ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS
F20AF00145

COASTAL FISHERY RESOURCE ASSESSMENT
TRAWL SURVEY
2020

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

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Division of Marine Fisheries

March 2020

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, 2020 – December 31, 2020.

PROJECT SUMMARY: Job 1, summary accomplished:

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

B: Data on weight, length, sex and numbers were gathered on 67 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 2020

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 – May)/ Fall (September – October) 2020

PROJECT SUMMARY: Job 2, summary accomplished:

A: 44, twenty-minute tows were successfully completed during the Spring 2020 survey (26 NB. – 6 RIS – 12 BIS).

B: 44, twenty-minute tow were successfully completed during the Fall 2020 survey (26 NB. – 6 RIS – 12 BIS)

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

69 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 2020.

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

JOBS 1 & 2

RECOMMENDATIONS: Continuation of both the Monthly and Seasonal Trawl surveys into 2021, Data provided by these surveys is used extensively in the Atlantic States Marine Fisheries Commission Fishery Management process and Fishery Management Plans.

RESULTS AND DISCUSSION: 156 tows were completed during 2020 Job 1 (Monthly survey). 67 species accounted for a combined weight of 7180.06 kgs. and 278,264 length measurements being added to the existing Narragansett Bay monthly trawl data set
By contrast, 88 tows were completed during 2020 Job 2 (Seasonal survey) 69 species accounted for a combined weight of 2187.99 kgs. and 102,657 length measurements added to the existing seasonal data set.

With the completion of the 2020 surveys, combined survey(s) Jobs (1&2) data now reflects the completion of 7,345 tows with data collected on 149 species over the entire timeseries.

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

APPROVED BY: ______________________ ______________________
Jason McNamee Date
Deputy Director
RIDEM – Bureau of Natural Resources

Coastal Fishery Resource Assessment – Trawl Survey

Introduction:

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

Since the inception of the Rhode Island Seasonal Trawl Survey (April 1979) and the Narragansett Bay Monthly Trawl Survey (January 1990), 7,345 tows have been conducted within Rhode Island territorial waters with data collected on 149 species. This performance report reflects the efforts of the 2020 survey year as it relates to the past 41 years. (Lynch T. R. Coastal Fishery Resource Assessment, 2007), (Olszewski S.D. Coastal Fishery Resource Assessment 2014)

Methods:

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

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

Depth Stratum Identification

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

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

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

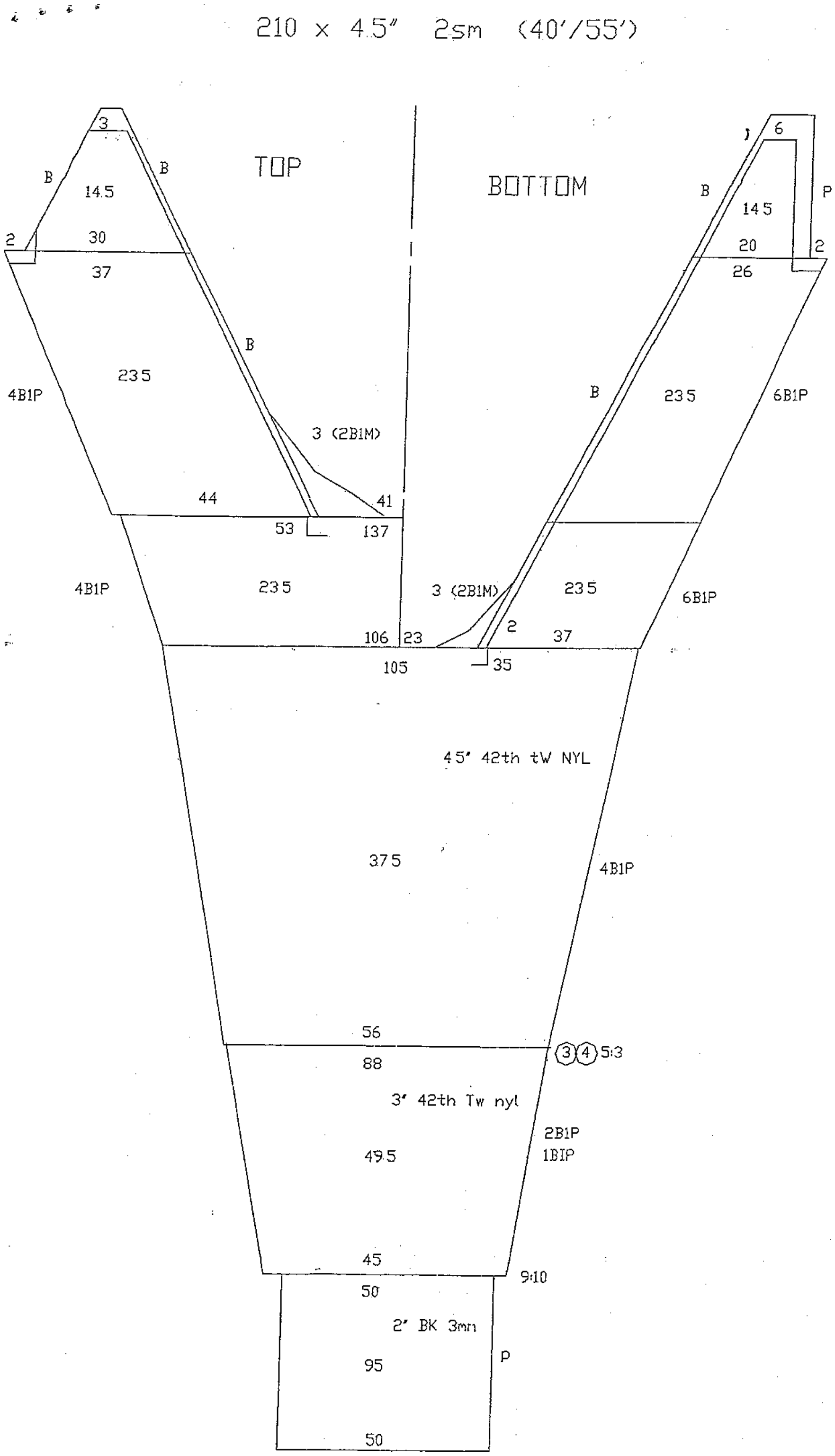
Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, Whelk lobster, blue crabs and horseshoe crabs.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

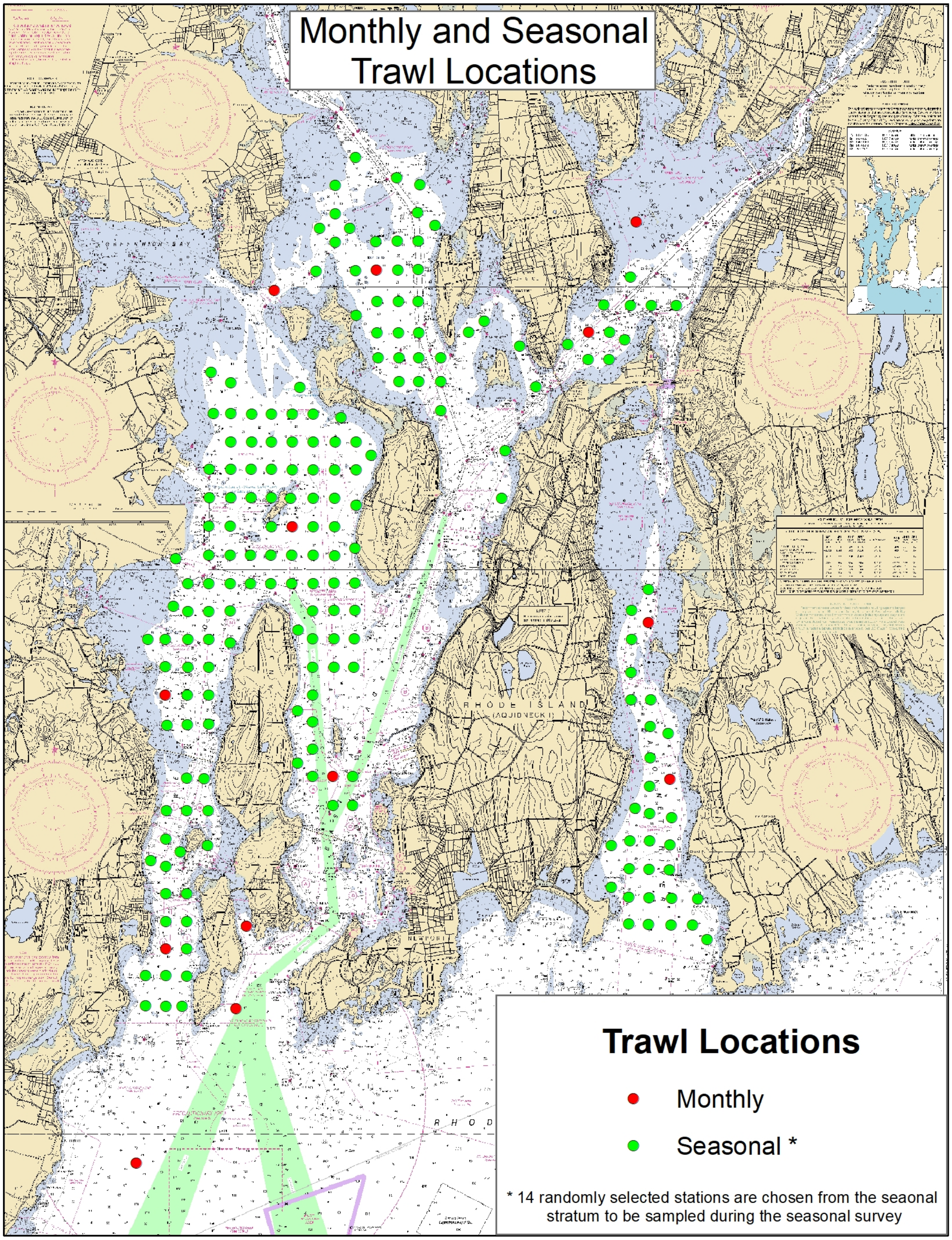
Acknowledgements:
Special thanks are again extended to Captain Patrick Brown and Assistant Captain Sean Fitzgerald, and the entire seasonal staff and volunteers. The support given over the years has been greatly appreciated.

Figure 1



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

Map 1: Monthly (fixed) and Seasonal (grid) Stations in Narragansett Bay



Monthly and Seasonal Trawl Locations

* 14 randomly selected stations are chosen from the seaonal stratum to be sampled during the seasonal survey

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

A total of 67 species were observed and recorded during the 2020 Narragansett Bay Monthly Trawl Survey totaling 278,264 individuals or 1783.7 fish per tow. In weight, the catch accounted for 7180.0 kg. or 46.02 kg. per tow. (Figures 2 and 3) The top ten species by number and catch are represented in figures 4 and 5. The catch between demersal and pelagic species is represented in figures 6 and 7and shows a clear shift from demersal species to a more pelagic or multi-habitat species.

Figure 2 (Total Catch in Number)

Scientific Name	Common Name	Total #
LOLIGO PEALEI	Longfin Squid	84520
ANCHOA MITCHILLI	Bay Anchovy	45744
CLUPEA HARENGUS	Atlantic Herring	40945
STENOTOMUS CHRYSOPS	Scup	36437
CYNOSCION REGALIS	Weakfish	19066
BREVOORTIA TYRANNUS	Atlantic Menhaden	17028
PEPRILUS TRIACANTHUS	Butterfish	14152
MENIDIA MENIDIA	Atlantic Silverside	7759
ALOSA PSEUDOHARENGUS	Alewife	7235
POMATOMUS SALTATRIX	Bluefish	898
UROPHYCIS REGIA	Spotted Hake	686
MERLUCCIUS BILINEARIS	Silver Hake	585
SELENE SETAPINNIS	Atlantic Moonfish	493
ALOSA AESTIVALIS	Blueback Herring	396
LEUCORAJA ERINACEA	Little Skate	287
UROPHYCIS CHUSS	Red Hake	276
CENTROPRISTIS STRIATA	Black Sea Bass	248
CANCER IRRORATUS	Rock Crab	221
ALOSA SAPIDISSIMA	American Shad	208
HOMARUS AMERICANUS	American Lobster	193
PRIONOTUS EVOLANS	Striped Sea Robin	129
GADUS MORHUA	Atlantic Cod	116
TAUTOGA ONITIS	Tautog	103
PLEURONECTES AMERICANUS	Winter Flounder	93
MUSTELUS CANIS	Smooth Dogfish	80
PARALICHTHYS DENTATUS	Summer Flounder	36
MORONE SAXATILIS	Striped Bass	34
CALLINECTES SAPIDUS	Blue Crab	32
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	28
MENTICIRRHUS SAXATILIS	Northern Kingfish	26
PRIONOTUS CAROLINUS	Northern Sea Robin	26
PARALICHTHYS OBLONGUS	Fourspot Flounder	22

POLLACHIUS VIRENS	Pollock	20
LIMULUS POLYPHEMUS	Horseshoe Crab	17
CANCER BOREALIS	Jonah Crab	13
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	11
PETROMYZON MARINUS	Sea Lamprey	9
TAUTOGOLABRUS ADSPERSUS	Cunner	9
RAJA EGLANTERIA	Clearnose Skate	8
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	8
SPHYRAENA BOREALIS	Northern Sennet	8
BUSYCON CARICA	Knobbed Whelk	7
ETROPUS MICROSTOMUS	Smallmouth Flounder	6
SQUILLA EMPUSA	Mantis Shrimp	5
LEUCORAJA OCELLATA	Winter Skate	4
ALOSA MEDIOCRIS	Hickory Shad	4
DOROSOMA CEPEDIANUM	Gizzard Shad	4
ENCHELYOPUS CIMBRIUS	Fourbeard Rockling	3
CARANX CRYSOS	Blue Runner	3
HEMITRIPTERUS AMERICANUS	Sea Raven	3
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	2
GASTEROSTEUS ACULEATUS	Threespine Stickleback	2
CARANX HIPPOS	Crevalle Jack	2
SQUALUS ACANTHIAS	Spiny Dogfish	1
DASYATIS SAY	Bluntnose Stingray	1
ANCHOA HEPSETUS	Striped Anchovy	1
OSMERUS MORDAX	Rainbow Smelt	1
SYNGNATHUS FUSCUS	Northern Pipefish	1
MORONE AMERICANA	White Perch	1
MYOXOCEPHALUS AENAEUS	Grubby	1
PHOLIS GUNNELLUS	Rock Gunnel	1
AMMODYTES AMERICANUS	Sand Lance	1
OPSANUS TAU	Oyster Toadfish	1
LOPHIUS AMERICANUS	Goosefish	1
DECAPTERUS MACARELLUS	Mackerel Scad	1
TRACHURUS LATHAMI	Rough Scad	1
RHINOPTERA BONASUS	Cownose Eagle Ray	1

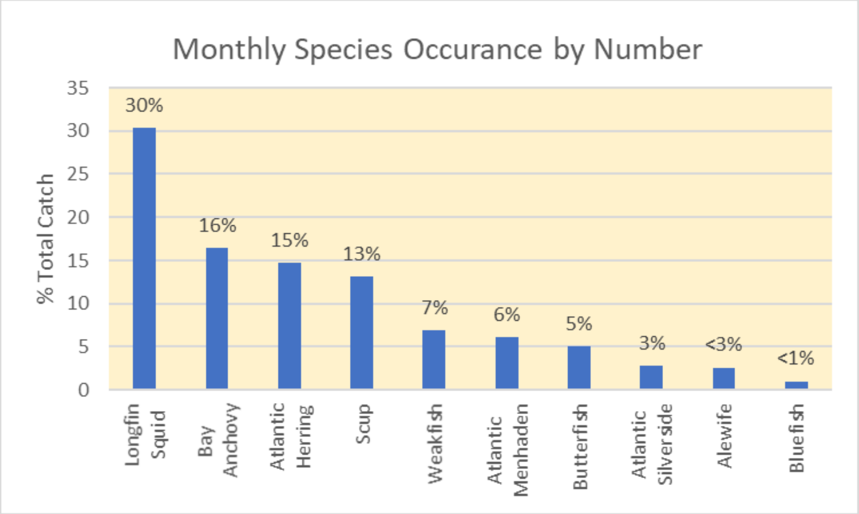
Figure 3 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight (kg)
STENOTOMUS CHRYSOPS	Scup	4944.284
CLUPEA HARENGUS	Atlantic Herring	333.1405
LOLIGO PEALEI	Longfin Squid	291.444
PEPRILUS TRIACANTHUS	Butterfish	209.663
LEUCORAJA ERINACEA	Little Skate	169.684
ALOSA PSEUDOHARENGUS	Alewife	157.574
TAUTOGA ONITIS	Tautog	143.297
CYNOSCION REGALIS	Weakfish	129.14
MUSTELUS CANIS	Smooth Dogfish	98.362
CENTROPRISTIS STRIATA	Black Sea Bass	86.608
BREVOORTIA TYRANNUS	Atlantic Menhaden	79.636
HOMARUS AMERICANUS	American Lobster	70.191
ANCHOA MITCHILLI	Bay Anchovy	54.344
PRIONOTUS EVOLANS	Striped Sea Robin	46.759
LIMULUS POLYPHEMUS	Horseshoe Crab	42.55
MORONE SAXATILIS	Striped Bass	39.811
POMATOMUS SALTATRIX	Bluefish	37.307
MERLUCCIUS BILINEARIS	Silver Hake	34.458
CANCER IRRORATUS	Rock Crab	25.83
PLEURONECTES AMERICANUS	Winter Flounder	24.866
MENIDIA MENIDIA	Atlantic Silverside	24.631
PARALICHTHYS DENTATUS	Summer Flounder	22.17
UROPHYCIS REGIA	Spotted Hake	21.371
UROPHYCIS CHUSS	Red Hake	16.058
RAJA EGLANTERIA	Clearnose Skate	11.554
GADUS MORHUA	Atlantic Cod	8.044
CALLINECTES SAPIDUS	Blue Crab	6.322
ALOSA SAPIDISSIMA	American Shad	5.724
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	4.987
PARALICHTHYS OBLONGUS	Fourspot Flounder	4.957
HEMITRIPTERUS AMERICANUS	Sea Raven	4.575
PRIONOTUS CAROLINUS	Northern Sea Robin	4.541
ALOSA AESTIVALIS	Blueback Herring	2.765
CANCER BOREALIS	Jonah Crab	2.759
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	2.749
LEUCORAJA OCELLATA	Winter Skate	2.634
SELENE SETAPINNIS	Atlantic Moonfish	2.463
ALOSA MEDIOCRIS	Hickory Shad	2.164
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	1.931

BUSYCON CARICA	Knobbed Whelk	1.801
MENTICIRRHUS SAXATILIS	Northern Kingfish	1.662
DASYATIS SAY	Bluntnose Stingray	1.48
RHINOPTERA BONASUS	Cownose Eagle Ray	0.99
LOPHIUS AMERICANUS	Goosefish	0.624
OPSANUS TAU	Oyster Toadfish	0.544
SPHYRAENA BOREALIS	Northern Sennet	0.304
CARANX CRYSOS	Blue Runner	0.29
SQUILLA EMPUSA	Mantis Shrimp	0.198
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	0.12
ENCHELYOPUS CIMBRIUS	Fourbeard Rockling	0.117
DOROSOMA CEPEDIANUM	Gizzard Shad	0.116
SQUALUS ACANTHIAS	Spiny Dogfish	0.078
CARANX HIPPOS	Crevalle Jack	0.076
MORONE AMERICANA	White Perch	0.075
PETROMYZON MARINUS	Sea Lamprey	0.058
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.041
TAUTOGOLABRUS ADSPERSUS	Cunner	0.037
POLLACHIUS VIRENS	Pollock	0.026
TRACHURUS LATHAMI	Rough Scad	0.026
DECAPTERUS MACARELLUS	Mackerel Scad	0.014
ANCHOA HEPSETUS	Striped Anchovy	0.01
AMMODYTES AMERICANUS	Sand Lance	0.01
OSMERUS MORDAX	Rainbow Smelt	0.006
MYOXOCEPHALUS AENAEUS	Grubby	0.004
GASTEROSTEUS ACULEATUS	Threespine Stickleback	0.002
SYNGNATHUS FUSCUS	Northern Pipefish	0.001
PHOLIS GUNNELLUS	Rock Gunnel	0.001

Figure 4 Monthly Survey Top Ten Species Catch in Number

Scientific Name	Common Name	%
LOLIGO PEALEI	Longfin Squid	30.37%
ANCHOA MITCHILLI	Bay Anchovy	16.44%
CLUPEA HARENGUS	Atlantic Herring	14.71%
STENOTOMUS CHRYSOPS	Scup	13.09%
CYNOSCION REGALIS	Weakfish	6.85%
BREVOORTIA TYRANNUS	Atlantic Menhaden	6.12%
PEPRILUS TRIACANTHUS	Butterfish	5.09%
MENIDIA MENIDIA	Atlantic Silverside	2.79%
ALOSA PSEUDOHARENGUS	Alewife	2.60%
POMATOMUS SALTATRIX	Bluefish	0.32%



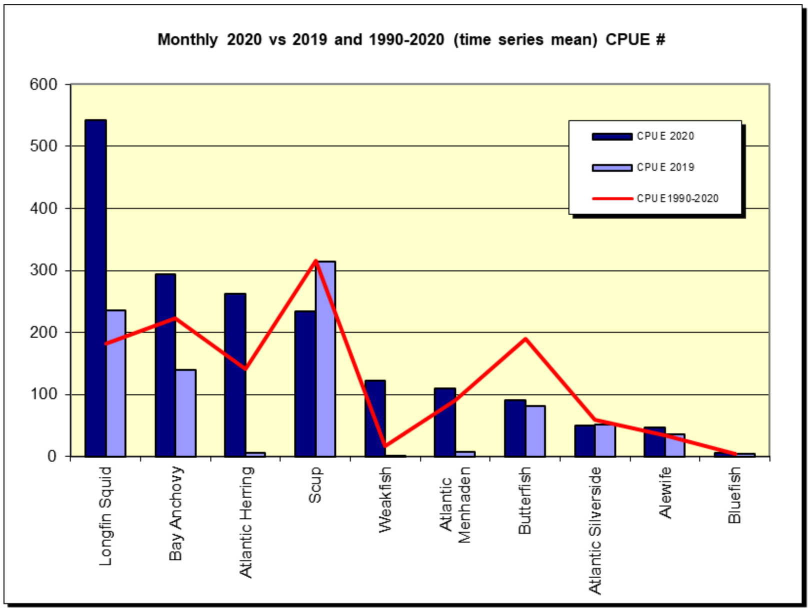
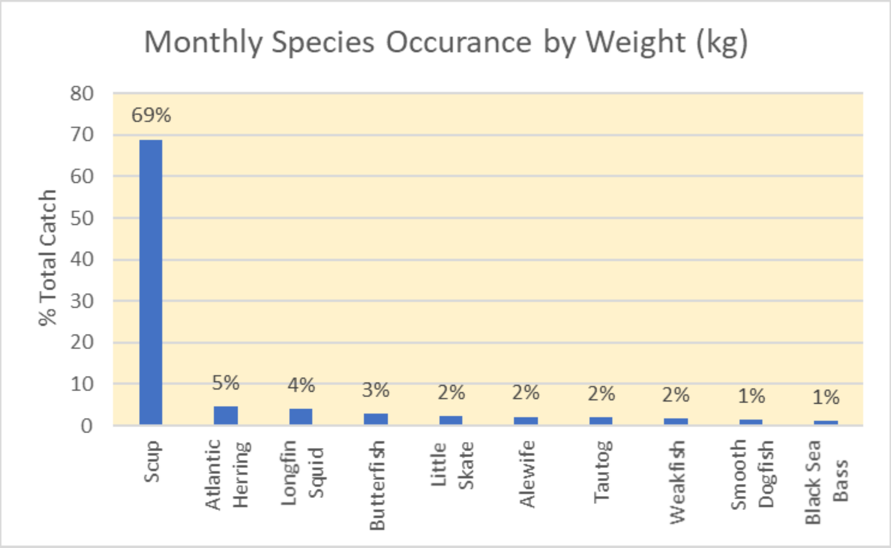


Figure 5 Top Ten Species Catch in Kilograms

Scientific Name	Common Name	%
STENOTOMUS CHRYSOPS	Scup	68.86%
CLUPEA HARENGUS	Atlantic Herring	4.64%
LOLIGO PEALEI	Longfin Squid	4.06%
PEPRILUS TRIACANTHUS	Butterfish	2.92%
LEUCORAJA ERINACEA	Little Skate	2.36%
ALOSA PSEUDOHARENGUS	Alewife	2.19%
TAUTOGA ONITIS	Tautog	2.00%
CYNOSCION REGALIS	Weakfish	1.80%
MUSTELUS CANIS	Smooth Dogfish	1.37%
CENTROPRISTIS STRIATA	Black Sea Bass	1.21%



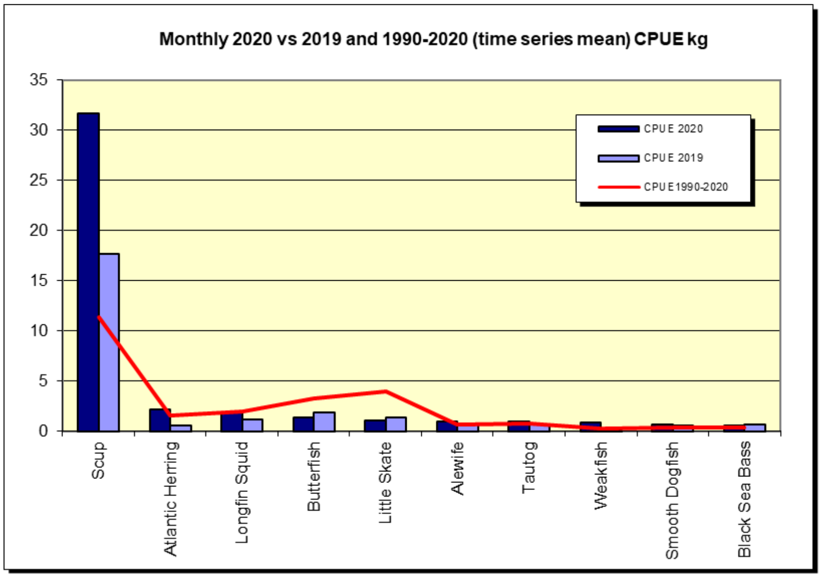
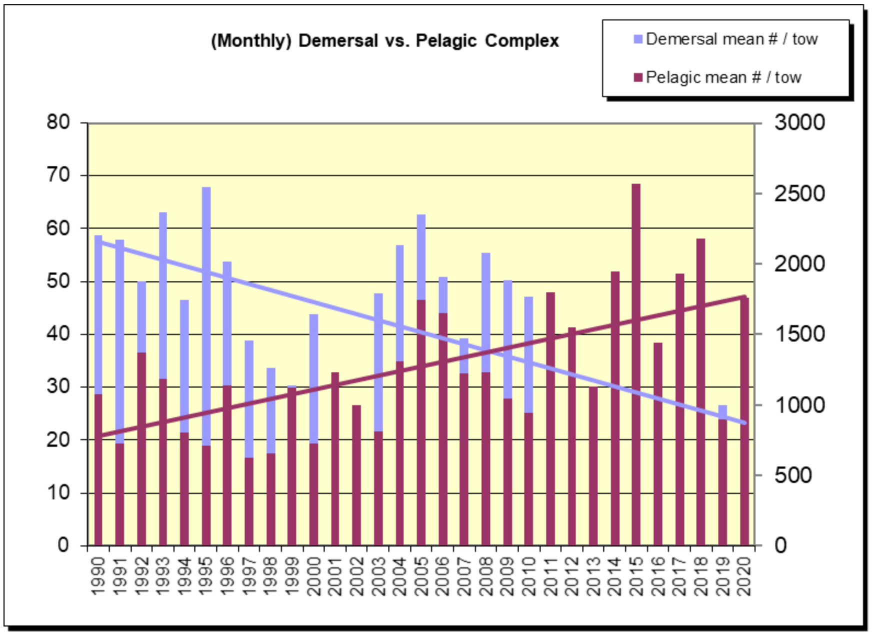
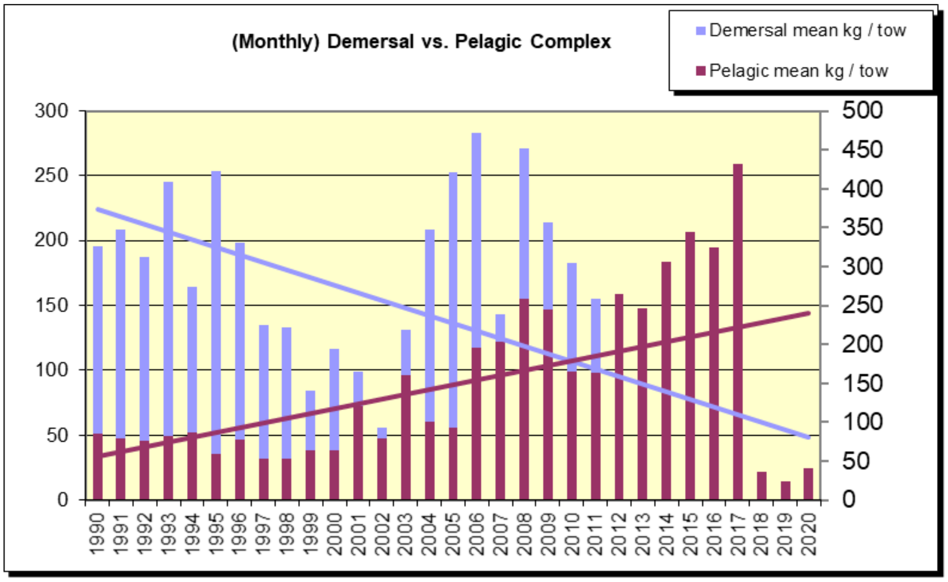


Figure 6 and 7: Demersal vs. Pelagic Species Complex

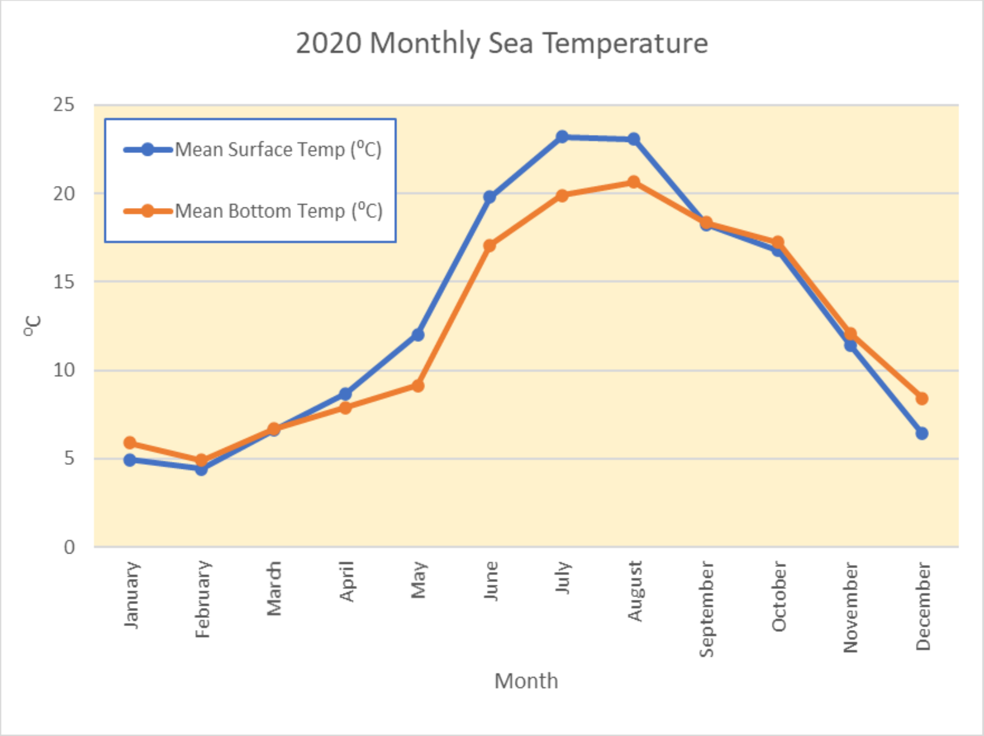
Demersal Species		Pelagic/Multi-Habitat Species	
Smooth Dogfish	Hogchoker	Atlantic Herring	Bluefish
Spiny Dogfish	Longhorn Sculpin	Alewife	Striped Bass
Skates	Sea Raven	Blueback Herring	Black Sea Bass
Silver Hake	Northern Searobin	Shad	Scup
Red Hake	Striped Searobin	Menhaden	Weakfish
Spotted Hake	Cunner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

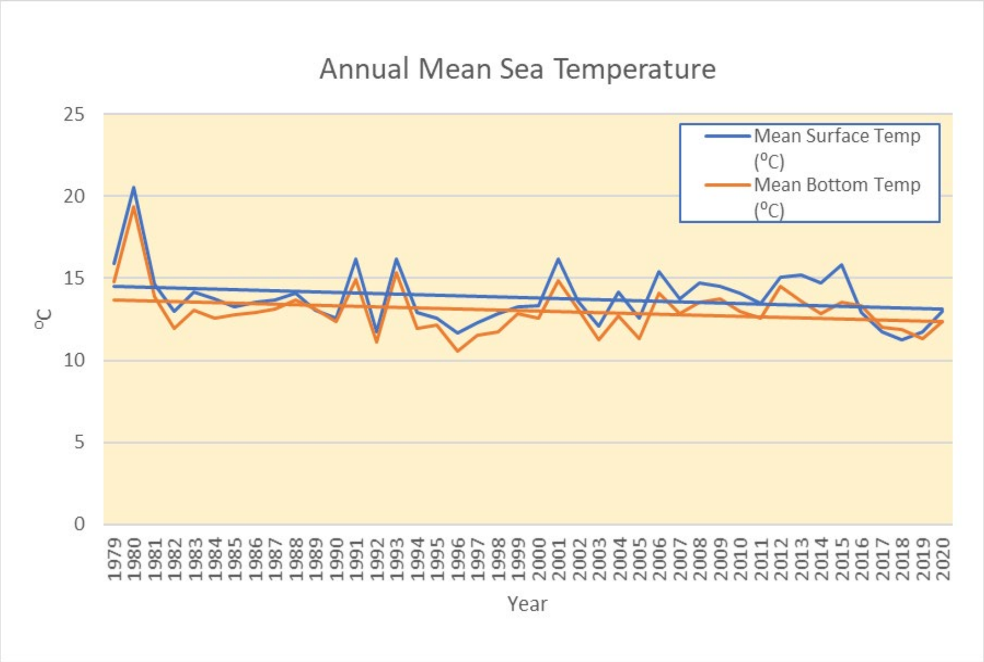




Monthly Survey Temperature Profile (Annual mean surface and bottom temperature)

Surface and bottom temperatures are collected at every station. The bottom temperature was collected by Niskin bottle until June 2019 at the average or maximum depth for each station. From June 2019 onward bottom temperature is the average over an entire tow as record by a Starmon TD® temperature and depth sensor attached to the footrope of the net.





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. 69 species were observed and recorded during the 2020 Rhode Island Seasonal Trawl Survey, totaling 102,657 individuals or 1166.5 fish per tow. In weight, the catch accounted for 2187.99 kg. or 24.8 kg. per tow. (Figures 8 and 9) The top ten species by number and catch are represented in figures 10 and 11. The change between demersal and pelagic species is represented in figures 12 and 13 and shows a clear shift from demersal species to a more pelagic or multi-habitat species.

Figure 8 (Total Catch in Number)

Scientific Name	Common Name	Total #
ANCHOA MITCHILLI	Bay Anchovy	49962
STENOTOMUS CHRYSOPS	Scup	19912
LOLIGO PEALEI	Longfin Squid	13087
PEPRILUS TRIACANTHUS	Butterfish	6421
ALOSA PSEUDOHARENGUS	Alewife	3478
CLUPEA HARENGUS	Atlantic Herring	2393
POMATOMUS SALTATRIX	Bluefish	2090
SELENE SETAPINNIS	Atlantic Moonfish	1565
CYNOSCION REGALIS	Weakfish	817
BREVOORTIA TYRANNUS	Atlantic Menhaden	480
ALOSA AESTIVALIS	Blueback Herring	261
LEUCORAJA ERINACEA	Little Skate	238
ALOSA SAPIDISSIMA	American Shad	231
MERLUCCIUS BILINEARIS	Silver Hake	223
UROPHYCIS REGIA	Spotted Hake	210
UROPHYCIS CHUSS	Red Hake	162
CENTROPRISTIS STRIATA	Black Sea Bass	151
PRIONOTUS CAROLINUS	Northern Sea Robin	143
PLEURONECTES AMERICANUS	Winter Flounder	106
LEUCORAJA OCELLATA	Winter Skate	103
CANCER IRRORATUS	Rock Crab	76
PARALICHTHYS DENTATUS	Summer Flounder	57
HOMARUS AMERICANUS	American Lobster	57
MENIDIA MENIDIA	Atlantic Silverside	48
MUSTELUS CANIS	Smooth Dogfish	45
GADUS MORHUA	Atlantic Cod	40
MENTICIRRHUS SAXATILIS	Northern Kingfish	40
PRIONOTUS EVOLANS	Striped Sea Robin	29
MORONE SAXATILIS	Striped Bass	25
LIMULUS POLYPHEMUS	Horseshoe Crab	25

TAUTOGA ONITIS	Tautog	23
AMMODYTES AMERICANUS	Sand Lance	21
CALLINECTES SAPIDUS	Blue Crab	20
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	12
RAJA EGLANTERIA	Clearnose Skate	11
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	11
SPHYRAENA BOREALIS	Northern Sennet	9
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	6
PARALICHTHYS OBLONGUS	Fourspot Flounder	5
CARANX CRYSOS	Blue Runner	5
CARANX HIPPOS	Crevalle Jack	5
HEMITRIPTERUS AMERICANUS	Sea Raven	4
TAUTOGOLABRUS ADSPERSUS	Cunner	4
PLACOPECTEN MAGELLANICUS	Sea Scallop	4
DOROSOMA CEPEDIANUM	Gizzard Shad	4
CANCER BOREALIS	Jonah Crab	4
SQUILLA EMPUSA	Mantis Shrimp	4
ETROPUS MICROSTOMUS	Smallmouth Flounder	3
LOPHIUS AMERICANUS	Goosefish	3
FISTULARIA TABACARIA	Cornetfish	2
SPHOEROIDES MACULATUS	Northern Puffer	2
TRACHURUS LATHAMI	Rough Scad	2
BUSYCON CARICA	Knobbed Whelk	2
SQUALUS ACANTHIAS	Spiny Dogfish	1
POLLACHIUS VIRENS	Pollock	1
SYNGNATHUS FUSCUS	Northern Pipefish	1
SCOMBER SCOMBRUS	Atlantic Mackerel	1
PRIACANTHUS ARENATUS	Bigeye	1
MORONE AMERICANA	White Perch	1
MYOXOCEPHALUS AENAEUS	Grubby	1
PHOLIS GUNNELLUS	Rock Gunnel	1
OPSANUS TAU	Oyster Toadfish	1
MACROZOARCES AMERICANUS	Ocean Pout	1
CHILOMYCTERUS SCHOEPFI	Striped Burrfish	1
DECAPTERUS MACARELLUS	Mackerel Scad	1
SELAR CRUMENOPHTHALMUS	Bigeye Scad	1
RHINOPTERA BONASUS	Cownose Eagle Ray	1
SYNODUS FOETENS	Inshore Lizardfish	1
ALUTERUS SCHOEPFI	Orange Filefish	1

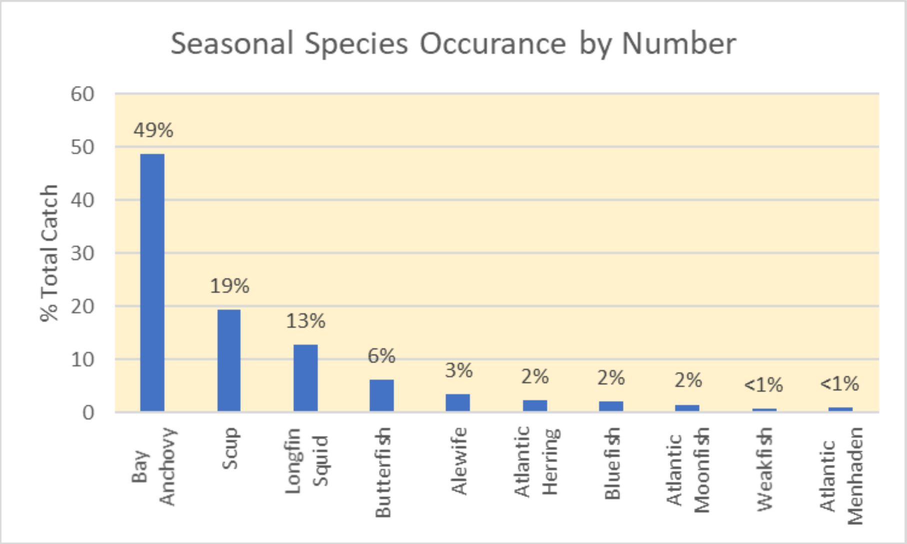
Figure 9 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight
STENOTOMUS CHRYSOPS	Scup	789.067
LOLIGO PEALEI	Longfin Squid	272.868
PEPRILUS TRIACANTHUS	Butterfish	185.001
LEUCORAJA ERINACEA	Little Skate	133.729
ALOSA PSEUDOHARENGUS	Alewife	95.022
LEUCORAJA OCELLATA	Winter Skate	75.708
CLUPEA HARENGUS	Atlantic Herring	59.301
LIMULUS POLYPHEMUS	Horseshoe Crab	57.482
MUSTELUS CANIS	Smooth Dogfish	54.316
POMATOMUS SALTATRIX	Bluefish	52.369
CENTROPRISTIS STRIATA	Black Sea Bass	49.131
ANCHOA MITCHILLI	Bay Anchovy	45.149
PLEURONECTES AMERICANUS	Winter Flounder	38.013
PARALICHTHYS DENTATUS	Summer Flounder	37.356
CYNOSCION REGALIS	Weakfish	29.008
PRIONOTUS CAROLINUS	Northern Sea Robin	24.695
HOMARUS AMERICANUS	American Lobster	21.322
MORONE SAXATILIS	Striped Bass	20.063
RAJA EGLANTERIA	Clearnose Skate	15.608
PRIONOTUS EVOLANS	Striped Sea Robin	15.009
MERLUCCIUS BILINEARIS	Silver Hake	13.307
TAUTOGA ONITIS	Tautog	13.116
CANCER IRRORATUS	Rock Crab	12.092
UROPHYCIS REGIA	Spotted Hake	9.89
BREVOORTIA TYRANNUS	Atlantic Menhaden	9.453
SELENE SETAPINNIS	Atlantic Moonfish	8.794
UROPHYCIS CHUSS	Red Hake	8.535
LOPHIUS AMERICANUS	Goosefish	6.744
ALOSA SAPIDISSIMA	American Shad	6.231
ALOSA AESTIVALIS	Blueback Herring	4.398
CALLINECTES SAPIDUS	Blue Crab	3.746
MENTICIRRHUS SAXATILIS	Northern Kingfish	3.26
HEMITRIPTERUS AMERICANUS	Sea Raven	3.095
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	2.819
SQUALUS ACANTHIAS	Spiny Dogfish	2.27
MACROZOARCES AMERICANUS	Ocean Pout	2.1
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	1.085
RHINOPTERA BONASUS	Cownose Eagle Ray	1.01
PARALICHTHYS OBLONGUS	Fourspot Flounder	0.922

CANCER BOREALIS	Jonah Crab	0.722
SPHOEROIDES MACULATUS	Northern Puffer	0.684
CARANX CRYSOS	Blue Runner	0.545
CHILOMYCTERUS SCHOEPFI	Striped Burrfish	0.375
SCOMBER SCOMBRUS	Atlantic Mackerel	0.336
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	0.327
CARANX HIPPOS	Crevalle Jack	0.296
SPHYRAENA BOREALIS	Northern Sennet	0.285
AMMODYTES AMERICANUS	Sand Lance	0.173
MENIDIA MENIDIA	Atlantic Silverside	0.161
PLACOPECTEN MAGELLANICUS	Sea Scallop	0.155
DOROSOMA CEPEDIANUM	Gizzard Shad	0.137
SQUILLA EMPUSA	Mantis Shrimp	0.116
BUSYCON CARICA	Knobbed Whelk	0.105
ALUTERUS SCHOEPFI	Orange Filefish	0.09
OPSANUS TAU	Oyster Toadfish	0.082
TRACHURUS LATHAMI	Rough Scad	0.08
FISTULARIA TABACARIA	Cornetfish	0.064
GADUS MORHUA	Atlantic Cod	0.038
SELAR CRUMENOPHTHALMUS	Bigeye Scad	0.03
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.026
TAUTOGOLABRUS ADSPERSUS	Cunner	0.026
MORONE AMERICANA	White Perch	0.02
DECAPTERUS MACARELLUS	Mackerel Scad	0.014
POLLACHIUS VIRENS	Pollock	0.005
PRIACANTHUS ARENATUS	Bigeye	0.005
SYNODUS FOETENS	Inshore Lizardfish	0.005
MYOXOCEPHALUS AENAEUS	Grubby	0.004
SYNGNATHUS FUSCUS	Northern Pipefish	0.001
PHOLIS GUNNELLUS	Rock Gunnel	0.001

Figure 10 Top Ten Species Catch in Number

Scientific Name	Common Name	%
ANCHOA MITCHILLI	Bay Anchovy	48.67%
STENOTOMUS CHRYSOPS	Scup	19.40%
LOLIGO PEALEI	Longfin Squid	12.75%
PEPRILUS TRIACANTHUS	Butterfish	6.25%
ALOSA PSEUDOHARENGUS	Alewife	3.39%
CLUPEA HARENGUS	Atlantic Herring	2.33%
POMATOMUS SALTATRIX	Bluefish	2.04%
SELENE SETAPINNIS	Atlantic Moonfish	1.52%
CYNOSCION REGALIS	Weakfish	0.80%
BREVOORTIA TYRANNUS	Atlantic Menhaden	0.47%



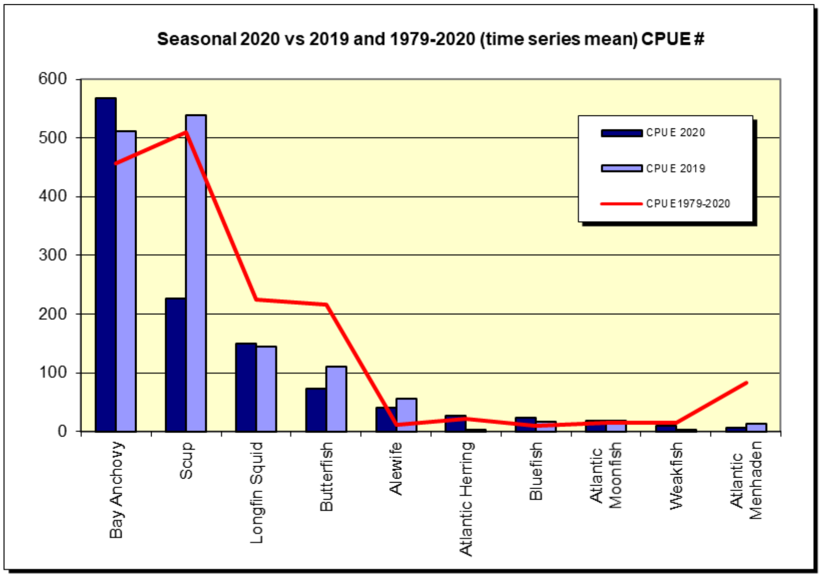
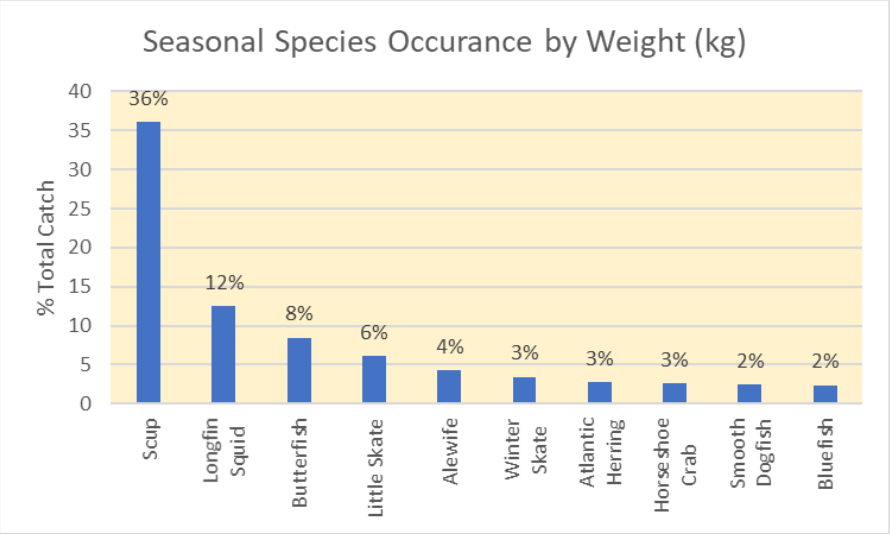


Figure 11 Top Ten Species Catch in Kilograms

Scientific Name	Common Name	%
STENOTOMUS CHRYSOPS	Scup	36.06%
LOLIGO PEALEI	Longfin Squid	12.47%
PEPRILUS TRIACANTHUS	Butterfish	8.46%
LEUCORAJA ERINACEA	Little Skate	6.11%
ALOSA PSEUDOHARENGUS	Alewife	4.34%
LEUCORAJA OCELLATA	Winter Skate	3.46%
CLUPEA HARENGUS	Atlantic Herring	2.71%
LIMULUS POLYPHEMUS	Horseshoe Crab	2.63%
MUSTELUS CANIS	Smooth Dogfish	2.48%
POMATOMUS SALTATRIX	Bluefish	2.39%



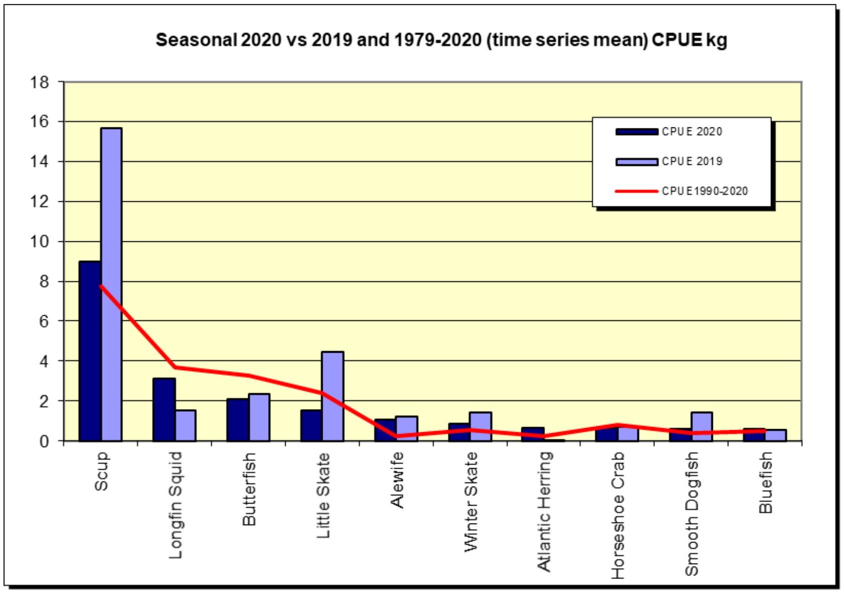
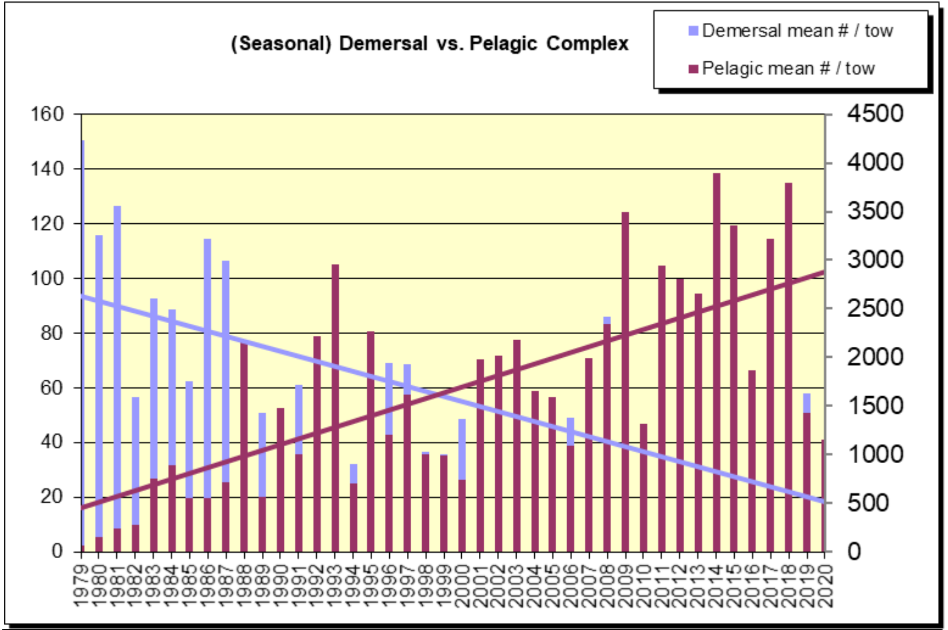
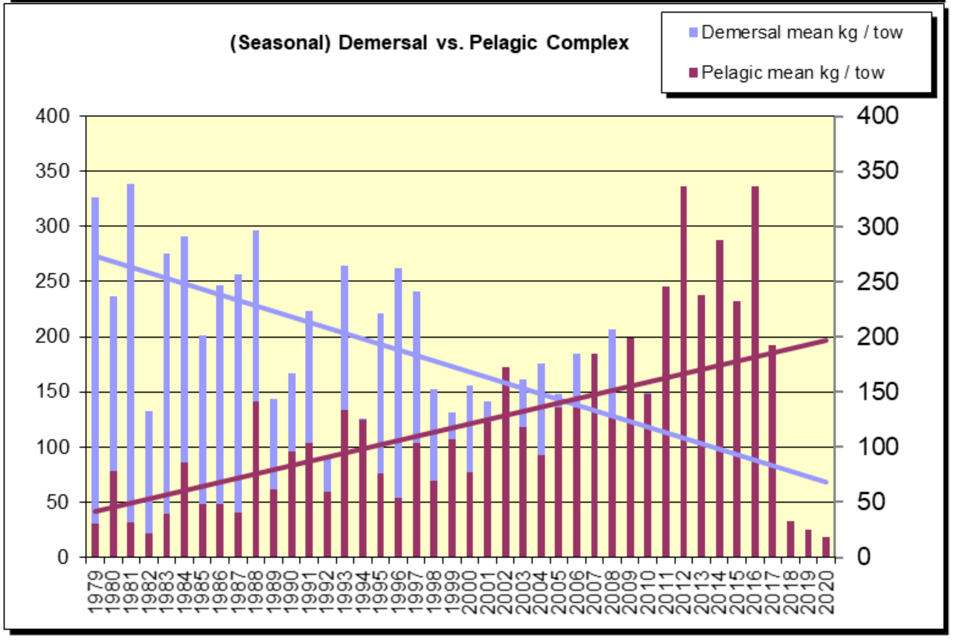


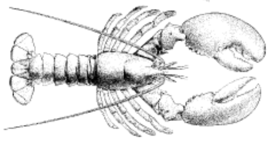
Figure 12 and 13: Demersal vs. Pelagic Species Complex

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



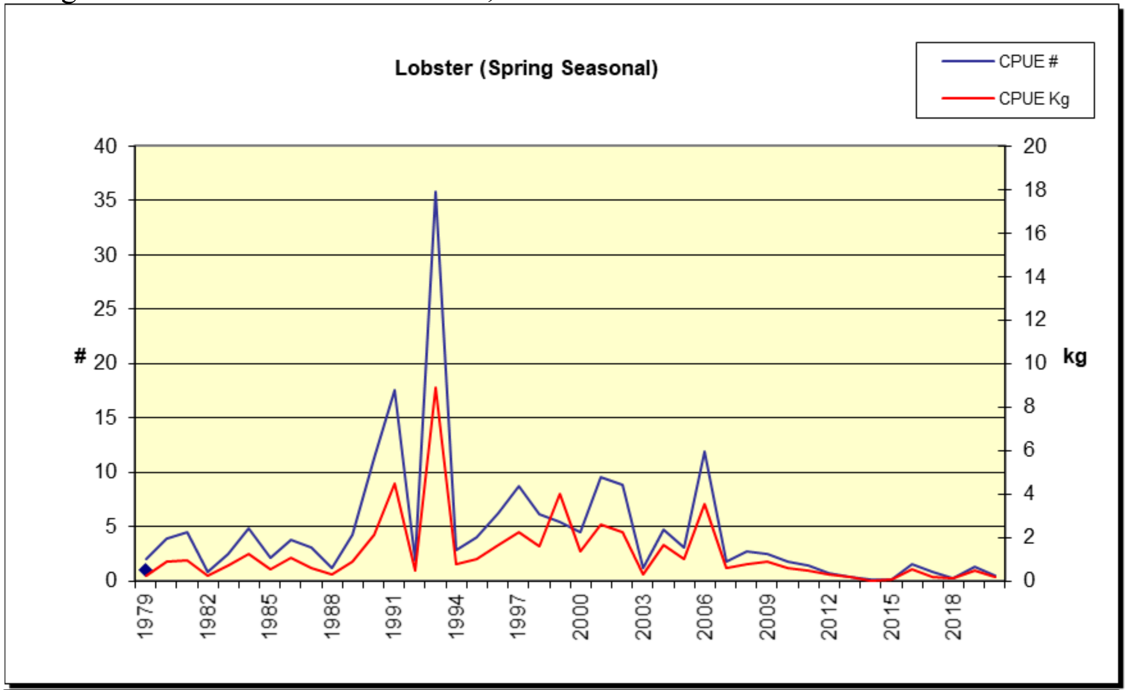


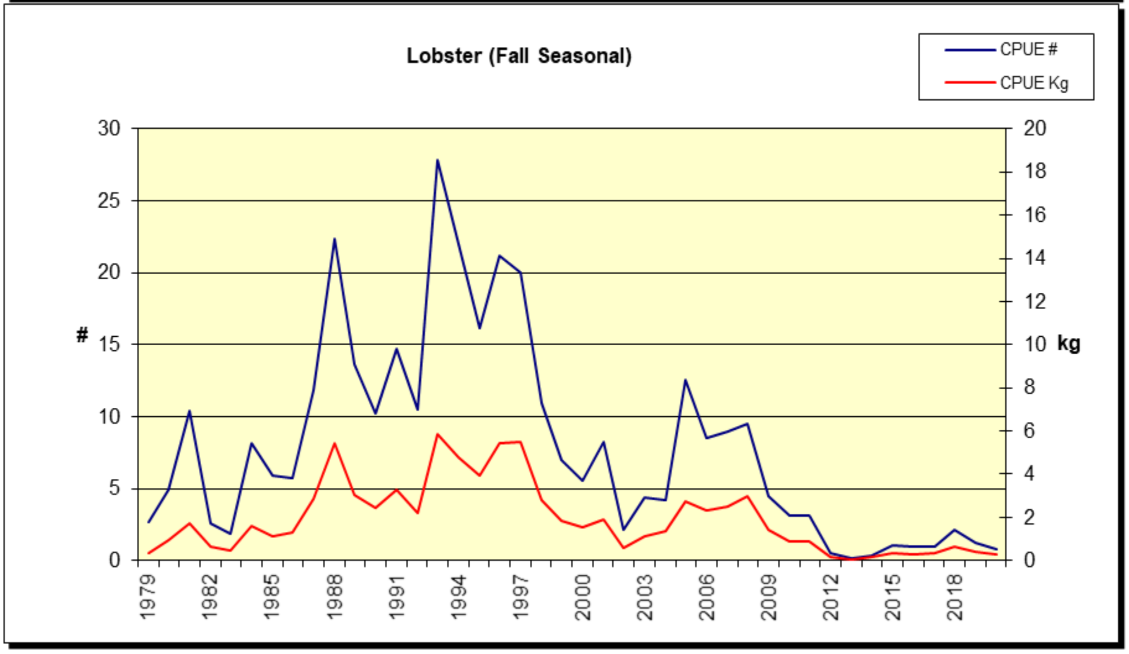
The following species represented are of high importance and are currently managed under fishery management plans through the Atlantic States Marine Fisheries Commission, New England Fishery Management Council, or the National Marine Fisheries Service. The seasonal portion of the Rhode Island Coastal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

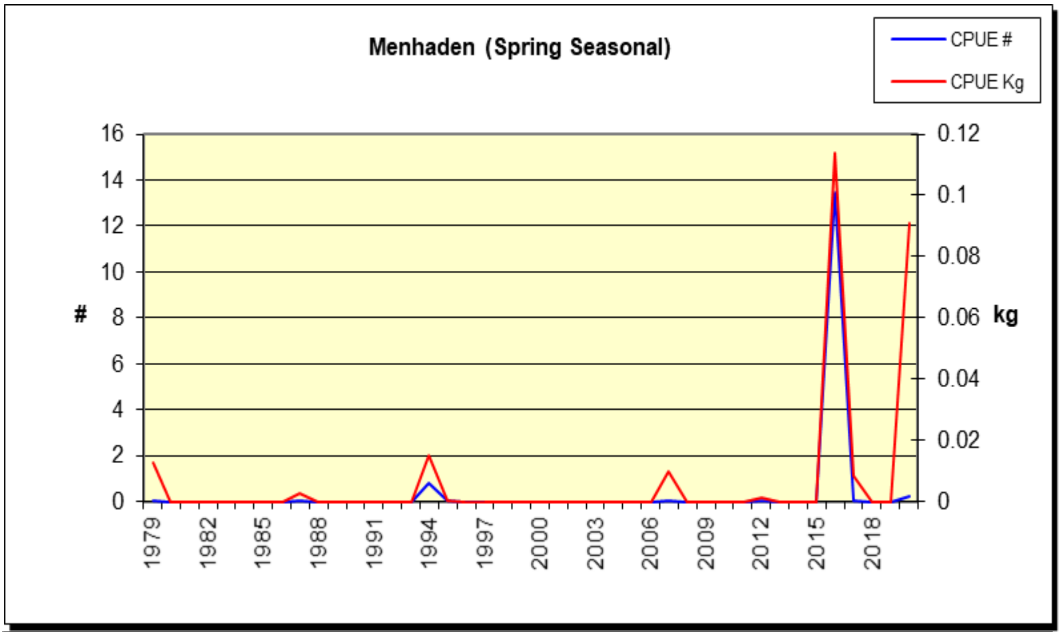
Stock Status: Southern New England Stock: overfished. Depleted Poor condition.
Management: ASMFC Amendment III, Addendum XXVI

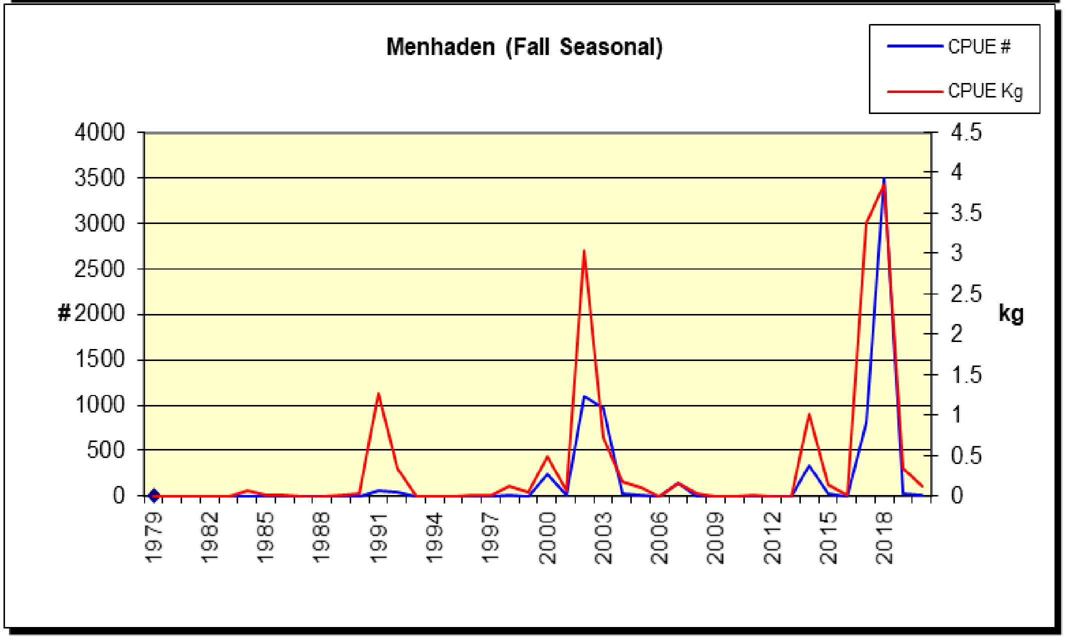




Atlantic Menhaden ***Brevoortia tyrannus***

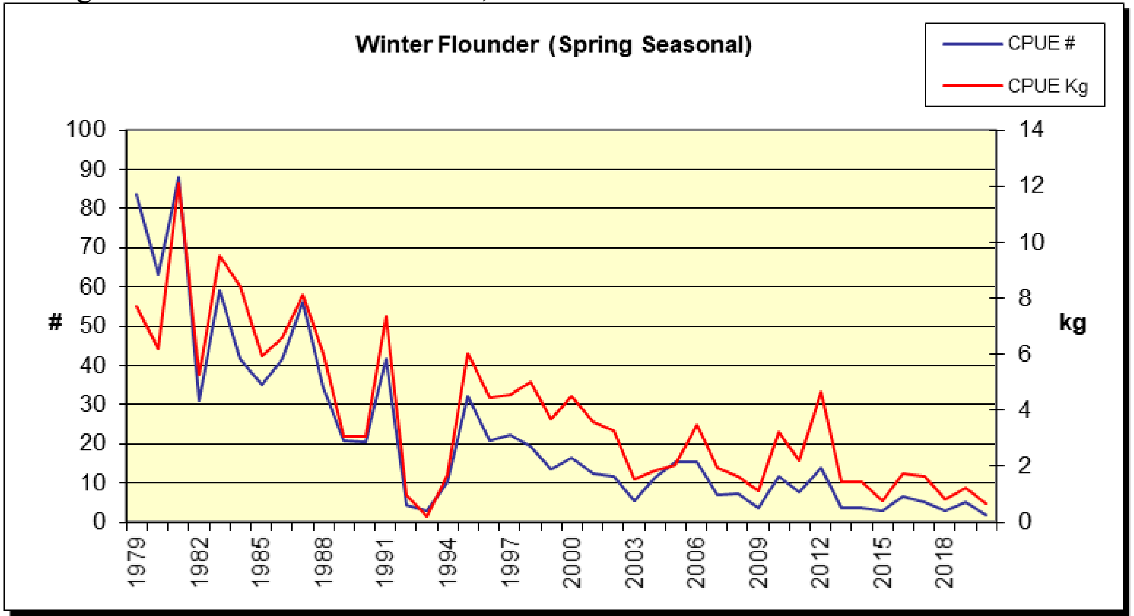
Stock Status: Not Overfished and overfishing is not occurring.
Management: ASMFC Amendment III, Addendum I

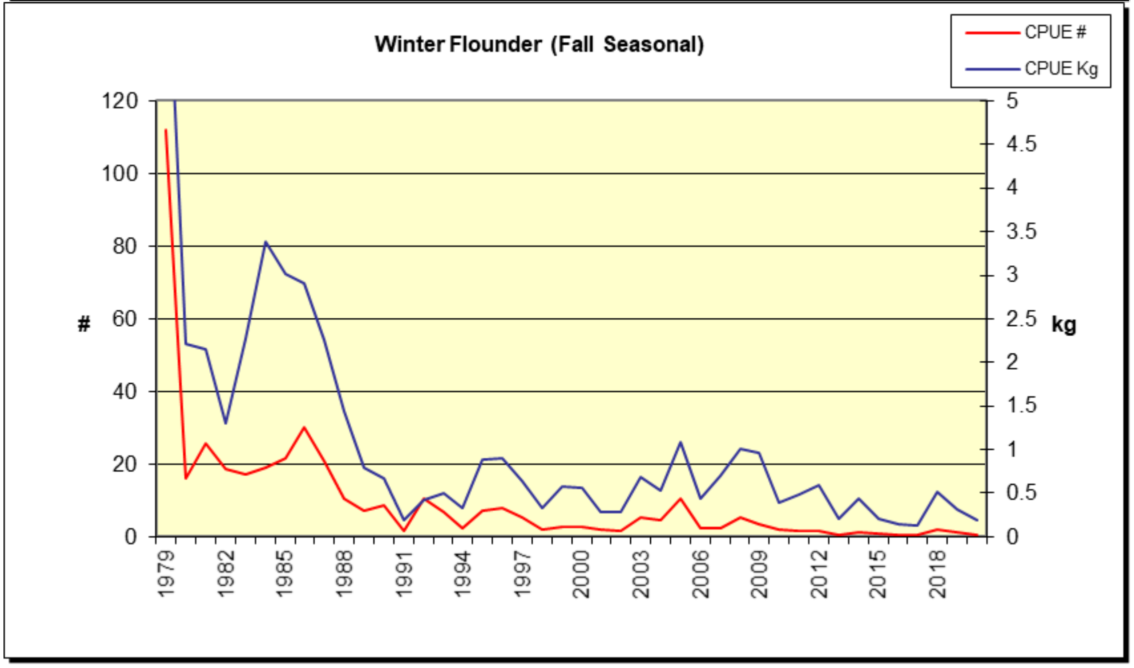


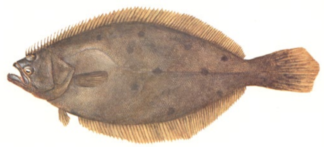


Winter Flounder ***Pleuronectes americanus***

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

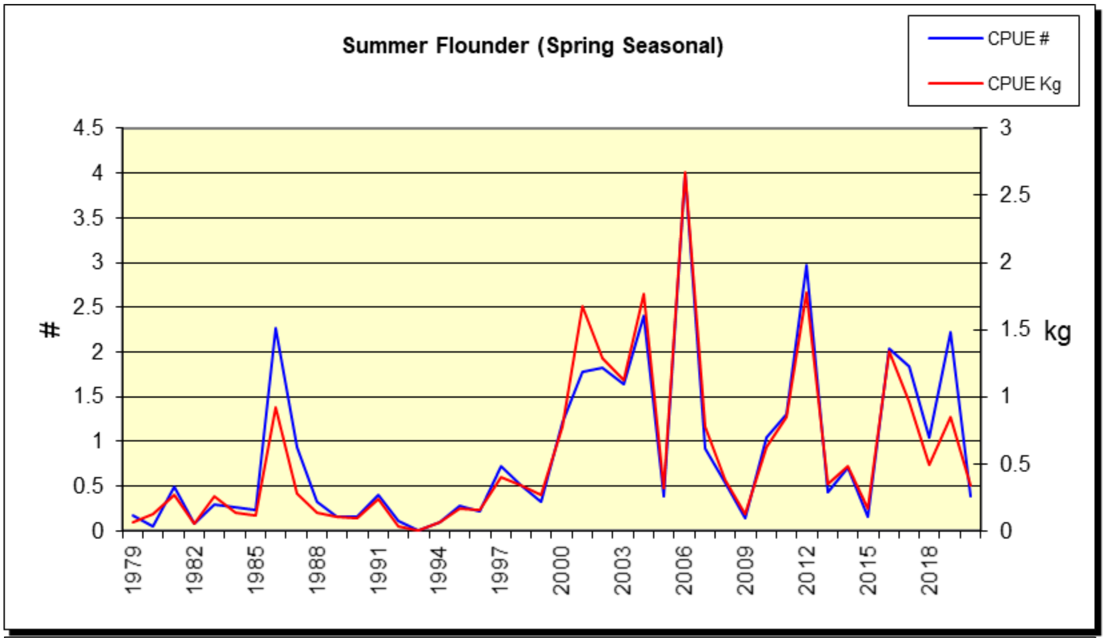


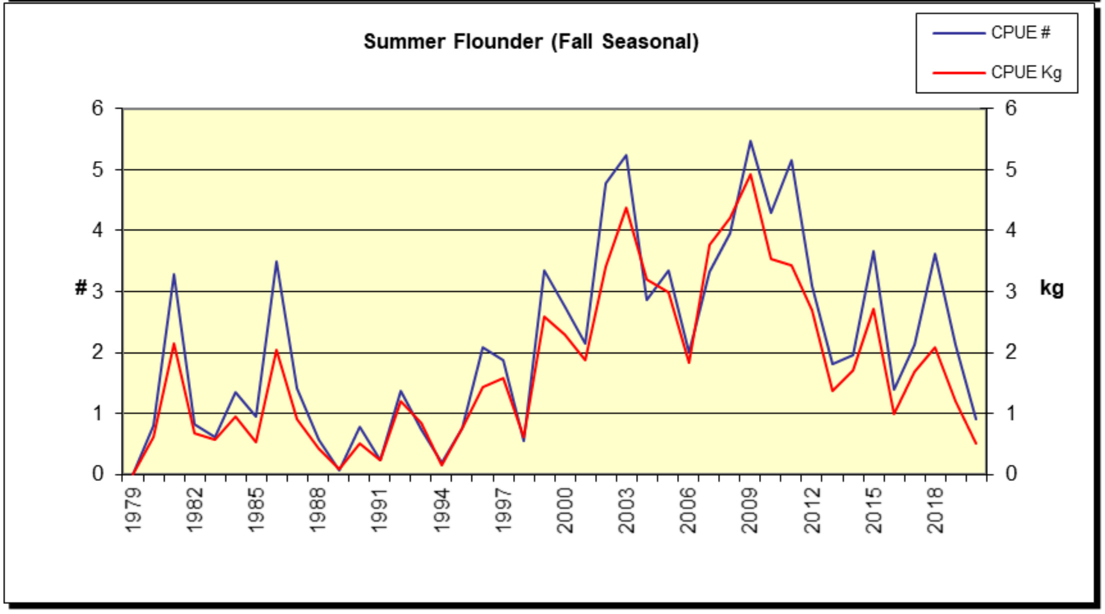


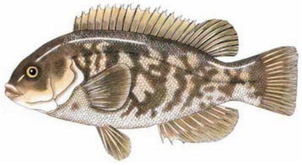


Sumer Flounder ***Paralichthys dentatus***

Stock Status: Not overfished and overfishing is occurring.
Management: ASMFC Amendment XIII Addendum XXXII

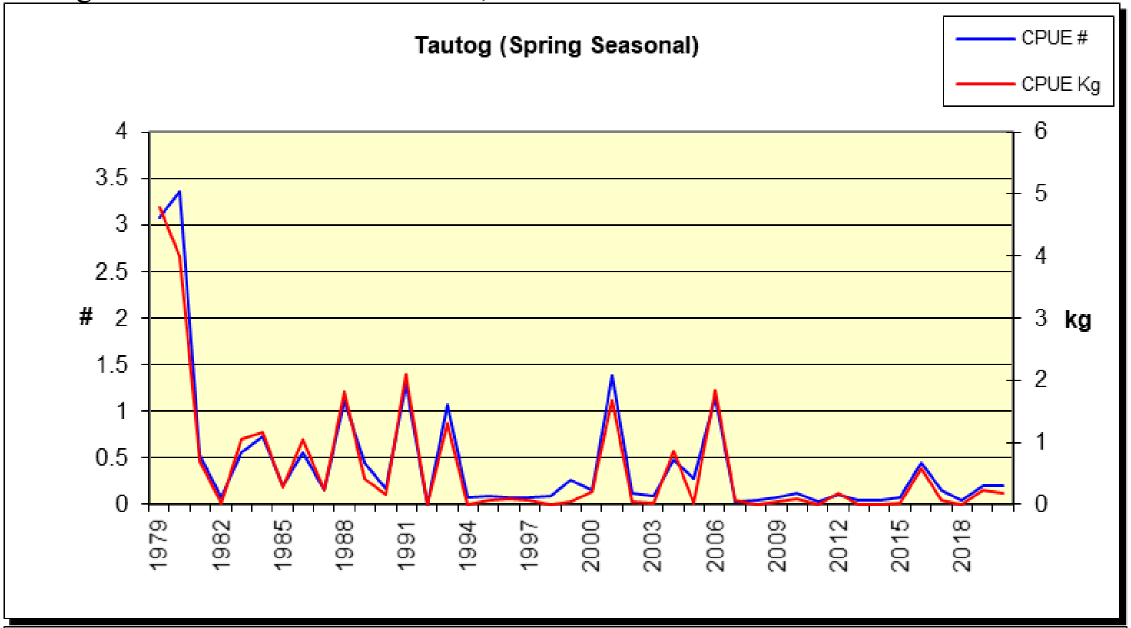


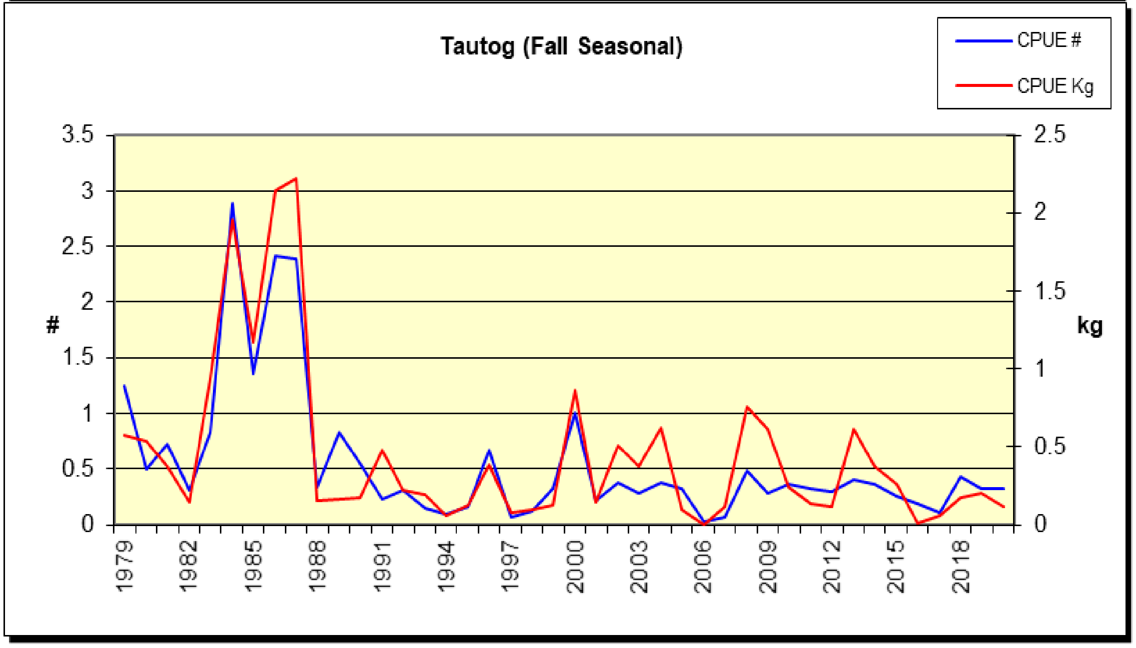


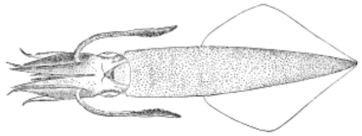


Tautog ***Tautoga onitis***

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

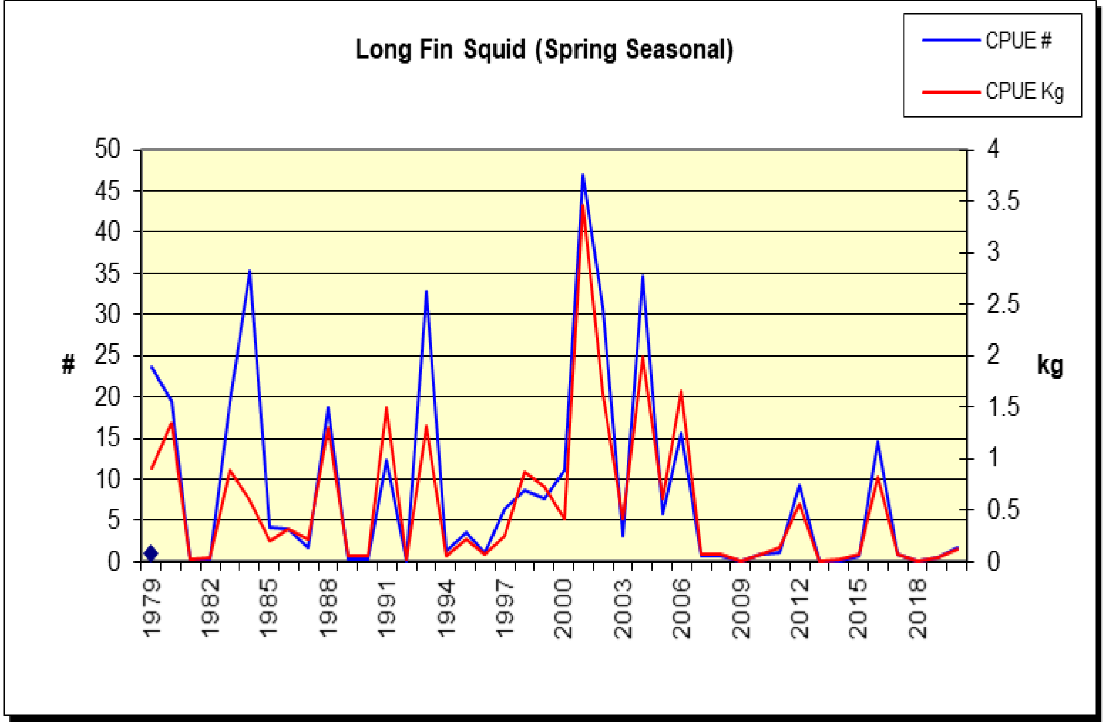


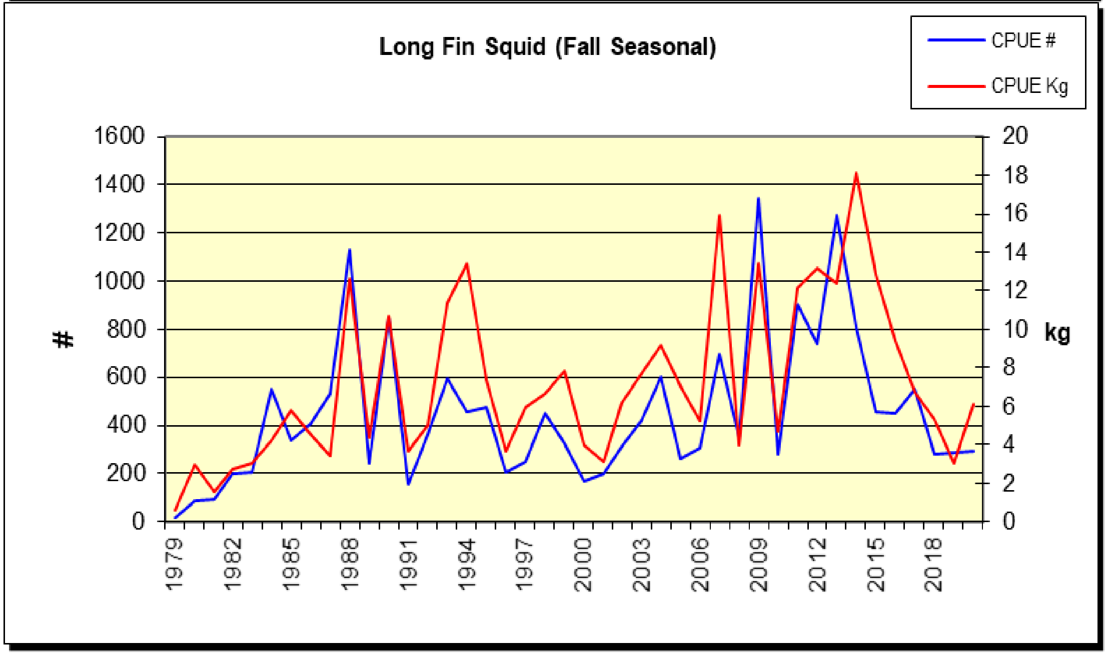


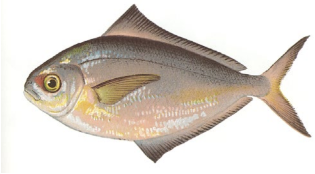


Longfin Squid ***Loligo pealei***

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

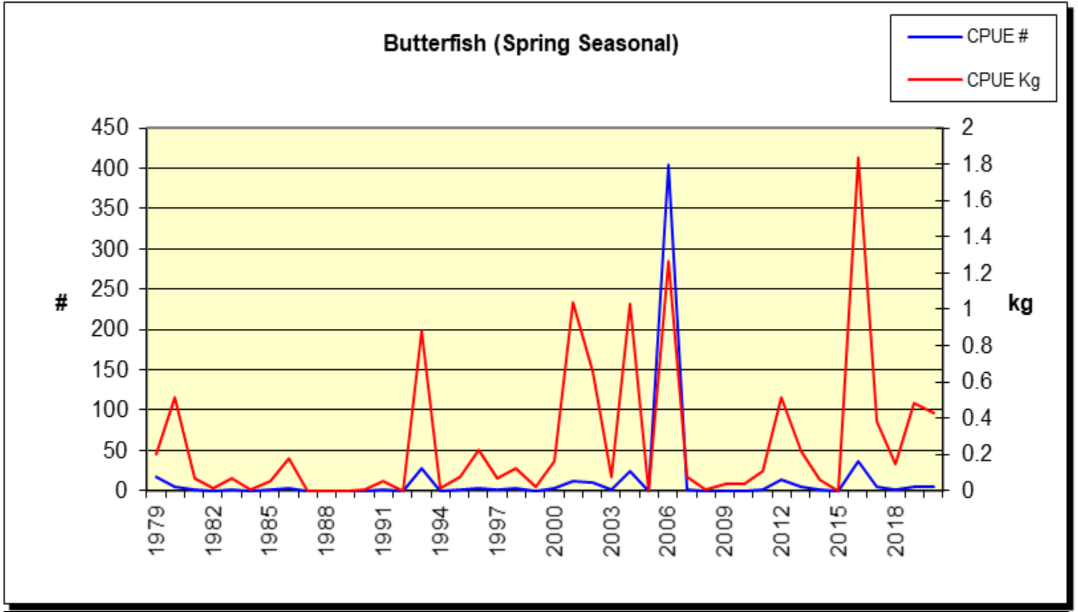


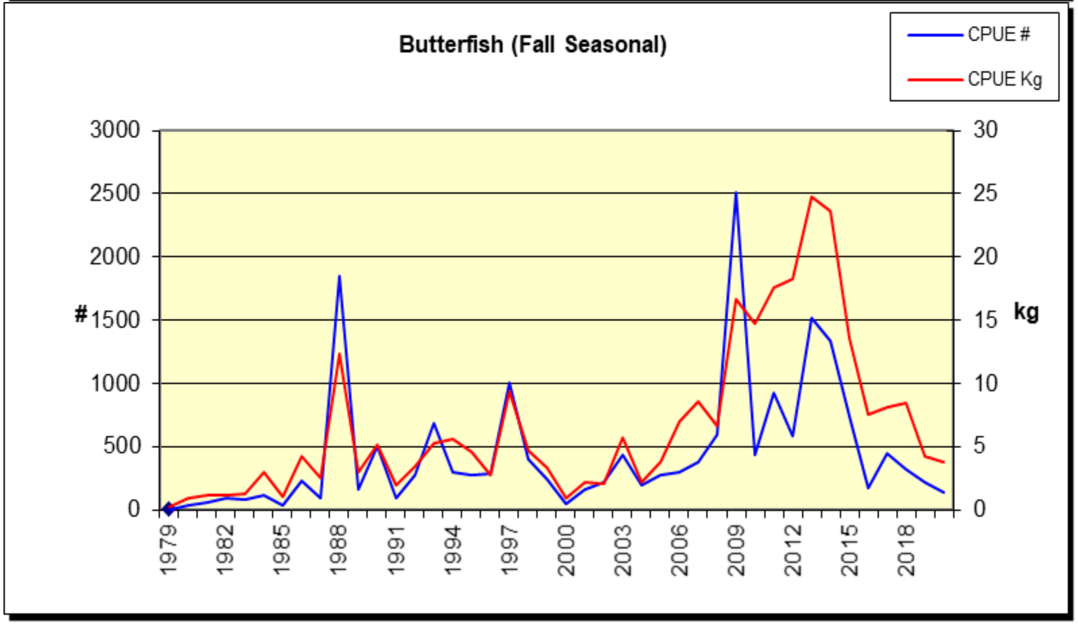




Butterfish ***Peprlilus triacanthus***

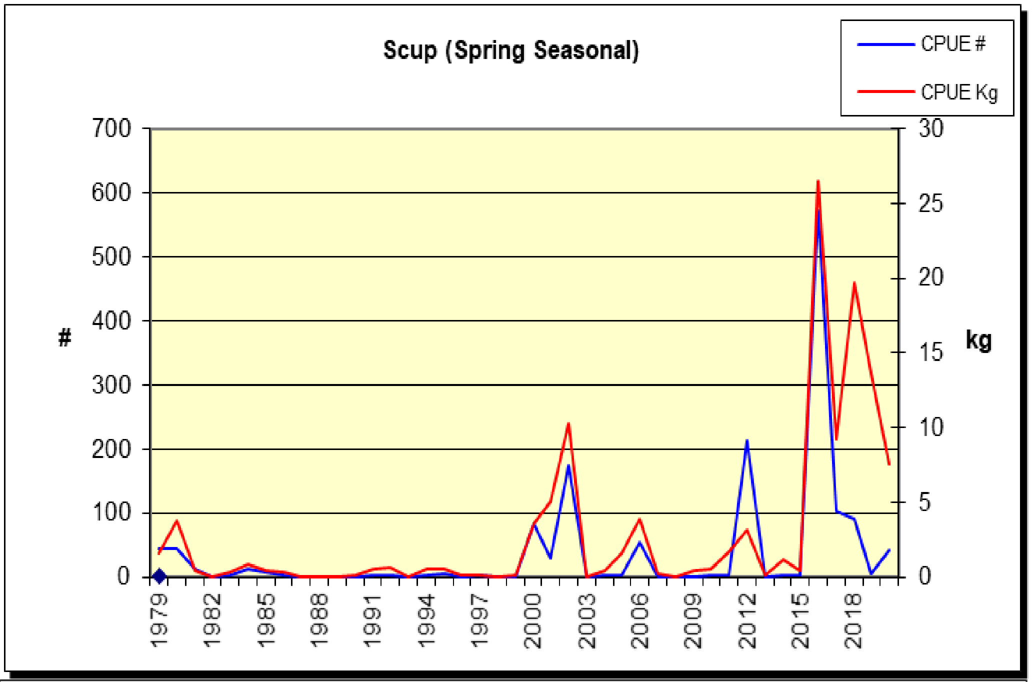
Stock Status: Variable / Uncertain
Management: Mid Atlantic Fishery Management Council, Atlantic Mackerel, Squid Butterfish FMP, ACL

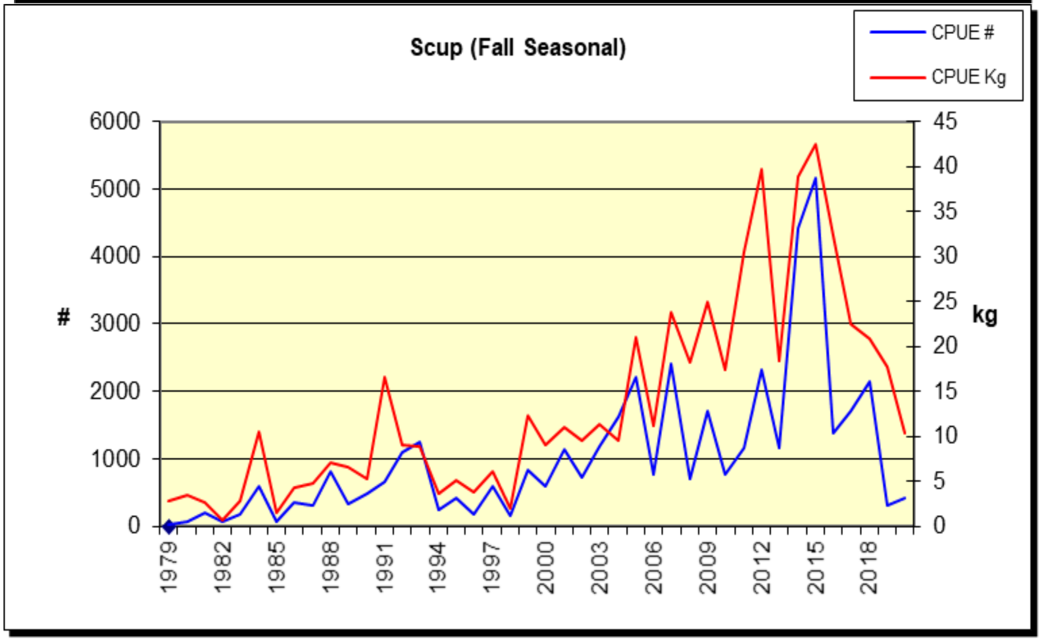


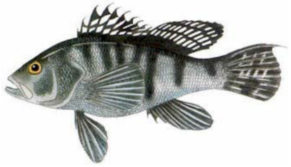


Scup ***Stenotomus chrysops***

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

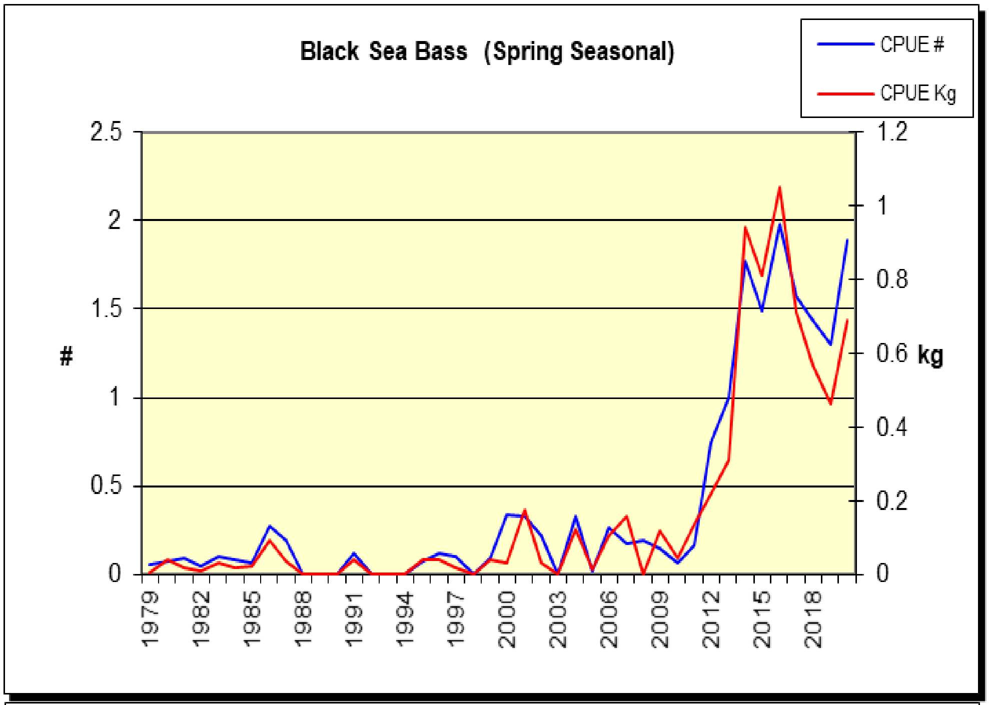


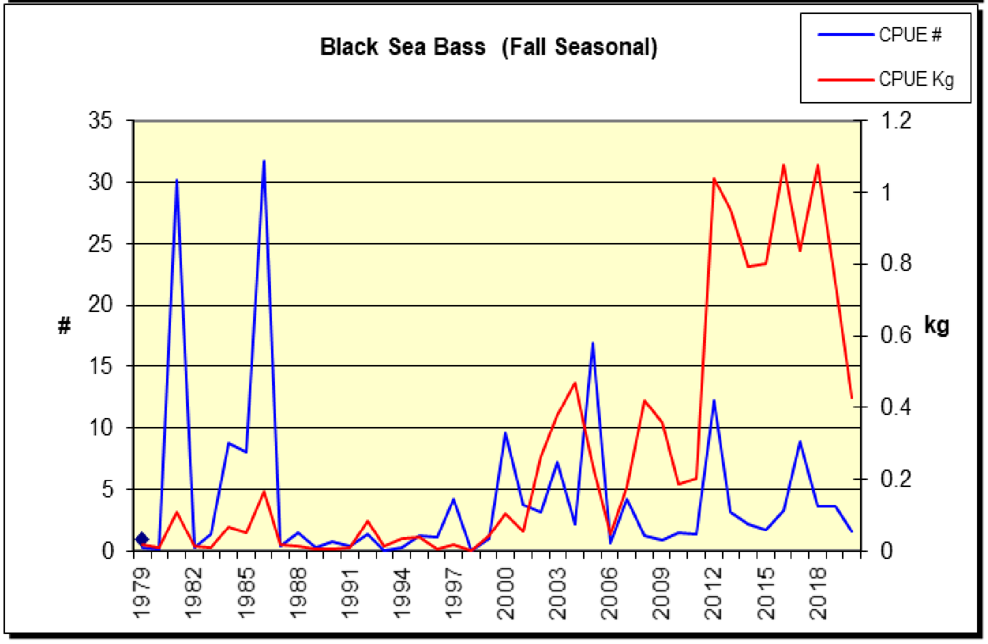




Black Sea Bass *Centropristis striata*

Stock Status: Rebuilt, not overfished overfishing is not occurring
Management: ASMFC Amendment XIII, Addendum XXXI





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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

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Federal Aid in Sportfish Restoration
F-61-R

Performance Report – Job 3

March 2021

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, 2020 – December 31, 2020

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

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 2020, investigators caught 44 species of finfish representing 29 families within the Washington County coastal ponds. This number is fairly consistent with 2019, where 51 species from 30 families were collected. The number of individuals caught in 2020 decreased from the 2019 survey, with 51,997 collected in 2020 and 79,928 collected in 2019. All 144 seine samples were completed in 2020. The Block Island juvenile finfish seine survey was completed by Diandra Verbeyst, Great Salt Pond Scientist, The Nature Conservancy. The report for this component of the survey begins on page 34.

Target Date: December, 2020

Status of Project: On Schedule

Significant Deviations: There were no significant deviations in 2020.

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

Remarks:

During 2020, investigators successfully sampled all twenty-four traditional stations in eight coastal ponds from May through October: Winnapaug Pond, Quonochontaug Pond, Charlestown Pond, Point Judith Pond, Green Hill Pond, Potter Pond, Little Narragansett Bay and Narrow River (Figures 1-3). Since 2018, the time series species indices for young of the year (YOY) winter flounder includes the data taken from the new stations added in 2011 (PP 1 and 2, GH 1 and 2, PR 1 through 3, PJ4). These stations were previously excluded due to potential unknown bias the new stations could introduce to the time series.

The abundance indices for winter flounder targets only YOY individuals. For the purpose of consistency, only individuals with a total length (TL) less than 12 cm are included in these analyses.

Materials and Methods:

As in previous years, investigators attempted to perform all seining on an outgoing tide. To collect animals, investigators used a seine 130 ft. long (39.62m), 6 ft deep (1.67m) with ¼” mesh (6.4mm). The seine has a bag at its midpoint, a weighted foot rope and floats on the head rope. Figure 4 describes the area covered by the seine net. The beach seine is set in a semi-circle away from the shoreline and back again using an outboard powered 16' Polarkraft aluminum boat. The net is then hauled toward the beach by hand and the bag is emptied into a large water-filled tote. All animals collected are identified to species, measured, enumerated, and sub-samples taken when appropriate. Water quality parameters including temperature, salinity and dissolved oxygen are measured at each station. Figure 1 shows the location of the subject coastal ponds and embayments, while figures 2-3 indicate the location of the sampling stations within each waterbody.

Results and Discussion:

Winter Flounder (*Pseudopleuronectes americanus*)

Juvenile winter flounder were collected at all 24 stations over the course of the season. Winter flounder ranked sixth in overall species abundance (n=1,784) in 2020, with the highest mean abundance (fish/seine haul) occurring in June (Table 2, Total Pond Index=35.33). This is slightly earlier than usual, as the highest abundance is typically observed in July (Total Pond Index for 2020=15.75). The June index being almost double than the July index is largely driven by the unusually high number of YOY captured at station 1 in Green Hill Pond (n=362, Green Hill Pond June index=197), but Pawcatuck River, Point Judith Pond, and Winnapaug Pond all had highest winter flounder abundance indices in June as well (23.3, 31.25, and 56.7 respectively). Quonochontaug Pond and Potter Pond showed peak winter flounder abundance in July (21.3 and 1.5 respectively) and Narrow River in August (9.33). Charlestown Pond peaked unusually early at 17.75 in May.

Winter flounder abundance increased from a low of 811 individuals in 2019 to 1,784 in 2020. The juvenile winter flounder abundance index (YOY WFL index) for the survey measured using the mean fish/seine haul increased from 5.63 fish/seine haul in 2018 to 12.33 fish/seine haul in 2020. Figure 5 displays the abundance indices by pond over the duration of the coastal pond survey. Table 2 and Figure 6 display the mean catch per seine haul (CPUE) of winter flounder for each month by pond during the 2020 survey. Figure 8 displays the annual winter flounder abundance index plotted over time, along with average recorded water temperature.

Winter flounder abundance increased from 2019 in all waterbodies except Narrow River and Quonochontaug Pond, although the CPUE was nearly the same in 2020 (9 and 9.4 respectively, compared to 9.9 and 9.8 in 2019). Green Hill Pond showed the largest increase in abundance index, going from 0.25 in 2019 to 33.1 in 2020, although this was driven by an unusually large catch at Station 1 in June (n=362). Much more winter flounder were caught in Winnapaug pond and Point Judith Pond compared to last year as well (23.7 and 15.0 respectively compared to 9.9 and 5.1 in 2019). Figure 17 is a map showing the total number of YOY winter flounder collected at each station.

With increasing seasonal temperatures, Rhode Island waters have seen an ecological shift from resident demersal species (including winter flounder) to a pelagic community dominated by more southern species (Collie et al. 2008, Oviatt 2004). Over the course of this survey, average water temperature of the coastal ponds has steadily increased, while winter flounder YOY CPUE has decreased (Figure 8). Average water temperature measured during the survey has not been below 20°C since 2006 (19.3°C). The highest average temperature was observed in 2016 at 22.5°C. These findings are consistent with the overall trend occurring in northeast region and the observed declines in winter flounder population.

In 2020, juvenile winter flounder ranged in size from 2.0 to 16.3 cm, representing age groups 0-1+ (Figure 7). The size range of animals collected is similar to those caught in previous years. Length-frequency distributions indicate that 99.9% of individuals collected during sampling season were group 0 fish (less than 12 cm total 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.

Two other RIDFW surveys target juvenile and adult winter flounder: the Narragansett Bay Spring Seasonal Trawl Survey (Spring Trawl) and the Narragansett Bay Juvenile Finfish Survey (NBS). A comparison of the Coastal Pond Survey (CPS) to these other projects reveals that despite some slight differences, they display similar trends (Figure 9). The NBS saw a low winter flounder abundance in 2020 of 1.59, close to the all-time low of 1.55 in 2018 (1.55). The Spring Trawl Survey WFL index was down from 2019, going from 5.07 fish/tow to 1.84 fish/tow. These low numbers are relatively consistent with the past few years (2013 to 2018). This may in part reflect regulations which changed ending the prohibition on possession of winter flounder in federal waters of Southern New England in 2012. Federal possession limits were either unlimited or set to 5,000 lbs per trip depending on the permit category of the vessel. It is believed that these high limits encourage a directed fishery for winter flounder in the spring. NOAA Fisheries has changed their procedures for administration of common pool possession limit, restricting it to lower values during the year than allowed (typically 2,000 lbs per day) in 2013. Possession limits remain 50 pounds in State waters.

The Narragansett Bay Seine Survey collects the most YOY WFL in June (McNamee Pers Comm). It should be noted that the Narragansett Bay Survey does not begin sampling until June and may miss those juvenile fish which occur in May in the shallow coves. 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 0.73 fish/seine haul in 2008. Between 2009 and 2019, the overall YOY WFL index in Point Judith pond increased slightly from the low 2008 value and since then (with the exception of the low abundances of 1.29 fish/haul in 2010 and 2.9 fish/haul in 2018) has remained relatively level with index values averaging approximately 5 fish/haul. In 2020, an unusually high number of winter flounder were caught, with a CPUE of 14.7. This trend in abundance might reflect the no possession rule in the pond as well as the former coast wide closure. Despite this, the pond's winter flounder population has not rebounded to historic levels. A winter fyke net survey (Adult Winter Flounder Tagging Survey) is also conducted targeting adult winter flounder that use the ponds to spawn. Currently, Point Judith, Potter Pond, and Charlestown Ponds are the only coastal ponds where both a juvenile survey and an adult winter flounder survey occur annually (winter fyke net stations in Charlestown Pond were sampled from 2012-2015 and continued in 2019). 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 in Point Judith Pond, an overall declining trend in relative abundance of winter flounder is observed in both surveys (Figure 10). The index value observed in the adult spawner survey was the lowest ever recorded at 0.8 WFL per net haul in 2014, recovering slightly in 2016-2018 (1.1 fish/haul-6 fish/haul). In 2019, the number of captured fish declined again, with an index value of 0.67 fish/haul, but increased slightly in 2020 to 1.6 fish/haul. Most fish caught were mature females (54%). A total of 3 mature fish were tagged and released in Point Judith Pond, and 17 total in all three ponds. Survey data for 2020 is summarized in Table 16. 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 on April 8, 2011 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.

Bluefish *(Pomatomus saltatrix)*

A total of 68 bluefish were collected in 2020 (CPUE=0.47 fish/haul). The majority were caught in Winnapaug Pond and Green Hill Pond in September, with small numbers in Pawcatuck River in July and August and in Narrow River in September. This is a slight increase from 2019 (CPUE=0.29 fish/haul). Table 4 contains the abundance indices for the 2020 survey by month and pond. Bluefish ranged in size from 4 cm to 25 cm. Figure 11 displays the annual abundance index of bluefish for all stations combined.

Tautog (*Tautoga onitis*)

From May to October of 2020, 277 (CPUE= 1.92 fish/haul) tautog were collected in all ponds. This is down from the 448 tautog caught in 2019 (CPUE=3.1 fish/haul) but consistent with the last few years (CPUE= ~2 for 2015-2018). Table 5 contains the abundance indices for the 2020 survey by month and pond. The highest abundances in 2020 occurred in the Pawcatuck River in August, with lower numbers caught throughout all ponds throughout the season. Tautog caught in 2020 ranged in size from 1.4 cm to 20.4 cm. Figure 12 displays the annual abundance index of tautog for all stations combined.

Black Sea Bass (*Centropristis striata*)

A total of 79 juvenile black sea bass were collected from June to October of 2020 from all ponds except Green Hill Pond, Pawcatuck River, and Potter Pond (CPUE=0.55 fish/haul). This is a decrease from 2019 (CPUE=1.02 fish/haul) and from 2018 in which the highest abundance of black sea bass in the history of the survey was recorded (CPUE=4.2). This is also the lowest abundance seen in the last few years (overall CPUE from 2014-2019=1.7 fish/haul). The highest abundance in 2020 was seen in Charlestown Pond and Narrow River in August (CPUE=6.0 and 5.3 respectively). None we caught in June or July. Table 6 contains the abundance indices for the survey by month and pond. Black sea bass caught in 2019 ranged in size from 3 cm to 11 cm.

Scup *(Stenotomus chrysops)*

In 2020, 49 scup were collected from July to September in all ponds except Green Hill

Pond, Point Judith Pond, and Winnapaug Pond (CPUE=0.34 fish/haul). This is down from 2017-2019 (all time high of 3.9 fish/haul in 2017 and 2.7 and 1.8 fish/haul in 2018-2019). Despite this, an increase in scup caught has been seen since 2014 (CPUE=0.21). Table 7 contains the abundance indices for the 2020 survey by month and pond. Figure 14 displays the annual abundance index of scup for all stations combined. Scup caught in 2020 ranged in size from 2 cm to 29 cm.

Clupeids:

In 2020, four species of clupeids were caught in the coastal pond survey: Atlantic menhaden (*Brevoortia tyrannus*), Atlantic herring (*Alosa harengus*), Alewife (*Alosa pseudoharengus*), and Bay Anchovy (*Anchoa mitchilli)*. The most prevalent clupeid caught in 2020 was by far Atlantic Menhaden, with 23,069 individuals captured from May to October (excluding July) in all ponds (CPUE=160 fish/haul). This is about half of what was caught in 2019 (390 fish/haul) but consistent with 2018. In multiple instances, high numbers of YOY menhaden were caught in a single seine haul, likely because a school was present at a given station upon sampling. The second most abundant clupeid observed in 2020 was Bay Anchovy. A total of 182 were captured from May to October in all ponds except Quonochontaug, Winnapaug, and Charlestown (CPUE=1.26). Only 33 Alewife were caught in 2020 (CPUE=0.23), down from 257 in 2019. No blueback herring were caught in 2020. From May to June, 27 Atlantic herring were captured (CPUE=0.19), a decrease from the 171 caught in 2019, but consistent with the 36 caught in 2018. Table 8 contains the abundance indices for clupeids by month pooled across all 8 ponds. Figure 15 displays the annual abundance indices of clupeids for all stations combined. Menhaden are plotted on a separate axis due to scale issues.

Baitfish Species:

Silversides *(Menidia sp.)*

Silversides had the second highest abundance of all species, with 17,016 caught during the 2020 survey (CPUE=118.2 fish/haul). This is slightly up from 2018 and 2019, where ~11,000 were caught each year. Silversides were collected in each of the ponds throughout the time period of the survey, with the exception of Green Hill Pond and Narrow River in May. The highest abundances were observed in Charlestown Pond, and in September across most ponds. Table 9 contains the abundance indices for the survey by month and pond. Atlantic silversides caught in 2020 ranged in size from 2 cm to 14 cm.

Striped Killifish *(Fundulus majalis)*

Striped killifish ranked third in species abundance with 2,978 fish caught during 2020 (CPUE=20.68). This is consistent with 2018 and 2019, where ~2,000 fish were caught each year. They occurred in each of the ponds at least once and were caught each month during the survey. Narrow River and Winnapaug Pond had the highest abundance of striped killifish, and overall, they were most prevalent in October. Table 10 contains the abundance indices for the survey by month and pond. Striped killifish caught in 2020 ranged in size from 2 cm to 13 cm.

Common Mummichog *(Fundulus heteroclitus)*

The mummichog ranked fourth in overall abundance in 2020 with 2,530 individuals (CPUE=17.6), slightly down from 2019 (3,310 individuals) but consistent with 2018 (2,251 individuals). They occurred in each of the ponds at least once and were caught each month during the survey. Narrow River had the highest abundances of Mummichogs. This year continues the rebound from the lowest mummichog abundance on record of 2.09 fish/seine haul in 2013. Table 11 contains the abundance indices for the survey by month and pond. Mummichogs caught in 2020 ranged in size from 1 cm to 10 cm.

Sheepshead Minnow *(Cyprinodon variegatus)*

The Sheepshead minnow ranked fifth in overall abundance with 1,925 individuals collected (CPUE=13.36). This is an increase from the 1,012 fish caught in 2019. Sheepshead minnow occurred in each of the ponds and were caught between May and October in Charlestown Pond, but not until later in the season in most other ponds. Overall, the highest abundances were seen in September. Narrow River had the highest abundances of Sheepshead minnows. Table 12 contains the abundance indices for the survey by month and pond. Sheepshead minnow caught in 2020 ranged in size from 1 cm to 5 cm.

Figure 16 displays the annual abundance index of the baitfish species for all stations combined.

Physical and Chemical Data:

Physical and Chemical data for the 2020 Coastal Pond Survey is summarized in tables 13-15 and Figure 23. The water quality meter used on the survey was not functional in July, and so salinity, DO, and temperature readings in some ponds are not available. Water temperature in 2020 averaged 21.9 ºC, with the lowest observed value of 13.4 ºC in May in Point Judith Pond and the highest at 32 ºC in Charlestown Pond in August. A heat wave in July and August caused high water temps in all ponds. Temperature continues on an annual upward trend. Salinity ranged from 9.79 ppt to 32.48 ppt, and averaged 27.02 ppt. Dissolved oxygen ranged from 4.85 mg/l to 15.65 mg/l with an average of 7.93 mg/l. The highest measured DO was 15.65 mg/L in May in Charlestown Pond, however this was likely inaccurate as this is an abnormally high value. The YSI water quality meter being used at this time was starting to fail, which may explain the inaccuracy.

New Station Preliminary Data

This year was the tenth year of sampling stations in the three additional ponds. On a whole, the samples were consistent with 2011-2019. Since 2018, data from these additional stations has been included in the abundance indices for all species, including YOY winter flounder. This data will continue to be included in future analyses. 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, but 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 fine, muddy sand. WFL YOY have been caught in relatively high abundance in May, suggesting spawning activity within the pond. The WFL YOY decrease in abundance at the stations in July and August when the water is warm and are not caught frequently after it cools 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. However, the local geography is such that more tidal flushing occurs than in Green Hill Pond. 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. Also similar to Green Hill Pond, WFL YOY are highest in abundance in May and decrease in abundance as the season progresses. The water temperature in Potter 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 eight years had small catches of 1-year old flounder at station PP-1 during the late summer and early fall. Water temperatures are generally higher than the pond proper, while dissolved oxygen near this station is lower. The rest of the pond does not have the same water quality issues. Other species frequently caught in the pond include the baitfish species, American eel, oyster toad fish, naked goby, tautog, and blue crabs.

Lower Pawcatuck River: The lower Pawcatuck River (also known as 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 typically has the most consistent catch of WFL YOY which are present during all months of the survey. However, in 2018, WFL were only captured June-August. PR-2 is located on a sand bar island in the middle of Little Narragansett Bay on the protected (inland) 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 catches WFL YOY, but usually at lower frequencies than PR-1. 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 now 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 juvenile tautog, the baitfish species, alewife, tomcod, menhaden, and bluefish.

Point Judith Pond: 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 has higher catch frequencies of WFL YOY than the other stations in the pond, but still is low in comparison to the other ponds.

The first six years of sampling the new stations successfully collected target species, notably WFL YOY. It is recommended that these stations be sampled into the future so as to continue to provide species assemblage information from these coastal ponds. The additional catch frequencies and distributions of WFL YOY will provide a better understanding of the population, notably in areas where the fish only occur in the spring/early summer. Moving forward, this data will be included in the time series abundance indices.

Summary

In 2020, investigators caught 44 species of finfish representing 29 families. This number is fairly consistent with 2019, where 51 species from 30 families were collected. The number of individuals caught in 2020 decreased from the 2019 survey, with 51,997 collected in 2020 and 79,928 collected in 2019. All 144 seine samples were completed in 2020. Appendix 1 displays the frequency of all species caught by station during the 2020 Coastal Pond Survey. Additional data is available by request.

