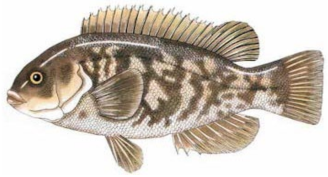
ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

COASTAL FISHERY RESOURCE ASSESSMENT
TRAWL SURVEY
2021

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



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Rhode Island Department of Environmental Management
Division of Marine Fisheries

March 2021

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, 2021 – December 31, 2021.

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

TARGET DATE: December 2021

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) 2021

PROJECT SUMMARY: Job 2, summary accomplished:

A: 44, twenty-minute tows were successfully completed during the Spring 2021 survey (26 NB. – 6 RIS – 12 BIS).

B: 44, twenty-minute tow were successfully completed during the Fall 2021 survey (26 NB. – 6 RIS – 12 BIS)

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

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

TARGET DATE: DECEMBER 2021.

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

JOBS 1 & 2

RECOMMENDATIONS: Continuation of both the Monthly and Seasonal Trawl surveys into 2022, 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 2021 Job 1 (Monthly survey). 64 species accounted for a combined weight of 6646.48 kgs. and 203,860 length measurements being added to the existing Narragansett Bay monthly trawl data set
By contrast, 88 tows were completed during 2021 Job 2 (Seasonal survey) 61 species accounted for a combined weight of 6076.28 kgs. and 371,748 length measurements added to the existing seasonal data set.

With the completion of the 2021 surveys, combined survey(s) Jobs (1&2) data now reflects the completion of 7,563 tows with data collected on 149 species over the entire timeseries.

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

APPROVED BY: ________________________ ________________________
Conor McManus Date
Chief
RIDEM – Division of Marine Fisheries

Coastal Fishery Resource Assessment – Trawl Survey

Introduction:

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

Since the inception of the Rhode Island Seasonal Trawl Survey (April 1979) and the Narragansett Bay Monthly Trawl Survey (January 1990), 7,563 tows have been conducted within Rhode Island territorial waters with data collected on 149 species. This performance report reflects the efforts of the 2021 survey year as it relates to the past 42 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. 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.

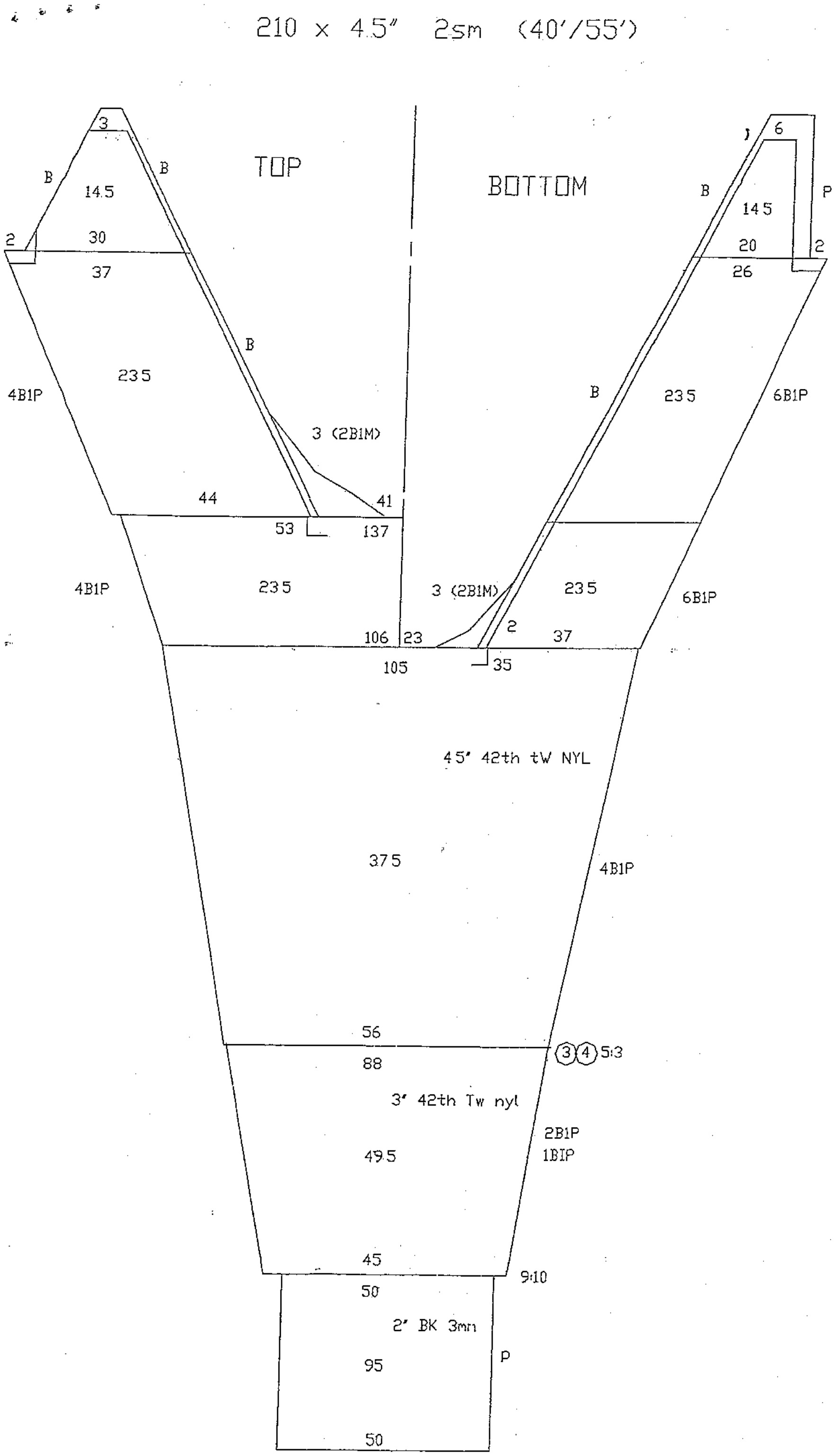
Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, Whelk lobster, blue crabs and horseshoe crabs.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

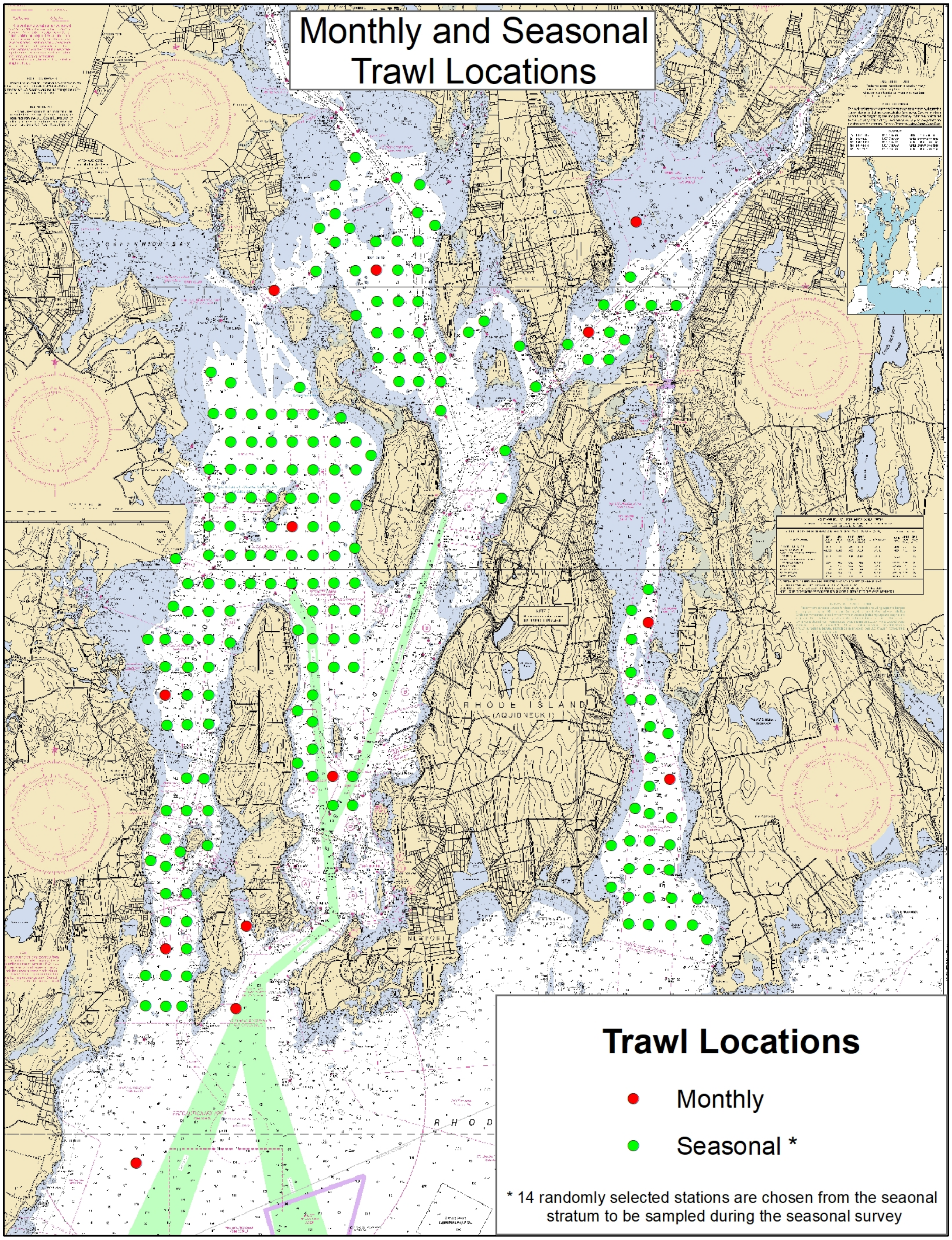
Acknowledgements:
Special thanks are again extended to Captain Patrick Brown and Assistant Captain Sean Fitzgerald, and the entire seasonal staff and volunteers. The support given over the years has been greatly appreciated.

Figure 1

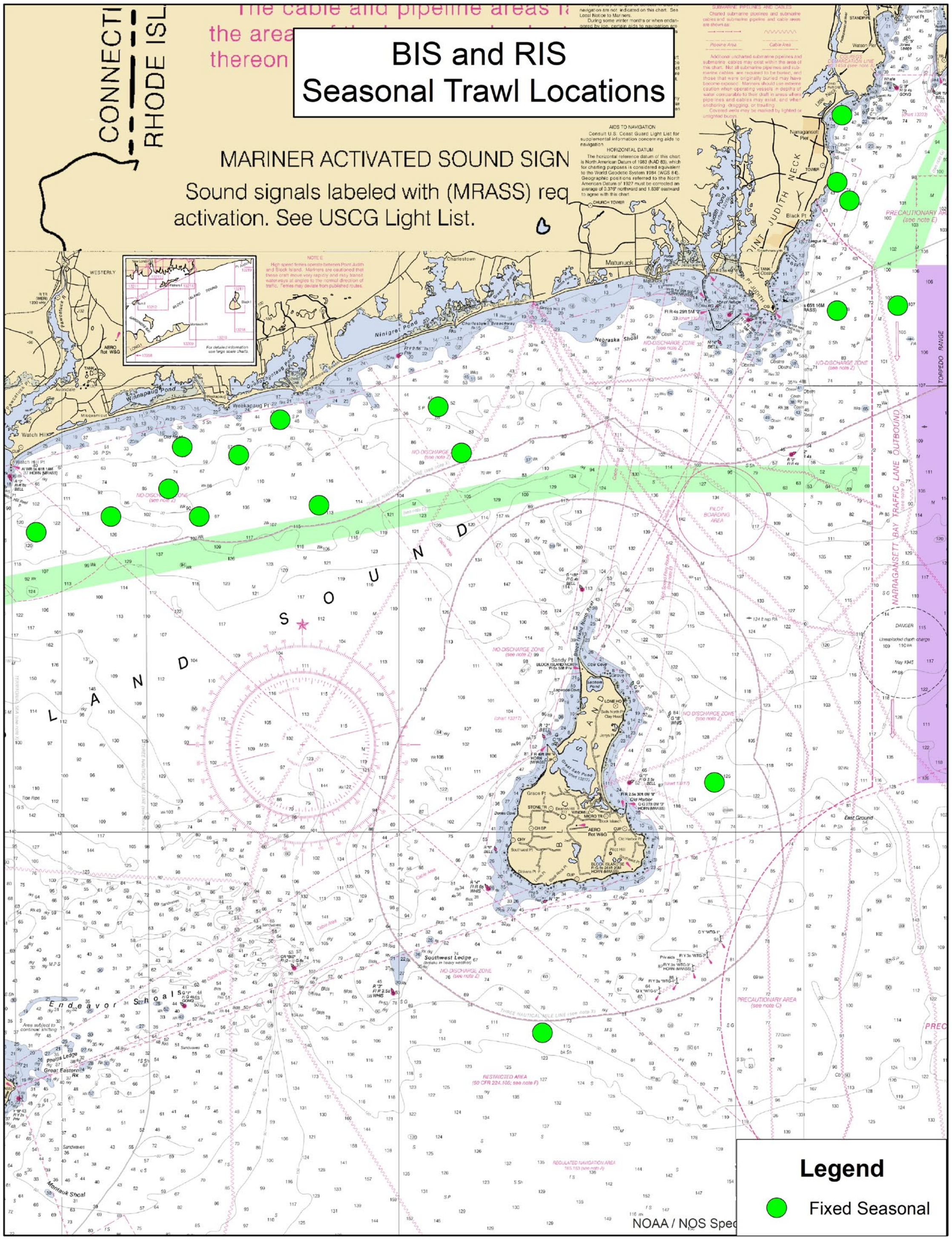


210 x 4.5" 2sm (40'/55')
TOP
BOTTOM
3
B
B
14.5
2
30
37
B
235
4B1P
3 (2B1M)
44
41
53
137
4B1P
235
106
23
105
6
P
B
14.5
20
2
26
B
235
6B1P
3 (2B1M)
235
6B1P
2
37
35
45' 42th tW NYL
375
4B1P
56
③④5:3
88
3' 42th Tw nyl
2B1P
1B1P
495
45
9:10
50
2' BK 3mm
95
P
50

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



Map 2: Seasonal Fixed Stations in Rhode Island Sound and Block Island Sound



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

A total of 64 species were observed and recorded during the 2021 Narragansett Bay Monthly Trawl Survey totaling 203,860 individuals or 1306.8 fish per tow. In weight, the catch accounted for 6646.48 kg. or 42.6 kg. per tow. (Figures 2 and 3) The top ten species by number and catch are represented in figures 4 and 5. The catch between demersal and pelagic species is represented in figures 6 and 7and shows a clear shift from demersal species to a more pelagic or multi-habitat species.

Figure 2 (Total Catch in Number)

Scientific Name	Common Name	Total #
STENOTOMUS CHRYSOPS	Scup	58719
DORYTEUTHIS PEALEII	Longfin Squid	35910
ANCHOA MITCHILLI	Bay Anchovy	26865
CYNOSCION REGALIS	Weakfish	21677
SELENE SETAPINNIS	Atlantic Moonfish	13446
PEPRILUS TRIACANTHUS	Butterfish	12456
MENIDIA MENIDIA	Atlantic Silverside	11140
BREVOORTIA TYRANNUS	Atlantic Menhaden	10492
ALOSA PSEUDOHARENGUS	Alewife	6375
CLUPEA HARENGUS	Atlantic Herring	1646
GADUS MORHUA	Atlantic Cod	1247
POMATOMUS SALTATRIX	Bluefish	982
ALOSA AESTIVALIS	Blueback Herring	447
MERLUCCIUS BILINEARIS	Silver Hake	323
UROPHYCIS REGIA	Spotted Hake	287
CENTROPRISTIS STRIATA	Black Sea Bass	245
LEIOSTOMUS XANTHURUS	Spot	147
LEUCORAJA ERINACEA	Little Skate	140
MUSTELUS CANIS	Smooth Dogfish	132
CANCER IRRORATUS	Rock Crab	123
TAUTOGA ONITIS	Tautog	119
ILLEX ILLECEBROSUS	Shortfin Squid	94
HOMARUS AMERICANUS	American Lobster	92
ALOSA SAPIDISSIMA	American Shad	86
SPHYRAENA BOREALIS	Northern Sennet	75
PARALICHTHYS DENTATUS	Summer Flounder	74
PLEURONECTES AMERICANUS	Winter Flounder	73
TRACHURUS LATHAMI	Rough Scad	71
UROPHYCIS CHUSS	Red Hake	61
MENTICIRRHUS SAXATILIS	Northern Kingfish	43
PRIONOTUS EVOLANS	Striped Sea Robin	38
CALLINECTES SAPIDUS	Blue Crab	35

RAJA EGLANTERIA	Clearnose Skate	27
PRIACANTHUS ARENATUS	Bigeye	21
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	21
MORONE SAXATILIS	Striped Bass	19
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	14
SYNODUS FOETENS	Inshore Lizardfish	14
PRIONOTUS CAROLINUS	Northern Sea Robin	12
PARALICHTHYS OBLONGUS	Fourspot Flounder	8
LIMULUS POLYPHEMUS	Horseshoe Crab	7
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	5
AMMODYTES AMERICANUS	Sand Lance	5
ARGOPECTEN IRRADIANS	Bay Scallop	5
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	4
CARANX CRYSOS	Blue Runner	4
CANCER BOREALIS	Jonah Crab	4
LEUCORAJA OCELLATA	Winter Skate	3
ALOSA MEDIOCRIS	Hickory Shad	3
POLLACHIUS VIRENS	Pollock	3
ETROPUS MICROSTOMUS	Smallmouth Flounder	3
SPHOEROIDES MACULATUS	Northern Puffer	3
SCOMBER SCOMBRUS	Atlantic Mackerel	2
BUSYCON CARICA	Knobbed Whelk	2
SQUILLA EMPUSA	Mantis Shrimp	2
PETROMYZON MARINUS	Sea Lamprey	1
TRINECTES MACULATUS	Hogchoker	1
FISTULARIA TABACARIA	Cornetfish	1
HEMITRIPTERUS AMERICANUS	Sea Raven	1
TAUTOGOLABRUS ADSPERSUS	Cunner	1
MACROZOARCES AMERICANUS	Ocean Pout	1
ACIPENSER OXYRHYNCHUS	Atlantic Sturgeon	1
PRISTIGENYS ALTA	Short Bigeye	1
APLYSIS MORIO	Atlantic Black Sea Hare	1

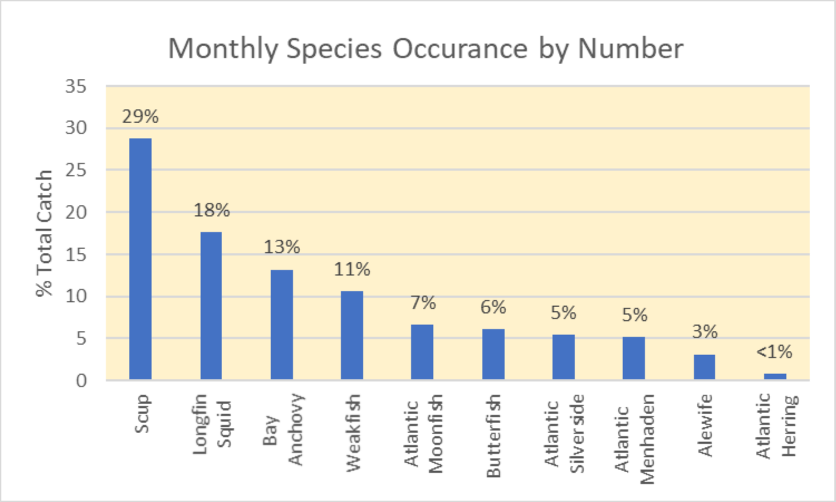
Figure 3 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight (kg)
STENOTOMUS CHRYSOPS	Scup	3886.324
DORYTEUTHIS PEALEII	Longfin Squid	505.459
CYNOSCION REGALIS	Weakfish	486.805
PEPRILUS TRIACANTHUS	Butterfish	398.017
TAUTOGA ONITIS	Tautog	169.861
MUSTELUS CANIS	Smooth Dogfish	154.901
CENTROPRISTIS STRIATA	Black Sea Bass	136.221
ALOSA PSEUDOHARENGUS	Alewife	117.998
LEUCORAJA ERINACEA	Little Skate	79.685
SELENE SETAPINNIS	Atlantic Moonfish	78.096
POMATOMUS SALTATRIX	Bluefish	63.64
BREVOORTIA TYRANNUS	Atlantic Menhaden	60.0725
CLUPEA HARENGUS	Atlantic Herring	60.044
ACIPENSER OXYRHYNCHUS	Atlantic Sturgeon	56.69
PARALICHTHYS DENTATUS	Summer Flounder	51.235
RAJA EGLANTERIA	Clearnose Skate	43.278
MENIDIA MENIDIA	Atlantic Silverside	38.225
ANCHOA MITCHILLI	Bay Anchovy	37.43
HOMARUS AMERICANUS	American Lobster	35.527
MORONE SAXATILIS	Striped Bass	25.07
MERLUCCIUS BILINEARIS	Silver Hake	18.571
LEIOSTOMUS XANTHURUS	Spot	18.334
CANCER IRRORATUS	Rock Crab	17.141
PLEURONECTES AMERICANUS	Winter Flounder	17.101
PRIONOTUS EVOLANS	Striped Sea Robin	16.301
LIMULUS POLYPHEMUS	Horseshoe Crab	13.294
UROPHYCIS REGIA	Spotted Hake	8.147
CALLINECTES SAPIDUS	Blue Crab	7.392
UROPHYCIS CHUSS	Red Hake	5.664
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	4.51
SPHYRAENA BOREALIS	Northern Sennet	3.606
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	3.313
ALOSA AESTIVALIS	Blueback Herring	3.211
GADUS MORHUA	Atlantic Cod	3.145
LEUCORAJA OCELLATA	Winter Skate	3.04
MENTICIRRHUS SAXATILIS	Northern Kingfish	2.586
PRIONOTUS CAROLINUS	Northern Sea Robin	2.518
ALOSA SAPIDISSIMA	American Shad	2.37
ALOSA MEDIOCRIS	Hickory Shad	1.96

PARALICHTHYS OBLONGUS	Fourspot Flounder	1.442
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	1.23
TRACHURUS LATHAMI	Rough Scad	0.926
SYNODUS FOETENS	Inshore Lizardfish	0.925
MACROZOARCES AMERICANUS	Ocean Pout	0.825
ILLEX ILLECEBROSUS	Shortfin Squid	0.675
HEMITRIPTERUS AMERICANUS	Sea Raven	0.438
ARGOPECTEN IRRADIANS	Bay Scallop	0.424
CARANX CRYSOS	Blue Runner	0.413
PRIACANTHUS ARENATUS	Bigeye	0.376
CANCER BOREALIS	Jonah Crab	0.368
SPHOEROIDES MACULATUS	Northern Puffer	0.321
SCOMBER SCOMBRUS	Atlantic Mackerel	0.319
APLYSIS MORIO	Atlantic Black Sea Hare	0.308
BUSYCON CARICA	Knobbed Whelk	0.245
TRINECTES MACULATUS	Hogchoker	0.135
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	0.1
POLLACHIUS VIRENS	Pollock	0.07
SQUILLA EMPUSA	Mantis Shrimp	0.057
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.048
AMMODYTES AMERICANUS	Sand Lance	0.028
PETROMYZON MARINUS	Sea Lamprey	0.015
PRISTIGENYS ALTA	Short Bigeye	0.01
TAUTOGOLABRUS ADSPERSUS	Cunner	0.004
FISTULARIA TABACARIA	Cornetfish	0.002

Figure 4 Monthly Survey Top Ten Species Catch in Number

Scientific Name	Common Name	%
STENOTOMUS CHRYSOPS	Scup	28.80%
DORYTEUTHIS PEALEII	Longfin Squid	17.62%
ANCHOA MITCHILLI	Bay Anchovy	13.18%
CYNOSCION REGALIS	Weakfish	10.63%
SELENE SETAPINNIS	Atlantic Moonfish	6.60%
PEPRILUS TRIACANTHUS	Butterfish	6.11%
MENIDIA MENIDIA	Atlantic Silverside	5.46%
BREVOORTIA TYRANNUS	Atlantic Menhaden	5.15%
ALOSA PSEUDOHARENGUS	Alewife	3.13%
CLUPEA HARENGUS	Atlantic Herring	0.81%



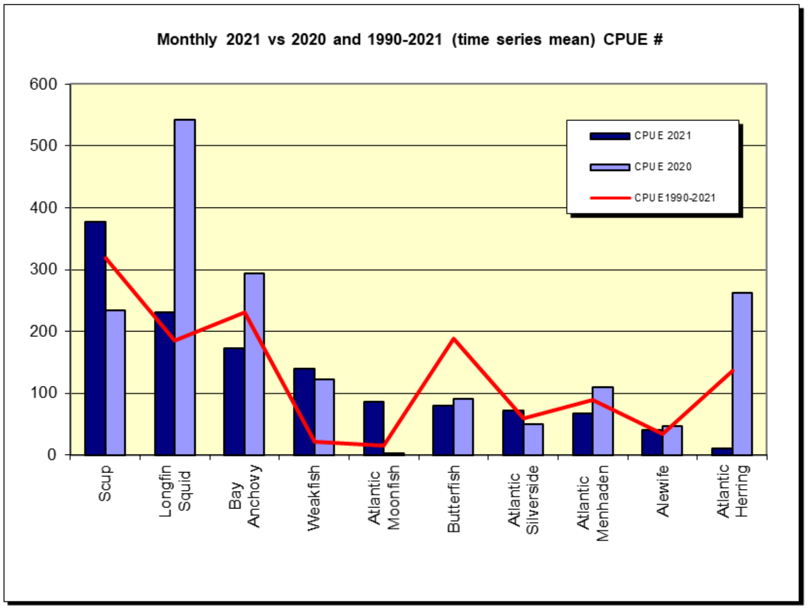
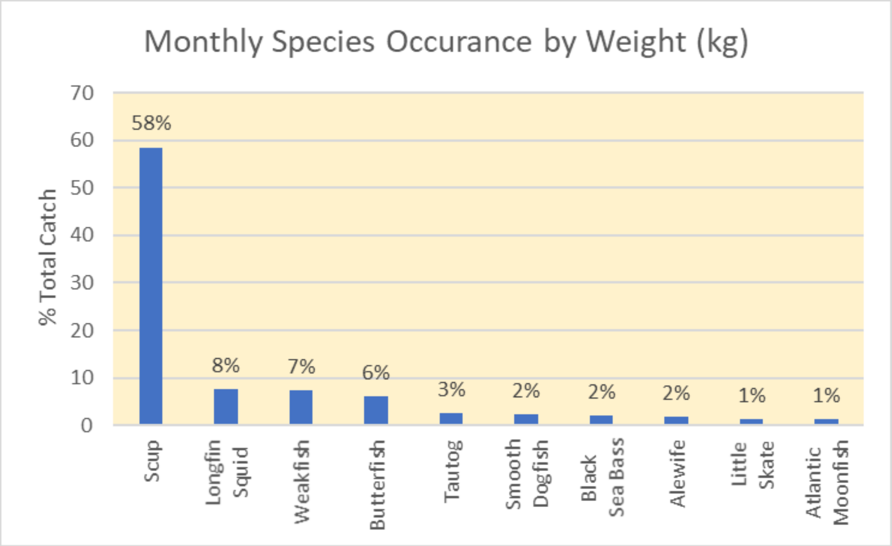


Figure 5 Top Ten Species Catch in Kilograms

Scientific Name	Common Name	%
STENOTOMUS CHRYSOPS	Scup	58.47%
DORYTEUTHIS PEALEII	Longfin Squid	7.60%
CYNOSCION REGALIS	Weakfish	7.32%
PEPRILUS TRIACANTHUS	Butterfish	5.99%
TAUTOGA ONITIS	Tautog	2.56%
MUSTELUS CANIS	Smooth Dogfish	2.33%
CENTROPRISTIS STRIATA	Black Sea Bass	2.05%
ALOSA PSEUDOHARENGUS	Alewife	1.78%
LEUCORAJA ERINACEA	Little Skate	1.20%
SELENE SETAPINNIS	Atlantic Moonfish	1.17%



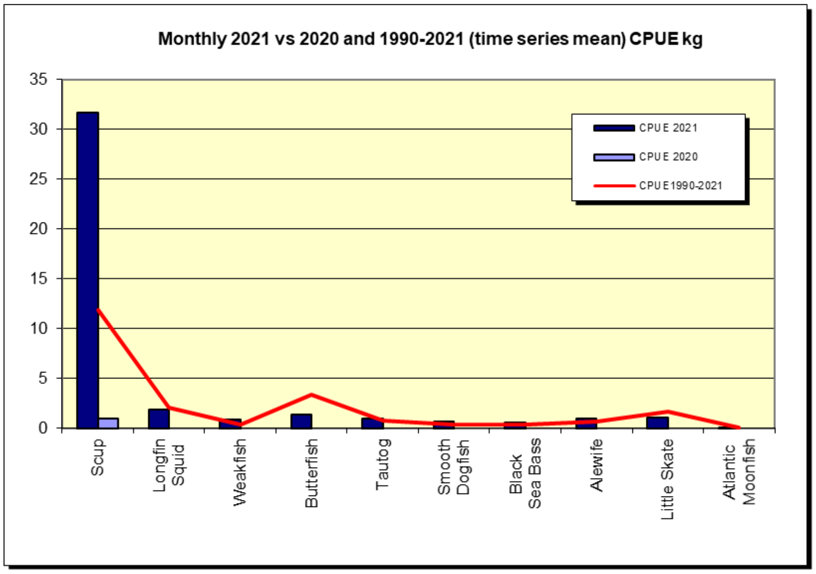
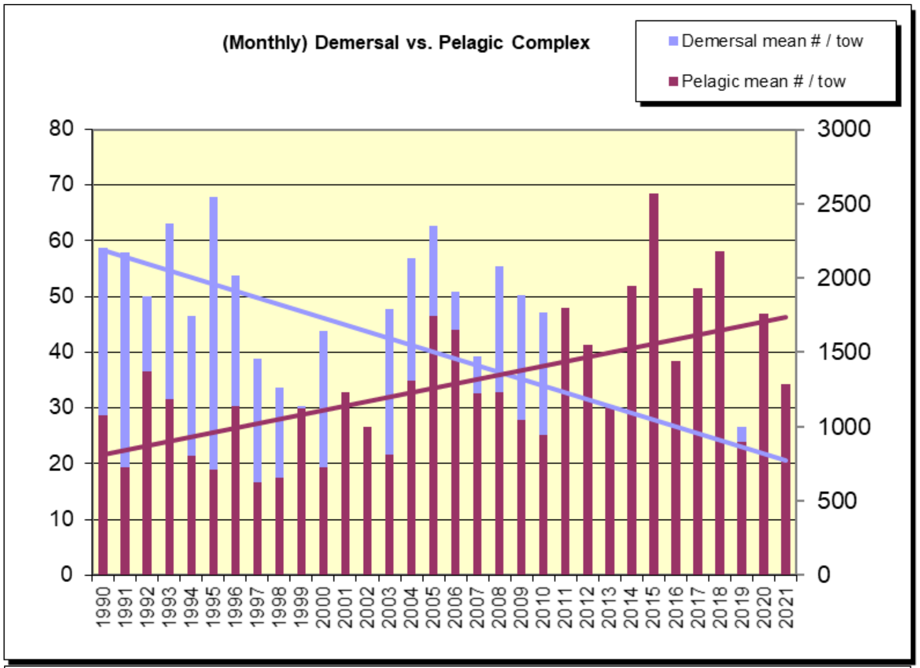
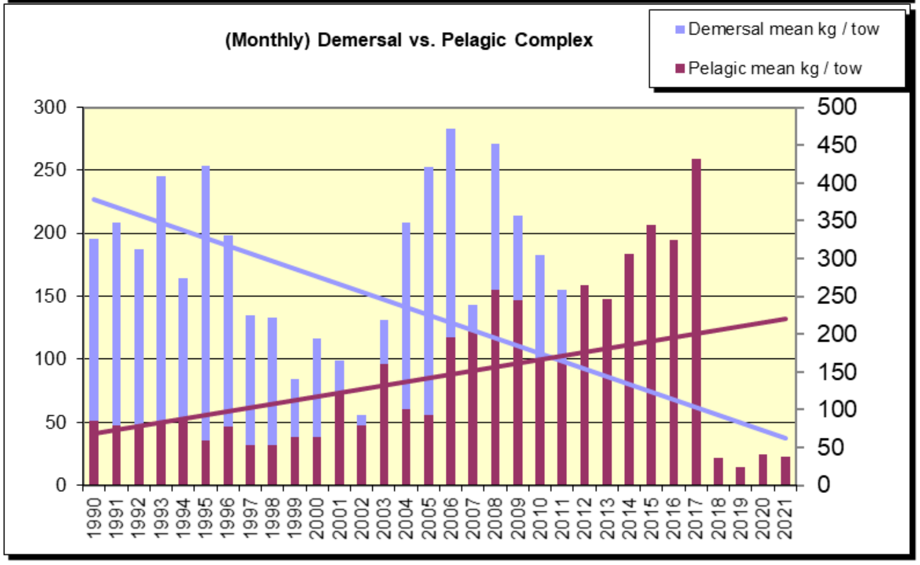


Figure 6 and 7: Demersal vs. Pelagic Species Complex

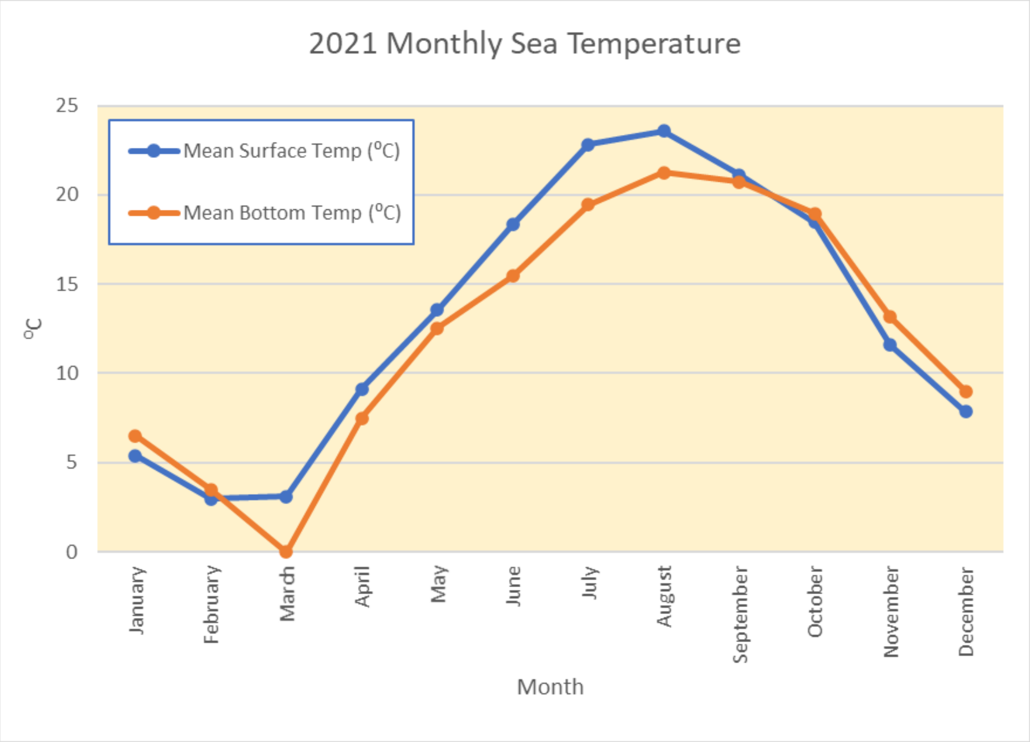
Demersal Species		Pelagic/Multi-Habitat Species	
Smooth Dogfish	Hogchoker	Atlantic Herring	Bluefish
Spiny Dogfish	Longhorn Sculpin	Alewife	Striped Bass
Skates	Sea Raven	Blueback Herring	Black Sea Bass
Silver Hake	Northern Searobin	Shad	Scup
Red Hake	Striped Searobin	Menhaden	Weakfish
Spotted Hake	Cunner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

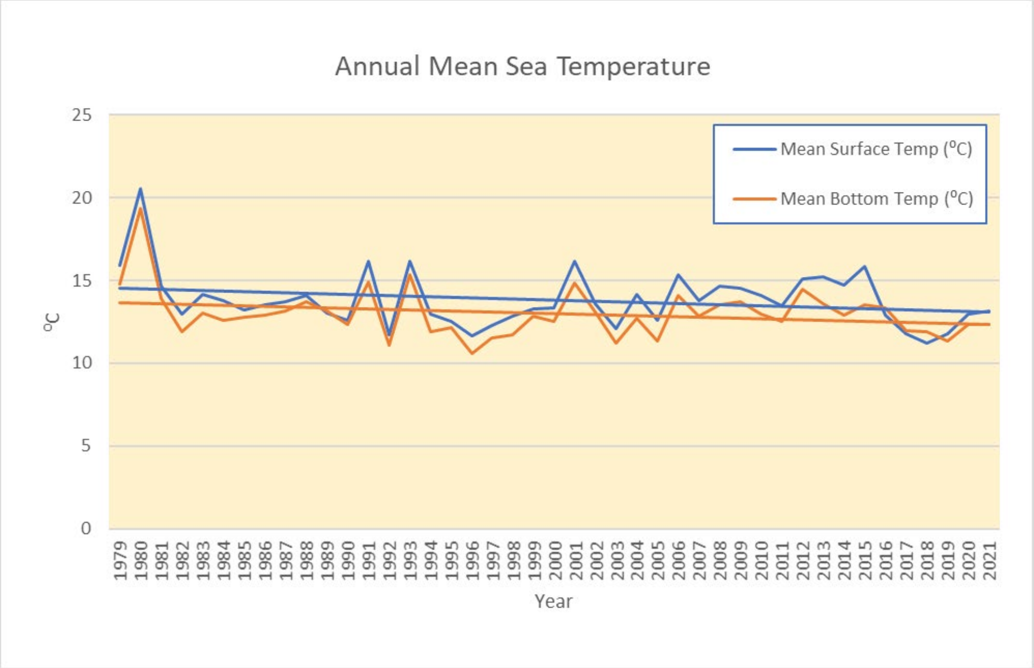




Monthly Survey Temperature Profile (Annual mean surface and bottom temperature)

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. 61 species were observed and recorded during the 2021 Rhode Island Seasonal Trawl Survey, totaling 371,748 individuals or 4224.4 fish per tow. In weight, the catch accounted for 6076.28 kg. or 69.04 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	217408
STENOTOMUS CHRYSOPS	Scup	78786
DORYTEUTHIS PEALEII	Longfin Squid	17312
PEPRILUS TRIACANTHUS	Butterfish	17101
SELENE SETAPINNIS	Atlantic Moonfish	13045
CYNOSCION REGALIS	Weakfish	11355
BREVOORTIA TYRANNUS	Atlantic Menhaden	7556
POMATOMUS SALTATRIX	Bluefish	3156
GADUS MORHUA	Atlantic Cod	1462
CLUPEA HARENGUS	Atlantic Herring	794
PRIONOTUS CAROLINUS	Northern Sea Robin	661
ANCHOA HEPSETUS	Striped Anchovy	602
ALOSA PSEUDOHARENGUS	Alewife	508
LEUCORAJA ERINACEA	Little Skate	211
MUSTELUS CANIS	Smooth Dogfish	168
CENTROPRISTIS STRIATA	Black Sea Bass	136
LEIOSTOMUS XANTHURUS	Spot	132
PLEURONECTES AMERICANUS	Winter Flounder	131
PARALICHTHYS DENTATUS	Summer Flounder	90
CANCER IRRORATUS	Rock Crab	81
UROPHYCIS REGIA	Spotted Hake	79
LEUCORAJA OCELLATA	Winter Skate	76
SPHYRAENA BOREALIS	Northern Sennet	62
MERLUCCIUS BILINEARIS	Silver Hake	55
PRIONOTUS EVOLANS	Striped Sea Robin	51
MENTICIRRHUS SAXATILIS	Northern Kingfish	50
TRACHURUS LATHAMI	Rough Scad	41
AMMODYTES AMERICANUS	Sand Lance	39
HOMARUS AMERICANUS	American Lobster	39
SYNODUS FOETENS	Inshore Lizardfish	31

UROPHYCIS CHUSS	Red Hake	30
TAUTOGA ONITIS	Tautog	27
ALOSA SAPIDISSIMA	American Shad	24
LIMULUS POLYPHEMUS	Horseshoe Crab	21
RAJA EGLANTERIA	Clearnose Skate	20
PRIACANTHUS ARENATUS	Bigeye	20
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	18
ALOSA AESTIVALIS	Blueback Herring	15
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	13
MACROZOARCES AMERICANUS	Ocean Pout	12
MORONE SAXATILIS	Striped Bass	11
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	8
ETROPUS MICROSTOMUS	Smallmouth Flounder	5
SPHOEROIDES MACULATUS	Northern Puffer	5
CALLINECTES SAPIDUS	Blue Crab	5
BUSYCON CARICA	Knobbed Whelk	4
SCOMBER SCOMBRUS	Atlantic Mackerel	3
CARANX CRYSOS	Blue Runner	3
TAUTOGOLABRUS ADSPERSUS	Cunner	3
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	2
HEMITRIPTERUS AMERICANUS	Sea Raven	2
LOPHIUS AMERICANUS	Goosefish	2
PARALICHTHYS OBLONGUS	Fourspot Flounder	1
MENIDIA MENIDIA	Atlantic Silverside	1
SYNGNATHUS FUSCUS	Northern Pipefish	1
FISTULARIA TABACARIA	Cornetfish	1
PHOLIS GUNNELLUS	Rock Gunnel	1
OPSANUS TAU	Oyster Toadfish	1
MICROGADUS TOMCOD	Atlantic Tomcod	1

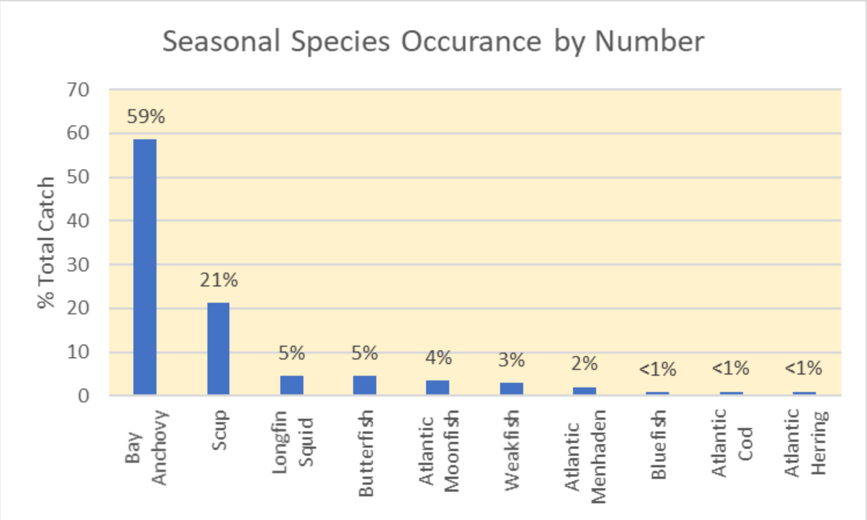
Figure 9 (Total Catch in Kilograms)

Scientific Name	Common Name	Total Weight
STENOTOMUS CHRYSOPS	Scup	3729.543
PEPRILUS TRIACANTHUS	Butterfish	399.255
CYNOSCION REGALIS	Weakfish	306.869
DORYTEUTHIS PEALEII	Longfin Squid	290.289
ANCHOA MITCHILLI	Bay Anchovy	188.666
MUSTELUS CANIS	Smooth Dogfish	181.341
POMATOMUS SALTATRIX	Bluefish	179.214
PRIONOTUS CAROLINUS	Northern Sea Robin	121.993
LEUCORAJA ERINACEA	Little Skate	105.045
SELENE SETAPINNIS	Atlantic Moonfish	73.29
PARALICHTHYS DENTATUS	Summer Flounder	60.639
BREVOORTIA TYRANNUS	Atlantic Menhaden	57.582
LEUCORAJA OCELLATA	Winter Skate	53.2
LIMULUS POLYPHEMUS	Horseshoe Crab	49.432
CENTROPRISTIS STRIATA	Black Sea Bass	47.209
PLEURONECTES AMERICANUS	Winter Flounder	38.342
RAJA EGLANTERIA	Clearnose Skate	32.578
TAUTOGA ONITIS	Tautog	21.141
PRIONOTUS EVOLANS	Striped Sea Robin	19.776
LEIOSTOMUS XANTHURUS	Spot	16.94
HOMARUS AMERICANUS	American Lobster	15.37
CANCER IRRORATUS	Rock Crab	12.555
MACROZOARCES AMERICANUS	Ocean Pout	9.255
ALOSA PSEUDOHARENGUS	Alewife	8.12
CLUPEA HARENGUS	Atlantic Herring	7.895
MORONE SAXATILIS	Striped Bass	7.555
MYOXOCEPHALUS OCTODECEMSPINOS	Longhorn Sculpin	4.811
SPHYRAENA BOREALIS	Northern Sennet	4.372
UROPHYCIS REGIA	Spotted Hake	4.168
SCOPHTHALMUS AQUOSUS	Windowpane Flounder	3.538
SYNODUS FOETENS	Inshore Lizardfish	3.536
MENTICIRRHUS SAXATILIS	Northern Kingfish	3.492
MERLUCCIUS BILINEARIS	Silver Hake	3.226
LOPHIUS AMERICANUS	Goosefish	2.46
UROPHYCIS CHUSS	Red Hake	2.437
HEMITRIPTERUS AMERICANUS	Sea Raven	1.772
TRACHURUS LATHAMI	Rough Scad	1.338
ANCHOA HEPSETUS	Striped Anchovy	1.222
BUSYCOTYPUS CANALICULATUS	Channeled Whelk	1.221

SCOMBER SCOMBRUS	Atlantic Mackerel	1.01
CALLINECTES SAPIDUS	Blue Crab	0.886
GADUS MORHUA	Atlantic Cod	0.774
BUSYCON CARICA	Knobbed Whelk	0.76
ALOSA SAPIDISSIMA	American Shad	0.465
PRIACANTHUS ARENATUS	Bigeye	0.305
AMMODYTES AMERICANUS	Sand Lance	0.274
SPHOEROIDES MACULATUS	Northern Puffer	0.24
ALOSA AESTIVALIS	Blueback Herring	0.236
CARANX CRYSOS	Blue Runner	0.225
PARALICHTHYS OBLONGUS	Fourspot Flounder	0.204
OPSANUS TAU	Oyster Toadfish	0.07
ETROPUS MICROSTOMUS	Smallmouth Flounder	0.045
CITHARICHTHYS ARCTIFRONS	Gulfstream Flounder	0.03
FISTULARIA TABACARIA	Cornetfish	0.025
PETROMYZON MARINUS	Sea Lamprey	0.015
TAUTOGOLABRUS ADSPERSUS	Cunner	0.01
PRISTIGENYS ALTA	Short Bigeye	0.01
PHOLIS GUNNELLUS	Rock Gunnel	0.008
MENIDIA MENIDIA	Atlantic Silverside	0.005
SYNGNATHUS FUSCUS	Northern Pipefish	0.001
MICROGADUS TOMCOD	Atlantic Tomcod	0.001

Figure 10 **Top Ten Species Catch in Number**

Scientific Name	Common Name	%
ANCHOA MITCHILLI	Bay Anchovy	58.53%
STENOTOMUS CHRYSOPS	Scup	21.21%
DORYTEUTHIS PEALEII	Longfin Squid	4.66%
PEPRILUS TRIACANTHUS	Butterfish	4.60%
SELENE SETAPINNIS	Atlantic Moonfish	3.51%
CYNOSCION REGALIS	Weakfish	3.06%
BREVOORTIA TYRANNUS	Atlantic Menhaden	2.03%
POMATOMUS SALTATRIX	Bluefish	0.85%
GADUS MORHUA	Atlantic Cod	0.39%
CLUPEA HARENGUS	Atlantic Herring	0.21%



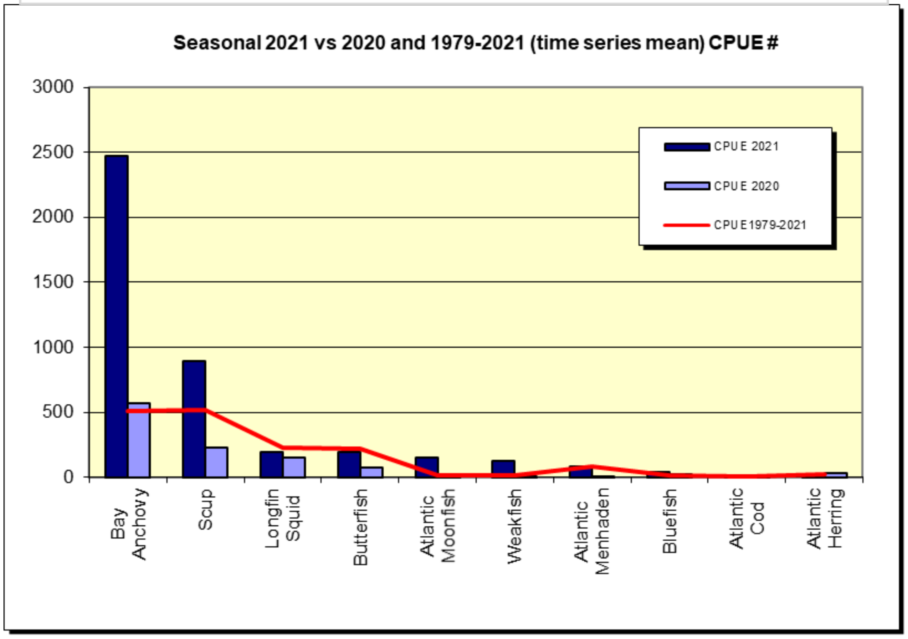
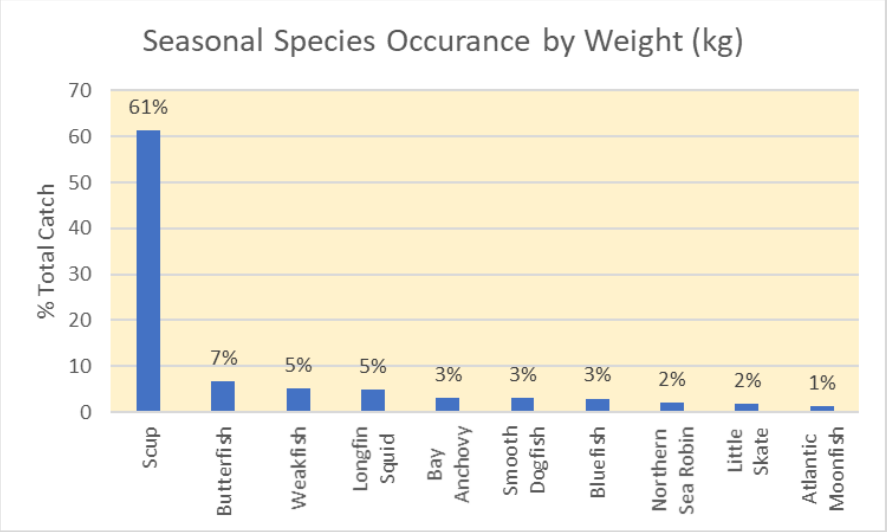


Figure 11 Top Ten Species Catch in Kilograms

Scientific Name	Common Name	%
STENOTOMUS CHRYSOPS	Scup	61.38%
PEPRILUS TRIACANTHUS	Butterfish	6.57%
CYNOSCION REGALIS	Weakfish	5.05%
DORYTEUTHIS PEALEII	Longfin Squid	4.78%
ANCHOA MITCHILLI	Bay Anchovy	3.10%
MUSTELUS CANIS	Smooth Dogfish	2.98%
POMATOMUS SALTATRIX	Bluefish	2.95%
PRIONOTUS CAROLINUS	Northern Sea Robin	2.01%
LEUCORAJA ERINACEA	Little Skate	1.73%
SELENE SETAPINNIS	Atlantic Moonfish	1.21%



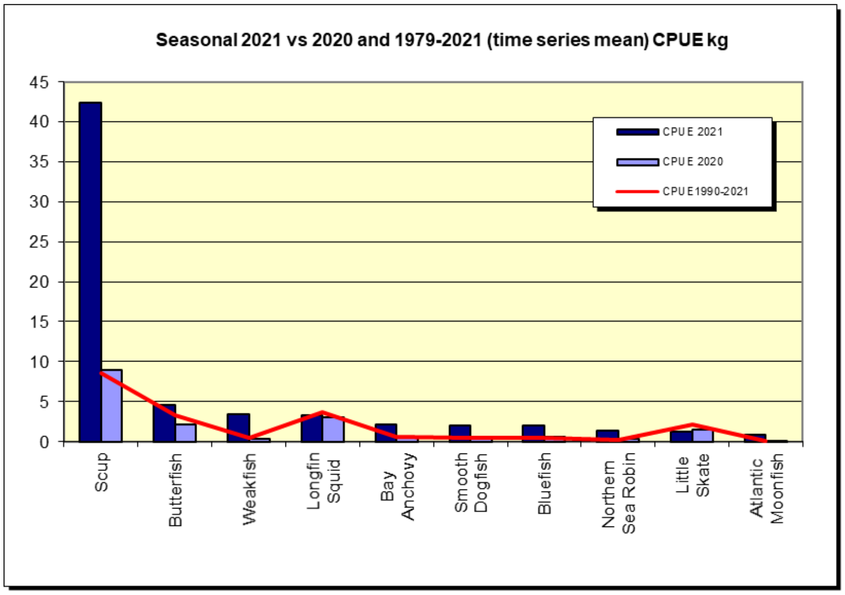
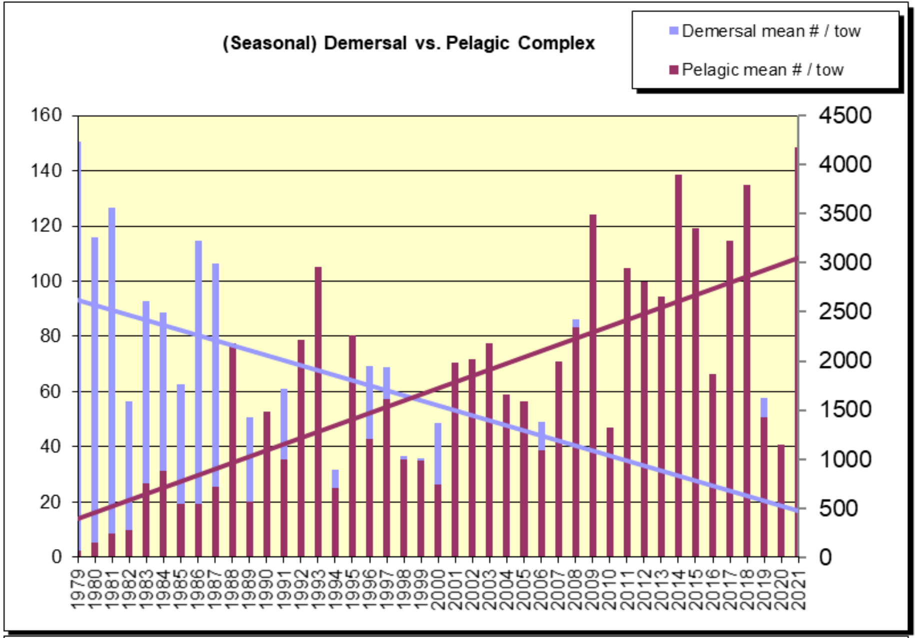
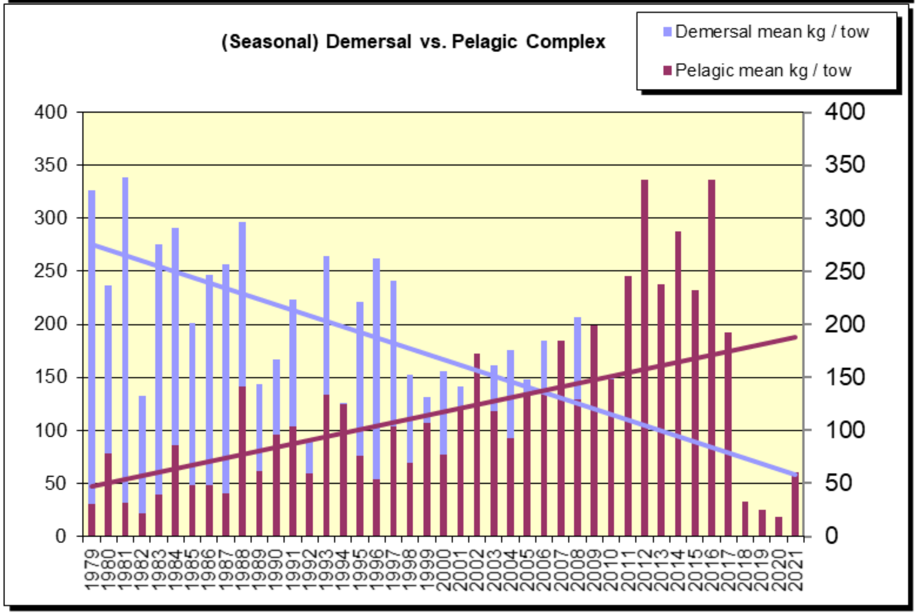


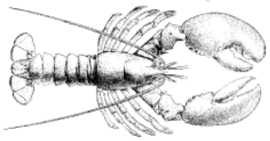
Figure 12 and 13: Demersal vs. Pelagic Species Complex

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	



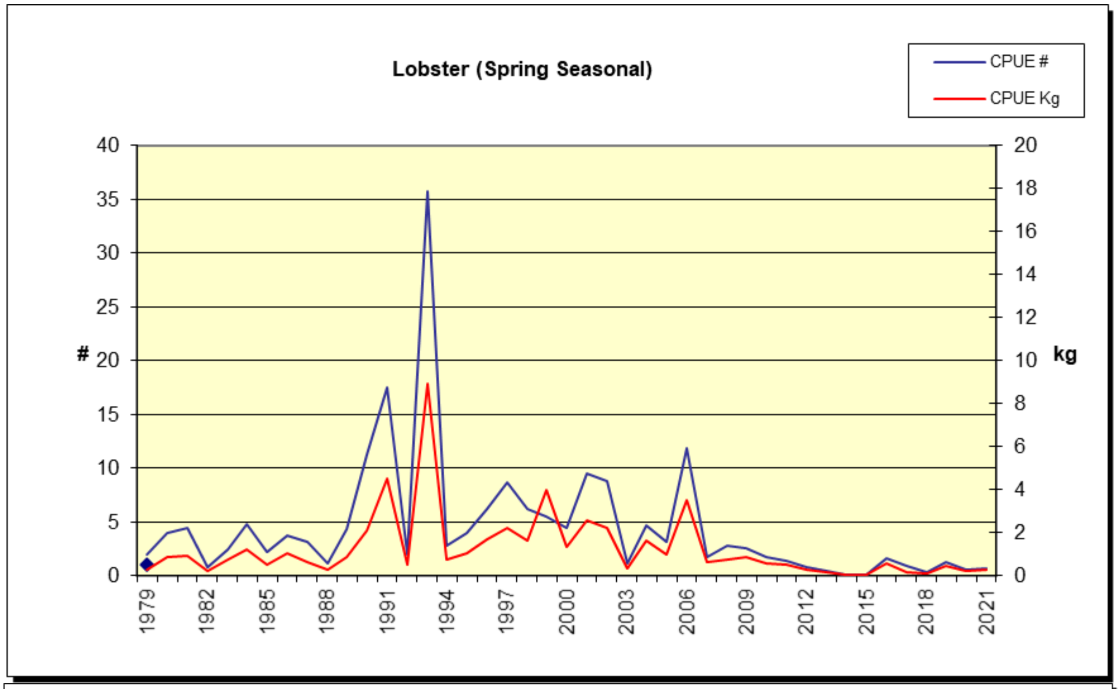


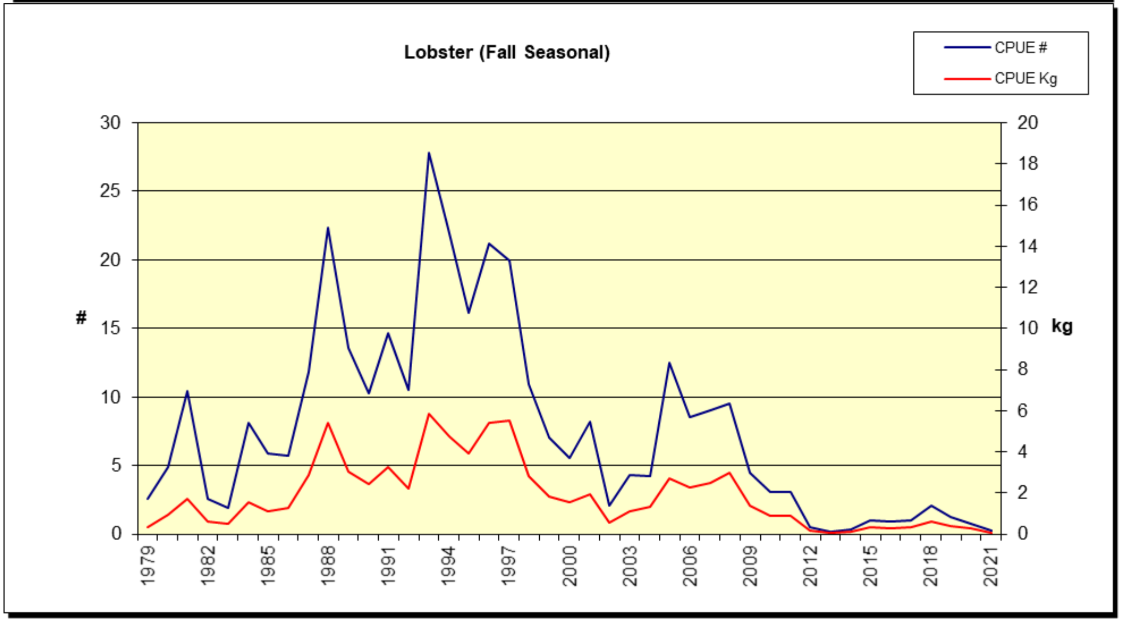
The following species represented are of high importance and are currently managed under fishery management plans through the Atlantic States Marine Fisheries Commission, New England Fishery Management Council, or the National Marine Fisheries Service. The seasonal portion of the Rhode Island Coastal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

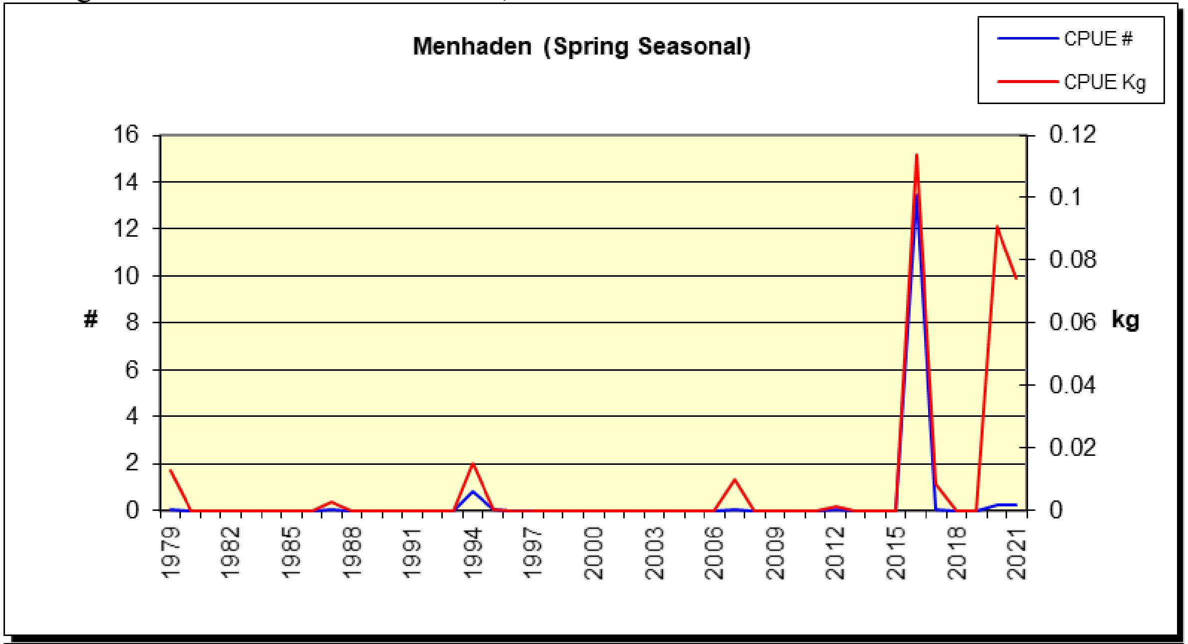
Stock Status: Southern New England Stock: overfished. Depleted Poor condition.
Management: ASMFC Amendment III, Addendum XXVI

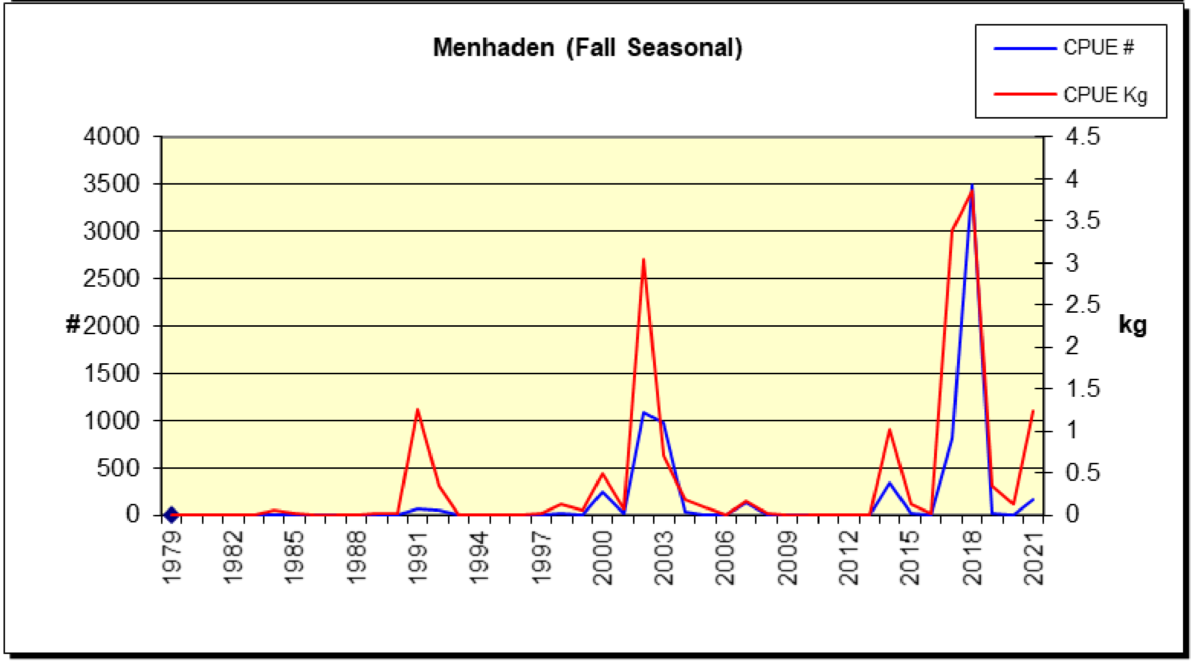




Atlantic Menhaden ***Brevoortia tyrannus***

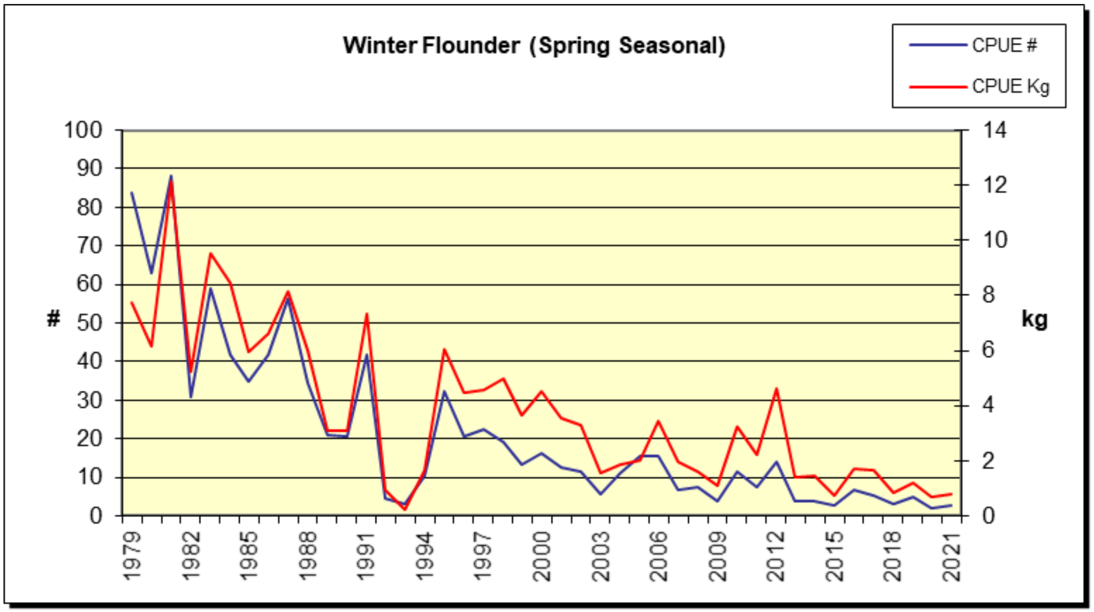
Stock Status: Not Overfished and overfishing is not occurring.
Management: ASMFC Amendment III, Addendum I

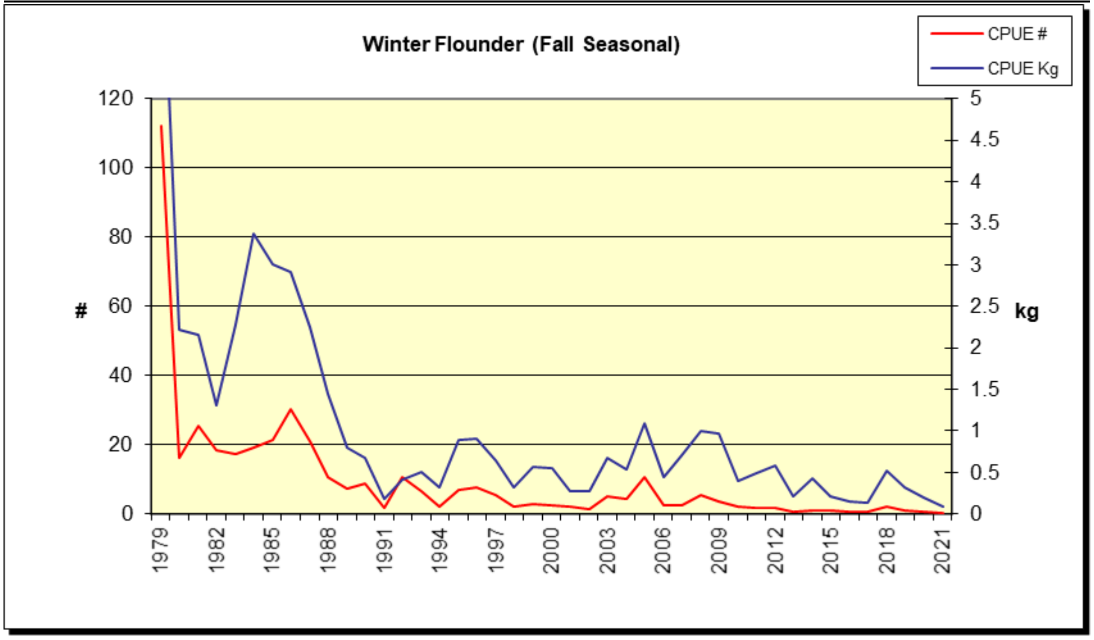


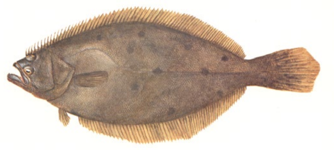


Winter Flounder ***Pleuronectes americanus***

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

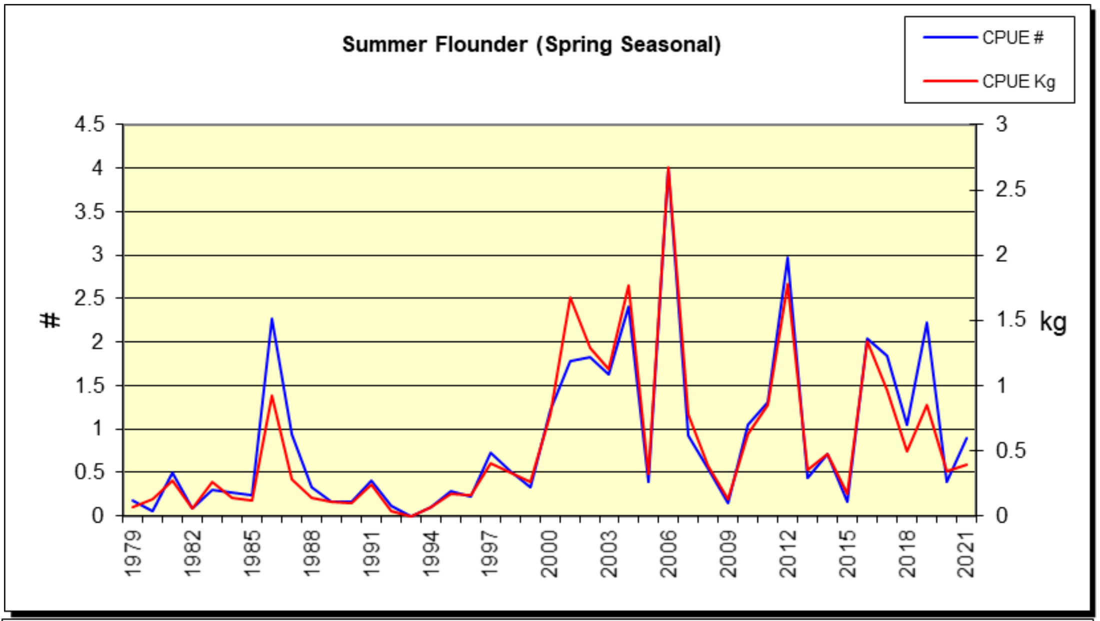


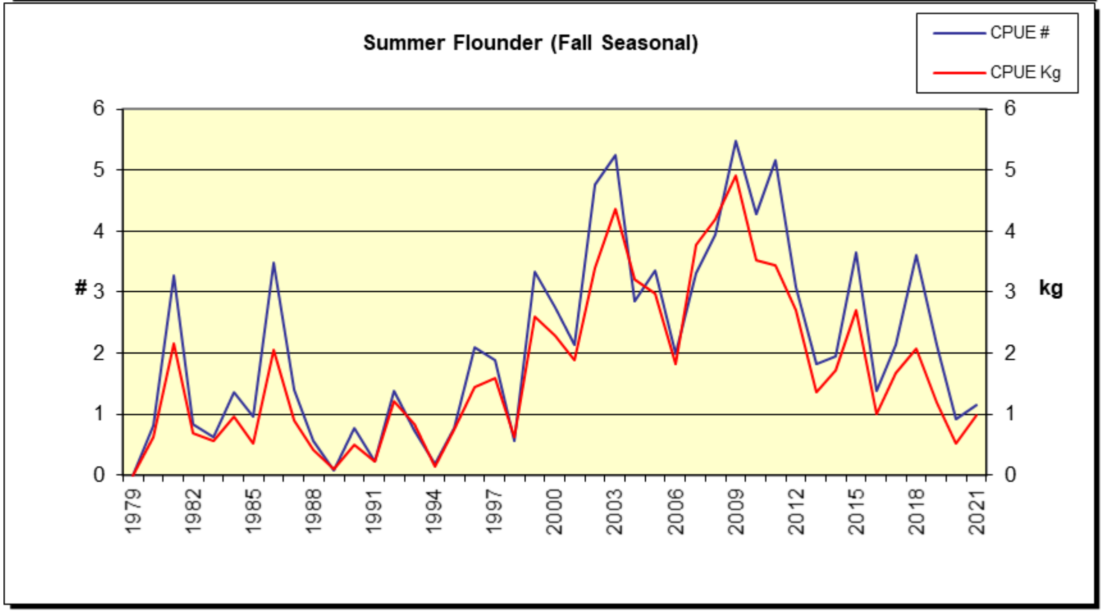




Sumer Flounder ***Paralichthys dentatus***

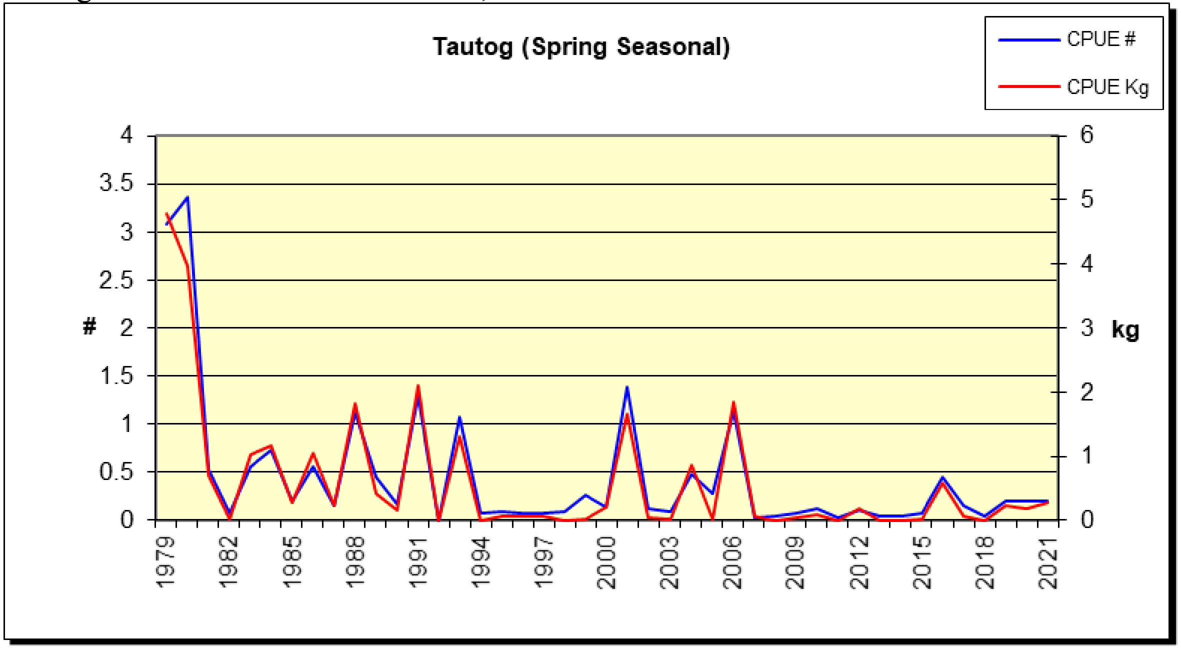
Stock Status: Not overfished and overfishing is occurring.
Management: ASMFC Amendment XIII Addendum XXXII

