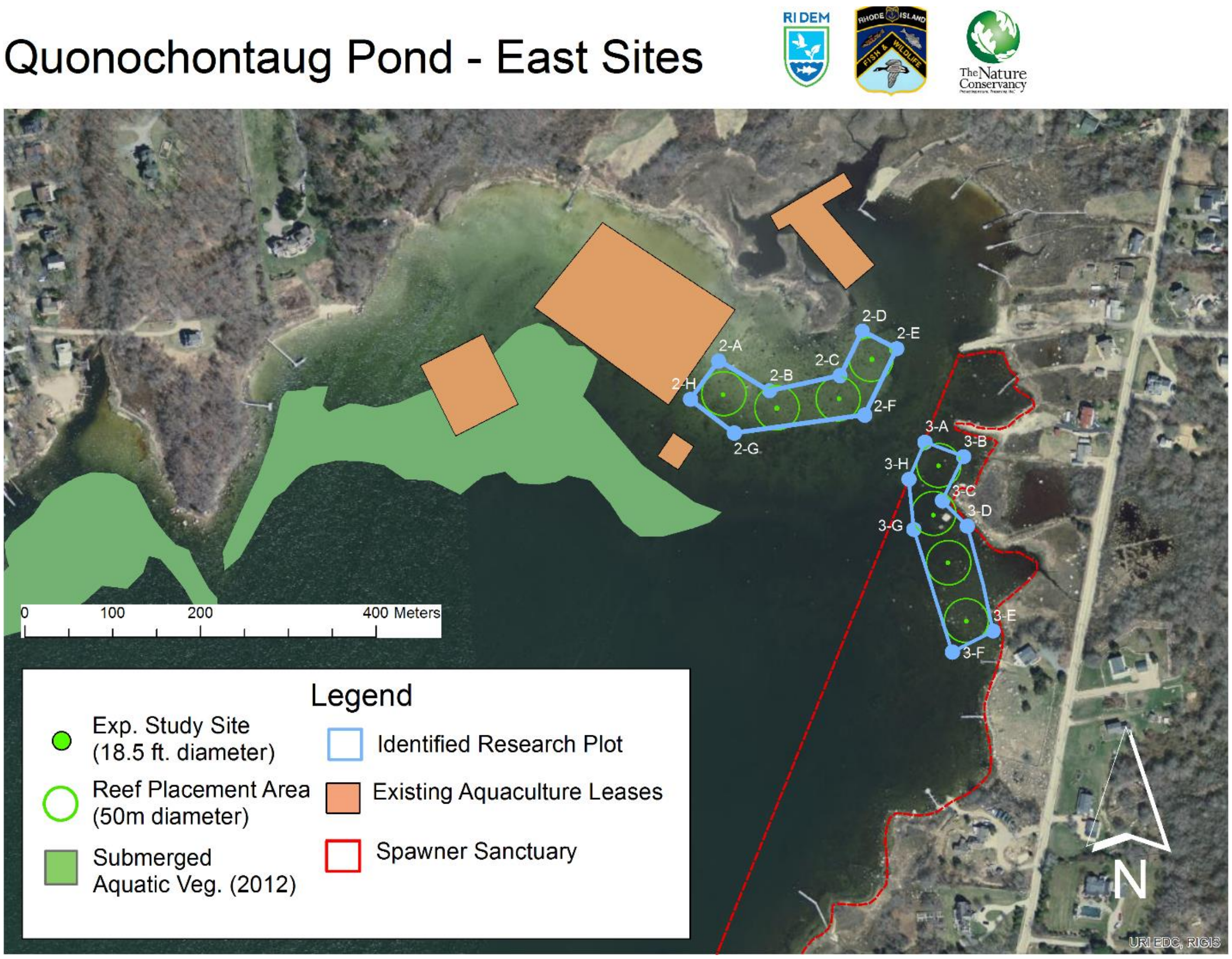
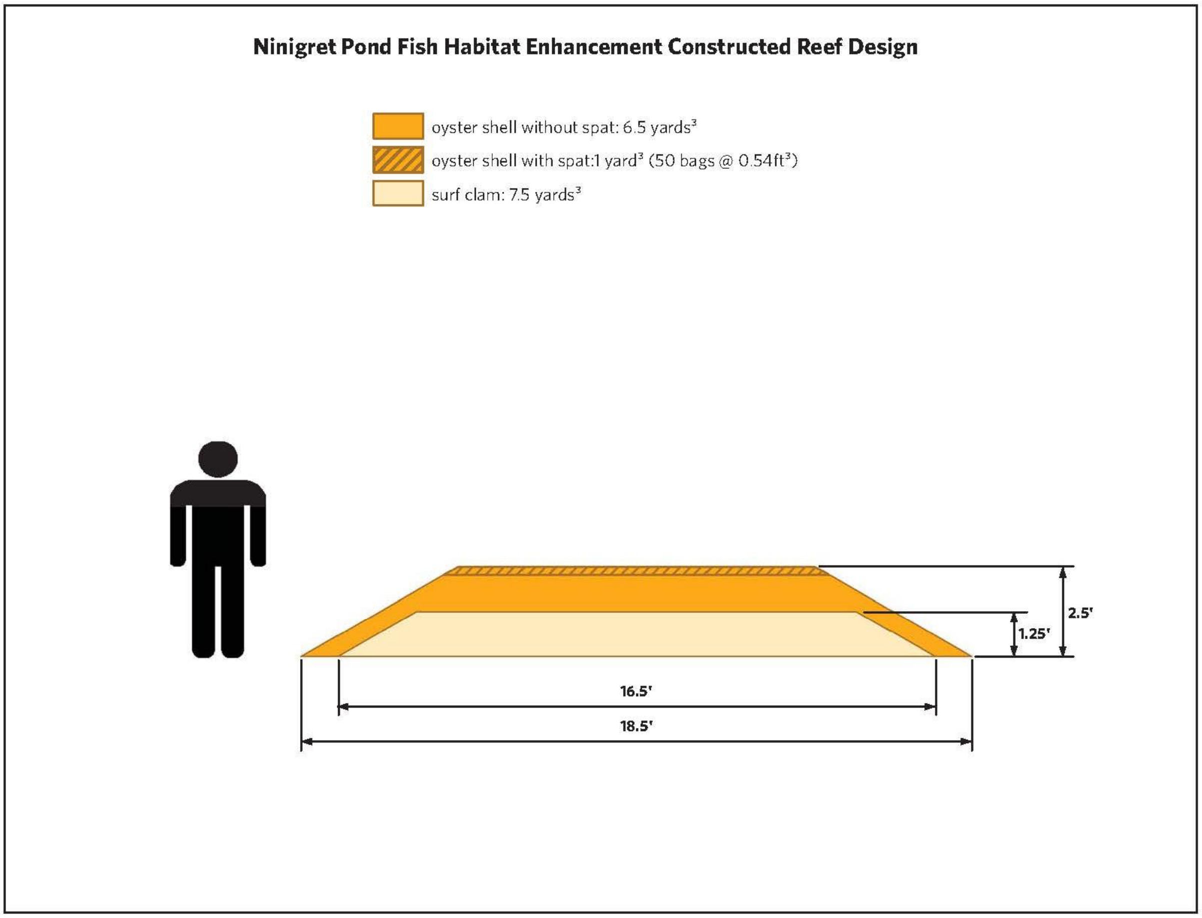


Figure 2. Side profile of an experimental reef showing the maximum ñbuiltò height immediately following reef creation. We note that the volume of shell at a given site will be a function of desired final reef height and water depth at the site, as well as expected effects from reef subsidence. Each reef will be round extending 18.5 feet from the center, have a total footprint of ~ 269 ft^2, and comprised not more than 15 cubic yards (y^3) of steam-shucked surf clam and seasoned oyster shell. We anticipate the top of each reef will be typically 12-30 inches below mean low water depending on the site and given tide.



--- End of Permit Application Request ---

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, 2016 ï December 31, 2016

JOB NUMBER 8 TITLE: Sportfish Assessment and Management in Rhode Island Waters
During this segment, several fish stock assessments were completed that included a striped bass stock assessment update, a black sea bass benchmark stock assessment, a summer flounder update assessment, and a weakfish benchmark assessment. In addition to completed stock assessments, a menhaden update assessment has been initiated and multiple stocks with important recreational fisheries operating on them will be benchmarked in 2017 and 2018 to test the effect of the new Marine Recreational Information Program (MRIP) effort survey (going from a phone survey to a mail survey). 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, which includes setting the recreational management plans for 2017. The project leaders participated at the Atlantic States Marine Fisheries Commissionøs 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 2017 (Finfish Sector Management Plan 2015, see: http://www.dem.ri.gov/pubs/regs/regs/fishwild/mpfinfsh.pdf).

Previous versions of this report synthesized all of the assessment work done by the Division, and this included species that do not qualify for sportfish funds. No sportfish funds were used for those species, they were simply reported under the blanket of all of the assessment work performed by the Division. To avoid confusion about what funds are being used for which species, this practice will be discontinued and only qualifying sportfish species that at least in part used sportfish funds to support the work will be reported on in this progress report in the future.

The following is a summary of the activities that took place in 2016:

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, 2015, and 2016. 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 were active members of the southern demersal working group that reviewed all of the update stock assessment information including data and research on summer flounder.

2. STRIPED BASS

The ASMFC completed 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 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. Staff collects the information and processes it for the assessment. Staff also participates in meetings where the assessment information is reviewed.

3. BLACK SEA BASS

Beginning when the new statistical catch at length stock assessment (SCALE = statistical catch at length) was introduced and peer reviewed in 2008, an annual update has been performed for the coastwide stock for black sea bass. These updates are less time consuming than full benchmark assessments, but still require some work to be able to perform the update. In 2012, a full benchmark assessment was performed and was peer reviewed which switched to a statistical catch at age modeling framework. This assessment did not pass peer review so has not been used for management. A new benchmark assessment was initiated in 2015 and went to review in 2016. The main tasks are to gather both catch and fishery independent information 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 meetings where the assessment information is released, and staff are active members of the southern demersal working group. In addition to our participation with our federal and state partners, RI staff helped develop two new catch at age models, one in the software package Age Structured Assessment Program (ASAP) and one in the software package Stock Synthesis 3 (SS3) that incorporates spatial considerations in to the modeling framework, as well as mechanisms that help to account for the atypical life history. The spatially explicit model proposed as the main model (using ASAP) passed peer review and is now being used for management. This model has allowed for a dramatic increase in commercial and recreational quota for this species.

4. WEAKFISH

Weakfish has not had an approved assessment for many years and management has been based on external, non-analytical indicators. In 2016, a full benchmark assessment was performed and was peer reviewed which switched to a statistical catch at age modeling framework that used Bayesian statistical applications to account for time varying natural mortality, which is unique amongst the many sportfish species assessments that RI participates in. Other models were also tested, including a standard statistical catch at age model (using the ASAP software package), but the Bayesian model was selected as the preferred model by the assessment team. This assessment passed peer review so is now used for management, the report is located at the following link: http://www.asmfc.org/uploads/file/5751b3db2016WeakfishStockAssessment_PeerReviewReport_May2016.pdf. The main tasks associated with the assessment were to gather both catch and fishery independent information and stratify that information by. 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 meetings where the assessment information is released. This model has allowed for an ability to get back to better informed management processes for this species.

5. 2016 SCHEDULE

As previously noted, several stock assessments for important sportfish will be initiated in 2017, and are scheduled to conclude in 2018.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

Age and Growth Study

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March 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: January 1, 2016 ï December 31, 2016

JOB NUMBER AND TITLE: 9, Age and Growth Study

JOB OBJECTIVE: To collect age, growth, and diet composition 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 the target sample numbers for bluefish and summer flounder, however fell slightly short on target sample numbers for black sea bass, menhaden, scup, striped bass, tautog, and weakfish. Ageing structures were also collected for winter flounder although it is not a 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 2016 is complete.

In addition to age and growth data collected in 2016, investigators continued the collection of stomach content, sex, and maturity stage data from target species in 2016. This data was collected through collaboration with investigators on the RIDEM monthly and seasonal trawl survey (Jobs 1 and 2) and fish pot survey (Job 13).

TARGET DATE: Ongoing

STATUS OF PROJECT: On schedule

SIGNIFICANT DEVIATIONS: No significant deviations occurred in 2016. Investigators achieved sampling targets for two species, but fell slightly short on the sampling targets for the remaining species. This was due to the dynamics of the fisheries as well as the availability of fish.

RECOMMENDATIONS: Move into the next project segment and continue data collection in 2017.

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). RIDEM is in the process of hiring a full-time contracted Fisheries Specialist I through the Atlantic States Marine Fisheries Commission (ASMFC) that will assist on this project to ensure that all sampling targets are met in 2017.

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 ï 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 (FMPõs) 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, except for menhaden for which only scale samples were taken and weakfish and bluefish for which only otolith samples were taken.

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 November of 2016. Data collected included lengths, weights and the appropriate age structure for the specific species (i.e. scale, otolith, or operculum). 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, and Rhode Island Division of Fish and Wildlife (RIDFW) 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 RIDFW seasonal and monthly bottom trawl surveys, RIDFW Fish Pot survey, or from fish racks and whole fish collected during port sampling. 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 database.

Black sea bass

A total of 88 black sea bass age samples were collected from multiple sources including hook and line, RIDFW otter trawl, RIDFW fish pots, and commercial lobster pots in 2016. 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 8.4-22.4 inches (21.4-57.0 cm) total length and were 2-7 years old (Figure 1). Biological samples were dominated by 5-year-old fish due to a strong 2011 year class. Stomach content and maturity stage data was collected from 39 black sea bass. Stomach contents included prey items from 6 taxonomic groups (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10 and indicates that black sea bass stomachs were dominated by bivalve molluscs (78%) and crustaceans (15%). However, the bivalve mollusc identified in stomach contents was the Ocean quahog (*Arctica islandica*), the same species used as bait in fish pot survey gear, and therefore may not be representative of the natural diet. Removal of this data from the analysis resulted in stomach contents being dominated by crustaceans (54%), followed by finfish (10%).

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, staff successfully collected 203 bluefish age samples in 2016. Bluefish samples ranged in fork length from 22.8-33.7 inches (58-85.5 cm) and 2-11 years old (Figure 2). Stomach content and maturity stage data was collected from 72 and 70 bluefish, respectively. Many of the fish caught in the commercial gillnet gear had missing stomachs, gonads, or both due to attack by amphipods or other predators. Stomach contents included prey items from 2 taxonomic groups (Table 3). Figure 10 shows that, of the bluefish stomachs examined, cephalopod molluscs (44%) and finfish (25%) comprised 69% of identifiable stomach contents encountered.

Menhaden

Atlantic menhaden age samples were collected in 2016 from a floating fish trap operation. Typically, additional samples are collected from commercial purse seine operations when they are actively fishing in Narragansett Bay. In 2016, 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. The 60 menhaden samples that were collected from fish traps ranged in fork length from 10.6-12.4 inches (26.8-31.6 cm) and age from 2-3 years old (Figure 3). Only maturity stage data was collected from all 60 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 2016 (Table 3). Generally speaking, menhaden stomach contents should reflect the dominant planktonic species present at the time of sample collection.

Scup

Scup age samples were collected in 2016 from multiple sources including commercial otter trawls, the RIDFW otter trawl, and RIDFW fish pot survey. Investigators successfully collected scales from 79 scup ranging in fork length from 5.0-14.6 inches (12.8-37 cm) and age from 1-9 years old (Figure 4). Furthermore, staff collected lengths from an additional 155 fish. As a result of our sampling protocol, collecting two age samples per cm of length, age samples were not collected for all fish. Had staff collected scale samples from all fish, they would have satisfied the sampling requirement for age structures but violated the sampling protocol. Stomach content and maturity stage data was collected from 33 scup. Stomach contents included prey items from 2 taxonomic groups (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10 and shows that 96% of identifiable stomach contents were comprised of bivalve molluscs. The bivalve mollusc identified in the stomach contents was the bait (*Arctica islandica*, Ocean quahog) used in the fish pot survey gear and may not be representative of the natural diet. Removal of this data from the analysis results in stomach contents being dominated by crustaceans (25%) and polychaetes (14%).

Striped Bass

A total of 164 striped bass scale samples were collected and aged in 2016. 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 26ò while the commercial general category fishery has a minimum size of 34ò. Sampling from both of these operations allows us to sample a wider size range of striped bass. Due to the dynamics of the floating fish trap fishery, where there is an unlimited possession limit and the floating fish trap quota may be caught in a small number of large landing events, obtaining samples from this sector proved difficult in 2016. Staff supplemented traditional sampling by collecting 10 striped bass age samples from RIDFW 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 8.3-41.6 inches fork length (21.2-117.0 cm) and 1-13 years old (Figure 5). Stomach content and maturity stage data was collected from 9 and 5 striped bass, respectively. All stomach content and maturity stage data was collected from fish caught in RIDFW gillnets where several fish had missing stomachs, gonads, or both due to attack by amphipods or other predators. Stomach contents included prey items from 4 taxonomic groups with 41% of identifiable stomach contents being other finfish (Table 3). Polychaetes (19%) and bivalve molluscs (19%) combined for 38% of identifiable stomach contents encountered. The bivalve found in the stomach contents was the bait (*Arctica islandica*, Ocean quahog) used in the fish pot survey gear and may not be representative of the natural diet. Removal of this data from the analysis results in stomach contents being dominated by finfish (68%). The proportional contribution of stomach contents encountered is shown in Figure 10.

Summer Flounder

A total of 110 summer flounder scale samples were collected in 2016. The majority of these samples (n=58) came from a finfish dealer with an unknown gear type and additional samples were collected by RIDFW staff (n=52) on board our RIDFW otter trawl and fish pot surveys (Jobs 1, 2, and 13). Summer flounder samples collected varied in size from 9.8-22.4 inches (25-57 cm) total length and 1-6 years old (Figure 6). Stomach content and maturity stage data was collected from 42 summer flounder. Stomach contents included prey items from 3 taxonomic groups (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10 and shows that identifiable summer flounder stomach contents were dominated by crustaceans (21%) and finfish (8%).

Tautog

A total of 158 tautog operculum samples were collected in 2016 from the hook and line fishery and RIDFW fish pot survey. 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. As a result, staff fell slightly short of their sample target in 2016. Tautog samples that were collected ranged from 7-22.1 inches (17.7-56.1 cm) total length and 0-10 years old (Figure 7). Stomach content and maturity stage data was collected from 85 tautog. Stomach contents included prey items from 6 taxonomic groups (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10 and shows that the identifiable tautog diet was primarily comprised of crustaceans (40%) and gastropod molluscs (20%). In 2017 staff will begin to explore a new, non-lethal ageing technique for tautog. This new technique uses a cross-section of a pectoral spine for age determination. After staff receive training at an upcoming workshop in April 2017, staff will be able to utilize this new method which aid in achieving our sampling targets in 2017 due to the fact that samples can be collected from live fish.

Weakfish

The state of Rhode Island is required to collect three age structures per metric ton of weakfish landed commercially in the state by the ASMFC. In 2016, this would have resulted in a sampling target of 8 fish. In recent yearsôweakfish 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 2016 prevented the availability of this species for sampling. A total of 3 weakfish otolith samples were collected in 2016. Weakfish sampled ranged from 14.2-19.5 inches (36.1-49.6 cm) total length and were all 2 years old (Figure 8). Stomach content and maturity stage data was collected from 3 weakfish. Stomach contents included prey items from 2 taxonomic groups with finfish comprising 77% of identifiable stomach contents (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10. In 2017, staff will collect more weakfish samples from the RIDFW trawl survey to ensure our sampling targets are met, although these are usually small YOY and age 1 fish.

Winter Flounder

A total of 20 winter flounder scale samples were collected in 2016. These samples were collected by RIDFW staff on board our RIDFW otter trawl survey (n=15) (Jobs 1 and 2) and donated by a commercial otter trawl fisherman (n=5). Winter flounder samples collected varied in size from 8.9-16.5 inches (22.7-41.9 cm) total length and 1-5 years old (Figure 9). Stomach content and maturity stage data was collected from 20 winter flounder. Stomach contents included prey items from 3 taxonomic groups with crustaceans making up 44% of identifiable stomach contents (Table 3). The proportional contribution of stomach contents encountered is shown in Figure 10.

SUMMARY

In 2016 investigators were able to collect the target sample numbers for bluefish and summer flounder while slightly under-achieving target sample numbers for black sea bass, menhaden, scup, striped bass, and weakfish. 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 2016 and staff completed an ageing precision exercise. The ageing precision exercise involved staff reading samples collected in 2015 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 2017, 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 is being hired by DFW 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 2016. 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 2017.

FIGURES

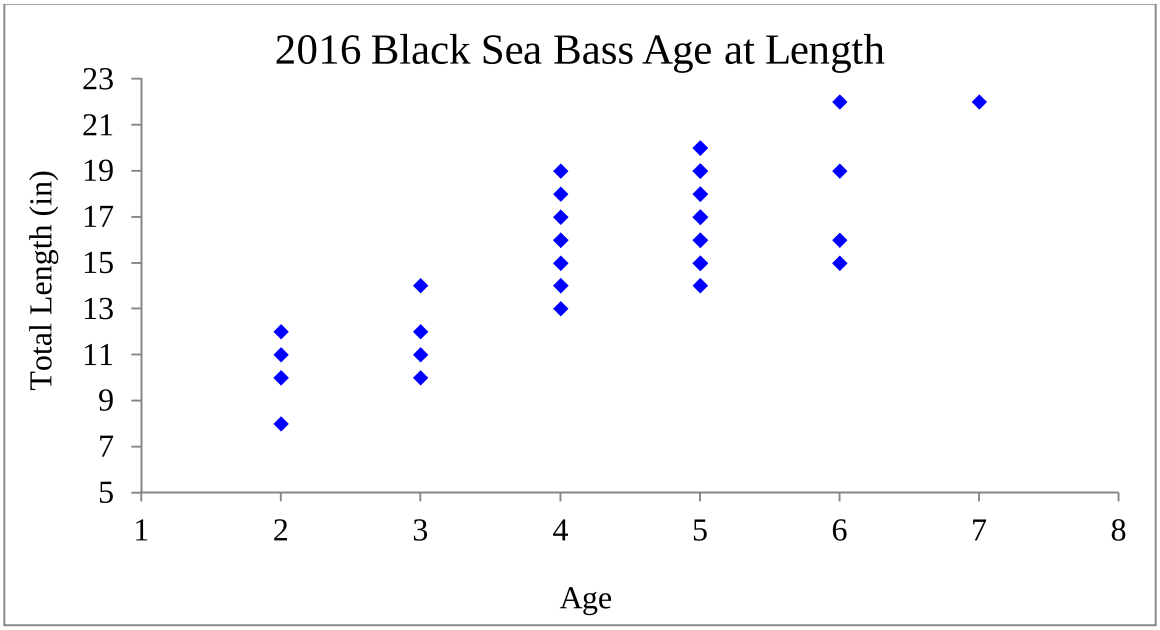


Figure 1. Black sea bass age at length.