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Table 1: 2020 Coastal Pond Survey Winter Flounder Frequency by Station and Month

Station	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Totals**	**Mean**	**STD**
CP1	62	7	7	0	1	0	**77**	**12.83**	**24.31**
CP2	4	2	0	0	0	0	**6**	**1.00**	**1.67**
CP3	2	10	0	0	0	0	**12**	**2.00**	**4.00**
CP4	3	3	0	0	0	0	**6**	**1.00**	**1.55**
GH1	0	362	0	0	0	0	**362**	**60.33**	**147.79**
GH2	0	32	3	0	0	0	**35**	**5.83**	**12.88**
NR1	4	13	7	0	0	0	**24**	**4.00**	**5.25**
NR2	14	22	10	47	1	0	**94**	**15.67**	**17.42**
NR3	10	6	8	19	0	1	**44**	**7.33**	**6.92**
PJ1	2	1	2	0	0	0	**5**	**0.83**	**0.98**
PJ2	66	16	34	15	0	5	**136**	**22.67**	**24.23**
PJ3	0	99	7	3	0	0	**109**	**18.17**	**39.70**
PJ4	47	15	39	4	0	4	**109**	**18.17**	**20.03**
PP1	2	1	0	0	0	0	**3**	**0.50**	**0.84**
PP2	0	0	3	0	0	1	**4**	**0.67**	**1.21**
PR1	0	15	55	1	5	1	**77**	**12.83**	**21.40**
PR2	14	53	1	4	1	6	**79**	**13.17**	**20.09**
PR3	0	2	3	0	0	0	**5**	**0.83**	**1.33**
QP1	7	0	7	10	0	4	**28**	**4.67**	**4.08**
QP2	4	6	28	12	10	2	**62**	**10.33**	**9.42**
QP3	0	32	29	1	1	17	**80**	**13.33**	**14.76**
WP1	19	95	89	27	6	4	**240**	**40.00**	**41.20**
WP2	14	61	40	9	15	8	**147**	**24.50**	**21.38**
WP3	13	15	6	0	3	3	**40**	**6.67**	**6.02**
Totals	**287**	**868**	**378**	**152**	**43**	**56**	**1784**		
Mean	**11.96**	**36.17**	**15.75**	**6.33**	**1.79**	**2.33**	**74.33**		
STD	**19.01**	**74.86**	**22.19**	**11.29**	**3.74**	**3.89**	**84.31**		

Table 2: 2020 Coastal Pond Survey winter flounder abundance indices (fish/seine haul) by pond and month

Waterbody	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
Charlestown Pond	17.75	5.50	1.75	0.00	0.25	0.00
Green Hill Pond	0.00	197.00	1.50	0.00	0.00	0.00
Narrow River	9.33	9.33	8.33	22.00	0.33	0.33
Pawcatuck River	4.67	23.33	19.67	1.67	2.00	2.33
Point Judith Pond	28.75	31.25	20.50	5.50	0.00	2.25
Potter's Pond	1.00	0.50	1.50	0.00	0.00	0.50
Quonochontaug Pond	3.67	12.67	21.33	7.67	3.67	7.67
Winnapaug Pond	15.33	56.67	45.00	12.00	8.00	5.00
Total Pond Index	**11.96**	**35.33**	**15.75**	**6.33**	**1.79**	**2.33**

Table 3: 2020 Coastal Pond Survey average lengths (cm) of juvenile winter flounder by pond and month

Waterbody	May	June	July	August	September	October
Ninigret Pond	3.37	5.97	6.83		9.70	
Green Hill Pond	4.95	6.37	7.27			
Narrow River	3.39	5.62	5.90	5.87	7.60	8.30
Point Judith Pond	3.32	6.20	5.40	5.83		7.80
Potter Pond	4.55	8.00	6.70			9.70
Pawcatuck River	3.64	4.49	5.08	5.02	6.85	7.13
Quonochontaug Pond	3.49	4.23	4.94	6.28	6.39	9.00
Winnapaug Pond	3.31	4.63	4.71	5.15	5.61	8.11
Overall	**3.60**	**3.93**	**3.48**	**3.48**	**4.44**	**6.13**

Table 4: 2020 Coastal Pond Survey bluefish abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	0.00	0.00	0.00	0.00	0.00
Green Hill Pond	0.00	0.00	0.00	0.00	7.50	0.00
Narrow River	0.00	0.00	0.00	0.00	0.33	0.00
Pawcatuck River	0.00	0.00	0.33	1.33	0.00	0.00
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	0.00
Potter Pond	0.00	0.00	0.00	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	0.00	0.00	0.00
Winnapaug Pond	0.00	0.00	0.00	0.00	9.67	0.00
Total Pond Index	**0.00**	**0.00**	**0.04**	**0.92**	**1.88**	**0.00**

Table 5: 2020 Coastal Pond Survey tautog abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	2.25	0.00	2.00	5.50	0.25	0.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	2.00	0.00	0.33	9.00	4.00	1.00
Pawcatuck River	0.00	2.50	1.67	19.33	2.00	0.67
Point Judith Pond	0.00	0.00	1.00	2.50	0.00	0.50
Potter Pond	0.00	0.00	7.50	1.50	3.50	2.50
Quonochontaug Pond	0.00	0.33	1.67	2.00	1.00	0.00
Winnapaug Pond	0.00	0.00	0.33	1.67	12.33	0.67
Total Pond Index	**0.79**	**0.29**	**1.63**	**5.46**	**2.75**	**0.63**

Table 6: 2020 Coastal Pond Survey black sea bass abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.50	0.00	0.00	6.00	0.00	0.50
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.00	0.00	5.33	2.00	0.67
Pawcatuck River	0.00	0.00	0.00	0.00	0.00	0.00
Point Judith Pond	0.25	0.00	0.00	4.25	0.00	0.00
Potter Pond	0.00	0.00	0.00	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	0.00	0.33	0.00
Winnapaug Pond	0.00	0.00	0.00	1.67	0.33	0.00
Total Pond Index	**0.13**	**0.00**	**0.00**	**2.58**	**0.33**	**0.25**

Table 7: 2020 Coastal Pond Survey Scup abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	0.00	0.00	0.75	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	9.33	1.00	0.00
Pawcatuck River	0.00	0.00	0.00	3.67	0.00	0.00
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	0.00
Potter Pond	0.00	0.00	1.00	0.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	0.67	0.00	0.00
Winnapaug Pond	0.00	0.00	0.00	0.00	0.00	0.00
Total Pond Index	0.00	0.00	0.00	0.00	0.00	0.00

Table 8: 2020 Coastal Pond Survey Clupeid abundance indices (fish/seine haul) by month

Species	May	June	July	August	September	October
Alewife	0.00	0.00	1.08	0.00	0.17	0.13
Bay Anchovy	0.17	0.08	5.21	1.17	0.29	0.67
Atlantic Herring	0.54	0.58	0.00	0.00	0.00	0.00
Blueback herring	0.00	0.00	0.00	0.00	0.00	0.00
Atlantic Menhaden	1.21	175.08	0.00	636.29	61.17	87.46

Table 9: 2020 Coastal Pond Survey Silverside abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	15.25	12.50	76.00	77.50	1024.50	272.25
Green Hill Pond	0.00	11.75	7.00	324.50	786.00	54.00
Narrow River	0.00	11.50	22.00	87.67	31.67	87.00
Pawcatuck River	19.00	21.25	11.33	128.33	15.33	2.33
Point Judith Pond	16.75	42.50	163.25	51.50	57.00	185.50
Potter Pond	12.50	13.00	27.00	55.50	190.00	123.50
Quonochontaug Pond	4.00	4.00	39.00	43.00	61.73	12.00
Winnapaug Pond	31.00	1.00	41.33	516.33	242.00	504.67
Total Pond Index	**12.33**	**17.33**	**56.92**	**150.08**	**305.43**	**166.83**

Table 10: 2020 Coastal Pond Survey Striped Killifish abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	2.00	0.75	20.75	64.50	5.00	48.75
Green Hill Pond	0.00	0.00	0.50	0.00	0.00	0.00
Narrow River	0.67	0.33	1.00	13.67	11.33	107.67
Pawcatuck River	0.00	0.00	0.00	7.67	59.67	1.33
Point Judith Pond	23.00	2.00	23.75	17.25	3.50	8.25
Potter Pond	0.00	0.00	0.50	4.00	0.00	0.50
Quonochontaug Pond	0.00	0.00	3.00	33.67	37.67	4.00
Winnapaug Pond	4.00	0.00	3.00	21.67	95.67	290.33
Total Pond Index	**4.75**	**0.50**	**8.38**	**23.54**	**27.00**	**60.00**

Table 11: 2020 Coastal Pond Survey Mummichog abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	33.75	3.50	6.25	99.00	2.50	5.75
Green Hill Pond	0.50	5.00	20.50	15.00	10.50	0.50
Narrow River	14.33	82.67	35.67	89.00	1.67	6.33
Pawcatuck River	0.00	5.33	0.00	2.67	0.00	0.00
Point Judith Pond	3.75	6.50	7.75	66.25	0.75	5.00
Potter Pond	32.50	66.00	27.00	44.50	19.00	11.50
Quonochontaug Pond	0.00	0.00	1.33	6.00	1.00	0.00
Winnapaug Pond	2.00	0.33	3.33	65.33	31.33	5.67
Total Pond Index	**11.04**	**18.63**	**11.33**	**52.88**	**7.25**	**4.29**

Table 12: 2020 Coastal Pond Survey Sheepshead Minnow abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	2.50	0.50	7.25	25.00	11.75	3.50
Green Hill Pond	0.00	0.00	0.00	2.00	1.50	0.00
Narrow River	0.00	0.00	4.00	36.33	0.00	117.33
Pawcatuck River	0.00	0.00	0.00	0.00	38.00	0.33
Point Judith Pond	0.00	0.00	0.00	0.00	0.00	2.25
Potter Pond	0.00	0.00	0.00	4.50	14.00	12.50
Quonochontaug Pond	0.00	0.00	0.00	2.33	0.67	0.67
Winnapaug Pond	0.00	0.33	0.33	21.67	222.67	103.67
Total Pond Index	**0.42**	**0.13**	**1.75**	**12.25**	**35.92**	**29.75**

Table 13: 2020 Coastal Pond Survey average water temperature (°C) by pond and month*

Waterbody	May	June	July	August	September	October
Charlestown Pond	20.98	22.08	29.57	30.33	19.10	17.68
Green Hill Pond	19.40	22.60	27.60	28.25	17.60	17.55
Narrow River	17.70	24.20		28.90	22.33	16.17
Pawcatuck River	16.50	21.43	24.53	23.53	18.17	16.10
Point Judith Pond	16.40	21.15		27.58	17.08	16.80
Potter's Pond	19.10	20.85	25.00	27.95	18.70	17.35
Quonochontaug Pond	18.87	23.37		24.23	17.23	16.77
Winnapaug Pond	15.23	20.20		23.90	19.30	16.20
Average	**18.32**	**21.98**	**27.05**	**27.23**	**19.21**	**16.82**

*Data not available for some ponds for July.

Table 14: 2020 Coastal Pond Survey average salinity (ppt) by pond and month*

Waterbody	May	June	July	August	September	October
Charlestown Pond	29.04	26.63		30.75	31.08	31.10
Green Hill Pond	18.98	21.74		23.69	28.73	24.38
Narrow River	18.29	21.92		19.63	28.27	28.56
Pawcatuck River	12.74	17.86		29.34	30.56	30.17
Point Judith Pond	29.05	22.72		25.72	31.94	31.11
Potter's Pond	28.23	24.68		26.83	28.58	30.24
Quonochontaug Pond	29.95	28.31		31.52	32.04	31.60
Winnapaug Pond	29.54	28.06		30.93	31.72	31.04
Average	**24.86**	**23.87**		**27.17**	**30.70**	**29.49**

*Data not available for July.

Table 15: 2020 Coastal Pond Survey average dissolved oxygen (mg/L) by pond and month*

Waterbody	May	June	July	August	September	October
Charlestown Pond	12.58	10.34		11.02	10.99	7.72
Green Hill Pond	8.07	7.82		6.44	8.40	7.79
Narrow River	10.18	6.52		7.81	7.03	7.77
Pawcatuck River	11.13	9.33		7.49	8.63	8.59
Point Judith Pond	9.59	12.85		8.59	8.35	7.96
Potter's Pond	10.91	8.87		8.24	7.84	8.83
Quonochontaug Pond	9.96	8.92		7.18	8.80	8.57
Winnapaug Pond	9.97	7.48		6.62	7.45	7.92
Average	**10.39**	**9.17**		**8.16**	**8.41**	**8.00**

*Data not available for July.

Table 16: 2020 Adult Winter Flounder tagging Survey (Fyke Net Survey) summary

Waterbody	Total WFL Caught	Total CPUE (fish/net hauls)	Mature Males	Mature Females	Immature/ Unknown	Tagged Fish
Point Judith	53	1.6	23	22	8	3
Potter	14	1	2	12	0	8
Charlestown	103	6.4	41	45	17	6

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

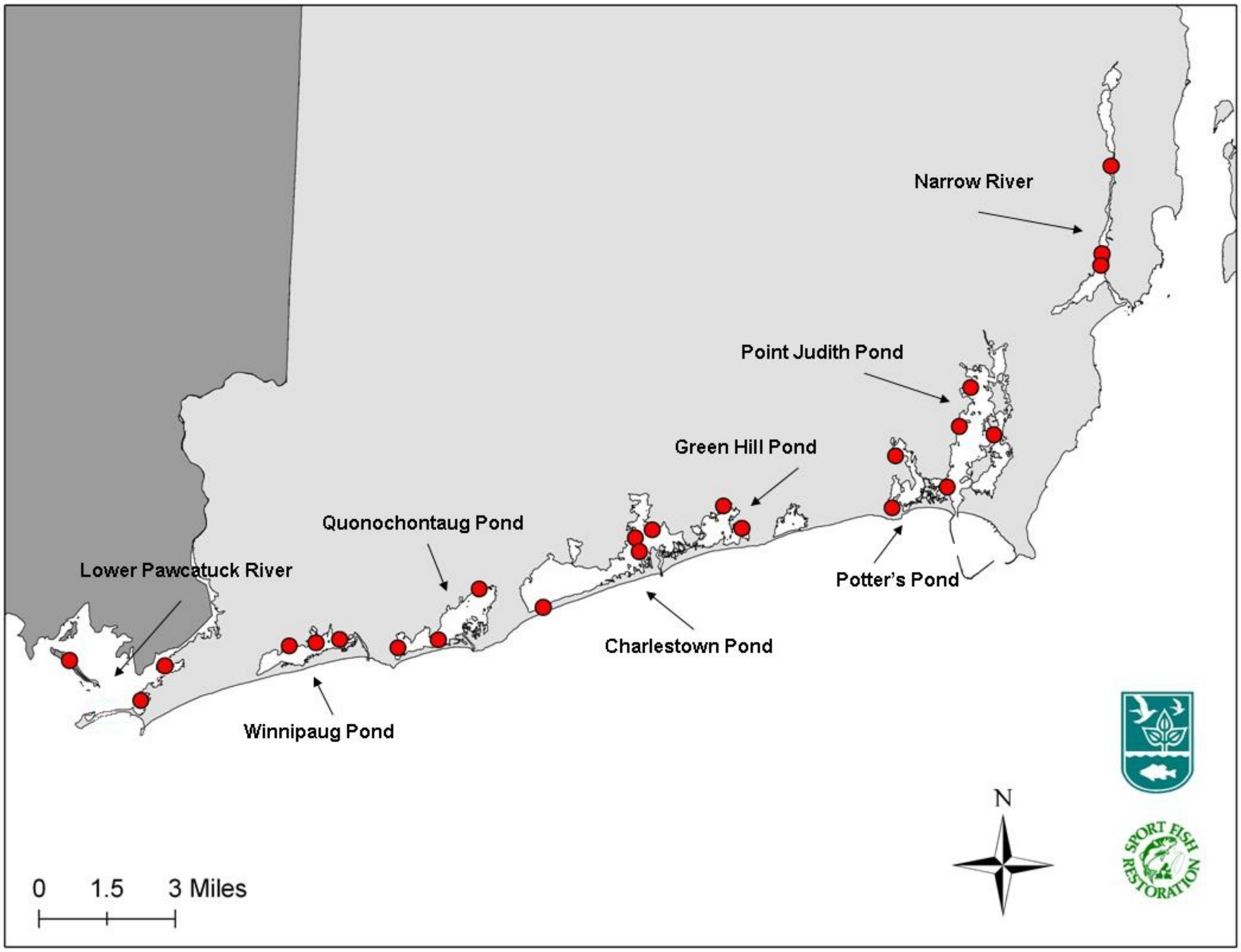


Figure 2: Coastal Pond Juvenile Finfish Survey station locations (western ponds).

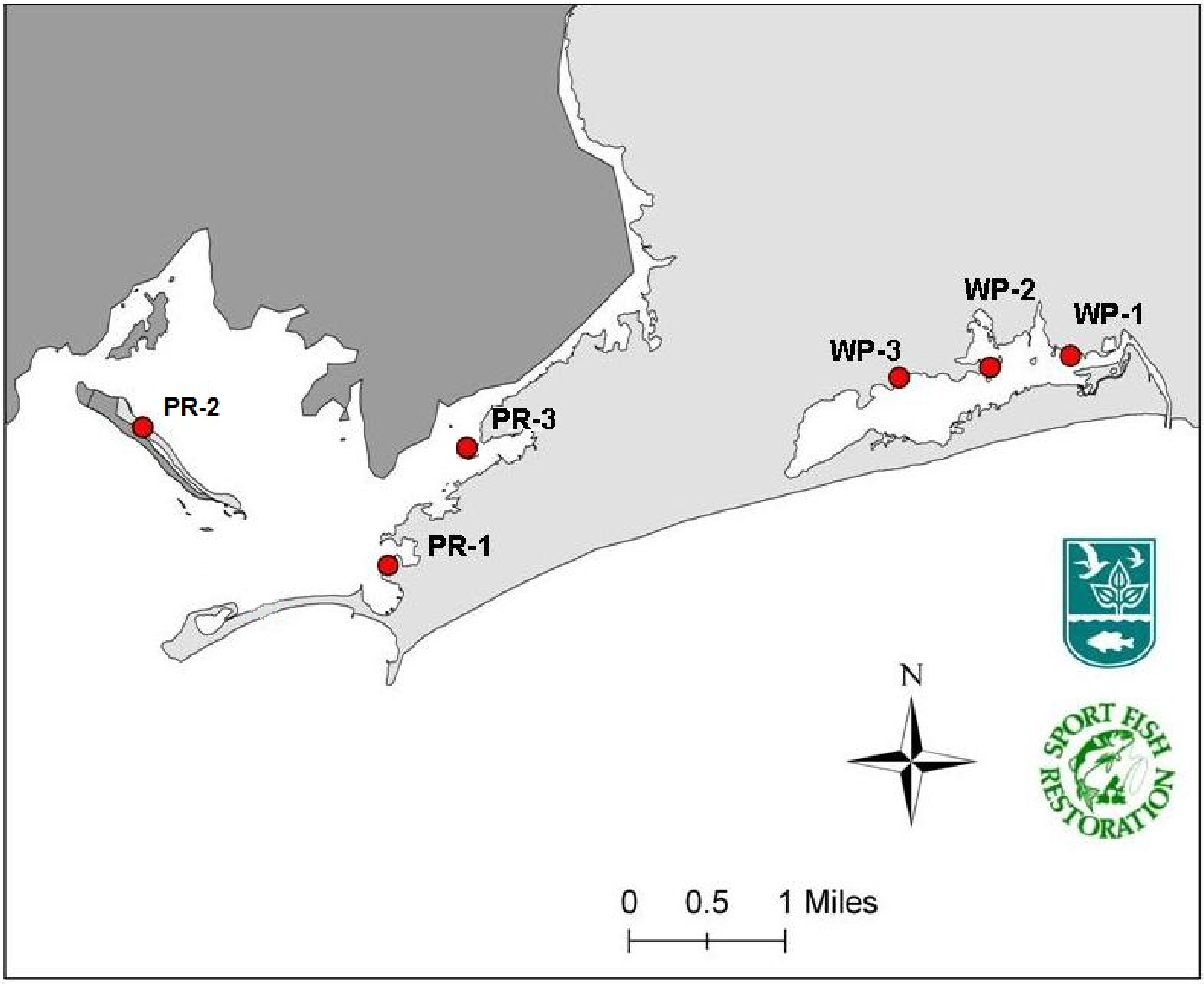


Figure 2 (cont): Coastal Pond Juvenile Finfish Survey station locations (western ponds).

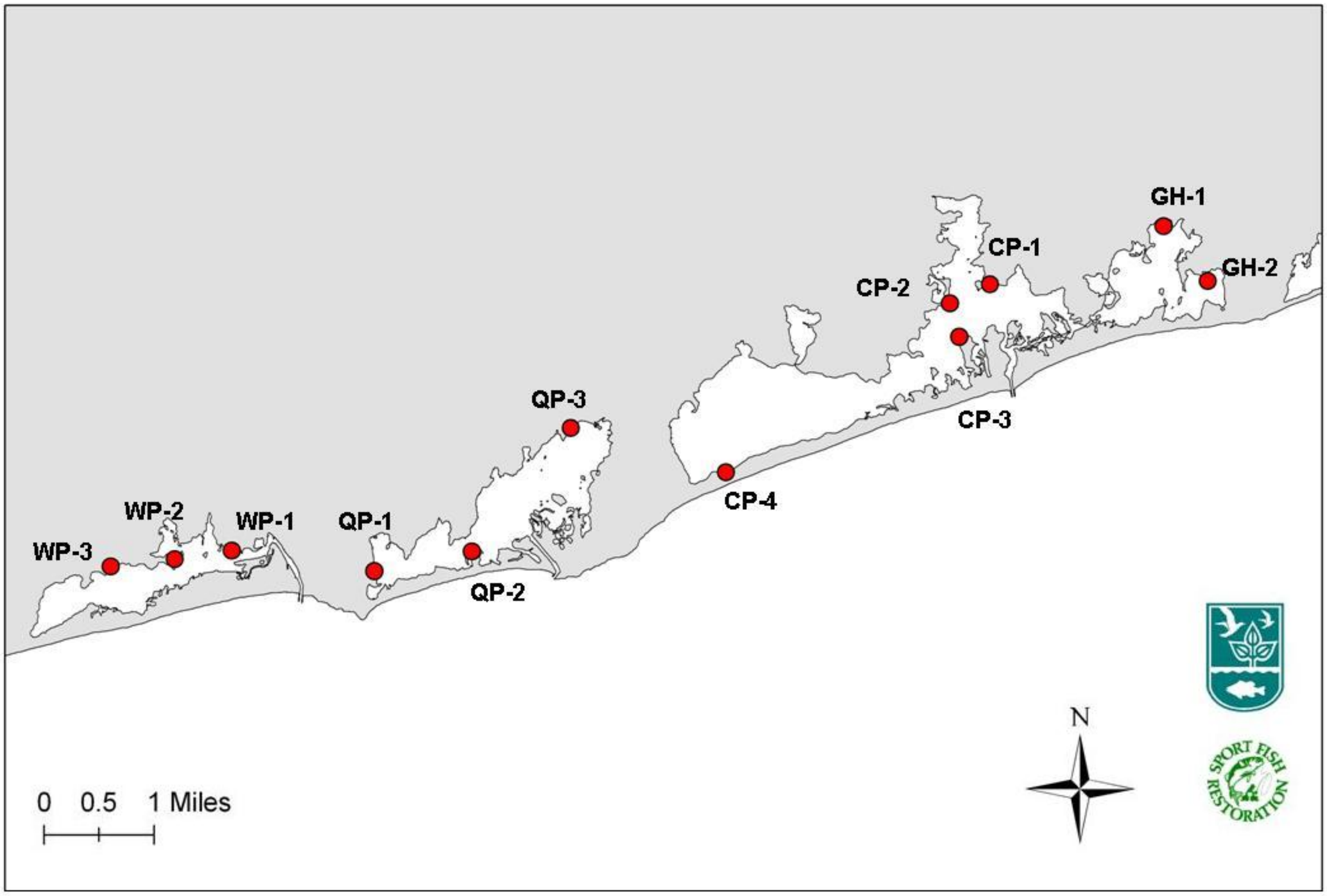


Figure 3: Coastal Pond Juvenile Finfish Survey station locations (eastern ponds).

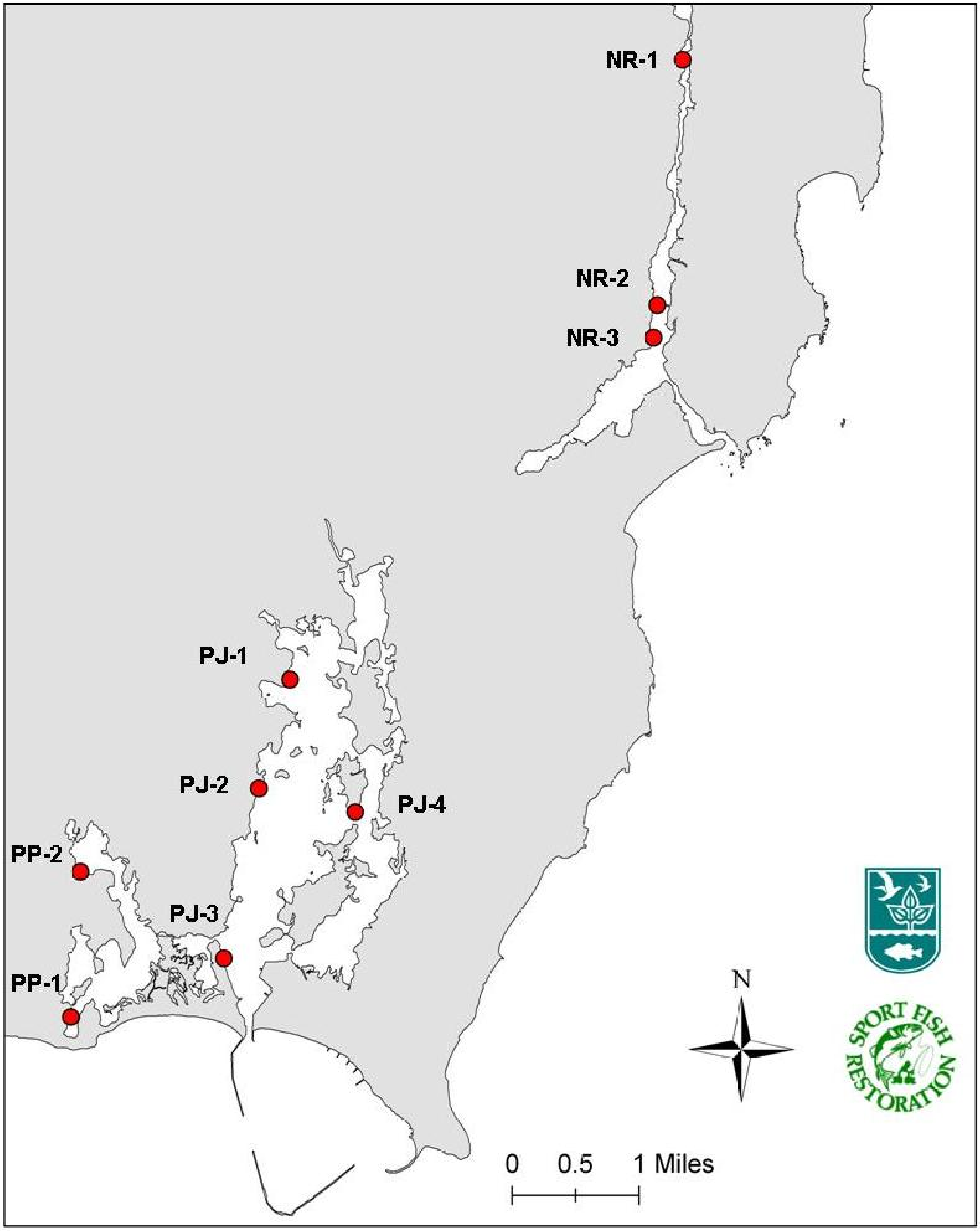
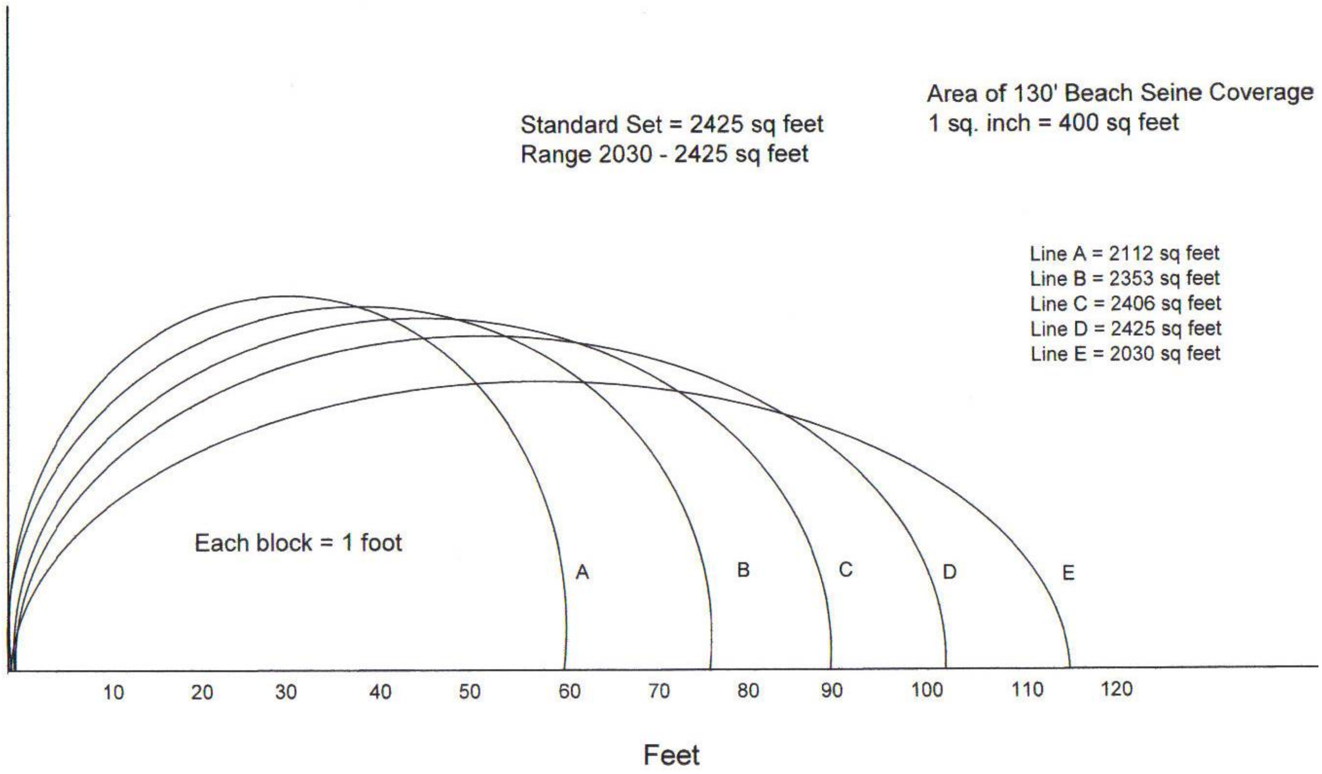


Figure 4
Coastal Pond Juvenile Finfish Survey



Standard Set = 2425 sq feet
Range 2030 - 2425 sq feet

Area of 130' Beach Seine Coverage
1 sq. inch = 400 sq feet

Line A = 2112 sq feet
Line B = 2353 sq feet
Line C = 2406 sq feet
Line D = 2425 sq feet
Line E = 2030 sq feet

Each block = 1 foot

Figure 5: Time series of abundance indices (fish/seine haul) for winter flounder YOY from all coastal ponds. Note: the vertical dashed line marks the addition of new stations in 2011.

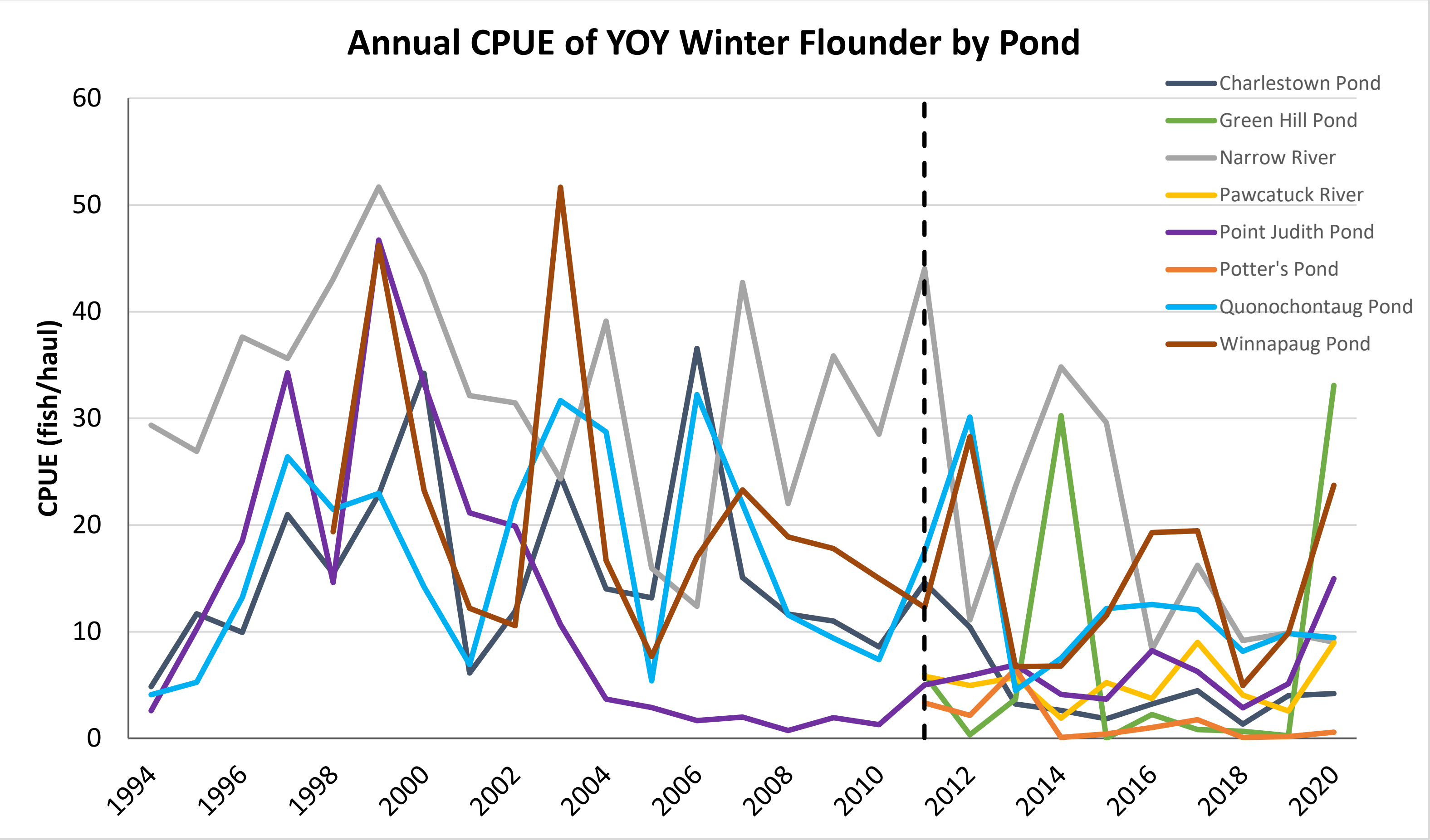


Figure 6: 2020 abundance indices (fish/seine haul) for YOY winter flounder for each pond by month.

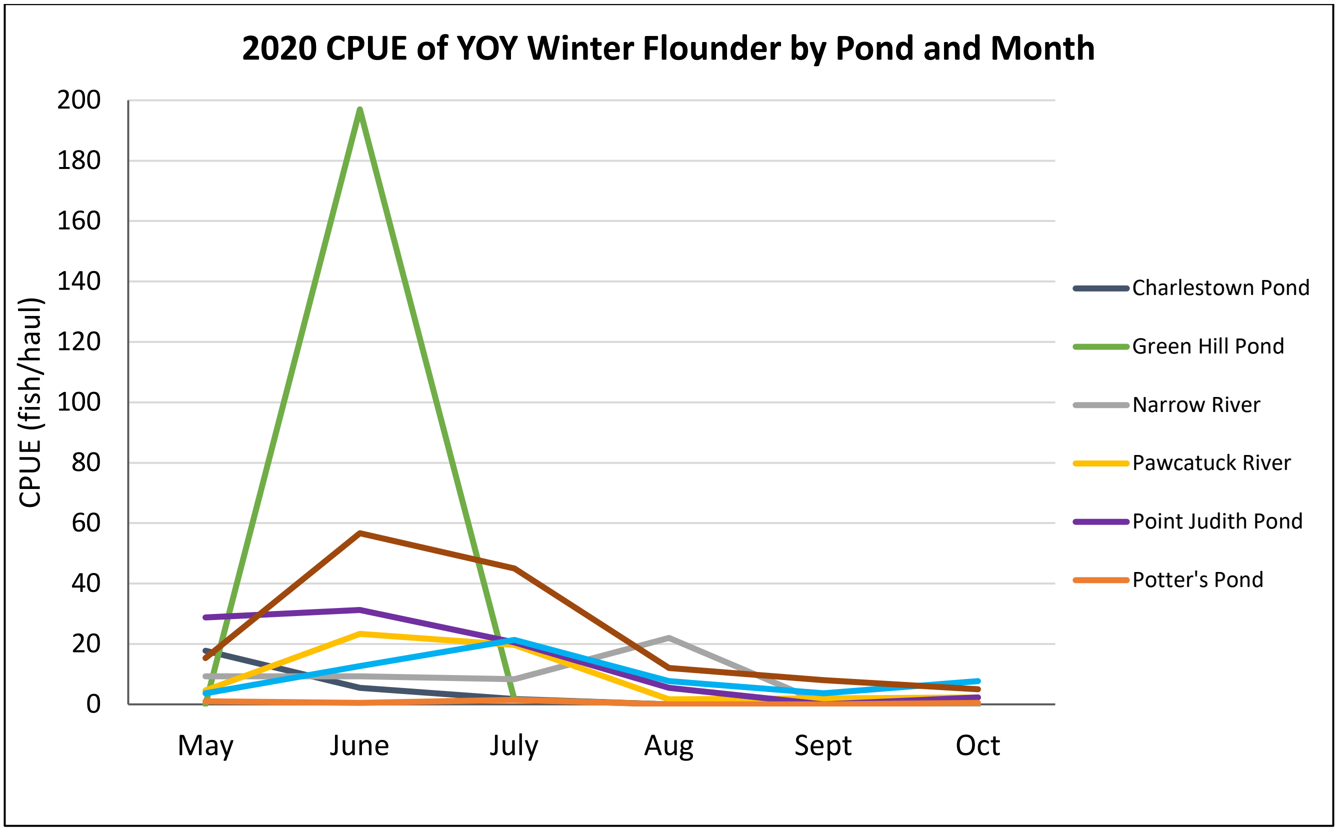


Figure 7: Length frequency of all winter flounder caught in Coastal Pond Survey during 2020. Note: YOY are to the left of the dashed line (<12cm TL)

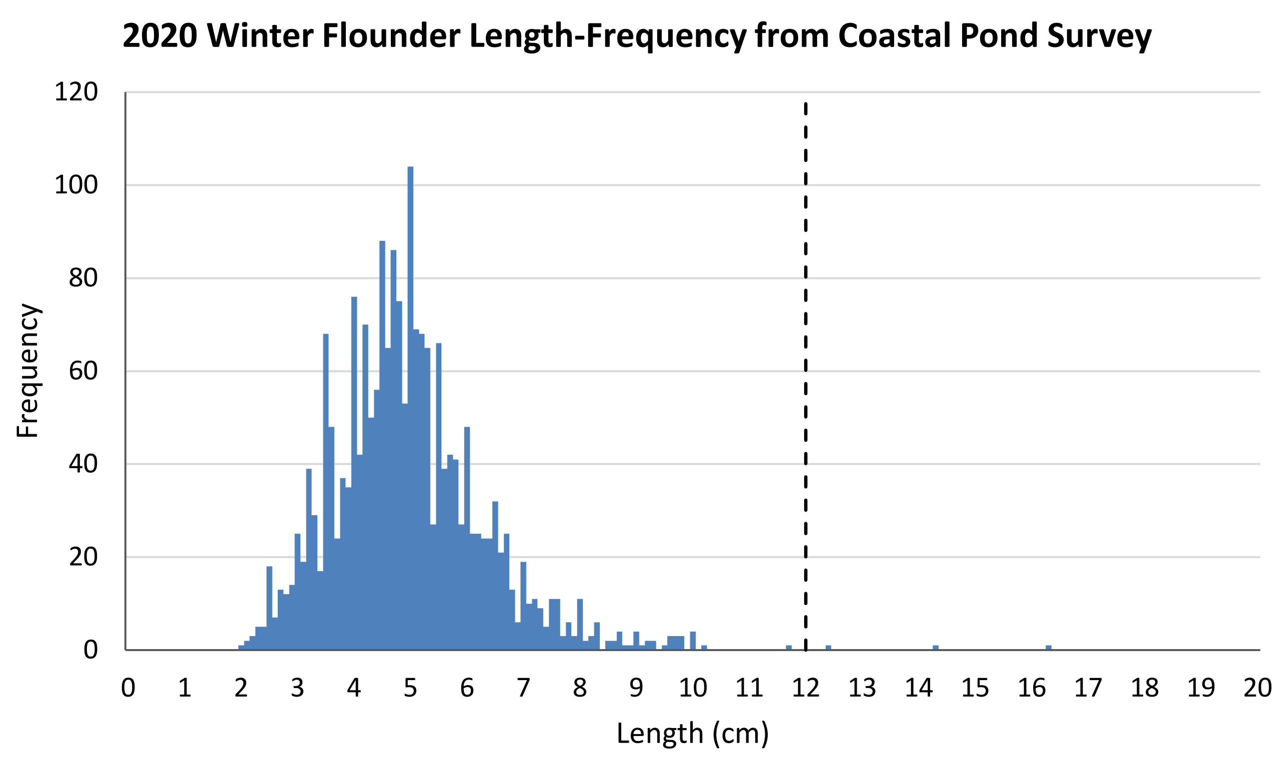


Figure 8: Time series of annual abundance indices for winter flounder YOY from the coastal pond survey. Errors bars show standard error for CPUE. Note: the vertical dashed line marks the addition of new stations in 2011.

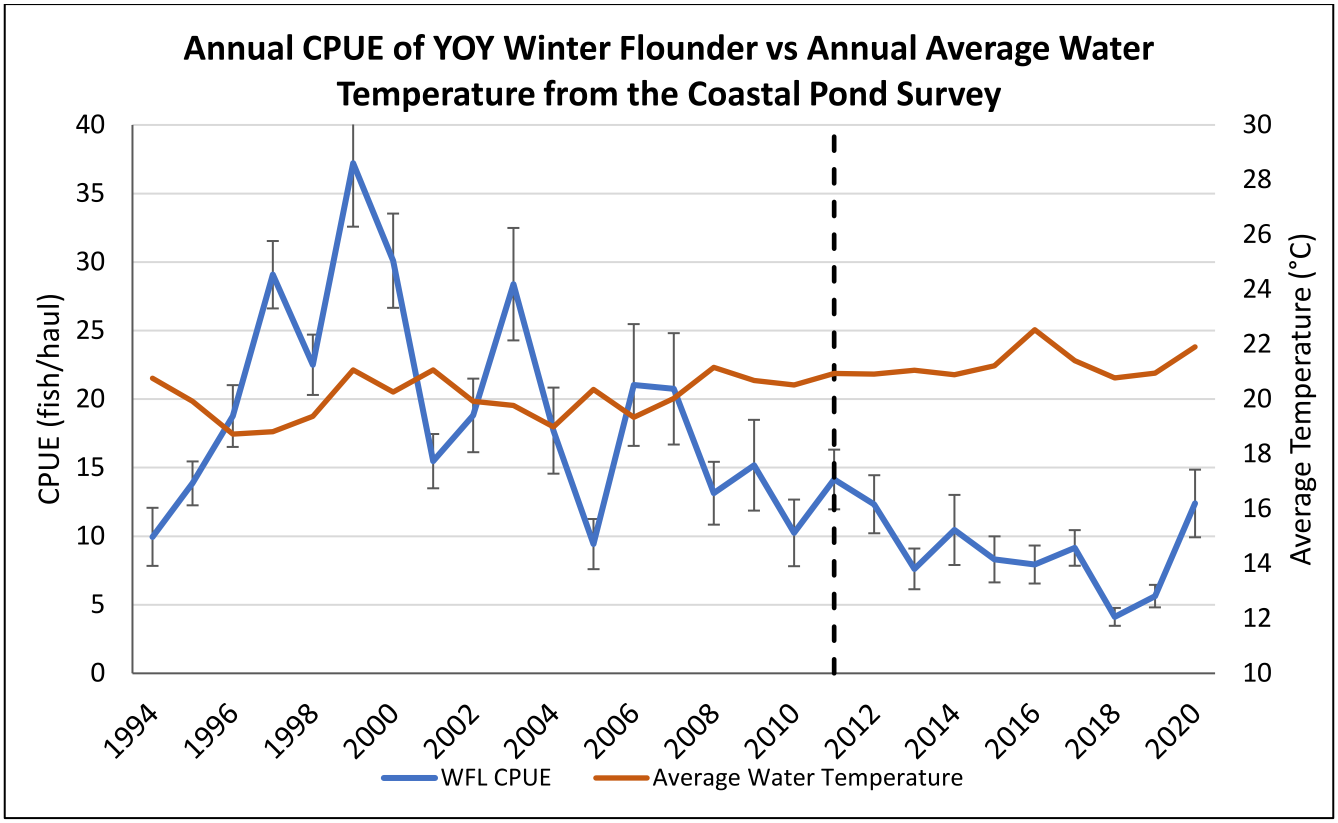


Figure 9: Abundance indices (fish/haul) from the RIDMF Coastal Pond Survey, Narragansett Bay Seine Survey, and Spring Trawl Survey for winter flounder.

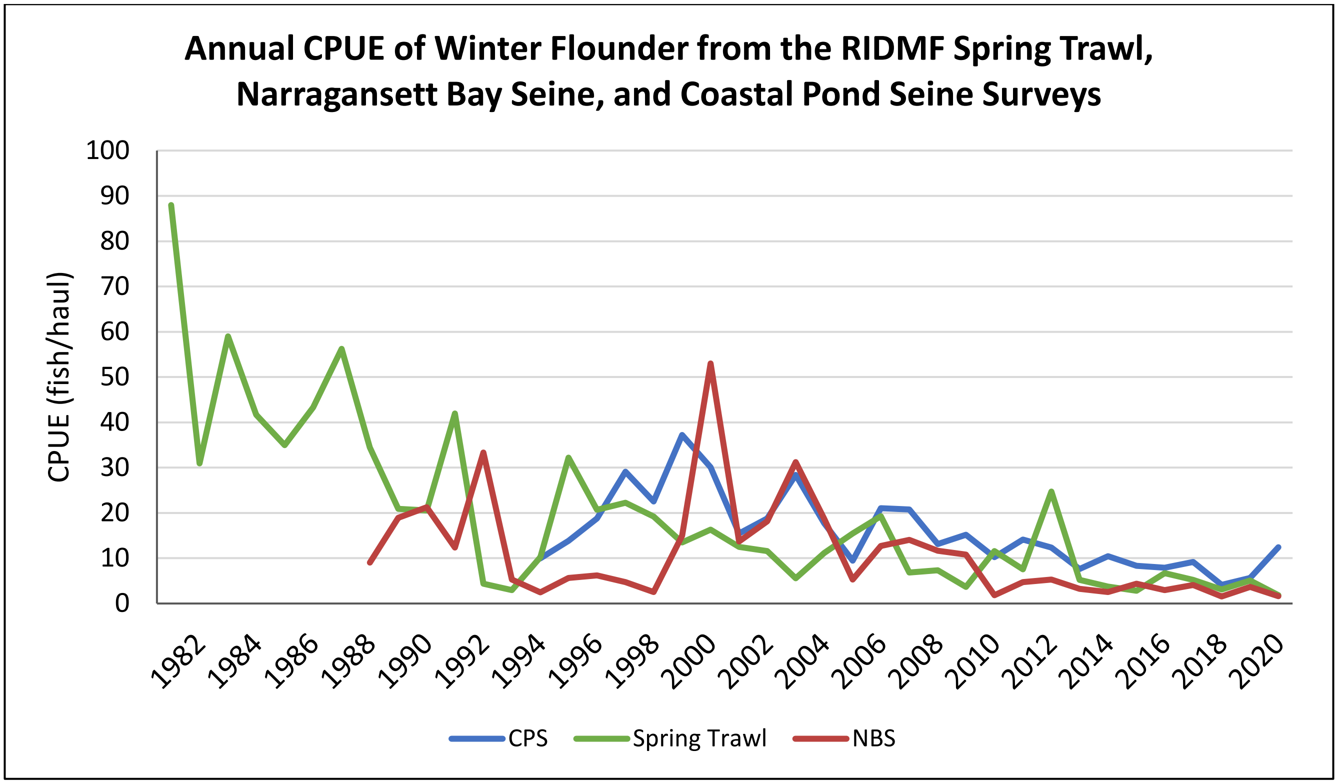


Figure 10: Abundance indices (fish/haul) from the Coastal Pond Survey and the Adult Winter Flounder Tagging Survey for winter flounder.

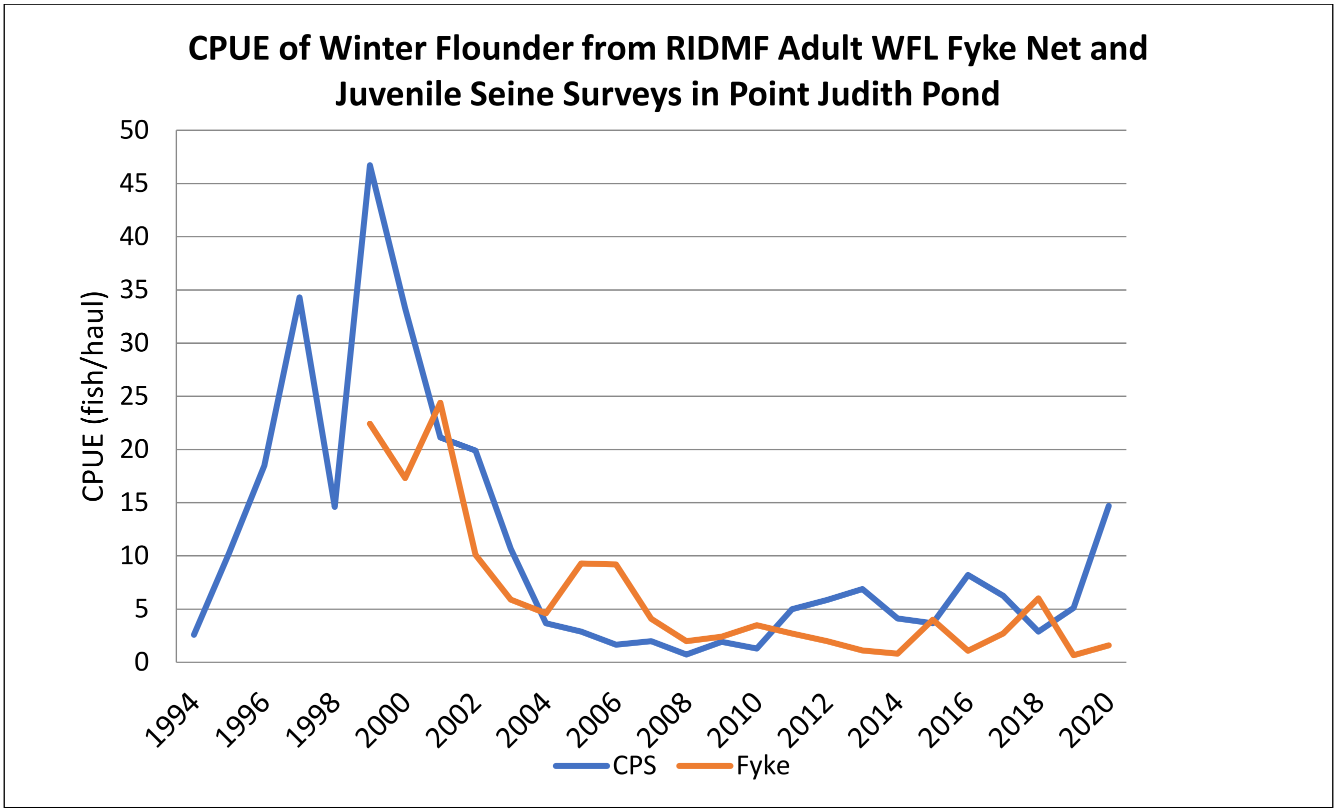


Figure 11. Time series of annual abundance indices for bluefish from the coastal pond survey. Error bars show SE.

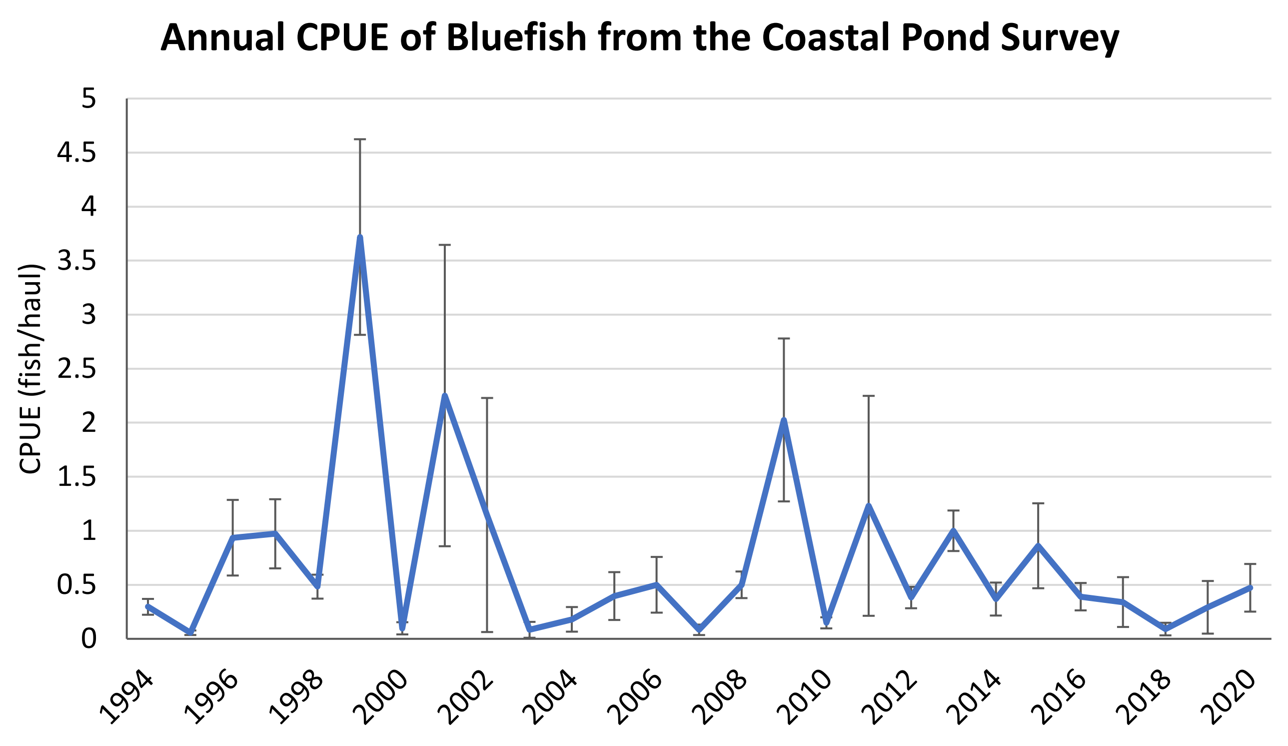


Figure 12. Time series of annual abundance indices for Tautog from the coastal pond survey. Error bars show SE.

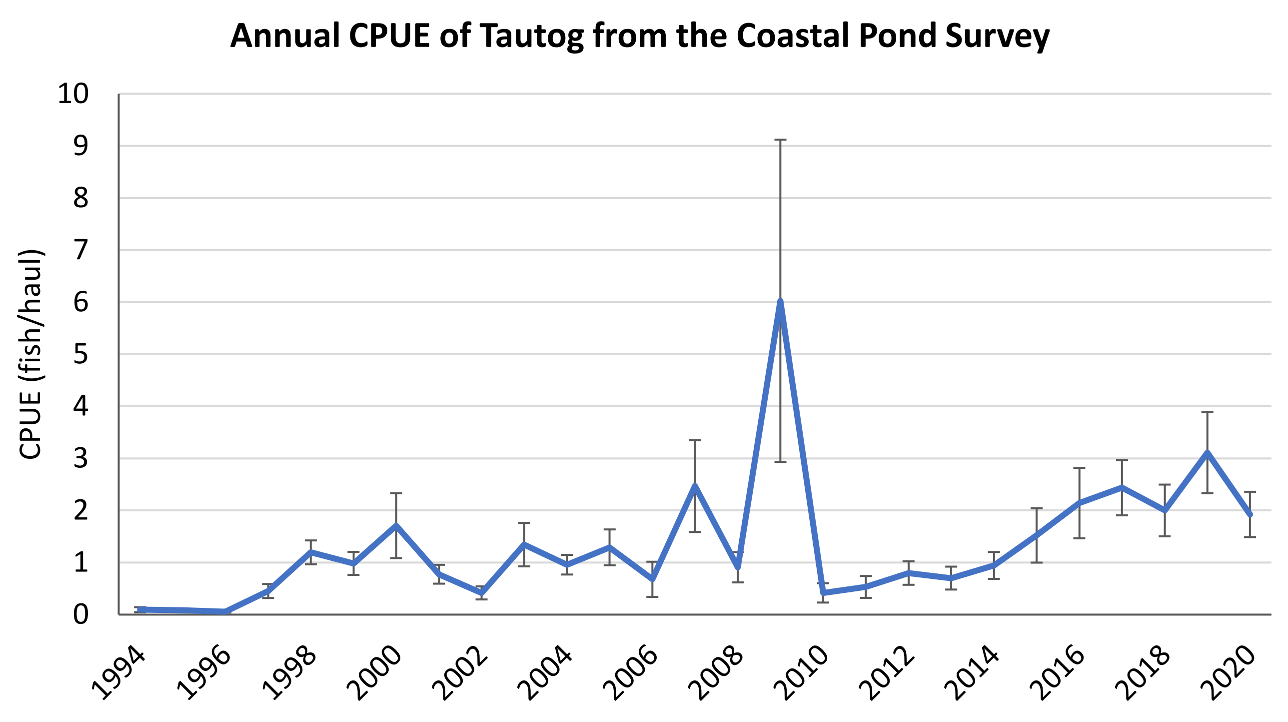


Figure 13. Time series of annual abundance indices for Black Sea Bass from the coastal pond survey. Error bars show SE.

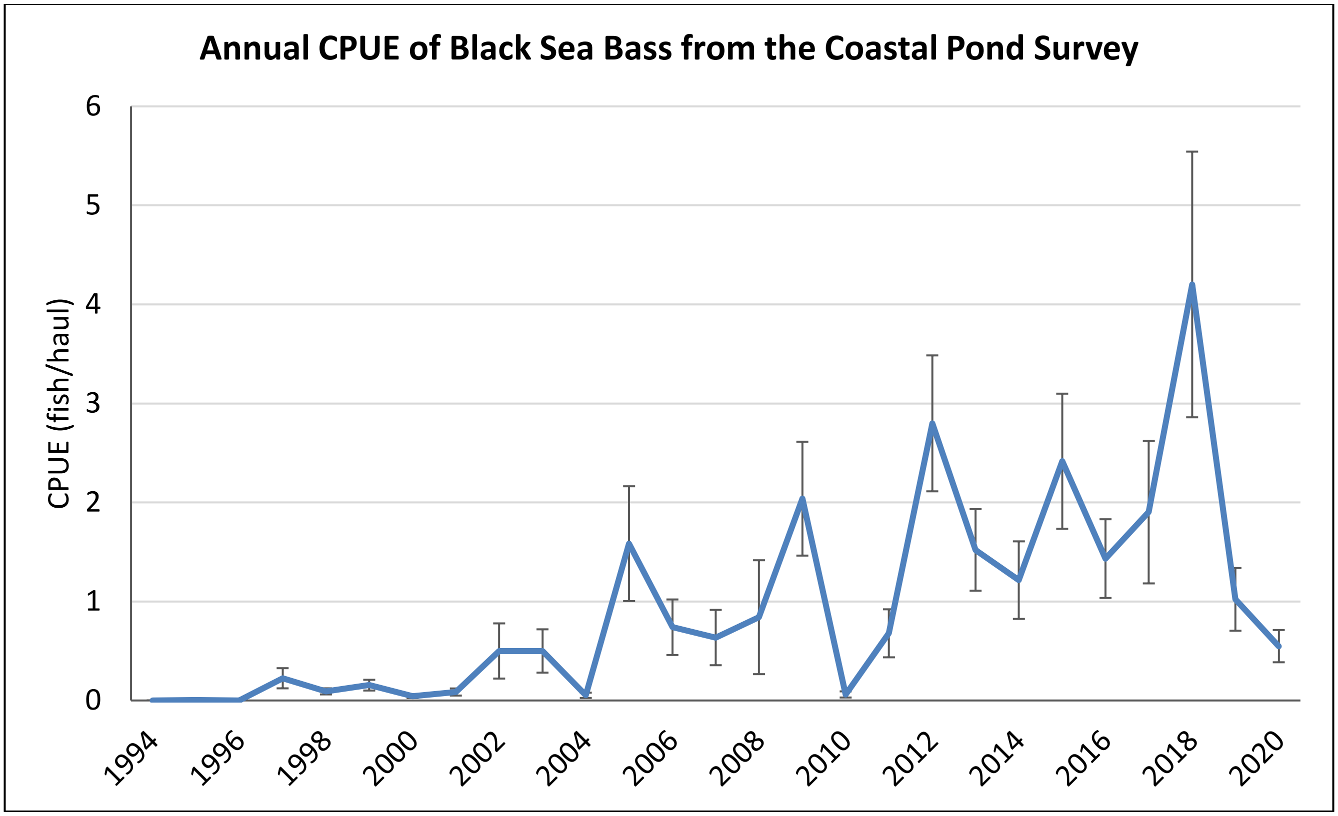


Figure 14. Time series of annual abundance indices for Scup from the coastal pond survey. Error bars show SE.

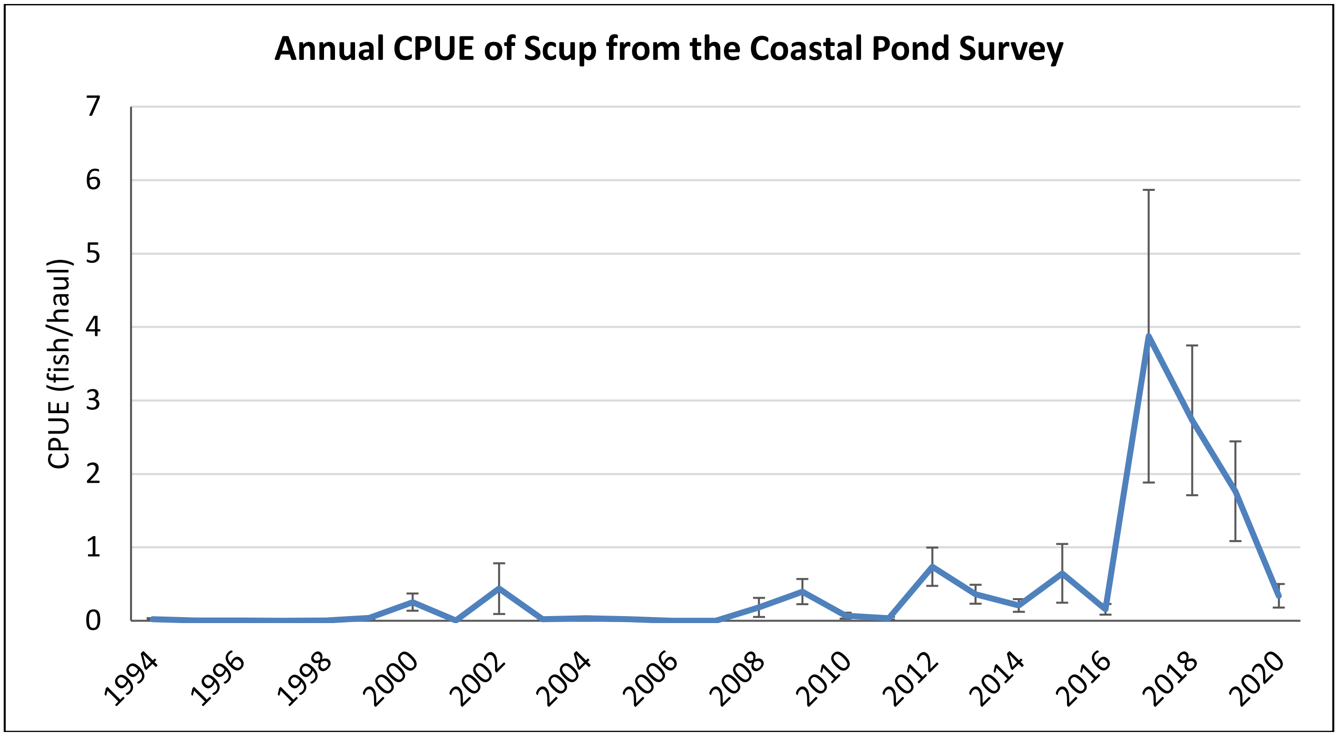


Figure 15. Time series of annual abundance indices for Clupeids from the coastal pond survey (Atlantic Menhaden on left y-axis, all other species on right y-axis)

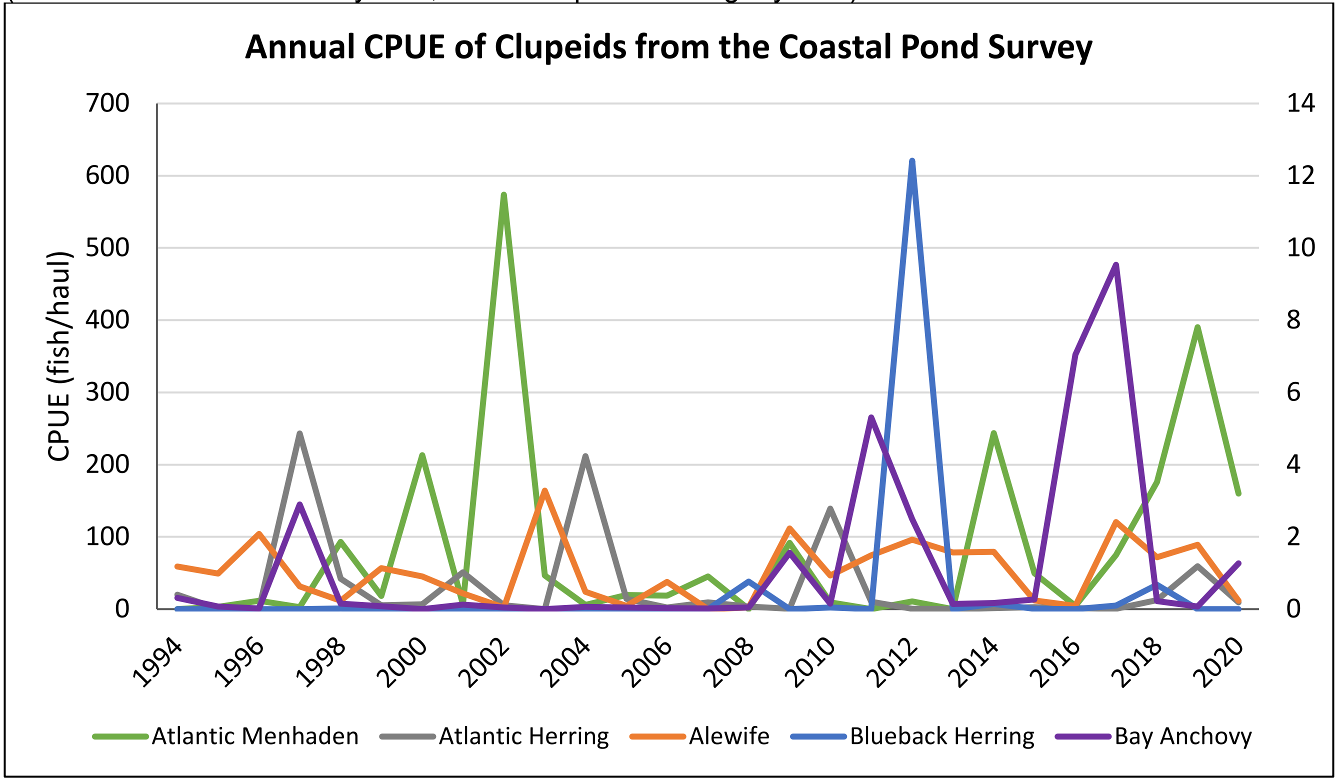


Figure 16. Time series of annual abundance indices for Baitfish from the coastal pond survey (Atlantic Silversides on left y-axis, all other species on right y-axis).

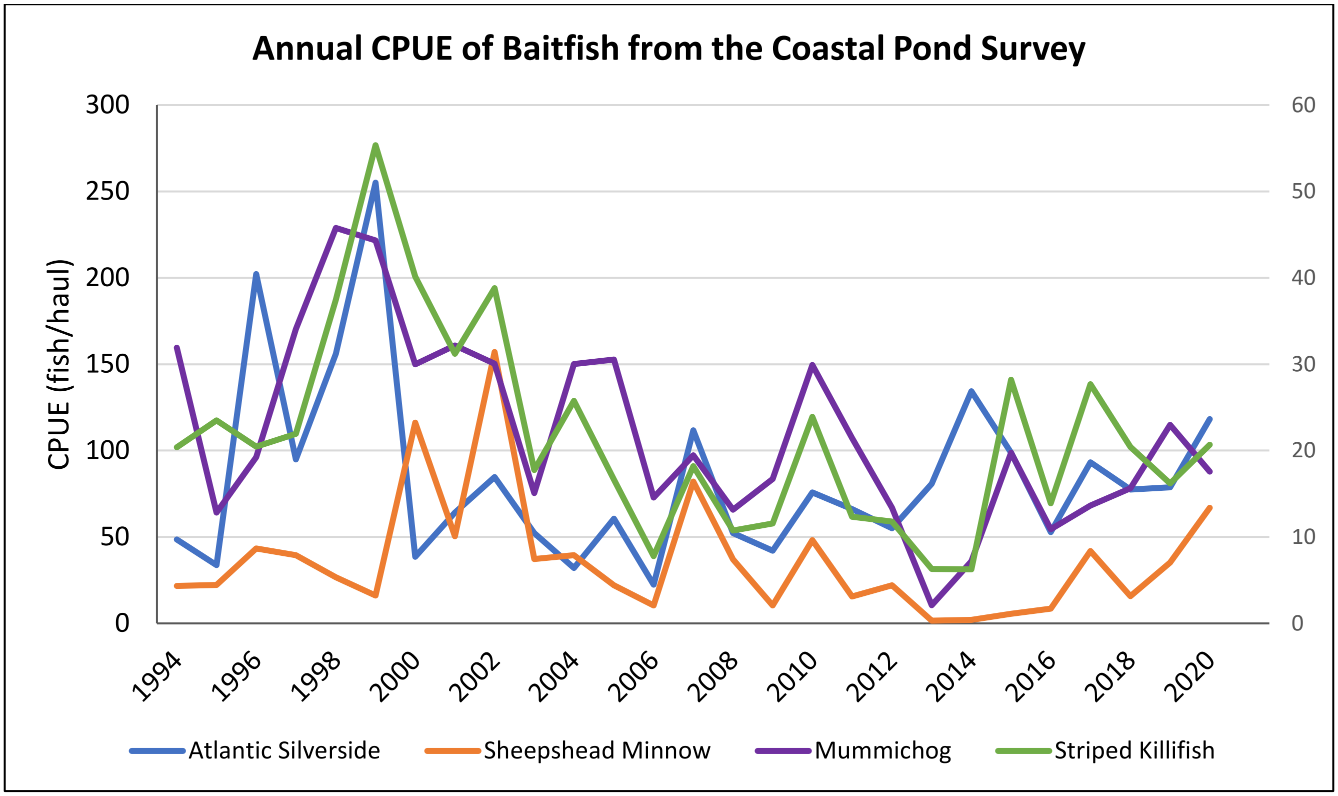


Figure 17: Map of total YOY WFL collected at each station in 2020.

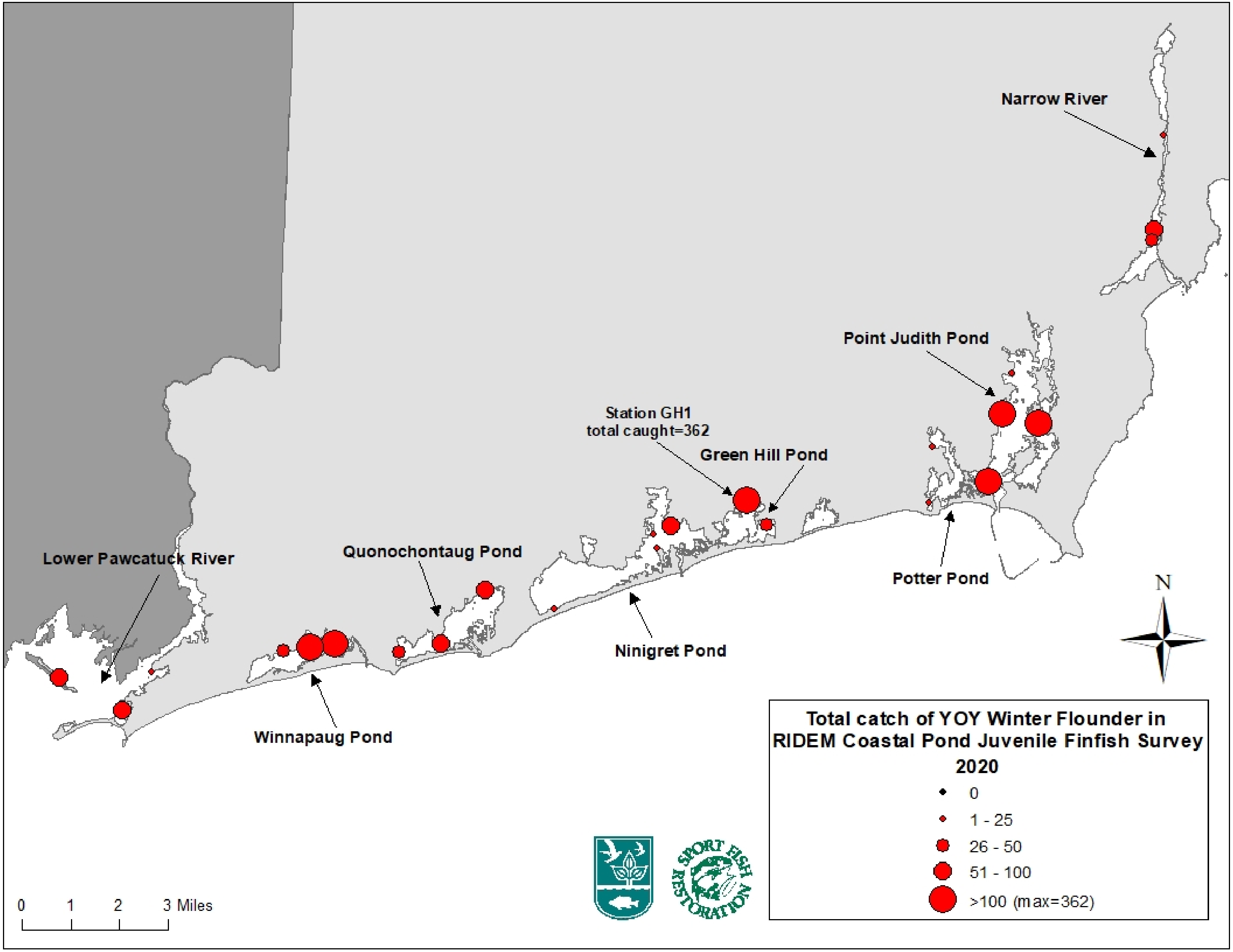
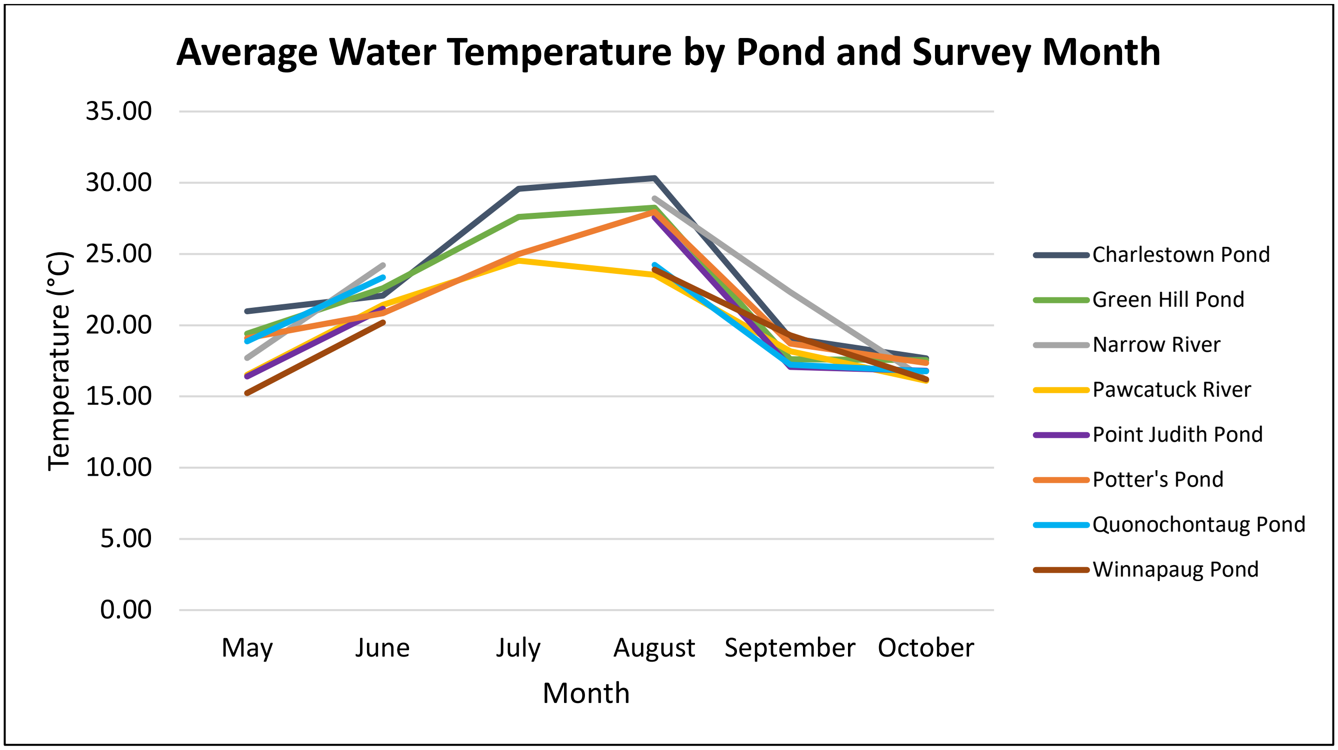


Figure 23. Average recorded water temperature in the coastal ponds by month for 2020. Some data not available in July.



Appendix 1: Catch frequency of all species by station for 2020 Coastal Pond Survey.

Species	CP1	CP2	CP3	CP4	GH1	GH2	NR1	NR2	NR3	PJ1	PJ2	PJ3	PJ4	PP1	PP2	PR1	PR2	PR3	QP1	QP2	QP3	WP1	WP2	WP3
ALEWIFE (ALOSA PSEUDOHARENGUS)					2		2										17	7						5
ANCHOVY BAY (ANCHOA MITCHILLI)					16	18		1		1				7	138	1								
BLUE CRAB (CALLINECTES SAPIDIUS)	1			5	4	2	2	1																2
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)	21	12	8	27	48	21	45	16	3	15			10	6	4	3	2	5	1	1	3			3
BLUE CRAB MALE (CALINECTES SAPIDIUS)	10	11	9	23	90	28	56	14	5	8	3		9	13	13	2	1	7	4	1	3			4
BLUEFISH (POMATOMUS SALTATRIX)					2	13	1									5						11	10	26
COD ATLANTIC (GADUS MORHUA)														1		1		3						
CUNNER (TAUTOGOLABRUS ADSPERSUS)	1							1	3		1		3			5				2		1	2	
EEL AMERICAN (ANGUILLA ROSTRATA)		2				1	1	1							1			2						
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)				1							8		13		11				6	1	1		1	6
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)	1		2		3			1		1	1		1		2				3				1	
FLOUNDER WINTER (PSEUDOPLEURONECTES AMERICANUS)	77	6	12	6	362	35	24	94	44	5	136	109	109	3	4	77	79	5	28	62	80	240	147	40
GOBY NAKED (GOBIOSOMA BOSC)					12	6		1	7	3	1		4	7		1						3		1
GRUBBY (MYOXOCEPHALUS AENAEUS)			1						8							2		2	4	20		2	4	
HAKE RED (UROPHYCIS CHUSS)	1																							
HERRING ATLANTIC (CLUPEA HARENGUS)										14		1			4	1								7
HOGCHOKER (TRINECTES MACULATUS)					1																			
HORSESHOE CRAB (LIMULUS POLYPHEMUS)				1																		1	2	
HORSESHOE CRAB FEMALE (LIMULUS POLYPHEMUS)																1					1			1
HORSESHOE CRAB MALE (LIMULUS POLYPHEMUS)	2																							
KILLIFISH STRIPED (FUNDULUS MAJALIS)	98	35	341	93		1	19	359	26	21	14	262	14	7	3	131	75		2	43	190	123	100	1021
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)						1		1							1	9								1
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)	5	2			3	16	48	65	11	256			1	749	1239	38	14		4284	8		14787	453	1090
MINNOW SHEEPSHEAD (CYPRINODON VARIEGATUS)	3	104	16	79	3	4	13	456	4	6	1	2		31	31	110	5			2	9	72	25	949
MOJARRA SPOTFIN (EUCINOSTOMUS ARGENTEUS)			1	2				1																
MULLET WHITE (MUGIL CUREMA)							5							1										
MUMMICHOG (FUNDULUS HETEROCLITUS)	43	151	387	22	53	51	157	448	84	304	14	12	30	191	210	2		22	5	15	5	135	61	128
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)	2		1	7				8					5	7							1		1	4
PERCH WHITE (MORONE AMERICANA)							24	5																
PERMIT (TRACHINOTUS FALCATUS)																				1				
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)	1	7	6	1	2		2		1	2	4			2	12		1						2	
POLLOCK (POLLACHIUS VIRENS)								2	4			1				1							4	
PUFFER NORTHERN (SPHOEROIDES MACULATUS)	1			17		1	8	3	11		2	2	1			6			9	5	2		1	4
RAINWATER KILLIFISH (LUCANIA PARVA)	80	25	43	14			1	74	15	19			5	2	32				1	5	1	1	1	15
SCULPINS (COTTIDAE)											1													
SCUP (STENOTOMUS CHRYSOPS)	3						2	11	18						2	10		1	2					

Species	CP1	CP2	CP3	CP4	GH1	GH2	NR1	NR2	NR3	PJ1	PJ2	PJ3	PJ4	PP1	PP2	PR1	PR2	PR3	QP1	QP2	QP3	WP1	WP2	WP3
SEA BASS BLACK (CENTROPRISTIS STRIATA)	9	11	8					11	13	1	15		2		2					1			6	
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)	1																			1				
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)				1			2	10	3		4		1						1			1	1	6
SEAROBIN STRIPED (PRIONOTUS EVOLANS)	3															3			2	3	1			
SHAD GIZZARD (DOROSOMA CEPEDIANUM)														2	2									
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	941	200	4149	622	1485	905	100	310	298	363	464	580	659	133	710	195	123	277	198	176	119	2262	887	860
SPOT (LEIOSTOMUS XANTHURUS)	1				1																			
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	31	161	127	2	2	37		85	33	30				31	1	6	1	10	2				3	4
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)	2	8	2											1										
TAUTOG (TAUTOGA ONITIS)	4	23	14					28	21	7	3		6	11	19	35	5	41	11	4		3	6	36
TOADFISH OYSTER (OPSANUS TAU)								3						7	2	1								
TOMCOD ATLANTIC (MICROGADUS TOMCOD)								1										1		2			1	

The Rhode Island Chapter of The Nature Conservancy
Annual Performance Report

Submitted to

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

Title: Block Island Seine Survey

Cooperative Agreement Award Number: 3425240

Award Term: January 15, 2020 to December 31, 2024

Reporting Period: January 1, 2020 to December 31, 2020

Prepared By

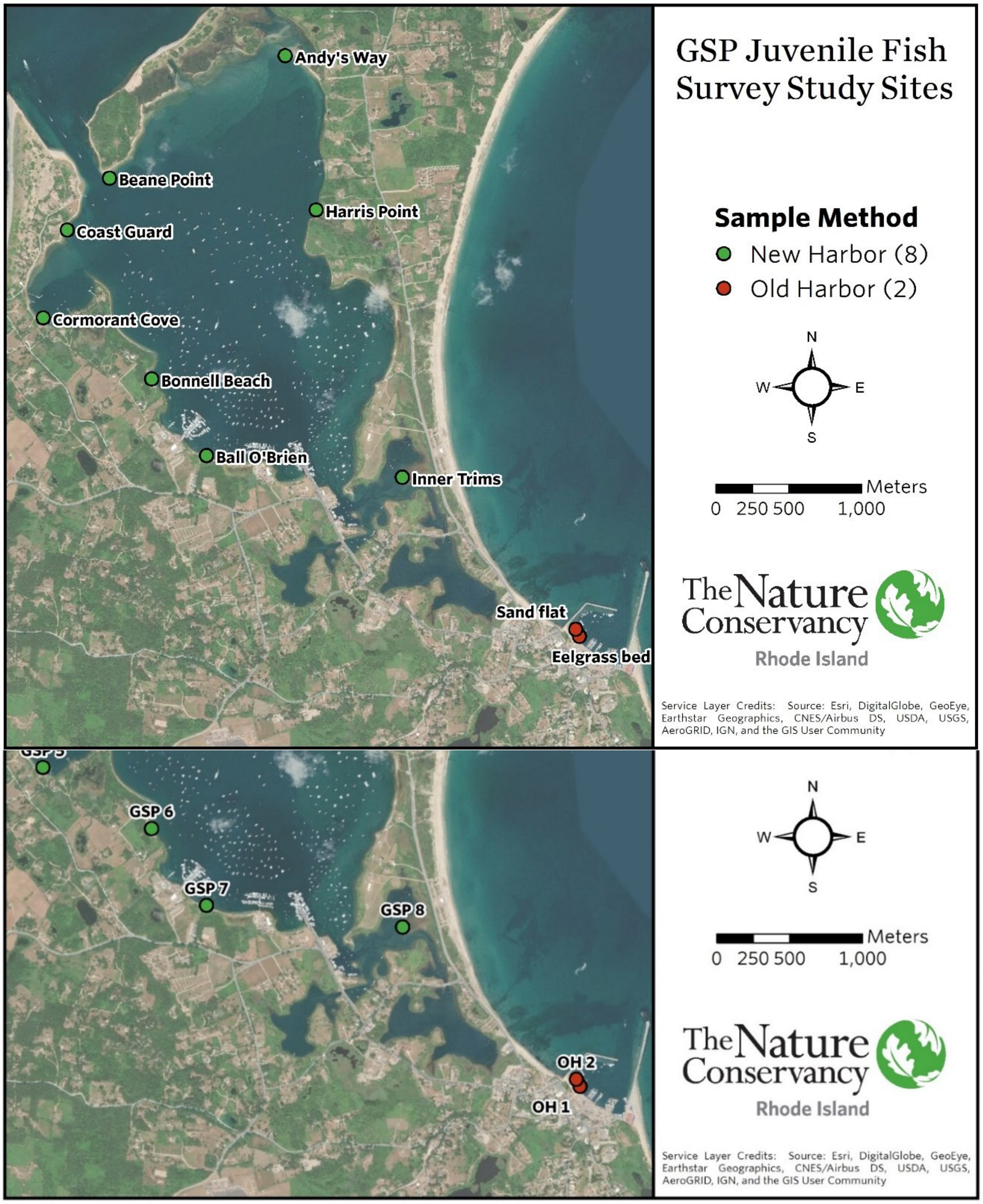
Diandra Verbeyst (Great Salt Pond Scientist)

Approved By

Scott Comings, Associate State Director

The Nature Conservancy Rhode Island Chapter
159 Waterman Street
Providence, RI 02906

Maps of study area and sampling locations.



SUMMARY:

During the 2020 season, a total of 60 seines were hauled across ten sites on Block Island (BI), Rhode Island (RI) in May through October resulting in the enumeration of 30,813 individuals. Of the animals caught, 3,192 were measured and 45 species were identified (see Table 1). Despite the additional considerations for safely working in the field during the COVID-19 pandemic, all scoped work was completed. All raw data have been shared with the appropriate staff of the Division of Marine Fisheries (DMF) and The Nature Conservancy (TNC) for incorporation into existing datasets.

TARGET DATE:

December 31, 2020

NEXT STEPS:

Investigators intend to continue sampling with the same methodology during the 2021 field season. Additionally, the project team will coordinate with the primary investigators of the Coastal Ponds (CP) and Providence River Estuary (PRE) juvenile fish surveys to evaluate variations in fish assemblages across study areas.

INTRODUCTION:

Estuaries are dynamic coastal habitats that play a vital role for many marine species at various stages of life (Able and Fahay 1998; Fay et al. 1983). Often referred to as “nurseries,” these semi-enclosed bodies of mixed salt and freshwater develop where connective waterways meet the ocean, creating unique habitat gradients that are particularly conducive to supporting juvenile life (Ayzvazian et al. 1992; Beck et al. 2001; Meng and Powell 1999). BI’s interior marine environment: Great Salt Pond (GSP), is characterized as an offshore lagoon, or a body of salt water surrounded by salt water (Hale 2000). The GSP is generally known as deeper, saltier, and clearer than salt ponds on the mainland; thus, providing a unique ecological niche for migratory and resident finfish species (Katz 2000; Neumann 1993).

While a number of investigations have focused on the finfish of mainland RI and the importance of estuaries during early life stages, assessments on BI were inconsistent and sparsely reported on until recently. This lack of empirical data presented an opportunity for primary investigators to set up a long-term monitoring program with the intention to become more knowledgeable of the GSP’s ecological function as a productive resource for commercially and recreationally important finfish.

In 2014, the DMF and TNC entered into a cooperative agreement to begin evaluating the GSP and PRE and their role in supporting finfish populations. Through a comprehensive approach to monitoring, the estuaries’ coastal habitat features, water quality, and fish assemblages were evaluated. The results of these initial evaluations revealed that the GSP and PRE supported commercially and recreationally important juvenile finfish; thus, contributing to DMF’s work in the CP and the ability to evaluate juvenile finfish populations across the State and other established seine surveys. Continuation of this collective seine survey proves to be a valuable tool for DMF in managing fish populations. It is also recognized that this monitoring could help support future projects aimed at increasing fish recruitment through habitat improvements within these study areas.

METHODS:

All eight stations in the GSP and two stations in OH were sampled at monthly intervals from May through October. Sampling dates were selected for tides between 1.2 m and 0.6 m. Sampling occurred on the incoming tide and in the rocky intertidal zone at depths shallower than 2 m. At each site a 130' long, 5.5'deep, ¼" mesh net beach seine was used. This net was also outfitted with a midpoint pocket, weighted footrope, and a floated headrope, all consistent with the net used in the Young of the Year Survey of Selected RI Coastal Ponds and Embayments (conducted as part of F-61-R-23, Job #3). For sampling in the GSP, the net was deployed along the shoreline in a semicircle by boat. In OH, sampling required investigators to set and haul the net without a vessel. The net was then hauled onto shore from both ends toward the beach by hand and the contents were transferred into a large water-filled tote. The average area swept of the net was calculated to be 2,112 sq ft.

All finfish species caught were identified to genus or species and measured and enumerated to the nearest centimeter for total length (TL) (except for winter flounder which were measured to the nearest millimeter). If more than 20 of a single species were collected, a sub-sample was taken. The sub-sample was then measured and counted (except for winter flounder where all individuals were measured). 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 (YOY). Upon completion, all animals were released immediately back into the water at the collection site. Species and number of individuals (both juveniles and adults) of invertebrate species and aquatic vegetation were also recorded with the use of relative index of abundance (abundant, many, few). Further, investigators recorded the total carapace length (CL) and gender of blue crab individuals collected during sampling to serve as reference points for future fisheries research in RI. Physical measurements, such as weather conditions, water temperature (°C), salinity (ppt), dissolved oxygen (mg/L), water depth, and transparency were also recorded at each station. A Professional Plus series handheld YSI multiparameter meter and Secchi disk were used during the time of seine as point measurements and were taken one meter below surface water. The YSI unit was calibrated monthly throughout the sampling season per manufacturer recommendations.

RESULTS & DISCUSSION:

In 2020, a total of 60 seines were hauled across fixed stations in the GSP and OH. A total of 30,813 individuals were identified and enumerated, and 3,192 of those were measured. A total of 45 species from 28 families were caught in the beach seines this season (Table 1). The total catch from 2020 marked the highest number of individuals collected for the time series. All invertebrates and crustaceans were removed in the results to focus on fish assemblage.

A mean of 513.55 ± 103.57 SE finfish were caught per haul. Catch per haul across sites was greatest at Andy's Way (GSP 2) at 1106.33 ± 587.03 SE and lowest at Inner Trims (GSP 8) at 310.33 ± 128.56 SE (Figure 1). Catch per haul across months was greatest in August at 1731.80 ± 422.13 SE and lowest in June at 46.90 ± 10.97 SE (Figure 2).

Winter Flounder (*Pseudopleuronectes americanus*)

Of the total 215 winter flounder caught in 2020 seines, 200 individuals were YOY (max length = 120 mm) and five individuals were age 1+ (max length = 220 mm). The maximum lengths by month for YOY winter flounder used for this report are supported by growth rates in local and regional waters as reported and compared in the literature (Able and Fahay 1998; Berry et al. 1965; Meng et al. 2000; Penttila et al. 1989).

Juvenile winter flounder were present in 63.3 percent of the seine hauls for 2020. For the first time since the start of the time series, winter flounder were present at all stations and were collected in all months in 2020 (see table in Appendix). This percentage was an increase from the 131 individuals collected during the 2019 survey when they were present in 31.7 percent of hauls.

The 2020 juvenile winter flounder abundance index was 3.58 ± 1.63 SE fish/seine haul; this is greater than the 2019 index of 2.18 ± 0.75 SE. Figure 3a shows the 2020 abundance index continues to be lower than most years since 2016, the survey high. In 2019, the DMF beach seine survey data also saw a decrease in winter flounder since their peak abundance over the last grant cycle in 2014.

In 2020, September had the highest mean monthly abundance of 6.80 ± 1.96 SE fish/seine haul. The eelgrass bed site (OH 1) had the highest mean station abundance of 10.17 ± 2.35 SE. Overall, stations GSP 5 and OH 1 continue to have higher abundances than other stations as presented in the time series (Figure 3b).

Summer Flounder (*Paralichthys dentatus*)

One individual was caught in 2020 at the site located on the eastern entrance of the GSP channel (Beane Point; GSP 3) in July at 44 mm TL. Summer flounder were the least abundant catch for target species in 2020 with a catch per haul of 0.02 ± 0.02 SE (Figure 3a). In 2019, three individuals were caught in June at GSP 3 and one individual was caught in July at GSP 4, which is the site located on the west side of the GSP channel (Coast Guard Station), with a catch per haul of 0.07 ± 0.06 SE (Figure 3b). The species has been the least abundant catch for the interest group for each year of the time series.

Tautog (*Tautoga onitis*)

During the 2020 survey 596 juvenile tautog were collected and ranged in size from 1 cm to 13 cm. This is a slight increase from the 2019 survey when 573 juveniles were collected. The 2020 abundance index was 9.93 ± 3.29 SE, an increase from the 2019 index 9.55 ± 2.71 SE.

Tautog were collected in 56.7 percent of the seine hauls in 2020. This is an increase from 2019 when they were present in 50 percent of the seine hauls. Juveniles were caught at every station except GSP 4 (Coast Guard Station) in 2020. Of the nine stations tautog were caught at, the species was most abundant at GSP 8 (Inner Trims) with a catch per haul of 44.83 ± 24.68 SE (Figure 3a). The most individuals were caught in September at a catch per haul of 36.00 ± 14.54 SE. The time series data shows the survey years 2016 and 2019 supported highest abundance of tautog in August, whereas all other survey years indicated the species were most abundant in September (Figure 3b).

Black Sea Bass (*Centropristis striata*)

Three-hundred and fifteen black sea bass were caught in 2020, which was a decrease from the 905 fish that were collected in 2019. The number of black sea bass has been highly variable from year to year during the time series survey, but the 2015 and 2019 numbers stand out as unique. Black sea bass were caught in 40 percent of the seine hauls in 2020. Individuals collected during sampling ranged in size between 1 cm and 10 cm in 2020.

The highest mean monthly abundances for 2020 occurred during September at 17.10 ± 9.12 SE (Figure 3b). Black sea bass were caught at all stations this year and the Bonnell Beach site (GSP 6) had the highest mean station abundance of 27.83 ± 14.33 SE (Figure 3a).

The abundance index for 2020 was 5.25 ± 1.98 SE fish/seine haul. This was lower than the 2019 index 44.64 ± 21.74 SE. While the 2020 index decreased from the previous season's index, the 2020 abundance was still much greater than it has been since the survey began in 2014. The fall index dropped down from the high values in 2015 and 2016 but did show increase in abundances starting in 2018. This recruitment signal in recent years was observed all along the Northern Atlantic coast (Tuckey and Fabrizio 2019).

The multi-gear fish pot survey seems to be a better indicator for local abundance of black sea bass. The BI seine survey does not catch them in a consistent manner leading one to believe that they may be using deeper water and/or the coastal ponds as preferred nursery areas. There are no indications that there are any problems with the local abundance of black sea bass, information that is also documented by the coastwide assessment for the species, which indicates no overfishing and a rebuilt stock (NEFSC 2017).

Scup (*Stenotomus chrysops*)

Two-hundred and forty-seven scup were collected in 2020 during July, August, and September, a slight decrease from 2019 year when 285 scup were collected. The total survey abundance for 2020 was 4.12 ± 1.71 SE. Scup were caught at all sites except at Andy's Way (GSP 2) in 2020 and were most abundant at Harris Point (GSP 1) with a catch per haul of 11.67 ± 10.47 SE. Cormorant Cove (GSP 5) and Bonnell Beach (GSP 6) also had comparable catch per haul rates of 11.17 ± 6.35 SE and 10.17 ± 7.75 SE, respectively (Figure 3a). The most individuals were caught in August at a catch per haul of 17.70 ± 8.14 SE in 2020 (Figure 3b). Scup caught in 2020 ranged in size between 3 cm and 33 cm, representing ages-0-8 based on mean length-at-age data from a combination of studies based out of the Mid-Atlantic, southern New England, Georges Bank, Gulf of Maine, and Nova Scotia (Penttila et al. 1989).

Bluefish (*Pomatomus saltatrix*)

During the 2020 survey six juvenile bluefish were collected. Individuals ranged in size between 7 cm and 20 cm and were caught at a single sampling event and site: October and the Coast Guard Station (GSP 4). Length frequency data for 2020 indicates that all juveniles collected were YOY and were most likely products of this season's spawning (Penttila et al. 1989). In waters south of Cape Cod, young bluefish are reported to be between a length of 10.6 cm and 22.8 cm by autumn, which are common sizes observed in RI coastal waters and estuaries in October (Nyman and Conover 1988).

The abundance index for 2020 was 0.10 fish/seine haul. This is less than the 2017 abundance index of 1.31 ± 0.23 SE, which was the only other year for the BI time series that generated values greater than 1.00. The spatial distribution and abundance of juvenile bluefish in RI waters is highly variable and is dependent on a number of factors: natural mortality, fishing mortality, spawning success, number of cohorts, size of offshore spawning stocks, success of juvenile migration into estuaries, and the availability of appropriate size prey species such as bay anchovy, striped killifish, and Atlantic silversides when juveniles enter salt ponds and bay habitats (Juanes et al. 1993; Scharf et al. 1997).

While the species' abundances have not been well represented in the BI survey time series, there are no indications that there are any problems with the local stock based on projections corroborated with our partners and other coastwide assessments.

Family Clupeidae

Four species of clupeids were collected during the 2020 survey: alewife and blueback herring, collectively referred to as river herring, bay anchovy, hickory shad, and Atlantic Menhaden. Atlantic herring have also been collected during the time series but in very small numbers and were not captured during the 2015 and 2020 surveys. While large schools of clupeid species were not encountered this year during the BI survey, investigators acknowledge that they were most likely present in the system, particularly in large schools, but may have been missed during sampling.

River Herring: Alewife (*Alosa pseudoharengus*) & Blueback Herring (*Alosa aestivalis*)

In 2020, a total of 15 river herring were caught in the beach seines (14 alewives and one blueback herring). River herring ranged in size between 3 cm and 4 cm and were found in July. The blueback herring individual was recorded at Bonnell Beach (GSP 6) and the alewives were recorded at the sand flat site (OH 2). The total survey mean abundance for 2020 was 0.25 ± 0.23 SE.

Hickory Shad (*Alosa mediocris*)

One hickory shad was caught in 2020 at Cormorant Cove (GSP 5) in September. The individual's TL was measured at 10 cm. Limited data is available for length-at-age but as reported in Bigelow and Schroeder (1953c) growth of juveniles are estimated with total lengths between 140-190 mm attained by age-1 fish. Hickory shad was also one of the five new species added to the time series catalogue of species list (see table in Appendix for list of all species and catch frequencies).

Atlantic Menhaden (*Brevoortia tyrannus*)

Atlantic menhaden was the most frequent clupeid species documented in 2020, with 6,896 individuals caught in both the GSP and OH from August through October. This is a slight increase from the 2019 survey when several schools of menhaden were caught during the months of August and September, totaling 5,953 individuals. In 2020, menhaden accounted for 22.4 percent of species total catch. The total survey mean abundance index was 114.93 ± 60.10 SE in 2020. Menhaden were caught at Andy's Way (GSP 2), Coast Guard Station (GSP 4), Cormorant Cove (GSP 5), and both sites in OH (OH 1-2). The species was most abundant at OH 1 station (eelgrass site) with a catch per haul of 461.17 ± 387.49 SE (Figure 3a). The highest number of individuals were caught in August at a catch per haul of 609.90 ± 331.71 SE (Figure 3b). Menhaden TL measurements ranged from 2 cm to 9 cm in 2020.

Juvenile menhaden have been observed in very large schools on BI since 2015. This behavior often results in single large catches resulting in high abundance indices and large standard errors. It also contributes to the variability of their spatial and temporal abundance from year to year. In 2020, there were three instances in which more than 1,000 individuals were caught in a single haul, indicating a school was present at a given station upon sampling. Because of these characteristics, it is difficult to develop an abundance index that will accurately reflect the number of juveniles observed in the field rather than the number represented in the samples.

Baitfish Species

Baitfish species are commonly encountered across stations and months during the sampling season. In 2020, silversides, striped killifish, and common mummichog comprised more than 70 percent of the total catch, which is also consistent with percentages recorded for previous survey years.

Silversides spp. (*Menidia spp.*)

Silversides had the highest abundance of all finfish species caught during the 2020 survey. The species has been ranked as the most abundant finfish species since the start of the survey in 2014. For the purposes of this survey, both Atlantic silversides (sp.) and inland silversides (sp.) are categorized as silversides (*Menidia spp.*).

A total of 18,730 silversides were caught in 2020. The total mean abundance was 312.17 ± 72.53 SE in 2020, and surpassed last year's index at 212.57 ± 39.51 SE, making it the time series highest abundance index. The species was most abundant at the Coast Guard Station (GSP 4) with a catch per haul of 640.83 ± 534.63 SE in 2020. This is different than previous survey years when the species was documented as most abundant at Andy's Way (GSP 2). In comparison, the highest number of silversides were caught in August at a catch per haul of 946.10 ± 343.44 SE in 2020, which is consistent with past survey records.

Silversides ranged in size from 3 cm to 15 cm and were found in all months and stations. This range in size suggests the presence of multiple year classes. The larger individuals (n=5) recorded with TL greater than 14 cm, caught at Andy's Way site (GSP 2) and Bonnell Beach (GSP 6), confirmed age-2 fish, which is unusual in other estuarine systems and reported infrequently in the literature (Fay et al. 1983). The occurrence of age-2 silversides has been observed on several occasions in the BI survey, suggesting localized adaptation for a resident GSP sub-population based on growing empirical evidence (Therkildsen and Baumann 2018, 2020). In past survey years (2018 and 2019), individuals with TL greater than 14 cm were collected, preserved, and sent to Dr. Hannes Baumann, Marine Science Professor at the University of Connecticut (UCONN), for the purpose of conducting otolith analyses.

Striped Killifish (*Fundulus majalis*)

A total of 2,249 striped killifish were collected in 2020 and ranged in size from 1 cm to 20 cm. The species ranked third in abundance this season, which is consistent with previous survey years when the species was ranked either second or third for all species caught. In 2020, striped killifish occurred in all stations and months, except for one station in OH (OH 1). The total mean abundance was 37.48 ± 16.39 SE in 2020, which is slightly higher than the 2019 index of 30.07 ± 10.69 SE. In 2020, the highest number of striped killifish were caught in September at a catch per haul of 115.10 ± 90.60 SE, and they were most abundant at station GSP 2 (Andy's Way) with a catch per haul of 196.00 ± 135.27 SE. Striped killifish were caught in 46.7 percent of the seine hauls in 2020.

Common Mummichog (*Fundulus heteroclitus*)

Four hundred and thirty-seven mummichogs were caught during the 2020 survey. The individuals ranged in size from 3 cm to 11 cm in 2020, which is a wider range of TL sizes recorded in past survey seasons. The species occurred at each station in the GSP study area but did not occur at either of the OH stations this year. In 2020, mummichogs were most abundant in August at a catch per haul of 21.40

± 10.91 SE, which is consistent to recent years in the time series. The species had the highest abundance at the Cormorant Cove site (GSP 5), with a catch per haul of 21.00 ± 17.18 SE in 2020. The total mean abundance was 7.28 ± 2.37 SE in 2020. Overall, the catch frequencies of mummichogs across the time series has been highly variable for the BI seine survey.

Physical and Chemical Data

Water quality data for the 2020 season can be found in Table 2. In the GSP, water temperature ranged from 13.9°C in May to 26.8°C in July. In OH, water temperature ranged from 13.5°C in May and 22.4°C in August. The mean salinity of the eight sites within the GSP was 31.09 ppt ± 0.14 SE, and the mean salinity of the two sites within OH were 31.76 ppt ± 0.25 SE. The lowest dissolved oxygen value recorded across the GSP sites was 7.14 mg/L in July at Inner Trims site (GSP 8), while the mean was 8.82 mg/L ± 0.11 SE. In, OH, the eelgrass site (OH 1) recorded the lowest dissolved oxygen value at 6.76 mg/L in August, with a mean of 8.88 mg/L ± 0.33 SE between the two sites.

SUMMARY:

In 2020, investigators caught 45 species of finfish representing 28 families. These numbers are fairly consistent with 2019, where 49 species from 31 families were collected. They are also fairly consistent with the average number of species caught per year over the last seven years (39) representing an average of 26 families. The number of individuals caught in 2020 increased from the 2019 survey, with 30,813 collected in 2020 and 23,741 collected in 2019. This year was also the highest number of individuals captured over the last seven years.

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FIGURES:

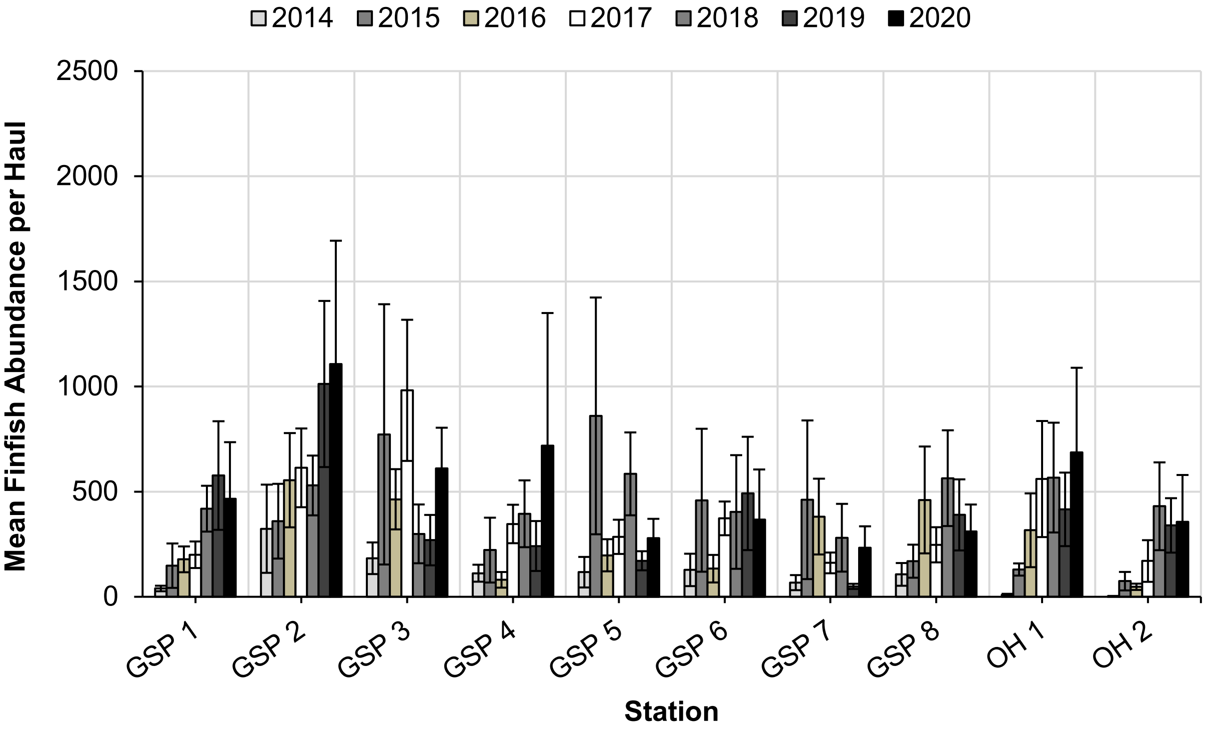


Figure 1. Mean abundance of finfish across stations (± SE) in 2014-2020 beach seines.

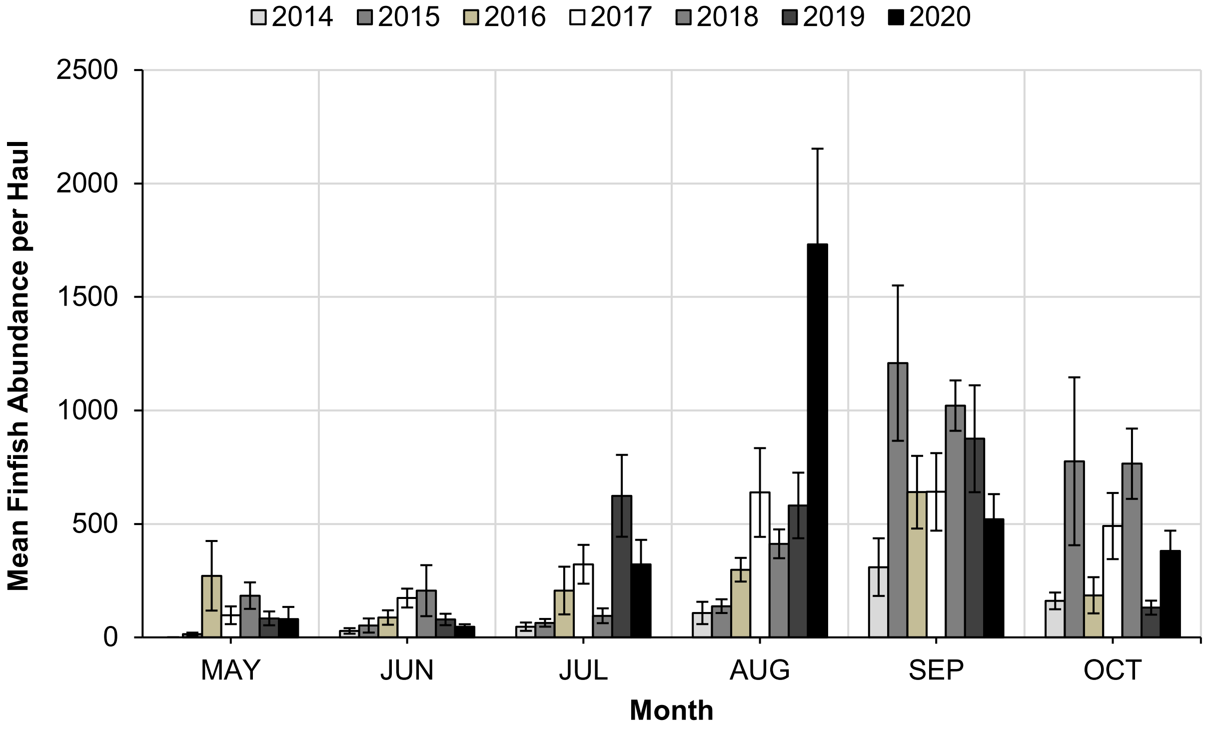


Figure 2. Mean abundance of finfish caught each month (± SE) in 2014-2020 beach seines.

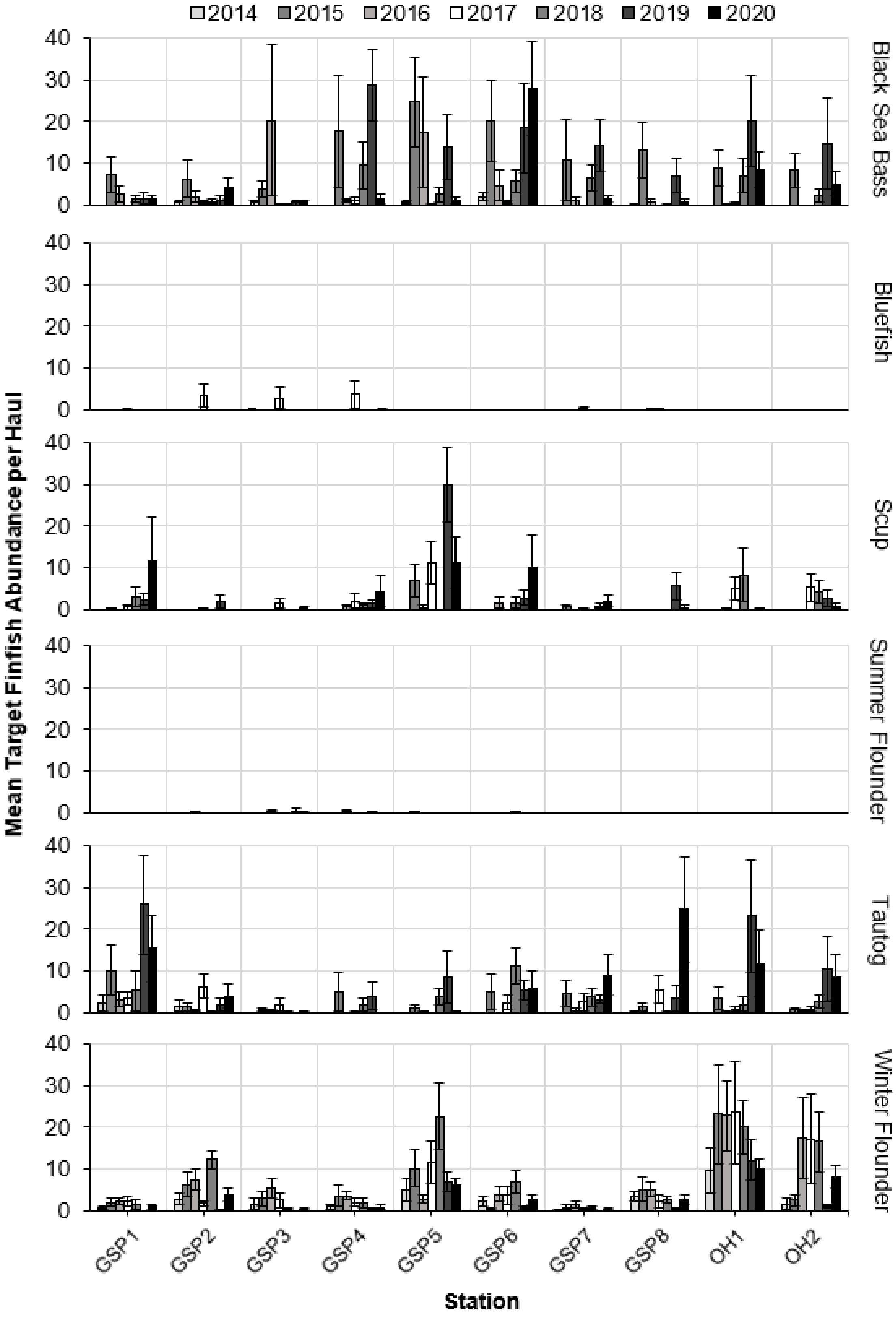


Figure 3a. Mean abundance of target finfish caught by site (± SE) in 2014-2020 beach seines.