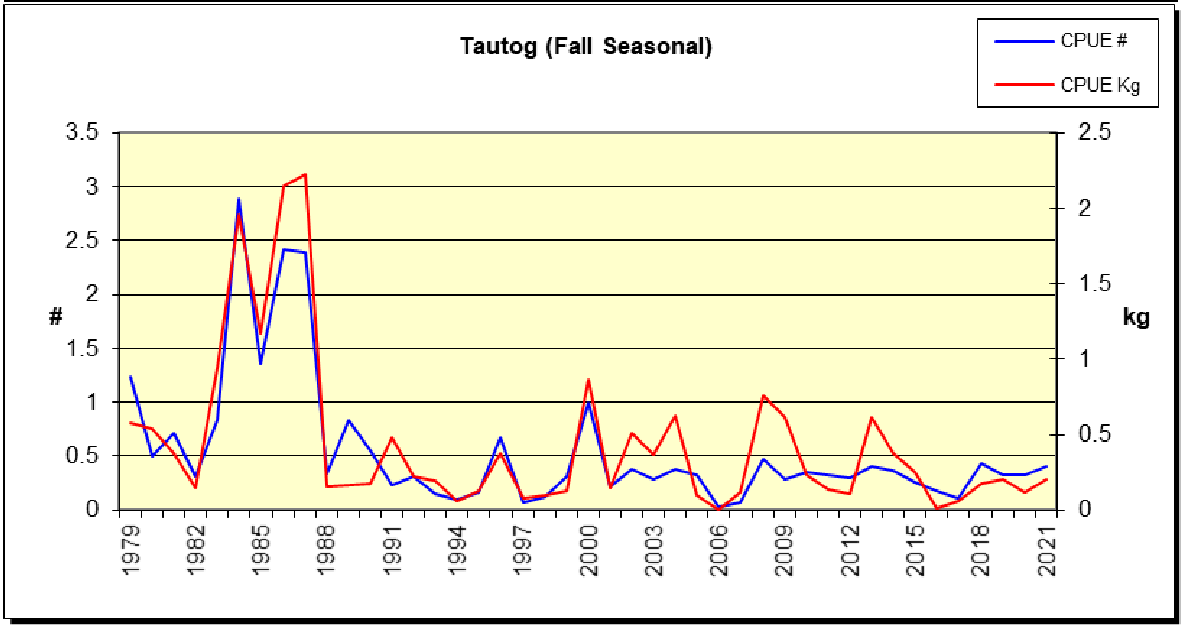


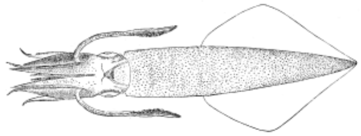


Tautog ***Tautoga onitis***

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

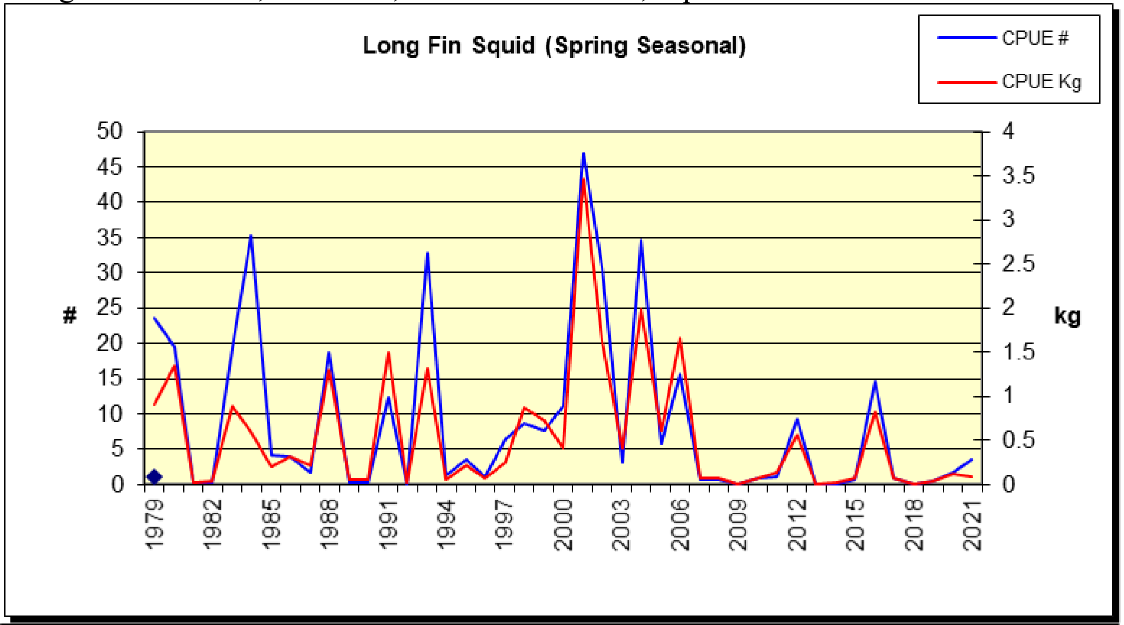


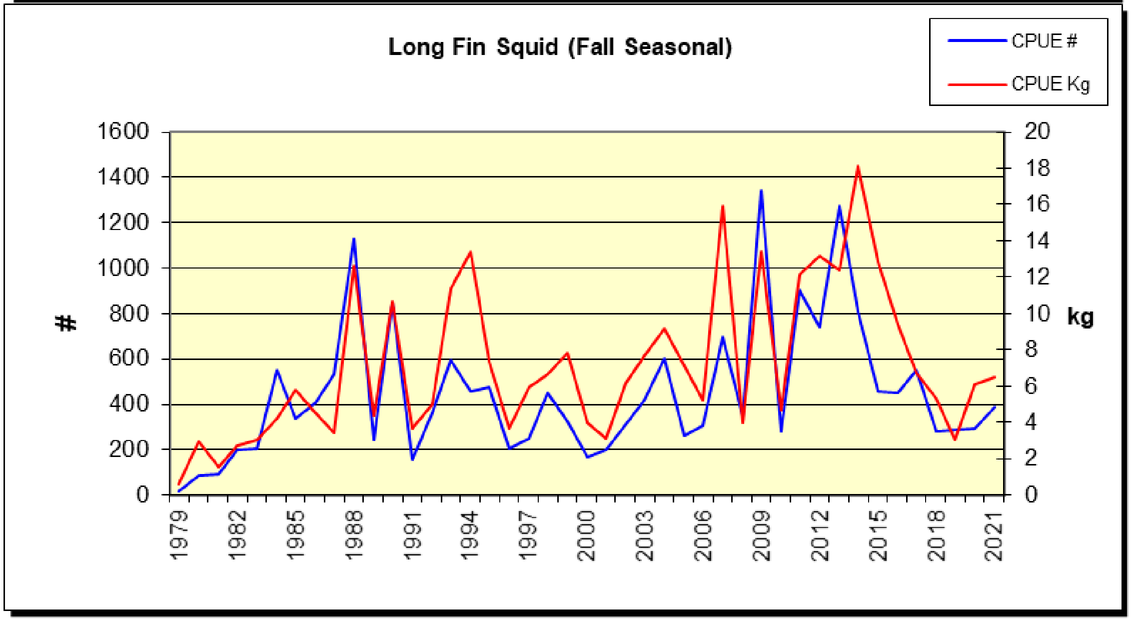


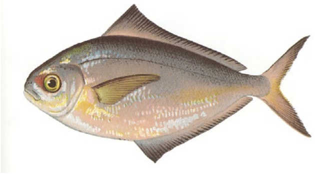


Longfin Squid ***Doryteuthis pealeii***

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

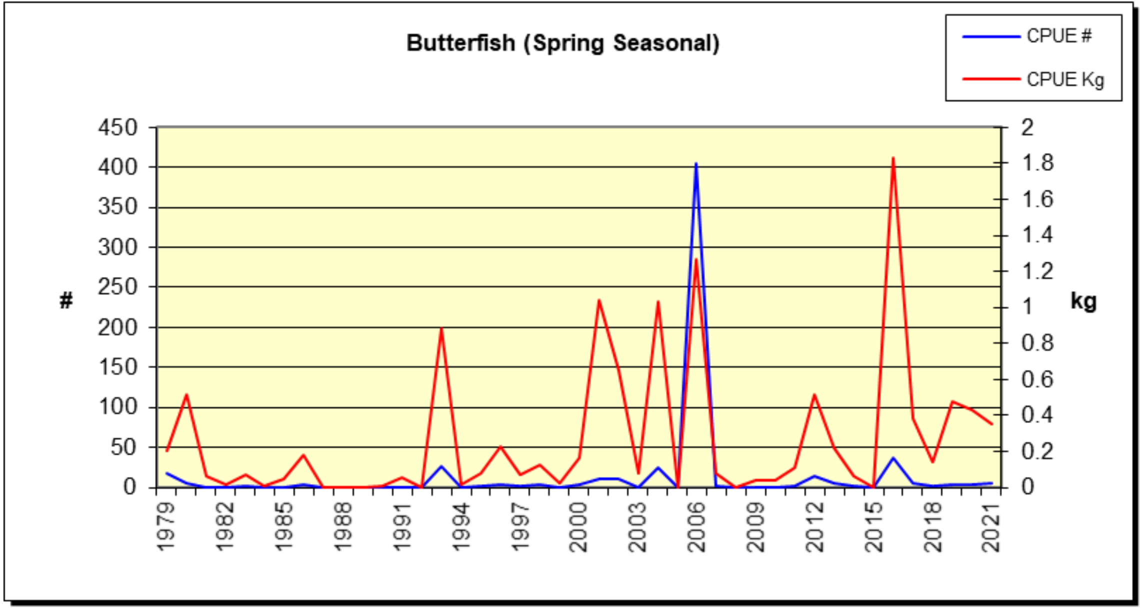


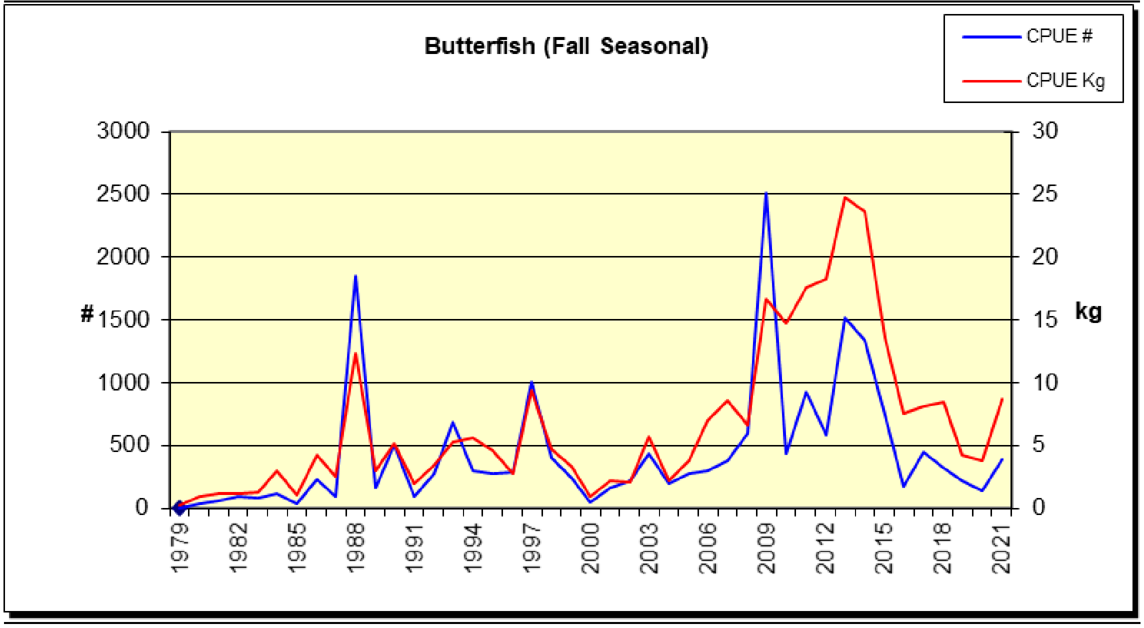




Butterfish ***Peprlilus triacanthus***

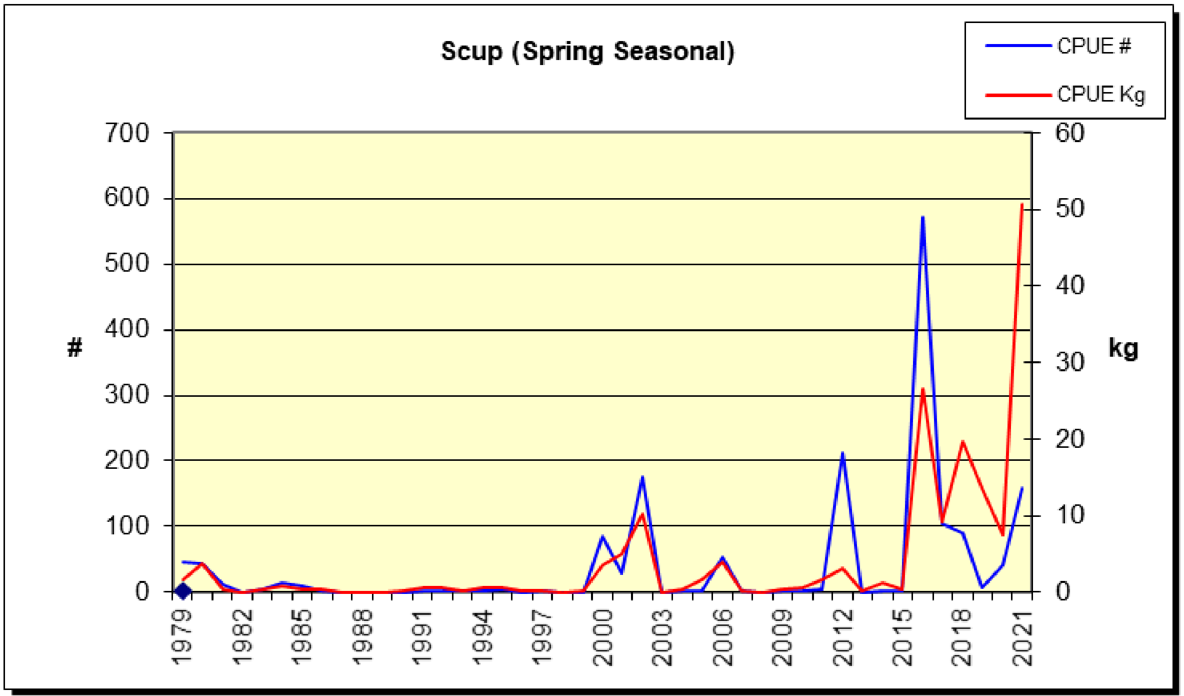
Stock Status: Variable / Uncertain
Management: Mid Atlantic Fishery Management Council, Atlantic Mackerel, Squid Butterfish FMP, ACL

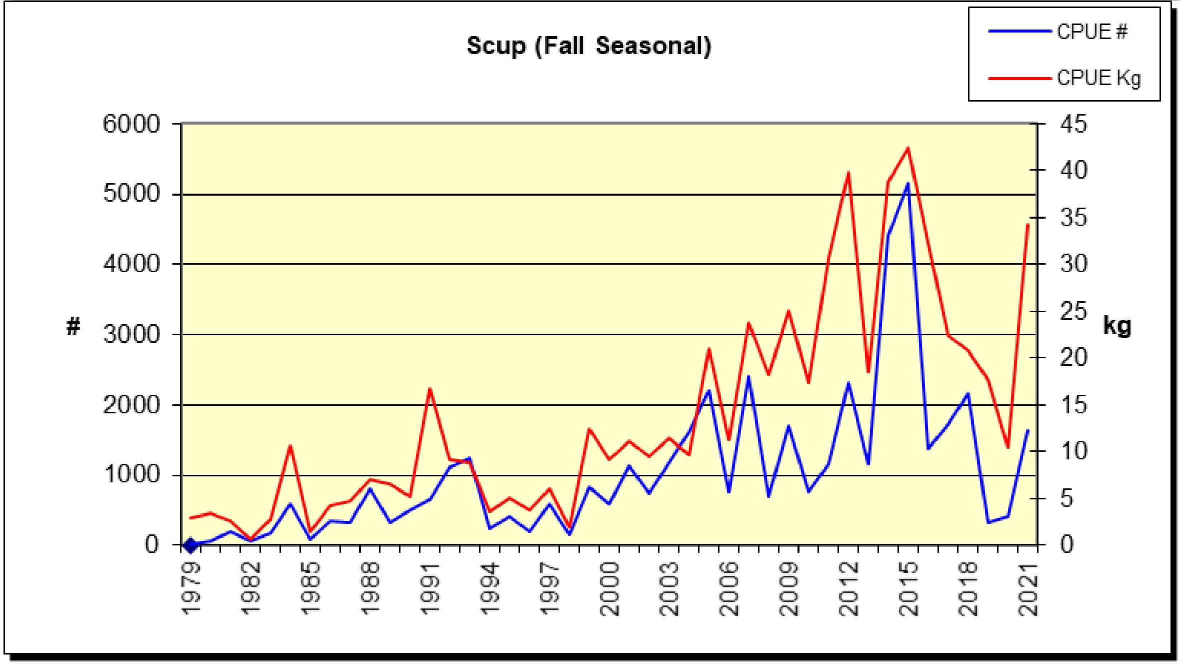




Scup ***Stenotomus chrysops***

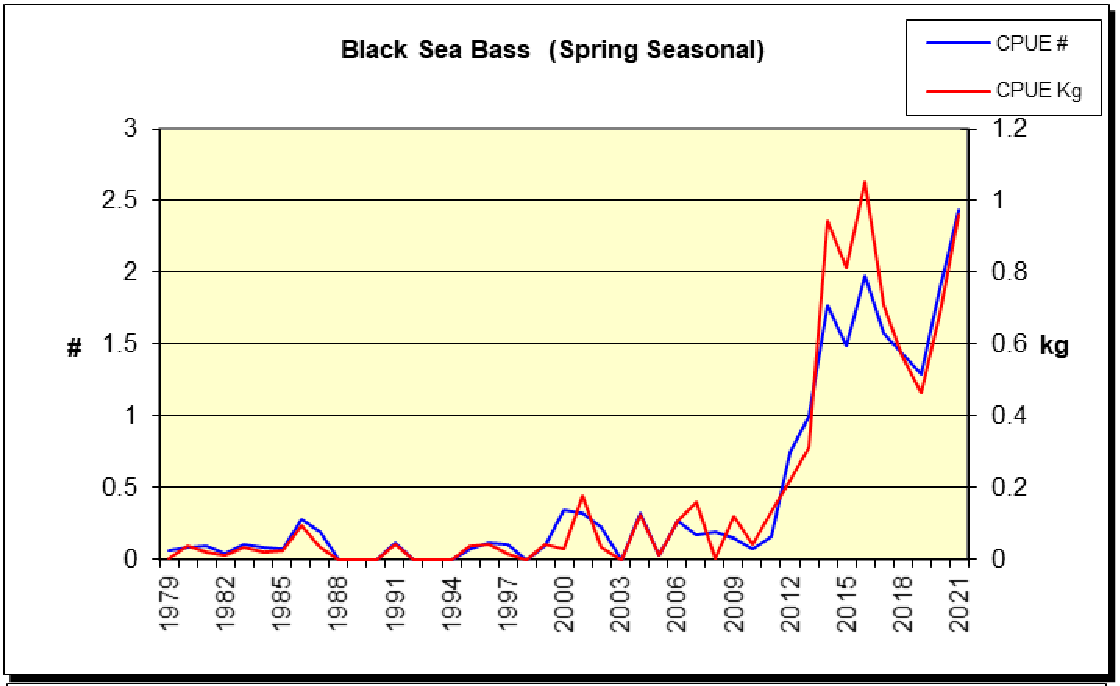
Stock Status: Rebuilt, not overfished and overfishing is not occurring
Management: ASMFC Amendment XIII, Addendum XXXI, Summer Flounder, Scup Black Sea Bass FMP

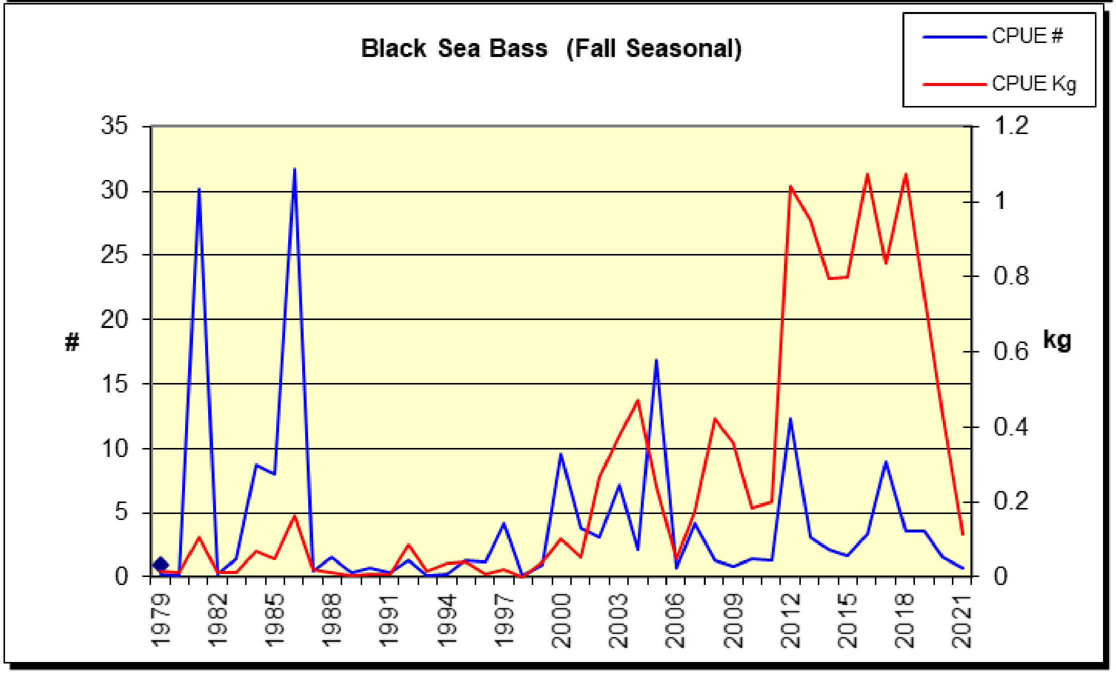




Black Sea Bass *Centropristis striata*

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 2022

Performance Report

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

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

Period Covered: January 1, 2021 – December 31, 2021

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 2021, investigators caught 58 species of finfish representing 36 families within the Washington County coastal ponds. This number is up from 2020, where 44 species from 29 families were collected. However, the number of individuals caught in 2021 decreased from the 2020 survey, with 38,576 collected in 2021 and 51,997 collected in 2020. All 144 seine samples were completed in 2021. The Block Island juvenile finfish seine survey was completed by Diandra Verbeyst, Great Salt Pond Scientist, The Nature Conservancy.

Target Date: December 2021

Status of Project: On Schedule

Significant Deviations: There were no significant deviations in 2021.

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

Remarks:

During 2021, 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 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 fifth in overall species abundance (n=1,579) in 2021, with the highest mean abundance (fish/seine haul) occurring in July (Table 1, Total Pond Index=25.75). This is consistent with usual, as the highest abundance is typically observed in July. This was true for Narrow River, Winnapaug Pond, Quonochontaug Pond, Point Judith Pond, and Charlestown Pond (CPUE = 58.3, 44.3, 40.3, 23.3 and 11.0 respectively). Two ponds saw peak abundance slightly earlier, with Green Hill Pond in May (37.5) and Pawcatuck River in June (29.3). Potter Pond had low peak abundance that occurred in August (7.0 fish/haul).

Winter flounder abundance decreased slightly from 2020 (1,784 individuals caught vs. 1,579 in 2021), but this is still an increase a low of 811 individuals in 2019. The juvenile winter flounder abundance index (YOY WFL index) for the survey measured using the mean fish/seine haul decreased slightly from 12.33 fish/seine haul in 2020 to 10.96 fish/seine haul in 2021. Figure 5 displays the abundance indices by pond over the duration of the coastal pond survey. Table 1 and Figure 6 display the mean catch per seine haul (CPUE) of winter flounder for each month by pond during the 2021 survey. Figure 8 displays winter flounder abundance against mean recorded water temperature.

Winter flounder abundance increased most significantly from 2020 in Narrow River (CPUE=19.06 in 2021 and 8.28 in 2020). Slight increases were observed in Pawcatuck River, Potter Pond, and Quonochontaug, although the differences in CPUE are minimal. The largest decrease was seen in Green Hill Pond, going from 33.1 in 2020 to 7.25 in 2021, although this high index in 2020 was driven by an unusually large catch at Station 1 in June (n=362). Slightly less winter flounder were caught in Charlestown Pond, Point Judith Pond, and Winnapaug Pond in 2021 compared to 2020.

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. 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 2021, juvenile winter flounder ranged in size from 1.8 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 99.7% of individuals collected during sampling season were group 0 fish (less than 12 cm total length, 1,579/1,583). 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).

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 much higher winter flounder abundance in 2021 of 8.87 fish/haul, compared to the very low abundance of 1.59 seen in 2020. The Spring Trawl Survey WFL index was slightly up from 2020, going from 1.84 fish/tow to 2.66 fish/tow. Despite the slight increases, these low numbers are still relatively consistent with the time series lows seen over the last decade. 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 and 2021, higher numbers of winter flounder were caught, with a CPUE of 14.9 in 2020 and 9.6 in 2021. 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. This number was again down in 2021, with only 0.5 fish/haul. Most fish caught were mature females (67%). A total of 2 mature fish were tagged and released in Point Judith Pond, and 117 total in all three ponds. 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 40 bluefish were collected in 2021 (CPUE=0.28 fish/haul). The majority were caught in Pawcatuck River in July and Winnapaug Pond in September This is consistent with 2020 (CPUE=0.29 fish/haul). Table 2 contains the abundance indices for the 2021 survey by month and pond. Bluefish ranged in size from 3 cm to 16 cm. Figure 11 displays the annual abundance index of bluefish for all stations combined.

Tautog (*Tautoga onitis*)

From May to October of 2021, 227 (CPUE= 1.57 fish/haul) tautog were collected in all ponds except Green Hill. This is slightly down from the 277 tautog caught in 2020 (CPUE=1.92 fish/haul) but fairly consistent with the last few years (CPUE= ~2 for 2015-2018). Table 3 contains the abundance indices for the 2020 survey by month and pond. The highest abundances in 2021 occurred in the Potter Pond in July, with lower numbers caught throughout all ponds throughout the season. Tautog caught in 2021 ranged in size from 1.1 cm to 14.3 cm. Figure 12 displays the annual abundance index of tautog for all stations combined.

Black Sea Bass (*Centropristis striata*)

A total of 92 juvenile black sea bass were collected from July to October of 2021 from all ponds except Green Hill Pond and Pawcatuck River (CPUE=0.64 fish/haul). This is an increase from last year (CPUE=0.55 fish/haul) but down from 2018 in which the highest abundance of black sea bass in the history of the survey was recorded (CPUE=4.2). The highest abundance in 2021 was seen in Charlestown Pond in August (CPUE=12.25). None we caught in May or June. Table 4 contains the abundance indices for the survey by month and pond. Black sea bass caught in 2019 ranged in size from 1 cm to 8 cm.

Scup *(Stenotomus chrysops)*

In 2020, 63 scup were collected from July to October in all ponds except Green Hill Pond and Winnapaug Pond (CPUE=0.44 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) but fairly consistent with 2020 (0.3 fish/haul). Despite this, an increase in scup caught has been seen since 2014 (CPUE=0.21). Table 5 contains the abundance indices for the 2021 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 27 cm.

Clupeids:

In 2021, 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 2021 was by far Atlantic Menhaden, with 11,454 individuals captured from July to October (CPUE=79.5 fish/haul). This is a slight decrease from 2020, but menhaden catches are highly variable. In many instances, high numbers of YOY menhaden are 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 2021 was Atlantic Herring. A total of 54 were captured in June and July (CPUE=0.38). Only 29 Alewife were caught in 2021 (CPUE=0.20), consistent with the 33 caught in 2020. No blueback herring were caught in 2021. From May to October (excluding June and July), only 21 bay anchovies were captured (CPUE=0.15). Table 6 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. Due to the highly variable magnitude of catches, abundance is in log-scale

Baitfish Species:

Silversides *(Menidia sp.)*

Silversides had the highest abundance of all species, with 15,139 caught during the 2021 survey (CPUE=105.13fish/haul). This is fairly consistent with observed abundances in the last few years. Silversides were collected in each of the ponds throughout the time period of the survey, with the exception of Quonochontaug Pond in May. The highest abundance index was observed in Quonochontaug Pond, and in August across most ponds. Table 7 contains the abundance indices for the survey by month and pond. Atlantic silversides caught in 2021 ranged in size from 2 cm to 15 cm.

Striped Killifish *(Fundulus majalis)*

Striped killifish ranked third in species abundance with 3,380 fish caught during 2021 (CPUE=23.47). This is up slightly from the last few years ~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. Charlestown Pond and Point Judith Pond had the highest abundance of striped killifish, and overall, they were most prevalent in August and September. Table 8 contains the abundance indices for the survey by month and pond. Striped killifish caught in 2020 ranged in size from 1 cm to 14 cm.

Common Mummichog *(Fundulus heteroclitus)*

The mummichog ranked fourth in overall abundance in 2021 with 2,743 individuals (CPUE=19.0), consistent with the last few years where catches averaged ~2,000 fish per year. They occurred in each of the ponds at least once and were caught each month during the survey. Potter Pond 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 9 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 sixth in overall abundance with 1,387 individuals collected (CPUE=9.63). This is a slight decrease from 2020 (CPUE=13.36). Sheepshead minnow occurred in each of the ponds and were caught between June and October. Overall, the highest abundances were seen in October. Table 10 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 2021 Coastal Pond Survey is summarized in tables 11-13 and Figure 17. Water temperature in 2021 averaged 21.6 ºC, with the lowest observed value of 10.8 ºC in May in Point Judith Pond and the highest at 30 ºC in Charlestown Pond in July. Temperature continues on an annual upward trend. Salinity ranged from 8.74 ppt to 32.20 ppt, and averaged 28.0 ppt. Dissolved oxygen ranged from 5.49 mg/l to 29.62 mg/l with an average of 8.85 mg/l.

New Station Preliminary Data

This year was the eleventh year of sampling stations in the three additional ponds. On a whole, the samples were consistent with 2011-2020. 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 2021, investigators caught 58 species of finfish representing 36 families within the

Washington County coastal ponds. This number is up from 2020, where 44 species from 29 families were collected. However, the number of individuals caught in 2021 decreased from the 2020 survey, with 38,576 collected in 2021 and 51,997 collected in 2020. All 144 seine samples were completed in 2021.Appendix 1 displays the frequency of all species caught by station during the 2021 Coastal Pond Survey. Additional data is available by request.

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Table 1: 2021 Coastal Pond Survey winter flounder abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	Aug	Sept	Oct
Charlestown Pond	5.00	6.50	2.75	2.50	1.75	0.00
Green Hill Pond	37.50	6.00	0.00	0.00	0.00	0.00
Narrow River	10.67	12.00	58.33	25.00	4.67	3.67
Pawcatuck River	2.67	29.33	28.33	1.67	0.33	0.67
Point Judith Pond	12.00	11.50	23.25	6.00	4.75	0.00
Potter's Pond	0.00	3.00	0.00	7.00	1.50	0.00
Quonochontaug Pond	8.67	24.67	40.33	13.33	0.67	0.00
Winnapaug Pond	18.00	42.33	44.33	11.67	6.00	1.00
Total Pond Index	**10.96**	**17.29**	**25.75**	**8.46**	**2.67**	**0.67**

Table 2: 2021 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	0.25	0.00	0.50	0.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.33	0.00	0.00	0.00	0.67	0.00
Pawcatuck River	0.00	0.00	0.00	4.00	0.00	0.00
Point Judith Pond	0.00	0.00	0.50	0.00	0.00	0.00
Potter Pond	0.00	0.50	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	0.33	5.67	0.00
Total Pond Index	**0.04**	**0.04**	**0.13**	**0.54**	**0.88**	**0.04**

Table 3: 2021 Coastal Pond Survey tautog abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	0.00	1.50	3.75	0.25	0.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.67	4.67	4.33	3.00	2.67
Pawcatuck River	0.67	2.33	2.67	5.67	0.00	0.00
Point Judith Pond	0.50	0.25	1.50	4.50	1.25	0.50
Potter Pond	0.00	0.50	15.00	6.00	7.50	2.50
Quonochontaug Pond	0.00	0.00	1.33	3.33	0.33	0.67
Winnapaug Pond	0.00	0.00	2.33	0.33	0.67	0.00
Total Pond Index	**0.17**	**0.46**	**3.13**	**3.58**	**1.37**	**0.75**

Table 4: 2021 Coastal Pond Survey black sea bass abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	0.00	0.00	12.25	1.50	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	3.67	0.67	0.00
Pawcatuck River	0.00	0.00	0.00	0.00	0.00	0.00
Point Judith Pond	0.00	0.00	0.00	0.25	0.00	0.00
Potter Pond	0.00	0.00	0.00	5.00	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	1.67	0.00	0.00
Winnapaug Pond	0.00	0.00	0.33	0.00	1.67	0.00
Total Pond Index	**0.13**	**0.00**	**0.04**	**3.17**	**0.54**	**0.08**

Table 5: 2021 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	3.75	6.00	0.00	0.25
Green Hill Pond	0.00	0.00	0.00	0.00	0.00	0.00
Narrow River	0.00	0.00	1.33	0.33	0.33	0.00
Pawcatuck River	0.00	0.00	0.00	0.00	0.67	0.00
Point Judith Pond	0.00	0.00	0.00	0.50	0.00	0.00
Potter Pond	0.00	0.00	1.50	3.50	0.00	0.00
Quonochontaug Pond	0.00	0.00	0.00	1.00	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	0.92	1.54	0.13	0.04

Table 6: 2021 Coastal Pond Survey Clupeid abundance indices (fish/seine haul) by month

Species	May	June	July	August	September	October
Alewife	0.00	0.00	0.13	0.33	0.71	0.04
Bay Anchovy	0.46	0.00	0.00	0.04	0.17	0.21
Atlantic Herring	0.00	2.21	0.04	0.00	0.00	0.00
Blueback herring	0.00	0.00	0.00	0.00	0.00	0.00
Atlantic Menhaden	0.00	0.00	14.3	296.3	164.5	2.21

Table 7: 2021 Coastal Pond Survey Silverside abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	44.75	141.25	259.00	138.00	41.00	136.75
Green Hill Pond	8.50	10.00	58.00	14.00	118.00	76.50
Narrow River	9.67	8.00	28.00	121.00	51.00	44.67
Pawcatuck River	0.67	7.33	12.67	55.00	16.33	17.33
Point Judith Pond	3.75	1.00	121.50	27.50	607.00	83.00
Potter Pond	17.00	16.00	96.50	58.50	47.50	349.50
Quonochontaug Pond	0.00	8.33	37.67	933.67	28.00	81.67
Winnapaug Pond	4.67	62.00	150.33	334.67	195.00	119.33
Total Pond Index	**12.08**	**36.58**	**104.9**	**214.2**	**158.1**	**105.0**

Table 8: 2021 Coastal Pond Survey Striped Killifish abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	133.25	64.25	123.00	0.00	13.50
Green Hill Pond	0.00	0.00	0.00	0.50	0.00	0.00
Narrow River	0.33	0.33	1.33	26.33	14.33	31.00
Pawcatuck River	0.00	0.00	2.00	5.00	10.67	8.33
Point Judith Pond	1.75	13.50	29.25	43.50	105.25	6.25
Potter Pond	0.00	0.00	0.00	2.50	2.00	3.00
Quonochontaug Pond	0.00	10.67	11.67	59.33	0.67	30.67
Winnapaug Pond	0.00	24.33	45.67	35.00	74.67	17.67
Total Pond Index	**0.33**	**28.88**	**23.17**	**43.71**	**30.25**	**14.5**

Table 9: 2021 Coastal Pond Survey Mummichog abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.50	7.75	13.50	77.00	0.50	0.00
Green Hill Pond	0.00	0.00	10.50	23.50	0.50	5.50
Narrow River	8.67	17.67	40.33	9.00	2.33	67.00
Pawcatuck River	0.33	2.00	3.67	0.67	0.00	3.33
Point Judith Pond	20.00	35.50	83.25	15.25	2.25	1.25
Potter Pond	11.00	30.50	52.50	74.50	89.00	28.00
Quonochontaug Pond	0.33	0.00	11.00	18.00	0.00	0.67
Winnapaug Pond	0.33	45.67	40.00	50.33	12.00	21.67
Total Pond Index	**5.54**	**17.92**	**33.25**	**33.29**	**9.71**	**14.58**

Table 10: 2021 Coastal Pond Survey Sheepshead Minnow abundance indices (fish/seine haul) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	0.00	133.25	64.25	123.00	0.00	13.50
Green Hill Pond	0.00	0.00	0.00	0.50	0.00	0.00
Narrow River	0.33	0.33	1.33	26.33	14.33	31.00
Pawcatuck River	0.00	0.00	2.00	5.00	10.67	8.33
Point Judith Pond	1.75	13.50	29.25	43.50	105.25	6.25
Potter Pond	0.00	0.00	0.00	2.50	2.00	3.00
Quonochontaug Pond	0.00	10.67	11.67	59.33	0.67	30.67
Winnapaug Pond	0.00	24.33	45.67	35.00	74.67	17.67
Total Pond Index	**0.00**	**0.29**	**1.54**	**3.00**	**1.00**	**51.96**

Table 11: 2021 Coastal Pond Survey average water temperature (°C) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	15.33	23.13	27.40		23.20	20.60
Green Hill Pond	16.70	24.35	28.00	27.20	23.65	18.30
Narrow River	12.53		24.97	24.37	21.80	20.53
Pawcatuck River	15.57	21.57	23.73	23.80	22.50	16.70
Point Judith Pond	13.65	22.18	26.05	25.28	23.88	18.40
Potter's Pond	14.90	23.10	26.95	27.05	24.70	18.35
Quonochontaug Pond	14.87	21.53	24.73	25.30	22.47	21.17
Winnapaug Pond	12.33	21.23	24.50	24.73	22.83	20.07
Average	**14.48**	**22.44**	**25.79**	**25.39**	**23.13**	**19.26**

Table 12: 2021 Coastal Pond Survey average salinity (ppt) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	30.10	30.58	29.80		29.81	29.51
Green Hill Pond	24.21	23.16	24.78	24.16	22.72	24.60
Narrow River	24.25		24.85	27.02	26.45	24.46
Pawcatuck River	16.12	23.63	21.24	21.45	28.67	24.78
Point Judith Pond	29.61	25.39	30.05	30.07	29.07	31.14
Potter's Pond	29.39	28.44	29.03	25.36	28.30	29.81
Quonochontaug Pond	31.09	31.62	31.50	31.73	31.18	31.64
Winnapaug Pond	30.76	30.52	30.06	31.02	30.87	31.53
Average	**26.94**	**27.62**	**27.66**	**27.26**	**28.38**	**28.43**

Table 13: 2021 Coastal Pond Survey average dissolved oxygen (mg/L) by pond and month

Waterbody	May	June	July	August	September	October
Charlestown Pond	11.08	9.60	10.33		9.45	10.00
Green Hill Pond	8.56	7.52	7.78	9.23	7.51	7.20
Narrow River	8.36		7.64	6.73	8.36	7.64
Pawcatuck River	9.43	10.20	13.25	7.59	7.43	8.30
Point Judith Pond	8.52	13.87	7.74	8.96	8.30	8.57
Potter's Pond	8.27	10.57	8.63	7.26	8.17	8.27
Quonochontaug Pond	9.11	7.75	8.83	9.74	7.18	8.21
Winnapaug Pond	8.93	9.03	8.73	7.73	8.02	8.95
Average	**9.03**	**9.79**	**9.12**	**8.18**	**8.05**	**8.39**

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

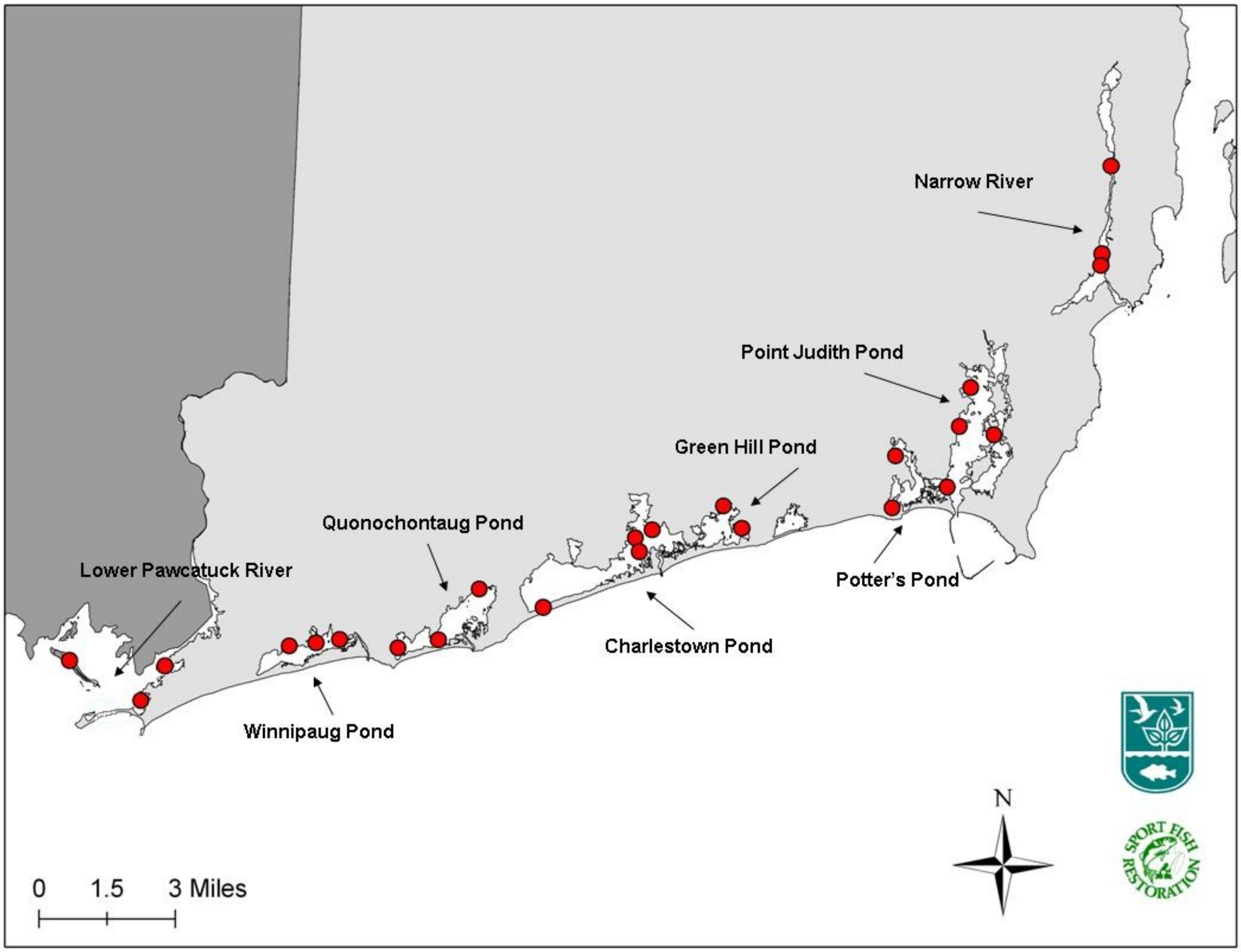


Figure 2: Coastal Pond Juvenile Finfish Survey station locations (western ponds).

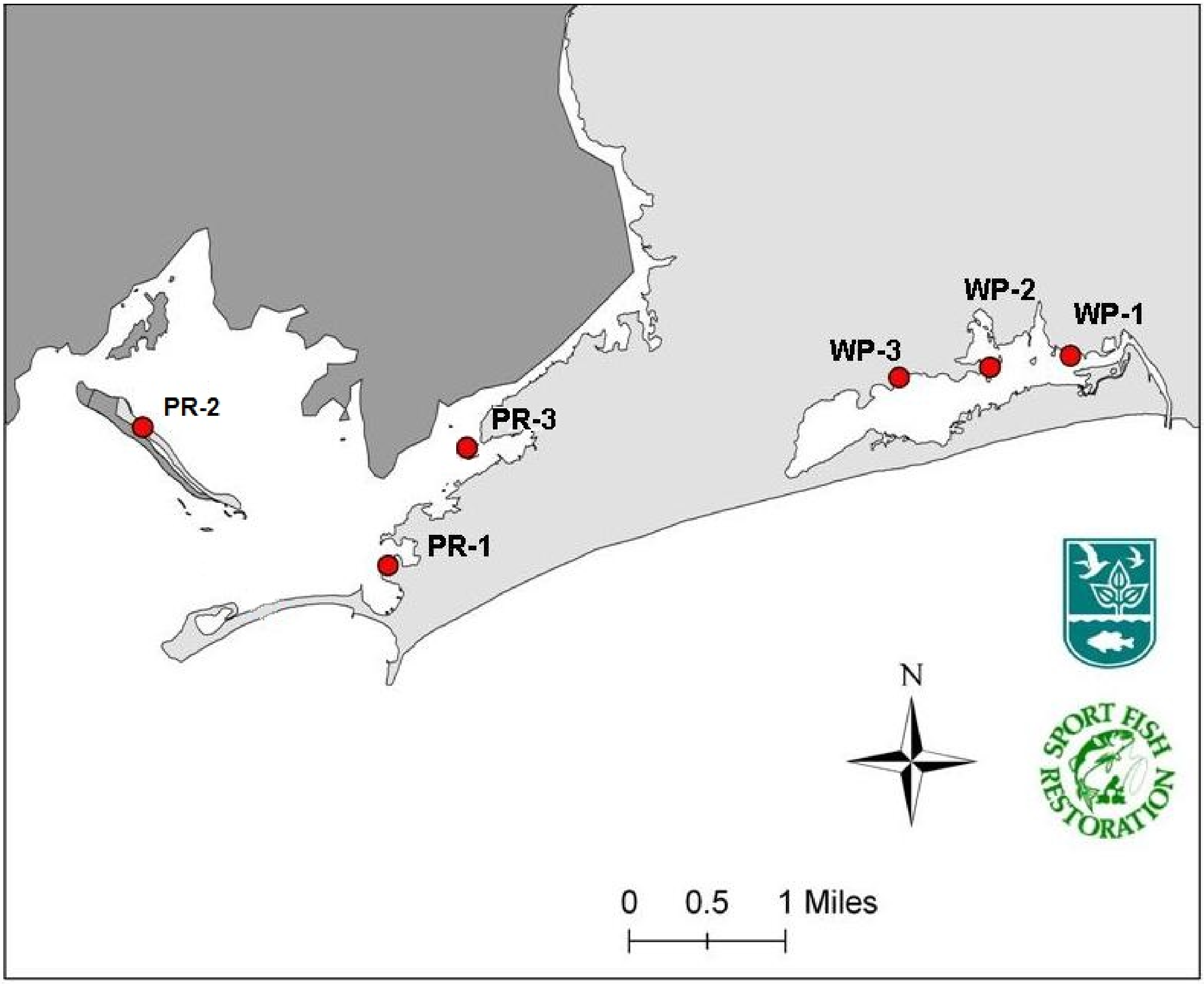


Figure 2 (cont): Coastal Pond Juvenile Finfish Survey station locations (western ponds).

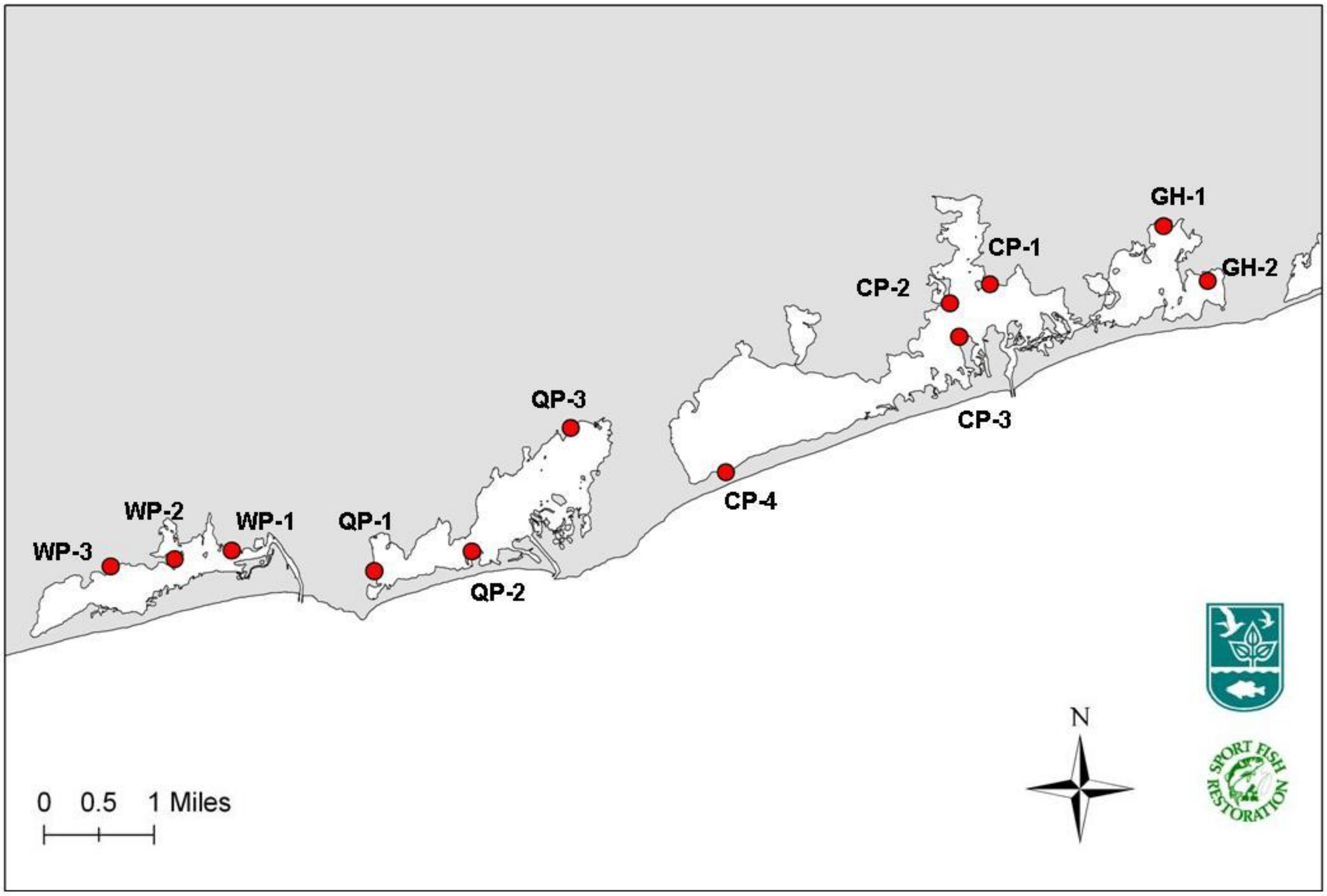


Figure 3: Coastal Pond Juvenile Finfish Survey station locations (eastern ponds).

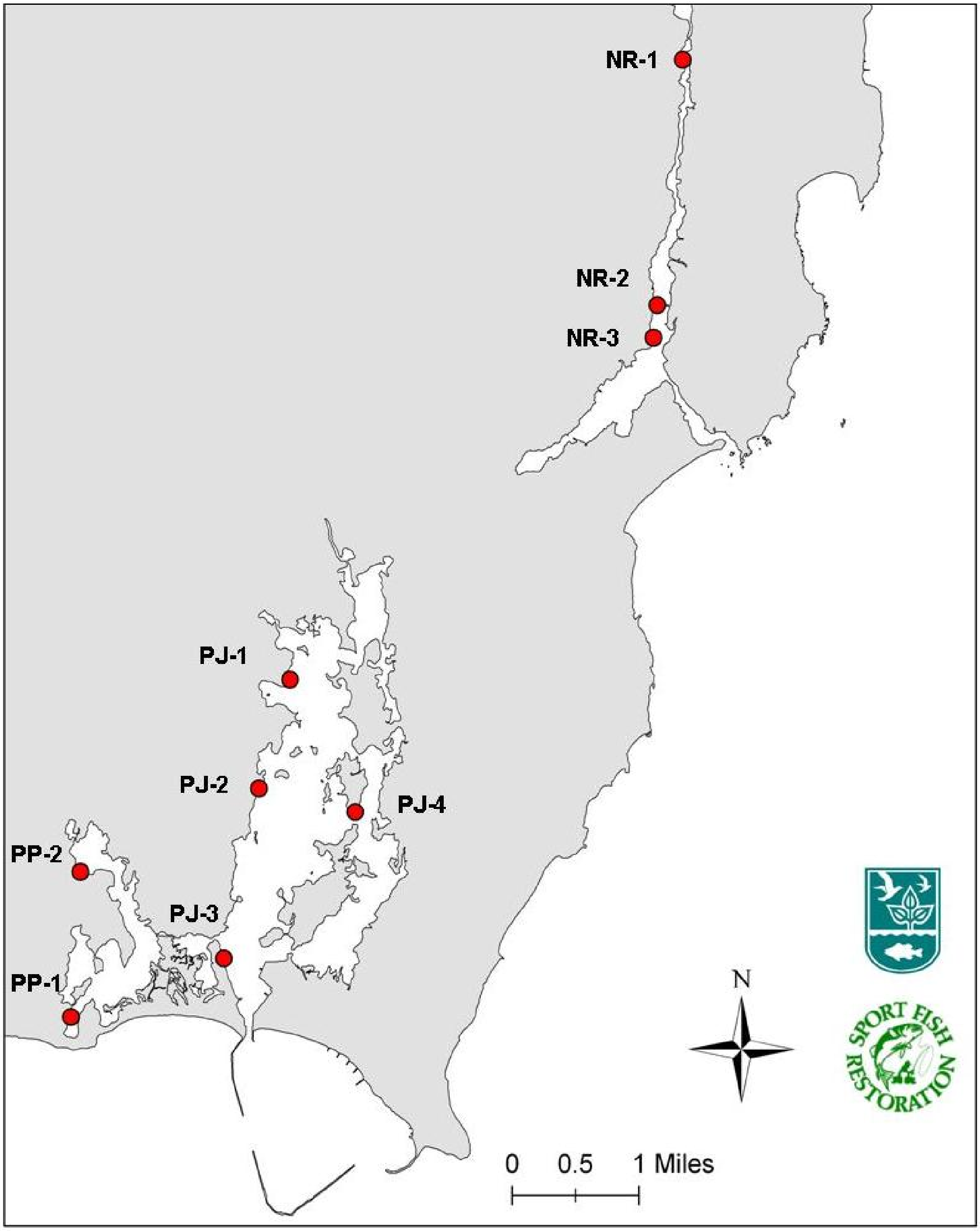


Figure 4
Coastal Pond Juvenile Finfish Survey

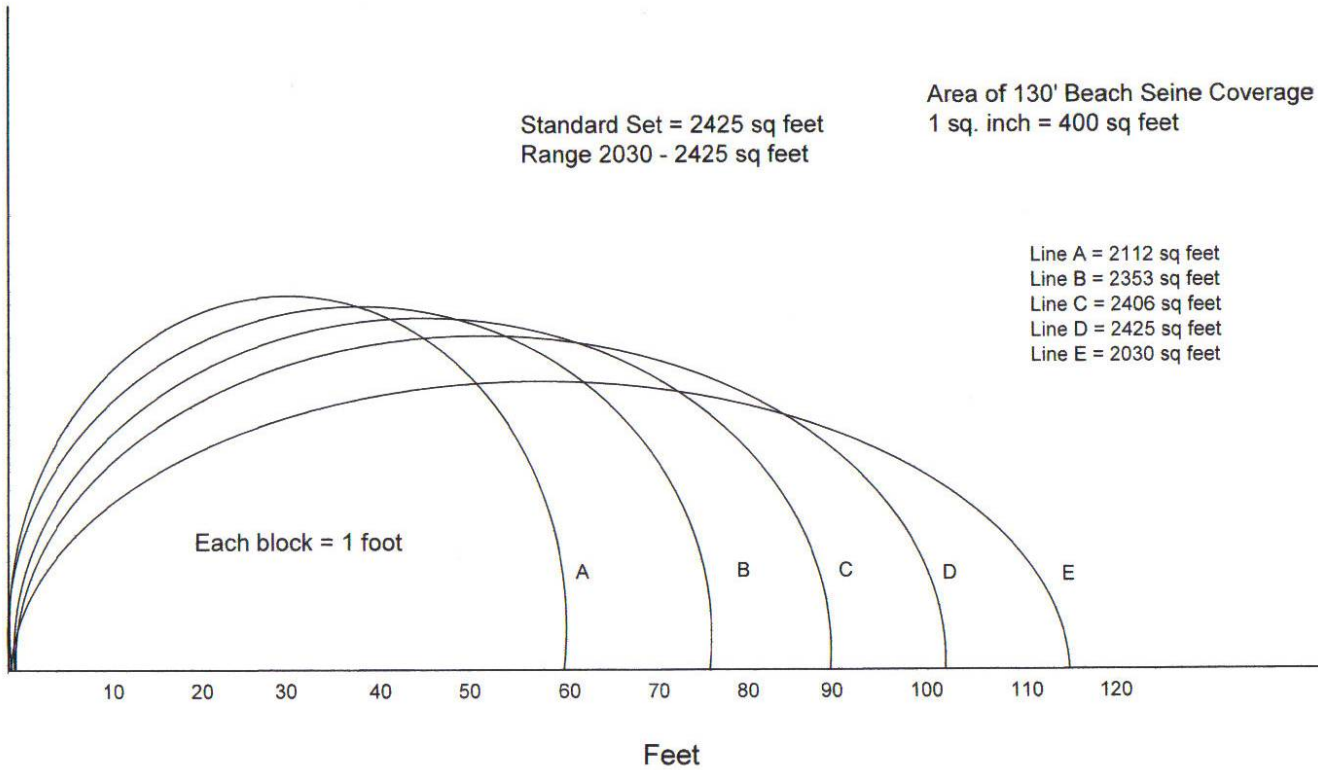


Figure 5: Time series of abundance indices (fish/seine haul) for winter flounder YOY from all coastal ponds. Lines are loess smoothing curves with approximate 95% confidence intervals in grey. Grey dashed line is time series median.

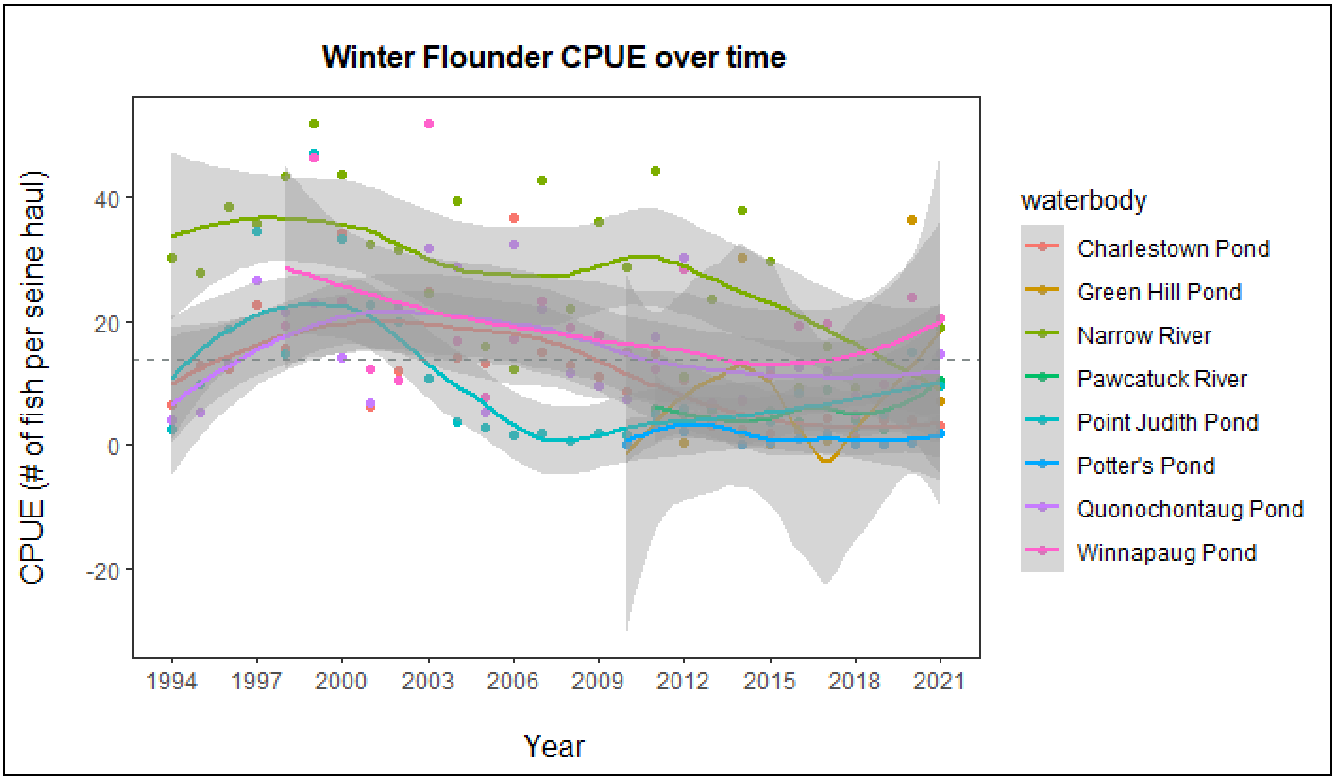


Figure 6: 2021 abundance indices (fish/seine haul) for YOY winter flounder for each pond by month. Grey dashed line is 2021 median.

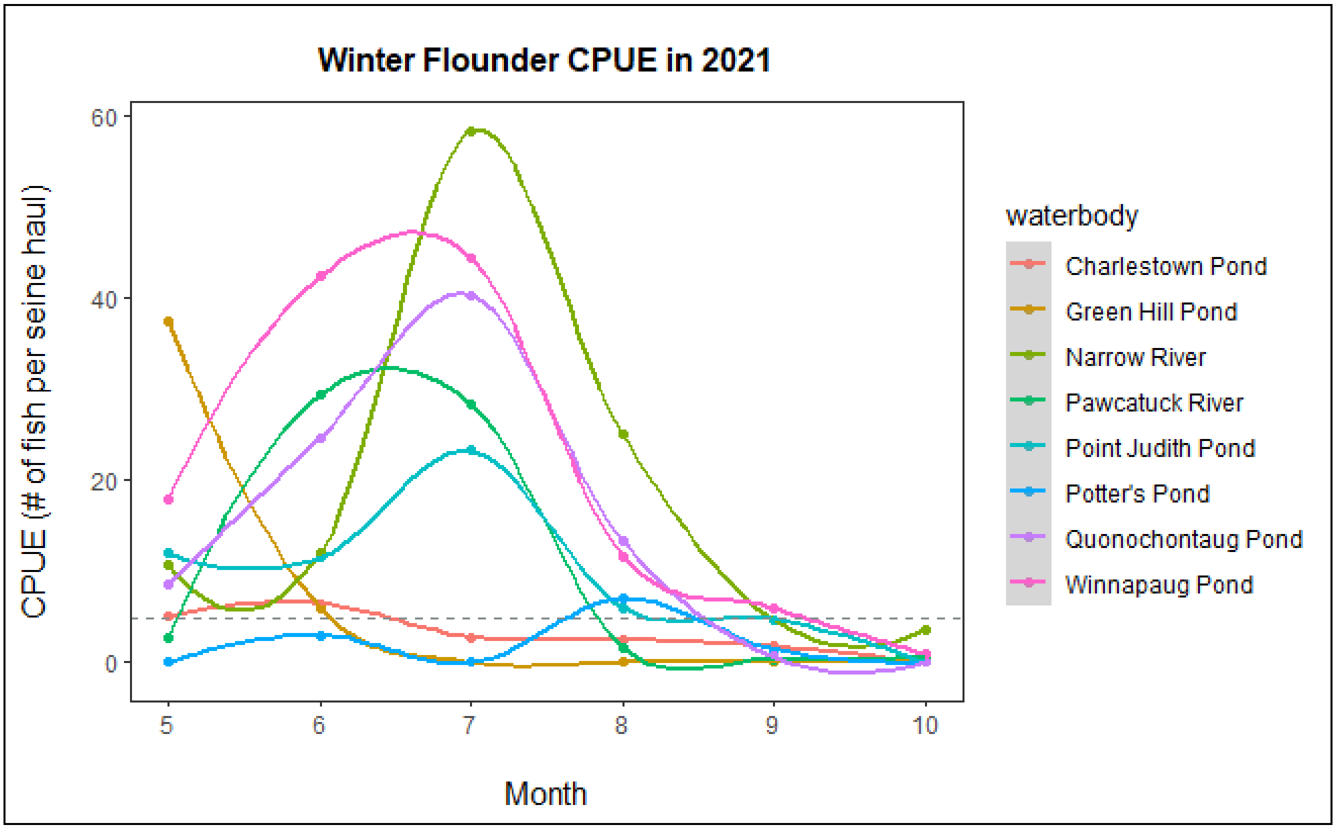


Figure 7: Length frequency of all winter flounder caught in Coastal Pond Survey during 2020. Note: YOY are to the left of the dashed line (<12cm TL)

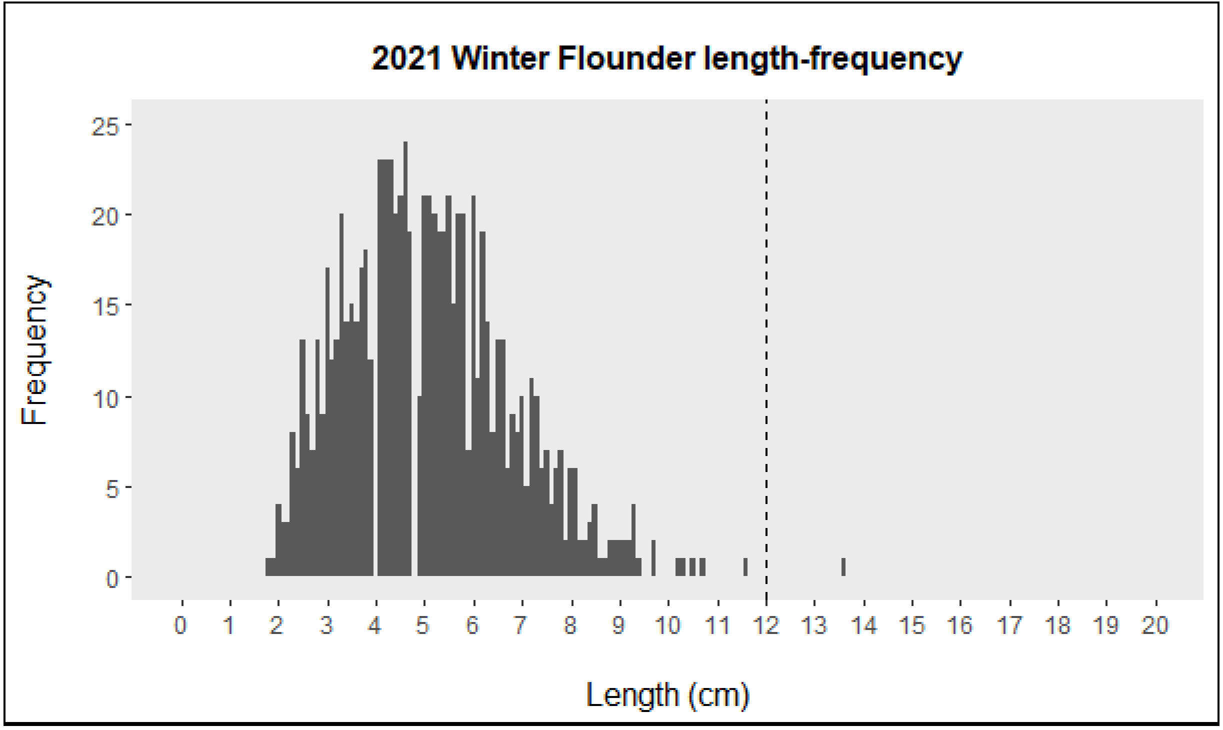


Figure 8: Winter flounder CPUE against mean measured water temperature. With increasing water temperature, we see a decrease in winter flounder catch. Line is a loess smoothing curve with approximate 95% confidence intervals in grey.

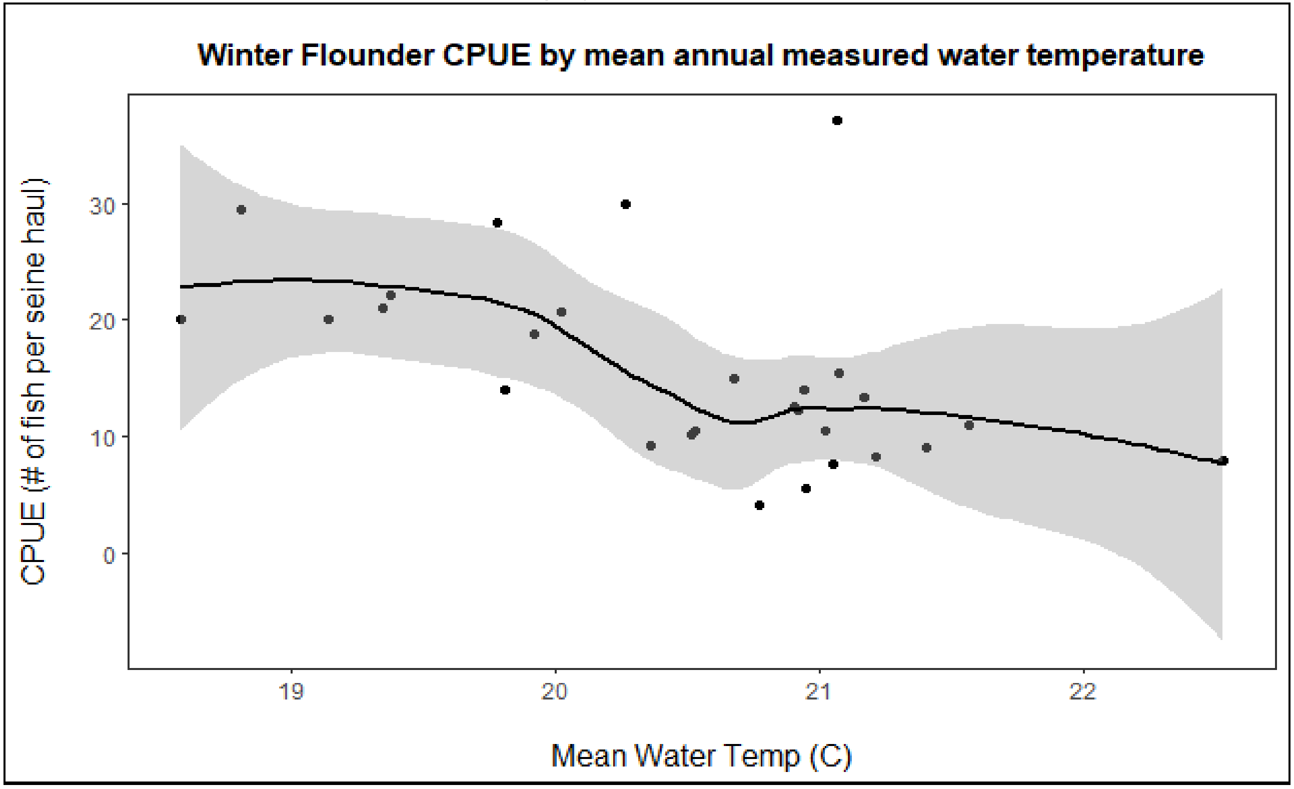


Figure 9: Abundance indices (fish/haul) from the RIDMF Coastal Pond Survey, Narragansett Bay Seine Survey, and Spring Trawl Survey for winter flounder.

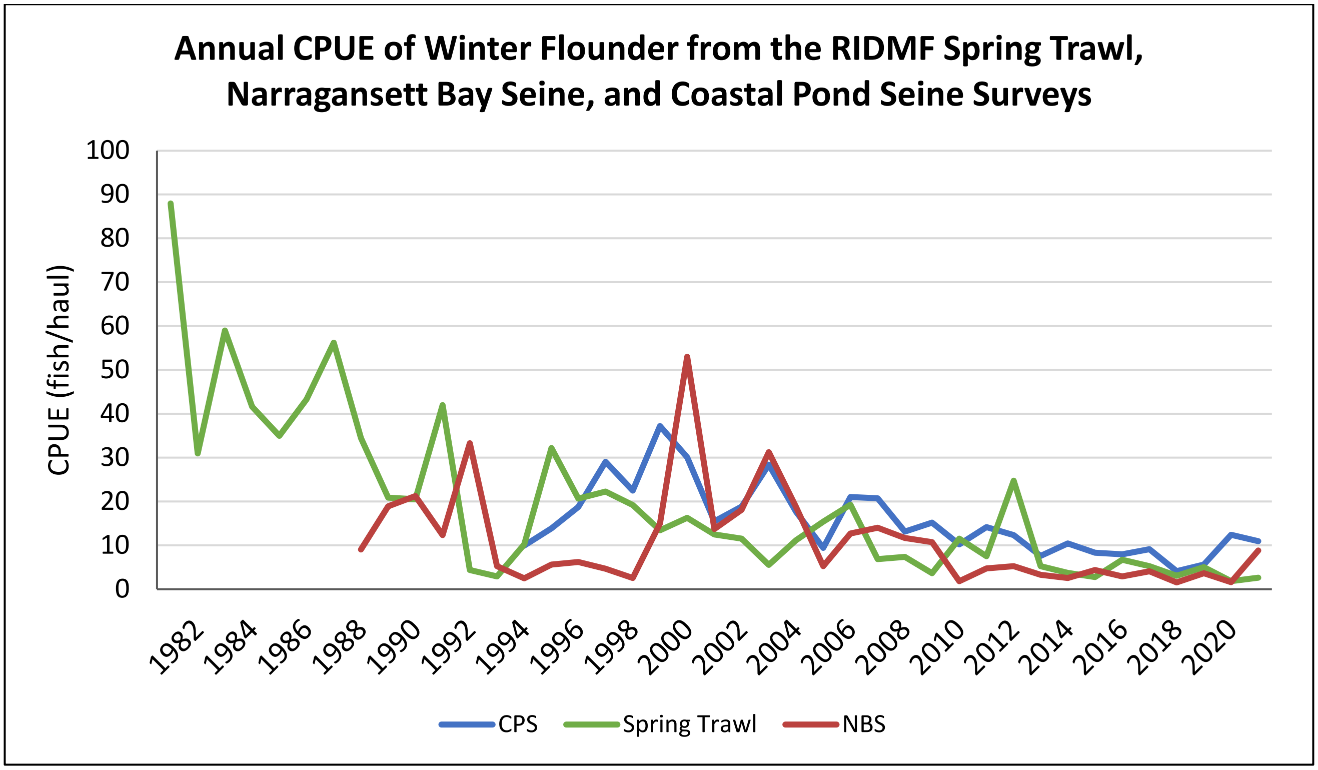


Figure 10: Abundance indices (fish/haul) from the Coastal Pond Survey and the Adult Winter Flounder Tagging Survey for winter flounder.

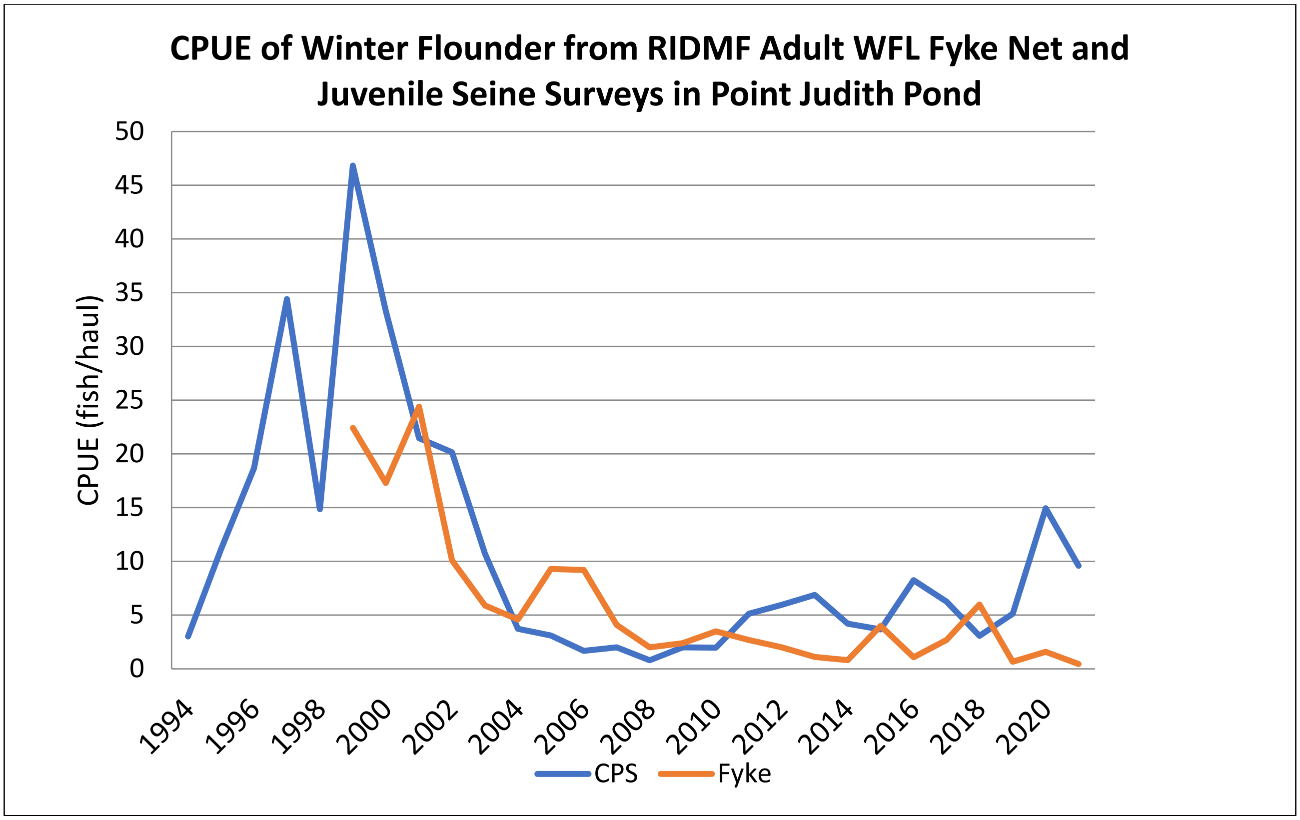


Figure 11. Time series of abundance indices for bluefish from the coastal pond survey. Black line is a loess smoothing curve with approximate 95% confidence intervals in grey. Grey dashed line is time series median.

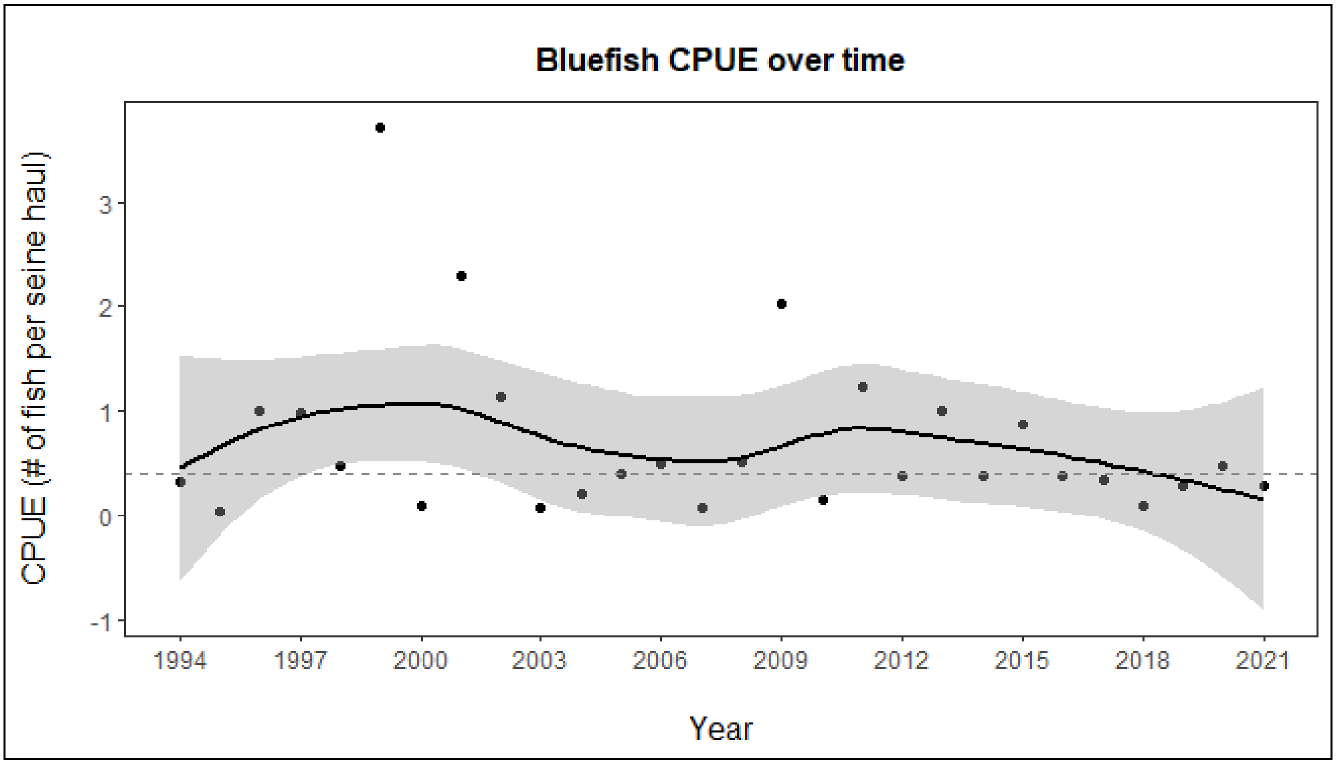


Figure 12. Time series of abundance indices for tautog from the coastal pond survey. Black line is a loess smoothing curve with approximate 95% confidence intervals in grey. Grey dashed line is time series median.