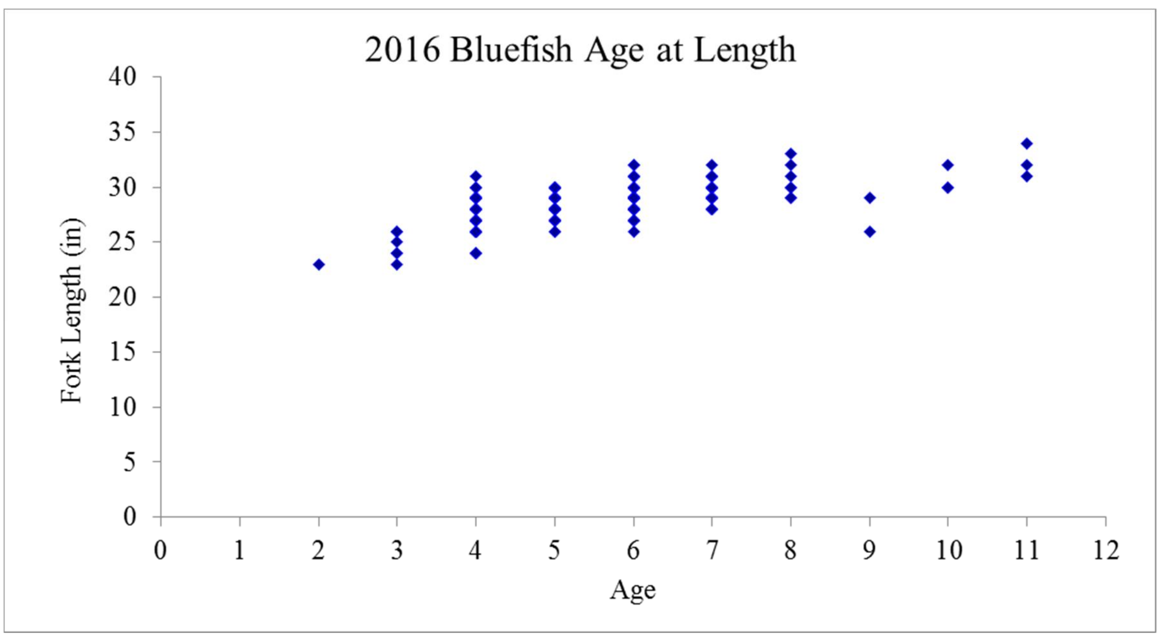


Figure 2. Bluefish age at length.

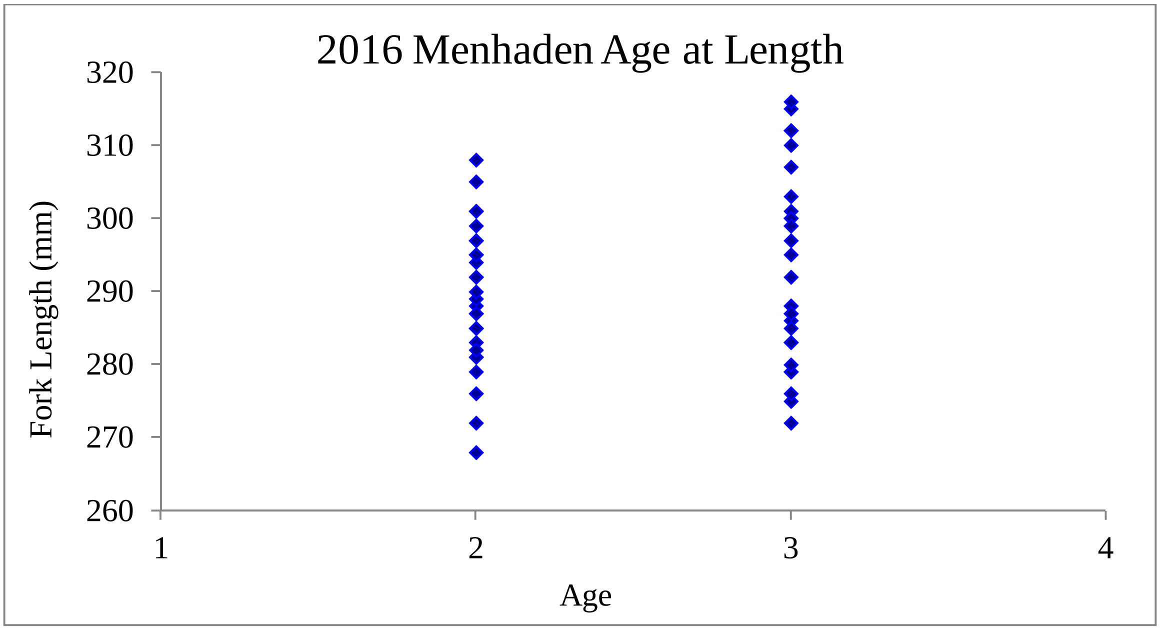


Figure 3. Menhaden age at length.

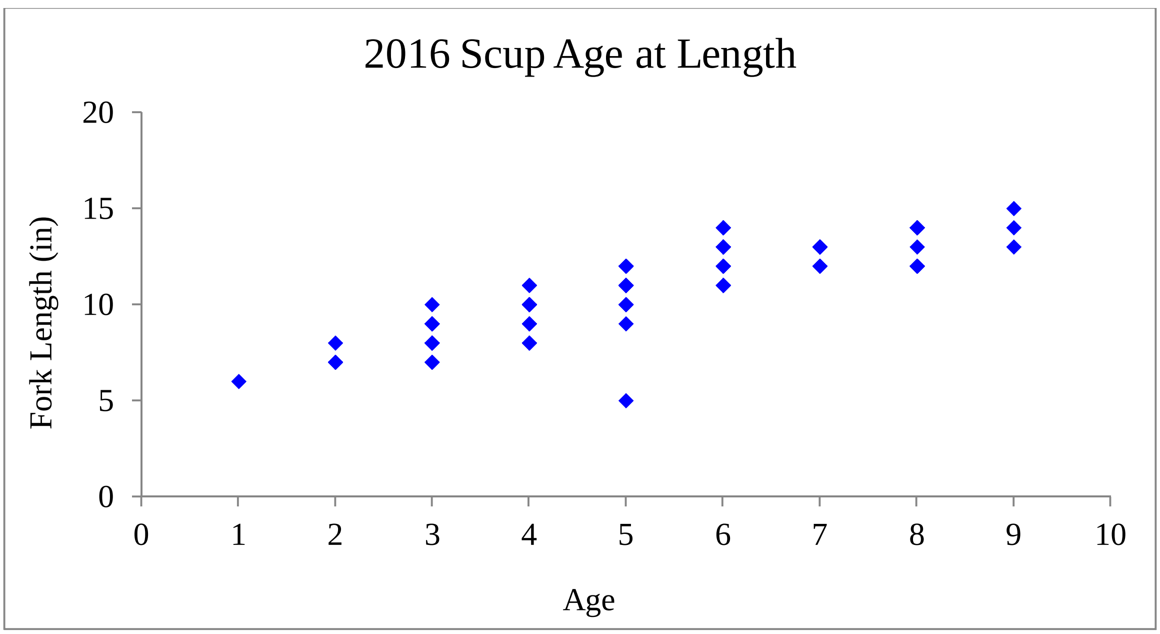


Figure 4. Scup age at length.

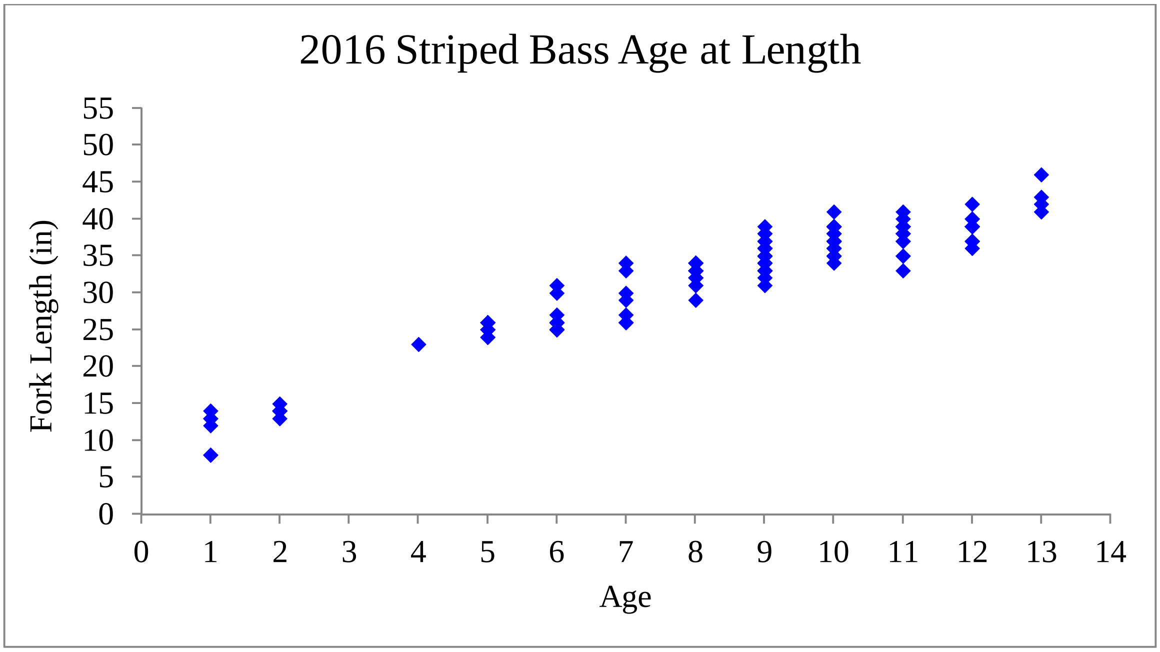


Figure 5. Striped bass age at length.

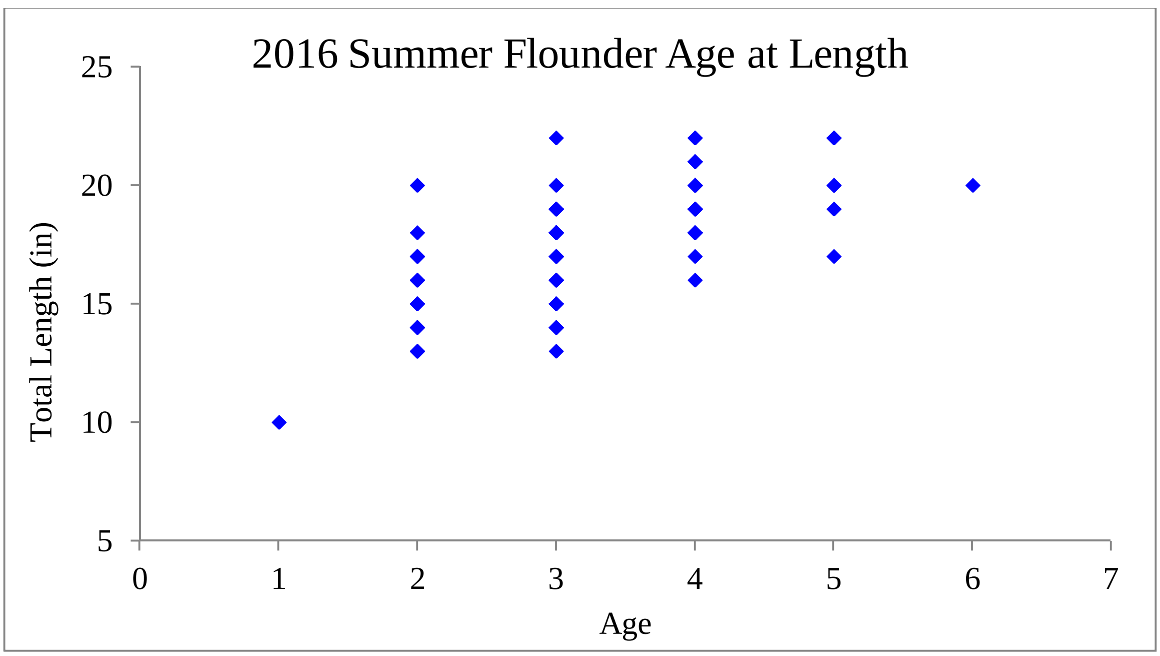


Figure 6. Summer flounder age at length.

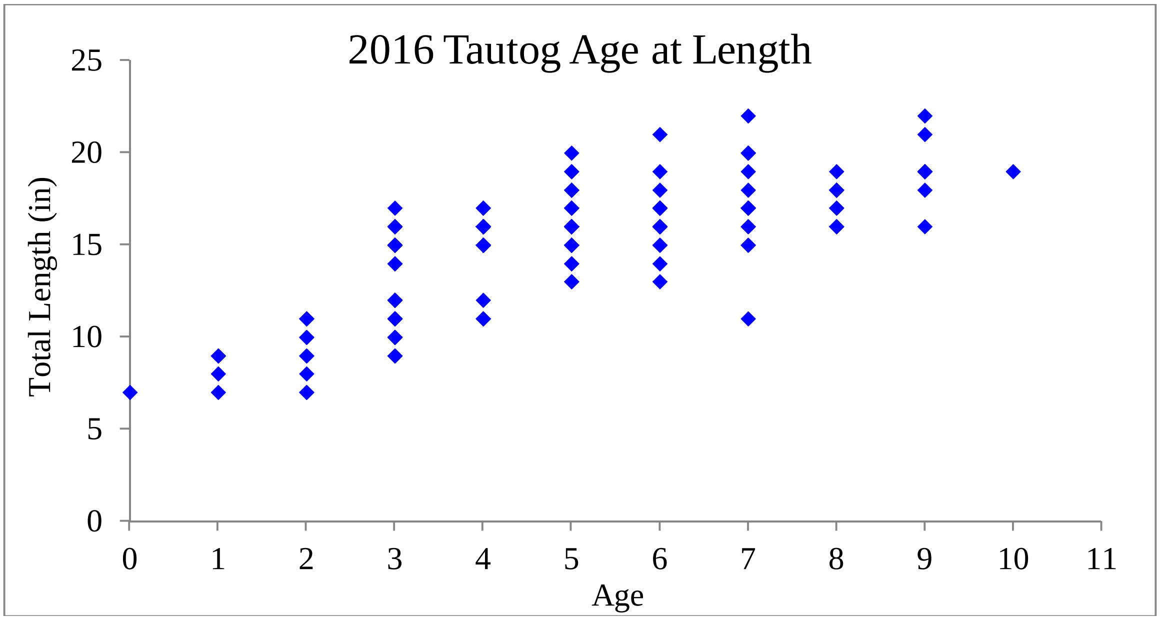


Figure 7. Tautog age at length.

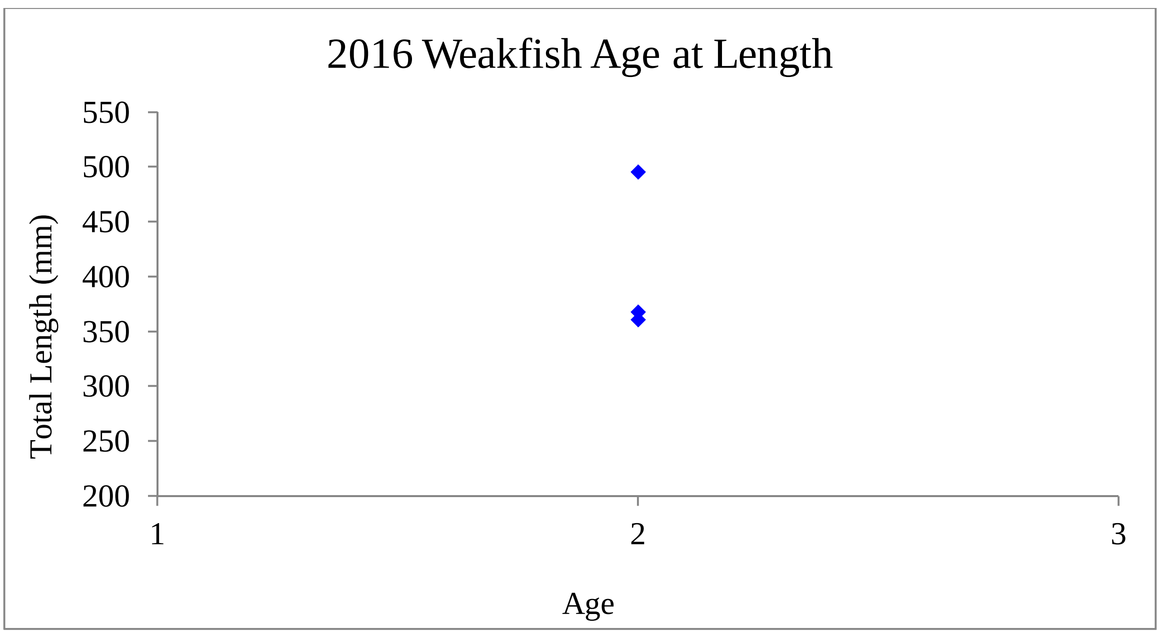


Figure 8. Weakfish age at length.

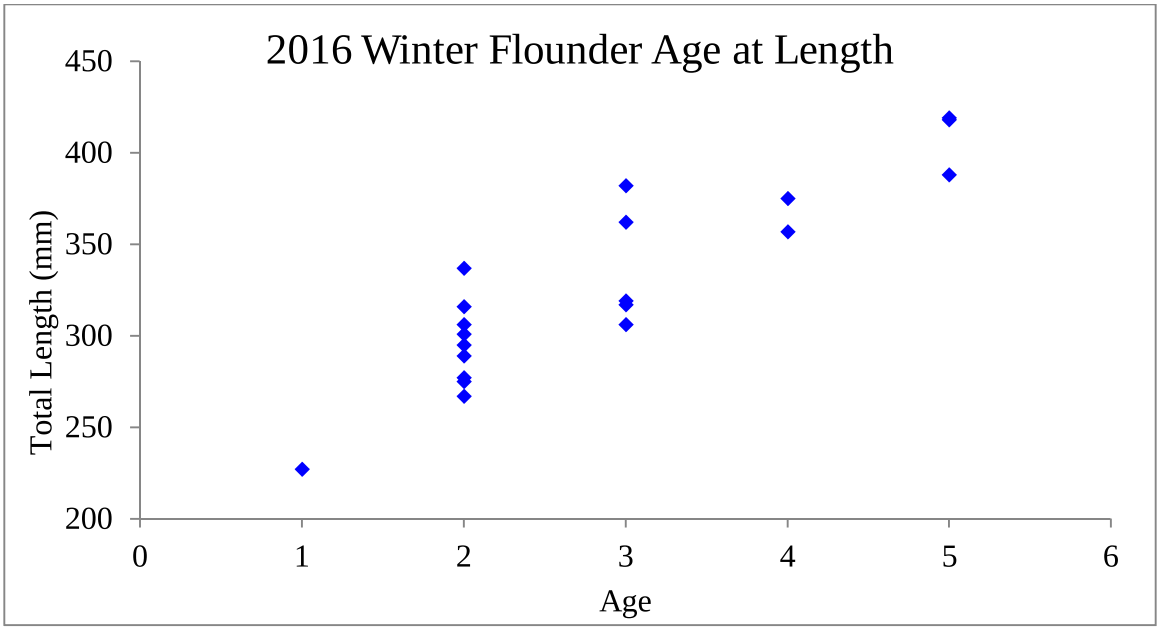


Figure 9. Winter flounder age at length.

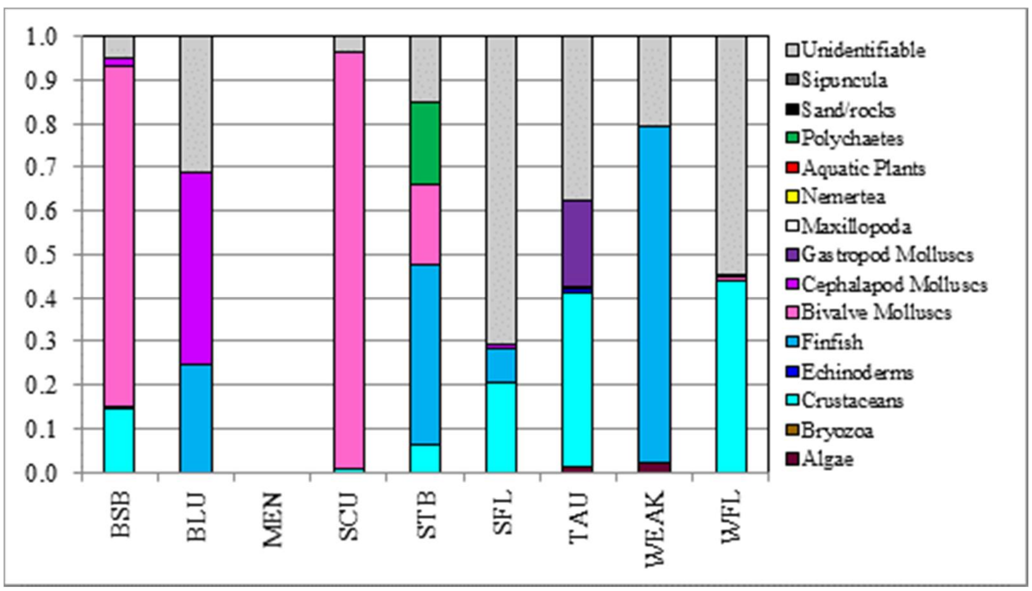


Figure 10. 2016 Proportional contribution of stomach content types by species.

TABLES

Table 1. Species, number of ageing structures, and number of fish sampled in 2016.

Common name	**Ageing structure**	**Target number of ageing structures**	**Number of ageing structures collected**
Black sea bass	Scale	100	88
Bluefish***	Otolith	100	203
Menhaden***	Scale	100	60
Scup	Scale	100	79
Striped bass	Scale	150 fish/gear type**	164
Summer Flounder	Scale	100	110
Tautog***	Operculum/Otolith	200	158
Weakfish***	Otolith	3 fish aged per metric ton landed*	3
Winter Flounder	Scale	NA	20

*Per ASMFC FMP requirements, 6 ages required for 2016
**Gear types include floating fish trap and general category
***Required by ASMFC

Table 2. Gear type sampled for each species collected in 2016 (FFT=Floating Fish trap).

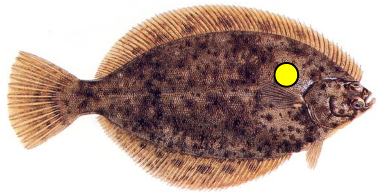
Common name	**Gear Type**
Black sea bass	Hook and Line, Fish Pot, Otter Trawl, Lobster Pot
Bluefish	Hook and Line, Otter Trawl
Menhaden	FFT
Scup	Fish Pot, Otter Trawl
Striped bass	FFT, Hook and Line, Otter Trawl, Gillnet
Summer Flounder	FFT, Hook and Line, Fish Pot, Otter Trawl
Tautog	Hook and Line,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

Table 3. Summary of stomach content sampling by species.

SPECIES	Target # Stomachs	# Stomachs sampled	# PREY TAXA
Black Sea Bass	40	39	6
Bluefish	40	72	2
Menhaden	40	0	0
Scup	40	33	2
Striped Bass	40	9	4
Summer Flounder	40	42	3
Tautog	40	85	6
Weakfish	40	3	2
Winter Flounder	40	20	3

Table 4. Proportional contribution of stomach content types by species (see Figure 10).

	BSB	BLU	MEN	SCU	STB	SFL	TAU	WEAK	WFL
Algae	0.0004						0.0146	0.0235	
Bryozoa									
Crustaceans	0.1452			0.0069	0.0645	0.2073	0.3989		0.4422
Echinoderms							0.0105		
Finfish	0.0059	0.2456			0.4108	0.0766		0.7706	
Bivalve Molluscs	0.7786			0.9584	0.1871		0.0001		0.0068
Cephalopod Molluscs	0.0195	0.4405				0.0080			
Gastropod Molluscs	0.0004						0.2006		
Maxillopoda							0.0005		
Nemertea									
Polychaetes					0.1871				0.0068
Sipuncula									
Aquatic Plants									
Sand/rocks		0.0005					0.0001		
Unidentifiable	0.0500	0.3134		0.0346	0.1505	0.7081	0.3749	0.2059	0.5442



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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Federal Aid in Sportfish Restoration
F-61-21

Performance Report March, 2017

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, 2016 ï December 31, 2016	
Job Number and Title:	Job 10 - 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:	None	

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 are 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.