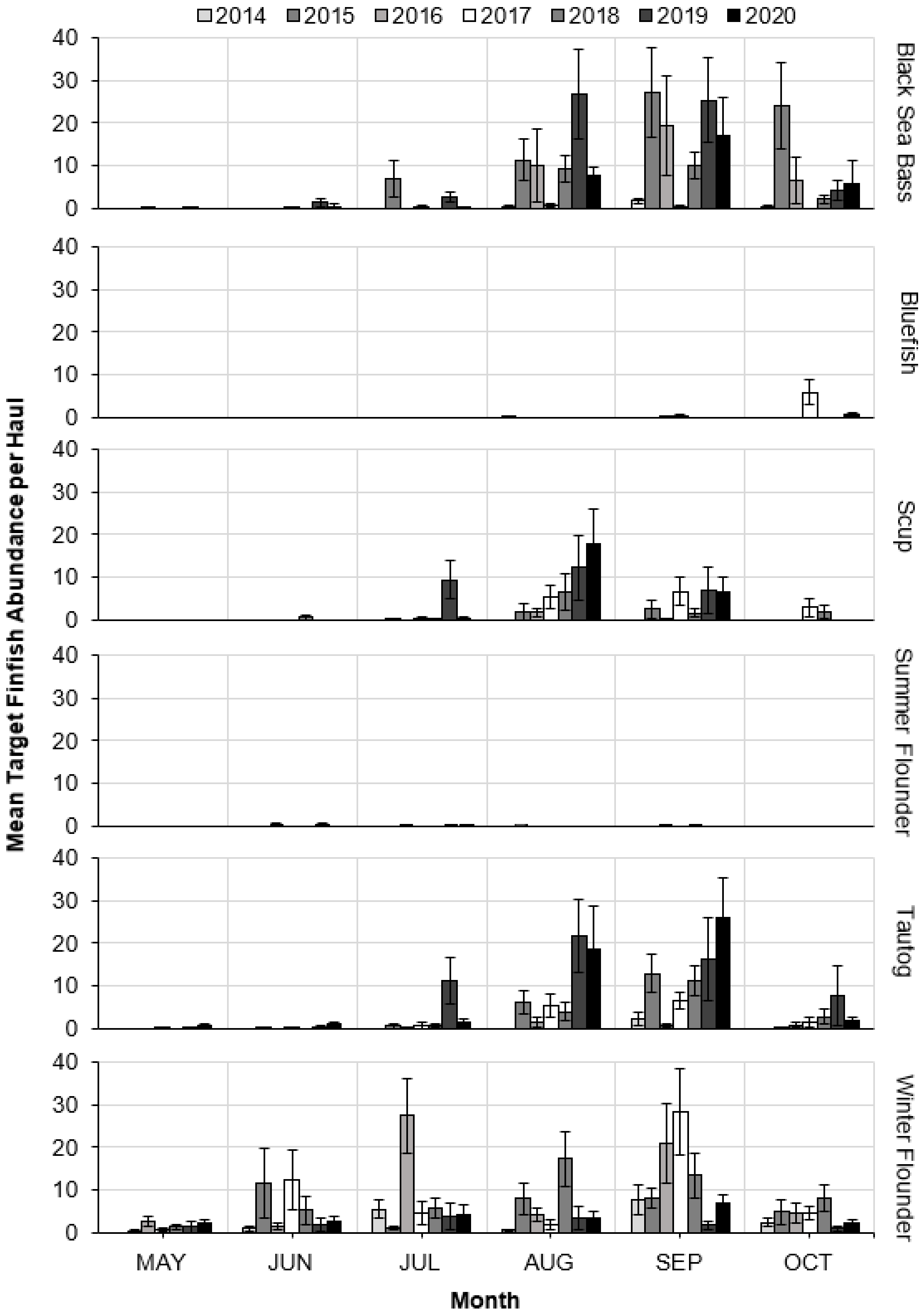


Figure 3b. Mean target finfish per seine haul (± SE) plotted for each month sampled during the 2017-2020 field seasons.

TABLES:

Table 1. Common, scientific names, and total abundance of all species collected in beach seines during 2020.

Common Name	Scientific Name	Abundance
Silversides spp.	*Atherinopsidae spp.*	18730
Atlantic Menhaden	*Brevoortia tyrannus*	6896
Striped Killifish	*Fundulus majalis*	2249
Tautog	*Tautoga onitis*	596
Mummichog	*Fundulus heteroclitus*	473
Black Sea Bass	*Centropristis striata*	315
Pollock	*Pollachius virens*	295
Scup	*Stenotomus chrysops*	247
Cunner	*Tautogolabrus adspersus*	219
Winter Flounder	*Pseudopleuronectes americanus*	215
Atlantic Cod	*Gadus moruha*	156
Sheepshead Minnow	*Archosargus probatocephalus*	88
American Sand Lance	*Ammodytes americanus*	83
Northern Sennet	*Sphyraena borealis*	76
Northern Puffer	*Sphoeroides maculatus*	36
Grubby	*Myoxocephalus aenaeus*	35
Longfin Squid	*Loligo pealei*	28
Striped Searobin	*Prionotus evolans*	22
Northern Pipefish	*Syngnathus fuscus*	16
Alewife	*Alosa pseudoharengus*	14
Oyster Toadfish	*Opsanus tau*	10
Bluefish	*Pomatomus saltatrix*	6
Bay Anchovy	*Anchoa mitchilli*	5
Northern Searobin	*Prionotus carolinus*	5
Snakefish	*Trachinocephalus myops*	4
Bay Whiff	*Citharichthys spilopterus*	3
Lined Seahorse	*Hippocampus erectus*	3
Naked Goby	*Gobiosoma bosc*	3
Striped Bass	*Morone saxatilis*	3
Leopard Searobin	*Prionotus scitulus*	2
Pinfish	*Lagodon rhomboides*	2
Bighead Searobin	*Prionotus tribulus*	1
Blueback Herring	*Alosa aestivalis*	1
Bluespotted Cornetfish	*Fistularia tabacaria*	1
Chain Pipefish	*Syngnathus louisianae*	1
Dusky Pipefish	*Syngnathus floridae*	1
Flying Gurnard	*Dactylopterus volitans*	1
Hickory Shad	*Alosa mediocris*	1
Horse-eye Jack	*Caranx latus*	1
Lookdown	*Selene vomer*	1
Mojarras spp.	*Gerreidae spp.*	1
Northern Kingfish	*Menticirrhus saxatilis*	1
Rainwater Killifish	*Lucania parva*	1
Sargassum Pipefish	*Syngnathus pelagicus*	1
Summer Flounder	*Paralichthys dentatus*	1

Table 2. Temperature, salinity, and dissolved oxygen by station and month during 2020 beach seines.

Station	**Water Quality Parameters**	**Month**						**Total Average**
		MAY	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	
GSP 1	Temperature (°C)	15.2	18.2	26.1	22.1	19.8	17.0	19.7
	Salinity (ppt)	30.92	29.87	30.24	31.49	31.87	32.34	31.12
	Dissolved Oxygen (mg/L)	9.34	8.93	8.74	8.03	8.16	9.54	8.79
GSP 2	Temperature (°C)	15.0	18.9	26.8	22.3	20.0	17.3	20.1
	Salinity (ppt)	30.80	30.10	30.66	31.76	31.43	32.16	31.15
	Dissolved Oxygen (mg/L)	9.61	8.99	8.89	8.62	8.45	9.46	9.00
GSP 3	Temperature (°C)	15.4	18.4	23.5	22.9	19.7	17.2	19.5
	Salinity (ppt)	31.23	30.00	30.71	31.97	31.88	32.54	31.39
	Dissolved Oxygen (mg/L)	9.12	9.74	7.96	8.75	8.49	9.63	8.95
GSP 4	Temperature (°C)	15.5	18.3	24.1	23.0	19.8	17.1	19.6
	Salinity (ppt)	30.14	30.15	30.78	31.61	31.97	32.48	31.19
	Dissolved Oxygen (mg/L)	9.15	9.09	8.09	8.15	9.25	9.58	8.89
GSP 5	Temperature (°C)	14.8	18.9	24.4	21.9	20.0	16.2	19.4
	Salinity (ppt)	29.88	30.10	30.95	31.09	31.80	32.64	31.08
	Dissolved Oxygen (mg/L)	10.02	7.96	7.79	9.11	7.83	9.09	8.63
GSP 6	Temperature (°C)	15.1	18.1	25.7	22.8	19.5	16.7	19.7
	Salinity (ppt)	30.55	29.93	31.06	30.56	32.02	32.4	31.09
	Dissolved Oxygen (mg/L)	10.10	8.62	7.41	8.70	8.32	9.16	8.72
GSP 7	Temperature (°C)	14.9	18.2	25.3	22.6	18.3	16.4	19.3
	Salinity (ppt)	31.24	29.48	30.07	30.97	32.38	32.37	31.09
	Dissolved Oxygen (mg/L)	8.73	9.50	7.48	7.93	9.58	9.23	8.74
GSP 8	Temperature (°C)	13.9	18.0	25.4	22.0	19.6	15.9	19.1
	Salinity (ppt)	29.06	28.61	30.92	30.94	31.97	32.01	30.59
	Dissolved Oxygen (mg/L)	10.14	10.08	7.14	7.87	8.02	9.92	8.86
OH 1	Temperature (°C)	13.5	17.2	21.5	22.3	20.5	16.6	18.6
	Salinity (ppt)	32.20	29.89	31.74	32.12	32.59	32.18	31.79
	Dissolved Oxygen (mg/L)	9.33	10.28	8.25	6.76	8.83	9.31	8.79
OH 2	Temperature (°C)	13.5	18.0	21.4	22.4	20.4	16.4	18.7
	Salinity (ppt)	32.22	30.11	31.81	32.11	31.47	32.62	31.72
	Dissolved Oxygen (mg/L)	9.30	10.40	8.74	6.89	8.68	9.74	8.96

APPENDIX

Species presence by station for May 2020 beach seines.

MAY	**Station**										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
Mummichog							1	1			**2**
Northern Pipefish		1				1					**2**
Pollock	1						1		1	1	**4**
Silversides spp.	1	1	1	1			1	1			**6**
Striped Killifish	1	1		1							**3**
Tautog	1	1					1	1			**4**
Winter Flounder					1	1		1	1	1	**5**

APPENDIX

Species presence by station for June 2020 beach seines.

JUN	**Station**										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
Bay Anchovy		1	1	1	1						**4**
Black Sea Bass									1		**1**
Dusky Pipefish		1									**1**
Grubby							1		1	1	**3**
Longfin Squid					1	1	1				**3**
Mummichog	1						1				**2**
Northern Pipefish		1							1		**2**
Pollock									1	1	**2**
Silversides spp.	1	1	1	1	1	1	1	1		1	**9**
Striped Killifish		1		1	1		1	1			**5**
Tautog	1					1	1		1		**4**
Winter Flounder		1		1	1				1		**4**

APPENDIX

Species presence by station for July 2020 beach seines.

JUL	**Station**										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
Alewife										1	**1**
American Sand Lance	1			1							**2**
Atlantic Cod									1		**1**
Black Sea Bass									1		**1**
Blueback Herring						1					**1**
Chain Pipefish	1										**1**
Cunner	1					1					**2**
Grubby	1							1			**2**
Lined Seahorse			1								**1**
Longfin Squid							1				**1**
Mojarras spp.						1					**1**
Mummichog	1	1		1	1	1	1	1			**7**
Naked Goby			1						1		**2**
Northern Pipefish				1		1					**2**
Northern Puffer			1								**1**
Northern Searobin		1				1					**2**
Pinfish								1			**1**
Scup					1				1		**2**
Silversides spp.	1	1	1	1	1	1	1	1	1	1	**10**
Striped Bass							1				**1**
Striped Killifish	1	1			1			1			**4**
Striped Searobin		1		1		1					**3**
Summer Flounder			1								**1**
Tautog	1					1	1	1	1		**5**
Winter Flounder		1	1		1	1		1	1	1	**7**

APPENDIX

Species presence by station for August 2020 beach seines.

AUG	Station										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
American Sand Lance	1									1	**2**
Atlantic Menhaden		1			1				1	1	**4**
Black Sea Bass	1	1	1	1	1	1	1	1	1	1	**10**
Cunner	1			1	1	1	1	1	1	1	**8**
Grubby	1			1	1	1			1		**5**
Horse-eye Jack										1	**1**
Mummichog	1	1	1	1	1	1	1	1			**8**
Northern Kingfish			1								**1**
Northern Pipefish	1			1			1		1	1	**5**
Northern Puffer					1	1			1	1	**4**
Northern Searobin			1								**1**
Northern Sennet				1							**1**
Oyster Toadfish								1			**1**
Scup	1		1	1	1	1	1	1			**7**
Sheepshead Minnow	1										**1**
Silversides	1	1	1	1	1	1	1	1	1	1	**10**
Snakefish			1			1					**2**
Striped Bass							1				**1**
Striped Killifish	1	1	1	1	1	1		1			**7**
Striped Searobin			1	1						1	**3**
Tautog	1	1	1			1	1	1	1	1	**8**
Winter Flounder	1	1	1		1			1	1	1	**7**

APPENDIX

Species presence by station for September 2020 beach seines.

SEP	Station										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
Atlantic Menhaden				1	1				1	1	**4**
Bay Whiff					1						**1**
Bighead Searobin										1	**1**
Black Sea Bass	1	1		1	1	1	1		1	1	**8**
Cunner	1	1				1	1	1	1	1	**7**
Flying Gurnard						1					**1**
Grubby		1				1			1		**3**
Hickory Shad					1						**1**
Leopard Searobin		1				1					**2**
Lined Seahorse									1	1	**2**
Longfin Squid								1			**1**
Lookdown									1		**1**
Mummichog		1	1	1	1	1	1				**6**
Northern Pipefish										1	**1**
Northern Puffer		1			1	1	1	1			**5**
Northern Searobin					1						**1**
Oyster Toadfish								1			**1**
Rainwater Killifish	1										**1**
Scup	1			1	1					1	**4**
Sheepshead Minnow	1	1	1								**3**
Silversides spp.	1	1	1	1	1	1	1	1	1	1	**10**
Striped Bass							1				**1**
Striped Killifish		1	1		1	1	1				**5**
Striped Searobin									1		**1**
Tautog	1	1				1	1	1	1	1	**7**
Winter Flounder	1	1		1	1	1	1	1	1	1	**9**

APPENDIX

Species presence by station for October 2020 beach seines.

OCT	**Station**										
Species	GSP1	GSP2	GSP3	GSP4	GSP5	GSP6	GSP7	GSP8	OH1	OH2	**Total**
American Sand Lance				1							**1**
Atlantic Menhaden					1				1	1	**3**
Black Sea Bass	1					1			1	1	**4**
Bluefish				1							**1**
Bluespotted Cornetfish				1							**1**
Cunner									1	1	**2**
Grubby	1								1	1	**3**
Longfin Squid	1							1			**2**
Mummichog		1			1						**2**
Northern Pipefish									1		**1**
Pinfish					1						**1**
Sargassum Pipefish	1										**1**
Sheepshead Minnow		1			1						**2**
Silversides spp.	1	1	1	1	1	1	1	1	1	1	**10**
Striped Killifish	1		1	1	1	1	1			1	**7**
Tautog	1	1			1	1		1	1		**6**
Winter Flounder	1	1			1	1		1	1	1	**7**

APPENDIX

Abundances of winter flounder in 2020 beach seines.

	Station												
Month	**GSP 1**	**GSP 2**	**GSP 3**	**GSP 4**	**GSP 5**	**GSP 6**	**GSP 7**	**GSP 8**	**OH 1**	**OH 2**	Mean	SD	SE
MAY	0	0	0	0	7	2	0	2	7	4	2.20	2.86	0.90
JUN	0	4	0	4	11	0	0	0	7	0	2.60	3.86	1.22
JUL	0	5	1	0	2	1	1	0	19	14	4.30	6.70	2.12
AUG	1	1	1	0	1	0	0	6	10	15	3.50	5.19	1.64
SEP	4	12	0	1	10	8	1	1	16	15	6.80	6.20	1.96
OCT	1	1	0	0	5	4	0	7	2	1	2.10	2.42	0.77
Mean	1.00	3.83	0.33	0.83	6.00	2.50	0.33	2.67	10.17	8.17			
SD	1.41	4.06	0.47	1.46	3.74	2.81	0.47	2.81	5.76	6.62		Total Fish	
SE	0.58	1.66	0.19	0.60	1.53	1.15	0.19	1.15	2.35	2.70		215	
Number	6	23	2	5	36	15	2	16	61	49			

APPENDIX

Abundances of summer flounder in 2020 beach seines.

	Station												
Month	**GSP 1**	**GSP 2**	**GSP 3**	**GSP 4**	**GSP 5**	**GSP 6**	**GSP 7**	**GSP 8**	**OH 1**	**OH 2**	Mean	SD	SE
MAY	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	1	0	0	0	0	0	0	0	0.10	0.32	0.10
AUG	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
SEP	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
OCT	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
SD	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00		Total Fish	
SE	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00		1	
Number	0	0	1	0	0	0	0	0	0	0			

APPENDIX

Abundances of tautog in 2020 beach seines.

	Station												
Month	**GSP 1**	**GSP 2**	**GSP 3**	**GSP 4**	**GSP 5**	**GSP 6**	**GSP 7**	**GSP 8**	**OH 1**	**OH 2**	Mean	SD	SE
MAY	1	0	0	0	0	0	2	4	0	0	0.70	1.34	0.42
JUN	2	0	0	0	0	3	2	0	3	0	1.00	1.33	0.42
JUL	6	0	0	0	0	1	3	3	2	0	1.50	2.01	0.64
AUG	19	4	1	0	0	2	13	104	6	36	18.50	32.10	10.15
SEP	58	19	0	0	0	28	34	152	55	14	36.00	45.98	14.54
OCT	6	1	0	0	1	1	0	6	4	0	1.90	2.47	0.78
Mean	15.33	4.00	0.17	0.00	0.17	5.83	9.00	44.83	11.67	8.33			
SD	19.96	6.86	0.37	0.00	0.37	9.96	11.94	60.44	19.47	13.39		Total Fish	
SE	8.15	2.80	0.15	0.00	0.15	4.06	4.88	24.68	7.95	5.47		596	
Number	92	24	1	0	1	35	54	269	70	50			

APPENDIX

Abundances of black sea bass in 2020 beach seines.

Month	**Station**												
	GSP 1	**GSP 2**	**GSP 3**	**GSP 4**	**GSP 5**	**GSP 6**	**GSP 7**	**GSP 8**	**OH 1**	**OH 2**	Mean	SD	SE
MAY	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	0	0	0	0	0	0	0	0	5	0	0.50	1.58	0.50
JUL	0	0	0	0	0	0	0	0	1	0	0.10	0.32	0.10
AUG	6	9	4	1	5	20	6	5	10	13	7.90	5.43	1.72
SEP	1	16	0	8	1	94	3	0	31	17	17.10	28.85	9.12
OCT	1	0	0	0	0	53	0	0	4	1	5.90	16.60	5.25
Mean	1.33	4.17	0.67	1.50	1.00	27.83	1.50	0.83	8.50	5.17			
SD	2.13	6.23	1.49	2.93	1.83	35.11	2.29	1.86	10.56	7.06			
SE	0.87	2.54	0.61	1.20	0.75	14.33	0.94	0.76	4.31	2.88			
Number	8	25	4	9	6	167	9	5	51	31			

Total Fish
315

APPENDIX

Abundances of scup in 2020 beach seines.

	Station												
Month	**GSP 1**	**GSP 2**	**GSP 3**	**GSP 4**	**GSP 5**	**GSP 6**	**GSP 7**	**GSP 8**	**OH 1**	**OH 2**	Mean	SD	SE
MAY	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	0	0	2	0	0	0	1	0	0.30	0.67	0.21
AUG	69	0	2	2	39	52	10	3	0	0	17.70	25.76	8.14
SEP	1	0	0	24	26	9	2	0	0	5	6.70	10.08	3.19
OCT	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	11.67	0.00	0.33	4.33	11.17	10.17	2.00	0.50	0.17	0.83			
SD	25.64	0.00	0.75	8.83	15.56	18.99	3.65	1.12	0.37	1.86		Total Fish	
SE	10.47	0.00	0.30	3.60	6.35	7.75	1.49	0.46	0.15	0.76		247	
Number	70	0	2	26	67	61	12	3	1	5			

APPENDIX

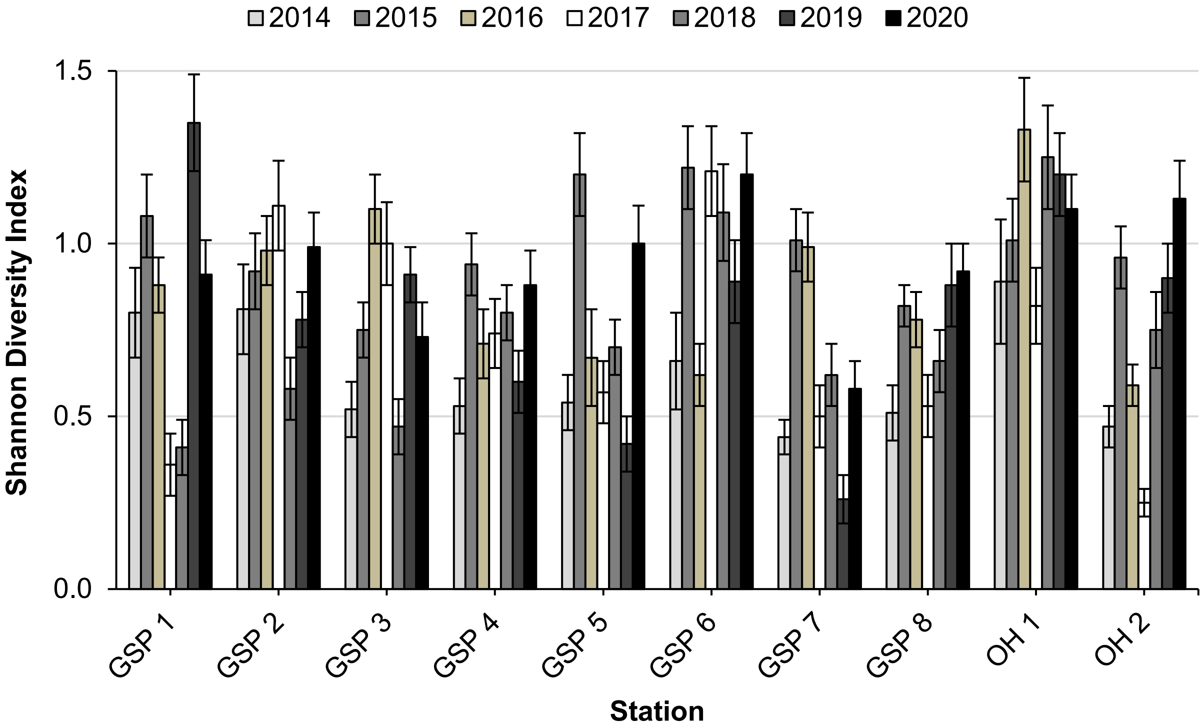
Abundances of bluefish in 2020 beach seines.

Month	GSP 1	GSP 2	GSP 3	GSP 4	GSP 5	GSP 6	GSP 7	GSP 8	OH 1	OH 2	Mean	SD	SE
MAY	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	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	0.00	0.00	0.00
AUG	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
SEP	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
OCT	0	0	0	6	0	0	0	0	0	0	0.60	1.90	0.60
Mean	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00			
SD	0.00	0.00	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00		Total Fish	
SE	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00		6	
Number	0	0	0	6	0	0	0	0	0	0			

Station (column group header over GSP 1 – OH 2)

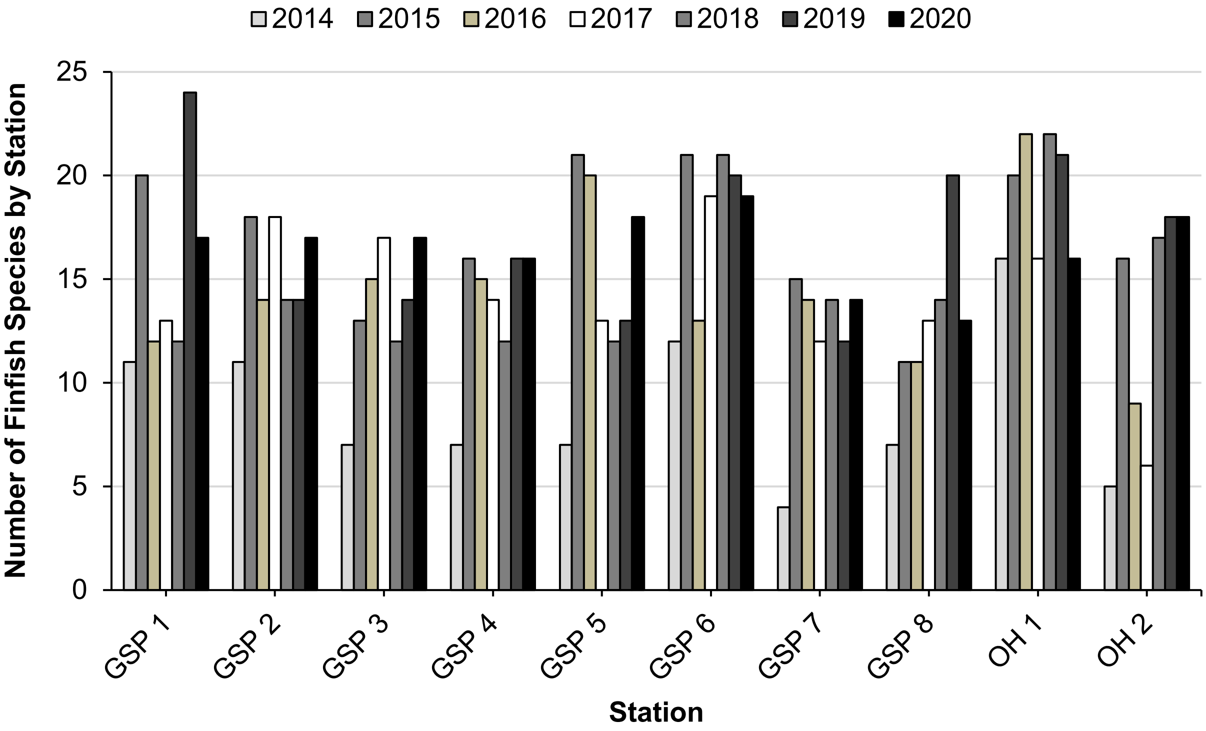
APPENDIX

Mean Shannon diversity across stations in 2014-2020 beach seines.



APPENDIX

Cumulative number of finfish species by station in 2014-2020 beach seines.



ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS
F20AF00145

NARRAGANSETT BAY JUVENILE FINFISH SURVEY

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2020

PERFORMANCE REPORT

STATE: Rhode Island **PROJECT NUMBER:** F-61-R
SEGMENT NUMBER: 24

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

PERIOD COVERED: 1 January 2020 - 31 December 2020

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 2020 with the standard 61 x 3.05 m beach seine. Adults and juveniles of sixty-three were collected during the 2020 survey, which is a decrease from the 2019 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 – 2020), 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 (with the exception of blue crabs, horseshoe crabs and squid). Data on weather, water temperature, salinity, and dissolved oxygen were recorded at each station.

TARGET DATE: December 2020

SIGNIFICANT DEVIATIONS: There were no significant deviations to methodology in 2020.

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 RIDMF 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 most of the target species do not have any significant long-term trend, bluefish (p = 3.5e-5) and winter flounder (p = 0.012) are showing a decreasing trend (Table 1a). However, River Herring (p = 0.005), Tautog (p = 0.0013), and Menhaden (p = 0.016) show a positive increasing trend in the shortened 10-year analysis (Table 1b). Striped bass show no abundance trend for either the full dataset or the past ten years (Table 1a, b).

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

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

METHODS, RESULTS & DISCUSSION: A 61m x 3.05m beach seine, deployed from a 22' boat, was used to sample the juvenile life stage of selected fish species in Narragansett Bay. Monthly seine collections were completed at the eighteen standard survey stations (Figure 1) from June through October 2020.

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 2018 survey. Tables 9-13 provide the number of fish/seine haul for each station along with the station mean, monthly mean, and annual abundance index for each target species. Figures 2 – 10 show the annual abundance index trends for a number of important species for both the original and standardized indices. It should be noted when interpreting these data, that the survey began in 1986 with fifteen stations. The data represented in the graphs begins in 1988 as the period of time when the survey began using consistent methodology with the 15 stations. Station 16 (Dyer Is.) was added in June 1990, station 17 (Warren R.) was added in July of 1993, and station 18 (Wickford) was added in July of 1995. The addition of the stations is standardized in the analysis, see appendix A.

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

Winter flounder

Juvenile winter flounder (*Pseudopleuronectes americanus*) were present in thirty-four percent of the seine hauls for 2020. This is a decrease from 2019 when they were present in forty-two percent of the hauls. A total of 143 fish were collected in 2019 (all of the fish collected in 2020 would be considered young-of-the-year (YOY) according to Table 2 winter flounder maximum size by month). This was a decrease from the 327 individuals collected during the 2019 survey. They were present at thirteen of the eighteen stations and were collected in all months (Table 9).

The 2020 juvenile winter flounder standardized abundance index was 1.59 ± 0.97 fish/seine haul; this is lower than the 2019 index of 3.63 ± 1.46 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, but a decreasing trend in the last 10 years (Table 1a, b).

June had the highest mean monthly abundance of 3.5 ± 1.1 S.E. fish/seine haul. Hog Island (Sta. 9), Wickford (Sta. 18), and the Warren River (Sta. 17) had the highest mean station abundance of 6.6 ± 2.98, 4.8 ± 2.75 S.E., and 4.2 ± 2.37 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.

Winter flounder length frequency data from the 2020 survey indicate that all of 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 2020 abundance index continues to be lower than most years since 2000, the survey high. The Division of Fish and Wildlife's trawl survey data (sampling both adults and juveniles) saw decrease in winter flounder from 2019 to 2020. 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 2018. The Mann-Kendall trend analysis shows no trend in the abundance of juvenile winter flounder in Narragansett Bay over the entire time series, and the declining trend indicated for the shortened 10-year time series in the terminal year of 2012 has dissipated, now showing no trend as we move away from the peak years of the early 2000's. The dramatic abundance fluctuations over the past ten years shown in Figure 2 and the declining trend over the last decade continue to be a concern to resource managers.

Tautog

During the 2019 survey 547 juvenile and 6 adult (>26 cm length) tautog (*Tautoga onitis*) were collected. This is a decrease from the 2019 survey when 1689 juveniles and 8 adults were collected. The 2020 abundance index was 6.14 ± 1.63 S.E. fish/seine haul, a decrease from the 2019 index 18.86 ± 5.00 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. However, the last 10-year time series Mann-Kendall test shows no significant trend (p = 0.06) during the 2020 analysis, unlike the 2019 review. It may take some time for a slow growing species such as tautog to recoup its spawning stock biomass to levels that will have significant impacts and major increases in biomass; therefore, we will continue to monitor this species closely in the coming years.

Juvenile tautog were collected in sixty-eight percent of the seine hauls in 2020 (Table 10). This is an increase from 2019 when they were present in sixty-two percent of the seine hauls. August and September had the highest mean monthly abundances of 13.67 ± 3.34 S.E. and 5.61 ± 1.69 S.E. fish per seine haul, which corresponds to the majority of the survey time series data which indicates August as being the month with the highest abundance. Hog Island (Sta. 9) had the highest mean station abundance of 16.40 ± 10.00 S.E. which was driven by high sampling numbers in August (54 fish) when there was a large amount of seaweed accumulated at the sampling station, which provided preferred habitat to many juvenile finfish. Patience (Sta. 5) and Warren River (Sta. 17) had the next highest abundances with a mean station abundance of 15.60 ± 5.63 S.E. and 14.20 ± 6.50 S.E. fish/seine haul respectively. The Mann-Kendall test showed a long-term increase in juvenile abundance, but no short-term increase in abundance for juvenile tautog is present for the 10-year series (Table 1a, b). It is plausible that the spawning closure is positively impacting the juvenile tautog population, and the increasing trend in the Mann-Kendall test supports this. It should be noted that this survey data was used as a young of the year index for the benchmark stock assessment for tautog by the Atlantic States Marine Fisheries Commission (ASMFC 2016).

Our Narragansett Bay trawl survey had an increase in biomass and a stable abundance for tautog from 2019 to 2020. 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 2020 survey 2,898 juvenile bluefish (*Pomatomus saltatrix*) were collected. This is an increase from the 992 juveniles collected in 2019. Juveniles were present in thirty percent of the seine hauls and were collected at thirteen of the eighteen stations (Table 11). They were present in all months except for June, with the highest abundance occurring in September. June 2020 had no juvenile bluefish collected during the survey, which is most likely due to the colder water temperatures (14.3 – 22.0° C in June). Since this survey began and prior to 2016, only two hundred seventy-nine juvenile bluefish have been collected in October, in eight different years (1990, 1997, 1999, 2005, 2011, 2012, 2015, 2016, 2017, and 2020), and only when water temperatures were 16 – 21° C.

The abundance index for 2020 was 32.2 ± 3.59 S.E. fish/seine haul. This is much higher than the 2019 abundance index of 3.63 ± 1.46 S.E. fish/seine haul (Figure 4). The Mann-Kendall test showed a significant decrease in the 10-year abundance, however there is no long-term abundance trend for this species (Table 1a, b).

August had the highest mean monthly abundance of 129.78 ± 111.54 S.E. fish/seine haul, which was driven by a large catch (2,016) at Gaspee Point (Sta. 1) (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.

Length frequency data for 2020 indicates that all juveniles collected were young-of-the-year individuals.

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

Striped Bass

During the 2020 survey 44 striped bass (*Morone saxatalis*) were collected. This is an increase from 2019 which had an abundance of 23 fish. Striped bass were present in fourteen percent of the seine hauls and were collected at eight of the eighteen stations (Table 14). They were present in June, July, August, and October.

The abundance index for 2020 was 0.49 ± 0.23 S.E. fish/seine haul. This is slightly higher than in 2019, which had an abundance index of 0.24 ± 0.12 S.E. fish/seine haul (Figure 8). The Mann-Kendall test showed no abundance trend for this species for the entire dataset or for the shortened 10-year series (Table 1a, b).

August had the highest mean monthly abundance of 1.06 ± 1.06 S.E. fish/seine haul (Table 12). June had the second highest mean monthly abundance at 0.83 ± 0.40 S.E. fish/seine haul. September and October are usually the months with the highest abundance for the entire time series. However, during 2020 they had the lowest abundance (Table 12).

In 2020, striped bass were only present at 8 stations, Pojac Point (Sta. 4), Dutch Island (Sta. 7), Rose Island (Sta. 10), Spar Island (Sta. 12), Spectacle Cove (Sta. 13), Third Beach (Sta. 15), Dyer Island (Sta. 16), and Warren River (Sta. 17). The highest abundance was found at Pojac Point with 3.80 ± 3.80 S.E. fish/seine haul, which was driven by a single catch of 19 fish in August. 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 2020 indicates that a mix of juveniles and adults were collected. This is normal for the seine survey. The spatial distribution and abundance of striped bass in Narragansett Bay is highly variable and is most likely highly dependent on the availability of appropriate size prey species like Atlantic silversides (*Menidia menidia*) and juvenile menhaden (*Brevoortia tyrannus*) when fish enter the bay. The annual abundance indices since 1988 show fluctuations in abundance from year to year (Figure 8), but generally appears to have had an increasing trend during the late 90s to early 2000s, but now appears to be on a downward trajectory since 2008, although in recent years there seems to be a very slight upward trend. The standardized index, which accounts for some of these factors, follows a similar trend year to year as the straight catch per unit effort (CPUE) index.

Clupeidae

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

River Herring

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

River herring were present in thirty-four percent of the seine hauls and were collected at seventeen of the eighteen stations during 2020 and were present during the warmer months of July, August, and September. A total of 6,479 juveniles were collected in 2020, a decrease from the number collected in 2019 (44,599 fish).

The highest mean monthly abundance for 2020 occurred during July and was 323.39 ± 174.97 S.E. fish/seine haul. Gaspee Point (Sta. 1), Chepiwanoxet (Sta. 3), Potters Cove (Sta. 8), Hog Island (Sta. 9), and the Warren River (Sta. 17) had the highest mean station abundance of 613.60 ± 607.61 S.E., 100.20 ± 100.20 S.E., 184.80 ± 184.55 S.E., 153.60 ± 152.35 S.E., and 138.20 ± 137.70 S.E., respectively (Table 13). Gaspee Point experienced a single large catch in July (3,044 fish), Potters Cove experienced a single large catch in July (923 fish), Hog Island experienced a single large catch in July (763 fish), and the Warren River experienced a single large catch in July (689), which drove their mean station abundances. Single large catches of these species are due to their schooling behavior and is the reason for the high standard error associated with the indices.

The standardized abundance index for 2020 was 71.99 ± 27.06 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 Mann-Kendall test for the long-term abundance data (Table 1a), however, the short-term shows a significant increase over the past 10-year (Table 1b).

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

Four hundred and sixty-three Atlantic menhaden (*Brevoortia tyrannus*) were collected during the 2020 survey, a decrease from 2019 when 24,610 fish were caught. The 2017 abundance is one of the highest in recent years; the last high abundance was 2007, when eight thousand two hundred fifty-three juveniles were collected. They were present in twenty-one percent of the seine hauls and were collected at sixteen of the eighteen stations (Table 12).

The highest mean monthly abundance for 2020 occurred during August and was 14.83 ± 12.37 S.E. fish/seine haul. Chepiwanoxet (Sta. 3) had the highest mean station abundance of 44.80 ± 44.80 S.E. (Table 14) which was driven by a single large catch in August of 224 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 2020 was 5.14 ± 56.14 S.E. fish/seine haul. This is less than 2019 (107.04 ± 91.44 S.E. fish/seine haul, Figure 7). The standardized index indicates an increased abundance during the 2000s followed by lower numbers through the 2010s. In the most recent years an increasing abundance is evident. Our Narragansett Bay trawl survey showed a decrease in menhaden abundance from 2018 to 2019. The trawl survey catches juveniles as well as some age one fish. The Mann-Kendall test showed no long-term abundance trend but an increasing 10-year trend for this species (Table 1a and 1b).

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 observed in the field rather than the number represented in the samples. The standardization techniques used for analysis this year are an effort to take in to account this variability and high percentage of zero catches through the use of a delta lognormal model (Appendix A).

Weakfish

There was one weakfish, *Cynocion regalis,* collected during the 2020 survey. Weakfish were present in one percent of the seine hauls and were collected at one (Conimicut Point) of the eighteen stations during 2020, a decrease from the number collected in 2019 (6 fish). 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 typically collected most frequently.

The abundance trend over the past several years indicate the juvenile population of this species in Narragansett Bay fluctuates dramatically, a trend also reflected in our trawl survey. There, have been 11 years since 1988 where no fish have been caught. Seven of the 11 total zero catch years occur after 2004. Possible reasons for this high variability in abundance, other than fishing pressure, may be environmental and anthropogenic factors that affect spawning and nursery habitat. Survival rate at each life history stage may also be influenced by these factors. The literature indicates this species spawns in calm coves within the estuary and juveniles move up the estuary to nursery areas of lower salinity. These are the same areas of the bay where anthropogenic impacts are high, often resulting in hypoxic and/or anoxic events that may increase mortality of the early life history stages of this species.

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

Black Sea Bass

Fifty-five black sea bass (*Centropristis striata*) were caught in 2020, a decrease from the 302 fish that were collected in 2019. The number of black sea bass has been highly variable from year to year during the time series of this survey, but the high abundance during 2012 and 2015 (Figure 10) stand out as unique. Black sea bass were caught in ten percent of the seine hauls in 2020.

The highest mean monthly abundances for 2020 occurred during August and September at 2.39 ± 1.56 S.E. fish/seine haul and 0.44 ± 0.25 S.E. fish/seine haul, respectively. Black sea bass were caught at 7 of the 18 stations; Spectacle Cove (Sta. 13) and Third Beach (Sta. 15) had the highest mean station abundances of 5.40 ± 5.15 S.E. and 3.40 ± 2.52 S.E. fish/seine haul, respectively (Table 15).

The abundance index for 2020 was 0.33 ± 0.61 S.E. fish/seine haul. This was a decrease from the 2019 index 11.02 ± 4.66 S.E. (Figure 10). Our Narragansett Bay trawl survey had a small increase in the abundance of black sea bass from 2019 to 2020 in the spring and a decrease in the fall. However, the abundance was still much greater than it has been since the survey began in 1979. The fall index dropped down from the high values in 2012 and 2013, but did show a small increase in abundance from 2016 to 2018. 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 2020 survey. These juveniles included scup (*Stenotomus chrysops*), and Northern kingfish (*Menticirrhus saxatilis*).

Two hundred and fifty-one juvenile and adult scup were collected in 2020 during August, September, and October, a decrease from 2019 when 1,146 scup were collected. One thousand, one hundred and ninty-six Northern kingfish were collected in 2019 and were present in the greatest numbers during July and August. This is an increase from 2019 when 369 Northern kingfish were caught. Four summer flounder were collected in 2020 in July and September. Four smallmouth flounder were caught in 2020. Relative to the sixty-eight smallmouth flounder that were caught in 2011, and the thirty-three that were caught in 2010, the decrease in abundance continued in 2020. This species will have to be monitored in future years to see if, due to changing habitat conditions or possible vacant niches, it is increasing its residency in the Bay. No juvenile Haddock were caught in 2020, unlike June 2016 when 44 juvenile haddock were caught, or June 2015 when 27 were caught. They were caught primarily in the lower portion of the bay. 2015 was the first recorded observance of juvenile Haddock in the history of the survey, this species will continue to be monitored in future years to see if there is an increasing abundance over time in Narragansett Bay. See Tables 3-8 for additional survey data on these species.

Physical & Chemical Data

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

Water temperatures during the 2020 survey ranged from a low of 14.3°C at Rose Island (Sta. 10) in June to a high of 27.7°C at Pojac Point (Sta. 4) in August.

Salinities ranged from 22.7 *ppt* at Gaspee Point (Sta. 1) in June to 29.5 *ppt* at Third Beach (Sta. 15) in October.

Dissolved oxygen ranged from 4.9 *ppm* at the Kickimuit (Sta. 11) in July to a high of 11.5 *ppm* at Dutch Island (Sta. 7) in October.

SUMMARY: In summary, data from the 2020 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, tautog, river herring, menhaden and striped bass, showed no long-term abundance trends but indicated a significant long-term decrease in bluefish and winter flounder abundance. There are some species abundance trends from this survey that agree with those from our coastal pond survey and/or trawl survey, however, in some instances they do not relate. This outcome is probably influenced by the species-specific use of habitat and looking at appropriate data lags between the juvenile life stages and the adult stages. Hopefully, juvenile survey abundance indices will be reflected later in the abundance of adults in the trawl survey, but this is not always the case.

Sixty-one, both vertebrates and invertebrates, were collected in 2020. This is slightly higher than the survey mean for the past twenty-five years of sixty species. An initial audit of the earlier time series and information contained on the field logs was undertaken to determine if some of the species diversity was missing from the earlier time series. Some issues were resolved from this analysis, however there are still some unresolved issues contained in the historical field logs. These final issues will be addressed over the coming year.

During 2020 one tropical species (*Fistularia tabacaria*) was 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

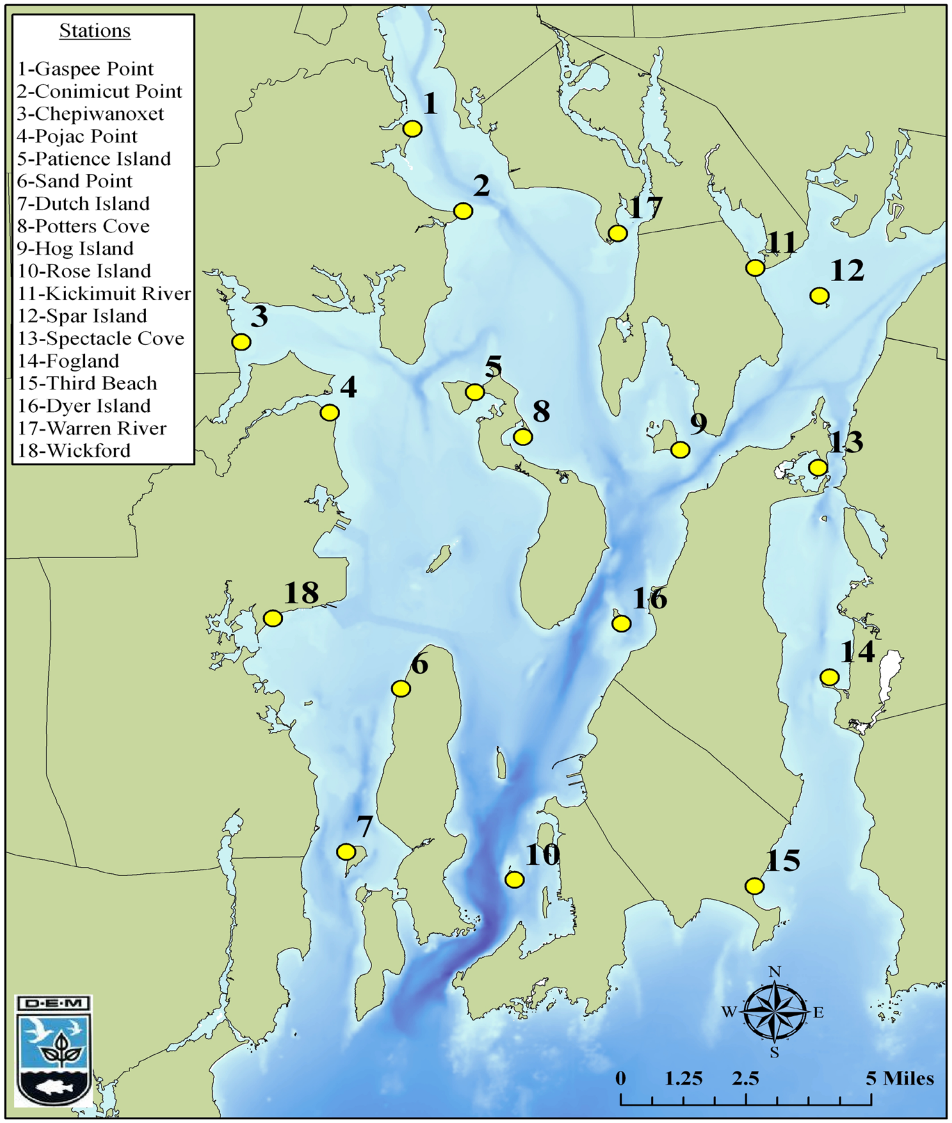


Figure 1. Survey station location map.

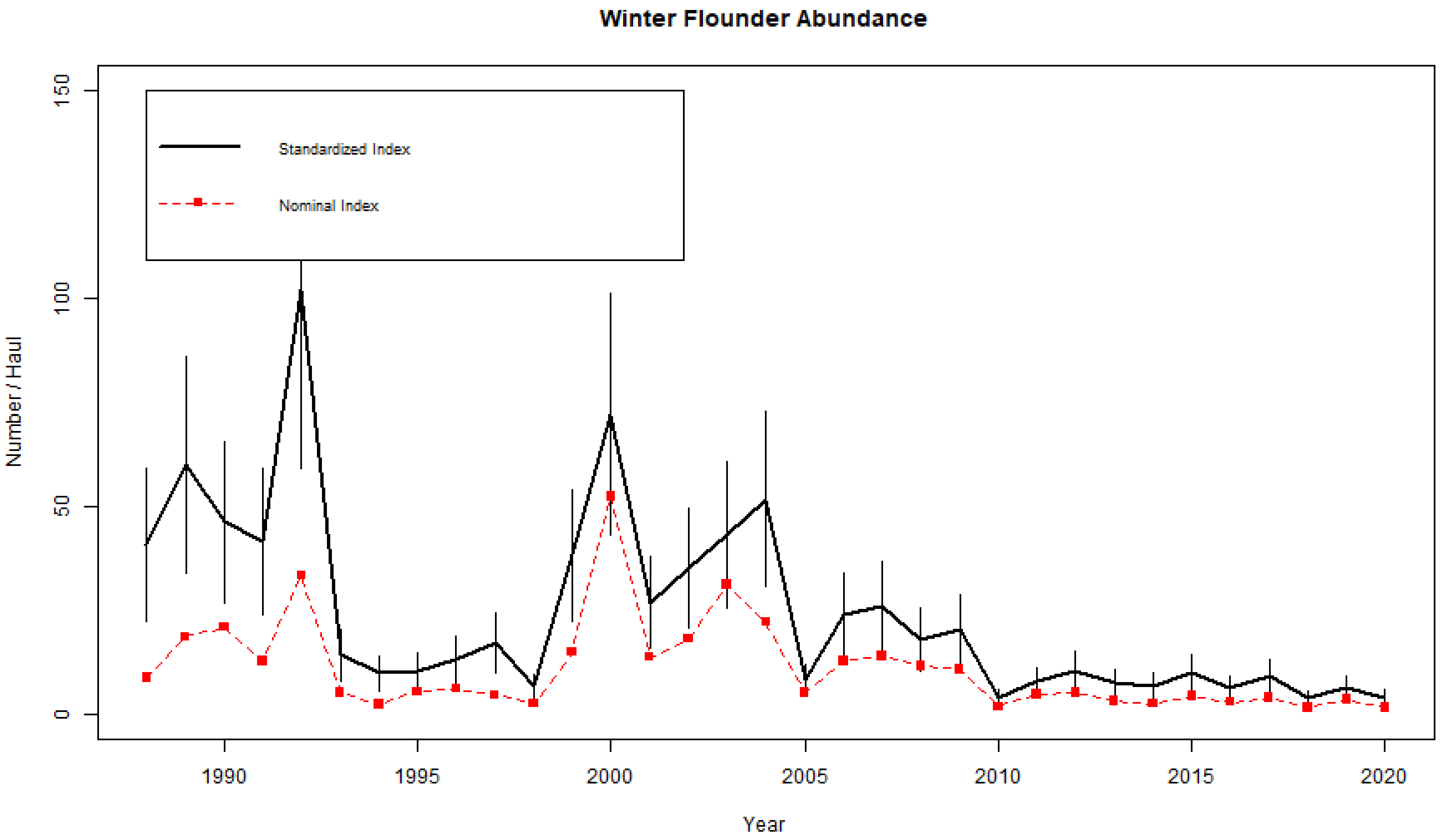


Figure 2. Juvenile winter flounder standardized abundance index 1988 – 2020 (see appendix A for standardization methodology).

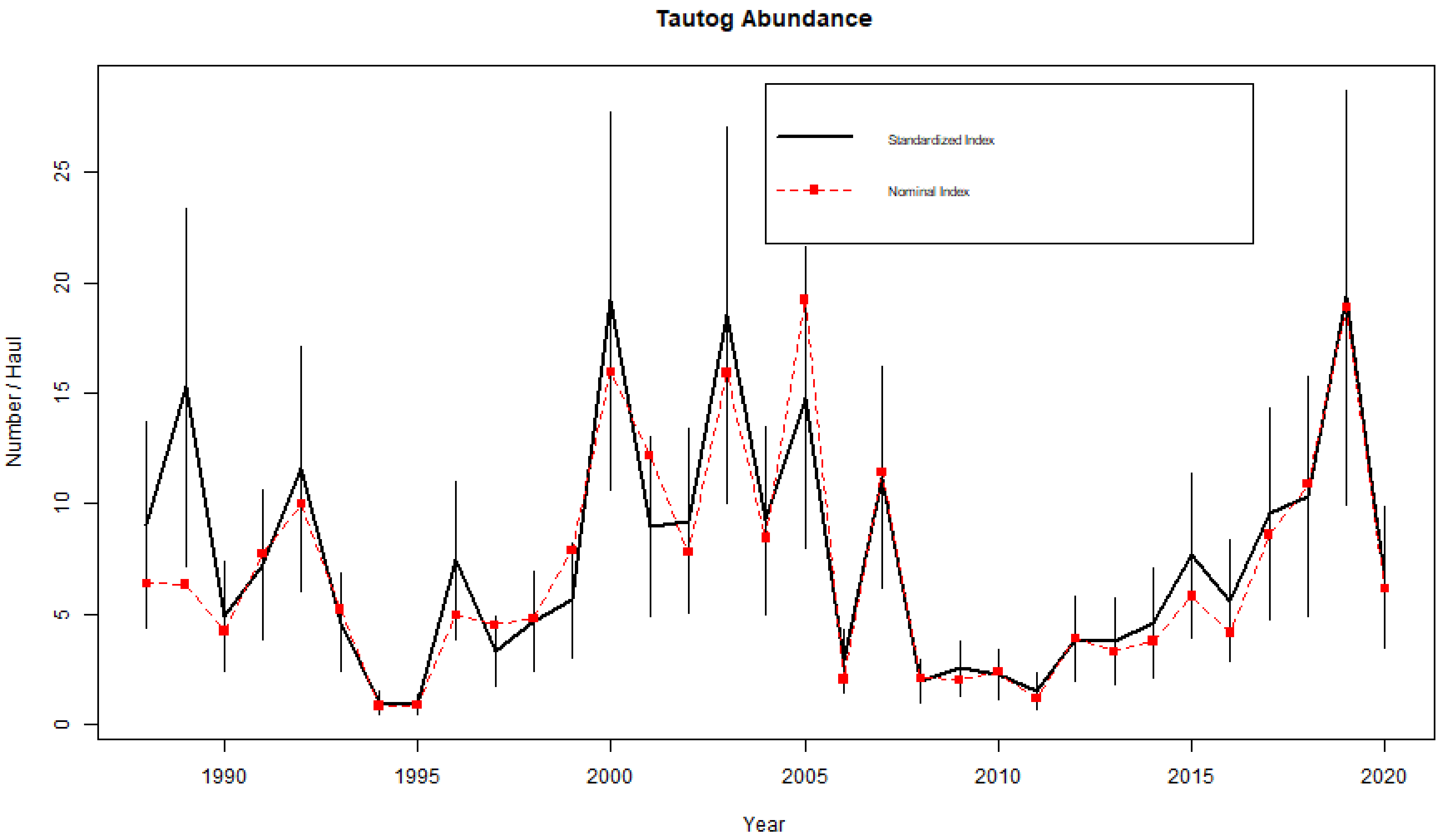


Figure 3. Juvenile tautog standardized annual abundance index 1988 – 2020 (see appendix A for standardization methodology).

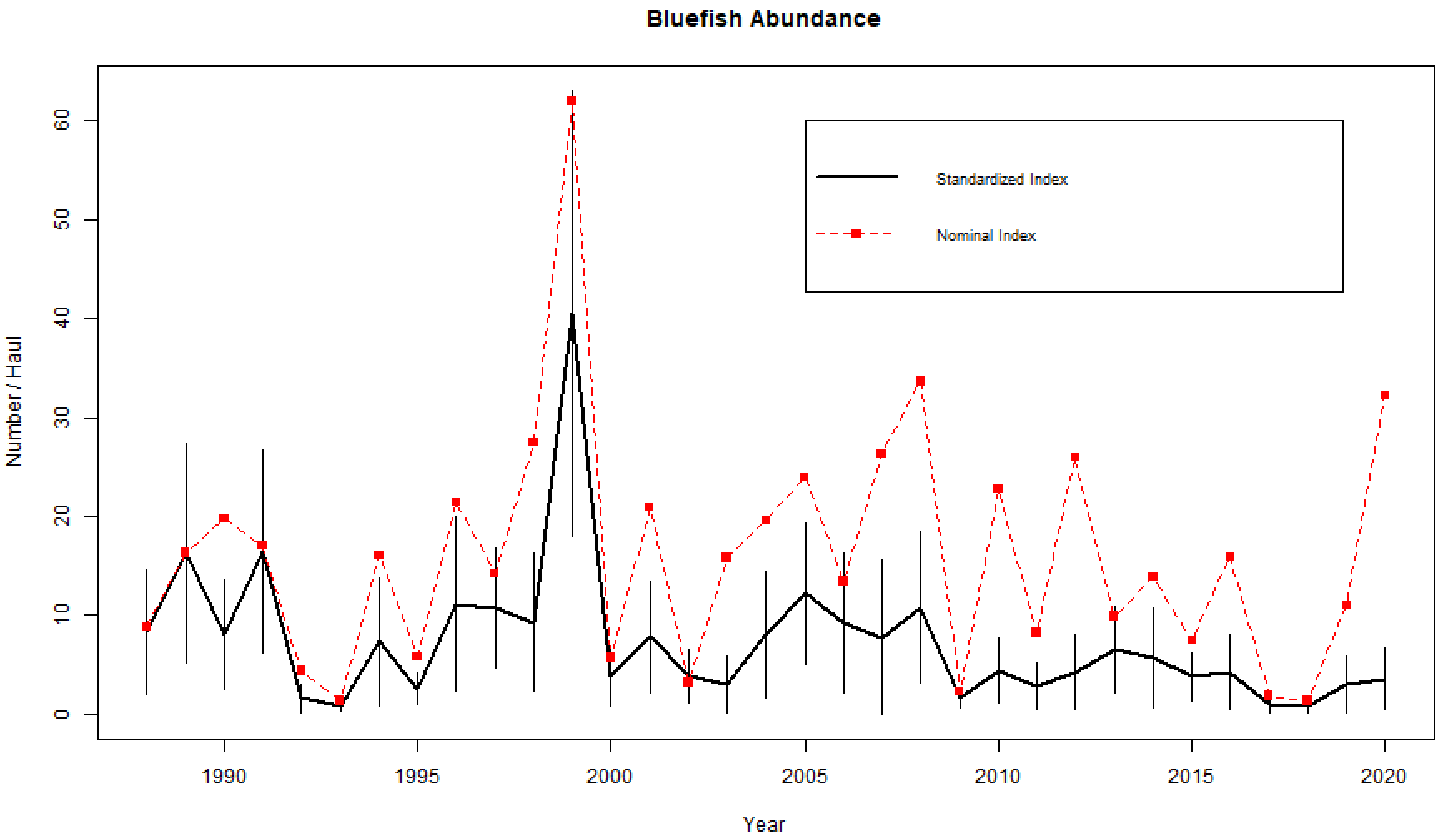


Figure 4. Juvenile bluefish standardized annual abundance index 1988 – 2020 (see appendix A for standardization methodology).

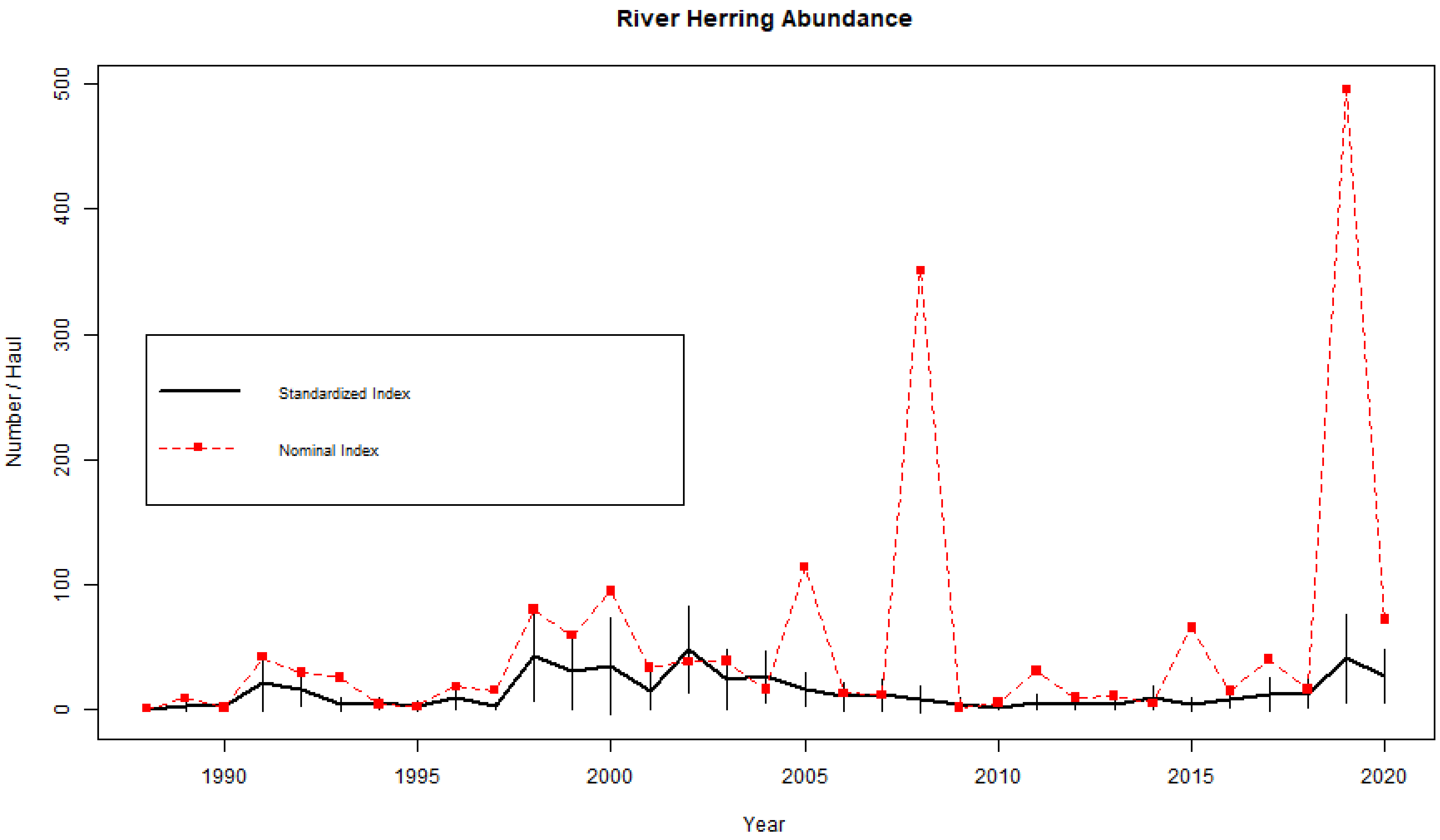
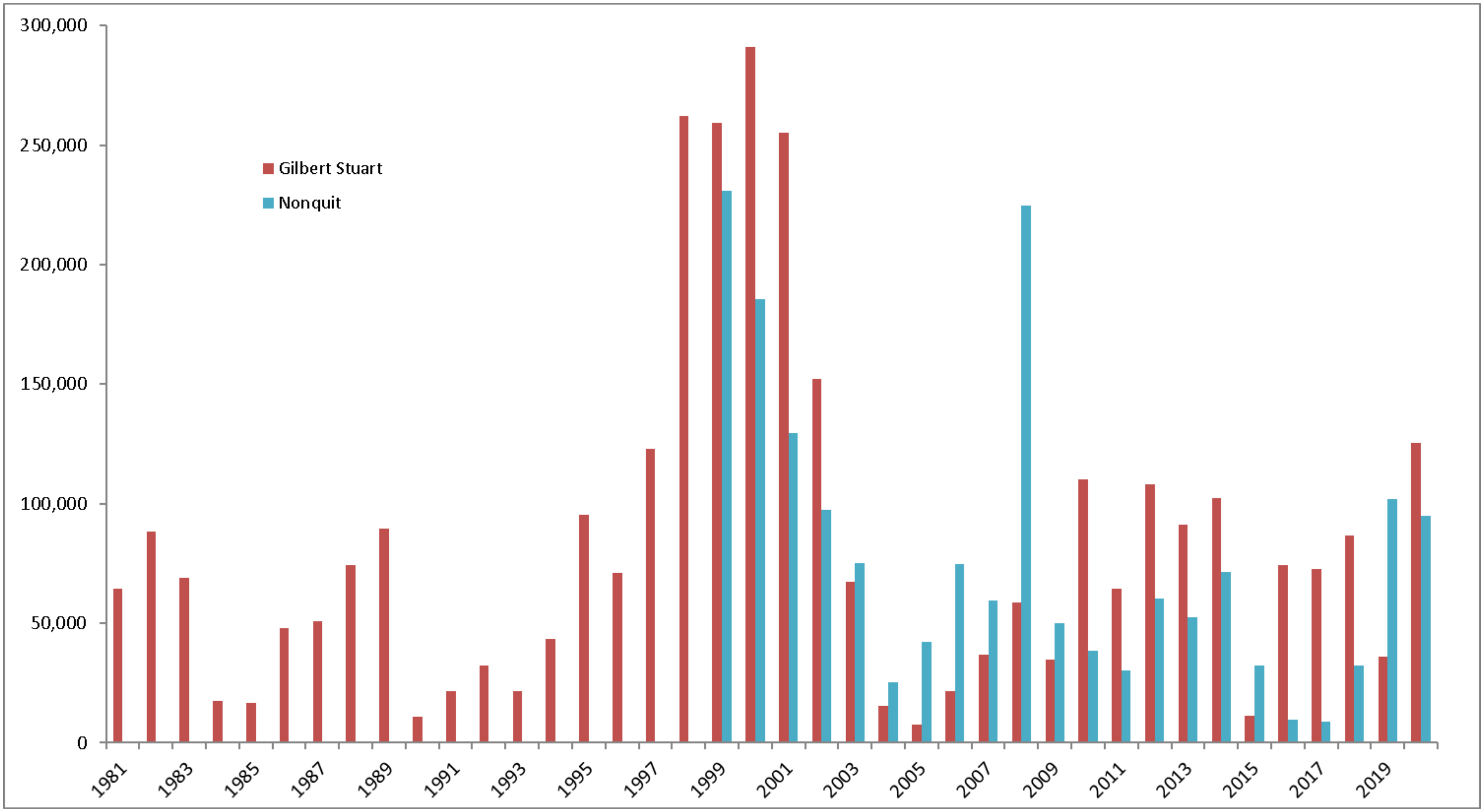


Figure 5. Juvenile river herring standardized annual abundance index 1988 – 2020 (see appendix A for standardization methodology).



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

Figure 6. River herring spawning stock size from monitoring at two locations 1999 – 2020.

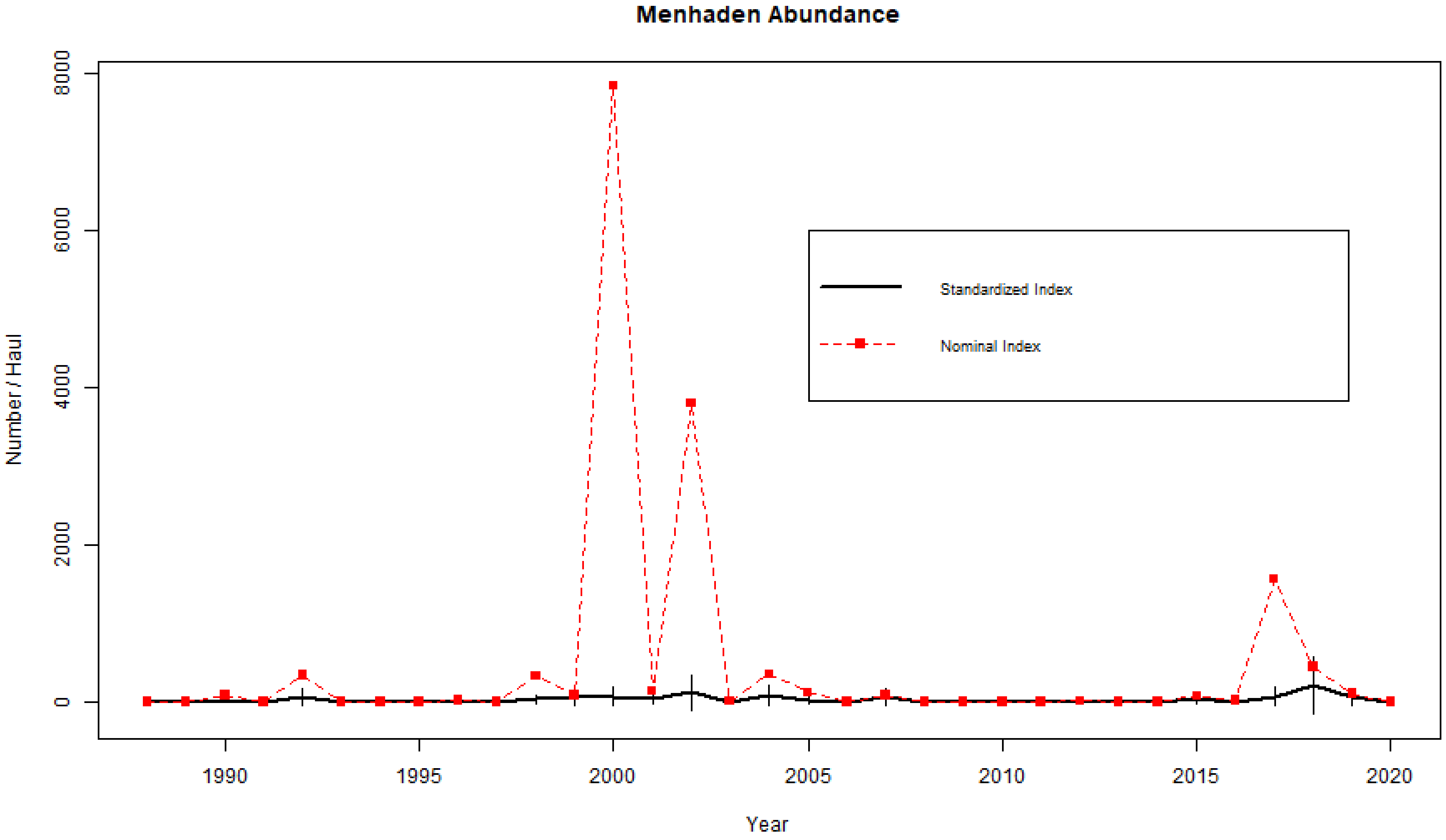


Figure 7. Juvenile menhaden standardized annual abundance index 1988 – 2020 (see appendix A for standardization methodology).

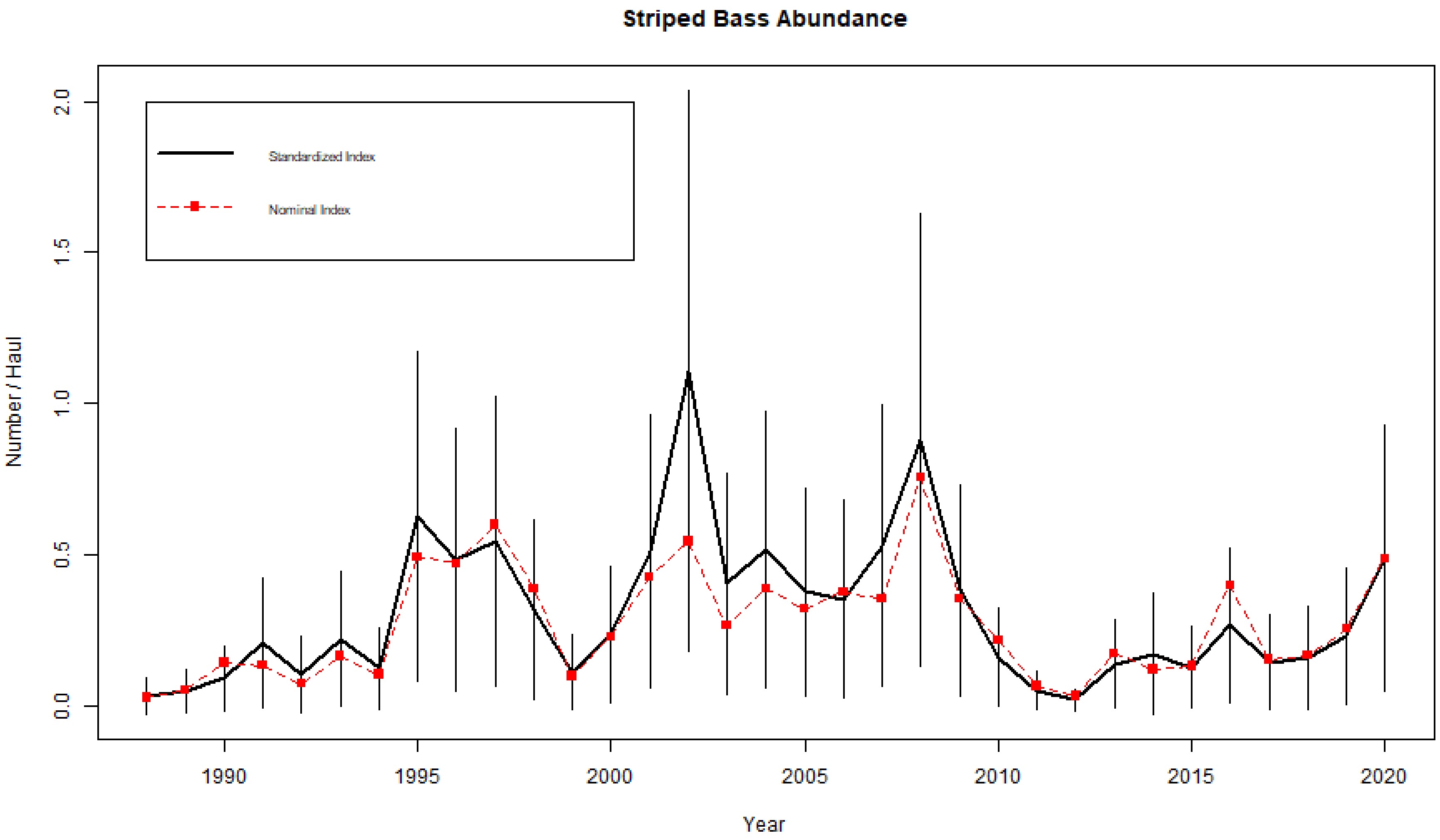


Figure 8. Striped bass standardized annual abundance index 1988 – 2020 (see appendix A for standardization methodology).

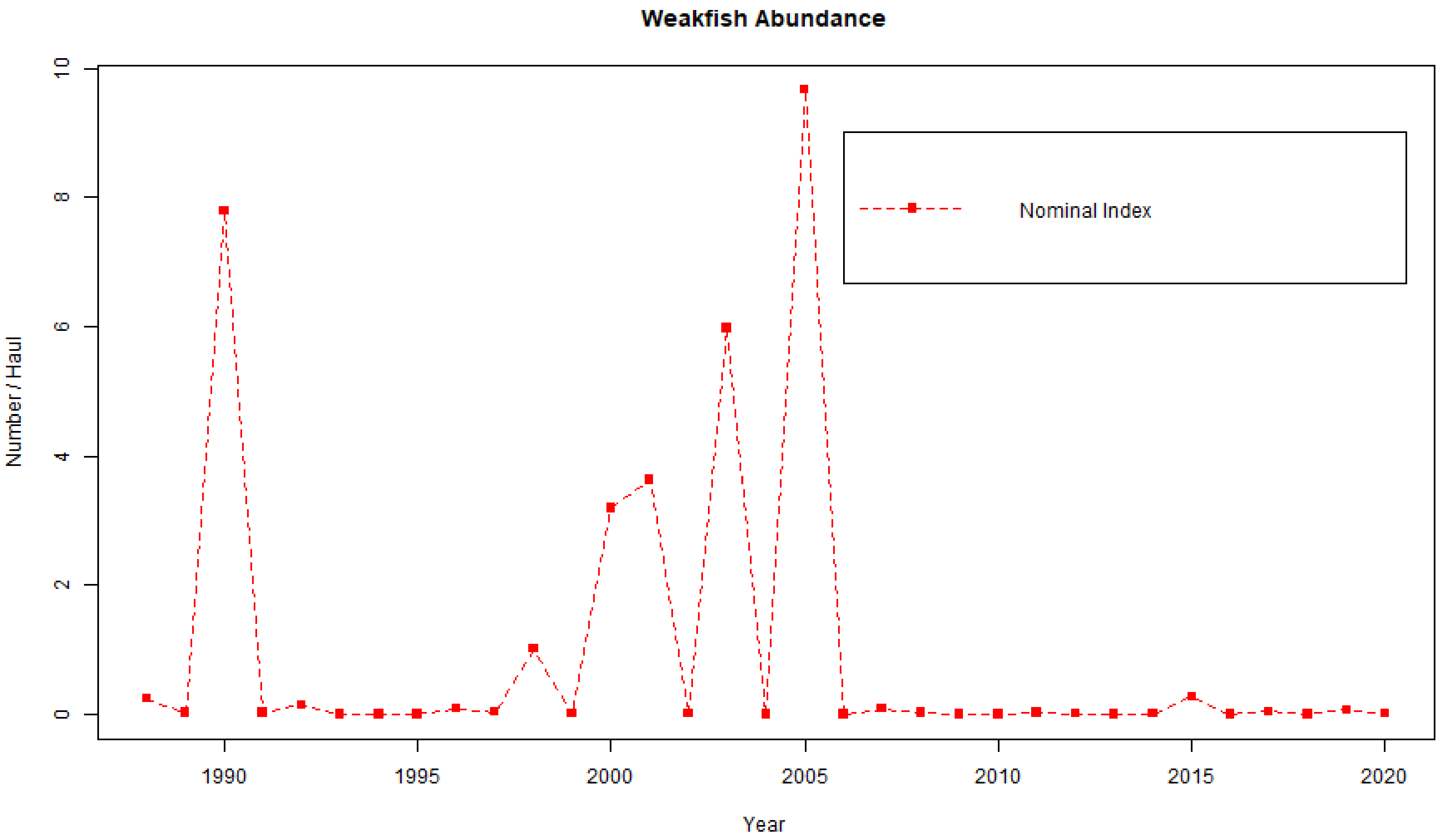


Figure 9. Weakfish annual abundance index 1988 – 2020.

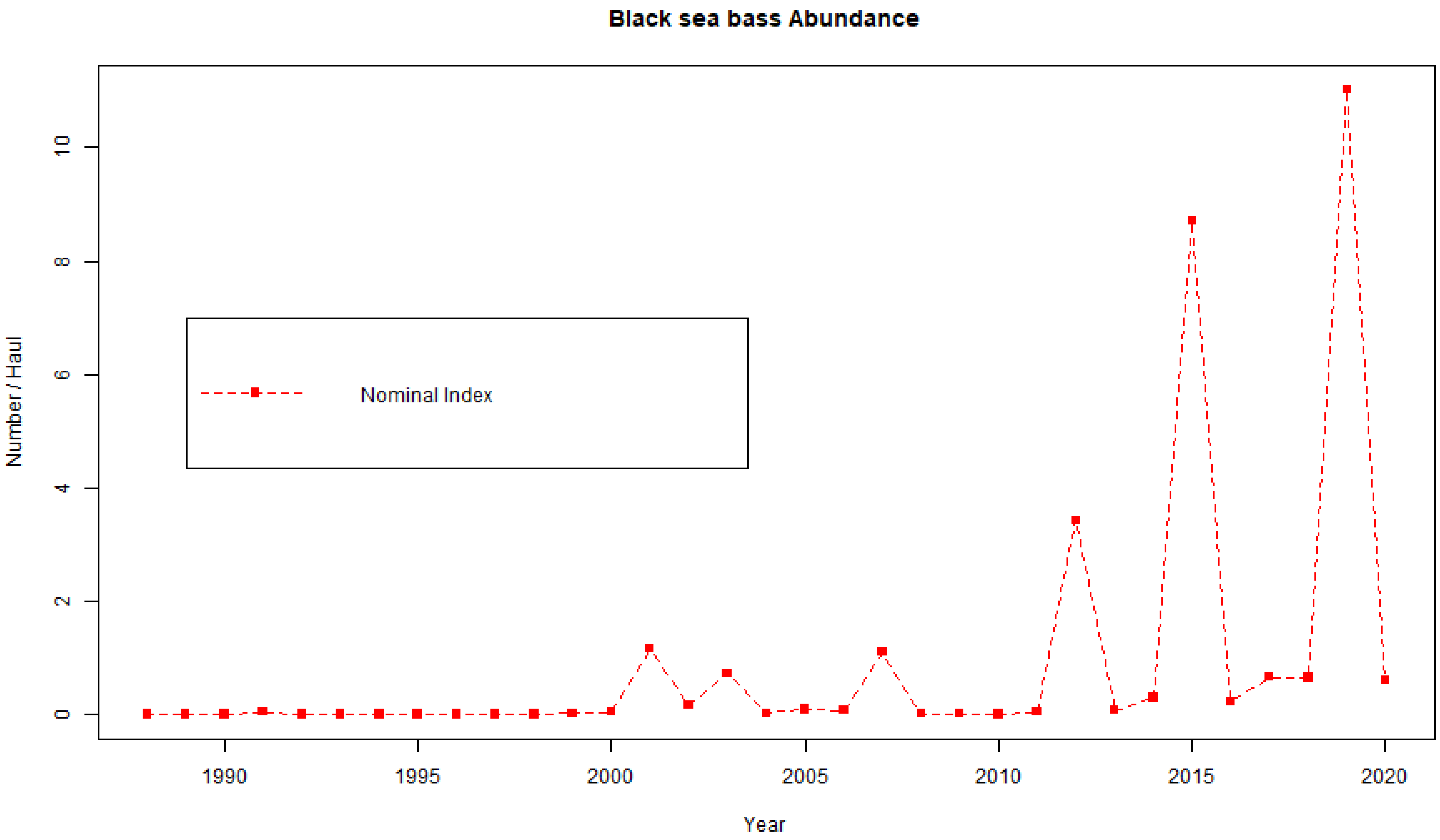


Figure 10. Black sea bass annual abundance index 1988 – 2020.

TABLES

Table 1a. Mann-Kendall test for target species abundance trend analysis (Full dataset; 1988 - 2020).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-268	-28	-164	60	88	40
n Observations	33	33	33	33	33	33
Variance	4165.33	212.67	4165.33	4165.33	4165.33	4165.33
Tau	-0.508	-0.424	-0.311	0.114	0.167	0.0748
2-sided p value	3.5e-5	0.0641	0.01155	0.36063	0.17765	0.54566
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	Yes ↓	No	Yes ↓	No	No	No

Table 1b. Mann-Kendall test for target species abundance trend analysis (2010 - 2020).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-28	48	-14	42	36	18
n Observations	10	10	10	10	10	10
Variance	212.67	212.67	212.67	212.67	212.67	212.67
Tau	-0.424	0.727	-0.212	0.636	0.545	0.273
2-sided p value	0.064104	0.001269	0.37269	0.0049314	0.016393	0.24372
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	Yes ↑	No	Yes ↑	Yes ↑	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 2020.

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			501														2		503
Anchoa mitchilli			103	6															109
Calinectes sapidus			1	1									1				2		5
Carcinus maenus	x			x		x		x			x		x	x					x
Crangon septemspinosa		x					x	x	x					x					x
Crepidula fornicata									x										x
Cyprinodon variegatus																		1	1
Etropus microstomus							1								1				2
Fundulus heteroclitus	6		91		40	3					23						11		174
Fundulus majalis	77			2	3				28		1						7	1	119
Gobiosoma bosc		2			1														3
Isopoda order															x				x
Libinia emarginata	x																x		x
Limulus polyphemus					4	1		4											9
Littorina littorea								x											x
Menidia menidia	3	4	2	231	27	37		18	43		15			6			670	15	1071
Menticirrhus saxatilis			5																5
Microgadus tomcod					6				1	3	1						5		16
Morone saxatilis							1					4	2		2	6			15
Myoxocephalus aenaeus					1					1	4	1	2						9
Mytilus edulis								x	x							x			x
Nassarius obsoletus	x	x		x			x					x	x	x					x
Pagurus spp				x			x	x		x	x	x	x	x	x		x		x
Palaemonetes vulgaris	x		x	x	x			x	x		x		x			x	x		x
Panopeus spp					x			x								x			x
Prionotus evolans																	1		1
Pseudopleuronectes americanus	3	2	2	5					11		13		2	3			10	12	63
Sphoeroides maculatus			2															2	4
Syngnathus fuscus	2												1				2		5
Tautoga onitis	9	19			23	2			1	1	1	1	1	3			10		71
Tautogolabrus adspersus					9					2	1						2		14
Urophycis regia											1				1				2
Grand Total	**100**	**27**	**707**	**245**	**114**	**43**	**2**	**22**	**84**	**7**	**60**	**6**	**9**	**12**	**4**	**6**	**722**	**31**	**2201**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 4. Species presence by station for July 2020.

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	3044	73		6	2			923	763		21		261	39			689		5821
Anchoa mitchilli		8													4				12
Anguilla rostrata					2														2
Apeltes quadracus											1								1
Brevoortia tyrannus					2			1											3
Calinectes sapidus	3	2	4	1	3						1						5		19
Carcinus maenus				x		x		x	x		x		x	x		x			x
Crangon septemspinosa		x				x	x				x							x	x
Ctenophora phylum	x	x		x		x	x	x		x	x	x		x					x
Cyprinodon variegatus		1																	1
Fundulus heteroclitus	8		72	3	160			2			49		15				2		311
Fundulus majalis	494	34			3			2	4		7		1	88	1		31		665
Gasterosteus aculeatus															2				2
Gobiosoma bosc																	1		1
Libinia emarginata		x						x	x										x
Limulus polyphemus																	1		1
Menidia menidia	215	695	58	166	514	382	3	1632	75	1	387	2	41	278	27	3	178	129	4786
Menticirrhus saxatilis	13	4	472		1	1					1				37		1	42	572
Mercenaria mercenaria		x																	x
Microgadus tomcod										1	1			1		3	3		9
Morone americana											x								x
Morone saxatilis							1								1	2	2		6
Myoxocephalus aenaeus									1										1
Myoxocephalus octodecemspinos		4		1						4								3	12
Mytilus edulis		x														x			x
Nassarius obsoletus			x													x			x
Opsanus tau																	1		1
Pagurus spp		x		x			x		x		x		x		x	x		x	x
Palaemonetes vulgaris			x	x									x						x
Panopeus spp	x																		x
Paralichthys dentatus															2				2
Pomatomus saltatrix	1	1						11						2			3	12	30
Prionotus evolans				2															2
Pseudopleuronectes americanus	4					1			3		x		5			1	10	11	35
Sphoeroides maculatus	2	11		20	6	6	14		19			1	1	1	4	2	5	41	133
Syngnathus fuscus					2				1	3	1						1		8
Tautoga onitis	1	2			2	2	2		2	19	1	1	1	8		3	40		84
Tautogolabrus adspersus										4							1		5
Grand Total	**3785**	**835**	**606**	**199**	**697**	**392**	**20**	**2571**	**868**	**32**	**470**	**4**	**325**	**417**	**78**	**14**	**974**	**238**	**12525**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 5. Species presence by station for August 2020.

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	18	3				1	17		5		4	1							49
Anguilla rostrata			2						1										3
Brevoortia tyrannus			224				1		10	20	8			4					267
Calinectes sapidus	5	2	86	11				1			4		7			1	1		118
Carcinus maenus								x					x	x		x			x
Centropristus striata									2				1		4		1		8
Crangon septemspinosa																x			x
Crepidula fornicata																x	x		x
Ctenophora phylum				x			x			x						x	x	x	x
Cynoscion regalis		1																	1
Cyprinodon variegatus											5								5
Dorosoma cepedianum									5		1								6
Emerita talpoida															x				x
Fundulus heteroclitus	71	5	78	11	4	23		15	213		60		14	2		24	2		522
Fundulus majalis	266	291	103		12	17		93	233	47	64	7	13	2850	5	39	11	9	4060
Gasterosteus aculeatus																	1		1
Gobiosoma bosc				1															1
Gobiosoma genus									1										1
Isopoda order															x				x
Libinia emarginata									x			x				x			x
Menidia menidia	181	625	289	147	170	95	1426	105	814	1267	106	863	65	698	150	79	160	342	7582
Menticirrhus saxatilis	57	15	67	1	8			1	9		3	1	1	6	249		6	109	533
Microgadus tomcod							1									1			2
Morone saxatilis				19															19
Mugil curema						1												2	3
Myoxocephalus aenaeus				14	1	2	3		87							2		5	114
Myoxocephalus octodecemspinos													1						1
Mytilus edulis					x					x									x
Nassarius obsoletus		x		x				x											x
Opsanus tau									46										46
Ovalipes ocellatus		x					x												x
Pagurus spp		x		x				x	x		x	x		x				x	x
Palaemonetes vulgaris		x	x						x		x	x	x						x
Panopeus spp			x						x		x			x					x
Pomatomus saltatrix	2016	28	3				10	195	1		82							1	2336
Prionotus carolinus																1			1
Prionotus evolans	7	15																	22
Pseudopleuronectes americanus				8			1		16				5	2			1	1	34
Sphoeroides maculatus	1	9				1	1		15			1			10		1	7	46
Sphyraena borealis										1									1
Stenotomus chrysops		29		25			8		41			1		2	65		1	33	205
Strongylura marina		7		8			1	6	1				80				1	4	108
Syngnathus fuscus									1		1					1	5		8
Tautoga onitis		13	18	1	28	19	8	4	54	3	2	22	13	18		33	8	2	246
Tautogolabrus adspersus	1				9	6	47		35	3	1	1		10		24		4	141
Grand Total	**2623**	**1043**	**870**	**246**	**232**	**165**	**1524**	**420**	**1590**	**1341**	**341**	**897**	**200**	**3592**	**483**	**205**	**199**	**519**	**16490**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 6. Species presence by station for September 2020.

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	8						1		9		8	1	3	12				43
Brevoortia tyrannus		1		2						2		1	1	11				1	19
Calinectes sapidus			17	1								1	10		1		3		33
Carcinus maenus					x				x										x
Centropristus striata										2	1		26		13		1		43
Cliona celata											x								x
Crangon septemspinosa									x		x								x
Ctenophora phylum						x	x			x	x	x				x		x	x
Cyprinodon variegatus				1	3						10								14
Emerita talpoida															x				x
Etropus microstomus											1								1
Fistularia tabacaria										1									1
Fundulus heteroclitus	1		41					38			247		28	22					377
Fundulus majalis	195	201	42	3		27	1	49	34	1	150		22	53	3	1	35	4	821
Gobiosoma bosc					1				1		1	1	2						6
Libinia emarginata									x								x		x
Limulus polyphemus											1								1
Lucania parva																		1	1
Menidia menidia	1297	4130	46	718	1248	507	95	1157	93	1240	976	1281	1363	1238	1623	135	1198	638	18983
Menticirrhus saxatilis	28	4			2						1	5			7	1	6	1	55
Mugil curema														44				18	62
Myoxocephalus aenaeus									2						1				3
Nassarius obsoletus														x					x
Opsanus tau					1								1						2
Ovalipes ocellatus									1						6				7
Pagurus spp	x					x			x	x		x	x	x	x		x	x	x
Palaemonetes vulgaris		x	x		x							x		x		x		x	x
Panopeus spp				x					x	x							x		x
Paralichthys dentatus													1					1	2
Pomatomus saltatrix	97	30						4		2		63		18	208		103		525
Prionotus carolinus								1	2										3
Prionotus evolans													1				1	1	3
Prionotus genus															1				1
Pseudopleuronectes americanus		1				1	1												3
Sphoeroides maculatus	1	1						1	1			8	2				2		16
Stenotomus chrysops	3						5	11	2			4		12			6		43
Strongylura marina	13	3				11													27
Syngnathus fuscus	2			4						2									8
Tautoga onitis	4	6	1	2	23				20	11		3	15	3		8	5		101
Tautogolabrus adspersus					15	1	1		1	41		1		1		17	1		79
Grand Total	**1642**	**4385**	**147**	**731**	**1293**	**547**	**103**	**1262**	**157**	**1311**	**1388**	**1376**	**1473**	**1405**	**1875**	**162**	**1361**	**665**	**21283**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 7. Species presence by station for October 2020.

OCTOBER	**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	5	2								51						5			63
Brevoortia tyrannus	63	108													1		2		174
Calinectes sapidus			4	6		1											1	2	14
Carcinus maenus		x						x	x		x		x	x					x
Centropristus striata							4												4
Crangon septemspinosa			x			x												x	x
Crepidula fornicata	x							x								x			x
Ctenophora phylum	x				x	x	x				x	x					x	x	x
Cyanea capillata															x				x
Etropus microstomus																	1		1
Fistularia tabacaria							1												1
Fundulus heteroclitus			92	1					13				1	2			2		111
Fundulus majalis	170	600	69	46	1	4		48	27	4			5	72	5		9	89	1149
Gobiosoma bosc	1			1			1				1								4
Haliclona oculata											x								x
Libinia emarginata					x			x											x
Menidia menidia	4053	1170	815	249	5	1204	10	406	8	71	780	586	63	386	89	499	1000	65	11459
Menticirrhus saxatilis	8	18							1								4		31
Morone saxatilis										1		1				2			4
Mugil curema														1					1
Mytilus edulis										x									x
Nassarius obsoletus														x				x	x
Ovalipes ocellatus									4						3		1		8
Pagurus spp		x	x	x		x	x	x	x		x					x	x	x	x
Palaemonetes vulgaris			x	x	x		x	x	x		x	x	x	x		x	x		x
Panopeus spp	x		x	x	x						x								x
Peprilus triacanthus											2				1				3
Pomatomus saltatrix	1						1		1					1	3				7
Prionotus carolinus						1			1										2
Pseudopleuronectes americanus				2			2		3					1					8
Sphoeroides maculatus									1										1
Stenotomus chrysops							1		1								1		3
Strongylura marina									1				3						4
Syngnathus fuscus													1					2	3
Tautoga onitis					2	5	14		5	1		4	1	2		9	8		51
Tautogolabrus adspersus							21			1						1			23
Grand Total	**4301**	**1898**	**980**	**305**	**8**	**1215**	**55**	**454**	**66**	**129**	**783**	**591**	**74**	**465**	**102**	**516**	**1029**	**158**	**13129**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 8. Summary of species occurrence by station in 2020. 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).

ALL MONTHS	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	3068	86	501	6	2	1	17	924	768	60	25	9	262	42	12	5	691		6479
Anchoa mitchilli		8	103	6											4				121
Anguilla rostrata			2		2				1										5
Apeltes quadracus											1								1
Brevoortia tyrannus	63	109	224	2	2		1	1	10	22	8	1	1	15	1		2	1	463
Calinectes sapidus	8	4	112	20	3	1		1			5	1	18		1	1	12	2	189
Carcinus maenus	x	x		x	x	x		x	x		x		x	x		x			x
Centropristus striata							4		2	2	1		27		17		2		55
Cliona celata											x								x
Crangon septemspinosa		x	x			x	x	x	x		x			x		x		x	x
Crepidula fornicata	x							x	x							x	x		x
Ctenophora phylum	x	x		x	x	x	x	x		x	x	x		x		x	x	x	x
Cyanea capillata															x				x
Cynoscion regalis		1																	1
Cyprinodon variegatus		1		1	3						15							1	21
Dorosoma cepedianum									5		1								6
Emerita talpoida															x				x
Etropus microstomus							1				1				1		1		4
Fistularia tabacaria							1			1									2
Fundulus heteroclitus	86	5	374	15	204	26		55	226		379		58	26		24	17		1495
Fundulus majalis	1202	1126	214	51	19	48	1	192	326	52	222	7	41	3063	14	40	93	103	6814
Gasterosteus aculeatus															2		1		3
Gobiosoma bosc	1	2		2	2		1		1		2	1	2				1		15
Gobiosoma genus									1										1
Haliclona oculata											x								x
Isopoda order															x				x
Libinia emarginata	x	x			x			x	x			x				x	x		x
Limulus polyphemus					4	1		4			1						1		11
Littorina littorea								x											x
Lucania parva																		1	1
Menidia menidia	5749	6624	1210	1511	1964	2225	1534	3318	1033	2579	2264	2732	1532	2606	1889	716	3206	1189	43881
Menticirrhus saxatilis	106	41	544	1	11	1		1	10		5	6	1	6	293	1	17	152	1196
Mercenaria mercenaria		x																	x
Microgadus tomcod					6		1		1	4	2			1		4	8		27
Morone americana											x								x
Morone saxatilis				19			2			1		5	2		3	10	2		44
Mugil curema						1								45				20	66

Myoxocephalus aenaeus				14	2	2	3		90	1	4	1	2		1	2		5	127
Myoxocephalus octodecemspinos		4		1						4			1					3	13
Mytilus edulis		x			x			x	x	x						x			x
Nassarius obsoletus	x	x	x	x			x	x				x	x	x		x		x	x
Opsanus tau					1				46				1				1		49
Ovalipes ocellatus		x					x		5						9		1		15
Pagurus spp	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Palaemonetes vulgaris	x	x	x	x	x		x	x	x		x	x	x	x		x	x	x	x
Panopeus spp	x		x	x	x			x	x	x	x			x		x	x	x	x
Paralichthys dentatus													1		2			1	4
Peprilus triacanthus											2				1				3
Pomatomus saltatrix	2115	59	3				11	210	2	2	82	63		21	211		106	13	2898
Prionotus carolinus						1		1	3							1			6
Prionotus evolans	7	15		2									1				2	1	28
Prionotus genus															1				1
Pseudopleuronectes americanus	7	3	2	15		2	4		33		13		12	6		1	21	24	143
Sphoeroides maculatus	4	21	2	20	6	7	15	1	36			10	3	1	14	2	8	50	200
Sphyraena borealis										1									1
Stenotomus chrysops	3	29		25			14	11	44			5		14	65		8	33	251
Strongylura marina	13	10		8		11	1	6	2				83				1	4	139
Syngnathus fuscus	4			4	2				2	5	2		2			1	8	2	32
Tautoga onitis	14	40	19	3	78	28	24	4	82	35	4	31	31	34		53	71	2	553
Tautogolabrus adspersus	1				33	7	69		36	51	2	2		11		42	4	4	262
Urophycis regia											1				1				2
Grand Total	**12451**	**8188**	**3310**	**1726**	**2344**	**2362**	**1704**	**4729**	**2765**	**2820**	**3042**	**2874**	**2081**	**5891**	**2542**	**903**	**4285**	**1611**	**65628**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few.

Table 9. Numbers of juvenile winter flounder per seine haul in 2020.

	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	3	2	2	5	0	0	0	0	11	0	13	0	2	3	0	0	10	12	3.50	4.66	1.10
JUL	4	0	0	0	0	1	0	0	3	0	0	0	5	0	0	1	10	11	1.94	3.47	0.82
AUG	0	0	0	8	0	0	1	0	16	0	0	0	5	2	0	0	1	1	1.89	4.11	0.97
SEP	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0.17	0.38	0.09
OCT	0	0	0	2	0	0	2	0	3	0	0	0	0	1	0	0	0	0	0.44	0.92	0.22
Mean	1.40	0.60	0.40	3.00	0.00	0.40	0.80	0.00	6.60	0.00	2.60	0.00	2.40	1.20	0.00	0.20	4.20	4.80			
St Dev	1.95	0.89	0.89	3.46	0.00	0.55	0.84	0.00	6.66	0.00	5.81	0.00	2.51	1.30	0.00	0.45	5.31	6.14		Total Fish	
SE	0.87	0.40	0.40	1.55	0.00	0.24	0.37	0.00	2.98	0.00	2.60	0.00	1.12	0.58	0.00	0.20	2.37	2.75		143	
Number	7	3	2	15	0	2	4	0	33	0	13	0	12	6	0	1	21	24			

Table 10. Numbers of juvenile tautog per seine haul in 2020.

	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	9	19	0	0	23	2	0	0	1	1	1	1	1	3	0	0	10	0	3.94	6.90	1.63
JUL	1	2	0	0	2	2	2	0	2	19	1	1	1	8	0	3	40	0	4.67	9.90	2.33
AUG	0	13	18	1	28	19	8	4	54	3	2	22	13	18	0	33	8	2	13.67	14.18	3.34
SEP	4	6	1	2	23	0	0	0	20	11	0	3	15	3	0	8	5	0	5.61	7.16	1.69
OCT	0	0	0	0	2	5	14	0	5	1	0	4	1	2	0	9	8	0	2.83	4.00	0.94
Mean	2.80	8.00	3.80	0.60	15.60	5.60	4.80	0.80	16.40	7.00	0.80	6.20	6.20	6.80	0.00	10.60	14.20	0.40			
St Dev	3.83	7.91	7.95	0.89	12.58	7.70	6.10	1.79	22.37	7.87	0.84	8.93	7.16	6.69	0.00	13.05	14.53	0.89		Total Fish	
SE	1.71	3.54	3.56	0.40	5.63	3.44	2.73	0.80	10.00	3.52	0.37	3.99	3.20	2.99	0.00	5.84	6.50	0.40		553	
Number	14	40	19	3	78	28	24	4	82	35	4	31	31	34	0	53	71	2			

Table 11. Numbers of juvenile bluefish per seine haul in 2020.

	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	1	1	0	0	0	0	0	11	0	0	0	0	0	2	0	0	3	12	1.67	3.68	0.87
AUG	2016	28	3	0	0	0	10	195	1	0	82	0	0	0	0	0	0	1	129.78	473.21	111.54
SEP	97	30	0	0	0	0	0	4	0	2	0	63	0	18	208	0	103	0	29.17	55.93	13.18
OCT	1	0	0	0	0	0	1	0	1	0	0	0	0	1	3	0	0	0	0.39	0.78	0.18
Mean	637.20	13.76	0.75	0.00	0.00	0.00	2.50	52.50	0.25	0.50	20.50	15.75	0.00	5.00	52.00	0.00	26.50	3.25			
St Dev	891.49	15.72	1.50	0.00	0.00	0.00	5.00	95.11	0.50	0.89	36.67	28.17	0.00	8.72	104.00	0.00	51.02	5.27		Total Fish	
SE	398.69	7.03	0.67	0.00	0.00	0.00	2.24	42.53	0.22	0.40	16.40	12.60	0.00	3.90	46.51	0.00	22.82	2.36		2898	
Number	2115	59	3	0	0	0	11	210	2	2	82	63	0	21	211	0	106	13			

Table 12. Numbers of striped bass per seine haul in 2020.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	0	0	0	0	0	1	0	0	0	0	4	2	0	2	6	0	0	0.83	1.69	0.40
JUL	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	2	0	0.33	0.69	0.16
AUG	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.06	4.48	1.06
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	1	0	1	0	0	0	2	0	0	0.22	0.55	0.13
Mean	0.00	0.00	0.00	3.80	0.00	0.00	0.40	0.00	0.00	0.20	0.00	1.00	0.40	0.00	0.60	2.00	0.40	0.00			
St Dev	0.00	0.00	0.00	8.50	0.00	0.00	0.55	0.00	0.00	0.45	0.00	1.73	0.89	0.00	0.89	2.45	0.89	0.00		Total Fish	
SE	0.00	0.00	0.00	3.80	0.00	0.00	0.24	0.00	0.00	0.20	0.00	0.77	0.40	0.00	0.40	1.10	0.40	0.00		44	
Number	0	0	0	19	0	0	2	0	0	1	0	5	2	0	3	10	2	0			

Table 13. Numbers of juvenile river herring per seine haul in 2020.

	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	501	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	27.94	118.06	27.83
JUL	3044	73	0	6	2	0	0	923	763	0	21	0	261	39	0	0	689	0	323.39	742.32	174.97
AUG	18	3	0	0	0	1	17	0	5	0	4	1	0	0	0	0	0	0	2.72	5.59	1.32
SEP	1	8	0	0	0	0	0	1	0	9	0	8	1	3	12	0	0	0	2.39	3.93	0.93
OCT	5	2	0	0	0	0	0	0	0	51	0	0	0	0	0	5	0	0	3.50	11.97	2.82
Mean	613.60	17.20	100.20	1.20	0.40	0.20	3.40	184.80	153.60	12.00	5.00	1.80	52.40	8.40	2.40	1.00	138.20	0.00			
St Dev	1358.65	31.33	224.05	2.68	0.89	0.45	7.60	412.67	340.67	22.15	9.11	3.49	116.61	17.16	5.37	2.24	307.91	0.00		Total Fish	
SE	607.61	14.01	100.20	1.20	0.40	0.20	3.40	184.55	152.35	9.90	4.07	1.56	52.15	7.67	2.40	1.00	137.70	0.00		6479	
Number	3068	86	501	6	2	1	17	924	768	60	25	9	262	42	12	5	691	0			

Table 14. Numbers of juvenile menhaden per seine haul in 2020.

	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	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0.17	0.51	0.12
AUG	0	0	224	0	0	0	1	0	10	20	8	0	0	4	0	0	0	0	14.83	52.47	12.37
SEP	0	1	0	2	0	0	0	0	0	2	0	1	1	11	0	0	0	1	1.06	2.58	0.61
OCT	63	108	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	9.67	28.65	6.75
Mean	12.60	21.80	44.80	0.40	0.40	0.00	0.20	0.20	2.00	4.40	1.60	0.20	0.20	3.00	0.20	0.00	0.40	0.20			
St Dev	28.17	48.19	100.18	0.89	0.89	0.00	0.45	0.45	4.47	8.76	3.58	0.45	0.45	4.80	0.45	0.00	0.89	0.45		Total Fish	
SE	12.60	21.55	44.80	0.40	0.40	0.00	0.20	0.20	2.00	3.92	1.60	0.20	0.20	2.14	0.20	0.00	0.40	0.20		463	
Number	63	109	224	2	2	0	1	1	10	22	8	1	1	15	1	0	2	1			

Table 15. Numbers of juvenile black sea bass per seine haul in 2020.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
AUG	0	0	0	0	0	0	0	0	2	0	0	0	1	0	4	0	1	0	0.44	1.04	0.25
SEP	0	0	0	0	0	0	0	0	0	2	1	0	26	0	13	0	1	0	2.39	6.63	1.56
OCT	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0.22	0.94	0.22
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.40	0.40	0.20	0.00	5.40	0.00	3.40	0.00	0.40	0.00			
St Dev	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.89	0.89	0.45	0.00	11.52	0.00	5.64	0.00	0.55	0.00		Total Fish	
SE	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.40	0.40	0.20	0.00	5.15	0.00	2.52	0.00	0.24	0.00		55	
Number	0	0	0	0	0	0	4	0	2	2	1	0	27	0	17	0	2	0			

Table 15. Temperature, salinity, and dissolved oxygen by station and month – 2020

		Month					
Station		JUN	JUL	AUG	SEP	OCT	Total Average
1	Temperature (C)	21.2	24.1	24.2	22.9	18.4	110.80
	Salinity	22.7	24.3	24.9	26.5	24.9	123.30
	Dissolved Oxygen	9.9	6.1	6.8	6.7	7.7	37.20
2	Temperature (C)	20.4	23.4	26.7	23.1	18.5	112.10
	Salinity	24.1	26.3	25.2	26.9	26	128.50
	Dissolved Oxygen	8.2	6	6.6	7.6	8.5	36.90
3	Temperature (C)	22	25.7	27.3	17.6	15.9	108.50
	Salinity	25.8	26.3	27.4	28.1	27.7	135.30
	Dissolved Oxygen	8.6	5.8	5.8	8	8.9	37.10
4	Temperature (C)	21.6	23.7	27.7	16.6	14.7	104.30
	Salinity	25.4	27	27.5	27.3	27.9	135.10
	Dissolved Oxygen	7.3		6.1	8.5	8.8	30.70
5	Temperature (C)	20.4	25.3	27.6	17.5	18.3	109.10
	Salinity	26.6	27.4	28.1	28.5	28.2	138.80
	Dissolved Oxygen	8	7.1	8.2	7.8	7.8	38.90
6	Temperature (C)	20	22	26.5	18.7	17.3	104.50
	Salinity	27.2	27.9	28.7	29.1	29.4	142.30
	Dissolved Oxygen	8.5	6.2	9.9	8.2	9.1	41.90
7	Temperature (C)	17.3	21.3	24.5	18.1	18	99.20
	Salinity	27.8	28.2	28.8	29.3	29.5	143.60
	Dissolved Oxygen	9.2	7.2	6.7	7.7	11.5	42.30
8	Temperature (C)	20.2	24.3	26.3	22.8	18.6	112.20
	Salinity	26.1	27.5	27.9	28.4	28.4	138.30
	Dissolved Oxygen	8.5	6.6	6.5	7.9	8	37.50
9	Temperature (C)	18.6	22.3	23.1	18.9	19	101.90
	Salinity	24.8	27.7	28.5	29.1	28.9	139.00
	Dissolved Oxygen	9.2	6.5	6.2	9.6	9.6	41.10
10	Temperature (C)	14.3	20.6	23.8	21.2	18.2	98.10
	Salinity	28.7	28.8	28.8	29.2	29.5	145.00
	Dissolved Oxygen	11.2	8.4	7.9	6.5	10.5	44.50
11	Temperature (C)	20.3	25.2	24.1	17.9	16.4	103.90
	Salinity	24.8	26.2	27.9	28.4	27.1	134.40
	Dissolved Oxygen	6.3	4.9	5.7	7.3	8.7	32.90
12	Temperature (C)	19	24.1	26.3	23.4	19	111.80
	Salinity	24.9	26.5	27.1	28.1	28.2	134.80
	Dissolved Oxygen	9.7	6.6	7.1	7.1	7.4	37.90
13	Temperature (C)	19.7	24.7	26.7	23.9	19.3	114.30
	Salinity	26.8	27.3	28	28.6	28.8	139.50
	Dissolved Oxygen	6.7	6.6	7.1	9.1	7.6	37.10
14	Temperature (C)	19.5	23.7	26.2	23.7	18.8	111.90
	Salinity	27.4	28.3	28.5	28.9	29.1	142.20
	Dissolved Oxygen	8	6.1	6.6	9	9.4	39.10
15	Temperature (C)	18.2	21.9	24.9	22.1	18.4	105.50
	Salinity	27.6	28.8	28.8	29.3	29.5	144.00
	Dissolved Oxygen	9.1	6.6	8.1	7	8.1	38.90
16	Temperature (C)	17	21.2	24.2	18.7	17.1	98.20
	Salinity	27.1	26.1	28.3	29.3	28.9	139.70
	Dissolved Oxygen	8.9	7.4	7	7.9	8.8	40.00
17	Temperature (C)	18.7	25.6	26.6	24.1	18.9	113.90
	Salinity	26	26.5	27.2	27.8	28.2	135.70
	Dissolved Oxygen	9	7	0	7.5	7	30.50
18	Temperature (C)	21.5	22.7	26.9	17.9	16.1	105.10
	Salinity	27	27.6	28.5	29	29.1	141.20
	Dissolved Oxygen	7.7	6.2	7.2	9	8.9	39.00

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	33	1988-2020
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	33	1988-2020
	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	33	1988-2020
	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	33	1988-2020
	Station Periods	4	Stations were added to the survey on 3 separate occasions (station 16 added June 1990, station 17 added July 1993, station 18 added July 1995)
	Temperature (°C)	Continuous	
	Salinity (ppt)	Continuous	
	Station	18	18 fixed stations throughout bay
	Month	5	June - October

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

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

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

The final models for the analysis of catch rates were:

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

Assessment of Recreationally Important Finfish
Stocks in Rhode Island Coastal Waters
F20AF00145

2020 Performance Report for Job V:

Holistic Fish Habitat Assessment and Fish Productivity Estimations

Edited By

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Federal Aid in Sportfish Restoration
F-61-R

PERFORMANCE REPORT

STATE: Rhode Island

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

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: V: Holistic Fish Habitat Assessment and Fish Productivity Estimations

STAFF: Pat Barrett (Fisheries Specialist), Eric Schneider (Principal Biologist), and Conor McMannus (Deputy Chief), RI DEM, Div. of Marine Fisheries, Austin Humphries (Associate Professor), University of Rhode Island (URI), Will Helt (Coastal Restoration Scientist) and Heather Kinney (Coastal Restoration Science Technician), The Nature Conservancy of Rhode Island (TNC), and Randall Hughes (Associate Professor) and Jon Grabowski (Assistant Professor), Northeastern University (NU)

OVERVIEW:

Rhode Island marine sportfish are supported by a variety of coastal marine habitat types. As such, the preservation of said habitats are critical to sustaining their populations and associated recreational opportunities. However, which habitat types are best suited for sustaining recreational finfish populations has been challenging to assess given the multitude of habitats and varying ways in which fish abundance is monitored across habitat types. This project uses standardized surveys and analytical approaches to holistically assess fish habitat and quantify the fish production of recreationally important species that these habitats support. In doing so, it will result in new insights into the relative differences in the success of different coastal habitats in supporting local fish populations, and thereby provide guidance on future priorities for preserving and restoring certain habitat types. Job V is divided into following projects (A) kelp, (B) artificial reefs, (C) oyster reefs, and (D) eelgrass.

The work from all four projects will begin to codify a “RI Marine Habitat Program” that is proactive in assessing and enhancing sensitive and important marine habitat to support a healthy RI marine ecosystem. Results from this job would support aspects of a Marine Habitat Management and Restoration Plan, which would provide guidance for current (on-going) projects, as well as future work. Results will be a vital resource when prioritizing work and seeking funds via a competitive grant process. By establishing relationships between resource management agencies, environmental non-profits, academics, recreational sport fishing organizations, and commercial fisheries, we aim to facilitate -dialogue on establishing scientifically and socially-sound fish habitat enhancement practices in RI state waters.

PERFORMANCE REPORT

STATE: Rhode Island

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

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: V: Holistic Fish Habitat Assessment and Fish Productivity Estimations; Part A: Kelp Monitoring and Productivity Assessment

STAFF: Pat Barrett (Fisheries Specialist) and Conor Mcmanus (Deputy Chief) RI DEM, Div. of Marine Fisheries, and Austin Humphries (Associate Professor), University of Rhode Island, URI.

JOB OBJECTIVE:
The objectives of this work are:

1) Understand how important kelps are in supporting recreationally-important fish species in Rhode Island.

2) Assess how changing environmental conditions affect kelps and their associated communities through time.

TARGET DATE: 12/31/2020

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2020. During this period, we continued previously established surveys at kelp monitoring sites in Fort Wetherill and King’s Beach to monitor and collect estimates benthic and fish community biomass that will be used in combination with other metrics to quantify the increase in production of juvenile sportfish at kelp sites compared to habitat controls. In response to the Covid-19 pandemic, staffing and field survey data collection approaches had to be modified to ensure the safety of staff and the public. Although additional effort was required, all field survey work was completed as scheduled. In 2020, we completed 11 kelp habitat monitoring dives.

RECOMMENDATIONS:

None

INTRODUCTION:

Kelp forests are abundant and cover approximately 25% of the coastline globally (Krumhansl et al. 2016). Kelps themselves are a critically important ecosystem engineer, forming the foundation of many temperate and boreal coastal ecosystems. For instance, in the Northeast U.S. kelps provide nursery and refuge habitat, as well as food for a myriad of recreationally important fisheries species such as striped bass (*Morone saxatilis*), tautog (*Tautoga onitis*), and scup (*Stenotomus chrysops*). Different aspects of climate change and nutrient dynamics affect kelps, and can therefore have a large impact on goods and services of kelps, including recreational fisheries (Gagné et al. 1982, Smale et al. 2013). Kelps serve as good indicators of change because they are highly responsive to environmental conditions and are directly exposed to a variety of human activities (Wernberg et al. 2013). It is uncertain, however, how such changes will impact kelps, the foodwebs they support, and the associated fisheries. Thus, through this project we seek to understand how kelp ecosystems may be changed in the future, and to what extent they will be resilient to changes.

APPROACH:

This report summarizes all work conducted for this project between January 1, 2020 and December 31, 2020. During this period we conducted fish habitat productivity surveys and conducted initial statistical analyses to understand how important kelps are in supporting recreationally-important fish species in Rhode Island and assess how changing environmental conditions affect kelps and their associated communities through time.

Fish Productivity Assessment

Sites were chosen in any area of Narragansett Bay and surrounding waters that is composed of primarily rock between 8-12m. All sites selected are sampled annually during the mid to late summer (i.e., July – September) to monitor the local kelp communities at peak diversity and abundance of finfish. Each site has five to six transects sampled to ensure a good site-level description of the community, each separated by at least 100m. Treatment sites should have kelps present, whereas control sites should not. At least one Hobo Onset 64K Pendant Loggers UA-001-64 are placed within the site. Transects are 40m in length and should run roughly parallel to shore following a depth contour line between 8-12m. Five sampling methodologies are used along each transect:

1) **Quadrat:** Along each transect, a diver places a 1m^2 PVC frame on the bottom and the diver records the number of all target species. Substrate beneath understory algae is searched, however, neither the substrate nor the organisms attached to it are removed. For a 40m transect line, there are 6 sample points 8m apart, half on the onshore side and half on the offshore side.
2) **Uniform point count:** The diver swims the length of the 40m transect centering a 1m PVC stick perpendicular to the transect tape at each 1m interval. The diver then records the species that intersects an imaginary vertical line (operationally defined as a distinct "point" ~2mm in diameter) positioned at each end of the meter stick (n = 80 points per transect). Additionally, the substrate type under each point is noted. If there are multiple

species encountered under the point (e.g., algae on top of a tunicate), then all species of plant/animal should be recorded.