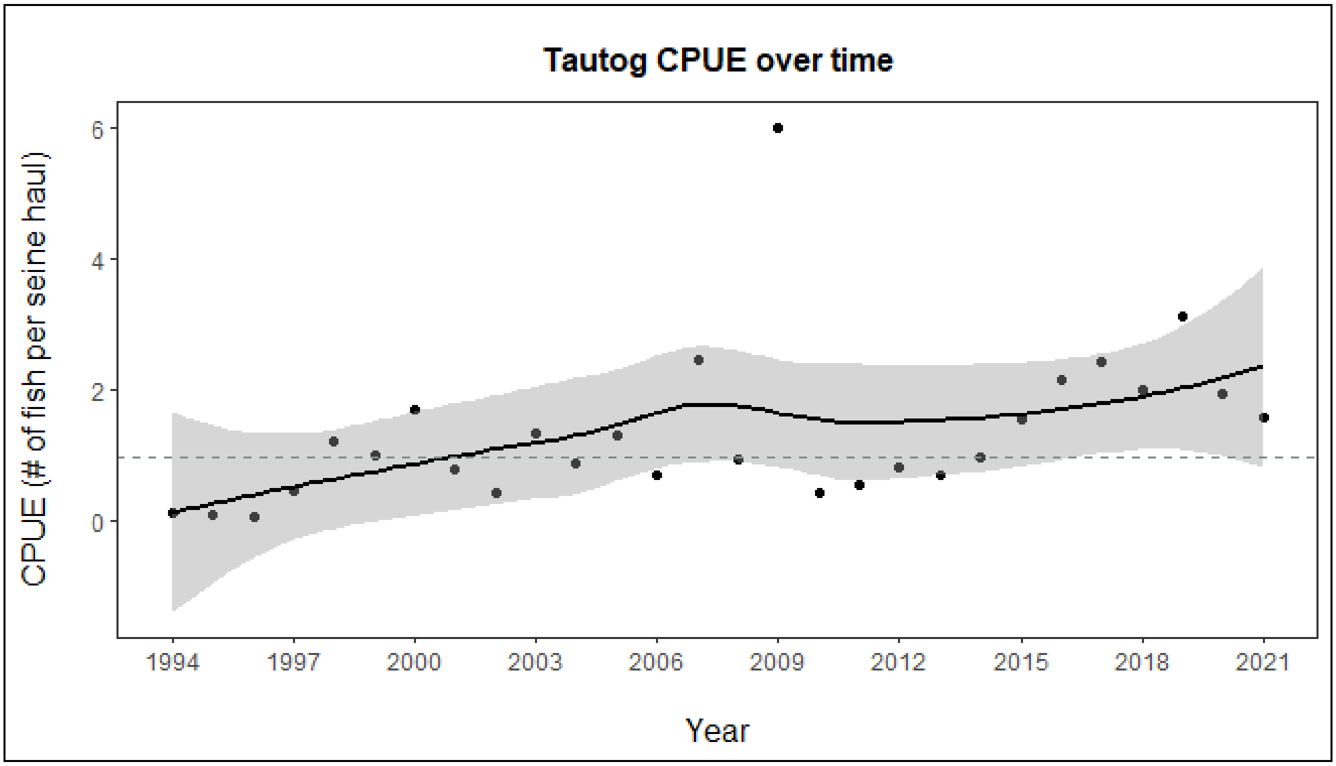


Figure 13. Time series of abundance indices for black sea bass from the coastal pond survey. Black line is a loess smoothing curve with approximate 95% confidence intervals in grey. Grey dashed line is time series median.

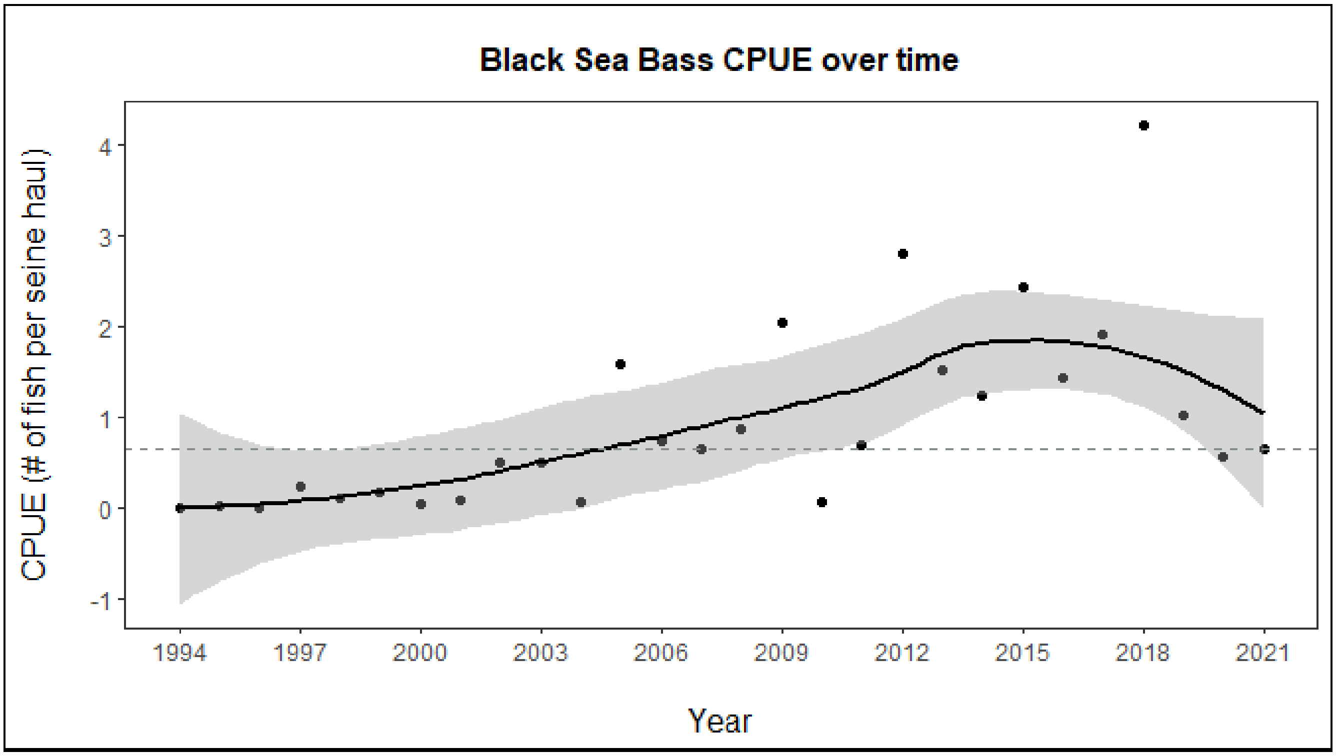


Figure 14. Time series of abundance indices for scup from the coastal pond survey. Black line is a loess smoothing curve with approximate 95% confidence intervals in grey. Grey dashed line is time series median.

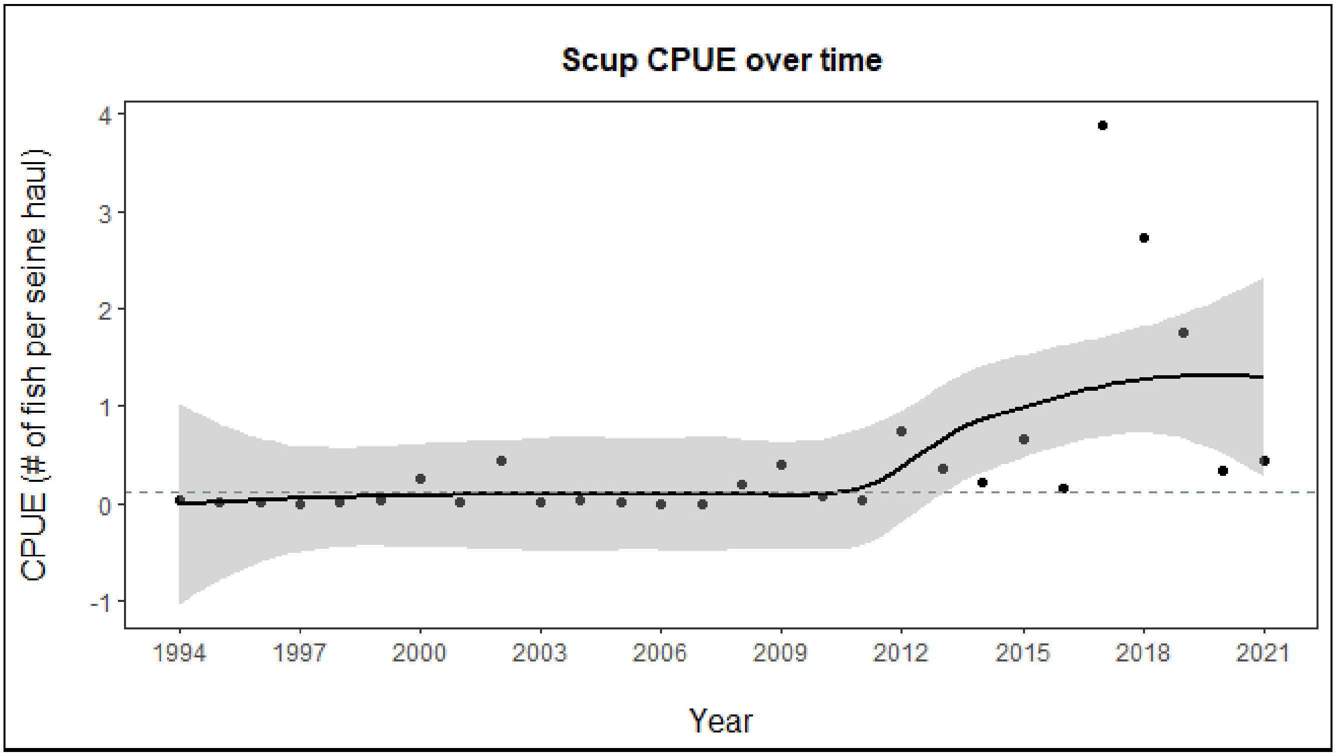


Figure 15. Time series of abundance indices for clupeids from the coastal pond survey. Lines are loess smoothing curves with approximate 95% confidence intervals in grey.

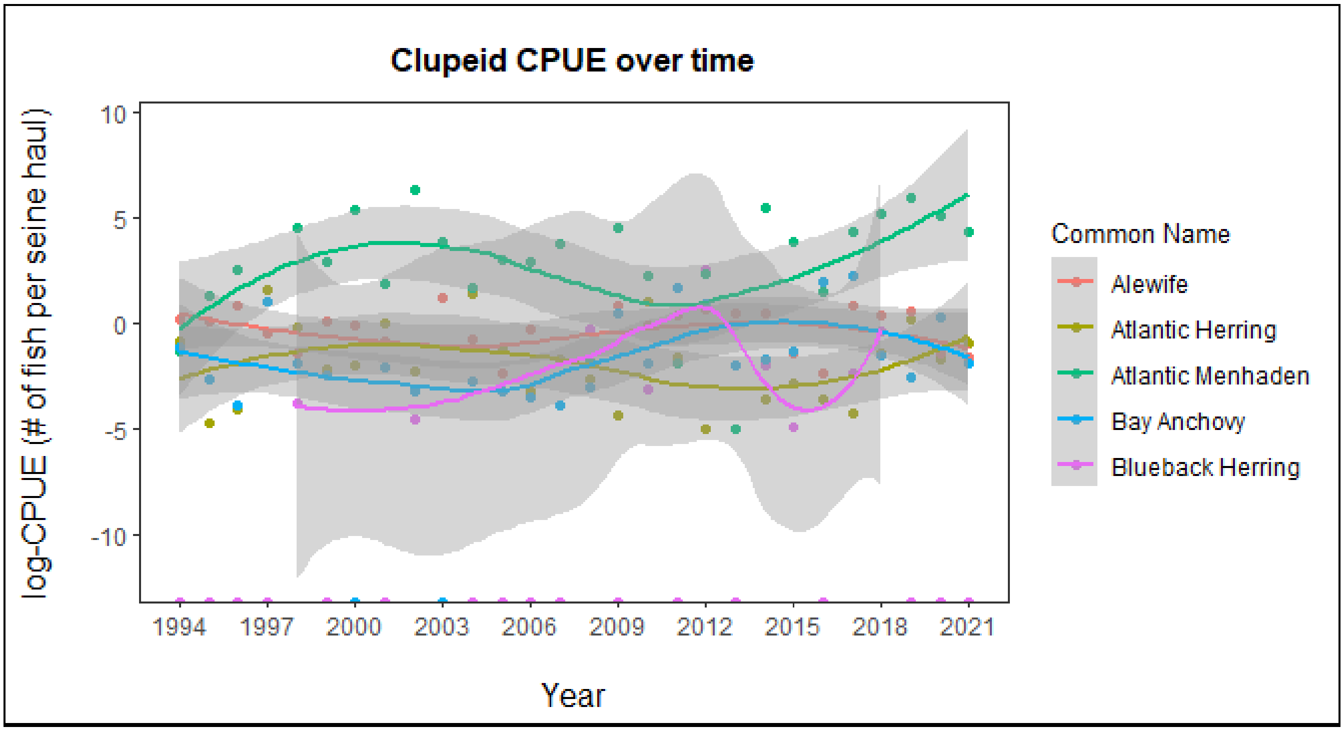


Figure 16. Time series of abundance indices for baitfish from the coastal pond survey. Lines are loess smoothing curves with approximate 95% confidence intervals in grey.

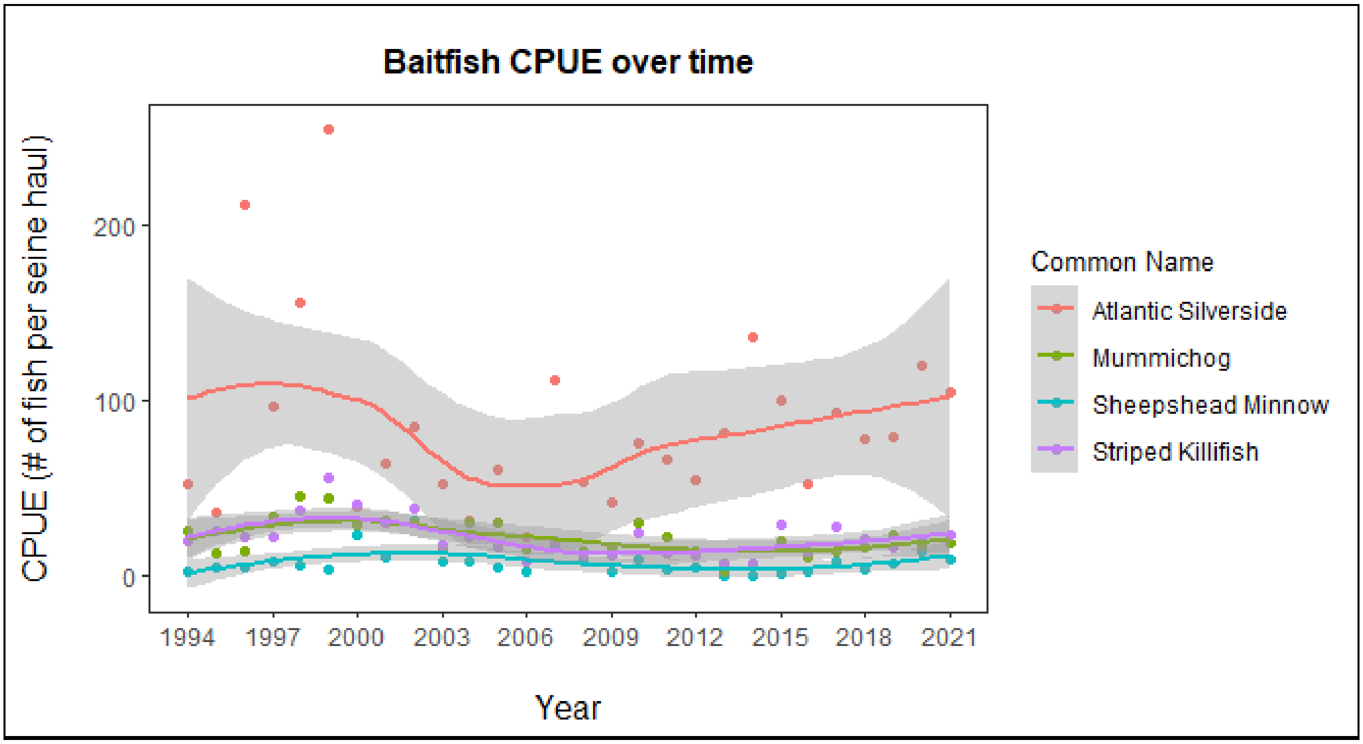
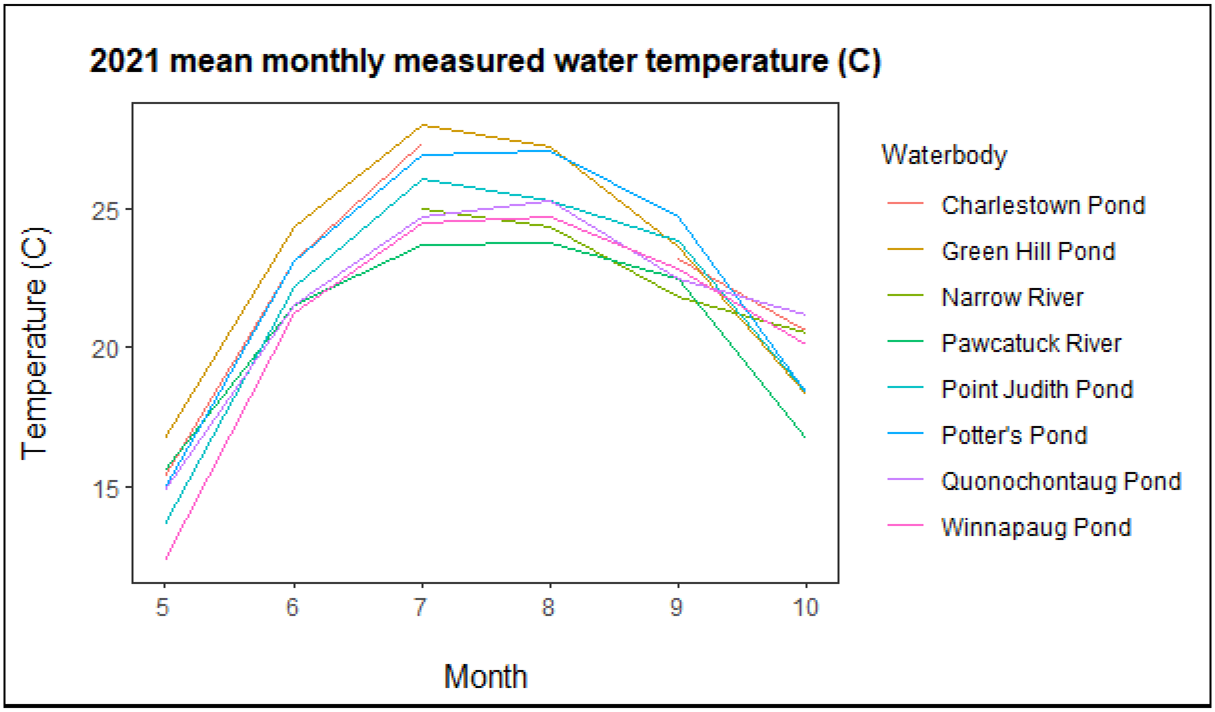


Figure 17. Average recorded water temperature in the coastal ponds by month for 2021.



Appendix 1: Catch frequency of all species by station for 2021 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)						15	1			3				5	4								1	
ANCHOVY BAY (ANCHOA MITCHILLI)							13	1			1			3	1								2	
BASS STRIPED (MORONE SAXATILIS)									1									5						
BIGEYE SHORT (PRISTIGENYS ALTA)								1																
BLUE CRAB (CALLINECTES SAPIDIUS)	1	1		3	8	2	2	1					3			1	1	1	7		2		6	1
BLUE CRAB FEMALE (CALINECTES SAPIDIUS)	9	9	15	31	49	6	18	21	12	3	3	2	15	2	13	6	5	8	8	2	12		9	7
BLUE CRAB MALE (CALINECTES SAPIDIUS)	12	15	25	23	48	8	26	16	9	7			22	3	13	11	6	8	8	5	14		10	12
BLUEFISH (POMATOMUS SALTATRIX)		2		2			1	2		1	1			1				12				1	1	16
BROWN SHRIMP (Farfantepenaeus aztecus)	3	16	5		56	6	197	36	1	6			1	13				2				1		
CORNETFISH BLUESPOTTED (FISTULARIA TABACARIA)		2									1													
CUNNER (TAUTOGOLABRUS ADSPERSUS)											1				1			1			1		1	
EEL AMERICAN (ANGUILLA ROSTRATA)	1				2			3	2					1									1	
FLOUNDER SMALLMOUTH (ETROPUS MICROSTOMUS)								1					2		1				1				1	5
FLOUNDER SUMMER (PARALICHTHYS DENTATUS)					2			1					2			1			1					
FLOUNDER TWOSPOT (BOTHUS ROBINSI)									1											1				
FLOUNDER WINTER (PSEUDOPLEURONECTES AMERICANUS)	41	14	19	2	82	5	33	161	151	16	34	67	113	11	12	162	7	20	69	45	149	147	196	27
GOBY NAKED (GOBIOSOMA BOSC)					19		1	6	1	3	2		1	5					2				1	1
GRUBBY (MYOXOCEPHALUS AENAEUS)								1	8							2	3		3	2		10	12	
HAKE SPOTTED (UROPHYCIS REGIA)								1								4								
HERRING ATLANTIC (CLUPEA HARENGUS)										53													1	
HORSESHOE CRAB FEMALE (LIMULUS POLYPHEMUS)	1	1						1																
HORSESHOE CRAB MALE (LIMULUS POLYPHEMUS)								1	1															
JACK CREVALLE (CARANX HIPPOS)			1	9			13	1				1												
JACKS (CARANGIDAE)															1						2			4
KILLIFISH STRIPED (FUNDULUS MAJALIS)	64	2	468	802	1		5	170	46	10	52	717	19	7	8	28	50		8	235	96	344	26	222
KINGFISH NORTHERN (MENTICIRRHUS SAXATILIS)							1	4	1				2		3						2			
LIZARDFISH INSHORE (SYNODUS FOETENS)	4							1			16	1	23			3	1		11		7		9	2
MENHADEN ATLANTIC (BREVOORTIA TYRANNUS)	3	15	761		1		24	1933	43	7	31	325	12	2		350	61	1103	81	2	2432	3530	738	
MINNOW SHEEPSHEAD (CYPRINODON VARIEGATUS)		3	1	3	10			1191	4		1	4		21		7				5	2	34	9	92
MOJARRA SPOTFIN (EUCINOSTOMUS ARGENTEUS)							2	4						2										
MULLET WHITE (MUGIL CUREMA)							10	8		1	2			5			8			13				22
MUMMICHOG (FUNDULUS HETEROCLITUS)	7	29	352	9	22	58	2	382	51	550	44	27	9	248	323	24		6	5	60	25	222	10	278
NEEDLEFISH ATLANTIC (STRONGYLURA MARINA)			2	2	2	1					1			18						1		1		3
PERCH WHITE (MORONE AMERICANA)							17	9						16										
PERMIT (TRACHINOTUS FALCATUS)																				1				
PIPEFISH NORTHERN (SYNGNATHUS FUSCUS)		2	2		1	1	2			1	2			3	10	1		1		2	2	4	1	1

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
POLLOCK (POLLACHIUS VIRENS)																				1				
PUFFER BANDTAIL (SPHOEROIDES SPENGLERI)		1																						
PUFFER NORTHERN (SPHOEROIDES MACULATUS)	1			2			4	8	2	1	6		5	1	3	2			1		9			1
RAINWATER KILLIFISH (LUCANIA PARVA)	11	84	81	43		9	1	34	12	15	7			41	53		5	4	1	2		15		66
SAND LANCE AMERICAN (AMMODYTES AMERICANUS)																1								
SCUP (STENOTOMUS CHRYSOPS)	25		15				2	4			1		1		10	2			2		1			
SEA BASS BLACK (CENTROPRISTIS STRIATA)	13	28	16					10	3		1				10					5		4	1	1
SEAHORSE LINED (HIPPOCAMPUS ERECTUS)											1												1	
SEAROBIN NORTHERN (PRIONOTUS CAROLINUS)							2														1			
SEAROBIN STRIPED (PRIONOTUS EVOLANS)	2		1	2				3	9	2	3		3	3	5	1	1						2	2
SENNET NORTHERN (SPHYRAENA BOREALIS)		1												1	13									
SILVERSIDE ATLANTIC (MENIDIA MENIDIA)	422	306	1015	1300	114	456	86	318	383	132	115	2916	212	124	1046	39	65	224	75	2952	241	1001	1427	170
SNAKEFISH (TRACHINOCEPHALUS MYOPS)																				1				
SNAPPER GRAY (LUTJANUS GRISEUS)										1														
SPOT (LEIOSTOMUS XANTHURUS)				1	1		20						2								1	1		3
STICKLEBACK FOURSPINE (APELTES QUADRACUS)	28	40	40	1		5	1	30	26	17				25	10	2	4	8	5			1	4	49
STICKLEBACK THREESPINE (GASTEROSTEUS ACULEATUS)	3	2													1				1					
TAUTOG (TAUTOGA ONITIS)	2	12	9					34	12	21	10		3	12	51	1	1	32	5	6	6	3	3	4
TOADFISH OYSTER (OPSANUS TAU)								2			1			21	1									
TOMCOD ATLANTIC (MICROGADUS TOMCOD)		1						1	1		1							1				1		
WATER HAUL ()												1												
WEAKFISH (CYNOSCION REGALIS)															9									

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND WATERS

NARRAGANSETT BAY JUVENILE FINFISH SURVEY

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2021

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 2021 - 31 December 2021

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 2021 with the standard 61 x 3.05 m beach seine. Adults and juveniles of seventy-two were collected during the 2021 survey, which is an increase from the 2020 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 – 2021), 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 2021

SIGNIFICANT DEVIATIONS: There were no significant deviations to methodology in 2021.

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 = 0.016) and winter flounder (p = 7.0988e-5) are showing a decreasing trend (Table 1a). However, River Herring (p = 0.043), Tautog (p = 0.0051), and Striped Bass (p = 0.0018) show a positive increasing trend in the shortened 10-year analysis (Table 1b). Menhaden show no abundance trend for either the full dataset or the past ten years (Table 1a, b).

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

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

METHODS, RESULTS & DISCUSSION: A 61m x 3.05m beach seine, deployed from a 22' boat, was used to sample the juvenile life stage of selected fish species in Narragansett Bay. Monthly seine collections were completed at the eighteen standard survey stations (Figure 1) from June through October 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 2021 survey. Tables 9-13 provide the number of fish/seine haul for each station along with the station mean, monthly mean, and annual abundance index for each target species. Figures 2 – 10 show the annual abundance index trends for a number of important species for both the original and standardized indices. It should be noted when interpreting these data, that the survey began in 1986 with fifteen stations. The data represented in the graphs begins in 1988 as the period of time when the survey began using consistent methodology with the 15 stations. Station 16 (Dyer Is.) was added in June 1990, station 17 (Warren R.) was added in July of 1993, and station 18 (Wickford) was added in July of 1995. The addition of the stations is standardized in the analysis, see appendix A.

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

Winter flounder

Juvenile winter flounder (*Pseudopleuronectes americanus*) were present in fifty-one percent of the seine hauls for 2021. This is an increase from 2020 when they were present in thirty-four percent of the hauls. A total of 798 fish were collected in 2021 (all of the fish collected in 2021 would be considered young-of-the-year (YOY) according to Table 2 winter flounder maximum size by month). This is an increase from the 143 individuals collected during the 2020 survey. They were present at sixteen of the eighteen stations and were collected in all months (Table 9).

The 2021 juvenile winter flounder standardized abundance index was 8.86 ± 4.21 fish/seine haul; this is higher than the 2020 index of 1.59 ± 0.97 S.E. fish/seine haul. Figure 2 shows the standardized annual abundance indices since 1988. The Mann-Kendall test showed a significant decreasing abundance trend for this species for the full dataset, but no short-term trend in the last 10 years (Table 1a, b).

June had the highest mean monthly abundance of 25.22 ± 9.05 S.E. fish/seine haul. Warren River (Sta. 17), Gaspee Point (Sta. 1), and the Conimicut Point (Sta. 2) had the highest mean station abundance of 31.20 ± 27.51, 24.80 ± 11.76 S.E., and 23.00 ± 16.74 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 2021 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 2021 abundance index continues to be lower than most years since 2000, the survey high. The Division of Marine Fisheries' trawl survey data (sampling both adults and juveniles) saw a slight increase in winter flounder from 2020 to 2021. 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 a decreasing 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 2021 survey 1,500 juvenile and 4 adult (>26 cm length) tautog (*Tautoga onitis*) were collected. This is a decrease from the 2020 survey when 547 juveniles and 6 adults were collected. The 2021 abundance index was 16.67 ± 5.71 S.E. fish/seine haul, an increase from the 2020 index 6.14 ± 1.63 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. The last 10-year time series Mann-Kendall test shows a significant increasing trend ($p = 0.005$) during the 2021 analysis, unlike the 2020 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-six percent of the seine hauls in 2021 (Table 10). This is a slight decrease from 2020 when they were present in sixty-eight percent of the seine hauls. August and September had the highest mean monthly abundances of 25.61 ± 8.02 S.E. and 22.44 ± 9.31 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. Dyer Island (Sta. 16) had the highest mean station abundance of 44.80 ± 27.29 S.E. which was driven by high sampling numbers in September (151 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 Spar Island (Sta. 12) had the next highest abundances with a mean station abundance of 37.80 ± 15.62 S.E. and 33.80 ± 16.64 S.E. fish/seine haul respectively. The Mann-Kendall test showed no long-term trend in juvenile abundance, but a 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 abundance for tautog from 2020 to 2021. 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 2021 survey 2,515 juvenile bluefish (*Pomatomus saltatrix*) were collected. This is a decrease from the 2,898 juveniles collected in 2020. Juveniles were present in thirty-four percent of the seine hauls and were collected at sixteen of the eighteen stations (Table 11). They were present in all months except for June, with the highest abundance occurring in August. June 2021 had no juvenile bluefish collected during the survey, which is most likely due to the colder water temperatures (15.4 – 28.5° C in June). Since this survey began and prior to 2016, only two hundred ninety-six juvenile bluefish have been collected in October, in eleven different years (1990, 1997, 1999, 2005, 2011, 2012, 2015, 2016, 2017, 2020, and 2021), and only when water temperatures were 16 – 21° C.

The abundance index for 2021 was 27.94 ± 1.99 S.E. fish/seine haul. This is a slight decrease from the 2020 abundance index of 32.2 ± 3.59S.E. fish/seine haul (Figure 4). The Mann-Kendall test showed no trend in the 10-year abundance, however there is a significant decrease in long-term abundance trend for this species (Table 1a, b).

August had the highest mean monthly abundance of 69.67 ± 44.67 S.E. fish/seine haul, which was driven by a large catch (792) at Wickford (Sta. 18) (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 2021 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 2021 survey 63 striped bass (*Morone saxatalis*) were collected. This is an increase from 2020 which had an abundance of 44 fish. Striped bass were present in six percent of the seine hauls and were collected at five of the eighteen stations (Table 14). They were present in June, July, and October.

The abundance index for 2021 was 0.7 ± 0.41 S.E. fish/seine haul. This is slightly higher than in 2020, which had an abundance index of 0.49 ± 0.23 S.E. fish/seine haul (Figure 8). The Mann-Kendall test showed no abundance trend for this species for the entire dataset but a significant increasing trend for the shortened 10-year series (Table 1a, b).

October had the highest mean monthly abundance of 2.82 ± 2.74 S.E. fish/seine haul (Table 12). June had the second highest mean monthly abundance at 0.56 ± 0.33 S.E. fish/seine haul. September is usually one of the months with the highest abundance for the entire time series. However, during 2021 there were no striped bass collected in the survey (Table 12).

In 2021, striped bass were only present at 5 stations, Patience Island (Sta. 5), Hog Island (Sta. 9), Spar Island (Sta. 12), 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 2021 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-one percent of the seine hauls and were collected at sixteen of the eighteen stations during 2021 and were present during each month of the survey. A total of 2,326 juveniles were collected in 2021, a decrease from the number collected in 2020 (6,479 fish).

The highest mean monthly abundance for 2021 occurred during June and was 65.50 ± 65.38 S.E. fish/seine haul. Potters Cove (Sta. 8), Hog Island (Sta. 9), Kickimuit River (Sta. 11) and the Warren River (Sta. 17) had the highest mean station abundance of 38.00 ± 37.25 S.E., 55.40 ± 55.40 S.E., 239.60 ± 234.39 S.E., and 198.40 ± 107.66 S.E., respectively (Table 13). Potters Cove experienced a single large catch in July (187 fish), Hog Island experienced a single large catch in July (277 fish), the Kickimuit River experienced a single large catch in June (1,177 fish), and the Warren River experienced a single large catch in July (540), 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 2021 was 25.84 ± 3.39 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

Three hundred and seventy-five Atlantic menhaden (*Brevoortia tyrannus*) were collected during the 2021 survey, a decrease from 2020 when 463 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 twelve of the eighteen stations (Table 12).

The highest mean monthly abundance for 2021 occurred during September and was 17.17 ± 7.53 S.E. fish/seine haul. Conimicut Point (Sta. 2) had the highest mean station abundance of 21.60 ± 21.60 S.E. (Table 14) which was driven by a single large catch in September of 108 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 2021 was 4.17 ± 11.88 S.E. fish/seine haul. This is less than 2020 (5.14 ± 6.14 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 and no 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 fifty-eight weakfish, *Cynocion regalis,* collected during the 2021 survey. Weakfish were present in eighty-four percent of the seine hauls and were collected at four (Gaspee Point, Chepiwanoxet, Pojac Point, and Spectacle Cove) of the eighteen stations during 2021, an increase from the number collected in 2020 (1 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

Forty-one black sea bass (*Centropristis striata*) were caught in 2021, a decrease from the 55 fish that were collected in 2020. 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 sixteen percent of the seine hauls in 2020.

The highest mean monthly abundances for 2021 occurred during August and September at 0.67 ± 0.30 S.E. fish/seine haul and 0.94 ± 0.47 S.E. fish/seine haul, respectively. Black sea bass were caught at 12 of the 18 stations; Patience Island (Sta. 5) and Dutch Island (Sta. 7) had the highest mean station abundances of 1.80 ± 1.11 S.E. and 1.40 ± 1.40 S.E. fish/seine haul, respectively (Table 15).

The abundance index for 2021 was 0.46 ± 0.13 S.E. fish/seine haul. This was a decrease from the 2020 index 0.61 ± 0.33 S.E. (Figure 10). Our Narragansett Bay trawl survey had an increase in the abundance of black sea bass from 2020 to 2021 in the spring and fall. 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 2021 survey. These juveniles included scup (*Stenotomus chrysops*), and Northern kingfish (*Menticirrhus saxatilis*).

Five hundred and eighty-three juvenile and adult scup were collected in 2021 during July, August, and September, an increase from 2020 when 251 scup were collected. One thousand, seven hundred and fifty-five Northern kingfish were collected in 2020 and were present in the greatest numbers during July and August. This is an increase from 2020 when 1,196 Northern kingfish were caught. Four summer flounder were caught in 2021. One smallmouth flounder was caught in 2021, 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 2021. 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 2021 survey ranged from a low of 13.8°C at Spectacle Cove (Sta. 13) in October to a high of 26.3°C at Spectacle Cove (Sta. 13) in August.

Salinities ranged from 10.9 *ppt* at Gaspee Point (Sta. 1) in July to 31.4 *ppt* at Rose Island (Sta. 10) in October.

Dissolved oxygen ranged from 4.1 *ppm* at the Chepiwanoxet (Sta. 3) in July to a high of 11.0 *ppm* at Conimicut Point (Sta. 2) in July.

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.

Seventy-two, both vertebrates and invertebrates, were collected in 2021. 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 2021 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

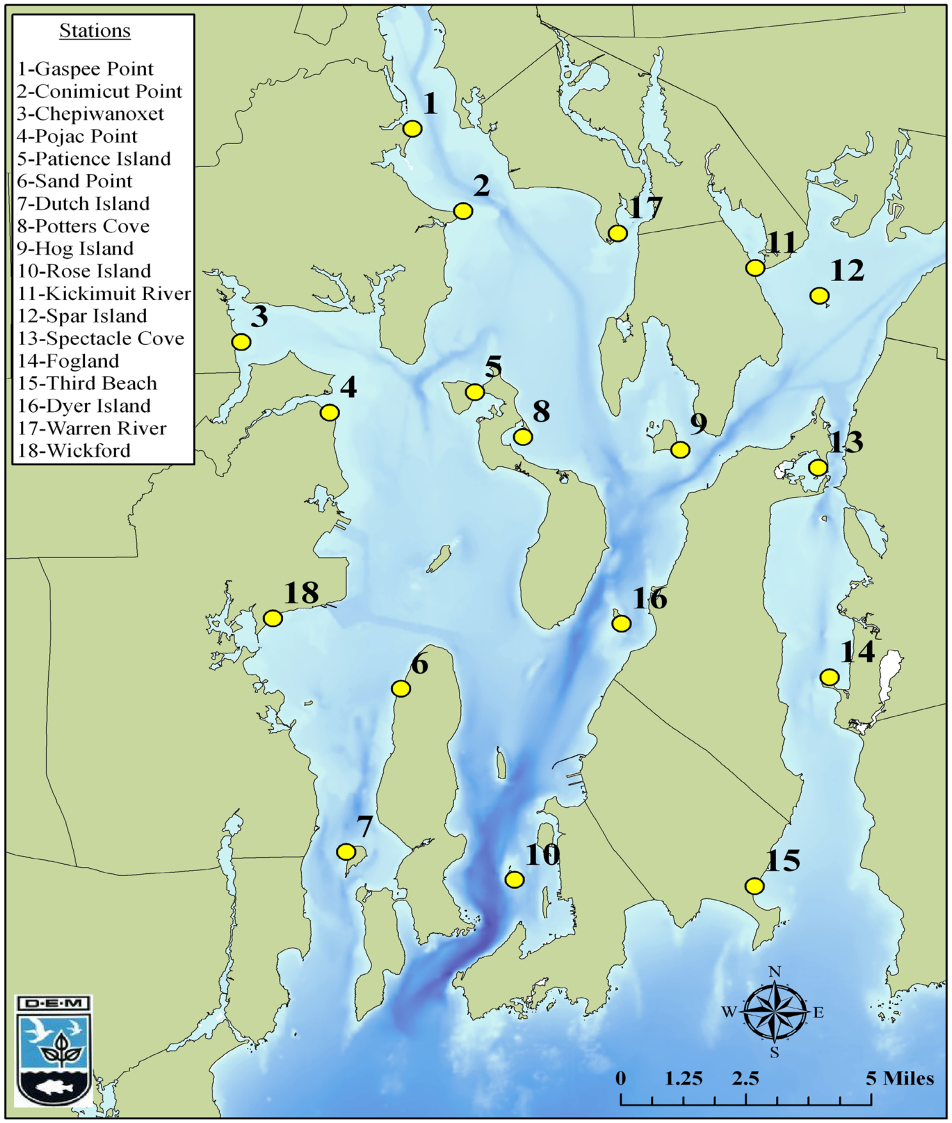


Figure 1. Survey station location map.

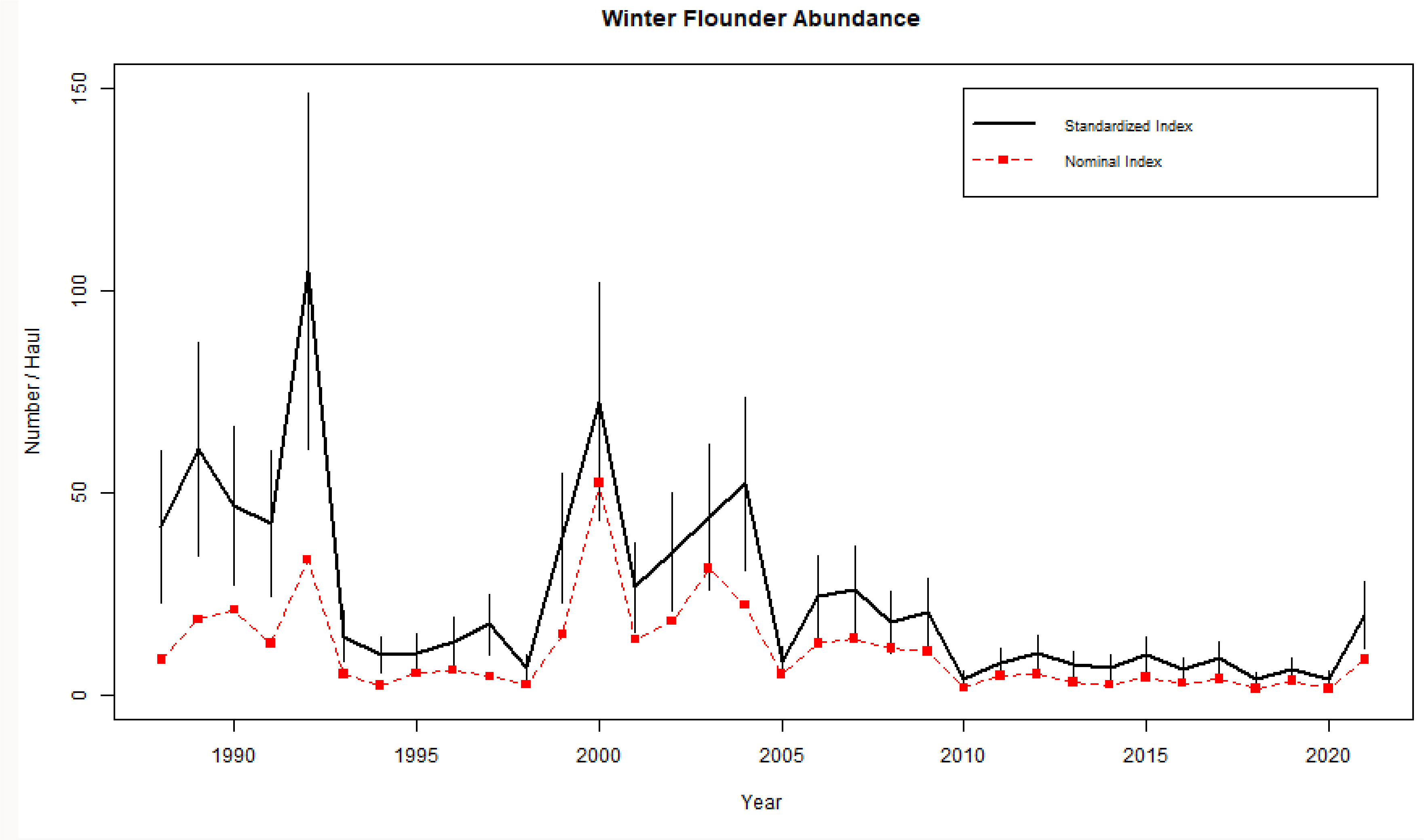


Figure 2. Juvenile winter flounder standardized abundance index 1988 – 2021 (see appendix A for standardization methodology).

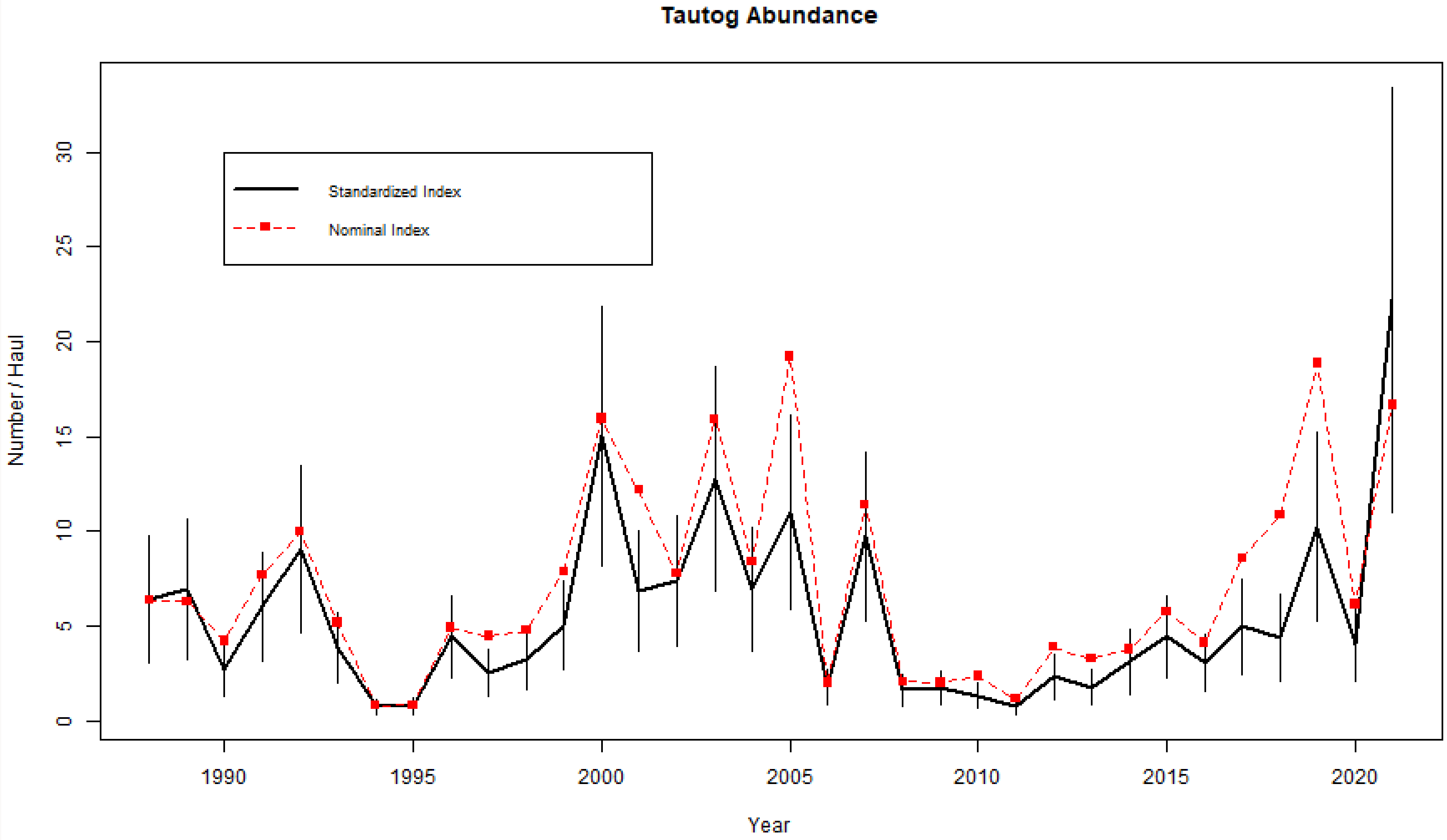


Figure 3. Juvenile tautog standardized annual abundance index 1988 – 2021 (see appendix A for standardization methodology).

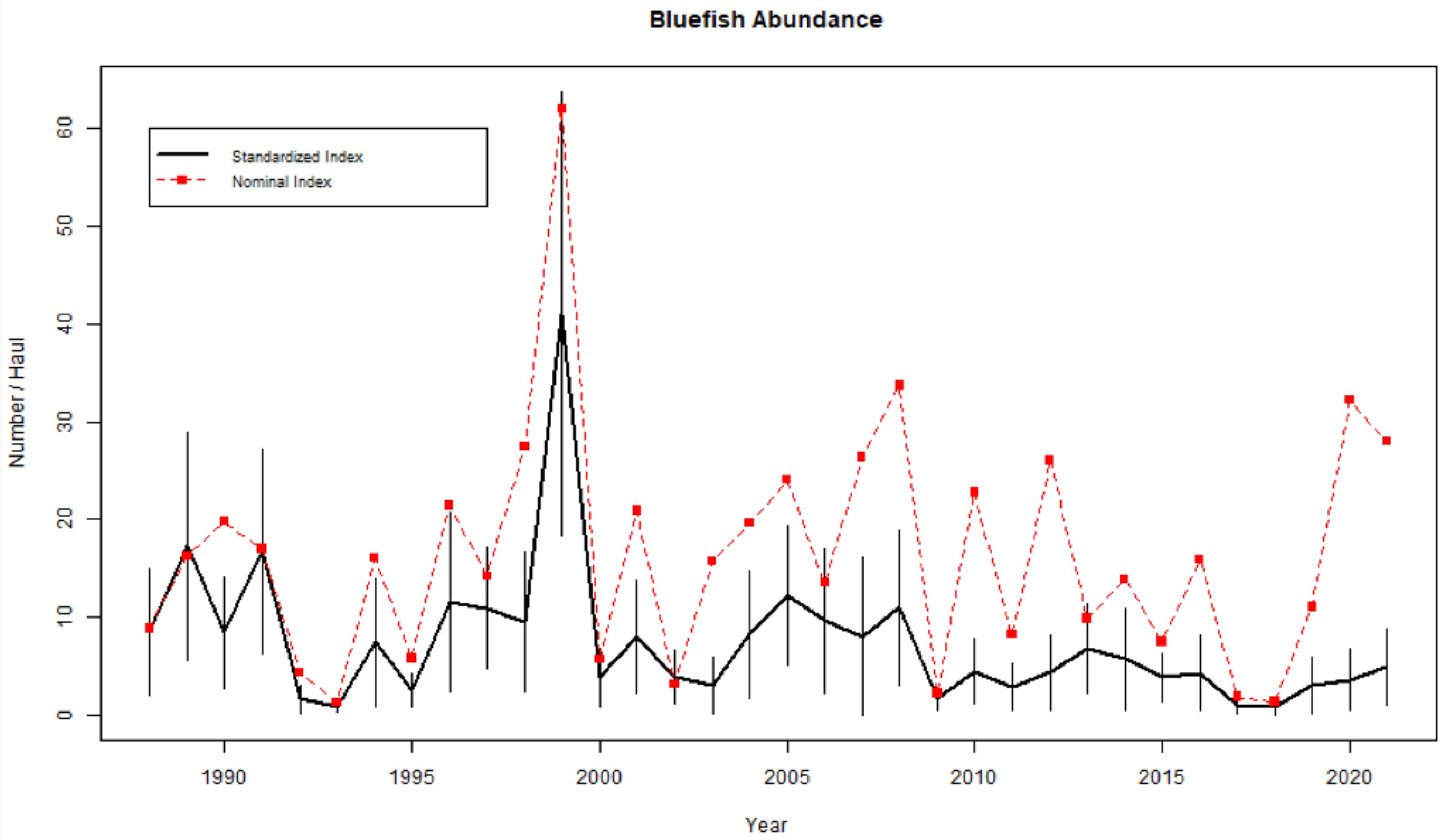


Figure 4. Juvenile bluefish standardized annual abundance index 1988 – 2021 (see appendix A for standardization methodology).

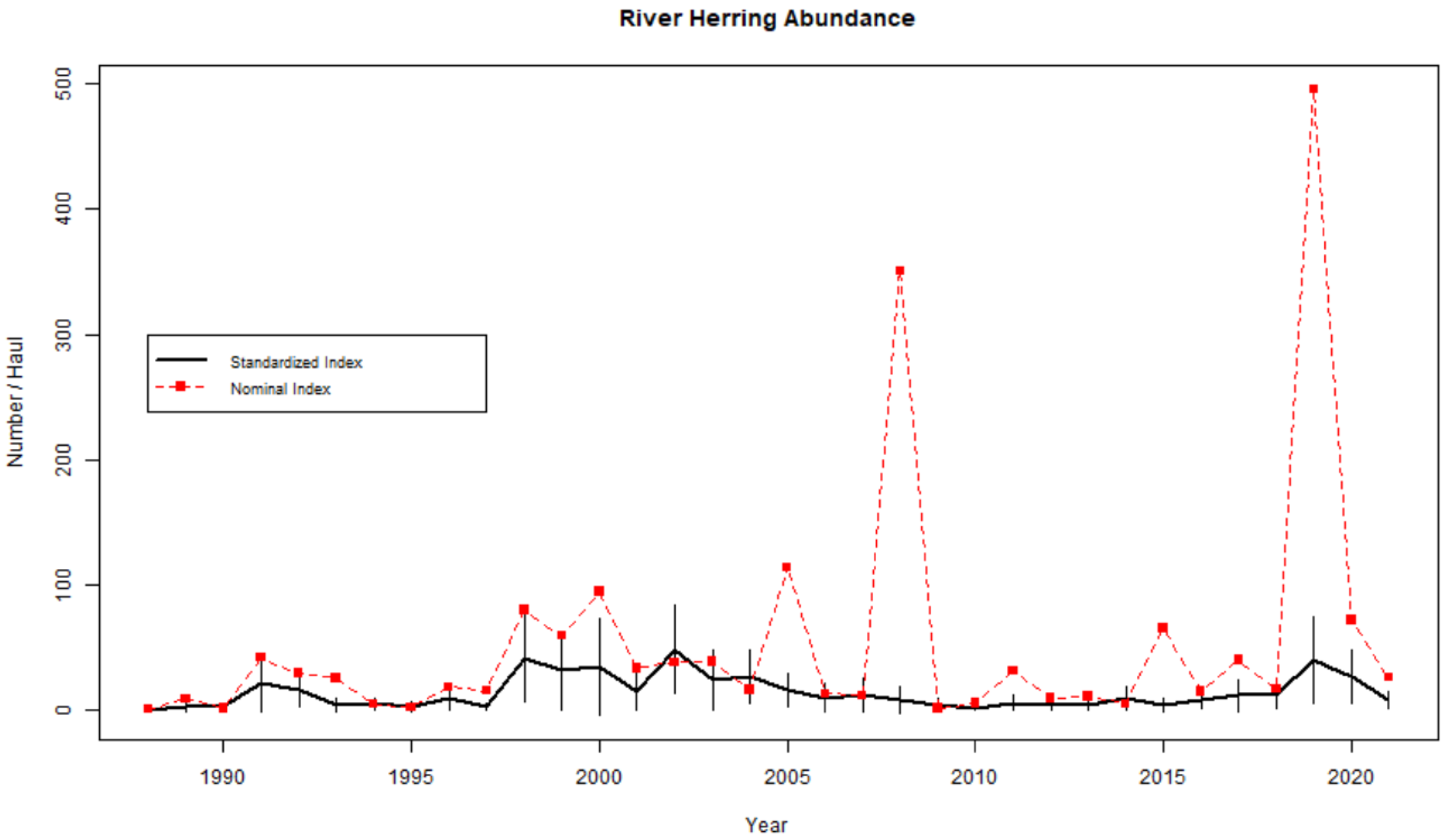
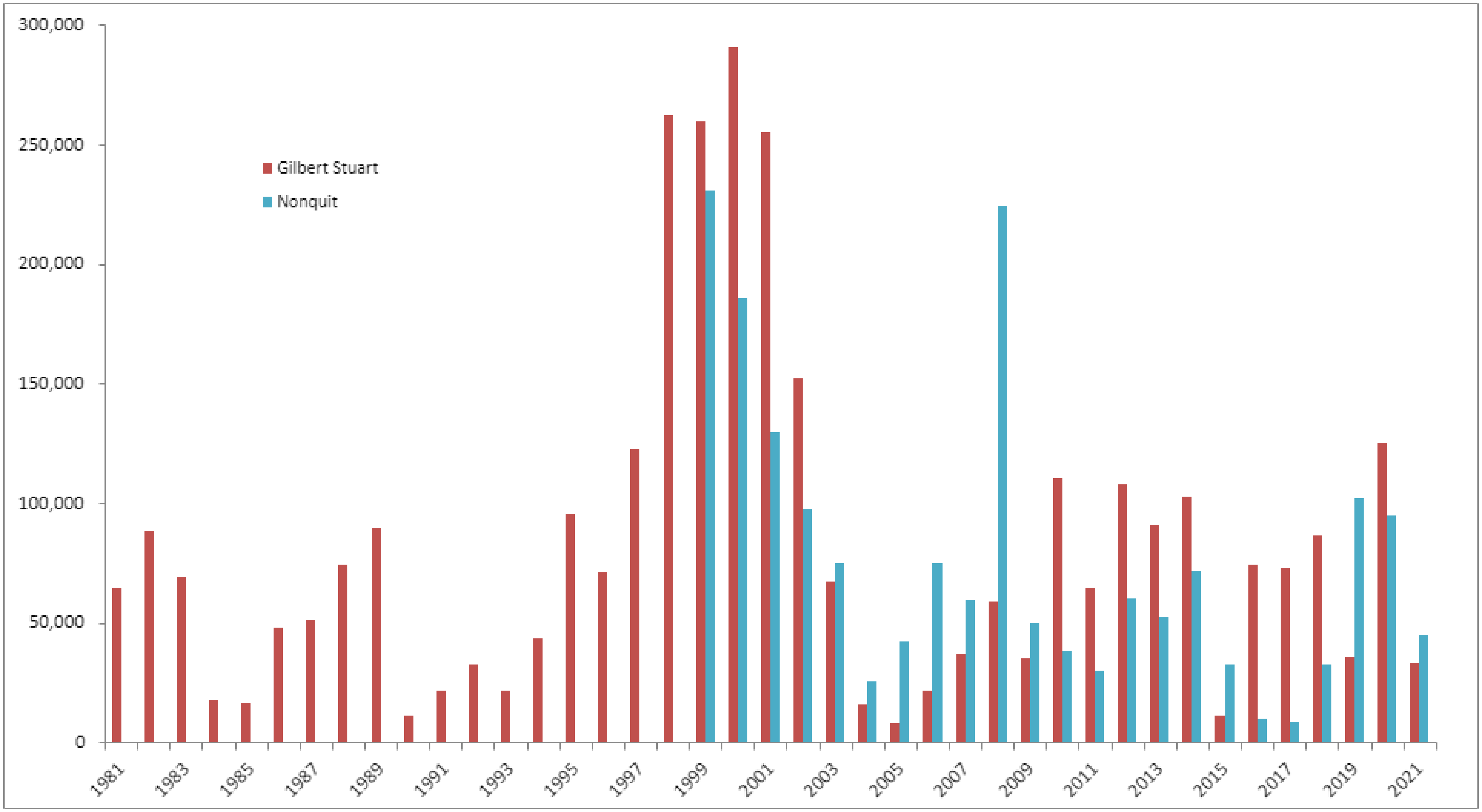


Figure 5. Juvenile river herring standardized annual abundance index 1988 – 2021 (see appendix A for standardization methodology).



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

Figure 6. River herring spawning stock size from monitoring at two locations 1999 – 2021.

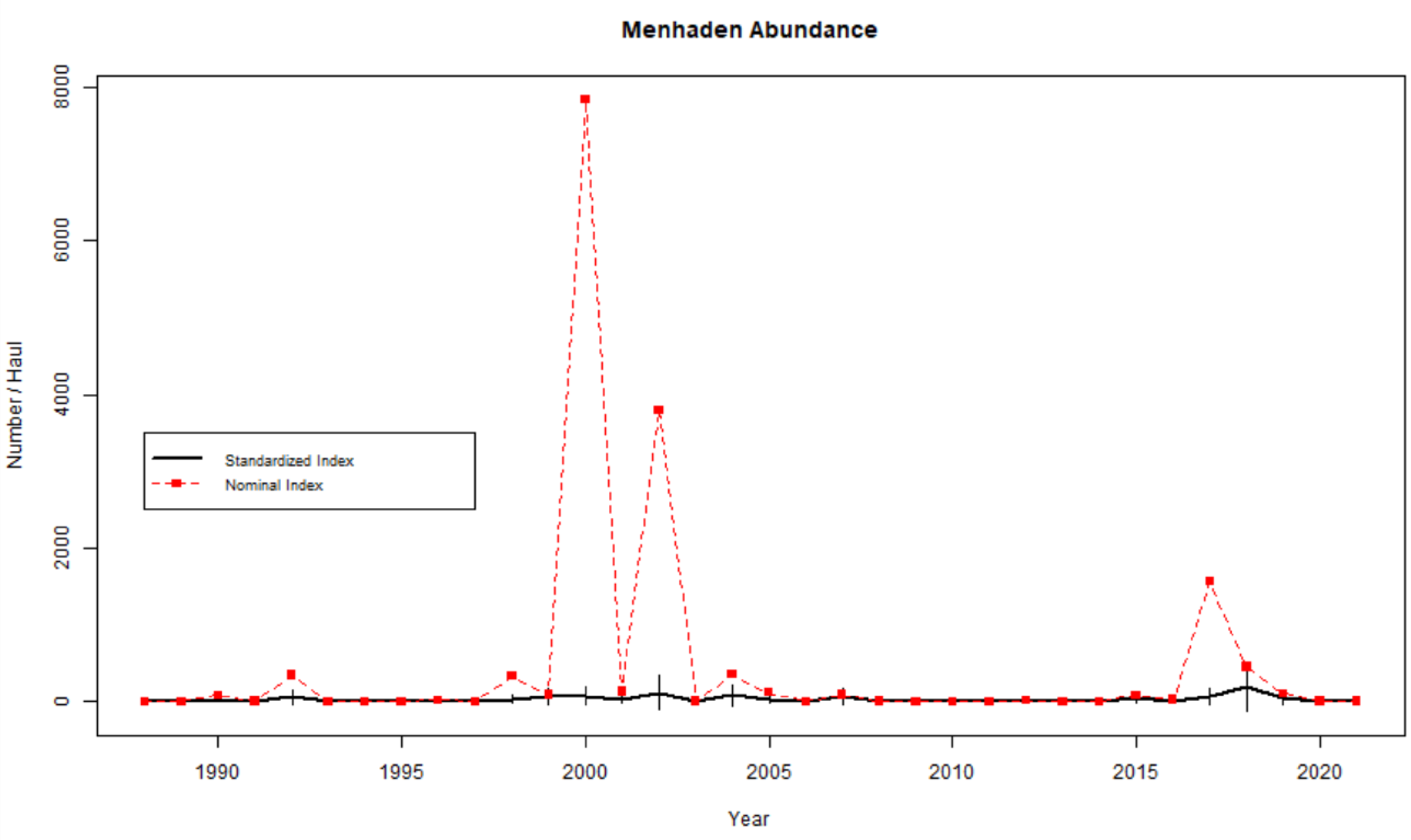


Figure 7. Juvenile menhaden standardized annual abundance index 1988 – 2021 (see appendix A for standardization methodology).

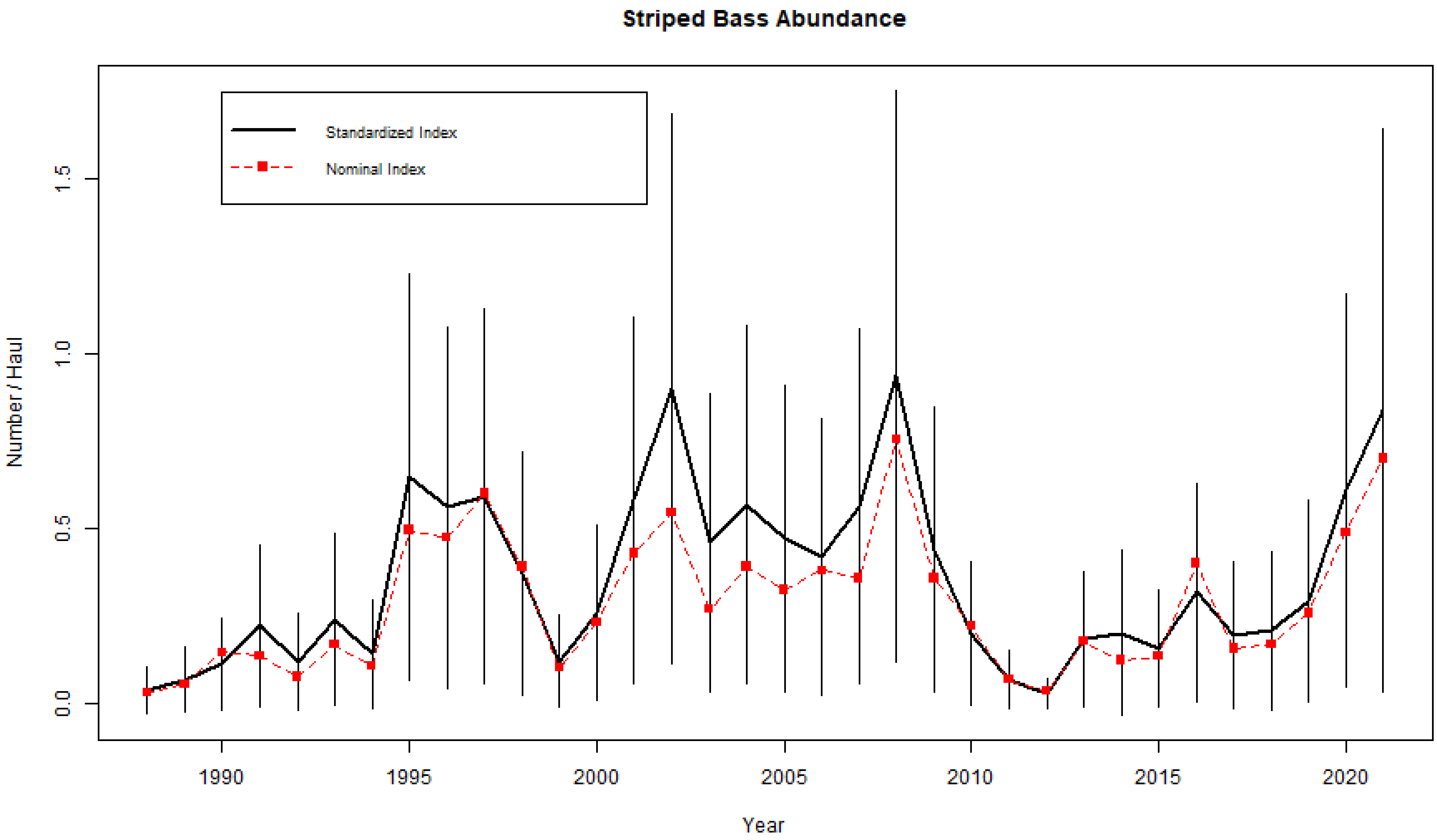


Figure 8. Striped bass standardized annual abundance index 1988 – 2021 (see appendix A for standardization methodology).

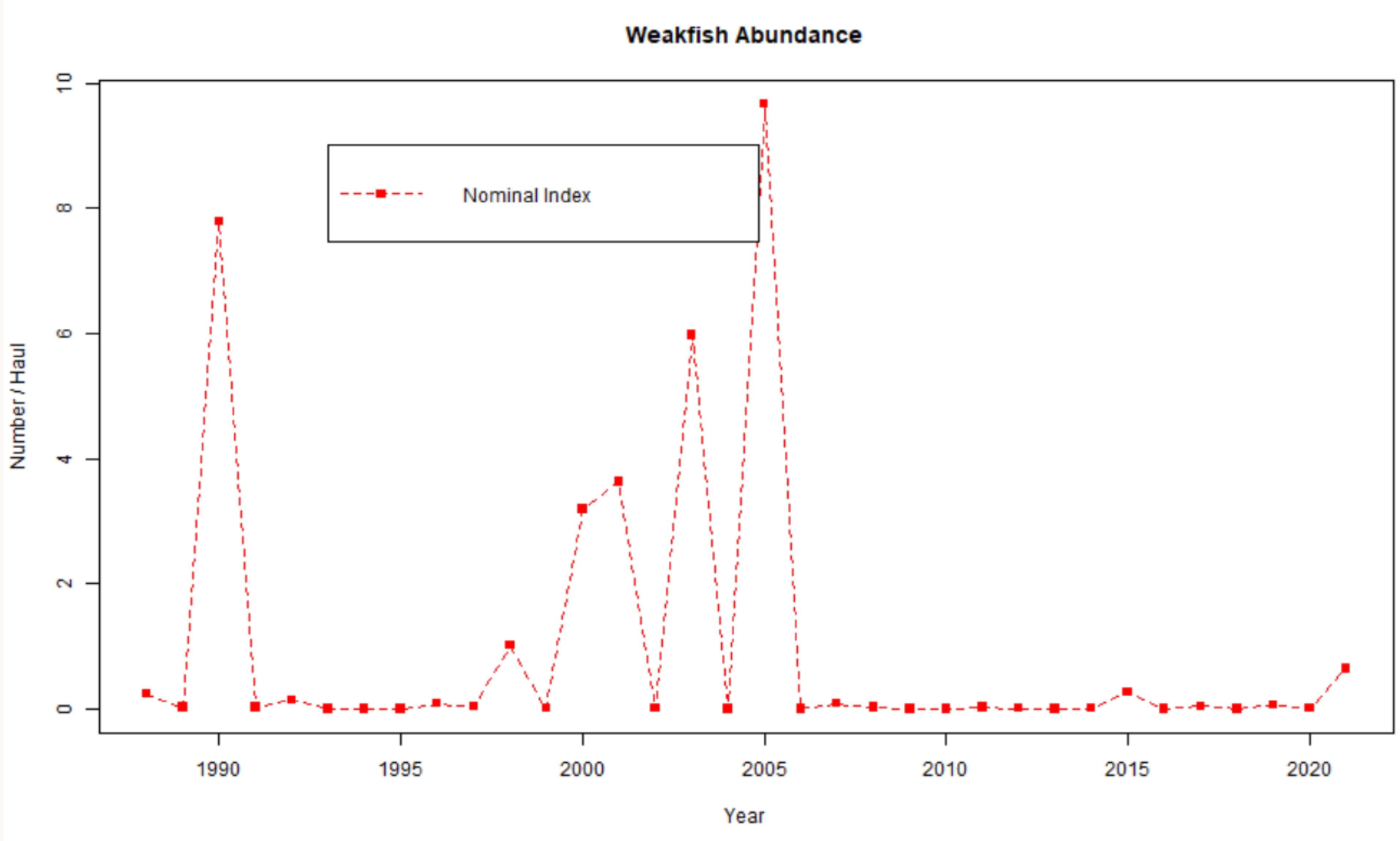


Figure 9. Weakfish annual abundance index 1988 – 2021.

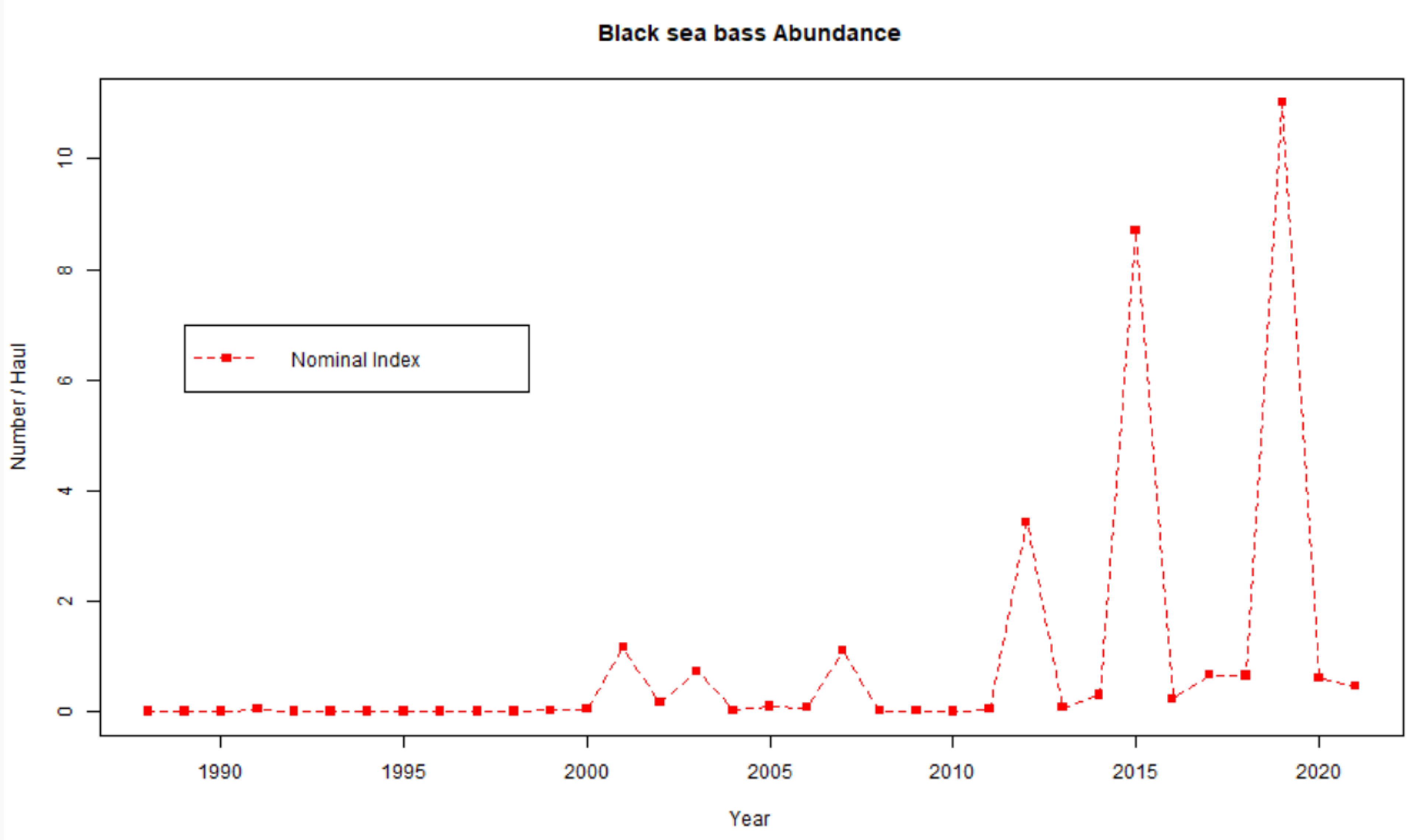


Figure 10. Black sea bass annual abundance index 1988 – 2021.

TABLES

Table 1a. Mann-Kendall test for target species abundance trend analysis (Full dataset; 1988 - 2021).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-269	-21	-163	51	85	79
n Observations	34	34	34	34	34	34
Variance	4550.33	165	4550.333	4550.333	4550.333	4550.333
Tau	-0.48	-0.382	-0.291	0.0909	0.152	0.141
2-sided p value	7.0988e-5	0.11947	0.016325	0.45856	0.21304	0.24756
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 (2011 - 2021).

Mann-Kendall test	Winter Flounder	Tautog	Bluefish	River Herring	Menhaden	Striped Bass
S	-15	37	-9	27	25	41
n Observations	10	10	10	10	10	10
Variance	165	165	165	165	165	165
Tau	-0.273	0.673	-0.164	0.491	0.455	0.745
2-sided p value	0.27576	0.0050693	0.53342	0.04296	0.061707	0.0018457
α	0.05	0.05	0.05	0.05	0.05	0.05
Significant Trend	No	Yes ↑	No	Yes ↑	No	Yes ↑

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 2021.

JUNE	Station																		
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	1										1177				1				1179
Ammodytes americanus							18												18
Anguilla rostrata					14														14
Apeltes quadracus	1														1				2
Calinectes sapidus	3		3	1	1								8				6		22
Carcinus maenus					x		x	x			x		x	x			x		x
Centropristus striata																3			3
Crangon septemspinosa		x		x													x		x
Crepidula fornicata						x													x
Ctenophora phylum				x															x
Emerita talpoida															x				x
Fundulus heteroclitus	12	1	19		120				22		49		16						239
Fundulus majalis	17		16		24						181		3					11	252
Gadus morhua										20									20
Gasterosteus aculeatus	1										1								2
Gobiosoma bosc		6																	6
Hemigrapsus sanguineus														x					x
Hippocampus genus																		1	1
Isopoda order										x					x				x
Libinia emarginata					x	x	x												x
Limulus polyphemus		1			1														2
Lucania parva		8	2								1								11
Menidia menidia		92	1	8				20	27		5	2	70	17				11	253
Microgadus tomcod		1			1		1			16						1			20
Morone saxatilis					5				2			3							10
Myoxocephalus aenaeus					1		4												5
Nassarius obsoletus	x			x	x						x		x	x				x	x
Opsanus tau	6								2										8
Ovalipes ocellatus			7	10									2						19
Pagurus spp		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	x
Panopeus spp	x		x		x				x						x				x
Paralichthys dentatus							1												1
Prionotus carolinus																	2		2
Prionotus evolans		1																	1
Prionotus genus									2										2
Pseudopleuronectes americanus	56	11	87	26	9		3	4	19	1	36		58				141	3	454
Sphoeroides maculatus	1			1		2												7	11
Syngnathus fuscus	7	2			2				1		1		1				2		16
Tautoga onitis	14	1			5	3	12		1						1		1		38
Tautogolabrus adspersus					4		20			5		1				1			31
Urophycis regia							3												3
Grand Total	**119**	**124**	**135**	**46**	**187**	**5**	**62**	**24**	**76**	**42**	**1451**	**6**	**158**	**17**	**3**	**5**	**152**	**33**	**2645**

* 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 2021.

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		2		13	1	2		187	277		21		2	8	2		540		1055
Bairdiella chrysoura																	4		4
Brevoortia tyrannus	1		5			1													7
Calinectes sapidus	5	2	288	4	3				1		5		5		14	1	9		337
Carcinus maenus					x						x			x				x	x
Centropristus striata		1	3																4
Crangon septemspinosa	x	x	x		x								x		x			x	x
Crepidula fornicata	x				x			x									x		x
Ctenophora phylum					x		x					x	x		x				x
Cynoscion regalis			51																51
Cyprinodon variegatus	1																		1
Emerita talpoida															x				x
Fistularia tabacaria														1					1
Fundulus diaphanus			8								4		3	67					82
Fundulus heteroclitus	155		14	1	1	160		1	12				2	20			1		367
Fundulus majalis	417	19	110	8	20	35		1	151		14		24	29			87	56	971
Gasterosteus aculeatus	1																		1
Gobiosoma bosc		1	3		1				4							1	1		11
Isopoda order																		x	x
Leiostomus xanthurus							1											2	3
Limulus polyphemus									1							1			2
Lucania parva	1	1	3														1		6
Menidia menidia	203	833	40	327	90	1157	108	305	1448	3	422	47	1113	226	613	15	86	427	7463
Menticirrhus saxatilis	4	102	10	23				6	10		2			1	444		225	181	1008
Merluccius bilinearis													1						1
Microciona prolifera																	x		x
Microgadus tomcod										3									3
Morone saxatilis																1	4		5
Mugil curema																	1		1
Myoxocephalus aenaeus							1	1	2										4
Myoxocephalus octodecemspinos	4						1											43	48
Mytilus edulis										x							x		x
Nassarius obsoletus				x															x
Ovalipes ocellatus	4	1													11				16
Pagurus spp		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
Panopeus spp	x				x			x	x										x
Paralichthys dentatus															3				3
Peprilus triacanthus																		2	2
Pogonias cromis																	1		1
Pomatomus saltatrix				2					33		3	1			3	1		12	55
Prionotus carolinus		49	188	8									2		4		2		253
Prionotus evolans																		1	1
Prionotus genus									8										8
Pseudopleuronectes americanus	20	30	26	7	8	3			21		7	2	36	1			10	18	189
Scomber scombrus								1											1
Sphoeroides maculatus		1		37		29	11	4	11			2	1		3	1	5	13	118
Squilla empusa			1				1												2
Stenotomus chrysops	2	15	73	158	1						10							1	260
Strongylura marina													3					1	4
Syngnathus fuscus	1		2		3		1			1		1	1						10
Synodus foetens			1	14											1				16
Tautoga onitis	13	20	19	1	55	6	2		10	9		40	79	28		10	99		391
Tautogolabrus adspersus	5				15						1	1	5	6		1	62		96
Grand Total	**837**	**1077**	**845**	**603**	**198**	**1393**	**126**	**506**	**1989**	**16**	**489**	**94**	**1277**	**387**	**1098**	**32**	**1138**	**757**	**12862**

* 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 2021.