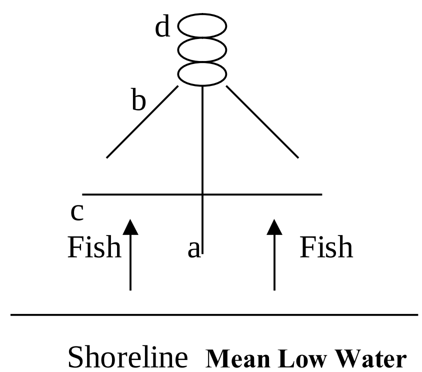
Additional Research : In 2012 an additional coastal pond system was added to the survey. As adult winter flounder abundance in the Point Judith system declined to all-time lows, an adjacent pond, Charlestown Pond, also known as Ninigret Pond (NOAA Nautical Chart 13205) was surveyed during the same time 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 partners 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 ï 2.5ô
Mesh size - 2.5" throughout

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



Fieldwork:

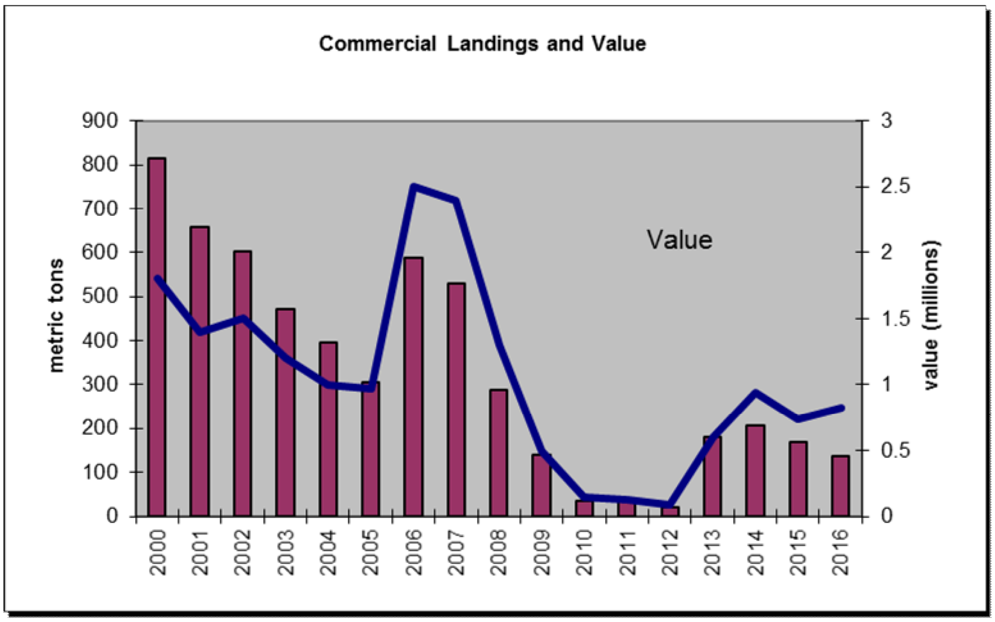
Three fyke nets were set at three fixed stations in Pt. Judith and Potter Ponds during January and April in 1999 - 2001 and two nets were set at four fixed stations from 2002 to present. The nets are fixed at mean low water and set perpendicular to the shoreline. Fyke nets are a passive fishing gear 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.

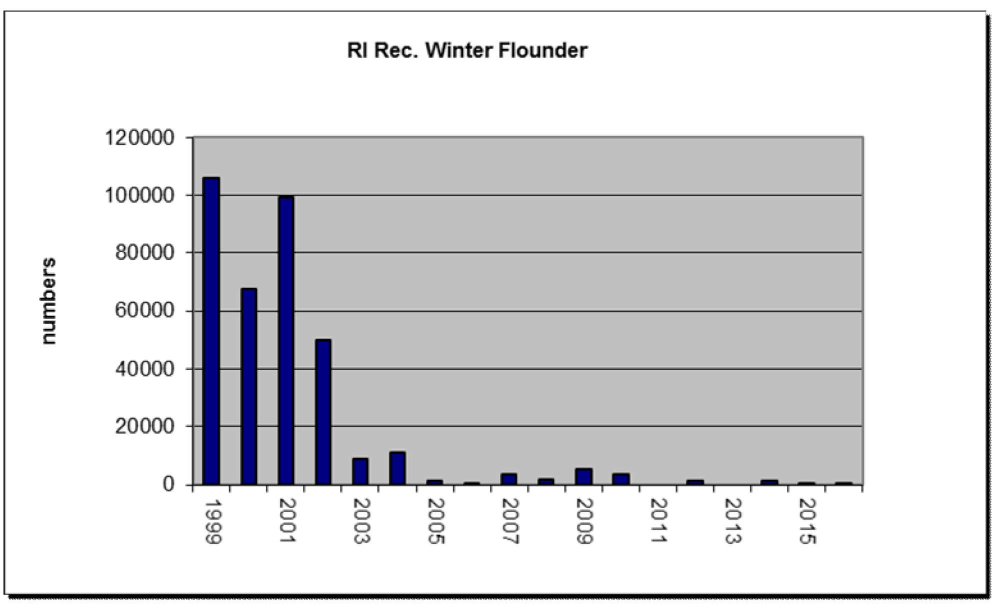
All fish captured are measured, sexed, enumerated and categorized to describe spawning stage. Spawning stage is defined as ripe (pre-spawn), ripe/running (active spawn), spent (post-spawn), resting (non-active spawn) and immature. These data illustrate how the spawning activity of flounder advances throughout 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:

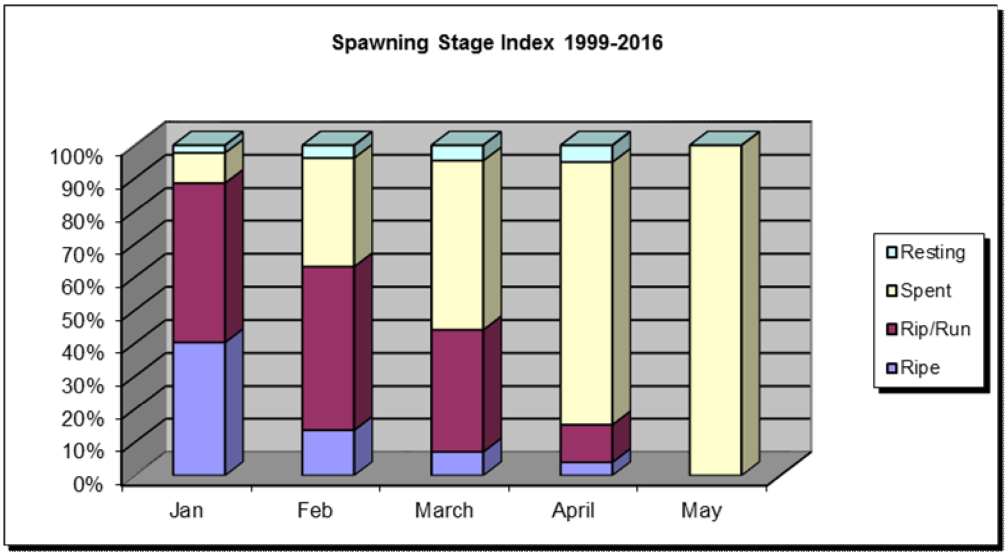
Winter Flounder (***Pseudopleuronectes americanus***) are both a commercially and recreationally important species to the State of Rhode Island. From 1999 - 2016 commercial landings of winter flounder in Rhode Island averaged over 300 metric tons and an average value of one million dollars annually. Recreational landings have declined rapidly throughout the period and remain low through 2016. (NMFS. 2016 Commercial landings query and MRFSS database)



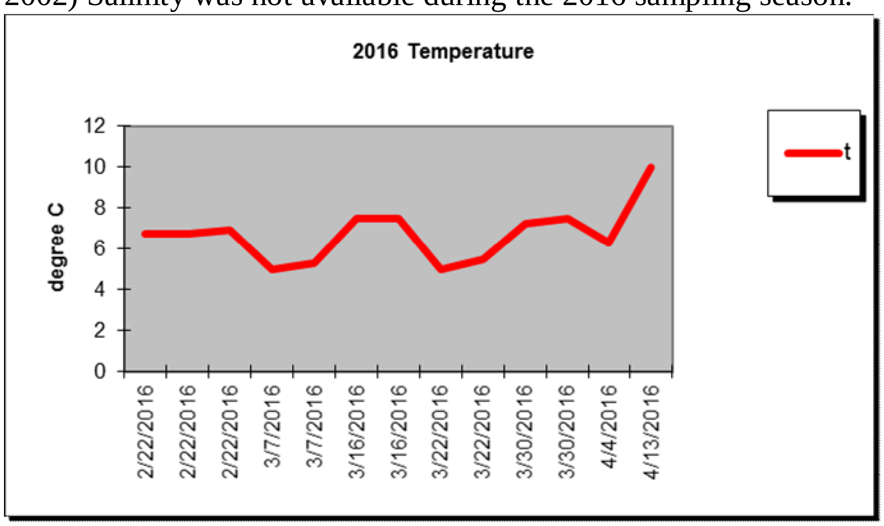


Spawning Behavior: Pt Judith / Potters Pond System

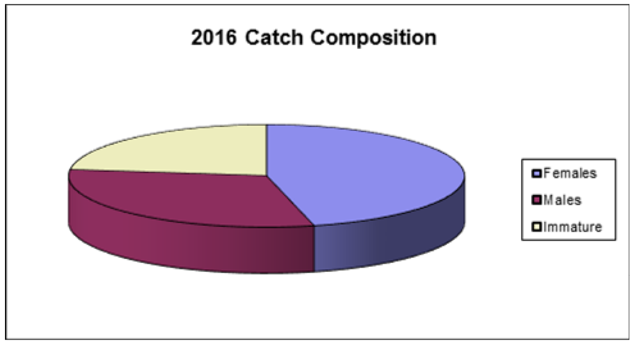
Winter Flounder enter the south shore coastal pond systems in Rhode Island to spawn in the early part of winter (November) and engage in spawning activity from January through May annually. Spawning and egg deposition takes place on sandy bottoms and algal accumulations. Winter Flounder eggs are non-buoyant 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.

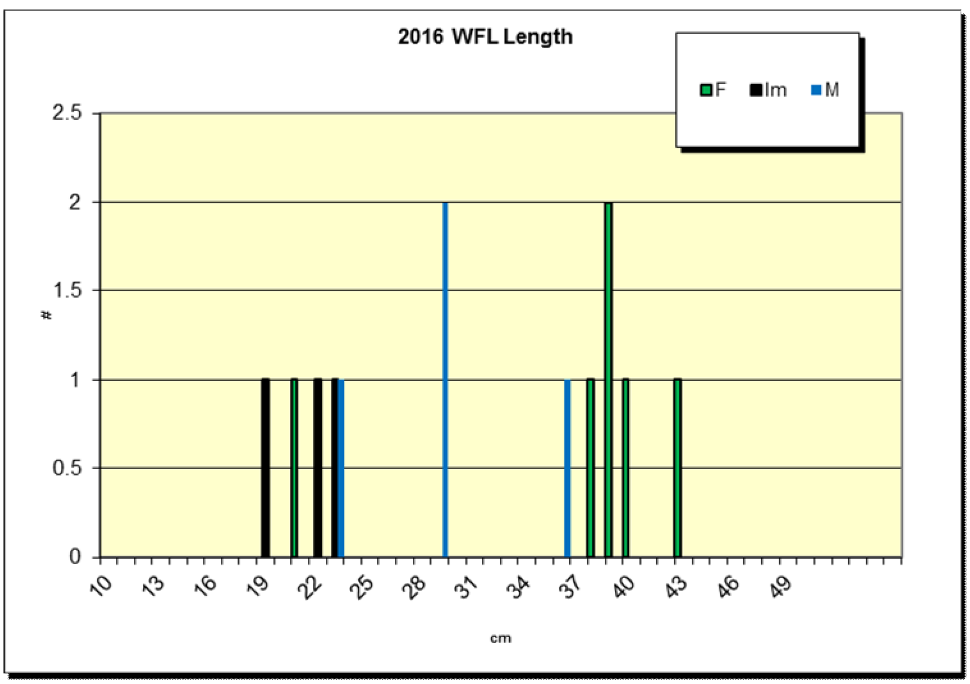


Sex ratios throughout the time series tend to favor females. Similar observations were made in Green Hill Pond, a neighboring coastal pond (Saila 1961), and in Narragansett Bay (Saila 1962).



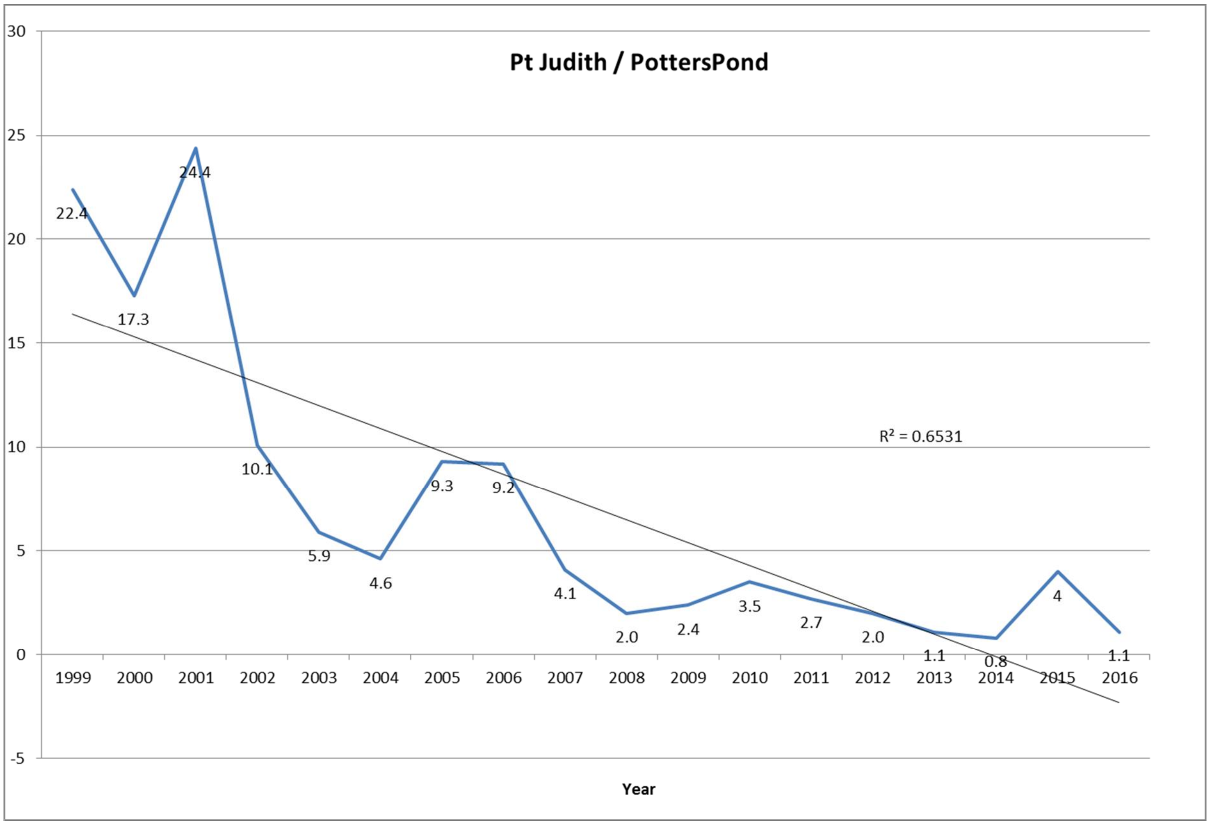
Size Distribution: Pt Judith / Potters Pond System

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:

2015 Adult winter flounder CPUE in Pt Judith Pond increased to 4.0 fish per net haul. A significant increase from the 2014 value of 0.4 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.



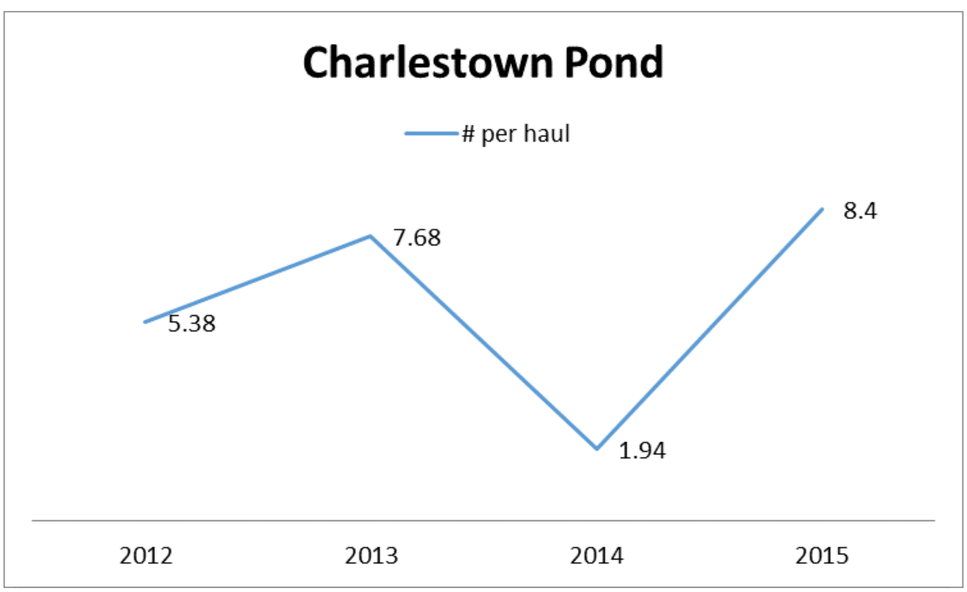


Table 1 Mark / recapture data 1999 - 2015 (Pt Judith / Potter Pond system)

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
Total	3976	1555	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	Total	% recap
1999	31	8	10	1	0	1	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	46	0.2211538
2001			43	11	1	2	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	5	0.0274725
2003					1	1	2	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	12	0.1875
2005							4	4	2	1	0	0	0	0	0	0	0	0	11	0.0956522
2006								3	2	0	0	0	0	0	0	0	0	0	5	0.0549451
2007									2	1	0	0	0	0	0	0	0	0	3	0.0857143
2008										0	0	0	0	0	0	0	0	0	0	0
2009											0	0	0	0	0	0	0	0	0	0
2010												0	0	0	0	0	0	0	0	0
2011													0	0	0	0	0	0	0	0
2012														0	0	0	0	0	0	0
2013															0	0	0	0	0	0
2014																0	0	0	0	0
2015																	0	0	0	0
2016																		0	0	0
Total	31	31	70	18	6	14	7	9	6	2	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	39	0.1174699
2000		18	9	0	1	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	44	0.122905
2002				1	3	1	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	4	0.045977
2004						9	1	2	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	7	0.0608696
2006								1	1	0	0	0	0	0	0	0	0	0	2	0.021978
2007									2	1	0	0	0	0	0	0	0	0	3	0.0857143
2008										0	0	0	0	0	0	0	0	0	0	0
2009											0	0	0	0	0	0	0	0	0	0
2010												0	0	0	0	0	0	0	0	0
2011													0	0	0	0	0	0	0	0
2012														0	0	0	0	0	0	0
2013															0	0	0	0	0	0
2014															0	0	0	0	0	0
2015																	0	0	0	
2016																		0	0	
Total	26	24	54	3	6	14	4	6	5	2	0	0	0	0	0	0	0	0	144	0.8045017

Ta le **Mark recapture data**

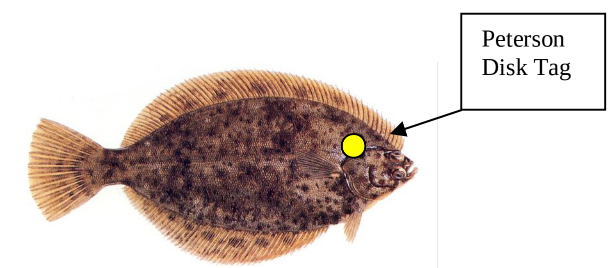
Charlestow n Pond

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

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***

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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, 2016 ï December 31, 2016

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; SEDAR, 2015). 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 have resulted in increased resource conflicts and make 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 Fish and Wildlife (DFW) 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 2016

SIGNIFICANT DEVIATIONS: No deviations occurred in 2016 compared to the previous year for this project.

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 2016 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 DFW staff. The commercial fishery interests also agree to carry a DFW observer on the fishing vessel upon request, or allow a port sample to occur while the catch is being offloaded. In 2016, port samples were undertaken where DFW biologists sampled the catch and recorded the weight of catch offloaded. 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 DFW also contracted a trained spotter pilot to make abundance estimates of menhaden in Narragansett Bay. When in the air, the pilot records counts of the number of menhaden schools observed, the estimated weight within the schools, and the location of the schools. An additional series of flights were taken in a state helicopter independent of the contracted spotter pilot. During these flights, DFW staff recorded the number and location of schools, allowing for independent verification of the spotter pilot estimates of school number. Other commercial harvesters such as floating fish trap operators were required to file logbook reports monthly with the DFW that detailed daily fishing activities. These fishers were also contacted for information and biological sampling during periods of increased menhaden activity on a more frequent basis. These fixed gear fisheries are 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 DFW 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 DFW to monitor the abundance of menhaden in Narragansett Bay. The existing regulatory framework governing state waters allows the DFW 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 DFW 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 DFW 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.

2016 Fishery Data

In 2016, one commercial menhaden fishing operation fulfilled requirements for fishing in Narragansett Bay. After biomass levels were estimated and confirmed, commercial fishing was allowed to commence in the Management Area on May 16, 2016. The RI commercial bait fishery operating under the RI state quota closed on May 19, 2016, 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. Additionally, this closure only applied to vessels landing menhaden in RI, the Narragansett Bay Management Area remained open and therefore non-bycatch vessels were allowed to fish in the management area provided they were not landing their catch in RI.

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 20, 2016, 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. While RI state waters outside of the management area remained open through November 1, 2015, the management area closed on June 27, 2016 as a result of hitting the biomass threshold. Biomass levels in the Bay remained below the threshold for the remainder of the summer. On September 1, 2016, the lower portion of the Bay opened at a reduced possession limit of 25,000 pounds/vessel/day and remained opened until the episodic event set aside program ended on November 1, 2016. On November 10, 2016, after receiving a small quota transfer from the state of Massachusetts, the lower portion of the bay was temporarily re-opened. The fishery was subsequently closed on December 5, 2016, and remained closed for the rest of 2016. Between May and November, a total of 302,748 lbs of menhaden was landed in the state of RI.

In 2016 the landings cap was not exceeded and a total of 30 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. In addition to the professional spotter pilot estimates, only two helicopter flights were conducted due the fact that biomass levels remained below the threshold for the majority of the summer. In the absence of fishable biomass, helicopter flights are not deemed necessary.

The model estimated a harvest cap of 1,915,000 pounds in 2016. This was driven by a couple of observations where 4-6 million pounds of menhaden was estimated to be in Narragansett Bay at the end of May. This high level of biomass only remained in the Bay for a period of less than two weeks. This large pulse in biomass was followed by a significant drop in biomass which persisted for the rest of the season (Figure 1). In the future staff hopes that moving the model in to a different software package (ADMB) will help improve the model performance.

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 30 spotter flights (Table 1) were taken and 2 helicopter flights 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 2016.

The RI State menhaden quota was exhausted, and thus the state waters fishery closed in May in 2016. 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 November 1, 2016. The fishery had a brief re-opening again from mid-November through early December after a quota transfer from Massachusetts.