3) **Swath:** This sampling is performed by a diver swimming the length of the 40m transect twice, once on the onshore and once on the offshore side of the transect. As the diver swims, they use a 1m long PVC stick perpendicular to the transect tape (and approximately 25cm off the bottom) and records the abundance of all targeted species encountered in each 40m x 1m area. The total area sampled is 80 m^2. The substrate beneath understory algae is searched for target species, as are the undersides of ledges and crevices.
4) **Fish counts:** Fish sampling is performed by a diver slowly swimming the length of the 40m transect about 1m above the transect line recording the abundance and size of all fish individuals encountered within a predefined imaginary "cube". This "cube" extends 3m on either side of the transect tape (6m across) and 3m up from the substrate (3m high). Every fish sighted within the sampling area during the survey is recorded in 10-cm size bins.
5) **Morphometrics:** Along the transect, divers should swim and collect 1 adult individual of each species of subsurface kelp every 4 meters (n=10 individuals per transect). This should be completed after all other protocols are carried out to avoid biasing any other results since it is destructive. Back on land or the boat, measure and record the relevant dimensions of the kelp to determine its biomass (e.g., for *Saccharina latissima*, record blade length and width, and record stipe length).

Analytical Approach

The Uniform Point Count (UPC) survey data was distilled into two categories, substrate and biological cover. The percent substrate for each transect was calculated by multiplying the number of substrate counts per substrate type by the total number of counts per transect (n=80). Biological percent cover is presented as the mean ± SE for each site (Fort Wetherill and King's Beach) and grouped by habitat type (Kelp or Control). Control sites are similar in rocky substrate to kelp ones, but contain less than 15% percent kelp coverage on average. The mean percent cover of algae and sessile inverts were used to calculate species richness and diversity, using both the abundance of unique species and the Shannon's H index of diversity respectively.

Kelp and invertebrate densities were determined using the quadrat and swath datasets. The quadrat dataset was used primarily to estimate kelp density as well as any inverts present in the quadrats. For each transect, a mean, ± SE, was calculated in order to present a more precise estimate of the overall transect kelp, or invertebrate, density. The swath dataset was used to count the total abundance of rare or less uniformly distributed sessile and mobile invertebrates species. For both the quadrat and swath methods, the average quadrat density or total abundance within the swath were standardized per meter squared. To compare how invertebrate densities differed between the habitat treatments (e.g., control and kelp) we present the average invertebrate density per meter squared, summarized for each site (Fort Wetherill and King's Beach) and grouped by survey method (Quad or Swath). For the two kelp species, *Sacharrina lattissima* and *Lamanaria digitia*, we leveraged previously collected kelp density data to add to the Rhode Island long term kelp dataset and calculate the rate of change for each kelp species since 2016. The rate was estimated using a maximum likelihood approach to fit the mean kelp density data to an exponential decay model to estimate the instantaneous rate change.

Using the fish count survey data, we converted abundance at estimated length, to total fish mass per transect, using the DMF age and growth lab data to convert fish length in cm, to weight in grams. Length-weight relationships for available species were calculated using coefficients provided by DEM and FishBase using the following equation (Froese and Pauly 2020):

$$Weight = \alpha Length^{\beta}$$

For species not currently dissected in the growth lab, we used the geometric mean alpha and beta coefficients presented on Fishbase.org. To compare total fish biomass between our kelp and control, we then standardized the total fish mass by dividing the total area surveyed, to get grams per meter squared. For the two years since the begging in of the King's Beach site (e.g. 2019 and 2020) we present total fish biomass per habitat treatment, ± SE, grouped by site (e.g., Fort Wetherill and King's Beach). In addition to the kelp density data, we also added the total fish biomass estimates to the long-term kelp data set (2016-2020) to investigate fish habitat linkages between kelp habitat and fish biomass over time.

In 2020, we began preliminary modeling efforts looking at the impact of kelp density on the observed biomass of finfish, uing a simple linear regression model to predict fish biomass as a function of increasing kelp density. We present observed fish biomass and kelp density data and the significant linear relationship as well as 95% confidence interval obtained resampling the data points via bootstrap methods. We resampled the data 1000 times, each time refitting a new linear model of fish biomass ~ a*kelp density + b. We then used the 97.5 and 2.5 quantiles of the slope and intercept to represent the 95 % CI interval around those predictions. In addition to the linear model, we also present non-linear fit using non least squares method. Kelp morphometrics were summarized using a histogram of blade lengths, for each species, site, and year of the concurrent running surveys (2019, 2020). In the future this information will be used to help transform mean kelp density into kelp biomass, leveraging the kelp morphometric data to estimate average kelp mass per fish productivity transect.

RESULTS:

In 2020, the kelp monitoring team completed 11 dives and monitored two separate kelp sites located at Fort Wetherill and King's Beach. We also added one control site to the long-term King's Beach monitoring location, bringing the total to 11 transects between the two sites (Figures 1 and 2). During the 2020 season, temperature loggers were left in place at the Fort Wetherill locations and continue to collect data. Temperature loggers will be added to the King's Beach location at the beginning of the 2021 field season.

We found the substrate conditions at each site (e.g. Fort Wetherill and King's Beach) to be fairly uniform between habitat types (e.g. Kelp or Control). On average the proportion of boulders (large, medium, and small combined) was approximately 72.42 and 52.2% percent coverage at our kelp and control locations (Figure 3). Both of kelp site are near the mouth of Narragansett Bay and represent nearshore rocky reef habitats, typical of the region. In 2020, the percent cover of kelp was 7.7% greater at the Fort Wetherill (30%) sites compared to those off of Newport

(22.3%) (Figure 4). In the absence of kelp, at our control locations (kelp less than 10% on average), we found the rocky reef locations to be dominated by a variety a branching and filamentous red aglae. Specifically, *Chondrus chrispus* and *truncatus*, as well as several *Ceramium* species. In 2020, the algae and invertebrate species richness and diversity were highest on our kelp transects locations regardless of the site within the Narragansett Bay region (Table 1). Similar to the UPC, we identified more unique species at the kelp locations with respect to mobile inverts than we did the control locations during the quadrat and swath methods. Although small, the density of sea stars, urchins, and lobsters were greater at the kelp locations as well. We also found that the density of the northern star coral, *Astrangia Poculata*, was over 3 times greater at the kelp sites (3.017 ind/m^2 ± 1.35) than the control locations (0.75 ind./m^2 ± .45) (Figure 5).We found the average kelp density, across all kelp locations, to reflect the ongoing trend observed in the 2016-2020 long term kelp dataset. Total kelp density remained constant, with the estimated instantaneous rate of change to be 0.04 ± 0.09 per year (Figure 6). When the two kelp species were separated, we found that *Sachharina lattissima* has been increasing at a rate of 0.13 ± 0.09, where as *Laminaria digitata* has been declining at -.74 ± 0.07 (Figure 7).

In 2020 we found the average fish biomass to be greater at both the Fort Wetherill and King's Beach kelp sites than their respective controls (Figure 8). Total fish biomass on the kelp beds averaged 168.62 ± 43.36 grams per meter squared of kelp habitat at the King's Beach location where as the highest biomass observed at the control sites was only 5.17 ± 2.96 g/m^2 (Figure 8). Utilizing data available from the RI long term kelp data set, we combined our current fish biomass to determine the relative enhancement of kelp habitat on specific finfish species of interest. We found the density of Tautog, Cunner, Scup, Summer Flounder, Striped Bass, and Black Sea Bass, to be enhanced at 239.5%, 65.58%, 689.74%, 71.43%, NA, 87.53% relative to their respective control sites (Figure 9). In the simple linear regression model we found a significant, positive relationship between fish biomass and kelp density (p-value < 0.05, R^2 - 0.54) (Figure 10). Kelp blade length was summarized using histograms to differentiate the difference between the 2019 and 2020 seasons. We found the average blade length for both kelp species to be greater in 2020 than 2019 (Figure 11). Future analyses will use this data set to convert kelp density into biomass.

DISCUSSION:

The global abundance and resilience of kelp species has been impacted by increasing environmental stressors, such as heatwaves and increasing sea surface temperatures and kelp harvest (Wernberg et al 2019). Globally there has only been a modest decline, with kelp average instantaneous rate of change of negative 0.018 per year, However, the regional variation does exist with 28 percent of the kelp systems declining and 38% increasing relative to the global average (Krumhansl 2016). In context for Narraganset Bay kelp beds, the instantaneous rates of change derived for total kelp showed a marginal increase since 2016 (0.04 ± 0.09), however, the standard error of this estimate does overlap with the global average decline of 0.018 suggesting a non-detectable change compared to the global average. However, when you separate the rate of change between the two kelp species present in RI, we found that from 2016-2020, the instantaneous rate of change for *Sacharinna lattissima* increased with respect to the global average, whereas *Laminaria digitia* experienced a significant decline. As the work progresses, we will work to incorporate environmental variables into our analyses to help inform how the impact of changing temperature impacts the kelp system and it's associated inhabitants.

This work is crucial to monitor how impacts and changes to kelp beds further impacts sportfish productivity. Our preliminary analyses showed a positive enhancement effect on our target sportfish species with respect to the control sites, or rocky reef habitat that does not have kelp. Using this work to model the fish-habitat linkages we can identify the strength of these relationships and leverage this information to predict how changes in kelp habitat would impact sportfish and the food web in Narragansett Bay.

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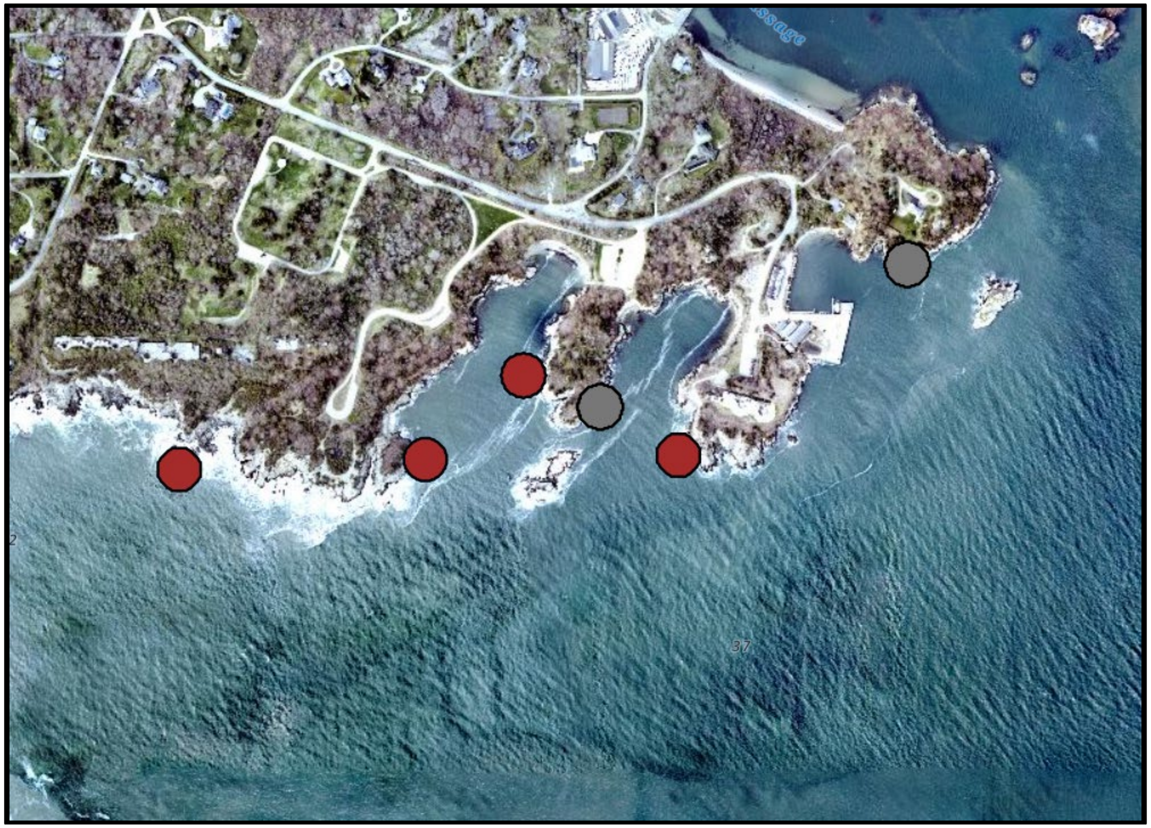


Figure 1: Fort Wetherill Kelp Productivity Dive Survey locations. Circles represent the general location of the six transects; Brown = Kelp, Grey = Control.

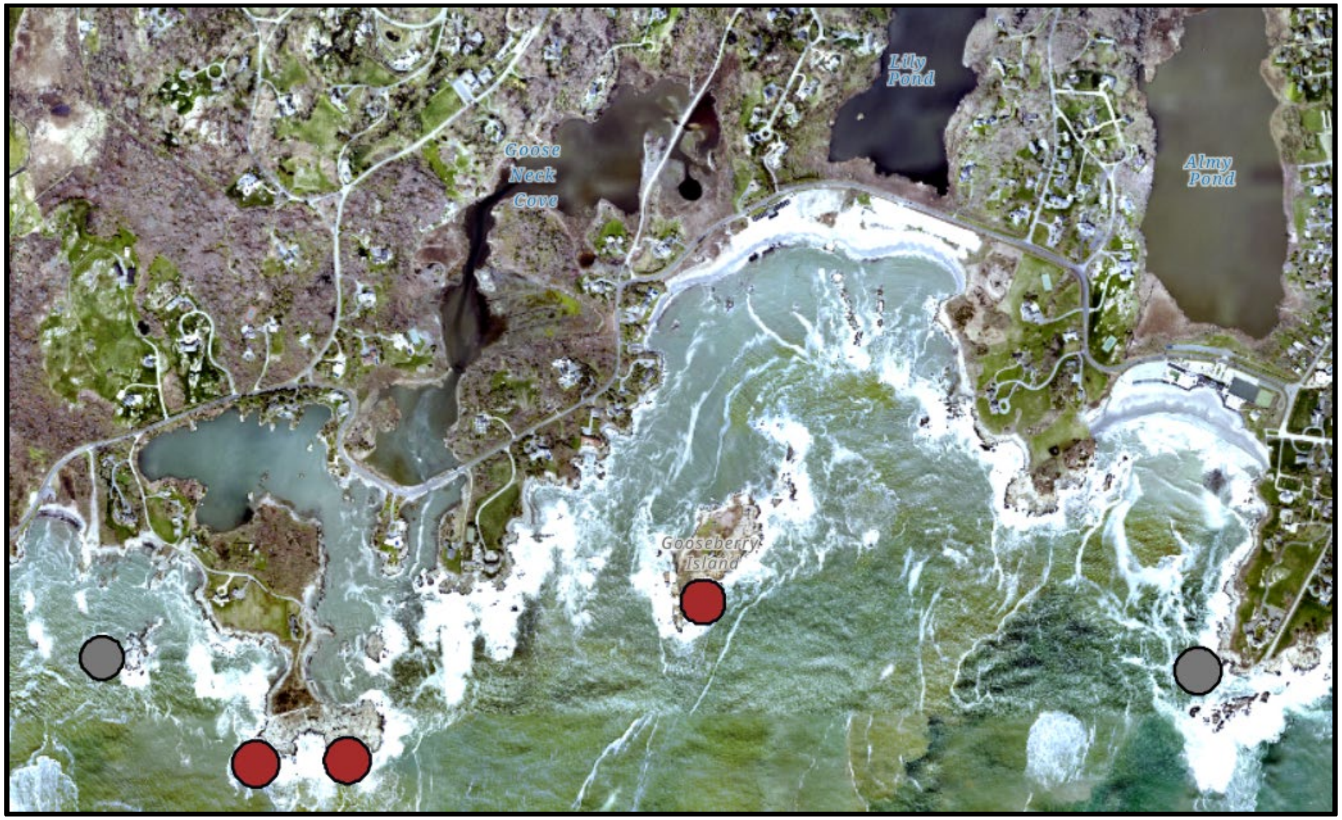


Figure 2: King’s Beach Kelp Productivity Dive Survey locations. Circles represent the general location of the five transects; Brown = Kelp, Grey = Control.

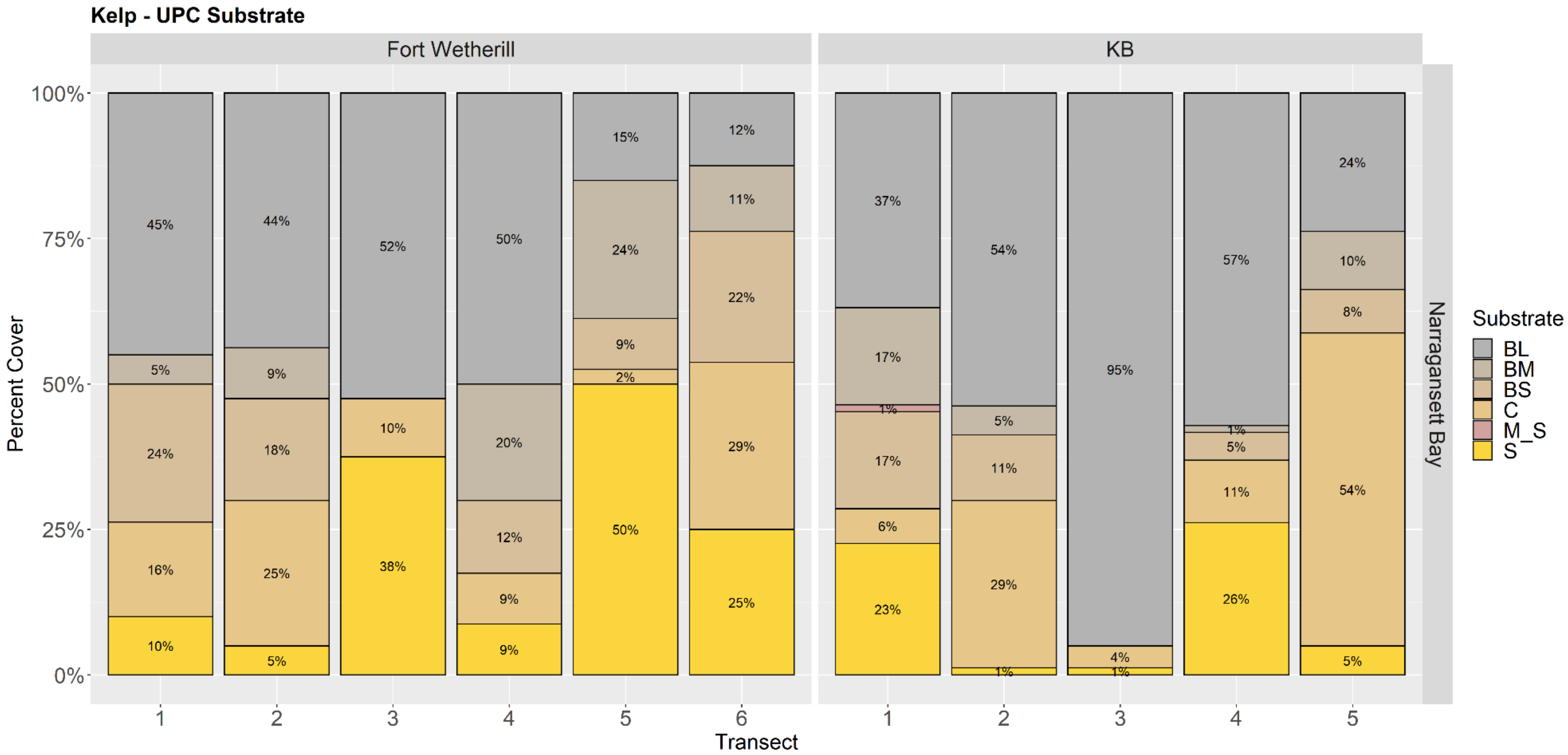


Figure 3. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 fish productivity survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, C= cobble, M = mud/fines, M_S = sandy mud mix, S = Sand, RB = Reef Ball) and faceted by Site (Fort Wetherill and KB = King's Beach)

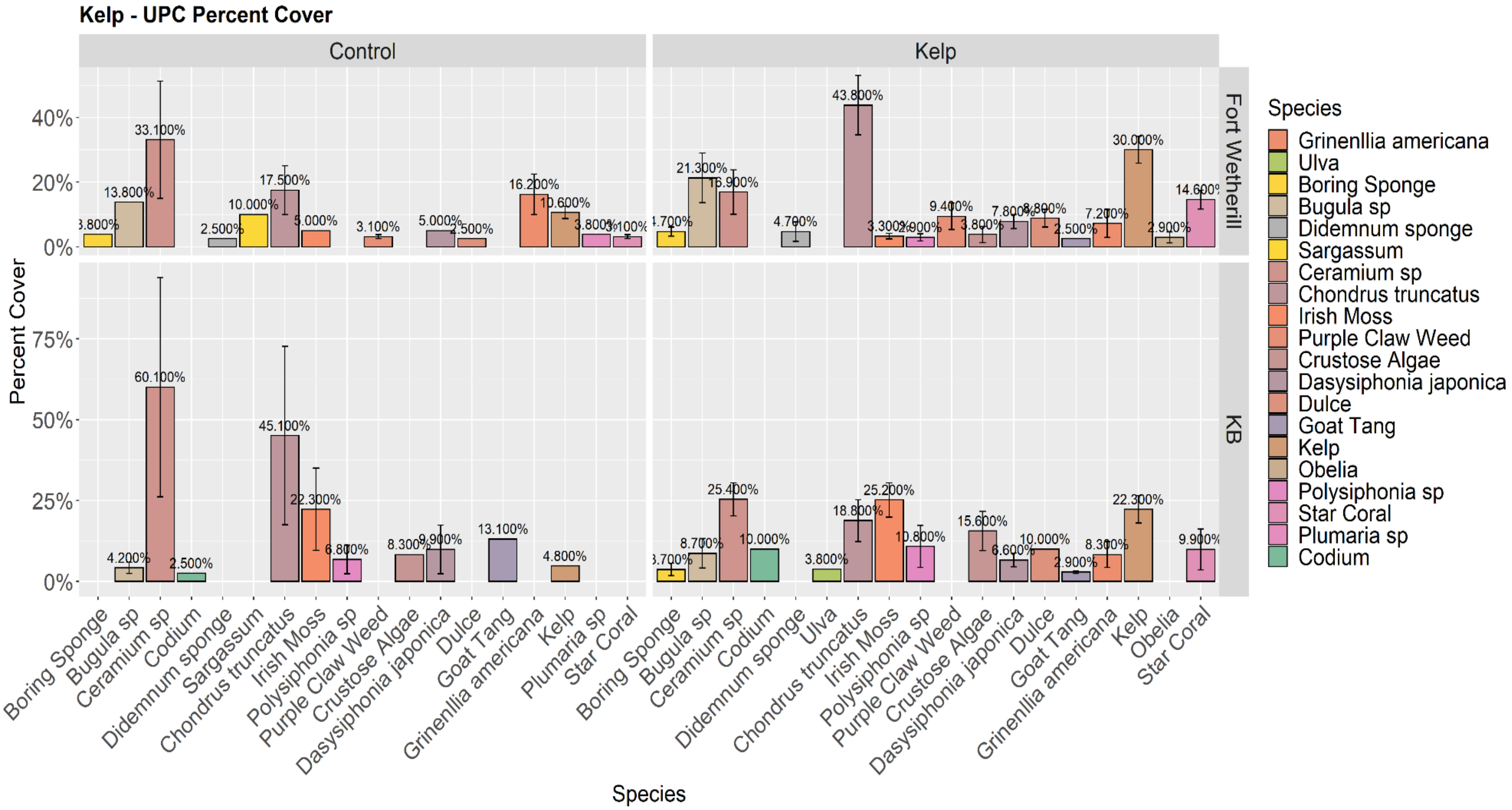


Figure 4. Mean algal and sessile invertebrate cover ± SE, for each habitat type (Kelp or Control) grouped by Site (Fort Wetherill and Kings Beach) during the 2020 productivity uniform point count survey.

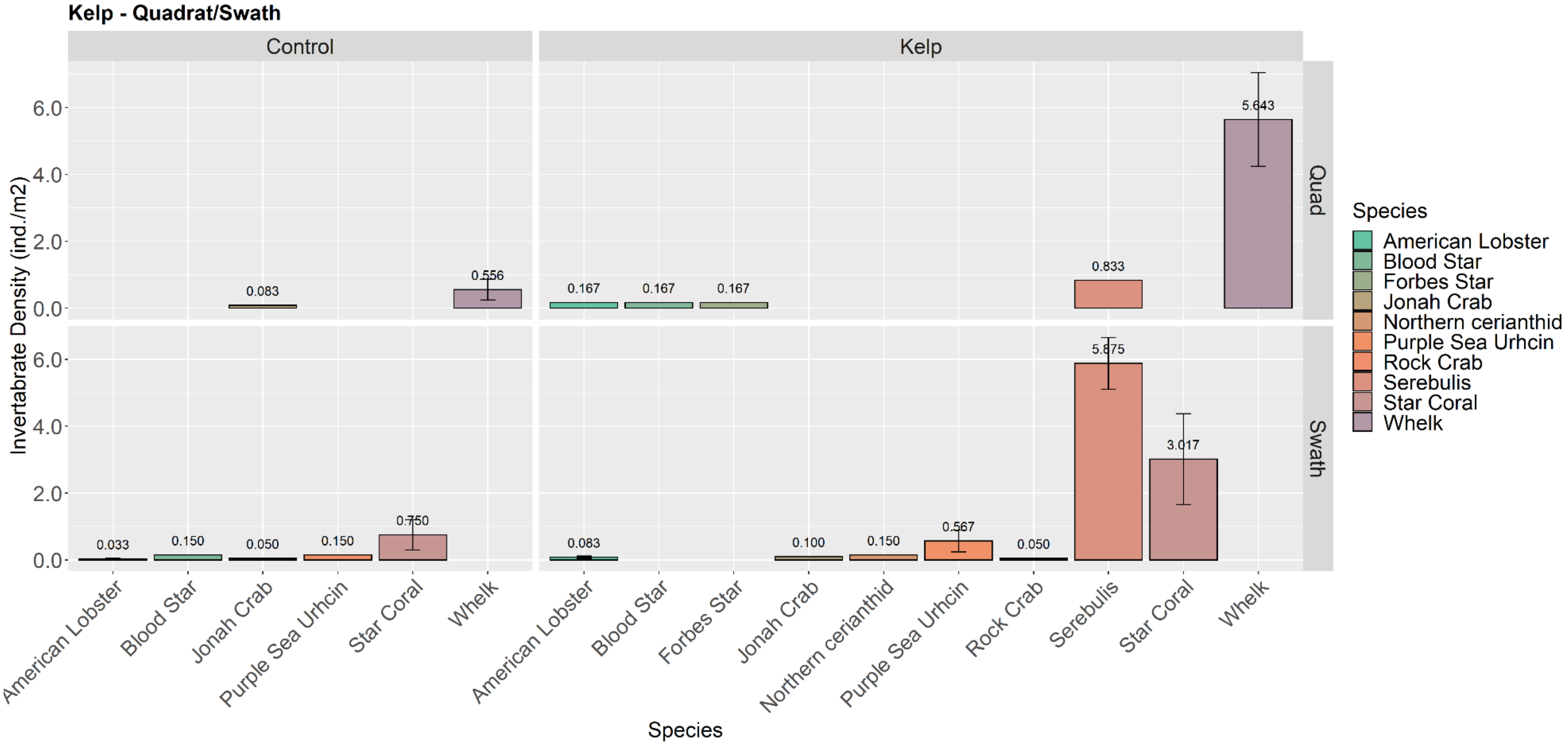


Figure 5. Mean invertebrate density ± SE, per habitat treatment (i.e., Kelp and Control) for the quadrat and swath transect surveys.

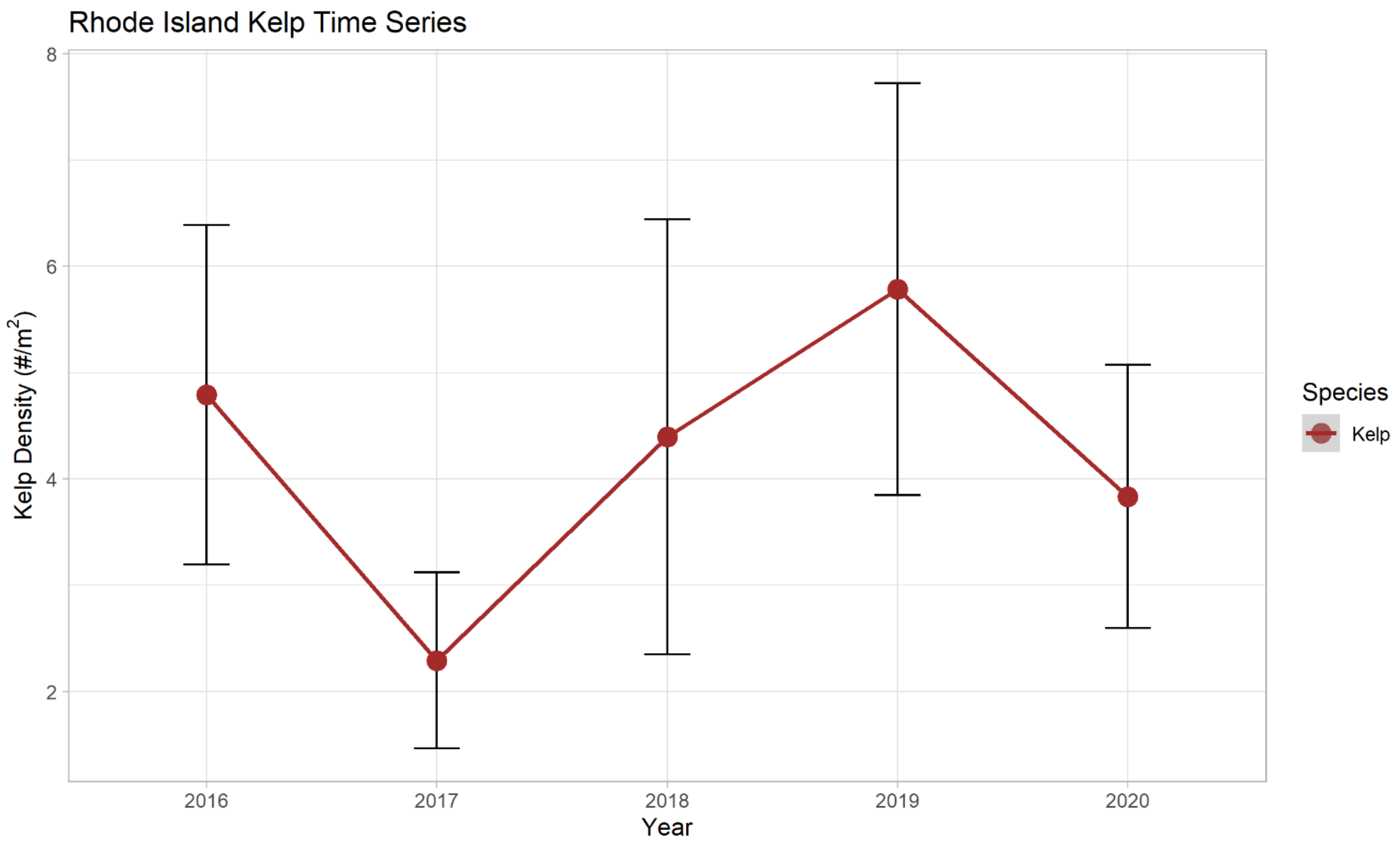


Figure 6: Average kelp density (mean ± SE) from 2016 – 2020 in the Narragansett Bay Region. Total kelp (e.g. *Sacharrina latissima* plus *Laminaria digitate*) density per meter squared for each year of the long-term Kelp monitoring survey. The instantaneous rate of change for total kelp over the 5 year dataset was 0.04 ± 0.09 per year.

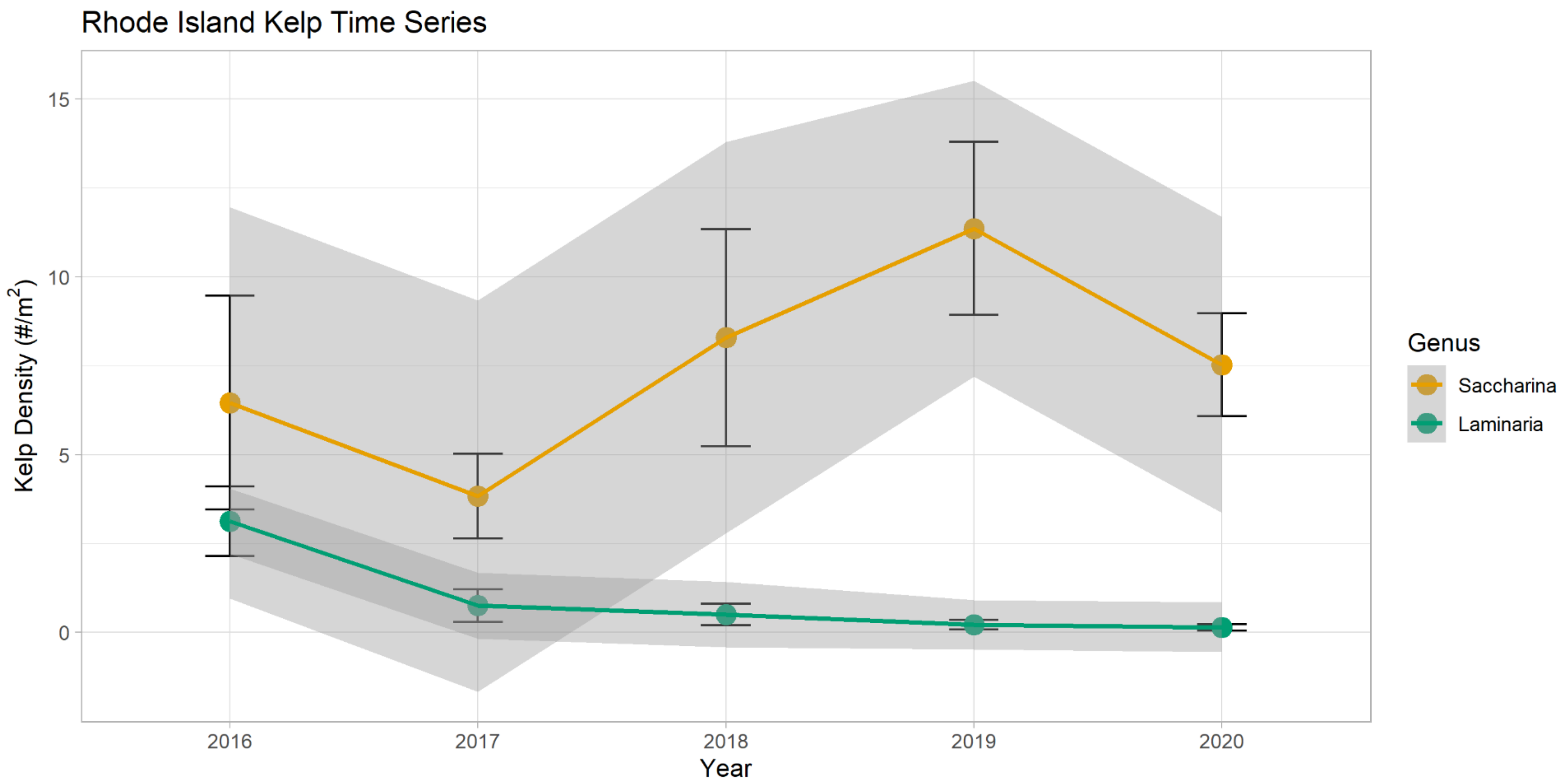


Figure 7. Average kelp density (mean ± SE) from 2016 – 2020 in the Narragansett Bay Region for each kelp specie (yellow = *Sacharrina latissima* and green = *Laminaria digitate*). Average density per meter squared (mean ± SE) for each year of the long-term Kelp monitoring survey plot. Grey ribbons represent the 95% CI. Instantaneous mortality rates of change for each species over the five year data was 0.13 ± 0.09 for *Sachharina lattisima* and -.74 ± 0.07 for *Laminaria digitia*.

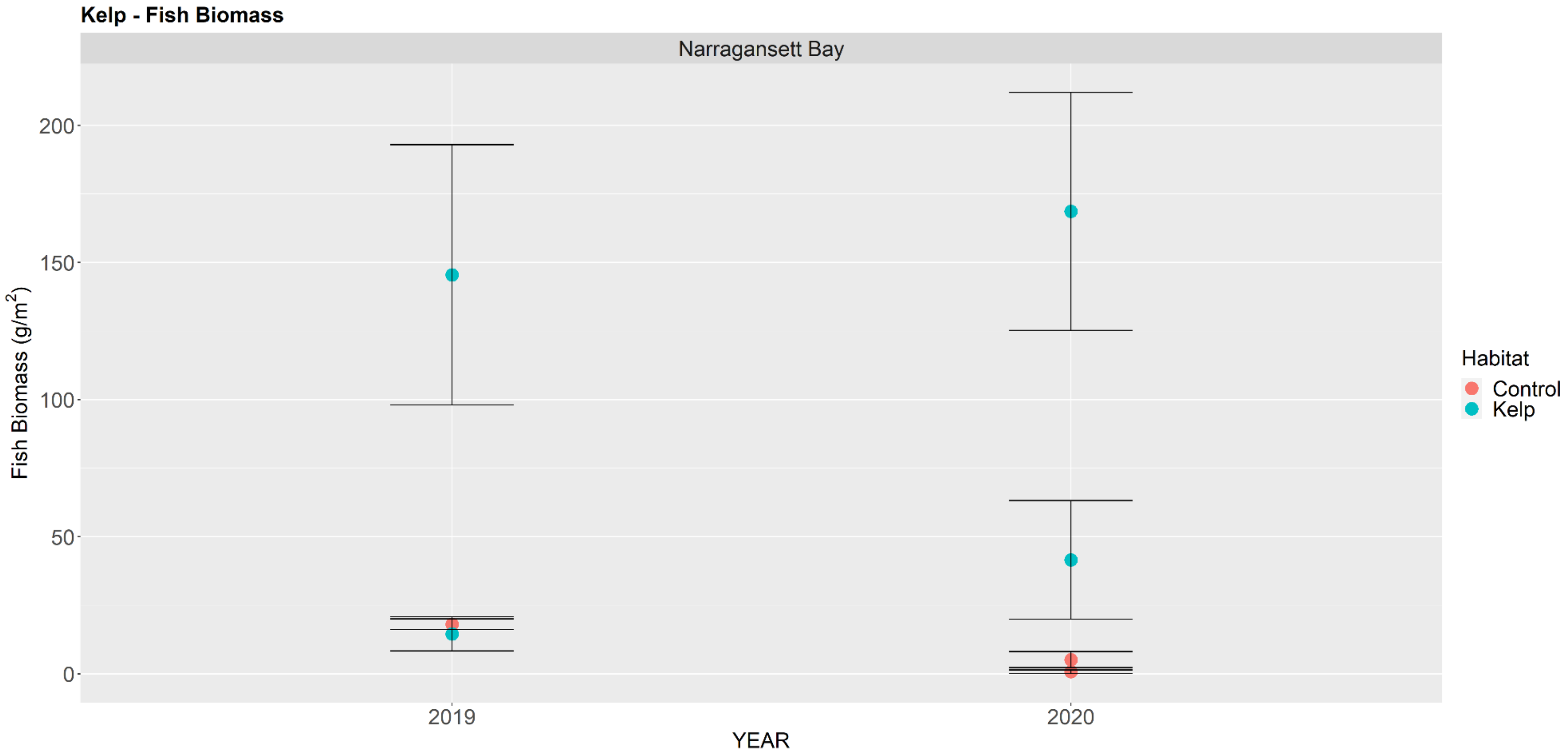


Figure 8. Mean fish biomass (g/m^2) for 2019 and 2020 kelp productivity fish count surveys. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (Kelp = blue, Control = red)

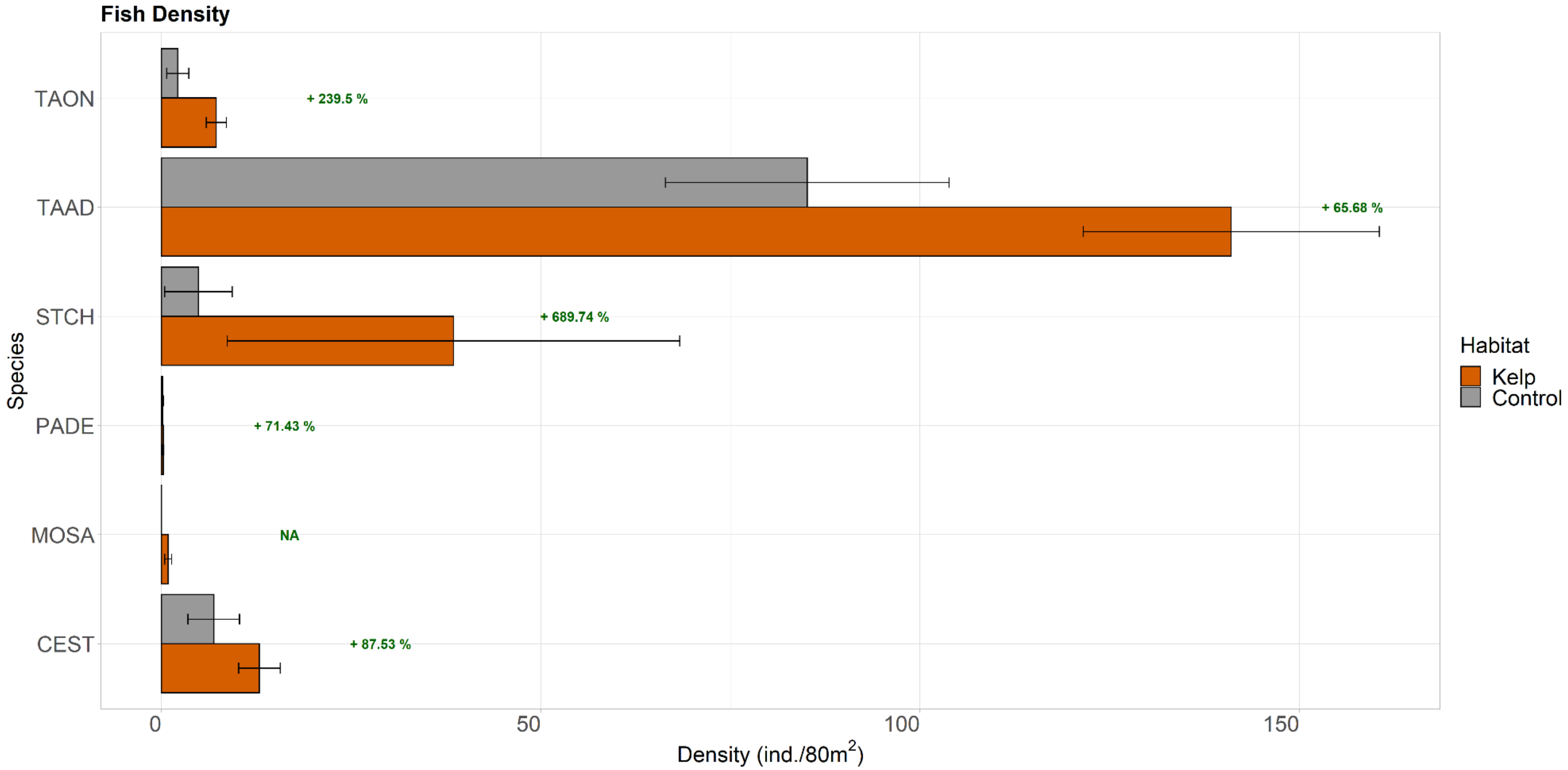


Figure 9: Average fish density (ind./80m^2) for species (y-axis) positively enhanced by kelp habitat (brown) relative to habitat controls (grey). The percent change between the control and the kelp habitat are shown for each enhanced species (TAON = Tautog, TAAD = Cunner, STCH = Scup, PADE = summer flounder, MOSA = Striped Bass, CEST = Black Sea Bass).

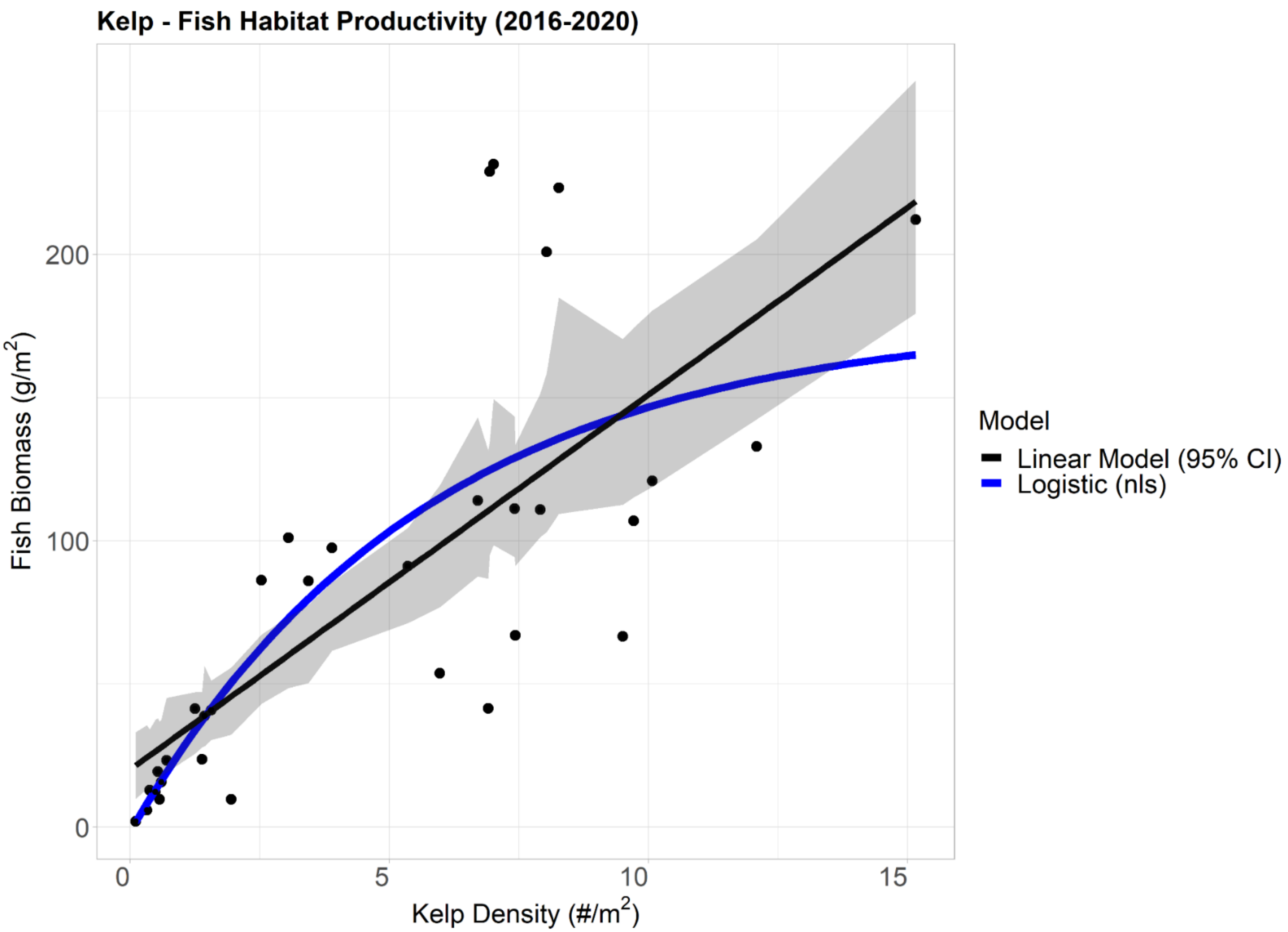


Figure 10. Linear model of observed fish biomass (grams) per meter squared of kelp habitat, as a function of observed kelp density (ind./m^2) (p.value < 0.05, R^2: 0.54). Data comes from the collective 2016-2020 kelp monitoring dataset. Grey line indicates 95%CI interval estimated via bootstrap method. Blue line represents an additional model fit using a non-linear least squares approach.

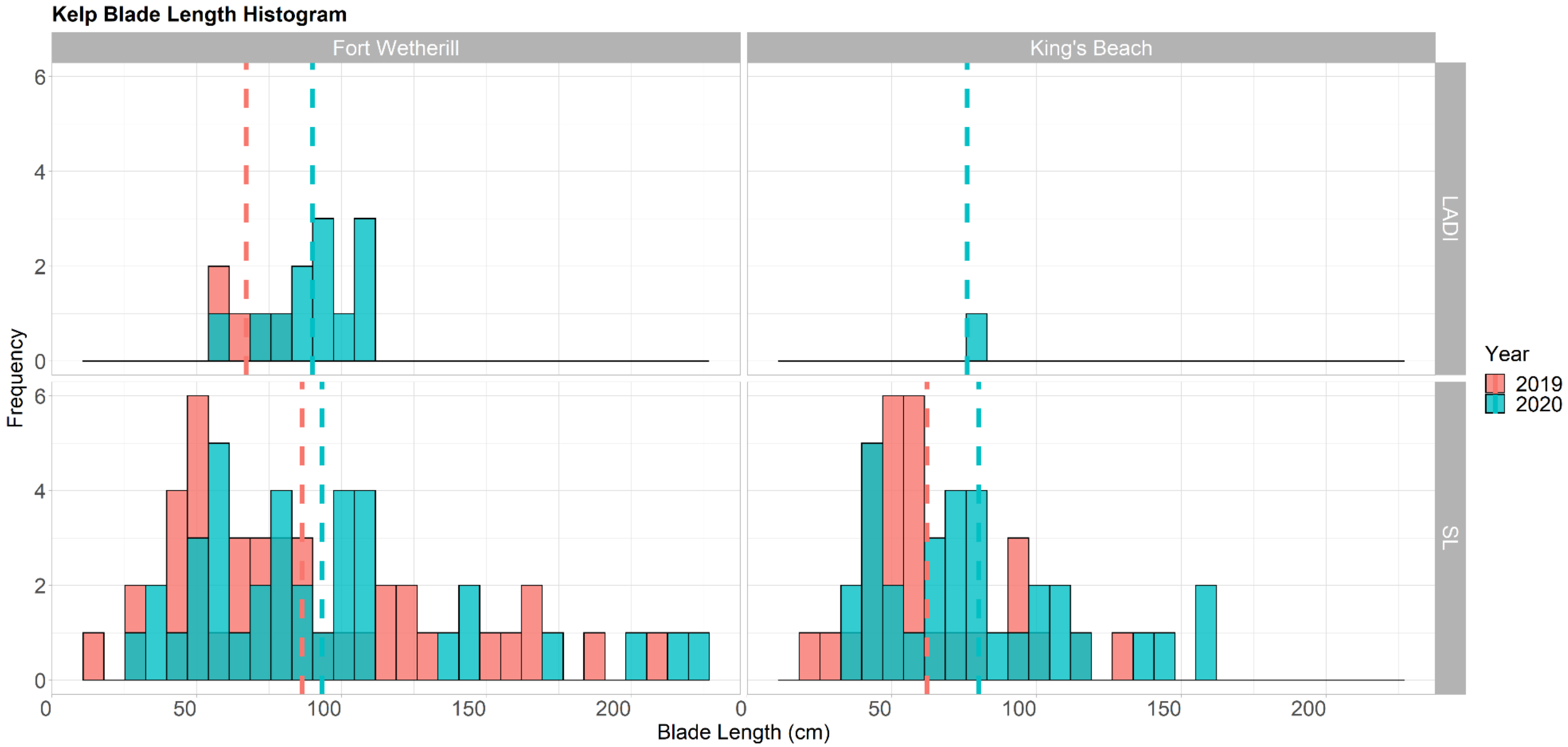
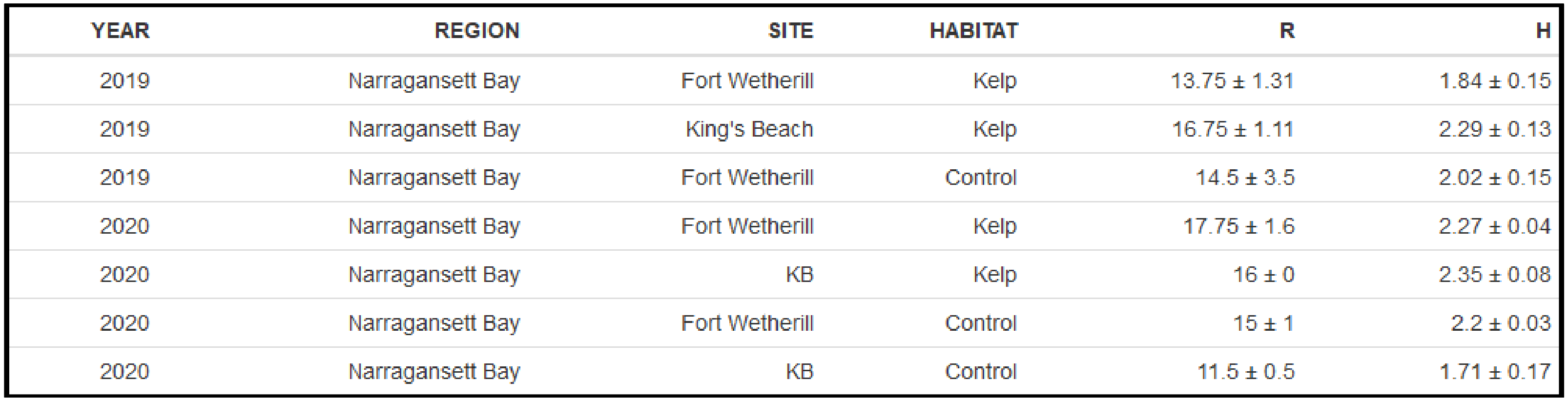


Figure 11 Histogram of blade length (cm) from 2019 – 2020 for each kelp species (LADI = *Lammaniria digitia*, SL = *Sacharina latissimi*) group by year (2019 = red, 2020 = blue). Dashed lines represent the mean blade length from the transect sub samples (n=10 per transect).

Table 1: Algae and Sessile Invertebrate species richness and diversity calculated from the uniform point count transect method in 2019 and 2020. These estimates only characterize the richness and diversity of species that adhere to the substrate or habitat and does not include mobile inverts or finfish.



YEAR	REGION	SITE	HABITAT	R	H
2019	Narragansett Bay	Fort Wetherill	Kelp	13.75 ± 1.31	1.84 ± 0.15
2019	Narragansett Bay	King's Beach	Kelp	16.75 ± 1.11	2.29 ± 0.13
2019	Narragansett Bay	Fort Wetherill	Control	14.5 ± 3.5	2.02 ± 0.15
2020	Narragansett Bay	Fort Wetherill	Kelp	17.75 ± 1.6	2.27 ± 0.04
2020	Narragansett Bay	KB	Kelp	16 ± 0	2.35 ± 0.08
2020	Narragansett Bay	Fort Wetherill	Control	15 ± 1	2.2 ± 0.03
2020	Narragansett Bay	KB	Control	11.5 ± 0.5	1.71 ± 0.17

2020 Performance Report for Job VI, Parts B March 19, 2021

PERFORMANCE REPORT

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

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: V: Holistic Fish Habitat Assessment and Fish Productivity Estimations; Part B: Artificial Reef Monitoring and Productivity Assessment

STAFF: Pat Barrett (Fisheries Specialist) RI DEM, Div. of Marine Fisheries, and Will Helt (Coastal Restoration Scientist) and Heather Kinney (Coastal Restoration Science Technician), The Nature Conservancy of Rhode Island (TNC)

JOB OBJECTIVE:
The objectives of this work are:

1) To monitor the Sabin Point Artificial Reef (SPAR) site constructed in October 2019 and compare it to adjacent sites in the Upper Narragansett Bay and Providence River.

2) Assess the success of the SPAR site, and identify and design plans to construct artificial reef habitat in different areas of Rhode Island (e.g., Narragansett Bay, Rhode Island Sound, South County Coastal Ponds) to assess the feasibility of artificial reefs as a cost-effective management strategy to increase the stock of important recreational finfish species

TARGET DATE: 12/31/2020

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2020. In response to the Covid-19 pandemic, staffing and field survey data collection approaches had to be modified to ensure the safety of staff and the public. Although additional effort was required, all field survey work was completed as scheduled. During this period, we continued to monitor the upper Narraganset Bay and Providence River via our fish pot survey, successfully deploying fish pots once a month at all stations from May-October. In 2020, we completed the first year of post artificial reef enhancement, fish productivity dive surveys. During this period, we continued previously established surveys at artificial reef monitoring sites in the Providence River, performing 10 dives to monitor and collect estimates benthic and fish community biomass that will be used in combination with other metrics to quantify the increase in production of sportfish at the Sabin Point Artificial Reef site compared to habitat controls.

RECOMMENDATIONS:

None

The Rhode Island Chapter of The Nature Conservancy
Annual Progress Report

Submitted to

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

Title: Holistic Fish Habitat Assessment and Fish Productivity Estimations of Artificial Reefs

Cooperative Agreement Award Number: 3374051

Award Term: 1/15/2020 – 12/31/2024

Reporting Period: 1/15/2020 to 12/31/2020

Prepared By

Heather Kinney (Coastal Restoration Science Technician),
William Helt (Coastal Restoration Scientist), and
Patrick Barrett (DEM – Fisheries Specialist)

Approved By

Scott Comings, Associate State Director

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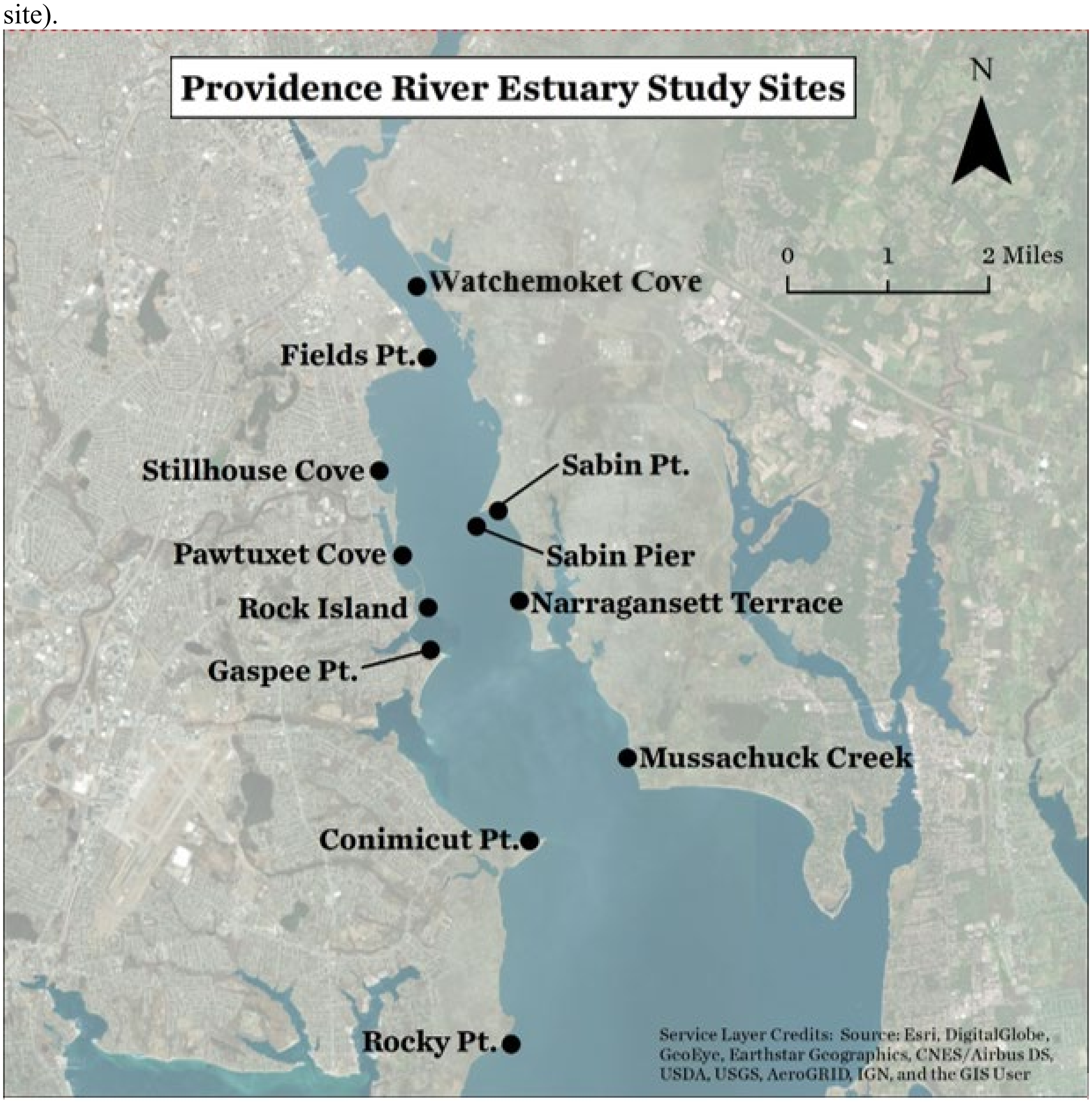
The Nature Conservancy
Protecting nature. Preserving life.

Map of study area and sampling locations (see Table 1 for descriptions of sampling method by site).



SUMMARY

In 2020, there were 12 species caught in the fish traps including 241 finfish (9 species) and 818 invertebrates (3 species). All target species were caught with the exception of winter flounder. Eel pots placed at the artificial reef site and three control sited caught a total of 13 species including 256 finfish (8 species) and 70 invertebrates (5 species) All five target species were caught in the eel traps with the exception of summer flounder.

Water quality monitoring, including temperature, salinity, and dissolved oxygen, was conducted with HOBO Data Loggers placed within fish traps during each sampling period. In addition, a YSI ProPlus was used to record the same parameters at the time the fish traps were deployed and retrieved allowing for quality control of the data. During the 2020 season the mean temperature ranged from 16.75 ±0.01°C to 24.93 ±0.03°C, salinity ranged from 30.0 ppt to 22.3 ppt and the greatest percentage of hypoxic instances recorded by the loggers was 20.32% (during August).

Investigators successfully conducted the first year of the post enhancement productivity dive surveys on the Sabin Point Artificial Reef (SPAR) and paired control sites. The SPAR site was visited on three separate occasions during the 2020 field season. During each dive, staff collected video and photo evidence of the reefs' colonization and succession as well as the annual productivity dive surveys completed on September 22 and 23, 2020. Despite the slight decrease in average richness and diversity across all sites compared to the previous year, species diversity was highest at the SPAR (Sabin Point Artificial Reef). Investigators found invertebrate densities to vary depending on the species and survey location. At the SPAR, investigators found the highest abundance of quahogs (7.5 ind./m^2), barnacles, and tunicate species while the control sites were dominated by eastern mud snails (~39 ind./m^2) and had the highest abundance of *Crepidula* (~ 2 ind./m^2). At the natural control site, investigators observed the greatest abundance of mud crabs (~14 ind./m^2). After installation and initial colonization by benthic organisms, an increase in fish biomass relative to both the unstructured controls as well as the natural control sites was also observed.

TARGET DATE: 12/31/2020

DEVIATIONS

In 2020, underwater photo quadrats at the Sabin Pier Artificial Reef (SPAR) site were conducted by SCUBA. Any fishing gear found attached to the reef was reefs and documented as recommended by DEM staff (See Appendix for Methods/more details on this deviation).

In order to capture water quality data specific to the soak duration of the traps the HOBO water quality devices were placed inside one the traps during each sampling effort. In previous years, the loggers were set at fixed locations at each site and left to record on a monthly basis.

NEXT STEPS

Sabin Pier Artificial Reef Study

Investigators will continue to study the SPAR site and surrounding control sites to determine how artificial reefs can be used as a fisheries resource and fish habitat enhancement tool within the study area. This includes fish trap and eel pot sampling, HOBO Dataloggers, and dive surveys beginning in May 2021. This work will attempt to address the following research questions:

1) How do reef balls affect the area's fish assemblage and abundance?
2) What is the primary succession of colonizing organisms on reef balls at the Sabin Point location?
3) How does fish biomass change over time?
4) Compared to the unstructured and natural controls, how does the artificial reef site compare post-enhancement in terms of fish biomass and production

Evaluation and Determination of Future Artificial Reef Installations

Investigators will utilize the growing datasets to evaluate additional locations in the Upper Bay for artificial reef installations. Considerations of habitat quality, fish assemblage, fishing opportunities and access, logistics and water quality will be considered.

INTRODUCTION

It is well known that fish habitat supporting spawning, breeding, feeding and/or growth of the species is critically important to the sustainability of healthy commercial and recreational fisheries (SFA 1996). In Rhode Island, recreationally significant marine finfish are supported by a variety of naturally occurring habitat types including but not limited to, rocky outcroppings, oyster reefs, kelp, and eelgrass beds that typically exist along shorelines and in estuarine rivers. Effectively preserving and enhancing these habitats helps to sustain important finfish populations and associated recreational opportunities. In areas where habitats have been historically degraded by anthropogenic stressors, artificial means of enhancement are necessary to help rectify damage caused by coastal urbanization and to help provide additional support to help reinvigorate functional ecosystems.

Since 2016, the Rhode Island Department of Environmental Management's Division of Marine Fisheries (RI DEM) and the Rhode Island chapter of The Nature Conservancy (TNC) have conducted benthic video monitoring and finfish surveys at selected sites in the Providence-Seekonk tidal rivers (Head of Narragansett Bay) to assess their suitability for various habitat enhancement techniques. These assessments have provided insight into the current habitat condition and fish assemblage in these areas and the ability to prioritize locations of where such fish habitat enhancement work would be most successful.

In 2019, an artificial reef was constructed off the southern shore of Sabin Point to provide enhancement to this important estuarine area and the first long-term artificial reef research station constructed with Reef Ball^{TM} units in Narragansett Bay. Investigators deployed 64 Reef Balls™, creating 4 distinct patch reefs (4 x 4 clusters) that range from 120 to 225 feet from the end of fishing pier at Sabin Point Park in East Providence. The Sabin Point artificial reef is divided into two nearshore and two bayside patch reefs designed to provide equal access to anglers (i.e., both shore and boat anglers). The permitted reef area can be found on the updated NOAA Nautical Chart 13224 (Providence River and Head of Narragansett Bay) denoted as the Fish Haven on the south side of Sabin Point Park. Divers from RIDEM DMF and TNC continue to monitor the succession of the reef.

Artificial reefs were selected as a habitat type because they have been used as a tool to create complex benthic habitat and increase fish production in southern Atlantic estuaries and provide a versatile tool to enhance fish habitat (Powers et. al. 2003). Manmade structures like artificial reefs, jetties, and shipwrecks that provide similar services as naturally occurring structures for managed species are recognized by NMFS as valuable habitat (MSA 67 FR 2343). Limited information exists on the benefits of artificial reef enhancement in Rhode Island let alone New England. Therefore, an additional facet of this study will help determine how artificial reefs can be used as a fisheries resource and fish habitat enhancement tool in Rhode Island waters. Finally, there are varying ways to monitor the different important fish habitats around the state, making it challenging to create meaningful comparisons. In order to address this challenge, standardized survey and innovative analytical approaches are being used to help investigators gain insight into the relative differences in habitat types' success in sustaining local fish populations and to provide guidance on future priorities for preserving and restoring these habitat types.

APPROACH

This report covers Objective 1 of Job V, Part B (Artificial Reef Installations). Objective 2 will be covered in subsequent years as agreed upon. Planning for accomplishing Objective 2 is underway for the 2021 season. This work is conducted under a multi-year cooperative agreement with TNC and RI DEM. The agreement addresses the following tasks:

Objective 1 – Overview

The purpose and scope of this objective is to monitor the SPAR site constructed in October 2019 and compare it to adjacent sites in the Upper Narragansett Bay and Providence River. The differences in structural complexity and successional stage of these sites will be evaluated with respect to their influence on recreational finfish species. In addition, the artificial reef site will be more easily compared to other essential habitat types within Narragansett Bay. This will help determine how artificial reefs can be used as a fisheries resource and fish habitat enhancement tool in Rhode Island waters.

a. Conduct monthly fish trap and eel pot survey (May – October)
b. Manage and QA/QC collected fish trap and eel pot data
c. Conduct annual dive survey at artificial reef study sites
d. Submit annual report to RIDEM
e. Attend team meetings

Objective 2 – Overview

The purpose and scope of this objective is to assess the success of the SPAR site, and identify and design plans to construct artificial reef habitat in different areas of Rhode Island (e.g., Narragansett Bay, Rhode Island Sound, South County Coastal Ponds) to assess the feasibility of artificial reefs as a cost-effective management strategy to increase the stock of important recreational finfish species

f. Draft and submit necessary permit applications for an artificial reef project
g. Attend permit-related meetings
h. Conduct site assessments for potential artificial reefs
i. Conduct any necessary stakeholder/community engagement

METHODS

Objective 1

Water Quality Data Loggers

HOBO Saltwater Conductivity/Salinity Data Loggers (Part # U24-002-C) and Dissolved Oxygen Data Loggers (Part # U25-001) were placed within one of the fish traps at each deployment from June - October. They were attached to the tops of the traps so that they hung ~ 0.5m from the bottom. The data loggers recorded temperature (°F), conductivity (uS/cm), and dissolved oxygen (mg/L) every 30 minutes. Data from the data loggers were uploaded monthly by connecting to a HOBO Waterproof Shuttle (Part # U-DTW-1) to upload information and resyncing the internal clock. Any fouling to the loggers was gently removed and the loggers were prepared to be redeployed during the following months sampling.

Fish Traps and Eel Pots

Black sea bass traps (43.5" x 23" x 16" (L x W x H) and 1.5" x 1.5" coated wire mesh) were deployed at 12 sites throughout the season (May – October). The traps contained a single mesh entry head and single mesh inverted parlor nozzle consistent with the black sea bass traps used in the Narragansett Bay Ventless Pot, Multispecies Monitoring and Assessment Program (conducted as part of F-61-R-23, Job #12). At each site, two traps were deployed by boat approximately 20 meters apart and left to soak for ~96 hours, unbaited. The traps were then hauled, all animals were identified to genus or species, measured to the nearest millimeter by fork length, enumerated, then discarded back into the water. Water salinity (ppt), temperature (°C), and dissolved oxygen (mg/L) were taken at the trap depth at the time of deployment and retrieval with a YSI handheld multiparameter. In addition, HOBO Saltwater Conductivity/Salinity Data Loggers (Part # U24-002-C) and Dissolved Oxygen Data Loggers (Part # U25-001) were placed within one trap at each site starting in June (see Water Quality Data Loggers section).

Eel traps (23" x 12" x 12" (L x W x H) and 0.5"x 0.5" coated wire mesh) were deployed at four sites throughout the season (Sabin Pier, Sabin Point, Rock Island, and Gaspee Point; from May – October). The traps contained a single wire mesh entry funnel and were consistent with the eel traps used in the Assessment of Recreationally Important Finfish Stocks in Rhode Island Coastal

Waters (conducted as part of F-61-R-21, Job #6 Part B). Two eel traps were deployed by boat approximately five meters from each black sea bass trap at each site and left to soak for ~96 hours, unbaited. The traps were then hauled, all animals were identified to genus or species, measured to the nearest millimeter by fork length, enumerated, then discarded back into the water.

Dive Survey

A survey of the floral and faunal communities was conducted by SCUBA at the Sabin Pier Artificial Reef (SPAR) site and three comparison sites (Sabin Point, Rock Island, and Gaspee Point) on September 22 & 23, 2020. Sampling before and after reef ball installation will be used to make comparisons between the community pre- and post- enhancement, while continued sampling of reference sites will allow comparison with relatively featureless habitats (Sabin Point and Gaspee Point) and a naturally rocky habitat (Rock Island).

Quadrat Sampling

Quadrat sampling was used to determine the abundance of common invertebrates, algae, and small cryptic fish. Along each transect an 1m^2 quadrat was placed every 8m, alternating between onshore and offshore sides of the transect, totaling six quadrats per transect. At each quadrat, all organisms and algae were identified to the lowest possible taxonomic level and enumerated.

Uniform Point Count

Uniform point count sampling was used to determine the percent cover of algae and sessile invertebrates. Along each transect a sample was taken every meter both one meter onshore and offshore of the transect. At each sample, the substrate composition and all species found within the point (a 2cm estimated diameter) were recorded.

Swath Sampling

Swath sampling was used to determine the abundance of common algae, invertebrates, and demersal cryptic fish that could be easily counted. Along each transect a swath was performed in a 1m wide area on each side of the transect. The abundance of all target species was recorded and binned within four 20m subsections (two on each side) along the transect.

Fish Count

A fish count was used to determine the abundance of common fish along the transect. A diver slowly swam long each transect while recording the abundance and estimated size of all fish encountered within a predefined “cube” based on depth and visibility.

YSI Sampling

During the dive survey at each site, a YSI Handheld multiparameter water quality meter was used to record temperature (°C), salinity (ppt), and dissolved oxygen (mg/L) at the surface and bottom of the water column.

Data Analysis

Summaries of fish and eel trap data for 2020 include all water hauls and evaluate each trap as its own data point. The catch rate (CPUE) was calculated using the following equation(see Table 1 for a description of effort at each station and month in 2020):

$$CPUE = \frac{Total\ catch\ at\ site}{Length\ of\ soak\ (days)\ \times\ Total\ number\ of\ samples}$$

Species presence, total abundance, abundance by station, and length frequency distributions for target species, were also calculated using R (R Core Team 2020). Finfish and invertebrate CPUE was calculated separately. Species specific CPUE was also calculated for the target species by month and site. Length-weight relationships for available species were calculated using coefficients provided by DEM and FishBase using the following equation (Froese and Pauly 2020):

$$Weight\ =\ \alpha Length^{\beta}$$

Statistical Approaches for dive survey

Benthic habitat characteristics were summarized for each transect by using the uniform point count data to derive both a geological and biological percent cover for each dive transect. The total number of observations were summarized for each species or substrate and then divided by the total number of uniform point counts collected along the length of each transect. Additionally, species richness and Shannon's Index of diversity were used to calculate the total number of unique species as well as at the weighted average, or diversity, of colonization algae and sessile invertebrate species at the SPAR and control locations. Algae and Invertebrate densities were summarized using the quadrat, and swath data sets when applicable, by averaging the total number of observations across all quadrats (n=4-6) within each transect. To evaluate how the artificial reef habitat compares to the unstructured and natural controls, the mean density of individuals per meter squared ± SE is calculated and grouped by habitat type and the corresponding controls, then facetted by survey method.

Using the fish count survey data, abundance at length was converted to total fish mass per transect by leveraging the DMF age and growth lab data to convert fish length in cm to weight in grams for our target species, using RI specific allometric growth models (see above equation). For species not currently dissected in the growth lab, the geometric mean a and B values estimated on Fishbase.org were used. To compare total fish biomass between the artificial reef, control, and natural control sites, the total fish mass was standardized by dividing the total area surveyed, to get grams per meter squared. Hedge's g index was also computed on the mean biomass per meter square estimates to investigate the effect size the artificial reef relative to unstructured and natural controls. Hedge's g effect size was calculated using the mean values and standard deviations from the mean biomass estimates using the "effsize" R package (R Core Team 2020).

RESULTS

Objective 1

Water Quality Data Loggers

All data loggers were deployed within one trap from each sampling event starting in June. A total of 10,240 instances were recorded with dissolved oxygen data loggers across all sites. Unfortunately, given that these loggers are a complex technology being applied in the marine environment, precursory analysis of the results showed some loggers recorded unreliable data. In previous years, similar equipment failure occurred and was mainly attributed to fouling on the housing units and loggers themselves. This season, using the loggers only during the four day soak period helped significantly reduce this issue. However, problems with the conductivity loggers persisted. For this report, investigators only summarized data that appeared to fall within expected values comparable to water quality information taken from the handheld YSI during other sampling.

Temperature ranges were fairly consistent across sites (Figure 1). Mean temperature values by site ranged from 19.91 ±0.11SE°C at Conimicut Point to 22.21 ±0.11°C at Fields Point during the sampled time period. Mean temperature across sites was highest in July at 24.93 ±0.03°C and lowest in October at 16.75 ±0.01°C (Figure 2).

Salinity data appeared to be the least accurately recorded parameter. Therefore, YSI salinity data at trap depth was used to compare across sites and the HOBO logger data was omitted. Salinity was calculated by averaging the salinity at trap depth on day the traps were set and the day they were hauled. Mean salinity values by site ranged from 29.5 ppt at Rocky Point to 22.0 ppt at Pawtuxet Cove. However, the majority of sites had a mean salinity of ~27 ppt (Figure 3). Mean salinity across sites was highest in September at 30.0 ppt and lowest in May at 22.3 ppt (Figure 4). Note: Mean salinity was not calculated in July because of issues with the YSI.

Dissolved Oxygen (DO) results appeared to be consistent with YSI recorded values. There were occasions where DO dropped to values less than 2 mg/L at some sites, suggesting hypoxia (Figure 5). DO values across all sites recorded the more frequent and intense hypoxia during July and August. Percentage of hypoxic instances (<2mg/L) by site ranged from 0% at Conimicut Point, Gaspee Point, Pawtuxet Cove, and Rock Island to 28.87% at Stillhouse Cove. Percentage of hypoxic instances by month ranged from 0.00% in September and October to 20.32% in August.

Fish Traps and Eel Pots

In 2020, there were 12 species caught in the fish traps including 241 finfish (9 species) and 818 invertebrates (3 species). All target species were caught with the exception of winter flounder (Table 2). The three most abundant finfish species were scup (153), tautog (33), and summer flounder (21). The most abundant invertebrate species were spider crabs (562). Maintaining a consistent average trap depth between sites can be challenging resulting in the greatest average difference of 10’ between Pawtuxet Cove (Avg. Depth = 5.4’) and Rocky Point (Avg. Depth = 15.6’). However, the greatest within site variation was at most ~4’ at Mussachuck Creek (Figure 6). The greatest number of finfish were caught in June (CPUE =2.75 ± 1.08 SE) and the least in October (0.15 ± 0.09 SE)(Table 3, Figure 7). Rock Island, Narragansett Terrace, and Stillhouse Cove had the highest catch rates overall (2.63 ± 1.89 SE, 1.63 ± 0.97 SE, 1.38 ± 1.28 SE) and Pawtuxet Cove had the lowest (0.15 ± 0.10 SE) (Figure 8).

Eel traps were used at four sites in 2020 (Gaspee Point, Rock Island, Sabin Pier (SPAR site), and Sabin Point). A total of 13 species were caught, including 256 finfish (8 species) and 70 invertebrates (5 species). The top five most abundant finfish species in the eel traps were black sea bass (175), oyster toadfish (21), cunner (15), scup (14), and American eel (11). The top three most abundant invertebrate species were blue crabs (27), mud crabs (23), and spider crabs (13) (Table 2). All five target species were caught in the eel traps with the exception of summer flounder. The highest catch rate in the eel pots was during the month of August and the SPAR site (Sabin Pier) had the highest overall catch rate in 2020 (Figure 9).

Scup were the most abundant finfish species caught in the traps in 2020 with a peak catch rate in June (2.46 ± 1.11 SE) (Table 3 and Figure 7). Similar to previous years, scup accounted for any considerable variations in finfish catch rate between sites. Scup were caught at ten of the twelve sites (Table 4). Their sizes ranged from 13.8 – 33.0cm (FL) and had a mean weight of ~0.5lbs (Figure 10). The highest catch rates were at Rock Island, Stillhouse cove, and Watchemoket Cove. Scup made up the largest percentage of fish catch by number (65.5%) and the second largest percentage by weight (38.5%) below tautog. Scup were also found at all four eel trap sites and were the fourth most abundant finfish with an average catch rate of 0.50± 0.20 SE. The sites with the greatest number of scup caught in the eel pots were Sabin Point (CPUE = 0.23 ± 0.09 SE) and Rock Island (CPUE = 0.20 ± 0.16 SE) and ranged in size from 7.0-15.5cm.

Tautog were the second most abundant finfish species caught in 2020 with a peak catch rate in May (0.56 ± 0.15 SE) with sizes ranging from 11.2 - 48cm (FL) (Figures 7 and 11). Though they were second in catch rate, tautog made up the largest weight of the target species at an average of 2.5lbs. Tautog were caught at nine of the twelve sites had the highest catch rates at Sabin Pier, Conimicut Point, and Rocky Point (Table 4 and Figure 8). Tautog made up about 13.7% of the total fish catch by number which was the second highest percentage after scup. However, tautog had the highest percentage of all fish species by weight (41.4%).

Summer flounder were the third most abundant finfish species caught in 2020 ranging in size from 26.2-45cm (Figure 12). Summer Flounder were second in weight out of the target species at an average of 1.1lbs, had a peak catch rate in July (0.21 ± 0.08 SE) and were caught at nine of the twelve sights (Table 4). The highest catch rates were at Fields Point and Conimicut Point. Summer flounder made up the third highest percentage of total fish catch by number and by weight (8.71% and 11.0% respectively)

Black sea bass were the fifth most abundant finfish species caught in the fish traps in 2020, ranging in size from 20.3-28cm and averaging at 0.37lbs (Figure 13). Black Sea Bass had a peak catch rate in September (0.23 ± 0.21 SE) and were caught at five of the twelve sites (Table 4 and

Figure 7). The highest catch rate was at Mussachuck Creek (Figure 8). Black sea bass shared the fourth highest percent of total finfish catch by number with oyster toadfish and had the fifth highest percentage by weight (5.81% and 2.56% respectively). Black sea bass were the most abundant species caught in the eel pots with a higher average catch rate than all other species (CPUE = 4.68 ± 0.21 SE) and were caught at all four eel trap sampling sites. The black sea bass caught in the eel pots ranged in size from 6.7-20.3cm (Figure 13). The greatest number of eel pot black sea bass were caught at Sabin Pier (CPUE =2.07± 0.92 SE).

Blue crabs were the second most abundant invertebrate species caught in 2020 with a peak catch rate in August (1.39 ± 0.28 SE) and the highest rate by site at Gaspee Point (1.54 ± 0.58 SE). Blue crabs were also sexed when possible and there was a higher ratio of males to females caught in the traps throughout the entire season. Blue crabs ranged in size from 4.1-26.6cm with the females making up the smaller range of sizes (Figure 14). The average male blue crab size was 13.7±0.2cm while the average female was 11.6±0.4cm. Blue crabs were the most abundant invertebrate species caught in the eel pots. Blue crabs were found at all four eel pot sites and ranged in size from 7.0-18.5cm.

Dive Survey

During September 2020, dive surveys were conducted to determine the baseline floral and faunal communities for use in productivity estimation at four locations near the mouth of the Providence River. The four sites included, Sabin Point Pier (artificial reef site, post enhancement), Sabin Point (unstructured control - east), Rock Island (natural rocky subtidal control - west), and Gaspee Point. (unstructured control – west). Using a multitude of dive transect methods, investigators were able to determine the substrate percent cover, mean proportion flora and fauna inhabiting the landscape, and the biomass of finfish utilizing these different habitats.

Investigators successfully conducted the first year of the post enhancement productivity dive surveys on the Sabin Point Artificial Reef (SPAR) and paired control sites. The SPAR site was visited on three separate occasions during the 2020 field season. During each dive, staff collected video and photo evidence of the reefs' colonization and succession as well as the annual productivity dive surveys completed on September 22 and 23, 2020.

Percent cover at the two Providence River control sites, Gaspee Point and Sabin Point Control, were similar with respect to the substrate condition. Both sites were composed of primarily mud and fine sediment, with intermixed cobble and *Crepidula* and quahog shells. The proportion, or percent cover, of mud/fines at the control sites ranged from 86.66 to 95% (Figure 15; GASP and SPCTR). Post deployment of the SPAR, the newly constructed reef location saw a 5-20 percent increase in complex benthic structure. During each of the three dives completed in 2020, no evidence of scouring or damage to the reef balls were observed. Compared the natural control, or Rock Island site, the percent cover of boulder substrate (5-50 percent boulder) was similar to that of the proportion of Reef Ball cover at the SPAR (5-20% reef ball). Both the SPAR and Rock Island sites have a higher proportion of more complex structure compared to the relatively sandy and flat control sites of Sabin Point Control and Gaspe Point. Aside for the reef balls, the SPAR site remains to be a sand dominated habitat with some shell, ranging from 80-95% sand cover

(Figure 15, SPAR).

Compared to 2019, the overall species richness and diversity, with respect to the algae and sessile invertebrate species, was lower in 2020 (Table 4). Despite the slight decrease in average richness and diversity across all sites, species diversity was highest at the Sabin Point artificial reef, relative to the unstructured and natural control sites during the post enhancement dive survey (Table 4 and Figure 16). The biggest difference between the rocky substrate locations and sand/mud flat controls is the abundance of branching and filamentous algae that are able to adhere to the firmer substrate. Most notably *Fucus visiculous, Argardehlia subulate,* and *Grinnellia Americana* (Figure 16).

Investigators found invertebrate densities to vary depending on the species and survey location. At the SPAR, investigators found the highest abundance of Quahogs (7.5 ind./m^2), barnacles, and tunicate species (Figure 17). The control sites were dominated by eastern mud snails (~39 ind./m^2) and had the highest abundance of *Crepidula* (~ 2 ind./m^2). At the natural control site, investigators observed the greatest abundance of mud crabs (~14 ind./m^2). When comparing swath and quadrat survey techniques, it seems the swath method provides a higher estimate of shellfish densities across all locations, as was the case for the Northern Quahog densities (Figure 17). Greater abundance of rare or less occurring species like red beard sponge or the orange sheath tunicate was also more effectively documented with the swath method, whereas the quadrats were most helpful for species occurring in abundances so large that counting along the entire swath of the transect would be not worthwhile, for example barnacle species, eastern mud snails, and mud crabs (Figure 17).

In 2019, during the pre-enhancement survey, total fish biomass at the SPAR (0.27 ± 0.03 g/m^2) was equal to the two control sites (GASP 2.23 ± 2.15 and SPCTR 0.76 ± 0.68). After installation and initial colonization by benthic organisms, an increase in fish biomass relative to both the unstructured controls as well as the natural control sites was observed (Figure 18). Fish biomass at the SPAR experienced a 10-fold increase to 10.58 ± 5.6 g/m^2 in just one year (Figure 18). When the mean biomass observed at Sabin Point Pier was compared between pre and post reef construction, the Hedge's g effect size calculated on the mean and standard deviation of fish biomass increased from -0.62 to 1.27 and 0.92 to 2.25, relative to the unstructured control and natural control averages respectively.

DISCUSSION:

Objective 1

Water Quality Data Loggers

Mean temperature, salinity, and dissolved oxygen fell within typical ranges associated with Upper Narragansett Bay (NBFSMN 2016; Reed and Oviatt 2006-2019). Pawtuxet Cove abnormally low salinity values during the month of May which is likely attributed to a heavy rain event as well as the YSI reading being taken at a shallow depth during an ebbing tide. The Pawtuxet Cove site is also adjacent to the mouth of the Pawtuxet River. Periodic instances of hypoxia (<2mg/L) at various sites in 2020 are typical of the area, especially within the upper reaches of the PRE (Hale et al 2018). With the exception of the salinity data, the use of the HOBO data loggers at shorter (four day) intervals were more successful than previous years' fixed site (30 day) approach.

Fish and Eel Traps

Data collected from the fish and eel traps were consistent with documented scup life history patterns described in the "Essential Fish Habitat Source Document: Scup, *Stenotomous chrysops*, Life History and Habitat Characteristics" by Steimle et al. 1999. Trends were similar to data recorded in 2018 in that peaks in scup catch rate occurred in June and dropped off throughout the rest of the summer. Scup are schooling fish and have been caught in high numbers at a time in the traps compared to other species. This year, the larger adult scup were first documented at Narragansett Terrace in May. By June, individuals from this larger cohort (estimated 16-27cm) were caught up to the northernmost fish trap site (Watchemoket Cove). Returning juveniles (10-13cm) were documented up to Sabin Point in the eel pots. In August, YOY scup were caught in the eel traps at Sabin Point and Rock Island. Reduced numbers of larger adult scup were documented in August and by September no adult scup were caught in the fish traps and few were caught in the eel pots.

Similar to previous years, the majority of tautog were caught in May and June and were composed of mostly adult fish (>25cm). Mature tautog have been reported in the upper estuary of Narragansett Bay spawning from May – July (Steimle and Shaheen 1999; Dorf and Powell 1997). In later months, juvenile and YOY tautog were caught in the eel pots in July - October. The lack of larger tautog in the summer months could be due to warmer temperatures as tautog are known to relocate when suboptimal conditions present themselves (Steimle and Shaheen 1999). However, because tautog are strongly associated with complex and structured habitats, a lack of available structure for the larger individuals may also be a factor. Though the sample size is small, the majority of YOY tautog were caught at Sabin Pier (SPAR site) compared to the other control sites. Investigators should continue document any differences in size class and abundance of this structure seeking target species as the artificial reef matures.
There were few summer flounder and winter flounder caught in the fish and eel traps. This could be due to the trap's inefficiency in catching flatfish species as the trap openings are not particularly wide limiting the size class that can fit in the eel and fish traps. In addition, although summer flounder do occasionally seek structure habitat for refuge, they tend to prefer sandy flat bottom habitat and therefore may not seek out the traps like structure associated fish (Packer et al. 1999).

Black sea bass were first caught in the fish traps in July at Rocky Point. Based on the size class (25-30cm) these individuals were most likely spawning adults (Northeast Fisheries Service Center 2017). Winter juveniles (7-11cm) were also documented at Sabin Pier and Gaspee Point in July in the eel traps. Few black sea bass were caught in the fish traps with the majority being caught at Mussachuck Creek (a southern site). By September and October, there were a few larger fish documented at Gaspee Point, Fields Point, and Watchemoket Cove (the northernmost site). At the sites where the eel traps were used, there was an abundance of year-1 and YOY black sea bass captured while none were caught in the fish traps. Larger black sea bass (>19cm) tend to stay in deeper water especially when there is limited structure available (Northeast

Fisheries Service Center 2017), so this could be why there were more caught in the deeper southern sites and none caught at the sites which had an abundance of smaller fish. The smaller black sea bass are likely able to escape the larger traps as well. This is consistent with the previous years' catches as well. As the fish trap time series becomes more developed it will be important to keep track of differences in where the various size, or age, classes are found.

Dive Survey and Sabin Point Artificial Reef Deployment

The artificial reef structures will continue to undergo successional changes and colonized by different algae and invertebrate species, further promoting the base of the food web that will ultimately support more mid-trophic level sportfish. Research on Reef Balls™ have been shown to create a more robust benthic habitats, ultimately attracting more fish to the reef (Bohnsack 1994, Lindberg 2006, Jordan 2005, Rosemond 2018). The reef will also provide shelter and food resources for sub-legal size sportfish and aggregating forage fish, promoting both the growth and survival of these individuals (Powers 2003, Caddy 2011). The Sabin Point project has begun to enhance fishing in the nearby Sabin Point waters, which currently provides fishing access and until recently, little structure for demersal reef fish like tautog and black sea bass. Through this work we have increased complex structure of the Sabin Point Pier benthos by an average of 15 percent. The species richness and diversity at be greatest in this site is now greater than the respective controls and has shown initial trends to suggest this enhanced productivity has resulted in a greater abundance and biomass of finish that utilize this location. that are available to catch at this location and will continue to monitor its progress over the next few years. Our results support the findings from a recent meta-analysis of 39 artificial reef studies conducted around the globe, that found the effect size of artificial reefs on fish density to be greatest in the Atlantic Ocean and artificial reefs made with concrete materials (Paxton et al 2020).In addition to the ocean and material used, the effect size of artificial reefs relative to natural reefs increased with increasing latitude, with positive effects for reefs in temperate regions (Paxton et al 2020). Our results also suggest that effect of artificial reefs on total fish biomass was positive relative to both the unstructured and natural rocky reefs.

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FIGURES:

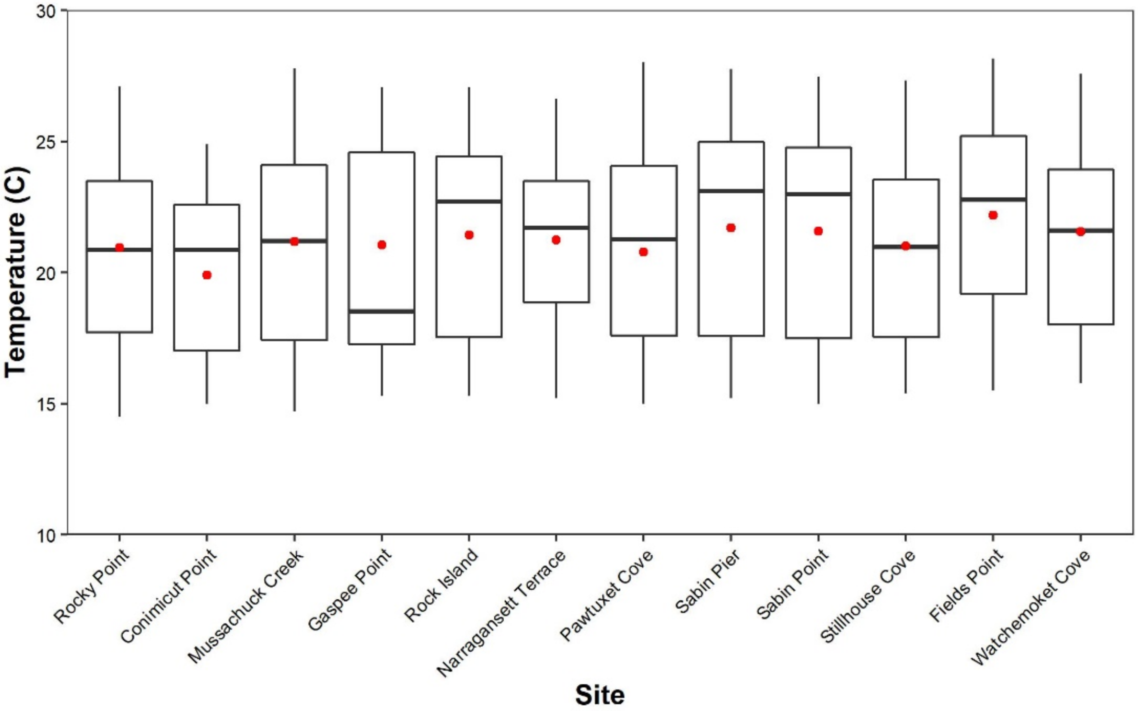


Figure 1. Boxplots of temperature (°C) recorded by the salinity data loggers at sites during 2020 with red center points representing mean values.

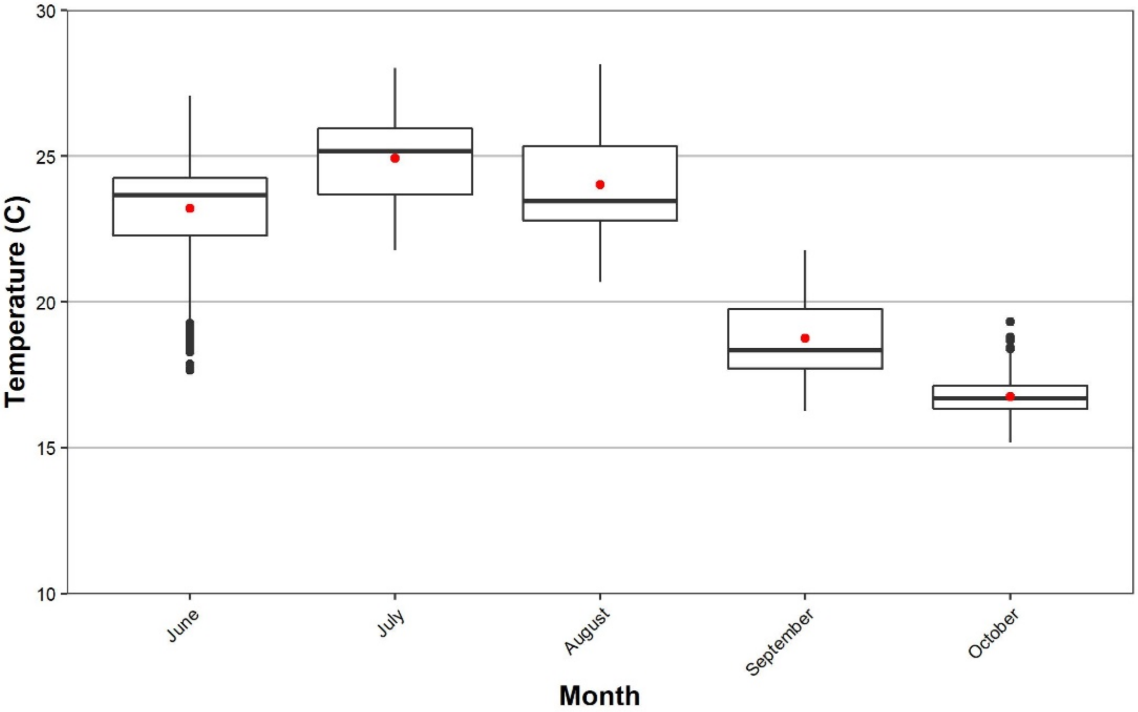


Figure 2. Boxplots of temperature (°C) recorded by the salinity data loggers at sites during 2020 with red center points representing mean values.

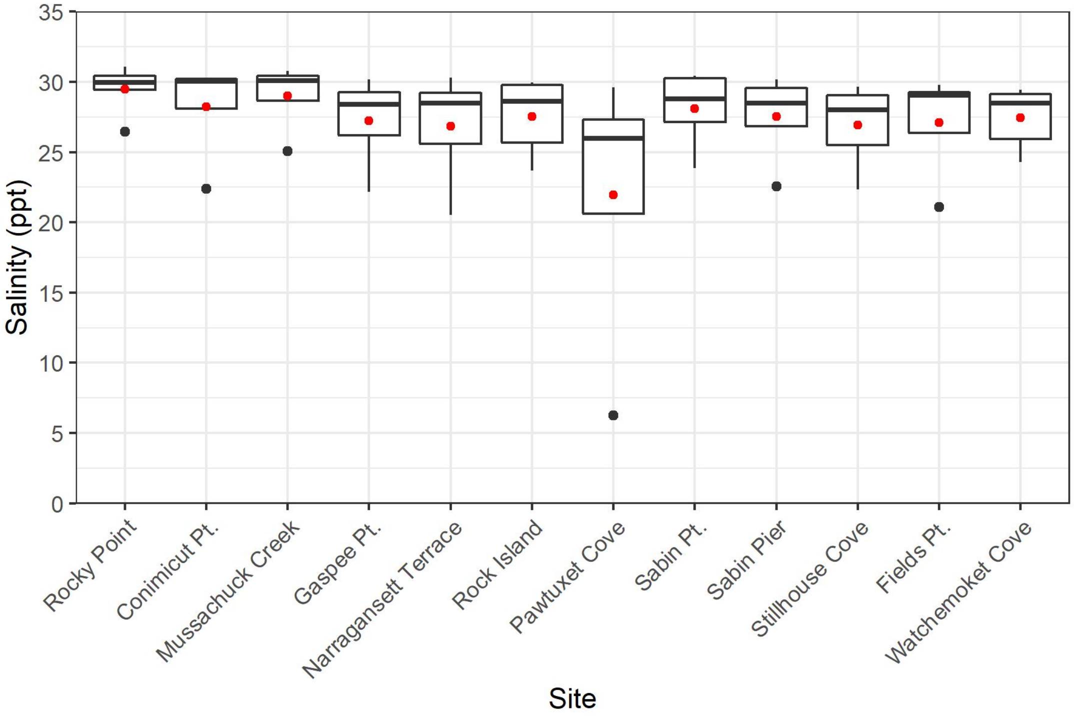


Figure 3. Boxplots of salinity (ppt) recorded with a YSI at sites during 2020 with red center points representing mean values. YSI data was recorded at the time the traps were deployed *and* hauled. This figure represents the average of those values.

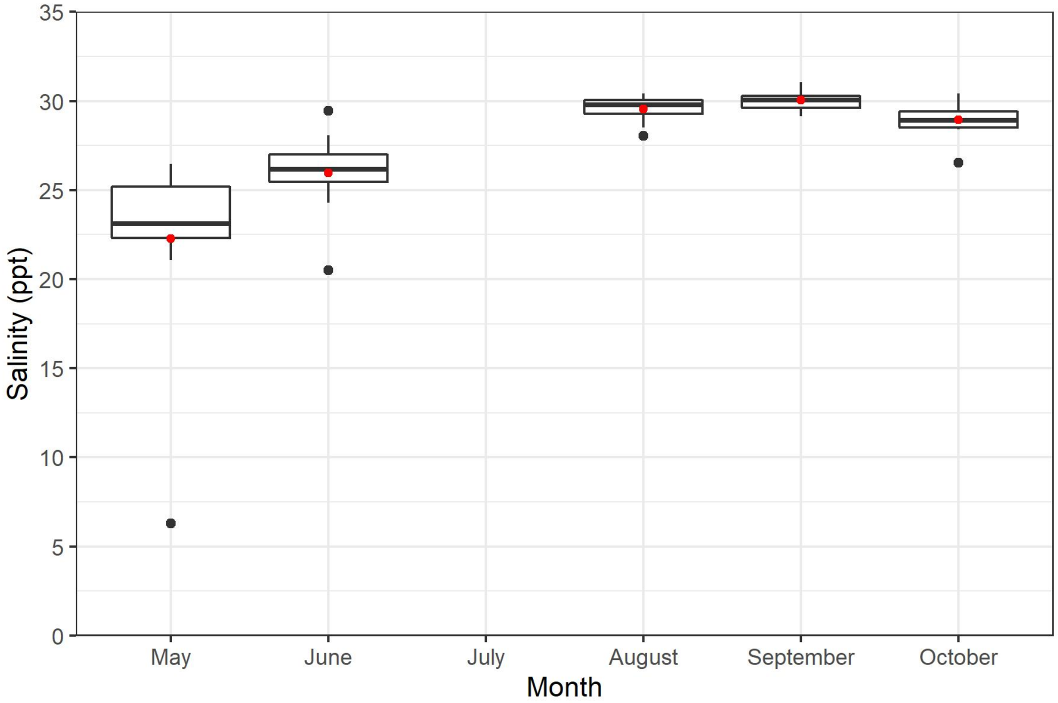


Figure 4. Boxplots of salinity (ppt) recorded with a YSI at sites during 2020 with red center points representing mean values. YSI data was recorded at the time the traps were deployed *and* hauled. This figure represents the average of those values.

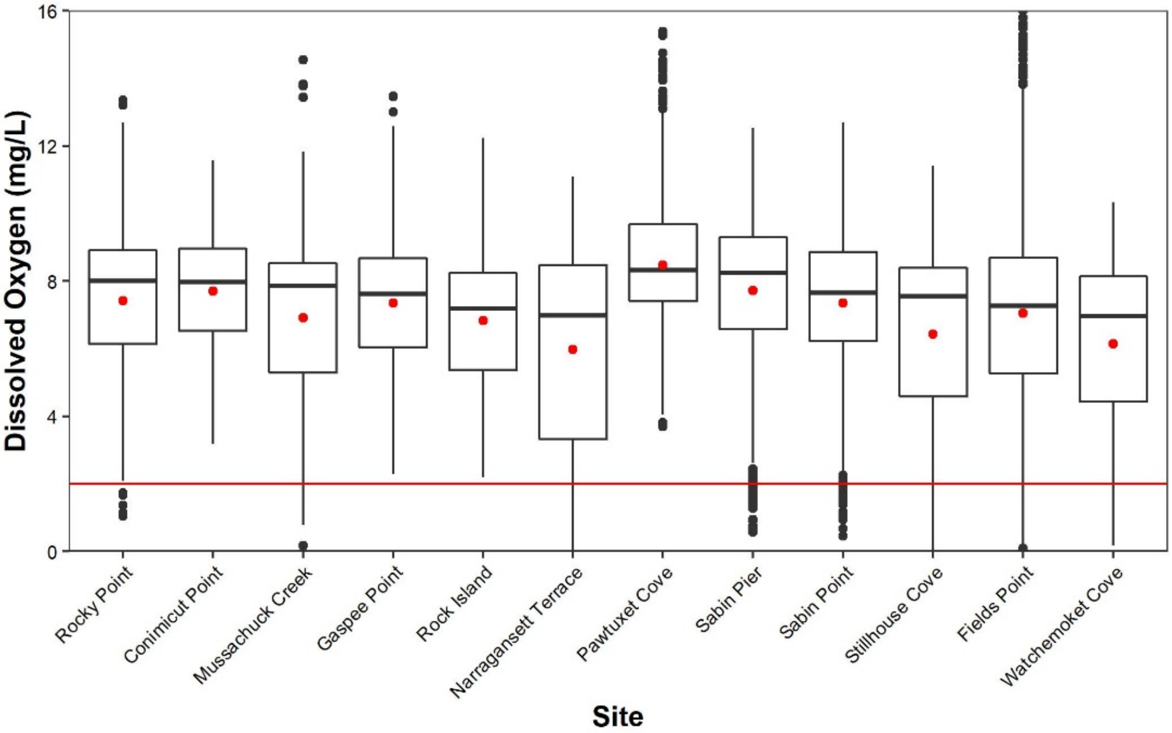


Figure 5. Boxplots of dissolved oxygen (mg/L) recorded by the data loggers at sites during 2020 with red center points representing mean values.

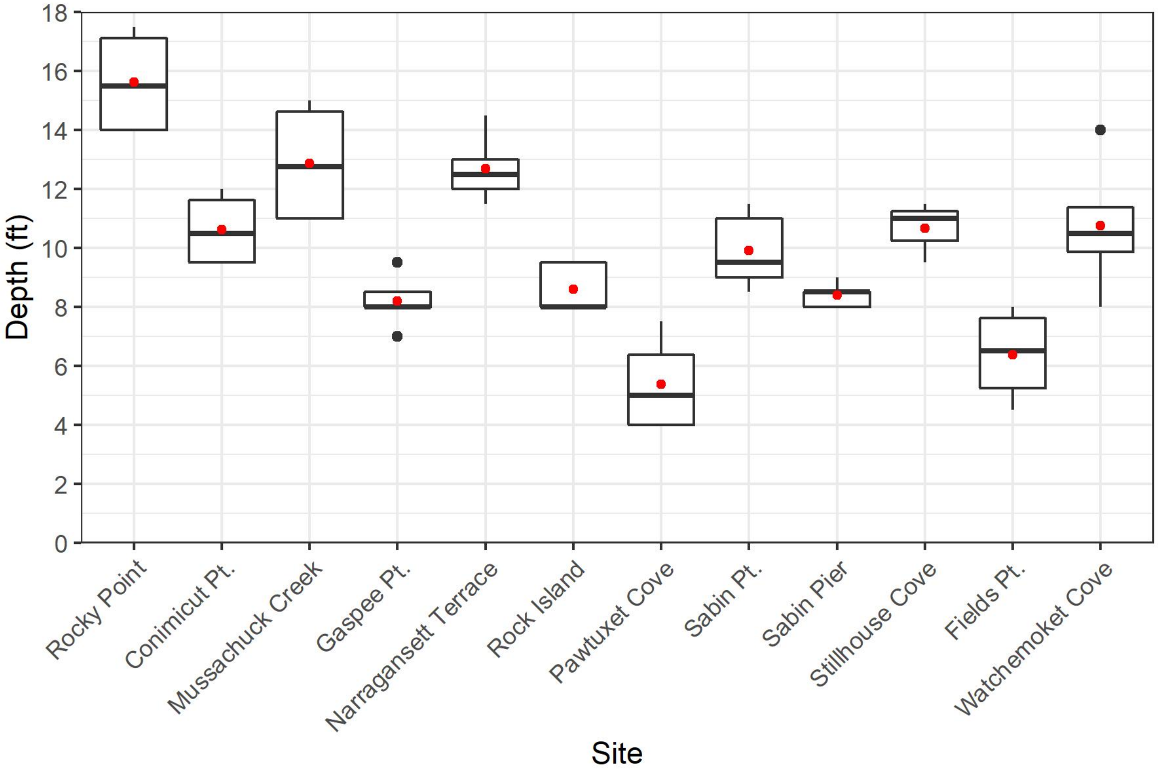


Figure 6. Boxplots of trap depth (ft) by site averaged by deployment and retrieval depths in 2020 with red center points representing mean values.

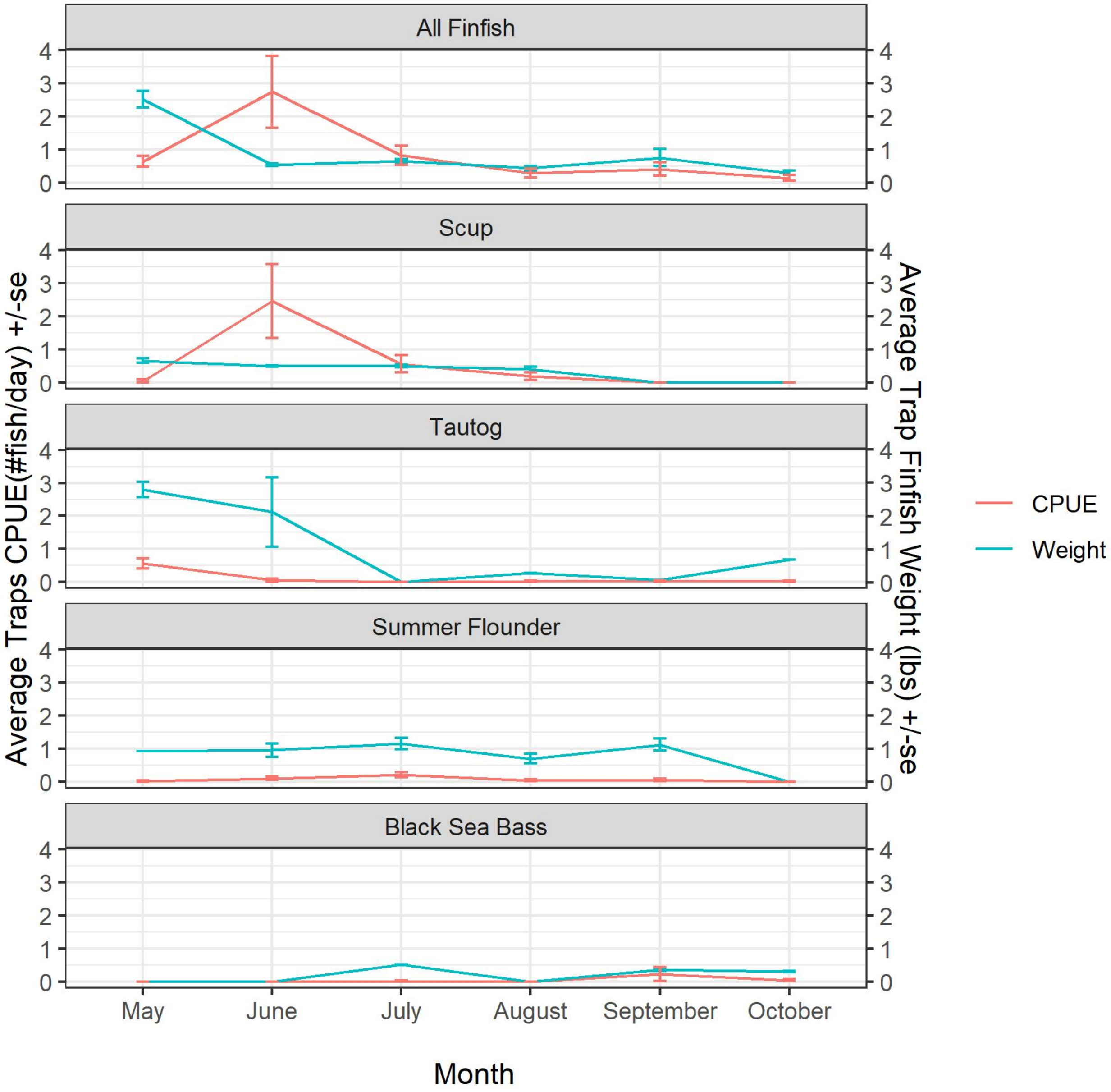


Figure 7. Mean finfish per haul (± SE) plotted for each month sampled during the 2020 field season.

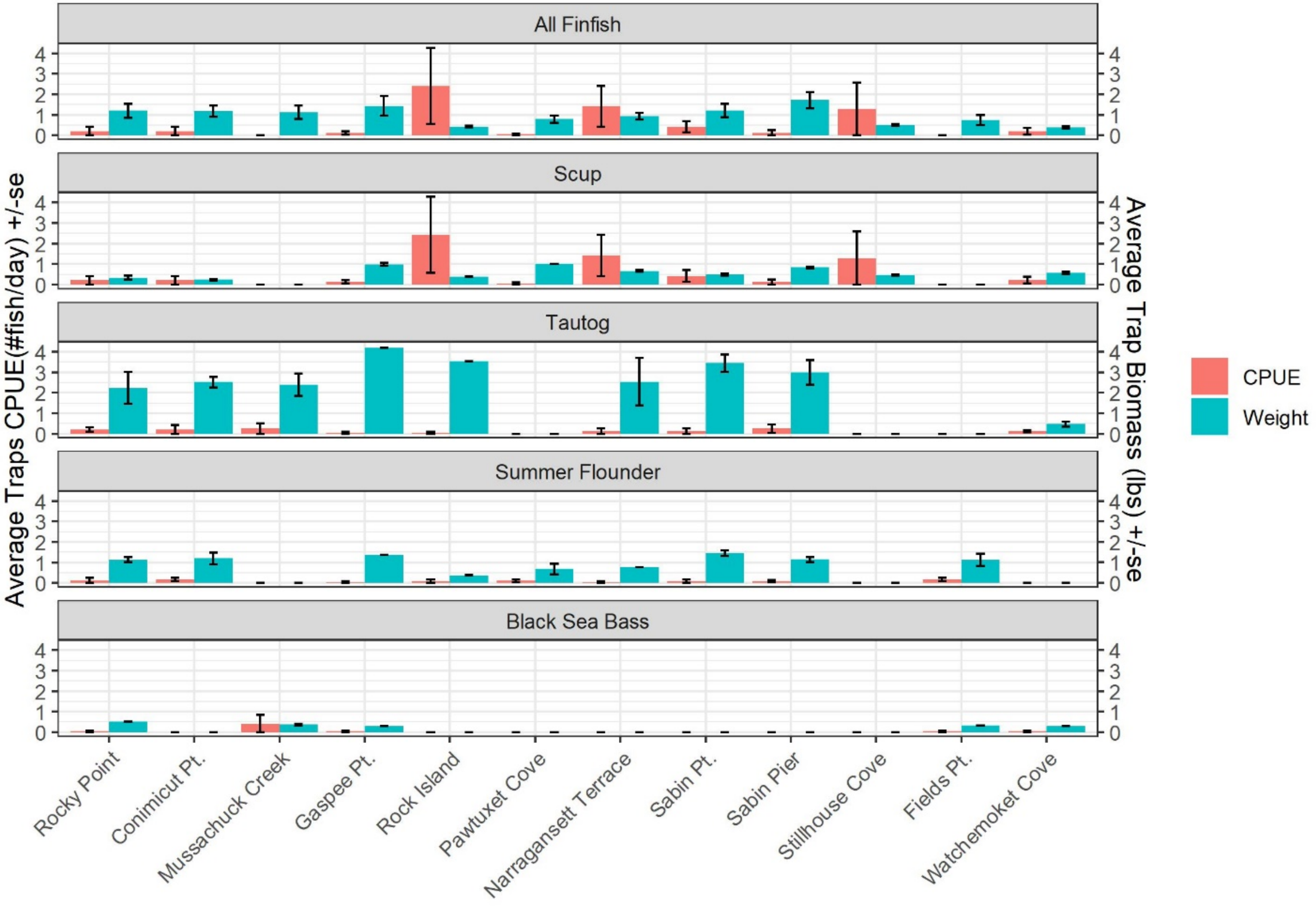


Figure 8. Mean finfish per haul (± SE) plotted for each site sampled during the 2020 field season.