AUGUST	Station																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus				1	14					2		1	3	30	1	23	6		81
Anchoa mitchilli												7							7
Brevoortia tyrannus														1					1
Calinectes sapidus	52	0	36	11	5			4	1				4		11		90		214
Carcinus maenus					x			x	x	x	x			x		x			x
Centropristus striata					4	1			3			1					3		12
Crangon septemspinosa					x														x
Ctenophora phylum				x		x		x	x		x	x				x	x	x	x
Cynoscion regalis	2			1									4						7
Cyprinodon variegatus																1	43		44
Farfantepenaeus aztecus																	x		x
Fistularia tabacaria										1									1
Fundulus diaphanus			4					1						24			7		36
Fundulus heteroclitus			8			31			3				3	11			1		57
Fundulus majalis	58	266	42	1	12	11		22	14	1		9	29	80		6	203	5	759
Gasterosteus aculeatus		1																	1
Gobiosoma bosc														1					1
Hemigrapsus sanguineus									x										x
Hippocampus genus		1																	1
Libinia emarginata											x	x							x
Limulus polyphemus									1								3		4
Lucania parva	1	1	1																3
Menidia menidia	740	316	393	61	1368	49	259	775	20	46	57	131	279	234	113	52	382	118	5393
Menticirrhus saxatilis	49	24	31	33	15	1	14	2	3		6	2	1		465		6	8	660
Merluccius bilinearis		3																	3
Microciona prolifera												x							x
Microgadus tomcod					1														1
Morone americana										1									1
Myoxocephalus aenaeus																	1		1
Mytilus edulis							x										x		x
Nassarius obsoletus			x	x	x		x					x	x						x
Opsanus tau													1						1
Ovalipes ocellatus															8				8
Pagurus spp			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
Panopeus spp					x							x							x
Peprilus triacanthus															3				3
Pomatomus saltatrix	190		1				1	1	167		2	11	3	5			81	792	1254
Prionotus carolinus				8															8
Prionotus evolans	9	9	4	4					2						2		2	11	43
Prionotus genus					6			2											8
Pseudopleuronectes americanus	48	18	2		28			1	4		1	2	20	3			5		132
Raja eglanteria					1														1
Scophthalmus aquosus															1				1
Sphoeroides maculatus			1	8		18	2	2	3		1		1		4				40
Stenotomus chrysops		106		42	1		10	2	31		10	2			1		11	8	224
Strongylura marina	2	1				1							1				2	10	17
Syngnathus fuscus		1			3				1						1				6
Synodus foetens	2	26		26											3		1	15	73
Tautoga onitis	8	33			90	38	9		48	4		22	46	122	1	27	13		461
Tautogolabrus adspersus		4			32	14	1							36		54	12		153
Grand Total	**1161**	**810**	**523**	**196**	**1580**	**164**	**296**	**812**	**301**	**55**	**77**	**188**	**395**	**547**	**614**	**163**	**872**	**967**	**9721**

* 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 2021.

SEPTEMBER	**Station**																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	3																1		4
Anguilla rostrata					1														1
Brevoortia tyrannus	6	108	92	10	14	2	36		11			1		28		1			309
Calinectes sapidus		1	32	1	2							1	3				3	1	44
Carcinus maenus					x			x				x	x			x	x		x
Centropristus striata					5		7			3	1				1				17
Crangon septemspinosa				x															x
Crepidula fornicata	x	x							x			x							x
Ctenophora phylum	x			x															x
Cyprinodon variegatus																	2		2
Etropus microstomus															1				1
Farfantepenaeus aztecus								x								x			x
Fistularia tabacaria							1			1									2
Fundulus heteroclitus	1		331										41	1			1		375
Fundulus majalis	216	257	489		28	60		13	72	13	1	2	493		9	1	52		1706
Gobiosoma bosc												1							1
Hemigrapsus sanguineus																x			x
Hippocampus genus												1							1
Isopoda order						x				x									x
Libinia emarginata										x		x							x
Lucania parva		3																	3
Menidia menidia	3259	740	479	708	460	434	2304	17	356	41	3	3002	689	845	4	1769	1187	949	17246
Menticirrhus saxatilis	9	5	16		1	4	14		2		2				1			26	80
Microgadus tomcod					1														1
Mugil curema														1				43	44
Myoxocephalus aenaeus					2					1		1							4
Mytilus edulis									x							x			x
Nassarius obsoletus								x				x							x
Ovalipes ocellatus															1				1
Pagurus spp	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
Panopeus spp					x			x			x	x					x		x
Pholis gunnellus										1									1
Pomatomus saltatrix	932		5		37		9		68		2	5		3	16	11	101		1189
Prionotus carolinus				1															1
Prionotus evolans			1						1									1	3
Pseudopleuronectes americanus					1	2	4	1	2										10
Sphoeroides maculatus						3			1							1		2	7
Stenotomus chrysops	23	1					45		15		7		1				7		99
Strongylura marina	6			1													1	1	9
Syngnathus fuscus															2				2
Synodus foetens	1												1					8	10
Tautoga onitis				1	27	24	25	1	9	34		95	16	2		151	19		404
Tautogolabrus adspersus					11		3		3	11		10				51	2		91
Tylosurus crocodilus	1					1													2
Grand Total	**4457**	**1115**	**1445**	**722**	**590**	**530**	**2448**	**32**	**540**	**105**	**16**	**3119**	**1244**	**880**	**35**	**1985**	**1376**	**1031**	**21670**

* 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 2021.

OCTOBER	**Station**																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15***	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus			3					3				1							7
Aurelia aurita		x																	0
Brevoortia tyrannus				44		2						10					2		58
Busycotypus canaliculatus								1											1
Calinectes sapidus			2				2						2				1	18	25
Carcinus maenus					x	x		x	x	x	x		x	x		x	x		0
Centropristus striata										4		1							5
Crangon septemspinosa											x							x	0
Crepidula fornicata	x					x										x			0
Ctenophora phylum				x			x			x				x				x	0
Cyprinodon variegatus	21	7	7														3		38
Farfantepenaeus aztecus							x			x									0
Fundulus heteroclitus	1		39	4		1		7					6				22		80
Fundulus majalis	87	97	177	96	15	7	2	25				1	20				37	56	620
Gobiosoma bosc						1					1			1					3
Hemigrapsus sanguineus														x					0
Limulus polyphemus	1								1										2
Menidia menidia	28	285	3833	187	209	2536	45	611	273	20	92	17	2531	571		474	2123	865	14700
Menticirrhus saxatilis						3												4	7
Microgadus tomcod										3									3
Morone saxatilis									48										48
Mugil curema																		1	1
Myoxocephalus aenaeus										1						1			2
Mytilus edulis																x			0
Nassarius obsoletus	x		x								x								0
Pagurus spp		x	x		x		x	x	x	x	x			x				x	0
Palaemonetes vulgaris		x	x	x	x			x	x		x		x			x	x	x	0
Panopeus spp		x			x				x		x			x					0
Pomatomus saltatrix		2	15																17
Pseudopleuronectes americanus					3		1		8		1								13
Syngnathus fuscus	1									1			1					1	4
Tautoga onitis	32	24			12	17			9	48	1	12	8			36	6	1	206
Tautogolabrus adspersus	5	1			3	3			1	25	1	12		2		34			87
Urophycis regia													1					2	3
Grand Total	**176**	**416**	**4076**	**331**	**242**	**2570**	**50**	**647**	**340**	**102**	**96**	**54**	**2569**	**574**		**545**	**2194**	**948**	**15930**

* x indicates that the non-target species was collected but the abundance was recorded as abundant, many or few. Station 15 was attempted to be sampled in October but the boat was pushed ashore and the seining wasn’t completed.

Table 8. Summary of species occurrence by station in 2021. 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																		
Row Labels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Grand Total**
Alosa aestivalis &/or pseudoharengus	4	2	3	14	15	2		190	277	2	1198	2	5	38	4	23	547		2326
Ammodytes americanus							18												18
Anchoa mitchilli												7							7
Anguilla rostrata					15														15
Apeltes quadracus	1														1				2
Aurelia aurita		x																	x
Bairdiella chrysoura																	4		4
Brevoortia tyrannus	7	108	97	54	14	5	36		11			11		29		1	2		375
Busycotypus canaliculatus								1											1
Calinectes sapidus	60	3	361	17	11		2	4	2		5	1	22		25	1	109	19	642
Carcinus maenus					x	x	x	x	x	x	x	x	x	x		x	x	x	x
Centropristus striata		1	3		9	1	7		3	7	1	2			1	3	3		41
Crangon septemspinosa	x	x	x	x	x						x		x		x		x	x	x
Crepidula fornicata	x	x			x	x		x	x			x				x	x		x
Ctenophora phylum	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cynoscion regalis	2		51	1									4						58
Cyprinodon variegatus	22	7	7													1	48		85
Emerita talpoida															x				x
Etropus microstomus															1				1
Farfantepenaeus aztecus							x	x		x						0	x		x
Fistularia tabacaria							1			2				1					4
Fundulus diaphanus			12					1			4		3	91			7		118
Fundulus heteroclitus	169	1	411	5	121	192		8	37		49		68	32			25		1118
Fundulus majalis	795	639	834	105	99	113	2	61	237	14	196	12	569	109	9	7	379	128	4308
Gadus morhua										20									20
Gasterosteus aculeatus	2	1									1								4
Gobiosoma bosc		7	3		1	1			4		1	1		2		1	1		22
Hemigrapsus sanguineus									x					x		x			x
Hippocampus genus		1										1						1	3
Isopoda order						x				x					x			x	x
Leiostomus xanthurus							1											2	3
Libinia emarginata					x	x	x			x	x	x							x
Limulus polyphemus	1	1			1				3							1	3		10
Lucania parva	2	13	6								1						1		23
Menidia menidia	4230	2266	4746	1291	2127	4176	2716	1728	2124	110	579	3199	4682	1893	730	2310	3778	2370	45055
Menticirrhus saxatilis	62	131	57	56	16	8	28	8	15		10	2	1	1	910		231	219	1755
Merluccius bilinearis		3											1						4
Microciona prolifera												x					x		x
Microgadus tomcod		1			3		1			22						1			28
Morone americana										1									1
Morone saxatilis					5				50			3				1	4		63
Mugil curema														1			1	44	46

Myoxocephalus aenaeus					3		5	1	2	2		1				1	1		16
Myoxocephalus octodecemspinos	4						1											43	48
Mytilus edulis							x		x	x						x	x		x
Nassarius obsoletus	x		x	x	x		x	x			x	x	x	x				x	x
Opsanus tau	6								2				1						9
Ovalipes ocellatus	4	1	7	10									2		20				44
Pagurus spp	x	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	x	x	x
Panopeus spp	x	x	x		x			x	x		x	x		x	x		x		x
Paralichthys dentatus							1								3				4
Peprilus triacanthus															3			2	5
Pholis gunnellus										1									1
Pogonias cromis																	1		1
Pomatomus saltatrix	1122	2	21	2	37		10	1	268		7	17	3	8	19	12	182	804	2515
Prionotus carolinus		49	188	17									2		4		4		264
Prionotus evolans	9	10	5	4					3						2		2	13	48
Prionotus genus					6			2	10										18
Pseudopleuronectes americanus	124	59	115	33	49	5	8	6	54	1	45	4	114	4			156	21	798
Raja eglanteria					1														1
Scomber scombrus								1											1
Scophthalmus aquosus															1				1
Sphoeroides maculatus	1	1	1	46		52	13	6	15		1	2	2		7	2	5	22	176
Squilla empusa			1				1												2
Stenotomus chrysops	25	122	73	200	2		55	2	46		27	2	1		1		18	9	583
Strongylura marina	8	1		1		1							4				3	12	30
Syngnathus fuscus	9	3	2		8		1		2	2	1	1	3		3		2	1	38
Synodus foetens	3	26	1	40									1		4		1	23	99
Tautoga onitis	67	78	19	2	189	88	48	1	77	95	1	169	149	152	2	224	138	1	1500
Tautogolabrus adspersus	10	5			65	17	24		4	41	2	24	5	44		141	76		458
Tylosurus crocodilus	1					1													2
Urophycis regia							3						1					2	6
Grand Total	**6750**	**3542**	**7024**	**1898**	**2797**	**4662**	**2982**	**2021**	**3246**	**320**	**2129**	**3461**	**5643**	**2405**	**1750**	**2730**	**5732**	**3736**	**62828**

* 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 2021.

	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	56	11	87	26	9	0	3	4	19	1	36	0	58	0	0	0	141	3	25.22	38.40	9.05
JUL	20	30	26	7	8	3	0	0	21	0	7	2	36	1	0	0	10	18	10.50	11.70	2.76
AUG	48	18	2	0	28	0	0	1	4	0	1	2	20	3	0	0	5	0	7.33	13.07	3.08
SEP	0	0	0	0	1	2	4	1	2	0	0	0	0	0	0	0	0	0	0.56	1.10	0.26
OCT	0	0	0	0	3	0	1	0	8	0	1	0	0	0		0	0	0	0.76	2.02	0.48
Mean	24.80	11.80	23.00	6.60	9.80	1.00	1.60	1.20	10.80	0.20	9.00	0.80	22.80	0.80	0.00	0.00	31.20	4.20			
St Dev	26.29	12.74	37.43	11.26	10.71	1.41	1.82	1.64	8.70	0.45	15.35	1.10	24.80	1.30	0.00	0.00	61.52	7.82		Total Fish	
SE	11.76	5.70	16.74	5.04	4.79	0.63	0.81	0.73	3.89	0.20	6.86	0.49	11.09	0.58	0.00	0.00	27.51	3.50		798	
Number	124	59	115	33	49	5	8	6	54	1	45	4	114	4	0	0	156	21			

Table 10. Numbers of juvenile tautog per seine haul in 2021.

	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	14	1	0	0	5	3	12	0	1	0	0	0	0	0	1	0	1	0	2.11	4.19	0.99
JUL	13	20	19	1	55	6	2	0	10	9	0	40	79	28	0	10	99	0	21.72	28.91	6.81
AUG	8	33	0	0	90	38	9	0	48	4	0	22	46	122	1	27	13	0	25.61	34.02	8.02
SEP	0	0	0	1	27	24	25	1	9	34	0	95	16	2	0	151	19	0	22.44	39.52	9.31
OCT	32	24	0	0	12	17	0	0	9	48	1	12	8	0		36	6	1	12.12	14.71	3.47
Mean	13.40	15.60	3.80	0.40	37.80	17.60	9.60	0.20	15.40	19.00	0.20	33.80	29.80	30.40	0.50	44.80	27.60	0.20			
St Dev	11.78	14.57	8.50	0.55	34.92	14.19	9.91	0.45	18.58	20.93	0.45	37.22	32.55	52.56	0.58	61.01	40.49	0.45		Total Fish	
SE	5.27	6.52	3.80	0.24	15.62	6.35	4.43	0.20	8.31	9.36	0.20	16.64	14.55	23.51	0.26	27.29	18.11	0.20		1500	
Number	67	78	19	2	189	88	48	1	77	95	1	169	149	152	2	224	138	1			

Table 11. Numbers of juvenile bluefish per seine haul in 2021.

	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	2	0	0	0	0	33	0	3	1	0	0	3	1	0	12	3.06	8.00	1.89
AUG	190	0	1	0	0	0	1	1	167	0	2	11	3	5	0	0	81	792	69.67	189.52	44.67
SEP	932	0	5	0	37	0	9	0	68	0	2	5	0	3	16	11	101	0	66.06	217.85	51.35
OCT	0	2	15	0	0	0	0	0	0	0	0	0	0	0		0	0	0	1.00	3.64	0.86
Mean	283.04	0.64	1.50	0.50	7.40	0.00	2.50	0.25	67.00	0.00	1.75	4.25	0.75	2.00	4.75	3.00	45.50	201.00			
St Dev	404.03	0.89	2.38	1.00	16.55	0.00	4.36	0.50	72.22	0.00	1.34	4.72	1.34	2.45	7.63	4.83	53.17	352.89		Total Fish	
SE	180.69	0.40	1.06	0.45	7.40	0.00	1.95	0.22	32.30	0.00	0.60	2.11	0.60	1.10	3.41	2.16	23.78	157.82		2515	
Number	1122	2	21	2	37	0	10	1	268	0	7	17	3	8	19	12	182	804			

Table 12. Numbers of striped bass per seine haul in 2021.

	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	5	0	0	0	2	0	0	3	0	0	0	0	0	0	0.56	1.38	0.33
JUL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0.28	0.96	0.23
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
SEP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
OCT	0	0	0	0	0	0	0	0	48	0	0	0	0	0		0	0	0	2.82	11.64	2.74
Mean	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	10.00	0.00	0.00	0.60	0.00	0.00	0.00	0.20	0.80	0.00			
St Dev	0.00	0.00	0.00	0.00	2.24	0.00	0.00	0.00	21.26	0.00	0.00	1.34	0.00	0.00	0.00	0.45	1.79	0.00		Total Fish	
SE	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	9.51	0.00	0.00	0.60	0.00	0.00	0.00	0.20	0.80	0.00		63	
Number	0	0	0	0	5	0	0	0	50	0	0	3	0	0	0	1	4	0			

Table 13. Numbers of juvenile river herring per seine haul in 2021.

	Station																				
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	Mean	St Dev	SE
JUN	1	0	0	0	0	0	0	0	0	0	1177	0	0	0	1	0	0	0	65.50	277.39	65.38
JUL	0	2	0	13	1	2	0	187	277	0	21	0	2	8	2	0	540	0	58.61	141.87	33.44
AUG	0	0	0	1	14	0	0	0	0	2	0	1	3	30	1	23	6	0	4.50	8.79	2.07
SEP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.22	0.73	0.17
OCT	0	0	3	0	0	0	0	3	0	0	0	1	0	0		0	0	0	0.41	1.00	0.24
Mean	0.80	0.40	0.60	2.80	3.00	0.40	0.00	38.00	55.40	0.40	239.60	0.40	1.00	7.60	1.00	4.60	109.40	0.00			
St Dev	1.30	0.89	1.34	5.72	6.16	0.89	0.00	83.30	123.88	0.89	524.10	0.55	1.41	12.99	0.82	10.29	240.73	0.00		Total Fish	
SE	0.58	0.40	0.60	2.56	2.76	0.40	0.00	37.25	55.40	0.40	234.39	0.24	0.63	5.81	0.37	4.60	107.66	0.00		2326	
Number	4	2	3	14	15	2	0	190	277	2	1198	2	5	38	4	23	547	0			

Table 14. Numbers of juvenile menhaden per seine haul in 2021.

	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	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0.39	1.20	0.28
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0.06	0.24	0.06
SEP	6	108	92	10	14	2	36	0	11	0	0	1	0	28	0	1	0	0	17.17	31.96	7.53
OCT	0	0	0	44	0	2	0	0	0	0	0	10	0	0		0	2	0	3.41	10.74	2.53
Mean																					
St Dev	2.61	48.30	40.64	19.06	6.26	1.00	16.10	0.00	4.92	0.00	0.00	4.38	0.00	12.42	0.00	0.45	0.89	0.00		Total Fish	
SE	1.17	21.60	18.18	8.52	2.80	0.45	7.20	0.00	2.20	0.00	0.00	1.96	0.00	5.55	0.00	0.20	0.40	0.00		375	
Number	7	108	97	54	14	5	36	0	11	0	0	11	0	29	0	1	2	0			

Table 15. Numbers of juvenile black sea bass per seine haul in 2021.

	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	3	0	0	0.17	0.71	0.17
JUL	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0.73	0.17
AUG	0	0	0	0	4	1	0	0	3	0	0	1	0	0	0	0	3	0	0.67	1.28	0.30
SEP	0	0	0	0	5	0	7	0	0	3	1	0	0	0	1	0	0	0	0.94	2.01	0.47
OCT	0	0	0	0	0	0	0	0	0	4	0	1	0	0		0	0	0	0.29	0.99	0.23
Mean	0.00	0.20	0.60	0.00	1.80	0.20	1.40	0.00	0.60	1.40	0.20	0.40	0.00	0.00	0.25	0.60	0.60	0.00			
St Dev	0.00	0.45	1.34	0.00	2.49	0.45	3.13	0.00	1.34	1.95	0.45	0.55	0.00	0.00	0.50	1.34	1.34	0.00		Total Fish	
SE	0.00	0.20	0.60	0.00	1.11	0.20	1.40	0.00	0.60	0.87	0.20	0.24	0.00	0.00	0.22	0.60	0.60	0.00		41	
Number	0	1	3	0	9	1	7	0	3	7	1	2	0	0	1	3	3	0			

Table 16. Temperature, salinity, and dissolved oxygen by station and month – 2021

		Month					
Station		**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**Total Average**
1	Temperature (C)	20	24.7	23.1	22.7	18.4	108.9
	Salinity	20.9	10.9	21.1	14.6	20.3	87.8
	Dissolved Oxygen	10.6	8.3	5.2	0	7.38	31.48
2	Temperature (C)	20.9	24.1	23.9	22.9	18.9	110.7
	Salinity	20.7	16.7	19.7	16.6	22.4	96.1
	Dissolved Oxygen	9.6	11	8.7	0	8.33	37.63
3	Temperature (C)	21.5	24.6	25.4	21.4	19.6	112.5
	Salinity	24.8	23.2	25.2	0	27.2	100.4
	Dissolved Oxygen	7.4	4.1	0	0	9.87	21.37
4	Temperature (C)	21.9	23.6	24.3	22.6	19.6	112
	Salinity	20	24.4	26.2	24.1	28.4	123.1
	Dissolved Oxygen	7.9	5.6	6	0	8.58	28.08
5	Temperature (C)	19.9	20.9	22.2	23.9	19.2	106.1
	Salinity	25.7	22.7	25.8	24.2	29.8	128.2
	Dissolved Oxygen	7.7	5.8	5.3	0	8.93	27.73
6	Temperature (C)	20.6	22.3	23.4	21.8	17.2	105.3
	Salinity	18	22.6	27.6	27.3	30.4	125.9
	Dissolved Oxygen	8.9	8.3	5.8	5.2	9.22	37.42
7	Temperature (C)	18.8	21.5	22	21.8	17.3	101.4
	Salinity	18.6	25.3	28.3	28	31	131.2
	Dissolved Oxygen	8.2	6.9	6.9	0	8.16	30.16
8	Temperature (C)	22.1	22.3	23	18.9	18.6	104.9
	Salinity	25.1	18.6	26	28.7	29.3	127.7
	Dissolved Oxygen	8	10	6.1	7.96	7.21	39.27
9	Temperature (C)	20.7	22.3	22.7	23.1	19	107.8
	Salinity	26	22.8	25.5	23.6	29.5	127.4
	Dissolved Oxygen	9.2	8.1	6.1	7.5	8.27	39.17
10	Temperature (C)	18.2	22.1	22.4	0	19.4	82.1
	Salinity	27.8	26.3	28.6	0	31.4	114.1
	Dissolved Oxygen	8.8	8.8	9.8	0	8.86	36.26
11	Temperature (C)	24.3	24.3	25.9	21.2	13.8	109.5
	Salinity	15.4	23.1	23.9	26.8	26.6	115.8
	Dissolved Oxygen	7.8	5.9	10.8	5.8	8	38.3
12	Temperature (C)	21.4	24.2	23.9	44.4	18.7	132.6
	Salinity	24.2	19.8	23	47.5	27.3	141.8
	Dissolved Oxygen	8.5	8.1	0	14.11	10.1	40.81
13	Temperature (C)	24.3	25.7	26.3	20.8	14.2	111.3
	Salinity	16.5	24.6	26.8	28.4	29.5	125.8
	Dissolved Oxygen	7.4	6.6	0	9.81	8.96	32.77
14	Temperature (C)	23.5	24.3	24.7	19.9	14.3	106.7
	Salinity	28	27.2	27.9	29.4	30.3	142.8
	Dissolved Oxygen	6.8	7.9	0	10.26	9.04	34
15	Temperature (C)	21.7	22.9	23.9	20.6	*	89.1
	Salinity	28.5	28.4	28.5	30.9	*	116.3
	Dissolved Oxygen	7.9	7.6	0	8.62	*	24.12
16	Temperature (C)	19.6	21.8	21.6	22.4	18.7	104.1
	Salinity	26.5	25.7	27	25.6	30.8	135.6
	Dissolved Oxygen	7.7	7.7	7	7	7.84	37.24
17	Temperature (C)	20.2	21.5	26	20.4	19.1	107.2
	Salinity	25.5	25.8	23.8	26.4	28.2	129.7
	Dissolved Oxygen	7	0	0	7.39	8.17	22.56
18	Temperature (C)	20.4	22.1	24	22	16.6	105.1
	Salinity	17.9	21.4	27.1	26.8	29.9	123.1
	Dissolved Oxygen	8	8.4	6.4	5.6	8.19	36.59

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	34	1988-2021
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	34	1988-2021
	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	34	1988-2021
	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	34	1988-2021
	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

2021 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

2021 Performance Report for Job V, March 21, 2021

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, 2021 - December 31, 2021

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: Holistic Fish Habitat Assessment and Fish Productivity Estimations

PERIOD COVERED: January 1, 2021 - December 31, 2021

JOB NUMBER AND TITLE: V, 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: December 2024

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 food webs they support, and the associated fisheries. Thus, we seek to understand how kelp ecosystems may be impacted 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, 2021 and

December 31, 2021. During this period 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 are 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 two to four 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, set to collect data every 30 mins. 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 Rhode Island long term kelp dataset to calculate the rate of change for each 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. 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 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 beginning of the King's Beach site, 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 (2016-2021) to investigate fish habitat linkages between kelp habitat and fish biomass over time.

In 2021, we began preliminary modeling efforts looking at the impact of kelp density on the observed biomass of finfish, using 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. Kelp Morphometrics were summarized using a histogram of blade lengths, for each species, site, and year of the concurrent running surveys (2019, 2020, 2021). In the future this information will be used to help transform mean kelp density into kelp biomass, using the kelp morphometric data to estimate average kelp mass per transect.

RESULTS:

In 2021, 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 2021 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 2022 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 averages the proportion of boulders (large, medium, and small combined) was between 31.25 and 41.87% percent coverage at our transect locations (Figure 3). Both of Sites are at the mouth of Narragansett Bay and represent nearshore rocky reef habitats, typical of the region. Both sites had an average of 18% kelp cover, down from 30% recorded last year (Figure 4). In the absence of kelp, at our control locations (kelp less than 10 percent on average), we found the rocky reef locations to be dominated by a variety a branching and filamentous red alae. Specifically, *Chondrus crispus* and *truncatus*, as well as several *Ceramium* species. In 2021, the algae and invertebrate species richness and diversity were higher at the kelp sites at King's Beach but no difference existed between controls and kelp at the Fort Wetherill locations (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. 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 (19.06 ± 5.25) than the control locations (3.66 and 3 ± 2) (Figure 6).We found the average total kelp density (*Saccharina latissima* and *Laminaria digitata*) has declined in 2021 compared to past years of the kelp survey. With densities declining as much as 75% at King's Beach since 2019 (Figure 7).

In 2021 we found the average fish biomass greater at both the Fort Wetherill and King's Beach kelp sites than their respective controls. Total fish biomass on the kelp beds averaged 23.54 ± 4.3 and 103.18 ± 57.62 grams per meter squared of kelp habitat at Fort Wetherill and King's Beach location respectively (Figure 8). In the linear regression model we found a positive relationship between fish biomass and kelp density with a slope of 16.065) (Figure 9). Kelp blade length was summarized using histograms to differentiate the difference between the 2019 and 2021 seasons. We found the average blade length for both kelp species to be smaller in 2021 than the past two years (2019-2020) (Figure 10). 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 from 2016- 2020 (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, in 2021 we saw declines in kelp density and a correlated decrease in total fish biomass, demonstrating the importance of tracking these beds through time. As the work progresses, we will work to incorporate environmental variables into our analyses to determine the impact of changing temperature impacts the kelp system and it's associated inhabitants. For example, we that fish biomass was greatest at the kelp sites and has thus far trended with the overall density of kelp.

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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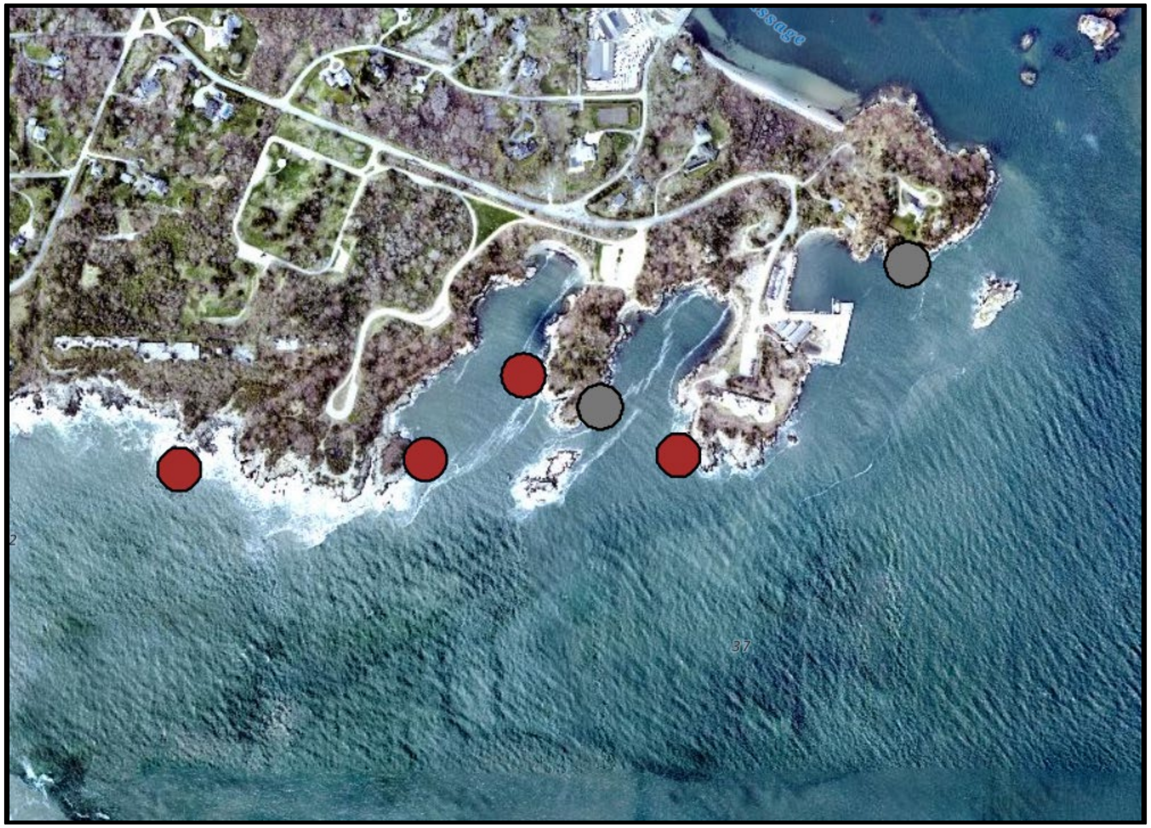

Figure 1: Fort Wetherill Kelp Productivity Dive Survey locations. Circles represent the general location of the six transects; Brown = Kelp, Grey = Control.

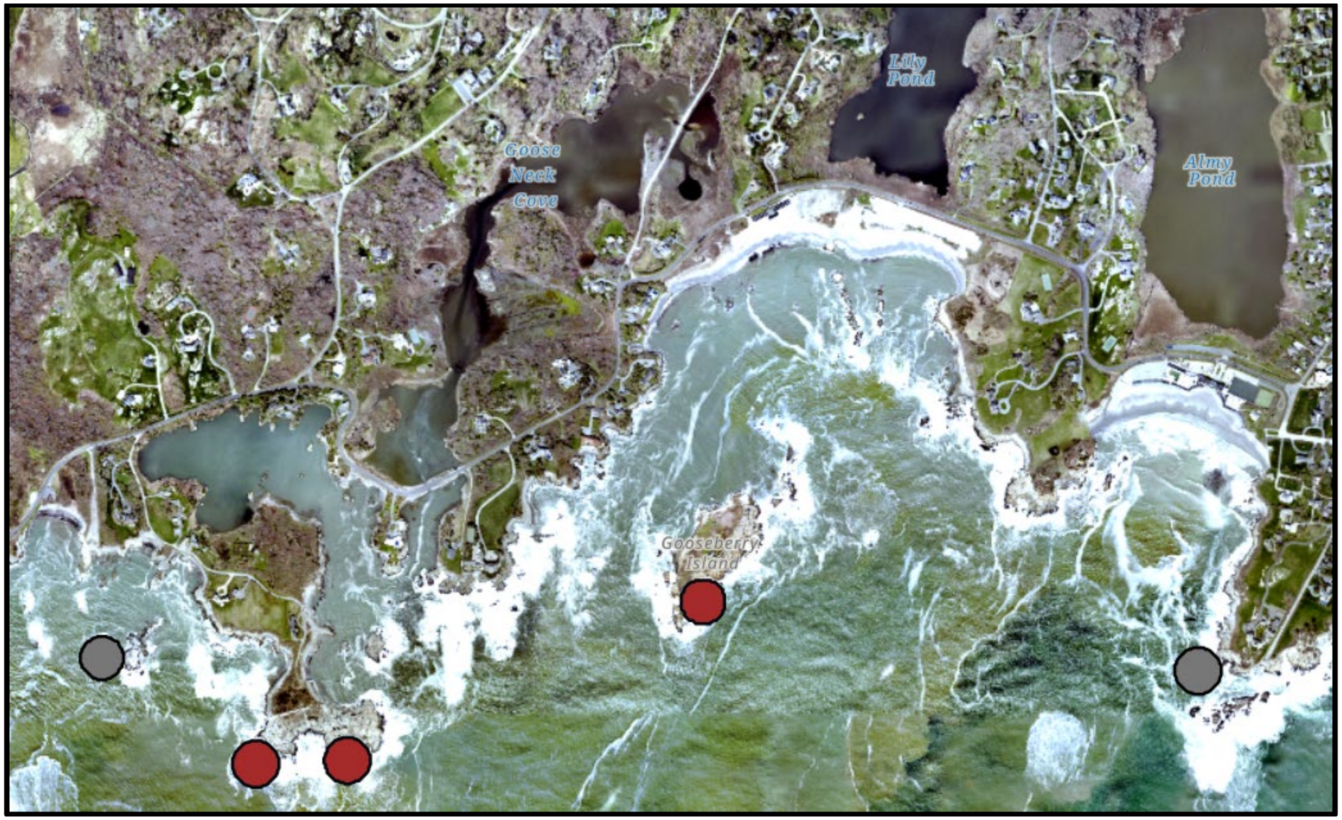

Figure 2: King’s Beach Kelp Productivity Dive Survey locations. Circles represent the general location of the five transects; Brown = Kelp, Grey = Control.

Table 1. Kelp Uniform Point Count survey estimated species richness (R) and diversity (Shannon's H-index) for each site from 2019-2021.

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	16.5 ± 0.96	2.28 ± 0.13
2019	Narragansett Bay	Fort Wetherill	Control	14.5 ± 3.5	2.02 ± 0.15
2020	Narragansett Bay	Fort Wetherill	Kelp	17.25 ± 1.93	2.2 ± 0.11
2020	Narragansett Bay	King's Beach	Kelp	15.67 ± 0.33	2.34 ± 0.08
2020	Narragansett Bay	Fort Wetherill	Control	15 ± 1	2.2 ± 0.03
2020	Narragansett Bay	King's Beach	Control	11.5 ± 0.5	1.71 ± 0.17
2021	Narragansett Bay	Fort Wetherill	Kelp	14.6 ± 0.87	1.98 ± 0.07
2021	Narragansett Bay	King's Beach	Kelp	17.67 ± 0.67	2.33 ± 0.11
2021	Narragansett Bay	Fort Wetherill	Control	24 ± NA	2.47 ± NA
2021	Narragansett Bay	King's Beach	Control	15 ± 1	2.07 ± 0.19

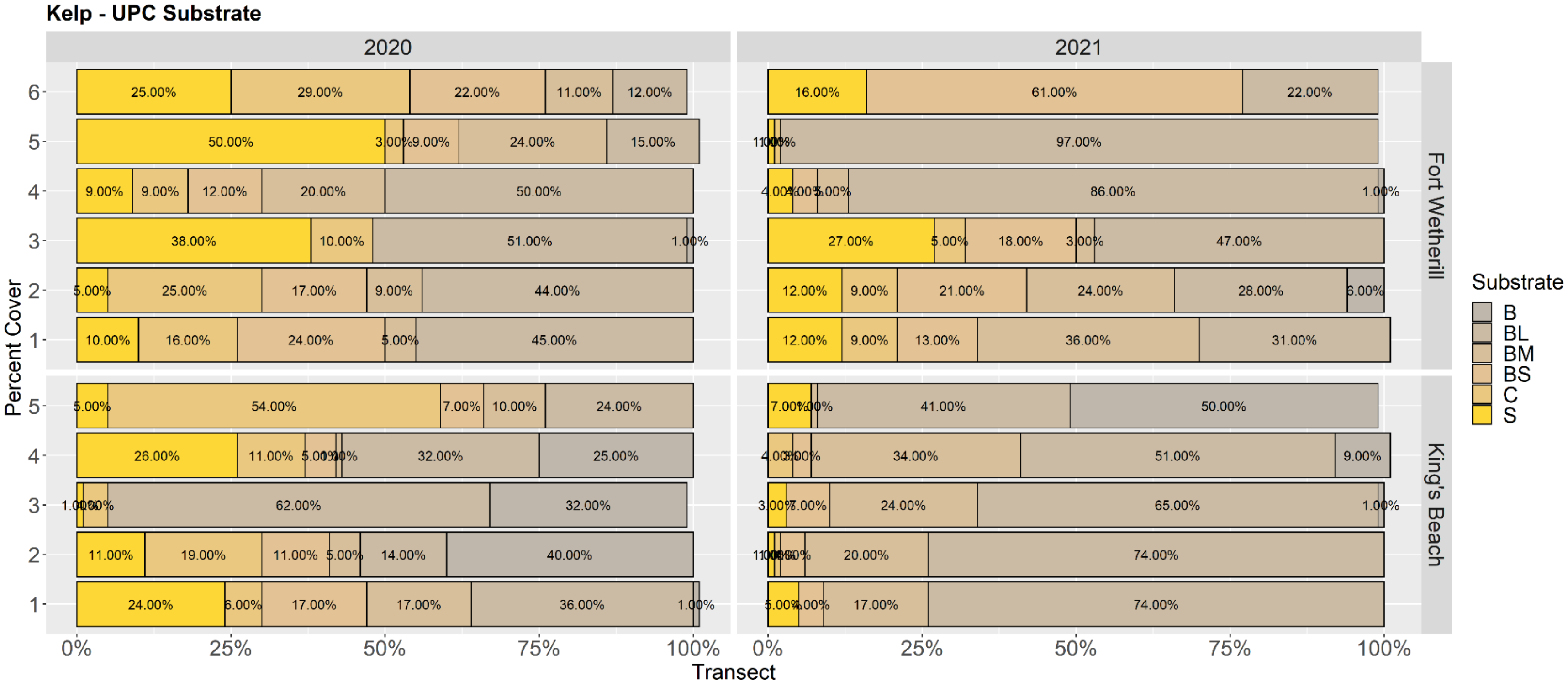

Figure 3. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each fish productivity survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, C= cobble, M = mud/fines, M_S = sandy mud mix, S = Sand, B = Bedrock) and faceted Year (2020,2021) and Site (Fort Wetherill and KB = King's Beach).

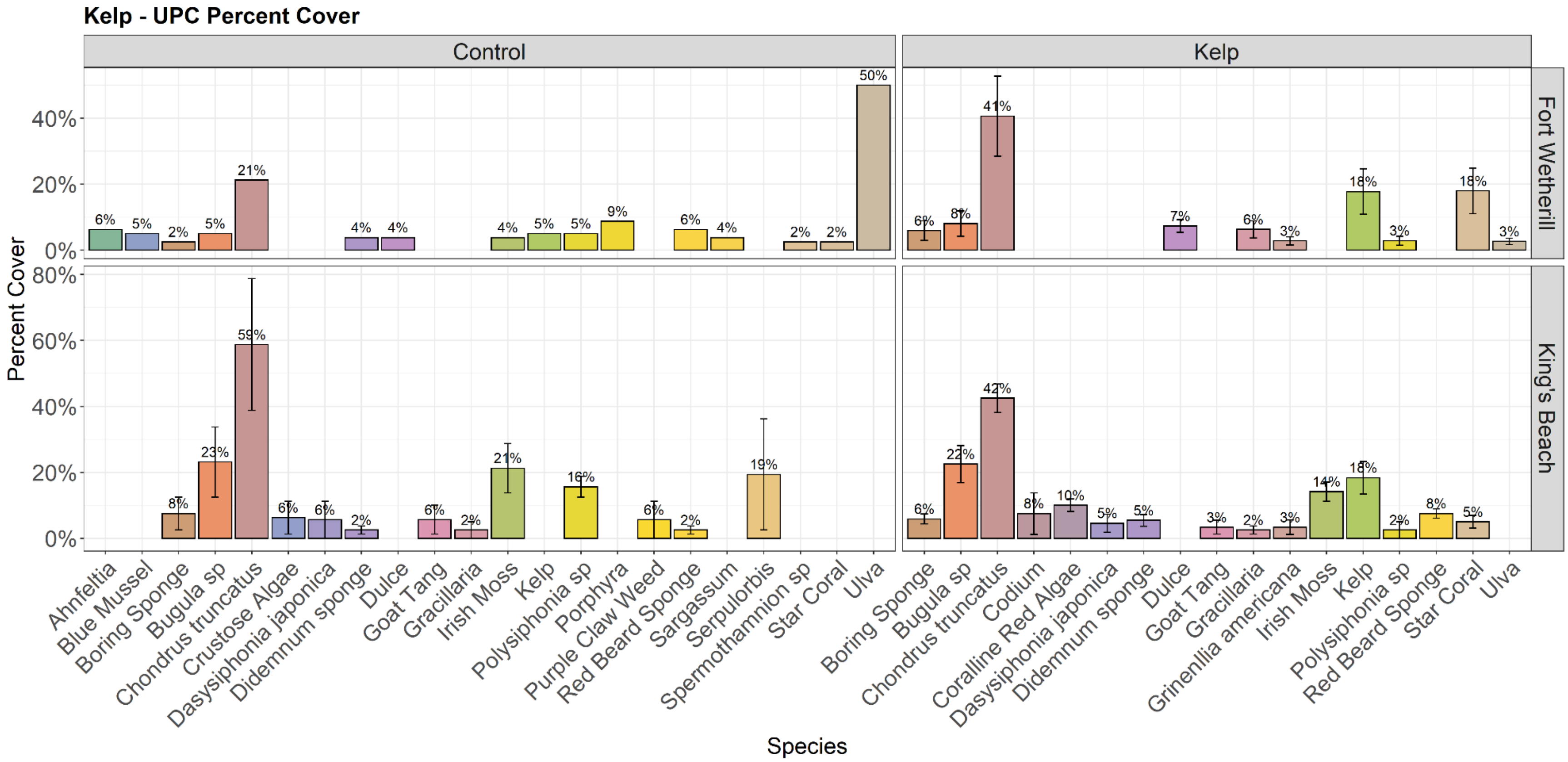

Figure 4. Mean algal and sessile invertebrate cover ± SE, for each habitat type (Kelp or Control) grouped by Site (Fort Wetherill and Kings Beach) during the 2021 productivity uniform point count survey.

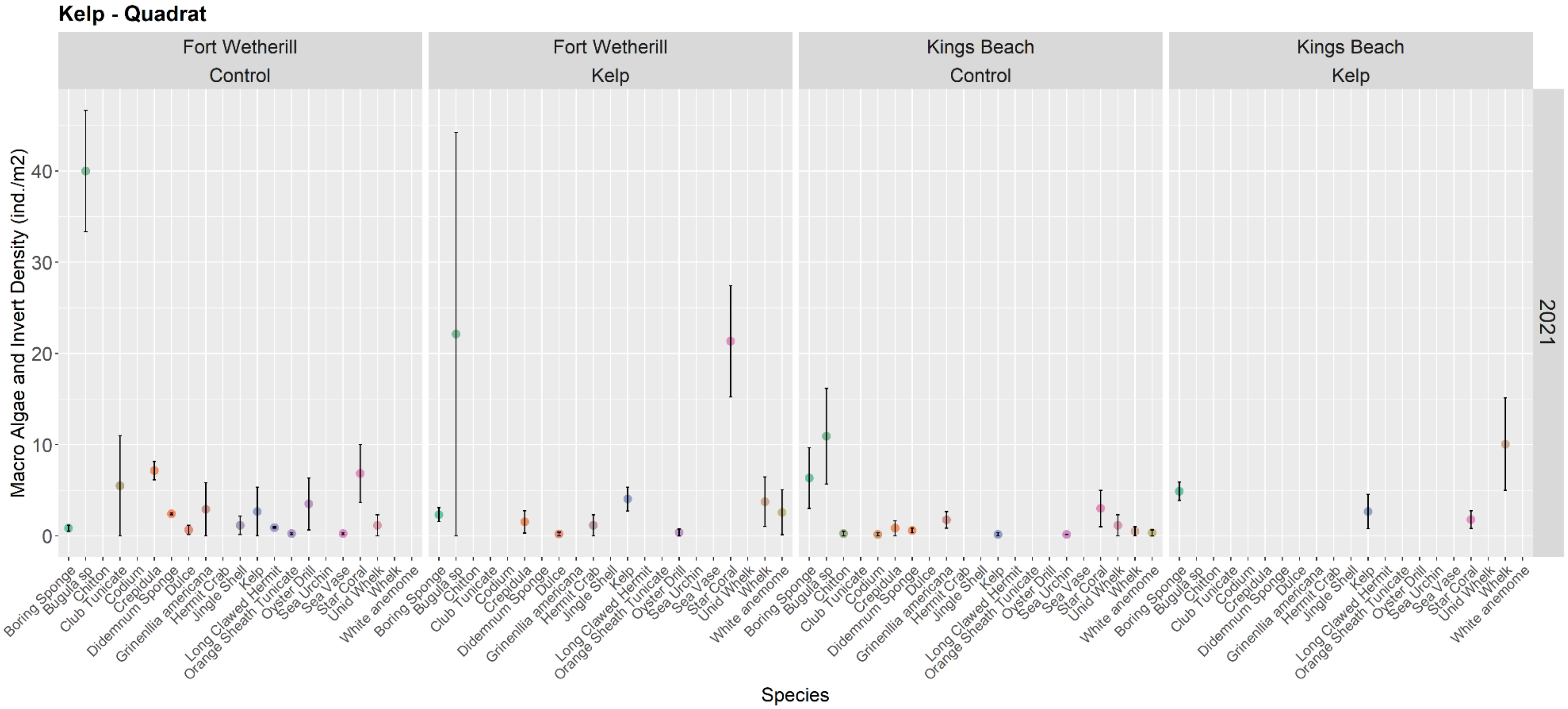

Figure 5. Mean invertebrate and macro algae density ± SE, per habitat treatment (i.e., Kelp and Control) for the quadrat transect during the 2021 surveys.

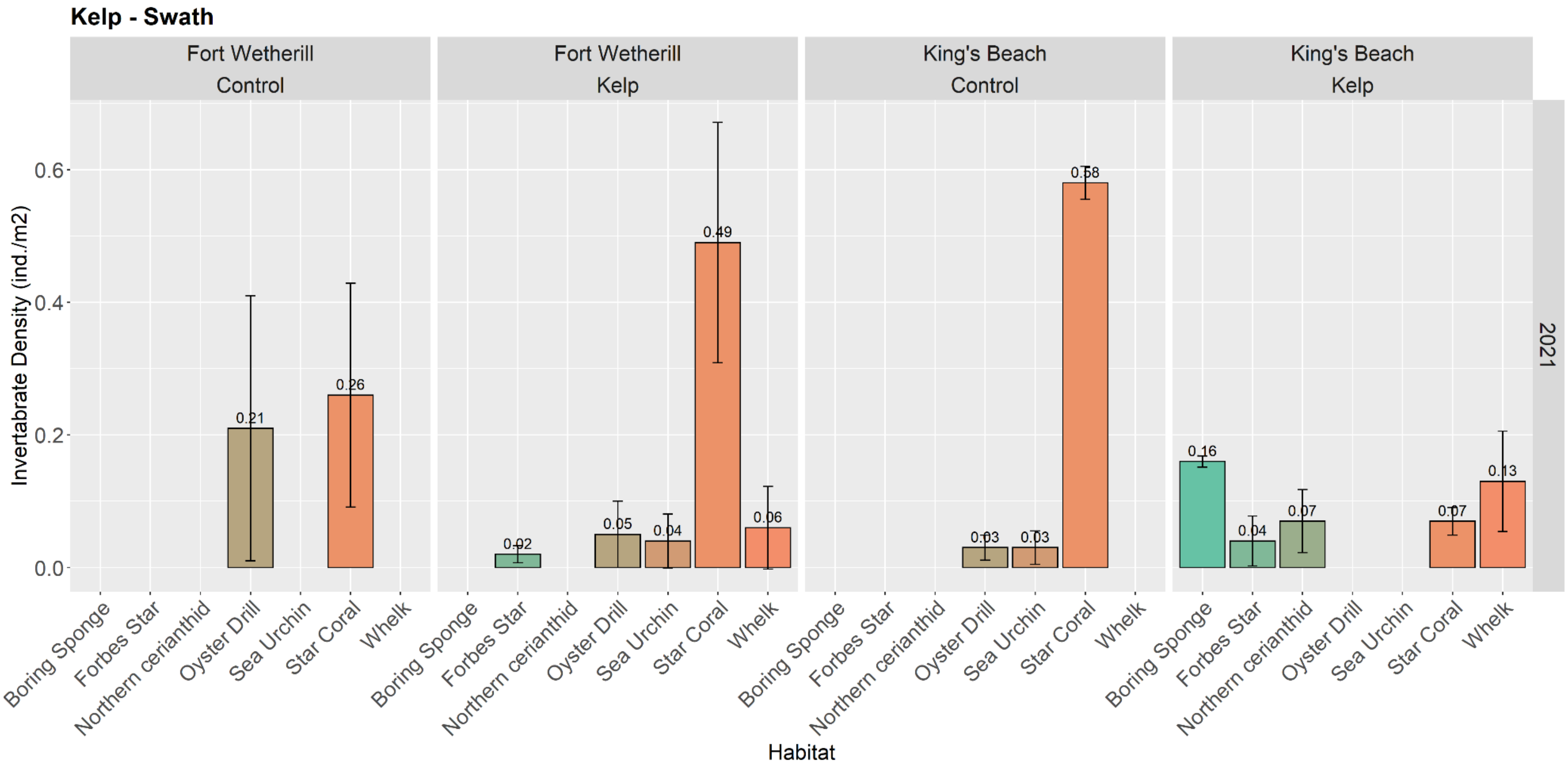

Figure 6. Mean invertebrate density ± SE, per habitat treatment (i.e., Kelp and Control) and Site (Fort Wetherill and King's Beach) for 2021 transect surveys.

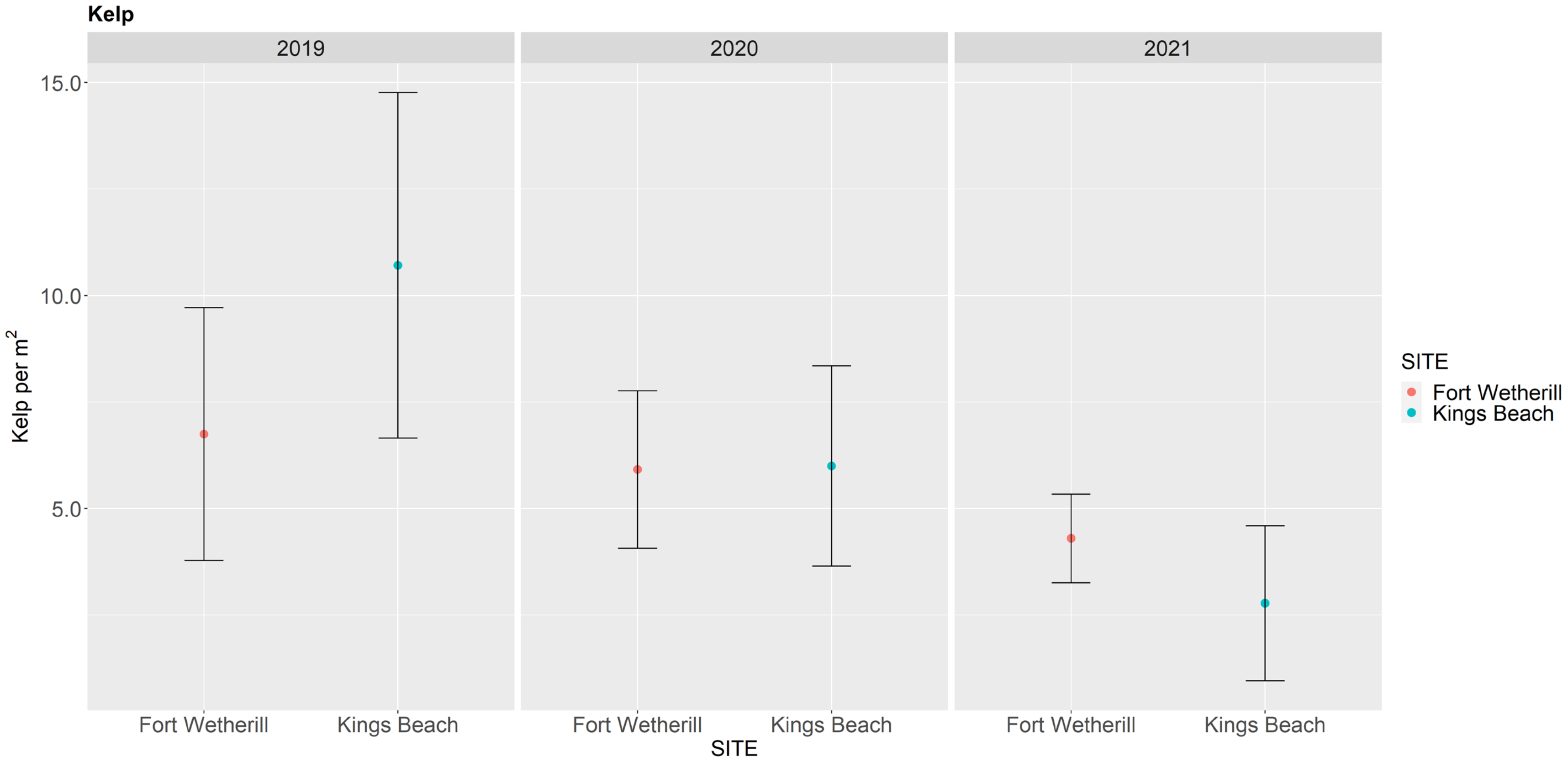

Figure 7: Average kelp density (mean ± SE) from 2019 – 2021 in the Narragansett Bay Region grouped by site(Fort Wetheril = Red, King's Beach = blue). Total kelp (e.g. *Sacharrina latissima* plus *Laminaria digitate*) density per meter squared for each year of the long-term Kelp monitoring survey.

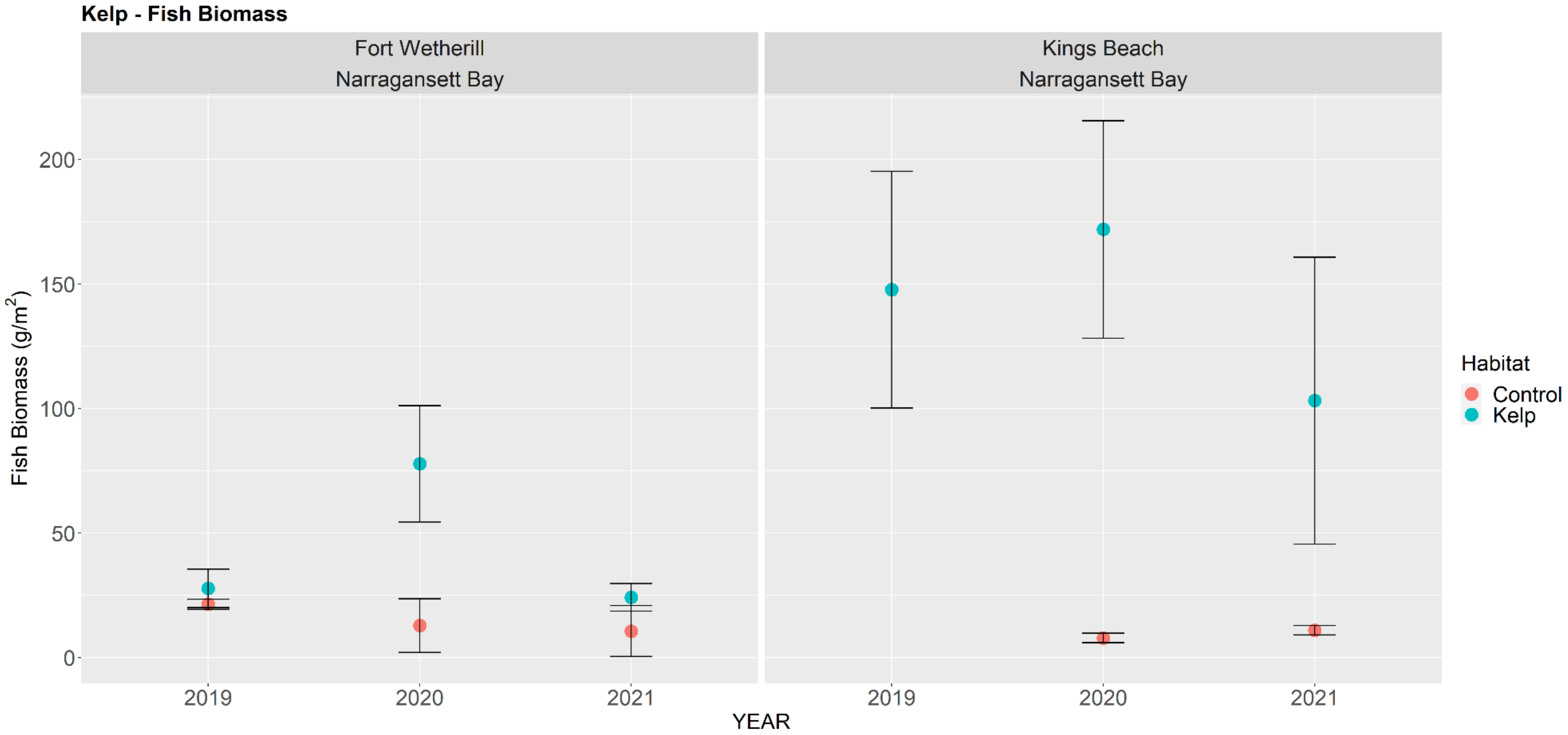

Figure 8. Mean fish biomass (g/m^2) for 2019 and 2021 kelp productivity fish count surveys. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (Kelp = blue, Control = red)

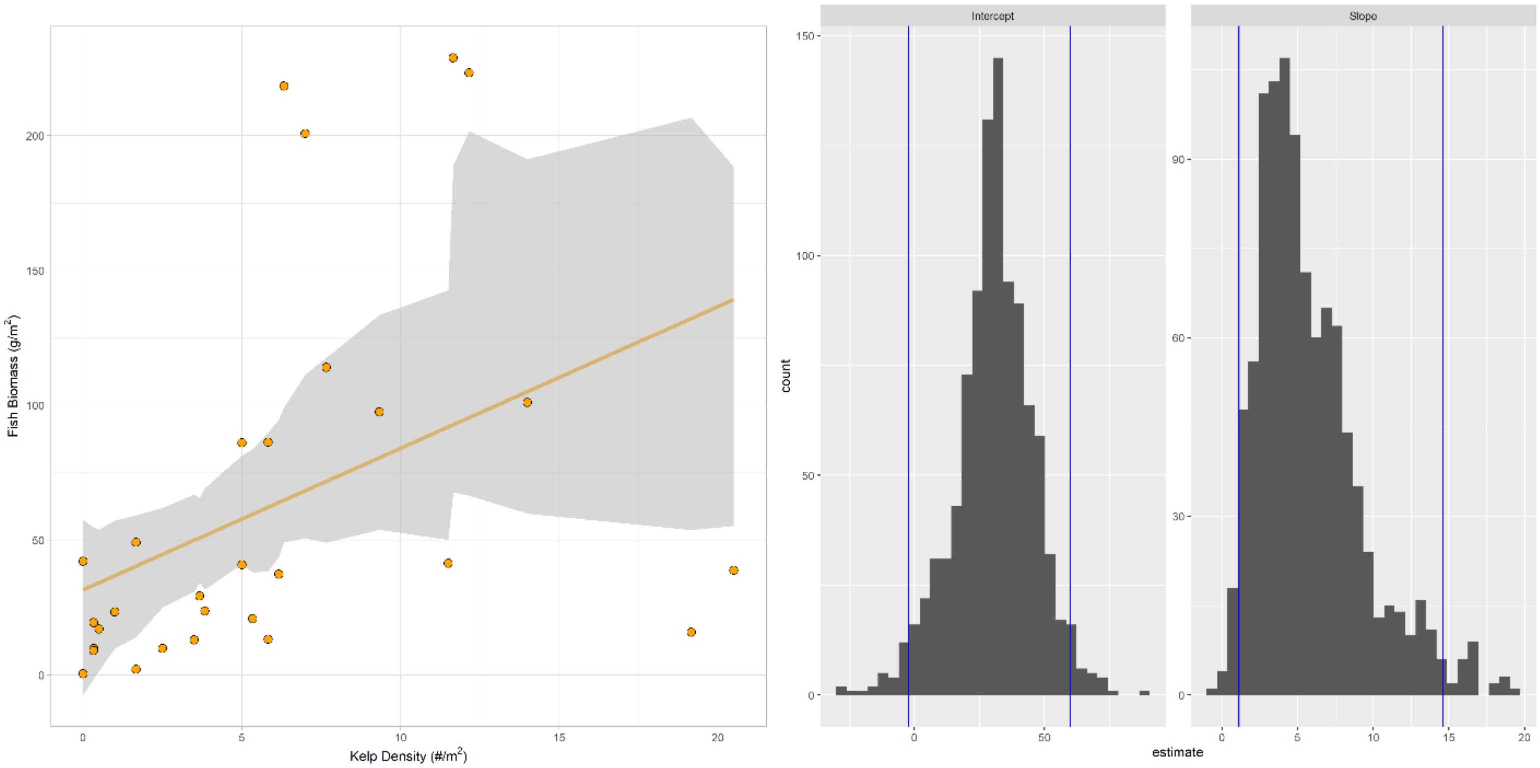

Figure 9. Linear model of observed fish biomass (grams) per meter squared of kelp habitat, as a function of observed kelp density (ind./m^2). Data comes from the collective 2020-2021 kelp monitoring dataset. Grey line indicated 95% CI interval estimated via bootstrap method.

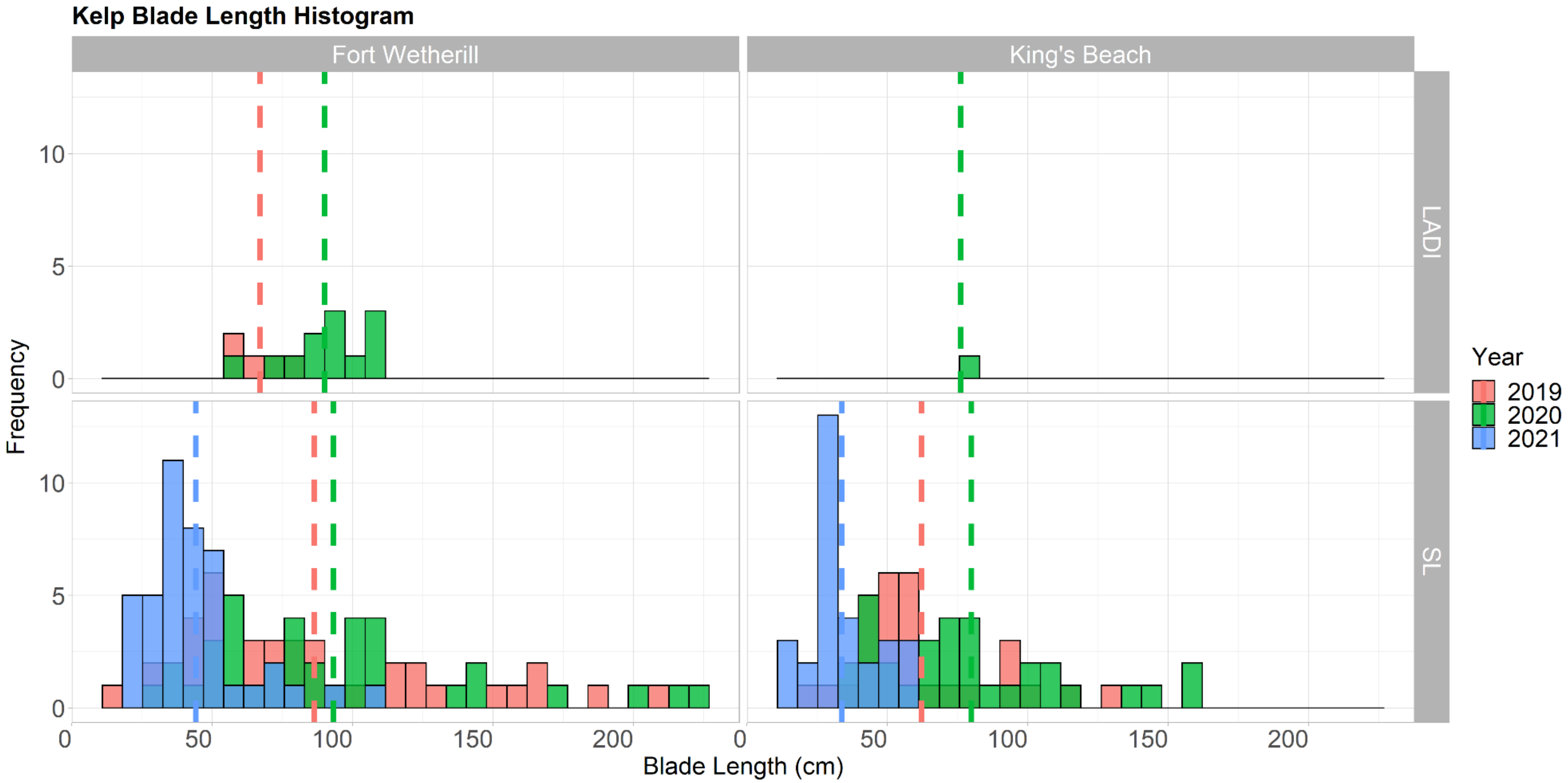

Figure 10. Histogram of blade length (cm) from 2019 – 2021 for each kelp species (LADI = *Lammaniria digitia*, SL = *Sacharina latissimi*) group by year (2019 = red, 2020 = green, 2021 = blue). Dashed lines represent the mean blade length from the transect sub samples (n=10 per transect).

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, 2021 - December 31, 2021

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: 12/31/2021

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2021. 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 2021, 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: 1/15/2021 to 12/31/2021

Prepared By

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William Helt (Coastal Restoration Scientist), and
Patrick Barrett (DEM –Principal Biologist)

Approved By

Scott Comings, Associate State Director

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Providence, RI 02906

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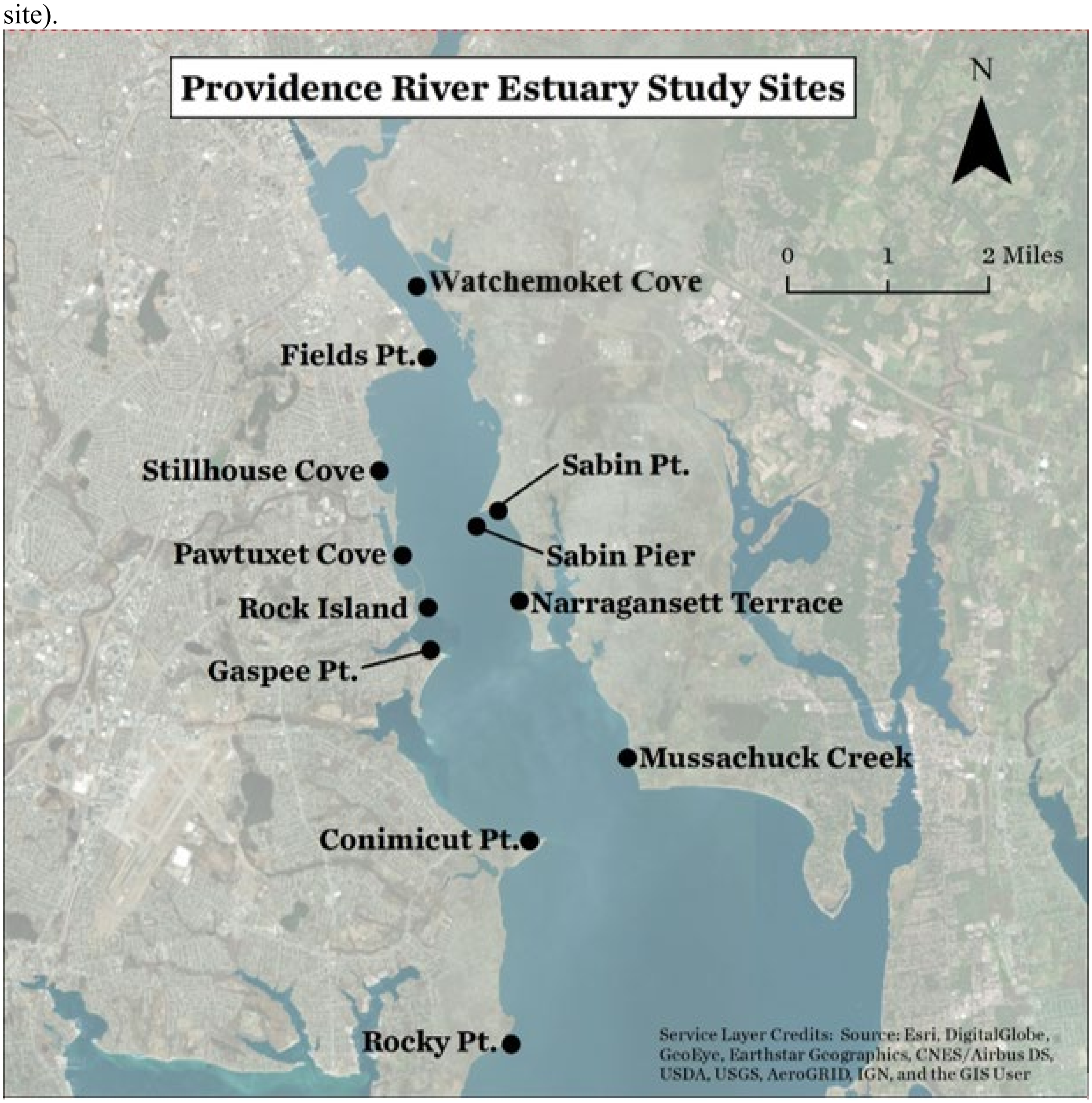
Map of study area and sampling locations. (see Table 1 for descriptions of sampling method by site).



SUMMARY

In 2021, there were 13 species caught in the fish traps including 156 finfish (7 species) and 596 invertebrates (6 species). All target species were caught with the exception of winter flounder. Eel pots placed at the artificial reef site and three control sites caught a total of 11 species including 430 finfish (8 species) and 79 invertebrates (3 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 during fish traps deployment and retrieval allowing for quality control of the data. During the 2021 season, the mean temperature ranged from 16.80 ± 0.03°C to 23.90 ± 0.02°C, salinity ranged from 20.56 ± 0.15 ppt to 30.49 ± 0.06 ppt and the greatest percentage of hypoxic instances recorded by the loggers was 36% (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 blue mussels (~54.6 ind./m^2) and barnacles, while the control sites were dominated by eastern mud snails (~3 ind./m^2) and hermit crabs (~ 6 ind./m^2). After installation and initial colonization by benthic organisms, an increase in total fish biomass (< 1 g/m^2 to over 30g/m^2 in two years) and greater abundances relative to both the unstructured controls as well as the natural control sites was also observed.

TARGET DATE: 12/31/2021

DEVIATIONS

Sampling of Watchemoket Cove was not completed during the month of June. In addition, one eel pot was lost at Sabin Pier in July. These deviations have been reflected in the trap catch rate data.

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. 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 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 on a yearly basis.

Artificial reefs were selected as the enhancement habitat type because they have been successfully used as a tool to create complex benthic habitat and increase fish production in southern Atlantic estuaries and are versatile for enhancing fish habitat (Powers et. al. 2003). In addition, 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 methods 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 2022 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 were 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 returned 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 (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 (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 returned to 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 21 & 28, 2021. 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

Fish trap and eel pot data summaries for 2021 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 2021):

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

The minimum account for a positive species presence was one individual found in the fish traps/eel pots at each site, every month. The total abundance and total abundance by station was calculated by removing all water hauls and bivalve data, then adding all remaining enumerated fish and invertebrates. Length frequency distributions for target species were also calculated and provided as histograms comparing trap type and sex when relevant. Finfish and invertebrate CPUE was calculated separately for both fish traps and eel pots. Species specific CPUE was also calculated for the target species by month and site using the same equation above. Length-weight relationships for available species were calculated using coefficients provided by DEM and FishBase using the following equation (Froese and Pauly 2020):

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

Average trap depth is determined by calculating the mean depth of the trap when it is deployed and hauled to account for any tidal variation.

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. The average fish biomass per meter squared is presented with mean ± S.E.

RESULTS

Objective 1:

Physical Data Summary

Achieving a consistent trap depth between sites can be challenging due to competing factors of desired site location, proximity to fishing areas, and bathymetric variation between each site. Trap depth can impact species composition, abundance, and size since adults from certain species may be less likely to venture into shallower waters (e.g., scup (Bigelow and Schroeder 2002)). Investigators attempt to maintain an intra-site variation less than or equal to an expected tidal range of 1-2m and attempt to minimize the average variation in depth between sites as much as possible. This year, the greatest difference in minimum average depth was 10' between Pawtuxet Cove (min. avg. depth = 4.5') and Rocky Point (min. avg. depth = 14.5'). The greatest difference in maximum average depth was 9' between Fields Point/Pawtuxet Cove (max average depth = 8.0') and Narragansett Terrace (max avg. depth = 17.0'). The greatest within site variation was 7' at Mussachuck Creek (Figure 1).

All data loggers were deployed within one trap from each sampling event starting in May. A total of 13.748 instances were recorded with dissolved oxygen data loggers and 12,994 instances with the conductivity loggers across all sites. Similar to last season, using the loggers only during the four day soak period helped significantly reduce the equipment failure and unreliable data that had occurred in previous years. However, some problems with the conductivity loggers persisted but had substantially improved. 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 2). Mean temperature values by site ranged from 19.92 ±0.08 SE°C at Rocky Point to 22.96 ±0.08°C at Pawtuxet Cove during the sampled time period. Mean temperature across sites was highest in August at 23.90 ±0.02°C and lowest in May at 16.80 ±0.03°C (Figure 3).

Though there was an improvement with the data quality in 2021, there seemed to be some inconsistencies in October between the HOBO loggers and the YSI values. Mean salinity values by site ranged from 19.91 ± 0.24 ppt at Pawtuxet Cove to 29.0 ± 0.03 ppt at Rocky Point. However, the majority of sites had a mean salinity of ~27 ppt (Figure 4). Mean salinity across sites was highest in October at 30.49± 0.06 ppt and lowest in July at 20.56 ± 0.15 ppt (Figure 5).

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 6). DO values across all sites recorded the more frequent and intense hypoxia during July and August (Figure 7). Percentage of hypoxic instances (<2mg/L) by site ranged from 0% at Pawtuxet Cove to 36% at Stillhouse Cove. Percentage of hypoxic instances by month ranged from 0.00% in May, June, September and October to 36% in August.

Fish Trap Summary

There were 13 species caught in the fish traps including 156 finfish (7 species) and 596 invertebrates (6 species). All target species were caught with the exception of winter flounder (Table 2). The three most abundant finfish species were scup (74), tautog (38), and oyster toadfish (21). The most abundant invertebrate species were spider crabs (383).The greatest number of finfish were caught in June (CPUE =1.45 ± 0.54 SE) and the least in July (0.11 ± 0.05 SE) (Table 3). Mussachuck Creek, Conimicut Point, and Rocky Point had the highest catch rates overall (1.37 ± 0.44 SE, 1.30 ± 0.95 SE, 1.28 ± 0.66 SE) and Sabin Point (control site) had the lowest (0.10 ± 0.04 SE) (Figure 8). Total finfish catch rate in the fish traps this season was the lowest on record for many of the sites since the beginning of this study in 2018 (Figure 9).

Eel Pot Summary

Eel pots were used at Gaspee Point, Rock Island, Sabin Pier (SPAR site), and Sabin Point (control). A total of 11 species were caught, including 430 finfish (8 species) and 79 invertebrates (3 species). The top three most abundant finfish species in the eel pots were black sea bass (347), scup (31) oyster toadfish (21).The top three most abundant invertebrate species were mud crabs (32), blue crabs (27), and spider crabs (20) (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 (12.83 ± 2.08) and the SPAR site (Sabin Pier) had the highest average catch rate (5.3 ± 2.39) compared to the other three sites (Table 4, Figure 10). Unlike the fish traps the total eel pot catch rates this season were highest since the beginning of this sampling in 2019 (Figure 11).

SPAR Summary

There were 10 different species caught at the artificial reef site (7 finfish species). The most abundant species were black sea bass (83) followed by spider crabs (32) and scup (22). Black sea bass were also the most abundant species at the three control sites, making up the majority of the catch in 2021 (Figure 12). About 95% of the total fish caught (by abundance) this season were found in the eel pots and 73% of the invertebrates were from the fish traps. At the SPAR site, finfish CPUE in the fish traps was low at 0.23 ± 0.16 SE (Figure 11). As stated previously, low fish trap CPUE was also seen across most other sites in 2021. However, the finfish CPUE from the eel pots was higher than previous years (5.3 ± 2.39 SE) and higher than the control sites (Figure 11). The SPAR site also displayed higher or equivalent species richness, evenness and diversity to the control sites (Table 5).

Target Species Summary

Scup were the most abundant finfish species caught in the traps with a peak catch rate in June (1.27 ± 0.53 SE) (Table 6). 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 8). Their sizes ranged from 12.5 – 31.5cm (FL) and had an estimated mean weight of 0.58 lbs (Figure 13). The highest catch rate was at Conimicut Point. Scup made up the largest percentage of fish catch by number (47.4%) and the second largest percentage by weight (26.6%) below tautog. Scup were also found at all four eel trap sites and were the third most abundant finfish with an average catch rate of 0.32 ± 0.19 SE (Table 7). The sites with the greatest number of scup caught in the eel pots was Sabin Pier (CPUE = 0.75 ± 0.75 SE). Scup size in the eel pots ranged from 5.4-10.4cm (Figure 13)(Avg biomass: 0.03lbs and 3.3% of the catch by weight).

Tautog were the second most abundant finfish species caught with a peak catch rate in May (0.71 ± 0.35 SE) with sizes ranging from 23.3-51.2cm (FL) (Table 6 and Figure 14). Though they were second in catch rate, tautog made up the largest weight of the target species at an average of 2.4lbs. Tautog were caught at ten of the twelve sites had the highest catch rate at Rocky Point

(Table 7). Tautog made up about 24.4% 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 (55.3%). Tautog were found at three of the four eel trap sites with an average catch rate of 0.07 ± 0.04 SE (Table 6). Tautog size in the eel pots ranged from 5.6-13.7cm (Figure 14)(Avg biomass: 0.04lbs and 1.3% of the catch by weight).

Summer flounder were the fourth most abundant finfish species (tied with black sea bass) caught ranging in size from 30.0-46.0cm (Figure 15). Summer Flounder were third in weight out of the target species at an average of 1.3lbs, had a peak catch rate in August (0.06 ± 0.04 SE) and were caught at five of the twelve sites (Table 5 and 7). The highest catch rates were at Pawtuxet Cove and Narragansett Terrace. Summer flounder made up the fourth highest percentage of total fish catch by number and third by weight (5.8% and 7.4% respectively). No summer flounder were caught in the eel pots.