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

Date	Biomass Estimate
05/07/16	1560000
05/10/16	1300000
05/12/16	2610000
05/17/16	2260000
05/19/16	2370000
05/23/16	5895000
05/26/16	5800000
05/29/16	4670000
06/01/16	4300000
06/04/16	3010000
06/07/16	2105000
06/15/16	3005000
06/18/16	1330000
06/24/16	390000
07/01/16	1195000
07/10/16	300000
07/15/16	23000
07/21/16	0
07/26/16	46000
08/04/16	189000
08/09/16	125000
08/15/16	30000
08/23/16	20000
08/30/16	426500
09/10/16	425000
09/13/16	267000
09/21/16	150000
09/26/16	120000
10/03/16	100000
10/08/16	30000

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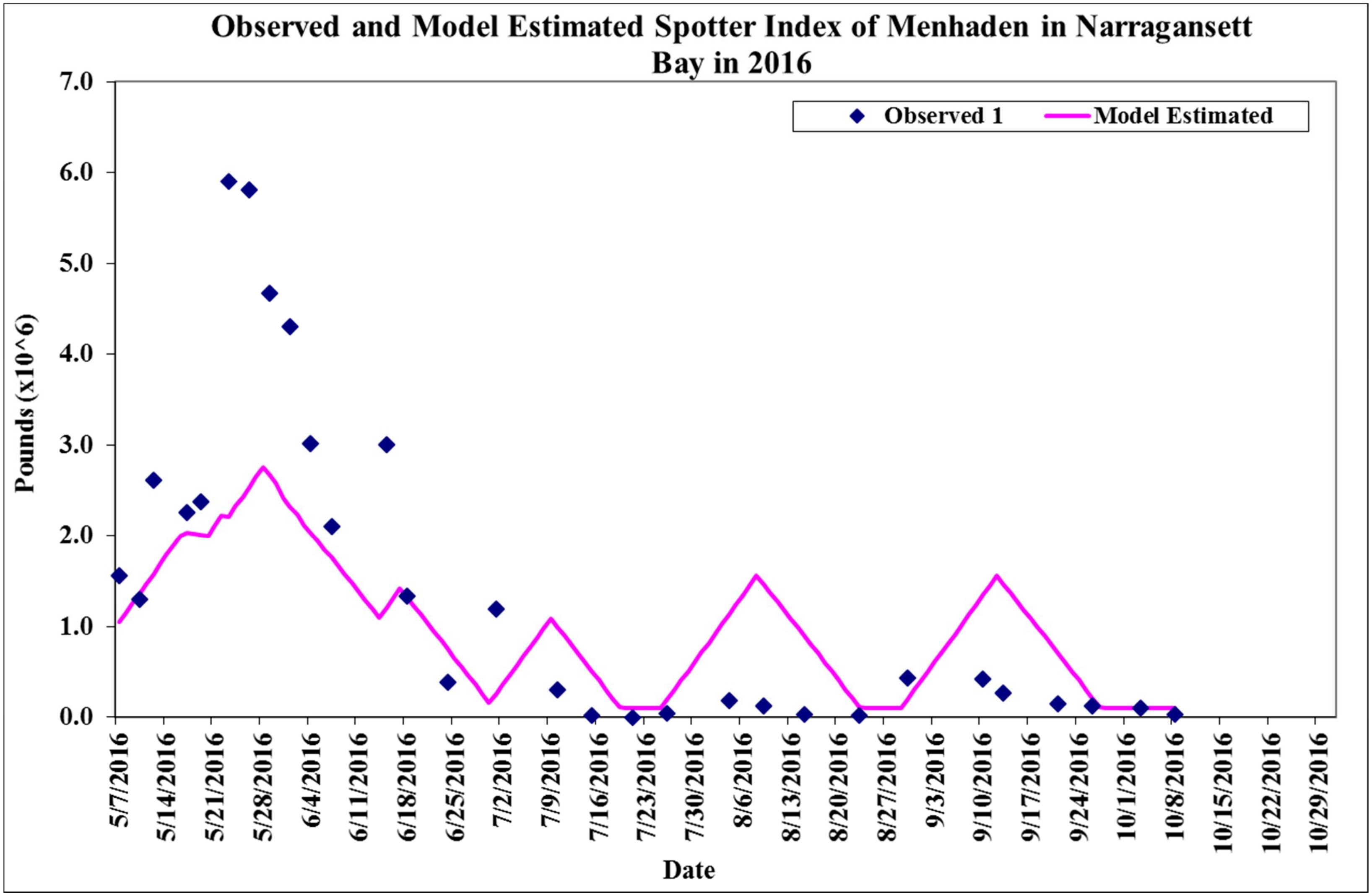

Figure 1. Predicted spotter pilot estimates and observed biomass in Narragansett Bay in 2016.

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

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Rhode Island Department of Environmental Management
Division of Fish and Wildlife

Performance Report - Job - 12 March 2017

F M T

State Rhode Island Project Number: F-61-R

ro ect T pe Resource Monitoring

ro ect Title Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

eriod o ered January 1, 2016 to December 31, 2016

o um er Title 12- Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program

o ecti e 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 coastwide stock assessments for the target species.

Summar In 2016, investigators began sampling in April as scheduled. Table 1. Enumerates the number of sets of each type of gear set by month. We were unable to complete the sets if scup pots each month due to high winds which restricted vessel operations until August. Additionally, in September we again experienced an issue with the vessel, hydro-lock, which effectively ended the project for the year. Despite the limited sampling season, we added to the established database for Scup, Black Sea Bass, and Tautog. The majority of Black Sea Bass, Scup, and Tautog caught were in excess of three or four years old. Which is what this project was designed to do. Investigators are confident that this project is working properly as designed and getting the desired results. In 2016, we caught 3,454 Scup, 658 Black Sea Bass, 236 Tautog, as well as 12 other species of finfish and eight species of commercially important shellfish Table 2.

Target ate 2017

Status of ro ect On Schedule

Significant e iations Investigators were unable to complete sampling during the entire sampling season due to vessel problems and high winds.

ecommendations To continue on into the next segment.

emarks Investigators began sampling as scheduled in April, 2016. We were able to accomplish one of the two projects, launching and hauling Black Sea Bass trawls, embedded within the project each month from April through August, Table 1. However, frequent fronts passing through the area resulting in high winds resulted in a lot of vessel down time for the safety of personnel through July. August was the only month in which Investigators were able to set and retrieve all traps. Sampling was suspended in September after setting one Black Sea Bass Trawl Station and the vessel developed what would later be diagnosed as hydro-lock or water in the cylinders which wouldn't allow compression on one side of the engine. In the months April through August, we set and hauled ten Black Sea Bass Trawls, two in each sampling area, see Figure 1. In April, we were only able to set ten scup pots in each of two sampling areas, while in May we were able to set ten scup pots in each of three and one half sampling areas. In June, Investigators were only able to set and haul 40 scup pots in four areas and in July could only manage to set and haul 30 scup pots in three areas. August was by far the most successful month where 50 scup pots were set and hauled in all five sampling areas and the season was closed in early September.

Sampling was suspended in September after setting one Black Sea Bass Trawl Station and the vessel developed what would later be diagnosed as hydro-lock or water in the cylinders which wouldn't allow compression on one side of the engine. The vessel was hauled, and trucked to a repair facility and returned in early December, much too late to finish the survey. However, the vessel is ready to go for the 2017 season, unless the Division procures a new vessel in the meantime.

In spite of the vessel down time and limitations caused by the adverse weather, the 2016 field season was fairly successful. Investigators captured and measured 4458 individual fish representing 15 species, Table 2, and 491 invertebrates representing 8 species, Table 2a. Additionally, we harvested 11,262 Spider crabs, *Libinia spp*., 33 Green crabs, *Carcinus maenus*, 293 Rock crab, *Cancer irroratus*, 25 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, 40 Blue Crabs, *Callinectes sapidus,* six Jonah crabs, *Cancer Borealis* which currently is covered by an ASMFC fisheries management plan. Additionally, we measured 304 Channeled Whelk, *Busycotypus canaliculatus*, 76 Knobbed Whelk, *Busycon carica*, one Blue Mussel, *Mytilus edulis*, and 17 Bay Quahaug, *Mercenarea mercenerea*, which were brought into the traps caught on the feet of spider crabs.

In 2016, we caught approximately 18.9% more finfish than in 2015 despite the abbreviated season, however, the 2015 season was even shorter where investigators only fished 54.5% as many trap hauls as in 2016. Even though these seasons are abbreviated, the results obtained are well within the scope of the project.

In 2015, the Division received maps, PDF's and computer images of Narragansett Bay which showed structure in excess of two meters in diameter. Additionally, Investigators have replaced the original chart of sampling locations with the King sidescan data files. A new chart was created utilizing King's PDF with an overlaid .05 degree grid system. The squares or stations were then numbered and stations selected randomly for structure or non-structure.

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.

ntroduction 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 Upon obtaining a sidescan chart of Narragansett Bay from John King's Lab, investigators had a 0.5 deg. of latitude and longitude squares superimposed over it. The PDF was then enlarged to the approximate size of a nautical chart. It was subsequently 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) and numbered. These numbered boxes were referred to as stations. Investigators were provided with a key to the hardness of the bottom on the chart. 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 April through August and one set in September. 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 moved to a new areas and 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 **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.

esults iscussion

Due to intermittent high winds throughout the spring and early summer and a serious vessel problem, hydro-lock, which ended the project in September. As a result, we were unable to set all of our gear as scheduled. We were able to set the Black sea Bass Trawls 10 times, Table 1, or twice per area each month April through August but only once in September. The scup pots were set 20 times in April, 35 times in May, 40 times in June, 30 times in July, 50 times in August, and not at all in September and , Table 1. 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 3,454 individuals which comprised 77.49% of the total catch. However, only 658 black sea bass were caught which equaled 14.76%. In 2016, 236 Tautog were caught which equaled 5.29% of the total catch. Of the remaining species, Oyster Toad Fish, Stripped Sea Robins, and Gray Triggerfish were the only other species caught in any numbers, 27, 45, and 12 animals respectively. Despite our abbreviated sampling season, we made inroads on our goals for the fourth year of the project due to the efficiency of the gear in capturing the target species We again added to the established database for Scup, Black Sea bass and Tautog with substantial numbers.

Black Sea Bass Investigators noted that according to the length at age graphs for this species, figure 2b, the majority of black sea bass caught ranged in age from three years to in excess of ten years old, figure 2a, which where we want to be sampling. Additionally in 2016, we wrapped the Sea Bass Traps with 1" vexar in order to capture yoy Sea Bass. This was successful for August where we captured 31 fish 0 to 1 year old. We were not able to utilize them in September due to vessel issues and we wonder if this species might be spawning earlier due to increasing water temperatures since very small fish were not caught as in previous years, 5 – 10 cm.

Figure 3 compares black sea bass length frequencies from the RI Trawl Survey and the Ventless Trap survey. In this case, both survey's began catching the animals at a smaller size <10 cm. This is understandable, since the trawl survey uses a ¼' liner in the trawl net and will retain just about anything that enters the cod end and the Ventless survey was utilizing the ¼" mesh on the traps in August which would have the same effect. However, the trawl survey tends to capture slightly larger fish, up to 55 cm, this may be due to constraints of the traps although this didn't seem to be a factor in 2016. The Ventless catch ranged from a Minimum of 7 cm to a maximum of 52 cm and a mean of 29.02 cm and an overall catch of 658 fish. In comparison, the Trawl Survey catch ranged from a minimum of 6 cm to a maximum of 54 cm with a mean of 30.31 and an overall catch of 275. It should be noted that this graph is presented in a percent frequency, this was done for consistency with all graphs comparing the trawl survey to the ventless survey due to the very large numbers of scup caught by the trawl survey. However, the two nodes on the graph which stand out are still very evident one is the yoy and one year old and the second is the five to ten year old node, and the third is fish older than 10 years of age. This data is exactly what this project was designed to provide. It should be noted that the fish captured in the first node were all captured in August when the traps were coved with vexar.

Investigators also compared the length frequencies of sea bass caught in Sea Bass Traps vs. Scup pots, fig 4. This graph illustrates that in 2016 the scup pots seemed to capture the desired sizes of sea bass in greater numbers that did the traps. This may bear looking into or it may be as simple as the traps are set unbaited and the scup pots are bated with sea clams. It is fairly obvious when hauled that the sea bass are quite full of clams. Figure 5, enumerates the Black Sea Bass captured in a structure vs non-structure situation. This graph seems to indicate that non-structure may be the preferable route to capture, however, there is such a small sample size that this graph is really inconclusive. For instance, the smaller fish less that 16cm were all caught in traps covered with vexar and might easily have escaped otherwise thus changing the results.

Scup: Length frequency histograms for Scup with associated length at age graphs are presented in figures 5 a. and 5 b. The scup caught ranged from approximately zero or yoy to as old as 11.5, however, the majority of the fish caught were in the two to six year old range. Again without too much repetition, we seem to be sampling right where the project was designed to be.

Figure 6 compares scup length frequencies from the RI Trawl Survey and the Ventless Trap survey. Since the trawl survey caught in excess of 93,000 scup, we derived a proportionate frequency by dividing each frequency by the total caught. This was done in order to compare trawl survey data with ventless trap data. This was done consistently for each species in the comparison. From the graph, it is obvious, that the trawl survey caught enormous numbers of yoy and one year old fish while still catching large numbers of older adult fish the numbers drop off precipitously. On the other hand, the ventless project caught very few, one or two yoy, and the majority of the fish were at least three years old or in some cases as old as ten years old. The Ventless catch ranged from a Minimum of 8 cm to a maximum of 38 cm and a mean of 23.5 and an overall catch of 3,454 fish. In comparison, the Trawl Survey catch ranged from a minimum of 3 cm to a maximum of 38 cm with a mean of 19.6 and an overall catch of 93,123.

Investigators again compared the catch of scup with the black sea bass traps vs, the scup pots and it seems that the traps catch and retain larger numbers of smaller scup and decreasing numbers of the larger animals. The scup pots, on the other hand, capture in a reverse scenario where animals between 13 cm and 18 cm are captured and in low numbers and a great deal more of are caught between 18 cm and 30 cm, figure 7. We have also compared the catch of Scup in areas of structure vs non-structure, figure 8. There has been no analysis done on this data since we have just adopted the King system, we have not had a complete sampling season and figure 8 looks like there is almost no difference in either structure or non-structure. Even the numbers caught are almost identical.

Tautog In 2016, we caught 236 Tautog throughout the season almost entirely in the sea bass trawls. Again utilizing the length at age graph, these fish ranged in age from approximately 1 to 2 years of age to approximately 26 or 27 years of age. Investigators are confident that this project is working properly as designed and getting the desired results. Figures 8 a, shows the various size classes of Tautog that were caught in 2016. We caught 236 Tautog, 79 fish less than in 2015.

Figure 9, compares the length frequencies of the RI Trawl Survey and the Ventless Survey. The ventless survey caught more Tautog than the trawl survey, which isn't surprising because of where the gear is set. The trawl survey caught fish from 6cm to 72cm in length with a mean of 38.7 cm and a total caught of 105 fish. Whereas the Ventless Survey caught fish starting at 13 cm to 58 cm with a mean of 35.2 cm and a total fish count of 236. Investigators again surmise that the reason the trawl catches larger fish up to 72 cm may be a function of the larger fish not being able to gain entry into the traps, or they may be more sensitive to crowding within the trap than smaller fish.

Figure 10, again enumerates the length frequencies of Tautog caught in sea bass traps vs. scup pots. The results are hardly unexpected, investigators rarely catch Tautog in scup pots. Figure 11 seems to infer that there is no difference between structure and non-structure in Tautog. Even the numbers are within 10% of each other. However, on closer examination one can discern that the larger fish greater than 38 cm are never caught on non-structure and those smaller than 18 cm are never caught on structure. The fish between 18 cm and 38 do however seem to be capable of being caught either on structure or non-structure.

Temperature, Salinity, and Dissolved Oxygen:

Investigators were not able to take enough readings due to equipment malfunctions throughout the season to produce any graphics. However, we noticed that surface water temperatures varied from month to month influenced by the air temps and the area where they were taken. For example, in the early spring they were highly influenced by the outflows from the many fresh water systems in the northern sections of the Bay, which made the water warmer than those of the southern sections. In May the first month when data was taken, surface temperatures ranged from 11.4 °C to 16.98 °C. The temperatures changed only slightly from station to station within each area but rose constantly throughout the season and ranged from a low of 11.4 °C on May 17 to as High of 27.62 °C on August 15. This constant rise was probably attributable to the air temperatures which were intermittent throughout the time and ranged from 12 °C to 27.98 °C. Bottom temperatures ranged from 10.7 °C on May 17 to a high of 26.38 °C on August 18. Surface salinities ranged from 21.5‰ to 32.62‰ and surface dissolved oxygen ranged from 6.06 mg/L to 10.69 mg/L.   Bottom salinities ranged from 28.22‰ to 32.99‰ and dissolved oxygen ranged from 5.21 mg/L to 1.11 mg/L. Again it should be noted that temperatures, salinities, and dissolved oxygen readings were clustered at stations in parts of each sampling area, e.g. the Providence River, and Greenwich Bay.

Prepared by: ____________________ Richard J. Satchwill, Principal Biologist, Marine Fisheries

Approved by: ________________________ Jason McNamee, Chief, Marine Resources

eferences

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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	10	10	10	10	10	1	0
Scup Pots	20	35	40	30	50	0	0
Total	30	45	50	40	60	1	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	3,454	77.49
Centropristis striata	Sea Bass Black	658	14.76
Tautoga onitis	Tautog	236	5.29
Opsanus tau	Toadfish Oyster	27	0.61
Paralichthys dentatus	Flounder Summer	7	0.16
Prionotus evolans	Searobin Striped	45	1.01
Sphoeroides maculates	Puffer Northern	5	0.11
Balistes capriscus	Triggerfish Gray	12	0.27
Menticirrhus saxatilus	Kingfish Northern	1	0.02
Prionotus carolinus	Searobin Northern	3	0.04
Morone saxatilis	Bass Striped	2	0.04
Anguilla rostrate	American Eel	1	0.02
Pleuronectes americanus	Flounder Winter	1	0.02
Gadus morhua	Cod Atlantic	1	0.02
Conger Oceanicus	Conger Eel	5	0.11

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
Busycotypus canaliculatus	Channeled Whelk	304	62.04
Busycon carica	Knobbed Whelk	76	15.51
Homarus americanus	American Lobster	46	9.39
Callinectes sapidus	Blue Crab	40	8.16
Squilla empusa	Mantis Shrimp	1	0.20
Mercenarea mercenarea	Bay Quahaug	17	3.47
Cancer borealis	Jonah Crab	6	1.22
Mytilus edulis	Blue Mussel	1	0.20

Figure 1. – Chart of Narragansett Bay with Colregs line of demarcation and Location of Five Sampling Areas.

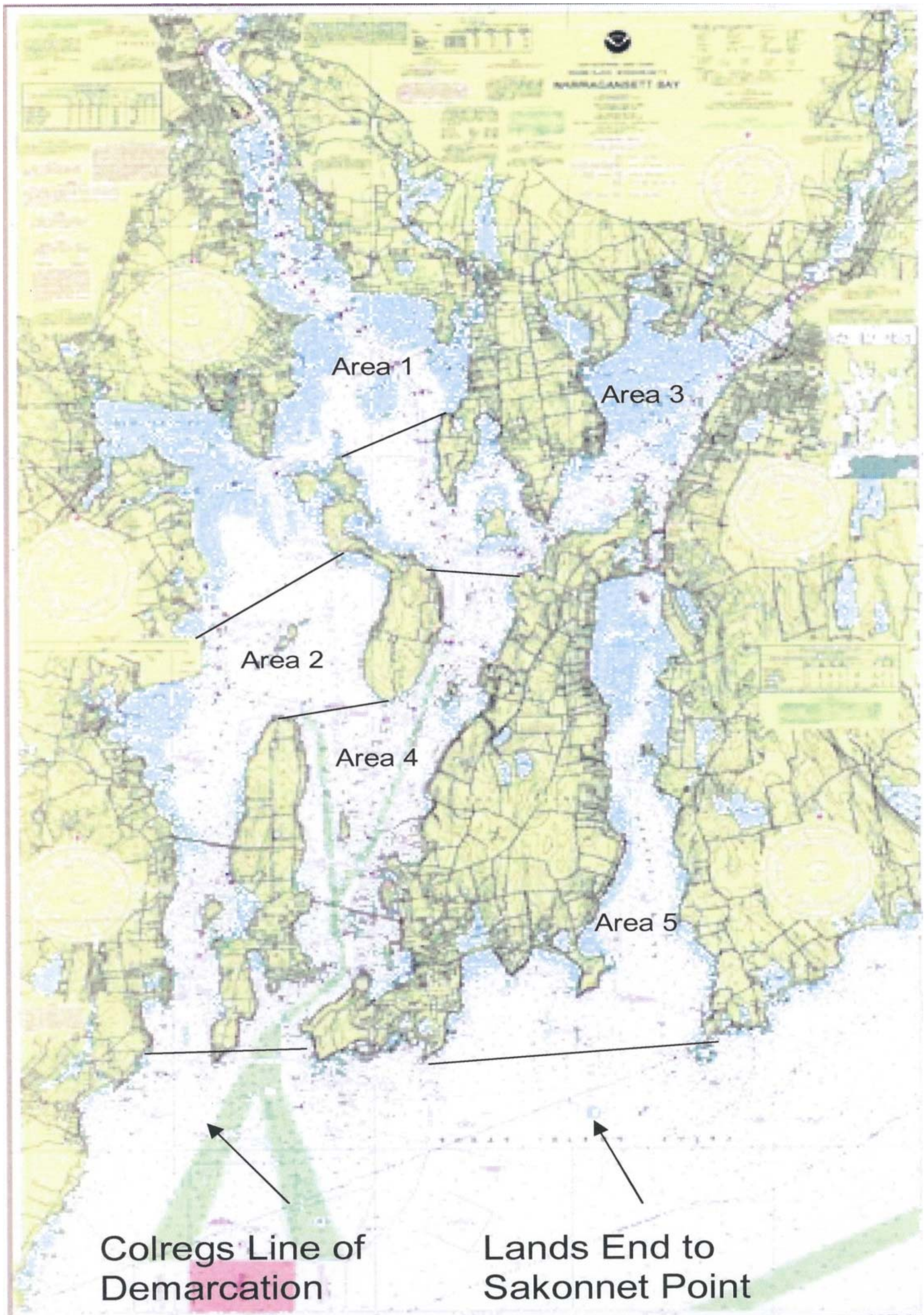


Figure 2a... Length Frequency Histogram for Black Sea Bass.