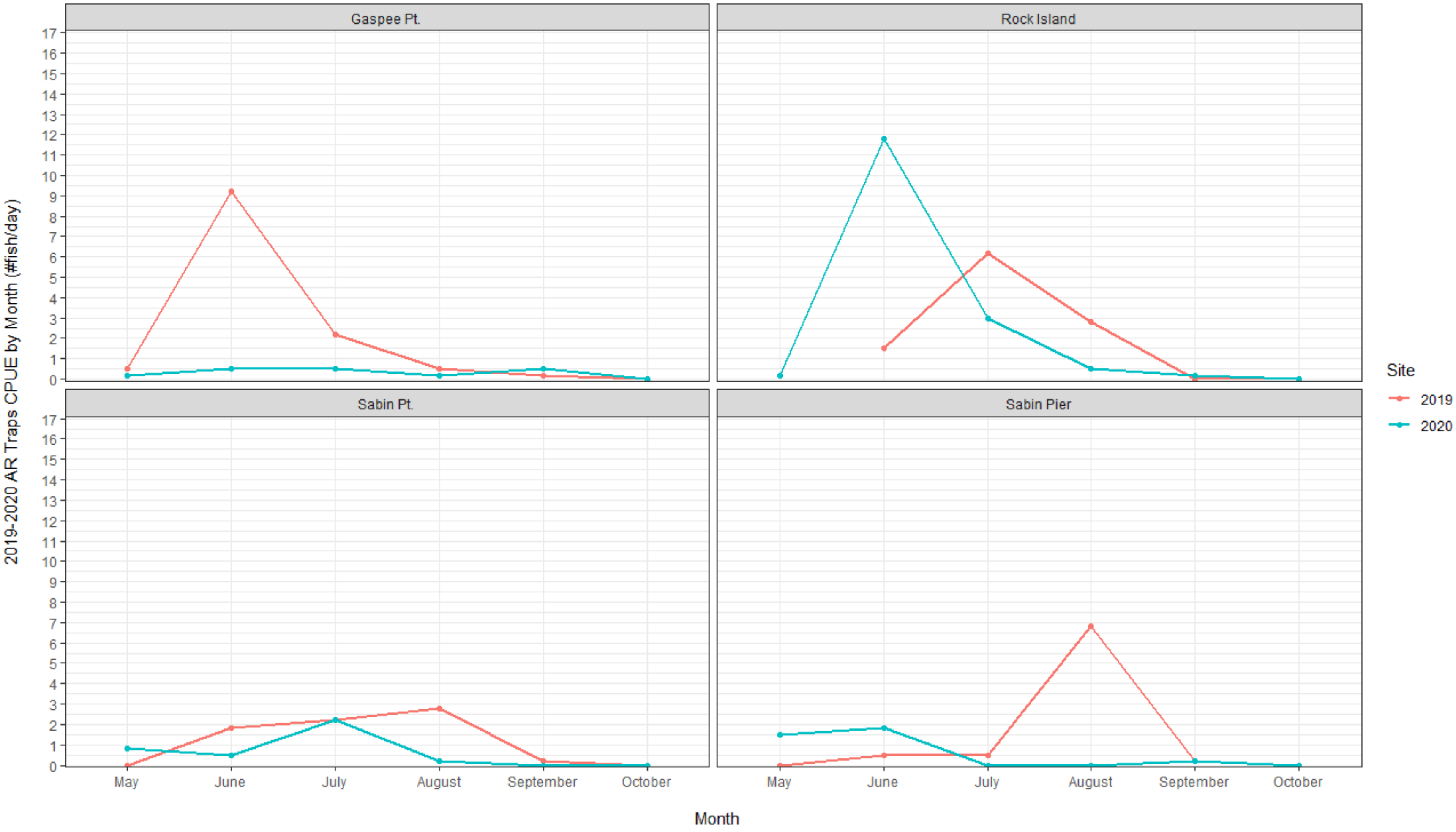


Figure 9. Eel pot catch rate in 2019 and 2020 across the four sites each month.

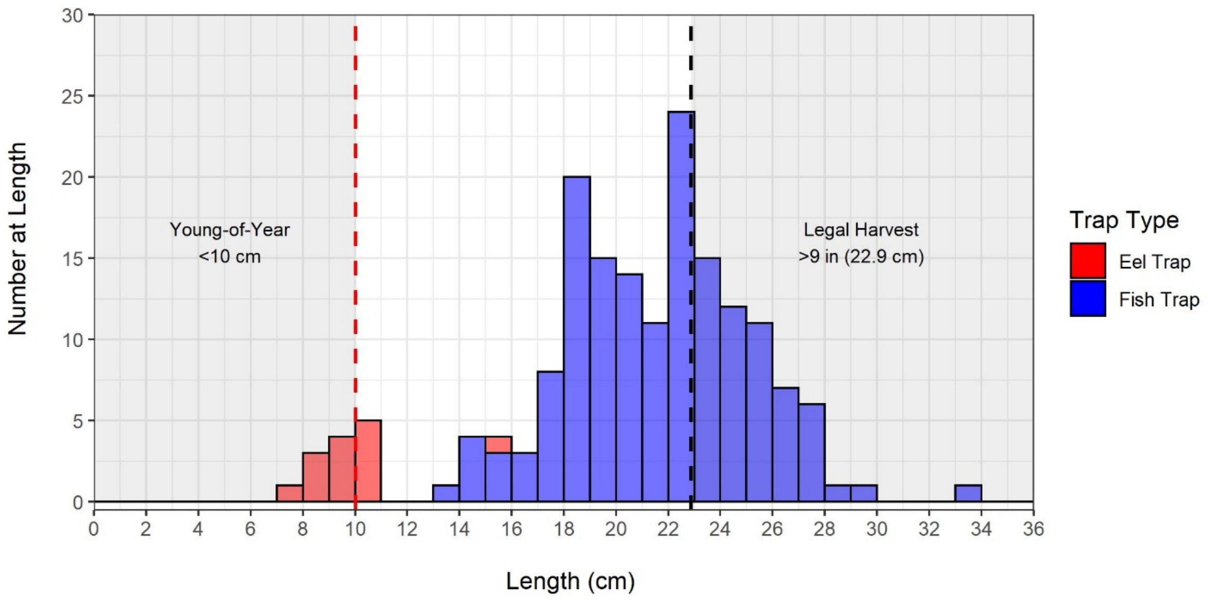


Figure 10. Histogram showing the size frequency at length of scup species caught in eel traps and fish traps.

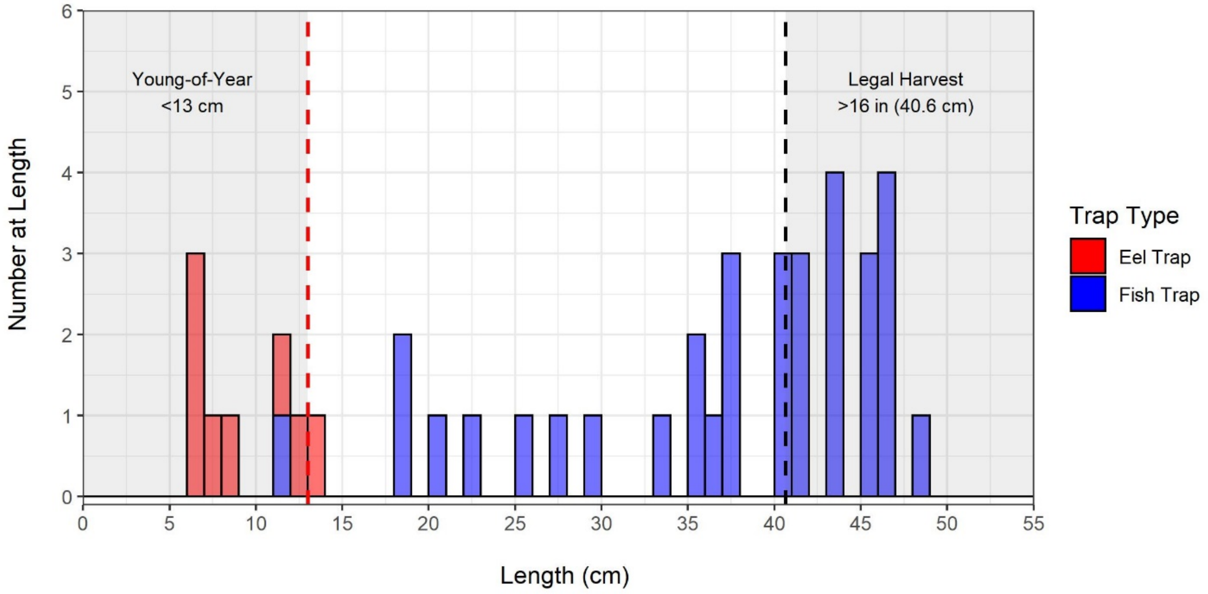


Figure 11. Histogram showing the size frequency at length of tautog species caught in eel traps and fish traps.

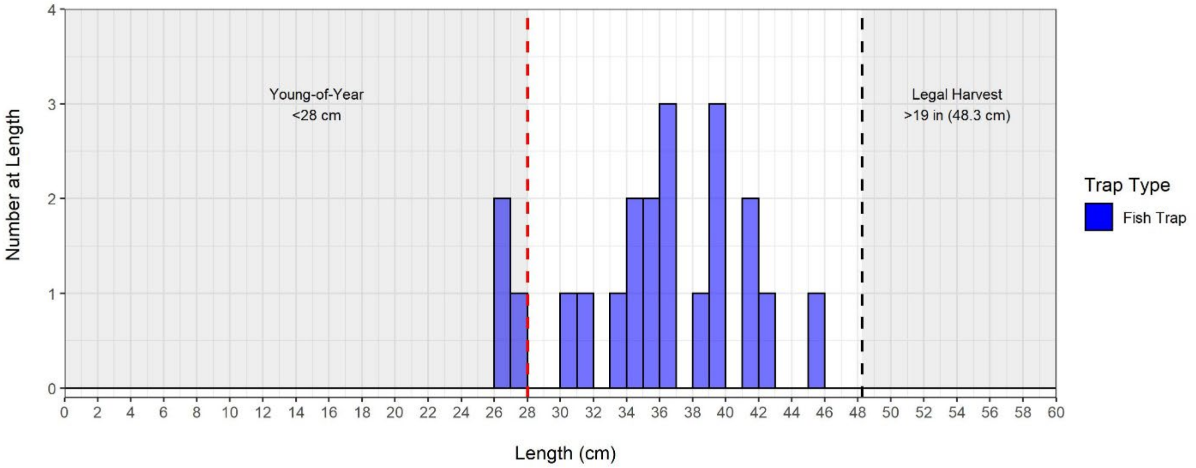


Figure 12. Histogram showing the size frequency at length of summer flounder species caught in eel traps and fish traps.

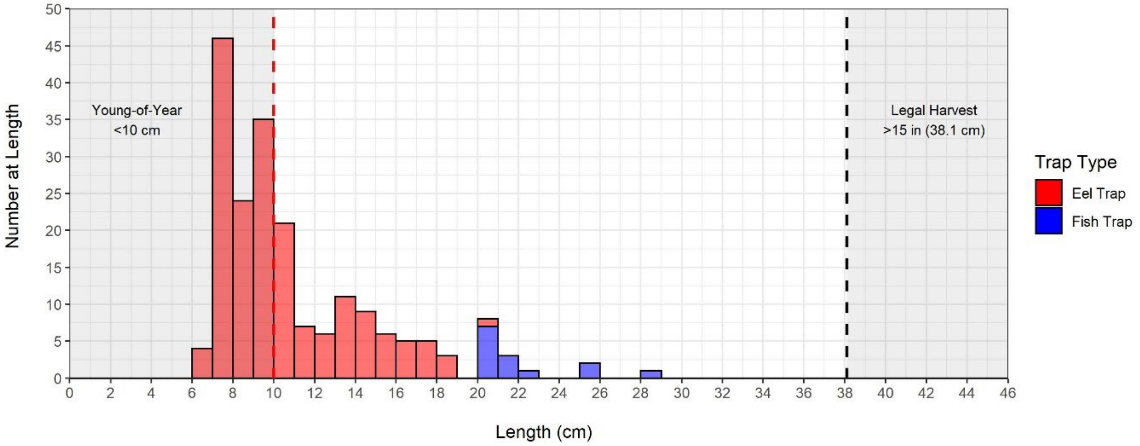


Figure 13. Histogram showing the size frequency at length of black sea bass species caught in eel traps and fish traps.

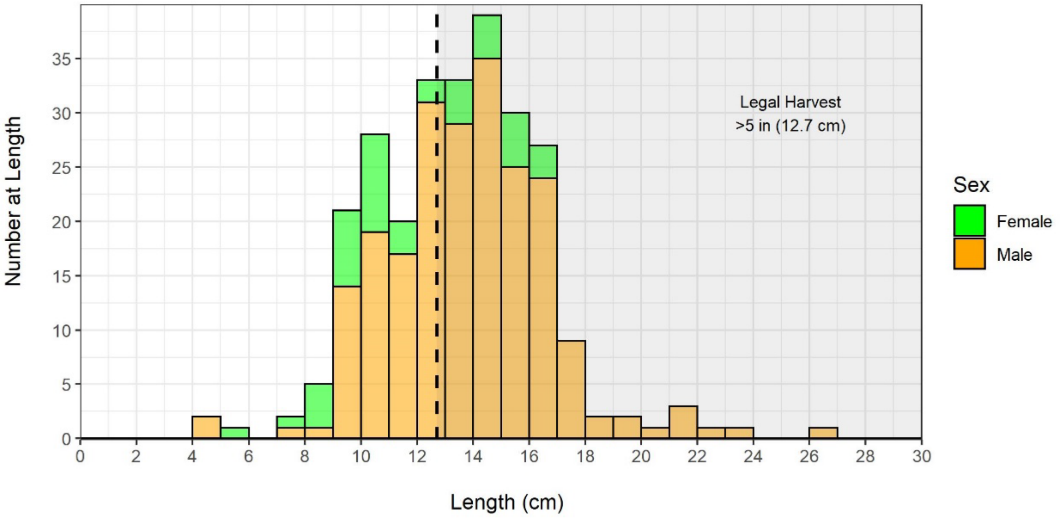


Figure 14. Histogram showing the size frequency at length of blue crabs caught in fish traps separated by sex.

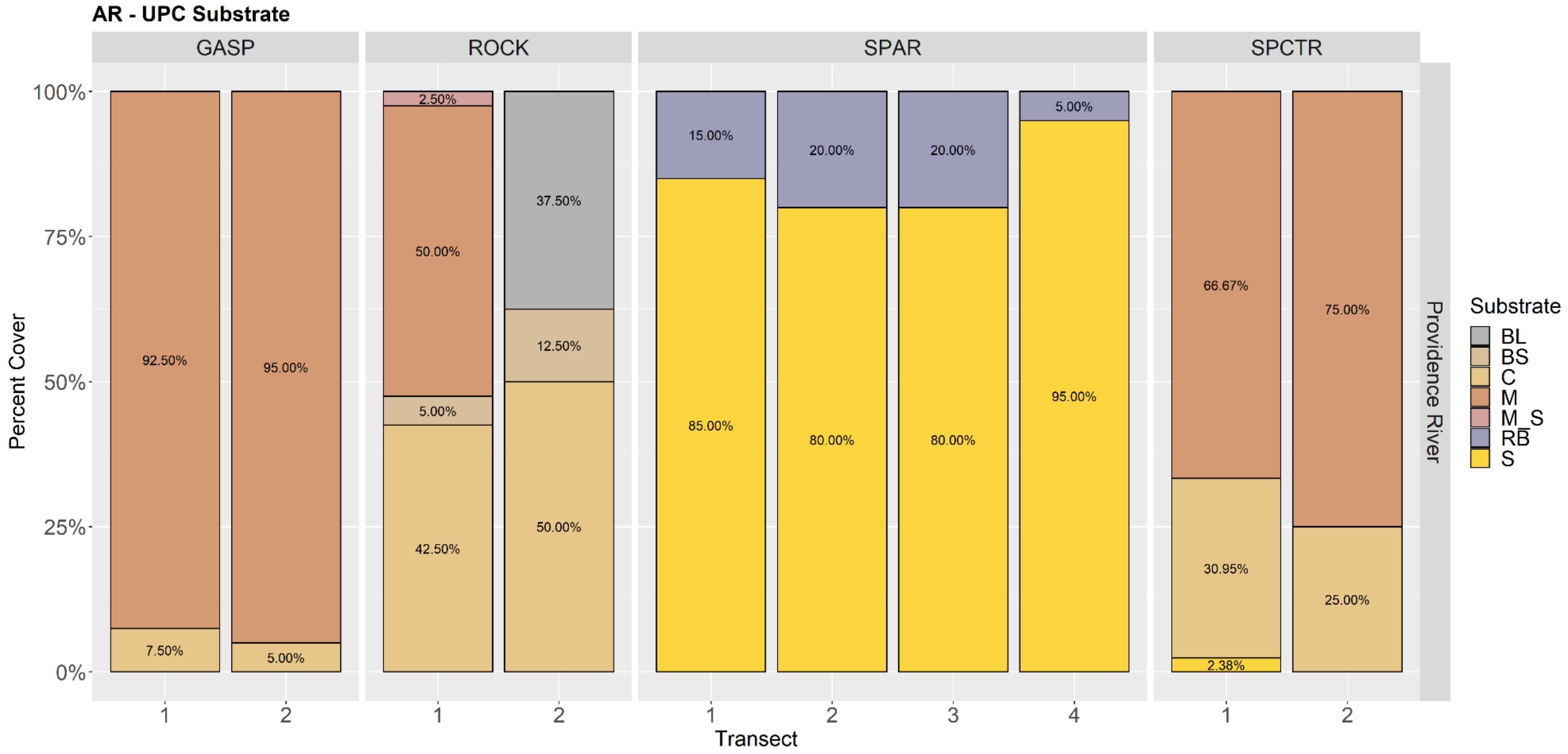


Figure 15. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 fish productivity survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, M = mud/fines, M_S = sandy mud mix, S = Sand, RB = Reef Ball) and faceted by Site (GASP = Gaspee Point (Control), ROCK = Rock Island (Natural Control), SPAR = Sabin Point Artificial Reef (Reef), SPCTR = Sabin Point Control (Control)).

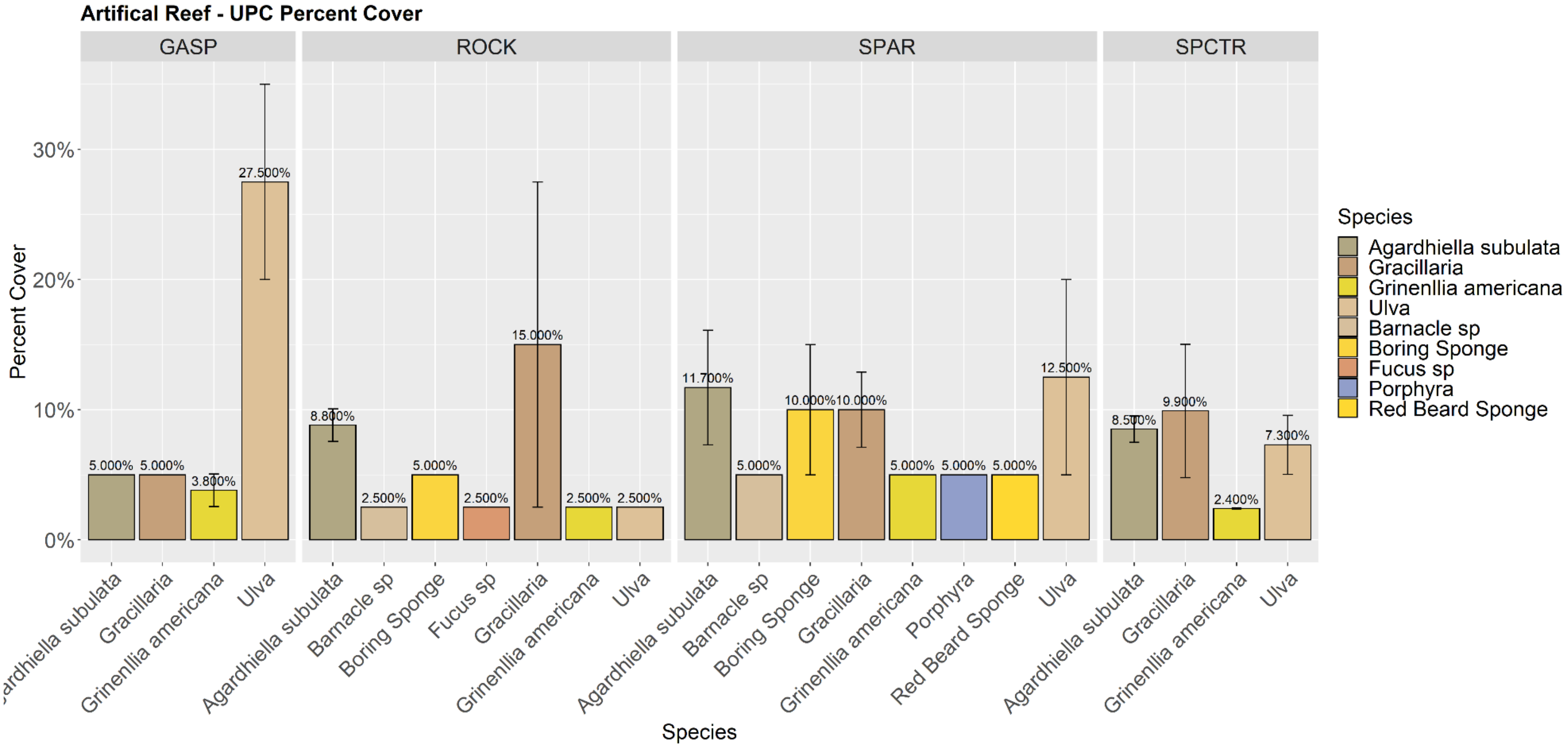


Figure 16. Mean algal and sessile invertebrate cover ± SE, for each Site (GASP = Gaspee Point (Control), ROCK = Rock Island (Natural Control), SPAR = Sabin Point Artificial Reef (Reef), SPCTR = Sabin Point Control (Control)) during the 2020 productivity dive survey.

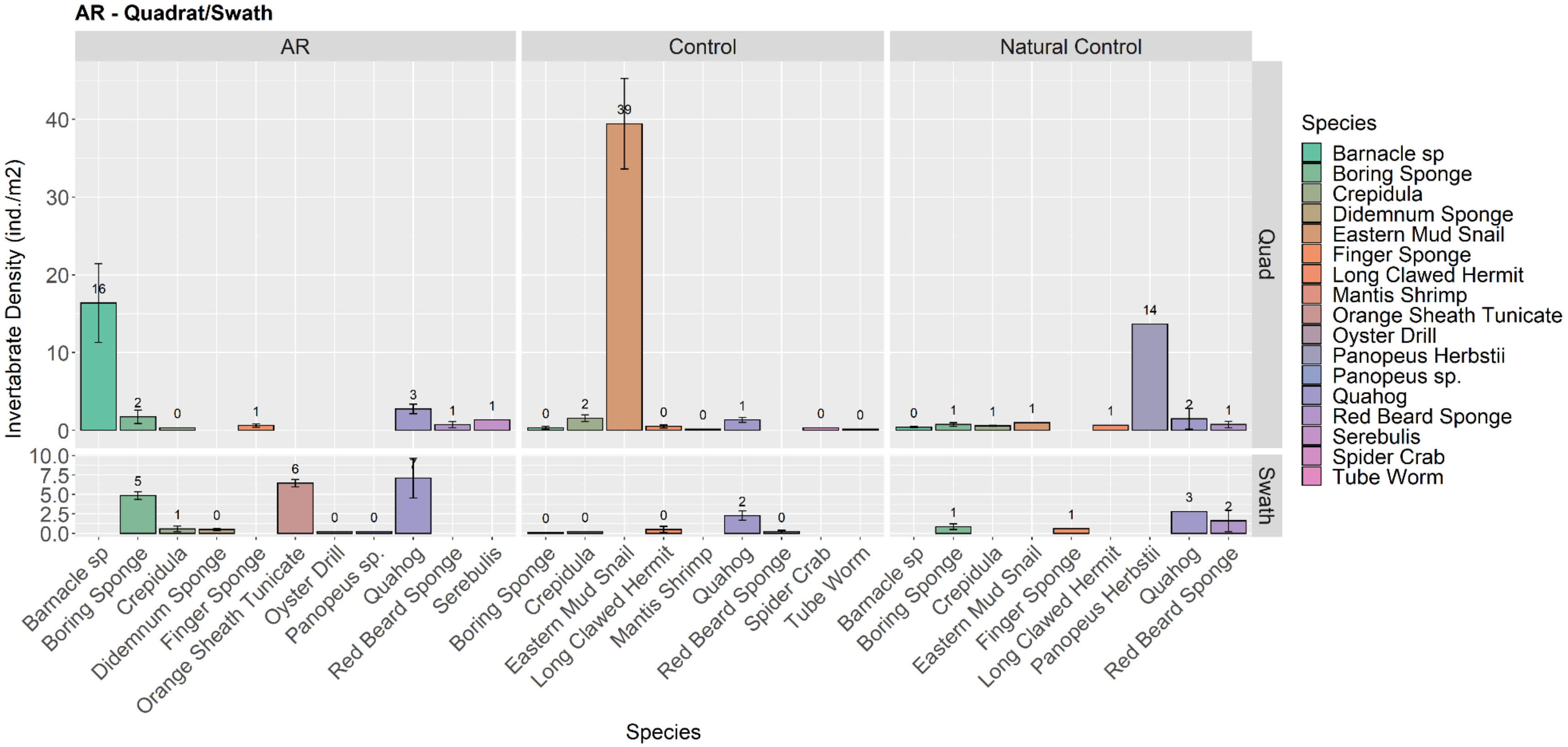


Figure 17. Mean invertebrate density ± SE, per habitat treatment (GASP = Gaspee Point (Control), ROCK = Rock Island (Natural Control), SPAR = Sabin Point Artificial Reef (Reef), SPCTR = Sabin Point Control (Control)), grouped by transect survey method (quadrat or swath).

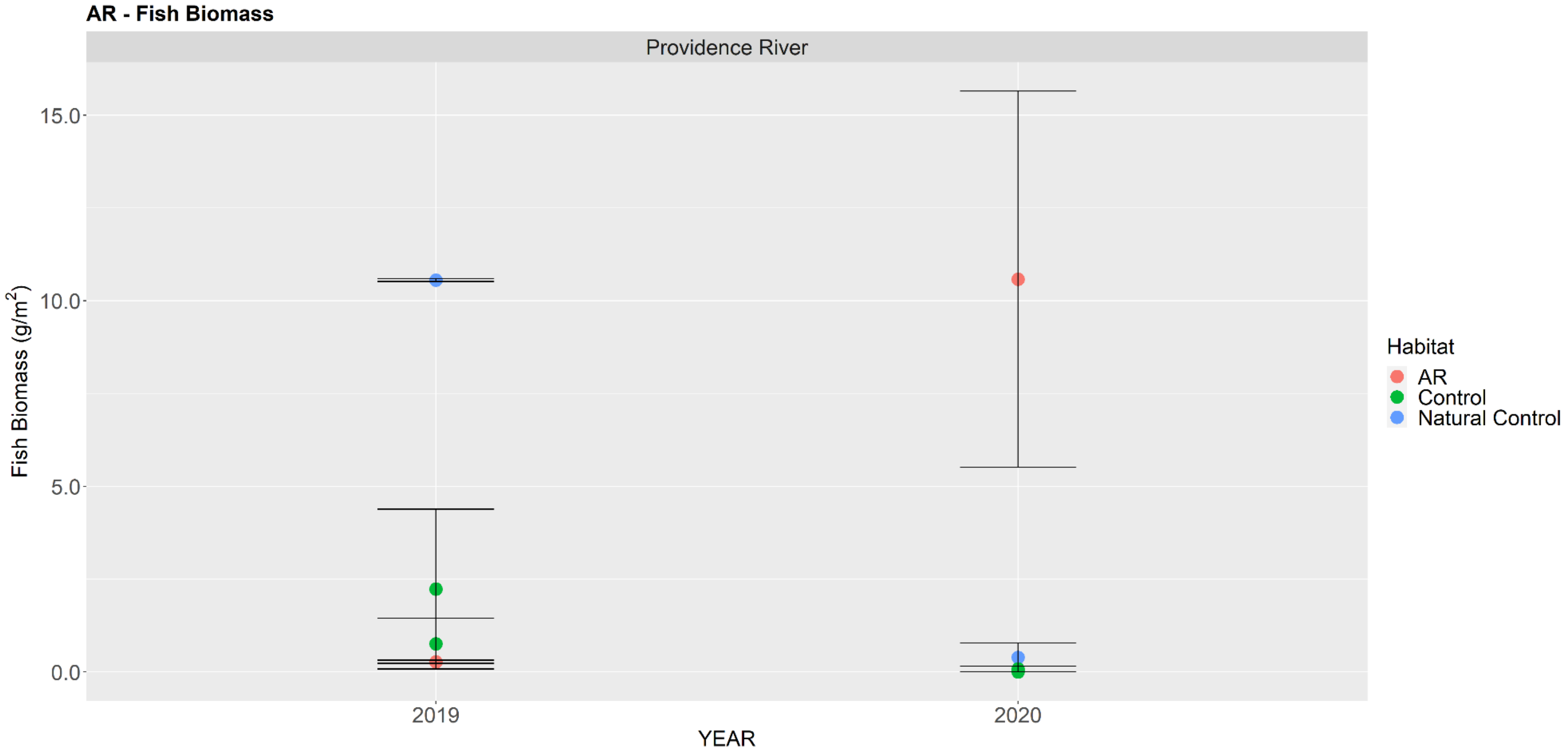


Figure 18. Mean fish biomass (g/m^2) before (2019) and after (2020) the construction of the Sabin Point Artificial Reef. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (AR = red, Control = green, Natural Control = blue)

TABLES:

Table 1 . Summary of fishing effort in 2020. X = two ventless un-baited black sea bass traps set ~20m apart and left to soak for 4 days (96 hours). XX = months where eel pots and fish traps were both used. * = indicates lost trap

2020	May	June	July	Aug	Sept	Oct	Total fish trap samples by site	Total eel pot samples by site
Watchemoket Cove	X	X*	X	X	X	X	6	0
Fields Point	X	X	X	X	X	X	6	0
Stillhouse	X	X	X	X	X	X	6	0
Sabin Point	XX	XX	XX	XX	XX	XX	6	6
Sabin Pier	XX	XX	XX	XX	XX	XX	6	6
Pawtuxet Cove	X	X	X		X	X	5	0
Narragansett Terrace	X	X	X	X	X	X	6	0
Rock Island	XX	XX	XX	XX	XX	XX	6	6
Gaspee Point	XX	XX	XX	XX	XX	XX	6	6
Conimicut	X	X	X	X	X	X	6	0
Mussachuck	X	X	X	X	X	X	6	0
Rocky Point	X	X	X	X	X	X	6	0
Total fish trap samples per month	12	12	12	11	12	12	**Total Trap Samples: 71**	-
Total eel pot samples per month	4	4	4	4	4	4	-	**Total Eel Pot Samples: 24**

Table 2. Total caught in 2020. Species of interest are bolded.

Common Name	Scientific Name	Total Fish Traps (12 Stations)	Total Eel Pots (4 Stations)
American Eel	Anguilla rostrata	2	11
Black Sea Bass	**Centropristus striata**	**14**	**175**
Blue Crab	Calinectes sapidus	240	27
Cunner	Tautogolabrus adspersus	0	15
Gobies	Gobiosoma genus	0	7
Green Crab	Carcinus maenus	16	6
Japanese Shore Crab	Hemigrapsus sanguineus	0	1
Mud Crab	Panopeus spp	0	23
Northern Puffer	Sphoeroides maculatus	1	0
Oyster Toadfish	Opsanus tau	14	21
Scup	**Stenotomus chrysops**	**153**	**14**
Smooth Dogfish	Mustelus Canis	1	0
Spider Crab	Libinia emarginata	562	13
Striped Searobin	Prionotus evolans	2	0
Summer Flounder	**Paralichthys dentatus**	**21**	**0**
Tautog	**Tautoga onitis**	**33**	**8**
Winter Flounder	**Pseudopleuronectes americanus**	**0**	**5**
Water Hauls	-	16	3
Total Fish	-	241	256
Total Crustaceans	-	818	70

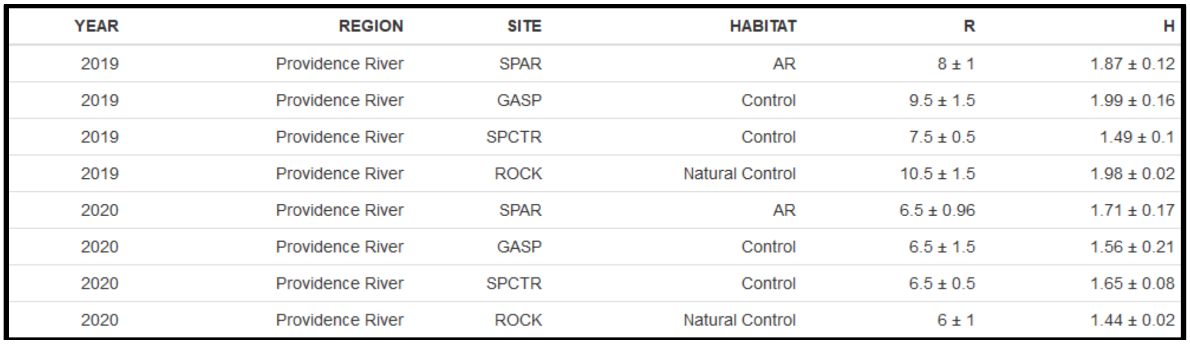
Table 3. Finfish catch rate from the black sea bass traps by station and month with calculated total, mean, standard deviation, and standard error.

	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pier	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Conimicut Pt.	Mussachuck Creek	Rocky Point	Total	Mean	SD	SE
May	0.25	-	-	1.50	0.75	1.25	0.25	0.25	0.25	1.50	1.25	0.50	7.75	0.65	0.58	0.17
June	1.00	1.00	7.75	1.75	0.50	6.25	0.50	11.75	0.50	-	0.25	1.75	33.00	2.75	3.76	1.08
July	0.50	0.25	0.25	-	2.25	1.75	-	3.00	0.50	-	0.50	1.00	10.00	0.83	0.98	0.28
August	0.50	0.25	-	-	0.25	-	NA	0.50	0.25	-	1.50	-	3.25	0.30	0.44	0.13
September	0.50	-	0.25	0.25	-	0.50	-	0.25	0.50	2.50	-	0.25	5.00	0.42	0.69	0.20
October	1.00	0.25	-	-	-	-	-	-	-	-	0.50	-	1.75	0.15	0.31	0.09
Total	3.75	1.75	8.25	3.50	3.75	9.75	0.75	15.75	2.00	4.00	4.00	3.50				
Mean	0.63	0.29	1.38	0.58	0.63	1.63	0.15	2.63	0.33	0.67	0.67	0.58				
SD	0.31	0.37	3.13	0.82	0.85	2.37	0.22	4.61	0.20	1.08	0.58	0.68				
SE	0.13	0.15	1.28	0.33	0.35	0.97	0.10	1.88	0.08	0.44	0.24	0.28				

Table 4. Total abundance of species caught in fish traps by station in 2020.

Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pier	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Conimicut Pt.	Mussachuck Creek	Rocky Point	Total
American Eel	-	-	2	-	-	-	-	-	-	-	-	-	2
Black Sea Bass	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**10**	**1**	**14**
Northern Puffer	-	-	-	-	-	-	-	-	1	-	-	-	1
Oyster Toadfish	6	2	-	2	-	-	-	2	-	2	-	-	14
Scup	**3**	**-**	**31**	**3**	**10**	**1**	**34**	**58**	**3**	**5**	**-**	**5**	**153**
Smooth Dogfish	-	-	-	-	-	-	1	-	-	-	-	-	1
Striped Searobin	-	-	-	1	-	-	-	-	1	-	-	-	2
Summer Flounder	**-**	**4**	**-**	**2**	**2**	**2**	**1**	**2**	**1**	**4**	**-**	**3**	**21**
Tautog	**3**	**-**	**-**	**6**	**3**	**-**	**3**	**1**	**1**	**5**	**6**	**5**	**33**
Total	13	7	33	14	15	3	39	63	8	16	16	14	241
Blue Crab	**7**	**32**	**27**	**18**	**27**	**21**	**15**	**26**	**37**	**13**	**14**	**3**	**240**
Green Crab	-	-	-	-	-	2	-	-	3	11	-	-	16
Spider Crab	7	-	9	9	32	2	45	23	15	85	203	132	562
Water Haul	3	2	1	2	-	2	1	1	3	-	-	1	16
Total	14	32	36	27	59	25	60	49	55	109	217	135	818

Table 4. Biological Cover, species richness and diversity. Average species richness (R) and diversity (Shanon's H index) derrived from the individual transect richness and diversity values for each site. This data only represents the diversity and richness observed via the uniform point count transect method and does not reflect mobile inverts and finfish species present at these locations.



YEAR	REGION	SITE	HABITAT	R	H
2019	Providence River	SPAR	AR	8 ± 1	1.87 ± 0.12
2019	Providence River	GASP	Control	9.5 ± 1.5	1.99 ± 0.16
2019	Providence River	SPCTR	Control	7.5 ± 0.5	1.49 ± 0.1
2019	Providence River	ROCK	Natural Control	10.5 ± 1.5	1.98 ± 0.02
2020	Providence River	SPAR	AR	6.5 ± 0.96	1.71 ± 0.17
2020	Providence River	GASP	Control	6.5 ± 1.5	1.56 ± 0.21
2020	Providence River	SPCTR	Control	6.5 ± 0.5	1.65 ± 0.08
2020	Providence River	ROCK	Natural Control	6 ± 1	1.44 ± 0.02

Table A. Fish and Eel Pot Locations in 2020. ^{X} = indicates sites where eel pots were used.

Name	Latitude	Longitude
Fields Point	41.7868	-71.3722
Stillhouse Cove	41.7729	-71.3855
Sabin Point^{X}	41.7631	-71.3669
Sabin Pier^{X}	41.7636	-71.3686
Pawtuxet Cove	41.7590	-71.3854
Narragansett Terrace	41.7522	-71.3654
Rock Island^{X}	41.7526	-71.3793
Gaspee Point ^{X}	41.7470	-71.3740
Mussachuck Creek	41.7278	-71.3431
Conimicut Point	41.7228	-71.3622
Kettle Point	41.7978	-71.3816
Rocky Point	41.6885	-71.3639

Table B. Presence of finfish and crustaceans by month captured by the fish traps in 2020.

MAY	**Site**												
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
Green Crab	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Oyster Toadfish	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Scup	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Spider Crab	0	0	1	1	1	0	1	1	1	1	1	1	**9**
Summer Flounder	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Tautog	1	0	0	1	1	0	1	1	1	1	1	1	**9**

JUNE	**Site**												
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
Blue Crab	1	1	1	1	1	1	1	1	1	0	1	1	**11**
Oyster Toadfish	0	1	0	0	1	0	0	1	0	0	0	0	**3**
Scup	1	0	1	1	1	1	1	1	1	0	0	1	**9**
Spider Crab	1	0	1	1	1	1	1	1	1	0	1	1	**10**
Striped Searobin	0	0	0	0	1	0	0	0	1	0	0	0	**2**
Summer Flounder	0	1	0	0	1	1	0	0	0	0	1	0	**4**
Tautog	0	0	0	0	1	0	0	0	0	0	0	1	**2**

JULY	**Site**												
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
American Eel	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Black Sea Bass	0	0	0	0	0	0	0	0	0	0	0	1	**1**
Blue Crab	1	1	1	1	1	1	1	1	1	1	1	0	**11**
Green Crab	0	0	0	0	0	0	0	0	1	0	1	0	**2**
Oyster Toadfish	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Scup	1	0	0	1	0	0	1	1	1	0	0	0	**5**
Spider Crab	1	0	1	0	0	0	1	1	0	1	1	1	**7**
Summer Flounder	0	1	0	1	0	0	0	1	0	0	1	1	**5**

AUGUST	**Site**												
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
Blue Crab	1	1	1	1	1	-	1	1	1	1	1	0	**10**
Northern Puffer	0	0	0	0	0	-	0	0	1	0	0	0	**1**
Oyster Toadfish	1	0	0	0	0	-	0	0	0	0	0	0	**1**
Scup	0	0	0	1	0	-	0	1	0	0	1	0	**3**
Spider Crab	0	0	1	0	0	-	0	1	0	1	1	1	**5**
Summer Flounder	0	1	0	0	0	-	0	0	0	0	1	0	**2**
Tautog	1	0	0	0	0	-	0	0	0	0	0	0	**1**

SEPTEMBER	**Site**												
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
American Eel	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Black Sea Bass	0	0	0	0	0	0	0	0	1	1	0	0	**2**
Blue Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Green Crab	0	0	0	0	0	1	0	0	1	0	0	0	**2**
Oyster Toadfish	1	0	0	0	0	0	0	1	0	0	0	0	**2**
Smooth Dogfish	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Spider Crab	1	0	1	1	0	0	1	0	0	1	1	1	**7**
Summer Flounder	0	0	0	0	1	0	1	0	1	0	0	0	**3**

OCTOBER	**Site**											
Species	Watchemoket Cove	Fields Pt.	Stillhouse Cove	Sabin Pt.	Sabin Pier	Pawtuxet Cove	Narragansett Terrace	Rock Island	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Rocky Pt.	**Total out of 12**
Black Sea Bass	1	1	0	0	0	0	0	0	0	0	0	0	**2**
Blue Crab	0	1	1	0	0	1	1	0	0	1	1	0	**6**
Green Crab	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Oyster Toadfish	1	0	0	0	0	0	0	0	0	0	1	0	**2**
Spider Crab	0	0	0	1	0	0	1	1	0	1	1	1	**6**
Tautog	1	0	0	0	0	0	0	0	0	0	0	0	**1**

Photoquadrat dive monitoring

Introduction

Underwater photo quadrats have been used in marine conservation work to address a number of different monitoring needs including observing fish behavior and abundances, temporal and spatial colonization of organisms over time, and macroscale rapid ecological assessments of algal assemblages (Robinson et al 2019; Van Rein et al 2011;Preskitt et al 2004). The use of photo quadrats has been shown to create fast, repeatable, reliable data sets that are lower in cost than intensive dive sampling and with the correct resolution and turbidity can provide an effective approach to rapid data collection (Van Rein et al 2011).

Artificial reef structures take time to mature. Sessile colonizing organisms are attracted to these structures at different rates and hold a certain successional order, similar to land-based ecosystems. Photo quadrats taken at the SPAR site were conducted to get quantifiable and repeatable data depicting the benthic communities colonizing this reef system over time and across the patch reefs. How fast the Reef Balls ^{TM} are colonized, what species are found on them, and in what order they appear may provide insight into the health of the system and what larger, mobile fauna may be present. In addition, compiling and comparing standardized photos of the structures over time can help investigators better understand any transition periods, impacts from large storm events or sudden changes in water quality, and the natural transition of species throughout different seasons.

Methods

During the months of May and July three reef balls were randomly selected within each patch reef of 16 Reef Balls ^{TM}. Investigators used SCUBA to take photos at each reef ball. Three to four replicate images were taken at the north, south, east, and west sides or at the bottom, middle, or top of the reef ball. Images were taken with a GoPro Hero 6 attached to a 1/4m quadrat (See images below).

Figure 1. Image of photoquadrat set up and GoPro view.

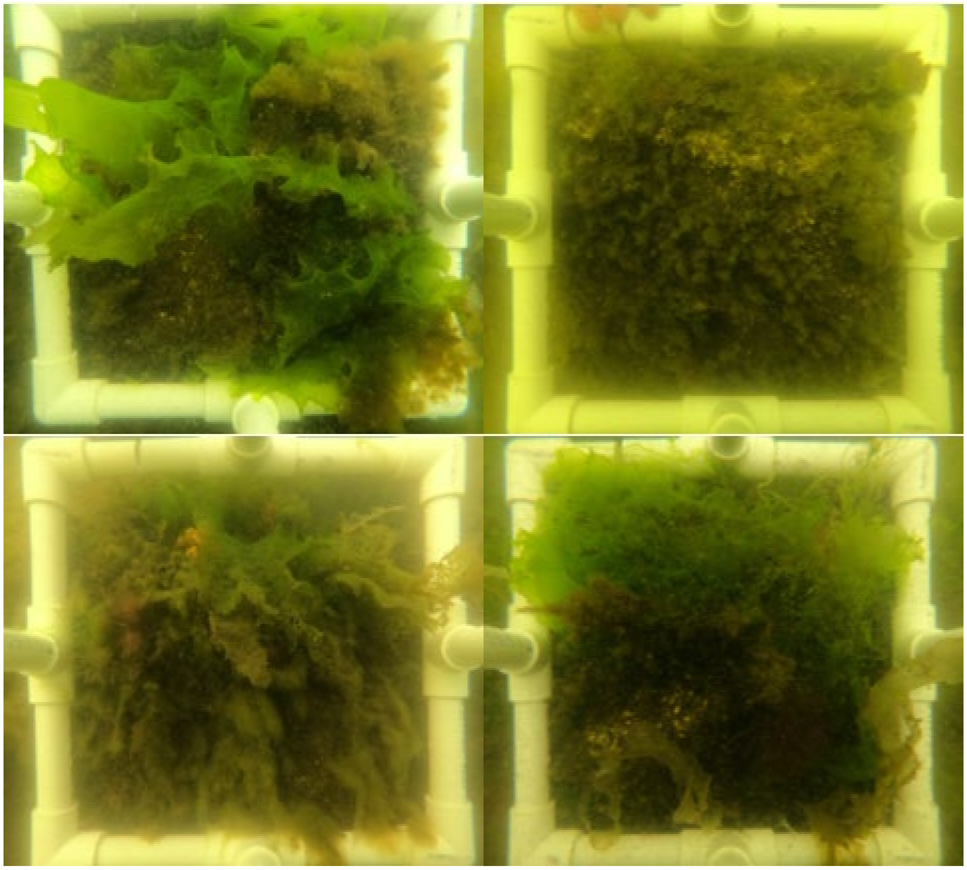


Figure 2. Image of four sample photoquadrats from the SPAR site in July.

PERFORMANCE REPORT

STATE: Rhode Island

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

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: V: Holistic Fish Habitat Assessment and Fish Productivity Estimations; Part C: Oyster Reef Monitoring and Productivity Assessment

STAFF: Patrick Barrett and Eric Schneider (RI DEM, Div. of Marine Fisheries) and Drs. Randall Hughes and Jon Grabowski (Northeastern University)

JOB OBJECTIVE: This project aims to positively affect local fish populations by improving degraded marine habitat. Specifically, the goal is to determine if oyster reef construction can be used to improve productivity of young of the year to juvenile 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*).

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2020. During this period, we continued previously established surveys at fish habitat enhancement (FHE) sites in Ninigret and Quonochontaug Ponds to monitor oyster status and fish abundance, while implementing new survey techniques, using habitat trays and dive transect surveys, to collect estimates benthic and fish community biomass that will be used in combination with other metrics to quantify the increase in production of juvenile sportfish at FHE oyster reefs compared to unenhanced habitat. In response to the Covid-19 pandemic, staffing and field survey data collection approaches had to be modified to ensure the safety of staff and the public. Although additional effort was required, all field survey work was completed as scheduled. Although laboratory work required to process habitat tray and oyster pathology samples was impacted by Covid-19 restrictions, the overall project timeline will not be impacted.

TARGET DATE: 12/31/2020

RECOMMENDATIONS:

None

INTRODUCTION

More than 70% of Rhode Island's recreationally and commercially important finfish spend part of their lives in coastal waters, usually when they are young (Meng & Powell, 1999). The shallow water, salt marshes, sea grasses, and oyster reefs provide excellent foraging and feeding areas as well as providing protection from larger, open-water predators. In Rhode Island, complex shellfish reefs formed by oysters (*Crassostrea virginica*) 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 growing recognition of the ecological and economic importance of these habitats have led to an increase in the efforts to construct structed habitats, such as oyster reefs (Coen and Luckenback 2000, Brumbaugh et al. 2006).

Previous work in the Mid-Atlantic and Gulf of Mexico shows that oyster reefs can increase the growth and survival of juvenile finfish (e.g., Peterson et al. 2003, zu Emgassen et al. 2016), as well as fish and invertebrate biomass (e.g., Grabowski et al. 2005, Humphries and La Peyre 2015, Ermgassen et al. 2016,) compared to unenhanced habitats. Work conducted from 2014-2019 via a partnership between RI DEM, Div. of Marine Fisheries (DMF), The Nature Conservancy (TNC), and Northeastern University (NU) during the last USFWS Sportfish Restoration (SPR) grant cycle (summarized in RI DEM 2019 F-61 Performance Report, Job 6-B) explicitly explored the response in the abundance and species assemblage of recreationally important finfish species to the creation of Fish Habitat Enhancement (FHE) oyster reefs in Rhode Island. Overall, results showed increased fish abundance at FHE oyster reefs after reef construction compared with the pre-enhancement baseline habitat (Barrett et al. in prep). In addition, specific reef-dwelling species, such as tautog and black sea bass, were observed more frequently at FHE reefs sites compared to unseeded reefs and unenhanced control plots. Although increases in abundance have been recorded, additional sampling and analyses are needed to better understand long-term fishery and habitat responses, and quantify the fisheries production provided by the FHE oyster reef habitat created by the previous USFWS SPR work.

APPROACH

Site Locations and Experimental Design

In partnership with Drs. Randall Hughes and Jon Grabowski (NU) we are utilizing oyster reef created for fish habitat enhancement (hereafter, FHE reefs) to determine if oyster reef construction can be used to improve productivity of young of the year to juvenile 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*). For this evaluation, we are using FHE reefs created using two different, but similar, experimental designs in the coastal ponds of Rhode Island (Figure 1). In Ninigret Pond we had previously created four replicates of three distinct treatments that include a cultch only reef, a seeded reef, and bare plot control, to test the influence of not only enhanced structure (cultch only reefs), but enhanced biomass (seeded reefs), have on the abundance of juvenile finfish that utilize these reef habitats. In the fall of 2019, we re-seeded both the cultch only and previously seeded reefs in Ninigret Pond with a new set of Green Hill Pond seed sourced oysters. In Quonochontaug Pond, the goal is to assess whether specific genetic lines (lineage) of oysters contain desirable traits for both fish habitat and reef longevity. To evaluate this effect, we used two 'wild' linages of oysters, spawned from adults collected from existing populations that will be compared against a commercial strain of oysters (eyed larvae purchased from Aquaculture Research Corporation in Dennis, Massachusetts) commonly used in oyster reef restoration and enhanced projects in RI. The commercial hatchery lineage in Quonochontaug Pond was the same used for all the 2015 Ninigret Pond FHE seeded reefs. The experimental design in Quonochontaug included creating three reefs, each seeded with one oyster linage, and a bare control plot at three different sites (replicates)~~.~~ In total, there are a 12 experimental reef plots, which is consistent with Ninigret Pond; however, the number of replicates from four to three (Figure 1).

Oyster reef monitoring

Consistent with monitoring conducted at these sites beginning in 2016, reef status was evaluated by monitoring each FHE reef twice a year (May and September) using the Rhode Island Oyster Restoration Minimum Monitoring Metrics and Assessment Protocols (Griffin et al. 2012). 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. Relief, quadrat height relative to the bottom, was measured by finding the difference between the water depth at the reef edge and the depth from the center of the quadrat. All oysters and dead shell were then excavated from the quadrat. All live oysters and dead oysters per quadrat were counted as well as the presence of boring sponge. The shell height of a sub-sampled of 50 living and 30 recently dead oysters were also measured for each quadrat. Density was calculated for both living and recently dead oysters by multiplying abundance per quarter meter quadrat by 4. All material was then returned to the sampling location so as not to disturb the reef. An additional 30 oysters from each reef are collected for disease and pathological work conducted by the Hughes Lab at NU.

In addition to the standard oyster sampling, mean spat length and density at the time of seeding were collected by averaging a sub sampled of seeded cultch bags provided by the oyster growers during reef construction. This average length and density per bag was then multiplied by the total number of bags deployed per reef, and divided by the total area (m^2) of the reef to calculate initial seed length and density. These initial seeding density and length measurements are only used during the creation of the oyster growth and mortality curves discussed below.

Habitat Trays

Beginning in 2020, habitat trays were initiated as a new standardized sampling approach to quantify the abundance of finfish and invertebrates at FHE oyster reefs and control sites. We expect habitat trays will be deployed for 30 days at selected FHE reefs and controls once a year between July and September from 2020-2023. This approach builds on previous work conducted by NU in collaboration with DEM, and summarized in T. Davenport 2022 (PhD Dissertation, in development).

During 2020, habitat trays consisting of plastic bread trays (22" x 26" each, 0.369 m^2) lined with 1mm mesh, were deployed at FHE reefs and controls sites in Ninigret and Quonochontaug Ponds. Habitat trays deployed at oyster reefs were filled with 5 gallons of recycled oyster shell; whereas trays deployed at control sites were filled with 10 gallons of sand. The additional volume of sand compensated for sand loss during filling and deployment. Once deployed, trays at both locations contained the same volume of material. At each site, trays were placed adjacent to the reef edge, so not the impact the intact oyster reef, at one of 4 predetermined random locations (e.g., north, east, south, or west edge of the reef). Trays were deployed at sites in Ninigret and Quonochontaug Pond on August 17 and 18, 2020, respectively. After 30 days trays were collected from each site by a diver at reef sites and pair of divers at control sites. The diver(s) would lift the tray directly up from the substrate, out of the water, and into a vessel anchored nearby. Once on the vessel, the contents of the trays were transferred to small-mesh sampling bags. Samples were transported to the laboratory and sorted to separate all biological material from the shell. Fish, crabs, and all other algae and macro invertebrates were separated into separate jars and preserved with ethanol. During the summer of 2021, samples will be sorted, and individuals of each species identified, enumerated, measured and weighed.

Eel Pot and Minnow Trap Survey

During 2020, we continued the previously conducted fishery survey work, using eelpots and minnow traps, once each month from April through October. Fish pot sampling consisted of setting 2 eel pots and 3 minnow pots connected on a trot line at each site once per month. The pots were soaked (i.e., fished) for 24 hours before hauling. Environmental data such as temperature, salinity, and dissolved oxygen are collected using YSI Professional Plus Multiparameter instrument at each sampling station while hauling gear.

Fish Productivity Assessment

Using methods similar to those used for kelp, artificial reefs, and eelgrass, we conducted dive survey transects at FHE oyster reef and control sites once during mid to late summer (July – September 2020). To assess fish-habitat linkages at oyster reefs the monitoring protocol utilized the same 5 dive transect methods outlined above (see Kelp section; 5A. Along each 10m transect a diver placed a 0.25m^2 PVC frame on the bottom (substrate or reef) at each the beginning and end of the transect, and two locations spaced in the middle of the transect on the targeted habitat (n = 4 quadrat per transect). Substrate beneath understory algae was searched, however, neither the substrate nor the organisms attached to it are removed. Due to the complex surface of an oyster reef, divers will search around and between oysters to locate and identify fish and invertebrates that may hide in crevasses. Substrate, reef habitat (i.e., oysters and shell), and organisms will not be removed or captured from the quadrant. The quadrant will remain in place for use in morphometrics. A subset of FHE oyster reefs are surveyed each year, with an expectation that two reefs and one control per site (replicate) in Quonochontaug Pond (9 transects) and at one reef and one control per site in Ninigret Pond (8 transects) will be surveyed annually.

Analytical Approach

Prior to ANOVA analyses, all oyster data were tested for homogeneity of variance and conformance to a normal distribution using a Levene's test and Shapiro Wilks, respectively (Levene's $p > 0.05$, Shapiro Wilks $p > 0.05$). Oyster quadrat data that did not meet the assumptions was log transformed prior to analysis. We present values as mean oyster density and mean shell length ± one standard error and set level of significance for all tests at $p <0.05$, unless stated otherwise. All significant differences between the ANOVA factors were denoted using letters derived from Tukey's post hoc tests on the ANOVA models.

Oyster density (ind./m^2) and mean length (mm) per quadrat were used to calculate a mean oyster density and length value for each oyster restoration reef. To evaluate if oyster density or length differed between monitoring events in Quonochontaug Pond, we used one-way ANOVAs testing the effect of time (monitoring event) on mean density and length per monitoring event. When only the main effects were significant, without a significant interaction, one-way ANOVAs were then run on the individual main effects. Since the treatments were changed during the 2019 re-seeding event in Ninigret Pond, mean density and oyster length for the 2020 season is presented as mean ± standard error and grouped by the new treatments (e.g. Green Hill Pond, and Green Hill Pond/Old Hatchery Reef). Before the Ninigret reefs were re-seeding in 2019, we determined the average oyster spat per tote deployed on each reef using the oyster spat on shell subsample collected before the reseeding began. By dividing by the average surface area of the FHE reefs in Ninigret, we were able to determine the oyster density per meter squared for the Fall of 2019 and compared that to the density of oysters that survived until the fall of 2020 to estimate 1st year survival of the Green Hill Pond brood stock spawned oysters that were set.

In 2020, we began the first year of post-reseeding fish monitoring at the FHE reef sites in Ninigret and began Year-4 of post-enhancement monitoring in Quonochontaug Pond.
A Before-After-Control-Impact (BACI) approach was used to determine how reef construction can impact the fish assemblage, relative species abundance, and juvenile length distributions in the coastal ponds. We specifically assessed how relative species abundance and community assemblages have changed over time between our baseline surveys and up to 3 years post reef construction. For the BACI analysis we derived mean catch per haul by aggregating the number of fish caught per minnow trap plus eel pot haul (herein after, CPUE) and then finding the average CPUE for each month by habitat treatment. For each recreational species of interest, such as Black Sea Bass, Winter Flounder, Tautog, and Cunner, we created a mean CPUE plots from the aforementioned CPUE data, and analysis of augmented YOY abundance when data permitted. Ninigret and Quonochontaug Ponds were analyzed separately for each species.

Substrate and species cover were summarized for each fish habitat productivity transect by using the uniform point count data to derive both a geological and biological percent cover for each dive transect. The total number of observations were summarized for each species or substrate and then divided by the total number of uniform point counts collected along the length of each transect ($n = 20$). We also estimated average species richness and Shannon's Index of diversity. Algae and invertebrate densities were summarized using the quadrat, and swath datasets when applicable, by averaging the total number of observations across all quadrats ($n=4$) within each transect. To evaluate how enhanced oyster habitat compares to the unstructured and natural controls, we calculated the mean density of individuals per meter squared ± SE and present the averages grouped by habitat type (e.g. oysters and corresponding controls).

Using the fish count survey data, fish abundance at length was converted to total fish mass per transect by leveraging the DMF age and growth lab data to convert fish length in centimeters, to weight in grams, for the target sportfish species (i.e. Tautog, Black Sea Bass, Winter Flounder). To do this we used Rhode Island specific allometric growth models. For species not currently dissected in the growth lab, the geometric mean alpha and beta coefficient estimated on Fishbase.org were considered. To compare total fish biomass between the oyster reef enhancement sites and unenhanced controls the total fish mass was standardized by dividing the total area surveyed, to get grams per meter squared. Then we calculated the effect size of the oyster reef with respect to the control sites using the Hedge's g computed on the mean biomass per meter square estimates. Hedge's g effect size was calculated using the mean values and standard deviations from the mean biomass estimates.

RESULTS

Oyster Reef Performance

In 2020, we monitored the status of the Fall 2019 FHE reseeding efforts. We found that the Green Hill Pond broodstock oysters we used to reseed the FHE reefs exhibited a 57.9% first year survival rate, and a mean density average of 682 and 564 ind./m^2 during the first two monitoring events following reef enhancement (Figure 2). The density of the remnant Hatchery line on the "old reef" treatments was roughly ranged from 0-20 with an average of 9 ind./m^2. In Quonochontaug Pond, we continued to see a significant effect of monitoring event on oyster density and shell length (Figure 3). Processing of pathology samples were impacted by Covid-19 restrictions and results were not available for inclusion in this report submission. Results will be submitted to DMF during March 2021 and included in the next performance report.

Habitat Trays

Samples collected during 2020 are preserved and will be sorted during 2021, once Covid-19 restrictions are eased and work can resume in the NU laboratory space used for fish sample processing and analyses.

Eel Pot and Minnow Trap Survey

Average CPUE per has been summarized for five target species, Black Sea Bass, Winter Flounders, Tautog, Cunner, and Oyster toadfish (Table 1). These five species are the most frequently caught species in the eel pot and minnow trap survey. In Ninigret pond, mean CPUE during the 2020 field season was greatest on the Green Hill Pond, or newly reseeded reefs, for all species besides Black Sea Bass, for which we saw the greatest abundance on the older, previously built hatchery reef (Figure 4). We found between both experiments, young of the year tautog were most positively augmented on the oyster reefs relative to the control sites. In Ninigret Pond there was a 1.7 times increase and in Quonochontaug there was a 3.6 fold increase for young of the year tautog (Figure 4 and Figure 5, respectively). In 2020, we found mean

CPUE in Quonochontaug to be greater for all target species, across all habitat types, when compared to Ninigret (Figure 4 and 5). However, the relative enhancement impact of the enhanced oyster reefs was not as uniform for each species of concern. For example, Black Sea Bass were 1.74 times greater on the reef habitat than the control sites (Figure 5). Whereas, for winter flounder and cunner, there were slight increases or decreases depending on the habitat treatment and location of the reef (Figure 5).

Fish Productivity Assessment

During September 2020, dive surveys were conducted to determine the baseline floral and faunal communities for use in productivity estimation at 9 enhancement reefs and 3 controls sites in Quonochontaug Pond. Investigators successfully conducted the first year of the post oyster reef productivity dive surveys, completing 11 dives in total. In Quonochontaug Pond, the percent cover at the three control sites varied depending on their location with Pond. In the north west region of the pond, the control habitat (1A) was 100% mud or fine sediment, whereas the North and North East control locations (2D, 3C) had increasingly more sand, gravel, and shell substrate. The North region, or Site 2 control, is sandier than Site 3, which had a higher percent of mud and finer sediment mixed in (3D = 55% ; Figure 6). Site 3 also contains a greater proportion of natural boulders compared to Site 2 (3C = 35%, 2D =15%. Figure 6).

In 2020, the overall species diversity, with respect to the algae and sessile invertebrate species, was greater on the oyster reef habitat than the controls (Table 2). The biggest difference between the reef substrate locations and controls is the abundance of branching and filamentous red algae sponge species are able to adhere to the firmer substrate. Most notably *Polysiphonia* species*,* *Ceramium* species*,* and Boring Sponge (Figure 7). Investigators found invertebrate densities to vary depending on the species and survey location. At the control sites, investigators found the highest abundance of Crepidula and Eastern Mud snails (11.33 and 2.667 ind./m^2) (Figure 7). The reef sites harbored a wider array of inverts, most notably increased abundance of barnacles, boring and red beard sponge, mud crabs, and Quahogs. The average Quahog density at the reef sites in Quonochontaug was 3.167 ind./m^2, two times greater than the density found at the controls, 1.33 ind./m^2 (Figure 8). highest abundance of *Crepidula* (~ 2 ind./m^2). When comparing swath and quadrat survey techniques, it seems the swath method provides a lower estimate of shellfish densities across all locations. In the swath we found greater abundance of rare or less occurring species like the orange sheath tunicate and hermit crabs (Figure 8). In 2019, during the pre-enhancement survey, average total fish biomass at the oyster reef treatments (4.33 ± 1.07 g/m^2) was greater than the unenhanced control sites (0.24 ± 0.09 g/m^2) (Figure 9). Using Hedge's g effect size we compared the average biomass per meter squared of reef habitat to control habitats, and found the enhancement reef to have an effect size of 1.98.

DISCUSSION

Oyster reef monitoring suggest our FHE reef establishment approaches have thus far been successful in both Ninigret and Quonochontaug Ponds. In Ninigret Pond, where surveys represented the first year of monitoring post re-seeding, we the Green Hill lineage exceeded the first-year survival of the previously used hatchery lineage by approximately 10 %. Various environmental and biological factors like predation play an important role in the survival of first year oysters, and determining how a given lineage may perform in certain environments provides crucial information for habitat restoration practitioners and resource managers. We will continue to look for evidence of enhanced performance in addition to susceptibility to different parasite borne diseases and the ability to enhance fish production. In Quonochontaug Pond, the oyster performance was status quo to 2019. We observed a slight drop in density and a slight increase in average oyster length suggesting that for the reefs that are successful are maintaining densities well above the minimum ecological threshold, with respect to augmented fish abundance, and that oyster growth is itself is starting to plateau at about 4.5- 5years of age.

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

In Ninigret Pond, we found similar catch rates for the target sportfish species between the habitat treatments. In Quonochontaug Pond, Black Sea Bass, Tautog, and Cunner all showed that enhancement potential of the oyster habitat, provided greater catch than their respective controls. Black Sea Bass and Winter Flounder were more positively influenced at the eastern basin that has a sandier and more rugose substrate, whereas Tautog were more positively increased at the western basin that is relatively flat and muddy between the reefs compared to the eastern sites. In accordance with reef production literature, Tautog are typically a recruitment enhanced species, as opposed to growth enhanced like black sea bass, and the placement of reefs in areas relatively devoid of other structured habitat may have a higher potential for fish augmentation by providing adequate substrate for juvenile tautog to recruit (Powers et al. 2003).

Scup and Summer Flounder have yet to show any strong trends at our FHE sites, which is similar to work in the Mid-Atlantic (Peterson et al. 2003) where It’s possible that the methodology used to determine the CPUE on and off reefs was not sufficient to document the relative use for these different FHE treatments by striped bass, scup, and other pelagic (e.g., bluefish, menhaden).

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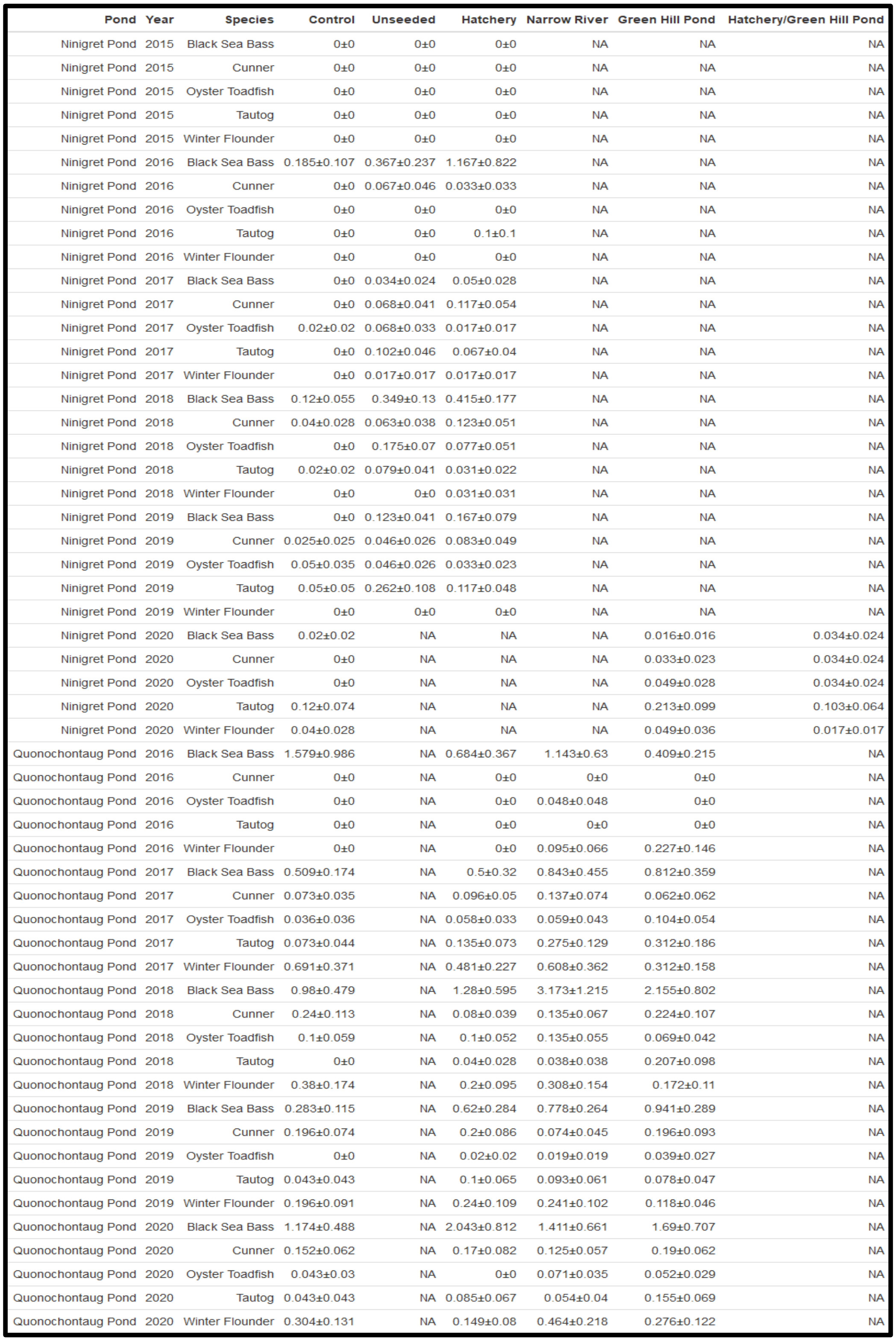
Table 1: Average Catch per unit effort, ± se, for finfish species of interest (Black Sea Bass, Tautog, Winter Flounder, Cunner, and Oyster toadfish), from 2015-2020 when applicable for each oyster reef enhancement region (Ninigret and Quonochontaug Pond), grouped by habitat treatment.



Pond	Year	Species	Control	Unseeded	Hatchery	Narrow River	Green Hill Pond	Hatchery/Green Hill Pond
Ninigret Pond	2015	Black Sea Bass	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2015	Cunner	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2015	Oyster Toadfish	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2015	Tautog	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2015	Winter Flounder	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2016	Black Sea Bass	0.185±0.107	0.367±0.237	1.167±0.822	NA	NA	NA
Ninigret Pond	2016	Cunner	0±0	0.067±0.046	0.033±0.033	NA	NA	NA
Ninigret Pond	2016	Oyster Toadfish	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2016	Tautog	0±0	0±0	0.1±0.1	NA	NA	NA
Ninigret Pond	2016	Winter Flounder	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2017	Black Sea Bass	0±0	0.034±0.024	0.05±0.028	NA	NA	NA
Ninigret Pond	2017	Cunner	0±0	0.068±0.041	0.117±0.054	NA	NA	NA
Ninigret Pond	2017	Oyster Toadfish	0.02±0.02	0.068±0.033	0.017±0.017	NA	NA	NA
Ninigret Pond	2017	Tautog	0±0	0.102±0.046	0.067±0.04	NA	NA	NA
Ninigret Pond	2017	Winter Flounder	0±0	0.017±0.017	0.017±0.017	NA	NA	NA
Ninigret Pond	2018	Black Sea Bass	0.12±0.055	0.349±0.13	0.415±0.177	NA	NA	NA
Ninigret Pond	2018	Cunner	0.04±0.028	0.063±0.038	0.123±0.051	NA	NA	NA
Ninigret Pond	2018	Oyster Toadfish	0±0	0.175±0.07	0.077±0.051	NA	NA	NA
Ninigret Pond	2018	Tautog	0.02±0.02	0.079±0.041	0.031±0.022	NA	NA	NA
Ninigret Pond	2018	Winter Flounder	0±0	0±0	0.031±0.031	NA	NA	NA
Ninigret Pond	2019	Black Sea Bass	0±0	0.123±0.041	0.167±0.079	NA	NA	NA
Ninigret Pond	2019	Cunner	0.025±0.025	0.046±0.026	0.083±0.049	NA	NA	NA
Ninigret Pond	2019	Oyster Toadfish	0.05±0.035	0.046±0.026	0.033±0.023	NA	NA	NA
Ninigret Pond	2019	Tautog	0.05±0.05	0.262±0.108	0.117±0.048	NA	NA	NA
Ninigret Pond	2019	Winter Flounder	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2020	Black Sea Bass	0.02±0.02	NA	NA	NA	0.016±0.016	0.034±0.024
Ninigret Pond	2020	Cunner	0±0	NA	NA	NA	0.033±0.023	0.034±0.024
Ninigret Pond	2020	Oyster Toadfish	0±0	NA	NA	NA	0.049±0.028	0.034±0.024
Ninigret Pond	2020	Tautog	0.12±0.074	NA	NA	NA	0.213±0.099	0.103±0.064
Ninigret Pond	2020	Winter Flounder	0.04±0.028	NA	NA	NA	0.049±0.036	0.017±0.017
Quonochontaug Pond	2016	Black Sea Bass	1.579±0.986	NA	0.684±0.367	1.143±0.63	0.409±0.215	NA
Quonochontaug Pond	2016	Cunner	0±0	NA	0±0	0±0	0±0	NA
Quonochontaug Pond	2016	Oyster Toadfish	0±0	NA	0±0	0.048±0.048	0±0	NA
Quonochontaug Pond	2016	Tautog	0±0	NA	0±0	0±0	0±0	NA
Quonochontaug Pond	2016	Winter Flounder	0±0	NA	0±0	0.095±0.066	0.227±0.146	NA
Quonochontaug Pond	2017	Black Sea Bass	0.509±0.174	NA	0.5±0.32	0.843±0.455	0.812±0.359	NA
Quonochontaug Pond	2017	Cunner	0.073±0.035	NA	0.096±0.05	0.137±0.074	0.062±0.062	NA
Quonochontaug Pond	2017	Oyster Toadfish	0.036±0.036	NA	0.058±0.033	0.059±0.043	0.104±0.054	NA
Quonochontaug Pond	2017	Tautog	0.073±0.044	NA	0.135±0.073	0.275±0.129	0.312±0.186	NA
Quonochontaug Pond	2017	Winter Flounder	0.691±0.371	NA	0.481±0.227	0.608±0.362	0.312±0.158	NA
Quonochontaug Pond	2018	Black Sea Bass	0.98±0.479	NA	1.28±0.595	3.173±1.215	2.155±0.802	NA
Quonochontaug Pond	2018	Cunner	0.24±0.113	NA	0.08±0.039	0.135±0.067	0.224±0.107	NA
Quonochontaug Pond	2018	Oyster Toadfish	0.1±0.059	NA	0.1±0.052	0.135±0.055	0.069±0.042	NA
Quonochontaug Pond	2018	Tautog	0±0	NA	0.04±0.028	0.038±0.038	0.207±0.098	NA
Quonochontaug Pond	2018	Winter Flounder	0.38±0.174	NA	0.2±0.095	0.308±0.154	0.172±0.11	NA
Quonochontaug Pond	2019	Black Sea Bass	0.283±0.115	NA	0.62±0.284	0.778±0.264	0.941±0.289	NA
Quonochontaug Pond	2019	Cunner	0.196±0.074	NA	0.2±0.086	0.074±0.045	0.196±0.093	NA
Quonochontaug Pond	2019	Oyster Toadfish	0±0	NA	0.02±0.02	0.019±0.019	0.039±0.027	NA
Quonochontaug Pond	2019	Tautog	0.043±0.043	NA	0.1±0.065	0.093±0.061	0.078±0.047	NA
Quonochontaug Pond	2019	Winter Flounder	0.196±0.091	NA	0.24±0.109	0.241±0.102	0.118±0.046	NA
Quonochontaug Pond	2020	Black Sea Bass	1.174±0.488	NA	2.043±0.812	1.411±0.661	1.69±0.707	NA
Quonochontaug Pond	2020	Cunner	0.152±0.062	NA	0.17±0.082	0.125±0.057	0.19±0.062	NA
Quonochontaug Pond	2020	Oyster Toadfish	0.043±0.03	NA	0±0	0.071±0.035	0.052±0.029	NA
Quonochontaug Pond	2020	Tautog	0.043±0.043	NA	0.085±0.067	0.054±0.04	0.155±0.069	NA
Quonochontaug Pond	2020	Winter Flounder	0.304±0.131	NA	0.149±0.08	0.464±0.218	0.276±0.122	NA

Table 2. Biological Cover, species richness and diversity. Average species richness (R) and diversity (Shanon's H index) derrived from the individual transect richness and diversity values for each site. This data only represents the diversity and richness observed via the uniform point count transect method and does not reflect mobile inverts and finfish species present at these locations.

YEAR	REGION	SITE	HABITAT	R	H
2020	Coastal Ponds	Quonochontaug Pond	Oyster	3.67 ± 0.5	1.08 ± 0.18
2020	Coastal Ponds	Quonochontaug Pond	Control	3.67 ± 1.33	0.97 ± 0.49

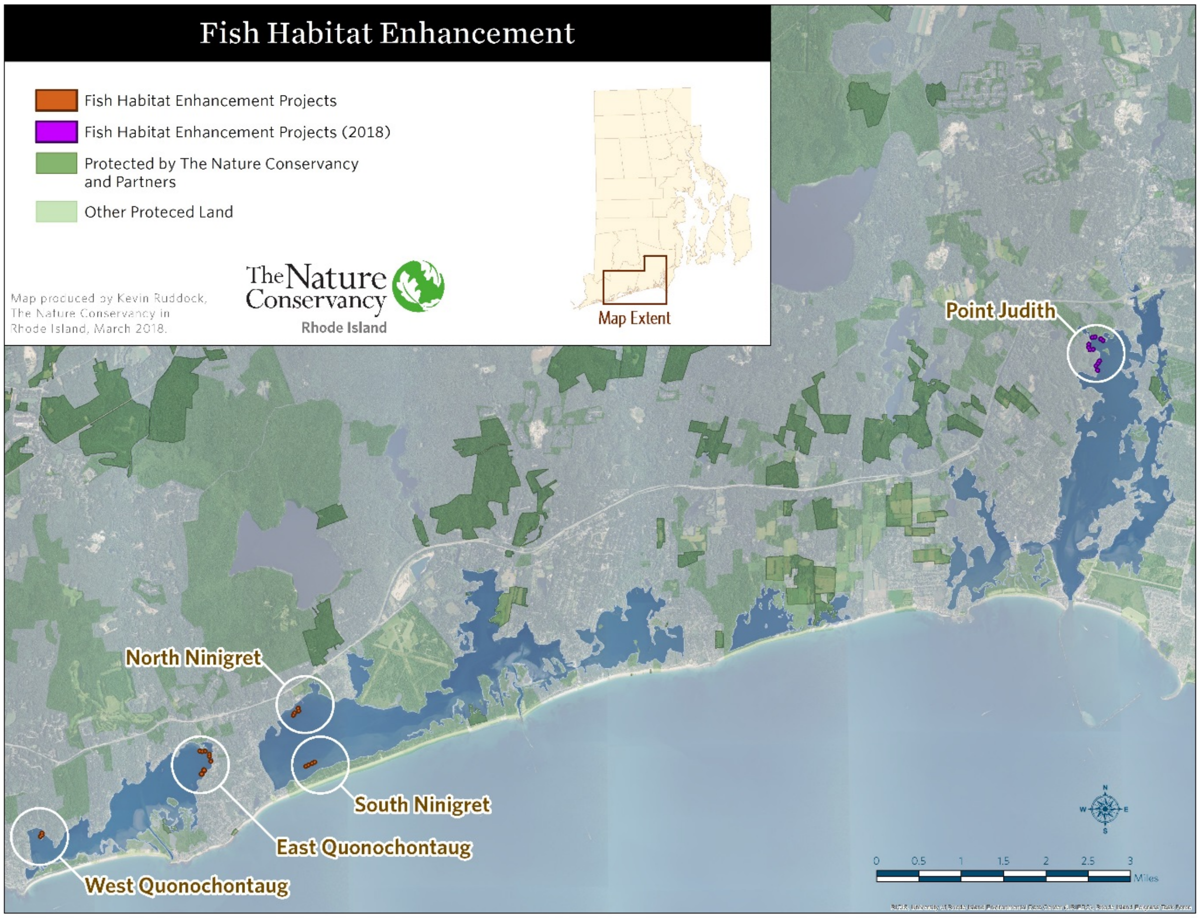


Figure 1. Coastal ponds located in Southern Rhode Island including constructed and formerly proposed (Pt Judith Pond) Fish Habitat Enhancement sites.

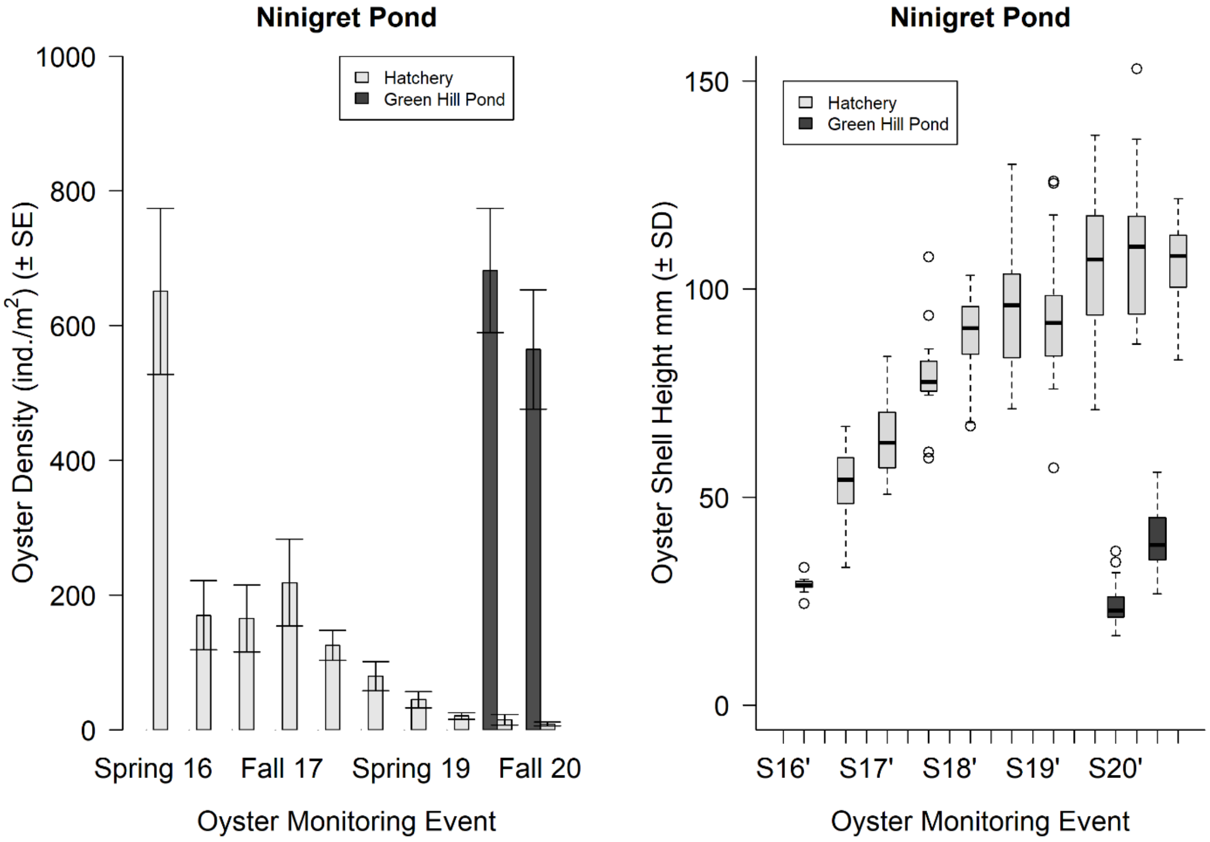


Figure 2: Bargraph of mean oyster density per meter squared, ± se, in Ninigret Pond as a function of oyster monitoring event, grouped by oyster seed source (grey = original hatchery lineage seeded in 2016, black = Green Hill Pond seeded in 2019). plot of oyster shell height (mm) as a function of oyster monitoring event in Ninigret Pond, grouped by oyster seed source (grey = original hatchery lineage seeded in 2016, black = Green Hill Pond seeded in 2019) (Right panel).

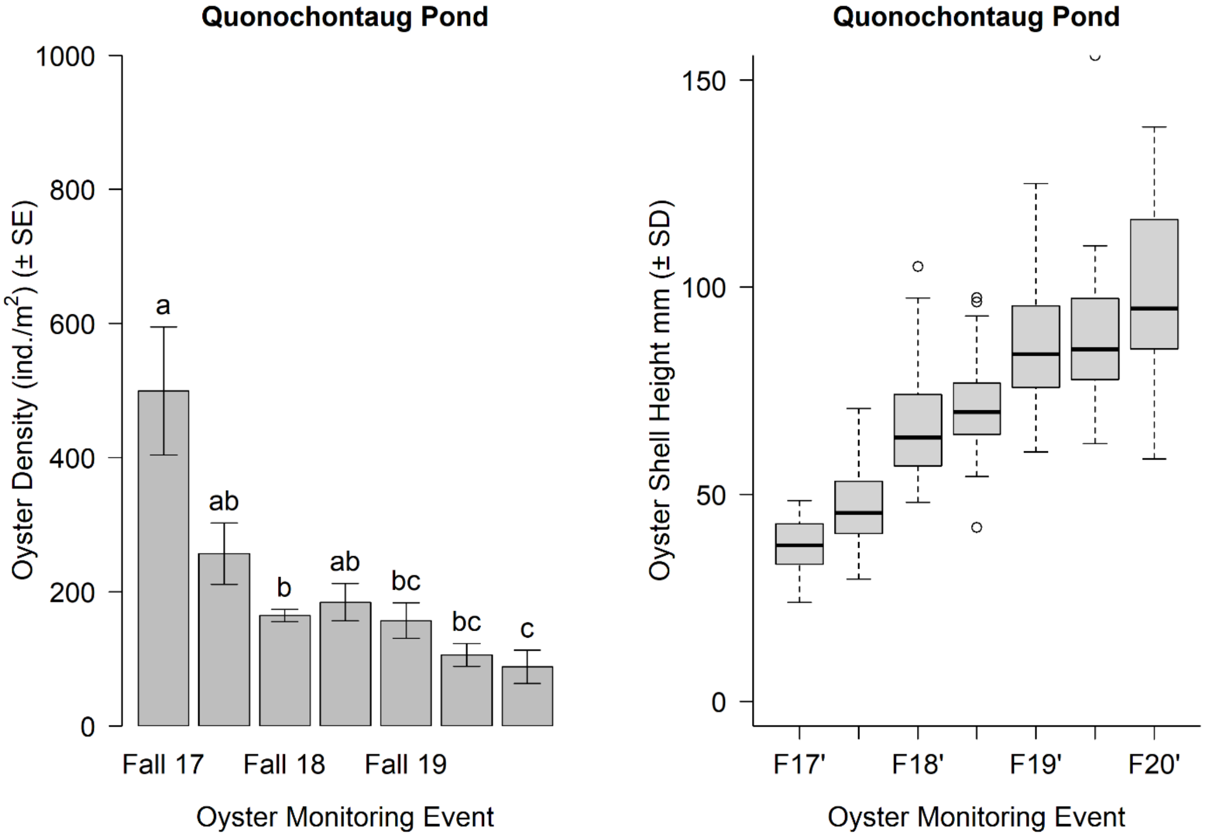


Figure 3: Bargraph of mean oyster density per meter squared, ± se, in Quonochontaug Pond as a function of oyster monitoring event, a proxy for time. Letter's denote significant differences between monotiling events (Tukey's post hoc test; p-value < 0.05) (Left panel). Box plot of oyster shell height (mm) as a function of oyster monitoring event in Quonochontaug Pond (Right panel).

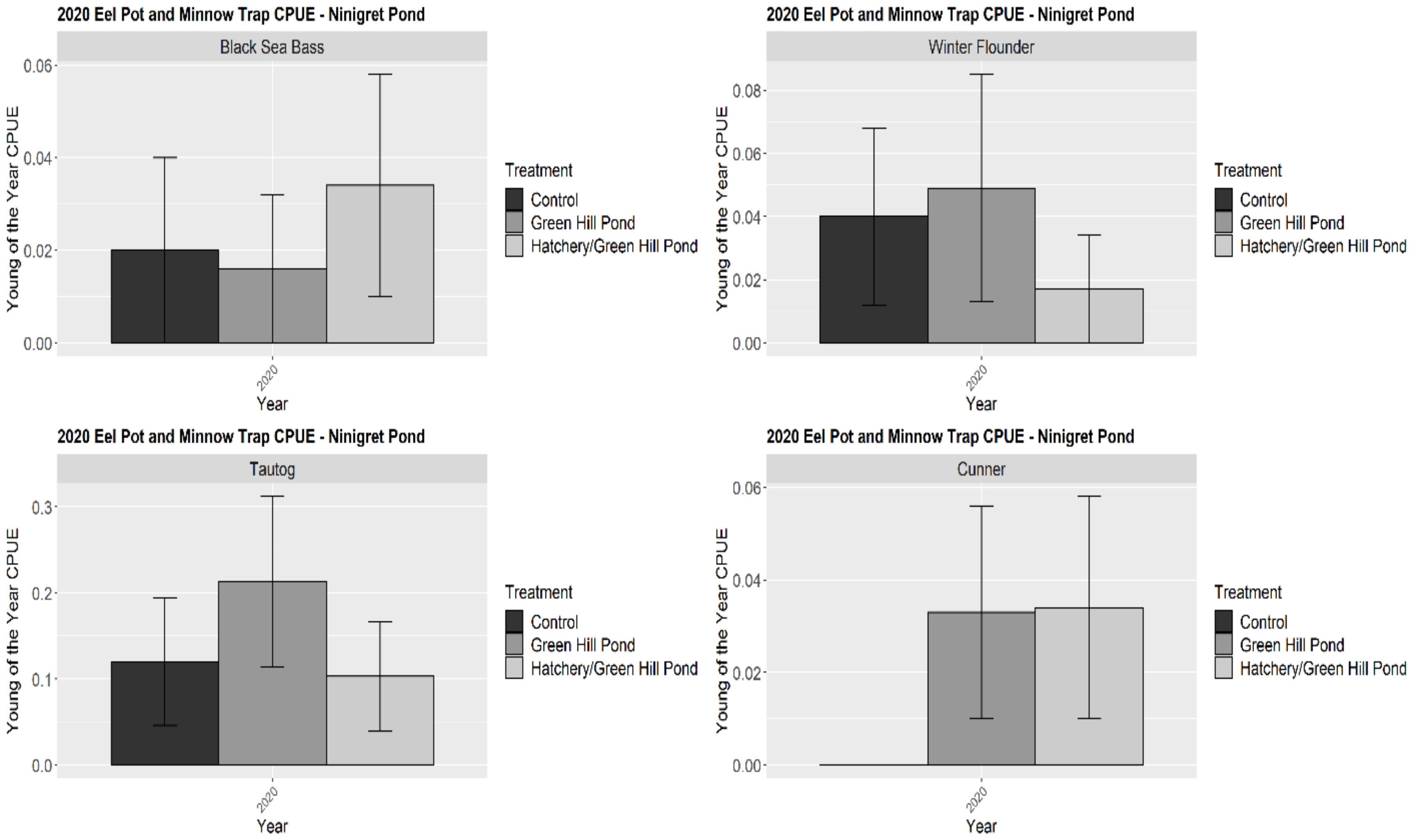


Figure 4: Ninigret Pond, mean catch per unit effort (CPUE) (ind./hours fished) ± se, observed during the 2020 field season. Averages represent the average monthly CPUE from each habitat treatment. The average CPUE is plotted by year, grouped by habitat treatment (black = control, dark grey = Green Hill Pond seed source, light grey = former hatchery reefs over seeded with Green Hill Pond), and facetted by finfish species (Top left = Black Sea Bass, Top right = Winter Flounder, Bottom Left = Tautog, Bottom Right = Cunner).

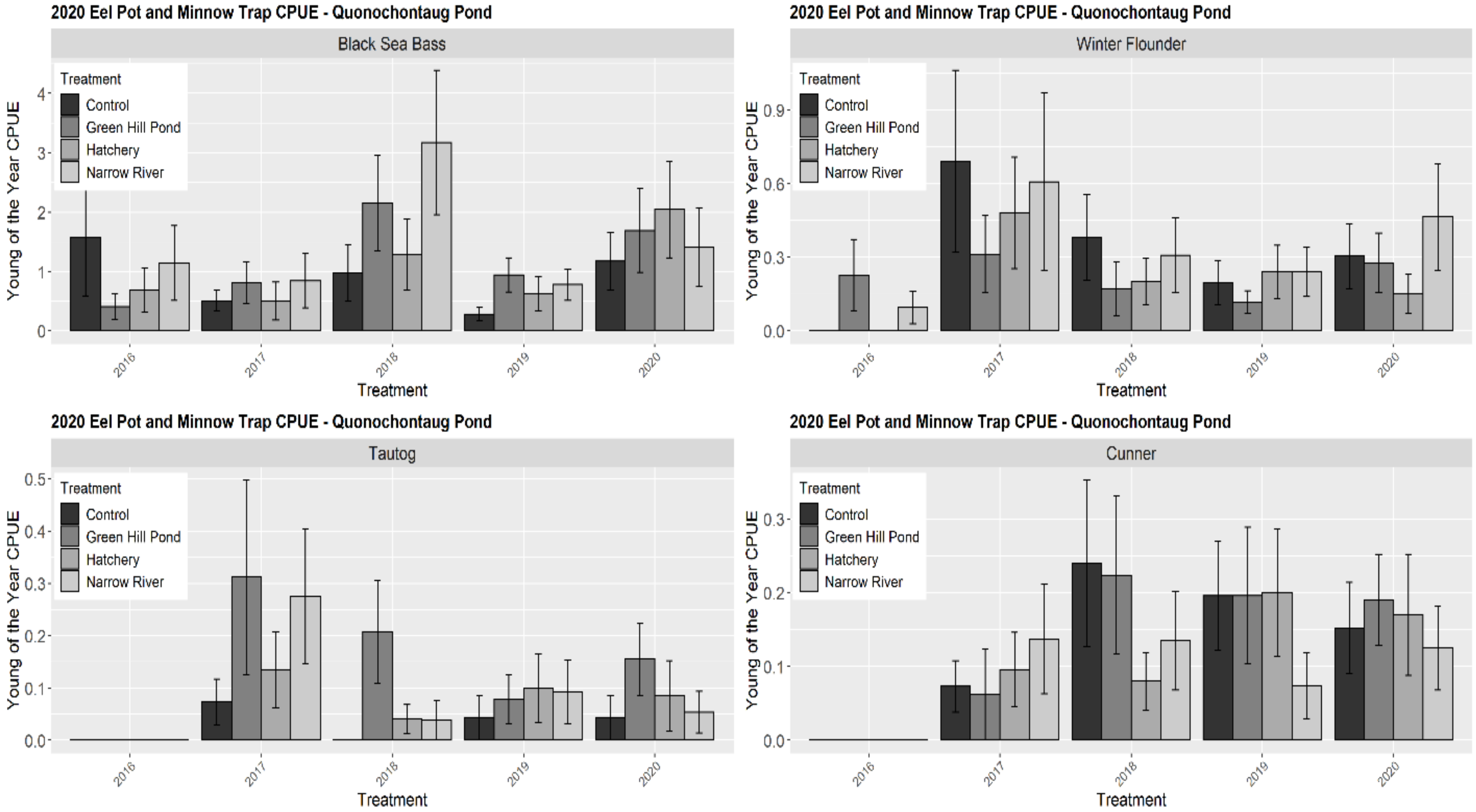


Figure 5: Quonochontaug Pond, mean catch per unit effort (CPUE) (ind./hours fished) ± se, observed during the 2016-2020 field seasons. Averages represent the average monthly CPUE from each habitat treatment. The average CPUE is plotted by year, grouped by habitat treatment (black = control, dark grey = Green Hill Pond seed source, grey = hatchery, light grey = narrow river seed source), and facetted by finfish species (Top left = Black Sea Bass, Top right = Winter Flounder, Bottom left = Tautog, Bottom Right = Cunner).

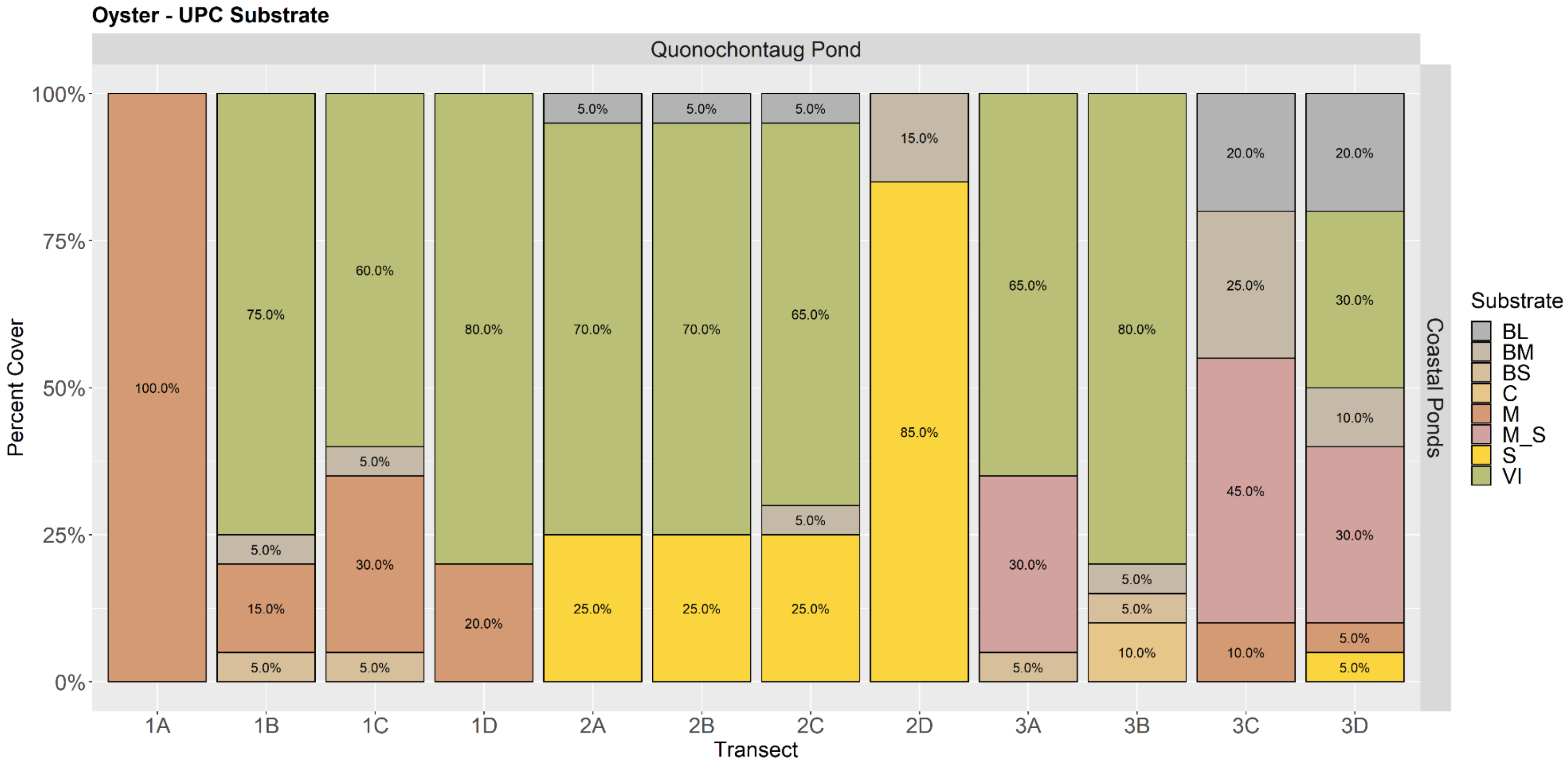


Figure 6. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 fish productivity survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, M = mud/fines, M_S = sandy mud mix, C = cobble , S = Sand, VI = Oyster/ Oyster Shell).

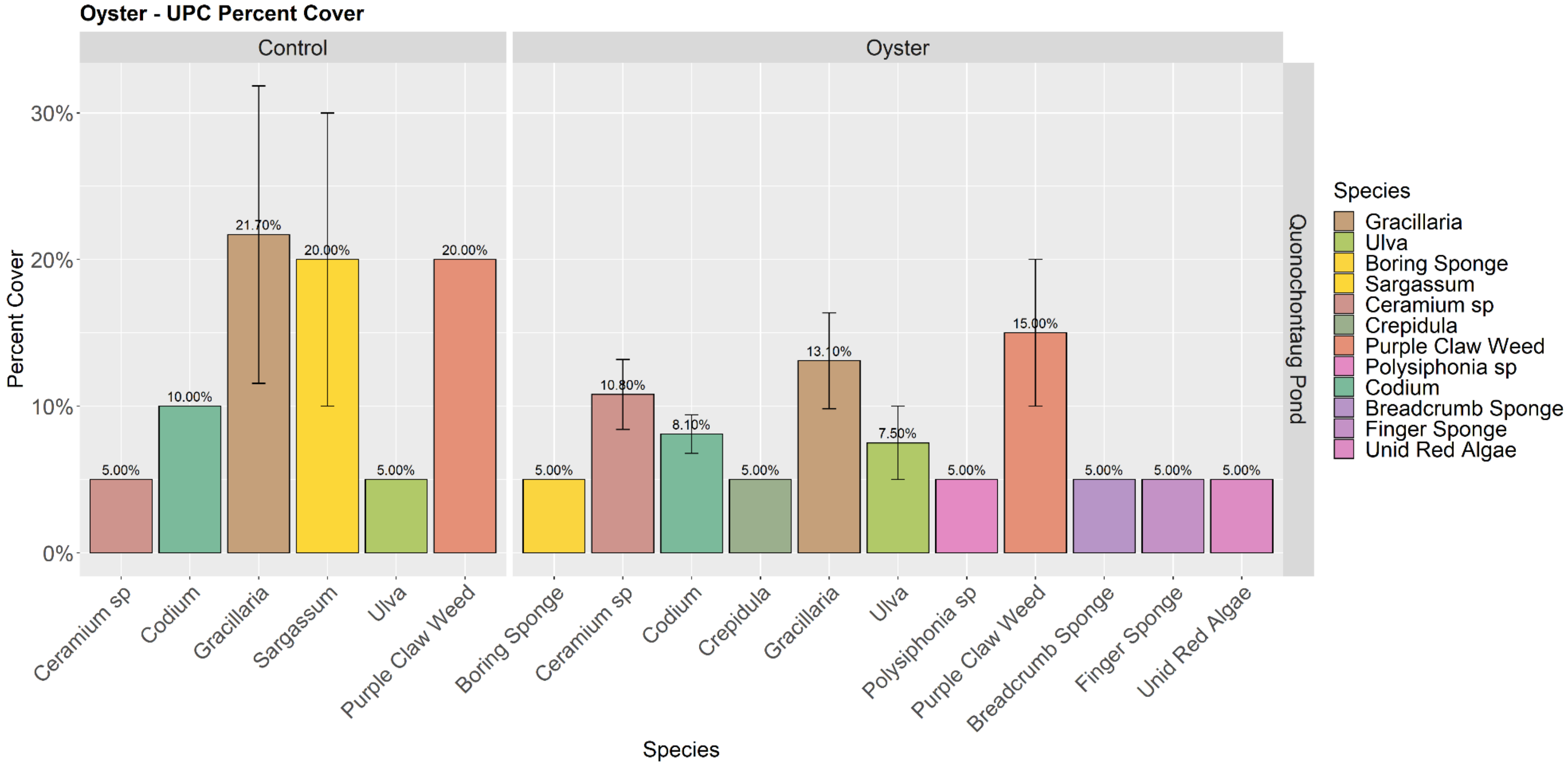


Figure 7 Quonochontaug Pond, mean algal and sessile invertebrate cover ± SE, for each habitat treatment (Control or Oyster Habitat) during the 2020 productivity dive survey.

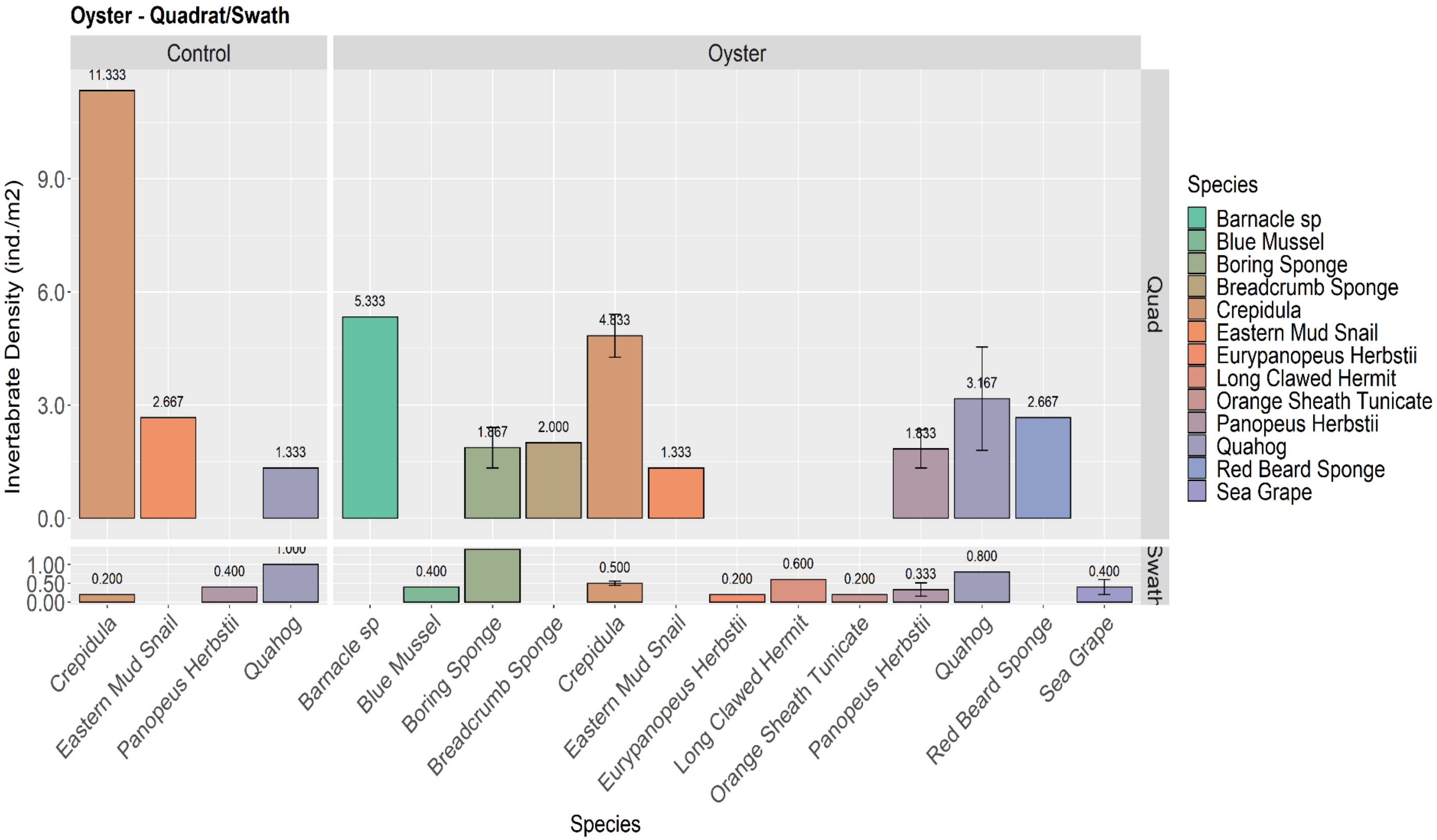


Figure 8. Quonochontaug Pond, mean invertebrate density ± SE, per habitat treatment Control or Oyster Habitat), grouped by transect survey method (quadrat or swath).

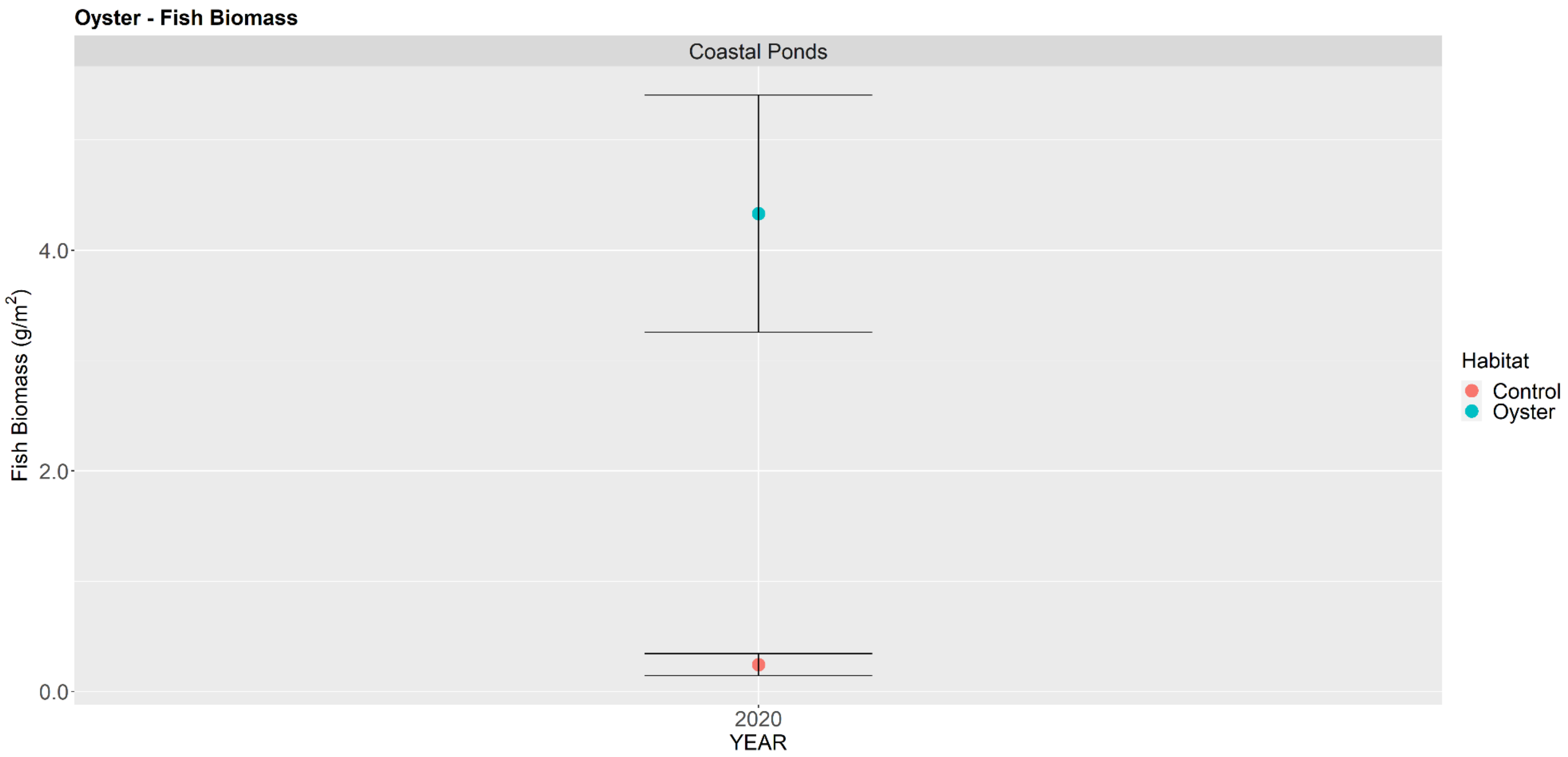


Figure 9. Quonochontaug Pond, mean fish biomass during the 2020 productivity dive surveys. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (Control = red, Oyster = blue)

2020 PERFORMANCE REPORT

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

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: V: Holistic Fish Habitat Assessment and Fish Productivity Estimations; Part D: Eelgrass Monitoring and Productivity Assessment

STAFF: Pat Barrett (Fisheries Specialist), Eric Schneider (Principal Biologist), and Conor Mcmanus (Deputy Chief) RI DEM, Div. of Marine Fisheries

JOB OBJECTIVE:
The goal of this project is to estimate production of recreationally important fish species by eelgrass habitat different areas in Rhode Island waters. We will address this goal with following objectives:

(1) Use standardized sampling approaches to quantify attributes of eelgrass habitat and measure abundance of finfish and invertebrates at targeted sampling locations.

(2) Use eelgrass, fisheries, and environmental data collected to produce estimates of production for recreationally important finfish at targeted sampling locations.

TARGET DATE: 12/31/2020

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2020. During this period, we selected a total of 12 eelgrass sites between Fort Wetherill and Quonochontaug Pond to monitor and collect estimates benthic and fish community biomass that will be used in combination with other metrics to quantify the increase in production of sportfish at eelgrass sites compared to habitat controls. In response to the Covid-19 pandemic, staffing and field survey data collection approaches had to be modified to ensure the safety of staff and the public. Although additional effort was required, all field survey work was completed as scheduled. In 2020, we completed 12 eelgrass habitat monitoring dives.

RECOMMENDATIONS:

The non-invasive methods used to collect Eelgrass morphometrics as described in Neckless et al 2012, was successful and proved to be time efficient since all measurements were collected in the field. We recommend adopting this method for all eelgrass canopy height estimates.

INTRODUCTION:

Species of submerged aquatic vegetation (SAV), including Eelgrass (*Zostera marina L.*), perform several ecological functions, including chemical cycling, sediment stabilization, structural modifications of the water column, as well as provide critical habitat for marine life (Dennison et al. 1993; Fonseca 1996, Havel and ASMFC Habitat Committee 2018). Several recreationally important finfish species found in RI utilize eelgrass beds for refugia and foraging, including tautog, black seabass, striped bass, summer flounder, and winter founder (Kritzer et al. 2016, Laney 1997). Although widely recognized as a both a sensitive and critical habitat for marine fish, studies that quantify fish productivity of SAV beds (in Nordlund et al. 2019) and responses of fish communities to changes in eelgrass bed size and health (e.g., Hughes et al. 2002, McCloskey and Unsworth 2015) have not focused on areas in the temperate northeast. Developing production estimates of recreationally important fish species for eelgrass habitat in Rhode Island waters will provide a quantitative metric for comparison with other important habitats (e.g., kelp, artificial reef, and oyster reef), as well as further information regarding the need for protecting this critical resource.

APPROACH:

Activities addressing Objective 1:

The approach will be similar to the dive transect survey methodologies proposed for kelp and artificial reefs, and comparable to oyster reefs. During 2020 we will use existing eelgrass habitat maps, combined with field survey work to identify two (2) targeted sampling locations (sites), one (1) near the mouth of Narragansett Bay for potential comparison with kelp bed survey sites, and one (1) in a coastal pond for potential comparison with FHE oyster reefs. Each site will have two (2) to four (4) transects, each separated by at least 100m, sampled annually between July and September, during peak biomass, to ensure a good site-level description of the community. Treatment sites should have continuous eelgrass beds, whereas control sites should not have eelgrass or complex structure present. All sites should have one temperature/light loggers (Hobo Onset 64K Pendant Loggers UA-002-64) placed within the site, set to collect data every 30 minutes.

We expect to address the same 5 components (Quadrat, Uniform Point Count, Swath, Fish Counts, and Morphometrics) as in kelp. Five sampling methodologies are used along each transect were the same as the kelp methods (See Section 5A) with the exception that quadrats for the eelgrass survey will be $0.25m^2$ and the morphometrics. For eelgrass morphometrics the transect, divers should swim and take selected morphometric measurements described in Neckles et al 2012 every 4 meters (n=10 plots transect). At each plot a 0.25m quadrant is placed, the percent coverage is estimated and eelgrass shoot density is estimated by direct counts of all shoots rooted within the entire quadrat if percent cover is ≤25% or shoot distribution is highly clumped; if percent cover is >25% and shoots are homogeneously distributed, all shoots within a 0.0625-m2 subquadrate are counted. Methods to estimate shoot length and epiphytes, in a non-destructive manner, will be developed during 2020. Transects will still be 40m in length and should run roughly parallel to shore following a depth contour line between 2-5m.

Activities addressing Objective 2:

Analytical Approach

The Uniform Point Count (UPC) survey data was distilled into two categories, substrate and biological cover. The percent substrate for each transect was calculated by multiplying the number of substrate counts per substrate type by the total number of counts per transect (n=80). Biological percent cover is presented as the mean ± SE for each site (Fort Wetherill and Quonochontaug Pond) and grouped by habitat type (Eelgrass or Control). The mean percent cover of algae and sessile inverts were used to calculate species richness and diversity, using both the abundance of unique species and the Shannon's H index of diversity respectively.