Black sea bass were also the fourth most abundant finfish species caught in the fish traps, ranging in size from 20.0-36.1cm and averaging at 0.63lbs (Figure 16). Black Sea Bass had a peak catch rate in August (0.10 ± 0.10 SE) and were caught at two of the twelve sites (Table 7). The highest catch rate was at Mussachuck Creek. Black sea bass shared the fourth highest percent of total finfish catch by number with summer flounder and had the fifth highest percentage by weight (5.8% and 3.5% 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 = 3.61 ± 0.87 SE) and were caught at all four eel trap sampling sites (Table 6). The black sea bass caught in the eel pots ranged in size from 6.4-12.5cm (Figure 16) (Avg biomass: 0.03lbs and 50.2% of the catch by weight). The greatest number of eel pot black sea bass were caught at Sabin Pier (CPUE = 0.75± 0.75 SE).

Blue crabs were the second most abundant invertebrate species caught in 2021 with a peak catch rate in June (1.21 ± 0.22 SE) and the highest rate by site at Pawtuxet Cove and Rock Island (1.08 ± 0.31 and 0.37 SE respectively). 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 4.6-19.7cm with the females making up the smaller range of sizes (Figure 17). The average male blue crab size was 12.7±0.2cm while the average female was 11.2 ± 0.5 cm. Blue crabs were the second most abundant invertebrate species caught in both the fish traps and eel pots (Table 1). Blue crabs were found at all four eel pot sites and ranged in size from 3.4-15.9cm.

Dive Survey

During September 2021, 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 second 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 two separate occasions during the 2021 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 28, 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 sand and fine sediment, with intermixed cobble and *Crepidula* and quahog shells. The proportion, or percent cover, of sand and shell at the control sites ranged from 86.66 to 95% (Figure 18; 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 six dives completed since 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 (5-55% 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 80-100% sand cover. During the most recent 2021 dive survey, investigators found that the Sabin Point reef site now has 26.6% cover of blue mussels (Figure 19).

In 2021, the overall species richness and diversity, with respect to the algae and sessile invertebrate species, were greater at the reference and Artificial Reef sites, relative to the controls (Table 9). 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 as well as shellfish that have recruited to the artificial reef. Most notably *Fucus visiculous, Argardehlia subulate,* and *Mytilus edulis* (Figure 19 and 20). Investigators found invertebrate densities to vary depending on the species and survey location. At the SPAR, investigators found the highest abundance of Blue Mussels (57.69 ind./m^2) covering approximately 26.6% of the uniform poi, and barnacle species (1.79 ind./m^2) (Figure 19). The control sites were dominated by eastern mud snails (~3 ind./m^2) and long clawed hermit crabs (~ 6 ind./m^2) (Figure 20). At the natural control site, investigators observed the greatest abundance of crepidula (~25 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 20 and 21). 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 eastern mud snails, and mud crabs (Figure 20).

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, and subsequent blue mussel set, an increase in fish biomass relative to both the unstructured controls as well as the natural control sites was observed (Figure 21). Fish biomass at the SPAR experienced a 3-fold increase from 10.58 ± 5.6

g/m^2 to 31.31 ± 15.52 from the first to second year after reef construction. (Figure 22).

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 had abnormally low salinity values during the month of July which is likely attributed to a heavy rain event since other sites also had lower salinities around the same time. Though heavy rain would impact all sites in the area to some degree, the Pawtuxet Cove site is adjacent to the mouth of the Pawtuxet River and therefore gets a higher degree of freshwater mixing than other sites. The periodic instances of hypoxia (<2mg/L) at various sites in 2021 are typical of the area, especially within the upper reaches of the PRE (Hale et al 2018). However, this year, the hypoxia rate was more acute in timeframe than previous years and was also more widespread across almost all the sites. Similar to 2020, the use of the HOBO data loggers at shorter (four day) intervals was 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 and 2020 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 most sites in June. By October, individuals from this larger cohort 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 all four eel trap sites though the majority were caught at the SPAR site. Reduced numbers of larger adult scup were documented after June.

Similar to previous years, the majority of tautog were caught in May 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 August - 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). This was especially true during the months of July and August this year when DO values were hitting hypoxic levels. Tautog are strongly associated with complex and structured habitats and were seen utilizing the SPAR reef structures during the dive transects. This could explain a reduction in tautog, and other structure-seeking species like cunner, in the fish traps and eel pots. Though the sample size is small, YOY tautog were caught at three of the eel trap 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 August at Rocky Point. Based on the size class (20-30cm) these individuals were most likely spawning adults (Northeast Fisheries Service Center 2017). Winter juveniles (7-11cm) were not documented until August in the eel traps but remained in relatively high numbers through October. Few black sea bass were caught in the fish traps, and all were caught at either Rock Island or Mussachuck Creek (the most southern sites. 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 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 especially across the AR study sites.

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 15-50 percent on average. The species richness and diversity at Sabin Point continues to remain higher than the control sites, and has recently received a massive set of blue mussels, averaging over 57 ind./m^2 with individual recordings up to 2,500 per meter squared. Fish biomass continues to be greatest at the new reef location as well, with increased juvenile and adult abundance of sportfish like cunner, tautog, and black sea bass. 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:

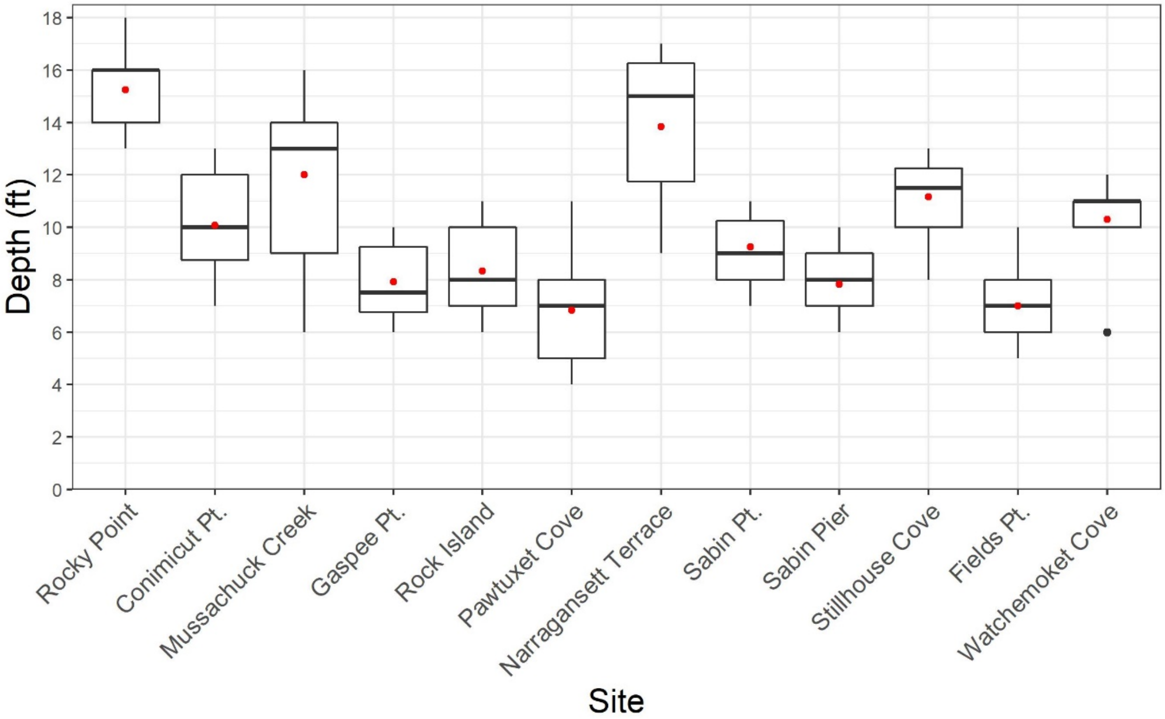


Figure 1. Boxplot of depth (ft) fish traps and eel pots were set at each site. Depth was recorded at the set and pull dates with red center points representing mean values.

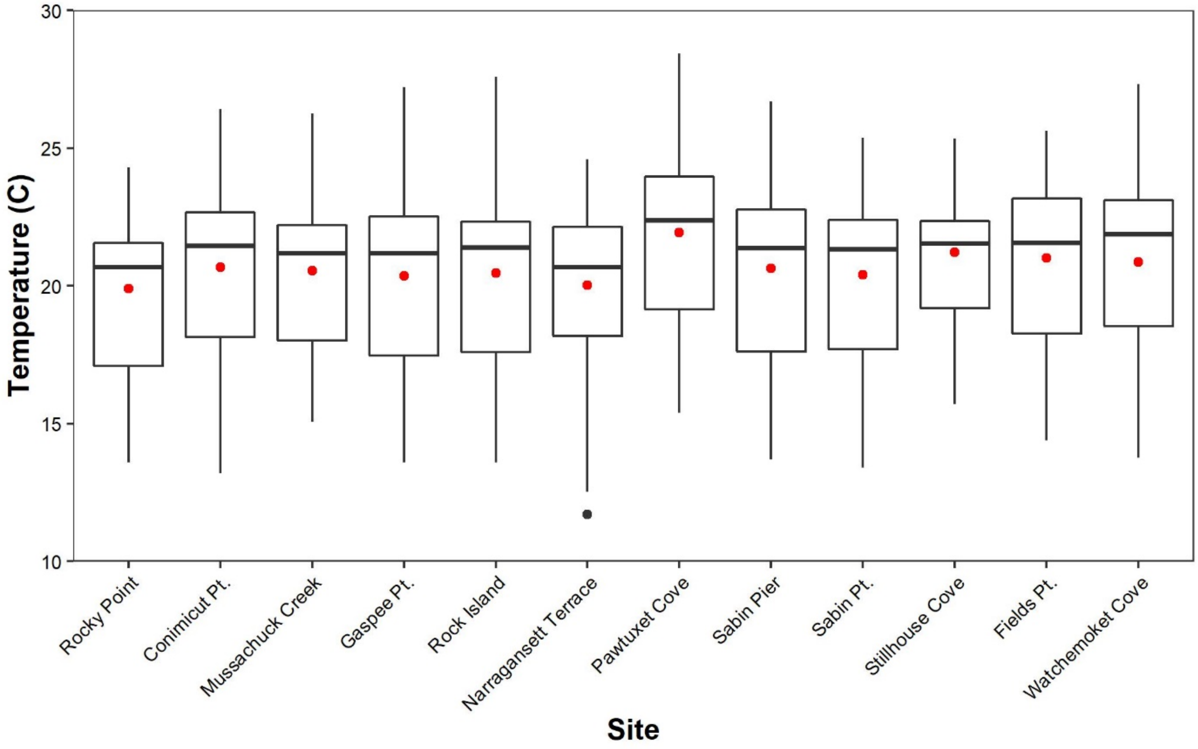


Figure 2. Figure 1. Boxplots of temperature (°C) recorded by the data loggers at sites during 2021 with red center points representing mean values.

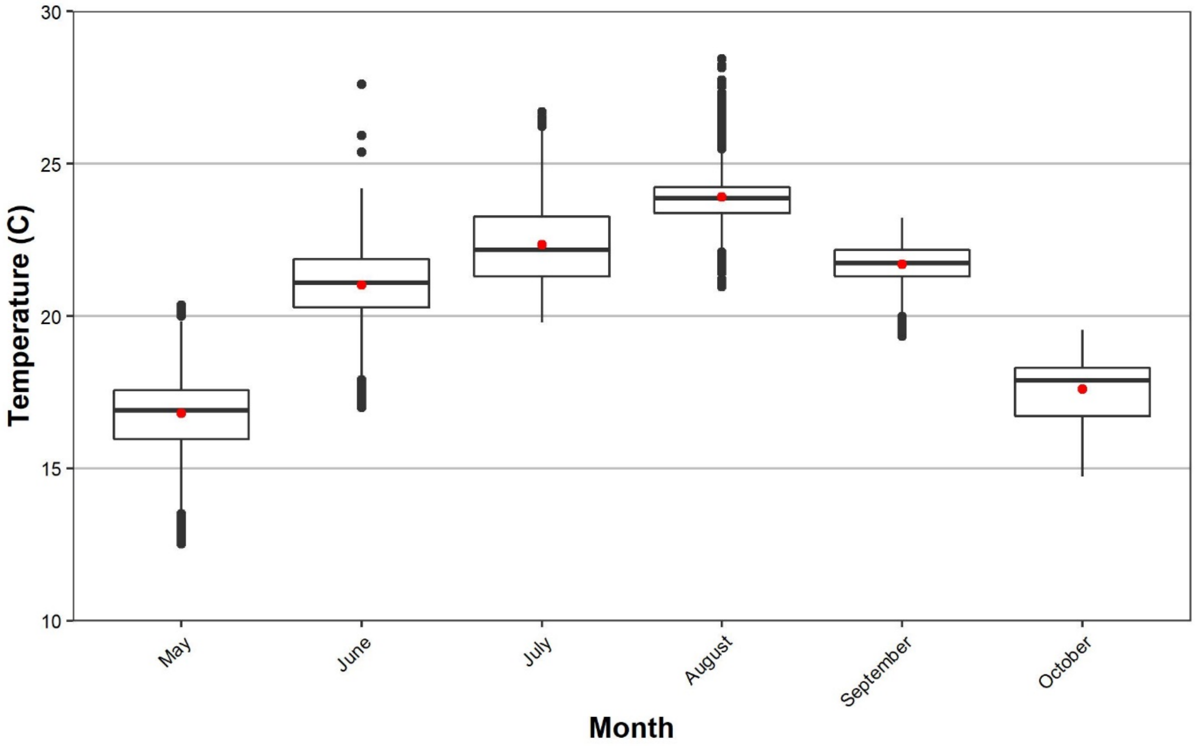


Figure 3. Boxplots of temperature (°C) recorded by the data loggers each month during 2021 with red center points representing mean values.

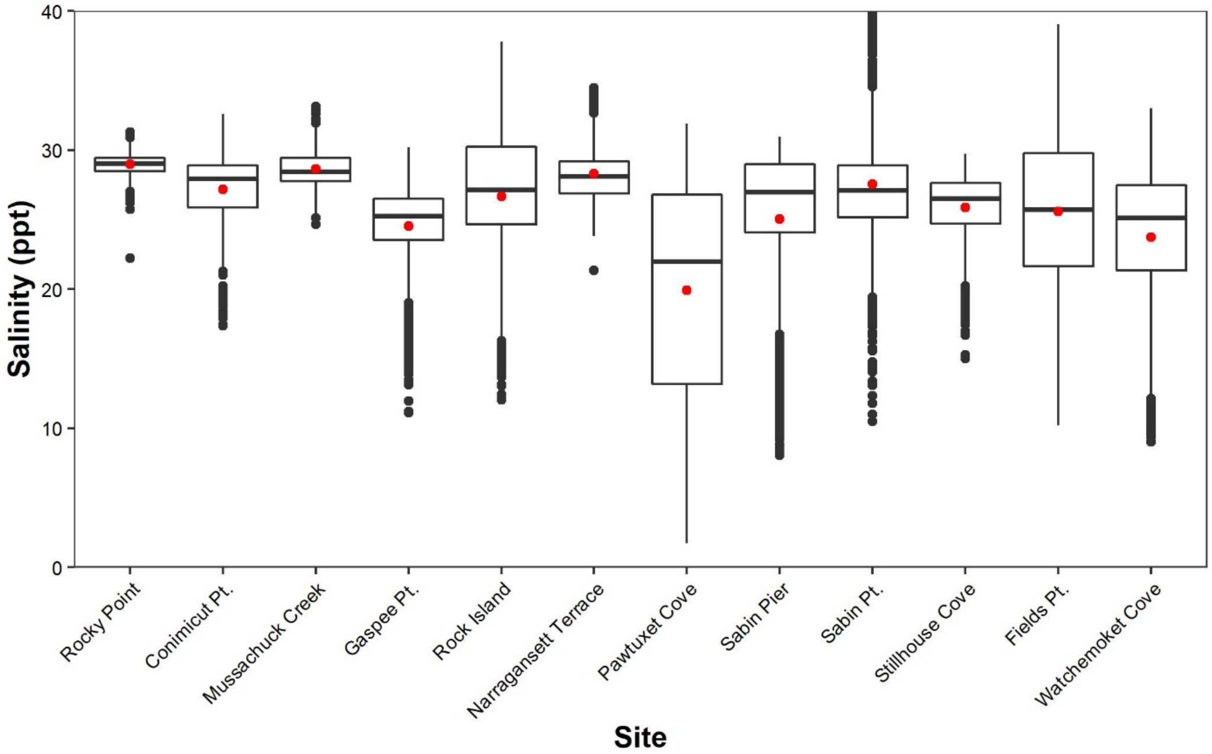


Figure 4. Boxplots of salinity (ppt) recorded by the data loggers at sites during 2021 with red center points representing mean values.

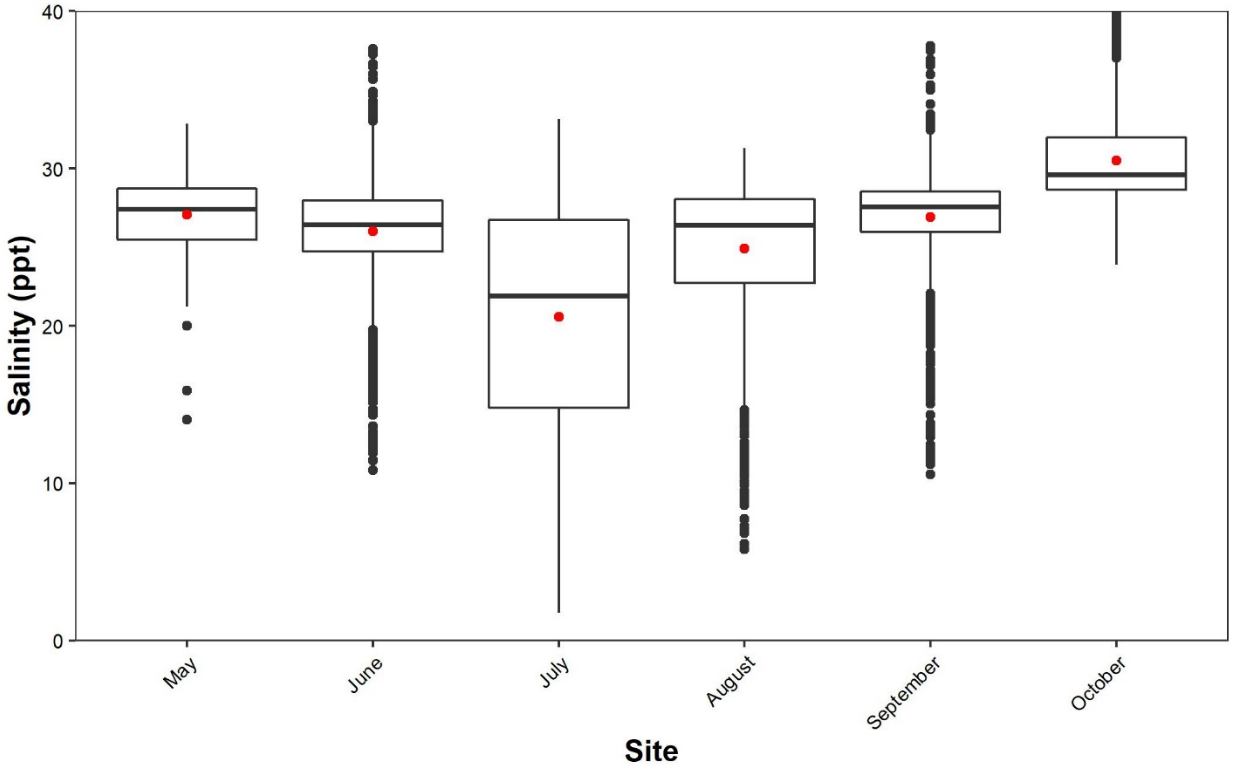


Figure 5. Boxplots of salinity (ppt) recorded by the data loggers across months during 2021 with red center points representing mean values.

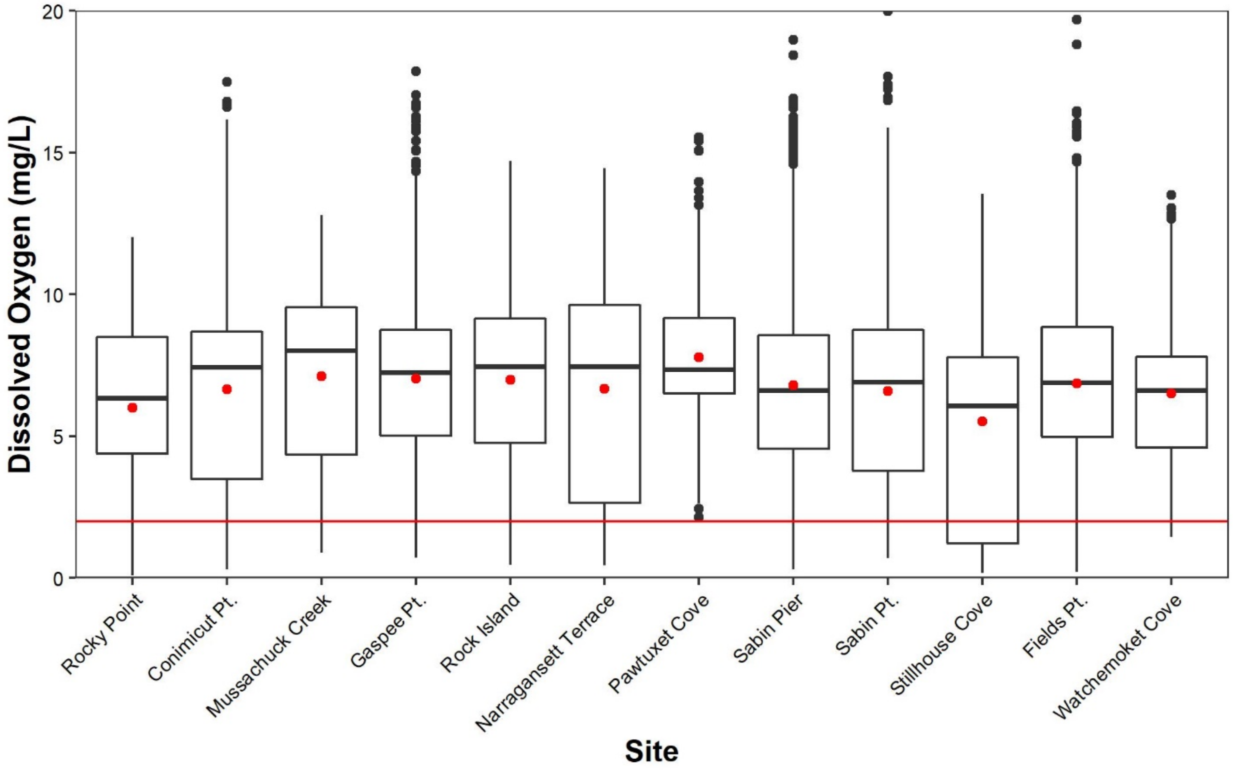


Figure 6. Boxplots of dissolved oxygen (mg/L) recorded by the data loggers at sites during 2021 with red center points representing mean values.

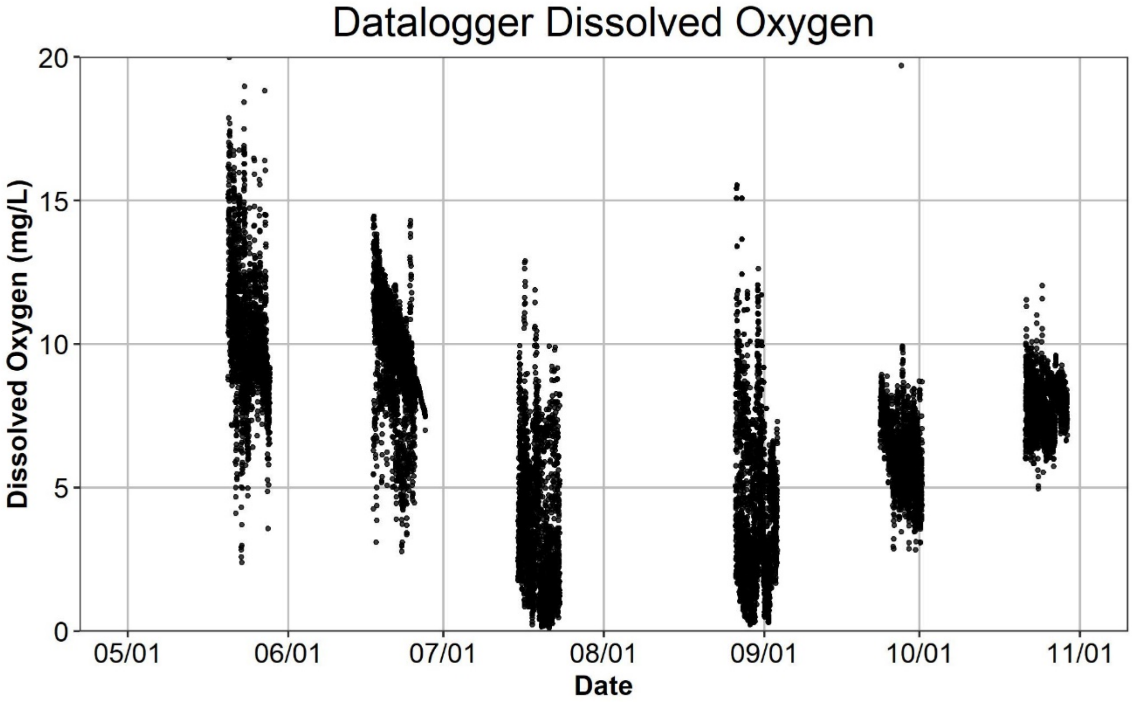


Figure 7. Dissolved oxygen (mg/L) values recorded by the data loggers each month during 2021 with red center points representing mean values.

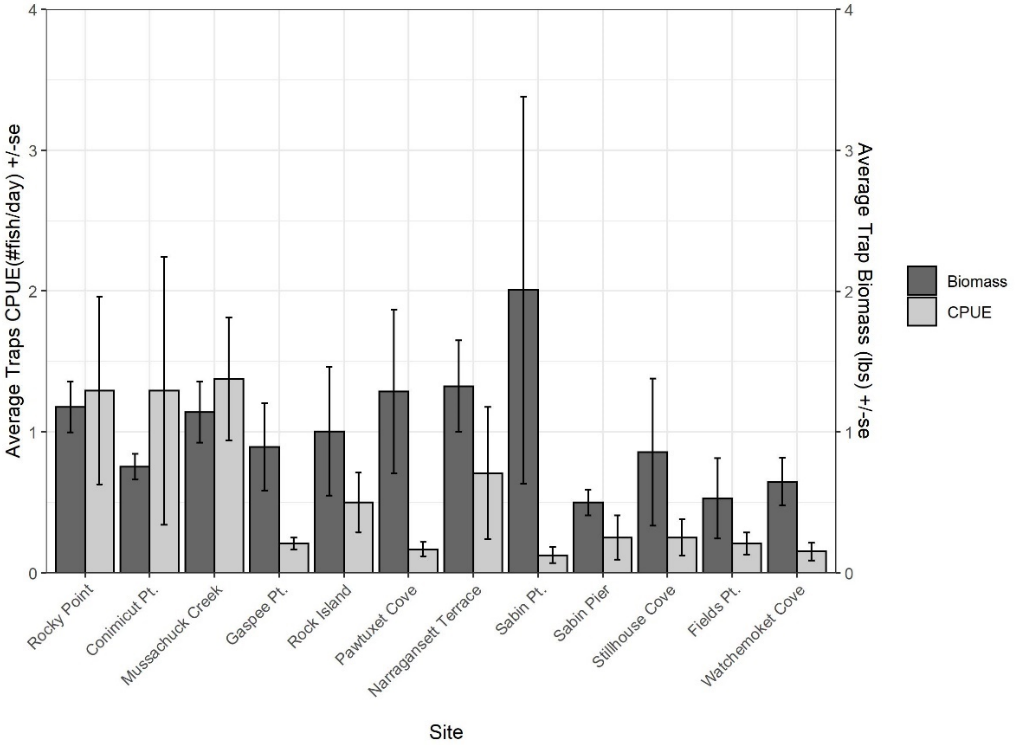


Figure 8. Average fish trap CPUE and biomass in 2021 across all sites. Error bars represent standard error.

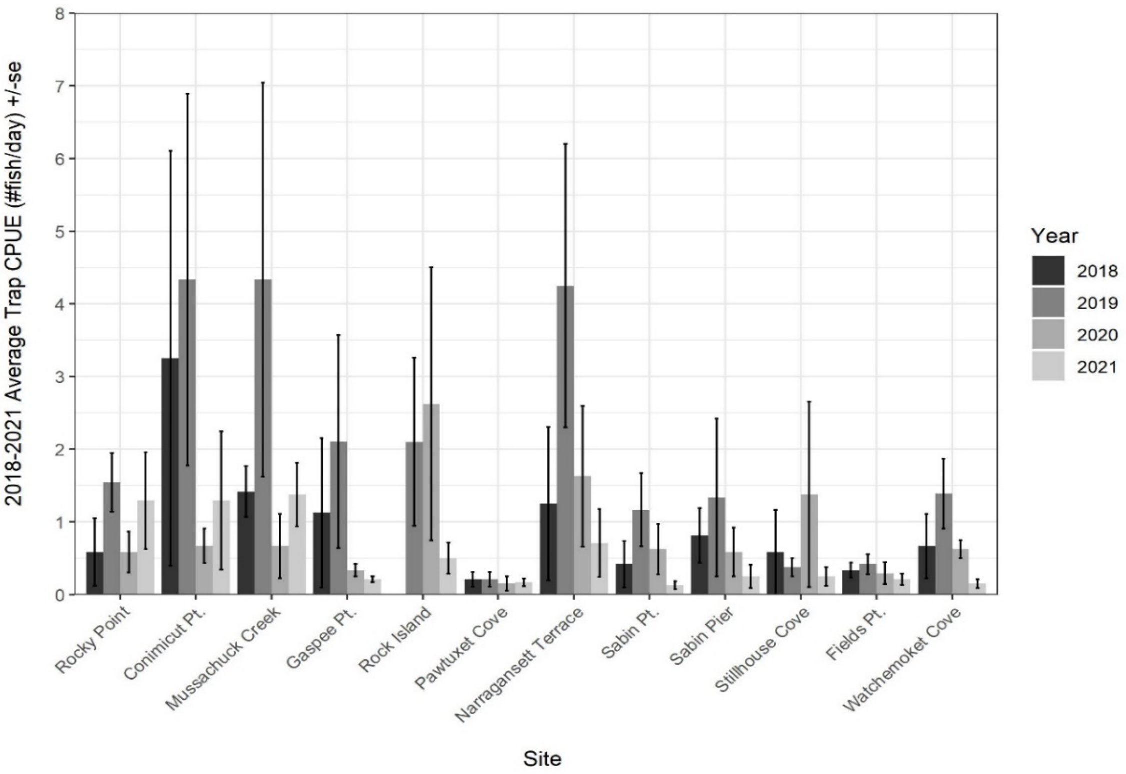


Figure 9. Average fish trap CPUE across all sites each year (2018-2021). Error bars represent standard error.

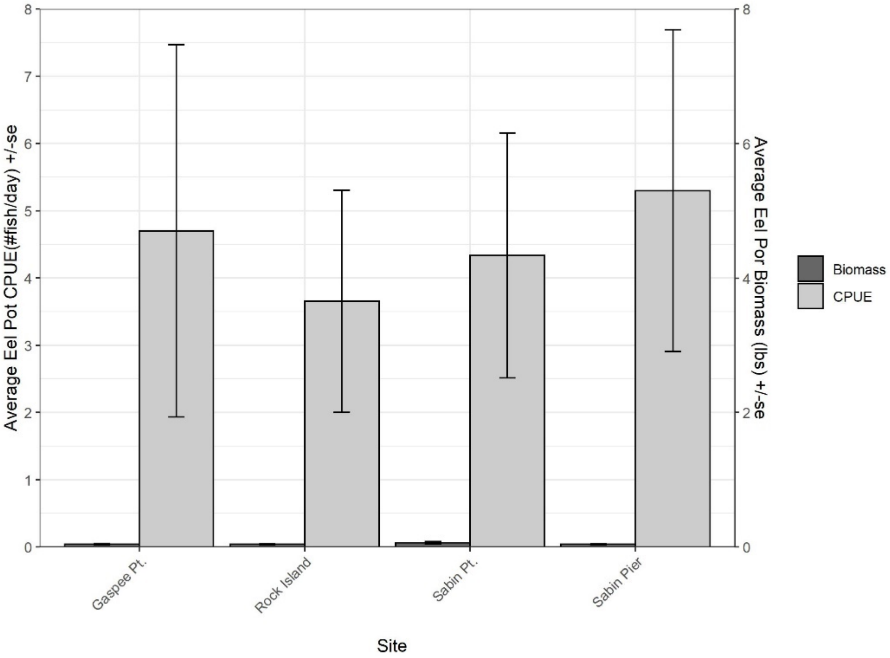


Figure 10. Average eel pot CPUE and biomass in 2021 across all stations. Error bars represent standard error.

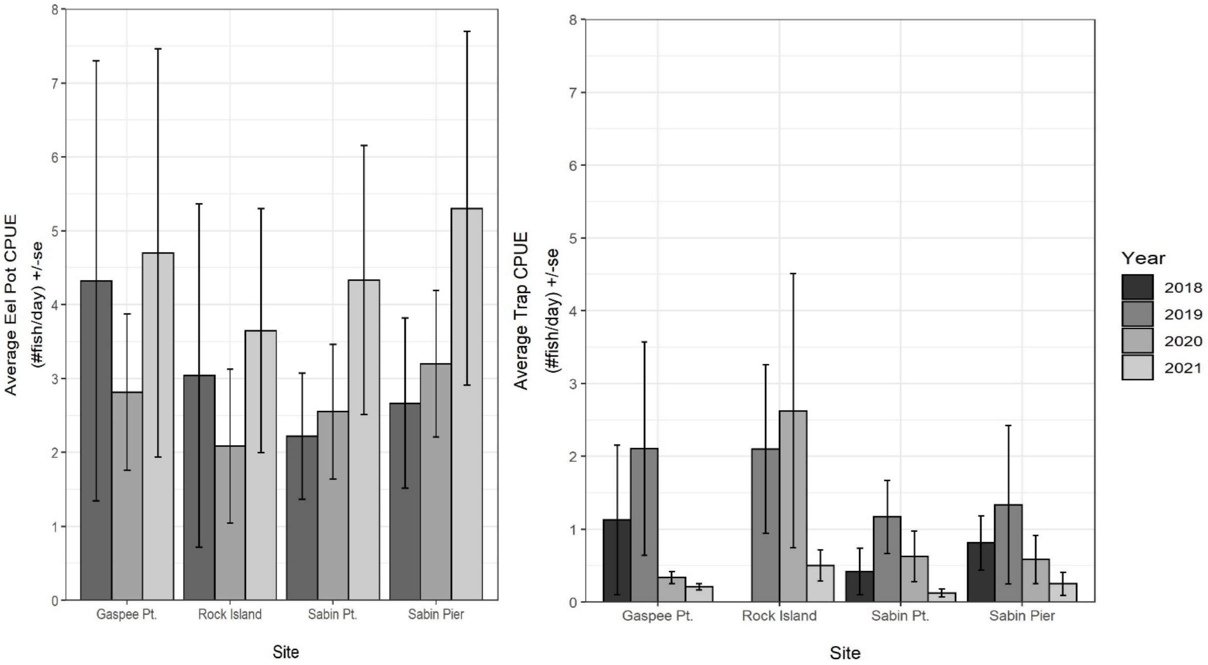


Figure 11. Average eel pot CPUE (left) and fish trap (right) across the four eel pot sites each year (2018-2021). Error bars represent standard error.

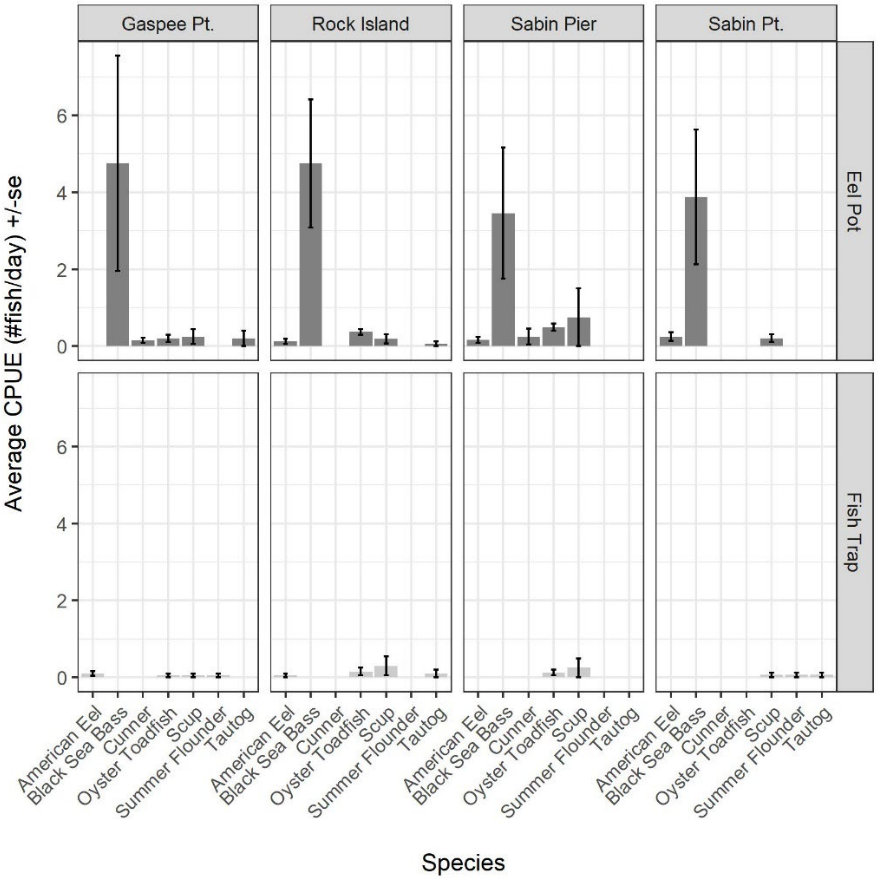


Figure 12. Average CPUE (# of fish/day) by species across all eel pot sites in 2021.

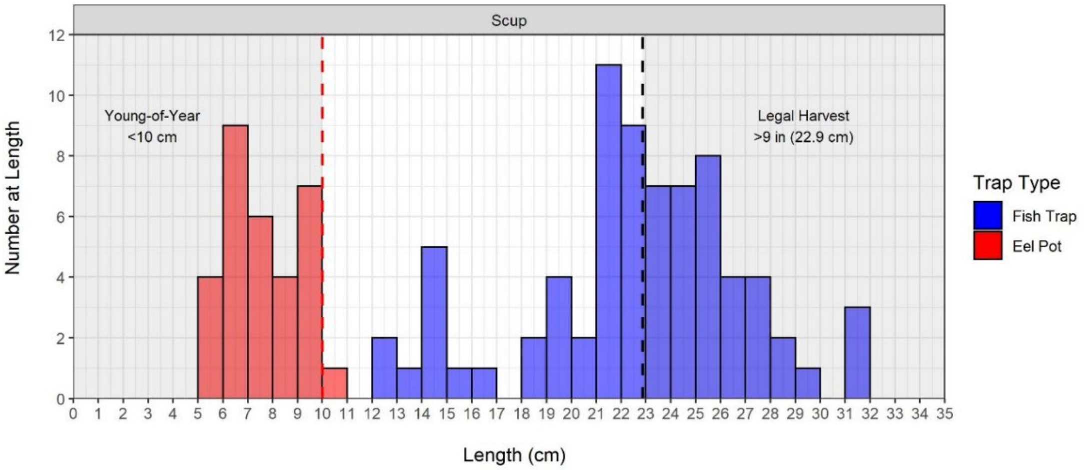


Figure 13. Histogram showing the size frequency at length of scup species caught in eel traps and fish traps.

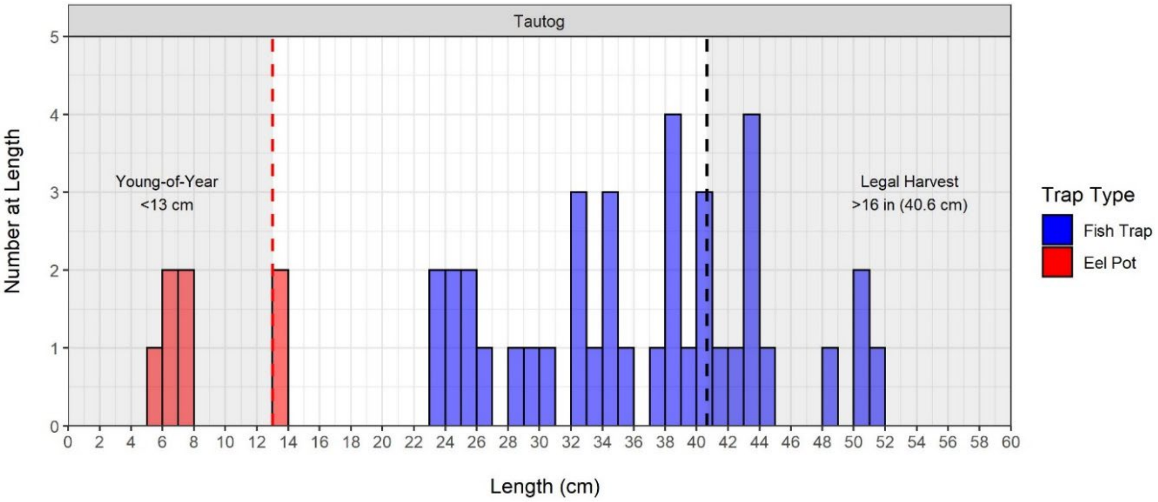


Figure 14. Histogram showing the size frequency at length of tautog species caught in eel traps and fish traps.

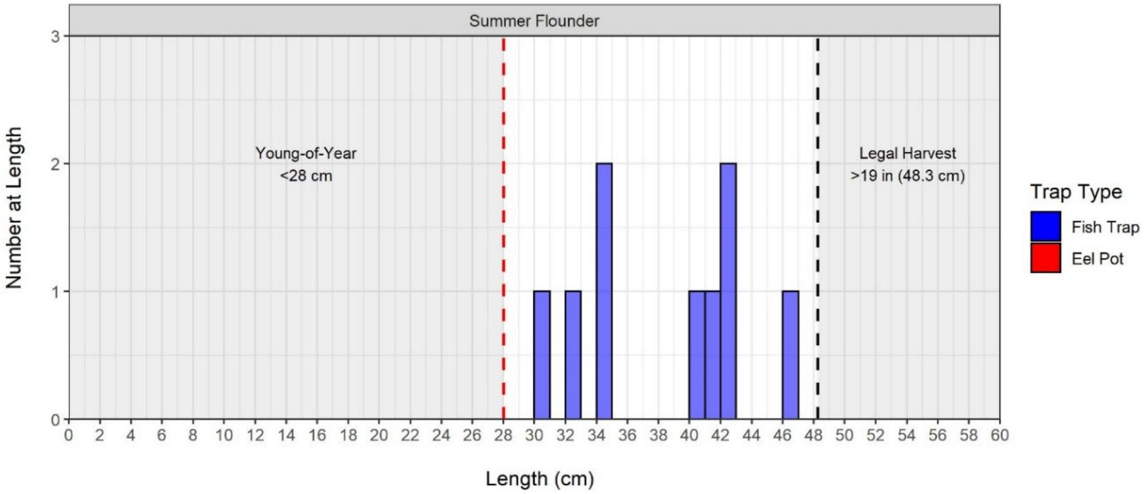


Figure 15. Histogram showing the size frequency at length of summer flounder species caught in eel traps and fish traps.

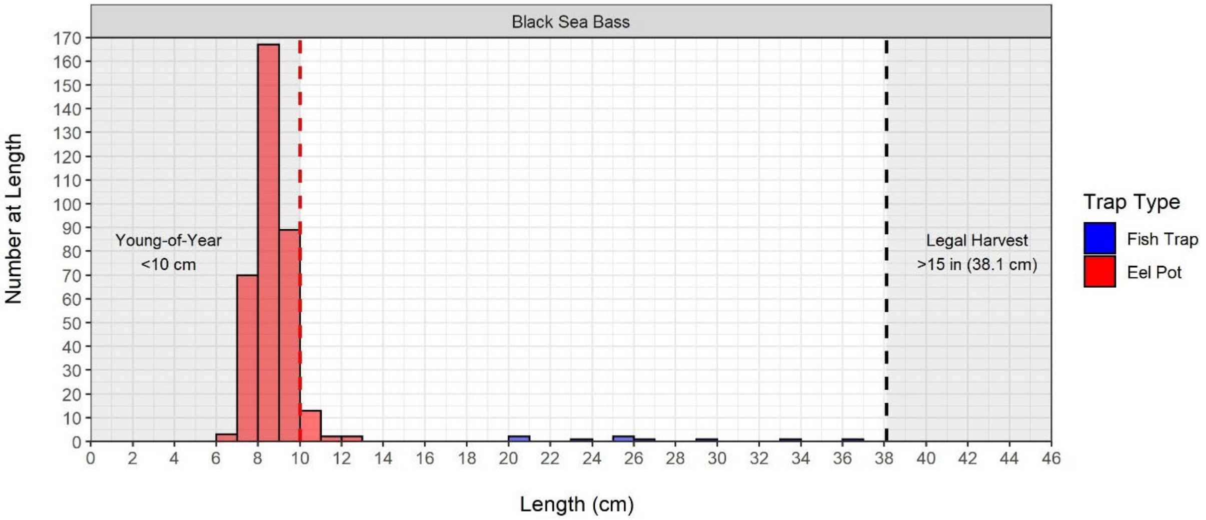


Figure 16. Histogram showing the size frequency at length of black sea bass species caught in eel traps and fish traps.

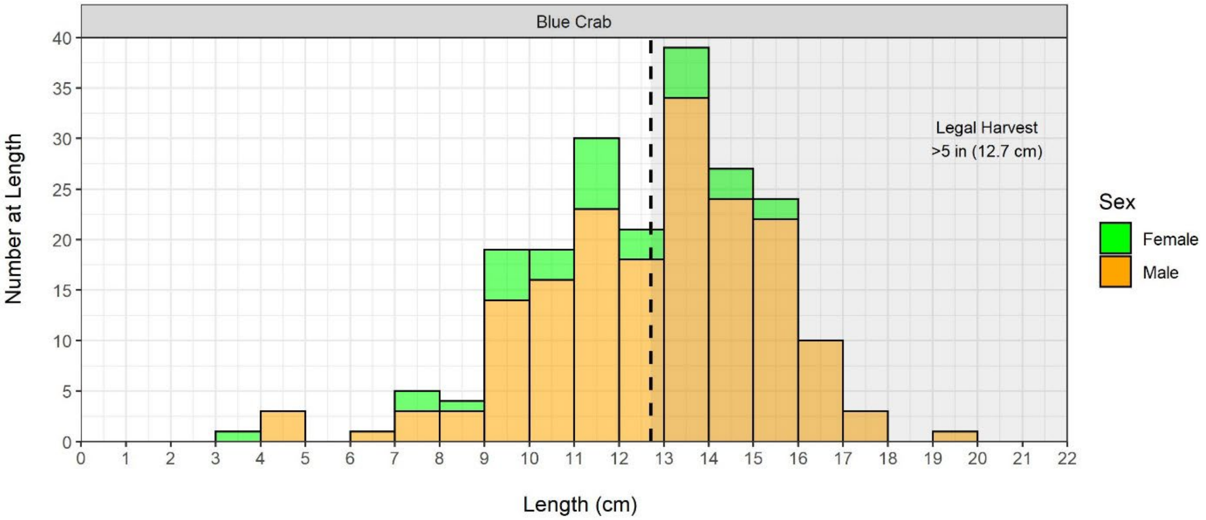


Figure 17. Histogram showing the size frequency at length of blue crabs caught in fish traps separated by sex.

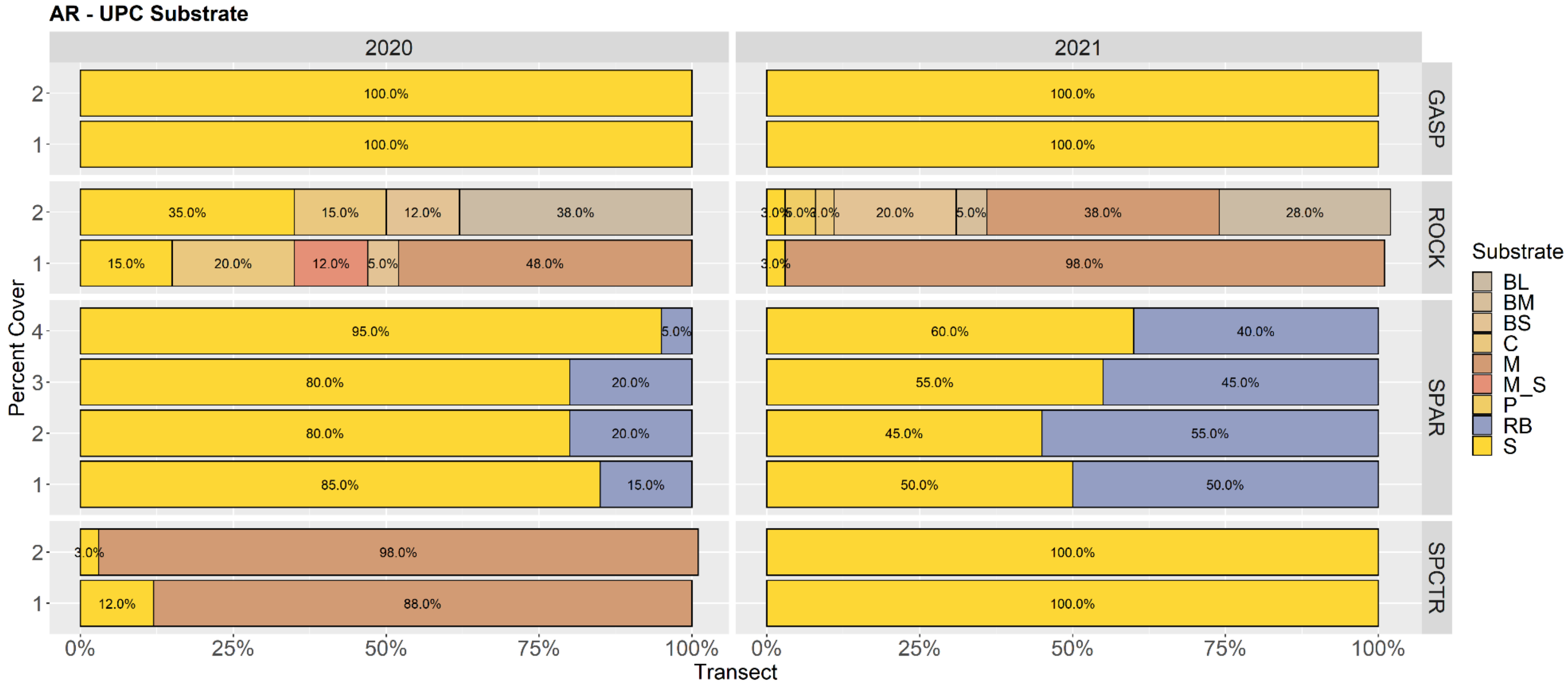


Figure 18. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 and 2021 fish productivity survey. Percent cover is grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, M = mud/fines, M_S = sandy mud mix, S = Sand, RB = 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)).

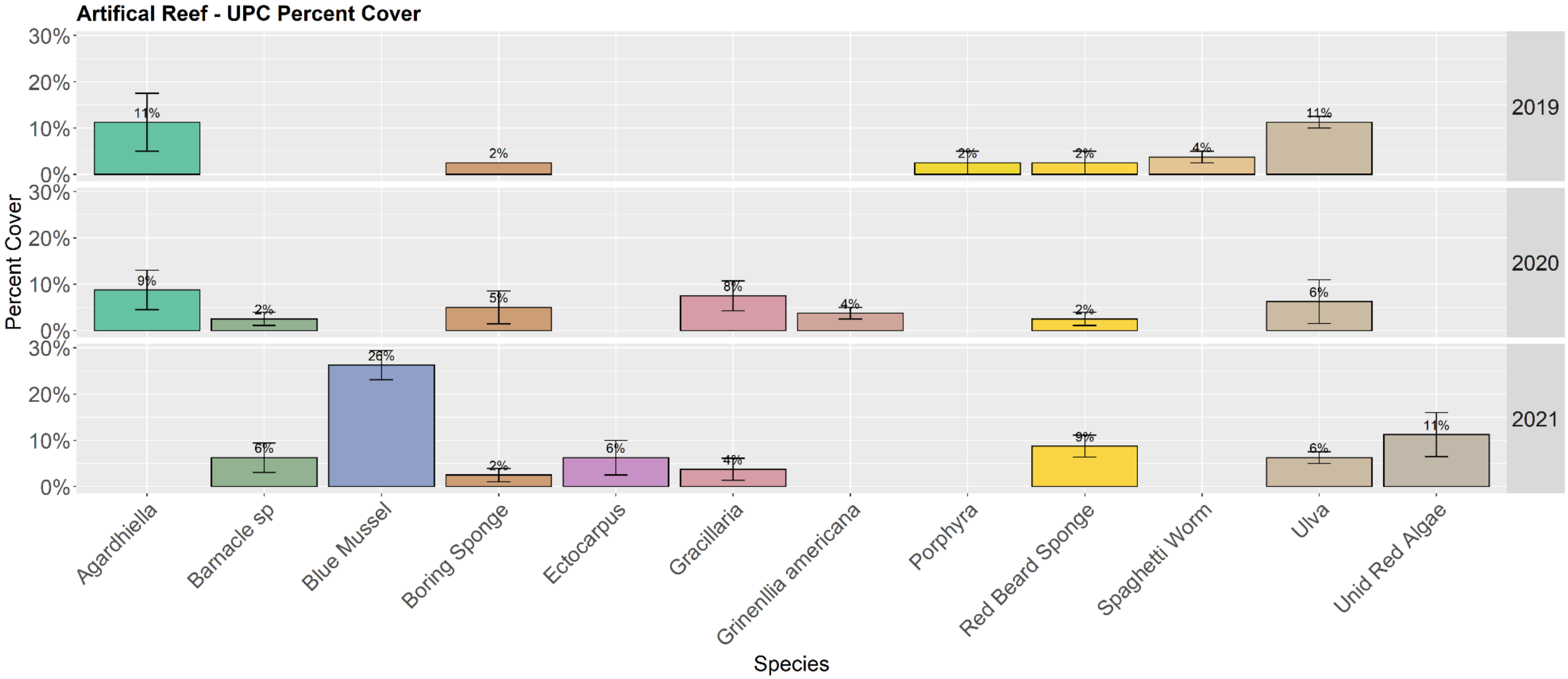


Figure 19. Mean algal and sessile invertebrate cover ± SE, greater than 2.5% cover, for all years of the study at the Sabin Point Artificial Reef Sites (SPAR) Reef Balls were deployed after the 2019 dive survey.

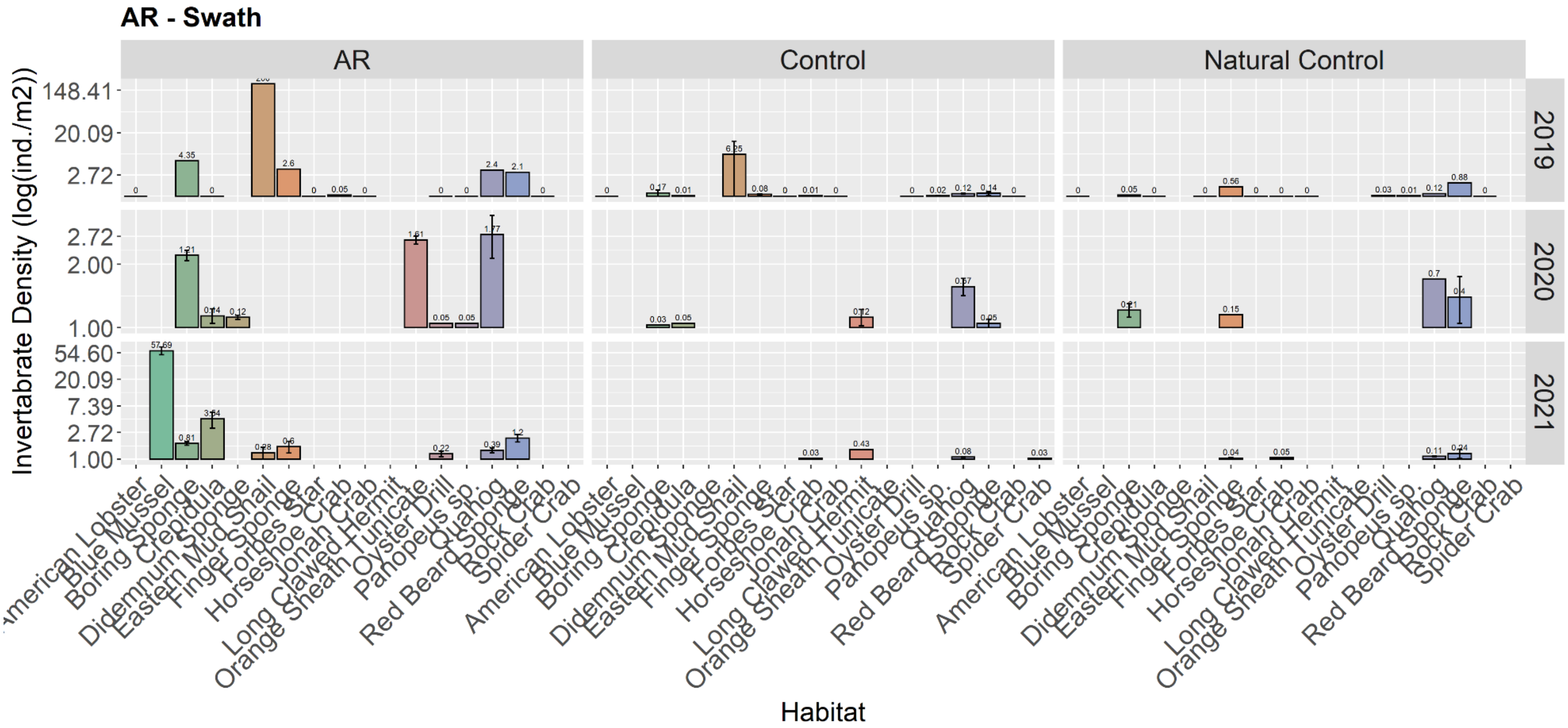


Figure 20. Mean invertebrate density ± SE, per habitat treatment (GASP = Gaspee Point (Control), ROCK = Rock Island (Natural Control), SPAR = Sabin Point Artificial Reef (Reef), SPCTR = Sabin Point Control (Control)), grouped by site (AR, Control, Natural Control) and year (2019-2021) for the swath survey method.

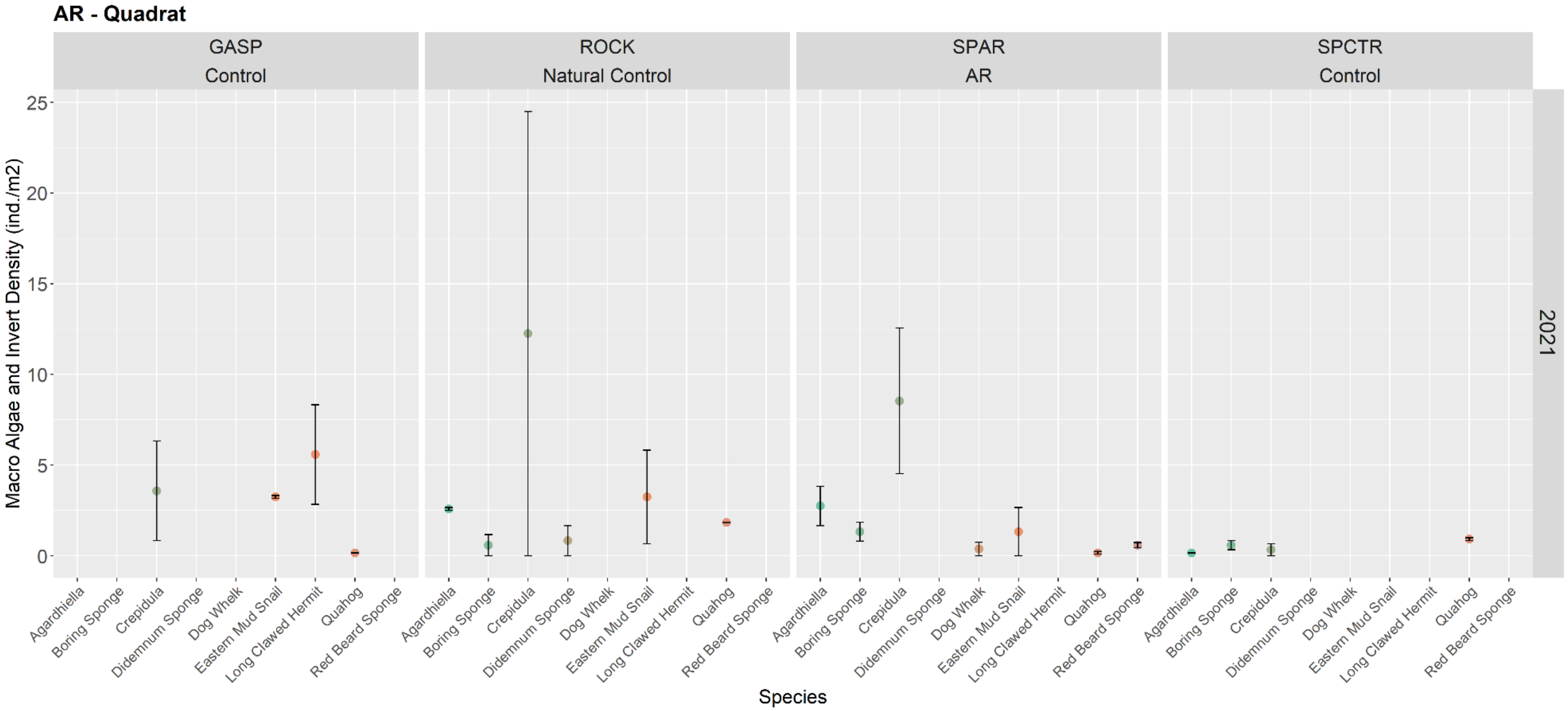


Figure 21. Mean invertebrate density ± SE, per habitat treatment (GASP = Gaspee Point (Control), ROCK = Rock Island (Natural Control), SPAR = Sabin Point Artificial Reef (Reef), SPCTR = Sabin Point Control (Control)), grouped by site (AR, Control, Natural Control) and year (2021) for the quadrat survey method.

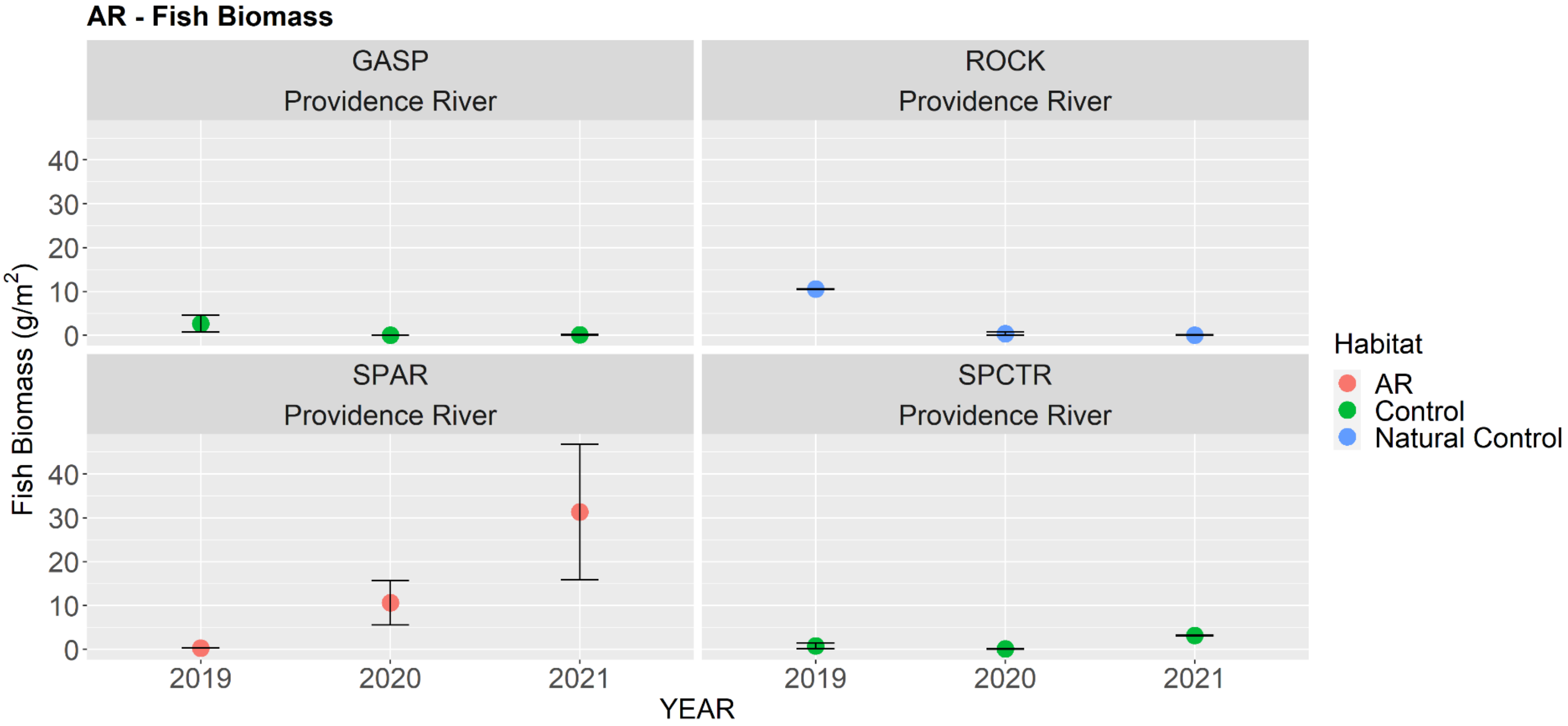


Figure 22. Mean fish biomass (g/m^2) before (2019) and after (2020,2021) the construction of the Sabin Point Artificial Reef. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (AR = red, Control = green, Natural Control = blue

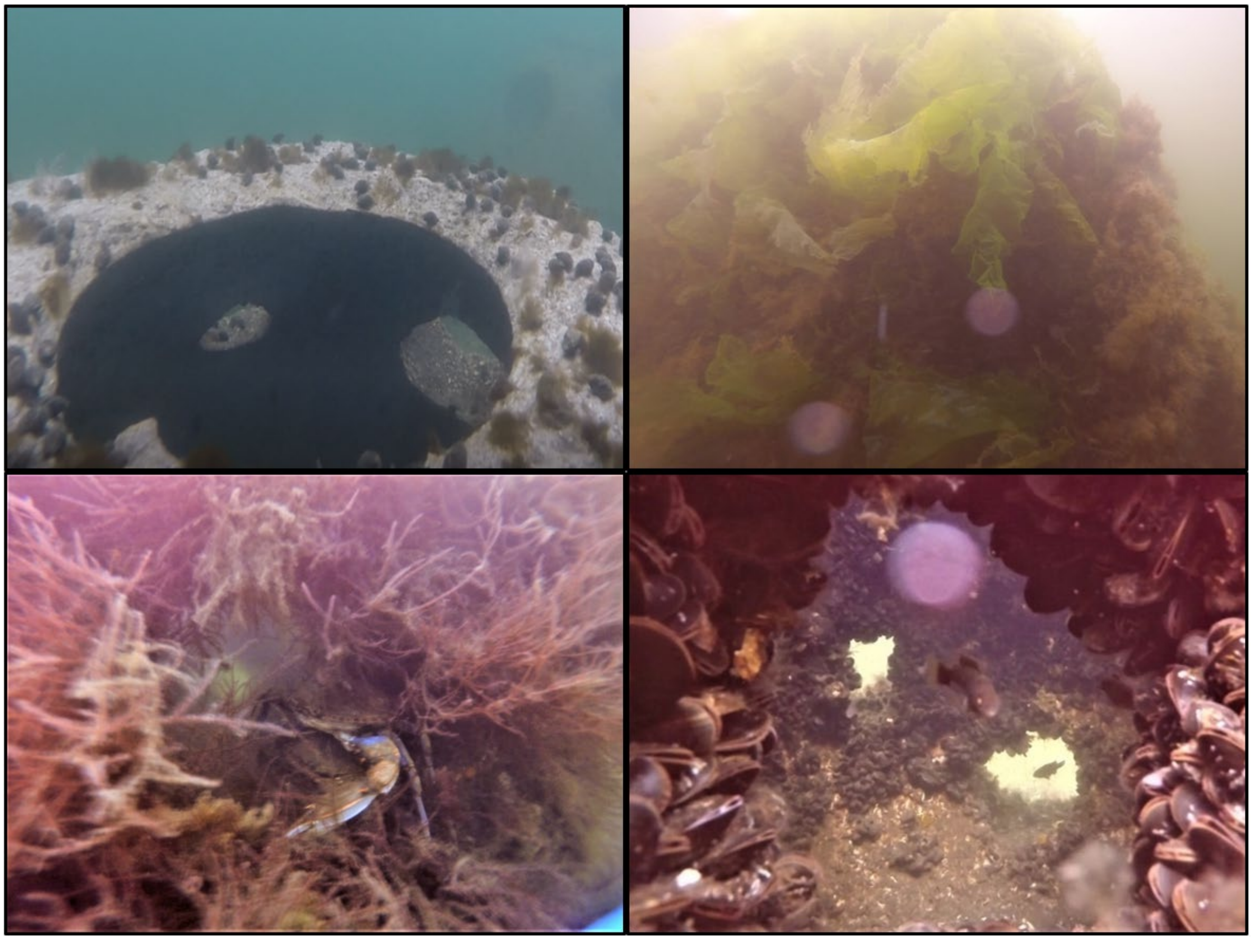


Photo: Succession of Reef Ball modules at Sabin Point Artificial Reef. (Top left – Fall 2019, Top Right – May 2020, Bottom left - September 2020, Bottom Right – September 2021)

TABLES:

Table 1. Summary of fishing effort in 2021. 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

2021	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	5	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	5.5
Pawtuxet Cove	X	X	X	X	X	X	6	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	11	12	12	12	12	**Total Trap Samples: 71**	-
Total eel pot samples per month	4	4	3.5	4	4	4	-	**Total Eel Pot Samples: 23.5**

Table 2. Total number of each species caught at all sites in eel pots (four sites) and fish traps (12 sites) in 2021.

Common Name	Scientific Name	Eel Pot	Fish Trap
American Eel	*Anguilla rostrata*	13	4
Black Sea Bass	***Centropristus striata***	**347**	**9**
Conger Eel	*Conger Oceanicus*	1	0
Cunner	*Tautogolabrus adspersus*	9	0
Oyster Toadfish	*Opsanus tau*	21	21
Scup	***Stenotomus chrysops***	**31**	**74**
Tautog	***Tautoga onitis***	**7**	**38**
Winter Flounder	***Pseudopleuronectes americanus***	**1**	**0**
Blue Crab	*Calinectes sapidus*	27	189
Mud Crab	*Panopeus spp*	32	1
Spider Crab	*Libinia emarginata*	20	383
Summer Flounder	***Paralichthys dentatus***	**0**	**9**
White Perch	*Morone americana*	0	1
Green Crab	*Carcinus maenus*	0	20
Hermit Crab	*Pagurus spp*	0	1
Horseshoe Crab	*Limulus polyphemus*	0	2
Water Hauls	-	2	21
Total Fish	-	430	156
Total Crustaceans	-	79	596

Table 3. Fish trap CPUE (#fish/day) at all sites each month with calculated mean, standard error and standard deviations.

	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	n	mean	SE	SD
May	4.2	0.8	2.5	0.2	0.5	0.2	0.5	0.2	0	0.2	0.2	0.2	12	0.81	0.36	1.26
June	0.5	6	2.5	0.2	1.5	0.2	3	0	1	0.8	0.2	NA	11	1.45	0.54	1.80
July	0	0	0.2	0.2	0.2	0	0.5	0.2	0	0	0	0	12	0.11	0.05	0.16
August	2	0.8	1.5	0.2	0	0	0	0	0.2	0	0.2	0	12	0.41	0.19	0.67
September	1	0	1.5	0	0.5	0.2	0.2	0	0.2	0	0.5	0.2	12	0.36	0.13	0.46
October	0	0.2	0	0.2	0.2	0.2	0	0.2	0	0.5	0	0.2	12	0.14	0.04	0.15
n	6	6	6	6	6	6	6	6	6	6	6	5				
mean	1.28	1.30	1.37	0.17	0.48	0.13	0.70	0.10	0.23	0.25	0.18	0.12				
SE	0.66	0.95	0.44	0.03	0.22	0.04	0.47	0.04	0.16	0.14	0.07	0.05				
SD	1.61	2.33	1.08	0.08	0.53	0.10	1.15	0.11	0.39	0.33	0.18	0.11				

Table 4. Eel pot CPUE (#fish/day) at all sites each month with calculated mean, standard error and standard deviations.

	Gaspee Pt.	Rock Island	Sabin Pt.	Sabin Pier	n	mean	SE	SD
May	0	0	0	2	4	0.50	0.50	1.00
June	0.8	0.2	0.2	0.2	4	0.35	0.15	0.30
July	0	0	0.8	1	4	0.45	0.26	0.53
August	17	9	9.5	15.8	4	12.83	2.08	4.16
September	8.2	6.5	7	7.8	4	7.38	0.38	0.77
October	2.2	6.2	8.5	5	4	5.48	1.31	2.62
n	6	6	6	6				
mean	4.70	3.65	4.33	5.30				
SE	2.76	1.65	1.82	2.39				
SD	6.77	4.04	4.46	5.86				

Table 5. Calculated species richness(S), Shannon diversity (*H'*), Pielou's evenness (*J'*), Simpson's index (*λ*)

Name	*S*	*H'*	*J'*	*λ*
Gaspee Pt.	12	1.58	0.63	0.69
Rock Island	9	1.61	0.73	0.73
Sabin Pt.	8	1.34	0.64	0.62
Sabin Pier	11	1.77	0.74	0.76

Table 6. Average fish trap CPUE (#fish/day) in 2021 by month ± standard error with overall mean and total CPUE for each target species.

Fish Traps	Scup	Black Sea Bass	Summer Flounder	Tautog	Winter Flounder
May	0	0	0.04 ± 0.03	**0.71 ± 0.35**	0
June	**1.27 ± 0.53**	0	0.02 ± 0.02	0.07 ± 0.04	0
July	0.08 ± 0.04	0	0.02 ± 0.02	0	0
August	0.13 ± 0.07	**0.10 ± 0.10**	**0.06 ± 0.04**	0	0
September	0.08 ± 0.06	0.08 ± 0.06	0.02 ± 0.02	0	0
October	0.08 ± 0.05	0	0.02 ± 0.02	0.02 ± 0.02	0
Mean Overall	**0.26 ± 0.09**	0.03 ± 0.02	0.03 ± 0.01	0.13 ± 0.06	0
2022 Total CPUE	**18.5**	2.25	2.25	9.5	0

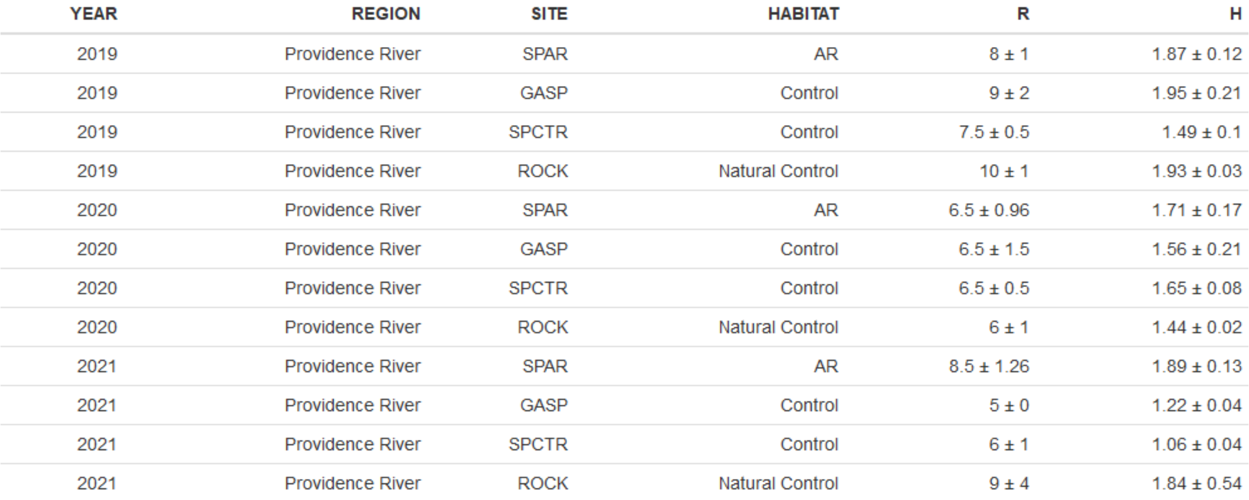
Table 7. Average eel pot CPUE (#fish/day) in 2021 by month ± standard error with overall mean and total CPUE for each target species.

Eel Pots	Scup	Black Sea Bass	Summer Flounder	Tautog	Winter Flounder
May	0	0	0	0	0
June	0	0	0	0	**0.06 ± 0.06**
July	0	0	0	0	0
August	**1.56 ± 0.99**	**10.19 ± 1.49**	0	**0.38 ± 0.22**	0
September	0.25 ± 0.10	6.63 ± 0.41	0	0.06 ± 0.06	0
October	0.13 ± 0.13	4.88 ± 1.26	0	0	0
Mean Overall	0.32 ± 0.19	**3.61 ± 0.87**	0	0.07 ± 0.04	0.01 ± 0.01
2021 Total CPUE	7.75	**86.75**	0	1.75	0.25

Table 8. Total abundance of species caught in fish traps by station in 2021.

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	-	1	-	-	-	-	-	1	2	-	-	-	4
Black Sea Bass	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**6**	**9**
Oyster Toadfish	1	3	1	2	-	-	-	3	1	1	6	3	21
Scup	**1**	**-**	**4**	**4**	**1**	**-**	**12**	**6**	**1**	**25**	**15**	**5**	**74**
Summer Flounder	**-**	**-**	**-**	**-**	**1**	**2**	**2**	**-**	**1**	**3**	**-**	**-**	**9**
Tautog	**1**	**1**	**1**	**-**	**1**	**1**	**3**	**2**	**-**	**2**	**9**	**17**	**38**
White Perch	-	-	-	-	-	1	-	-	-	-	-	-	1
Total	3	5	6	6	3	4	17	12	5	31	33	31	156
Blue Crab	**14**	**23**	**16**	**13**	**16**	**26**	**12**	**26**	**21**	**9**	**10**	**3**	**189**
Green Crab	-	1	-	-	-	1	0	-	2	15	1	-	20
Horseshoe Crab	-	2	-	-	-	-	-	-	-	-	-	-	2
Mud Crab	-	-	-	-	1	-	-	-	-	-	-	-	1
Spider Crab	7	11	27	30	17	9	46	26	30	22	119	39	383
Total	21	37	43	43	34	36	58	52	53	46	130	42	595
Water Haul	2	2	4	3	2	1	2	1	1	2	-	1	21

Table 9. Species Richness (R) and Shannon H-index (H) of diversity for each Artificial Reef Dive Survey Site (SPAR – Sabin Point Artificial Reef, GASP – Gaspee Point, SPCTR – Sabin Point Control, ROCK – Rock Island) from 2019 to 2021.



YEAR	REGION	SITE	HABITAT	R	H
2019	Providence River	SPAR	AR	8 ± 1	1.87 ± 0.12
2019	Providence River	GASP	Control	9 ± 2	1.95 ± 0.21
2019	Providence River	SPCTR	Control	7.5 ± 0.5	1.49 ± 0.1
2019	Providence River	ROCK	Natural Control	10 ± 1	1.93 ± 0.03
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
2021	Providence River	SPAR	AR	8.5 ± 1.26	1.89 ± 0.13
2021	Providence River	GASP	Control	5 ± 0	1.22 ± 0.04
2021	Providence River	SPCTR	Control	6 ± 1	1.06 ± 0.04
2021	Providence River	ROCK	Natural Control	9 ± 4	1.84 ± 0.54

Table A. Fish and Eel Pot Locations in 2021. ^{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 2021.