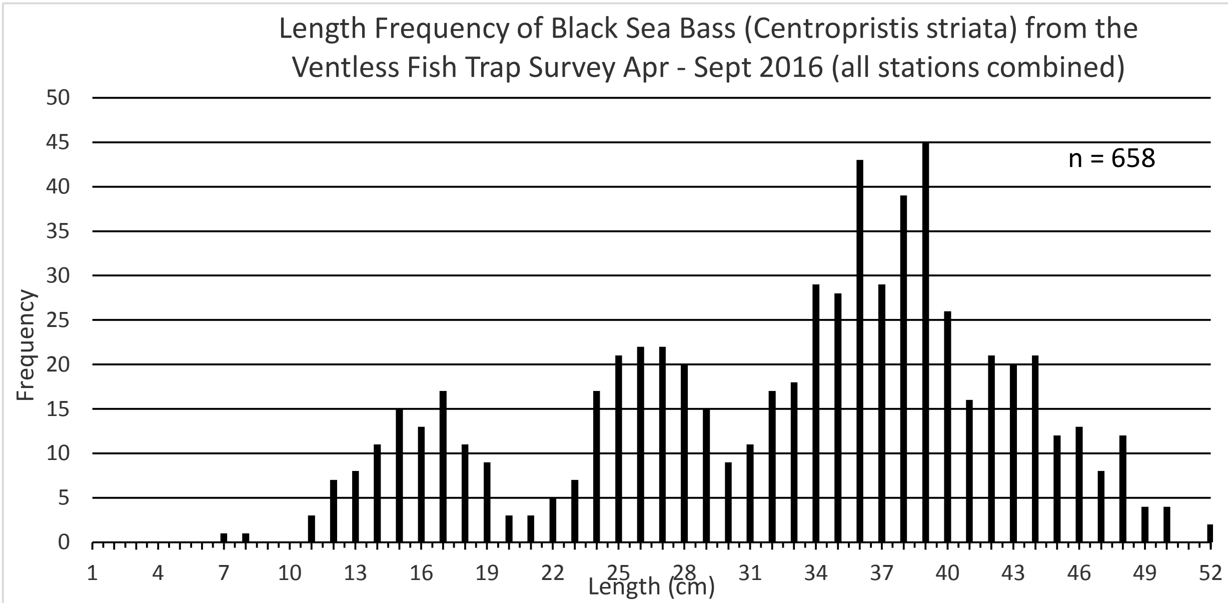


Figure 2b. Length at Age graph for Black Sea Bass

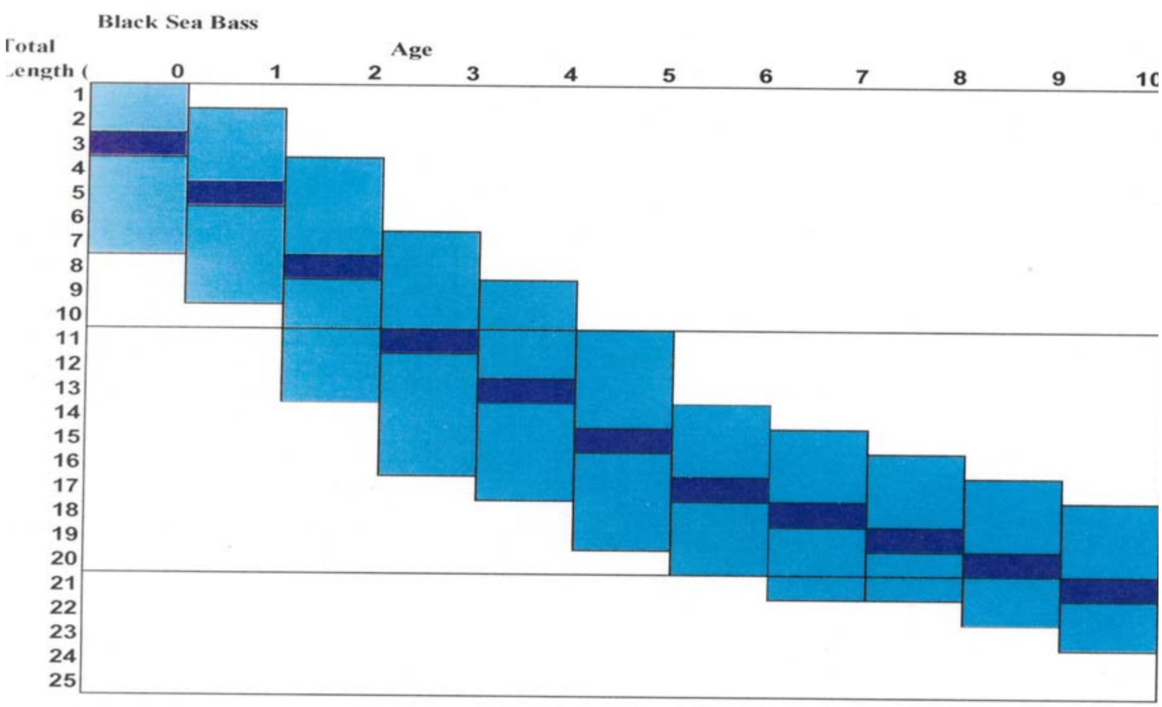


Figure 3. Comparison of Trawl Survey vs Ventless Trap Survey

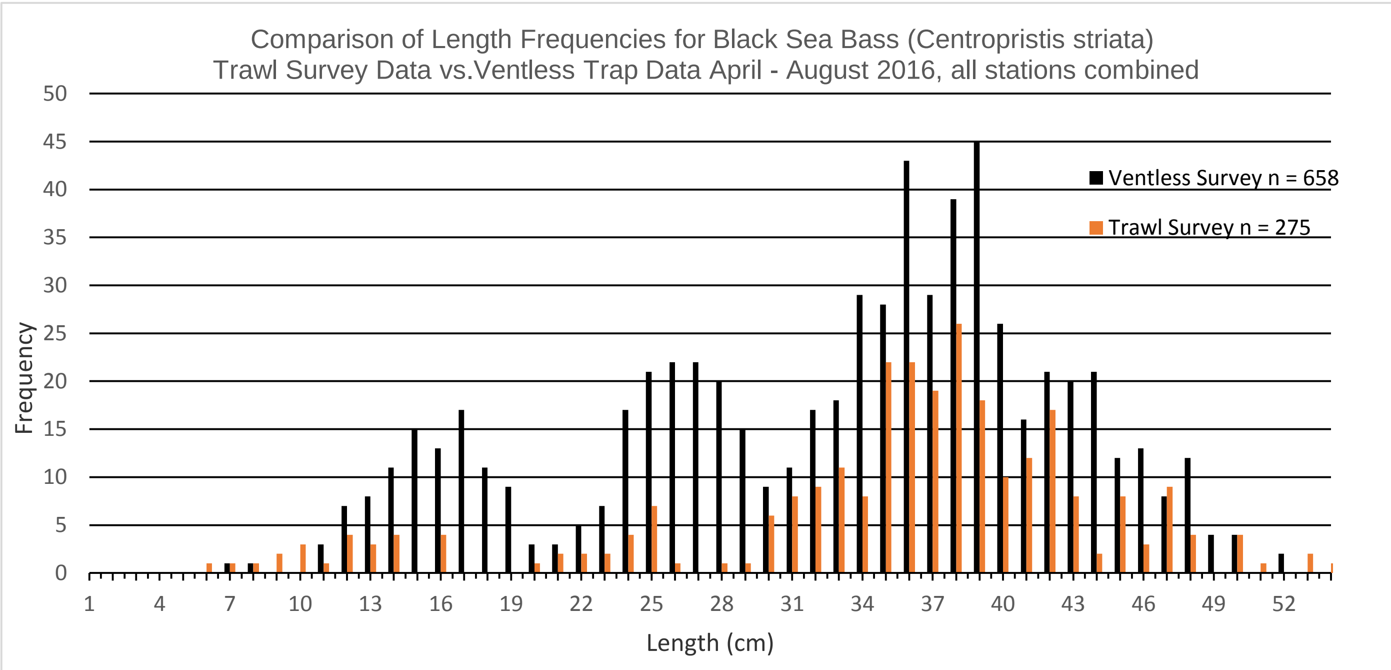


Figure 4. Comparison of Sea Bass Traps vs Scup Pots

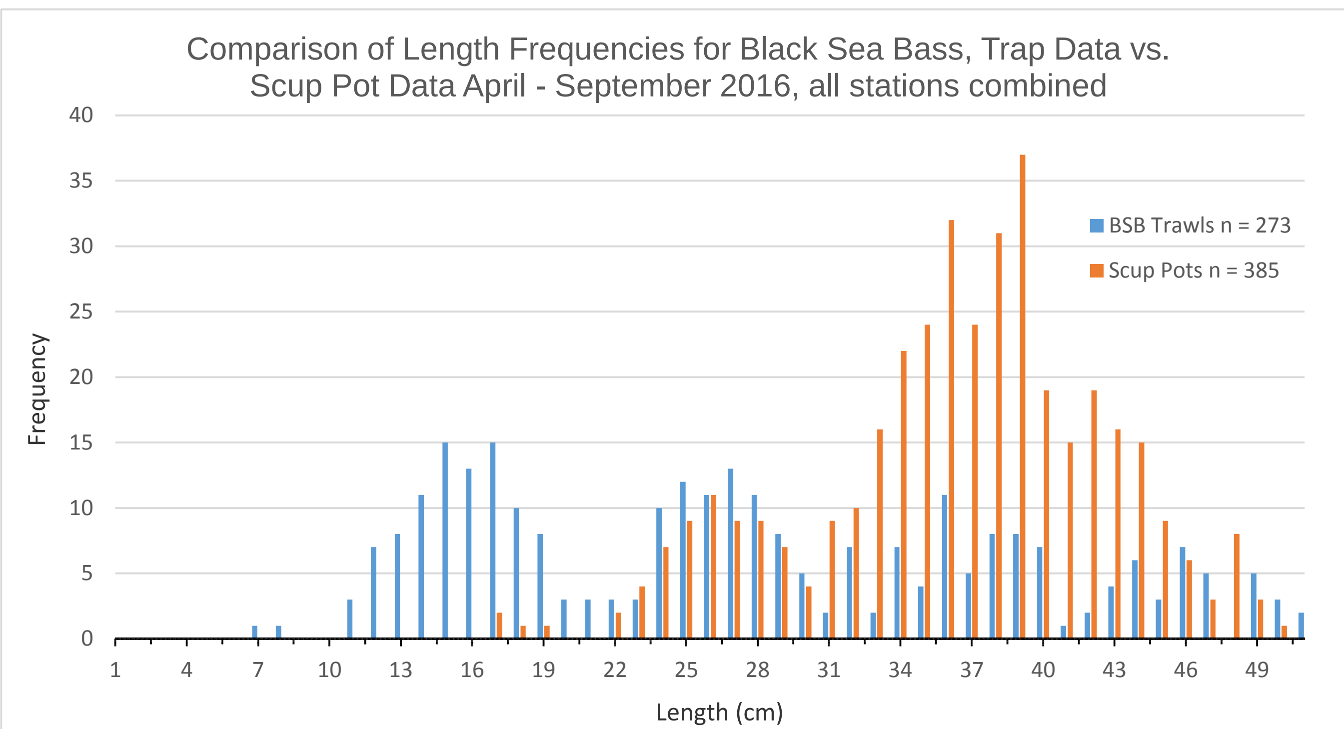


Figure 5. Comparison of Structure vs. Non-Structure

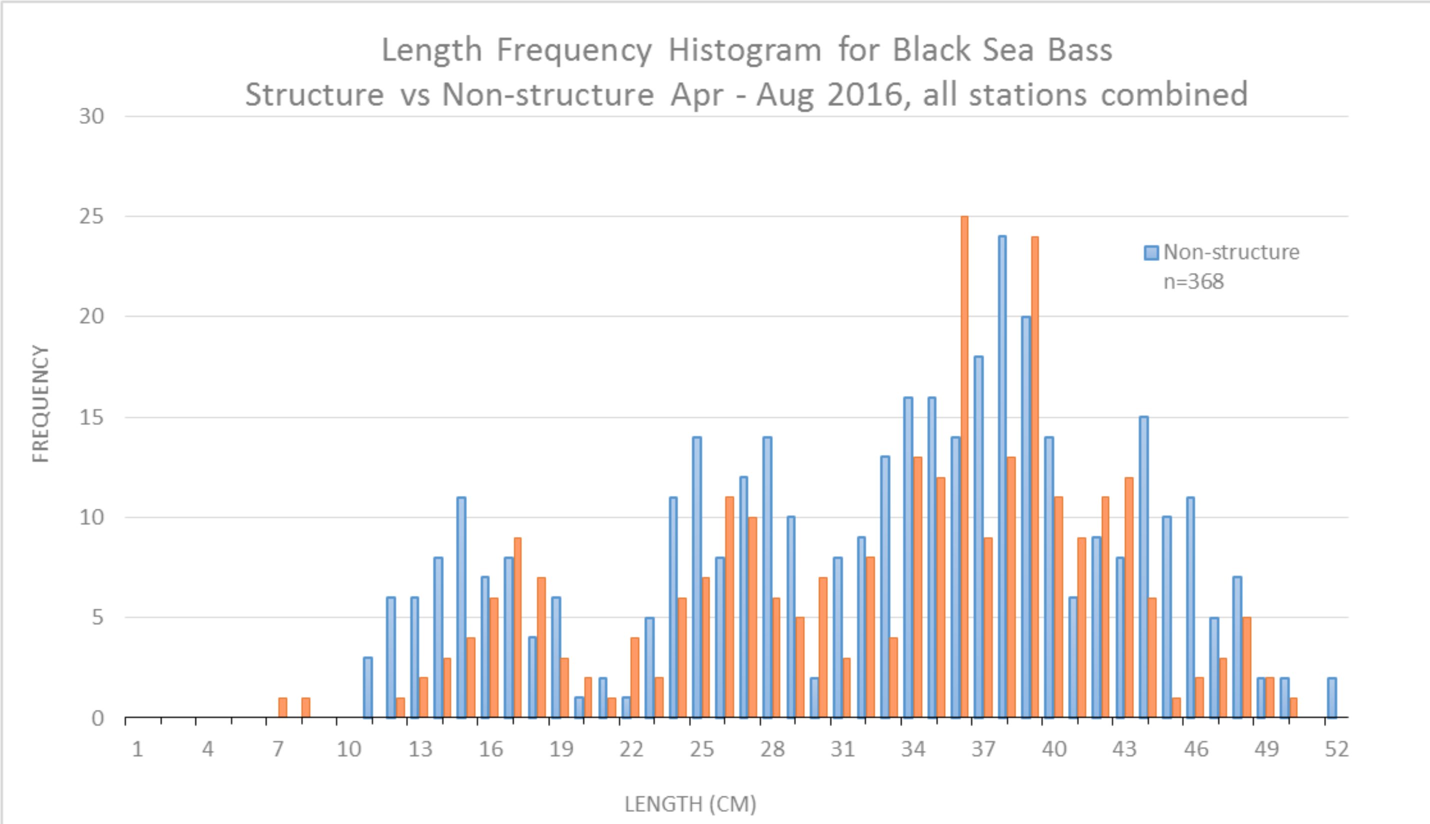


Figure 6 a. Length Frequency Histogram for Scup.