Eelgrass and invertebrate densities were determined using the quadrat and swath datasets. The quadrat dataset was used primarily to estimate eelgrass percent cover, shoot density, and canopy height, as well as invertebrates present in the quadrats. For each transect, a mean, ± SE, was calculated to present a more precise estimate of the overall transect eelgrass, or invertebrate, density. The swath dataset was used to count the total abundance of rare or less uniformly distributed sessile and mobile invertebrates species. For both the quadrat and swath methods, the average quadrat density or total abundance within the swath were standardized per meter squared. To compare how invertebrate densities differed between the habitat treatments (e.g., control and eelgrass) we present the average invertebrate density per meter squared, summarized for each site (Fort Wetherill and Quonochontaug Pond) and grouped by survey method (Quad or Swath). Using the fish count survey data, we converted abundance at estimated length, to total fish mass per transect, using the DMF age and growth lab data to convert fish length in cm, to weight in grams. For our target we used RI specific allometric growth models, $W = \alpha * L^{\beta}$ (where W = weight, L = length, and alpha and Beta are constants). For species not currently dissected in our growth lab, we used the geometric mean alpha and beta coefficients presented on Fishbase.org. To compare total fish biomass between our eelgrass and control, we then standardized the total fish mass by dividing the total area surveyed, to get grams per meter squared. For the two years since the beginning in of the King's Beach site, we present total fish biomass per habitat treatment, ± SE, grouped by region (e.g., Narragansett Bay and Coastal Ponds). We then proceeded to estimate the effect size of the eelgrass habitat with respect to the control sites for each eelgrass region using the average fish biomass and standard deviation for each habitat size using the "effsize" package in R (R Core Team 2020).

In 2020, we began preliminary modeling efforts looking at the impact of eelgrass density on the observed biomass of finfish, using a simple linear regression model to predict fish biomass as a function of increasing eelgrass density. We present observed fish biomass and Eelgrass density data and the significant linear relationship as well as 95% confidence interval obtained resampling the data points via bootstrap methods. We resampled the data 1000 times, each time refitting a new linear model of fish biomass ~ a*eelgrass density + b. We then used the 97.5 and 2.5 quantiles of the slope and intercept to represent the 95 % CI interval around those predictions. Linear regression models and mean biomass effect sizes were also summarized for other three habitats monitored in the greater Job5 assessment (5A, Kelp; 5B, AR; and 5C, Oyster) for the 2020 and 2019 field seasons when applicable.

RESULTS:

In 2020, the eelgrass monitoring team completed activities relating to objective one by setting up 2 eelgrass monitoring sites, one in Quonochontuag Pond and the other in Jamestown, RI (Figures 1 and 2). Each location contaimed 4 eelgrass transects and 2 control transects. These locations where chosen to represent the Coastal Pond and Narragansett Bay Regions and will be used to compare fish productivity between one another as well as kelp and oyster reef habitat contained within those respective regions (Kelp in Narragansett Bay and Oysters in Quonochontuag Pond). All eelgrass transects were selected based off specific knowledge of these regions as well as at least one confirmed observation from the SAV ariel surveys (2006, 2009, 2016). Control transects were also identified through the same process, thus these locations could contain eelgrass but the percent cover is less than 10%. In 2020, we completed 12 dives to monitor eelgrass habitat in RI waters. During the 2020 season, 6 temperature and light loggers were deployed in September of 2020 among the 12 transects and will be recovered and downloaded during the 2021 field season.

We found the substrate conditions at each eelgrass sites (e.g. Fort Wetherill and Quonochontaug Pond) to be quite different based on the regions they reside in (Narragansett Bay and Coastal Ponds). The most evident difference between the two eelgrass regions is that the substrate in the Coastal Ponds contained mostly mud and more fluid sediments whereas the Narragansett bay eelgrass sites were mostly sand and coble with sections of small boulders. On average the proportion of boulders (large, medium, and small combined) was approximately 8.9% at the Fort Wetherill eelgrass sites only and 1.0% percent at the coastal pond eelgrass transects (Figure 3). In 2020, the percent cover of eelgrass was only 4 % greater at the Fort Wetherill (83%) sites compared to those off Fort Wetherill (79%) (Figure 4). In the absence of eelgrass, at our control locations (where eelgrass was less than 2.5% percent on average), we found very little algae. In both the coastal ponds and the bay, in the absence of eelgrass we mostly observed *Gracillari*a sp. at low percent cover (e.g. <10% cover) (Figure 4). In 2020, the algae and invertebrate species richness was highest at the eelgrass sites regardless of region, but diversity was greater on the on the eelgrass sites in the coastal ponds but the controls in the bay (Table 1).

Similar to the UPC, we identified more unique species at the eelgrass locations with respect to mobile inverts than we did the control locations (Figure 5). The differences between the eelgrass quadrats and swaths varied by region but were mostly driven by the epiphytic organisms that were present on the blades of eelgrass. In eelgrass beds we saw a much higher percent of sponges and tunicates. We also found that the density of Northern Quahogs was 7ind./m^2 on average across both eelgrass regions. Especially in the coastal ponds, the control locations comprised of finer substrate had over eighty *Crepdidula* (~84.7 ind/m^2) per meter squared as well as a decent density of burrowing mantis shrimp (2.7 ind./m^2) (Figure 5). We found the average eelgrass shoot density to vary by transect location, but on average were similar, but slightly greater at Fort Wetherill than Quonochontaug Pond (Figure 6). Within the two regions, eelgrass shoot density varied by transect locations, ranging from 42-124 in Narragansett Bay and 64-97 in the Coastal Ponds (Table 2).

Despite a having a higher species diversity and eelgrass density, we found that both the mean fish biomass per meter squared of eelgrass habitat as well as the effect size of the eelgrass transects relative to the controls to be larger in the coastal pond region at the Quonochontaug Pond transect (Figure 7 and Table 3). In 2020, the effect size of eelgrass in the coastal ponds was over 4 times greater (0.5 in the ponds and only 0.1 in the bay). In our preliminary regression analyses comparing the rates at which each habitat enhances fish biomass per unit area, we found all habitats to positively correlate with increasing fish biomass, but the rate at which biomass increased, as well as total fish biomass was greatest at the kelp sites, compared to the eelgrass and oyster habitats. (Figure 8). Comparing the effect sizes between each habitat and their respective controls, we found the 2020 effect size for eelgrass to be the lowest regardless of eelgrass region. Both in the Coastal Pond and Narragansett Bay eelgrass sites, we estimated the smallest effects (0.1 and 0.5) out of all the habitats monitored. We found the kelp sites to have the greatest effect, then oyster and artificial reefs (Table 3).

DISCUSSION:

Across the globe, there has been an accelerating rate of decline of seagrass meadows. Waycott et al 2009, found that this rate was greater than that of the Amazon Rain forests and comparable to the rate of mangrove loss of -1.6 per year. As nursery seagrass habitats, like *Zostera marina*, continue to decline, our coastal ecosystems will be negatively impacted through the loss of services and enhanced fisheries production (Blandon et al 2014). Through this project we establish a long-term eelgrass and fish productivity dataset or RI, as well as track how changes in eelgrass density impact the community assemblage around them. In our inaugural year of the survey we found that Eelgrass had a larger effect on the fish biomass estimates in the Coastal Ponds than in the Bay. As the dataset continues to grow and more environmental parameters are added to the analyses we can more accurately address what factors may by driving the differences we observed. We acknowledge that there are often unique habitat associated fish-assemblages and that more target, species-specific analyses, may be required to establish how fish production differs by between eelgrass locations and other habitat types (e.g. eelgrass and kelp; Furness et al 2020). Landscape setting will also be important to consider, as the ecosystem function of eelgrass may differ depending on its proximity to different habitats. For example, the eelgrass transects in Narraganset Bay are in deeper water and in close proximity to kelp locations that had the highest effect size across all habitat types, but in a more nursery setting of coastal ponds, we found that the eelgrass beds had a much stronger impact on the finfish community around them.

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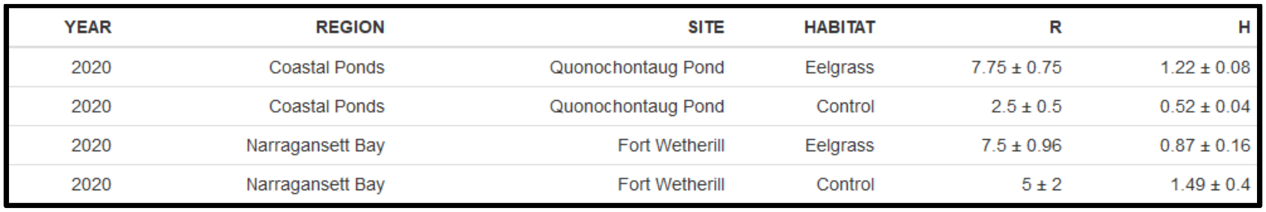
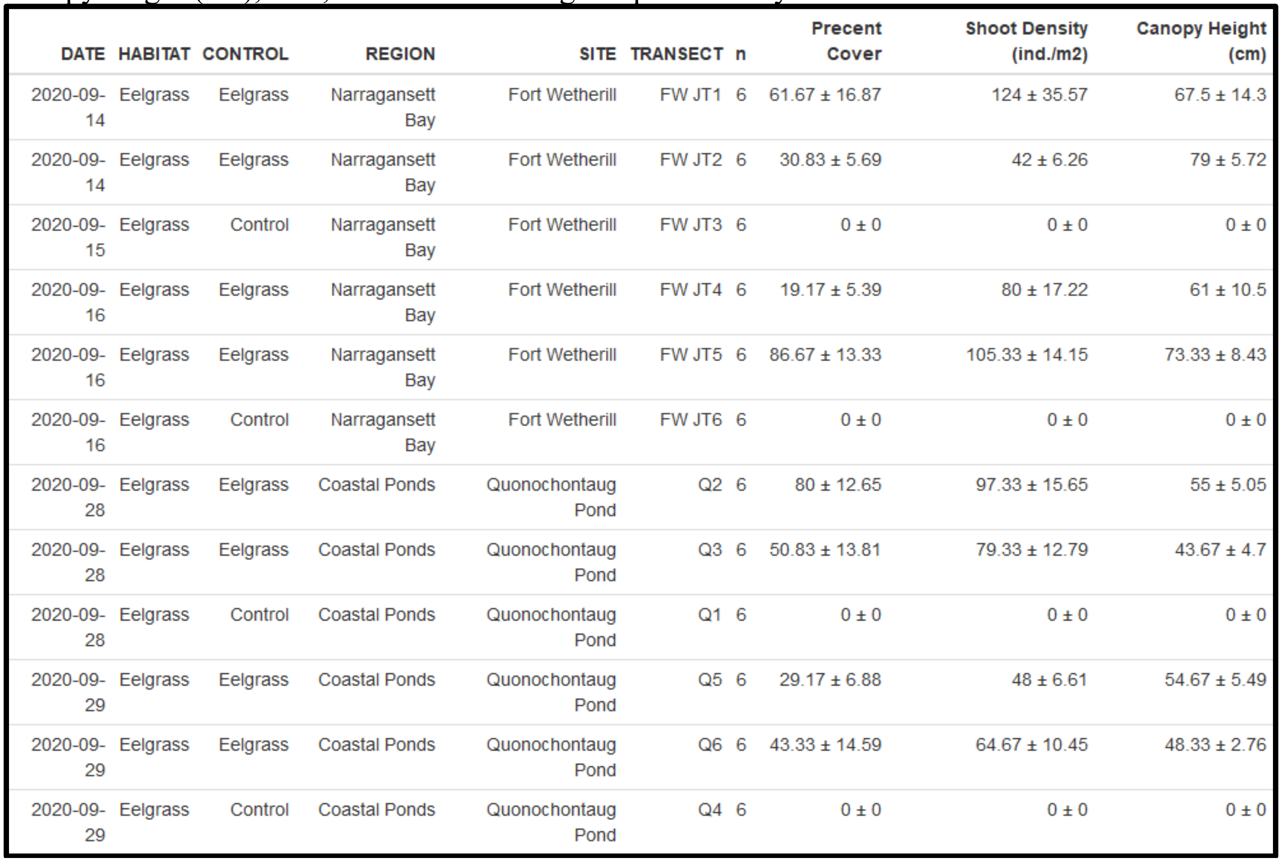
Table 1: Algae and Sessile Invertebrate species richness and diversity calculated from the uniform point count transect method for the 2020 Eelgrass surveys. These estimates only characterize the richness and diversity of species that adhere to the substrate or habitat and does not include mobile inverts or finfish.



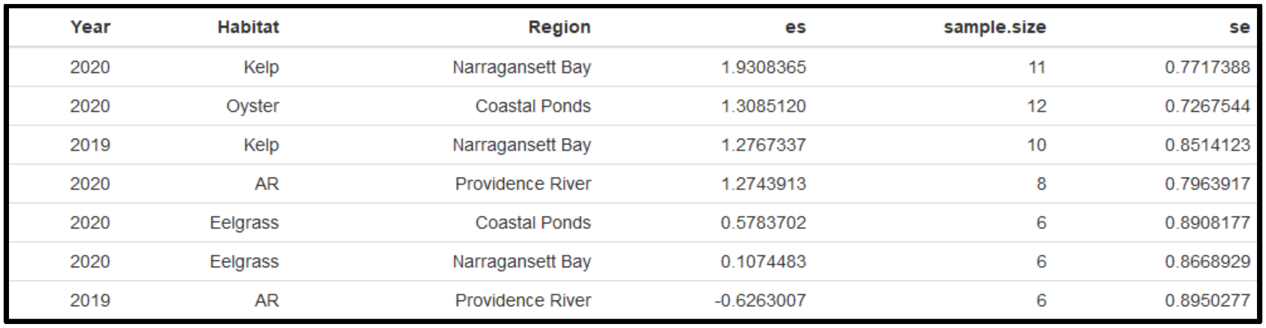
YEAR	REGION	SITE	HABITAT	R	H
2020	Coastal Ponds	Quonochontaug Pond	Eelgrass	7.75 ± 0.75	1.22 ± 0.08
2020	Coastal Ponds	Quonochontaug Pond	Control	2.5 ± 0.5	0.52 ± 0.04
2020	Narragansett Bay	Fort Wetherill	Eelgrass	7.5 ± 0.96	0.87 ± 0.16
2020	Narragansett Bay	Fort Wetherill	Control	5 ± 2	1.49 ± 0.4

Table 2: Eelgrass s Morphometrics table. Mean percent cover (%), shoot density (#/m^2), and canopy height (cm), ± se, for each 2020 eelgrass productivity transect.



DATE	HABITAT	CONTROL	REGION	SITE	TRANSECT	n	Precent Cover	Shoot Density (ind./m2)	Canopy Height (cm)
2020-09-14	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT1	6	61.67 ± 16.87	124 ± 35.57	67.5 ± 14.3
2020-09-14	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT2	6	30.83 ± 5.69	42 ± 6.26	79 ± 5.72
2020-09-15	Eelgrass	Control	Narragansett Bay	Fort Wetherill	FW JT3	6	0 ± 0	0 ± 0	0 ± 0
2020-09-16	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT4	6	19.17 ± 5.39	80 ± 17.22	61 ± 10.5
2020-09-16	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT5	6	86.67 ± 13.33	105.33 ± 14.15	73.33 ± 8.43
2020-09-16	Eelgrass	Control	Narragansett Bay	Fort Wetherill	FW JT6	6	0 ± 0	0 ± 0	0 ± 0
2020-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q2	6	80 ± 12.65	97.33 ± 15.65	55 ± 5.05
2020-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q3	6	50.83 ± 13.81	79.33 ± 12.79	43.67 ± 4.7
2020-09-28	Eelgrass	Control	Coastal Ponds	Quonochontaug Pond	Q1	6	0 ± 0	0 ± 0	0 ± 0
2020-09-29	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q5	6	29.17 ± 6.88	48 ± 6.61	54.67 ± 5.49
2020-09-29	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q6	6	43.33 ± 14.59	64.67 ± 10.45	48.33 ± 2.76
2020-09-29	Eelgrass	Control	Coastal Ponds	Quonochontaug Pond	Q4	6	0 ± 0	0 ± 0	0 ± 0

Table 3: Hedge's G effect size table. Effect size (es) was calculated with average fish biomass and standard deviation from the fish productivity survey estimated for each Habitat type (Eelgrass, Kelp, Oyster, and Artificial Reed) and Region (Providence River, Narragansett Bay, and Coastal Ponds) with respect to the habitat controls for each respective region.



Year	Habitat	Region	es	sample.size	se
2020	Kelp	Narragansett Bay	1.9308365	11	0.7717388
2020	Oyster	Coastal Ponds	1.3085120	12	0.7267544
2019	Kelp	Narragansett Bay	1.2767337	10	0.8514123
2020	AR	Providence River	1.2743913	8	0.7963917
2020	Eelgrass	Coastal Ponds	0.5783702	6	0.8908177
2020	Eelgrass	Narragansett Bay	0.1074483	6	0.8668929
2019	AR	Providence River	-0.6263007	6	0.8950277

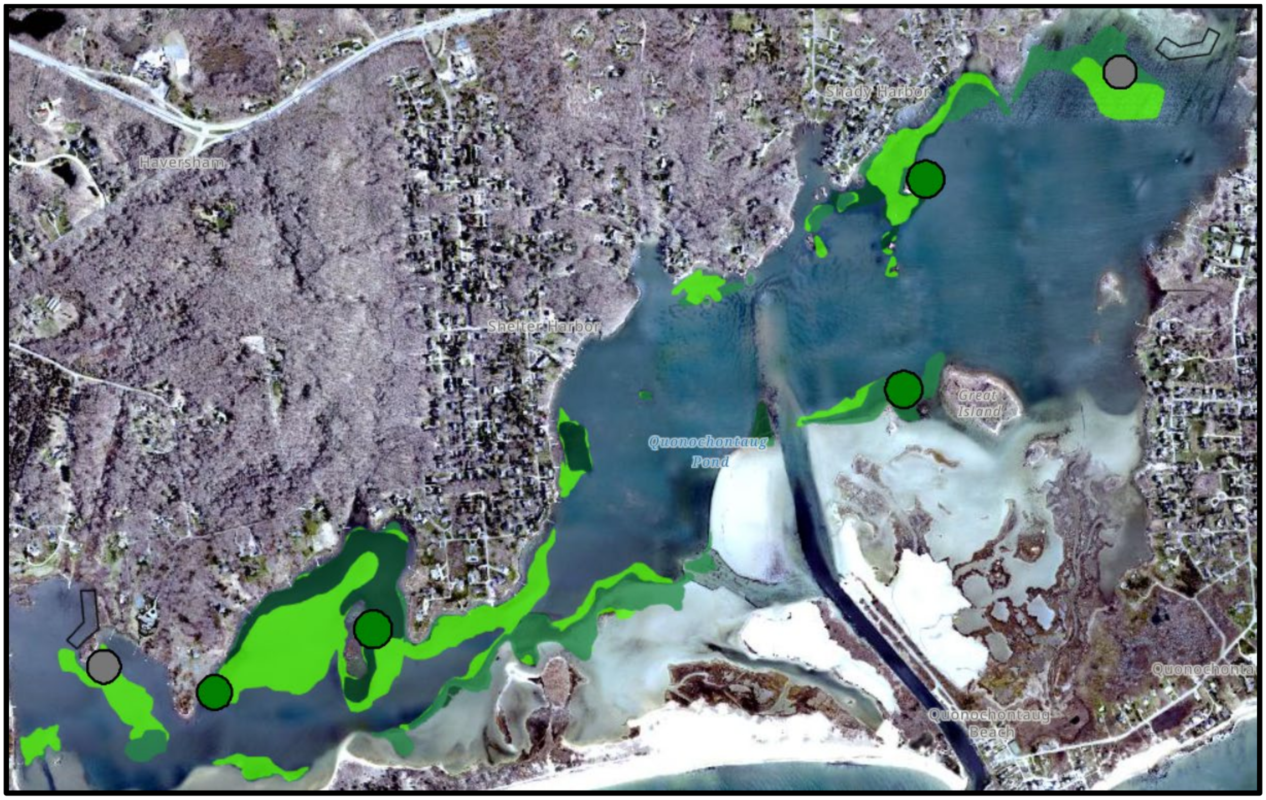


Figure 1: Eelgrass fish productivity transect locations for the Coastal Pond eelgrass region. Green circles denote eelgrass transects and grey circles are controls. Green map layers represent eelgrass layers identified during SAV mapping projects that took place from 2006-2016.

Figure 2: Eelgrass fish productivity transect locations for the Narragansett Bay eelgrass region. Green circles denote eelgrass transects and grey circles are controls. Green map layers represent eelgrass layers identified during SAV mapping projects that took place from 2006-2016. One additional control site, not pictured, is located further north located near the Jamestown Marina.

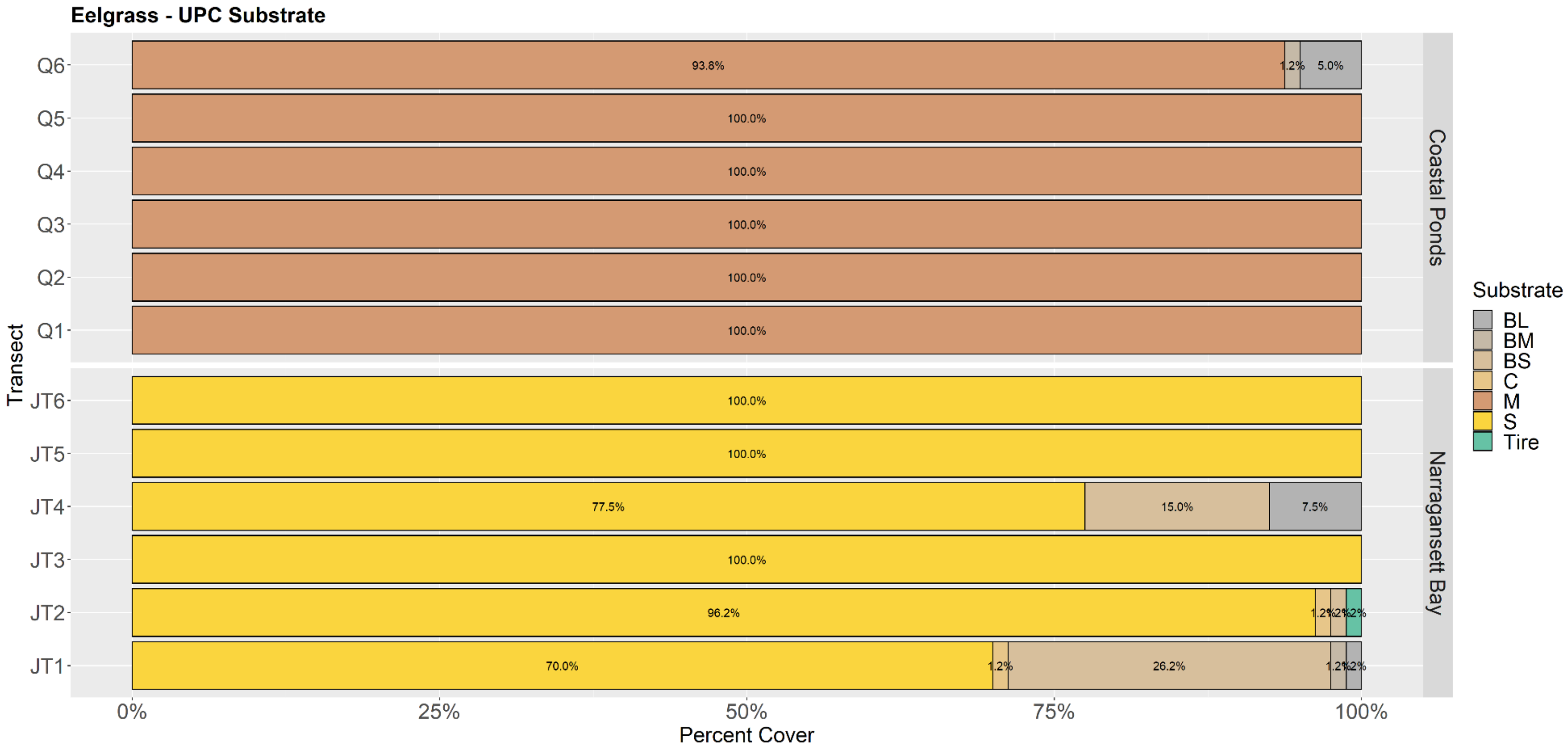


Figure 3. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 fish productivity Eelgrass survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, C= cobble, M = mud/fines, M_S = sandy mud mix, S = Sand

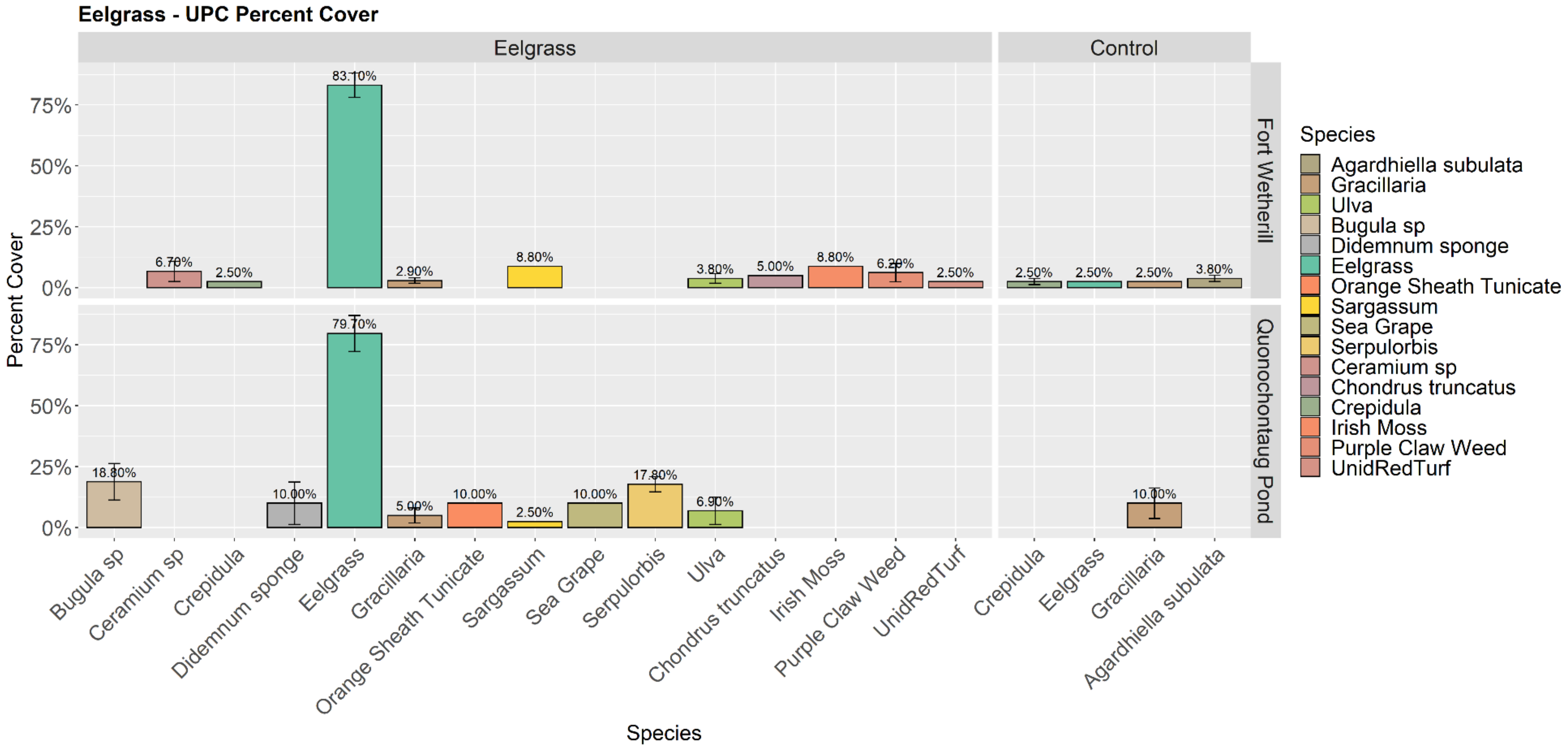


Figure 4. Mean algal and sessile invertebrate cover ± SE, for each site (Fort Wetherill and Quonochontaug Pond) and habitat type (Eelgrass or Control) during the 2020 eelgrass productivity uniform point count survey.

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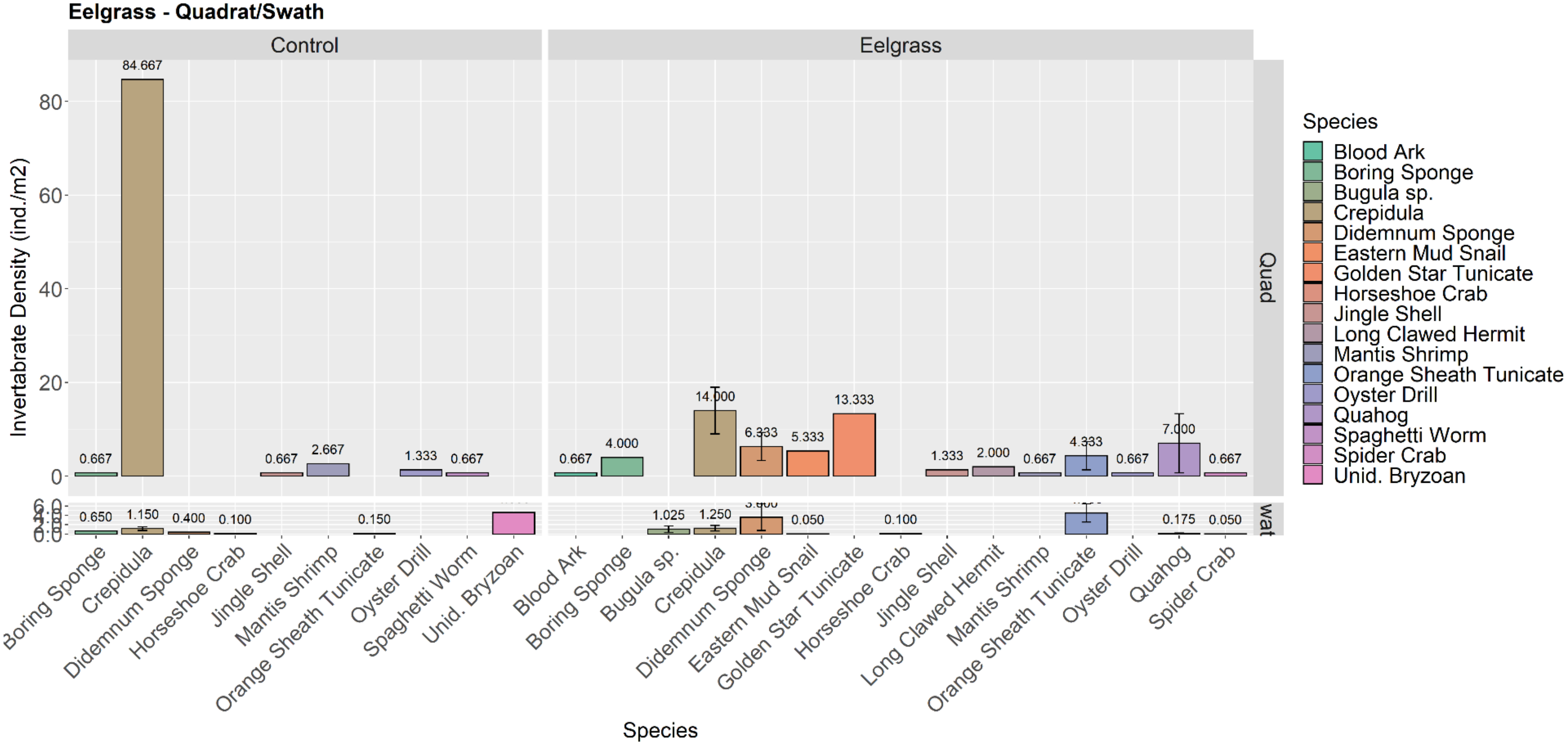

Figure 5. Mean invertebrate density ± SE, for each specie identified on the eelgrass productivity dive survey, with habitat treatment (Control, left panels; Eelgrass, right panels)for the quadrat and swath survey methods (Quadrat, top panels; Swath, bottom panels)

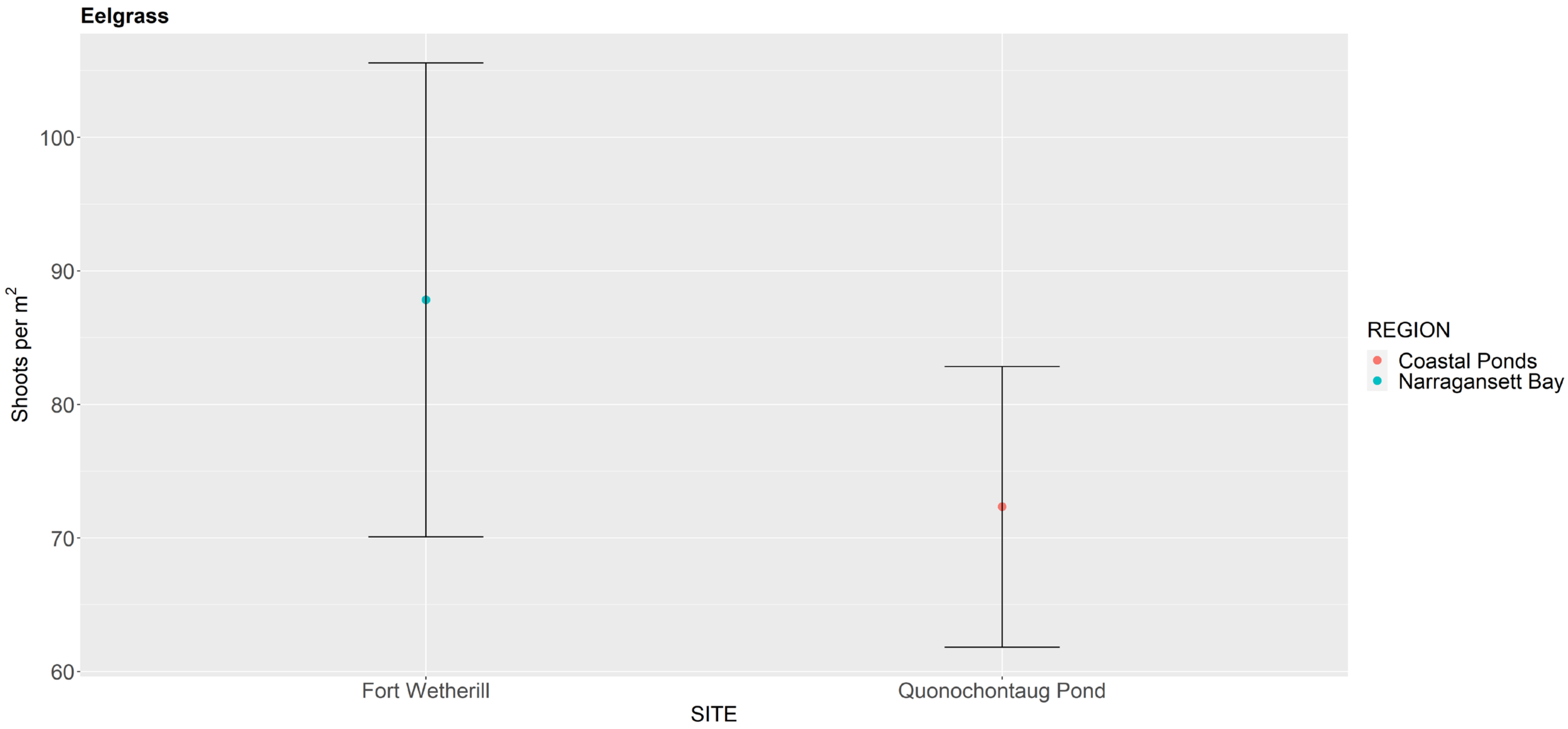

Figure 6. Eelgrass shoot density (y-axis), by mean density(x-axis), ± SE, for each eelgrass productivity region (Coastal Ponds = Red, Narragansett Bat = Blue)

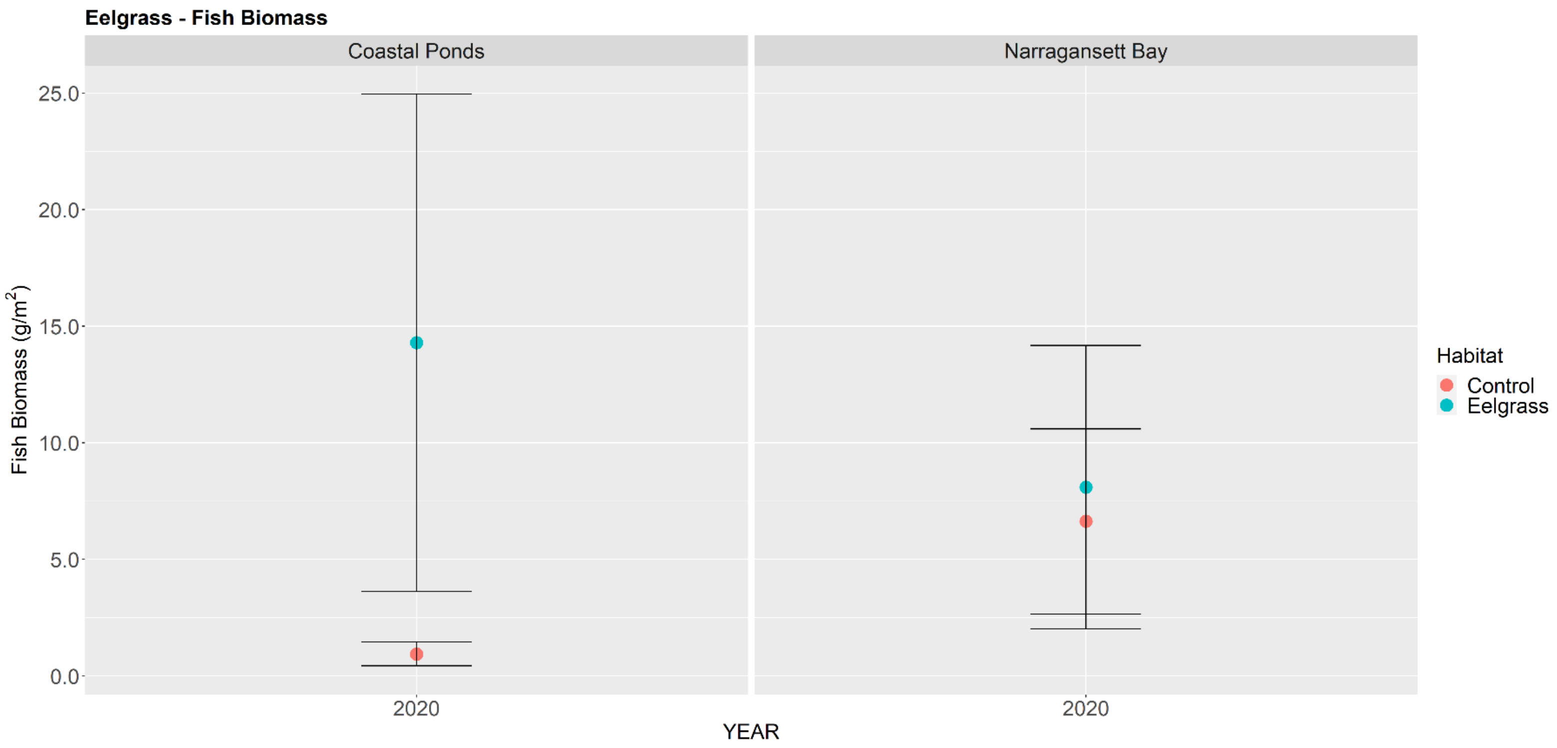

Figure 7: Mean fish biomass (g/m^2) estimates for the Eelgrass productivity fish count survey grouped by Habitat type (Control = Red, and Eelgrass = Blue) for each region (Coastal Pond, left panel; Narragansett Bay, right panel). of the Sabin Point Artificial Reef. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (AR = red, Control = green, Natural Control = blue)

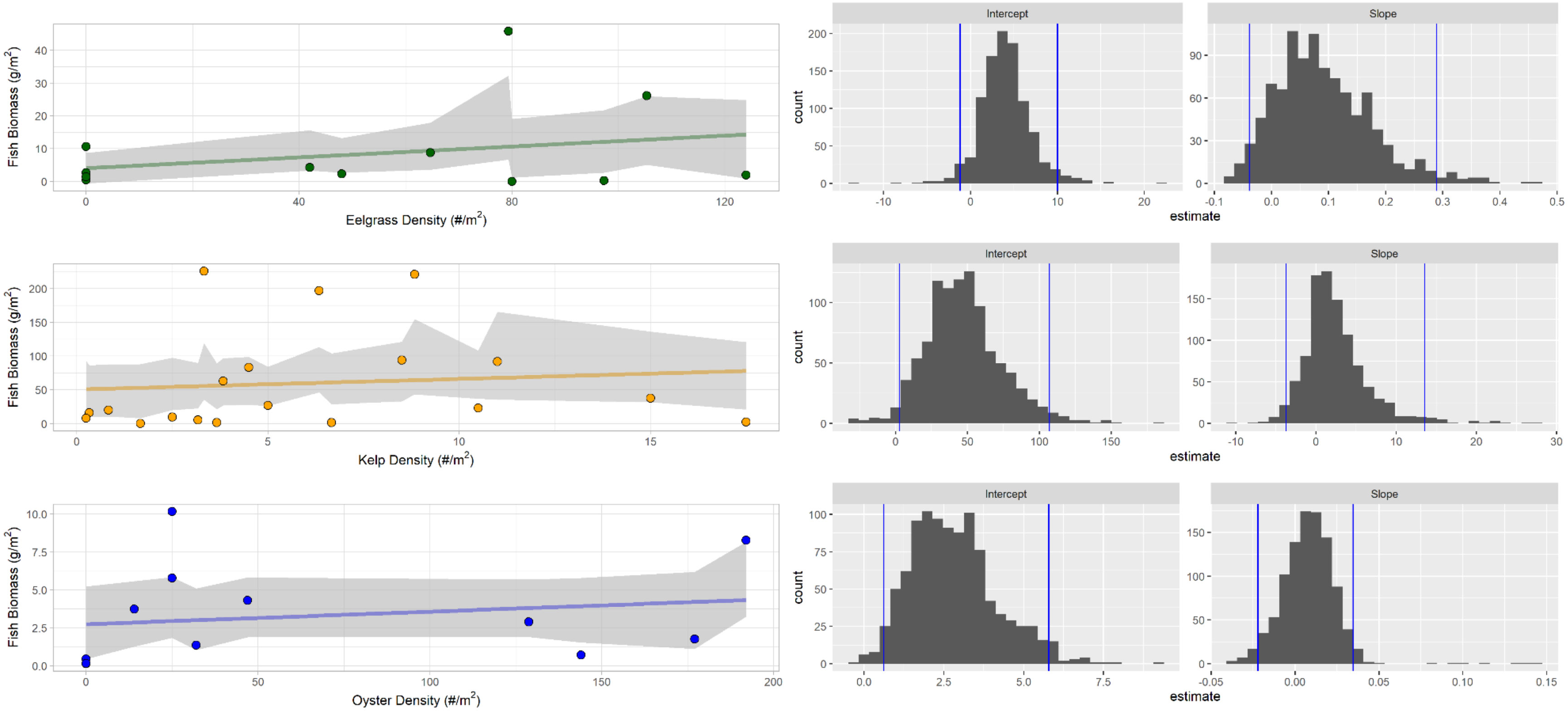

Figure 8: Mean fish biomass (g/m^2) as a function of increasing habitat density for each of the habitat forming species in Job 5 (Eelgrass = green (top row); Kelp = orange (middle row); Oyster = blue (bottom row)). Linear regression models plotted with 95% CI estimated from 1,000 bootstrap samples for the 2020 fish productivity dive surveys. The slope and intercept estimates from the 1,000 bootstraps samples are plotted next to their respective model with blue lines indicating the 95% CI of the estimates themselves.

Protecting and Minimizing Adverse Impacts to Marine Fish Habitat

Eric Schneider, Anna Gerber-Williams, and Katie Rodrigue

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Federal Aid in Sportfish Restoration
F-61-R-21

2020 Performance Report

Performance Report: Job 6 **March 19, 2021**

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

Period Covered: January 1, 2020 - December 31, 2020

Job Number: Job 6: Protecting and Minimizing Adverse Impacts to Marine Fish Habitat

Staff: Eric Schneider, Anna Gerber-Williams, and Katie Rodrigue

Job Objectives:
The goal of this project is to protect important marine habitat to support healthy marine ecosystems and stocks of recreationally important sportfish by addressing the following objectives:

(1) Provide a comprehensive review of permit applications for projects that occur in Rhode Island 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.

(2) In the event of a significant environmental incident: coordinate hazard mitigation, assessment of natural resource damages, and resulting habitat restoration.

(3) Collect and contribute data and staff expertise in municipal, state-wide, and regional planning processes, risk assessments, and habitat and/or spatial planning processes and committees to ensure marine habitat data is incorporated and/or impacts to marine habitat and recreational important sportfishing opportunities are adequately considered and addressed.

Target Date: December 31, 2020

Deviations: No deviations occurred during 2020.

Recommendations: *None*

Remarks: *None*

Summary:

Objective 1: As part of its environmental review program during 2020, DMF reviewed 118 permit applications that contained approximately 248 separate activities of concern or potential impacts to marine resources. The 2020 figures represent a 57% increase relative to the average number of permits reviewed per year over the last six years, when on average per year DMF reviewed 75 permit applications with 101 activities of concern or potential impacts to marine resources. Despite the Covid-19 Pandemic, DMF responded to all applications on-time and did not delay the review or issuance of permits.

This past year, the DMF participated in and formulated responses for 5 preliminary determination meetings with aquaculture applicants. DMF also created site maps for 10 prospective applicants by meeting with them prior to their full aquaculture application submissions; this practice serves to mitigate habitat and fisheries concerns by eliminating important biological areas from consideration. 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 15 public noticed lease applications, and held RI Marine Fishery Council (RIMFC) Shellfish Advisory Panel (SAP) meetings to gain input from industry on aquaculture sites for and to provide scientific opinion to the RIMFC regarding the sites. We coordinated all responses with RI DEM Fish and Wildlife Program for waterfowl habitat and hunting concerns, and drafted DMF official response letters related to fish habitat impacts that were identified through a detailed review of applications for new and modifications to aquaculture leases starting in Jan 2020.

Objective 2: DMF staff continued to participate in collaborative emergency response training and engagement with other state agencies, NOAA, and the University of Rhode Island by attending the annual summer workshop for SSEER (Scientific Support for Environmental Emergency Response). In addition, RI DMF received a total of 17 reports of fish kill events. Thirteen of these reports required RI DMF to respond and assess the scene.

Objective 3: DMF staff participated in the Northeast Regional Marine Fish Habitat Assessment (NRHA), which is a collaborative effort lead by the Mid-Atlantic Marine Fishery Management Council (MAMFC) in partnership with the New England Fishery Management Council (NRFMC), to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. The project aims to develop habitat science products that support habitat and stock assessments. Work associated with the NRHA is expected to occur from July 2019 through July 2022. During 2020 the team developed a spatial data inventory, assembled habitat and fishery-independent resource survey data for an area spanning the Northeast U.S. shelf ecosystem, including coastal and estuarine waters from eastern Maine to the South Carolina. The team also conducted literature reviews to summarize habitat use, life history, and management of the focus fish species in the assessment. These include all the species managed by NEFMC, MAFMC, and Atlantic States Marine Fishery Council (ASFMC), as well as others that are common within the ecosystem but for which there is no fishery management plan.

Objective No. 1

Objective 1 – Approach

To address Objective 1, the DMF 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 occur in 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 provide important information to permitting agencies to allow for more informed permitting decisions.

Depending on the size, scope, and location of the proposed project or activity the review process 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 need to be collected, analyzed, and summarized. Prior to data collection a sampling plan is designed to address specific permitting-related data deficiencies and outline anticipated field and data analyses methods. When possible, any information that would improve anticipated future reviews should be collected. Similarly, when possible this work takes advantage of collaborative efforts by other agencies. Collection of marine habitat and resource (finfish) data may require 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, acoustic receivers, 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. Other sources of habitat data may need to be purchased, such as aerial photography, lidar, side-scan sonar, or GIS data depicting habitat (e.g. eelgrass, submerged aquatic vegetation, sediment, or structures).

In most cases the aforementioned data sources must be compiled, reviewed, and analyzed before a permit can be issued. Given the regulatory timelines set up for permit reviews, being able to accomplish these tasks timely and accurately often requires a collaborative approach that utilizes present and cutting-edge technologies, and sometimes outside expertise.

Objective 1 – Results and Discussion

As part of its environmental review program during 2020, DMF reviewed 118 permit applications that contained approximately 248 separate activities of concern or potential impacts to marine resources (Table 1). The 2020 figures represent a 57% increase relative to the average number of permits reviewed per year over the last six years (Table 2), when on average per year DMF reviewed 75 permit applications with 101 activities of concern or potential impacts to marine resources. Despite the Covid-19 Pandemic, DMF responded to all applications on-time and did not delay the review or issuance of permits.

Verbal and/or written comments were provided on all general permit reviews through the monthly general permit meeting with CRMC, RI DEM OWR, U.S. EPA, and USACE. As part of these reviews, RI DMF provided comments and time of year windows for all dredge-related all projects. The DMF continued to participate in the Manchester Street Power Station 316(b) review process, as well several additional large-scale projects.

Other examples of large-scale, complex projects included work at the Quonset Development Corporation (QDC) to facilitate the delivery of Naval submarines and deeper draft commercial cargo ships. One project at QDC included the replacement of bulkhead, removal of a seaplane ramp, installation of a commercial pier, and dredging of a new commercial channel. During this work, the contractor encountered bedrock not detected during pre-dredge during profiling, which could not be removed with dredging equipment. The DMF in collaboration with NOAA, USACE, and CRMC reviewed and worked to collaboratively to inform an underwater blasting plan that could be implemented to clear the rock, while minimizing impacts to marine resources. This plan utilized TOY restrictions, hydrophones (to measure pressure waves), sonar (to detect fish and mammals within the work zone), and vessel-based marine observers. Based on observer records and project reports, no impacts to fish or marine mammals were recorded during this work.

In addition, DMF worked with the USACE to develop an eelgrass restoration plan that will be implemented over the next 4 year in Winnapaug Pond, contributed to resource impact assessments for a project to evaluate the construction of large scale hurricane barriers at several locations in Rhode Island to reduce future impacts of flooding from sea level rise, and continued planning for the dredging of the federal navigation channel in the Provide River. DMF also reviewed a RIPDES permit for discharge of ground water from underground drilling operations to the Seekonk River to ensure the volume and location of the discharge, as well as construction and deconstruction operations, would not impact marine resources or migrating anadromous species.

As part of DMF's responsivity to evaluate whether proposed aquaculture activities could impact recreational fisheries and the fish habitat, DMF participated in and formulated responses for 5 preliminary determination meetings with aquaculture applicants during 2020. DMF also created site maps for 10 prospective applicants by meeting with them prior to their full aquaculture application submissions; this practice serves to mitigate habitat and fisheries concerns by eliminating important biological areas from consideration. 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 15 public noticed lease applications, and held RI Marine Fishery Council (RIMFC) Shellfish Advisory Panel (SAP) meetings to gain input from industry on aquaculture sites for and to provide scientific opinion to the RIMFC regarding the sites. We coordinated all responses with RI DEM Fish and Wildlife Program for waterfowl habitat and hunting concerns, and drafted DMF official response letters related to fish habitat impacts that were identified through a detailed review of applications for new and modifications to aquaculture leases starting in Jan 2020.

During 2020 the DMF continued internal review and editing to the aquaculture siting review protocol. The aquaculture siting review protocol was created to provide general guidance and justification for siting recommendations for the DMF. Justification includes peer-reviewed and gray literature, conversations with topic-specific experts, and analysis of DEM survey data. Recommendations presented within the protocol are effective for applications currently under review or under future review, including proposed expansions to existing leases. Factors addressed within the aquaculture siting review protocol include: fish habitat, shellfish habitat, proximity to long-term monitoring and habitat restoration sites, proximity to seal habitats, shellfish densities, and commercial and recreational fishing densities, which are areas under the DMF purview. The document will be presented to the shellfishing and aquaculture industries for further feedback before being made public.

The Division has made the active sites layer public via an interactive map on the Department's website: http://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=8beb98d758f14265a84d69758d96742f. This interactive map features mapping tools for future applicants to aid in the site selection process and help them avoid areas of public use or historic eelgrass habitat. Several applicants utilized the interactive map since it was made available to the public and DMF plans to make further modifications and improvements during 2021.

Objective No. 2

Objective 2 - Approach

The DMF will provide available scientific information identifying important recreational fish habitat and pre-impact conditions in the event of a significant environmental incident classified as a Category 3 major environmental disaster incident (e.g., > 10,000 gal oil spill or wide coastal environmental impact likely). In addition, the DMF will provide a staff member with recreational fishery habitat expertise for coordination of DMF responses related to assisting the Office of Emergency Response Incident Command in assessing the environmental impacts of a major oil spill or incident on recreational habitat and biota in Rhode Island marine waters. The staff member will work with appropriate RIDEM and federal representatives in Incident Command during the response to provide needed DMF coordination and technical information during such an incident, including immediate responses related to impact assessment, monitoring of environmental conditions in the vicinity of a spill, immediate biota mortality estimates, as well as involvement in the Natural Resource Damage component of a major incident response following the "Bay Response Team" (BART) protocols. We will assess staff training needs and seek training and/or a refreshers that include response protocols and techniques, as needed.

Objective 2 – Results and Discussion

In 2020, RI DMF responded to 17 reports of fish kill events. Table 3 shows a summary of these events. Five of these kills were due to hypoxia, high water temperatures, or a combination of the two. The species most affected was Atlantic menhaden, but two of these events affected a mixture of other species as well, including blue mussel, striped killifish, mummichogs, Atlantic silverside, northern kingfish, summer flounder, American eel, and blue crab. One kill involved striped bass in Narrow River at the end of July. As with last year, a sample was sent for pathology testing and results indicated an infection by the bacteria *Photobacterium damselae*, which the fish likely succumbed to due to unfavorable water conditions (high temperatures and possibly a combination of low DO). Two other fish kill events were likely due to fishing discards. Finally, there was a period of Atlantic Menhaden kills in December 2020 and early January 2021. An unusually high number of menhaden remained in Narragansett Bay over the winter, and some of these kills were likely due to cold shock or succumbing to the stress of poor conditions (cold water and lack of available food). Connecticut, New York, and New Jersey also experienced similar events of menhaden mortality. New Jersey Fish and Wildlife took samples for testing and genetic analysis suggested that the mortality was associated with a neurologic bacterial infection caused by *Vibrio spp*. No samples were able to be collected and analyzed in RI, so the definitive cause of mortality is not known.

In the event of an incident that causes significant environmental impact, it is imperative for RI DMF to be able to respond quickly and efficiently to assess the effects on fish habitat in Rhode Island waters. Coordination with other state agencies (including RI DEM Office of Emergency Response, OWR, and Office of Law Enforcement) has proven fundamental to this fast response time and impact assessment. A relatively high number of fish kill events were reported in 2019 and 2020 (11 and 17 reported events respectively), and due to the diligence of staff throughout RI DEM, all events requiring action were responded to in a timely manner. The continuation of this coordinated effort is necessary to ensure that a fast and efficient response is maintained. Also, continued emergency response training will allow further improved response to these incidents. Trainings that RI DMF staff have participated in over the last few years include oil spill response training such as boom deployment and other geographic response protocols, Natural Resource Damage Assessment training, and FEMA's Incident Command System. RI DMF staff will continue to take advantage of training opportunities as they become available in the future to further hone our skills in emergency response.

Objective No. 3

Objective 3 – Approach

The DMF actively participates in municipal, state-wide, and regional planning processes, risk assessments, and habitat and/or spatial planning processes and committees, including but not limited to NOAA Environmental Assessment Indexes, Special Area Management Plans (SAMPs), Harbor Management Plans, state-side and regional Environmental Risk Assessments, Restoration Plans, and other plans and committees that include spatial management aspects with potential impacts to recreational sportfish activities and associated habitat. As needed, DMF provides marine habitat, recreational sportfish related data, survey data collected by DMF, and other pertinent marine data to these review and processes. DMF staff ensures that data is considered and used appropriately. As deemed necessary and appropriate, DMF provides analyses and technical assistance at various stages of these processes, as well as technical and logistical support for the activities that result in the collection of additional data that can increase the amount of information available to assess impacts (positive and negative) to recreational important sportfish. Support for data collection activities includes, but is not limited to on-water assistance with maintaining water quality meters, acoustic receivers, and other measures used for fish and habitat qualification within these processes.

Objective 3 – Results and Discussion

DMF staff participated in the Northeast Regional Marine Fish Habitat Assessment (NRHA), which is a collaborative effort lead by the Mid-Atlantic Marine Fishery Management Council (MAMFC) in partnership with the New England Fishery Management Council (NRFMC), to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. The project aims to develop habitat science products that support habitat and fish stock assessments. Work associated with the NRHA is expected to occur from July 2019 through July 2022.

During 2020 the team developed a spatial data inventory, assembled habitat and fishery-independent resource survey data for an area spanning the Northeast U.S. shelf ecosystem, including coastal and estuarine waters from eastern Maine to the South Carolina. The team also conducted literature reviews to summarize habitat use, life history, and management of the 65+ focus fish species in the assessment. These include all the species managed by NEFMC, MAFMC, and the Atlantic States Marine Fishery Council (ASFMC), as well as others that are common within the ecosystem but for which there is no fishery management plan.

Species habitat modeling will be a core component of the assessment, aimed at improving our understanding of how environmental variables govern species distribution. The team will also leverage climate forecasts to project how habitat distributions may change allowing the Councils, ASMFC, and NOAA Fisheries to consider future management scenarios. Initial modeling work was completed in 2020. During 2021 teams will review and begin to develop information products with the results during year two of the assessment.

Another aspect of the assessment is a review of information on inshore habitats, such as marshes, SAV, and oyster reefs. During 2021 the inshore working group will be considering how best to characterize status and trends for these habitat types and utilize current habitat data collected by sates using different methods over various time intervals.

Table 1. Activities and potential impacts identified during the permit review process performed in 2020 by RI DMF for 118 separate projects. Aquaculture-related reviews are excluded from this table.

		Narragansett Bay						
Activities & Potential Impacts	Coastal Ponds	Lower Bay	Upper Bay	Providence and Seekonk Rivers	Sakonnet River	Rivers	Coastal	Total
Potential Impacts to SAV or Benthic Habitat	8	8	6	3	1	3	1	30
Saltmarsh Restoration	4							4
Eelgrass Restoration	1							1
Artificial Reef								0
Maintenance Dredging	1	1	6			1	3	12
New Dredging		1	1	1				3
New Marina								0
Marina Expansion or Reconfiguration		1	7					8
Restoration of Tidal Flow to Coastal Pond	2							2
Residential Docks (New)	11	3	9		5	7		35
Residential Docks (Modifications)	6	6	14			4		30
Commercial/Municipal Piers or Docks		2	10			1		13
Commercial/Municipal Mooring Field Expansion			1					1
Salt Marsh or Coastal Wetland Impacts	6	1	4	2	1	7		21
Beach Nourishment or Coastal Feature Resiliency			1		1		2	4
Waterfront Bulkhead/Riprap			12	3	1	2		18
Waterfront Development			2					2
Public Works or Utility		2	5	5		4	1	17
Fish Passage				6		6		12
Potential Shellfish Impacts	1		4					5
Channel Maintenance	1	1	3				1	6
Boat Ramps	1		4	1		4		10
Oyster Restoration	1	1	1	1		1		5
Recreational Use (Improve/Impacts)	2		4	1		1		8
Impacts from Discharge				1	1		1	3
Total	45	27	94	24	10	41	9	250

Table 2. Activities and potential impacts identified during the permit review process over the last seven years, including the previous (2014 – 2019) and current (2020) grant cycle. Aquaculture-related reviews are excluded from this table.

	Permit Review During Previous 6 Years								2020 Total
Activities & Potential Impacts	2014	2015	2016	2017	2018	2019	Average Per Year	Total	
Potential Impacts to SAV or Benthic Habitat	0	0	1	5	11	13	5	30	30
Saltmarsh Restoration	4	5	3	3	6	4	4	25	4
Eelgrass Restoration	1	0	0	1	4	0	1	6	1
Artificial Reef	1	0	0	0	1	1	1	3	0
Maintenance Dredging	8	8	10	17	6	8	10	57	12
New Dredging	3	1	0	2	2	2	2	10	3
New Marina	3	2	0	0	2	0	1	7	0
Marina Expansion or Reconfiguration	0	1	3	2	2	5	2	13	8
Restoration of Tidal Flow to Coastal Pond	1	0	0	2	5	0	1	8	2
Residential Docks (New)	40	20	23	0	29	18	22	130	35
Residential Docks (Modifications)	7	2	7	39	39	13	18	107	30
Commercial/Municipal Piers or Docks	1	3	0	13	5	5	5	27	13
Commercial/Municipal Mooring Field Expansion	0	0	5	0	0	2	1	7	1
Salt Marsh or Coastal Wetland Impacts	0	0	0	16	14	8	6	38	21
Beach Nourishment or Coastal Feature Resiliency	2	0	3	1	4	6	3	16	4
Waterfront Bulkhead/Riprap	4	1	2	11	6	11	6	35	18
Waterfront Development	1	0	0	0	1	4	1	6	2
Public Works or Utility	1	0	1	1	6	7	3	16	17
Fish Passage	0	0	0	0	0	0	0	0	12
Potential Shellfish Impacts	0	0	0	4	4	4	2	12	5
Channel Maintenance	0	0	0	5	1	4	2	10	6
Boat Ramps	1	1	0	2	1	2	1	7	10
Oyster Restoration	0	4	0	2	4	0	2	10	5
Recreational Use (Improve/Impacts)	0	0	0	0	7	3	2	10	8
Impacts from Discharge	0	0	0	6	3	2	2	11	3
Coastal Restoration Other	0	0	0	5	0	0	1	5	0
Total - Activities & Potential Impacts	78	48	58	137	163	122	101	606	250
Total - Projects Reviewed	85	68	51	77	95	72	75	448	118

Table 3. Summary of fish kill events in 2020.

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause	Comments
7/29/2020	Narrow River	DEM DMF	None deemed necessary - was on standby for further investigation/sample collection	NA	Striped Bass *Morone saxatilis* Bluefish *Pomatomus saltatrix*	Minor (18 striped bass and 2 bluefish observed from 7/1/20 - 11/5/20) Less mortality than similar event in 2019, but over longer period	Y (temps taken by NRPA)	Y (whole fish)	Y	For individual fish tested, pathogen *Photobacterium damselae* present as with the individual tested last year. Likely succumbed to infection due to other stressors (water temps continually above 80F, low DO)	Link to NRPA list of STB observations
8/14/2020	Bullock Cove, Allin's Cove, Rumstick Pt	RI DOH, DEM OWR, DEM DMF, DEM DLE, STB	DEM DMF responded to the scene	8/14/2020	Atlantic menhaden Mummichog Striped killifish American eel Atlantic silverside Northern kingfish Summer flounder Blue mussel	Moderate to major (~5000)	Y	N	Y	Hypoxic conditions due to heat wave and algal blooms (rust tide *Cochlodinium polykrikoides* blooms obersved) . Upper temp threshold exceeded for blue mussel	

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause	Comments
8/14/2020	Apponaug Cove	RI DOH, DEM OWR, DEM DMF, DEM DLE, STB	DEM DMF responded to the scene	8/14/2020	None observed, reported as 1-2" baitfish species	Minor to moderate (reported as several hundred), none observed during response (eaten or washed off beach)	Y	N	N	Hypoxic conditions due to heat wave and algal blooms (rust tide *Cochlodinium polykrikoides* blooms obersved)	
8/18/2020	Mount Hope Bay at Common Fence Point	DEM DMF	DEM DMF responded to the scene	8/18/2020	Blue mussel	Major (hundreds of thousands, throughout month of August)	N	N	Y	Likely due to heat wave - Mt Hope Bay exceeded 80F multiple days from end of July-mid August. Mussels have temp threshold of 80-85F. Anecdtoal reports of large mussel bed in Mt Hope Bay forming in last 1-2 years. Could explain high abundance.	

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause	Comments
8/25/2020	Sakonnet River at Fogland Point (cove side)	DEM OWR, DEM DMF, DEM OER, DEM DLE, RI DOH	DEM DMF responded to the scene	8/25/20 and 8/27/20	Atlantic menhaden *Brevoortia tyrannus*	Moderate to major (thousands)	N	N	Y	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)	
8/24/2020	Mackerel Cove	DEM OWR, DEM DMF, DEM OER, DEM DLE, RI DOH	DEM DMF responded to the scene	8/24/2020	Striped burrfish *Chilomycterus schoepfi*	Minor (2)	N	N	Y	Possible recreational fishing discards. No evidence of water quality problems or other species affected	
9/3/2020	Buttonwoods and Brushneck Coves	DEM OWR, DEM DMF, DEM OER, DEM DLE, RI DOH	DEM DMF responded to the scene	9/4/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor to moderate (reported as several hundred), none observed during response (eaten or washed off beach)	Y	N	N	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)	

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause	Comments
9/9/2020	Block Island Sound at East Matunuck and Scarborough beaches	DEM OWR, DEM DMF, DEM OER, DEM DLE, RI DOH	DEM DMF responded to the scene	9/10/2020	False Albacore *Euthynnus alletteratus*	Minor (30-40)	N	N	Y	Possibly fishing discards that had blown to shore. No signs of water quality problem or other species affected	
9/15/2020	Kickemuit River	DEM DMF	DEM DMF responded to the scene	9/15/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor (~100)	Y	N	N	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)	
12/9/2020	Providence River at hurricane barrier	DEM OWR, DEM DMF, DEM OER, DEM DLE	DEM DMF responded to the scene	12/9/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor (~50)	N	N	Y	Likely due to cold shock	
12/10/2020	Greenwich Bay	DEM OWR, DEM DMF, DEM OER, DEM DLE	DEM DMF responded to the scene	12/10/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor (no fish observed)	N	N	N	Likely due to cold shock	
12/22/2020	Providence River at Appian Way, Barrington	DEM OWR, DEM DMF, DEM OER, DEM DLE	DEM DMF responded to the scene	12/22/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor (<20)	N	N	N	Likely due to cold shock or poor health due to increasingly cold conditions	
12/22/2020	Narrow River	DEM OWR, DEM DMF, DEM OER, DEM DLE	Response not deemed necessary	NA	Atlantic menhaden *Brevoortia tyrannus*	Minor (10-12 reported)	N	N	Y	Likely due to cold shock or poor health due to increasingly cold conditions	

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause	Comments
12/28/2020	Providence River near Pawtuxet Village	DEM OWR, DEM DMF, DEM OER, DEM DLE	Response not deemed necessary	NA	Atlantic menhaden *Brevoortia tyrannus*	Minor (<20)	N	N	N	Likely due to cold shock or poor health due to increasingly cold conditions	
12/28/2020	Ocean-facing beach near Weekapaug Breachway	DEM OWR, DEM DMF, DEM OER, DEM DLE, Watch Hill Conservancy	DEM DMF responded to the scene	12/29/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor to moderate (~170 observed)	N	N	Y	Likely due to cold shock or poor health due to increasingly cold conditions	
12/28/2020	Ocean-facing beach at Napatree Pt	DEM OWR, DEM DMF, DEM OER, DEM DLE, Watch Hill Conservancy	Response not deemed necessary	NA	Atlantic menhaden *Brevoortia tyrannus*	Minor to moderate (50-60 reported)	N	N	N	Likely due to cold shock or poor health due to increasingly cold conditions	
12/31/2020	Providence River at Gaspee Point	DEM OWR, DEM DMF, DEM OER, DEM DLE	DEM DMF responded to the scene	12/31/2020	Atlantic menhaden *Brevoortia tyrannus*	Minor (30-50)	N	N	Y	Likely due to cold shock or poor health due to increasingly cold conditions	

PERFORMANCE REPORT

STATE: Rhode Island

PROJECT NUMBER: F-61-R

SEGMENT NUMBER: 21

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

PERIOD COVERED: January 1, 2020 - December 31, 2020

JOB NUMBER AND TITLE: Job VII: Providence River Estuary Seine Narrative

STAFF: Pat Barrett (Fisheries Specialist) RI DEM, Div. of Marine Fisheries, and Will Helt (Coastal Restoration Scientist) and Heather Kinney (Coastal Restoration Science Technician), The Nature Conservancy of Rhode Island (TNC)

JOB OBJECTIVE:

The objective of this work is:

1) Continue to evaluate the contribution of the Providence River Estuary as a nursery habitat for commercially and recreationally important fish in response to changing habitat and water quality stressors.

TARGET DATE: 12/31/2020

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2020. In response to the Covid-19 pandemic, staffing and field survey data collection approaches had to be modified to ensure the safety of staff and the public. Although additional effort was required, all field survey work was completed as scheduled. During the 2020 season, a total of 72 seines were hauled across 12 sites in May through October resulting in the enumeration of 106,063 individuals.

RECOMMENDATIONS:

None

The Rhode Island Chapter of The Nature Conservancy
Annual Progress Report

Submitted to

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

Title: Providence River Estuary Seine Survey

Cooperative Agreement Award Number: 3481879

Award Term: January 30, 2020 to December 31, 2024

Reporting Period: January 30, 2020 to December 31, 2020

Prepared By

William Helt (Coastal Restoration Scientist) and
Heather Kinney (Coastal Restoration Science Technician)

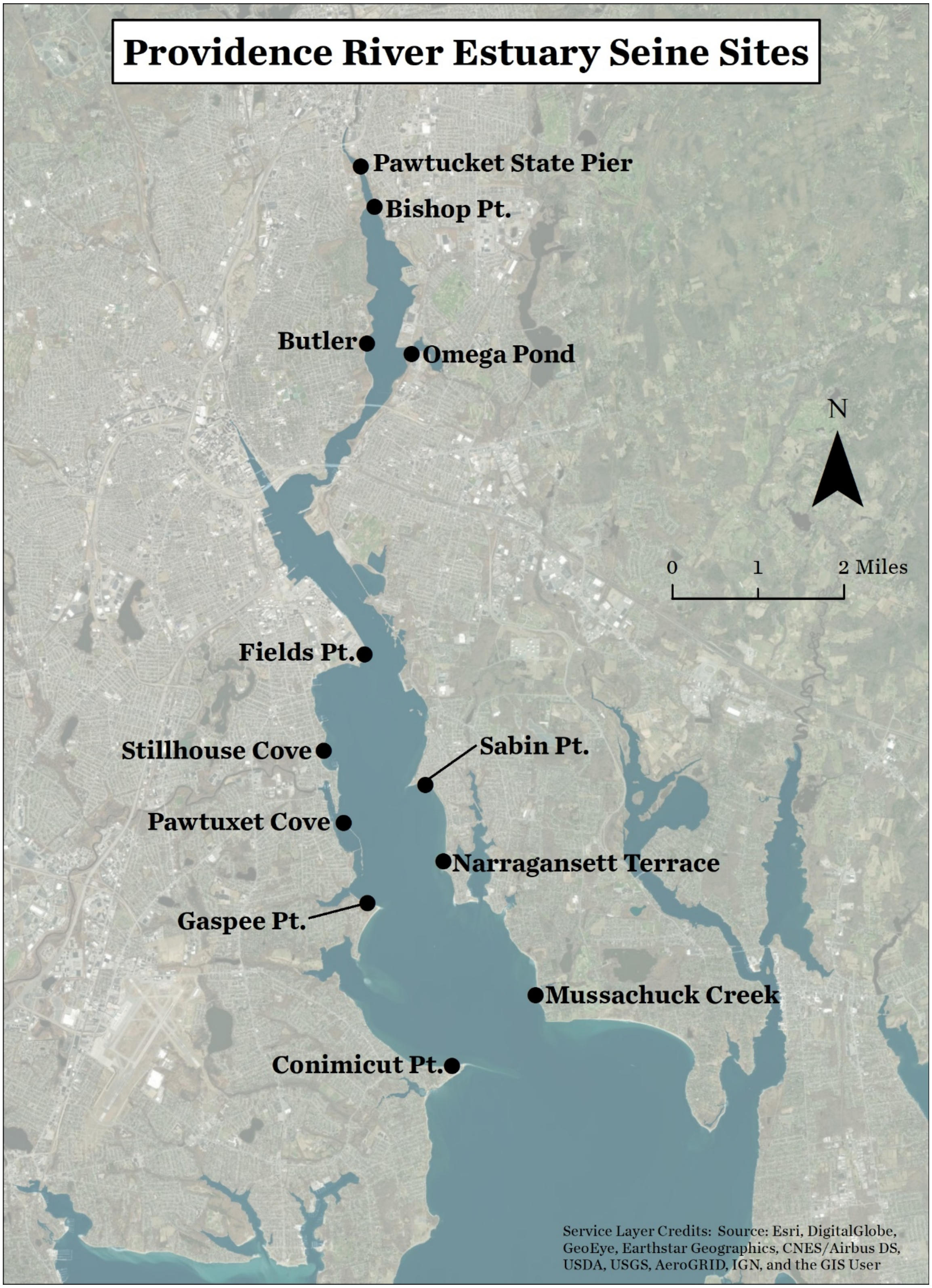
Approved By

Scott Comings, Associate State Director

The Nature Conservancy Rhode Island Chapter
159 Waterman Street
Providence, RI 02906

Protecting nature. Preserving life.

Map of study area and sampling locations.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

SUMMARY

During the 2020 season, a total of 72 seines were hauled across 12 sites in May through October resulting in the enumeration of 106,063 individuals. Of the animals caught, 5,912 were measured and 44 species were identified (see Table 1). Despite the additional considerations for safely working in the field during the COVID-19 pandemic, all scoped work was completed. All raw data have been shared with the appropriate staff at the Division of Marine Fisheries for incorporation into existing datasets.

TARGET DATE:

December 31, 2020

NEXT STEPS

Investigators intend to continue sampling with the same methodology during the field season of 2021. Additionally, the project team will begin coordinating with the primary investigators of the Coastal Ponds and Great Salt Pond juvenile fish surveys to evaluate variations in fish assemblages across regions.

INTRODUCTION

Estuaries are also known as “nurseries of the sea” because they provide critical habitat for so many marine species in the early parts of their life cycle. Unfortunately, estuaries are also some of the most threatened natural systems across the globe, primarily due to human development and industrialization (Halpern et al. 2008; Lotze et al. 2006). Rhode Island’s Narragansett Bay, the defining water feature of the state, is no exception, and negative human impacts on the bay have been well-documented (NBEP 2017). Among the most heavily degraded waters of Narragansett Bay are the Providence and Seekonk rivers, which are found in the northern range of Narragansett Bay and are collectively known as the Providence River Estuary (PRE). The PRE is located along the City of Providence and is fed by the Blackstone, Mosshasuck, and Woonasquatucket rivers.

For decades, nutrient over-enrichment has been found to have many negative effects on this area, including increases in hypoxic events and fish kills (Carey et al. 2005; Deacutis 2008). In recent years, improvements in wastewater treatment facilities have led to an estimated reduction in nutrient concentration of around 60% within the PRE (Oviatt et al. 2017). This notable and rapid improvement has been dubbed by Nixon et al. in 2008 as a “Grand Ecological Experiment” as not much was known about the impacts of this abrupt change. As a result of these reduced nutrient inputs and perceived improvements in water quality to support fish populations, interest from managers grew in evaluating the utilization of this historically important estuary by juvenile fishes. Additionally, a subsequent literature review revealed that very little empirical data existed on the fish assemblages within the estuary. In fact, the most recent fisheries resource study conducted by the Rhode Island Department of Environmental Management, Division of Marine Fisheries (DMF) within the Providence and Seekonk Rivers was in 1996 (Satchwill et al. 1997). This missing information is critically important because it has also been estimated that more than 70% of Rhode Island’s recreationally and commercially important finfish spend at least part of their lives in estuarine and coastal waters, usually when young (Meng and Powell 1999).

In 2014, the DMF and The Nature Conservancy (TNC) entered into a cooperative agreement to begin evaluating the PRE and its role in supporting fish populations. Through a holistic approach the estuary’s water quality, benthic and coastal habitat, and fish assemblages were evaluated. Not only did this monitoring reveal that the PRE supported recreationally and commercially important juvenile finfish, but it also recognized that the study area could support habitat improvements aimed at increasing fish recruitment.

Among the study’s approaches, a juvenile fish seine survey was established in 2016. The results of this initial evaluation have shown the seine survey to be a valuable tool for DMF in managing fish populations. Continuation of this survey contributes to DMF’s ability to evaluate juvenile fish populations across Rhode Island and aligns with other active, established seine surveys across the state within the coastal ponds along the southern shores of the state and Great Salt Pond on Block Island. As the habitat and water quality of the PRE continue to change, this seine survey will also serve to document how these changes affect the fish assemblage within the study area.

METHODS

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

RESULTS

For the 2020 field sampling season, a total of 72 seines were hauled across the 12 sampling sites. A total of 106,063 individuals were identified and enumerated, and 5,912 of those were measured. A total for 44 species were caught (Table 1). Of the species caught, only finfish were included in the results below (all crustaceans were excluded).

A mean of 1,468.39 ± 643.91 SE finfish were caught per haul. Catch per haul across sites was greatest at Butler at 7,128.00 ± 6,873 SE and lowest at Gaspee Point at 143.17 ± 70.50 SE (Figure 1). Catch per haul across months was greatest in September at 4,149.58 ± 3,406.84 SE and lowest at 88.67 ± 29.58 SE (Figure 2).

Winter Flounder (*Pseudopleuronectes americanus*)

Of the total 242 winter flounder caught in 2020 seines, all were young of the year (max length = 80mm; Able and Fahay 1998; Berry et al. 1965). Winter flounder were caught at all 12 sites. The most abundant site for winter flounder was Stillhouse Cove at a catch per haul of 10.50 ± 5.80 SE. The most abundant month for winter flounder was June at a catch per haul of 11.58 ± 3.29 SE (Figure 3a and 3b).

Summer Flounder (*Paralichthys dentatus*)

A total of 24 summer flounder were caught in 2020 beach seines ranging in size from 3cm to 11cm, Summer flounder were caught at 6 of the 12 sites: Pawtucket State Pier, Bishop Point, Butler, Omega Pond, Fields Point, Pawtuxet Cove. Summer flounder were most abundant at Butler, at a catch per haul of 2.33 ± 1.19 SE. Most individuals were caught in June at a catch per haul of 0.83 ± 0.41 SE (Figure 3a and 3b).

Tautog (*Tautoga onitis*)

A total of 173 tautog were caught in 2020 beach seines ranging in size from 3cm to 15cm. Tautog were caught at 6 of the 12 sites: Fields Point, Stillhouse Cove, Narragansett Terrace, Gaspee Point, Mussachuck Creek, and Conimicut Point. Of the 6 sites they were caught, tautog were most abundant at Fields Point, a catch per haul of 7.33 ± 4.03 SE. The most individuals were caught in July at a catch per haul of 4.83 ± 2.34 SE (Figure 3a and 3b).

Black Sea Bass (*Centropristis striata*)

A total of 2 black sea bass were caught in 2020 beach seines at 10cm and 11cm. Both were caught in September at Fields Point and Gaspee Point.

Scup (*Stenotomus chrysops*)

A total of 6 scup were caught in 2020 beach seines ranging in size from 6cm to 10cm. All scup were caught in the months of August and September at Sabin Point, Narragansett Terrace, and Conimicut Point.

Atlantic Menhaden (*Brevoortia tyrannus*)

In the 2020 sampling season, 80,952 Atlantic menhaden were caught, ranging in size from 3cm to 32cm. The total survey mean abundance index is 1,124.33 ± 632.81 SE. Atlantic menhaden were found July through October at all sites except Gaspee Point, Mussachuck Creek, and Conimicut Point.

River Herring (*Alosa pseudoharengus & Alosa aestivalis*)

A total of 2,941 river herring were caught in 2020. Both Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) are classified as river herring in this survey. River herring ranged in size from 4cm to 11cm and were found May through October at all sampling sites with a total survey mean abundance of 40.85 ± 25.45 SE.

Bluefish (*Pomatomus saltatrix*)

A total of 2,268 bluefish were caught in 2020. The total mean abundance is 31.50 ± 30.27 SE ranging in size from 8cm to 25cm. Bluefish were found July through September at all sites except Bishop, Butler, Omega Dam, and Stillhouse Cove. A large proportion of bluefish (2,180) were caught at Fields Point in September.

Gizzard Shad (*Dorosoma cepedianum*)

A total of 1,035 gizzard shad were caught in 2020. The total mean abundance is 14.38 ± 9.45 SE ranging in size from 4cm to 16cm. Gizzard Shad were found July through October at all four sites within the Seekonk River as well as Sabin Point and Mussachuck Creek.

Silverside (*Menidia spp.*)

A total of 11,955 silversides were caught in 2020. For the purposes of this survey, both Atlantic silversides (*Menidia menidia*) and inland silversides (*Menidia beryllina*) are categorized as silversides (*Menidia spp.*). The total mean abundance is 166.04 ± 37.98 SE and silversides ranged in size from 3cm to 15cm, found in all months and at all sites.

Striped Killifish (*Fundulus majalis*)

A total of 3,629 striped killifish were caught in 2020, ranging in size from 2cm to 13cm. The total mean abundance is 50.40 ± 14.53 SE, and they were found at all sites from May through October.

Common Mummichog (*Fundulus heteroclitus*)

A total of 573 common mummichog were caught in 2020, ranging in size from 3cm to 11cm. The total mean abundance is 7.96 ± 2.08 SE, and they were found at all sites but Conimicut Point from May through October.

Water Quality Data

Water quality data for the 2020 season can be found in Table 2. Water temperature ranged from 12.3C in May to 26.1C in August. The mean salinity of the four sites within the Seekonk River was 11.94ppt ± 1.42 SE and the mean salinity of the eight sites within the Providence River was 24.02ppt ± 0.95 SE. The lowest dissolved oxygen value recorded across all sites was 3.99mg/L in September at Bishop, while the mean was 7.62mg/L ± 0.26 SE.

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FIGURES:

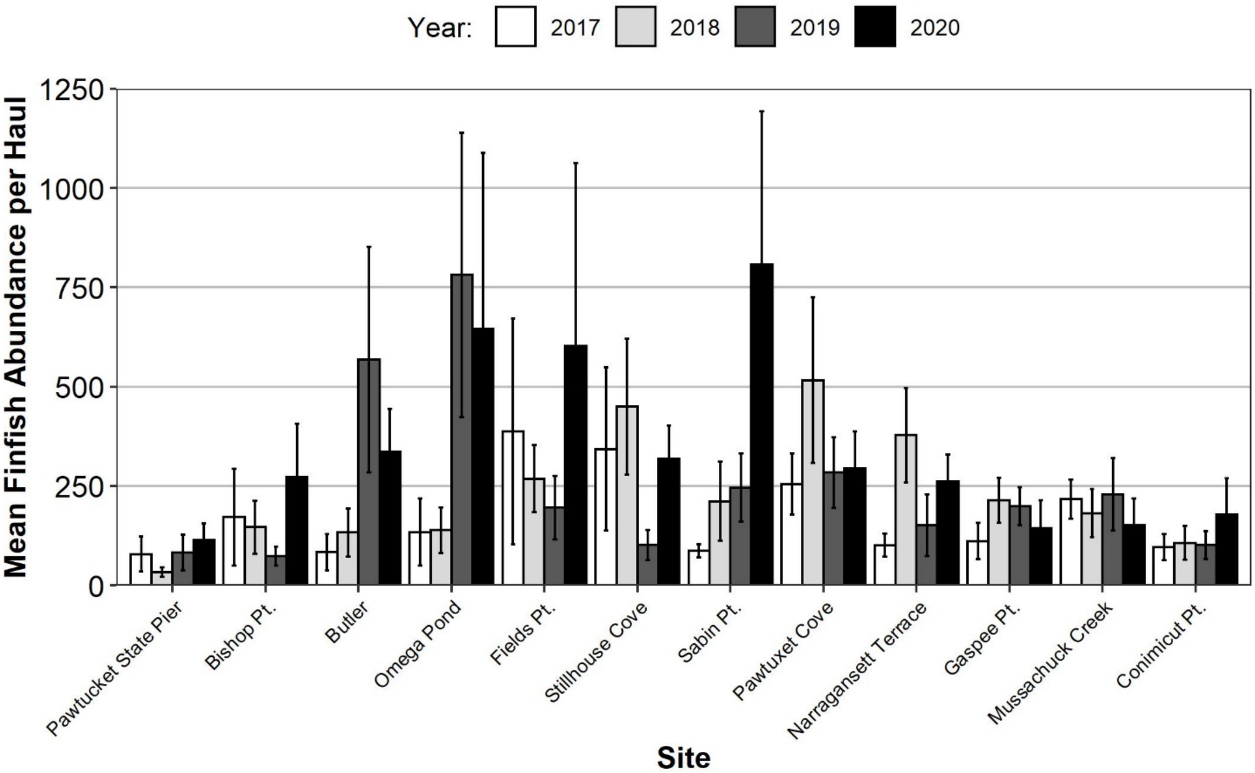


Figure 1. Mean abundance of finfish across sites (±SE) in 2017-2020 beach seines.

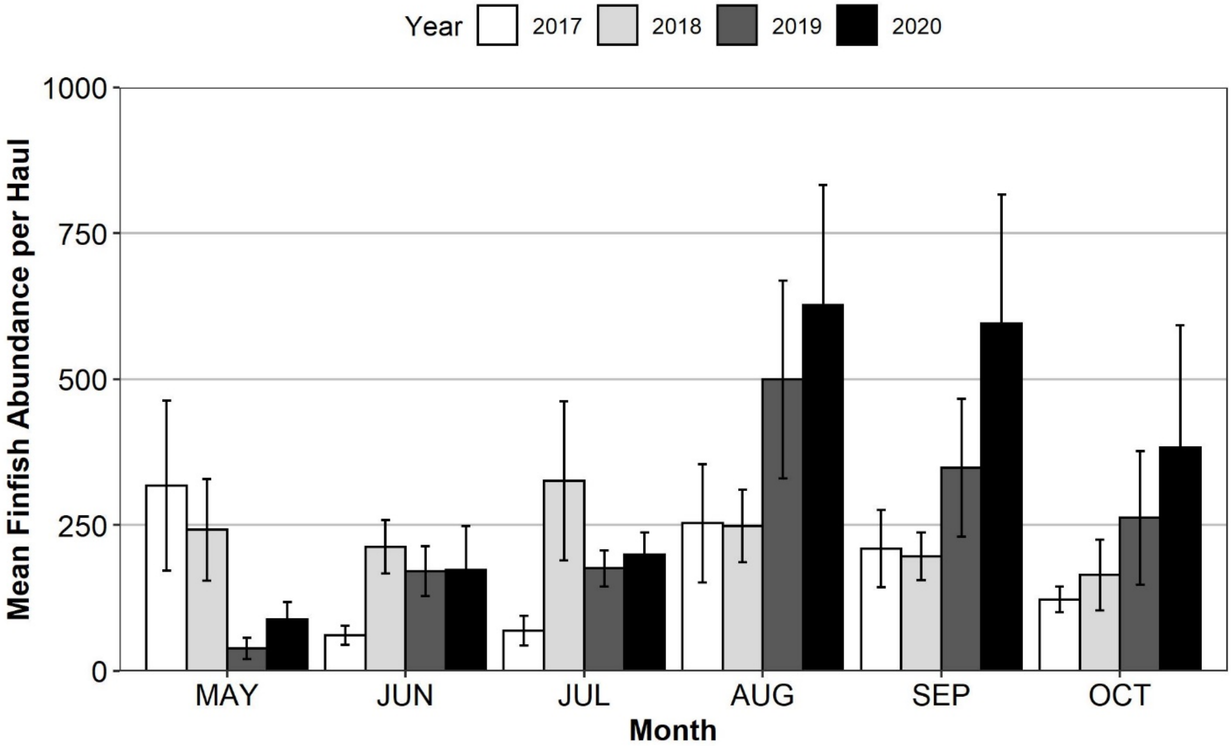


Figure 2. Mean abundance finfish caught each month (±SE) in 2017-2020 beach seines.

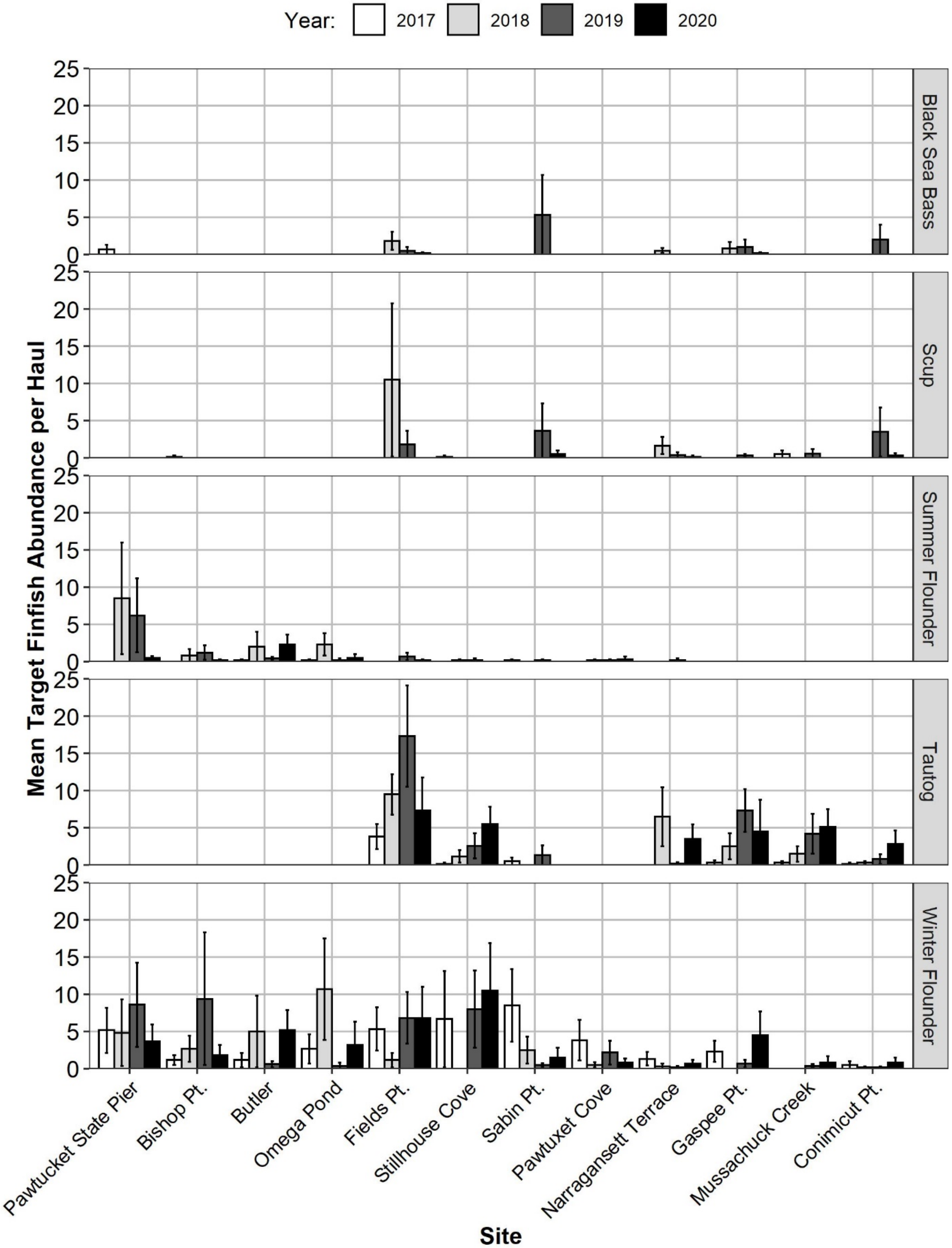


Figure 3a. Mean abundance of target finfish caught by site (±SE) in 2017-2020 beach seines.

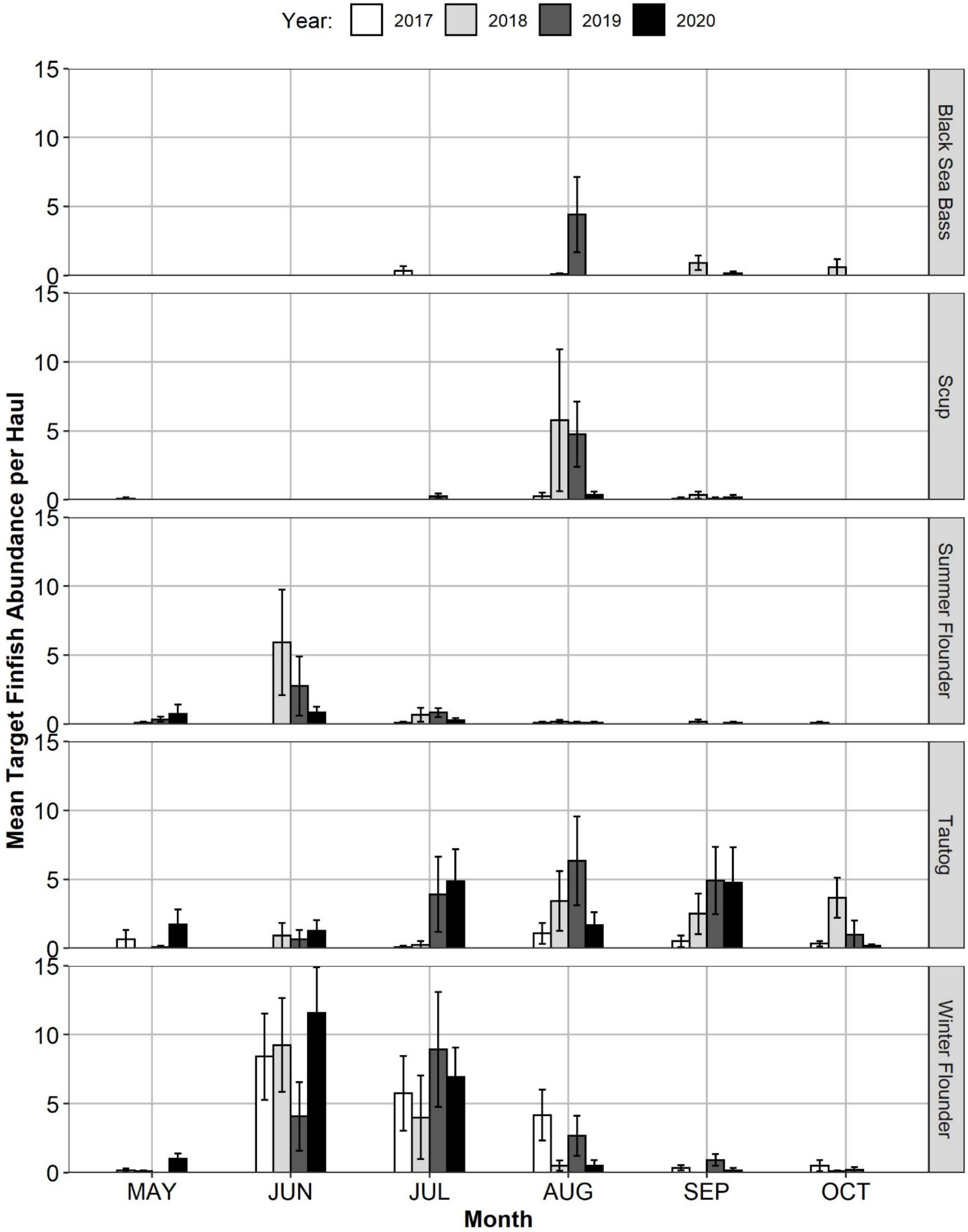


Figure 3b. Mean target finfish per seine haul (± SE) plotted for each month sampled during the 2017-2020 field seasons.

Table 1. Common, scientific names, and total abundance of all species collected in beach seines during 2020.

Common Name	**Scientific Name**	**Abundance**
Atlantic Menhaden	*Brevoortia tyrannus*	80,952
Atlantic Silverside	*Menidia menidia*	11,955
Striped Killifish	*Fundulus majalis*	3,629
River Herring	*Alosa aestivalis &/or pseudoharengus*	2,941
Bluefish	*Pomatomus saltatrix*	2,268
Gizzard Shad	*Dorosoma cepedianum*	1,035
Rainwater Killifish	*Lucania parva*	631
Common Mummichog	*Fundulus heteroclitus*	573
Sea Herring	*Clupea harengus*	534
Blue Crab	*Calinectes sapidus*	325
Winter Flounder	*Pseudopleuronectes americanus*	242
Tautog	*Tautoga onitis*	173
Northern Kingfish	*Menticirrhus saxatilis*	152
White Perch	*Morone americana*	150
Weakfish	*Cynoscion regalis*	122
Hogchoker	*Trinectes maculatus*	86
Northern Searobin	*Prionotus carolinus*	57
Sheepshead Minnow	*Cyprinodon variegatus*	31
Common Shiner	*Luxilus cornutus*	27
Summer Flounder	*Paralichthys dentatus*	24
Atlantic Tomcod	*Microgadus tomcod*	23
Bay Anchovy	*Anchoa mitchilli*	18
Northern Puffer	*Sphoeroides maculatus*	15
Largemouth Bass	*Micropterus salmoides*	14
Atlantic Needlefish	*Strongylura marina*	10
Striped Searobin	*Prionotus evolans*	8
Cunner	*Tautogolabrus adspersus*	7
4-Spine Stickleback	*Apeltes quadracus*	6
Lady Crab	*Ovalipes ocellatus*	6
Scup	*Stenotomus chrysops*	6
Oyster Toadfish	*Opsanus tau*	5
Spider Crab	*Libinia emarginata*	5
White Mullet	*Mugil curema*	5
American Eel	*Anguilla rostrata*	4
Northern Pipefish	*Syngnathus fuscus*	4
Bluegill	*Lepomis macrochirus*	3
Crevalle Jack	*Caranx hippos*	3
Golden Shiner	*Notemigonus crysoleucas*	3
Green Crab	*Carcinus maenus*	3
Atlantic Croaker	*Micropogonias undulatus*	2
Black Sea Bass	*Centropristus striata*	2
Naked Goby	*Gobiosoma bosc*	1
Searobins	*Prionotus genus*	1
Striped Bass	*Morone saxatilis*	1
Yellow Perch	*Perca flavescens*	1

Table 2. Temperature, salinity, and dissolved oxygen by site and month during 2020 beach seines (NA indicates when YSI device was not functional or available).

Site	Month	Temp (°C)	Sal. (ppt)	DO (mg/L)	Site	Month	Temp (°C)	Sal. (ppt)	DO (mg/L)
Pawtucket State Pier	MAY	17.1	2.0	NA	Narragansett Terrace	MAY	17.6	20.1	NA
	JUN	21.6	6.0	NA		JUN	14.0	25.5	NA
	JUL	NA	NA	NA		JUL	NA	22.0	NA
	AUG	23.2	6.8	6.65		AUG	23.2	29.1	8.92
	SEP	22.1	14.0	7.63		SEP	18.7	28.9	6.97
	OCT	15.1	6.2	9.40		OCT	14.8	26.0	7.40
Bishop Pt.	MAY	16.7	4.2	NA	Gaspee Pt.	MAY	16.2	21.6	NA
	JUN	21.9	11.2	NA		JUN	NA	NA	NA
	JUL	NA	NA	NA		JUL	NA	NA	NA
	AUG	24.0	15.6	8.22		AUG	26.1	25.0	7.35
	SEP	22.4	14.5	3.99		SEP	22.0	28.7	7.10
	OCT	15.5	6.6	9.33		OCT	16.7	28.1	7.70
Butler	MAY	18.0	6.0	NA	Mussachuck Creek	MAY	17.5	23.3	NA
	JUN	19.6	14.5	NA		JUN	20.0	26.5	NA
	JUL	NA	NA	NA		JUL	NA	NA	NA
	AUG	23.6	22.8	8.47		AUG	24.9	29.8	13.29
	SEP	21.9	18.0	8.60		SEP	19.5	30.4	6.05
	OCT	15.3	18.6	7.22		OCT	14.9	27.1	7.85
Omega Pond	MAY	19.0	7.9	NA	Conimicut Pt.	MAY	14.3	17.8	NA
	JUN	19.7	6.6	NA		JUN	18.7	26.6	NA
	JUL	NA	NA	NA		JUL	NA	NA	NA
	AUG	24.2	22.8	5.85		AUG	25.4	27.7	7.29
	SEP	22.4	17.4	7.00		SEP	22.1	30.7	7.45
	OCT	14.4	17.0	7.70		OCT	NA	NA	NA
Fields Pt.	MAY	12.3	24.4	NA	Sabin Pt.	MAY	17.1	16.2	NA
	JUN	20.6	21.7	NA		JUN	14.8	25.3	NA
	JUL	NA	NA	NA		JUL	NA	25.0	NA
	AUG	25.5	25.7	5.04		AUG	23.2	29.3	7.25
	SEP	21.9	28.5	7.35		SEP	18.7	28.7	6.92
	OCT	17.1	29.2	7.37		OCT	15.1	26.5	7.55
Pawtuxet Cove	MAY	14.7	4.2	NA	Stillhouse Cove	MAY	12.7	19.6	NA
	JUN	21.9	9.7	NA		JUN	20.8	22.7	NA
	JUL	NA	NA	NA		JUL	NA	NA	NA
	AUG	22.9	12.2	6.39		AUG	25.9	25.1	6.80
	SEP	22.1	19.7	7.58		SEP	23.5	28.8	9.46
	OCT	15.0	14.0	8.86		OCT	18.2	29.4	8.70

APPENDIX

Species presence by site for May 2020 beach seines.

MAY	**Site**												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
4-Spine Stickleback				1				1					**2**
Atlantic Menhaden					1								**1**
Atlantic Silverside		1	1	1	1	1		1	1	1	1	1	**10**
Atlantic Tomcod		1	1			1			1			1	**5**
Bay Anchovy			1			1							**2**
Common Mummichog			1	1		1		1			1		**5**
Cunner					1				1			1	**3**
Hogchoker	1												**1**
River Herring		1	1		1								**3**
Striped Killifish			1	1	1	1	1	1		1	1		**8**
Summer Flounder	1		1	1									**3**
Tautog						1			1			1	**3**
White Perch				1									**1**
Winter Flounder	1		1		1	1			1	1			**6**

APPENDIX

Species presence by site for June 2020 beach seines.

JUNE	**Site**												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
Atlantic Croaker				1									**1**
Atlantic Silverside		1	1			1	1	1	1	1	1		**8**
Atlantic Tomcod	1	1											**2**
Bay Anchovy			1										**1**
Common Mummichog		1	1					1					**3**
Hogchoker	1												**1**
Northern Searobin			1										**1**
River Herring		1											**1**
Striped Killifish			1		1		1	1	1	1			**6**
Summer Flounder			1	1	1			1					**4**
Tautog					1	1					1		**3**
White Perch	1	1											**2**
Winter Flounder	1	1	1	1	1	1	1	1	1	1	1	1	**12**

APPENDIX

Species presence by site for July 2020 beach seines.

JULY	**Site**												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
4-Spine Stickleback										1			**1**
Atlantic Menhaden					1	1							**2**
Atlantic Silverside	1		1	1	1	1	1	1	1	1	1	1	**11**
Atlantic Tomcod										1			**1**
Bay Anchovy								1					**1**
Bluefish										1	1	1	**3**
Common Mummichog			1			1	1	1		1			**5**
Crevalle Jack								1					**1**
Cunner												1	**1**
Gizzard Shad		1											**1**
Golden Shiner		1											**1**
Hogchoker	1												**1**
Largemouth Bass	1	1											**2**
Northern Kingfish			1		1	1	1	1	1	1	1	1	**9**
Northern Pipefish					1							1	**2**
Northern Puffer					1					1	1	1	**4**
Northern Searobin			1		1	1	1	1	1	1		1	**8**
Rainwater Killifish			1	1				1					**3**
River Herring		1				1		1		1	1	1	**6**
Striped Killifish			1	1	1	1	1	1	1	1			**8**
Summer Flounder		1	1										**2**
Tautog					1	1				1	1	1	**5**
Weakfish		1											**1**
White Perch	1	1						1					**3**
Winter Flounder	1	1	1		1	1	1	1	1	1		1	**10**
Yellow Perch	1												**1**

APPENDIX

Species presence by site for August 2020 beach seines.

AUGUST	**Site**												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
Atlantic Menhaden		1		1									**2**
Atlantic Needlefish							1		1				**2**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Bluefish							1			1			**2**
Common Mummichog	1	1	1	1		1		1	1	1			**8**
Crevalle Jack				1									**1**
Gizzard Shad	1	1		1							1		**4**
Hogchoker	1	1	1										**3**
Largemouth Bass	1												**1**
Northern Kingfish					1		1		1	1	1		**5**
Northern Pipefish									1				**1**
Northern Puffer									1				**1**
Rainwater Killifish	1	1	1	1		1	1	1			1	1	**9**
River Herring		1		1		1			1	1	1	1	**7**
Scup							1		1				**2**
Striped Killifish		1	1	1	1	1	1	1	1	1	1	1	**11**
Striped Searobin					1	1							**2**
Summer Flounder	1												**1**
Tautog					1	1			1		1		**4**
Weakfish	1	1	1	1					1				**5**
White Perch	1	1		1				1			1		**5**
Winter Flounder						1	1						**2**

Species presence by site for September 2020 beach seines.

APPENDIX

SEPTEMBER	Site												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
4-Spine Stickleback					1								**1**
American Eel					1								**1**
Atlantic Croaker					1								**1**
Atlantic Menhaden		1	1	1	1			1	1				**6**
Atlantic Needlefish						1		1		1			**3**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Black Sea Bass					1					1			**2**
Bluefish	1				1			1	1	1		1	**6**
Common Mummichog		1		1	1	1	1	1	1	1	1		**9**
Common Shiner	1												**1**
Crevalle Jack			1										**1**
Cunner					1								**1**
Gizzard Shad		1	1	1									**3**
Hogchoker	1												**1**
Largemouth Bass	1												**1**
Naked Goby					1								**1**
Northern Kingfish							1		1	1	1	1	**5**
Northern Pipefish						1							**1**
Northern Puffer											1		**1**
Oyster Toadfish					1								**1**
Rainwater Killifish	1	1		1				1					**4**
River Herring	1			1		1							**3**
Scup												1	**1**
Sea Herring					1	1							**2**
Searobins				1									**1**
Striped Killifish		1		1	1	1	1	1	1	1	1	1	**10**
Summer Flounder	1												**1**
Tautog					1	1			1	1	1		**5**
Weakfish		1			1								**2**
White Mullet					1			1					**2**
White Perch	1			1		1							**3**
Winter Flounder					1								**1**

APPENDIX

Species presence by site for October 2020 beach seines.

OCTOBER	**Site**												
Species	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Total**
Atlantic Menhaden	1	1	1		1	1	1		1				**7**
Atlantic Silverside	1	1	1	1		1	1	1	1	1	1	1	**11**
Bluegill	1												**1**
Common Mummichog	1		1	1				1		1			**5**
Gizzard Shad	1	1					1						**3**
Largemouth Bass	1	1											**2**
Rainwater Killifish	1	1	1			1		1					**5**
River Herring		1	1	1		1	1		1				**6**
Sea Herring							1						**1**
Sheepshead Minnow				1				1		1		1	**4**
Striped Bass	1												**1**
Striped Killifish	1	1	1	1		1	1	1	1	1	1	1	**11**
Tautog					1	1							**2**
Weakfish		1											**1**
White Perch		1											**1**

APPENDIX

Abundances of summer flounder in 2020 beach seines.

Month	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Mean	SD	SE
MAY	1	0	8	0	0	0	0	0	0	0	0	0	0.75	2.30	0.66
JUN	0	0	4	3	1	0	0	2	0	0	0	0	0.83	1.40	0.41
JUL	0	1	2	0	0	0	0	0	0	0	0	0	0.25	0.62	0.18
AUG	1	0	0	0	0	0	0	0	0	0	0	0	0.08	0.29	0.08
SEP	1	0	0	0	0	0	0	0	0	0	0	0	0.08	0.29	0.08
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	0.50	0.17	2.33	0.50	0.17	0.00	0.00	0.33	0.00	0.00	0.00	0.00			
SD	0.50	0.37	2.92	1.12	0.37	0.00	0.00	0.75	0.00	0.00	0.00	0.00		Total Fish	
SE	0.20	0.15	1.19	0.46	0.15	0.00	0.00	0.30	0.00	0.00	0.00	0.00		24	
Total	3	1	14	3	1	0	0	2	0	0	0	0			

APPENDIX

Abundances of winter flounder in 2020 beach seines.

Month	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	Mean	SD	SE
MAY	1	0	4	0	2	1	0	0	1	3	0	0	1.00	1.35	0.39
JUN	13	3	13	19	26	39	8	2	3	4	5	4	11.58	11.40	3.29
JUL	8	8	14	0	11	18	0	3	0	20	0	1	6.92	7.42	2.14
AUG	0	0	0	0	0	5	1	0	0	0	0	0	0.50	1.45	0.42
SEP	0	0	0	0	2	0	0	0	0	0	0	0	0.17	0.58	0.17
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	3.67	1.83	5.17	3.17	6.83	10.50	1.50	0.83	0.67	4.50	0.83	0.83			
SD	5.06	2.97	6.07	7.08	9.35	14.20	2.93	1.21	1.11	7.11	1.86	1.46		Total Fish	
SE	2.06	1.21	2.48	2.89	3.82	5.80	1.20	0.50	0.45	2.90	0.76	0.60		242	
Total	22	11	31	19	41	63	9	5	4	27	5	5			

APPENDIX

Abundances of black sea bass 2020 beach seines.

	Site														
Month	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Mean**	**SD**	**SE**
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
SEP	0	0	0	0	1	0	0	0	0	1	0	0	0.17	0.39	0.11
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.17	0.00	0.00			
SD	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.37	0.00	0.00		Total Fish	
SE	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.00		2	
Total	0	0	0	0	1	0	0	0	0	1	0	0			

APPENDIX

Abundances of scup in 2020 beach seines.

	Site														
Month	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Mean**	**SD**	**SE**
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
JUL	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
AUG	0	0	0	0	0	0	3	0	1	0	0	0	0.33	0.89	0.26
SEP	0	0	0	0	0	0	0	0	0	0	0	2	0.17	0.58	0.17
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.17	0.00	0.00	0.33			
SD	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.37	0.00	0.00	0.75		Total Fish	
SE	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.15	0.00	0.00	0.30		6	
Total	0	0	0	0	0	0	3	0	1	0	0	2			

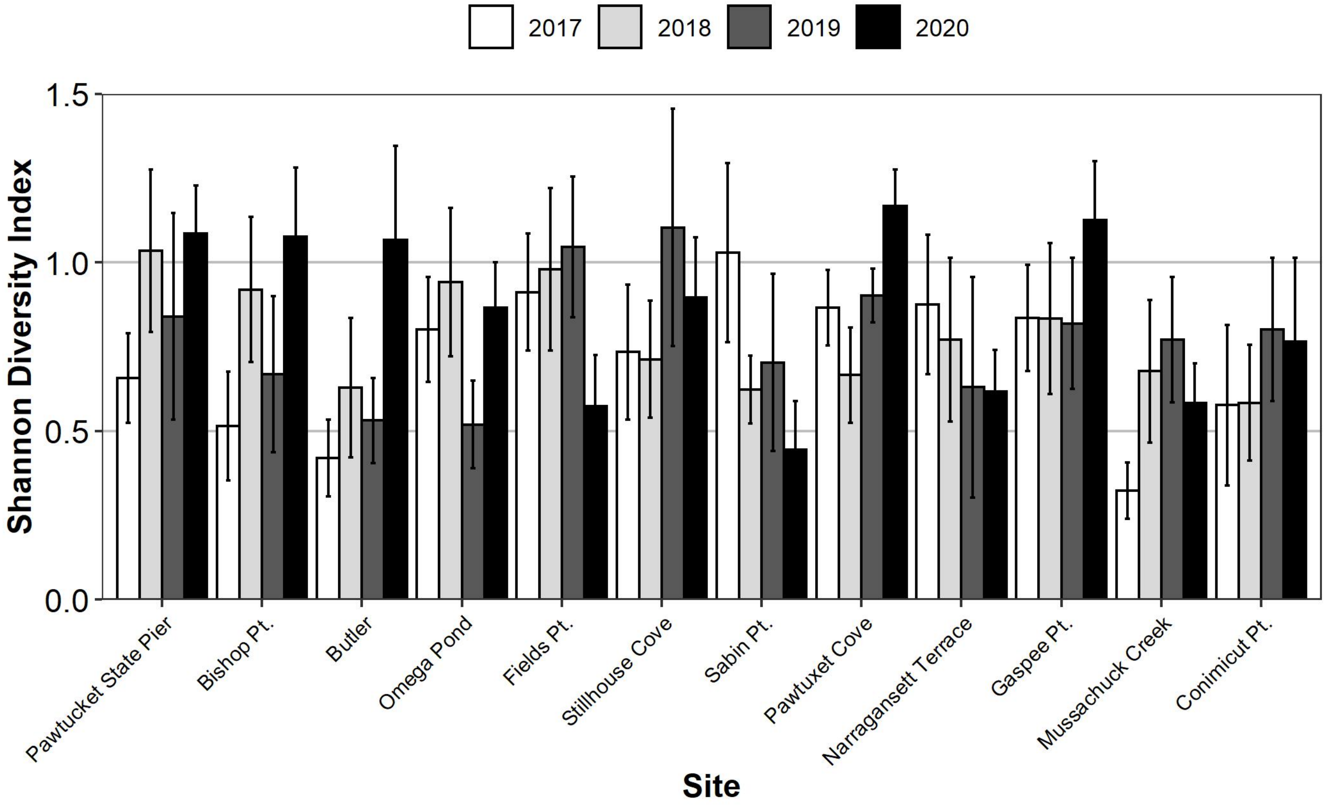
APPENDIX

Abundances of tautog in 2020 beach seines.