MAY	**Site**												
Species	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	**Total out of 12**
Black Sea Bass	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Oyster Toadfish	1	0	1	0	0	0	0	0	1	0	0	0	**3**
Scup	1	1	1	0	0	0	0	0	0	0	0	0	**3**
Spider Crab	1	0	1	1	0	0	1	0	0	0	0	0	**4**
Summer Flounder	0	1	0	1	0	0	0	0	0	0	0	0	**2**
Blue Crab	0	0	1	1	1	1	1	1	1	1	1	1	**10**
American Eel	0	0	0	0	0	0	0	0	0	0	1	0	**1**

JUNE	**Site**												
Species	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	**Total out of 12**
Spider Crab	1	1	1	1	1	0	1	0	0	0	0	0	**6**
Blue Crab	0	1	1	1	1	1	0	1	1	0	1	1	**9**
Green Crab	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Scup	0	0	1	0	1	0	1	1	0	0	0	0	**4**
American Eel	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Summer Flounder	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Mud Crab	0	0	0	0	0	0	0	1	0	0	0	0	**1**

JULY	**Site**												
Species	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	**Total out of 12**
Blue Crab	1	1	1	1	1	1	1	1	1	1	1	0	**11**
Scup	1	1	1	1	1	0	1	0	1	1	0	0	**8**
Spider Crab	1	1	1	1	1	0	1	0	1	1	0	0	**8**
Tautog	1	0	0	0	0	0	1	0	0	0	1	0	**3**
Oyster Toadfish	0	1	1	0	0	0	0	0	0	1	0	0	**3**
American Eel	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Quahog	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Green Crab	0	0	0	0	0	1	0	0	0	0	1	0	**2**
Summer Flounder	0	0	0	0	0	1	0	0	0	0	0	0	**1**

AUGUST	**Site**												
Species	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	**Total out of 12**
Oyster Toadfish	1	0	1	0	0	0	0	0	0	0	1	0	**3**
Spider Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Tautog	1	1	1	0	1	0	1	1	0	1	0	1	**8**
Green Crab	0	1	0	0	0	0	0	0	0	0	0	0	**1**
Summer Flounder	0	1	0	0	0	1	0	0	0	0	0	0	**2**
American Eel	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Blue Crab	0	0	0	0	1	1	0	0	0	0	0	0	**2**
Horseshoe Crab	0	0	0	0	0	0	0	0	0	0	1	0	**1**

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

OCTOBER	**Site**												
Species	Rocky Point	Conimicut Pt.	Mussachuck Creek	Gaspee Pt.	Rock Island	Pawtuxet Cove	Narragansett Terrace	Sabin Pt.	Sabin Pier	Stillhouse Cove	Fields Pt.	Watchemoket Cove	**Total out of 12**
Black Sea Bass	1	0	1	0	0	0	0	0	0	0	0	0	**2**
Oyster Toadfish	1	0	1	0	1	0	0	0	1	0	1	1	**6**
Scup	1	0	1	0	0	0	0	0	0	0	0	0	**2**
Spider Crab	0	1	0	1	1	0	1	1	1	0	0	0	**6**
Green Crab	0	0	1	1	0	0	0	0	0	0	0	0	**2**
Blue Crab	0	0	0	0	1	1	1	1	0	1	1	1	**7**
White Perch	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Summer Flounder	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Hermit Crab	0	0	0	0	0	0	0	0	1	0	0	0	**1**

PERFORMANCE REPORT

STATE: Rhode Island

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

PROJECT TITLE: Holistic Fish Habitat Assessment and Fish Productivity Estimations

PERIOD COVERED: January 1, 2021 - December 31, 2021

JOB NUMBER AND TITLE: V, Part C: Oyster Monitoring and Productivity Assessment

STAFF: Patrick Barrett and Eric Schneider (RI DEM, Div. of Marine Fisheries) and Drs. Randall Hughes and Jonathan 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, 2021. 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 of benthic and fish community biomass. These estimates will be used in combination with other metrics to quantify the degree to which FHE restored oyster reefs increase in production of juvenile sportfish. 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. Laboratory work required to process habitat tray and oyster pathology samples was impacted by Covid-19 restrictions; however, the overall project timeline will not be impacted.

TARGET DATE: December 2024

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 found 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, fish abundances at FHE oyster reefs after reef construction increased relative to 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. 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 reefs 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), 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 sample locations, 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. Habitat trays were deployed for 30 days at FHE reefs once a year between July and September in2020 and 2021, and will be deployed again in 2022 and-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 and 2021, 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 to minimize its impact to the intact oyster reef, at one of 4 predetermined random locations (e.g., north, east, south, or west edge of the reef). During 2020, habitat trays were deployed at sites in Ninigret and Quonochontaug Pond on August 17 and 18, respectively. During 2021, habitat trays were deployed at sites in Ninigret and Quonochontaug Pond on August 24 and 25, 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 all biological material was separated from the shell and sand. Fish, crabs, and all other macroinvertebrates were separated into separate jars, preserved with Ethyl Alcohol, and stored in a climate-controlled facility until processing.

Due to covid-related restrictions, samples collected during 2020 were processed at the Grabowski Lab at the Northeastern University Marine Science Center (Nahant, MA) beginning in the summer of 2021 through winter of 2021. For each sample jar (e.g., fish, crabs, or other) a subsample of 20 organisms were identified to species (if possible), measured, and weighed to the hundredth of a gram consistent with methods described in summarized in Davenport et al. 2022 (in review). Remaining organisms were counted and total biomass by species at size were extrapolated based on subsamples. We expect 2021 habitat tray samples to be processed during the spring and summer of 2022 using the same approach and facility.

Eel Pot and Minnow Trap Survey

During 2021, 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 2021). 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 searched 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 fro/m 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 Levine'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 2021 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 2021 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 2021, 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). Survival 18 months post construction for the newly reseeded Ninigret reefs were 54.13% and 47.28% for the Green Hill Pond only and Green Hill Pond overseeded reefs respectively (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, with the Green Hill Pond treatments out performing the other treatments with respect to overall density and mean length (Figure 2 and 3).

Despite on-going restrictions at NU during 2021 that affected lab staffing levels, pathology analyses were completed on time. Pathology results are most informative when considered in the context of multiyear analyses, as well as reef- and habitat-level variables. Results from FHE pathology work are being incorporated into two peer-review manuscripts (e.g., Barrett et al. 2022 (in review) and Hanley et al. 2022 (in prep)). These articles will be appended to future repots, once completed. Briefly, results from 2021 showed that the prevalence of macro-parasites, such as mud blister and boring sponge, often varied between reefs within regions and between ponds. The prevalence and intensity of micro-parasites (e.g., Dermo and SSO) also varied between reefs within and between sites, and between ponds. None of the FHE sites sampled in 2020 or 2021 had detectable levels of MSX.

Habitat Trays

Samples collected in 2020 have been sorted, counted, weighed, and measured. In general, there was roughly an order of magnitude more fish and invertebrate biomass on both the seeded and unseeded reefs than the controls at Ninigret (Figure 4). In particular, there was more fish (gobies, toadfish, and cunner) and crustaceans (xanthid crabs and palaemonid shrimp) on both unseeded and seeded reefs than on controls. Control plots were a mix of fish and crabs, whereas both reef treatments were dominated by crustaceans.

In Quonochontaug Pond, average biomass was slightly higher in controls than in the three reef treatments, but control biomass was highly variable among blocks (Figure 4). In particular, one of the controls had a lot of molluscan biomass, which consisted largely of mud snails, whereas the other two control plots had very little (< 3g total per tray) total fish and invertebrate biomass. Meanwhile, there was much more fish (gobies, toadfish, black seabass, and the American eel) and crustacean (xanthid crab and palaemonid shrimp) biomass on the three reef treatments (reefs seeded with oysters sourced from Green Hill Pond, the Narrow Rivers, or an aquaculture source). Thre three reef treatments did not vary much, with fish and invertebrate biomass ranging between 25 and 60 g per habitat tray on reefs.

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 2021 field season was generally lower than 2020. Out of the treatments, Green Hill Pond reef had the greatest abundance of tautog, where as no other Ninigret Pond reef had a significant biomass of fish all season (Figure 5). We found between both experiments, juvenile tautog were most positively augmented on the oyster reefs relative to the control sites. In Ninigret Pond there was a 3.6 times increase and in Quonochontaug there was a 1.7 fold increase for juvenile tautog (Figure 5 and Figure 6, respectively). In 2021, we found mean CPUE in Quonochontaug to be greater for all target species, when compared to Ninigret (Figure 5 and 6). Similarly the relative enhancement impact of the Green Hill Pond oyster reefs was greatest for Black Sea Bass, Tautog, Cunner, and Winter Flounder (Figure 6).

Fish Productivity Assessment

During September 2021, 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 northwest region of the pond, the control habitat (1A) was 100% mud or fine sediment, whereas the North and northeast control locations (2D, 3C) had increasingly more sand, gravel, and shell substrate. The northern region, or Site 2 control, is sandier than Site 3, which had a higher percent of mud and finer sediment mixed in (3D = 75% ; Figure 7). Site 3 also contains a greater proportion of natural boulders compared to Site 2 (3C = 55%, 2D =20%. Figure 7).

In 2021, the overall species diversity, with respect to the algae and sessile invertebrate species, was equal between 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 8). Investigators found invertebrate densities to vary depending on the species and survey location. At the control sites, investigators found the highest abundance of Mantis Shrimp (1.3 to 0 ind./m^2) (Figure 9). The reef sites harbored a wider array of inverts, most notably increased abundance of barnacles, boring sponge, and red beard sponge (Figure 9). 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 mud crabs on the oyster reefs and quahogs at the control sites (Figure 10). In 2020, the 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). Again in 2021, the oyster reef sites had a greater biomass than the controls but overall biomass was lower (Figure 11). 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 in 2020 and 0.68 in 2021.

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. 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 lower overall catch rates for the target sportfish species between the habitat treatments. This year was complicated a wet spring and rust tide during the warmer months. 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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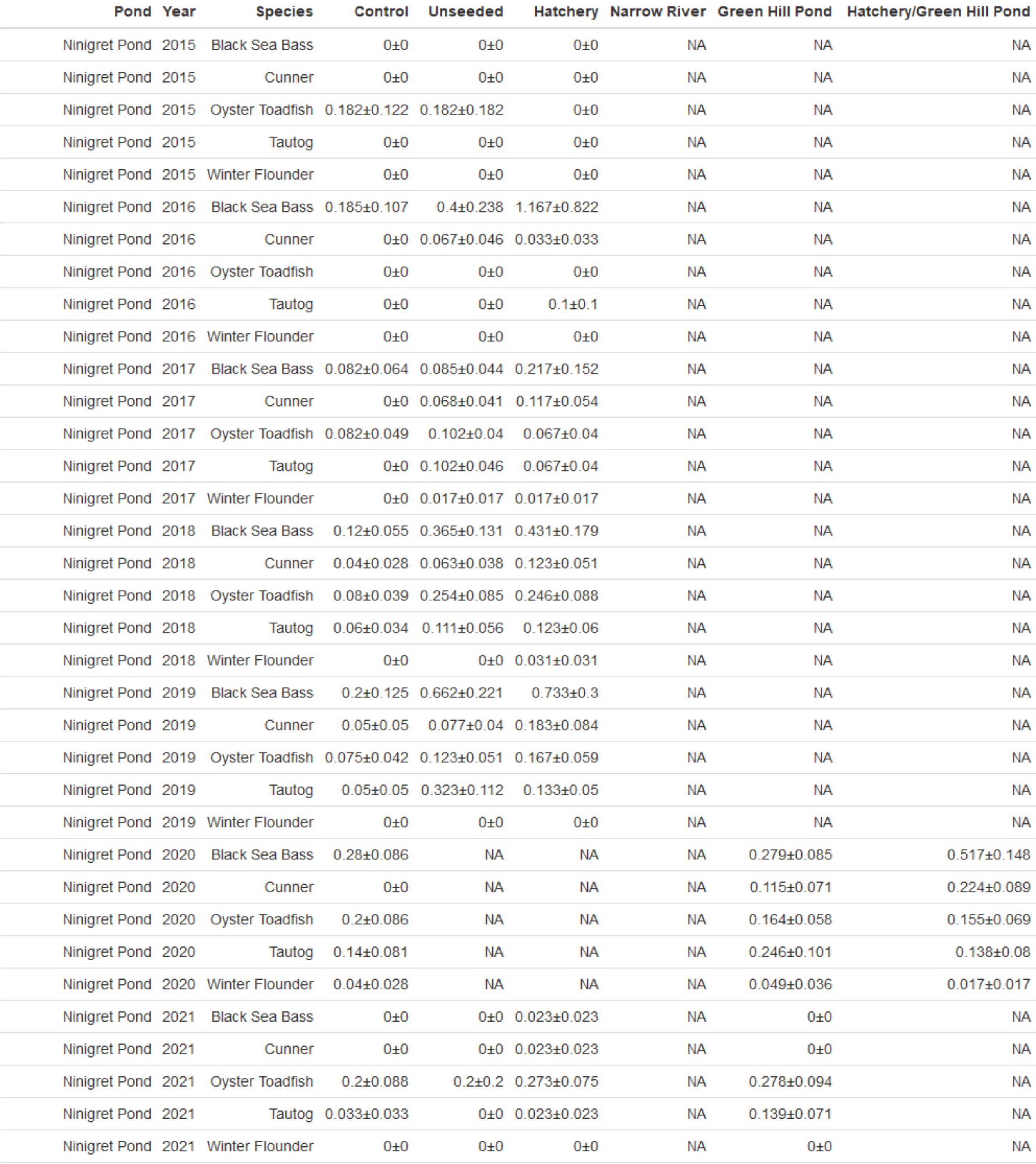
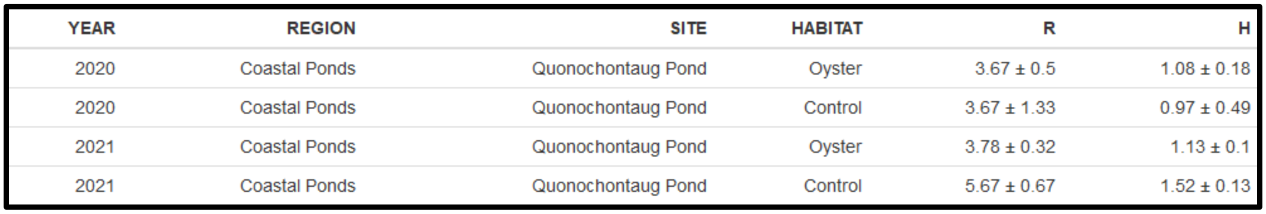
Table 1: Average Catch per unit effort, ± se, for finfish species of interest (Black Sea Bass, Tautog, Winter Flounder, Cunner, and Oyster toadfish), from 2015-2021 when applicable for each oyster reef enhancement region (Ninigret and Quonochontaug Pond), grouped by habitat treatment.



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	0.182±0.122	0.182±0.182	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	0.4±0.238	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	0.082±0.064	0.085±0.044	0.217±0.152	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	0.082±0.049	0.102±0.04	0.067±0.04	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	0.365±0.131	0.431±0.179	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	0.08±0.039	0.254±0.085	0.246±0.088	NA	NA	NA
Ninigret Pond	2018	Tautog	0.06±0.034	0.111±0.056	0.123±0.06	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	0.2±0.125	0.662±0.221	0.733±0.3	NA	NA	NA
Ninigret Pond	2019	Cunner	0.05±0.05	0.077±0.04	0.183±0.084	NA	NA	NA
Ninigret Pond	2019	Oyster Toadfish	0.075±0.042	0.123±0.051	0.167±0.059	NA	NA	NA
Ninigret Pond	2019	Tautog	0.05±0.05	0.323±0.112	0.133±0.05	NA	NA	NA
Ninigret Pond	2019	Winter Flounder	0±0	0±0	0±0	NA	NA	NA
Ninigret Pond	2020	Black Sea Bass	0.28±0.086	NA	NA	NA	0.279±0.085	0.517±0.148
Ninigret Pond	2020	Cunner	0±0	NA	NA	NA	0.115±0.071	0.224±0.089
Ninigret Pond	2020	Oyster Toadfish	0.2±0.086	NA	NA	NA	0.164±0.058	0.155±0.069
Ninigret Pond	2020	Tautog	0.14±0.081	NA	NA	NA	0.246±0.101	0.138±0.08
Ninigret Pond	2020	Winter Flounder	0.04±0.028	NA	NA	NA	0.049±0.036	0.017±0.017
Ninigret Pond	2021	Black Sea Bass	0±0	0±0	0.023±0.023	NA	0±0	NA
Ninigret Pond	2021	Cunner	0±0	0±0	0.023±0.023	NA	0±0	NA
Ninigret Pond	2021	Oyster Toadfish	0.2±0.088	0.2±0.2	0.273±0.075	NA	0.278±0.094	NA
Ninigret Pond	2021	Tautog	0.033±0.033	0±0	0.023±0.023	NA	0.139±0.071	NA
Ninigret Pond	2021	Winter Flounder	0±0	0±0	0±0	NA	0±0	NA

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	0.527±0.176	NA	0.5±0.32	0.843±0.455	0.854±0.388	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	0.073±0.044	NA	0.096±0.05	0.098±0.058	0.146±0.067	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	0.14±0.064	NA	0.14±0.057	0.154±0.058	0.121±0.05	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	0.326±0.121	NA	0.7±0.293	1.056±0.305	1.039±0.32	NA
Quonochontaug Pond	2019	Cunner	0.196±0.074	NA	0.2±0.086	0.074±0.045	0.216±0.102	NA
Quonochontaug Pond	2019	Oyster Toadfish	0.087±0.042	NA	0.06±0.034	0.074±0.036	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	0.259±0.103	0.118±0.046	NA
Quonochontaug Pond	2020	Black Sea Bass	1.283±0.501	NA	2.128±0.82	1.643±0.712	2±0.729	NA
Quonochontaug Pond	2020	Cunner	0.196±0.074	NA	0.255±0.103	0.268±0.097	0.362±0.109	NA
Quonochontaug Pond	2020	Oyster Toadfish	0.087±0.042	NA	0.085±0.067	0.143±0.069	0.069±0.042	NA
Quonochontaug Pond	2020	Tautog	0.065±0.048	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
Quonochontaug Pond	2021	Black Sea Bass	0.829±0.421	NA	0.844±0.419	1.342±0.718	1.026±0.441	NA
Quonochontaug Pond	2021	Cunner	0.371±0.193	NA	0.188±0.138	0.263±0.111	0.5±0.247	NA
Quonochontaug Pond	2021	Oyster Toadfish	0.029±0.029	NA	0.062±0.043	0.105±0.063	0.079±0.058	NA
Quonochontaug Pond	2021	Tautog	0.086±0.063	NA	0.031±0.031	0.079±0.058	0.158±0.133	NA
Quonochontaug Pond	2021	Winter Flounder	0.229±0.143	NA	0.344±0.204	0.395±0.194	0.368±0.17	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
2021	Coastal Ponds	Quonochontaug Pond	Oyster	3.78 ± 0.32	1.13 ± 0.1
2021	Coastal Ponds	Quonochontaug Pond	Control	5.67 ± 0.67	1.52 ± 0.13

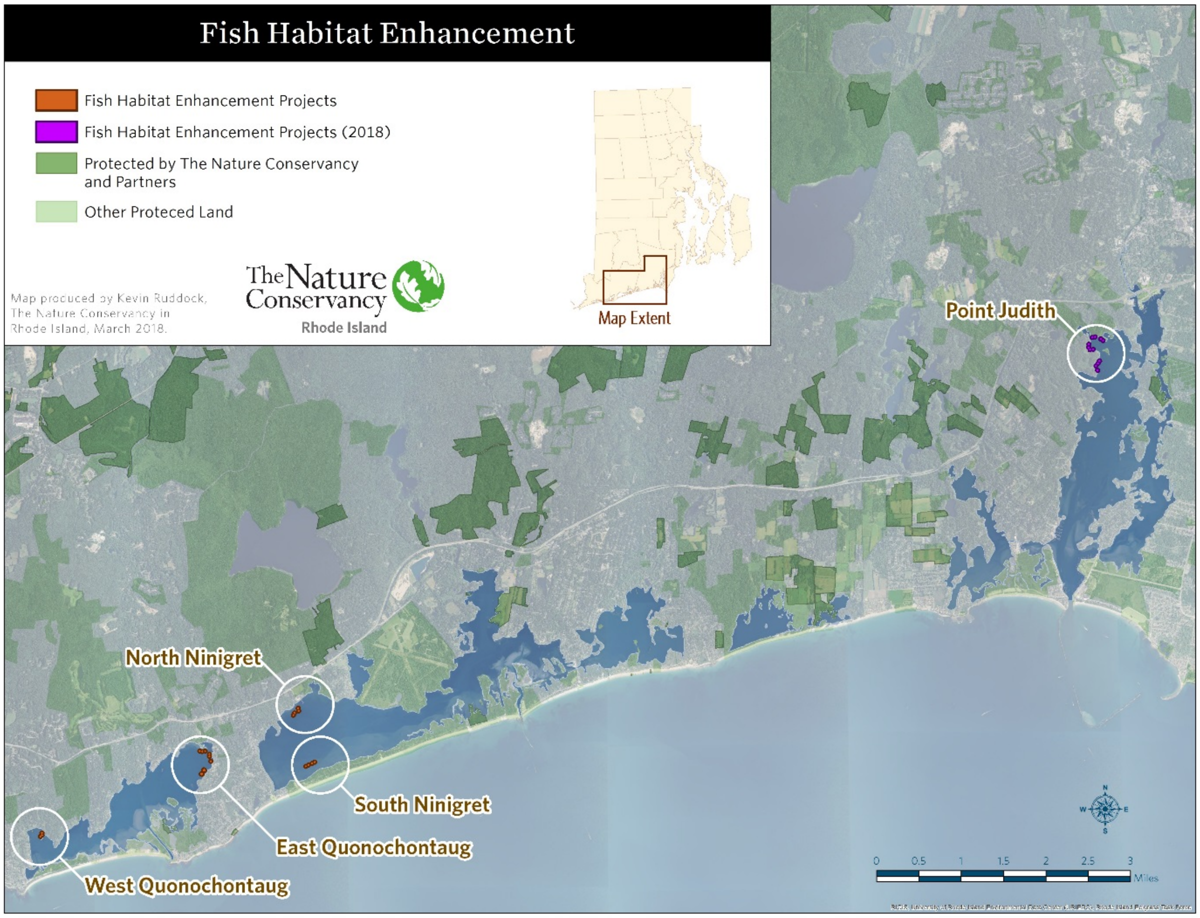


Figure 1. Coastal ponds located in Southern Rhode Island including constructed and formerly proposed (Pt Judith Pond) Fish Habitat Enhancement sites.

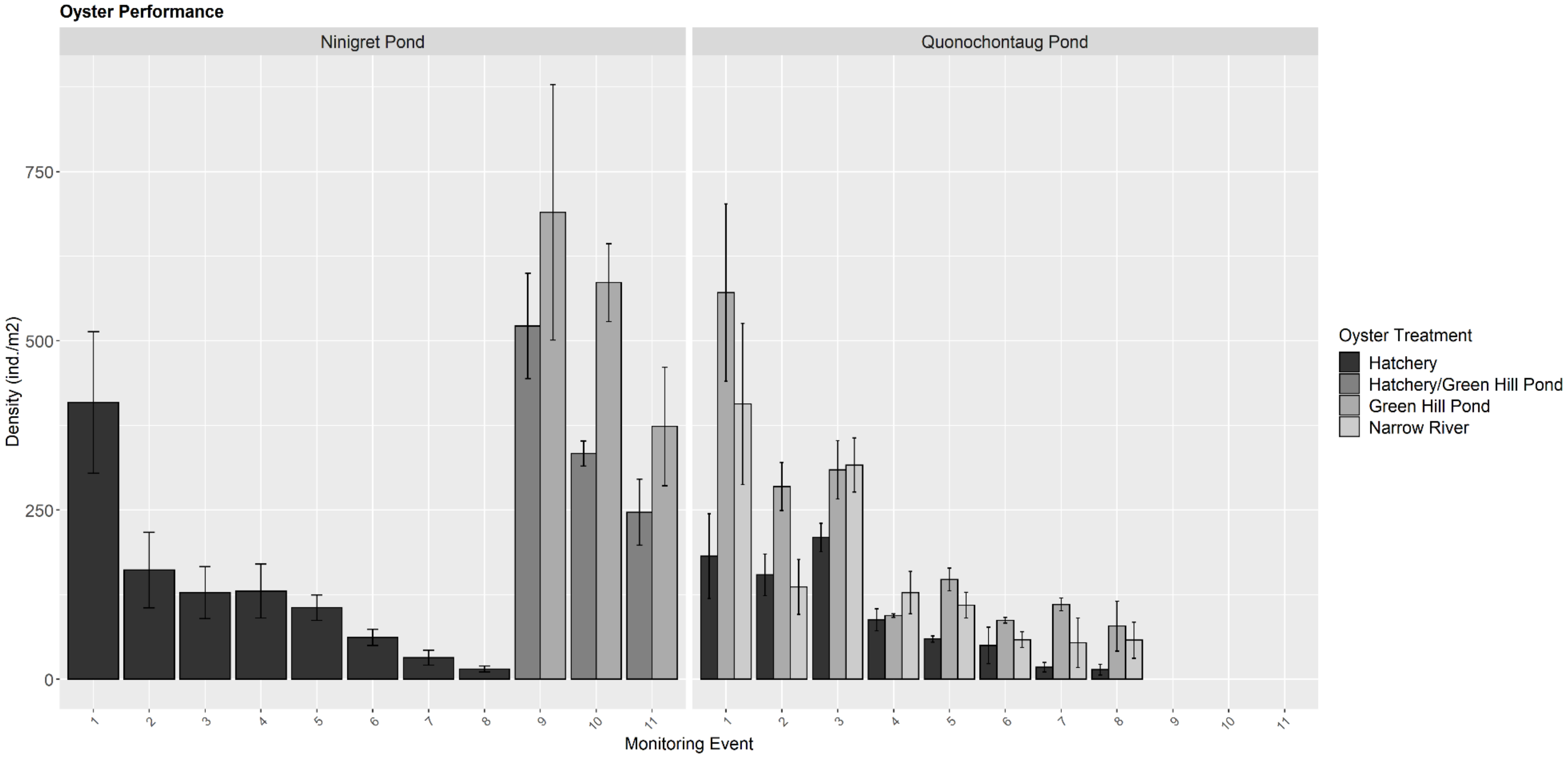


Figure 2: Bar graph of mean oyster density per meter squared, ± se, in Ninigret Pond as a function of oyster monitoring event, grouped by oyster seed source (Ninigret Pond: black = original hatchery lineage seeded in 2016, dark grey = Green Hill Pond overseeding, grey = Green Hill Pond only; Quonochontaug Pond: black = hatchery, grey = Green Hill Pond, light grey = Narrow River), for Ninigret (left) and Quonochontaug Pong (Right).

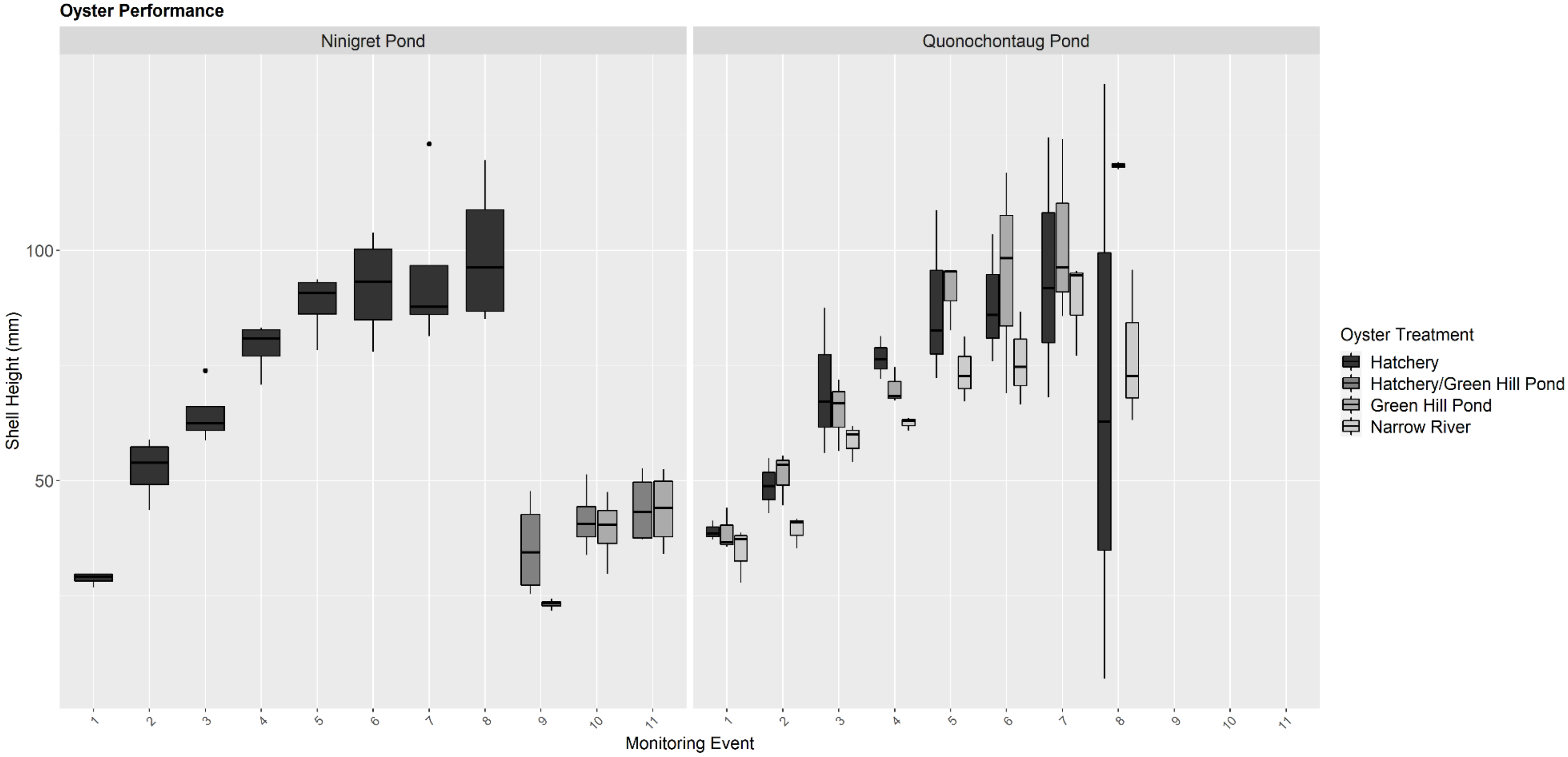


Figure 3: Box plot of mean oyster shell height (mm) per reef in both Ninigret Pond (left) and Quonochontaug Pond (right) as a function of oyster monitoring event, a proxy for time, and oyster seeding treatment (black = original hatchery, dark grey = green hill pond overseeding of old hatchery line, grey = Green Hill Pond only, light grey = Narrow River).

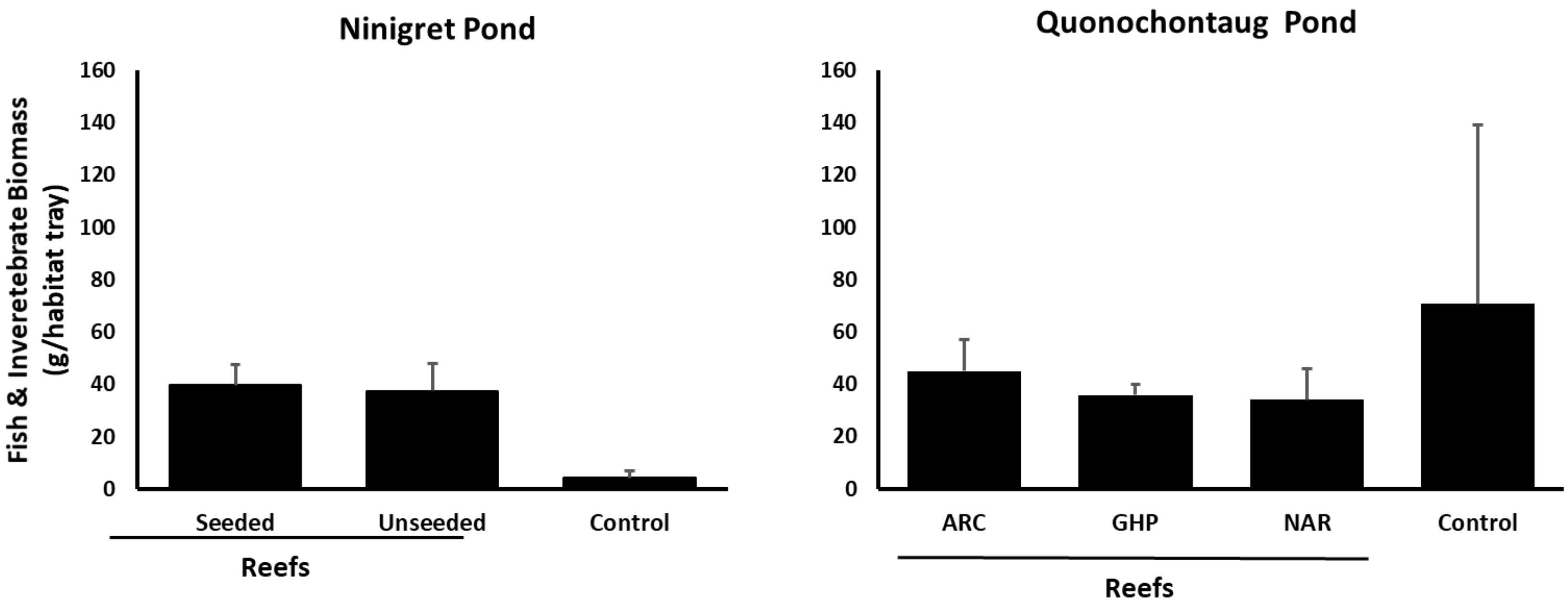


Figure 4. Mean fish and mobile invertebrate biomass, ± 1 se, per trey captured on reefs and control plots at Ninigret and Quonochontaug Ponds in habitat trays deployed in August 2020. In Ninigret, seeded reefs were originally seeded with remote set oysters, whereas

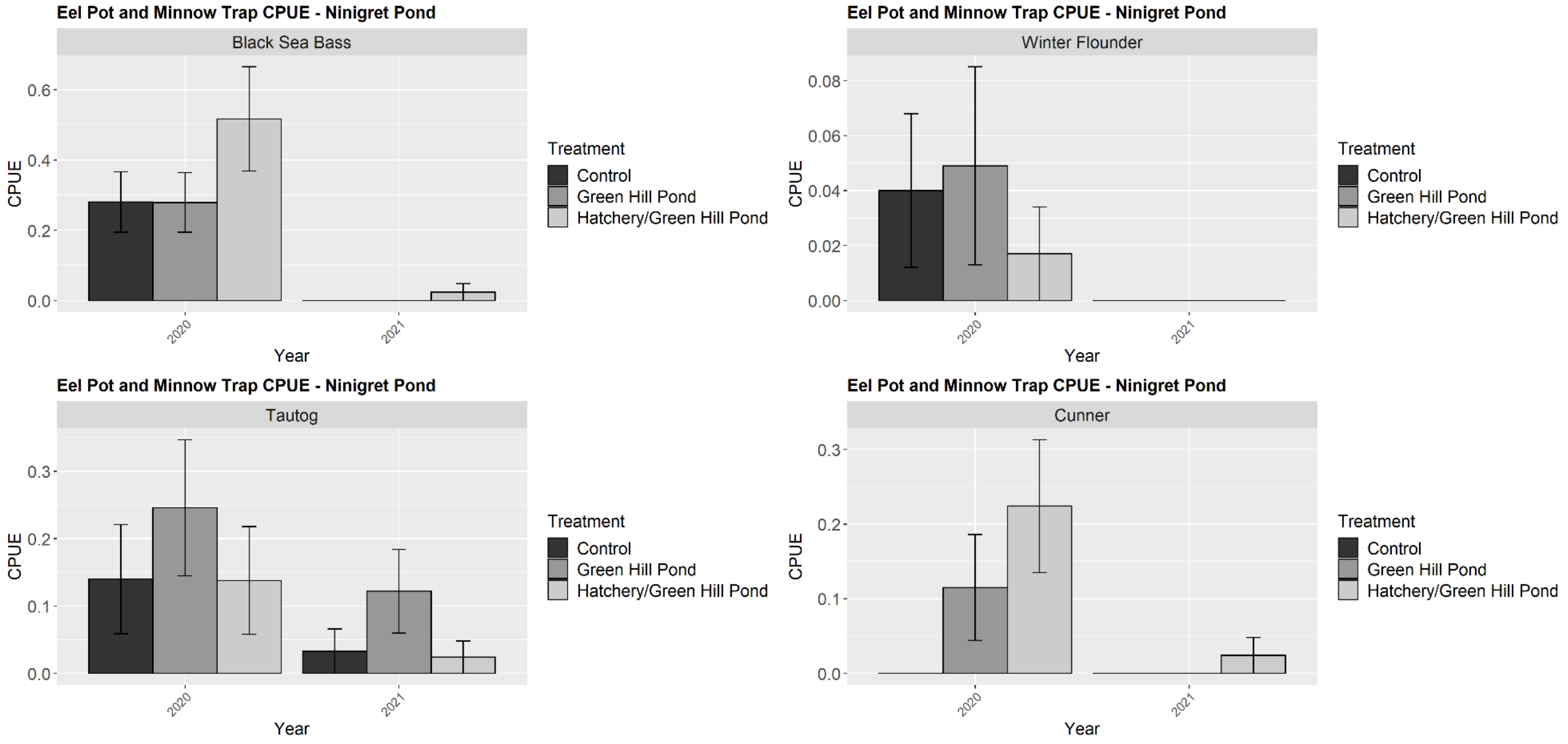


Figure 5: Ninigret Pond, mean catch per unit effort (CPUE) (ind./hours fished) ± se, observed during the 2020 and 2021 field season. Averages represent the average monthly CPUE from each habitat treatment. The average CPUE is plotted by year, grouped by habitat treatment (black = control, dark grey = 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).

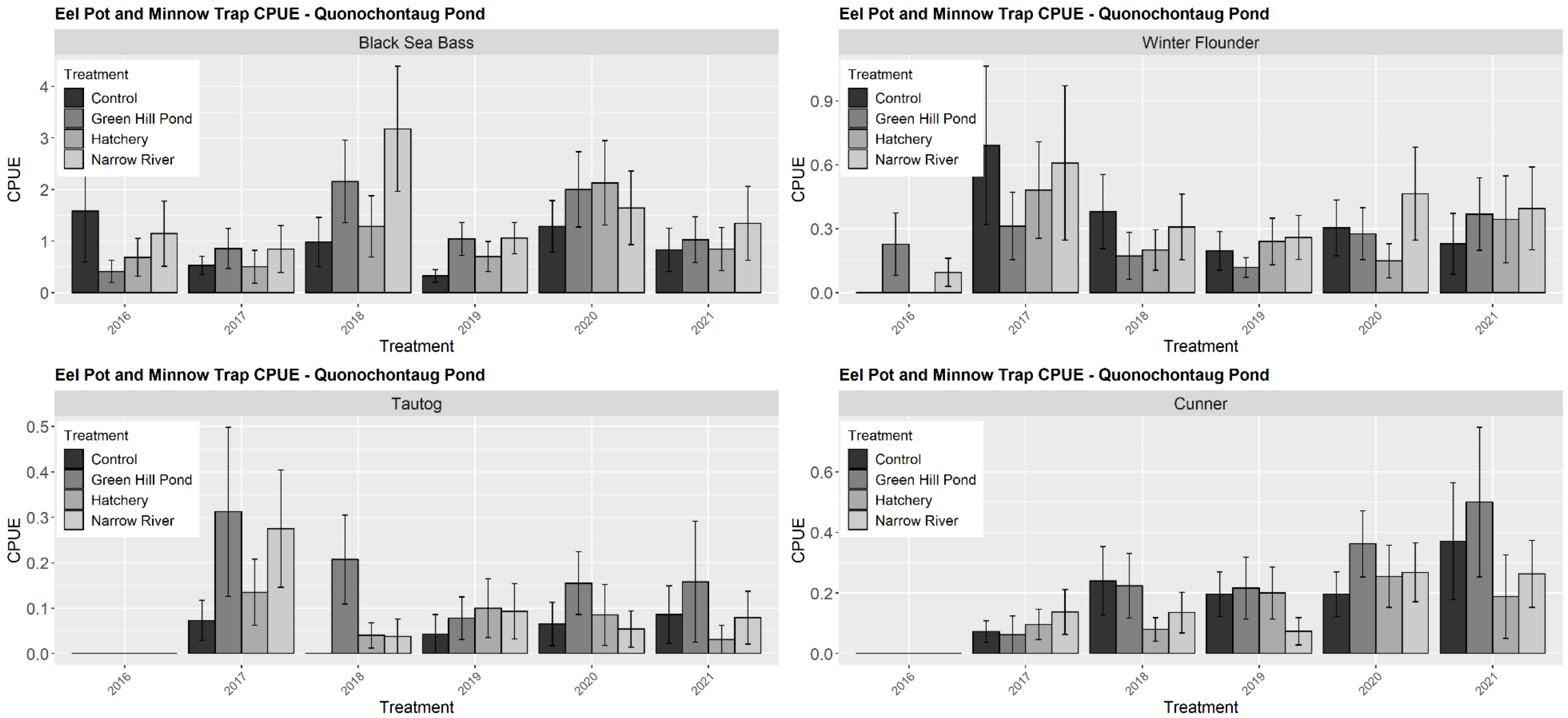


Figure 6: Quonochontaug Pond, mean catch per unit effort (CPUE) (ind./hours fished) ± se, observed during the 2016-2021 field seasons. Averages represent the average monthly CPUE from each habitat treatment. The average CPUE is plotted by year, grouped by habitat treatment (black = control, dark grey = 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 7. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2021 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).

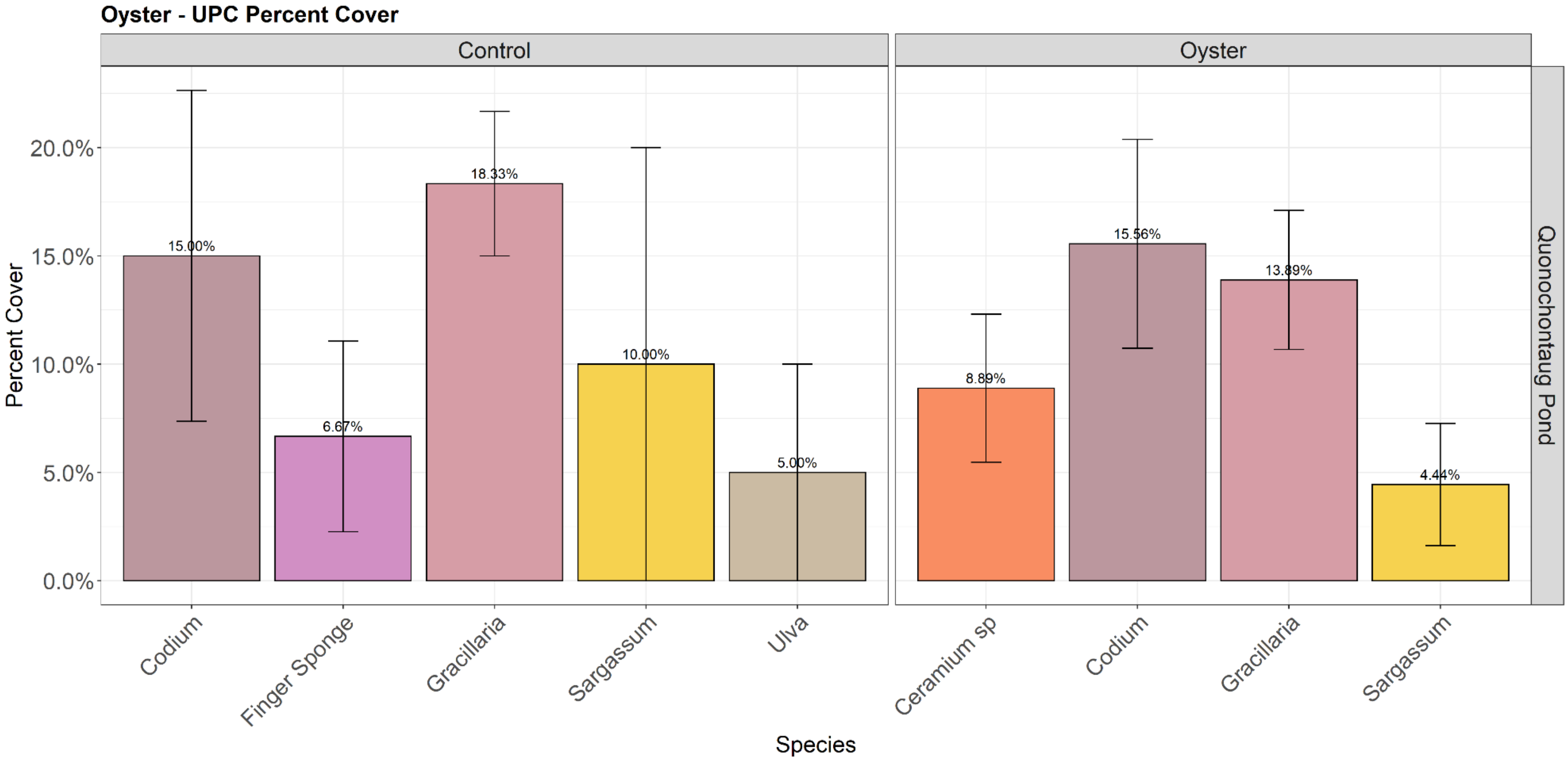


Figure 8. Quonochontaug Pond, mean algal and sessile invertebrate cover ± SE, for each habitat treatment (Control or Oyster Habitat) during the 2021 productivity dive survey.

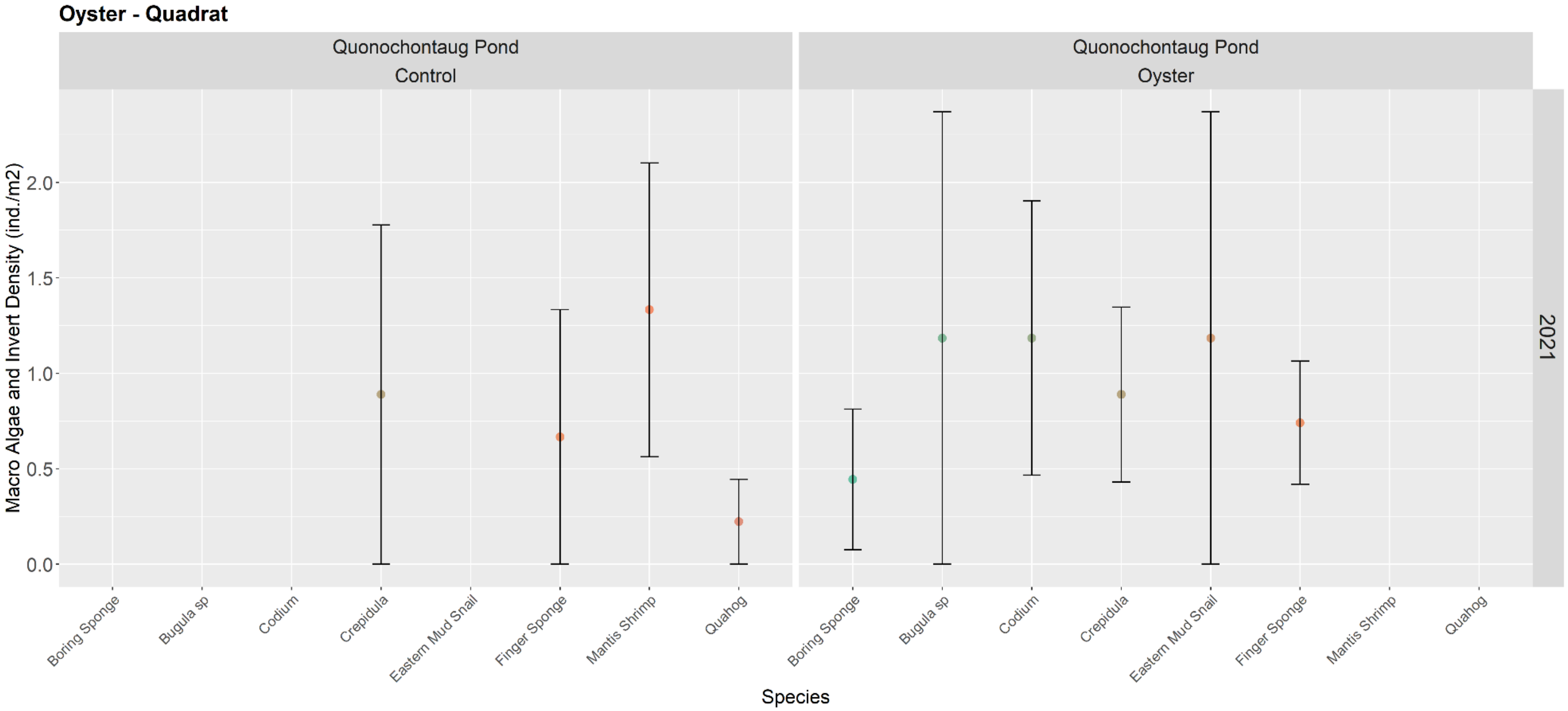


Figure 9. Quonochontaug Pond, mean invertebrate density ± SE, per habitat treatment Control or Oyster Habitat), grouped by transect survey method (quad).

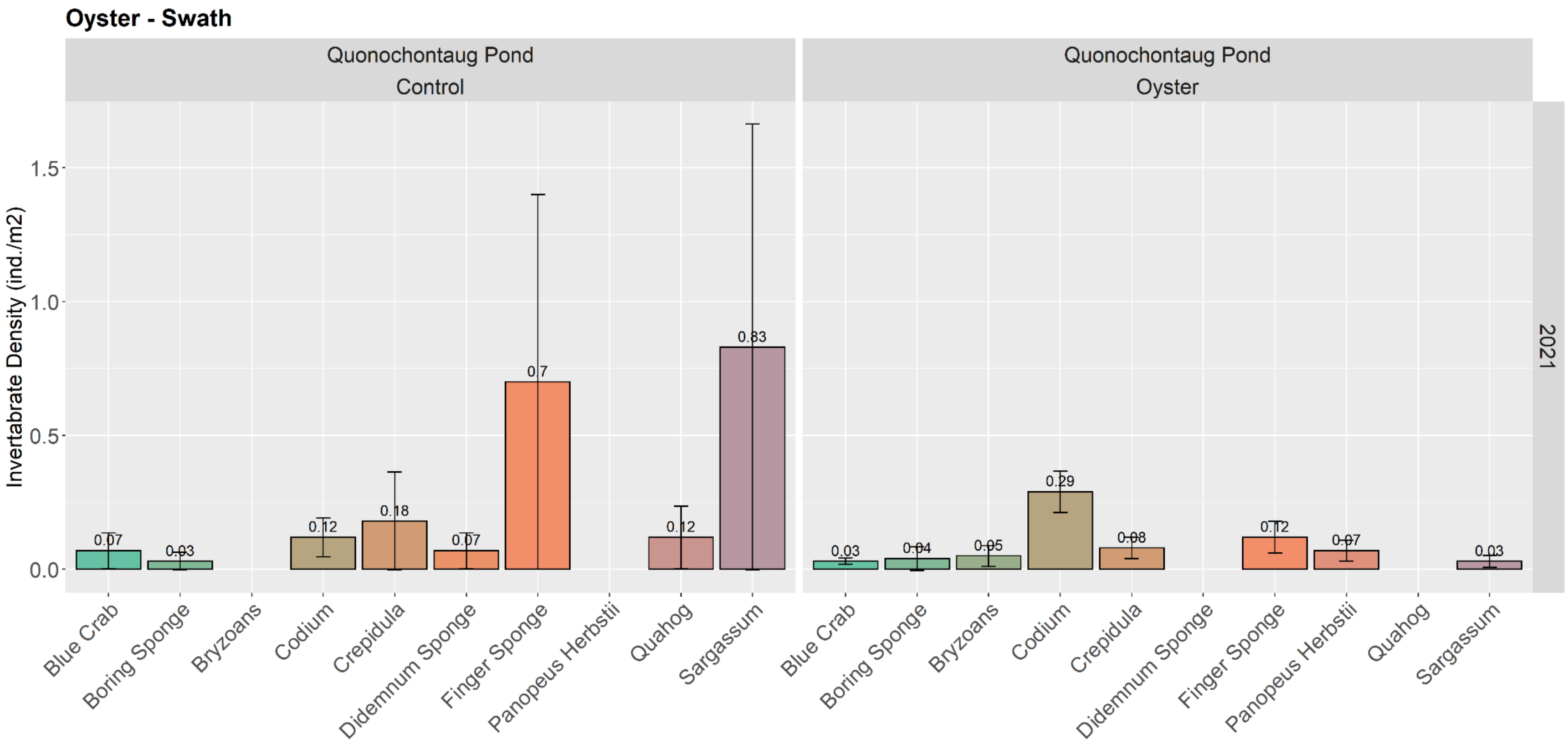


Figure 10. Quonochontaug Pond, mean invertebrate density ± SE, per habitat treatment Control or Oyster Habitat), grouped by transect survey method (swath).

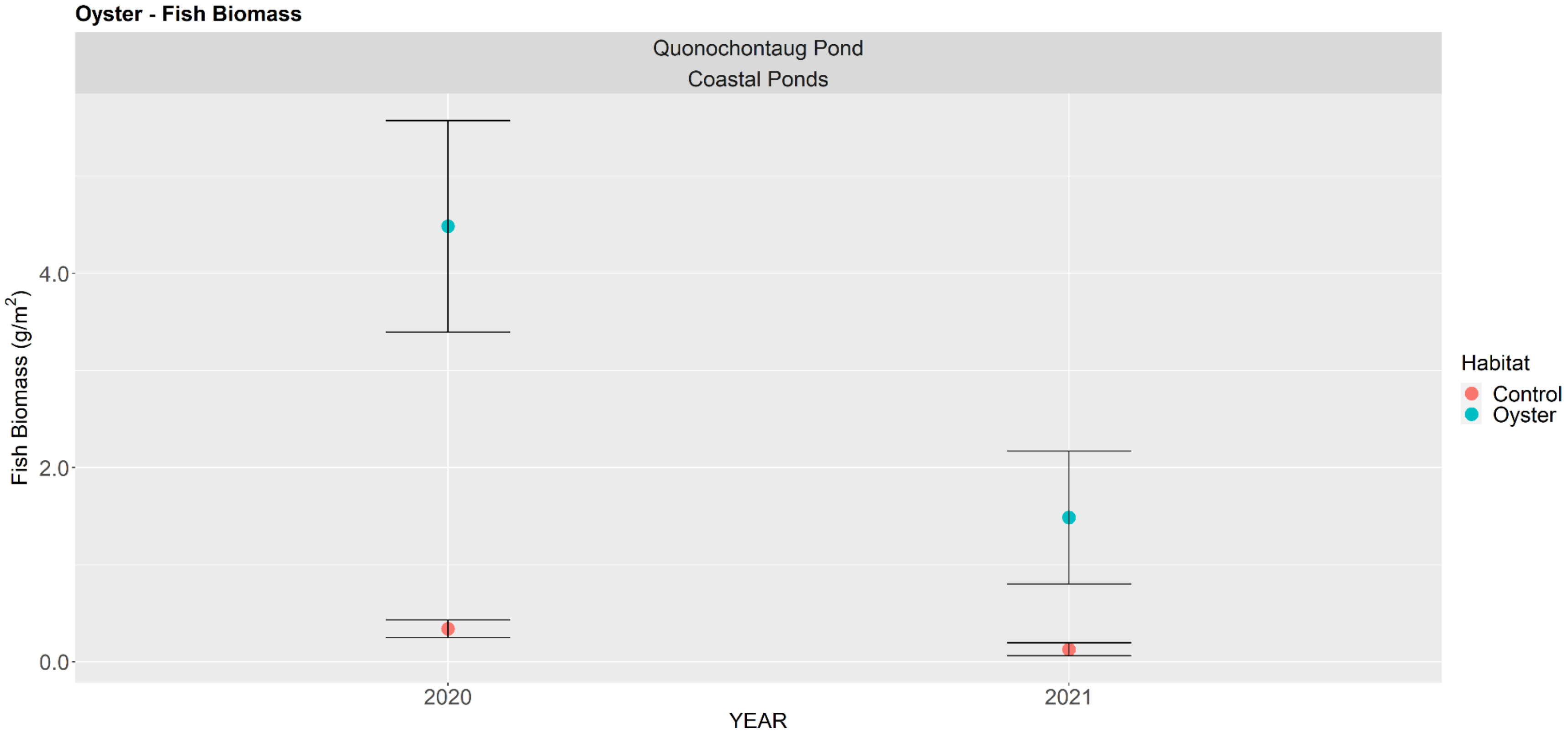


Figure 11. Quonochontaug Pond, mean fish biomass during the 2021 productivity dive surveys. Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment (Control = red, Oyster = blue).

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, 2021 - December 31, 2021

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: 12/31/2021

SUMMARY: This report summarizes project activities conducted between January 1 and December 31, 2021. 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.

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 continuing this method for all eelgrass canopy height, shoot density, and percent cover estimates. Hobo pendant loggers were unsuccessful and replacement temperature light loggers will be redeployed at the begging in of the 2022 season.

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 2021 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 2021. 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 in order 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 begging 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 2021).

In 2021, 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; 5D Eelgrass) for the 2020 and 2021 field seasons when applicable.

RESULTS:

In 2021, the eelgrass monitoring team completed activities relating to objective one by setting up

2 eelgrass monitoring sites, one in Quonochontaug Pond and the other in Jamestown, RI (Figures 1 and 2). Each location containing 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 Quonochontaug Pond). All eelgrass transects were selected based off of 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 2021, we completed 12 dives to monitor eelgrass habitat in RI waters. During the 2021 season, 3 of the temperature and light loggers were recover and all three received significant water damage. Different loggers will be purchased and deployed during the 2022 season 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 where as the Narragansett bay eelgrass sites were mostly sand and coble with sections of small boulders. In 2021, the average proportion of boulders (large, medium, and small combined) was approximately 2.5% at the Fort Wetherill eelgrass sites only and 0.66% percent at the coastal pond eelgrass transects (Figure 3). In 2021, the percent cover of eelgrass was numerically 4 % greater at the Quonochontaug Pond (89.38%) sites compared to those at Fort Wetherill (85.62%) (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 saw brown algae mats and *Gracillari*a sp. at low percent cover (Figure 4). In 2021, 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).

The major 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 (Figure 5 & 6). We found that Fort Wetherill quahog density was lower than the coastal ponds, with 0.83 ind/m^2 compared to 0.33 in the pond (Figure 5). Neither region was greater than the bay average of 0.8 ind./m^2. We found a higher density of crepidula across both the control and eelgrass sites in Fort Wetherill (10.56 ± 5.48 and 8.66 ± 1.33) relative to the coastal ponds (0 and 2.33 ± 2.1). Quonochontaug is a lower energy environment than Fort Wetherill and is comprised of finer substrate creating a more suitable habitat for burrowing mantis shrimp, which averaged (0.45 ± 0.142 ind./m^2) (Figure 6). We found the average 2021 eelgrass shoot density to vary by transect location, but on average were fairly similar, but slightly greater at Quonochontaug Pond than Fort Wetherill (Figure 7). Within the two regions, eelgrass shoot density varied by transect locations, ranging from 53.33 ± 10.86 – 123.33 ± 28.2 in Narragansett Bay and 77.33 ± 4.34 – 138 ± 29.84 in the Coastal Ponds (Table 2). Again in 2021, 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 8 and Table 3). In 2021, the effect size of eelgrass in the coastal ponds was over 4 times larger (2.39 ± 1.22 in the ponds and only 0.43 ± 0.86 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. (Figure 9). Comparing the effect sizes between each habitat and their respective controls, we found the 2021 effect size for eelgrass in the coastal pond to be the highest, whereas the bay eelgrass sites were lowest. Aside from the 2021 eelgrass sites in Quonochontaug Pond, we found the kelp sites typically have the greatest effect, then oyster and artificial reefs, the eelgrass (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 for RI, as well as track how changes in eelgrass density impact the community assemblage around them. In our second year of the survey we found that eelgrass in the coastal ponds continue to have one of the strongest effect on the fish biomass estimates regardless or region and habitat type. 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 2021). Landscape setting will also be important to consider, as the ecosystem function of eelgrass may differ depending on the 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.

Literature Cited:

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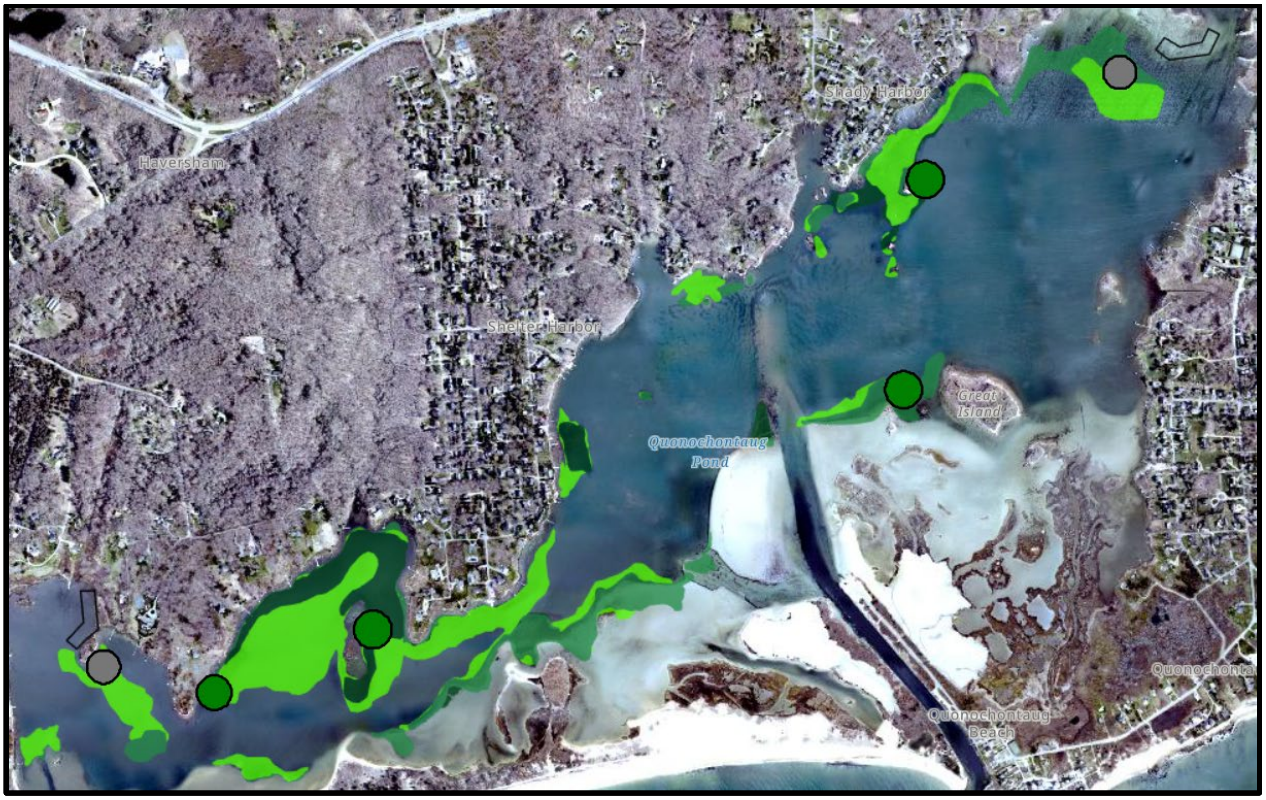


Figure 1: Eelgrass fish productivity transect locations for the Coastal Pond eelgrass region. Green circles denote eelgrass transects and grey circles are controls. Green map layers represent eelgrass layers identified during SAV mapping projects that took place from 2006-2016.

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.

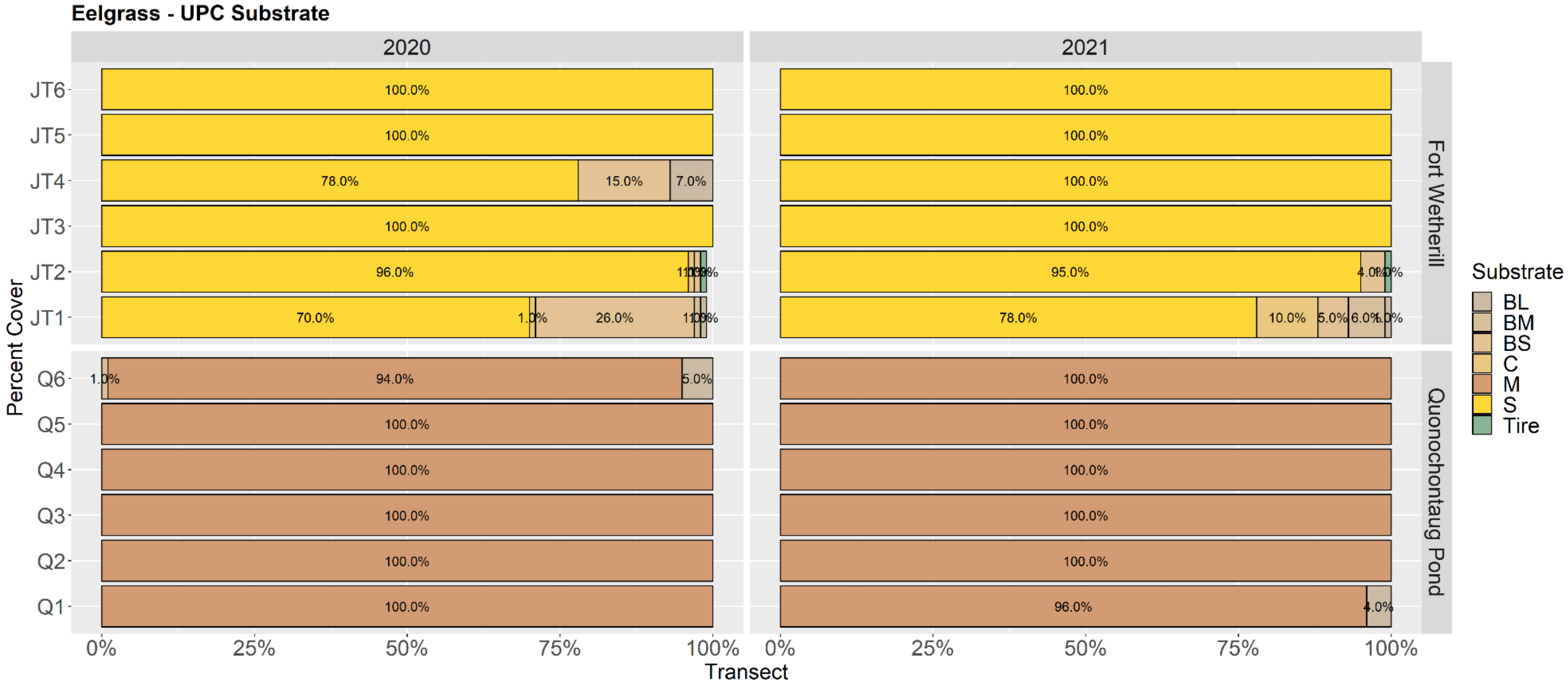


Figure 3. Percent cover of substrate along the y-axis plotted for each transect along the x-axis, for each 2020 and 2021 fish productivity Eelgrass survey. Percent cover is faceted by year and site (Fort Wetherill and Quonochontaug Pond), grouped by substrate type (BL = boulder large, BM = boulder medium, BS = boulder small, C= cobble, M = mud/fines, M_S = sandy mud mix, S = Sand

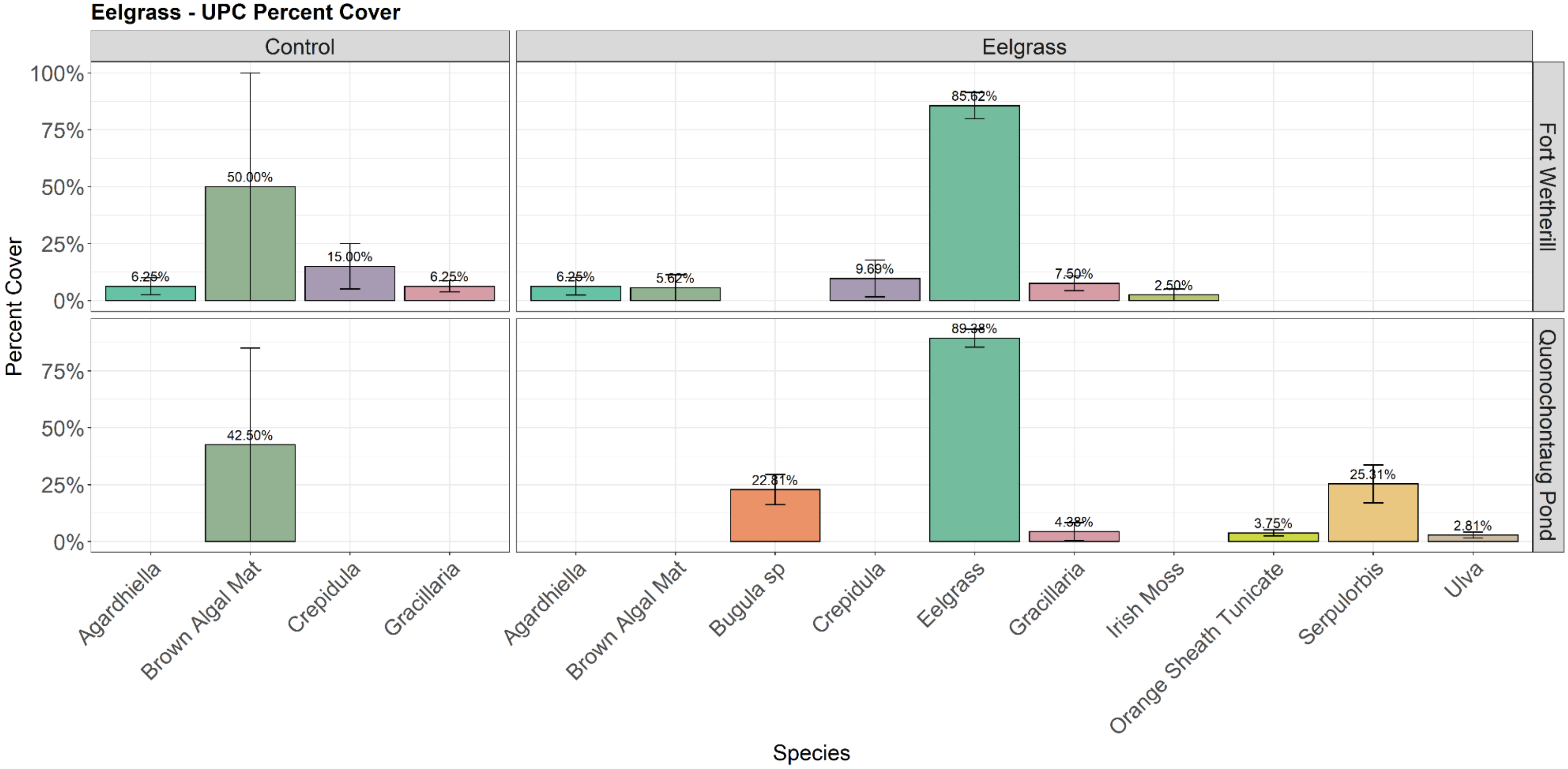


Figure 4. Mean algal and sessile invertebrate cover ± SE, for each site (Fort Wetherill and Quonochontaug Pond) and habitat type (Eelgrass or Control) during the 2021 eelgrass productivity uniform point count survey.

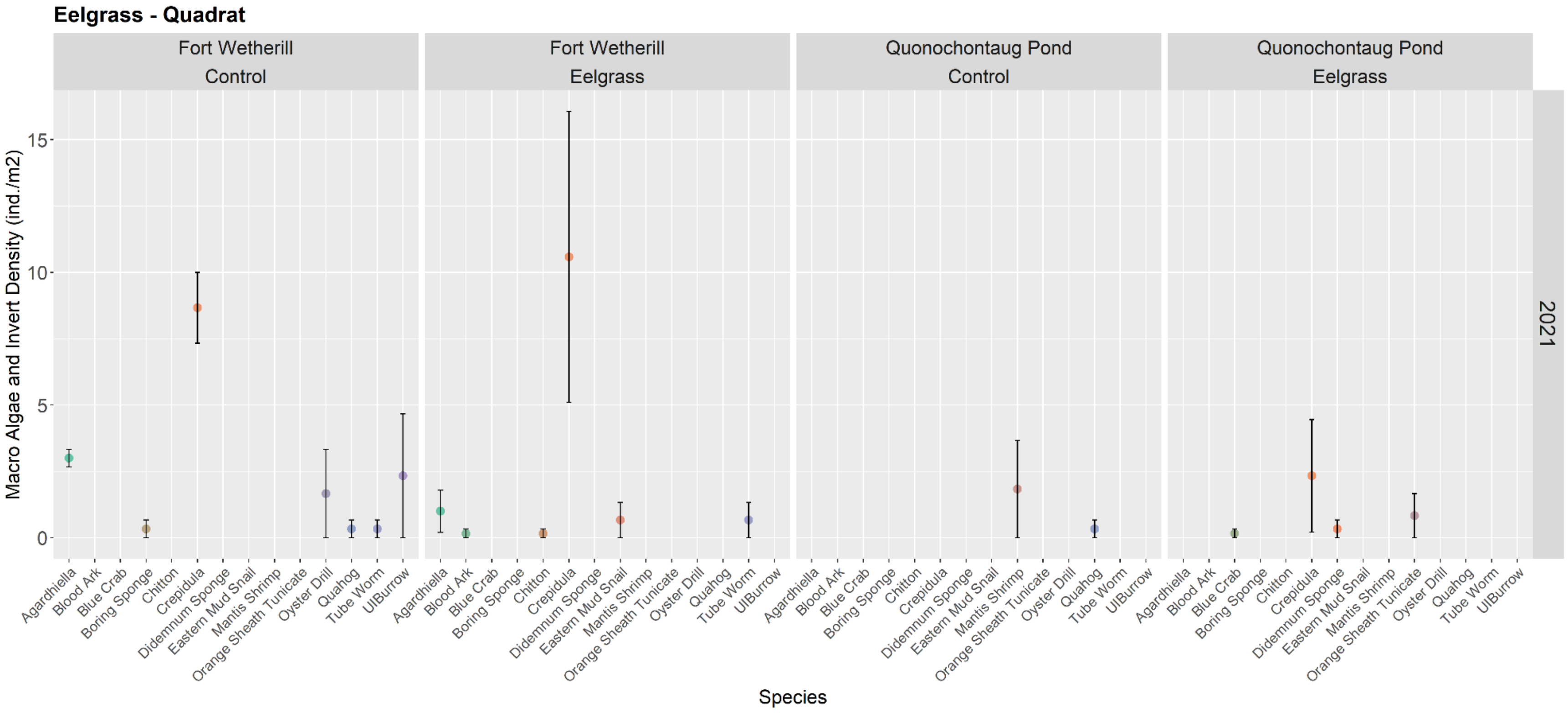


Figure 5. Mean invertebrate and macro algae density ± SE, for each species identified on the 2021 eelgrass productivity quadrat survey, faceted by habitat treatment (Control, Eelgrass) and site (Forth Wetherill and Quonochontaug Pond).

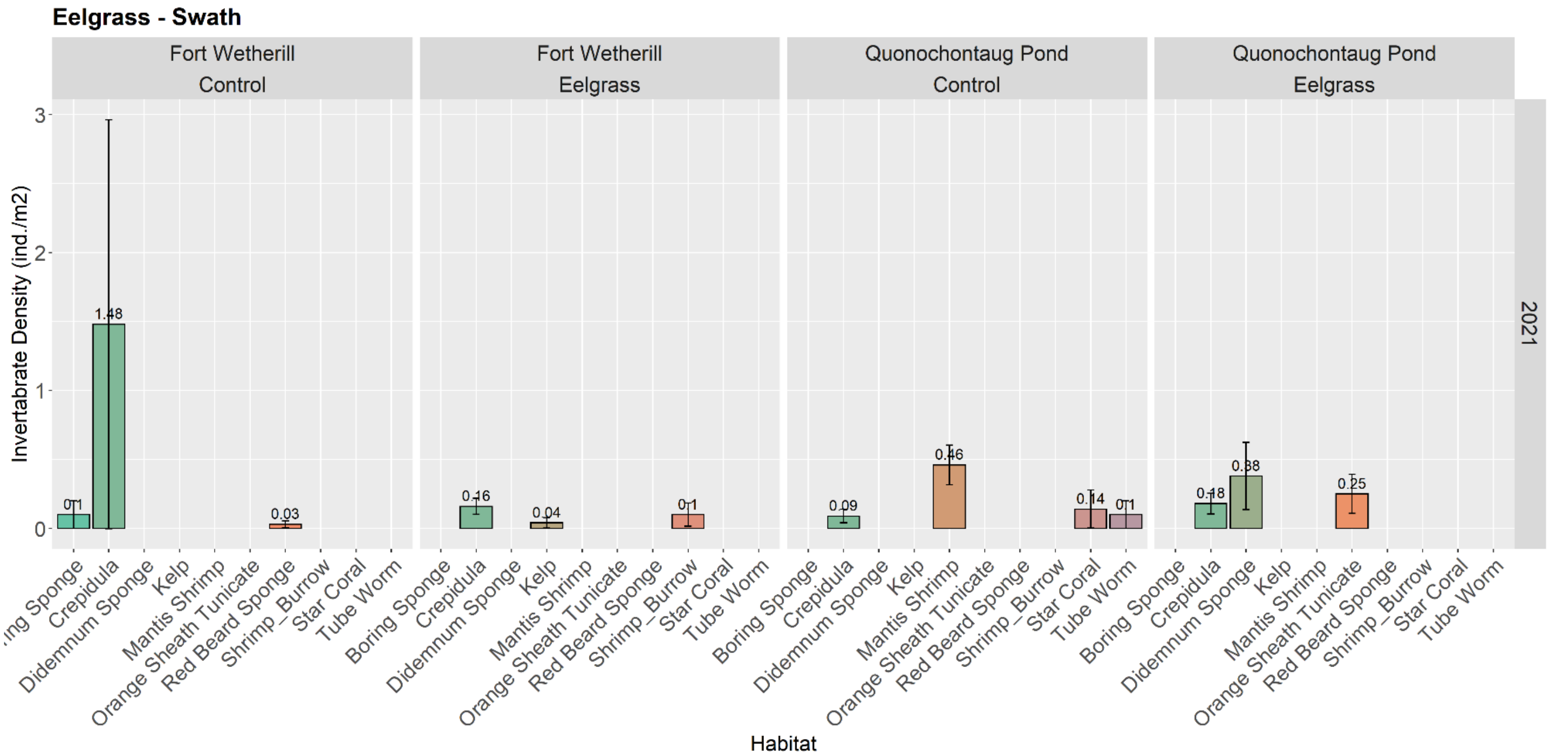


Figure 6. Mean invertebrate and macro algae density ± SE, for each species identified on the 2021 eelgrass productivity swath survey, faceted by habitat treatment (Control, Eelgrass) and site (Forth Wetherill and Quonochontaug Pond).