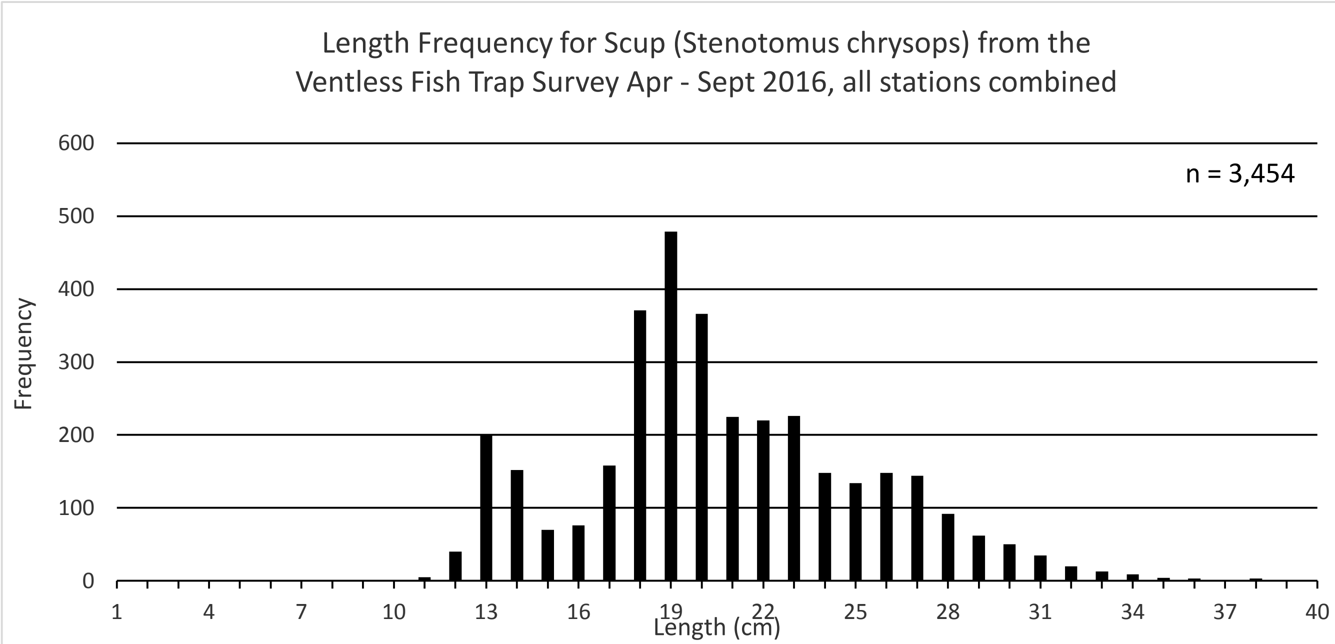


Figure 6b. Length at age graph for scup

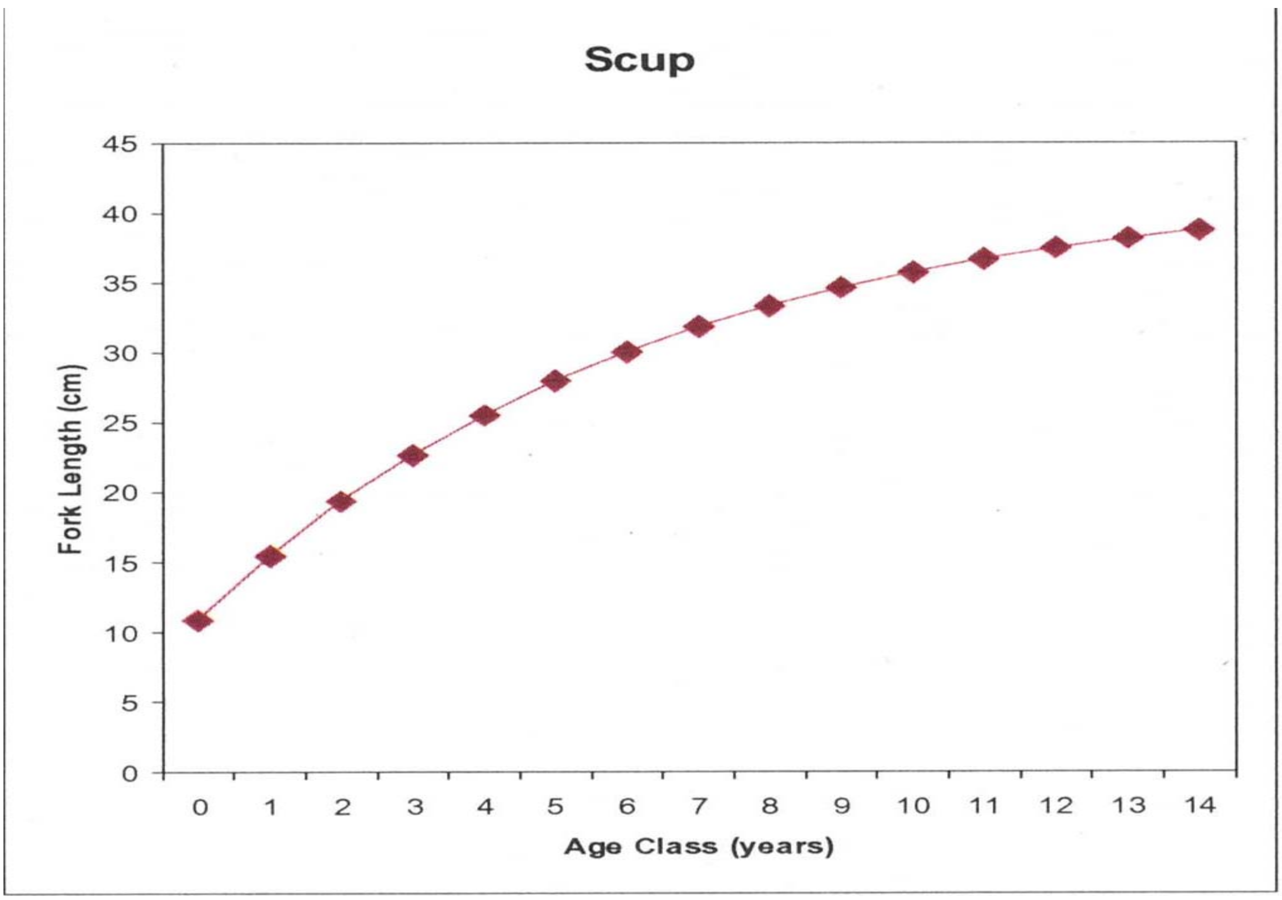


Figure 7 Comparison of Trawl Survey Data vs. Ventless Trap Data

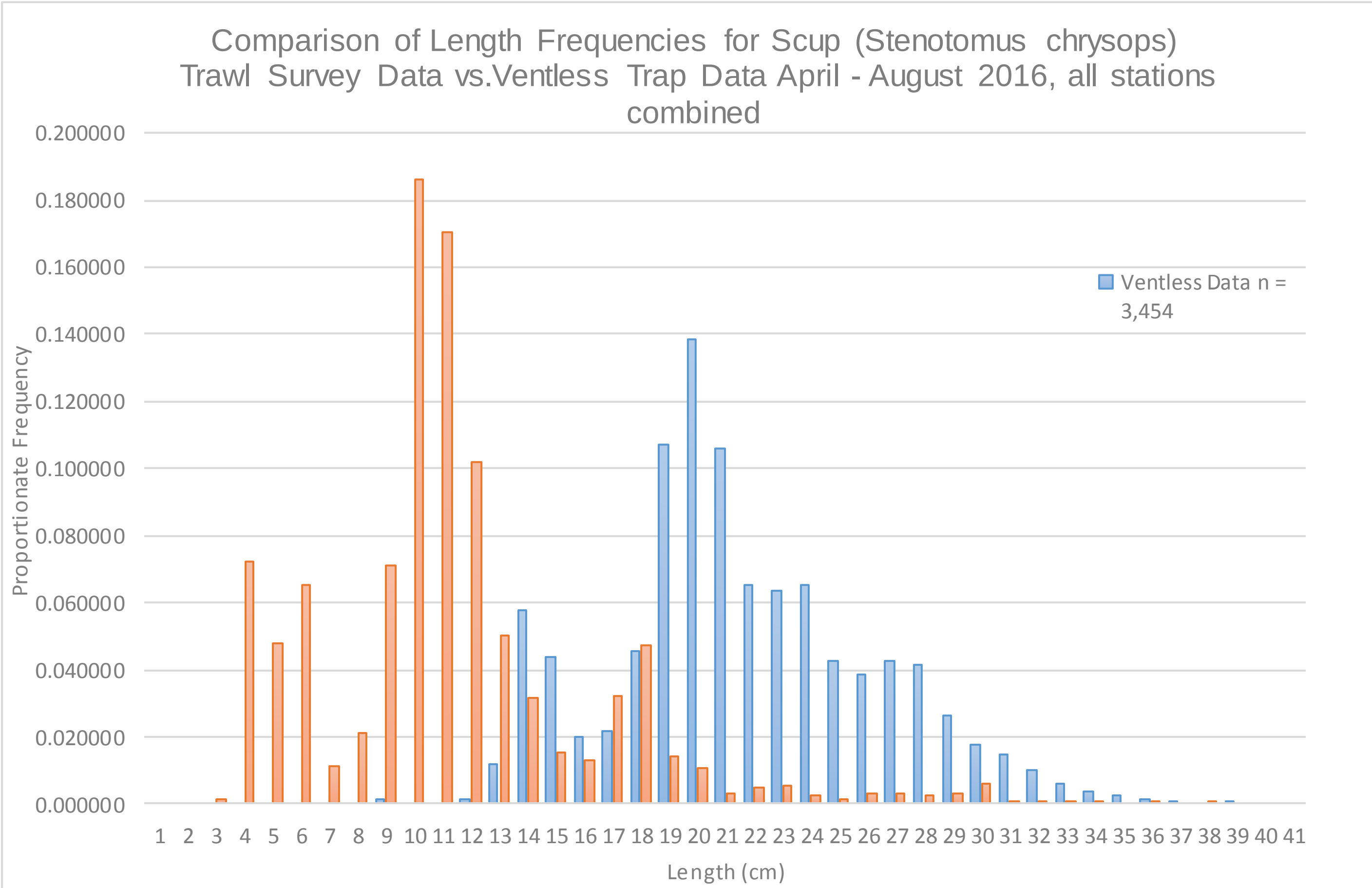


Figure 8 Comparison of Black Sea Bass Trawls vs. Scup Pots

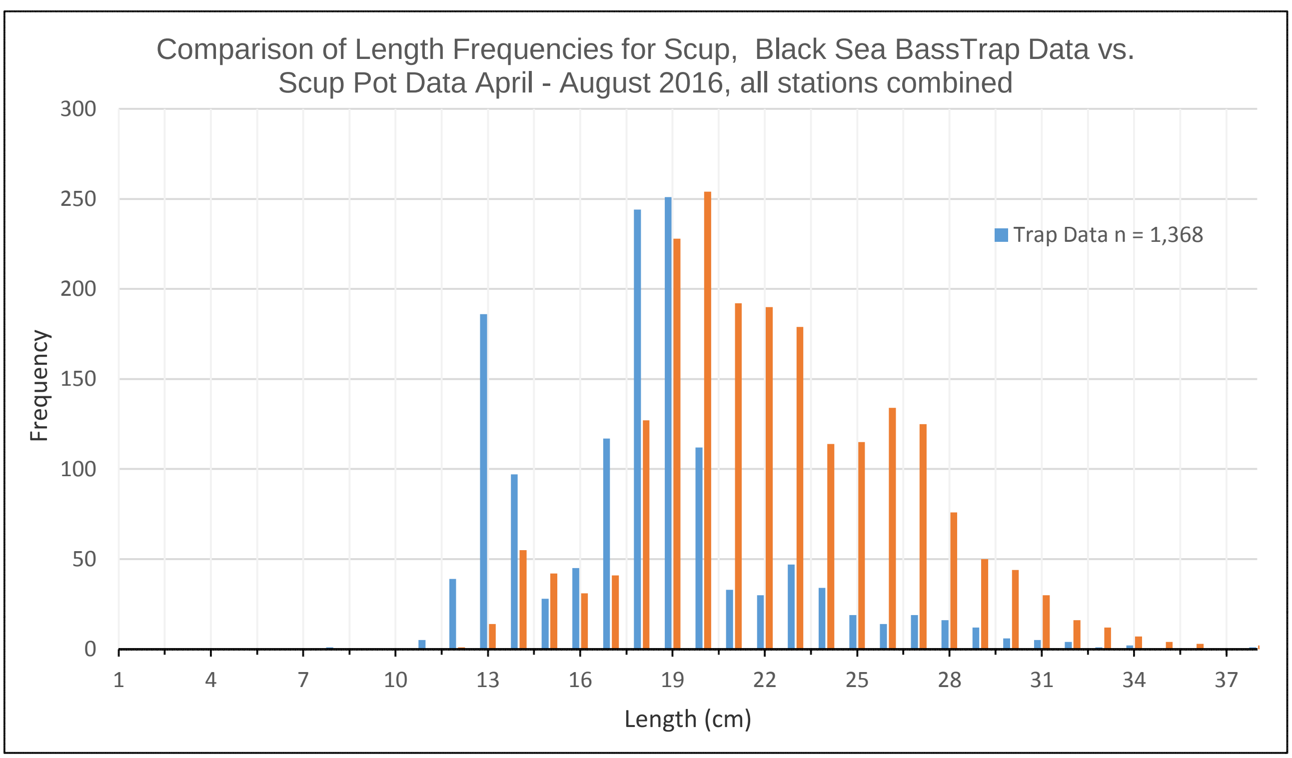


Figure 9. Comparison of Structure vs. Non-Structure

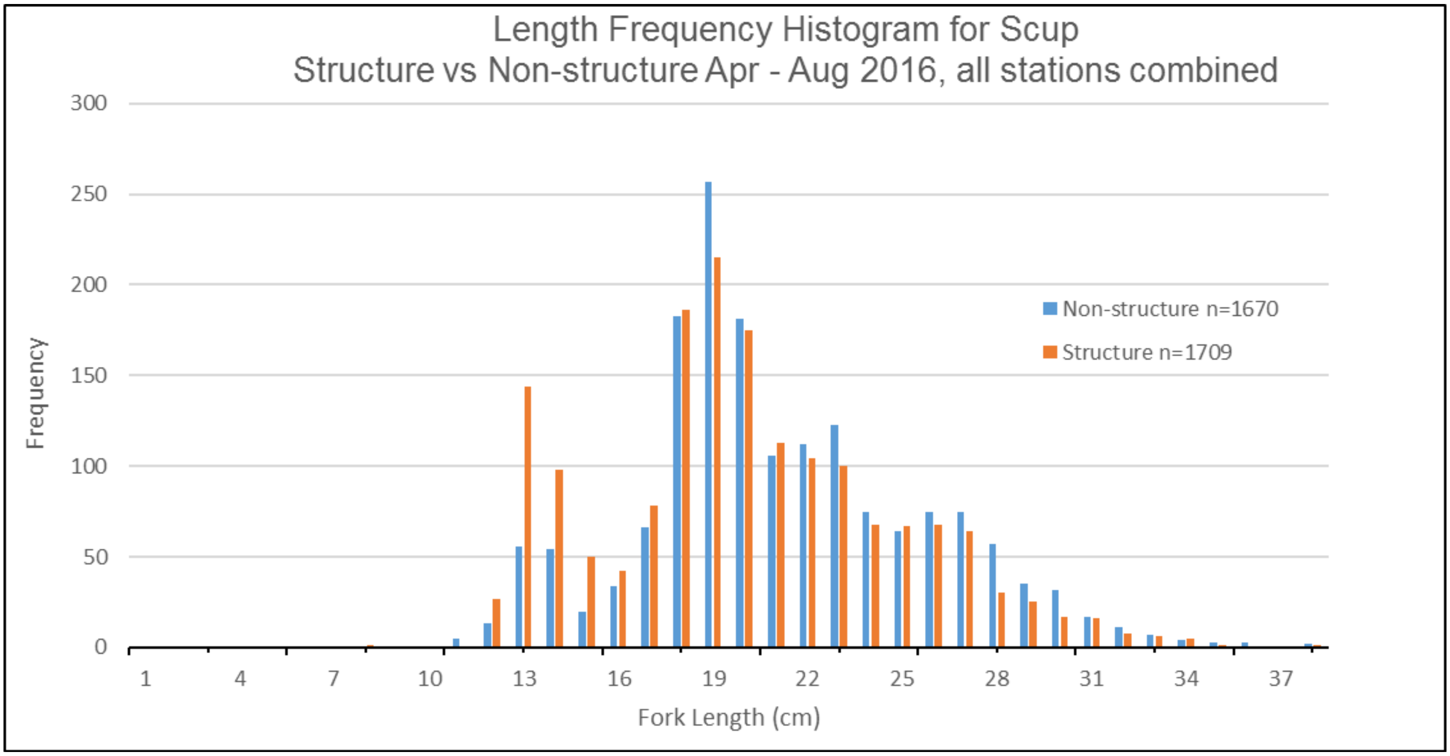


Figure 10 a. Length Frequency Histogram for Tautog.

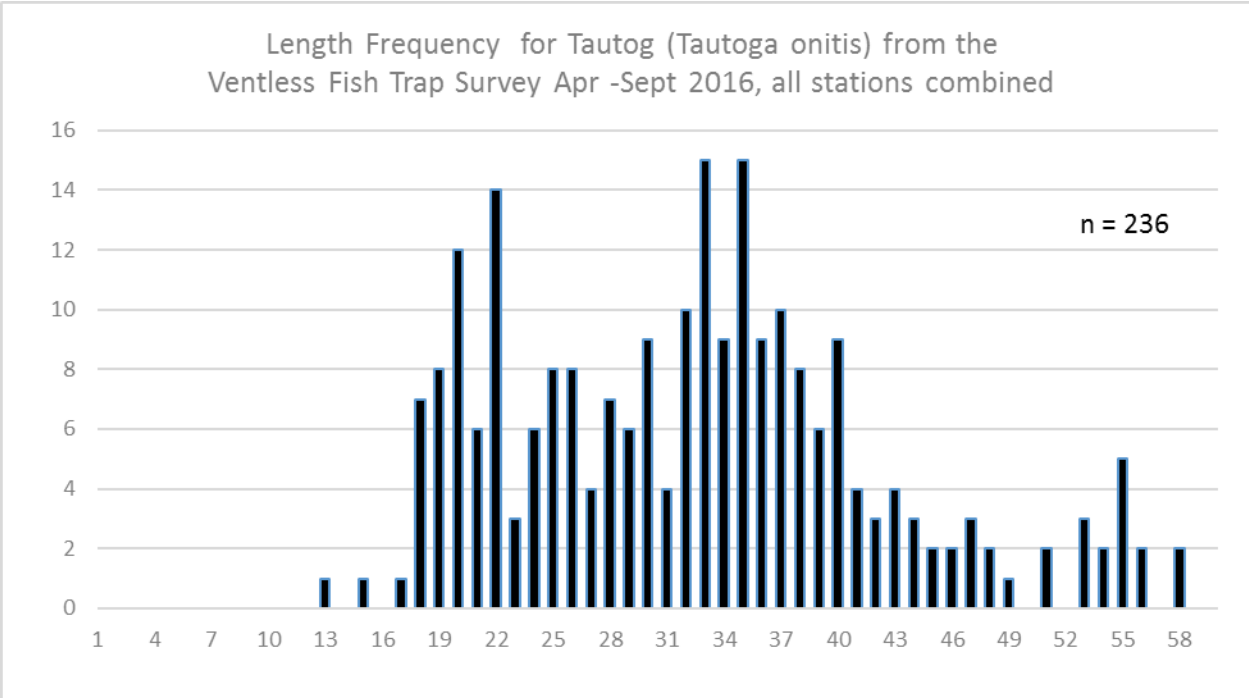


Figure 10 b. Length at age graph for Tautog

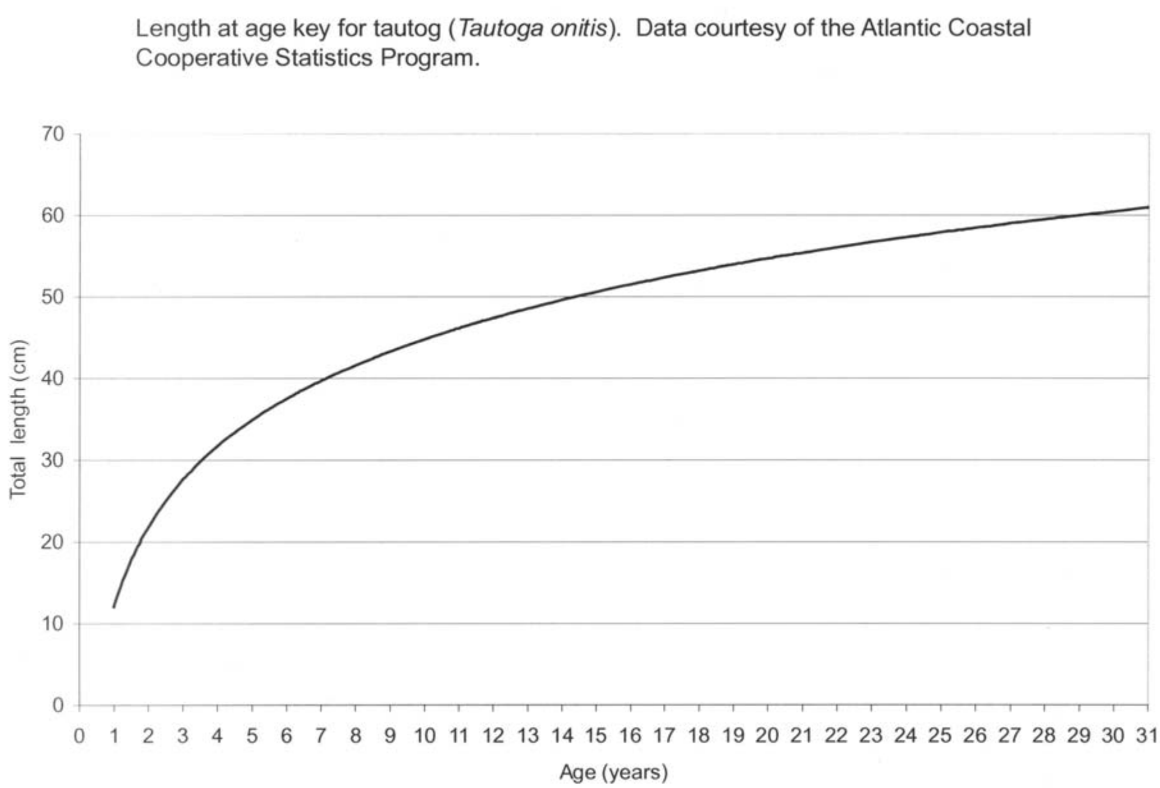


Figure 11. Comparison of Trawl Survey vs Ventless Trap Survey

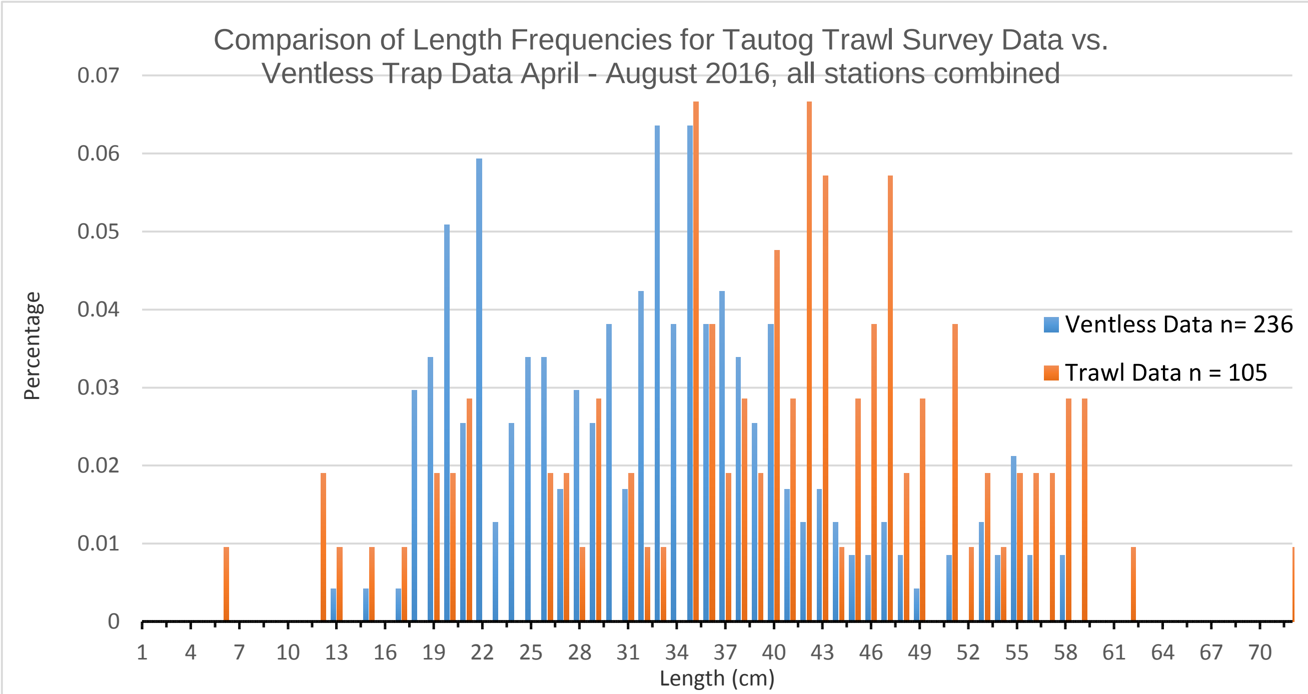


Figure 12. Comparison of Black sea Bass Traps vs. Scup Pots

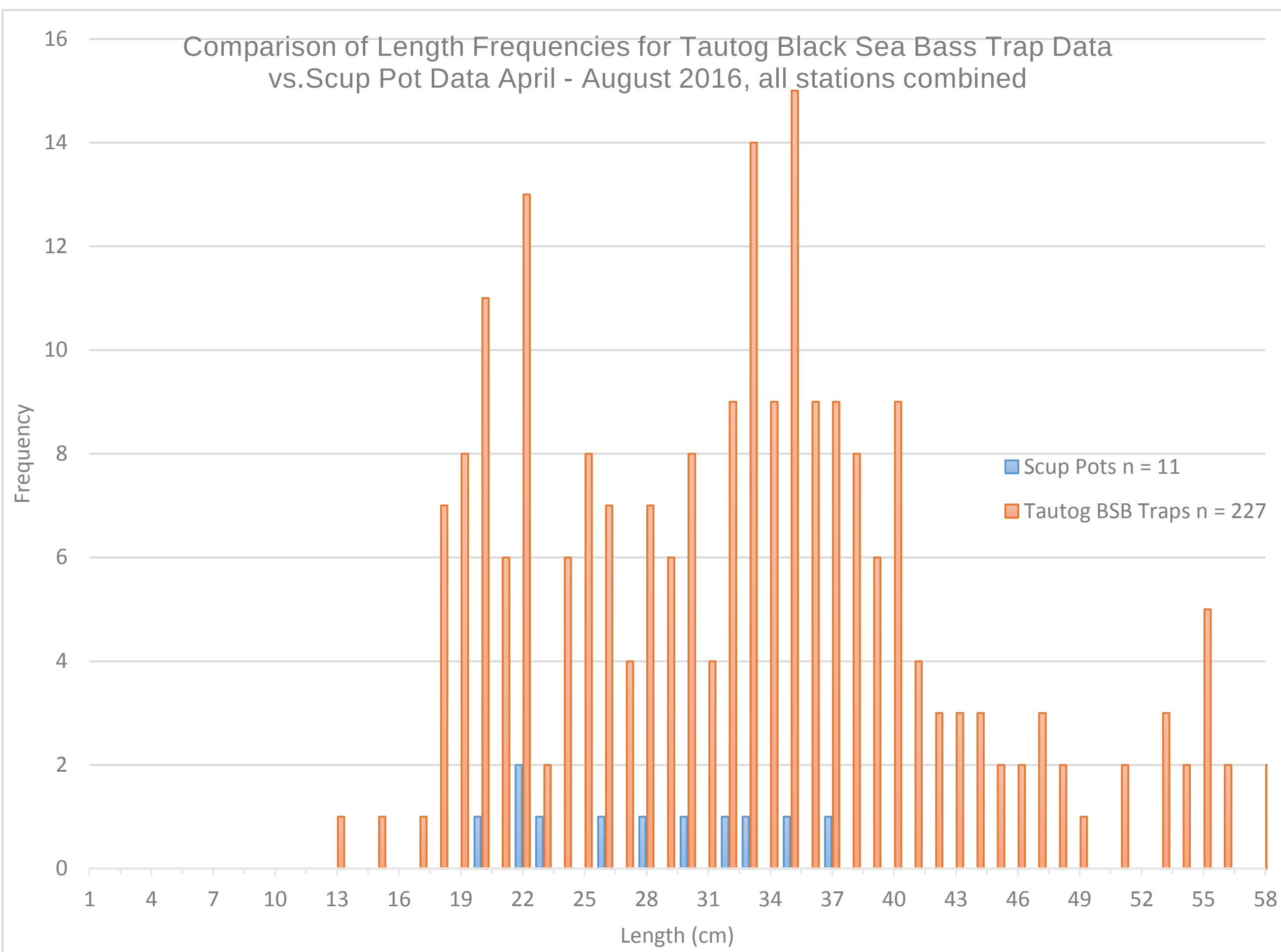
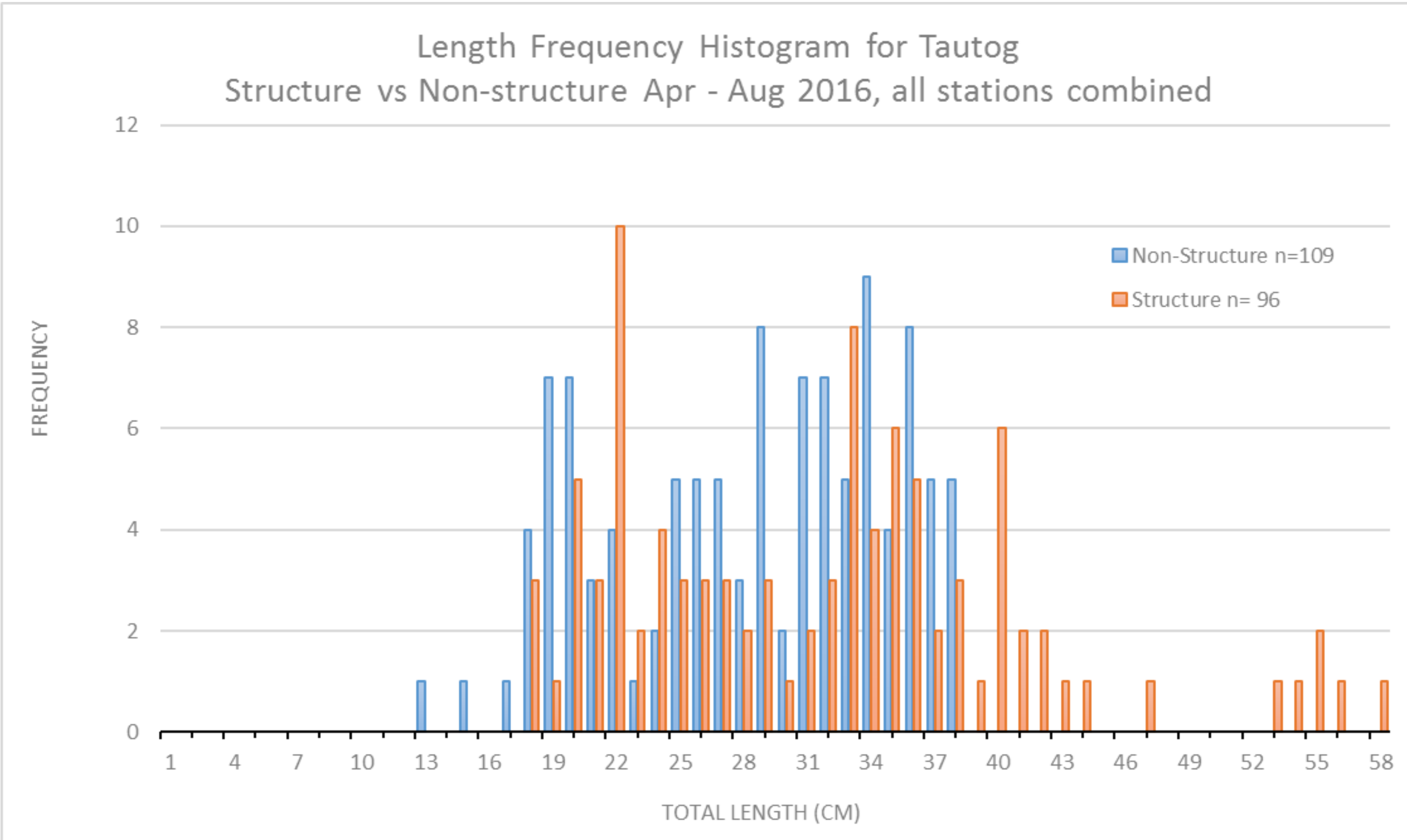


Figure 13. Comparison of Structure vs. Non-Structure



Marine Fishes of Rhode Island

By
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Rhode Island Department of Environmental Management
Division of Fish and Wildlife

Performance Report - Job - 13 March 2017

F M T

State Rhode Island Project Number: F-61-R

ro ect T pe Resource Monitoring

ro ect Title Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

eriod o ered January 1, 2016 to December 31, 2016

o um er Title 13- Marine Fishes of Rhode Island

o ecti e The goal of this project is to produce a manuscript which will act as a reference text for recreational fishermen, fisheries scientists, and commercial fishermen alike. The finished product will summarize existing knowledge on the appearance, distribution, and life history information where such information exists, including growth, reproduction, food habits, and longevity of fishes caught within the marine waters of Rhode Island. The results will be listed systematically and the manuscript will include scientific illustrations and photographs of fish and distribution maps delineating range of fishes within the state. This volume will be 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

Summar We spent the majority of the year working on "The Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program" and working on floating fish trap issues for the department. Meetings were held with superiors to discuss the issue created by the two projects and a resolution. We also modified our initial contract with the artist. He was told to begin drawing at the beginning of the list with the sharks.

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Target ate 2017

Status of ro ect Behind Schedule

Significant e iations Personnel were unable to complete significant amounts of work on this project. They were engaged in "Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program" sampling and vessel repair.

ecommendations To continue on into the next segment.

emarks Personnel spent the majority of the year, March through October, working on the Narragansett Bay Ventless Pot project, either completing field work, data entry and analysis, or working to restore our vessel to working order to resume sampling. When the ventless pot project ended in September, it was because of vessel issues which had to be resolved ASAP. In the interim, we were also involved in a floating fish trap issue for the department which took several months and continues on to this day. This issue robbed us of any extra time to work on this project we might have had in 2016.

Consequently, we met separately with the Chief and Supervisor to discuss the issue. After discussing the problems with them, I recommended that the project be transferred to a staff member who does not have a full time field project since the two are mutually exclusive. Approximately a week later, I was told to transfer all of my draft work to the staff directory.

I have been in contact with Robert Golder the artist early in 2016 and we modified the assignment. He indicated he wasn't able to easily draw those 14 species assigned. Therefore, we decided to start him drawing at the beginning with the sharks. Investigators have worked with the scientific illustrator, in 2016, we provided pictures of sea herring and froze specimens for his later use, photographs, etc., of the fish to assist the artist in his task.