	Site														
Month	Pawtucket State Pier	Bishop Pt.	Butler	Omega Pond	Fields Pt.	Stillhouse Cove	Sabin Pt.	Pawtuxet Cove	Narragansett Terrace	Gaspee Pt.	Mussachuck Creek	Conimicut Pt.	**Mean**	**SD**	**SE**
MAY	0	0	0	0	0	10	0	0	2	0	0	9	1.75	3.67	1.06
JUN	0	0	0	0	4	2	0	0	0	0	9	0	1.25	2.73	0.79
JUL	0	0	0	0	5	15	0	0	0	26	4	8	4.83	8.12	2.34
AUG	0	0	0	0	5	1	0	0	11	0	3	0	1.67	3.34	0.96
SEP	0	0	0	0	29	4	0	0	8	1	15	0	4.75	8.93	2.58
OCT	0	0	0	0	1	1	0	0	0	0	0	0	0.17	0.39	0.11
Mean	0.00	0.00	0.00	0.00	7.33	5.50	0.00	0.00	3.50	4.50	5.17	2.83			
SD	0.00	0.00	0.00	0.00	9.88	5.25	0.00	0.00	4.39	9.62	5.34	4.02		Total Fish	
SE	0.00	0.00	0.00	0.00	4.03	2.14	0.00	0.00	1.79	3.93	2.18	1.64		173	
Total	0	0	0	0	44	33	0	0	21	27	31	17			

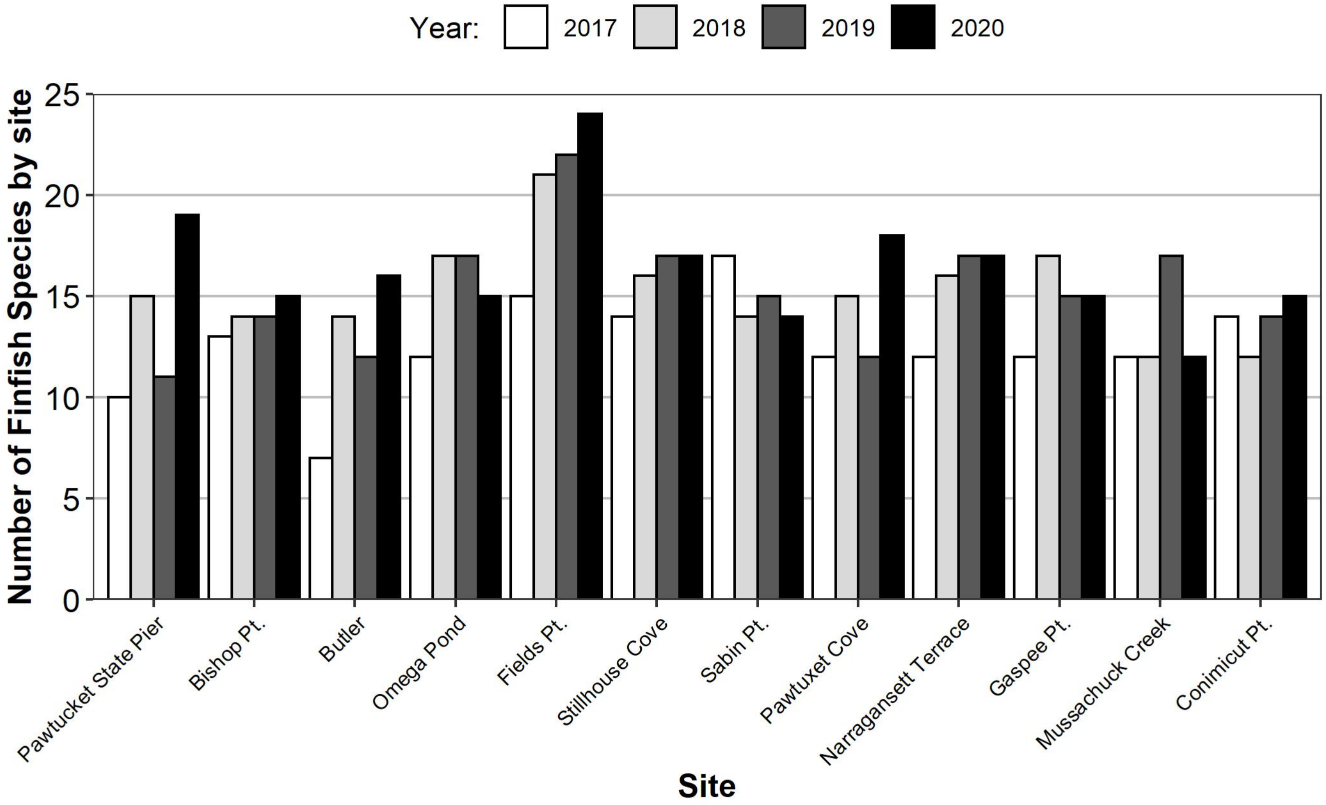
APPENDIX

Mean Shannon diversity across sites in 2017-2020 beach seines.



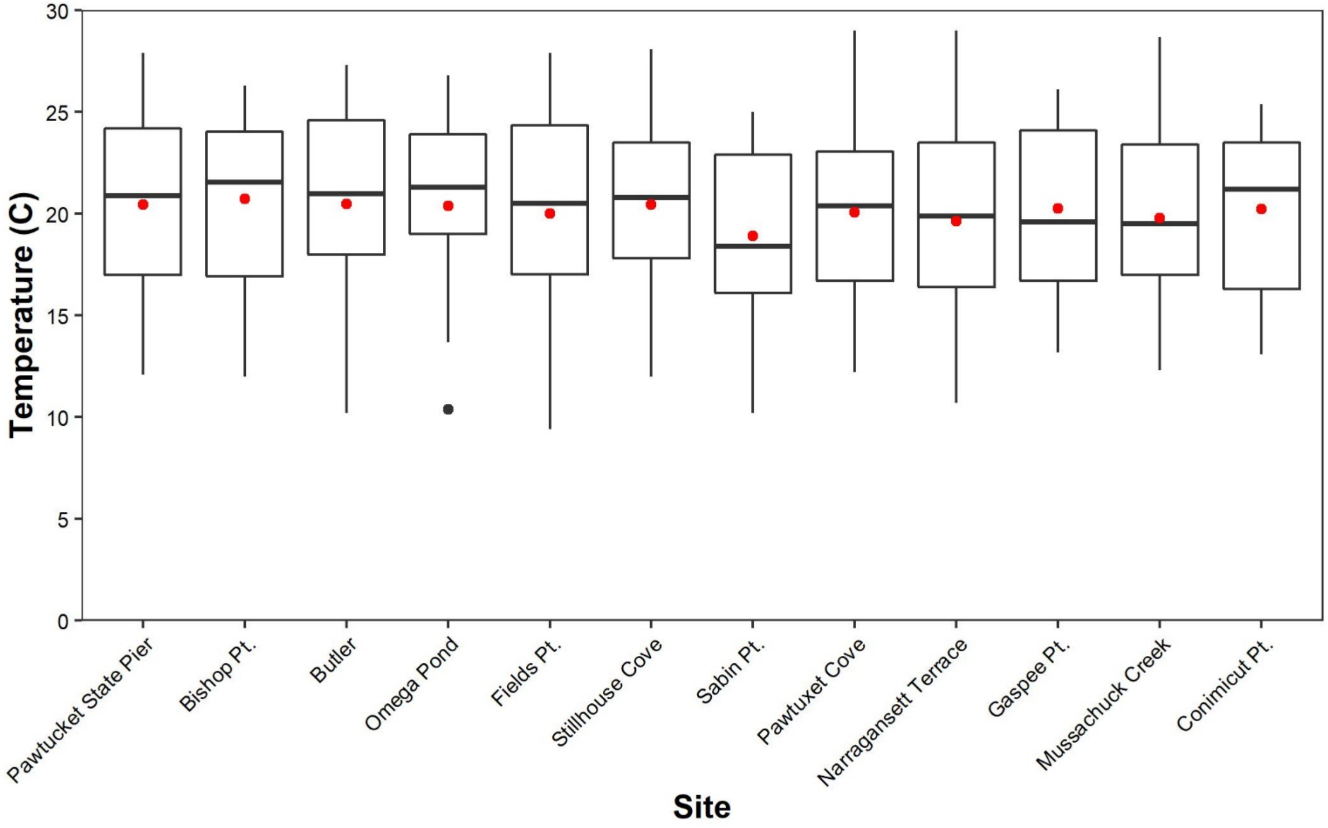
APPENDIX

Cumulative number of finfish species by site in 2017-2020 beach seines.



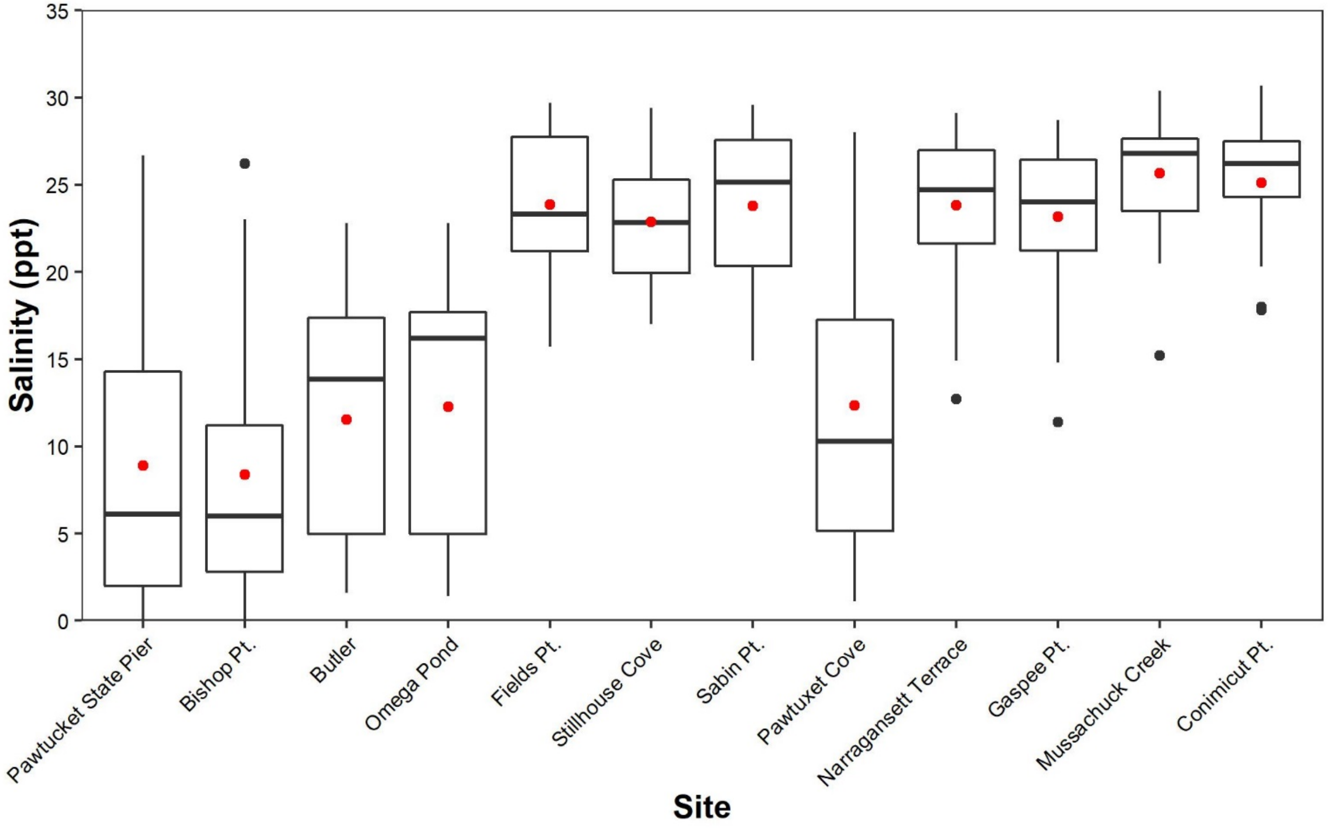
APPENDIX

Boxplot of temperature (C) recorded by handheld YSI across all seine stations in 2020 at the time of sample.



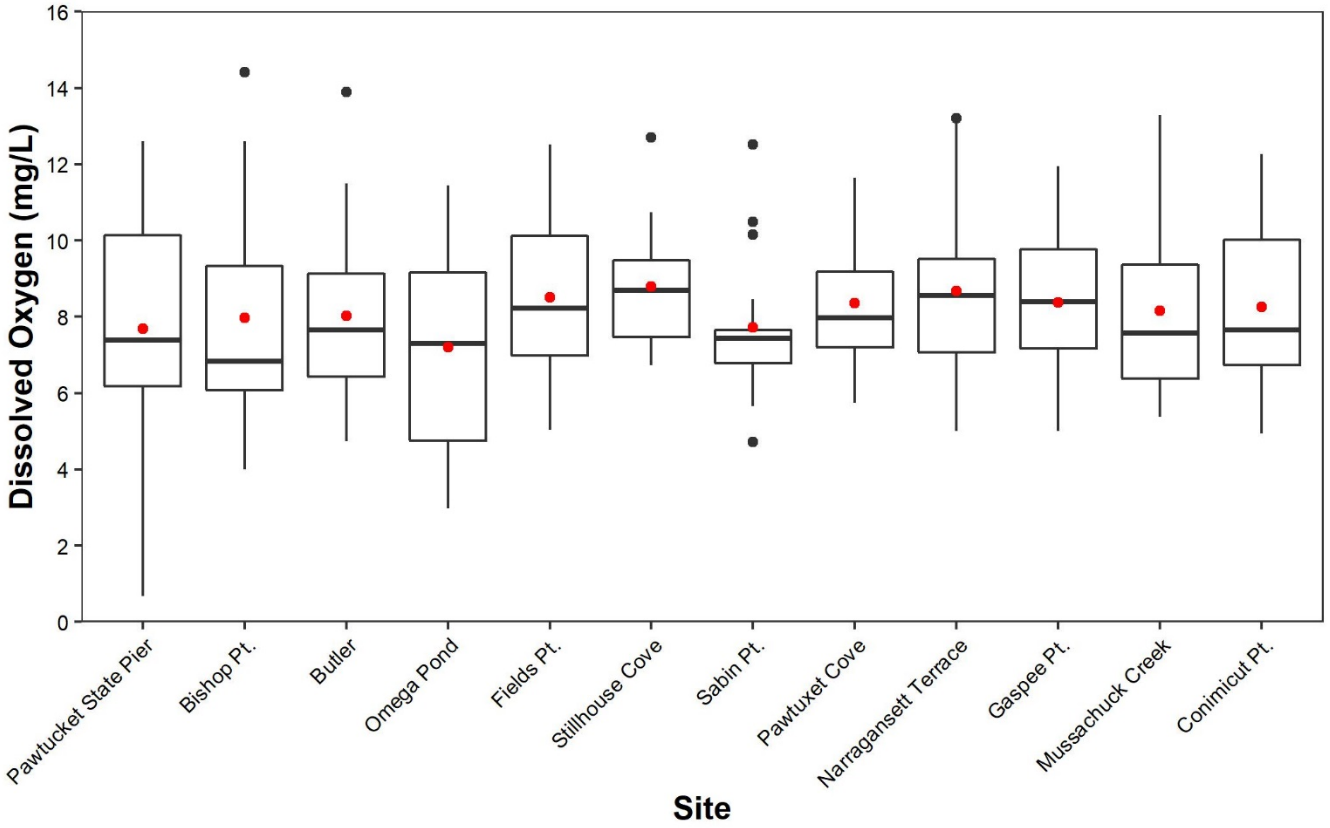
APPENDIX

Boxplot of salinity (ppt) recorded by handheld YSI across all seine stations in 2020 at the time of sample.



APPENDIX

Boxplot of dissolved oxygen (mg/L) recorded by handheld YSI across all seine stations in 2020 at the time of sample.



Sportfish Assessment and Management in Rhode Island Waters

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PERIOD COVERED: January 1, 2020 – December 31, 2021

JOB NUMBER 8 TITLE: Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters

During this period, several stock assessments for recreationally significant finfish species were conducted that RI staff participated, such as bluefish, menhaden, black sea bass, and scup. A management strategy evaluation for recreational summer flounder was also conducted. RI also contributed local small-scale stock assessments to help inform local management decisions, and these often rely on survey information that is derived from surveys funded by the sportfish restoration grant. Scientific advice to fisheries managers emerged from these assessments, particularly during the deliberations of the state's licensing provisions, which had impacts to recreational fisheries, as well as in the process for setting the recreational management plans. The project leaders participated at the Atlantic States Marine Fisheries Commission's (ASMFC) meetings relative to the management of recreationally important coastal stocks. They also participated in the National Oceanographic and Atmospheric Administration (NOAA) stock assessment meetings for species under their jurisdiction, including the peer review for striped bass, Atlantic mackerel, and summer flounder referred to as the SAW/SARC review process. Other project staff participated at fish stock assessment trainings conducted through the ASMFC and NOAA. The status of the most important recreationally caught species in Rhode Island were presented in the finfish sector management plan annually. The following information by species highlights some of the major contributions during this time period.

1. SUMMER FLOUNDER

A full benchmark assessment was performed and was peer reviewed at the SAW/SARC 66 meeting (https://www.nefsc.noaa.gov/publications/crd/crd1901/). This assessment passed peer review and is being used for management in 2019. This assessment process included multiple modeling frameworks such as sex specific and state-space models. The main tasks performed by staff were to gather both catch and fishery independent information from previous years and stratify that information by age based on aging information from the NOAA trawl survey. RI contributes its Division of Marine Fisheries trawl survey data (see job number 2 from this grant) and the University of Rhode Island Trawl Survey information (see job number 14 from this grant) to the assessment. Staff were active members of the benchmark stock assessment working group and participated in meetings where the assessment information was released. Additionally, the RI participant on this working group developed unique ways for combining survey indices, and ran multiple alternative assessment runs with this combined survey information.

The 2018 benchmark summer flounder stock assessment used recreational catch estimates from 1982 – 2017 as a source of removals in a combined sex statistical catch-at-age (SCA) model, like the previously approved assessment structure. Catch estimates included both direct harvest and live releases, but only a portion of the live releases are considered removals (dead). One big change from previous assessments for summer flounder was the use of the newly calibrated Marine Recreational Information Program (MRIP) data. The assessment compared uncalibrated and calibrated harvest and dead release estimates. These comparisons indicated that calibrated MRIP estimates were significantly higher than non-calibrated MRIP estimates. Calibrated harvest estimates increased total harvest by an average of 29% over the time period analyzed. The differences generally scaled the biomass of the population up, but the trends through time were similar to the old estimates.

The impact of the newly calibrated data on the summer flounder assessment was that it increased the population size to support the additional removals. For the case of summer flounder, stock status (relative to current reference points) and model diagnostics improved with the new data. Things generally improved with the new assessment, but the challenge will be how to contend with the resource allocation between the recreational and commercial fisheries. As a case in point, the commercial quota will increase significantly in 2019, but recreational regulations will stay close to what they are now due to the fact that the recreational harvest was higher than earlier projections anticipated due to the calibration, while the commercial fishery was constrained to the quota. Deciding how to handle this effect of the recalibration will likely keep fishery managers busy over the coming couple of years.

Beginning in 2018, a Management Strategy Evaluation (MSE) framework to test the performance of the current and potential alternative F-based management approaches for the recreational summer flounder fishery was developed. The intent with this project is to show the relative value of both current and potential management actions for satisfying management objectives. F-based management alternatives were constructed in the context of application to the existing specification setting process for summer flounder. An age-structured operating model of summer flounder population and fishery dynamics was constructed that explicitly included implementation uncertainty associated with application of management measures in the recreational fishery. Available data on the responses of recreational fishers to summer flounder management measures was synthesized to construct a set of plausible alternatives for these fleet dynamics and their associated uncertainty. Additionally, historical effects of various management measures on harvest and catch at various levels of refinement (e.g. state, wave, mode) based on MRIP data were used to quantify the most appropriate levels of effect and uncertainty to associate with the management choices made in the MSE analysis. The management approaches tested within the MSE seek to replicate the steps associated with data collection, interpretation, and decisions about whether and how to adjust recreational fishing measures. The simulations considered several broad sets of alternative management approaches including: 1) Status quo, where recreational harvest limits are compared to estimates of current recreational harvest based on the MRIP statistical sampling program, with adjustment measures to include: season length, minimum size, bag limits, and combinations thereof; 2) Risk-based status quo, where a percentile of the estimated uncertainty is used rather than point estimates of recreational harvest; 3) F-based management, where the stock assessment estimate of the current fishing mortality is compared to the target F, with one or more of the management measures described above being adjusted accordingly. Alternatives within this approach included incremental adjustments to encourage stability in advice and overfishing threshold projections based on expected probabilities of overfishing given different management measures; 4) Risk-based F-based management where similar approaches as for 3. are applied but percentiles of uncertainty estimates were used to determine appropriate adjustments instead of point estimates. The performance of the various management options was evaluated by comparing the projections of recreational harvest to prescribed limits (for options that retain RHLs), as well as projected stock biomass and fishing mortality rates relative to reference points and risk tolerances. The relative performance of these measures were presented to the ASMFC and the Mid Atlantic Fishery Management Council, and a RI staff member was one of the principal investigators on this project.

2. STRIPED BASS

A full benchmark assessment was performed and was peer reviewed at the SAW/SARC 66 meeting (https://www.nefsc.noaa.gov/publications/crd/crd1901/). This assessment passed peer review and will likely be used for the management process that will unfold in 2019. This assessment process included multiple modeling frameworks such as area specific modeling approaches. The main tasks performed by staff were to gather both catch and fishery independent information from previous years. RI contributed its survey information to the assessment, however none of those surveys were incorporated in to the final assessment. Staff were active members of the benchmark stock assessment working group and participated in meetings where the assessment information was released.

The 2018 benchmark striped bass stock assessment used recreational catch estimates from 1982 – 2017 as a source of removals in a statistical catch-at-age (SCA) model. Catch estimates included both direct harvest and live releases. Newly calibrated recreational data were used as noted in the summer flounder section. Calibrated harvest estimates were on average 140% higher while calibrated live releases were on average 160% higher. Despite these differences in removals, both the calibrated and non-calibrated estimates showed similar trends in spawning stock biomass (SSB) over time.

The impact of these data on the assessment findings was significant. In order for the striped bass population to be able to support the larger recreational removals indicated by the newly calibrated MRIP estimates, the model estimated that there was a higher level of SSB than previously indicated. Although the 2018 SCA model shows a similar declining trend in female SSB to that of the 2013 SCA model (the last benchmark assessment for striped bass), the decline since 2012 became much sharper. The striped bass population is defined as overfished when the female SSB is below the estimate of female SSB in 1995, the year the striped bass population was declared restored. Female SSB in 2017 was estimated at 68,476 mt, a value below the SSB threshold of 91,436 mt, indicating the striped bass stock is overfished.

The fishing mortality rate (F) that will maintain the striped stock at the SSB threshold is the defined as the F threshold. In the 2018 SCA model the F threshold was estimated to be 0.240 and F in 2017 was estimated to be 0.307, indicating the stock is experiencing overfishing.

While the newly calibrated MRIP estimates were thought to be a major factor contributing to the finding that the striped bass stock is overfished and overfishing is occurring, other contributing factors included the reduced bag limits from previous management actions and sizeable year classes that have not yet fully recruited to the fishery that are increasing discards in the Chesapeake Bay and along the coast.

3. ATLANTIC MENHADEN AND MULTISPECIES MODELS

The ASMFC began a benchmark assessment in 2018 for the coastwide stock for Atlantic menhaden and was completed by the working group in late 2019 for review in early 2020. The Atlantic menhaden stock is assessed with a statistical catch at age model called BAM (Beaufort Assessment Model). The main tasks were to gather both catch and fishery independent information from previous years and stratify that information by age based on aging information from the NOAA menhaden sampling program, which RI contributed locally caught samples to. RI contributes its Division of Marine Fisheries seine survey data (see job number 4 from this grant) and its trawl survey data (jobs 1 and 2 from this report) to the assessment. Staff collects the information and processes it for the assessment. Staff also participate in meetings where the assessment information is reviewed and are active members of the stock assessment sub-committee.

In addition to the single-species menhaden assessment, a series of multispecies models were produced for the same peer review as the menhaden single-species assessment. These models included an Ecopath with Ecosim model, a Steele-Henderson multispecies surplus production model, a Bayesian time-varying surplus production model, and RI staff have created a multispecies statistical catch-at-age model (MSSCAA). The MSSCAA model features menhaden, striped bass, bluefish, weakfish, and scup as the modeled species, all recreationally important species. The goal for these models was to incorporate more ecosystem and trophic interaction information in to the assessment process, and to create ecological reference points. The tasks associated with the preparation of these multispecies assessments are similar to that of the single-species assessments as mentioned in the other sections of this report. These models were also reviewed in late fall 2019, with RI staff presenting the MSSCAA model as the lead assessment scientist.

3. BLACK SEA BASS

NOAA began an update assessment in 2019 for the black sea bass stock. The black sea bass stock had been assessed with a spatial statistical stock assessment model. This spatial benchmark assessment was approved in 2016 and will be used for the update assessment in 2019. This is another species that will incorporate the newly recalibrated

MRIP data for the recreational harvest component. The main tasks are to gather both catch and fishery independent information from previous years and stratify that information by age based on aging information that is collected in each state and by NOAA. RI contributes its Division of Marine Fisheries trawl survey data (see jobs 1 and 2 from this document) and hopes to contribute the new ventless pot survey information in the future to the assessment. Staff collects the information and processes it for the assessment. Staff will also participate in meetings where the assessment information will be reviewed and will also be active members of the stock assessment sub-committee, with responsibilities for developing management analyses after the assessment is complete.

5. SCUP

NOAA began an update assessment in 2019 for the scup stock. The scup stock had been assessed with a statistical catch-at-age assessment model. This benchmark assessment was approved in 2015 and was used for the update assessment in 2019. This species' assessment also incorporated the newly recalibrated MRIP data for the recreational harvest component. The main tasks were to gather both catch and fishery-independent information from previous years and stratify that information by age based on aging information that is collected by NOAA. RI contributes its Division of Marine Fisheries trawl survey data (see jobs 1 and 2 from this document) and the University of Rhode Island Trawl Survey information (see job number 14 from this grant) and hopes to contribute the new ventless pot survey info in the future to the assessment. Staff collects the information and processes it for the assessment. Staff participated in several meetings where the assessment information was reviewed and were active members of the stock assessment sub-committee, with additional responsibilities for developing management analyses after the assessment was completed.

6. BLUEFISH

NOAA began an update assessment in 2019 for the bluefish stock. The bluefish stock had been assessed with a statistical catch-at-age assessment model. The benchmark assessment was approved in 2015 and was used for the update assessment in 2019. This is another species that incorporated the newly recalibrated MRIP data for the recreational harvest component. Importantly, recreational harvest represents the vast majority of the harvest in this fishery, much higher than the commercial component. The main tasks were to gather both catch and fishery-independent information from previous years and stratify that information by age based on aging information that is collected by NOAA. RI contributes its Division of Marine Fisheries trawl survey data (see jobs 1 and 2 from this document), the University of Rhode Island Trawl Survey information (see job number 14 from this grant), and seine survey data (see job number 4 from this grant). Staff collects the information and processes it for the assessment. Staff participated in several meetings where the assessment information was reviewed and were active members of the stock assessment sub-committee, and were responsible for developing management analyses following the assessment.

7. ATLANTIC MACKEREL

Atlantic mackerel is a significant recreationally caught species and forage fish for Rhode Island. RIDEM staff participated in the 2017 NOAA NEFSC benchmark stock assessment for Atlantic mackerel. Multiple working papers were prepared to address several of the assessment's Terms of Reference. Work contributed included (1) understanding larval habitat suitability changes due to changes in temperature and zooplankton abundances, (2) constructing a larval abundance index as an additional fisheries-independent index for the assessment model, (3) further characterization of environmental drivers on the northern and southern contingents of the stock, and (4) conducting a stochastic stock reduction analysis for provide historical reference on the population size currently as it relates to at the inception of the fishery (1803). These working paper materials can be found in the 2017 benchmark stock assessment's repository. The assessment passed peer-review and was used to inform fisheries management.

8. TAUTOG

The ASMFC began a benchmark assessment in 2013 for the tautog stock. The tautog stock had been assessed with a Virtual Population Analysis, but for the benchmark several other data rich and data poor models were tested. This was a full benchmark assessment, therefore is more time consuming than an update. In addition, the stock assessment has progressed from a coastwide assessment to a regional set of assessments. RI is in a region with Massachusetts. This benchmark assessment was approved in 2015, and was updated in 2016, with finalization occurring in 2017. The main tasks were to gather both catch and fishery independent information from the previous years for and stratify that information by age based on aging information that was collected in each state, and which RI contributed locally caught samples to. Staff were involved in each of the aforementioned assessments. RI contributed its Division of Fish and Wildlife seine survey data (see job number 4 from this grant), trawl survey data (see jobs 1 and 2 from this document), and hopes to contribute the new ventless pot survey info in the future to the assessment. Staff collected the information and processed it for the assessment. Staff also participated in several meetings where the assessment information was reviewed and were active members of the stock assessment sub-committee. In 2019, effort began for an updated assessment to be completed in 2020.

9. WINTER FLOUNDER

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

Committee that reviewed all the update stock assessment information including data and research on winter flounder. Additional work was requested in 2019 for the review of the ASMFC Fisheries Management Plan, which required updated life history information and data sources.

10. WEAKFISH

Weakfish has not had an approved assessment for many years and management had long 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 participated 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. An update assessment was conducted in 2019, of which similar to previous years, staff provided data and analytical assistance to the assessment.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

Age and Growth Study

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March 2021

PERFORMANCE REPORT

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

SEGMENT NUMBER: 22

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

PERIOD COVERED: January 1, 2020 – December 31, 2020

JOB NUMBER AND TITLE: 9, Age and Growth Study

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

SUMMARY: Investigators collected lengths, weights, and age structures from target species of recreationally important finfish. The type of age structure collected, and the number of samples collected varied by species. Investigators were able to collect, or exceed, the target sample numbers for the majority of species in 2020, however in some cases fell short on target sample numbers due to availability of fish and impacts from the covid-19 pandemic. Ageing structures were also collected for spiny dogfish and winter flounder although they are not target species for ageing. Investigators had difficulty in obtaining samples for certain species, particularly weakfish and menhaden, due to the dynamics of the fisheries and the availability of fish. Work to age the primary ageing structures collected in all years is complete.

In addition to the collection of age and growth data, investigators continued the collection of stomach content, sex, and maturity stage data from target species. This data was collected through collaboration with investigators on the RIDMF Monthly and Seasonal trawl surveys (Jobs 1 and 2), RIDMF Narragansett Bay Juvenile Finfish Beach Seine survey (Job 4), RIDMF Fyke Net survey (Job 10), commercial gillnetters, and fish donated by recreational hook and line fishers.

TARGET DATE: December 31, 2020

STATUS OF PROJECT: On schedule

SIGNIFICANT DEVIATIONS: No significant deviations occurred.

RECOMMENDATIONS: Move into the next project segment and continue data collection in 2021.

REMARKS: N/A

INTRODUCTION

Age and growth information is essential in estimating the age-structure of a fish population. Understanding the age-structure of a population allows scientists to make informed management decisions regarding acceptable harvest levels for a species. In recent years, diet composition of finfish has become increasingly important in understanding the age and growth of a population. Diet composition of a species may help to inform managers on whether an observed change in a population may be due to prey availability. Understanding predator-prey dynamics can also allow managers to utilize a multi-species modeling approaches 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. Most recently, ASMFC adopted an ecosystem-based management approach for assessing Atlantic menhaden. The data collected in this study will help contribute to the aforementioned efforts.

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

Collection of stomach content, sex, and maturity stage data for the species listed above was initiated in 2014. This task also included collection of both scale and otolith samples for ageing from most species, except for weakfish and bluefish for which only otolith samples were taken. For tautog, opercula, otoliths, and the first pectoral fin spine were collected (no scales).

METHODS, RESULTS & DISCUSSION

Seasonal port sampling of nine species of finfish considered to be extremely important to the recreational fishing community was conducted primarily from May through December of 2020. Data collected included lengths, weights and the appropriate age structure for the specific species (i.e. scale, otolith, operculum, pelvic spine). The number of samples and age structures collected varied depending on the species (Table 1). Investigators focused on obtaining samples from various locations throughout the state including various finfish dealers, recreational anglers, commercial gillnetters, and Rhode Island Division of Marine Fisheries (RIDMF) surveys (otter trawl, beach seine, fyke net) (Table 3).

Diet composition data was collected for high priority species by excising fish stomachs from fish collected during the RIDMF seasonal and monthly bottom trawl surveys, from fish racks and whole fish collected during port sampling, or fish racks and whole fish which were donated. For each species, the target number of stomachs to be examined is 40 (Table 4). Additional data collected from these samples included length, weight (if whole fish available), sex, maturity, and age structures. Once stomachs were removed, they were analyzed in the laboratory by sorting and identifying prey to the lowest taxonomic level possible and recording the wet mass for each taxon. All collected data were entered and stored in a Microsoft Access database.

Black sea bass

In 2020, a total of 578 black sea bass age samples were collected from multiple sources including commercial crab pots, and the RIDMF otter trawl (Table 2). In 2017, RIDMF began collaborating with the Commercial Fisheries Research Foundation (CFRF) on a project that would allow RIDMF to collect our required samples and provide additional data for stock assessment purposes. This resulted in our target number of samples (100) being exceeded during 2020.

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. Both scales and otoliths were collected from all black sea bass sampled in 2020. Black sea bass samples collected ranged in size from 10.6-18.3 inches (27-46.5 cm) total length. Age samples have been sent to the Virginia Institute of Marine Science (VIMS) and Massachusetts Division of Marine Fisheries (MADMF) for processing and ageing. This was primarily due to the fact that VIMS and MADMF will be collecting additional information as part of other ongoing research projects.

Stomach content and maturity stage data was collected from 209 black sea bass; stomach contents included prey items from 5 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Black sea bass stomach contents were dominated by crustaceans (15%) and finfish (11%); negligible amounts aquatic plants, bivalve molluscs, and cephalopod molluscs accounted for 0.11%; “unidentifiable” contents accounted for 74%. Removal of “unidentifiable” contents from the analysis resulted in crustaceans accounting for 57%, and finfish for 42%, with negligible contributions from aquatic plants, bivalve molluscs, and cephalopod molluscs (0.7% combined) (Figure 9, Table 5).

Bluefish

The ASMFC requires that a minimum of 100 bluefish age samples be collected annually by the state of Rhode Island. Due to the assistance of commercial gillnetters, recreational hook and line fishers, and the RIDMF otter trawl (Table 2), staff successfully collected 157 bluefish otolith samples in 2020. Bluefish samples ranged in fork length from 15.0-33.6 inches (38.0-85.3 cm) and 2-8 years old (Figure 1).

Stomach content and maturity stage data was collected from 59 bluefish; stomach contents included prey items from 2 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Of the bluefish stomachs examined in 2020, identifiable stomach contents encountered were finfish (50%) and cephalopod molluscs (2%); “unidentifiable” contents accounted for 48%. Removal of “unidentifiable” contents from the analysis resulted in finfish accounting for 95% and cephalopod molluscs for 5% of stomach contents (Figure 9, Table 5).

Menhaden

A total of 98 Atlantic menhaden age samples were collected in 2020 from the RIDMF otter trawl survey (Table 2). Samples can only be collected from commercial purse seine operations when the Narragansett Bay menhaden management area is open to commercial fishing. In 2020, the menhaden management area remained closed for the entire year and therefore no samples were collected from the purse seine fishery. Menhaden samples ranged in fork length from 5.5-12.4 inches (14-31.5 cm). Age samples will be sent to the NOAA Fisheries Beaufort Laboratory for processing and ageing.

Maturity stage data was collected from 98 fish. 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 during 2020. Generally, menhaden stomach contents should reflect the dominant planktonic species present at the time of sample collection.

Scup

In 2020, scup age samples were collected only from the RIDMF otter trawl survey (Table 2). Investigators successfully collected scales and otoliths from 107 scup. Scup samples ranged in fork length from 6.0-15.3 inches (15.3-38.9 cm) and age from 1-17 years old (Figure 2).

Stomach content and maturity stage data was collected from 44; stomach contents included prey items from 8 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (32%), crustaceans (14%), cephalopod molluscs (14%), bivalve molluscs (8%), and polychaetes (6%), with a small quantity of algae (2%) and negligible amounts of gastropod molluscs (0.16%) and echinoderms (0.11%); “unidentifiable” contents accounted for 24%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being dominated by finfish (42%), crustaceans (19%), cephalopod molluscs (18%), bivalve molluscs (10%), and polychaetes (8%), with a small quantity of algae (3%) and negligible amounts of gastropod molluscs (0.21%) and echinoderms (0.14%) (Figure 9, Table 5).

Spiny Dogfish

Spiny dogfish are not routinely sampled as they are not frequently encountered on the RIDMF otter trawl survey. No spiny dogfish were sampled in 2020.

Striped Bass

A total of 189 striped bass age samples were collected in 2020. Although otoliths remain the primary ageing structure, scales are frequently collected from commercial samples when staff are unable to collect otoliths due to the damage it would cause to the fish. Each year investigators set a sampling target of 150 samples from floating fish traps and 150 samples from the general category fishery. Floating fish traps have a minimum size of 26” while the commercial general category fishery has a minimum size of 34”. Sampling from both of these operations allows us to sample a wider size range of striped bass. In recent years there have been a very limited number of floating fish traps fishing in operation making obtaining striped bass samples from this fishery difficult. A total of 162 samples were obtained from the general category fishery and 0 samples from floating fish traps, for a total of 162 samples. Staff supplemented traditional sampling by collecting 27 striped bass age samples from the RIDMF Narragansett Bay Juvenile Finfish (Beach seine) survey (n=1), RIDMF otter trawl survey (n=25), RIDMF fyke net survey (n=1). These samples were generally below legal minimum size(s) but helped to expand the length frequency distribution sampled. Striped bass sampled ranged from 10.7-48.8 inches fork length (27.3-124 cm) and 3-20 years old (Figure 3).

Stomach content and maturity stage data was collected from 27 striped bass. Stomach contents included prey items from 7 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (60%) and crustaceans (18%), with small quantities of polychaetes (3%) and algae (2%) and negligible amounts of cnidaria, cephalopod molluscs, and sand/rocks (0.14% combined) also encountered; "unidentifiable" contents accounted for 16%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by finfish (72%) and crustaceans (22%), with small amounts of polychaetes (4%) and algae (2%) and negligible amounts of cnidaria, cephalopod molluscs, and sand/rocks (0.16% combined) (Figure 9, Table 5).

Summer Flounder

A total of 96 summer flounder scale and otolith samples were collected in 2020. The majority of these samples (n=74) were collected on board the RIDMF otter trawl survey with the remaining samples (n=22, racks only) donated from the commercial hook and line fishery. Summer flounder samples collected varied in size from 12.7-23.1 inches (32.3-58.6 cm) total length and 1-7 years old (Figure 4).

Stomach content and maturity stage data was collected from 55 summer flounder. Stomach contents included prey items from 4 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (47%), followed by crustaceans (13%) and cephalopod molluscs (11%), and a negligible amount of polychaetes (0.08%); "unidentifiable" contents accounted for nearly 29%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by finfish (66%), followed by crustaceans (19%), cephalopod molluscs (16%), and a negligible amount of polychaetes (0.11%) (Figure 9, Table 5).

Tautog

A total of 251 tautog age samples were collected in 2020. Although the primary ageing structure at this time remains the opercula, otoliths and pelvic spines have also been collected as secondary structures. Samples were primarily collected from the recreational hook and line fishery (n=186) with additional samples from the RIDMF Narragansett Bay Juvenile Finfish (Beach seine) survey (n=1) and RIDMF otter trawl survey (n=64). Tautog samples are typically collected in the fall months when the party and charter boat vessels are targeting them. The ability to obtain samples during this period of time can be quite variable due to weather conditions such as strong winds and high seas. Tautog samples collected ranged from 9.7-25.4 inches (24.6-64.5 cm) total length and 1-18 years old (Figure 5).

Stomach content and maturity stage data was collected from 45 tautog in 2020. Stomach contents included prey items from 13 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Identifiable tautog diet was primarily comprised of bivalve molluscs (39%), crustaceans (27%), and gastropod molluscs (10%), with a small quantity of maxillopods (1%) also observed; "unidentifiable" contents accounted for 22%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by bivalve molluscs (50%), crustaceans (34%), and gastropod molluscs (13%), with a minor contribution from maxillopods (1.5%) (Figure 9, Table 5).

In 2017 staff began to explore a new, non-lethal ageing technique for tautog. This new technique uses a cross-section of the first anal spine for age determination. Staff received training at a workshop held in April 2017 and are currently participating in ageing exchange with other agers along the Atlantic coast to determine the best structure to use for ageing tautog going forward.

Weakfish

Rhode Island is required by the ASMFC to collect three age structures and 6 lengths per metric ton of weakfish landed commercially in the state. In 2020, this would have resulted in a sampling target of 19 fish lengths and 10 ages. The weakfish stock assessment sub-committee and management board have requested that length samples come from the commercial fishery as these data are used in developing the commercial age-length keys. In recent years, weakfish have become scarce in RI, which has resulted in extreme difficulty in obtaining fishery-dependent samples. Investigators continue to attempt purchasing fish directly from seafood dealers at market value to ensure that they can obtain samples, however strong market demand and limited supply during 2020 prevented the availability of this species for sampling. In 2020, a total of 27 weakfish length and otolith samples were collected, with no fishery-dependent samples collected. Weakfish collected by the fishery-independent RIDMF otter trawl (n=27) consisted of 24 sub-legal sized fish and 3 legal-sized fish. Weakfish sampled ranged from 7.7-20.2 inches (19.6-51.2 cm) total length and were 1-3 years old (Figure 6).

Stomach content and maturity stage data was collected from 27 weakfish. Stomach contents included prey items from 4 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Of the weakfish stomachs examined in 2020, identifiable stomach contents were dominated by finfish (39%) and cephalopod molluscs (24%) with a minor contribution from crustaceans (3%) and a negligible amount of algae (0.06%); "unidentifiable" contents accounted for 33%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by finfish (59%) and cephalopod molluscs (36%), with a minor contribution from crustaceans (5%), and algae (0.08%) (Figure 9, Table 5).

Winter Flounder

A total of 40 winter flounder scale and otolith samples were collected in 2020. These samples were collected entirely by RIDMF staff on board the RIDMF otter trawl survey. Winter flounder samples collected varied in size from 9.4-16.9 inches (24.0-43.0cm) total length and 2-7 years old (Figure 7).

Stomach content and maturity stage data was collected from 40 winter flounder. Stomach contents included prey items from 8 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2020 is shown in Figure 8 and summarized in Table 4. Of the winter flounder stomachs examined in 2020, identifiable stomach contents were dominated by cnidarians (45%), crustaceans (14%), and polychaetes (12%) with a minor amount of gastropod molluscs (9%) and negligible contributions from echinoderms, bivalve molluscs, sipuncula, and urochordates (0.43% combined); "unidentifiable" contents accounted for 20%. Removal of "unidentifiable" contents from the analysis resulted in stomach contents being dominated by cnidarians (57%), crustaceans (17%), and polychaetes (15%) with a minor amount of gastropod molluscs (11%) and negligible contributions from echinoderms, bivalve molluscs, sipuncula, and urochordates (0.54% combined) (Figure 9, Table 5).

SUMMARY

In 2020 investigators were able to collect, or exceed, the target sample numbers for most species, while under-achieving target sample numbers for menhaden (97/100) and striped bass (189/300). Although our sample target for menhaden was not met, the ASMFC FMP sampling requirement of one 10-fish sample per 300 metric tons landed was satisfied. For striped bass, all commercial samples came from the general category fishery (n=162) and were supplemented with fishery-independent samples from RIDMF surveys (n=27). 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 2020. In 2021, 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. Additionally, staff had been working on the ASMFC ageing sub-committee to help draft a Gulf and Atlantic coasts ageing manual, which was completed in November 2020. Staff will continue to participate in ASMFC ageing workshops as they occur in 2021.

FIGURES

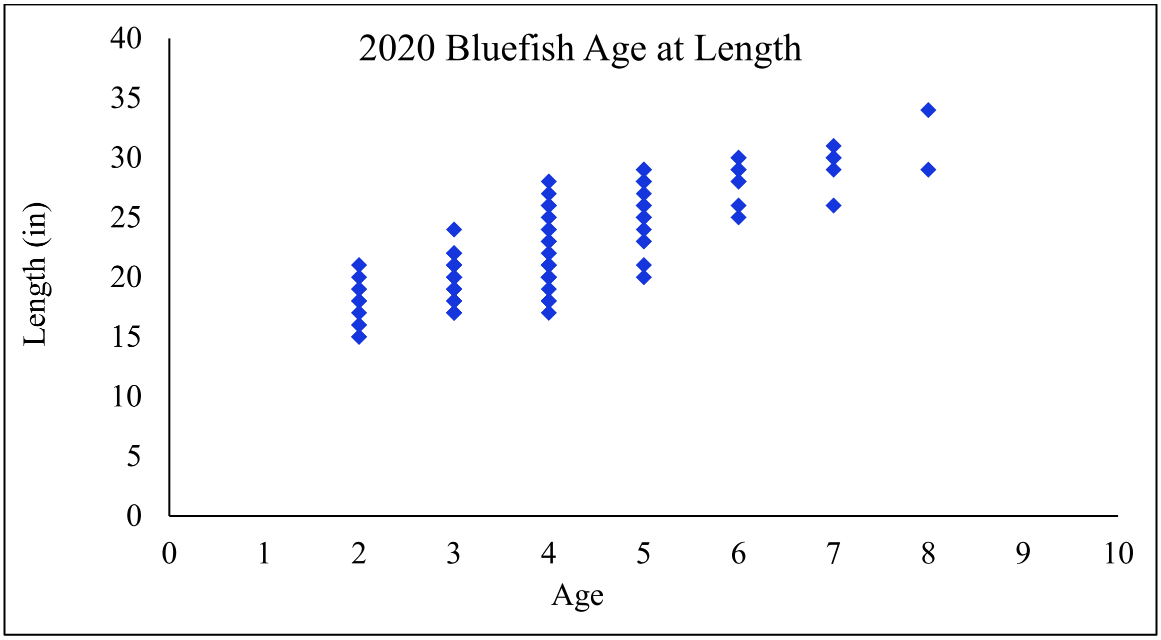


Figure 1. Bluefish age at length.

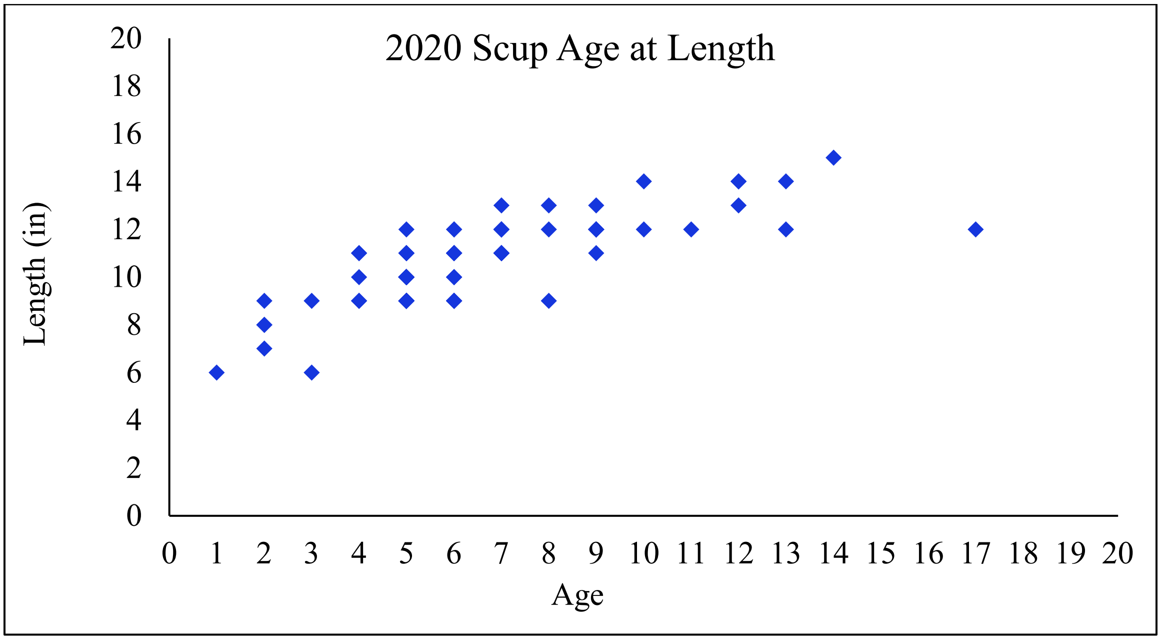


Figure 2. Scup age at length.

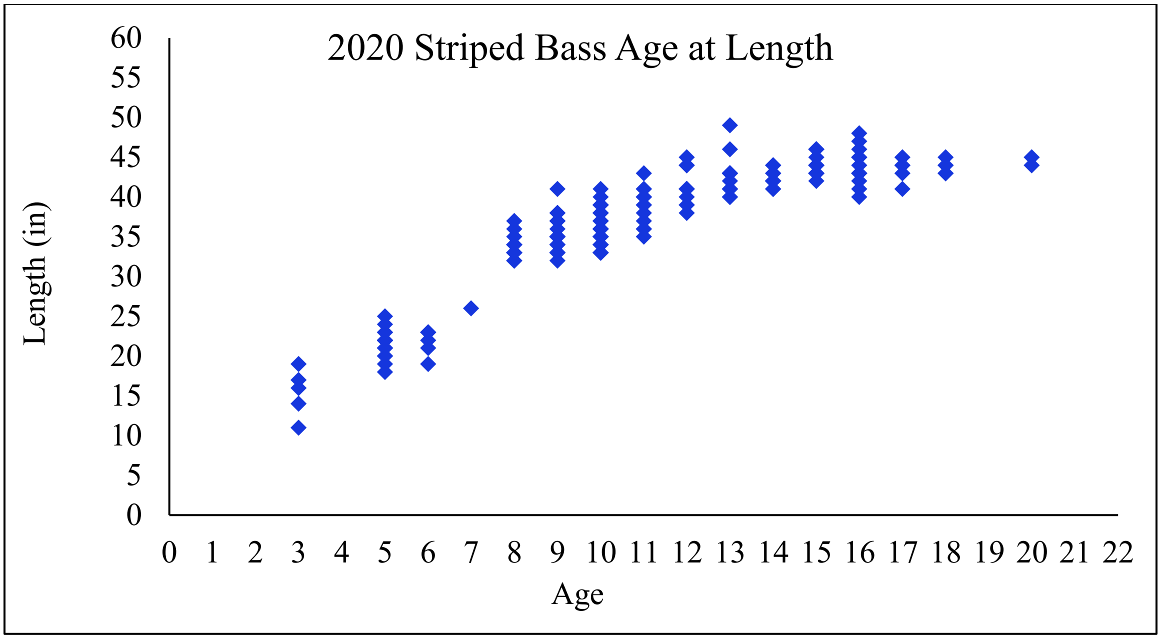


Figure 3. Striped bass age at length.

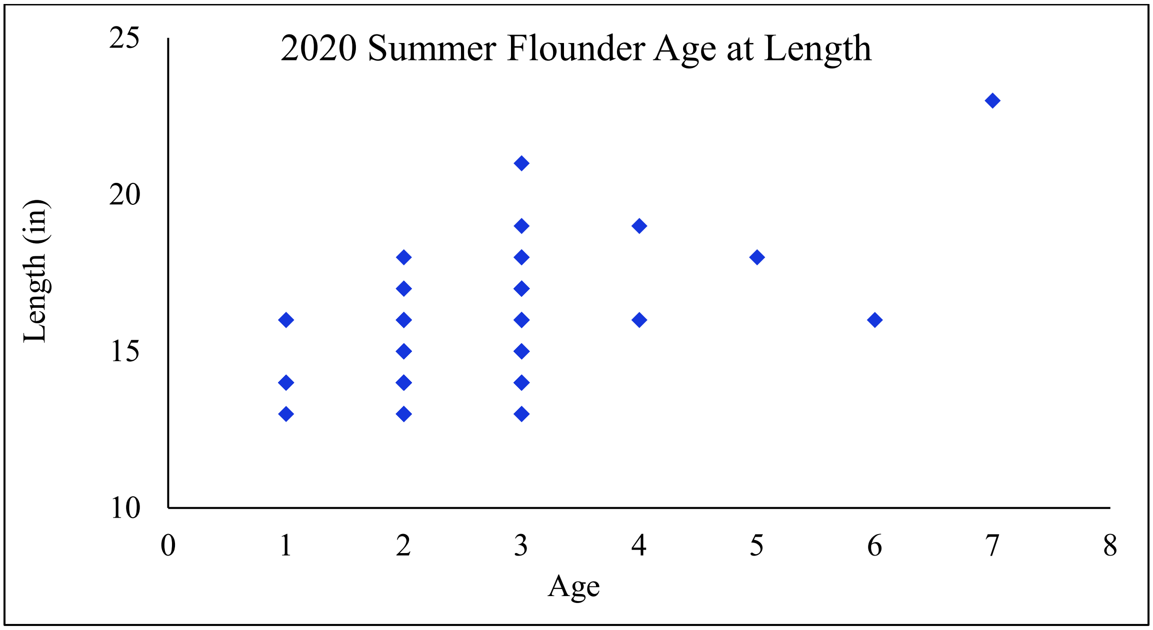


Figure 4. Summer flounder age at length.

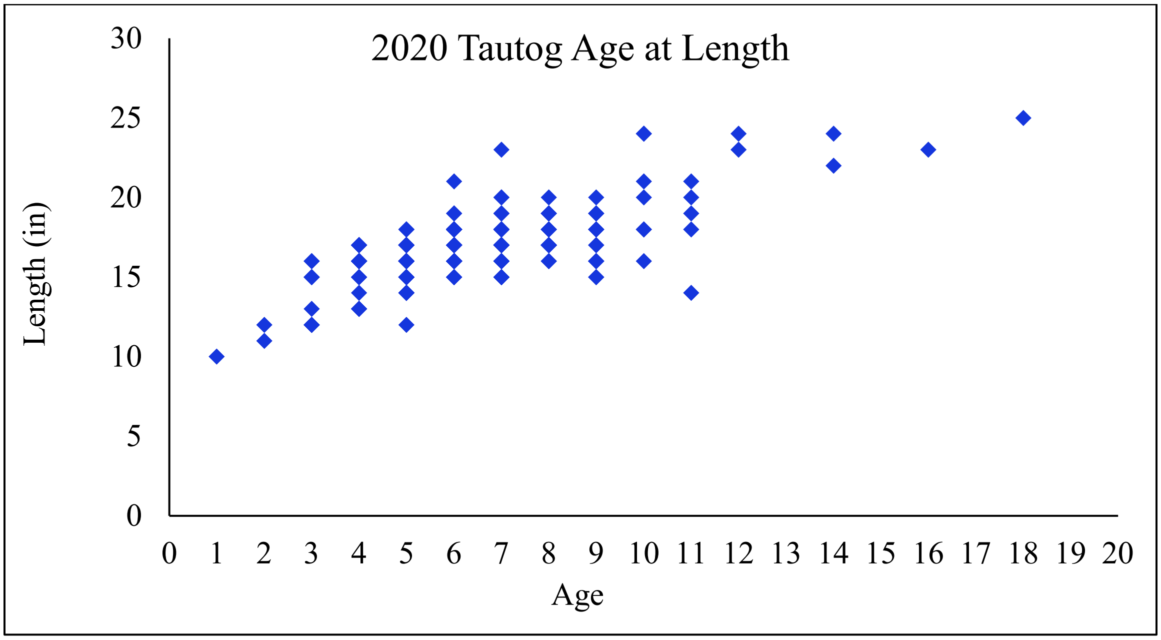


Figure 5. Tautog age at length.

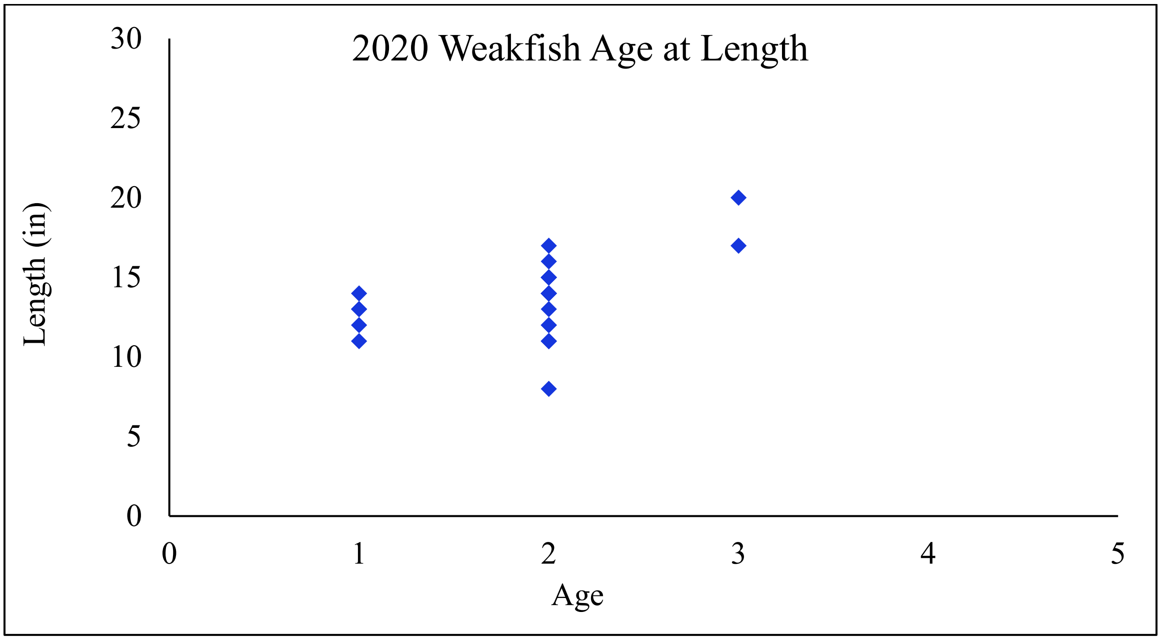


Figure 6. Weakfish age at length.

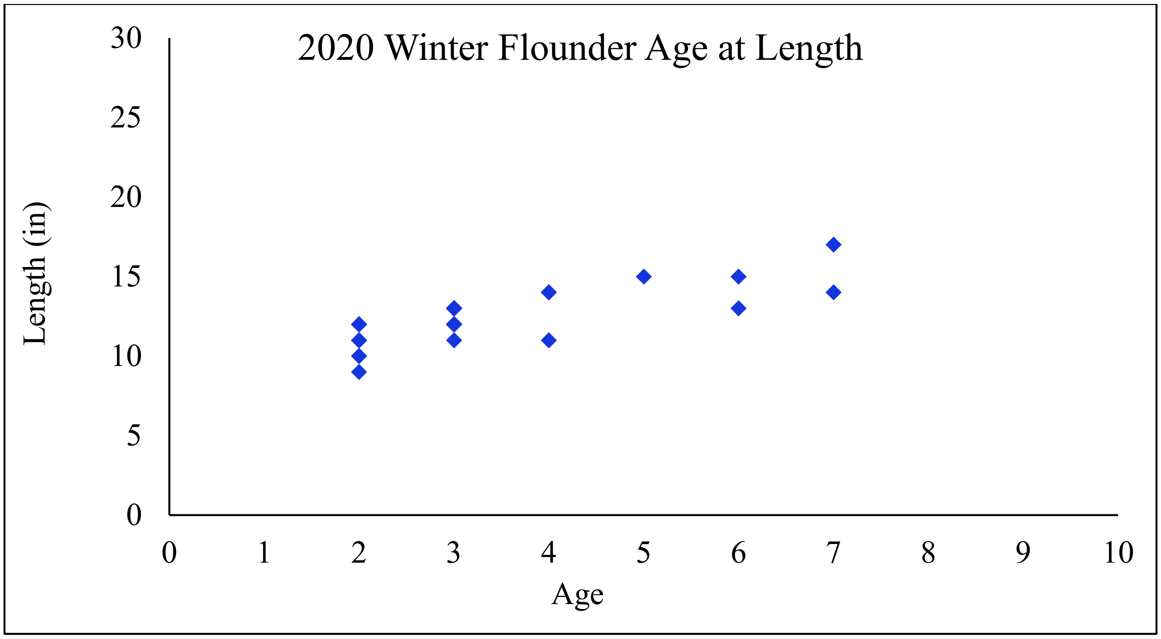


Figure 7. Winter flounder age at length.

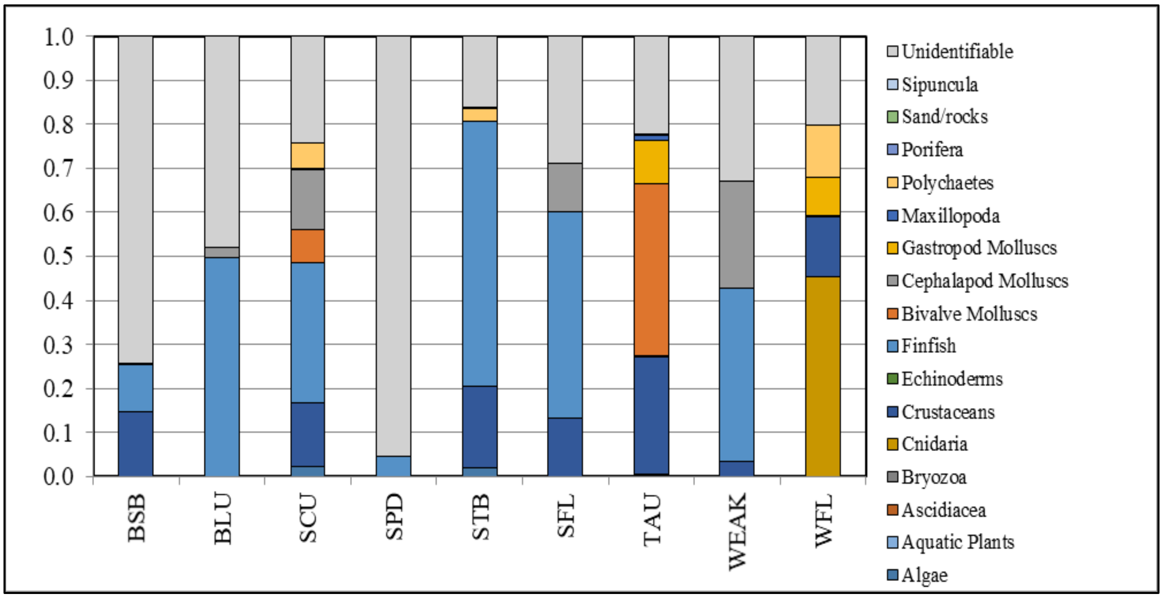


Figure 8. 2020 Proportional contribution of **all** stomach content types by species.

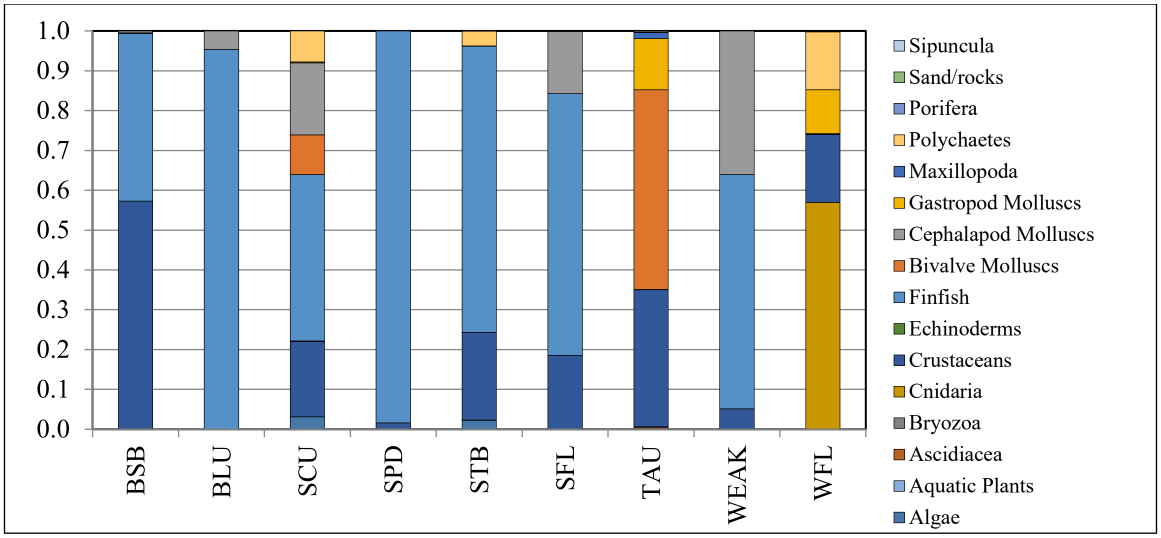


Figure 9. 2020 Proportional contribution of stomach content types by species; “unidentifiable” contents not included.

TABLES

Table 1. Number of ageing structures collected by species in 2020.

Common name	Ageing structure(s)	Target number of ageing structures	Number of ageing structures collected
Black sea bass	Scale, Otolith	100	578 scale, 578 otolith
Bluefish***	Otolith	100	157 otolith
Menhaden***	Scale, Otolith	100	98 scale, 98 otolith
Scup	Scale, Otolith	100	107 scale, 107 otolith
Striped bass	Scale, Otolith	150 fish/gear type**	189 scale, 27 otolith, 27 pelvic spines
Summer Flounder	Scale, Otolith	100	96 scale, 96 otolith
Tautog***	Operculum, Otolith, 1st pelvic	200	251 operculum, 251 otolith, 251 pelvic spines
Weakfish***	Otolith	3 fish aged per metric ton landed*	27
Winter Flounder	Scale, Otolith	NA	40 scale, 40 otolith

*Per ASMFC FMP requirements, 10 ages required for 2020

**Gear types include floating fish trap and general category

***Required by ASMFC

Table 2. Gear type sampled for each species collected in 2020 (FFT=Floating Fish trap).

Common name	Gear Type
Black sea bass	Otter Trawl, Crab Pot
Bluefish	Gillnet, Hook and Line, Otter Trawl
Menhaden	Otter Trawl
Scup	Otter Trawl
Striped bass	Hook and Line, Otter Trawl, Fyke Net, Beach Seine
Summer Flounder	Otter Trawl, Hook and Line
Tautog	Hook and Line, Otter Trawl, Beach Seine
Weakfish	Otter Trawl
Winter Flounder	Otter Trawl

Table 3. 2020 Summary of stomach content sampling by species (* Sand/rocks and "unidentifiable" stomach contents not included in number of prey taxa).

SPECIES	Target # Stomachs	# Stomachs sampled	# PREY TAXA*
Black Sea Bass	40	209	5
Bluefish	40	59	2
Scup	40	44	8
Striped Bass	40	27	7
Summer Flounder	40	55	4
Tautog	40	45	13
Weakfish	40	27	4
Winter Flounder	40	40	8

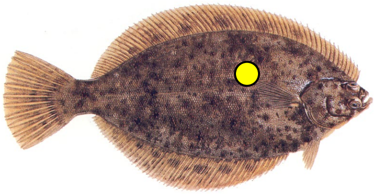
Table 4. 2020 Proportional contribution of **all** stomach content types by species (see Figure 9).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL
Algae	0	0	0.0235	0.0191	0	0.0004	0.0006	0
Aquatic Plants	0.0002	0	0	0	0	0.0003	0	0
Ascidiacea	0	0	0	0	0	0.0021	0	0
Bryozoa	0	0	0	0	0	0.0023	0	0
Cnidaria	0	0	0	0.0005	0	0	0	0.4549
Crustaceans	0.1465	0	0.1431	0.1843	0.1323	0.2674	0.0339	0.1358
Echinoderms	0	0	0.0011	0	0	0.0011	0	0.0007
Finfish	0.1076	0.4973	0.3166	0.6014	0.4677	0	0.3944	0
Bivalve Mollusc	0.0006	0	0.0754	0	0	0.3900	0	0.0017
Cephalopod Mollusc	0.0011	0.0244	0.1369	0.0001	0.1113	0	0.2418	0
Gastropod Mollusc	0	0	0.0016	0	0	0.1007	0	0.0874
Maxillopoda	0	0	0	0	0	0.0114	0	0
Nematoda	0	0	0	0	0	0	0	0
Nemertea	0	0	0	0	0	0	0	0
Platyhelminthes	0	0	0	0	0	0	0	0
Polychaetes	0	0	0.0590	0.0310	0.0008	0.0004	0	0.1162
Porifera	0	0	0	0	0	0.0003	0	0
Sand/rocks *	0	0	0	0.0007	0	0.0024	0	0.0007
Sipuncula	0	0	0	0	0	0	0	0.0013
Urochordata	0	0	0	0	0	0	0	0
Unidentifiable *	0.7441	0.4783	0.2428	0.1628	0.2879	0.2212	0.3294	0.2014

Table 5. 2020 Proportional contribution of stomach content types by species; "unidentifiable" stomach contents not included (see Figure 9).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL
Algae	0	0	0.0311	0.0228	0	0.0006	0.0008	0
Aquatic Plants	0.0006	0	0	0	0	0.0004	0	0
Ascidiacea	0	0	0	0	0	0.0027	0	0
Bryozoa	0	0	0	0	0	0.0030	0	0
Cnidaria	0	0	0	0.0006	0	0	0	0.5696
Crustaceans	0.5724	0	0.1890	0.2201	0.1857	0.3433	0.0506	0.1701
Echinoderms	0	0	0.0014	0	0	0.0014	0	0.0008
Finfish	0.4205	0.9532	0.4181	0.7184	0.6569	0	0.5880	0
Bivalve Mollusc	0.0021	0	0.0996	0	0	0.5007	0	0.0021
Cephalopod Mollusc	0.0043	0.0468	0.1808	0.0002	0.1563	0	0.3606	0
Gastropod Mollusc	0	0	0.0021	0	0	0.1293	0	0.1094
Maxillopoda	0	0	0	0	0	0.0146	0	0
Nematoda	0	0	0	0	0	0	0	0
Nemertea	0	0	0	0	0	0	0	0

Platyhelminthes	0	0	0	0	0	0	0	0
Polychaetes	0	0	0.0780	0.0370	0.0011	0.0006	0	0.1456
Porifera	0	0	0	0	0	0.0004	0	0
Sand/rocks *	0	0	0	0.0009	0	0.0031	0	0.0008
Sipuncula	0	0	0	0	0	0	0	0.0017
Urochordata	0	0	0	0	0	0	0	0



Assessment of Recreationally Important Finfish Stocks in Rhode Island Coastal Waters

Winter Flounder Spawning Stock Biomass Survey

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Federal Aid in Sportfish Restoration
F-61-21

Performance Report: Job 10 March 2021

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, 2020 – December 31, 2020

Job Number and Title: Job X – Winter Flounder 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: The survey ended in mid-March due to COVID-19 pandemic related restrictions. This was approximately one month earlier than the planned ending date.

Summary:

In 1999, the Rhode Island (RI) Coastal Ponds Project was expanded to support an adult winter flounder (*Pseudopleuronectes americanus*) 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 RI south shore coastal ponds. It was determined that 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 approximately January through April 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 twelve stations where data has been collected over the course of the survey, with six found in Point Judith Pond, four in Potter Pond, and two in Ninigret Pond (also known as Charlestown Pond). Point Judith and Potter Pond use the same breach to connect to the Atlantic Ocean.

Additional Research:

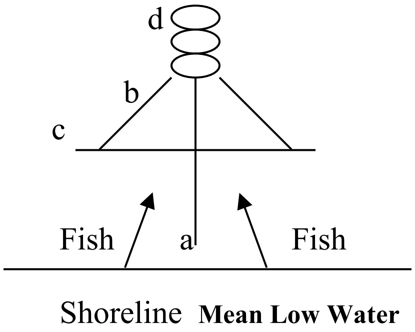
In 2012, the Ninigret Pond system was added to the survey. As adult winter flounder abundance in the Point Judith system declined to all-time lows, the adjacent Ninigret Pond was surveyed from the 2012 through the 2015 sampling year. During this period, RI Coastal Trawl Survey data (Spring Survey) showed a sharp increase in winter flounder relative abundance in the Block Island Sound area. This initially appeared to be similar to the trend seen in the Ninigret Pond system. However, in subsequent years, winter flounder catch per unit effort (CPUE) in the Spring Trawl Survey has declined and shown an overall downward trend throughout the time series. If, through this continuation of the multiple sampling areas, Point Judith Pond 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 Ninigret Pond sampling, that is now missing from the Point Judith Pond survey due to the inability to catch enough fish to effectively tag a large enough portion of the population to expect tag returns. The Environmental Protection Agency initially partnered in this project on Ninigret Pond and collected data for four winter survey seasons (2012-2015). Ninigret Pond was again added as a system to the survey again in 2019 and will continue to be sampled moving forward.

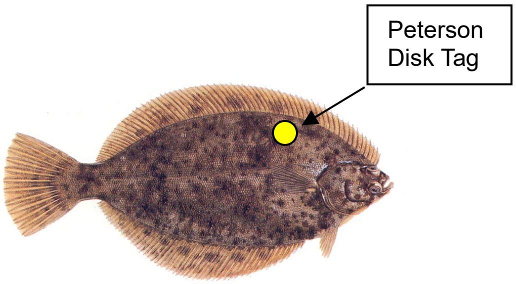
Methods and Materials:

Fyke nets are a passive fixed fishing gear, attached perpendicular to the shoreline at mean low water. A vertical section of net wall referred to as a 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. Adult winter flounder are tagged using Peterson Disk Tags.

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

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





Fieldwork:

In 2020 two to three nets were concurrently set in Point Judith and/or Potter Ponds and two nets were set concurrently in Ninigret Pond, for a total of four to five concurrently set nets among the three systems. A total of 63 fyke net sets were conducted in 2020. Nets were tended every two to nine days depending on the anticipated 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. Tagging and recapture data is presented in Tables 1-3.

Fisheries:

Winter flounder were historically a commercially and recreationally important species to the State of Rhode Island. From 1999-2019, commercial landings of winter flounder in Rhode Island averaged over 300 metric tons and an average value of one million dollars annually (Table 4, Figure 1). Throughout the time series, landings have shown an overall downward trend. Recreational harvest has declined rapidly throughout the period and remains extremely low through 2019 (Table 5, Figure 2) (NMFS 2019 commercial landings query and MRIP database through 2019). Note that due to the rarity of the MRIP Access Point Angler Intercept Survey encountering anglers who have captured winter flounder, the percent standard error (PSE) for these data points is commonly very high (Table 5). The Atlantic States Marine Fisheries Commission 2020 SNE/MA stock assessment update report indicates the stock is overfished, but overfishing is not occurring (NOAA 2020, Wood 2017). Spawning stock biomass in 2019 was estimated to be 3,638 metric tons, which is 30% of the biomass target and 60% of the biomass threshold. The 2019 fishing mortality was estimated to be 0.077 which is 27% of the overfishing threshold.

Spawning Behavior:

Winter flounder enter the south shore coastal pond systems in Rhode Island to spawn in the early part of winter (typically in November) and engage in spawning activity from approximately December 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. Figure 3 displays the ratios of spawning stages of winter flounder captured from 1999-2020 by month.

Sex ratios throughout the time series tend to favor females. Many decades ago similar observations were made in Green Hill Pond, a neighboring coastal pond (Saila 1961), and in Narragansett Bay (Saila 1962). Sex ratios for winter flounder captured from 1999-2020 are shown in Figure 4. Note that here immature fish in this figure refers to those individuals that were too young to sex, and not necessarily the spawning stage. Therefore, some of these male and female fish were still immature in terms of spawning stage.

Results:

A total of 63 fyke net sets were conducted in 2020 (Tables 1-3). The total number of winter flounder sampled during the 2020 survey was 170. This was a 362% increase from the 2019 survey. Sizes ranged from 14 cm to 48.8 cm (Figure 5). The CPUE across all ponds in 2020 was 2.7 fish/net haul. 2020 adult winter flounder CPUE in Pt Judith Pond was 1.6 fish per net haul (Figure 6). This value is well below the time series high of 24.4 in 2001, as well as below the time series median. The catch rates have shown a downward trend throughout the time series.

2020 adult winter flounder CPUE in Potter Pond was 1 fish per net haul (Figure 7). This value is well below the time series median. 2020 winter flounder CPUE in Ninigret Pond was 6.4 fish per net haul (Figure 8). In 2020, a total of eight mature fish were tagged in Potter Pond, 6 tagged in Ninigret Pond, and 3 fish were tagged within Point Judith Pond. Two winter flounder were recaptured in 2020 in Ninigret Pond. No tagged winter flounder were reported by the public in 2020.

Discussion:

Much lower catch rates are being observed in the recent decade of the adult coastal pond survey. Trends indicate that despite both commercial and recreational harvest limits put in place to reduce mortality, localized coastal pond winter flounder populations are not recovering. Continued sampling in the Point Judith Pond, Potter Pond, and Ninigret Pond systems is necessary to monitor these trends. Increased effort conducted in 2020 revealed similar population trends to those seen in the past few years.

Recommendations:

Continuation of all adult winter flounder work statewide in order to make accurate connections between coastal ponds, Narragansett Bay, and Rhode Island/Block Island Sound winter flounder stocks is necessary. In addition, the survey in the Ninigret Pond System will be continued in 2021 in order to track local adult winter flounder abundance and use the catch as a source of taggable animals to gain information on population size, mortality, and year class structure. The importance of returning tag data from the commercial trawl fleet in Rhode Island Sound and Block Island Sound should be stressed in order to facilitate continued reporting of recaptured fish. Utilization of the Division’s Marine Fisheries listserv is recommended to alert commercial and recreational anglers to the continued efforts of this survey. The addition of staff in 2019 successfully alleviated all issues that have led to reduced sampling effort in recent years.

Due to moratoriums on commercial and recreational fishing in Point Judith Pond and Potter’s Pond, it is recommended that additional effort be placed in Ninigret Pond and potentially another system moving forward to increase the likelihood of tag returns for fish within those systems. Additionally, the past several years has seen higher mortality rates of winter flounder within fyke nets in Point Judith Pond compared with the other sampled systems. This is likely due to predation by seals and otters. In an effort to reduce survey related mortalities, effort may be reduced in Point Judith Pond moving forward.

References:

Collette B. and Klein-MacPhee G. 2002 Bigelow and Schroeder’s Fishes of the Gulf of Maine. 3rd edition

NOAA. 2020. Southern New England Mid-Atlantic winter flounder. 2020 Assessment Update Report. October 2020.

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

Saila, S. B. 1962. Proposed hurricane barriers related to winter flounder movements in Narragansett Bay. Trans. American Fisheries Society.

Wood, A. 2017. Southern New England Mid-Atlantic winter flounder. 2017 operational stock assessment. Atlantic States Marine Fisheries Commission.

Table 1 – Winter flounder tagging/recapture totals in Point Judith Pond by year. Number recaptured indicates the number of tagged fish that were recaptured in that year, regardless of what year that tagged fish had been released.

Year	Number of fyke sets	Number caught	Number tagged	Number recaptured
1999	57	1297	329	38
2000	14	350	189	27
2001	22	540	354	50
2002	27	282	165	7
2003	27	160	87	4
2004	23	102	64	12
2005	27	252	116	5
2006	44	410	89	6
2007	31	121	35	3
2008	19	39	14	0
2009	26	62	0	0
2010	24	85	21	0
2011	23	60	5	0
2012	16	32	11	0
2013	14	12	0	0
2014	14	11	1	0
2015	7	10	4	0
2016	11	6	1	0
2017	1	0	0	0
2018	3	0	0	0
2019	12	8	0	0
2020	33	53	3	0
Total	**418**	**3892**	**1488**	**152**

Table 2 – Winter flounder tagging/recapture totals in Potter Pond by year. Number recaptured indicates the number of tagged fish that were recaptured in that year, regardless of what year that tagged fish had been released.

Year	Number of fyke sets	Number caught	Number tagged	Number recaptured
1999	0	0	0	0
2000	10	67	13	2
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	2	8	6	0
2012	5	9	3	0
2013	5	10	5	0
2014	3	3	2	0
2015	7	46	10	0
2016	2	8	1	0
2017	3	8	2	0
2018	3	35	5	0
2019	4	5	4	0
2020	14	14	8	0
Total	**58**	**213**	**59**	**2**

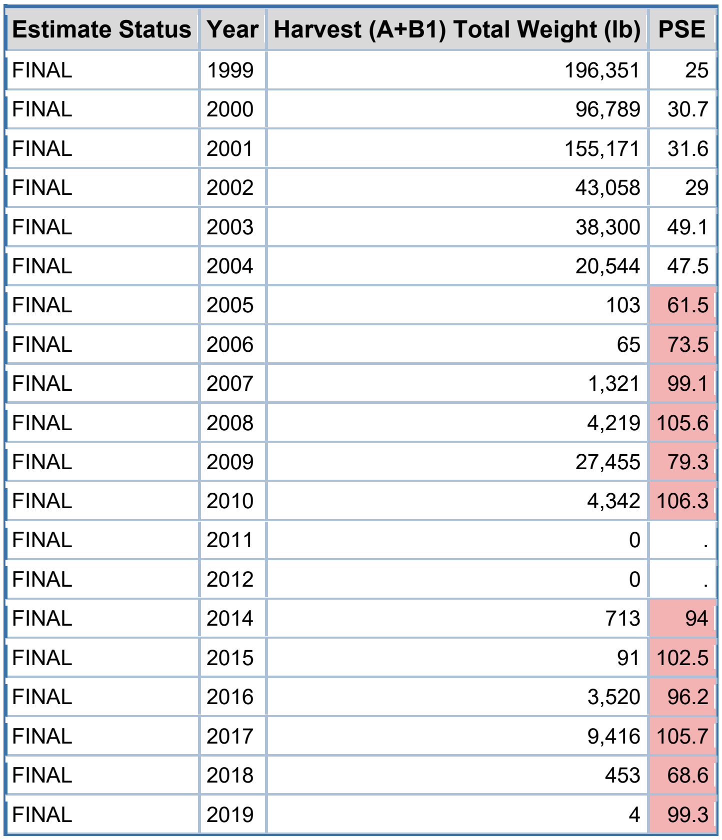
Table 3- Winter flounder tagging/recapture totals in Ninigret Pond by year. Number recaptured indicates the number of tagged fish that were recaptured in that year, regardless of what year that tagged fish had been released.

Year	Number of fyke sets	Number caught	Number tagged	Number recaptured
2012	19	113	98	10
2013	21	146	109	11
2014	14	33	33	4
2015	16	143	67	4
2016	0	0	0	0
2017	0	0	0	0
2018	0	0	0	0
2019	5	34	17	0
2020	16	103	6	2
Total	**91**	**572**	**330**	**31**

Table 4 - Commercial landings and value of winter flounder in Rhode Island by year.

Year	Landings (metric tons)	Value (millions of dollars)
1999	525	1.4
2000	813.1	1.8
2001	658.5	1.4
2002	602	1.5
2003	470.6	1.2
2004	394.5	1
2005	306.4	0.97
2006	586.4	2.5
2007	530.1	2.4
2008	289.3	1.3
2009	140.2	0.49
2010	34.1	0.15
2011	37.9	0.13
2012	20.1	0.09
2013	181.7	0.6
2014	206.2	0.94
2015	167.4	0.74
2016	135.7	0.82
2017	135.8	0.9
2018	86.7	0.58
2019	53.1	0.37
Average	**303.6**	**1.01**

Table 5 - MRIP Estimated Recreational Harvest for winter flounder in Rhode Island. Results from this query for 1981-2019 now contain estimates resulting from the full application of both the Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibration. PSE values greater than 50 are highlighted red and indicate a very imprecise estimate.



Estimate Status	Year	Harvest (A+B1) Total Weight (lb)	PSE
FINAL	1999	196,351	25
FINAL	2000	96,789	30.7
FINAL	2001	155,171	31.6
FINAL	2002	43,058	29
FINAL	2003	38,300	49.1
FINAL	2004	20,544	47.5
FINAL	2005	103	61.5
FINAL	2006	65	73.5
FINAL	2007	1,321	99.1
FINAL	2008	4,219	105.6
FINAL	2009	27,455	79.3
FINAL	2010	4,342	106.3
FINAL	2011	0	.
FINAL	2012	0	.
FINAL	2014	713	94
FINAL	2015	91	102.5
FINAL	2016	3,520	96.2
FINAL	2017	9,416	105.7
FINAL	2018	453	68.6
FINAL	2019	4	99.3

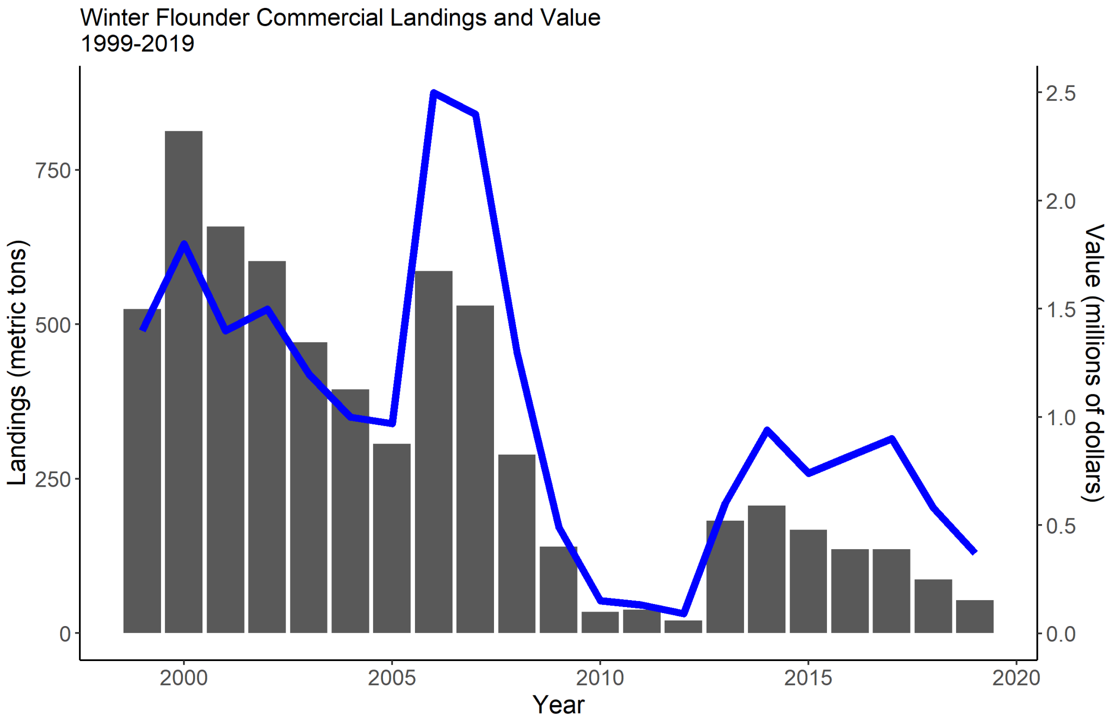


Figure 1 – Winter flounder commercial landings. Bars indicate landings and blue line indicates value.

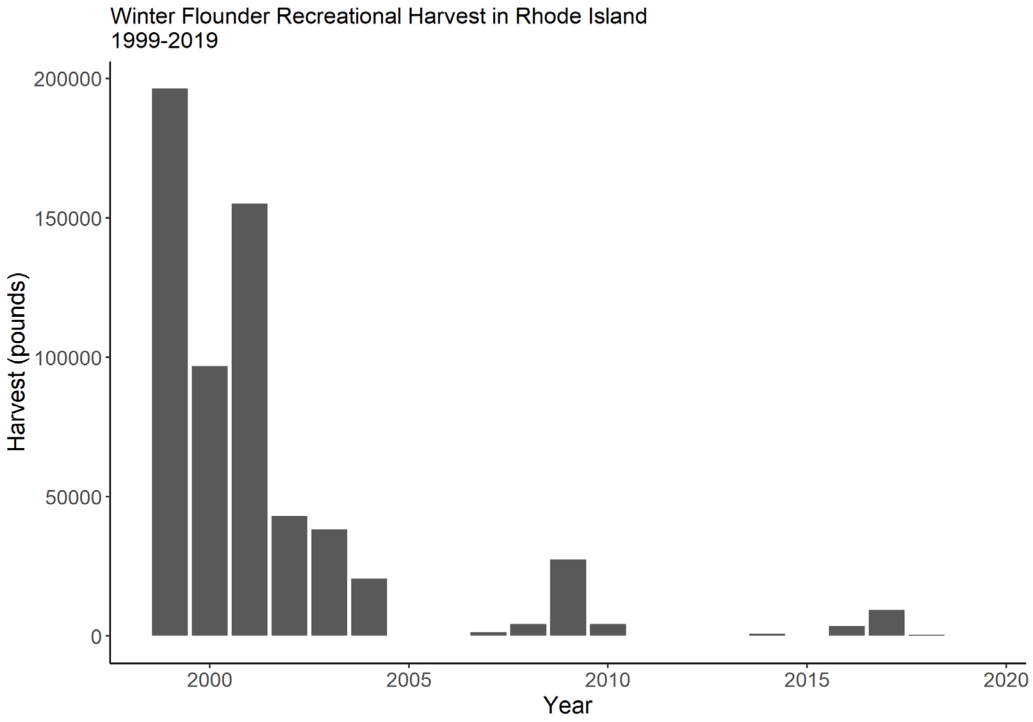


Figure 2 – Winter flounder recreational harvest from 1999 to 2019.

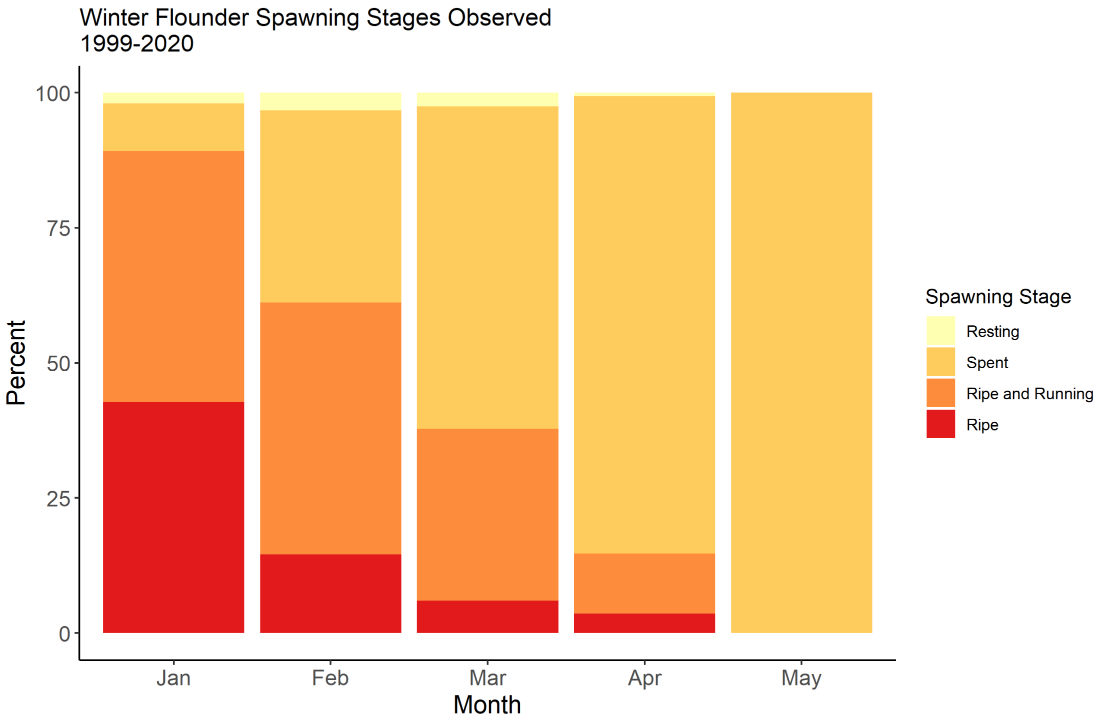


Figure 3 – Winter flounder spawning stages observed from 1999-2020.

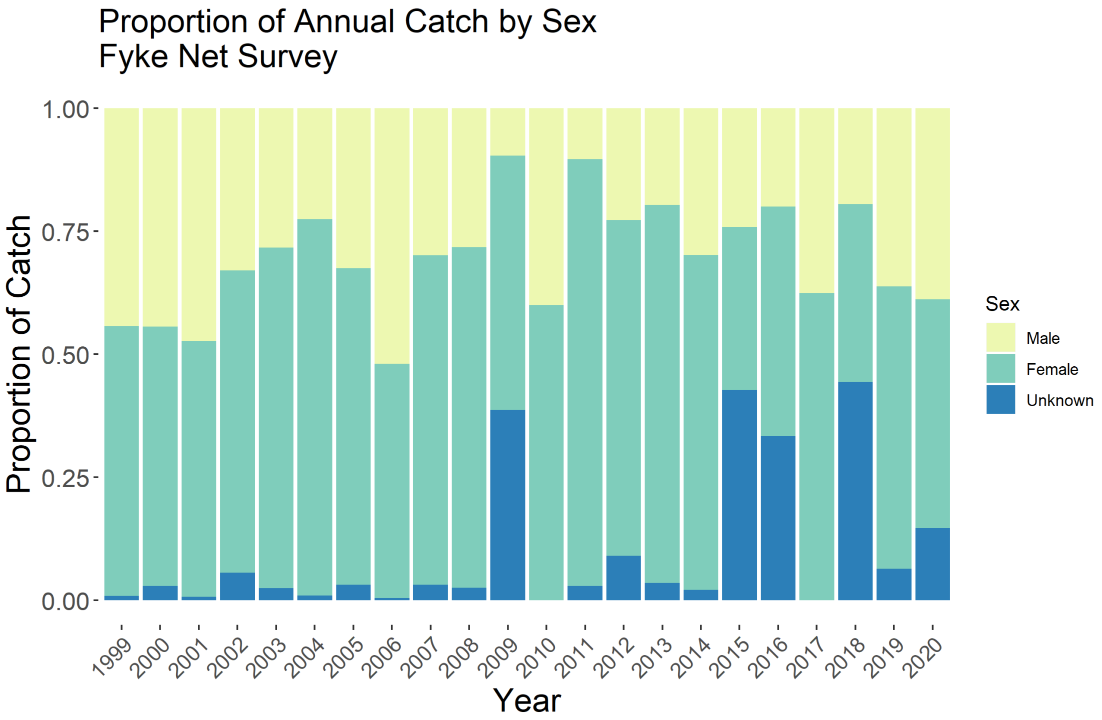


Figure 4 – Winter flounder male to female ratio from 1999-2020.

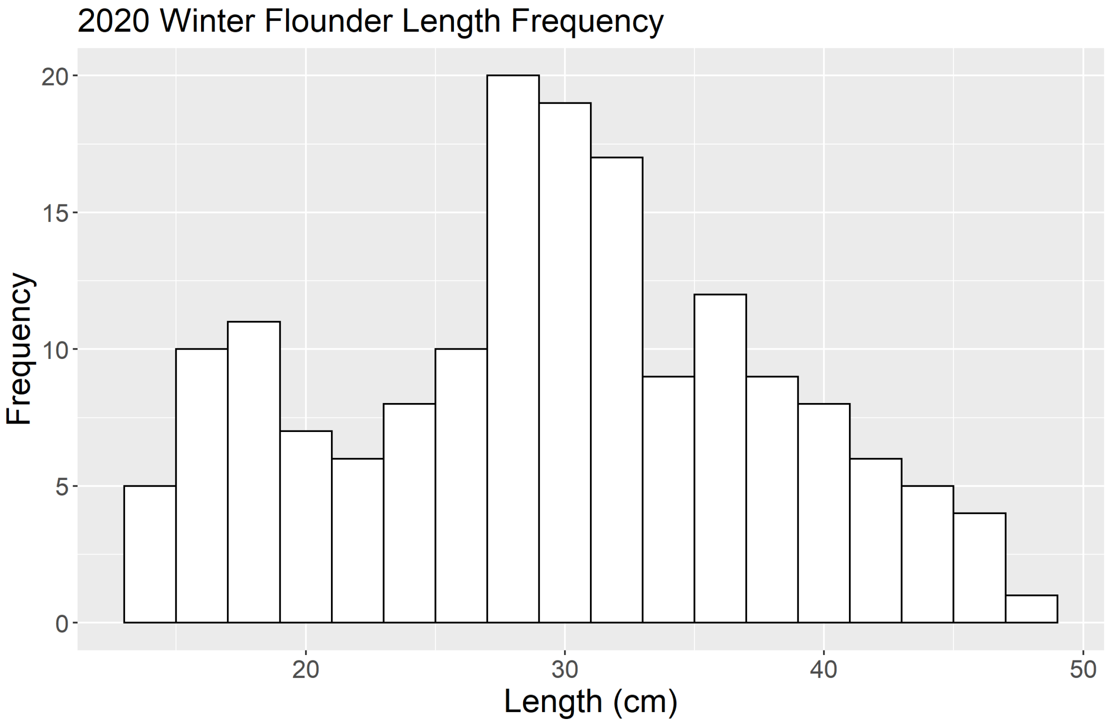


Figure 5 – Winter flounder length-frequency for 2020 survey.

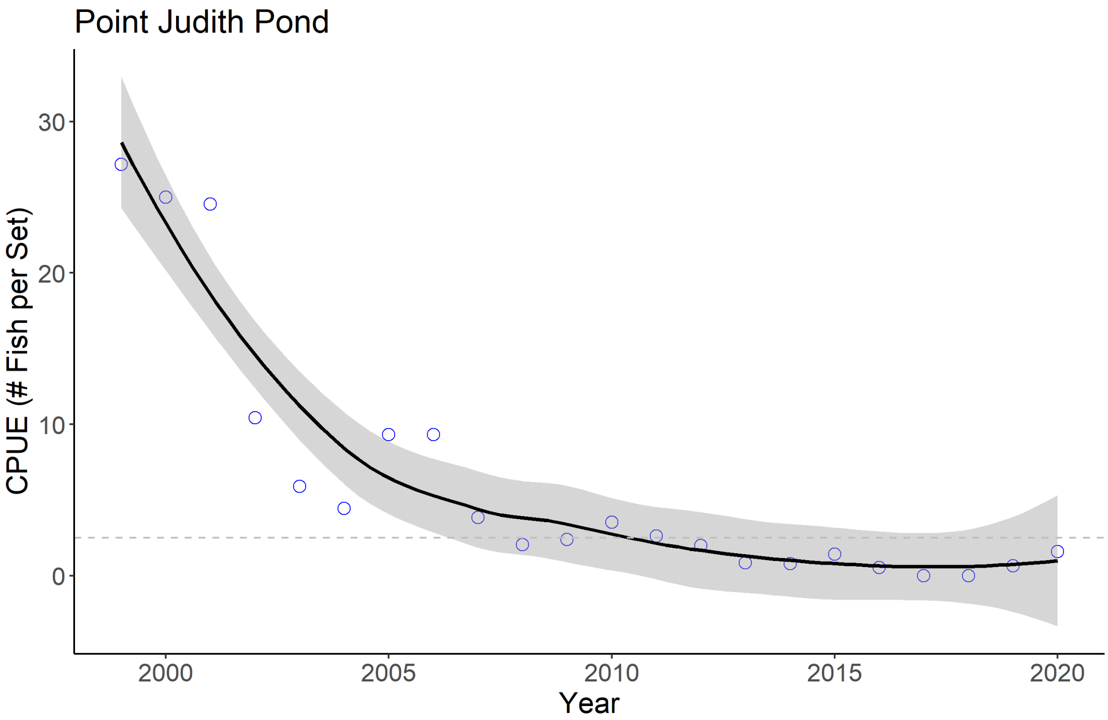


Figure 6 - WFL smoothed abundance index for Point Judith Pond. Gray dashed line is time series median; black line is time series Loess regression fit; and gray shaded area is the approximate 95% confidence limits for Loess regression fit.

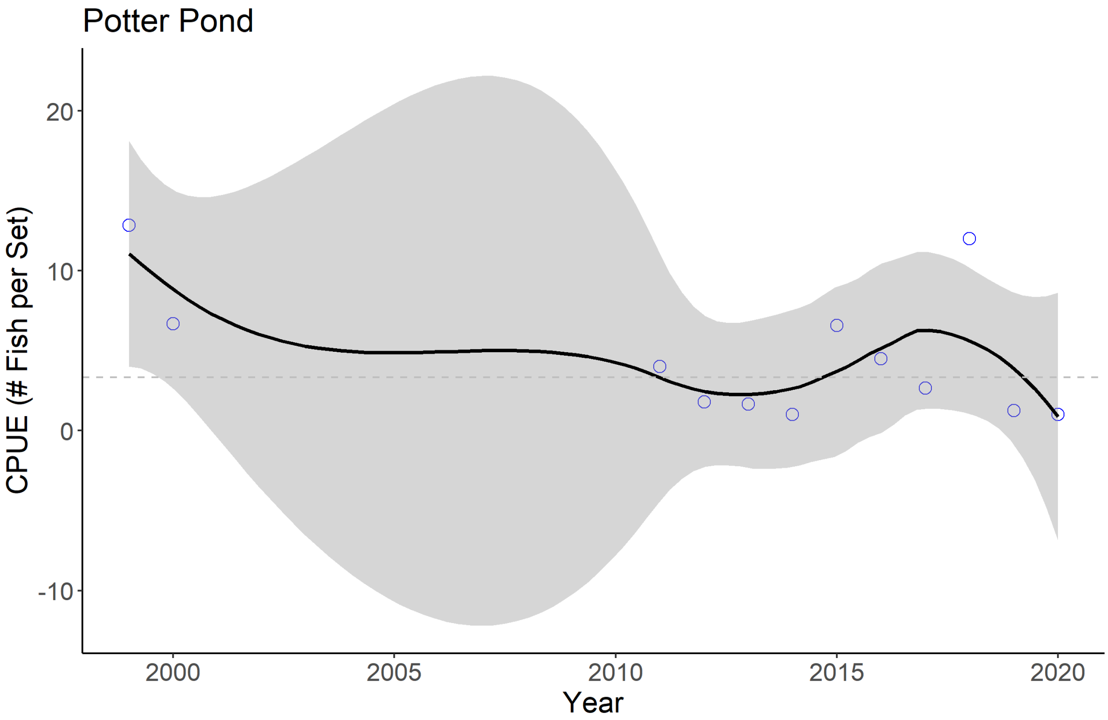


Figure 7 – Winter flounder smoothed abundance index for Potter Pond. Gray dashed line is time series median; black line is time series Loess regression fit; and gray shaded area is the approximate 95% confidence limits for Loess regression fit.

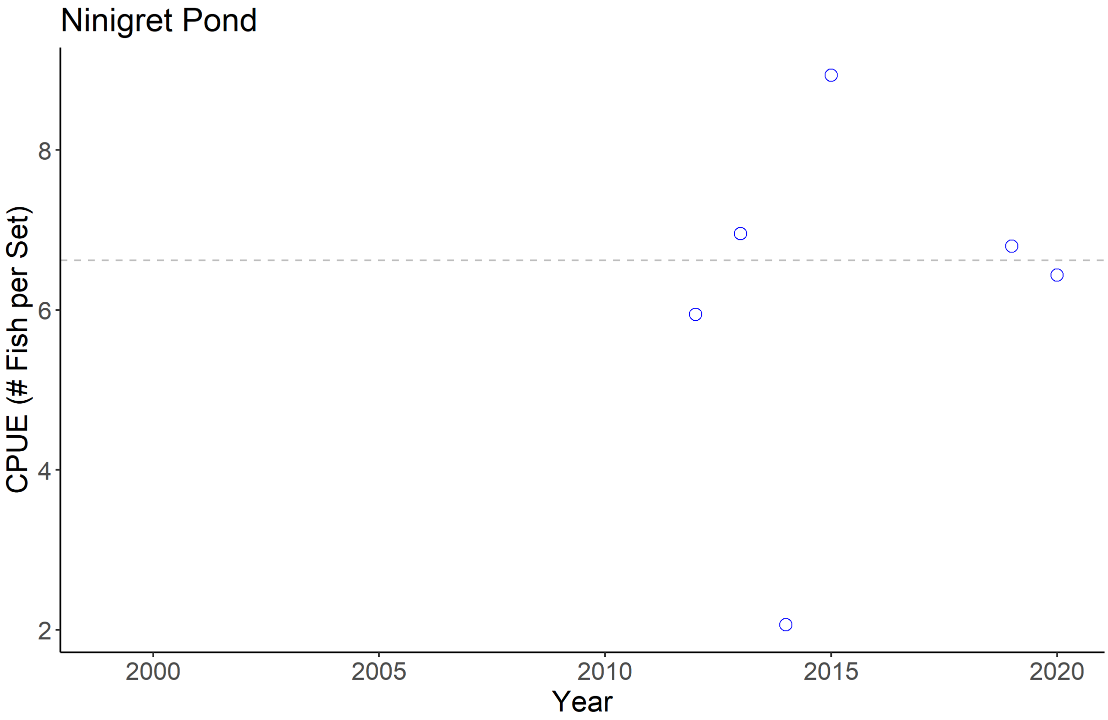


Figure 8 – Winter flounder smoothed abundance index for Ninigret Pond. Gray dashed line is time series median.

Narragansett Bay Atlantic Menhaden Monitoring Program

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STATE: Rhode Island

PROJECT NUMBER: F-61-R

SEGMENT NUMBER: 22

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

PERIOD COVERED: January 1, 2020 – December 31, 2020

JOB NUMBER 11 TITLE: Narragansett Bay Atlantic Menhaden Monitoring Program

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

SUMMARY: Atlantic menhaden (menhaden) undergo large coastwide migrations each year. After aggregating in the offshore waters of the Mid-Atlantic region during the winter, menhaden migrate west and north stratifying by size and age the further north they migrate (Arenholz, 1991). Menhaden arrive in RI coastal waters beginning in the early spring, and in some years, enter Narragansett Bay in large numbers, where they can reside for varying amounts of time until they begin their southward migration in the fall. During the period when they reside in Narragansett Bay, a number of user groups compete for the resource. Commercial bait companies begin to fish on the schools of menhaden and provide bait for both recreational fishing interests and for the lobster fishery. As well, recreational fishermen access the schools of menhaden directly and use the resource as bait for catching larger sport fish such as striped bass and bluefish. Large numbers of sport fishermen can be seen in their boats surrounding large schools of menhaden throughout the spring and summer using various methods to harvest them (snagging lures, cast nets, dip nets). The migration of menhaden to the north is also one factor which brings these larger sport fish to northern areas, as they are an important food resource for these species (Arenholz, 1991; ASMFC, 2017). During the period when the menhaden resource is within Narragansett Bay and multiple user groups are accessing it, user group conflicts are an inevitable outcome.

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 Department of Environmental Management Division of Marine Fisheries (Division) administers a menhaden monitoring program in Narragansett Bay. The program collectively uses sentinel fishery observations (floating fish trap data), spotter flight information with a trained spotter pilot, 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 2020

SIGNIFICANT DEVIATIONS: No significant deviations.

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.

REMARKS: Biomass 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 consists of three main elements: collection of fishery landings information through call in and logbook requirements, field work (spotter flights and biological sampling), and computer modeling work. DEM regulations require that commercial vessels fishing for menhaden in Narragansett Bay report their catches to Division staff daily. All RI licensed commercial harvesters, including floating fish trap and purse seine operators, are required to file logbook reports monthly with the Division that details daily fishing activities.

Each year the Division contracts a trained spotter pilot to make biomass estimates of menhaden in Narragansett Bay. When in the air, the pilot records counts of menhaden schools observed, the estimated weight within the schools, and the location of the schools.

Each year biological port samples are collected from commercial purse seine operations, floating fish traps that operate in state waters outside of the menhaden management area, or from the Divisions trawl survey (Jobs 1 and 2 of this grant). Sampling includes length frequencies, body weights, and collecting scales and otoliths for age determination (see Age and Growth Study, Job 9 of this F-61R grant progress report).

Collectively, these sources of information are analyzed using the theory of depletion estimation as applied to open populations. All of the aforementioned information is centrally collected and used in a computer modeling approach that allows the Division to monitor the abundance of menhaden in Narragansett Bay. The existing regulatory framework governing state waters allows the Division to use the output from the mathematical modeling approach to set a number of fishing activity parameters including a static amount of fish needed to be present to allow commercial fishing to commence, thus protecting recreational and ecological interests if only a small population enters the Bay. The framework also authorizes 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. The Divisions ability to close the fishery when the standing population of menhaden in Narragansett Bay drops back below the threshold level of fish helps to maintain a portion of the population for recreational fishermen and ecological services. This program also allows the Division to accurately track the state quota and provides justification for Rhode Island to participate in the Episodic Event Set Aside Program.

2020 Fishery Data

In 2020, biomass thresholds in the management area never reached the minimum 2 million pound threshold and consequently the menhaden management area remained closed. A total of 40 contractor spotter flights were completed in 2020 to accurately monitor biomass levels of menhaden within the management area (Figure 1).

SUMMARY: The menhaden monitoring program in Narragansett Bay remained closed in its entirety throughout the 2020 fishing year as a result of low menhaden biomass.

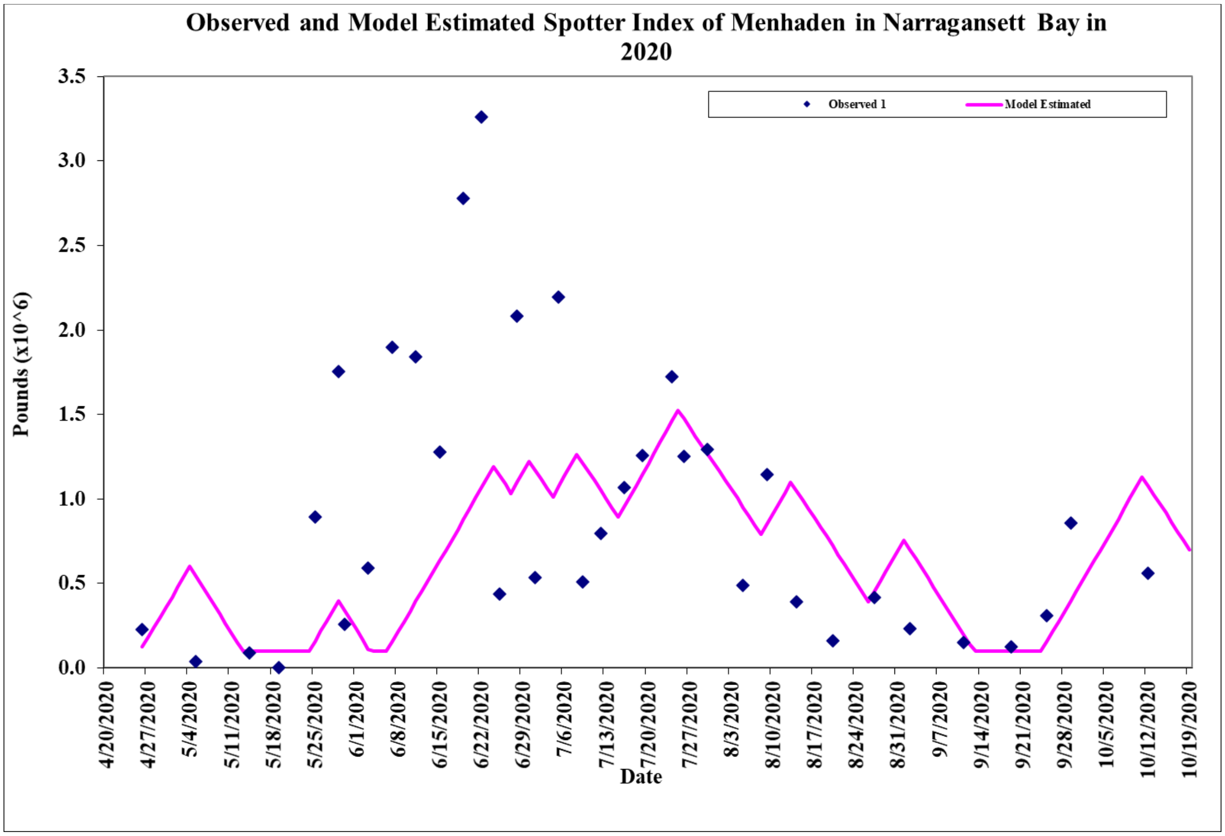

Figure 1. Predicted spotter pilot estimates and observed biomass in Narragansett Bay in 2020.

References

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Gibson, M. 2007. Estimating Seasonal Menhaden Abundance in Narragansett Bay from Purse Seine Catches, Spotter Pilot Data, and Sentinel Fishery Observations. http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/menabnnb.pdf

ASMFC

Narragansett Bay Ventless Pot Multi-Species Monitoring and Assessment Program

Ventless Fish Pot Survey

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Federal Aid in Sportfish Restoration
F-61-21

Performance Report: Job 12 March 2021

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, 2020 – December 31, 2020

Job Number Job XII - Narragansett Bay Ventless Pot Multi-Species Monitoring and Assessment Program

Job Objective: To assess and standardize a time series of relative abundance for structure-oriented finfish (scup, black sea bass, and tautog) in Narragansett Bay. Additional collection of age, weight at length, and other biological information for these species.

Significant Deviations: This job was not conducted in 2020. The vessel previously used to conduct the full survey was decommissioned before the survey began in 2019 and the new vessel designed to accommodate this study in the future will not be available until 2021 due to COVID-19 pandemic related delays.

Summary:

Finfish species that associate with bottom structure while inshore may be relatively unavailable to traditional bottom trawl gear. As such, traditional fisheries-independent survey designs are often imperfect in assessing the relative abundance of structure-oriented marine species due to their inability to sample such habitats. Various stock assessments for structure-oriented fish including scup (NEFSC 2002) and black sea bass (NEFSC 2011) have recommended exploring alternatives to trawl surveys to provide better analytical assessment data for these species. Additionally, working groups such as the Northeast Data Poor Stocks Working Group (NEFSC 2008, Shepard 2008, Terceiro 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, each of which is an important recreational finfish in Rhode Island waters, tend to associate with bottom structure for a large portion of the year and as a result have low catchability in traditional trawl surveys.

To address this concern, Rhode Island’s Division of Marine Fisheries (RIDMF) conducted a ventless fish pot (referred to alternately as ‘pots’ and ‘traps’ throughout and colloquially) survey in Narragansett Bay from 2013 through 2016. Based on data gathered since the start of this survey RIDMF is currently redesigning a standardized monitoring and assessment survey of recreationally important finfish utilizing fish pot gear. The goal of this survey program will be to assess and standardize a time series of relative abundance for structure-oriented finfish in Rhode Island state waters, particularly black sea bass, tautog, and scup. Relative abundance indices derived from this survey will ideally be integrated into both local and coastwide assessments for the target species and will supplement state and regional trawl survey abundance indices.

While a fish pot survey allows for monitoring species entire habitat range (i.e. soft and hard bottom), several survey design decisions can influence catch rates including directed placement on bottom type, pot design, soak time, and bait. These confounding factors on catch rates for recreationally significant finfish species for Rhode Island were evaluated in the summer and fall of 2019 through a directed study. The goal of this exploratory survey was to determine if there is a gear/soak time/bait combination that best maximizes catch for important finfish species while still providing a replicable methodology moving forward. Data from this study will be used to inform the design of a long-term fish pot survey within Rhode Island state waters, and perhaps serve as a template for future efforts within other regions of these species' stock bounds.

This job was not conducted in 2020. The vessel previously used to conduct the full survey was decommissioned before the survey began in 2019 and the new vessel designed to accommodate this study in the future will not be available until 2021 due to COVID-19 pandemic related delays.

Fisheries:

Black sea bass, tautog, and scup have all been commercially and recreationally important species in RI during the past decade. Summaries of RI commercial landings and values are found in Tables 1 through 3 and summaries of recreational harvest of each species are found in Tables 4 through 6. Throughout the time series, landings have shown generally stable or slightly increasing trends for each of these species.

The Atlantic States Marine Fisheries Commission (ASMFC) 2019 black sea bass northern stock operational stock assessment indicates the stock was not overfished and overfishing was not occurring in 2018 relative to revised reference points (ASMFC 2019). Starting in 2007, spawning stock biomass (SSB) increased rapidly and reached a peak in 2014 at over 76 million lbs., then decreased slightly. In 2018 SSB was estimated at 73.65 million pounds, 2.4 times the updated biomass target of 31.07 million lbs. (ASMFC 2019).

Based on the 2016 tautog ASMFC stock assessment update, the Massachusetts-Rhode Island stock of tautog is not overfished and overfishing is not occurring (ASMFC 2016). Similarly, for scup the 2019 operational stock assessment update indicated the stock is considered rebuilt and not experiencing overfishing, with SSB estimated at 411 million pounds, about two times the SSB target of 207 million pounds (ASMFC 2019).

Methods and Materials:

2013-2016 Standard Fish Pot Survey –

Narragansett Bay was divided into five sampling subareas, the Providence River including portions of the Upper Bay/Greenwich Bay, West Passage, East Passage, Mount Hope Bay including portions of the Upper Bay, and the Sakonnet River including the area from Land's End to Sakonnet Point (Figure 1). Each area was subdivided into 0.5-degree latitude and longitude squares and numbered (these grid cells are referred to as stations). Investigators then located areas of hard bottom (e.g., rocky outcropping, shipwreck, major bridge abutments, pilings) within each station. The specific locations of structure were noted in the stations containing structural elements. Each month half of the total randomly selected station replicates were selected from stations with known structure and half from stations without known structure.

All sampling stations were selected randomly. The survey was conducted monthly in Narragansett Bay from June to October. Two types of fish pot were deployed for sampling: unvented scup pots (2'x2'x2') constructed of 1.5” x 1.5” coated wire mesh and unvented black sea bass pots (43.5” x 23” x 6”) 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 pot trawls at two randomly selected stations in two separate sampling areas. One trawl was set on structured bottom and one on bottom without structure. These traps were fished unbaited and fished for 96+/- 1 hr. After the four-day soak, the traps were hauled, the catch processed, and the trawls held for 24 hours then moved to a new area and reset. Ten trawl sets were completed in total for Narragansett Bay in a month (one structured and one unstructured within each of the five subareas).

Additionally, investigators set scup pots at ten randomly selected stations within each respective subarea each month. Within each subarea, five scup pots were set on structured bottom and five on bottom without structure and soaked for 24+/- 1 hr. All pots were baited with sea clams. After the 24-hour soak the pots set were hauled, the catch processed, and gear either reset or removed from the water so investigators could tend trawls. 50 total pot sets were made throughout Narragansett Bay within a month (5 structured stations + 5 unstructured stations x 5 subareas).