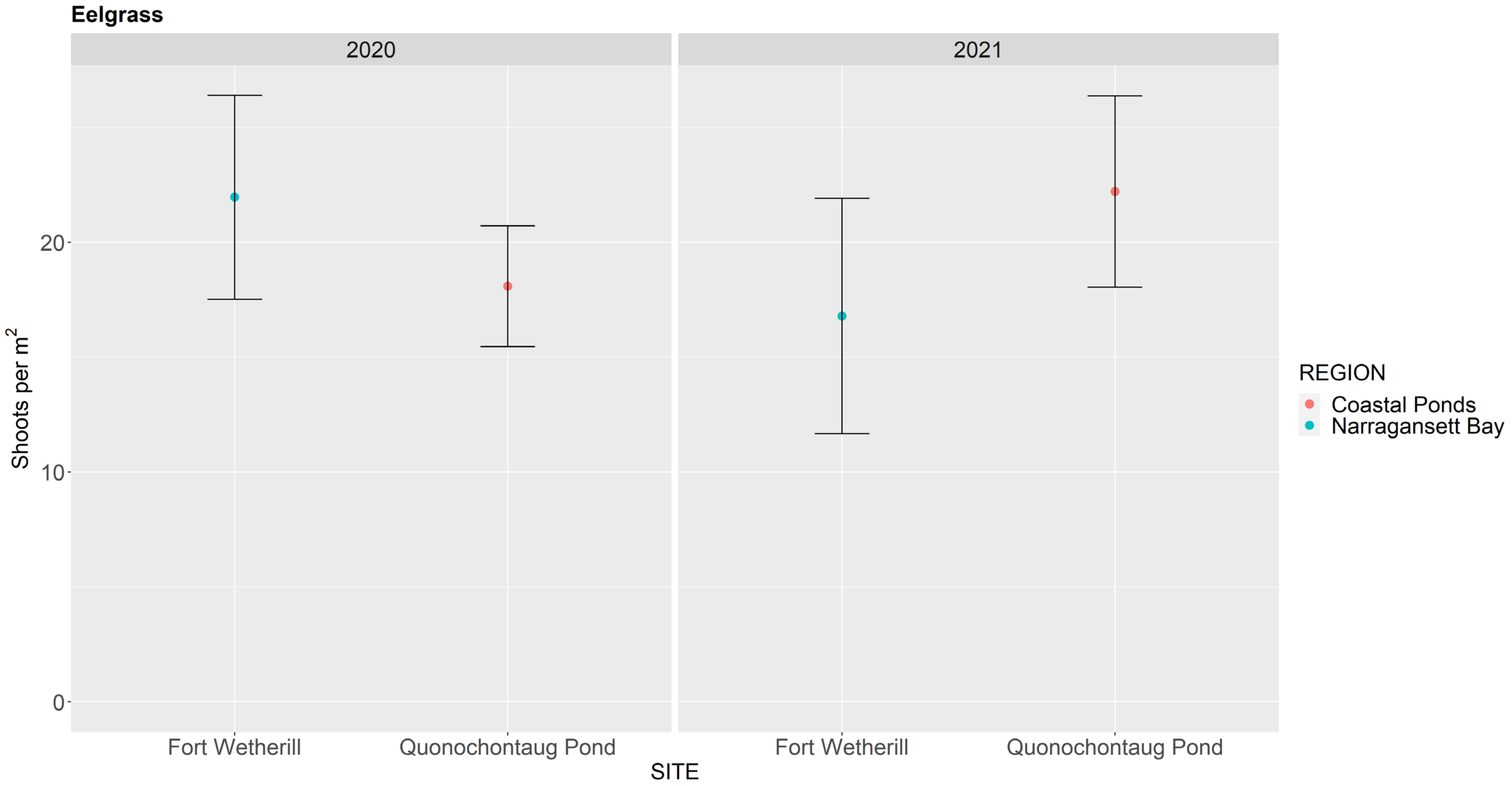


Figure 7. Eelgrass shoot density (y-axis), by mean density (x-axis), ± SE, by year and each eelgrass productivity region (Coastal Ponds = Red, Narragansett Bay = Blue).

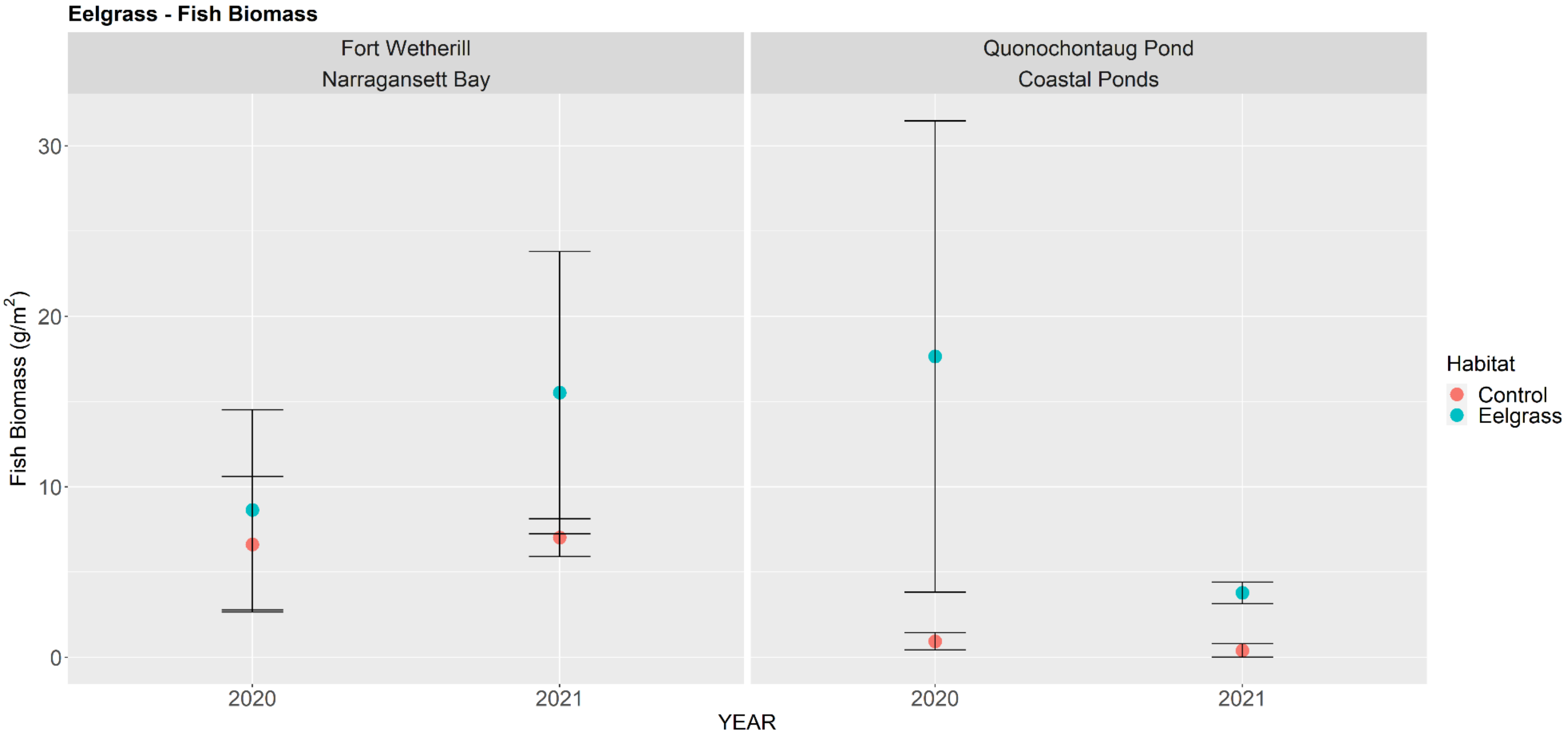


Figure 8: Mean fish biomass (g/m^2) estimates for the Eelgrass productivity fish count survey grouped by habitat treatment (Control = Red, and Eelgrass = Blue) and year for each site (Fort Wetherill, left panel; Quonochontaug Pond, right panel). Fish biomass is standardized per meter squared and presented as the average biomass ± SE, for each habitat treatment

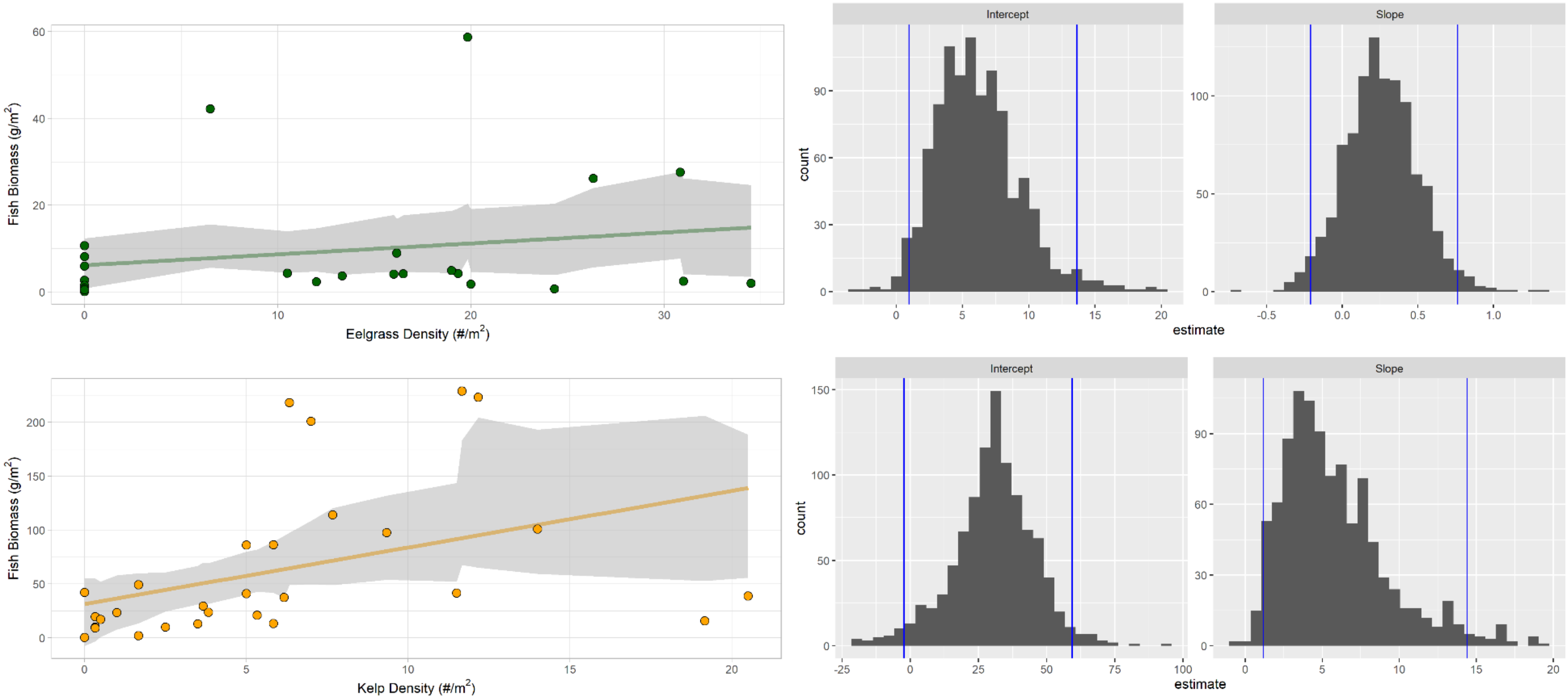
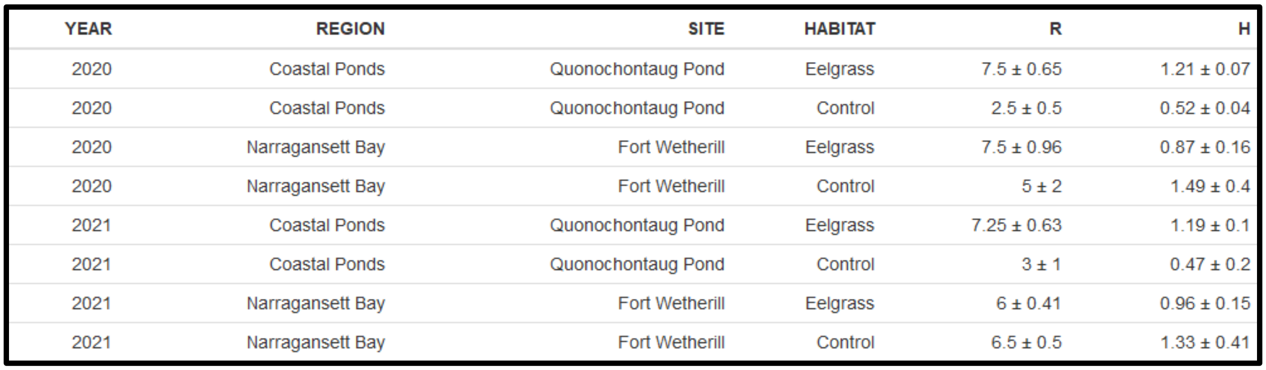


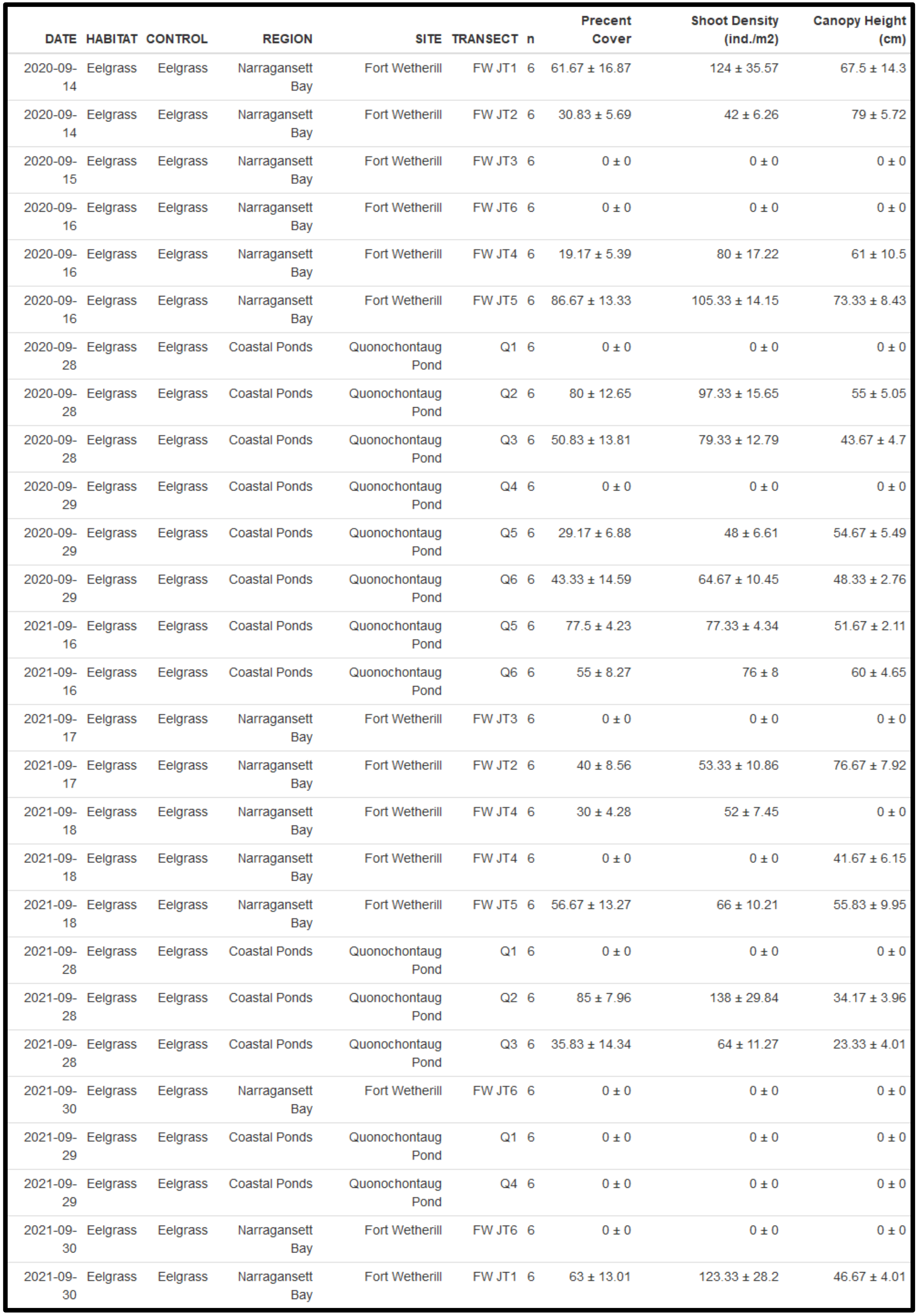
Figure 9: Mean fish biomass (g/m^2) as a function of increasing habitat density for each of the habitat forming species in Job 5 (Eelgrass = green (top row); Kelp = orange (bottom row). Linear regression models plotted with 95% CI estimated from 1,000 bootstrap samples for the 2021 fish productivity 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.

Table 1: Algae and Sessile Invertebrate species richness and diversity calculated from the uniform point count transect method for the 2020 and 2021 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.



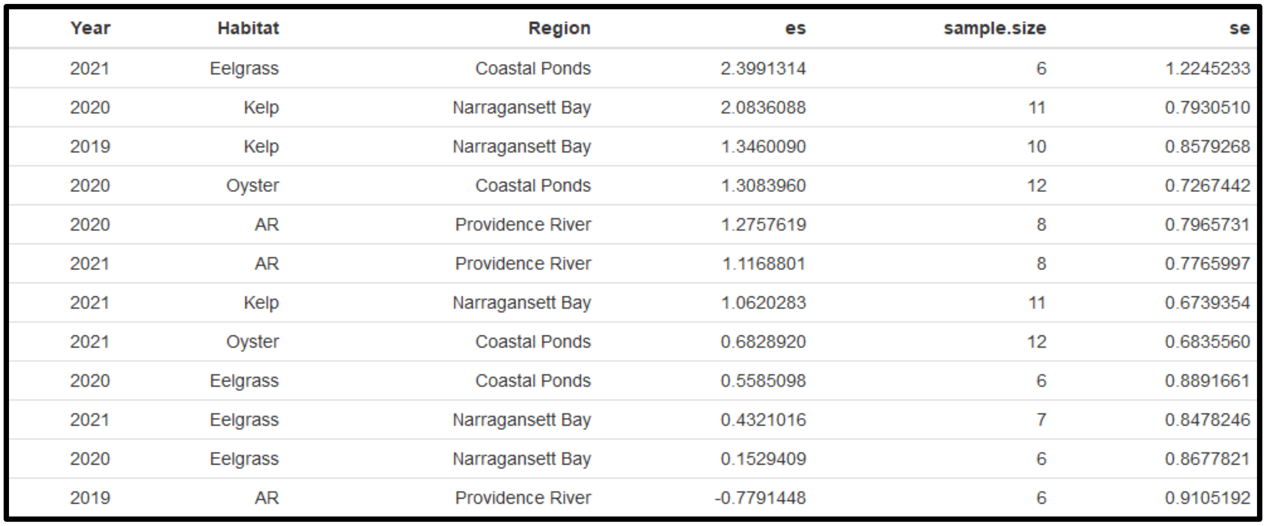
YEAR	REGION	SITE	HABITAT	R	H
2020	Coastal Ponds	Quonochontaug Pond	Eelgrass	7.5 ± 0.65	1.21 ± 0.07
2020	Coastal Ponds	Quonochontaug Pond	Control	2.5 ± 0.5	0.52 ± 0.04
2020	Narragansett Bay	Fort Wetherill	Eelgrass	7.5 ± 0.96	0.87 ± 0.16
2020	Narragansett Bay	Fort Wetherill	Control	5 ± 2	1.49 ± 0.4
2021	Coastal Ponds	Quonochontaug Pond	Eelgrass	7.25 ± 0.63	1.19 ± 0.1
2021	Coastal Ponds	Quonochontaug Pond	Control	3 ± 1	0.47 ± 0.2
2021	Narragansett Bay	Fort Wetherill	Eelgrass	6 ± 0.41	0.96 ± 0.15
2021	Narragansett Bay	Fort Wetherill	Control	6.5 ± 0.5	1.33 ± 0.41

Table 2: Eelgrass s Morphometrics table. Mean percent cover (%), shoot density (#/m^2), and canopy height (cm), ± se, for each 2020 and 2021 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	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT3	6	0 ± 0	0 ± 0	0 ± 0
2020-09-16	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT6	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
2020-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q1	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
2020-09-29	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q4	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
2021-09-16	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q5	6	77.5 ± 4.23	77.33 ± 4.34	51.67 ± 2.11
2021-09-16	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q6	6	55 ± 8.27	76 ± 8	60 ± 4.65
2021-09-17	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT3	6	0 ± 0	0 ± 0	0 ± 0
2021-09-17	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT2	6	40 ± 8.56	53.33 ± 10.86	76.67 ± 7.92
2021-09-18	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT4	6	30 ± 4.28	52 ± 7.45	0 ± 0
2021-09-18	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT4	6	0 ± 0	0 ± 0	41.67 ± 6.15
2021-09-18	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT5	6	56.67 ± 13.27	66 ± 10.21	55.83 ± 9.95
2021-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q1	6	0 ± 0	0 ± 0	0 ± 0
2021-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q2	6	85 ± 7.96	138 ± 29.84	34.17 ± 3.96
2021-09-28	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q3	6	35.83 ± 14.34	64 ± 11.27	23.33 ± 4.01
2021-09-30	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT6	6	0 ± 0	0 ± 0	0 ± 0
2021-09-29	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q1	6	0 ± 0	0 ± 0	0 ± 0
2021-09-29	Eelgrass	Eelgrass	Coastal Ponds	Quonochontaug Pond	Q4	6	0 ± 0	0 ± 0	0 ± 0
2021-09-30	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT6	6	0 ± 0	0 ± 0	0 ± 0
2021-09-30	Eelgrass	Eelgrass	Narragansett Bay	Fort Wetherill	FW JT1	6	63 ± 13.01	123.33 ± 28.2	46.67 ± 4.01

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
2021	Eelgrass	Coastal Ponds	2.3991314	6	1.2245233
2020	Kelp	Narragansett Bay	2.0836088	11	0.7930510
2019	Kelp	Narragansett Bay	1.3460090	10	0.8579268
2020	Oyster	Coastal Ponds	1.3083960	12	0.7267442
2020	AR	Providence River	1.2757619	8	0.7965731
2021	AR	Providence River	1.1168801	8	0.7765997
2021	Kelp	Narragansett Bay	1.0620283	11	0.6739354
2021	Oyster	Coastal Ponds	0.6828920	12	0.6835560
2020	Eelgrass	Coastal Ponds	0.5585098	6	0.8891661
2021	Eelgrass	Narragansett Bay	0.4321016	7	0.8478246
2020	Eelgrass	Narragansett Bay	0.1529409	6	0.8677821
2019	AR	Providence River	-0.7791448	6	0.9105192

Protecting and Minimizing Adverse Impacts to Marine Fish Habitat

Eric Schneider, Anna Gerber-Williams, and Katie Rodrigue

Rhode Island Department of Environmental Management,
Division of Marine Fisheries
Eric.Schneider@dem.ri.gov

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

2021 Performance Report

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

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

Period Covered: January 1, 2021 - December 31, 2021

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, 2021

Deviations: No deviations occurred during 2021.

Recommendations: *None*

Remarks: *None*

Summary:

Objective 1: As part of its environmental review program during 2021, DMF reviewed 85 permit applications that contained approximately 181 separate activities that posed potential impacts to marine resources (Table 1). Although the number of permits reviewed in 2021 (85 permits) returned to a level similar to the average over the previous seven years, the number of activities with potential impacts to marine resources was nearly 50% greater than the average number of over the past seven years (Table 2). Activities such as the construction of new residential docks, construction of new commercial and municipal piers, and projects with new dredging appeared greater than average over the last seven years, with potential impacts to submerged aquatic vegetation (SAV) and benthic habitat, and salt marsh or coastal wetlands appearing more often than average over the past seven years. Despite the ongoing 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 6 preliminary determination meetings with aquaculture applicants. DMF also created site maps for 4 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 3 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 January 2021.

Objective 2: DMF staff continued to participate in collaborative emergency response training and engagement with other state agencies, NOAA, the USCG, and the University of Rhode Island by attending the annual summer workshop for SSEER (Scientific Support for Environmental Emergency Response) as well as a “table-top” oil spill response training exercise for Sakonnet River. In addition, RI DMF received a total of seven reports of fish kill events. Six of these reports required RI DMF to respond and assess the scene.

Objective 3: DMF staff continue to participate 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 2021 the team completed the spatial data inventory and 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 has also nearly completed a literature review to summarize habitat use, life history, and management of the 65+ focus fish species in the assessment. In addition, initial modeling work was completed in 2021, during which the inshore and offshore teams began joint and single species modeling efforts to determine species distributions and habitat use. The inshore working group continued work to link species assemblages to habitat types and using an online shinny App, mapped locations and extent of habitat utilization by focus species including inshore habitat types (SAV, oyster reefs etc.), building on existing databases, and began to develop species distribution maps and future predicted distribution.

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 2021, DMF reviewed 85 permit applications that contained approximately 181 separate activities that posed potential impacts to marine resources (Table 1). Although the number of permits reviewed in 2021 (85 permits) returned to a level similar to the average over the previous seven years ($\bar{x}$ = 81, Table 2), the number of activities with potential impacts to marine resources was nearly 50% greater than the average number of over the past seven years ($\bar{x}$ = 122, Table 2). Activities such as the construction of new residential docks, construction of new commercial and municipal piers, and projects with new dredging (i.e., dredging in areas not previously dredged) appeared greater than average over the last seven years (Table 2), with potential impacts to submerged aquatic vegetation (SAV) and benthic habitat, and salt marsh or coastal wetlands appearing more often than average over the past seven years (Table 2). Despite the ongoing 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 continued work with the USACE to develop an eelgrass restoration plan that will be implemented over the next 3 years in Winnapaug Pond, participation in the updating and reissuance of the USACE Northeast Region General Permit for RI, and reviewing and working with applicants to update the application for removal of the Upper and Lower impoundments in the Kickemuit River. The latter project aims to reestablish aquatic connectivity between the freshwater and estuarine portions of the Kickemuit River, which will re-establish tidal estuarine habitat that was removed over 160 years ago when the impoundments were first created.

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 6 preliminary determination meetings with aquaculture applicants during 2021. DMF also created site maps for 4 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 3 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 January 2021.

During 2021 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 2022.

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 2021, RI DMF responded to seven reports of fish kill events. Table 3 shows a summary of these events. All events were due to natural causes, the majority of which being related to intermittent hypoxia and high water temperatures. The species most affected was Atlantic menhaden, but one event also affected blue crabs. Two fish kill events involving Atlantic menhaden occurred in December 2021, most likely due to cold shock or succumbing to the stress of poor conditions (cold water and lack of available food). Similar events were seen last year in Rhode Island, Connecticut, New York, and New Jersey. In 2020, 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 analyzed in RI in either 2020 or 2021, 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 continued its participation 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) and Atlantic States Marine Fishery Council (ASFMC), 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 2021 the team completed the spatial data inventory and, 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 nearly completed a literature review 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 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 2021, during which the inshore and offshore teams began joint and single species modeling efforts to determine species distributions and habitat use. The inshore working group continued work to link species assemblages to habitat types and using an online shinny App, mapped locations and extent of habitat utilization by focus species including inshore habitat types (SAV, oyster reefs etc.), building on existing databases, and began to develop species distribution maps and future predicted distribution. During 2022, teams are expected to develop a matrix that identifies habitat and species climate vulnerabilities, and the dependence of species on habitats. Results describing these relationships and highlighting areas of particular interest/concern will be shared with the Coordination Team.

Table 1. Activities and potential impacts identified during the permit review process performed in 2021 by RI DMF for 85 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	11	10	6	4	1		4	36
Saltmarsh Restoration	2		2	1				5
Eelgrass Restoration	2							2
Artificial Reef								0
Maintenance Dredging	1		2	2	1		3	9
New Dredging	3	2	2					7
New Marina								0
Marina Expansion or Reconfiguration	2		1					3
Restoration of Tidal Flow or Dam Removal			1					1
Residential Docks (New)	10	11	9	7	4			41
Residential Docks (Modifications)	4				1			5
Commercial/Municipal Piers or Docks	2	3	3	1			1	10
Commercial/Municipal Mooring Field Expansion		1						1
Potentail Salt Marsh or Coastal Wetland Impacts	6	2	5	1	1			15
Beach Nourishment or Coastal Feature Resiliency								0
Waterfront Bulkhead/Riprap		2	3	1				6
Waterfront Development		2	3	1				6
Public Works, Utility, Energy		2	2	2				6
Fish Passage		1	2	2			1	6
Potential Shellfish Impacts			1					1
Channel Maintenance	1		3	1	1		1	7
Boat Ramps	1							1
Oyster Restoration								0
Recreational Access or Fishing (Improve/Impacts)	1	1	2	2			1	7
Impacts from Discharge or Stromwater			3	3				6
Total	46	37	50	28	9	0	11	181

Table 2. Activities and potential impacts identified during the permit review process over the last seven years, including the previous (2014 – 2020) and current (2021) grant cycle. Aquaculture-related reviews are excluded from this table.

	Permit Review During Previous 7 Years									
Activities & Potential Impacts	2014	2015	2016	2017	2018	2019	2020	Total	Average Per Year	2021 Total
Potential Impacts to SAV or Benthic Habitat	0	0	1	5	11	13	30	60	8.6	36
Saltmarsh Restoration	4	5	3	3	6	4	4	29	4.1	5
Eelgrass Restoration	1	0	0	1	4	0	1	7	1.0	2
Artificial Reef	1	0	0	0	1	1	0	3	0.4	0
Maintenance Dredging	8	8	10	17	6	8	12	69	9.9	9
New Dredging	3	1	0	2	2	2	3	13	1.9	7
New Marina	3	2	0	0	2	0	0	7	1.0	0
Marina Expansion or Reconfiguration	0	1	3	2	2	5	8	21	3.0	3
Restoration of Tidal Flow to Coastal Pond	1	0	0	2	5	0	2	10	1.4	1
Residential Docks (New)	40	20	23	0	29	18	35	165	23.6	41
Residential Docks (Modifications)	7	2	7	39	39	13	30	137	19.6	5
Commercial/Municipal Piers or Docks	1	3	0	13	5	5	13	40	5.7	10
Commercial/Municipal Mooring Field Expansion	0	0	5	0	0	2	1	8	1.1	1
Salt Marsh or Coastal Wetland Impacts	0	0	0	16	14	8	21	59	8.4	15
Beach Nourishment or Coastal Feature Resiliency	2	0	3	1	4	6	4	20	2.9	0
Waterfront Bulkhead/Riprap	4	1	2	11	6	11	18	53	7.6	6
Waterfront Development	1	0	0	0	1	4	2	8	1.1	6
Public Works or Utility	1	0	1	1	6	7	17	33	4.7	6
Fish Passage	0	0	0	0	0	0	12	12	1.7	6
Potential Shellfish Impacts	0	0	0	4	4	4	5	17	2.4	1
Channel Maintenance	0	0	0	5	1	4	6	16	2.3	7
Boat Ramps	1	1	0	2	1	2	10	17	2.4	1
Oyster Restoration	0	4	0	2	4	0	5	15	2.1	0
Recreational Use (Improve/Impacts)	0	0	0	0	7	3	8	18	2.6	7
Impacts from Discharge	0	0	0	6	3	2	3	14	2.0	6
Coastal Restoration Other	0	0	0	5	0	0	0	5	0.7	0
Total - Activities & Potential Impacts	78	48	58	137	163	122	250	856	122	181
Total - Projects Reviewed	85	68	51	77	95	72	118	566	81	85

Table 3. Summary of fish kill events in 2021.

Date Reported	Water Body	Persons/Agencies Notified	Response	Date of Response	Species Affected	Approximate number affected/dead	Water Quality Measured	Samples Taken	Photos	Cause
6/22/2021	Providence River	DEM DLE, DEM DMF	DEM DMF responded to the scene	6/22/2021	Atlantic menhaden	~50	Y	N	Y	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)
7/22/2021	Greenwich Bay	DEM DLE, DEM DMF, DEM OWR	DEM DMF responded to the scene	7/22/2021	Atlantic menhaden	Moderate (100-1000)	Y	N	Y	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)
7/22/2021	Barrington River	DEM DMF, DEM OWR	Response not deemed necessary	NA	Blue crab	Minor to Moderate	N	N	N	Hypoxic conditions due to heat wave
9/27/2021	Seekonk River	DEM DMF, DEM DLE, DEM OWR	DEM DMF responded to the scene	9/27/2022	Atlantic menhaden	Moderate to major (thousands)	Y	N	Y	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)
10/4/2021	Pawtuxet Cove	DEM DMF	DEM DMF responded to the scene	10/4/2021	Atlantic menhaden *Brevoortia tyrannus*	Moderate (100-1000)	Y	N	Y	Natural - ongoing intermittent hypoxia combined with high concentration of fish and predators chasing them into shallow waters (localized depletion of DO)

12/2/2021	Pawtuxet Cove	DEM DMF	DEM DMF responded to the scene	12/2/2021	Atlantic menhaden	Minor (1-2 dozen)	N	Y	Y	Likely due to cold shock or poor health due to increasingly cold conditions. Freshly dead individual taken as sample and frozen in case of future pathology testing opportunity.
12/2/2021	Seekonk River	DEM OWR, DEM DMF,	DEM DMF responded to the scene	12/2/2021	Atlantic menhaden *Brevoortia tyrannus*	Minor to none	Y	N	N	Possibly due to cold shock based on similar event in Pawtuxet River on the same day. No dead fish seen upon investigation. Suggestion that this was due to an "oil spill" (tar seep from contaminated soils) but no evidence that this was the case.

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, 2021 to December 31, 2021

Prepared By

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

Approved By

Scott Comings, Associate State Director

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159 Waterman Street
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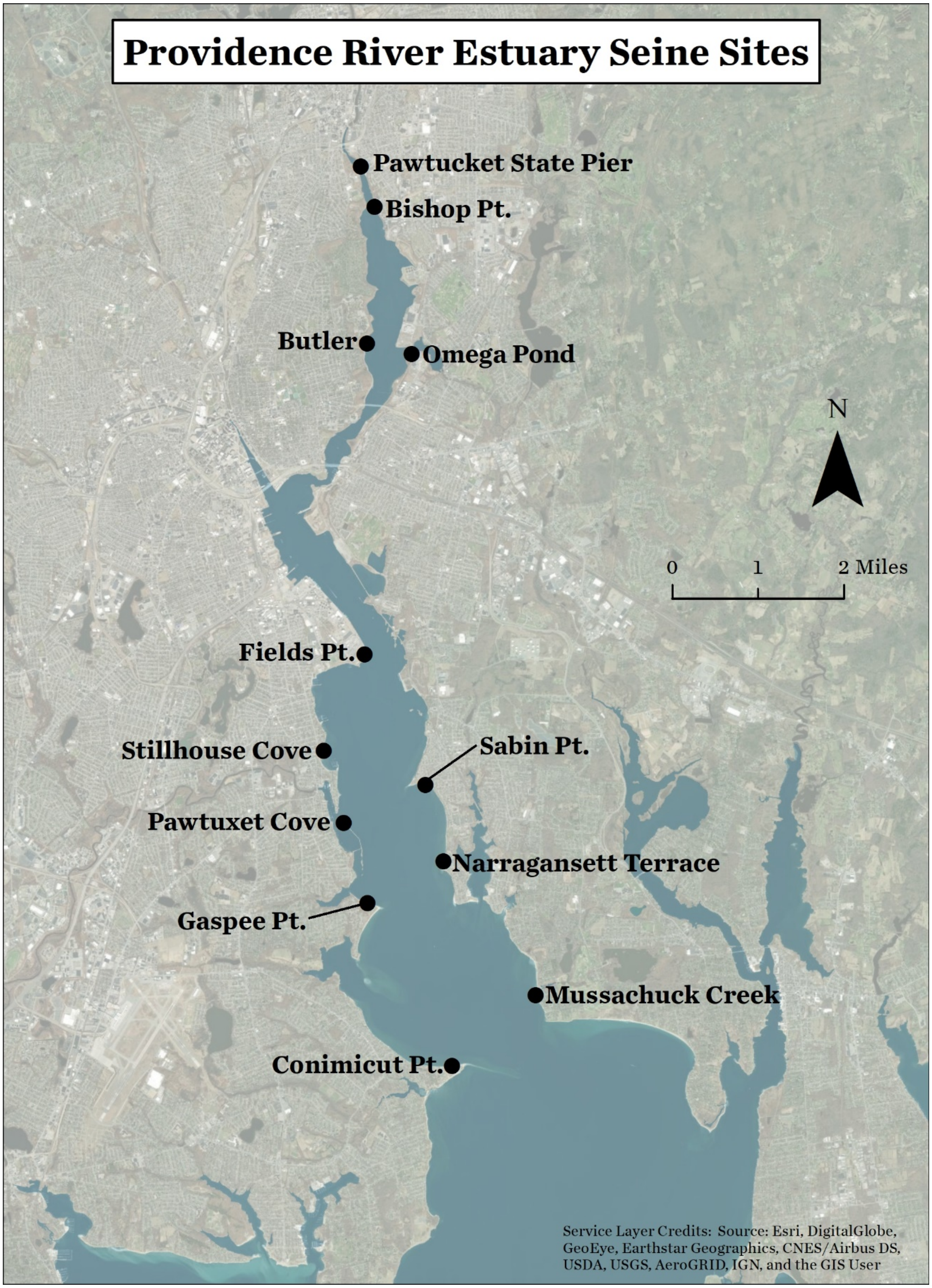
Protecting nature. Preserving life.

Map of study area and sampling locations.



SUMMARY

During the 2021 season, a total of 72 seines were hauled across 12 sites in May through October resulting in the enumeration of 88,570 individuals. Of the animals caught, 6,160 were measured and 48 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, 2021

NEXT STEPS

Investigators intend to continue sampling with the same methodology during the field season of 2022. Additionally, the project team will continue 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 2021 field sampling season, a total of 72 seines were hauled across the 12 sampling sites. A total of 88,570 individuals were identified and enumerated, and 6,160 of those were measured. A total of 68 species were caught (Table 1). Of the species caught, only finfish were included in the results below (all crustaceans were excluded).

A mean of 1,225.26 ± 700.05 SE finfish were caught per haul. Catch per haul across sites was greatest at Omega Pond at 8,623.67 ± 8,290.85 SE and lowest at Narragansett Terrace at 109.67 ± 54.07 SE (Figure 1). Catch per haul across months was greatest in September at 4,472.50 ± 4147.05 SE and lowest in July at 188.75 ± 71.54 SE (Figure 2).

Winter Flounder (*Pseudopleuronectes americanus*)

Of the total 4,756 winter flounder caught in 2021 seines, all were young of the year (max length = 99mm; Able and Fahay 1998; Berry et al. 1965). Winter flounder were caught at all 12 sites and in all months. The most abundant site for winter flounder was Bishop Point. at a catch per haul of 515.50 ± 379.14 SE. The most abundant month for winter flounder was May at a catch per haul of 275.83 ± 211.96 SE (Table 2).

Summer Flounder (*Paralichthys dentatus*)

A total of 44 summer flounder were caught in 2021 beach seines ranging in size from 3cm to 12cm, Summer flounder were caught at 8 of the 12 sites: Pawtucket State Pier, Bishop Point, Butler, Stillhouse Cove, Sabin Point, Fields Point, Pawtuxet Cove, and Gaspee Point. Summer flounder were most abundant at Pawtucket State Pier, at a catch per haul of 3.50 ± 2.28 SE. Most individuals were caught in May at a catch per haul of 1.75 ± 1.24 SE (Figure 3a and 3b).

Tautog (*Tautoga onitis*)

A total of 218 tautog were caught in 2021 beach seines ranging in size from 2cm to 14cm. Tautog were caught at 7 of the 12 sites: Fields Point, Stillhouse Cove, Sabin Point, Narragansett Terrace, Gaspee Point, Mussachuck Creek, and Conimicut Point. Of the 7 sites they were caught, tautog were most abundant at Conimicut Point, a catch per haul of 10.33 ± 8.00 SE. The most individuals were caught in August at a catch per haul of 8.67 ± 4.38 SE (Figure 3a and 3b).

Black Sea Bass (*Centropristis striata*)

A total of 28 black sea bass were caught in 2021 beach seines between 5cm and 27cm. These fish were caught at 3 sites: Fields Point, Gaspee Point, Conimicut Point. They were most abundance at Fields Point, at a catch per haul of 3.17 ± 2.24SE. Most individuals were caught in September at a catch per haul of 1.67 ± 1.28 SE (Figure 3a and 3b).

Scup (*Stenotomus chrysops*)

A total of 13 scup were caught in 2021 beach seines ranging in size from 3cm to 4cm. All scup were caught in June at Fields Point (Figure 3a and 3b).

Atlantic Menhaden (*Brevoortia tyrannus*)

In the 2021 sampling season, 63,842 Atlantic menhaden were caught, ranging in size from 3cm to 26m. The total survey mean abundance index is 866.69 ± 700.27 SE. Atlantic menhaden were found July through October at all sites except Gaspee Point.

River Herring (*Alosa pseudoharengus & Alosa aestivalis*)

A total of 3,159 river herring were caught in 2021. 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 14cm and were found May through October at all sampling sites except Pawtuxet Cove and Sabin Point with a total survey mean abundance of 43.88 ± 29.95 SE.

Bluefish (*Pomatomus saltatrix*)

A total of 274 bluefish were caught in 2021. The total mean abundance is 3.81 ± 1.98 SE ranging in size from 7cm to 21cm. Bluefish were found August through September at all sites except Pawtucket Boat Ramp and Bishop Point.

Gizzard Shad (*Dorosoma cepedianum*)

A total of 281 gizzard shad were caught in 2021. The total mean abundance is 3.90 ± 3.30 SE ranging in size from 3cm to 14cm. Gizzard Shad were found July, August, and October at three sites in the Seekonk River: Pawtucket Boat Ramp, Bishop Point, and Omega Pond.

Silverside (*Menidia spp.*)

A total of 9,557 silversides were caught in 2021. 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 132.74 ± 28.62 SE and silversides ranged in size from 4cm to 14cm, found in all months and at all sites.

Striped Killifish (*Fundulus majalis*)

A total of 2,821striped killifish were caught in 2021, ranging in size from 3cm to 13cm. The total mean abundance is 39.18 ± 9.88 SE, and they were found at all sites except Pawtucket Boat Ramp from May through October.

Common Mummichog (*Fundulus heteroclitus*)

A total of 1,815 common mummichog were caught in 2021, ranging in size from 3cm to 11cm. The total mean abundance is 25.21 ± 0.12 SE, and they were found at all sites from May through October.

Water Quality Data

Water quality data for the 2021 season can be found in Table 3. Water temperature ranged from 11.8C in May to 26.1C in June. The mean salinity of the four sites within the Seekonk River was 4.09ppt ± 0.67 SE and the mean salinity of the eight sites within the Providence River was 18.77ppt ± 0.91 SE. The lowest dissolved oxygen value recorded across all sites was 5.05mg/L in August at Sabin Point, while the mean was 8.68mg/L ± 0.23 SE.

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FIGURES:

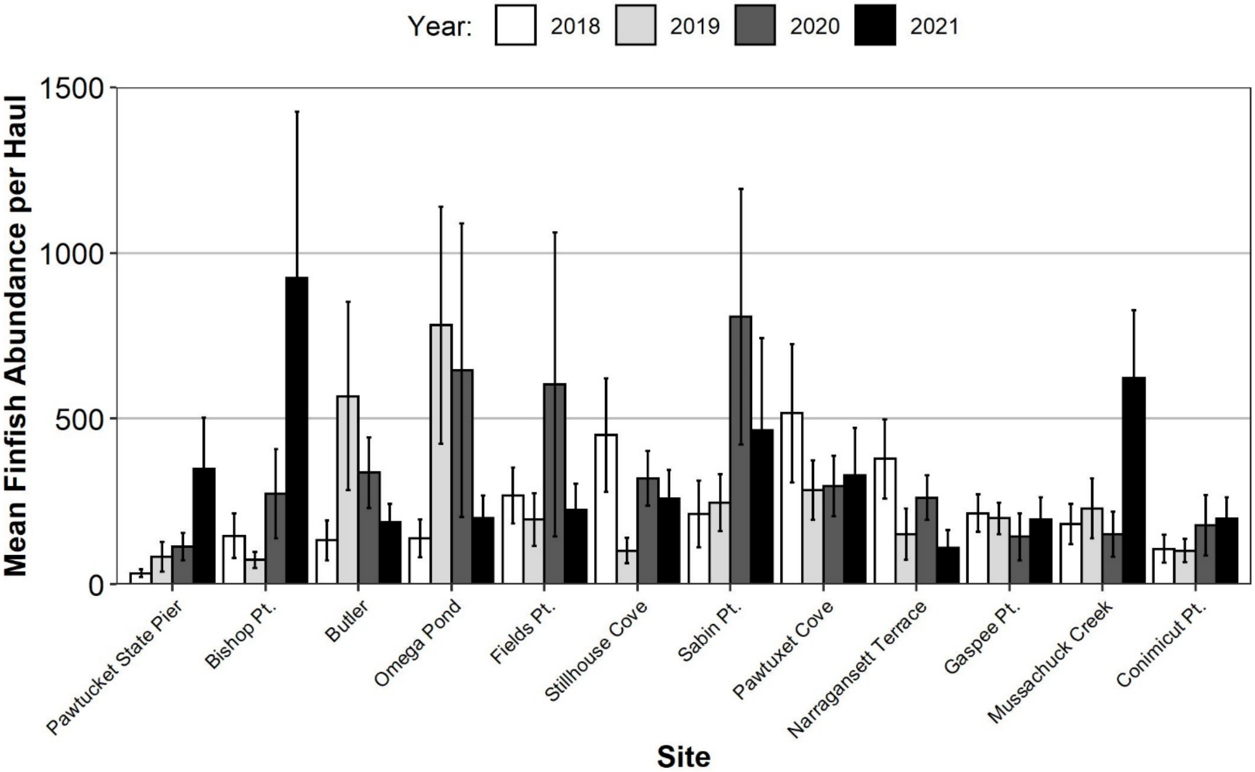


Figure 1. Mean abundance of finfish (excluding Atlantic Menhaden) across sites (±SE) in 2018-2021 beach seines.

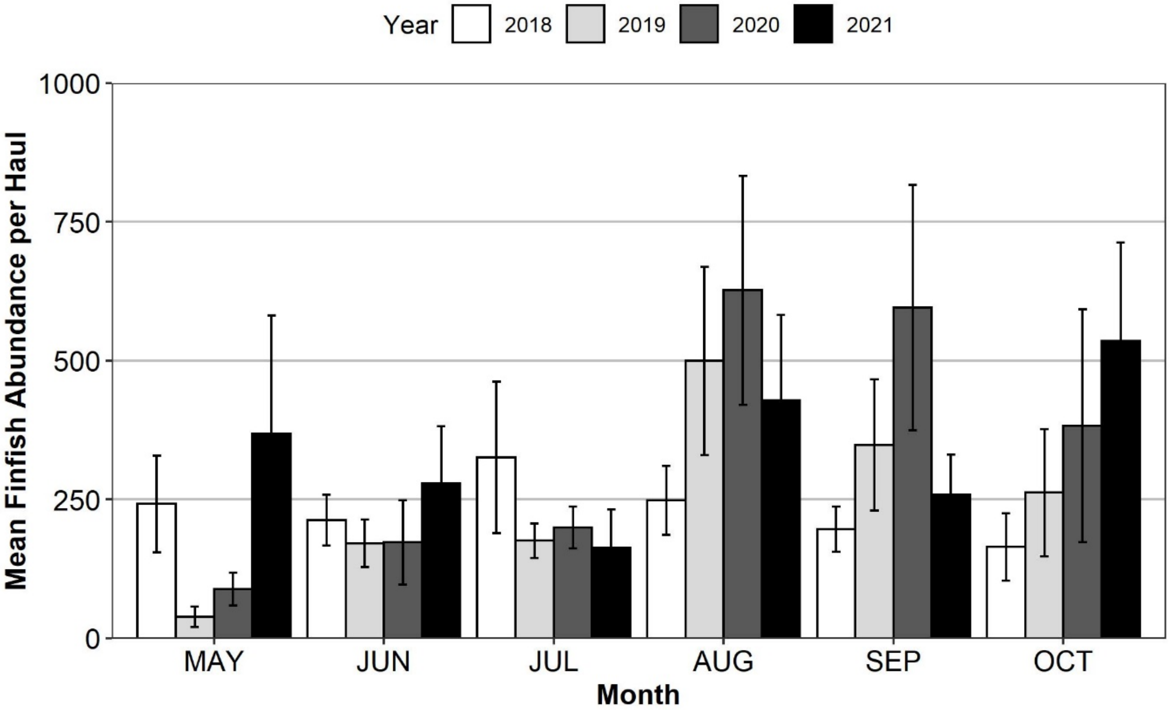


Figure 2. Mean abundance finfish (excluding Atlantic Menhaden) caught each month (±SE) in 2018-2021 beach seines.

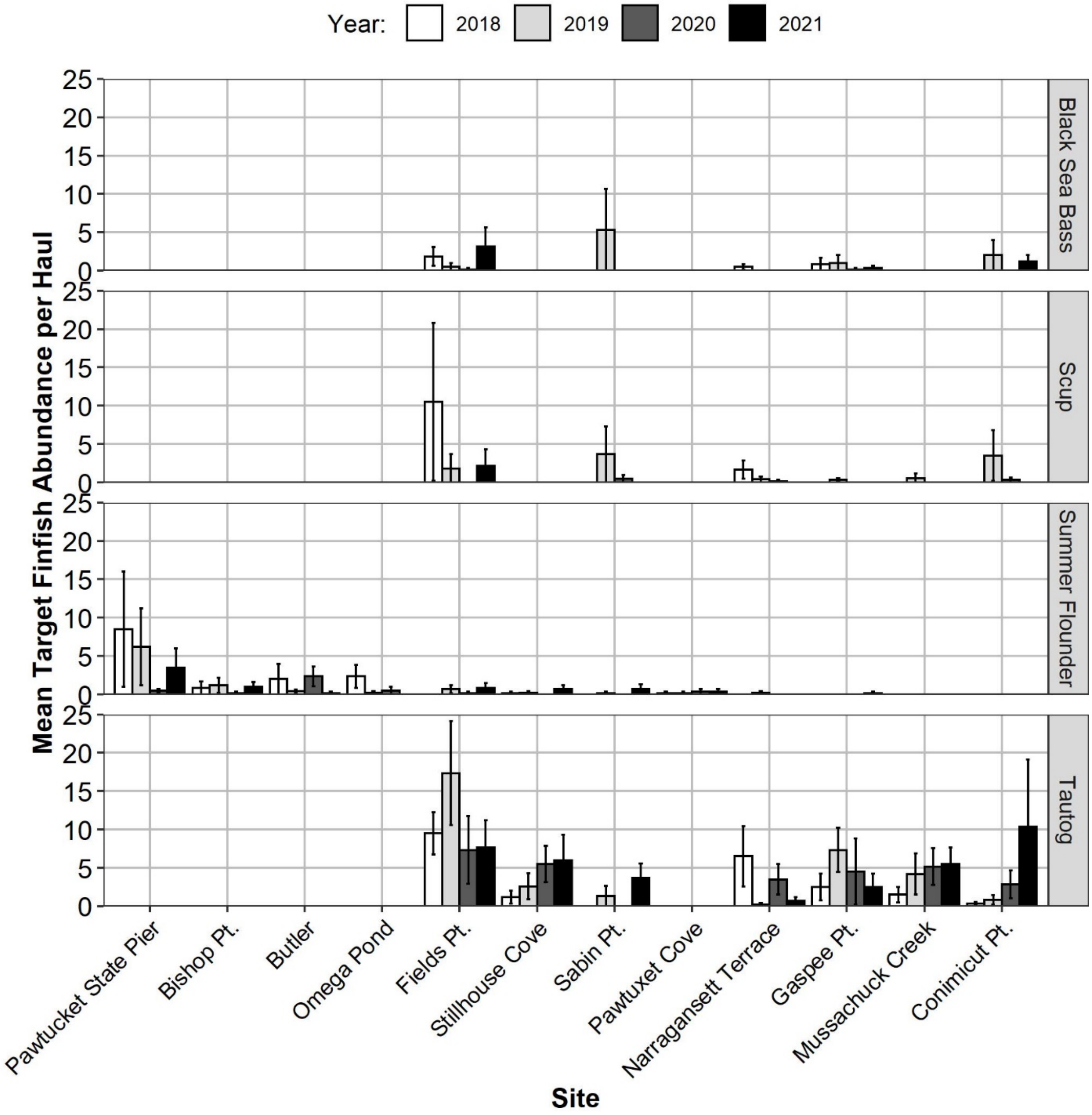


Figure 3a. Mean abundance of target finfish caught by site (±SE) in 2018-2021 beach seines.

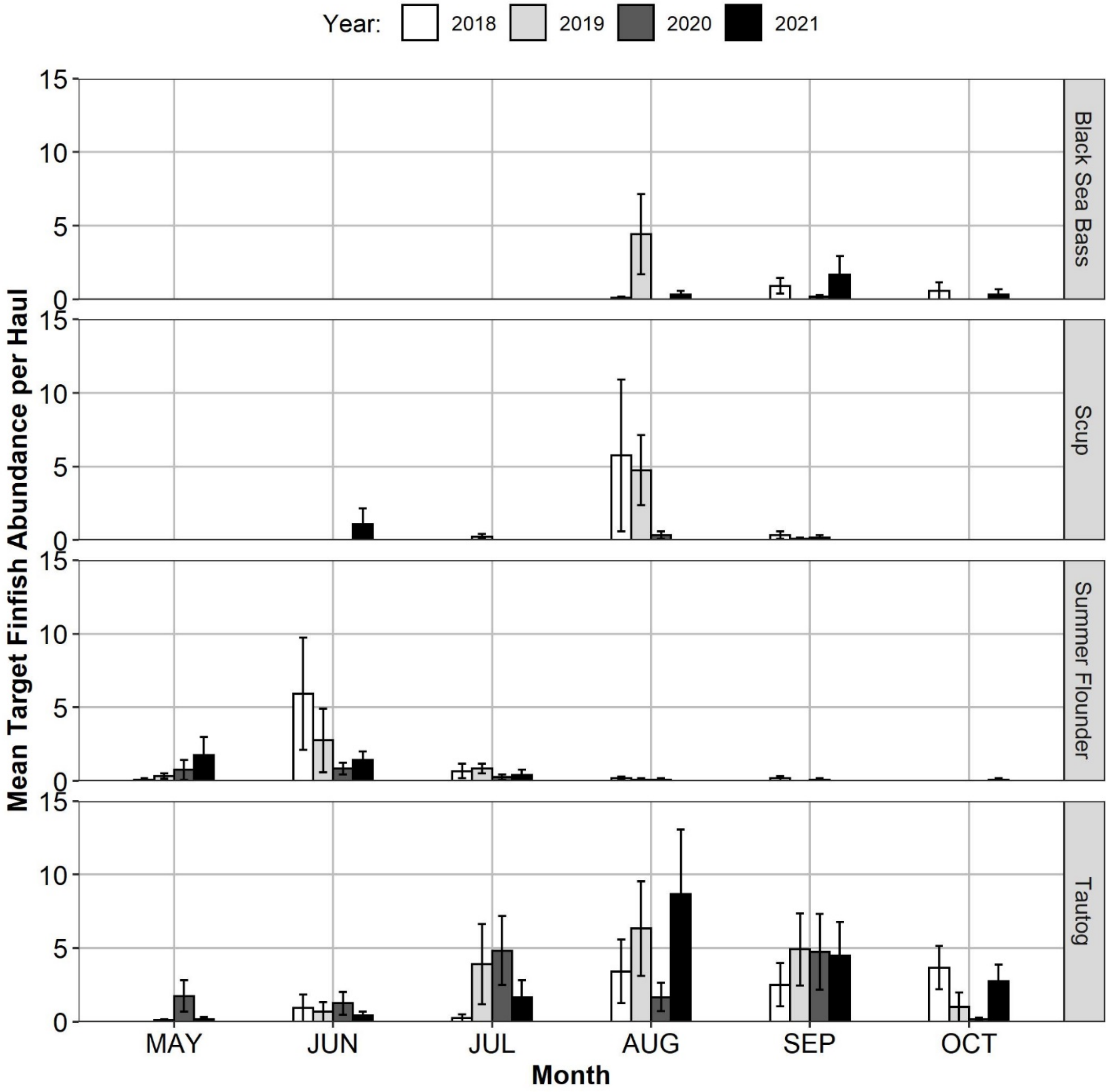


Figure 3b. Mean target finfish (except winter flounder) per seine haul (± SE) plotted for each month sampled during the 2018-2021 field seasons.

Table 1. Common, scientific names, and total abundance of all species collected in beach seines during 2021.

Common Name	**Scientific Name**	**Abundance**
Atlantic Menhaden	*Brevoortia tyrannus*	63,842
Atlantic Silverside	*Menidia menidia*	9,557
Winter Flounder	*Pseudopleuronectes americanus*	4,756
River Herring	*Alosa aestivalis & pseudoharengus*	3,159
Striped Killifish	*Fundulus majalis*	2,821
Common Mummichog	*Fundulus heteroclitus*	1,815
Atlantic Croaker	*Micropogonias undulatus*	410
Blue Crab	*Callinectes sapidus*	332
Gizzard Shad	*Dorosoma cepedianum*	281
Bluefish	*Pomatomus saltatrix*	274
Atlantic Tomcod	*Microgadus tomcod*	246
Tautog	*Tautoga onitis*	218
White Perch	*Morone americana*	192
Northern Kingfish	*Menticirrhus saxatilis*	155
Largemouth Bass	*Micropterus salmoides*	55
Summer Flounder	*Paralichthys dentatus*	44
White Sucker	*Catostomus commersonii*	35
Northern Searobin	*Prionotus carolinus*	29
Black Sea Bass	*Centropristus striata*	28
Bluegill	*Lepomis macrochirus*	28
Rainwater Killifish	*Lucania parva*	27
Yellow Perch	*Perca flavescens*	27
Hogchoker	*Trinectes maculatus*	27
Weakfish	*Cynoscion regalis*	25
Golden Shiner	*Notemigonus crysoleucas*	25
Inshore Lizardfish	*Synodus foetens*	23
Atlantic Needlefish	*Strongylura marina*	16
Sheepshead Minnow	*Cyprinodon variegatus*	15
Striped Searobin	*Prionotus evolans*	15
Scup	*Stenotomus chrysops*	13
Crevalle Jack	*Caranx hippos*	12
Northern Pipefish	*Syngnathus fuscus*	11
4-Spine Stickleback	*Apeltes quadracus*	8
Green Crab	*Carcinus maenus*	8
American Eel	*Anguilla rostrata*	7
Naked Goby	*Gobiosoma bosc*	5
Bay Anchovy	*Anchoa mitchilli*	4
Spider Crab	*Libinia emarginata*	4
Spot	*Leiostomus xanthurus*	3
Common Shiner	*Luxilus cornutus*	3
Oyster Toadfish	*Opsanus tau*	3
Hermit Crab	*Pagurus spp*	3
Japanese Shore Crab	*Hemigrapsus sanguineus*	2
Striped Bass	*Morone saxatilis*	2
White Mullet	*Mugil curema*	2
Horseshoe Crab	*Limulus polyphemus*	1
Mud Crab	*Panopeus spp*	1
Cunner	*Tautogolabrus adspersus*	1

Table 2. Abundances of winter flounder in 2021 beach seines.

Winter Flounder

		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	594	2543	20	152	0	0	0	1	0	0	0	0	275.83	734.24	211.96
JUN	418	550	3	26	9	2	24	10	0	17	4	17	90.00	186.37	53.80
JUL	0	0	0	3	57	141	21	5	4	9	3	3	20.50	41.21	11.90
AUG	12	0	2	11	0	2	11	4	32	7	1	11	7.75	8.97	2.59
SEP	0	0	0	3	8	7	0	0	0	0	0	0	1.50	2.94	0.85
OCT	0	0	0	4	0	0	3	1	0	0	0	1	0.75	1.36	0.39
Mean	170.67	515.50	4.17	33.17	12.33	25.33	9.83	3.50	6.00	5.50	1.33	5.33			
SD	242.54	928.70	7.17	53.75	20.34	51.78	9.72	3.40	11.72	6.29	1.60	6.45		Total Fish	
SE	99.01	379.14	2.93	21.94	8.30	21.14	3.97	1.39	4.78	2.57	0.65	2.63		4756	
Total	1024	3093	25	199	74	152	59	21	36	33	8	32			

Table 3. Temperature, salinity, and dissolved oxygen by site and month during 2021 beach seines.

Site	Month	Temp. (°C)	Sal. (ppt)	DO (mg/L)	Site	Month	Temp. (°C)	Sal. (ppt)	DO (mg/L)
Pawtucket State Pier	MAY	13.0	4.3	9.77	Sabin Pt.	MAY	11.8	22.7	12.26
	JUN	23.5	3.6	7.44		JUN	23.0	16.0	10.78
	JUL	19.5	0.1	9.72		JUL	23.0	13.9	8.99
	AUG	22.0	3.0	7.58		AUG	21.9	24.7	5.05
	SEP	18.7	1.8	9.00		SEP	21.0	23.9	5.13
	OCT	16.3	3.2	9.34		OCT	15.9	27.4	8.63
Bishop Pt.	MAY	14.2	3.0	10.85	Pawtuxet Cove	MAY	13.0	2.9	11.57
	JUN	23.1	5.2	7.19		JUN	20.8	6.4	7.63
	JUL	19.3	0.1	8.87		JUL	19.8	4.3	7.70
	AUG	22.2	3.3	6.75		AUG	24.3	9.8	8.65
	SEP	18.9	3.0	8.74		SEP	20.8	4.8	7.51
	OCT	16.8	2.8	9.14		OCT	15.6	9.8	8.93
Butler	MAY	12.5	5.5	9.73	Narragansett Terrace	MAY	15.6	15.8	11.71
	JUN	24.5	3.5	7.84		JUN	26.1	15.2	13.78
	JUL	19.4	0.2	8.32		JUL	21.8	14.8	7.56
	AUG	24.2	10.0	7.16		AUG	21.2	23.7	5.69
	SEP	19.9	3.5	8.05		SEP	20.7	21.4	5.90
	OCT	17.9	8.0	7.78		OCT	16.9	21.8	8.74
Omega Pond	MAY	13.3	2.9	10.12	Gaspee Pt.	MAY	11.9	23.2	11.60
	JUN	23.3	6.0	7.48		JUN	21.9	17.1	10.17
	JUL	19.7	0.4	8.07		JUL	20.4	20.8	8.40
	AUG	23.0	14.7	6.19		AUG	21.4	23.4	5.94
	SEP	20.5	4.9	7.96		SEP	20.8	16.4	6.45
	OCT	18.0	5.3	8.71		OCT	18.8	25.8	9.30
Fields Pt.	MAY	12.1	20.3	12.14	Mussachuck Creek	MAY	14.2	19.4	10.59
	JUN	25.2	14.2	12.55		JUN	18.9	24.8	9.00
	JUL	22.3	16.4	9.04		JUL	22.0	18.0	8.80
	AUG	25.2	21.7	8.65		AUG	21.3	24.9	5.79
	SEP	21.0	8.3	6.97		SEP	19.8	19.0	7.13
	OCT	16.3	27.3	7.54		OCT	16.2	23.9	8.10
Stillhouse Cove	MAY	11.8	22.8	12.00	Conimicut Pt.	MAY	14.2	21.1	11.96
	JUN	25.1	14.6	13.01		JUN	20.7	22.8	8.35
	JUL	22.3	18.0	8.33		JUL	20.1	21.9	7.85
	AUG	24.2	22.3	8.69		AUG	21.7	27.6	6.96
	SEP	20.0	19.5	5.29		SEP	19.9	18.9	7.54
	OCT	17.9	20.2	9.70		OCT	16.0	27.1	9.01

APPENDIX

Species presence by site for May 2021 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**
River Herring				1						1			**2**
Bay Anchovy											1		**1**
Summer Flounder	1	1						1		1			**4**
Winter Flounder	1	1	1	1				1					**5**
Atlantic Silverside		1	1	1	1	1	1	1		1	1	1	**10**
Northern Pipefish										1			**1**
Hogchoker		1											**1**
White Perch	1			1									**2**
Tautog										1			**1**
American Eel	1			1									**2**
Atlantic Tomcod	1	1		1	1						1	1	**6**
Common Mummichog	1	1		1	1	1							**5**
Striped Killifish		1	1	1			1	1		1			**6**
4-Spine Stickleback			1							1			**2**
Rainwater Killifish						1				1			**2**
Hermit Crab									1				**1**
Green Crab											1		**1**
Blue Crab Male	1	1	1	1									**4**
Blue Crab Female		1											**1**
Blue Crab Immature		1											**1**

APPENDIX

Species presence by site for June 2021 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**
Summer Flounder	1	1			1	1	1						**5**
Winter Flounder	1	1	1	1	1	1	1	1		1	1	1	**11**
Atlantic Silverside			1	1		1	1	1	1	1	1	1	**9**
Northern Pipefish					1					1		1	**3**
Hogchoker		1											**1**
Scup					1								**1**
Tautog					1					1	1		**3**
Atlantic Tomcod										1	1	1	**3**
Common Mummichog			1		1	1		1		1	1		**6**
Striped Killifish				1		1	1	1		1	1		**6**
4-Spine Stickleback										1			**1**
White Mullet	1												**1**
Atlantic Croaker			1	1									**2**
Hermit Crab												1	**1**
Spider Crab												1	**1**
Blue Crab Male	1	1	1			1	1	1					**6**
Blue Crab Female			1		1	1	1				1		**5**
Blue Crab Immature	1	1	1		1		1	1					**6**
Naked Goby					1				1			1	**3**
Japanese Shore Crab							1						**1**

APPENDIX

Species presence by site for July 2021 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**
River Herring			1						1	1	1	1	**5**
Atlantic Menhaden			1	1							1		**3**
Summer Flounder			1		1								**2**
Winter Flounder				1	1	1	1	1	1	1	1	1	**9**
Atlantic Silverside			1	1	1	1	1	1	1	1	1	1	**10**
Northern Pipefish						1				1			**2**
Striped Bass			1										**1**
White Perch		1		1	1			1	1		1		**6**
Northern Kingfish					1	1	1		1		1	1	**6**
Spot					1								**1**
Tautog					1				1	1	1	1	**5**
Gizzard Shad				1									**1**
Atlantic Tomcod					1				1	1			**3**
Common Mummichog					1	1	1	1		1	1		**6**
Striped Killifish					1	1	1	1		1	1	1	**7**
4-Spine Stickleback					1								**1**
Crevalle Jack							1		1				**2**
Bluegill			1	1									**2**
Rainwater Killifish								1					**1**
Largemouth Bass	1		1	1									**3**
Golden Shiner			1										**1**
Yellow Perch	1		1										**2**
White Sucker	1												**1**
Hermit Crab												1	**1**
Blue Crab Unidentified					1								**1**
Mud Crab					1								**1**
Blue Crab Male	1	1		1	1	1	1	1	1	1	1		**10**
Blue Crab Female	1		1		1	1	1				1		**6**
Blue Crab Immature	1				1	1	1						**4**
Naked Goby												1	**1**

APPENDIX

Species presence by site for August 2021 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**
River Herring						1							**1**
Atlantic Menhaden					1							1	**2**
Winter Flounder	1		1	1		1	1	1	1	1	1	1	**10**
Atlantic Silverside	1		1	1	1	1	1	1	1	1	1	1	**11**
Northern Pipefish										1			**1**
Hogchoker	1												**1**
Bluefish										1		1	**2**
Striped Bass			1										**1**
White Perch								1					**1**
Black Sea Bass										1		1	**2**
Weakfish						1	1						**2**
Northern Kingfish			1			1	1	1	1	1	1	1	**8**
Striped Searobin							1					1	**2**
Tautog					1	1	1			1	1	1	**6**
American Eel						1							**1**
Gizzard Shad				1									**1**
Inshore Lizardfish										1		1	**2**
Atlantic Needlefish					1		1	1		1			**4**
Sheepshead Minnow								1					**1**
Common Mummichog			1	1	1	1	1	1	1	1	1		**9**
Striped Killifish			1	1	1	1	1	1	1	1	1	1	**10**
Crevalle Jack					1			1					**2**
Bluegill				1									**1**
Largemouth Bass	1	1		1									**3**
White Sucker	1												**1**
Spider Crab										1			**1**
Green Crab						1							**1**
Blue Crab Male	1	1	1		1	1	1	1	1	1	1	1	**11**
Blue Crab Female	1				1	1	1	1		1	1	1	**8**
Blue Crab Immature						1	1	1					**3**
Northern Searobin	1				1		1			1			**4**

APPENDIX

Species presence by site for September 2021 beach seines.

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**
River Herring			1	1	1	1			1			1	**6**
Atlantic Menhaden		1	1	1	1	1	1	1	1		1		**9**
Winter Flounder				1	1	1							**3**
Atlantic Silverside		1	1	1	1	1	1	1	1	1	1	1	**11**
Northern Pipefish								1				1	**2**
Bluefish				1	1	1	1	1	1	1	1		**8**
White Perch					1								**1**
Black Sea Bass					1							1	**2**
Northern Kingfish							1		1	1		1	**4**
Tautog					1	1	1				1	1	**5**
Oyster Toadfish					1								**1**
Inshore Lizardfish												1	**1**
Atlantic Needlefish										1		1	**2**
Sheepshead Minnow								1					**1**
Common Mummichog			1	1		1	1	1	1			1	**7**
Striped Killifish				1	1	1	1	1	1	1	1	1	**9**
Crevalle Jack				1	1	1							**3**
White Mullet	1												**1**
Bluegill	1												**1**
Largemouth Bass	1			1									**2**
White Sucker	1												**1**
Spider Crab												1	**1**
Green Crab					1	1							**2**
Blue Crab Male				1	1	1	1				1		**5**
Blue Crab Female				1	1	1	1						**4**
Northern Searobin					1								**1**
Naked Goby												1	**1**

APPENDIX

Species presence by site for October 2021 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**
River Herring	1	1	1	1	1	1							**6**
Atlantic Menhaden	1	1	1	1	1	1		1			1		**8**
Summer Flounder						1							**1**
Winter Flounder				1			1	1				1	**4**
Atlantic Silverside	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Hogchoker	1	1		1									**3**
Bluefish			1			1			1				**3**
White Perch				1									**1**
Black Sea Bass					1								**1**
Northern Kingfish							1						**1**
Striped Searobin							1						**1**
Searobins							1						**1**
Cunner												1	**1**
Tautog					1	1	1		1		1	1	**6**
Gizzard Shad	1	1											**2**
Sheepshead Minnow	1							1				1	**3**
Common Mummichog					1	1		1			1		**4**
Striped Killifish					1	1	1	1	1	1	1	1	**8**
Rainwater Killifish	1												**1**
Largemouth Bass				1									**1**
Golden Shiner	1												**1**
Yellow Perch	1	1											**2**
Common Shiner	1												**1**
Horseshoe Crab					1								**1**
Spider Crab									1				**1**
Green Crab						1				1		1	**3**
Blue Crab Male		1				1	1						**3**
Blue Crab Female		1											**1**
Japanese Shore Crab								1					**1**

APPENDIX

Abundances of summer flounder in 2021 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**
Summer Flounder	**MAY**	15	3	0	0	0	0	0	2	0	1	0	0	1.75	4.29	1.24
	JUN	6	3	0	0	1	3	4	0	0	0	0	0	1.42	2.07	0.60
	JUL	0	0	1	0	4	0	0	0	0	0	0	0	0.42	1.16	0.34
	AUG	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	SEP	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	OCT	0	0	0	0	0	1	0	0	0	0	0	0	0.08	0.29	0.08
	Mean	3.50	1.00	0.17	0.00	0.83	0.67	0.67	0.33	0.00	0.17	0.00	0.00			
	SD	5.59	1.41	0.37	0.00	1.46	1.11	1.49	0.75	0.00	0.37	0.00	0.00		Total Fish	
	SE	2.28	0.58	0.15	0.00	0.60	0.45	0.61	0.30	0.00	0.15	0.00	0.00		44	
	Total	21	6	1	0	5	4	4	2	0	1	0	0			

APPENDIX

Abundances of black sea bass 2021 beach seines.

Month	**Site**														
	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	2	0	2	0.33	0.78	0.22
SEP	0	0	0	0	15	0	0	0	0	0	0	5	1.67	4.44	1.28
OCT	0	0	0	0	4	0	0	0	0	0	0	0	0.33	1.15	0.33
Mean	0.00	0.00	0.00	0.00	3.17	0.00	0.00	0.00	0.00	0.33	0.00	1.17			
SD	0.00	0.00	0.00	0.00	5.49	0.00	0.00	0.00	0.00	0.75	0.00	1.86		Total Fish	
SE	0.00	0.00	0.00	0.00	2.24	0.00	0.00	0.00	0.00	0.30	0.00	0.76		28	
Total	0	0	0	0	19	0	0	0	0	2	0	7			

APPENDIX

Abundances of scup in 2021 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
Scup	MAY	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	JUN	0	0	0	0	13	0	0	0	0	0	0	0	1.08	3.75	1.08
	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	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	OCT	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
	Mean	0.00	0.00	0.00	0.00	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	SD	0.00	0.00	0.00	0.00	4.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00		Total Fish	
	SE	0.00	0.00	0.00	0.00	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00		13	
	Total	0	0	0	0	13	0	0	0	0	0	0	0			

APPENDIX

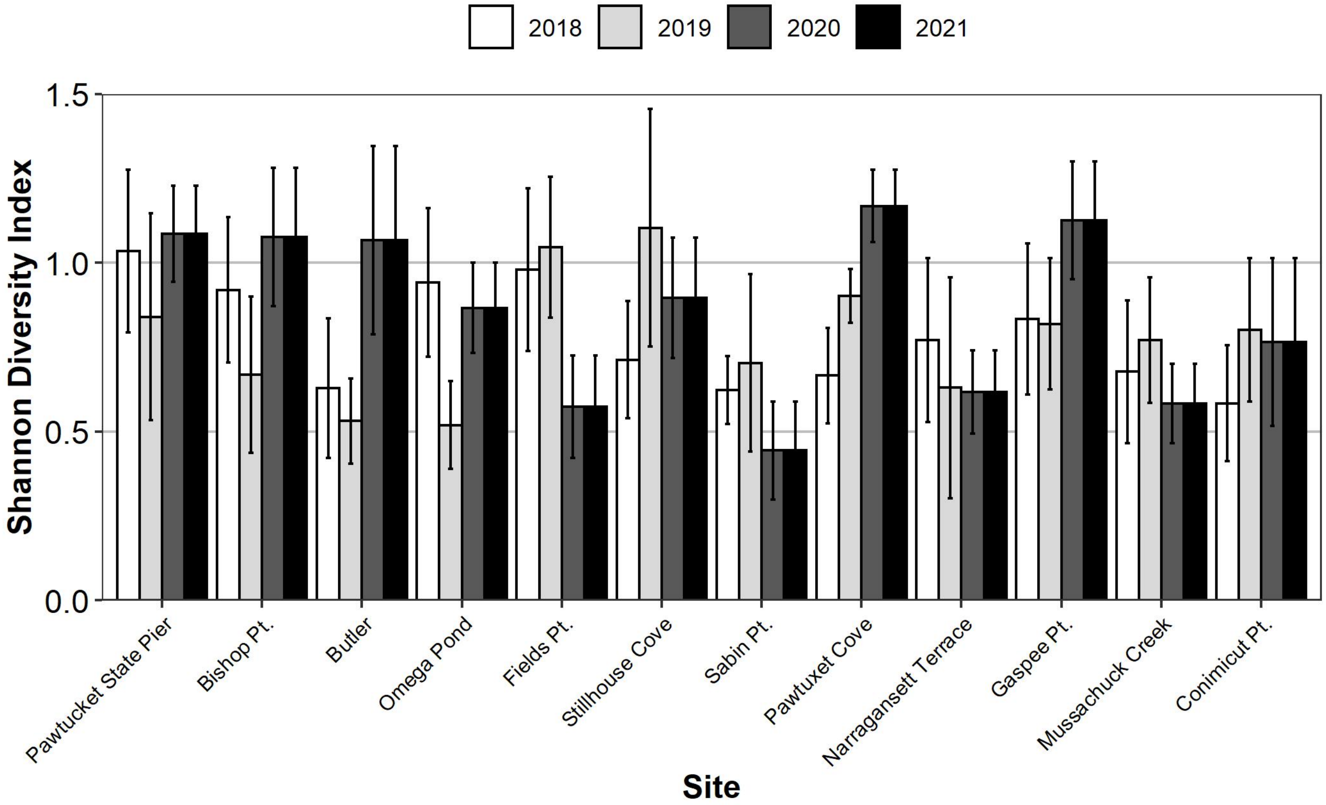
Abundances of tautog in 2021 beach seines.

Tautog

	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	2	0	0	0.17	0.58	0.17
JUN	0	0	0	0	3	0	0	0	0	1	1	0	0.42	0.90	0.26
JUL	0	0	0	0	1	0	0	0	1	1	14	3	1.67	3.98	1.15
AUG	0	0	0	0	10	13	7	0	0	11	9	54	8.67	15.18	4.38
SEP	0	0	0	0	23	19	4	0	0	0	4	4	4.50	7.95	2.29
OCT	0	0	0	0	9	4	11	0	3	0	5	1	2.75	3.84	1.11
Mean	0.00	0.00	0.00	0.00	7.67	6.00	3.67	0.00	0.67	2.50	5.50	10.33			
SD	0.00	0.00	0.00	0.00	7.82	7.42	4.19	0.00	1.11	3.86	4.79	19.58		Total Fish	
SE	0.00	0.00	0.00	0.00	3.19	3.03	1.71	0.00	0.45	1.58	1.95	8.00		218	
Total	0	0	0	0	46	36	22	0	4	15	33	62			

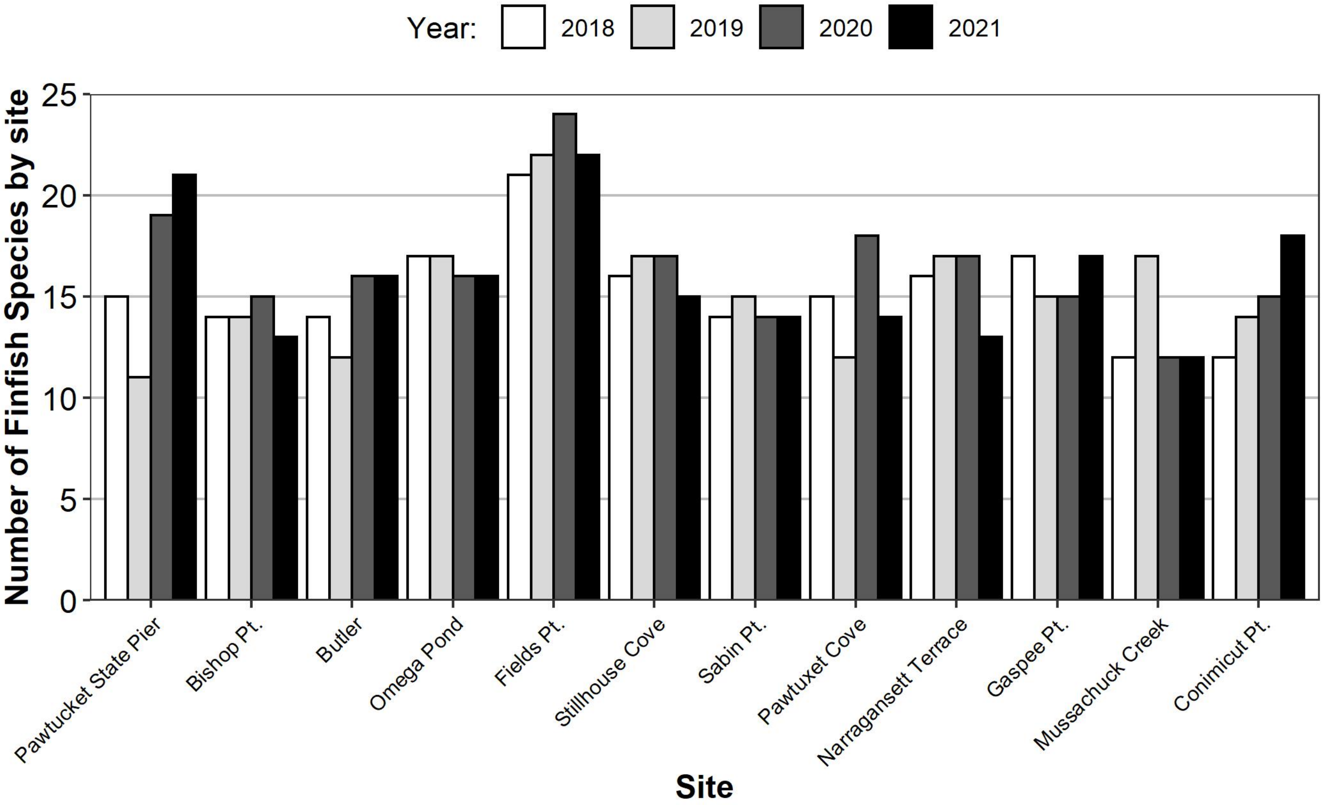
APPENDIX

Mean Shannon diversity across sites in 2018-2021 beach seines.