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Prepared by:_________________
Richard J. Satchwill
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Approved by:____________________
Jason McNamee
Chief,
Marine Fisheries

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

University of Rhode Island Graduate School of Oceanography Weekly
Fish Trawl
2016

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, 2016 ï December 31, 2016.

TARGET DATE: December 2016

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

RECOMMENDATIONS: Continuation of the weekly trawl survey into 2017; data provided by the survey are used extensively in the Atlantic States Marine Fisheries Commission and NOAA Fisheries fishery management process 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 2016. 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 2016 survey year as it relates to the past 57 years.

Methods:

A weekly trawl survey is conducted on the URI research vessel Capôn 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 56 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 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

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

(For more information about the GSO fish trawl go to www.gso.uri.edu/fishtrawl)

<u>Results</u>:

Fifty-one weekly tows were made at the bay (Fox Island) and sound (Whale Rock) stations. No exceptions or problems were encountered.

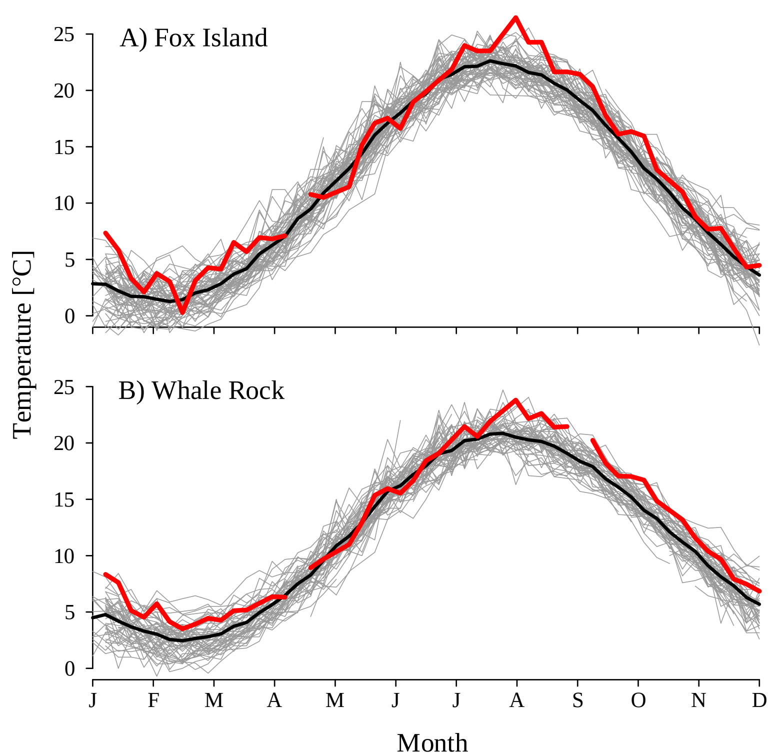

Figure 1. Weekly sea surface temperature of Narragansett Bay at each sampling station. The gray lines represent the seasonal temperature cycle for each previous year. The black line is the average temperature over all years. The most recent year, 2016, is labeled red.

Environmental conditions

Weekly water temperatures at both stations remained consistently higher than the historic average during most of 2016 (Fig. 1). Both January and August were drastically warmer with water temperatures at or near record highs. The surface temperature of 26.46 °C (79.6 °F) at Fox Island during the week of August 16 is the highest recorded temperature in trawl history. The warm winter temperatures at the beginning of the year are likely due to the strong El Niño in the Eastern Pacific Ocean and are likely to have a positive effect on warmer water species such as butterfish and scup.

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*)	25594	6728	32322
SQUID (*Loligo peali*)	524	2456	2980
BUTTERFISH (*Peprilus triancanthus*)	1227	1171	2398
ROCK CRAB (*Cancer irroratus*)	114	1981	2095
SPIDER CRAB (*Libinia emarginata*)	766	447	1213
LITTLE SKATE (*Leucoraja erinacea*)	47	919	966
WINTER FLOUNDER (*Pseudopleuronectes americanus*)	85	328	413
SUMMER FLOUNDER (*Paralichthys dentatus*)	144	230	374
NORTHERN SEAROBIN (*Prionotus carolinus*)	62	255	317
SILVER HAKE (*Merluccius bilinearis*)	3	253	256
STRIPED SEAROBIN (*Prionotus evolans*)	80	166	246
MENHADEN (*Brevootia tyrannus*)	143	89	232
CONCH (*Busycon canaliculatum* & *B. carica*)	5	182	187
HERMIT CRABS (*Pagurus pollicaris*)	180	3	183
LOBSTER (*Homarus americanus*)	2	172	174
MOONFISH (*Vomer setapinnis*)	107	37	144
FOURSPOT FLOUNDER (*Paralichthys oblongus*)	4	134	138
SAND FLOUNDER (*Scophthalmus aquosus*)	14	110	124
ATLANTIC (SEA) HERRING (*Clupea harengus*)	28	59	87
ALEWIFE (*Alosa pseudoharengus*)	26	57	83
TAUTOG (*Tautoga onitis*)	62	2	64
WEAKFISH (*Cynoscion regalis*)	13	46	59
BLUE CRAB (*Callinectes sapidus*)	28	22	50
BLACK SEA BASS (*Centropristes striatus*)	12	32	44
KINGFISH (KING WHITING) (*Menticirrhus saxatilis*)	4	40	44
TOTAL	**29274**	**15919**	**45193**

The top 10 species caught in 2016 (and the station where they were most numerous) were: Scup (FI), Squid (WR), Butterfish (FI), Rock crabs (WR), Spider crabs (FI), Little skate (WR), Winter flounder (WR), Summer flounder (WR), Northern searobin (WR), Silver hake (WR),

A number of species of recreational importance were collected during 2016 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 during the time period of the survey with some of the lowest estimates on record for both stations occurring in the last decade. However, 2016 produced the highest catch of winter flounder in the last 4 years (Figure 2). The survey information is used during the stock assessment process for winter flounder.

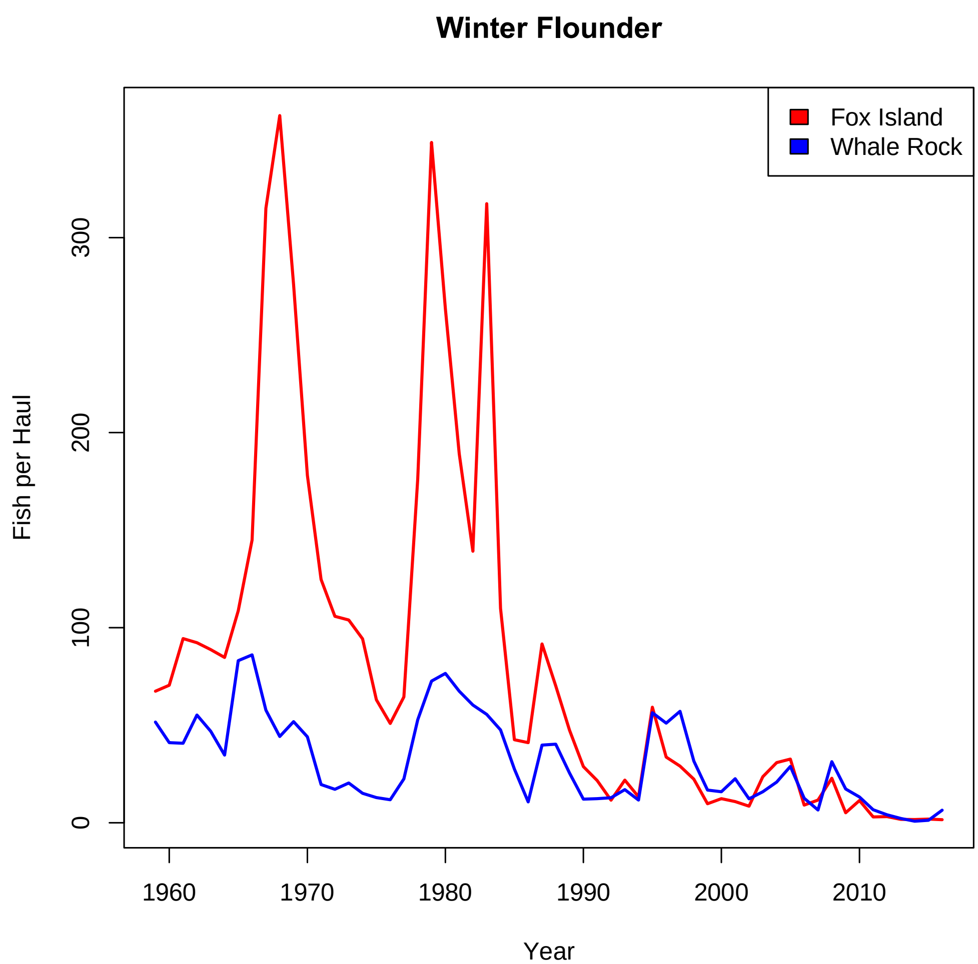

Figure 2 ï Survey data for entire time series for winter flounder at both sampling stations (Fox Island and Whale Rock).

Tautog

Tautog are another important recreational species caught by the survey. The population of tautog has declined dramatically during the time period of the survey, but does show some small improvement in the most recent period of time (Figure 3). 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.

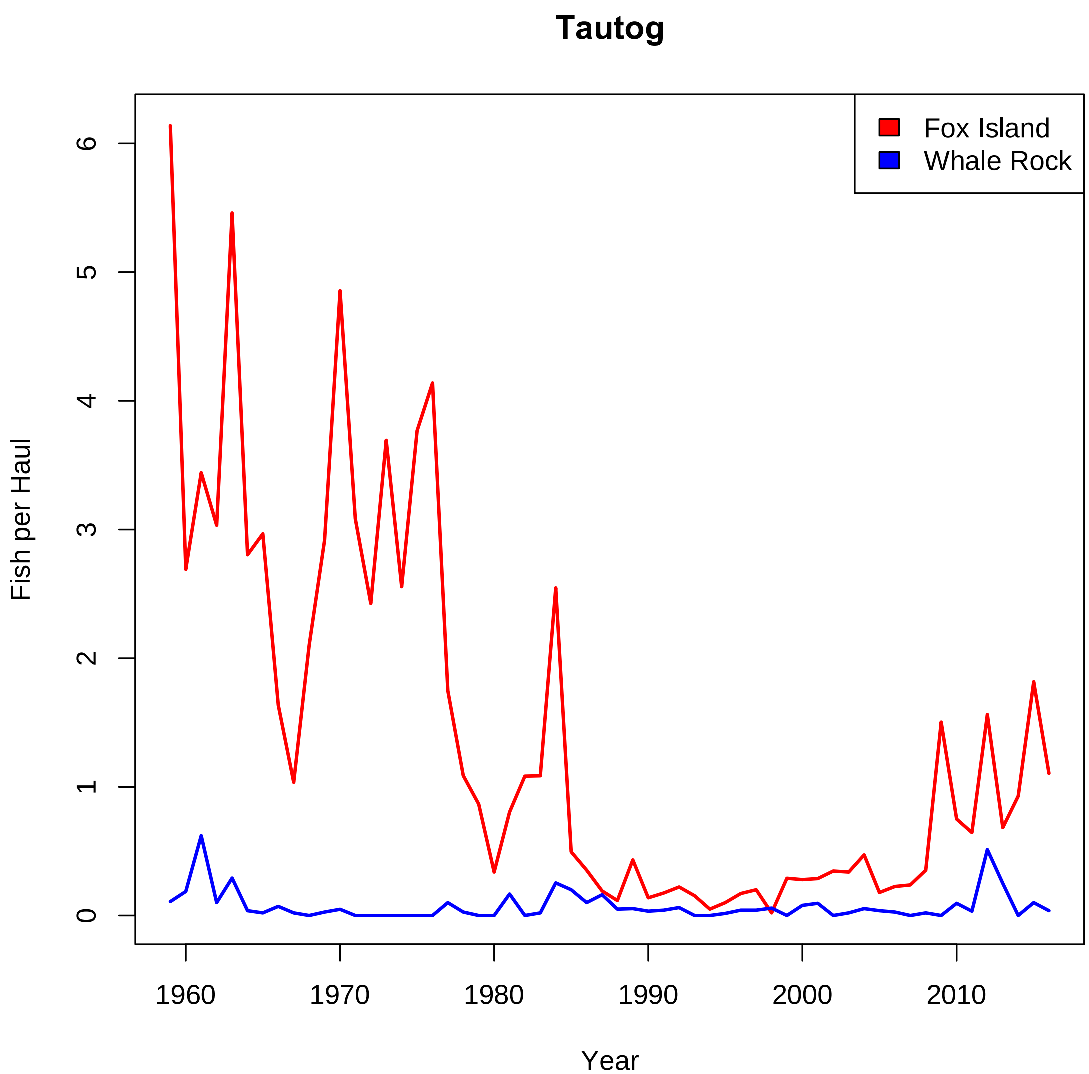

Figure 3 ï Survey data for entire time series for tautog at both sampling stations (Fox Island and Whale Rock).

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 4). Summer flounder are caught at both sampling stations pretty consistently, though abundance has increased at Whale Rock relative to Fox Island. 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.

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The summer flounder, *Paralichthys dentatus,* supports the most economically valuable fishery in the state of Rhode Island. Documented long-term increases in abundance of *P. dentatus* in Narragansett Bay may benefit the local economy, but may negatively impact resident prey and competitor species. In addition to such ecological consequences, management of summer flounder is complicated by sexually dimorphic growth and sex-specific spatial distributions. These sex-specific dynamics may increase the risk of disproportionate removal of females via fishing and diminish the reproductive capacity of the population. Specifically, females are believed to significantly outnumber males in inshore areas, where fishery dependent and independent data are generally lacking. To determine nearshore sex-driven population dynamics of summer flounder in Rhode Island waters, specimens were collected on the University of Rhode Island Graduate School of Oceanography weekly fish trawl and Rhode Island Department of Environmental Management monthly fish survey between April and October. Individuals were then dissected to determine their sex and stomach contents. The proportion of full stomachs was analyzed between the sexes to identify differences in feeding behavior, which could render differential vulnerability to the inshore recreational hook-and-line fishery. To investigate and characterize spatial sex segregation in *P. dentatus*, relationships between total length and sex were examined, along with differences in sex ratios between sampling locations. Our findings indicate that summer flounder larger than the minimum legal size for recreational harvest are predominantly female, and that sex ratios exhibit significant spatial trends tied to depth within Rhode Island state waters. Further, evaluation of stomach contents revealed no apparent difference in feeding frequency that would bias analyses using data from the recreational fishery. These results support the need for increased monitoring of summer flounder populations in order to incorporate sex-specific dynamics into management strategies in inshore waters throughout their range to sustain future fishery productivity.

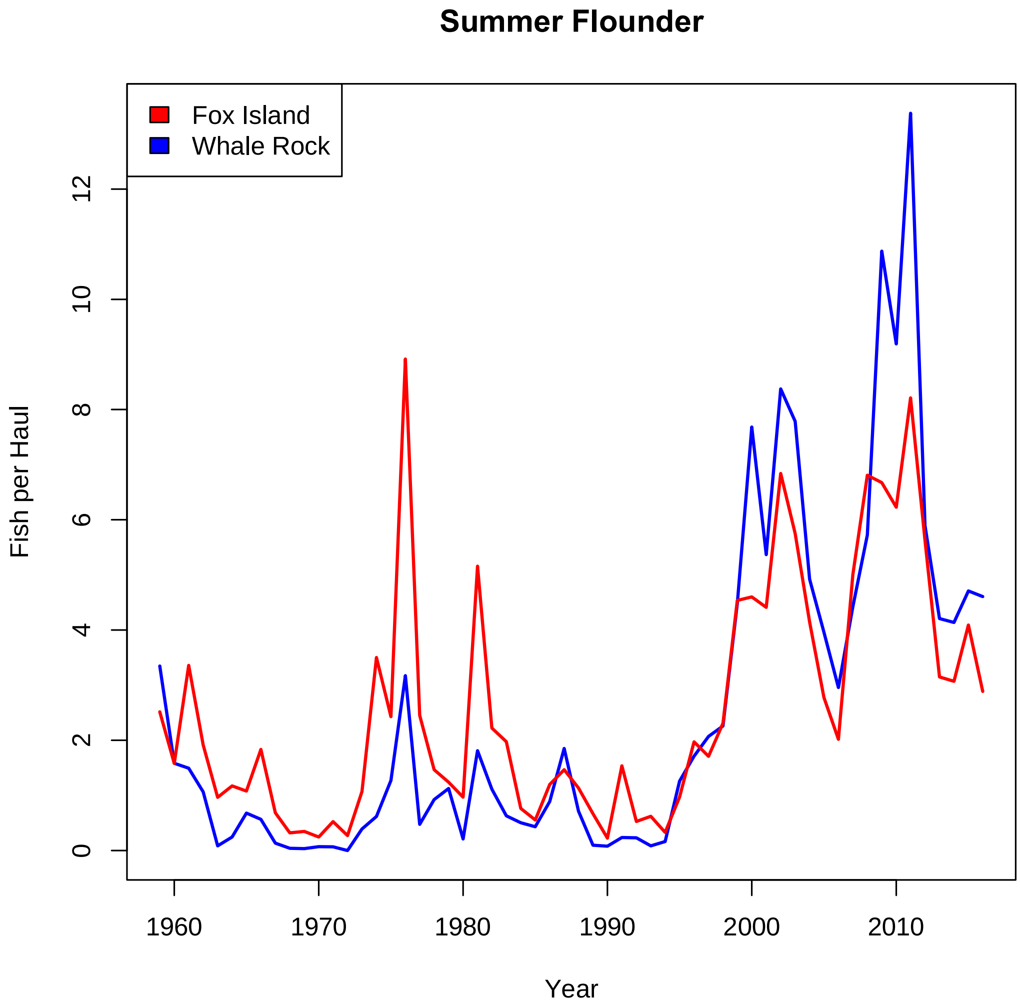

Figure 4 ï Survey data for entire time series for summer flounder at both sampling stations (Fox Island and Whale Rock).

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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 during the time period of the survey much like summer flounder, and also shows a fair amount of variability in the most recent time period (Figure 5). Black sea bass are caught at both sampling stations pretty consistently.

Black sea bass are protogynous hermaphrodites, transitioning from female to male as they grow and mature. Little is known about when this sexual transition occurs, particularly in southern New England waters. To address this uncertainty, a total of 96 black sea bass, ranging in size from 21 cm to 45.5 cm, were collected from Narragansett Bay from both this trawl survey as well as RIDEM's survey during the months of June and July 2015. A quantitative relationship was established between length and weight. Length-versus-age data were fitted with a von Bertalanffy curve to create a growth model for the Narragansett Bay black sea bass population. Results were compared with literature and NOAA black sea bass growth, maturity, and sexual transition data from other regions and decades. These data are consistent with NOAA estimates (4,221 fish) of weight-versus-length and size-at-age relationships. Additional samples were obtained during the summer of 2016 from both this trawl survey as well as RIDEM's monthly trawl surveys and the recorded data are pending analysis.

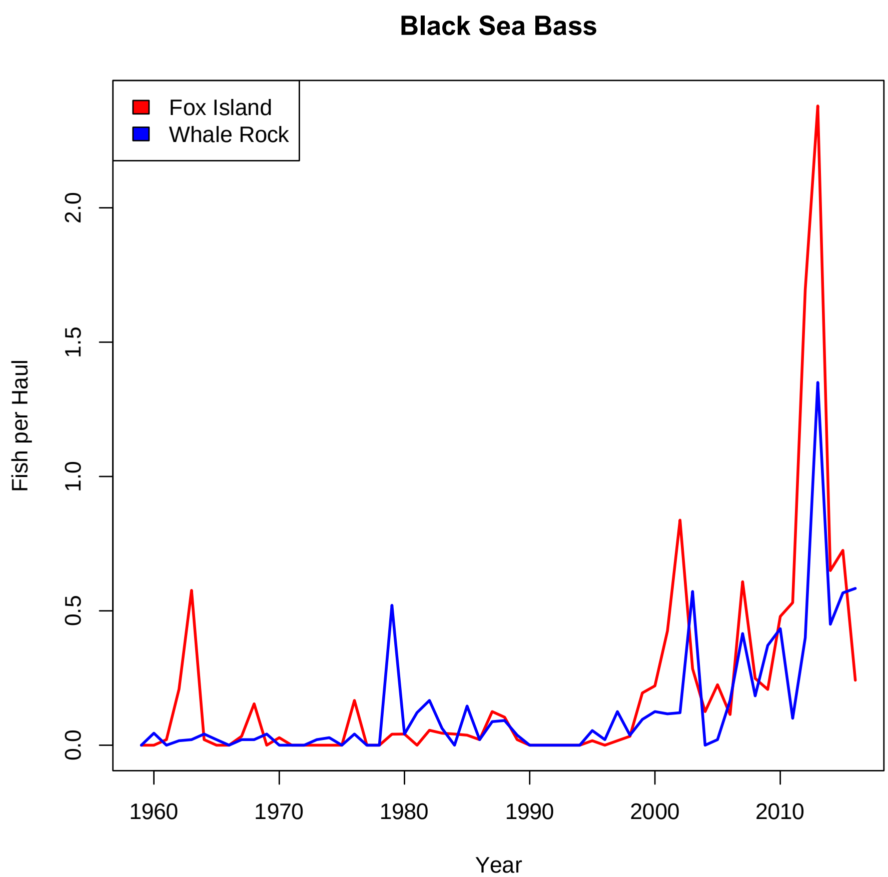

Figure 5 – Survey data for entire time series for black sea bass at both sampling stations (Fox Island and Whale Rock).

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, showing a high degree of variability going all the way back to the mid 1970s (Figure 6). 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. 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. 2016 produced the highest catch per unit effort for scup ever recorded in the survey. The survey information will be reviewed during the stock assessment process for scup.

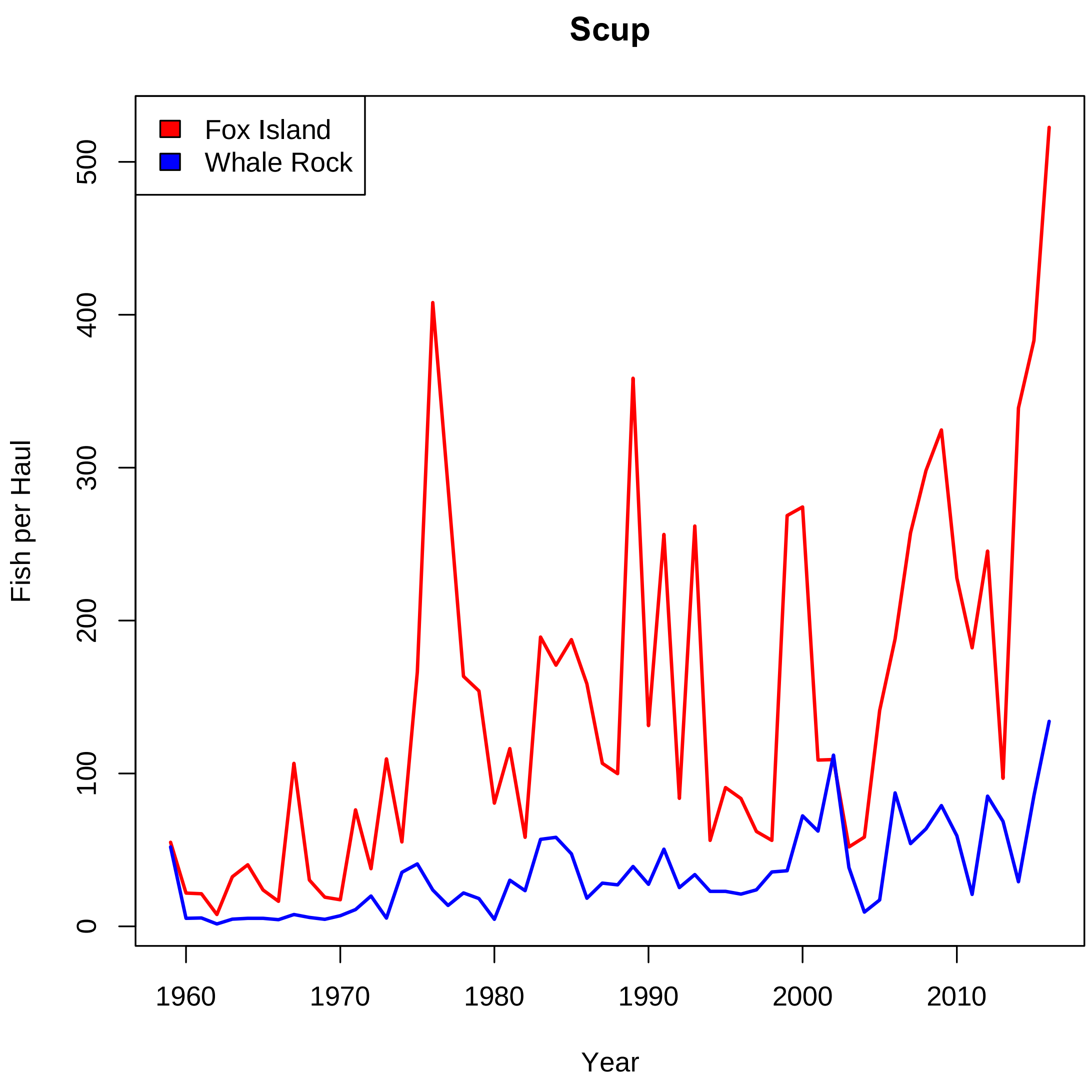

Figure 6 ï Survey data for entire time series for scup at both sampling stations (Fox Island and Whale Rock).