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) as species appropriate. Invertebrates were measured using a species-specific appropriate metric or counted. Personnel from the age and growth project collected scale samples and fish specimens from which to obtain stomach samples, otoliths and/or opercula. Project personnel collected data on water temperatures, salinities, dissolved oxygen, air temperature at each sampling station using a Eureka Systems Manta 2 Multiprobe.

2019 Exploratory Fish Pot Study -

In 2019, eight fixed sampling stations were sampled, six in the East Passage and two in the West Passage of Narragansett Bay. Three respective trap setups were deployed as singles during each sampling event: unbaited ventless black sea bass pot, baited black sea bass pot, and baited scup pot. During each sampling event six total traps (two of each setup) were deployed at a randomly selected fixed sampling station for a standardized soak time. Soak times deployed included 1.5 hours, 4 hours, 24 hours, 48 hours, and 72 hours. These soak times were based on soak times commonly used in other fish pot surveys as well as utilized by the commercial fleet. All six traps were then retrieved after the allotted soak time and catch processed as described above. Catch totals and composition were compared among trap setups and soak times.

Results:

2013-2016 Standard Fish Pot Survey –

From 2013 through 2016 a total of 12,634 fish and 1,054 invertebrates (not including *Libinia sp.*) were caught. Scup was the most commonly caught species with 8,781 individuals trapped (70% of total catch). Black sea bass were the second most commonly caught species (2,825 individuals, 22% of total catch) followed by tautog (645 individuals, 5% of total catch) These three species together accounted for over 97% of the total finfish catch.

Across all three target species, mean number of individuals caught and percent occurrence was higher in black sea bass pots than in scup pots (Table 7).

2019 Exploratory Fish Pot Study -

A total of 39 exploratory fish pot sets (234 total pots) were sampled during the 2019 survey. Over the course of the study in 2019, 857 fish and 747 invertebrates were caught. Scup were the most frequently trapped fish species with 713 individuals caught (83% of total fish catch), followed by black sea bass (14%) and tautog (2%). Catch biomass and diversity varied among soak times and trap types fished. Figure 2 shows relative species composition of fish by soak time and trap type.

Black sea bass were caught most efficiently in baited black sea bass pots and at soak times at and above 24 hours (Figures 3 and 4). Length composition of black sea bass did not differ significantly among each trap type (Figure 5). Scup catch biomass was greatest in scup pots, though not significantly different from baited black sea bass pots (Figure 6). Scup presence in any given trap was generally high across all trap types in the 2019 survey, particularly at soak times at and above four hours (Figure 7). Few tautog were trapped during the 2019 survey, potentially due to the location of the fixed stations, and catch biomass was greatest at higher soak times (Figure 8). Unbaited black sea bass pots generally caught fewer fish and invertebrates and less diverse catch than did the baited traps.

Discussion:

Results from both the 2013-2016 survey and the 2019 exploratory study indicate that fish pots effectively target the three species of interest for this job; black sea bass, tautog, and scup. Based on the continued importance of these species to RI, both recreationally and commercially, it is critical that these species be accurately assessed. Using the data collected thus far in the project, a slightly modified and expanded protocol has been developed for this survey moving forward. This expanded and modified survey design will better allow this project to meet its goals. These goals include:

- Collect fishery independent data to provide a relative index of abundance for species that may not be fully sampled by RI DMF bottom trawl
    - Collected data to be used in state and federal stock assessments and management
- Provide relatively high-density spatiotemporal coverage of gear selected black sea bass, scup, and tautog cohorts within state waters
    - Identify spatiotemporal trends of migration and abundance
    - Track annual cohorts
    - Track abundance consistency with other surveys (RI trawl, NMFS trawl)
    - Determine age structure of fish sampled
- Collect additional information on species biological characteristics
- Track the prevalence of trap prone mid-Atlantic/southern species (e.g., grey triggerfish, blue runner, pinfish, Atlantic croaker)

Data collected thorough this survey will be instrumental in meeting these objectives. It is hoped that the survey will also provide many pathways for cross collaborations with other agencies and departments in the future.

Recommendations:

Implementation of the modified survey design in 2021 and moving forward will allow the survey to meet all project goals. Utilization of the new RIDMF vessel designed to run this survey will increase efficiency and scope of the survey greatly. The addition of staff in 2019 will alleviate issues that have led to reduced sampling effort in recent years. Continuation of this survey will provide invaluable data on structure-oriented species to allow for effective management.

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Table 1 - Commercial landings and value of black sea bass landed in Rhode Island by year (NMFS 2020).

Year	Landings (lbs)	Value (dollars)
2009	128,084	400,202
2010	241,886	779,001
2011	211,597	734,732
2012	204,360	735,346
2013	265,610	988,877
2014	267,698	884,332
2015	238,647	808,797
2016	294,343	1,091,991
2017	457,153	1,603,746
2018	373,940	1,433,963
2019	397,902	1,508,814
Average	**280,111**	**997,255**

Table 2 - Commercial landings and value of tautog landed in Rhode Island by year (NMFS 2020).

Year	Landings (lbs)	Value (dollars)
2009	50,920	98,866
2010	44,054	101,431
2011	47,426	124,739
2012	50,126	151,036
2013	53,428	168,479
2014	53,384	182,347
2015	47,140	172,694
2016	50,680	195,296
2017	52,844	194,380
2018	51,450	196,276
2019	46,562	168,046
Average	**49,819**	**159,417**

Table 3 - Commercial landings and value of scup landed in Rhode Island by year (NMFS 2020).

Year	Landings (lbs)	Value (dollars)
2009	3,618,756	2,640,352
2010	4,298,488	2,833,017
2011	6,335,364	3,311,832
2012	6,309,352	3,904,255
2013	7,345,731	3,666,438
2014	6,948,846	4,117,991
2015	6,793,797	4,278,299
2016	6,808,917	4,053,288
2017	5,973,305	3,077,934
2018	4,713,742	2,739,752
2019	4,583,835	2,570,825
Average	**5,793,648**	**3,381,271**

Table 4 - MRIP Estimated Recreational Harvest for black sea bass in Rhode Island. Results from this query contain estimates resulting from the full application of both the Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibration. PSE values greater than 50 are highlighted red and indicate a very imprecise estimate.

Year	Harvest (A+B1) Total Weight (lb)	PSE
2009	128,218	30.7
2010	643,348	26.8
2011	236,607	53
2012	645,039	21.7
2013	313,315	19.2
2014	659,562	19.6
2015	807,840	19.7
2016	1,124,414	21.4
2017	747,262	21.1
2018	1,628,875	15.3
2019	1,225,058	16

Table 5 - MRIP Estimated Recreational Harvest for tautog in Rhode Island. Results from this query contain estimates resulting from the full application of both the Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibration. PSE values greater than 50 are highlighted red and indicate a very imprecise estimate.

Year	Harvest (A+B1) Total Weight (lb)	PSE
2009	1,648,614	26.4
2010	1,933,773	38.9
2011	328,959	54.3
2012	1,512,425	32.1
2013	2,602,962	47.6
2014	1,017,780	33.4
2015	1,105,259	24.3
2016	1,290,428	24.7
2017	600,869	25.3
2018	1,075,131	51.4
2019	1,483,123	24.1

Table 6 - MRIP Estimated Recreational Harvest for scup in Rhode Island. Results from this query contain estimates resulting from the full application of both the Access Point Angler Intercept Survey (APAIS) and Fishing Effort Survey (FES) calibration.

Year	Harvest (A+B1) Total Weight (lb)	PSE
2009	416,699	25.5
2010	771,713	22.5
2011	1,269,888	29.4
2012	1,119,378	22.7
2013	2,622,654	32.5
2014	2,650,482	22.9
2015	1,370,141	25.7
2016	1,552,395	33.1
2017	1,113,035	23.5
2018	2,030,258	13.1
2019	2,856,459	15.3

Table 7 – Comparison of mean catch, occurrence rates, and species richness between ventless black sea bass pots and scup pots for 2013-2016. Mean catch numbers display both the mean catch and standard error across the full sampling period.

Metric	Ventless Black Sea Bass Pots	Scup Pots
Mean Scup Catch (#)	1.3 ± 0.2	1.1 ± 0.1
Scup Occurrence (%)	83	76
Mean Black Sea Bass Catch (#)	0.5 ± 0.1	0.3 ± <0.1
Black Sea Bass Occurrence (%)	72	62
Tautog Catch Mean (#)	0.2 ± <0.1	<0.01
Tautog Occurrence (%)	62	3
Total Species Richness	24	19
Mean Species Richness per Set	3.4	2.1
n Sets	133	488

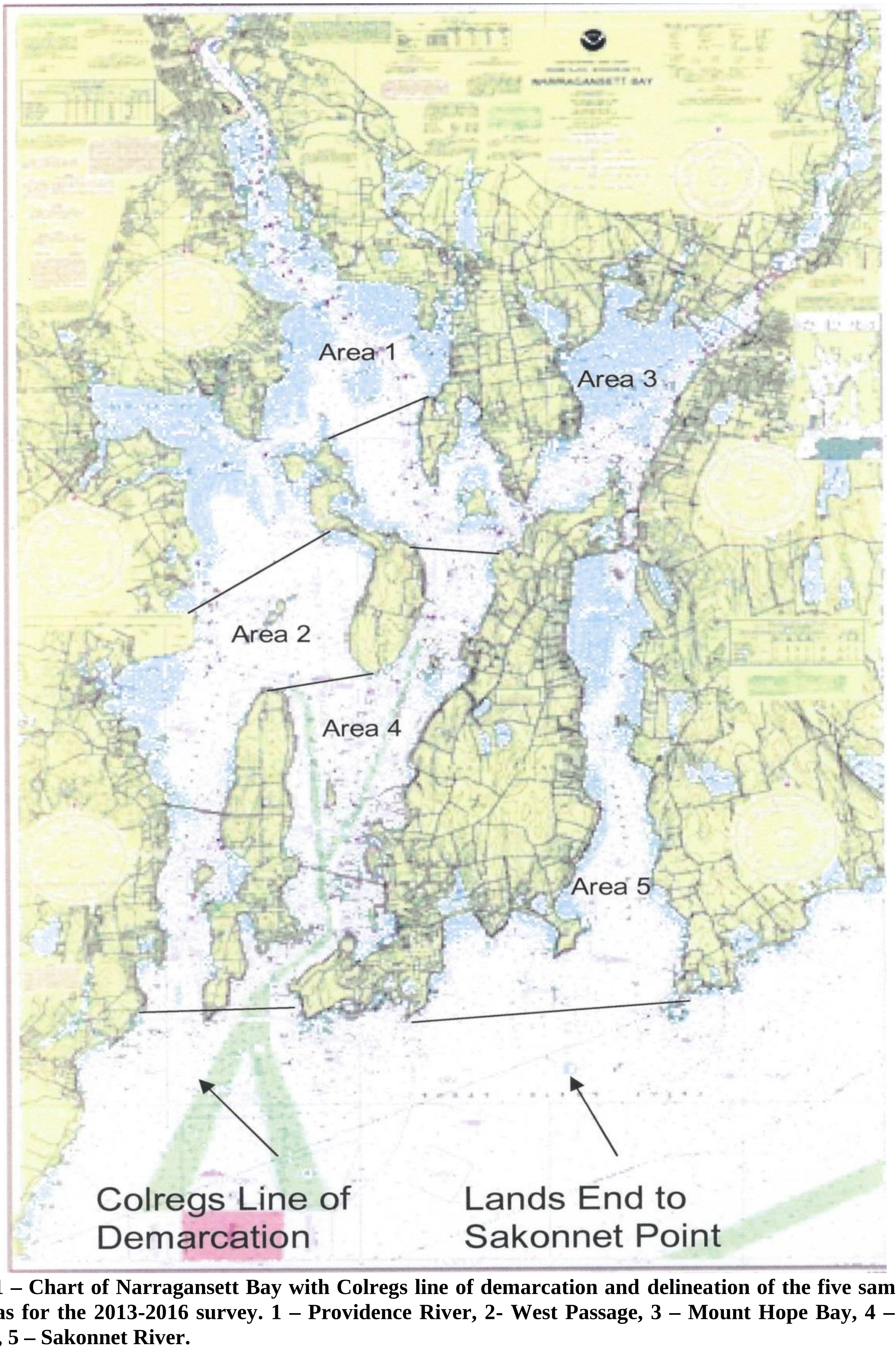

Figure 1 – Chart of Narragansett Bay with Colregs line of demarcation and delineation of the five sampling sub areas for the 2013-2016 survey. 1 – Providence River, 2- West Passage, 3 – Mount Hope Bay, 4 – East Passage, 5 – Sakonnet River.

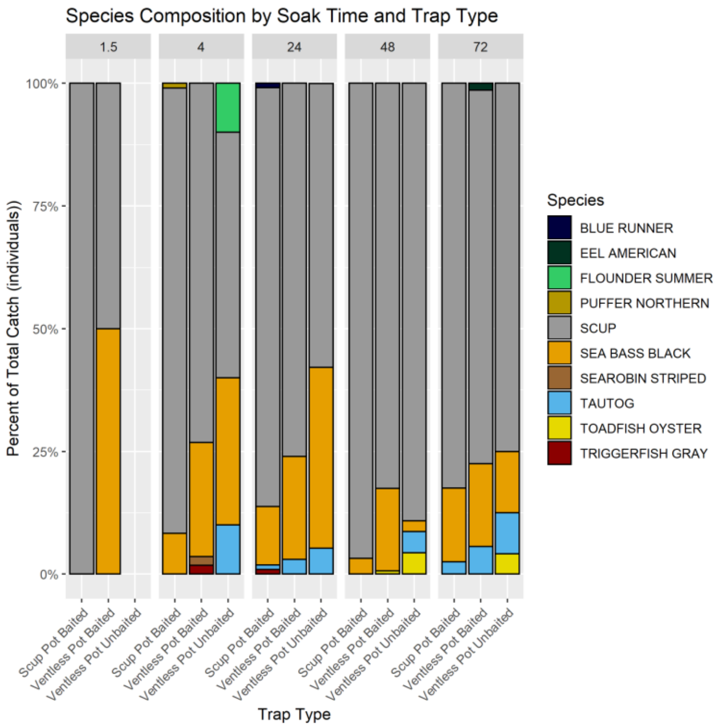

Figure 2 – Relative fish species composition by trap type and soak time from the 2019 survey.

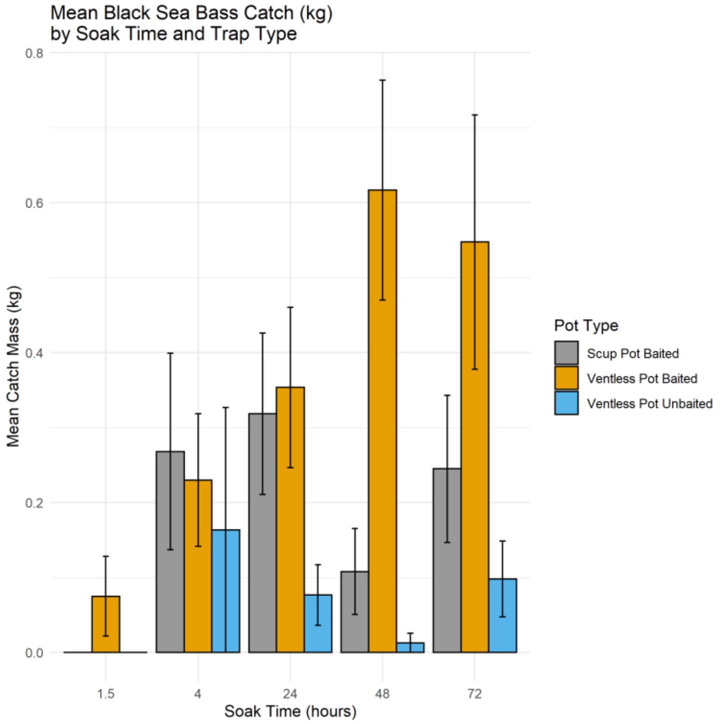

Figure 3 – Mean black sea bass biomass per pot across all pot types and soak times. Standard errors are indicated by error bars on each bar.

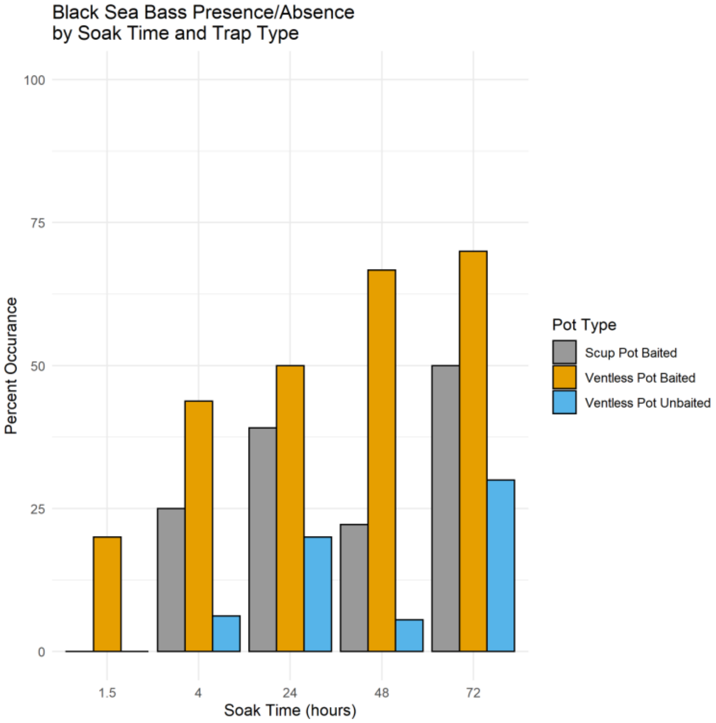

Figure 4 – Percent occurrence of black sea bass within each pot type at each sampled soak time.

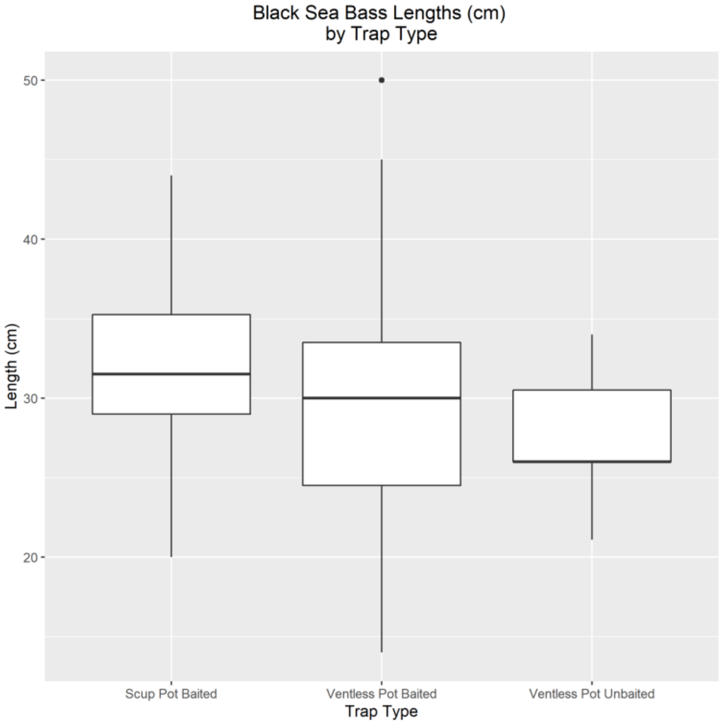

Figure 5 – Length composition of black sea bass by trap type from 2019 survey.

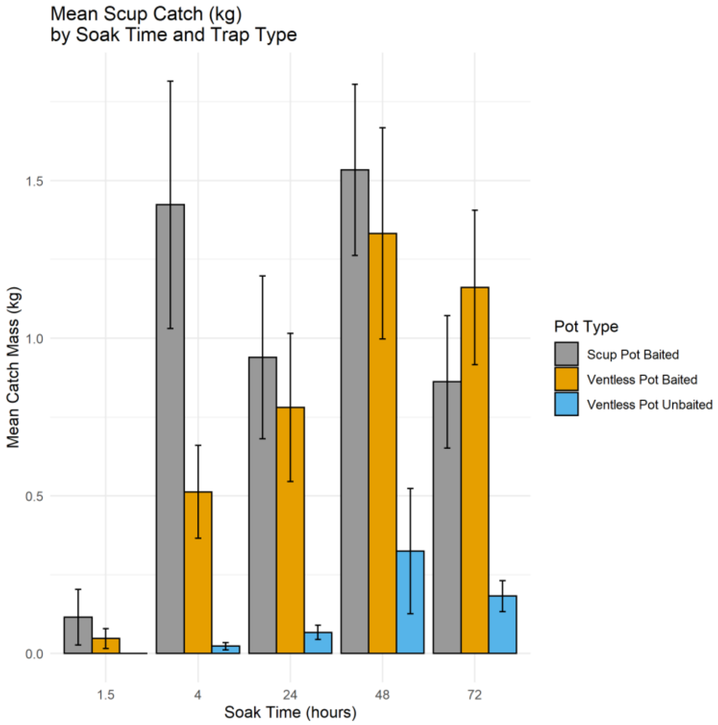

Figure 6 - Mean scup biomass per pot across all pot types and soak times. Standard errors are indicated by error bars on each bar.

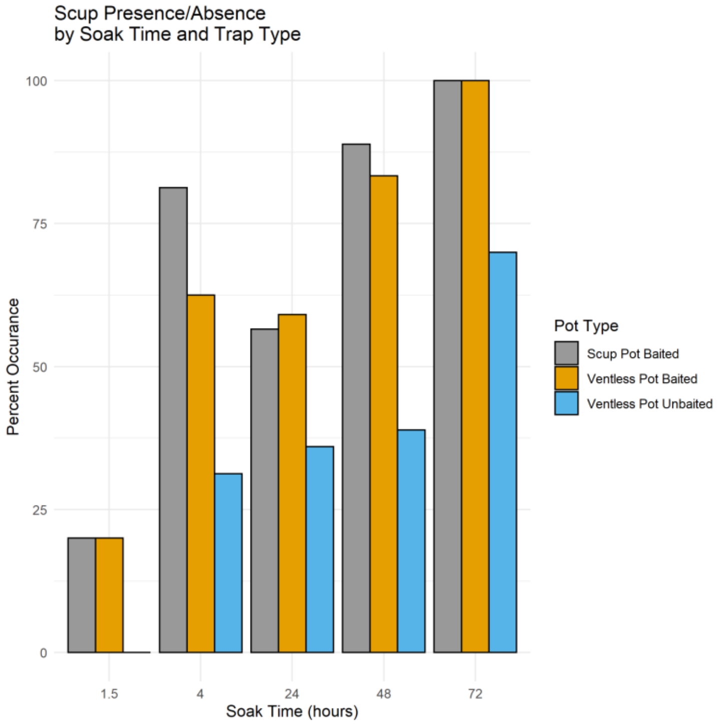

Figure 7 – Percent occurrence of scup within each pot type at each sampled soak time.

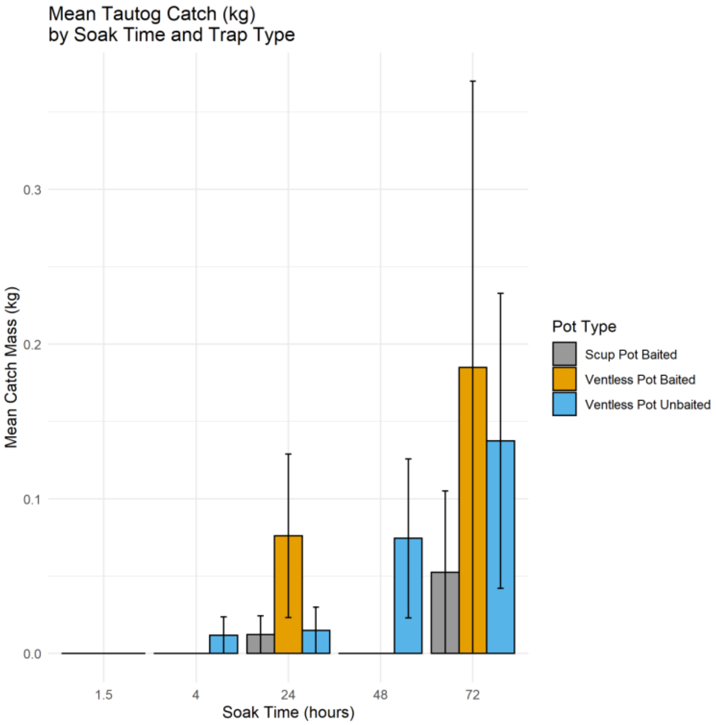

Figure 8 – Mean tautog biomass per pot across all pot types and soak times. Standard errors are indicated by error bars on each bar.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

2020 ANNUAL PERFORMANCE REPORT

Federal Aid in Sportfish Restoration
F-61-R
SEGMENT 22, JOB 13

MARINE FISHES OF RHODE ISLAND

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March 2021

STATE:	Rhode Island	PROJECT NUMBER:	F-61-R
		SEGMENT NUMBER:	22

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

JOB NUMBER: 13

JOB TITLE: Marine Fishes of Rhode Island

PERIOD COVERED: January 1, 2020 – December 31, 2020

JOB OBJECTIVE:

The goal of this project is to produce a manuscript which will act as a reference for recreational fishermen, commercial fishermen, and fisheries scientists alike. The finished product will summarize existing knowledge on the occurrence and distribution of fish species observed within Rhode Island marine waters, based on information collected through several field surveys conducted by Rhode Island Division of Marine Fisheries (RIDMF). The information will be presented systematically, and the manuscript will include scientific illustrations of fish species encountered occasionally to commonly in RIDMF surveys; rare species will not be illustrated. This work is designed to be a stand-alone manuscript, but also to be compatible with and be a companion volume to the "Inland Fishes of Rhode Island" book produced by the Rhode Island Division of Fish and Wildlife (RIDFW) in 2013.

SUMMARY:

The basic format and foundation of the book was laid out in 2017 during the previous grant award period for this project (January 1, 2014 – December 31, 2019) and included the following components: cover page, table of contents, acknowledgements, dedication, introduction, description of the data sources (field surveys) that collected the data with maps of survey sampling locations and survey activity photographs, tabular lists of species observed in RIDMF surveys (all surveys combined and by individual survey) and species reported to be observed historically by others with environmental and occurrence classifications, family descriptions, species names (including scientific and common name(s), species identification and description characteristics, species distribution (general and in RI), current management in RI (where applicable)), current RI sportfish and all-tackle (worldwide) records (where applicable), references used, glossary, and a taxonomic index.

The following sections and portions of the book were completed during the previous grant award period (January 1, 2014 – December 31, 2019) for this project (Table 1):

- cover page,
- acknowledgements,
- dedication page,
- table of contents,
- introduction,
- data source descriptions for 7 RIDMF field sampling surveys (including maps of sampling locations),
- tables of species (scientific and common name) caught in recent RIDMF surveys (all surveys combined and by individual survey) or observed by others

historically, environmental and occurrence classifications, and relative abundance level by species and survey (abundant, common, occasional, rare),
- scientific names,
- current RI sportfish record for each species (if applicable),
- all-tackle worldwide record for each species (if applicable),
- data to create species distribution maps has been compiled from GPS sampling location data for each species for each RIDMF survey. To date, species distribution information has been compiled for all 7 RIDFW / RIDMF field sampling surveys being used for the book, and
- illustrations for 55 species (1 species with male and female illustrations) for a total of 56 illustrations completed previously for “Inland Fishes of Rhode Island” book)

The glossary, references, and index sections are near completion but will need occasional revision/updates as more text is added. Tables 1 and 2 summarize the book sections completed to date. A substantial amount of progress was made on text compilation and editing during 2020 (Table 3).

A total of 284 species will appear in the “Marine Fishes of Rhode Island” book. Of these, 186 species were observed in recent RIDMF surveys and 98 species were reportedly observed by entities other than RIDMF, either recently or historically. Of the 186 species observed in RIDMF surveys, a total of 100 species will be illustrated, including 5 species with both sexes illustrated, for a total of 105 illustrations. There were 87 species observed rarely in RIDMF surveys that will not be illustrated.

A total of 56 illustrations previously completed for the RIDFW’s “Inland Fishes of Rhode Island” book (55 species; 1 species with both sexes illustrated; 2 species with only 1 of the sexes illustrated) will be utilized for this book, being species found in both agency’s sampling surveys, leaving 45 species with 49 species illustrations (2 species with both sexes illustrated; 2 species with only 1 of the sexes requiring illustration) to be completed for this book.

For this reporting period (January 1, 2020 – December 31, 2020), a total of 6 species illustrations were completed by the illustrator (Robert Jon Golder). There have been numerous (≈30) email correspondences with the illustrator during this report period and a meeting is planned for May 2021 at which time all completed illustrations will be received by RIDMF and the illustrator will receive another 10-12 frozen specimens of species requiring illustration (Table 4).

TARGET DATE: December 31, 2020 and continuing into the next grant segment
SIGNIFICANT DEVIATIONS: Species illustrations are slightly behind schedule

RECOMMENDATIONS: Continue into the next grant segment

REMARKS:

Except for illustrations completed for overlap species from our “Inland Fishes of Rhode Island” book, this marine fish illustration part of the job is now close to being on schedule. An unfortunate series of unforeseen complications occurred during the last 2 years (January 1, 2017 – December 31, 2019) of the previous grant award period (January 1, 2014 – December 31, 2019), including the death of the illustrator’s wife and 2 separate medical issues for the illustrator.

Table 1. Summary of book sections completed during previous grant award, January 1, 2014 - December 31, 2019.

Book Sections	**Number completed**	**Total Number**
Family Descriptions	60	117
Cover page	1	1
Table of Contents	1	1
Acknowledgements	1	1
Dedication	1	1
Introduction	1	1
Description of Data Sources	7	7
Survey sampling maps	7	7
Survey activity photos	4	4
Tables	6	6
Glossary	1	1
Taxonomic Index	1	1
Common / Species Name	284	284
Other Name(s)	204	284
RI Sportfish Record	284	284
All-Tackle Record	284	284
Species ID / Description	70	284
General / Local Distribution	73	284
Diet	71	284
Importance	73	284
Management	178	284
Illustrations	56 (55 species)	105 (100 species)
Species - text completed	66	284
Species - text incomplete	218	284

Table 2. Summary of book sections completed during current grant award and grant segment, January 1, 2020 - December 31, 2020.

Book Sections	**Number completed**	**Total Number**

Family Descriptions	32 (92 total)	117
Cover page	0 (1 total)	1
Table of Contents	0 (1 total)	1
Acknowledgements	0 (1 total)	1
Dedication	0 (1 total)	1
Introduction	0 (1 total)	1
Description of Data Sources	0 (7 total)	7
Survey sampling maps	0 (7 total)	7
Survey activity photos	0 (4 total)	4
Tables	0 (6 total)	6
Glossary	0 (1 total)	1
Taxonomic Index	0 (1 total)	1
Common / Species Name	0 (284 total)	284
Other Name(s)	17 (221 total)	284
RI Sportfish Record	0 (284 total)	284
All-Tackle Record	0 (284 total)	284
Species ID / Description	138 (208 total)	284
General / Local Distribution	135 (208 total)	284
Diet	39 (110 total)	284
Importance	35 (108 total)	284
Management	41 (219 total)	284
Illustrations	6 (6 species)	105 (101 species)
Species - text completed	75 (207 total)	284
Species - text incomplete	77	284

Table 3. Summary of book sections completed by species and illustration status for previous grant award (January 1, 2014 - December 31, 2019; x, done) and current grant award and segment (January 1, 2020 - December 31, 2020; **X**, **done**).

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Alosa aestivalis	x	x	x	x	x	x	x	x	x	x	done	YES	done
Alosa mediocris	x	x	x	x	x	x	x	x	x	x	done	YES	done
Alosa pseudoharengus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Alosa sapidissima	x	x	x	x	x	x	x	x	x	x	done	YES	done
Ameiurus nebulosus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	done
Ammodytes americanus	x	x	x	x	x	x	x	x	x	x	done	YES	
Anchoa hepsetus	x	x	x	x	x	x	x	x	x	x	done	YES	
Anchoa mitchilli	x	x	x	x	x	x	x	x	x	x	done	YES	done
Anguilla rostrata	x	x	x	x	x	x	x	x	x	x	done	YES	done
Apeltes quadracus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Bairdiella chrysoura		x		x	x							YES	
Brevoortia tyrannus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Caranx crysos	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Caranx hippos	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Catostomus commersoni	x	x	x	x	x	**X**	x	**X**	**X**	x	**done**	YES	done
Centropristis striata (F)		x	x	x	x			x				YES	
Centropristis striata (M)		x	x	x	x			x				YES	
Citharichthys arctifrons	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Clupea harengus	x	x	x	x	x	x	x	x	x	x	done	YES	
Conger oceanicus	x	x	x	x	x	x	x	x	x	x	done	YES	
Cynoscion regalis		x		x	x							YES	done
Cyprinodon variegatus (F)	x	x	x	x	x	x	x	x	x	x	done	YES	
Cyprinodon variegatus (M)	x	x	x	x	x	x	x	x	x	x	done	YES	done
Dorosoma cepedianum	x	x	x	x	x	x	x	x	x	x	done	YES	done
Esox niger	x	x	x	x	x	x	x	x	x	x	done	YES	done
Etropus microstomus	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Eucinostomus argenteus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Fundulus diaphanus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Fundulus heteroclitus (F)	x	x	x	x	x	x	x	x	x	x	done	YES	
Fundulus heteroclitus (M)	x	x	x	x	x	x	x	x	x	x	done	YES	done

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Fundulus majalis (F)	x	x	x	x	x	x	x	x	x	x	done	YES	done
Fundulus majalis (M)	x	x	x	x	x	x	x	x	x	x	done	YES	done
Gadus morhua	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Gasterosteus aculeatus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Gobiosoma bosc	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Hemitripterus americanus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Lagodon rhomboides	x	x		x	x							YES	done
Leiostomus xanthurus		x		x	x							YES	
Lepomis auritus	x	x	x	x	x	**X**	**X**	**X**	x	x	**done**	YES	done
Lepomis gibbosus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Lepomis macrochirus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Leucoraja erinacea		x		x	x							YES	
Leucoraja ocellata		x		x	x							YES	
Lophius americanus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Lucania parva	x	x	x	x	x	x	x	x	x	x	done	YES	done
Lutjanus griseus	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Luxilus cornutus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Melanogrammus aeglefinus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Menidia beryllina	x	x	x	x	x	x	x	x	x	x	done	YES	done
Menidia menidia	x	x	x	x	x	x	x	x	x	x	done	YES	done
Menticirrhus saxatilis		x		x	x							YES	done
Merluccius bilinearis	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Microgadus tomcod	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Micropterus dolomieu	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Micropterus salmoides	x	x	x	x	x	x	**X**	**X**	**X**	x	**done**	YES	done
Morone americana	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Morone saxatilis	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Mugil curema	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Mustelus canis		x		x	x							YES	
Myoxocephalus aenaeus	x	x	x	x	x	x	x	x	x	x	done	YES	
Myoxocephalus octodecemspinosus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Notemigonus crysoleucas	x	x	x	x	x	x	x	x	x	x	done	YES	done
Opsanus tau	x	x	x	x	x	x	x	x	x	x	done	YES	
Osmerus mordax	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Paralichthys dentatus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Paralichthys oblongus	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Peprilus triacanthus		x		x	x							YES	done
Petromyzon marinus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Pholis gunnellus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Pollachius virens	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Pomatomus saltatrix		x		x	x							YES	done
Pomoxis nigromaculatus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Priacanthus arenatus		x		x	x					x		YES	
Prionotus carolinus		x		x	x							YES	done
Prionotus evolans		x		x	x							YES	
Pseudopleuronectes americanus	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	done
Pungitius pungitius	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Raja eglanteria		x		x	x							YES	
Rhinichthys atratulus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Salmo salar		x		x	x							YES	done
Salmo trutta		x		x	x							YES	done
Salvelinus fontinalis		x		x	x							YES	done
Scomber scombrus		x		x	x							YES	
Scophthalmus aquosus		x		x	x							YES	done
Selene setapinnis	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Selene vomer	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Sphoeroides maculatus	x	x	x	x	x					x		YES	
Sphyraena borealis		x		x	x							YES	
Squalus acanthias		x		x	x							YES	
Stenotomus chrysops	x	x	x	x	x		x			x		YES	
Strongylura marina	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	done
Syngnathus fuscus	**X**	x	x	x	x					x		YES	done
Synodus foetens	x	x	x	x	x	x	x	x	x	x	done	YES	
Tautoga onitis (F)	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Tautoga onitis (M)	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Tautogolabrus adspersus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Trachurus lathami	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Trinectes maculatus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Upeneus parvus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Urophycis chuss	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	

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Urophycis regia	**X**	x	x	x	x					x		YES	
Urophycis tenuis	**X**	x	x	x	x					x		YES	
Zoarces americanus		x		x	x							YES	
Ablennes hians	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Abudefduf saxatilis		x		x	x							NO	N/A
Acanthostracion polygonius	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Acanthostracion quadricornis	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Acanthurus chirurgus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Acipenser brevirostrum	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Acipenser oxyrinchus oxyrinchus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Acipenser sturio	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Albula vulpes	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Alectis ciliaris	x	x	x	x	x	**X**	**X**	**X**	x	x	**done**	NO	N/A
Alepisaurus ferox	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Alopias vulpinus	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Aluterus heudelotii	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Aluterus monoceros	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Aluterus schoepfii	x	x	x	x	x	x	**X**	x	x	x	**done**	NO	N/A
Aluterus scriptus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Amblyraja radiata		x		x	x							NO	N/A
Ammodytes dubius	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Anarhichas lupus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Antigonia capros	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Apogon imberbis	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Archosargus probatocephalus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Ariopsis felis	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Aspidophoroides monopterygius	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Astroscopus guttatus		x		x	x					**X**		NO	N/A
Auxis thazard		x		x	x							NO	N/A
Bagre marinus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Balistes capriscus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Balistes vetula	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Bothus robinsi	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Brosme brosme	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Calamus bajonado	x	x		x	x							NO	N/A

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Carangoides bartholomaei	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Carcharhinus obscurus	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Carcharhinus plumbeus	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Carcharias taurus	x	x	x	x	x	x	x	x	x	**X**	**done**	NO	N/A
Carcharodon carcharias	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Caulolatilus microps	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Centrolophus niger	x	x	x	x	x	**X**	x	**X**	**X**	x	**done**	NO	N/A
Centropristis philadelphica		x		x	x							NO	N/A
Cetorhinus maximus	x	x	x	x	x	**X**	**X**	**X**	x	**X**	**done**	NO	N/A
Chaetodipterus faber	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Chaetodon capistratus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Chaetodon ocellatus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Chaetodon striatus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Cheilopogon furcatus	x	x	x	x	x	**X**	x	**X**	**X**	x	**done**	NO	N/A
Chilomycterus schoepfii	x	x	x	x	x	**X**	x	**X**	**X**	x	**done**	NO	N/A
Coryphaena hippurus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Cryptacanthodes maculatus	x	x	x	x	x	**X**	x	**X**	**X**	x	**done**	NO	N/A
Ctenogobius boleosoma	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Cyclopsetta fimbriata	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Cyclopterus lumpus	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Dactylopterus volitans	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Dasyatis centroura	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Dasyatis say	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Decapterus macarellus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Decapterus punctatus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Dibranchus atlanticus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Diodon hystrix	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Dipturus laevis		x		x	x							NO	N/A
Echeneis naucrates	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Echeneis neucratoides	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Elops saurus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Enchelyopus cimbrius	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Engraulis eurystole	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Epinephelus niveatus		x		x	x							NO	N/A
Etrumeus teres	x	x	x	x	x	x	x	x	x	x	done	NO	N/A

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Eucinostomus gula	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Euleptorhamphus velox	x	x	x	x	x	X	X	X	x	x	**done**	NO	N/A
Euthynnus alletteratus		x		x	x							NO	N/A
Fistularia tabacaria	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Gaidropsarus ensis	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Galeocerdo cuvier	x	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Gasterosteus wheatlandi	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Ginglymostoma cirratum	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Glyptocephalus cynoglossus	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Gobiosoma ginsburgi	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Gymnura altavela	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Helicolenus dactylopterus		x		x	x							NO	N/A
Heteropriacanthus cruentatus		x		x	x							NO	N/A
Hippocampus erectus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Hippoglossoides platessoides	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Hippoglossus hippoglossus	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Histrio histrio	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Holocentrus adscensionis	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Hyperoglyphe perciformis	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Hyporhamphus unifasciatus	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Isurus oxyrinchus	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Kajikia albida	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Katsuwonus pelamis		x		x	x							NO	N/A
Kyphosus sectator	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Lactophrys trigonus	x	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Lactophrys triqueter	x	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Lagocephalus laevigatus	x	x	x	x	x					x		NO	N/A
Lamna nasus	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Lampris guttatus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Lepophidium profundorum	X	x	X	x	x	X	X	X	X	x	**done**	NO	N/A
Leptoclinus maculatus		x		x	x							NO	N/A
Leucoraja garmani		x		x	x							NO	N/A
Limanda ferruginea	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Liopsetta putnami	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Liparis atlanticus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Liparis liparis	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Lobotes surinamensis	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Lopholatilus chamaeleonticeps	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Lutjanus analis	X	x	X	x	x	X	X	X	X	x	**done**	NO	N/A
Lutjanus aratus	X	x	X	x	x	X	X	X	X	x	**done**	NO	N/A
Lutjanus campechanus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Lycenchelys verrillii		x		x	x							NO	N/A
Lycodes reticulatus		x		x	x							NO	N/A
Macroramphosus scolopax	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Makaira nigricans	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Malacoraja senta		x		x	x							NO	N/A
Manta birostris	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Megalops atlanticus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Micropogonias undulatus		x		x	x							NO	N/A
Mobula hypostoma	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Mola mola	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Monacanthus ciliatus	x	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Mugil cephalus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Mullus auratus	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Mycteroperca microlepis		x		x	x							NO	N/A
Mycteroperca phenax		x		x	x							NO	N/A
Myliobatis freminvillii	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Myoxocephalus quadricornis	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Myoxocephalus scorpius	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Naucrates ductor	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Nomeus gronovii	X	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Oligoplites saurus	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Ophidion marginatum	X	x	X	x	x	X	X	X	X	x	**done**	NO	N/A
Opisthonema oglinum	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Orthopristis chrysoptera	X	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Paralichthys albigutta	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Parexocoetus hillianus	x	x	x	x	x	X	X	X	X	x	**done**	NO	N/A
Peprilus paru		x		x	x							NO	N/A
Peristedion miniatum		x		x	x							NO	N/A
Pogonias cromis		x		x	x							NO	N/A

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Prionace glauca	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Prionotus rubio		x	x	x	x							NO	N/A
Pristigenys alta		x		x	x					x		NO	N/A
Prognichthys gibbifrons	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Pseudupeneus maculatus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Rachycentron canadum		x		x	x							NO	N/A
Remora brachyptera	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Remora osteochir	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Remora remora	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Rhinoptera bonasus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Rypticus bistrispinus		x		x	x							NO	N/A
Sarda sarda		x		x	x							NO	N/A
Sardinella aurita	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Sargocentron vexillarium	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Sciaenops ocellatus		x		x	x					x		NO	N/A
Scomber colias		x		x	x							NO	N/A
Scomberesox saurus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Scomberomorus maculatus		x		x	x							NO	N/A
Scomberomorus regalis		x		x	x							NO	N/A
Scyliorhinus retifer		x		x	x							NO	N/A
Sebastes norvegicus		x		x	x							NO	N/A
Selar crumenophthalmus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Seriola lalandei	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Seriola zonata	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Sphoeroides spengleri	x	x	x	x	x	x		x	x	x		NO	N/A
Sphoeroides testudineus	x	x	x	x	x					x		NO	N/A
Sphyraena barracuda		x		x	x							NO	N/A
Sphyraena guachancho		x		x	x							NO	N/A
Sphyrna lewini		x	x	x	x							NO	N/A
Sphyrna tiburo		x	x	x	x							NO	N/A
Sphyrna zygaena		x	x	x	x							NO	N/A
Squatina dumeril		x		x	x							NO	N/A
Stegastes leucostictus		x		x	x							NO	N/A
Stegastes partitus		x		x	x							NO	N/A
Stephanolepis hispidus	x	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A

SPECIES	Family Description	Species Name/Common Name	Other Names	RI sportfish record	All-Tackle record	ID / Description	General / Local Distribution	Diet	Importance	Management	Text Status	Illustration	Illustration Status
Synodus synodus	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Thunnus alalunga		x		x	x							NO	N/A
Thunnus albacares		x		x	x							NO	N/A
Thunnus obesus		x		x	x							NO	N/A
Thunnus thynnus		x		x	x							NO	N/A
Torpedo nobiliana		x		x	x							NO	N/A
Trachinocephalus myops	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Trachinotus carolinus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Trachinotus falcatus	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Trichiurus lepturus		x		x	x							NO	N/A
Tylosurus crocodilus	x	x	x	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
Ulvaria subbifurcata		x		x	x							NO	N/A
Xiphias gladius		x		x	x							NO	N/A
Zenopsis conchifera	x	x	x	x	x	x	x	x	x	x	done	NO	N/A

Table 4. Summary of species illustrations completed during current grant award and grant period (January 1, 2020 - December 31, 2020; **x**, **done**) and species previously illustrated for the "Inland Fishes of Rhode Island" book to be used in the "Marine Fishes of Rhode Island" book.

SPECIES	COMMON NAME	Draft pencil sketches	Final pencil sketch	Draft INK illustration	Final INK illustration	Draft COLOR illustration	Final COLOR illustration	ILLUSTRATIONS COMPLETED	Book
Ammodytes americanus	American sand lance	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Anchoa hepsetus	Striped anchovy	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Bairdiella chrysoura	Silver perch								Marine Fishes of RI
Caranx crysos	Blue runner	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Centropristis striata (F)	Black sea bass								Marine Fishes of RI
Centropristis striata (M)	Black sea bass								Marine Fishes of RI
Citharichthys arctifrons	Gulfstream flounder								Marine Fishes of RI
Clupea harengus	Atlantic herring	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Cyprinodon variegatus (F)	Sheepshead minnow								Marine Fishes of RI
Decapterus macarellus	Mackerel scad								Marine Fishes of RI
Decapterus punctatus	Round scad								Marine Fishes of RI
Enchelyopus cimbrius	Fourbeard rockling								Marine Fishes of RI
Etropus microstomus	Smallmouth flounder								Marine Fishes of RI
Fundulus heteroclitus (F)	Mummichog								Marine Fishes of RI
Gadus morhua	Atlantic cod								Marine Fishes of RI
Hemitripterus americanus	Sea raven								Marine Fishes of RI
Leiostomus xanthurus	Spot								Marine Fishes of RI
Leucoraja erinacea	Little skate								Marine Fishes of RI
Leucoraja ocellata	Winter skate								Marine Fishes of RI
Lophius americanus	American goosefish								Marine Fishes of RI
Melanogrammus aeglefinus	Haddock								Marine Fishes of RI
Merluccius bilinearis	Silver hake								Marine Fishes of RI
Mugil cephalus	Striped mullet								Marine Fishes of RI
Mustelus canis	Smooth dogfish								Marine Fishes of RI
Myoxocephalus aenaeus	Grubby sculpin								Marine Fishes of RI

Myoxocephalus octodecemspinosus	Longhorn sculpin								Marine Fishes of RI
Opsanus tau	Oyster toadfish								Marine Fishes of RI
Paralichthys dentatus	Summer flounder								Marine Fishes of RI
Paralichthys oblongus	Fourspot flounder								Marine Fishes of RI
Pholis gunnellus	Rock gunnel	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Pollachius virens	Pollock	**X**	**X**	**X**	**X**	**X**	**X**	**done**	Marine Fishes of RI
Priacanthus arenatus	Bigeye								Marine Fishes of RI
Prionotus evolans	Striped searobin								Marine Fishes of RI
Raja eglanteria	Clearnose skate								Marine Fishes of RI
Scomber scombrus	Atlantic mackerel	**X**	**X**	**X**	**X**	**X**			Marine Fishes of RI
Selene setapinnis	Atlantic moonfish								Marine Fishes of RI
Sphoeroides maculatus	Northern puffer								Marine Fishes of RI
Sphyraena borealis	Northern sennet								Marine Fishes of RI
Squalus acanthias	Spiny dogfish								Marine Fishes of RI
Stenotomus chrysops	Scup								Marine Fishes of RI
Synodus foetens	Inshore lizardfish								Marine Fishes of RI
Tautoga onitis (F)	Tautog								Marine Fishes of RI
Tautoga onitis (M)	Tautog								Marine Fishes of RI
Tautogolabrus adspersus	Cunner								Marine Fishes of RI
Trachurus lathami	Rough scad								Marine Fishes of RI
Upeneus parvus	Dwarf goatfish								Marine Fishes of RI
Urophycis chuss	Red hake								Marine Fishes of RI
Urophycis regia	Spotted hake								Marine Fishes of RI
Urophycis tenuis	White hake								Marine Fishes of RI
Zoarces americanus	Ocean pout								Marine Fishes of RI
Alosa mediocris	Hickory shad	X	X	X	X	X	X	done	Inland Fishes of RI
Alosa pseudoharengus	Alewife	X	X	X	X	X	X	done	Inland Fishes of RI
Alosa sapidissima	American shad	X	X	X	X	X	X	done	Inland Fishes of RI
Ameiurus nebulosus	Brown bullhead	X	X	X	X	X	X	done	Inland Fishes of RI
Anchoa mitchilli	Bay anchovy	X	X	X	X	X	X	done	Inland Fishes of RI
Anguilla rostrata	American eel	X	X	X	X	X	X	done	Inland Fishes of RI
Apeltes quadracus	Fourspine stickleback	X	X	X	X	X	X	done	Inland Fishes of RI
Brevoortia tyrannus	Atlantic menhaden	X	X	X	X	X	X	done	Inland Fishes of RI
Caranx hippos	Crevalle jack	X	X	X	X	X	X	done	Inland Fishes of RI
Catostomus commersoni	White sucker	X	X	X	X	X	X	done	Inland Fishes of RI
Cynoscion regalis	Weakfish	X	X	X	X	X	X	done	Inland Fishes of RI
Cyprinodon variegatus (M)	Sheepshead minnow	X	X	X	X	X	X	done	Inland Fishes of RI
Dorosoma cepedianum	American gizzard shad	X	X	X	X	X	X	done	Inland Fishes of RI
Esox niger	Chain pickerel	X	X	X	X	X	X	done	Inland Fishes of RI
Eucinostomus argenteus	Spotfin mojarra	X	X	X	X	X	X	done	Inland Fishes of RI
Fundulus diaphanus	Banded killifish	X	X	X	X	X	X	done	Inland Fishes of RI

Fundulus heteroclitus (M)	Mummichog	X	X	X	X	X	X	done	Inland Fishes of RI
Fundulus majalis (F)	Striped killifish	X	X	X	X	X	X	done	Inland Fishes of RI
Fundulus majalis (M)	Striped killifish	X	X	X	X	X	X	done	Inland Fishes of RI
Gasterosteus aculeatus	Threespine stickleback	X	X	X	X	X	X	done	Inland Fishes of RI
Gobiosoma bosc	Naked goby	X	X	X	X	X	X	done	Inland Fishes of RI
Lagodon rhomboides	Pinfish	X	X	X	X	X	X	done	Inland Fishes of RI
Lepomis auritus	Redbreast sunfish	X	X	X	X	X	X	done	Inland Fishes of RI
Lepomis gibbosus	Pumpkinseed	X	X	X	X	X	X	done	Inland Fishes of RI
Lepomis macrochirus	Bluegill	X	X	X	X	X	X	done	Inland Fishes of RI
Lucania parva	Rainwater killifish	X	X	X	X	X	X	done	Inland Fishes of RI
Lutjanus griseus	Gray snapper	X	X	X	X	X	X	done	Inland Fishes of RI
Luxilus cornutus	Common shiner	X	X	X	X	X	X	done	Inland Fishes of RI
Menidia beryllina	Inland silverside	X	X	X	X	X	X	done	Inland Fishes of RI
Menidia menidia	Atlantic silverside	X	X	X	X	X	X	done	Inland Fishes of RI
Menticirrhus saxatilis	Northern kingfish	X	X	X	X	X	X	done	Inland Fishes of RI
Microgadus tomcod	Atlantic tomcod	X	X	X	X	X	X	done	Inland Fishes of RI
Micropterus dolomieu	Smallmouth bass	X	X	X	X	X	X	done	Inland Fishes of RI
Micropterus salmoides	Largemouth bass	X	X	X	X	X	X	done	Inland Fishes of RI
Morone americana	White perch	X	X	X	X	X	X	done	Inland Fishes of RI
Morone saxatilis	Striped bass	X	X	X	X	X	X	done	Inland Fishes of RI
Mugil curema	White mullet	X	X	X	X	X	X	done	Inland Fishes of RI
Notemigonus crysoleucas	Golden shiner	X	X	X	X	X	X	done	Inland Fishes of RI
Osmerus mordax	Rainbow smelt	X	X	X	X	X	X	done	Inland Fishes of RI
Peprilus triacanthus	Butterfish	X	X	X	X	X	X	done	Inland Fishes of RI
Petromyzon marinus	Sea lamprey	X	X	X	X	X	X	done	Inland Fishes of RI
Pomatomus saltatrix	Bluefish	X	X	X	X	X	X	done	Inland Fishes of RI
Pomoxis nigromaculatus	Black crappie	X	X	X	X	X	X	done	Inland Fishes of RI
Prionotus carolinus	Northern searobin	X	X	X	X	X	X	done	Inland Fishes of RI
Pseudopleuronectes americanus	Winter flounder	X	X	X	X	X	X	done	Inland Fishes of RI
Pungitius pungitius	Ninespine stickleback	X	X	X	X	X	X	done	Inland Fishes of RI
Rhinichthys atratulus	Blacknose dace	X	X	X	X	X	X	done	Inland Fishes of RI
Salmo salar	Atlantic salmon	X	X	X	X	X	X	done	Inland Fishes of RI
Salmo trutta	Brown trout	X	X	X	X	X	X	done	Inland Fishes of RI
Salvelinus fontinalis	Brook trout	X	X	X	X	X	X	done	Inland Fishes of RI
Scophthalmus aquosus	Windowpane flounder	X	X	X	X	X	X	done	Inland Fishes of RI
Selene vomer	Lookdown	X	X	X	X	X	X	done	Inland Fishes of RI
Strongylura marina	Atlantic needlefish	X	X	X	X	X	X	done	Inland Fishes of RI
Syngnathus fuscus	Northern pipefish	X	X	X	X	X	X	done	Inland Fishes of RI
Trinectes maculatus	Hogchocker	X	X	X	X	X	X	done	Inland Fishes of RI

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

University of Rhode Island
Graduate School of Oceanography
Weekly Fish Trawl
2020

PERFORMANCE REPORT
F-61-R SEGMENT 21
JOB 14

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March 2021

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, 2020 – December 31, 2020.

TARGET DATE: December 2020

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

RECOMMENDATIONS: Continuation of the weekly trawl survey into 2021; 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 2020. 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 2020 survey year as they relate to those of the past years since the beginning of the survey.

Methods:

A weekly trawl survey is conducted on the URI research vessel Cap’n Bert. Two stations are sampled each week (Figure 1): one off Wickford, RI 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 since the survey began. A 30-minute 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

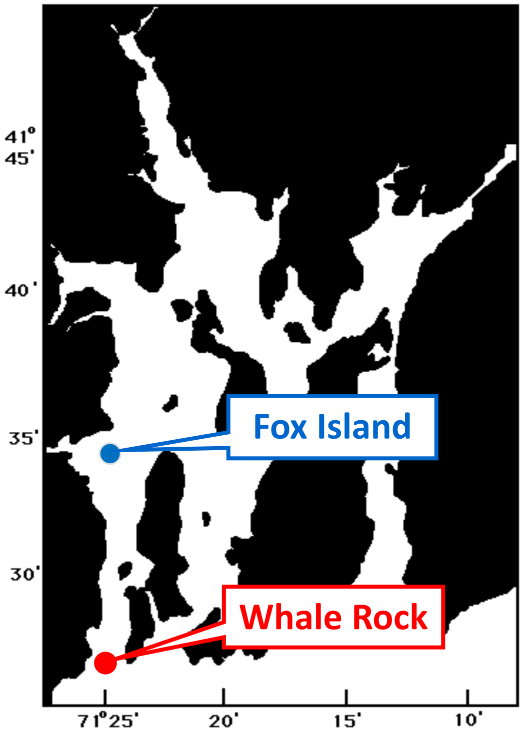


Figure 1. Location of trawl stations in Narragansett Bay.

(For more information about the GSO fish trawl go https://web.uri.edu/fishtrawl/)

Forty-two weekly tows were made at both the bay (Fox Island) and sound (Whale Rock) stations. A 9-week sampling gap occurred between March 17 and May 25, 2020 due to the outbreak of COVID-19.

For this report, the number of organisms caught at each station separately during the missing weeks was estimated by calculating the mean proportion of the year's total caught during the gap over the previous 10 years (excluding 2017 which had a similar data gap) after normalizing each year to ensure equal weighting. We then multiplied the non-gap proportion (1 – gap proportion) by the number caught during the remainder of 2021 to estimate how many individuals we expected to catch during the missing time period. Next, we distributed the catch by week by calculating the mean weekly cumulative sum since January 1 over the previous 10 years (excluding 2017) after normalizing each year to ensure equal weighting. We then calculated expected weekly catch rounded to the nearest whole fish based on the mean weekly cumulative sum and expected total sum during the time gap. More in-depth modelling approaches are being explored for a long-term solution.

Surface temperatures at Fox Island were replaced with observations at NOAA QPTR1 located in the West Passage off of Quonset Point. Surface temperatures at Whale Rock were replaced with observations at NOAA weather buoy NWPR1 located in the East Passage off of Newport. Input values from the buoy data were corrected based on consistent differences between the buoy temps and the recorded Fish Trawl temps for the rest of the year.

<u>Results</u>:

<u>Environmental conditions</u>

Weekly water temperatures at both stations were overall slightly warmer than the historic average throughout the year (Figure 2). The greatest difference between 2020 temperatures and the historical averages was at the beginning of the year.

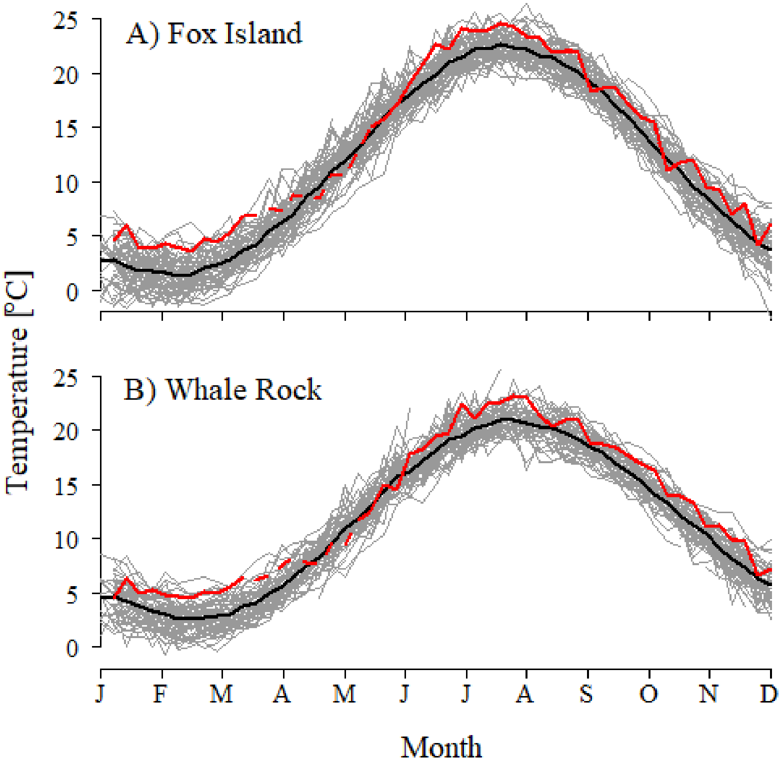


Figure 2. Weekly sea surface temperature of Narragansett Bay at each sampling station. The gray lines represent the seasonal temperature cycle for each previous year. The black line is the average temperature over all years. The most recent year, 2020, is labeled red. The dashed portion is the filled data gap.

Summary catch statistics

Table 3. Total catch by species at Fox Island (FI) and Whale Rock (WR) for the top 25 species. Per-station and overall totals include the recorded data and the catch estimates during the data gap period from March to May.

Species	**FI**	**WR**	**Total**
SCUP (*Stenotomus chrysops*)	5462	1037	6499
ROCK CRAB (*Cancer irroratus*)	40	4255	4295
SQUID (*Loligo peali*)	319	1696	2015
BUTTERFISH (*Peprilus triancanthus*)	171	1502	1673
SILVER HAKE (*Merluccius bilinearis*)	6	573	579
SUMMER FLOUNDER (*Paralichthys dentatus*)	302	271	573
HERMIT CRABS (*Pagurus pollicaris*)	529	12	541
SPIDER CRAB (*Libinia emarginata*)	183	316	499
LITTLE SKATE (*Raja erinacea*)	68	393	461
BAY ANCHOVY (*Anchoa mitchilli*)	349	39	388
BLUE CRAB (*Callinectes sapidus*)	207	123	330
STRIPED SEAROBIN (Prionotus evolans)	103	207	310
MOONFISH (*Selene setapinnis*)	185	109	294
CONCH (*Busycon canaliculatum & B. carica*)	252	16	268
WINTER FLOUNDER (*Pseudopleuronectes americanus*)	32	135	167
WEAKFISH (*Cynoscion regalis*)	28	135	163
SPOTTED HAKE (*Urophycis regia*)	8	152	160
ATLANTIC HERRING (*Clupea harengus*)	62	66	128
LOBSTER (*Homarus americanus*)	1	116	117
SAND FLOUNDER (*Scophthalmus aquosus*)	6	99	105
JONAH CRAB (*Cancer borealis*)	0	99	99
MANTIS SHRIMP (*Squilla empusa*)	12	81	93
SMOOTH DOGFISH (*Mustelus canis*)	77	15	92
SMALLMOUTH FLOUNDER (*Etropus microstomus*)	24	59	83
BLUE MUSSEL (*Mytilus edulis*)	82	0	82
Total	**8508**	**11506**	**20014**

The top 10 species caught in 2020 (and the station where they were most numerous) were: Scup (FI), Rock crabs (WR), Squid (WR), Butterfish (WR), Silver Hake (WR), Summer flounder (FI), Hermit crabs (FI), Spider crabs (WR), Little skate (WR), and Bay anchovy (FI).

A number of species of recreational importance were collected during 2020 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 (Figure 3). The survey information is used during the stock assessment process for winter flounder.

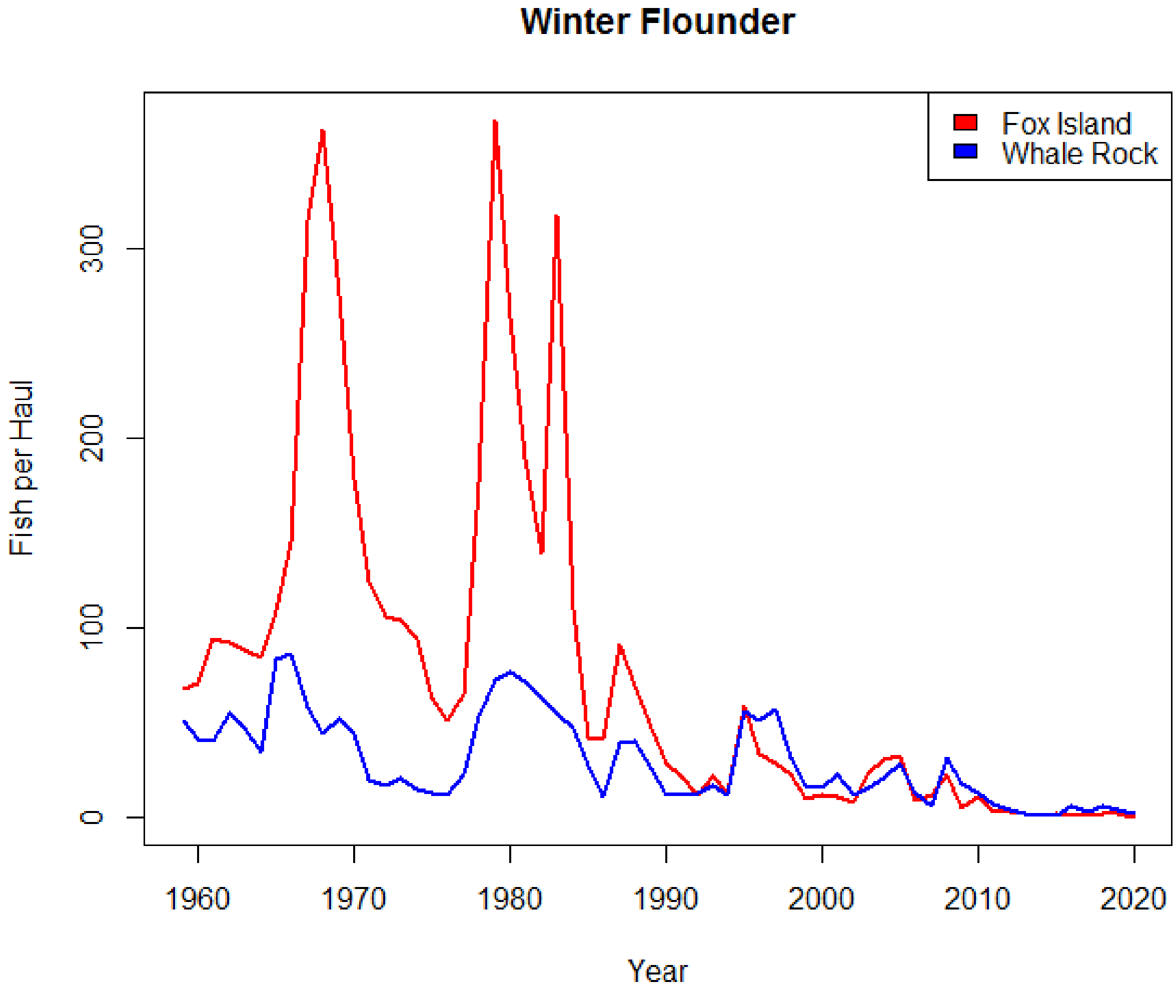


Figure 3 – Survey data for entire time series for winter flounder at both sampling stations (Fox Island and Whale Rock).

Tautog

Tautog are another important recreational species caught by the survey. The population of tautog has declined dramatically during the time period of the survey, but does show some small improvement in the most recent period of time (Figure 4). Despite the improvement, the population according to the survey has not rebounded to former levels. Tautog are mainly caught at the Fox Island station, with only random and infrequent catches occurring at Whale Rock. The survey information was reviewed during the stock assessment process for tautog.

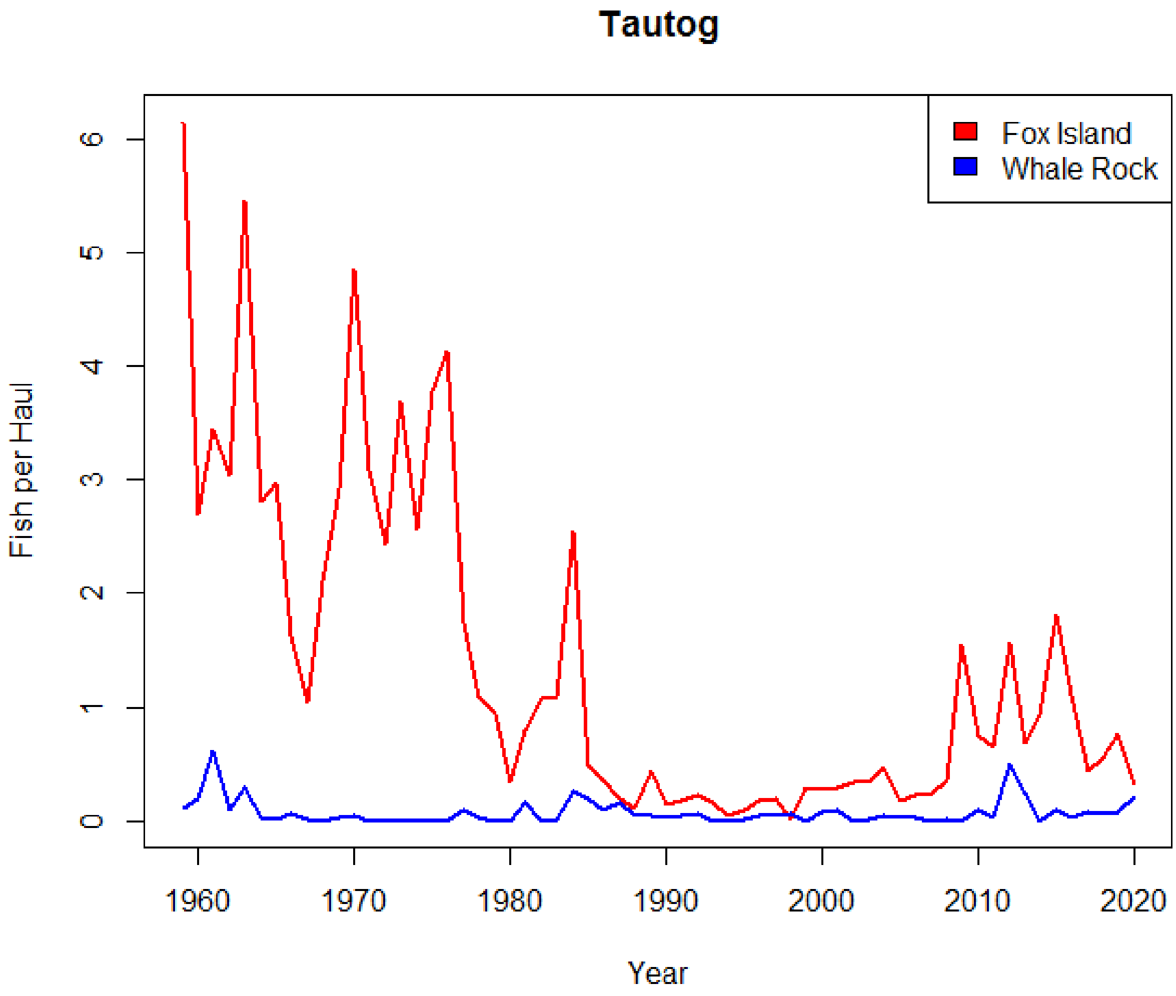


Figure 4 – Survey data for entire time series for tautog at both sampling stations (Fox Island and Whale Rock).

Summer Flounder

Summer flounder are another important recreational species caught by the survey. The population of summer flounder has increased dramatically during the time period of the survey, but does showing a fair amount of variability in the most recent time period (Figure 5). Summer flounder are caught at both sampling stations pretty consistently, though abundance has increased at Whale Rock relative to Fox Island. The survey information was reviewed during the stock assessment process for summer flounder, and the trends indicated by the survey are similar to those indicated by the overall population trends.

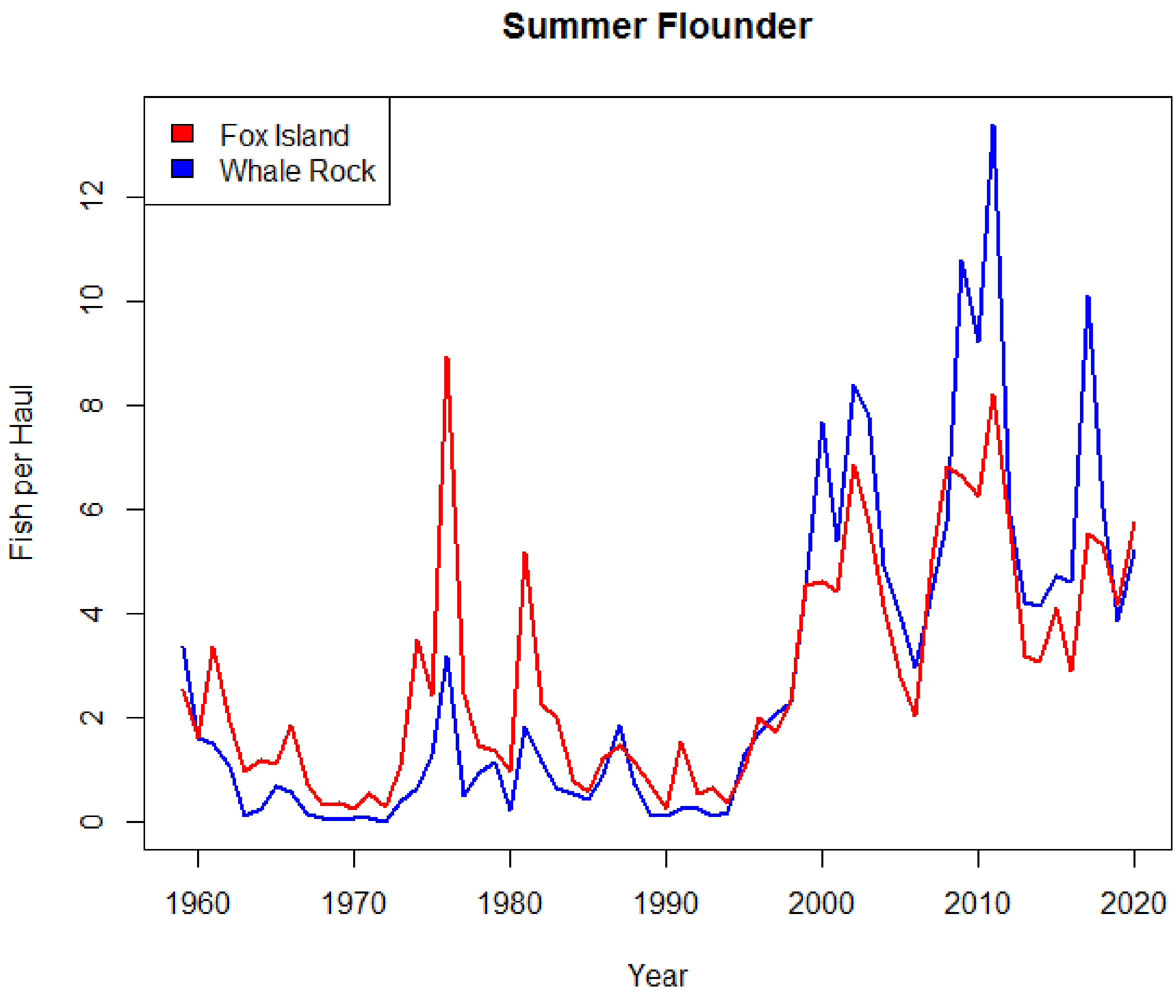
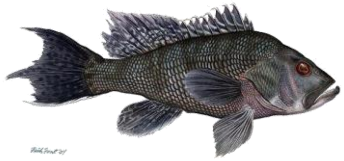


Figure 5 – Survey data for entire time series for summer flounder at both sampling stations (Fox Island and Whale Rock).



Black Sea Bass

Black sea bass are another important recreational species caught consistently by the survey. The population of black sea bass has increased dramatically 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 6). Black sea bass are caught at both sampling stations pretty consistently.

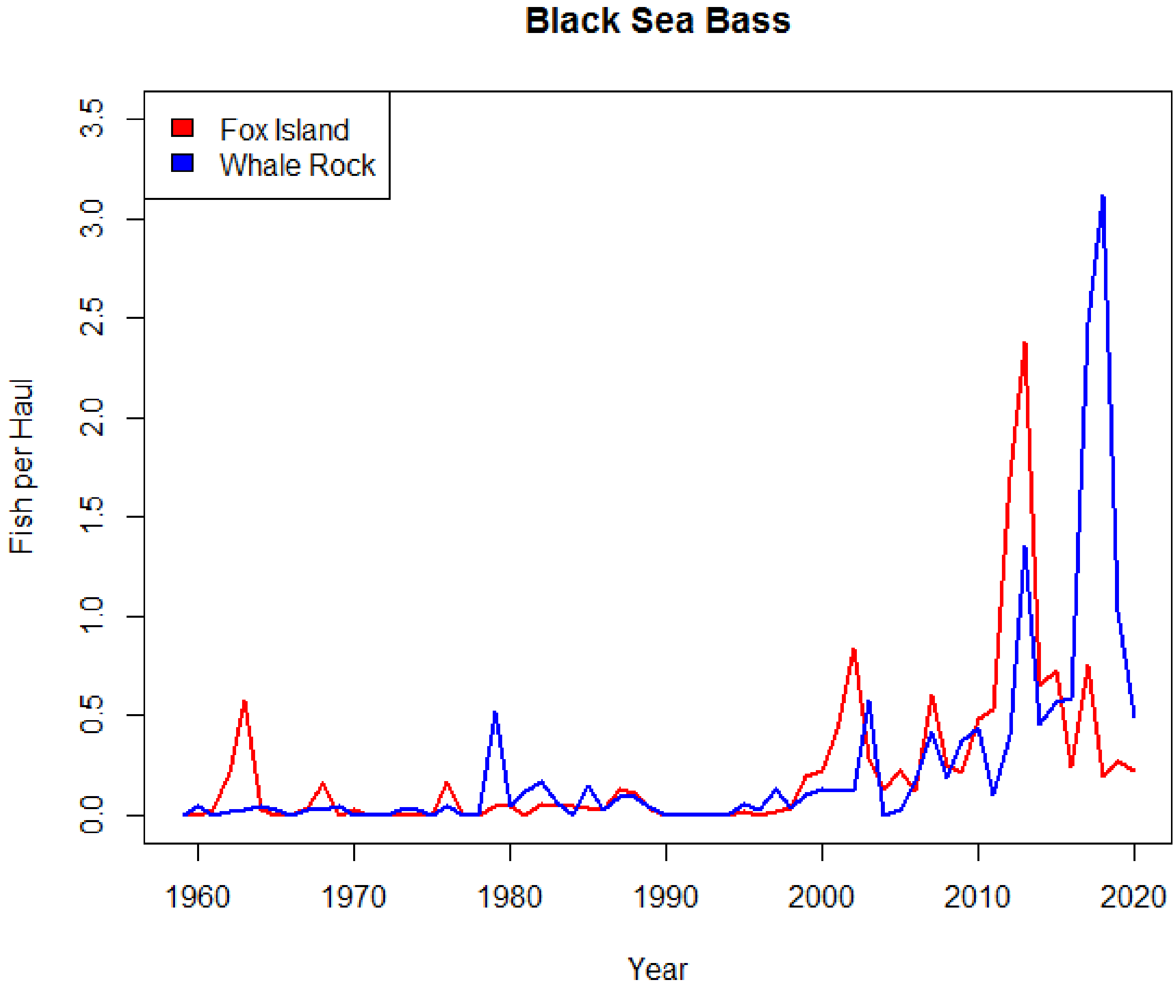


Figure 6 – Survey data for entire time series for black sea bass at both sampling stations (Fox Island and Whale Rock).

Scup

Scup is another of the Mid-Atlantic species caught consistently by the survey, along with summer flounder, black sea bass, bluefish, and menhaden. The population of scup has increased dramatically during the time period of the survey much like summer flounder and black sea bass, showing a high degree of variability going all the way back to the mid 1970s (Figure 7). Scup are caught at both sampling stations pretty consistently, though the Fox Island station catches a much higher magnitude than does the Whale Rock station. Some of this variability and magnitude difference for scup is driven by high recruitment events, the young of the year recruits being susceptible to the trawl gear. The survey information was reviewed during the stock assessment process for scup.

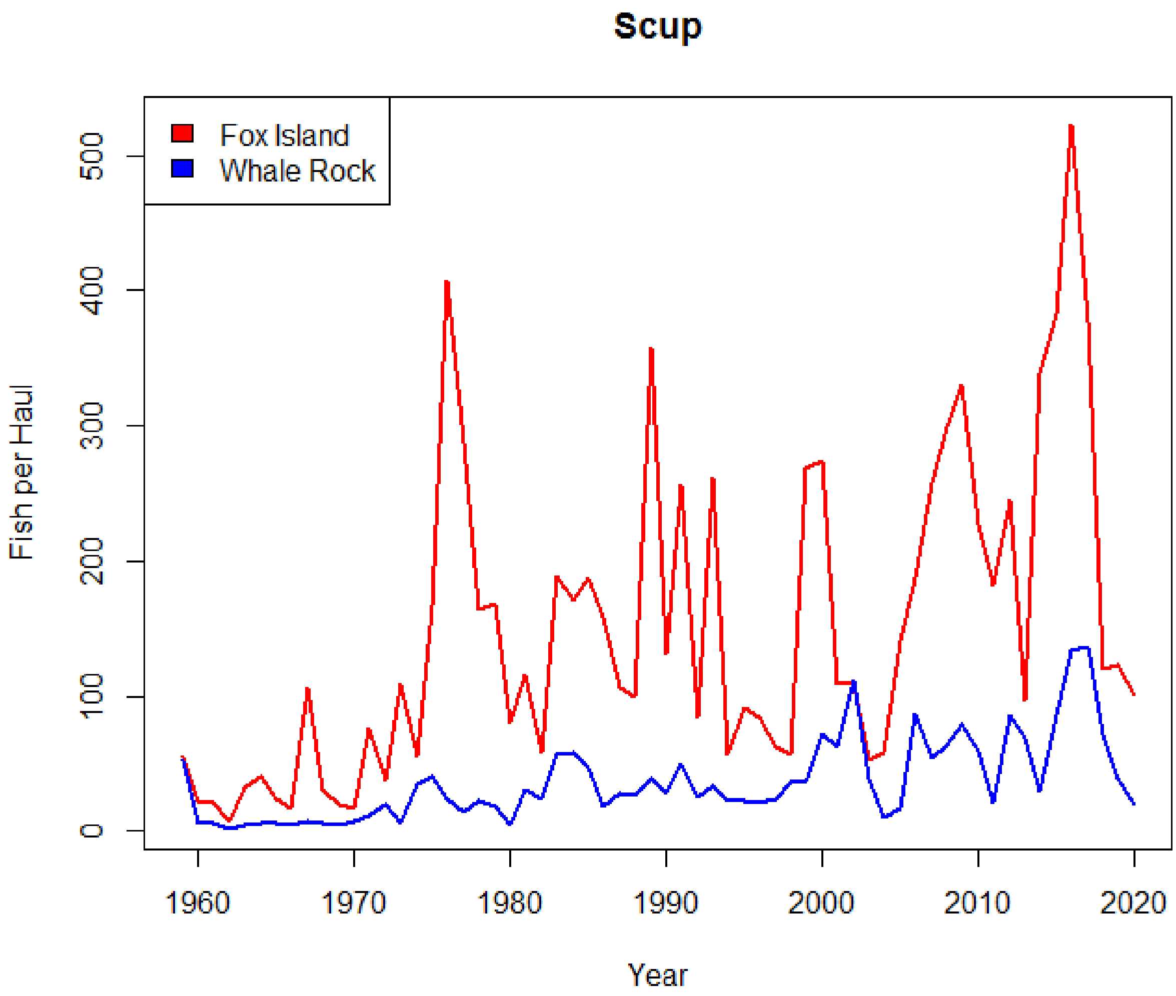


Figure 7 – Survey data for entire time series for scup at both sampling stations (Fox Island and Whale Rock).

Bluefish

Bluefish is another of the Mid-Atlantic species caught consistently by the survey. The population of bluefish 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 8). Bluefish are caught at both sampling stations pretty consistently.

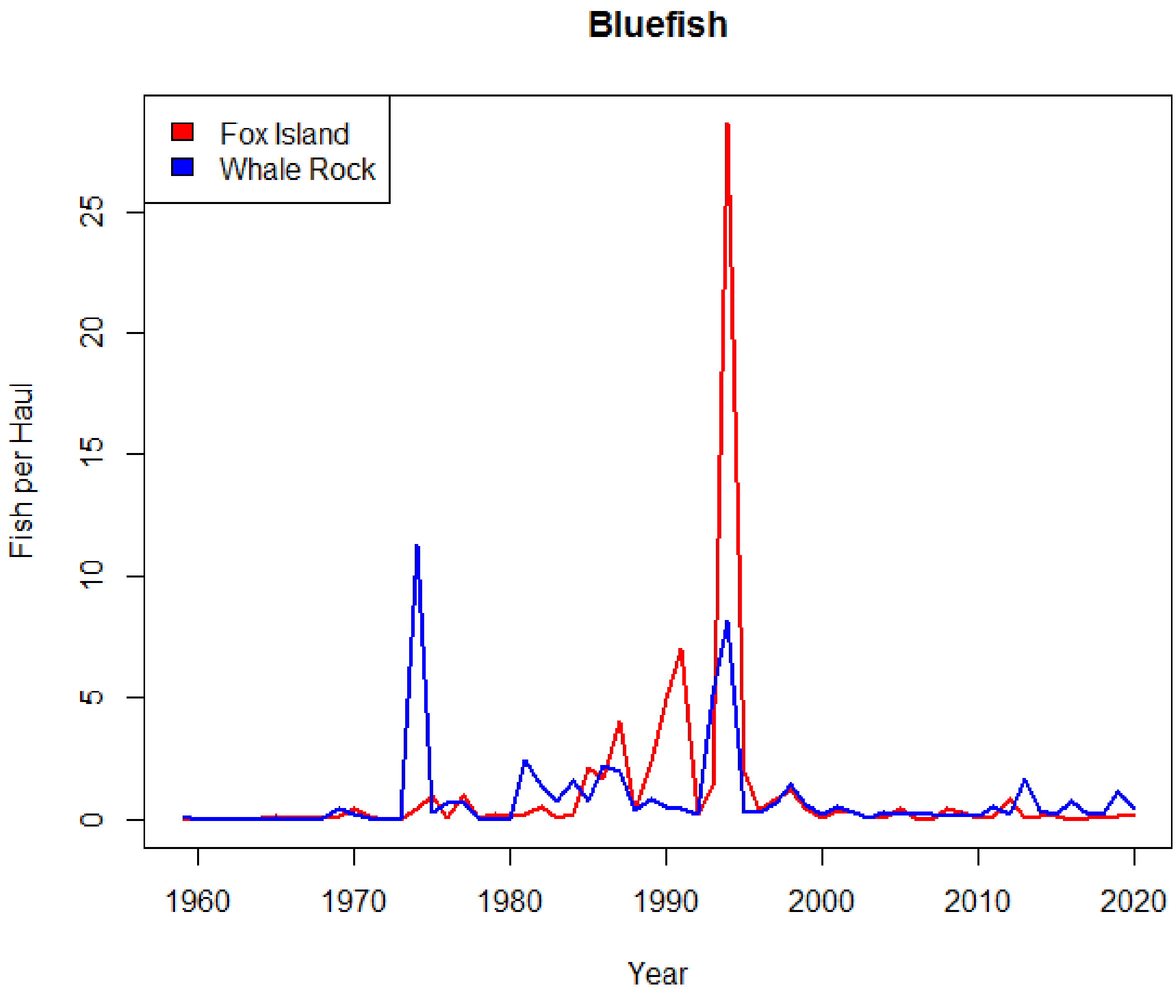
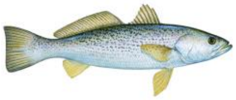


Figure 8 – Survey data for entire time series for bluefish at both sampling stations (Fox Island and Whale Rock).



Weakfish

Weakfish is another of the Mid-Atlantic species caught consistently by the survey, as weakfish use Narragansett Bay as a nursery habitat. The population of weakfish has been variable through the time period of the survey with periods of high abundance and periods of very low abundance. There is high variability for this species in the survey data, again mainly due to catching young of the year weakfish as opposed to adults (Figure 9), so this survey is probably a better indicator of recruitment than adult population size. Weakfish are caught at both sampling stations pretty consistently.

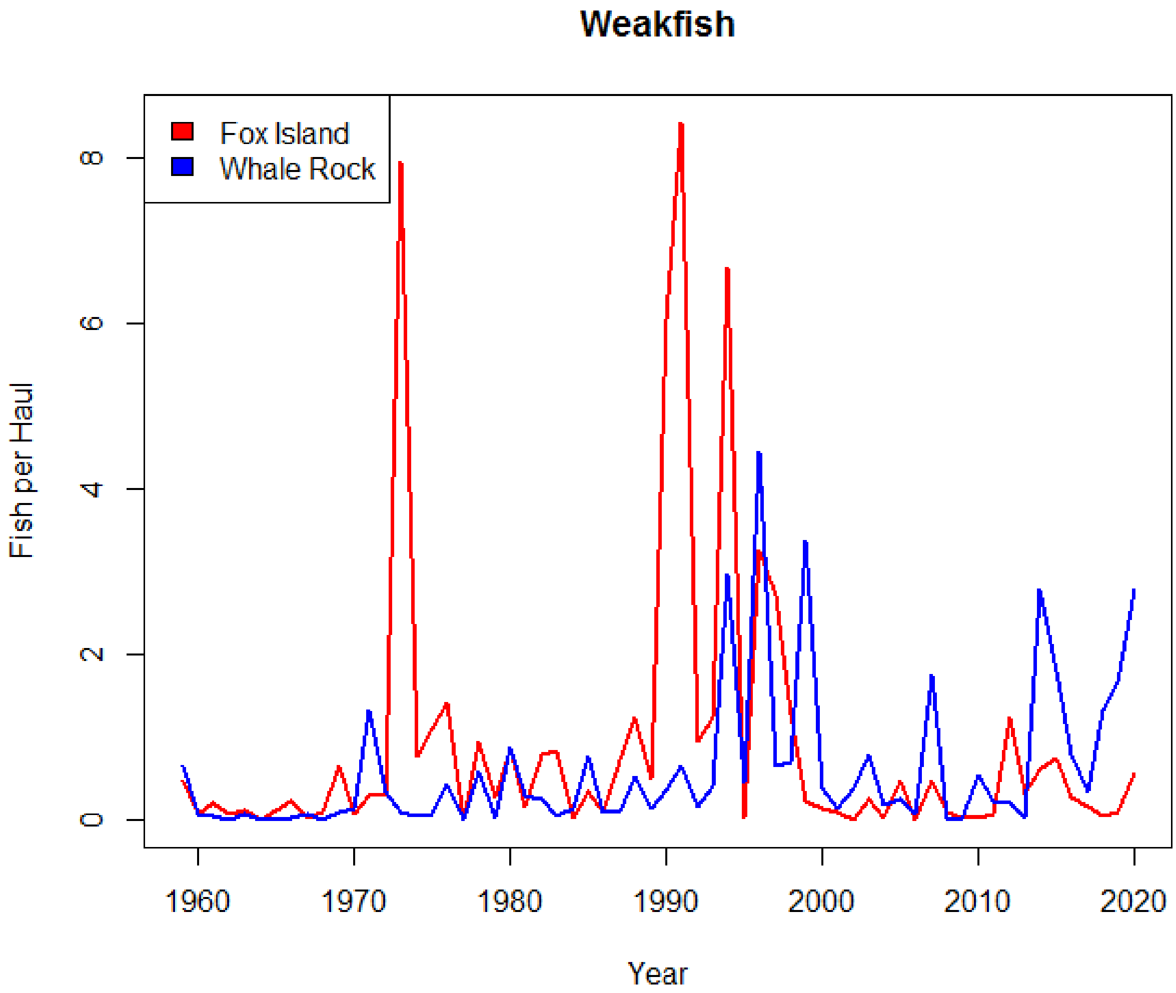


Figure 9 – Survey data for entire time series for weakfish at both sampling stations (Fox Island and Whale Rock).

Striped Bass

Striped bass is probably the premier recreational species caught by the survey. The catch of striped bass has been variable throughout the time period of the survey, with peaks between 1990 and 2010, and recently in 2018. There is high variability for this species in the survey data, but the survey catches both juveniles and adults (Figure 10). Striped bass are caught in greater abundance and frequency at Fox Island than at Whale Rock.

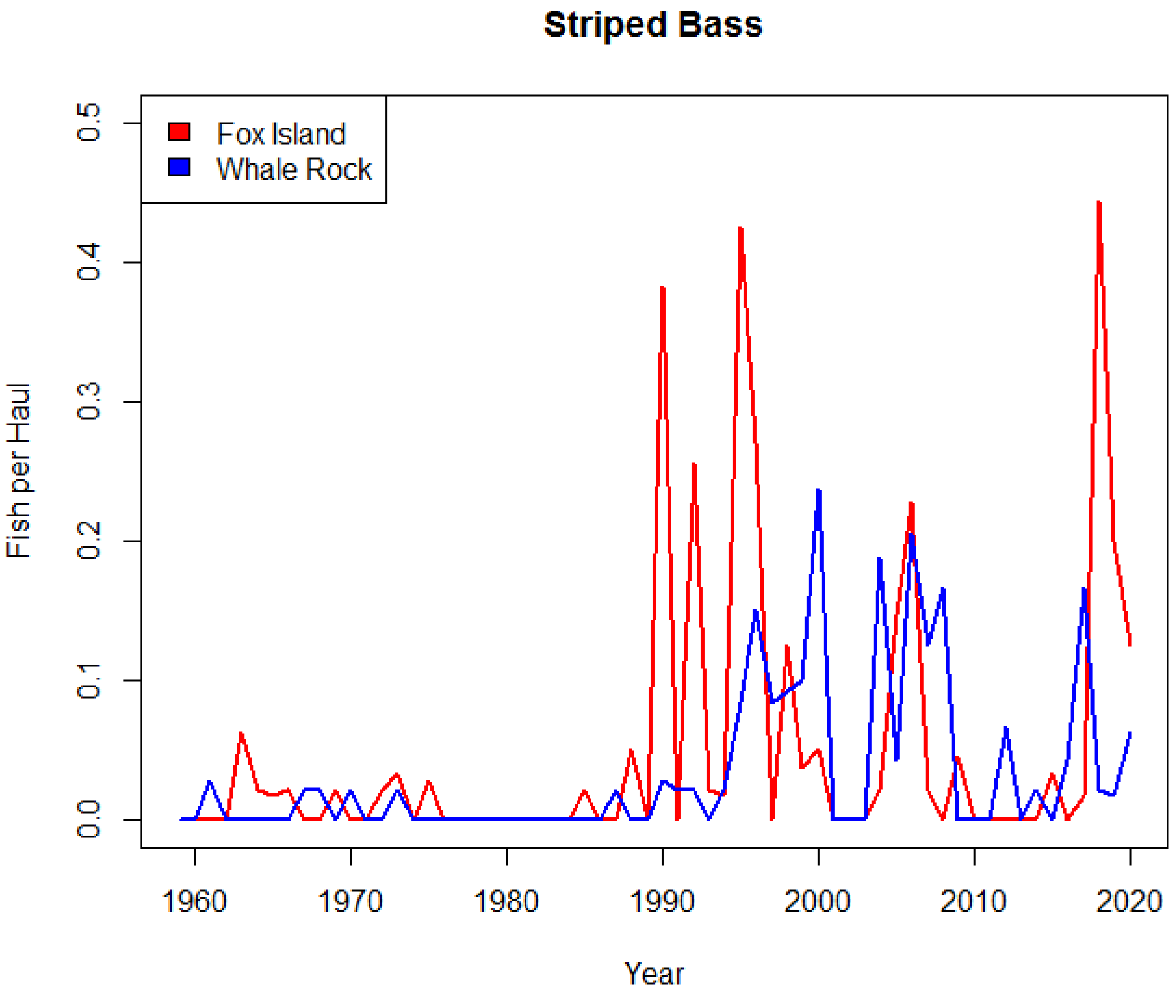


Figure 10 – Survey data for entire time series for striped bass at both sampling stations (Fox Island and Whale Rock).

Menhaden

Menhaden is another of the Mid-Atlantic species caught consistently by the survey. The catch of menhaden has been variable throughout the time period of the survey, mainly due to the schooling pelagic nature of this species. There is high variability for this species in the survey data, but the survey mainly catches juveniles (Figure 11). Menhaden are caught in greater abundance and frequency at Fox Island than at Whale Rock. The survey information was reviewed during the stock assessment process for menhaden.

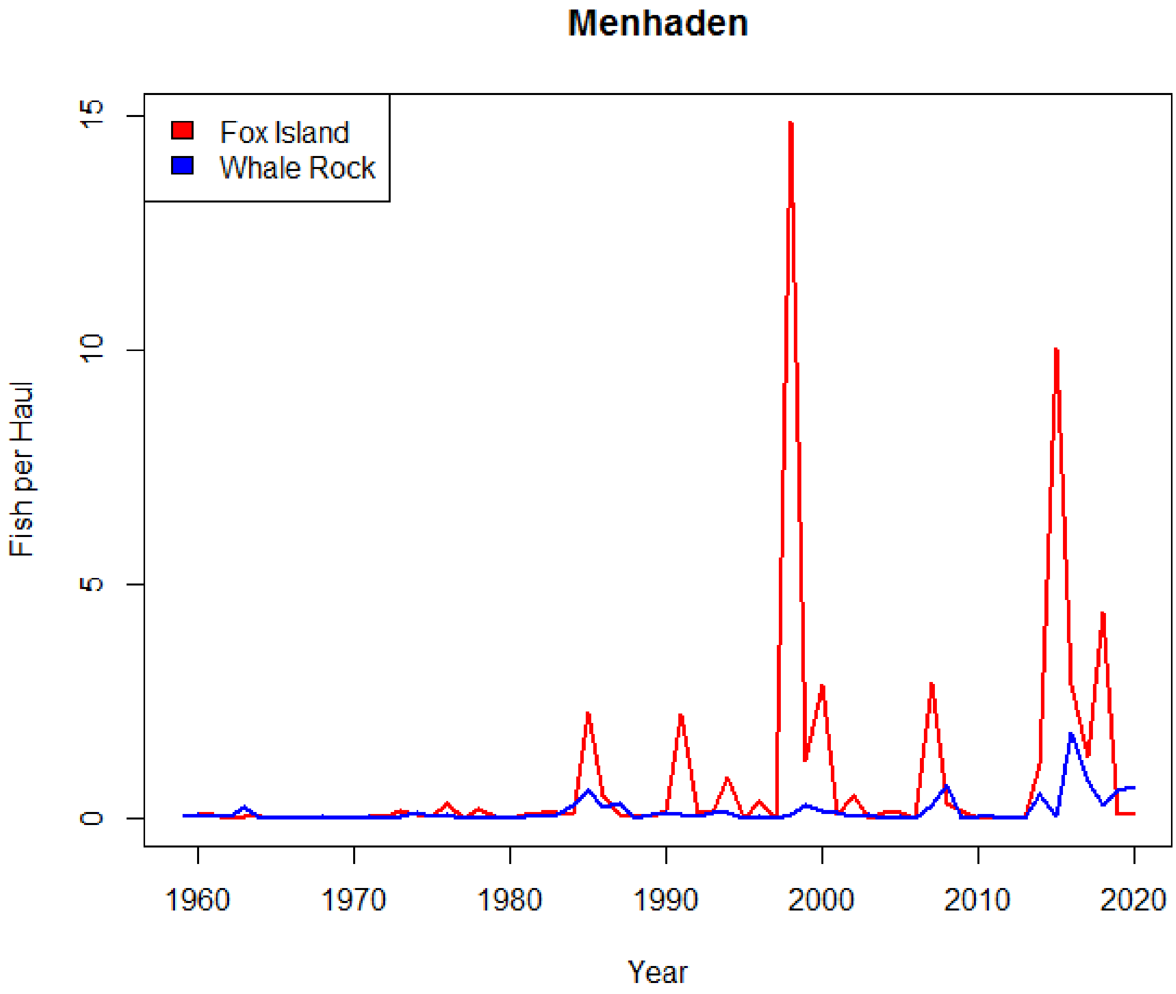


Figure 11 – Survey data for entire time series for menhaden at both sampling stations (Fox Island and Whale Rock)

Special Projects

Phenology of the Fish Community

The weekly trawl data have been statistically analyzed to investigate how the seasonal residence times (phenology) of fish in Narragansett Bay have changed in response to warming sea temperatures. Recreationally fished species considered in this study include summer flounder and scup, both of which have shown expanded residence periods over the past ten years as temperatures in Narragansett Bay have increased (Fig. 2). This study has been recently published in the *Marine Ecology Progress Series*; the abstract is included below.

Climate alters the migration phenology of coastal marine species

Joseph A. Langan, Gavino Puggioni, Candace A. Oviatt, M. Elisabeth Henderson, & Jeremy S. Collie

Marine Ecology Progress Series Vol. 660: 1-18, 2021
https://doi.org/10.3354/meps13612

ABSTRACT: Significant shifts in the phenology of life-cycle events have been observed in diverse taxa throughout the global oceans. While the migration phenology of marine fish and invertebrates is expected to be sensitive to climate change, the complex nature of these patterns has made measurement difficult and studies rare. With continuous weekly observations spanning 7 decades in Narragansett Bay, Rhode Island (USA), the University of Rhode Island Graduate School of Oceanography trawl survey provides an unprecedented opportunity to investigate the influence of climate on the migrations of marine species in the northwest Atlantic. Analyses of the survey observations of 12 species indicated that residence periods have changed by as much as 118 d, with shifts in the timing of both ingress to and egress from the coastal zone. The residence periods of warm-water species expanded while those of cold-water species contracted. Dirichlet regressions fit to the annual presence-absence patterns of each species identified interannual temperature variations, fluctuations in ocean circulation, and long-term warming all as having a significant effect on migration phenology. Additionally, temperature gradients within Narragansett Bay were shown by generalized additive models to cause detectable shifts in local spatial distributions during coastal residency. These novel findings mirror results found in the spatial domain and therefore suggest that the studied species are adapting their spatiotemporal distributions to track their thermal niche in a changing climate. If so, characterizing the spatial and temporal aspects of climate responses across species will be critical to understanding ongoing changes in marine ecosystems and successfully managing the fisheries they support.

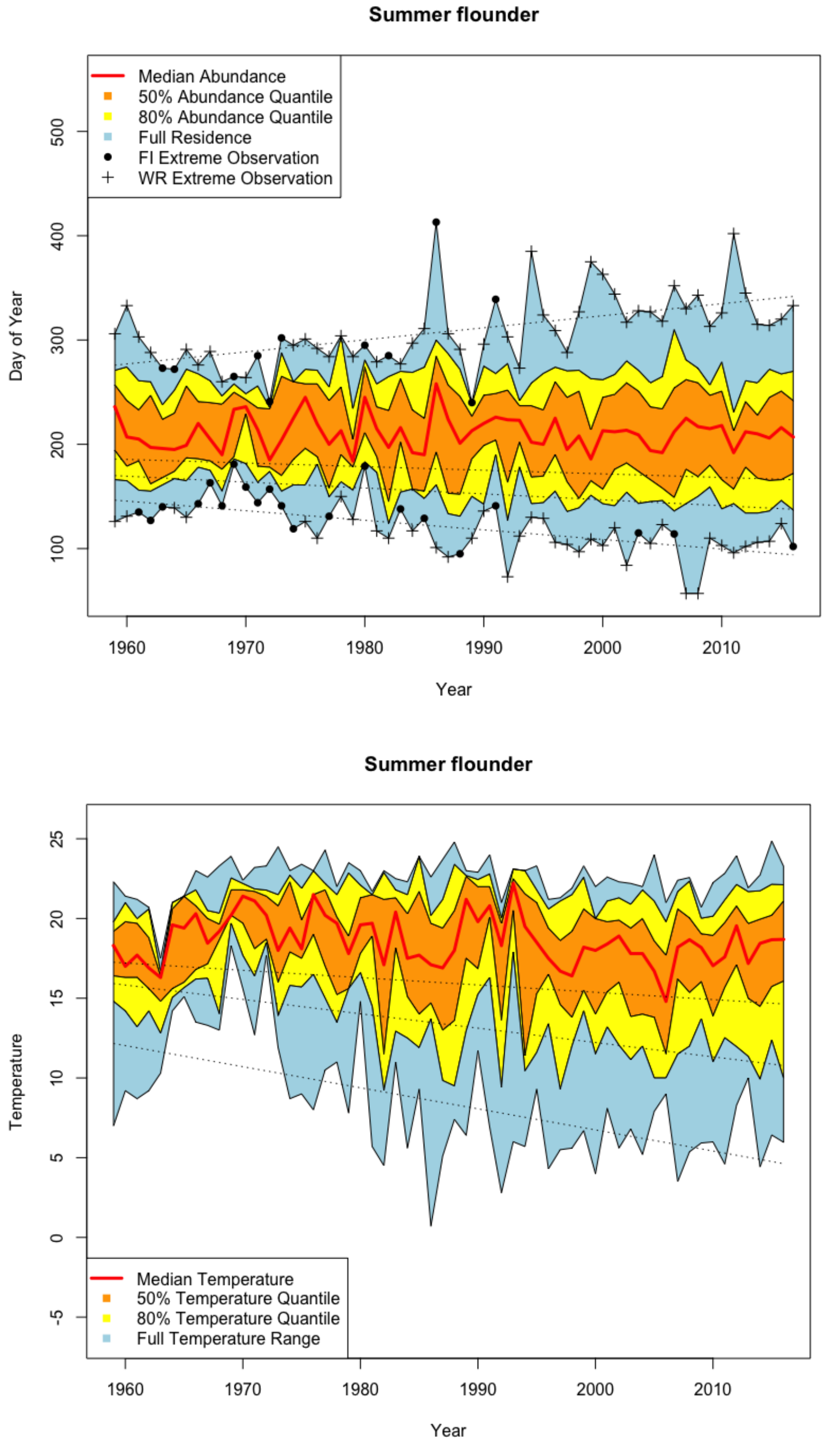


Figure 12. Phenology of summer flounder expressed in relation to (a) Day of year and (b) Temperature of occurrence. Compared with earlier years, summer flounder now arrive earlier to Narragansett Bay, stay later, and occupy cooler temperatures.

<u>List of references that have used the GSO Fish Trawl Survey data</u>:

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Recreational Coastal Sharks Monitoring

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Federal Aid in Sportfish Restoration
F-61-21

Performance Report: Job 15 March 2021

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

Project Title: Recreational Coastal Sharks Monitoring

Period Covered: January 1, 2020 – December 31, 2020

Job Number Job XV – Recreational Coastal Sharks Monitoring

Job Objective: To assess the migration patterns and presence of coastal sharks in and adjacent to Rhode Island waters state waters using a suite of tagging tools.

Significant Deviations: Of the 24 Vemco V-16 tags purchased for deployment, only 4 sharks were tagged.

Summary:

Coastal pelagic sharks of the North Atlantic Ocean are keystone species in regulating lower tropic levels, serving an important service in marine ecosystems. As top predators and larger fish, these species have also been long sought after by recreational fishers throughout the eastern United States, including Rhode Island. Many of these species frequent state waters through various months of the year, primarily during the warmer months of July through October in the northeast U.S. Several species of coastal sharks can be observed in Rhode Island state waters, including smooth dogfish (Mustelus canis), blue sharks (Prionace glauca), shortfin mako sharks (Isurus oxyrinchus), and thresher sharks (Alopias vulpinus). These and other species have supported pastimes of recreational fishing amongst avid anglers for leisure, as well as support party and charter businesses and shark diving tours during certain times of the year. In addition to recreational harvest, several coastal shark species can be caught and sold commercially, although these instances are few for Rhode Island. As such, the roles that coastal sharks serve in the marine ecosystem, recreation, and local economies is widely evident. Fisheries managers are charged to insure adequate, healthy stocks of these species for harvest. To do so, comprehensive data on the species’ life history, population trends, and harvest rates must be available to construct effective stock assessments and management plans. For coastal sharks, few data exist on the species’ abundance trends given the major fisheries-independent data surveys that are plentiful across the species range or stock bounds (e.g. trawl surveys) do not effectively catch them. This has been quite challenging for state fisheries programs that are charged with trying to understand the life history patterns of these fish in their waters.

Through a collaboration between Rhode Island Department of Environmental Management (RIDEM) Division of Marine Fisheries (DMF) and the Atlantic Shark Institute (ASI), the objective of this work is to initiate a coastal shark state monitoring for recreationally-significant species in the state of Rhode Island that can provide information on their use of state waters, the habitat they are associated with, and for use in ensuring their sustainable management. Given shark abundance data is often sparse within state waters (particularly for northern states), we hope to improve this data gap through this tagging endeavor.

In 2020, DMF and ASI purchased 24 Vemco V-16 tags for the project. Oreder and shipping for these trips was delayed due to the COVID-19 pandemic, resulting in missing sampling opportunities in June. However, upon receiving the tags, the team rigged all 24 tags for deployment. The team conducted nine research trips for shark tagging purposes (Table 1). Despite the effort, many of the sharks were further offshore during these months or had already moved through the area. As such, the team was only able to tag 4 sharks this year: 2 blue sharks and 2 shortfin mako sharks (Table 2). The data on these tags have been entered in the Atlantic Cooperative Telemetry (ACT) Network and Mid-Atlantic Acoustic Telemetry Observation System (MATOS) databases, so if telemetry scientists detect the species on their receivers, we will be able to obtain those detections. As of February 2021, partners have not detected the species within their arrays yet. The team has also conducted informal outreach efforts to educate both private and for-hire recreational fishermen on the goals of this work.

Upon completing the sampling season, the team constructed a system that will allow for other anglers to deploy the transmitters to ensure we meet target samples sizes moving forward. This effort for deploying tags will be in addition to the dedicated trips provided by ASI. We also plan to start sampling in June to increase our opportunities for tag deployment. For 2021, in addition to deploying 20 remaining Vemco V-16 transmitters, the team will also deploy 10 Lotek satellite tags on blue sharks. The team will target females given the paucity of such data on them but will tag males pending sample sizes and tag opportunities. Further, some of these species satellite tagged may be also tagged with a Vemco V-16 tag to compare telemetry methods across the species.

Table 1. Description of shark tagging trips conducted in 2020.

Date	Location
7/19/2021	The Fingers
7/20/2021	Tuna Ridge
7/30/2021	Montauk
8/2/2021	Mud Hole
8/5/2021	The Fingers
8/8/2021	Montauk
8/10/2021	Sharks Ledge
8/13/2021	Montauk
8/28/2021	Tuna Ridge

Table 2. Descriptions for sharks tagged with Vemco V-16 transmitters.

Species	Sex	Size, FL (in)
Blue shark	Male	90
Shortfin mako shark	Female	66
Blue shark	Male	72
Shortfin mako shark	Female	73

Enhancements to MRIP Data Collection

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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, 2020 – December 31, 2021

JOB NUMBER 8 TITLE: Enhancements to MRIP Data Collection

Job 16: Enhancements to MRIP Data Collection

During this segment the RIDMF Access Point Angler Interview Survey (APAIS) hired 2 additional seasonal staff members and provided 2 months of a full time employees time in support of the survey. These complement the staff that is provided by the NOAA MRIP base funding and allows RIDMF to order additional assignments from the NOAA Marine Recreational Information Program (MRIP). During 2020 RIDMF APAIS was able to add on 271 assignments in shore, private/rental and Party charter modes. Normally RIDMF APAIS would also add an additional ~ 30 samples in Head Boat mode for ride along, that did not occur in 2020 due to the COVID – 19 pandemic. These additional add on assignments were distributed amongst the other three modes. RIDMF APAIS was able to complete all of our shore, private/rental, and party/charter mode assignments during 2020 but did not send staff on Head Boats due to health and safety concerns. Staff hired via tis grant are also used to preform scouting assignments of existing and potentially new sites to determine site pressures and sampling feasibility.

Currently, the 2020 MRIP estimates are not available. A detailed summary of the total 2020 APAIS assignments is provided in table one. This table shows the assignments broken down by mode, the response statistics and the productivity rate which is the number of completed interviews over the number of assignments. Table 2 provides a summary of APAIS interview statistics from 2016-2020 by wave. While survey rates were on par with previous years 2020 did have higher refusal rates and lower interview completion rates than 2019 likely an artifact of the pandemic. The program hopes to improve the interview statistics back to the levels seen in 2019 as the pandemic eases and anglers are more likely to interact wit our samplers.

Table 1. APAIS Interview Statistics from 2020 Assignments. (CH = Party/Charter, PR = Private/Rental Boat, SH = Shore, HB = Head Boat)

Year	**Wave**	**Mode**	**Assignments**	**Completed**	**Initially Refused**	**Language Barrier**	**Missed Anglers**	**Productivity**
2020	2	CH	0	0	0	0	0	0
2020	2	HB	1	6	3	5	0	6
2020	2	PR	8	0	0	0	0	0
2020	2	SH	28	40	9	3	17	1.43
2020	3	CH	35	155	269	5	66	4.43
2020	3	HB	0	0	0	0	0	0
2020	3	PR	46	234	80	57	66	5.09
2020	3	SH	60	272	77	66	95	4.53
2020	4	CH	60	523	831	8	249	8.72
2020	4	HB	0	0	0	0	0	0
2020	4	PR	82	638	183	60	172	7.78
2020	4	SH	48	302	68	79	65	6.29
2020	5	CH	36	274	297	27	65	7.61
2020	5	HB	0	0	0	0	0	0
2020	5	PR	69	524	109	45	119	7.59
2020	5	SH	54	317	116	83	77	5.87
2020	6	CH	9	42	80	0	9	4.67
2020	6	HB	0	0	0	0	0	0
2020	6	PR	10	4	1	0	0	0.4
2020	6	SH	25	72	24	7	32	2.88
			571	**3403**	**2147**	**445**	**1032**	**5.96**

Table 2. Summary of APAIS interview Statistics from 2016 – 2020 assignments by wave.

Year	Wave	Completed	Refused	Missed	Percent Refused	Percent Complete
2016	2	116	63	8	35.20%	62.03%
2016	3	396	549	65	58.10%	39.21%
2016	4	857	1157	260	57.45%	37.69%
2016	5	665	557	143	45.58%	48.72%
2016	6	111	61	4	35.47%	63.07%
2016		**2145**	**2387**	**480**	**53.00%**	**42.80%**
2017	2	124	15	13	10.79%	81.58%
2017	3	759	579	146	43.27%	51.15%
2017	4	1908	1011	629	34.64%	53.78%
2017	5	901	518	267	36.50%	53.44%
2017	6	149	94	37	38.68%	53.21%
2017		**3841**	**2217**	**1092**	**36.60%**	**53.72%**
2018	2	149	46	19	23.58%	69.63%
2018	3	782	532	277	40.49%	49.15%
2018	4	1740	989	704	36.24%	50.68%
2018	5	1058	583	434	35.53%	50.99%
2018	6	199	147	87	42.48%	45.96%
2018		**3928**	**2297**	**1521**	**36.90%**	**50.71%**
2019	2	199	63	31	21.50%	67.92%
2019	3	1001	460	188	27.90%	60.70%
2019	4	1659	765	431	26.80%	58.11%
2019	5	1044	354	249	21.49%	63.39%
2019	6	140	75	10	33.33%	62.22%
2019		**4043**	**1717**	**909**	**25.75%**	**60.62%**
2020	2	46	12	17	20.69%	61.33%
2020	3	661	426	227	39.19%	50.30%
2020	4	1463	1082	486	42.51%	48.27%
2020	5	1115	522	261	31.89%	58.75%
2020	6	118	105	41	47.09%	44.70%
2020		**3403**	**2147**	**1032**	**38.68%**	**51.70%**

Recreational Fisheries Management Support

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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, 2020 – December 31, 2021

JOB NUMBER 8 TITLE: Enhancements to MRIP Data Collection

Job 17: Recreational Fisheries Management Support

During this segment RIDMF provided staff and support for state and regional recreational fishing program coordination, planning, and outreach meetings. These meetings include the ACCSP Recreational Technical committee, the Rhode Island Marine Fisheries Council, ASMFC technical and stock assessment committees for various recreationally important species, RIDEM Boating and Access point workgroup, and local stake holder meetings. Additionally, the Division published and produced recreational angler outreach materials including the annual saltwater recreational magazine, a one page informational brochure, and stickers for handing out at events and during APAIS interviews. The Covid -19 pandemic greatly impacted our outreach efforts. The RI Saltwater Fishing magazine can be viewed here: http://www.eregulations.com/rhodeisland/fishing/saltwater/ . The Division was forced to cancel its annual kids fish camp as well other youth fishing events. Governor's Bay day the annual free fishing day was scaled back with no in person presence. The large annual recreational fishing show which the Division attends and issues recreational saltwater fishing licenses at was cancelled as well. The Division is hopeful that as the pandemic eases n 2021 that outreach activities can begin again and continue as in the past.