Bluefish

Bluefish is another of the Mid-Atlantic species caught consistently by the survey. The population of bluefish increased during the middle of the survey time period, 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 7). Bluefish are caught at both sampling stations pretty consistently.

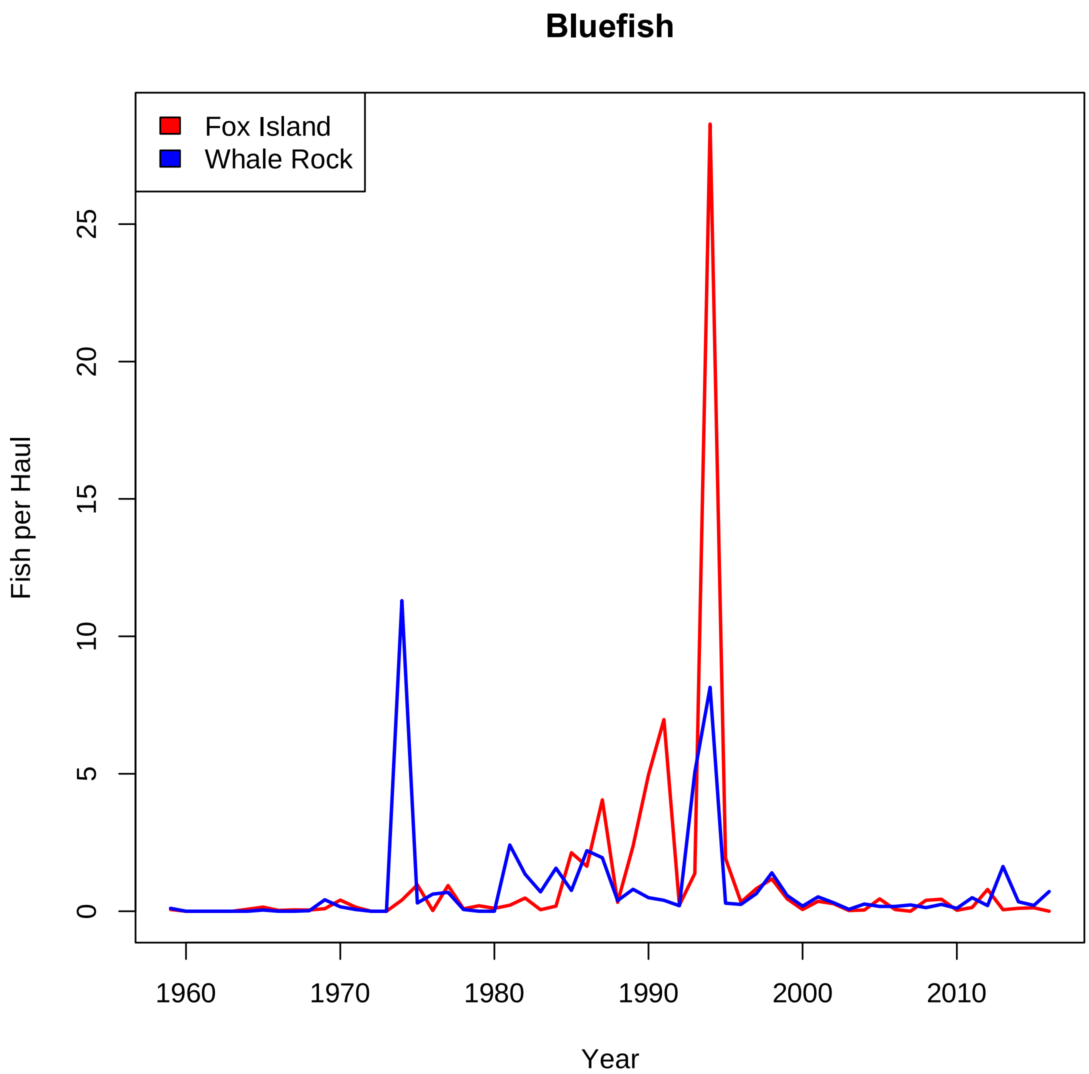

Figure 7 ï Survey data for entire time series for bluefish at both sampling stations (Fox Island and Whale Rock).

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 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 8), so this survey is probably a better indicator of recruitment than adult population size. Weakfish are caught at both sampling stations pretty consistently.

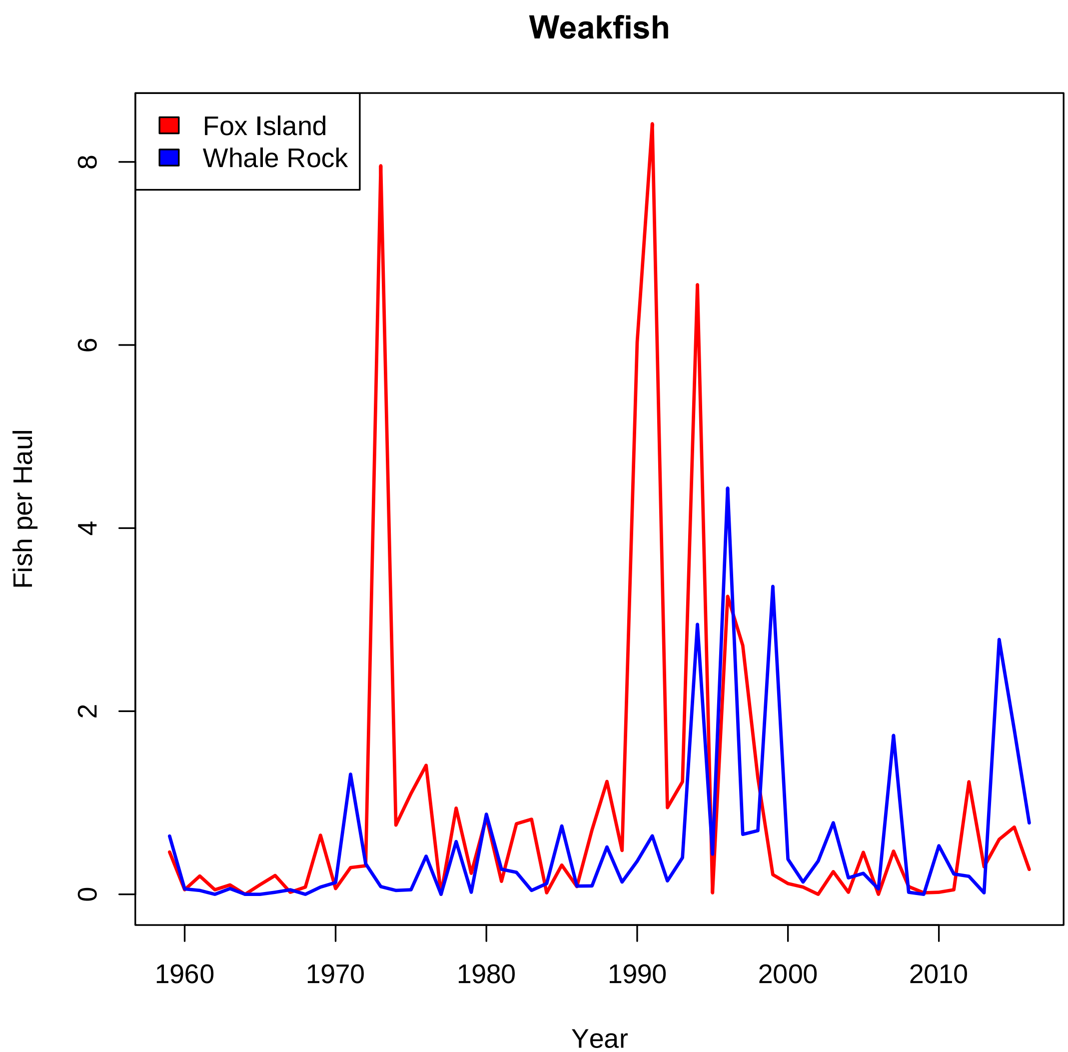

Figure 8 ï Survey data for entire time series for weakfish at both sampling stations (Fox Island and Whale Rock).

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, peaking between 1990 and 2010. There is high variability for this species in the survey data, but the survey catches both juveniles and adults (Figure 9). Striped bass are caught in greater abundance and frequency at Fox Island than at Whale Rock.

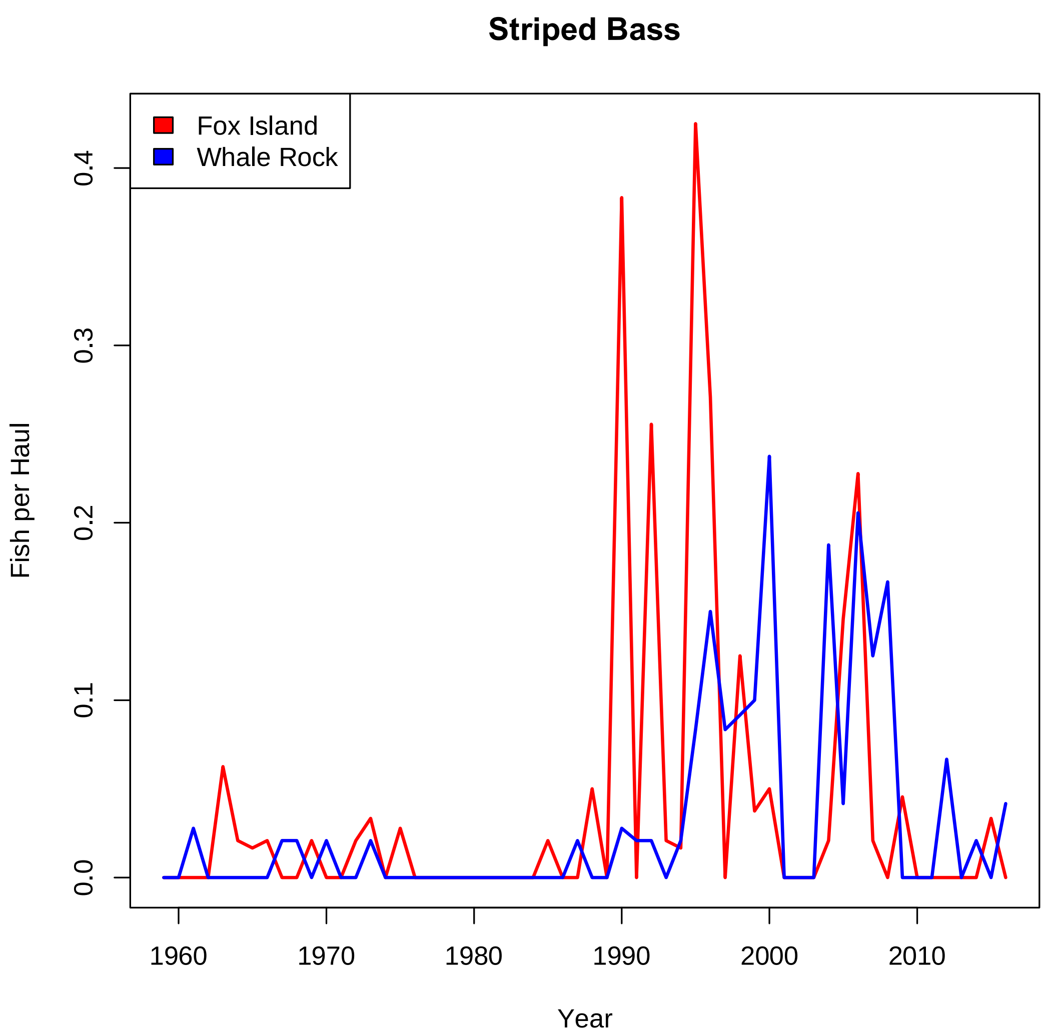

Figure 9 ï Survey data for entire time series for striped bass at both sampling stations (Fox Island and Whale Rock).

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. There is high variability for this species in the survey data, but the survey mainly catches juveniles (Figure 10). 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.

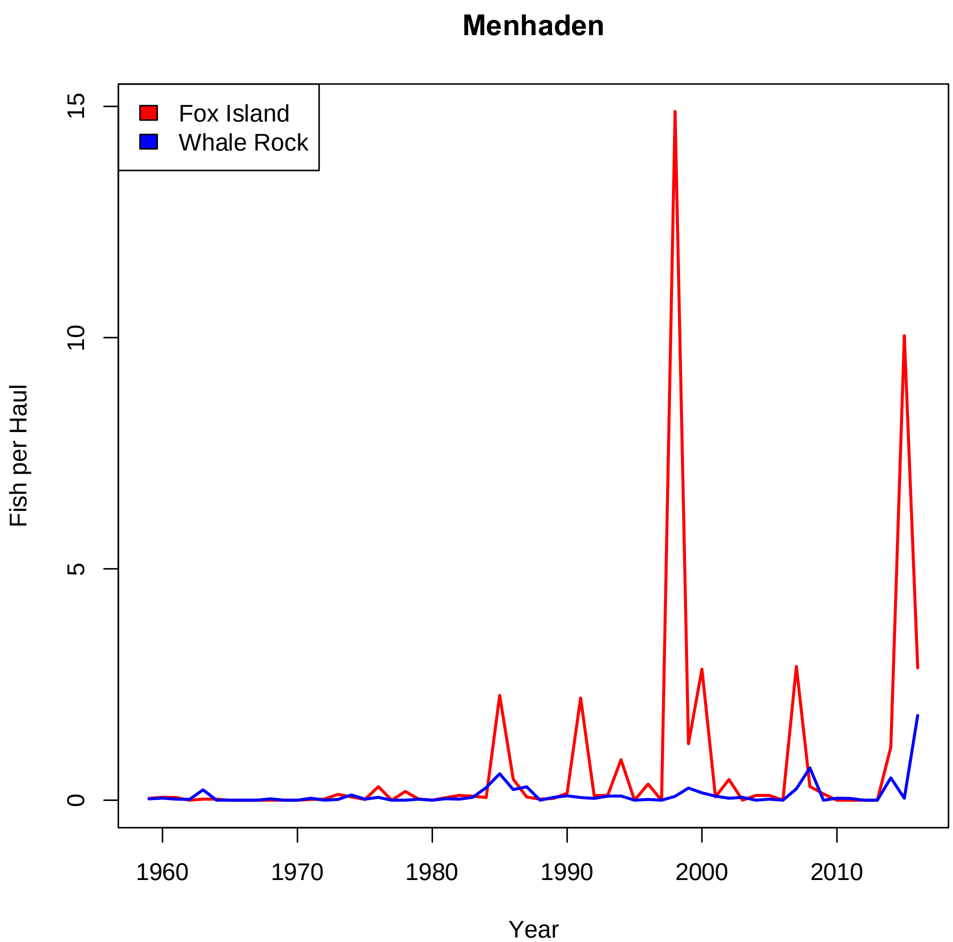

Figure 9 ï Survey data for entire time series for menhaden at both sampling stations (Fox Island and Whale Rock)

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Addendum

Combining URIGSO and RIDEM Surveys with Fisherman's Ecological Knowledge to Identify Essential Habitats for Atlantic Cod in Rhode Island Waters

Despite recent and intensive research conducted on Atlantic cod (*Gadus morhua*) inhabiting the Gulf of Maine and Georges Bank, relatively little is known about the life history and habitat use of this species in Southern New England (Loehrke, 2010; Zemeckis et al., 2014). Although tagging experiments have been done on known spawning grounds around Coxes Ledge (Loehrke, 2010), the exact timing of spawning remains uncertain and only limited habitat and movement data is available for this subpopulation (NEFSC, 2013; Zemeckis et al., 2014; Decelles et al., 2016). In Rhode Island waters, even localized management or monitoring is made difficult by a lack of consistent cod observations in Rhode Island Department of Environmental Management (RIDEM) and University of Rhode Island Graduate School of Oceanography (URIGSO) trawl surveys. However, recent abundant catches of this species in the Rhode Island and Block Island Sounds by fisherman (Staff of the Frances Fleet, personal comm.) suggest that a highly productive recreational fishery is present and further investigation will be required for its future sustainability.

Eggs & Larvae

While available data for Atlantic cod in Rhode Island is limited, combining multiple long-term time series was sufficient to elucidate patterns of habitat use in state waters at each major life history stage. Ichthyoplankton surveys conducted by RIDEM from 2001-2008 (McPhee GK, unpubl. data) and URIGSO in 2016 (Langan et al., unpubl. data) observed significant numbers of larval cod throughout Narragansett Bay, with the highest densities occurring between Mt. Hope Bay and the mouth of the Providence River. These observations are corroborated by regular catches of cod eggs and larvae in monitoring performed by the Brayton Point and Manchester Street Power Stations located in Mt. Hope Bay and the Providence River, respectively (BPE, 2016; Normandeau Associates, 2016). Because the URIGSO and RIDEM ichthyoplankton sampling only occurred within Narragansett Bay, the fate of cod larvae that are not advected into the surveyed area remains uncertain. However, it is likely these larvae survive to become juveniles at the mouth of the Bay and along the south coast of Rhode Island based on observations of later life stages (Figure 1). Prior research investigating the circulation patterns of the Rhode Island and Block Island Sounds and Narragansett Bay (Kincaid C, personal comm.) suggests that the source of the observed larval cod are known spawning aggregations that occur on Coxes Ledge and around Block Island (Loehrke, 2010; Zemeckis et al., 2014). However, reports from fishermen of large bodies of cod in the Rhode Island Sound north of Pt. Judith in the late Fall and the observation of a sexually mature female cod with developing eggs at the mouth of the West Passage of Narragansett Bay in January 2017 (Collie JS, unpubl. data) suggest the possibility of yet unknown inshore spawning grounds.

Measurements of the total length of cod larvae collected by URIGSO in 2016 were used to assign approximate ages (days since spawning) using age and growth relationships reported by Green et al. (2004) and egg stage duration times in Lough (2004). While using length to calculate age in larval fish, including cod, can be quite variable, it is assumed to be sufficient here to identify an approximate spawning season for Rhode Island waters. To that end, these estimated ages indicated that spawning occurred from January through mid-February, corroborating past estimates in the literature (Loehrke 2010; Zemeckis et al. 2014).

Juveniles

Juvenile cod are caught primarily in the RIDEM spring seasonal and monthly trawl survey due its use of a fine mesh liner in the codend of the net, with occasional observations in the RIDEM seine survey and URIGSO weekly trawl survey. While these young-of-the-year (YOY) fish appear throughout Rhode Island waters, the highest abundances occur in three primary areas: 1) between Mt. Hope Bay and the Providence River, and 2) outside the mouth of Narragansett Bay stretching to Point Judith, and 3) along the South Coast beaches. The very low abundance or absence of YOY cod in any of these survey efforts in the mid-Summer implies that after using these three areas as nurseries, they move into deeper waters that are not sampled as water temperatures rise beyond the tolerable range for the species (Lough, 2004). While it is unclear where age-0 cod spend their first summer, limited observations by the RIDEM fall seasonal trawl survey have occurred at the mouth of Narragansett Bay, southeast of Point Judith, and off of western Rhode Island (Figure 1). Given that juvenile cod are known to seek out cobble substrates (Lough, 2004) common in the Rhode Island Sound, it seems likely that they disperse throughout these offshore habitats and perhaps to deep or rocky areas that are not often sampled by the RIDEM trawl survey.

Adults

Charter captains report catching cod as small as 22 cm in the popular fishing grounds around Coxes Ledge and Block Island, indicating that age-1 cod join the movements of sexually mature adults after exiting more inshore habitats (Staff of the Frances Fleet, personal comm.; NEFSC, 2013). Therefore, it can be surmised that juvenile cod recruit to the fishery after their first year and reach sexual maturity as a part of the schools of adults well known to inhabit offshore habitats, thus completing their full life cycle within Rhode Island waters. While mixing with other sub-populations from the East or West is likely to occur, these findings verify past assertions that Southern New England cod may be a self-sustaining population unit (Zemeckis et al., 2014). However, there is still much to be learned about this species in this region. Although fishermen report abundant catches currently, management of the species is inhibited by a lack of the data necessary to monitor the local population and assess the threat of thermal habitat loss due to climate change (Fogarty et al., 2008). Given that cod can represent the sole winter source of income for charter boat captains and others in the recreational fishing industry, it is recommended here that directed investigations be conducted on cod in Rhode Island in order to properly manage the fishery and further evaluate the growing impacts of climate change to maintain the productivity of the resource in the future.

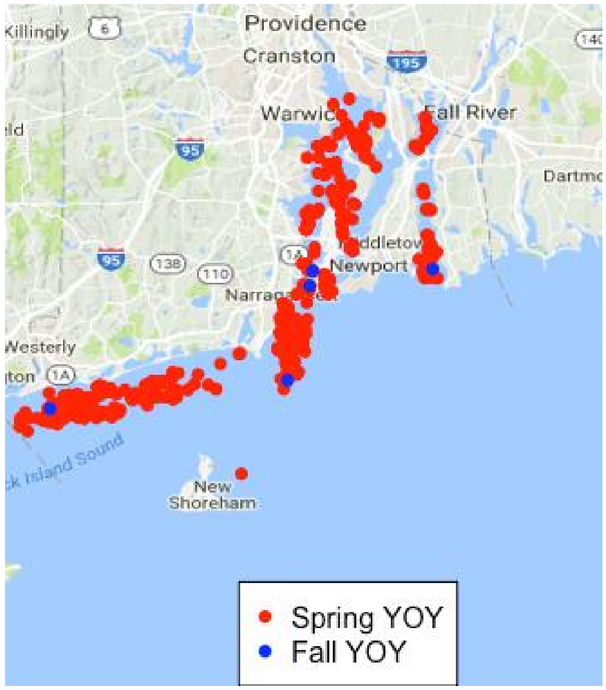

Figure 1: Locations spring (red) and fall (blue) of observations of young of the year (YOY) Atlantic cod in the RIDEM trawl survey. Individuals were determined to be YOY based upon their total length and the growth information given in the stock assessment (NEFSC, 2013).

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Unpublished Data Sets

Collie JS-
Data from the University of Rhode Island Graduate School of Oceanography Weekly Fish Trawl Survey 1959-2017. Overseen and Maintained by Jeremy S. Collie (jcollie@uri.edu)

McPhee GK-
Data from an icthyoplankton survey conducted from 2001-2008 by the Rhode Island Department of Environmental Management- Marine Fisheries Section and overseen by Grace Klein-McPhee. Contact: Eric Schneider (eric.schneider@dem.ri.gov)

Langan JA, Schneider E, Gibson M, & Collie JS-
Data from a 2016 survey conducted by a collaboration of the University of Rhode Island Graduate School of Oceanography and Rhode Island Department of Environmental Management- Marine Fisheries Section. Contact: Joseph Langan (joseph_langan@uri.edu)

Personal Communications

Staff of the Frances Fleet Charter Boats (2017). Contact: Francesflt@aol.com

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