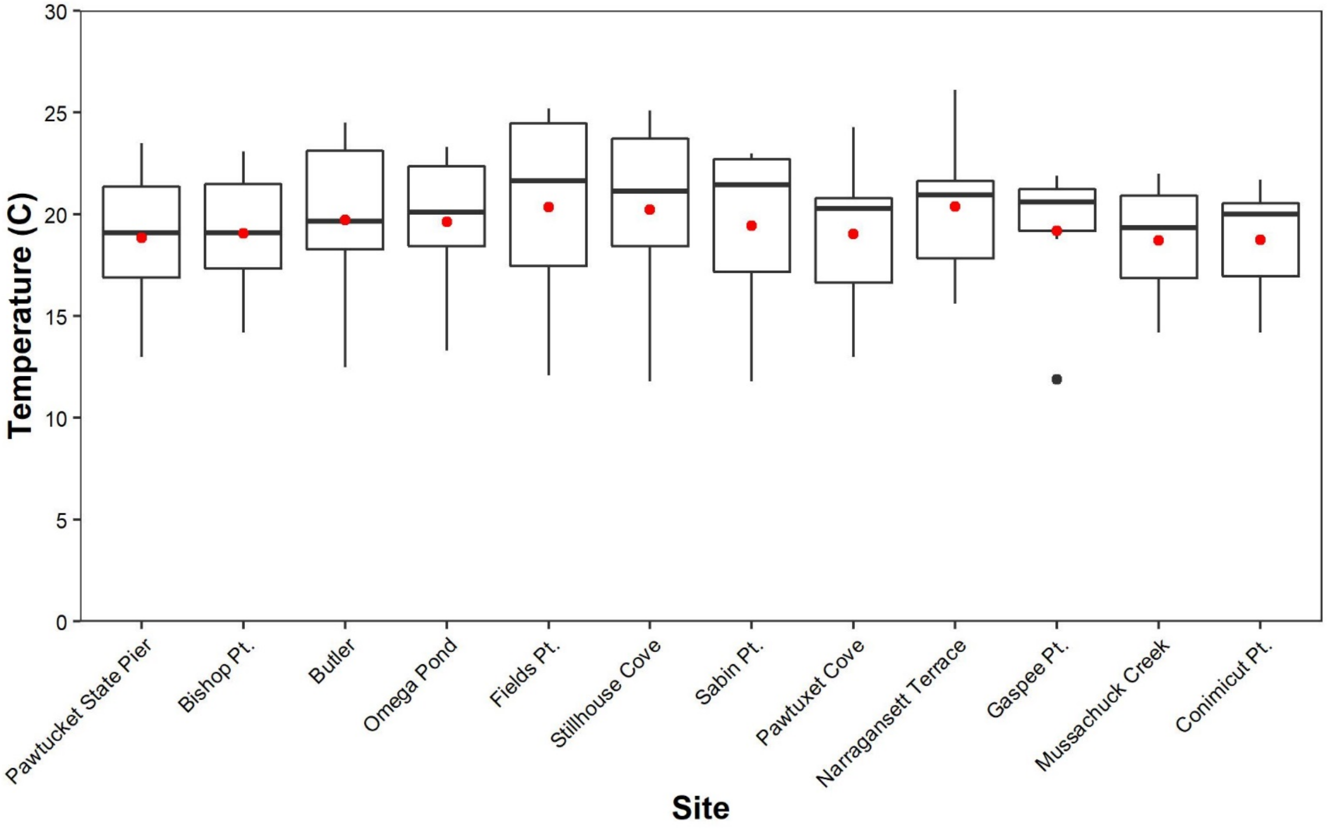
APPENDIX

Cumulative number of finfish species by site in 2018-2021 beach seines.



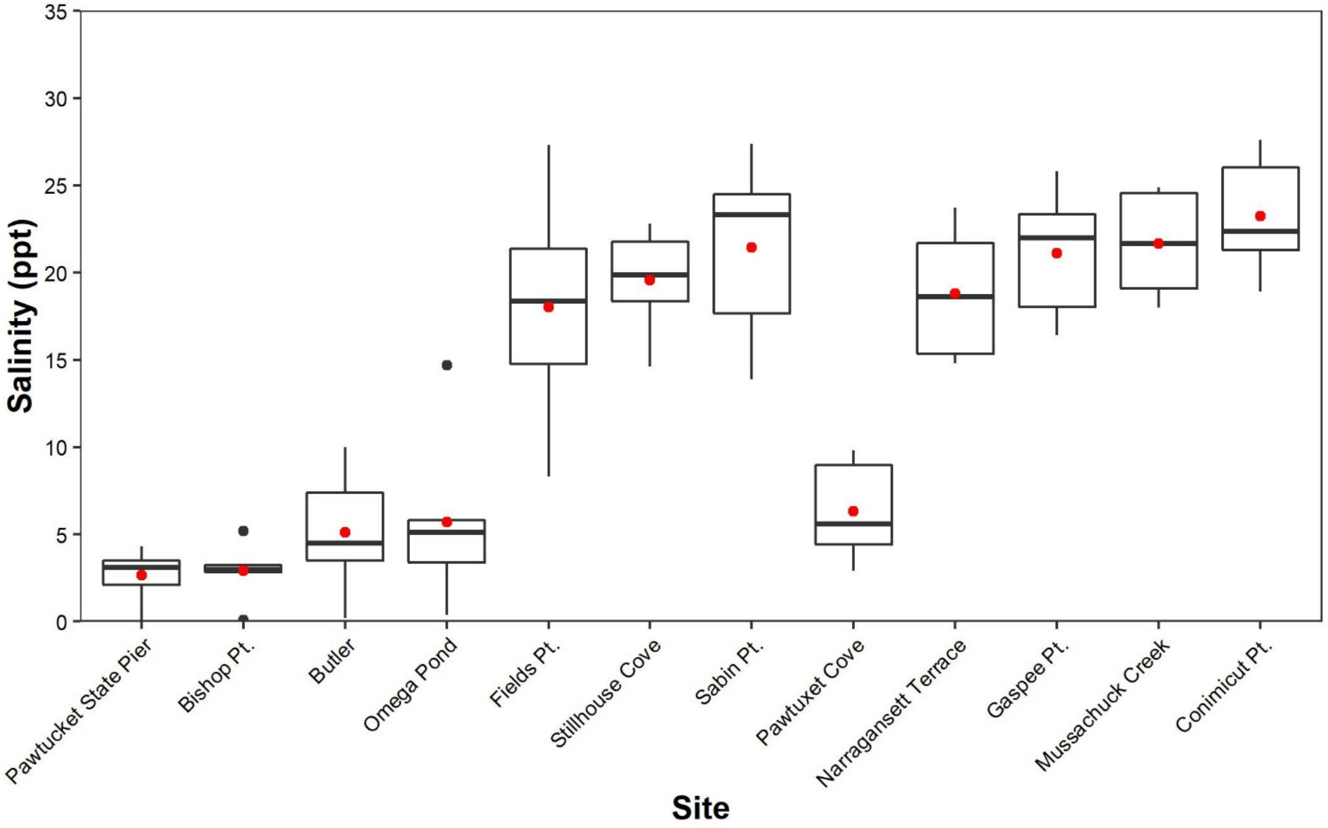
APPENDIX

Boxplot of temperature (C) recorded by handheld YSI across all seine stations in 2021 at the time of sample (red dot indicates mean).



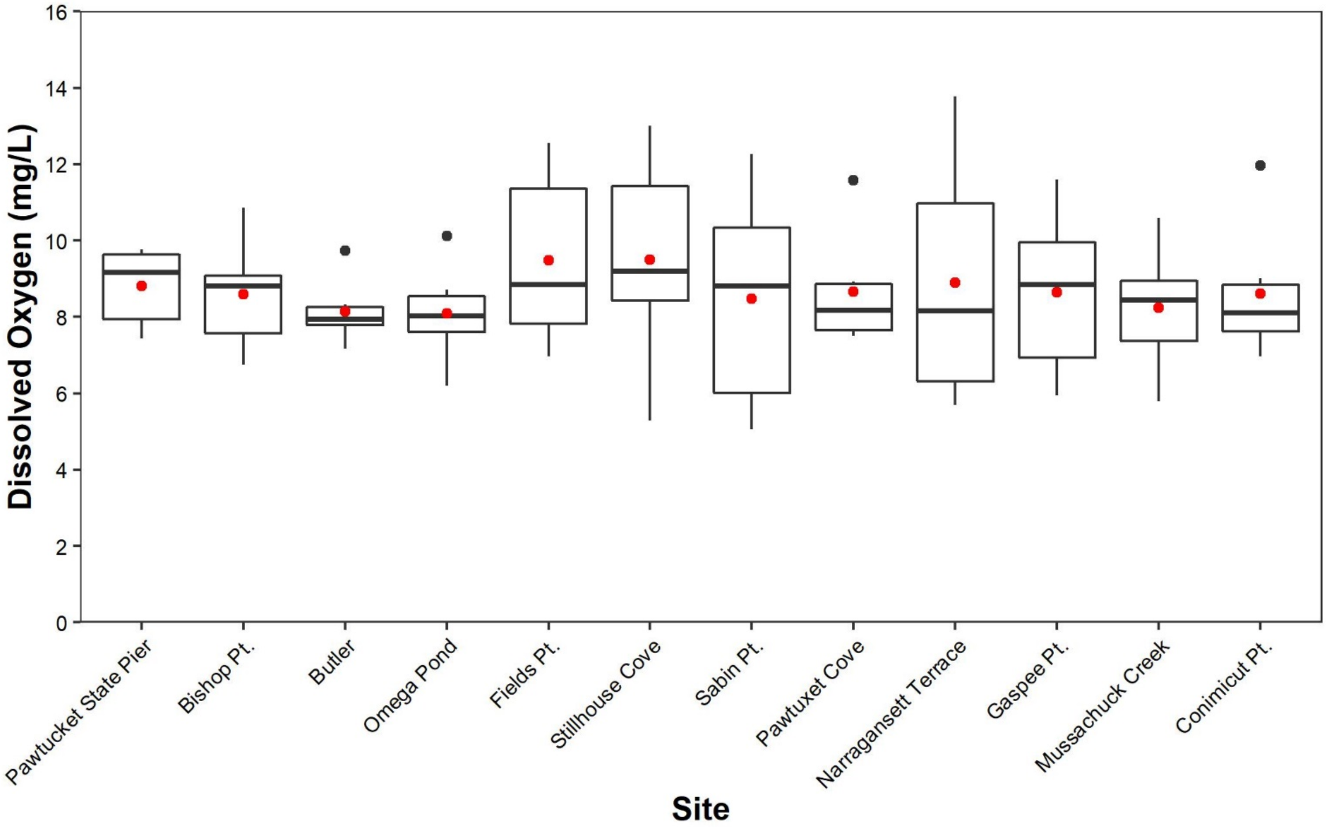
APPENDIX

Boxplot of salinity (ppt) recorded by handheld YSI across all seine stations in 2021 at the time of sample (red dot indicates mean).



APPENDIX

Boxplot of dissolved oxygen (mg/L) recorded by handheld YSI across all seine stations in 2021 at the time of sample (red dot indicates mean).



Sportfish Assessment and Management in Rhode Island Waters

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STATE: Rhode Island

PROJECT NUMBER: F-61-R

SEGMENT NUMBER: 21

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

PERIOD COVERED: January 1, 2021 – 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 in, either as stock assessment committee participants or by contributing data to the stock assessment process. RI also contributed local 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. 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 process for species under their jurisdiction by contributing data from jobs listed in this grant report, participating in stock assessment subcommittees, or via membership in the Scientific and Statistical Committee of the New England Fishery Management Council. The status of the most important recreationally caught species in Rhode Island were presented in the annual finfish sector management plan. The following information by species highlights some of the major contributions during this period.

1. SUMMER FLOUNDER

A management track stock assessment for summer flounder was completed in the summer of 2021. This assessment used the same methods and data as the 2019 benchmark assessment, with updated commercial and recreational catch data and research survey indices through 2019. The 2019 benchmark 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 Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council are in the process of developing a draft Framework/Addendum to potentially develop harvest control rules for the summer flounder, scup, black sea bass, and bluefish fisheries. As part of this initiative, staff of the Rhode Island Department of Environmental Management (RIDEM) are working on models that may be used in predicting recreational harvest to set management measures. This effort is ongoing and staff continue to develop these models to be considered for use in potential management procedures.

Summer flounder 2021 management track assessment:
https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/60ee366302e0767984f30a25/1626224228229/c_2021_summer_flounder_MTA_report.pdf

2. STRIPED BASS

The 2018 benchmark stock assessment for Atlantic striped bass estimated female spawning stock biomass in 2017 to be 151 million pounds, below both the SSB target and SSB threshold, 252 million pounds and 202 million pounds respectively. SSB has been declining since 2003 and has been below the threshold since 2010. F in 2017 was estimated to be 0.31, above both F target and F threshold, 0.20 and 0.24 respectively. F has been at or above the threshold in 13 of the last 15 years (NEFSC, 2019).
A striped bass stock assessment update is planned for 2022 and is anticipated to be presented to the ASMFC striped bass Board in October 2022. In preparation for this assessment, DMF staff will be submitting data through 2021 including commercial landings, recreational landings, recreational releases, and age and growth data (lengths, weights, ages).

Staff also spent a considerable amount of time in 2021 on the striped bass plan development team (PDT) working on Draft Amendment 7 to the Atlantic Striped Bass Fishery Management Plan. This amendment could result in significant changes to how the striped bass stock is managed in the future. Of particular interest are the revised management triggers and conservation equivalency restrictions as these are dependent upon stock status. The draft amendment is currently out for public comment with the striped bass management Board expected to take final action in May of 2022 for implementation in 2023.

Striped bass 2019 benchmark assessment (SAW/SARC 66):
http://www.asmfc.org/uploads/file/5d0d2b9b2019SFlounderBenchmarkAssmt_SAW_SARC.pdf

3. ATLANTIC MENHADEN AND MULTISPECIES MODELS

The ASMFC began a benchmark assessment in 2018 for the coastwide stock for Atlantic menhaden, which was accepted in February of 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 into the assessment process, and to create ecological reference points, which were ultimately accepted for use in management by the Atlantic Menhaden Management Board. 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.

Atlantic menhaden 2019 single species stock assessment:
http://www.asmfc.org/uploads/file/5e4c3a4bAtlMenhadenSingleSpeciesAssmt_PeerReviewReports.pdf

Atlantic menhaden 2019 ecological reference point assessment:
http://www.asmfc.org/uploads/file/5e4c4064AtlMenhadenERPAssmt_PeerReviewReports.pdf

3. BLACK SEA BASS

An operational assessment for black sea bass was completed in the summer of 2021. This assessment used the same methods and data as the 2019 operational assessment, with updated commercial and recreational catch data and research survey indices through 2019. Spatial statistical stock assessment models (separate northern and southern stocks) were developed in the 2016 benchmark assessment and have been used in the updates and operational assessments since.

Beginning in August of 2021, a research track stock assessment has been under way for black sea bass. For this assessment, new datasets will be evaluated for their utility to inform or be used in stock assessment models for the species. A Rhode Island DEM staff member is serving on the stock assessment committee and will be assisting in data analysis and model development/testing. Rhode Island DEM staff also contributed trawl survey (see job 2 from this grant) and seine survey data (see jobs 3 and 4) to be evaluated along with age and growth data (job 9) for use in the assessment. In the future, RIDEM DMF hopes to contribute new ventless pot survey information to the assessment (job 12).

As mentioned above for summer flounder, RIDEM staff are also contributing the Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council's process of developing harvest control rules for the black bass fishery as part of a greater recreational reform initiative. Rhode Island staff spent considerable time contributing to the ongoing development of recreational black sea bass harvest estimation models to be considered for use in potential management procedures.

Black sea bass 2021 operational assessment:
https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/60f03955e00eb31d7cf06ab7/1626356053324/c_BSB_Management+Track+Assessment_2021.pdf

5. SCUP

A management track stock assessment for scup was completed in the summer of 2021. This assessment used the same method (statistical catch-at-age model) and data as the 2019 operational assessment, with updated commercial and recreational catch data and research survey indices through 2019. 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 14 from this grant) and hopes to contribute the new ventless pot survey info in the future to the assessment (job 12). Staff collects the information and processes it for the assessment. Staff participated in several meetings where the assessment information was reviewed, with additional responsibilities for developing management analyses after the assessment was completed.

Scup 2021 management track stock assessment:
https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/60ee353e114e6b7b7de66ad7/1626223937644/c_2021_scup_MTA_report.pdf

6. BLUEFISH

An operational stock assessment was conducted by the Northeast Fisheries Science Center (NEFSC) in 2021. The assessment estimated spawning stock biomass (SSB) in 2019 to be 95,742 MT, which is less than the SSB threshold (100,865 MT) indicating the stock is overfished. Fishing mortality in 2019 was estimated to be 0.172, below the Fthreshold, indicating the stock is not experiencing overfishing (Fmsy proxy = F35%SPR = 0.181) (Northeast Fisheries Science Center (NEFSC) 2020).

In 2021, DMF staff participated in a Bluefish data Workshop to review data needs and sources for the 2022 management track assessment. As a result of this workshop, RI contributed updated data through 2020 for recreational release length-frequency data, age and growth port sampling data, young-of-year (YOY) abundance index data from the fall component of the RI Seasonal Trawl Survey, and YOY abundance index data from the Narragansett Bay Juvenile Finfish Seine Survey.

Bluefish 2020 management track assessment update:
https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/60ee3801df3d323292d019cd/1626224641819/c_Bluefish_2021_MT+Assessment_Update_v3.pdf (August 6, 2021)

7. TAUTOG

A stock assessment update was completed in 2021 and approved for management use using the same methodology as the 2015 benchmark stock assessment and the 2017 update. The assessment update uses the Age Structured Assessment Program v. 3.0.17, part of the NOAA Fisheries Toolbox for the four management regions coastwide (RI is in a region with Massachusetts, MARI). Data from 2016-2020 was added, and the newly calibrated MRIP data was included in the update. 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. RI staff served on the stock assessment subcommittee and provided support in the main tasks and ensuring the model was successfully completed. 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.

Tautog 2021 stock assessment update:
http://www.asmfc.org/uploads/file/618584cc2021TautogRegionalStockAssessmentUpdate_WithAppendices.pdf

8. WINTER FLOUNDER

Since the statistical catch-at-age stock assessment (age structured assessment program [ASAP]) was introduced and peer reviewed in 2010, the Southern New England/Mid-Atlantic (SNE/MA) winter flounder stock has undergone multiple update and operational assessments. Updates are less time consuming than full benchmark assessments, but still require updated data and additional work to effectively 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/parta.pdf). This assessment passed peer review and was updated through an operational assessment for management use in 2015, 2017, and 2020. 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 numbers 1 and 2 from this grant) as well as seine survey data (see job number 4 from this grant) to the assessment. Staff collected the requested 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 Scientific and Statistical Committee that reviewed all the update stock assessment information including data and research on winter flounder. In addition, staff were active participants in the NEFMC Groundfish Plan Development Team and ASMFC winter flounder TC that actively discussed both federal and state water management measures for the SNE/MA winter flounder stock.

Winter flounder 2020 stock assessment update report:
http://www.asmfc.org/uploads/file/6008bd822020_SNE-MA_WinterFlounderAssessmentUpdate.pdf

9. 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. 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, for which staff provided data and analytical assistance.

Weakfish 2019 stock assessment update:
http://www.asmfc.org/uploads/file/5de7fc7c2019WeakfishAssessmentUpdate.pdf

10. SPINY DOGFISH

In 2021, a Research Track Assessment (RTA) was initiated for spiny dogfish. The goal of RTAs is the bring forth new science, research, and assessment modeling tools to improve the stock assessment and be available for use in future management track assessments. RIDEM staff currently serve on the RTA Working Group for spiny dogfish. The goal of the current spiny dogfish RTA is to transition from the current index-based (i.e. data limited) stock assessment model into a more formalized size or age structured model that incorporates the species' population dynamics. The Working Group is hoping to develop a new sophisticated model using the program Stock Synthesis, version 3 (SS3). RIDEM participation includes helping organize the meetings and tasking, soliciting knowledge from industry and academia on spiny dogfish life history, presenting Rhode Island fisheries independent data for possible use in the assessment, and developing models and analysis that can describe the environmental drivers on the species as well as explain the population’s trend and size. The RTA is scheduled to be completed in July 2022.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

Age and Growth Study

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March 2022

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, 2021 – December 31, 2021

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 2021, however in some cases fell short on target sample numbers due to the availability of fish and impacts from the covid-19 pandemic. Ageing structures were also collected for 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 Rhode Island Division of Marine Fisheries (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, 2021

STATUS OF PROJECT: On schedule

SIGNIFICANT DEVIATIONS: No significant deviations occurred.

RECOMMENDATIONS: Move into the next project segment and continue data collection in 2022.

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, the diet composition of finfish has become increasingly important in understanding the age and growth of a population. The 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 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 the 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 2021. 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, otter trawlers, and 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 2021, a total of 93 black sea bass age samples were collected from multiple sources including recreational and commercial rod & reel fishers, the RIDMF otter trawl survey, and RIDMF finfish ventless trap survey (Table 2). Although RIDMF began collaborating with the Commercial Fisheries Research Foundation (CFRF) in 2017 on a project that would assist RIDMF in collecting our required samples and provide additional data for stock assessment purposes, the target number of samples (100) was not achieved during 2021. This was mostly the result of the covid-19 pandemic and difficulty in getting samples.

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 2021. Black sea bass samples collected ranged in size from 7.3-20.6 inches (18.5-52.4 cm) total length and 3 – 12 years old (Figure 1). Age samples collected as part of the collaboration between RIDMF and CFRF have been sent to the Virginia Institute of Marine Science (VIMS) for processing and ageing.

Stomach content and maturity stage data were collected from 93 black sea bass; stomach contents included prey items from 7 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Black sea bass stomach contents were dominated by cephalopod molluscs (36.4%), crustaceans (33.1%), and bivalve molluscs (9.6%); finfish accounted for 2.4% and negligible amounts of algae, polychaetes, and gastropod molluscs accounted for the remaining 1.4%; "unidentifiable" contents accounted for 17.1%. Removal of "unidentifiable" contents from the analysis resulted in cephalopod molluscs accounting for 44%, crustaceans for 39.9%, bivalve molluscs for 11.6%, finfish for 2.9%; negligible amounts of algae, polychaetes, and gastropod molluscs accounted for 1.6% (Figure 10, 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 floating fish traps, recreational hook and line fishers, and the RIDMF otter trawl (Table 2), staff successfully collected 107 bluefish otolith samples in 2021. Bluefish samples ranged in fork length from 17.7-32.9 inches (44.9-83.6 cm) and 2-8 years old (Figure 2).

Stomach content and maturity stage data were collected from 59 bluefish; stomach contents included prey items from 2 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Of the bluefish stomachs examined in 2021, identifiable stomach contents encountered were finfish (41.5%), cephalopod molluscs (2%), and sand/rocks (0.5%); "unidentifiable" contents accounted for 56%. Removal of "unidentifiable" contents from the analysis resulted in finfish accounting for 94.4%, cephalopod molluscs for 4.6%, and sand/rocks for 1% of stomach contents (Figure 10, Table 5).

Menhaden

A total of 104 Atlantic menhaden age samples were collected in 2021 from the RIDMF otter trawl survey and commercial floating fish trap fishery (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 2021, the menhaden management area opened briefly for approximately three weeks in Mid-May. Landings during this opening were sporadic and from multiple vessels making obtaining samples difficult. As a result, bait samples were collected from the floating fish trap fishery and supplemented with samples from the DMF trawl survey. Menhaden samples ranged in fork length from 8.3-12.2 inches (21.0-30.9 cm). Age samples will be sent to the NOAA Fisheries Beaufort Laboratory for processing and ageing.

Maturity stage data were collected from 104 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 2021. Generally, menhaden stomach contents should reflect the dominant planktonic species present at the time of sample collection.

Scup

In 2021, scup age samples were collected only from the RIDMF otter trawl survey (Table 2). Investigators successfully collected scales and otoliths from 120 scup. Scup samples ranged in fork length from 8.4-14.6 inches (21.4-37.0 cm) and age from 3-15 years old (Figure 3).

Stomach content and maturity stage data were collected from 48 scup. Stomach contents included prey items from 6 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents included bivalve molluscs (12%), algae (8.1%), polychaetes (7.5%), crustaceans (5%), sipunculids (3.5%), and gastropod molluscs (0.2%); "unidentifiable" contents accounted for 63.7%. Removal of "unidentifiable" contents from the analysis resulted in bivalve molluscs accounting for 33.1%, algae for 22.4%, polychaetes for 20.6%, crustaceans for 13.7%, sipunculids for 9.6%, and gastropod molluscs for 0.5% (Figure 10, 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 2021.

Striped Bass

A total of 254 striped bass age samples were collected in 2021. 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 in operation making obtaining striped bass samples from this fishery difficult. A total of 168 samples were obtained from the general category fishery and 60 samples from floating fish traps, for a total of 228 samples. Staff supplemented traditional sampling by collecting a total of 26 striped bass age samples from the RIDMF Narragansett Bay Juvenile Finfish (Beach seine) survey (n=4), RIDMF otter trawl survey (n=12), and RIDMF fyke net survey (n=10). These samples were generally below legal minimum size(s) but helped to expand the length-frequency distribution sampled. Striped bass sampled ranged from 16.9-48.4 inches fork length (42.9-123.0 cm) and 3-19 years old (Figure 4).

Stomach content and maturity stage data were collected from 26 striped bass. Stomach contents included prey items from 8 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (62.4%) and crustaceans (25%), with small quantities of algae (0.42%%), aquatic plants (0.16%), cephalopod molluscs (0.16%), bivalve molluscs (0.11%), gastropod molluscs (0.10%), and polychaetes (0.02%); "unidentifiable" contents accounted for 11.6%. Removal of "unidentifiable" contents from the analysis resulted in finfish accounting for 70.6% and crustaceans accounting for 28.3%, with small quantities of algae (0.47%), aquatic plants (0.18%), cephalopod molluscs for (0.18%), bivalve molluscs for 0.12%, gastropod molluscs for 0.11%, and polychaetes for 0.03% making up the remainder. (Figure 10, Table 5).

Summer Flounder

A total of 95 summer flounder scale and otolith samples were collected in 2021. The majority of these samples (n=93) were collected onboard the RIDMF otter trawl survey with the remaining samples (n=2) collected from the RIDMF finfish ventless trap survey. Summer flounder samples collected varied in size from 8.9-22.7 inches (22.6-57.6 cm) total length and 0-5 years old (Figure 5).

Stomach content and maturity stage data were collected from 43 summer flounder. Stomach contents included prey items from 4 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Identifiable stomach contents were dominated by finfish (52.6%), followed by cephalopod molluscs (14.2%), crustaceans (12.7%), and a negligible amount of algae (0.11%); "unidentifiable" contents accounted for nearly 20.4%. Removal of "unidentifiable" contents from the analysis resulted in finfish accounting for 66.1%, cephalopod molluscs for 17.8%, crustaceans for 15.9%, and a negligible amount of algae (0.14%) (Figure 10, Table 5).

Tautog

A total of 282 tautog age samples were collected in 2021. 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=229) with additional samples obtained from the RIDMF otter trawl survey (n=47), RIDMF finfish ventless trap survey (n=1), and recreational spear fishery (n=5). Tautog samples are typically collected in the fall months when the party and charter boat vessels are targeting them. The ability to obtain samples during this period of time can be quite variable due to weather conditions such as strong winds and high seas. Tautog samples collected ranged from 8.7-23.6 inches (22.0-60.0 cm) total length and 2-15 years old (Figure 6).

Stomach content and maturity stage data were collected from 42 tautog in 2021. Stomach contents included prey items from 6 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Identifiable tautog diet was primarily comprised of crustaceans (33.7%), bivalve molluscs (28.2%), and gastropod molluscs (5.5%), with a small quantity of polychaetes (0.45%), sand/rocks (0.39%), algae (0.23%), and maxillopods (0.07%) also observed; “unidentifiable” contents accounted for 31.4%. Removal of “unidentifiable” contents from the analysis resulted in crustaceans accounting for 49.2%, bivalve molluscs for 41.1%, gastropod molluscs for 8%, with a small quantity of polychaetes (0.65%), sand/rocks (0.57%), algae for 0.34%, and maxillopods for 0.10% (Figure 10, 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 pelvic spine for age determination. Staff received training at a workshop held in April 2017 and subsequently participated in an ageing exchange with other agers along the Atlantic coast to determine the best structure to use for ageing tautog going forward. The results of the ageing workshop and exchange suggest that tautog spines are an acceptable ageing structure and should be used by those states that can exhibit spine ages that are consistent with ages from other tautog structures. As a result, RI collected multiple structures in 2021 to allow for the comparison of ages among structures with the hope of transitioning to spines only in 2022.

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 2021, this would have resulted in a sampling target of 66 fish lengths and 33 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 to purchase fish directly from seafood dealers at market value to ensure that they can obtain samples, however strong market demand and limited supply during 2021 prevented the availability of this species for sampling. In 2021, a total of 46 weakfish length and otolith samples were collected, with no fishery-dependent samples collected. Weakfish collected by the fishery-independent RIDMF otter trawl (n=46) consisted of 5 sub-legal sized fish and 41 legal-sized fish. Weakfish sampled ranged from 14.6-21.3 inches (37.1-54.2 cm) total length and were 2-4 years old (Figure 7).

Stomach content and maturity stage data were collected from 46 weakfish. Stomach contents included prey items from 5 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Of the weakfish stomachs examined in 2021, identifiable stomach contents were dominated by cephalopod molluscs (19.9%), crustaceans (14.8%), and polychaetes (10.4%) with minor contributions from finfish (3%) and algae (1.4%); “unidentifiable” contents accounted for 50.6%. Removal of “unidentifiable” contents from the analysis resulted in cephalopod molluscs accounting for 40.2%, crustaceans for 29.8%, and polychaetes for 21.1%, with minor contributions from finfish (6%) and algae (2.8%) (Figure 10, Table 5).

Winter Flounder

A total of 24 winter flounder scale and otolith samples were collected in 2021. These samples were collected entirely by RIDMF staff on board the RIDMF otter trawl and fyke net surveys. Winter flounder samples collected varied in size from 10.7-15.0 inches (27.3-38.0cm) total length and 2-5 years old (Figure 8).

Stomach content and maturity stage data were collected from 24 winter flounder. Stomach contents included prey items from 8 taxonomic groups (Table 3). The proportional contribution of all stomach contents encountered in 2021 is shown in Figure 9 and summarized in Table 4. Of the winter flounder stomachs examined in 2021, identifiable stomach contents were dominated by cnidarians (61%), algae (3.8%), polychaetes (3.6%), and nemerteans (2.6%), with a minor amount of crustaceans (1%) and negligible contributions from gastropod molluscs (0.32%), bivalve molluscs (0.28%, and sipunculids (0.11%); “unidentifiable” contents accounted for 27.2%. Removal of “unidentifiable” contents from the analysis resulted in stomach contents being dominated by cnidarians (83.9%), followed by algae (5.2%), polychaetes (5%), and nemerteans (3.6%), with a minor amount of crustaceans (1.4%) and negligible contributions from gastropod molluscs (0.44%), bivalve molluscs (0.39%), and sipunculids (0.16%) (Figure 10, Table 5).

SUMMARY

In 2021 investigators were able to collect, or exceed, the target sample numbers for bluefish, scup, and tautog, while under-achieving target sample numbers for black sea bass (93/100), striped bass (254/300), summer flounder (95/100), and weakfish length samples (46/66; 41/46 were legal-sized). For striped bass, target sample numbers from the general category fishery were achieved and exceeded (168/150) while target sample numbers from the floating fish trap fishery were not achieved (60/150); striped bass samples were supplemented with fishery-independent samples from RIDMF surveys (n=26). In the cases where the sample targets were not achieved, this was due to the dynamics of the fisheries, inclement weather, and availability of fish. Processing and ageing of all hard parts is complete for 2021. In 2022, 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. Staff will continue to participate in ASMFC ageing workshops as they occur in 2022.

FIGURES

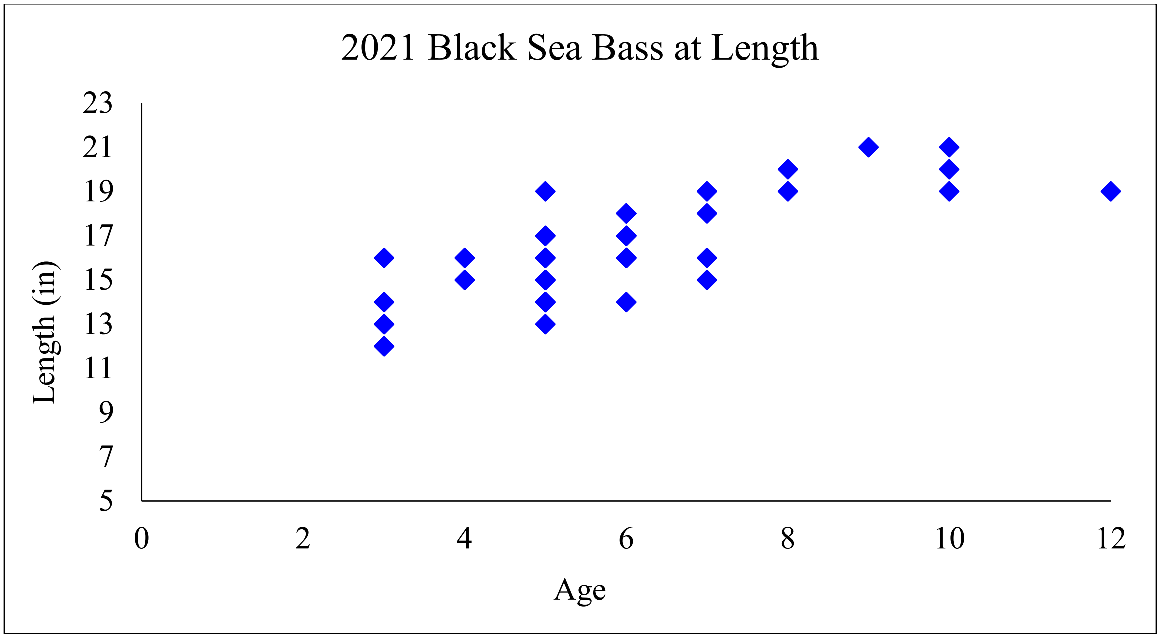


Figure 1. Black sea bass age at length.

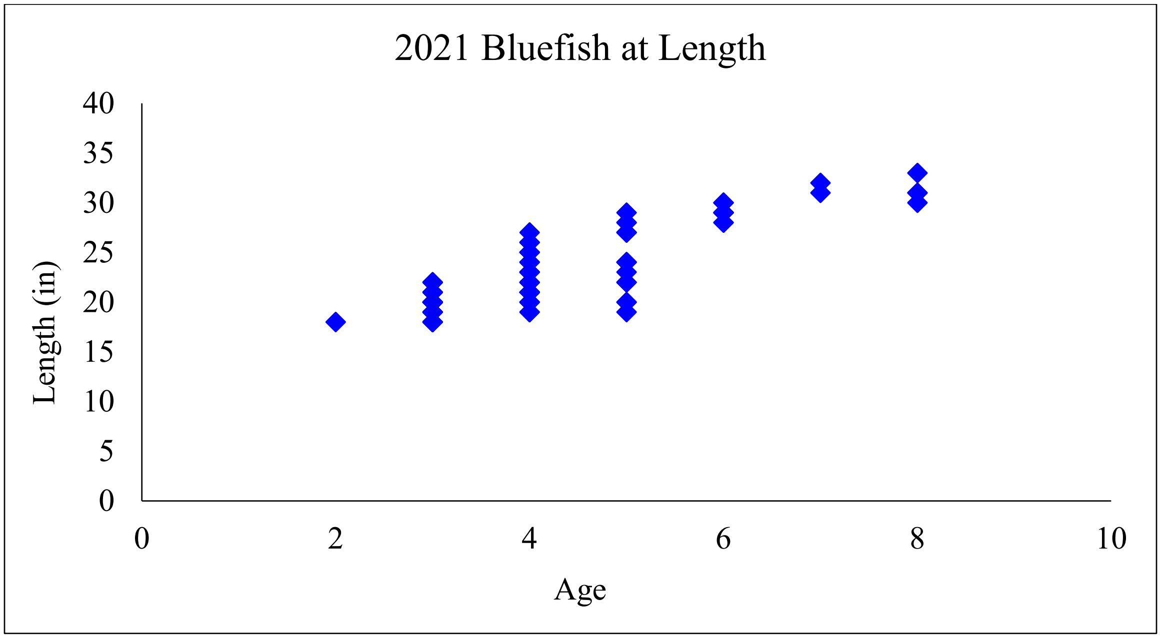


Figure 2. Bluefish age at length.

Figure 3. Scup age at length.

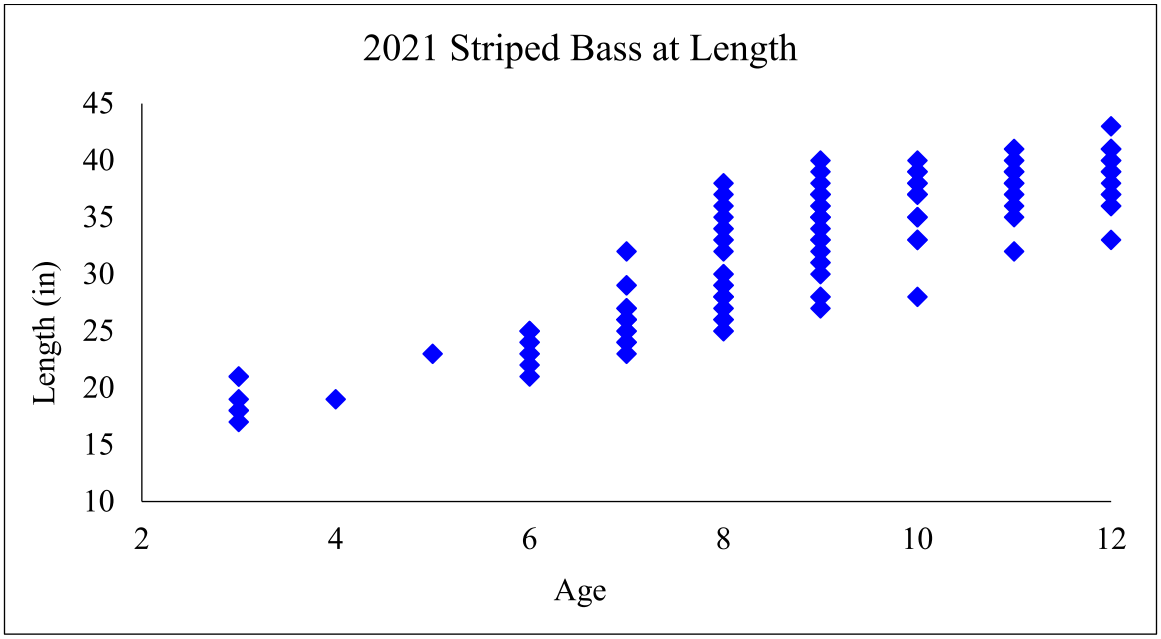


Figure 4. Striped bass age at length.

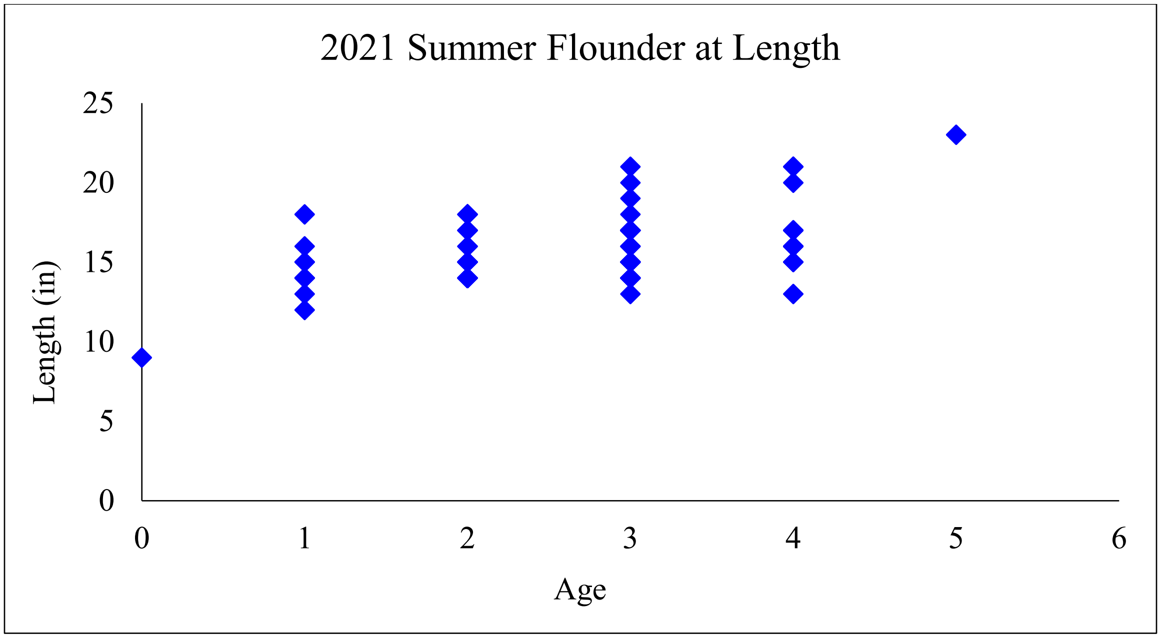


Figure 5. Summer flounder age at length.

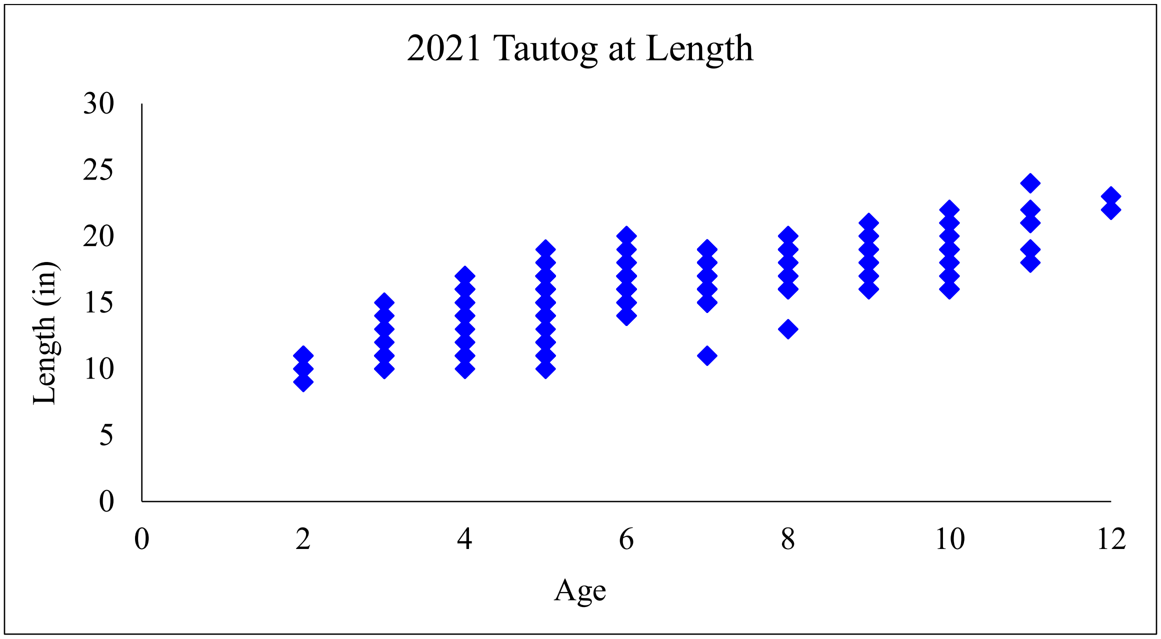


Figure 6. Tautog age at length.

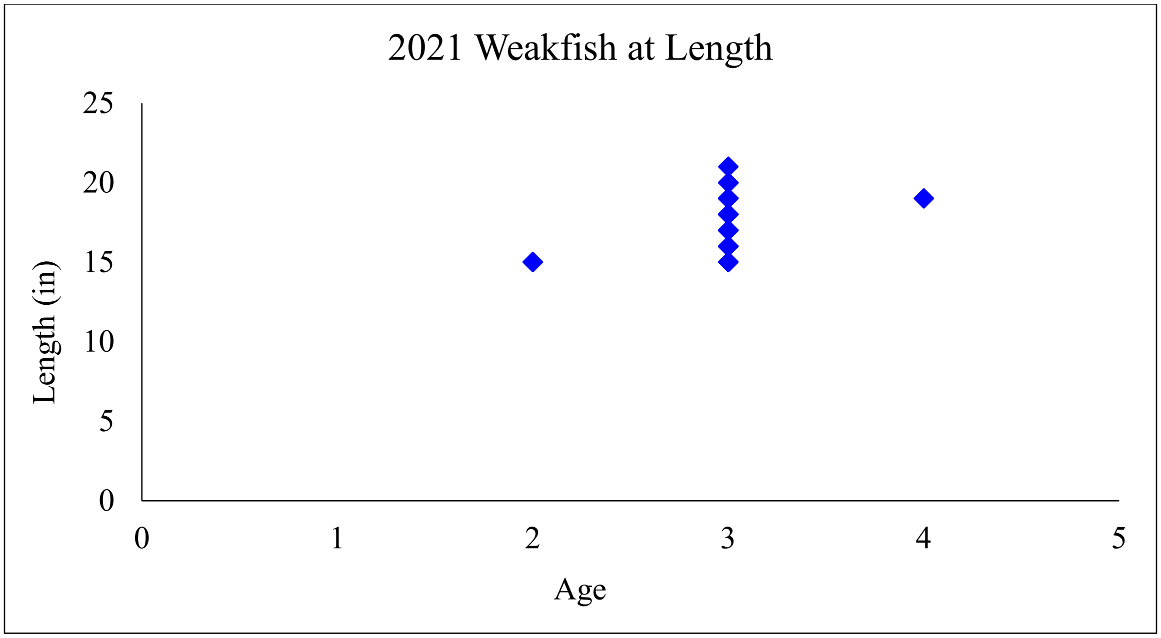


Figure 7. Weakfish age at length.

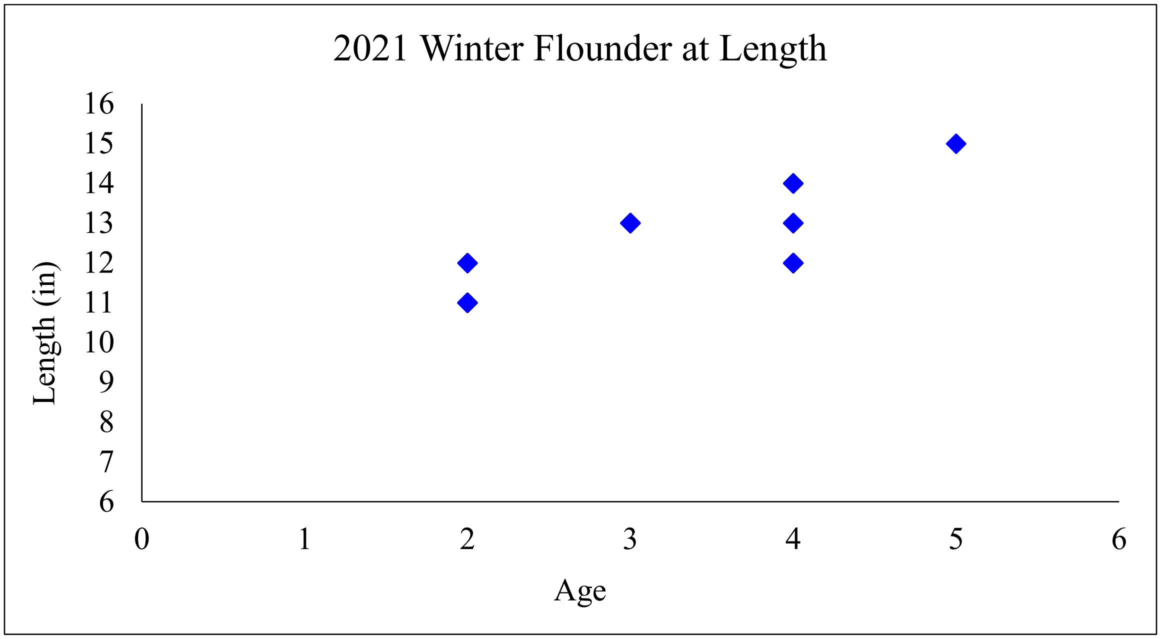


Figure 8. Winter flounder age at length.

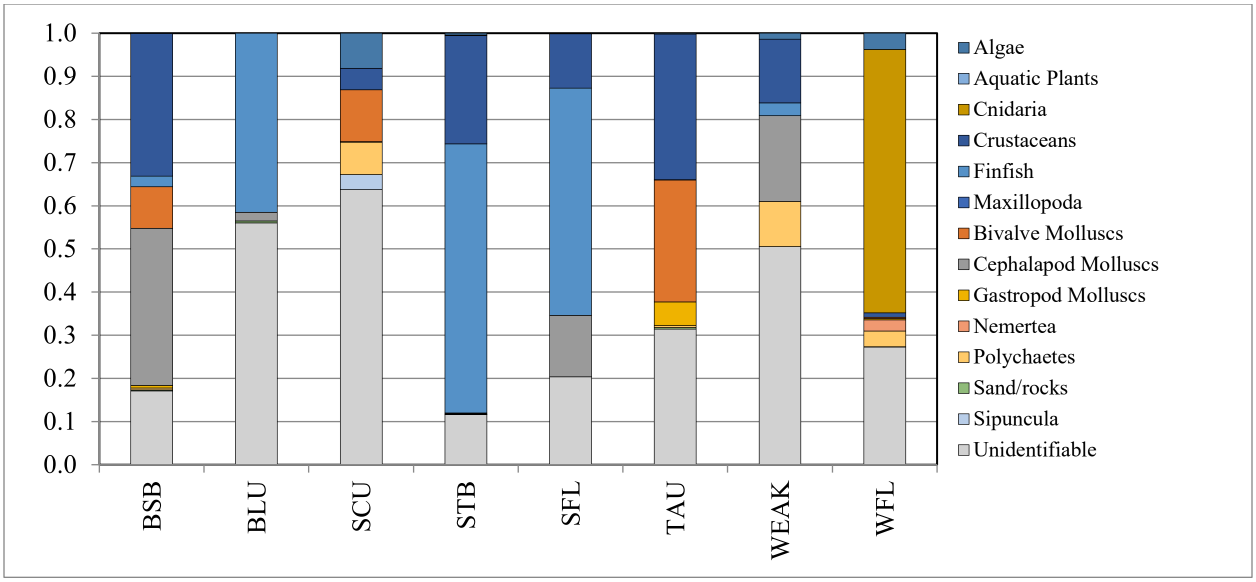


Figure 9. 2021 Proportional contribution of **all** stomach content types by species.

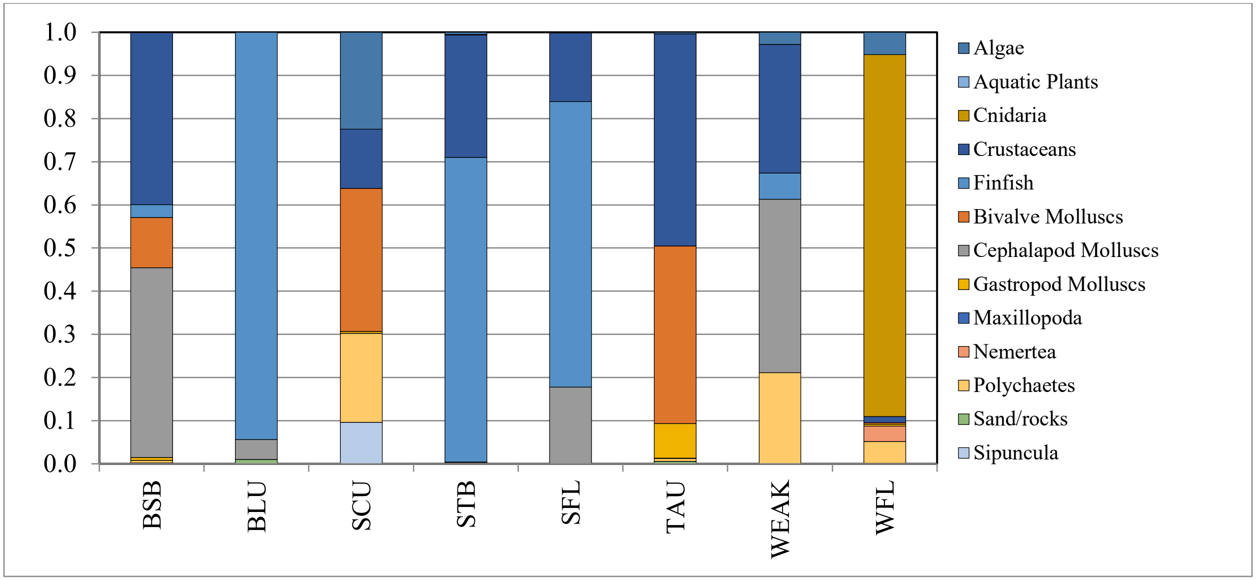


Figure 10. 2021 Proportional contribution of stomach content types by species; “unidentifiable” contents not included.

TABLES

Table 1. Number of ageing structures collected by species in 2021.

Common name	Ageing structure(s)	Target number of ageing structures	Number of ageing structures collected
Black sea bass	Scale, Otolith	100	93 scale, 93 otolith
Bluefish***	Otolith	100	107 otolith
Menhaden***	Scale, Otolith	100	104 scale, 104 otolith
Scup	Scale, Otolith	100	120 scale, 120 otolith
Striped bass	Scale, Otolith	150 fish/gear type**	254 scale, 26 otolith
Summer Flounder	Scale, Otolith	100	95 scale, 95 otolith
Tautog***	Operculum, Otolith, 1st pelvic	200	282 operculum, 282 otolith, 282 pelvic spines
Weakfish***	Otolith	3 fish aged per metric ton landed*	46 otoliths
Winter Flounder	Scale, Otolith	NA	24 scale, 24 otolith

*Per ASMFC FMP requirements, 33 ages required for 2021

**Gear types include floating fish trap and general category

***Required by ASMFC

Table 2. Gear type sampled for each species collected in 2021 (FFT=Floating Fish trap).

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

Table 3. 2021 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	93	7
Bluefish	40	59	2
Scup	40	48	6
Striped Bass	40	26	8
Summer Flounder	40	43	4
Tautog	40	42	6
Weakfish	40	46	5
Winter Flounder	40	24	8

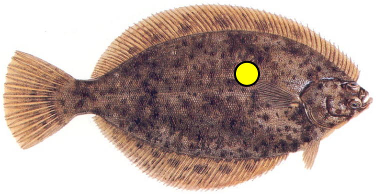
Table 4. 2021 Proportional contribution of **all** stomach content types by species (see Figure 9).

	BSB	BLU	SCU	STB	SFL	TAU	WEAK	WFL
Algae	0.0006	0	0.0813	0.0042	0.0011	0.0023	0.0139	0.0375
Aquatic Plants	0	0	0	0.0016	0	0	0	0
Ascidiacea	0	0	0	0	0	0	0	0
Bryozoa	0	0	0	0	0	0	0	0
Cnidaria	0	0	0	0	0	0	0	0.6105
Crustaceans	0.3306	0	0.0497	0.2503	0.1266	0.3373	0.1475	0.0103
Echinoderms	0	0	0	0	0	0	0	0
Finfish	0.0244	0.4148	0	0.6241	0.5265	0	0.0297	0
Bivalve Mollusc	0.0965	0	0.1201	0.0011	0	0.2821	0	0.0028
Cephalopod Mollusc	0.3642	0.0202	0	0.0016	0.1418	0	0.1990	0
Gastropod Mollusc	0.0059	0	0.0018	0.0010	0	0.0551	0	0.0032
Maxillopoda	0	0	0	0	0	0.0007	0	0
Nematoda	0	0	0	0	0	0	0	0
Nemertea	0	0	0	0	0	0	0	0.0259
Platyhelminthes	0	0	0	0	0	0	0	0
Polychaetes	0.0046	0	0.0748	0.0002	0	0.0045	0.1044	0.0365
Porifera	0	0	0	0	0	0	0	0
Sand/rocks *	0.0018	0.0046	0	0	0	0.0039	0	0
Sipuncula	0	0	0.0347	0	0	0	0	0.0011
Urochordata	0	0	0	0	0	0	0	0
Unidentifiable *	0.1714	0.5604	0.6375	0.1160	0.2040	0.3141	0.5055	0.2724

Table 5. 2021 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	0.0007	0	0.2244	0.0047	0.0014	0.0033	0.0281	0.0516
Aquatic Plants	0	0	0	0.0018	0	0	0	0
Ascidiacea	0	0	0	0	0	0	0	0
Bryozoa	0	0	0	0	0	0	0	0
Cnidaria	0	0	0	0	0	0	0	0.8390
Crustaceans	0.3990	0	0.1372	0.2832	0.1591	0.4918	0.2984	0.0141
Echinoderms	0	0	0	0	0	0	0	0
Finfish	0.0294	0.9436	0	0.7060	0.6614	0	0.0601	0
Bivalve Mollusc	0.1164	0	0.3313	0.0012	0	0.4113	0	0.0038
Cephalopod Mollusc	0.4395	0.0460	0	0.0018	0.1781	0	0.4024	0
Gastropod Mollusc	0.0072	0	0.0050	0.0011	0	0.0803	0	0.0044
Maxillopoda	0	0	0	0	0	0.0010	0	0
Nematoda	0	0	0	0	0	0	0	0
Nemertea	0	0	0	0	0	0	0	0.0357

Platyhelminthes	0	0	0	0	0	0	0	0
Polychaetes	0.0055	0	0.2062	0.0003	0	0.0065	0.2110	0.0498
Porifera	0	0	0	0	0	0	0	0
Sand/rocks *	0.0021	0.0104	0	0	0	0.0057	0	0
Sipuncula	0	0	0.0958	0	0	0	0	0.0016
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-61-22

Performance Report: Job 10 March 2022

State:	Rhode Island	Project Number: F-61-R-22
Project Title:	Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters	
Period Covered:	January 1, 2020 – December 31, 2021	
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:	None to report.	

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 fifteen stations where data has been collected over the course of the survey, with seven found in Point Judith Pond, four in Potter Pond, and four in Ninigret Pond (also known as Charlestown Pond). Point Judith and Potter Pond use the same breach to connect to the Atlantic Ocean. A few additional scoping locations were surveyed briefly in Ninigret and Point Judith Pond in 2021.

Additional Research:

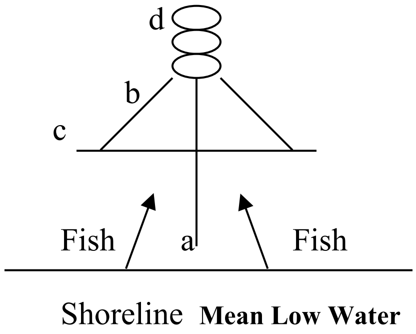
In 2012, the Ninigret Pond system was added to the survey. As adult winter flounder abundance in the Point Judith system declined to all-time lows, the adjacent Ninigret Pond was surveyed from the 2012 through the 2015 sampling year. During this period, RI Coastal Trawl Survey data (Spring Survey) showed 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.

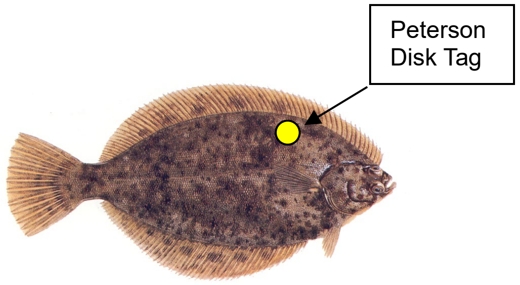
Methods and Materials:

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 2021 two to three nets were concurrently set in Point Judith/Potter Pond and two to three nets were set concurrently in Ninigret Pond, for a total of four to six concurrently set nets among the three systems. A total of 96 fyke net sets were conducted in 2021. Nets were tended every two to seven 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 1999-2020, commercial landings of winter flounder in Rhode Island averaged just under 300 metric tons and an average value of just below 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 2020 (Table 5, Figure 2) (NMFS 2021 commercial landings query and MRIP database through 2021). While an increase in recreational catch in seen in the preliminary data from 2021, this value carries a very high PSE. Note that due to the rarity of the MRIP Access Point Angler Intercept Survey encountering anglers who have captured winter flounder since 2005, 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 RI south shore coastal pond systems 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 1999-2021 by month.

Sex ratios throughout the time series tend to skew slightly female dominant (Figure 4). Many decades ago similar observations were made in Green Hill Pond, a neighboring coastal pond (Saila 1961), and in Narragansett Bay (Saila 1962). 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 96 fyke net sets were conducted in 2021 (Tables 1-3). The total number of winter flounder sampled during the 2021 survey was 222. This was a 130% increase of total catch from the 2020 survey. Sizes ranged from 13.5 cm to 49.5 cm (Figure 5). The CPUE across all ponds in 2021 was 2.3 fish/net haul. 2021 adult winter flounder CPUE in Pt Judith Pond was 0.45 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. 2021 adult winter flounder CPUE in Potter Pond was 2.5 fish per net haul (Figure 7). This value is near the time series median. 2021 winter flounder CPUE in Ninigret Pond was 3.0 fish per net haul (Figure 8). In 2021, a total of 35 mature fish were tagged in Potter Pond, 79 tagged in Ninigret Pond, and 3 fish were tagged within Point Judith Pond. Two tagged winter flounder were recaptured in 2021 in Potter Pond during the survey. One tagged winter flounder recapture was reported by the public in 2021.

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 sampling effort conducted in 2021 revealed similar population trends to those seen in the past few years. More winter flagged were tagged in 2021 than in the previous five years combined; it will be interesting to see if recreational, commercial, or research recaptures increase.

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 2022 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 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, sampling effort may be reduced in Point Judith Pond moving forward.

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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
2021	20	9	3	0
Total	**438**	**3901**	**1491**	**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	2
2021	36	305	35	0
Total	**94**	**213**	**94**	**4**

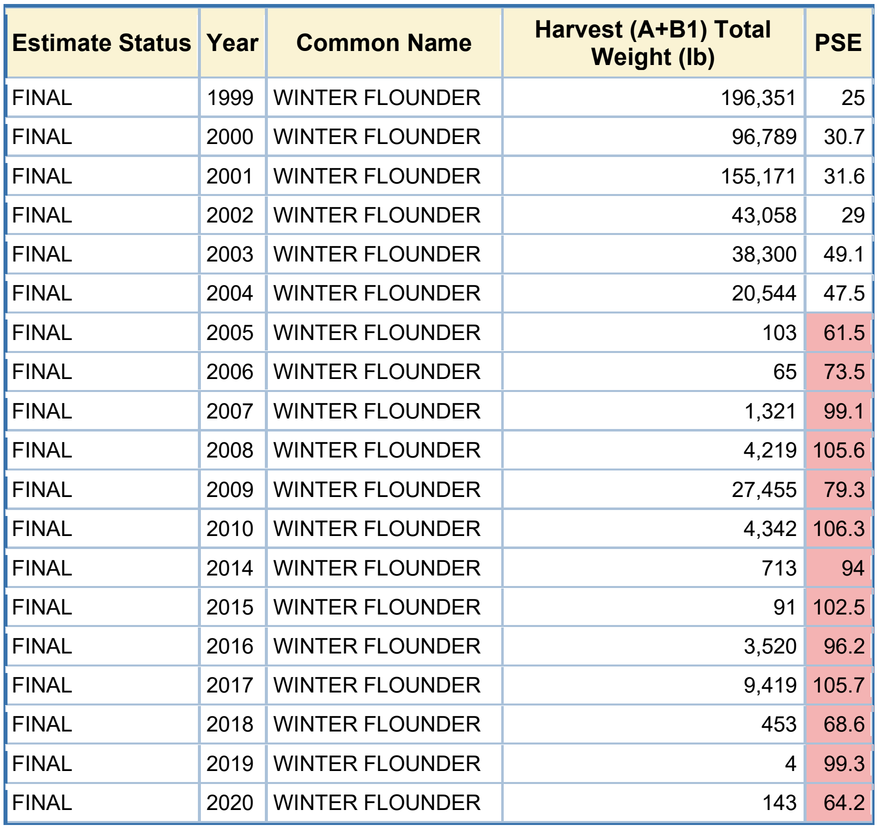
Table 3- Winter flounder tagging/recapture totals in Ninigret Pond by year. Number recaptured indicates the number of tagged fish that were recaptured in that year, regardless of what year that tagged fish had been released.

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	3
2021	40	121	79	0
Total	**131**	**693**	**409**	**32**

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
2020	41.9	0.19
Average	**291.7**	**0.98**

Table 5 - MRIP Estimated Recreational Harvest for winter flounder in Rhode Island. Results from this query for 1999-2019 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. Results display harvest (Type A + B1). Values from 2020 are 100% contributed from imputed data.



Estimate Status	Year	Common Name	Harvest (A+B1) Total Weight (lb)	PSE
FINAL	1999	WINTER FLOUNDER	196,351	25
FINAL	2000	WINTER FLOUNDER	96,789	30.7
FINAL	2001	WINTER FLOUNDER	155,171	31.6
FINAL	2002	WINTER FLOUNDER	43,058	29
FINAL	2003	WINTER FLOUNDER	38,300	49.1
FINAL	2004	WINTER FLOUNDER	20,544	47.5
FINAL	2005	WINTER FLOUNDER	103	61.5
FINAL	2006	WINTER FLOUNDER	65	73.5
FINAL	2007	WINTER FLOUNDER	1,321	99.1
FINAL	2008	WINTER FLOUNDER	4,219	105.6
FINAL	2009	WINTER FLOUNDER	27,455	79.3
FINAL	2010	WINTER FLOUNDER	4,342	106.3
FINAL	2014	WINTER FLOUNDER	713	94
FINAL	2015	WINTER FLOUNDER	91	102.5
FINAL	2016	WINTER FLOUNDER	3,520	96.2
FINAL	2017	WINTER FLOUNDER	9,419	105.7
FINAL	2018	WINTER FLOUNDER	453	68.6
FINAL	2019	WINTER FLOUNDER	4	99.3
FINAL	2020	WINTER FLOUNDER	143	64.2

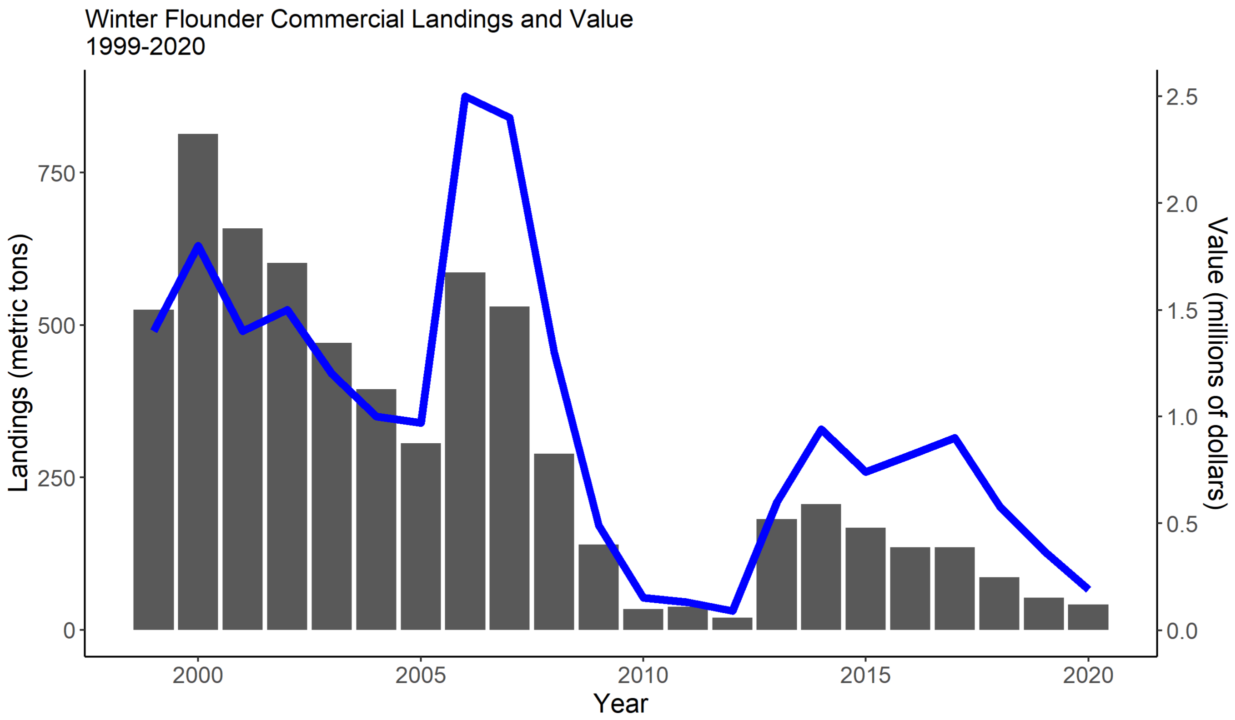


Figure 1 – Winter flounder commercial landings from 1999-2020. Grey bars indicate landings (mt) and the blue line indicates value (millions of dollars).

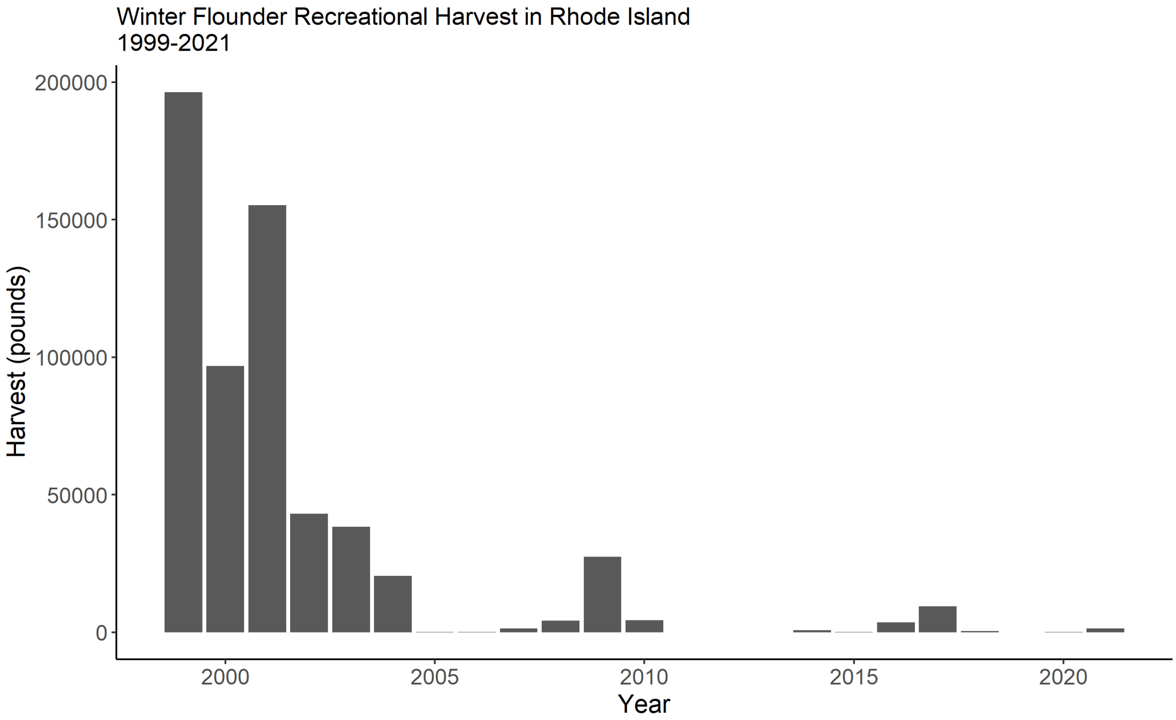


Figure 2 – Winter flounder recreational harvest (lbs) from 1999 to 2021. Note that 2021 data is preliminary.

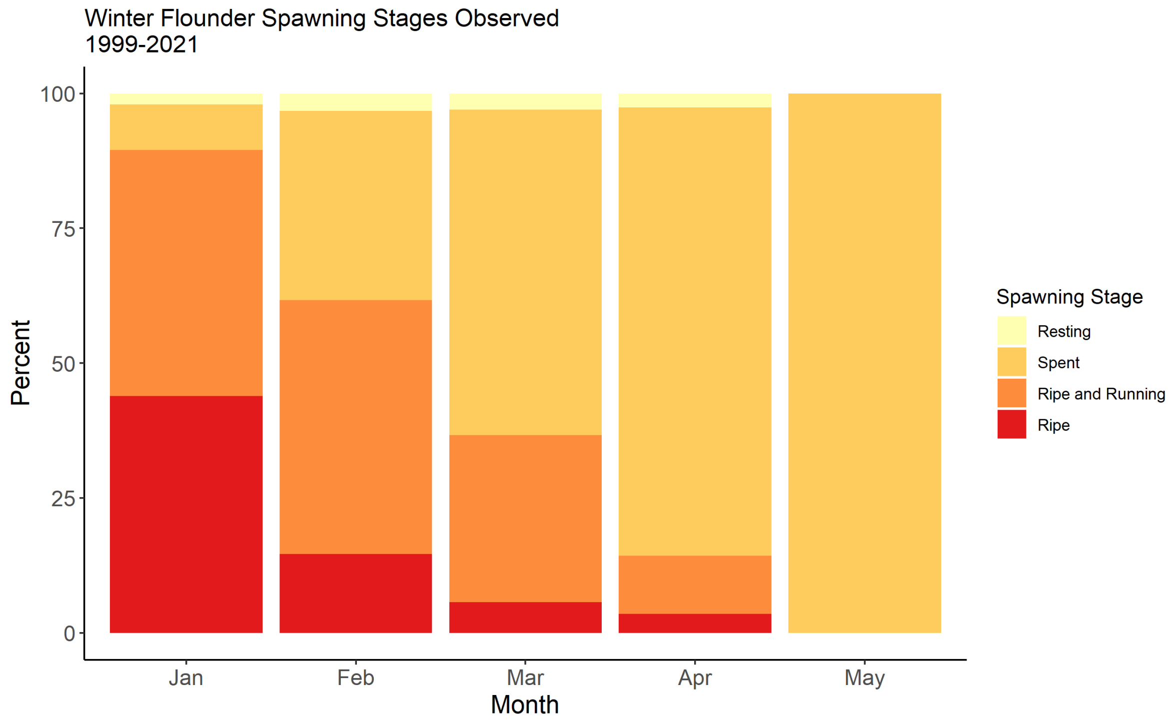


Figure 3 – Winter flounder spawning stages observed by month from 1999-2021.

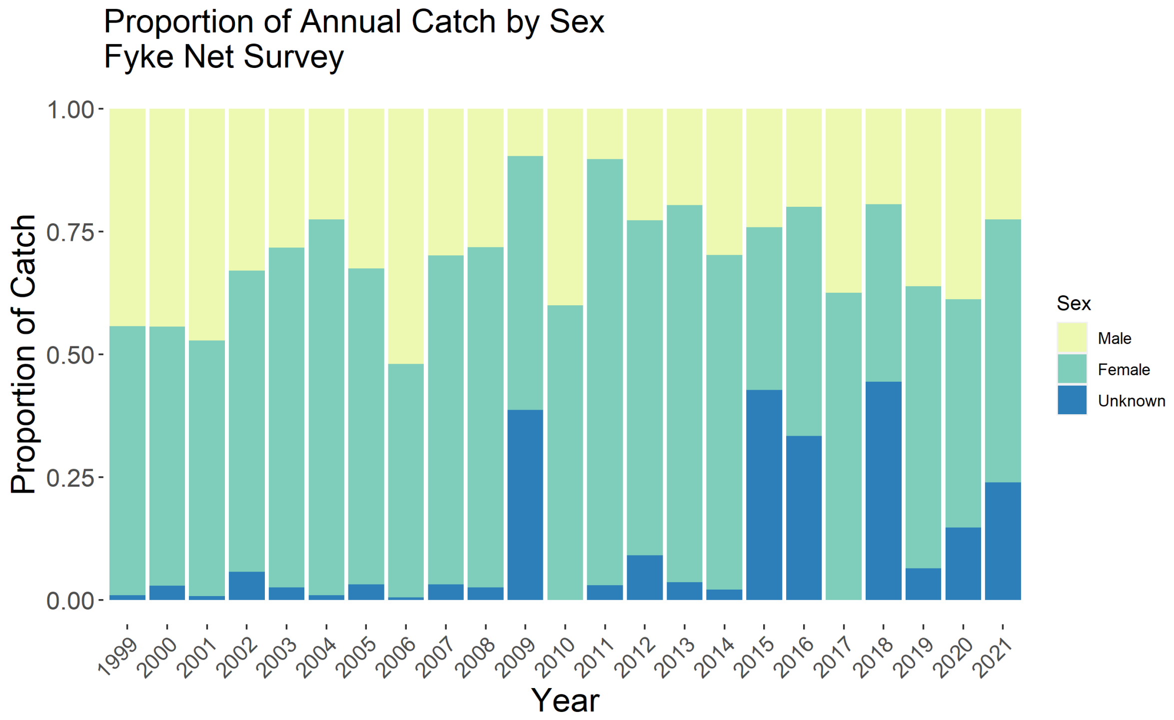


Figure 4 – Winter flounder male to female ratio from 1999-2021 across all three sampled coastal ponds.

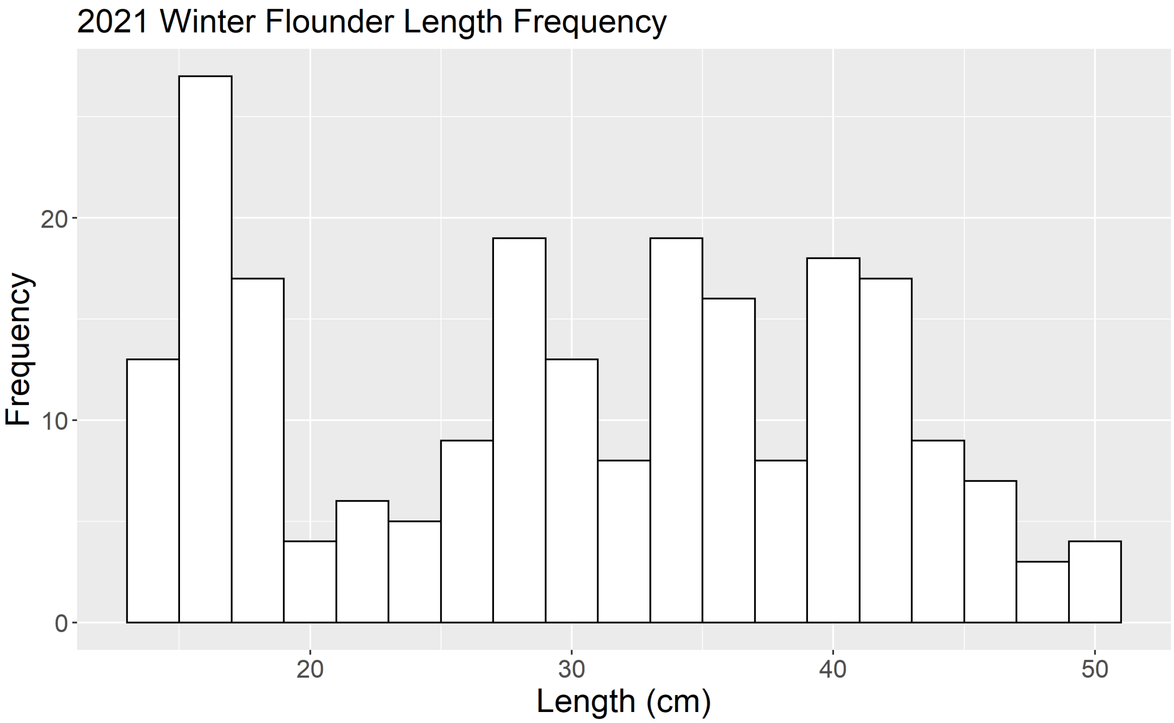


Figure 5 – Winter flounder length-frequency for 2021 survey across all sampled ponds.

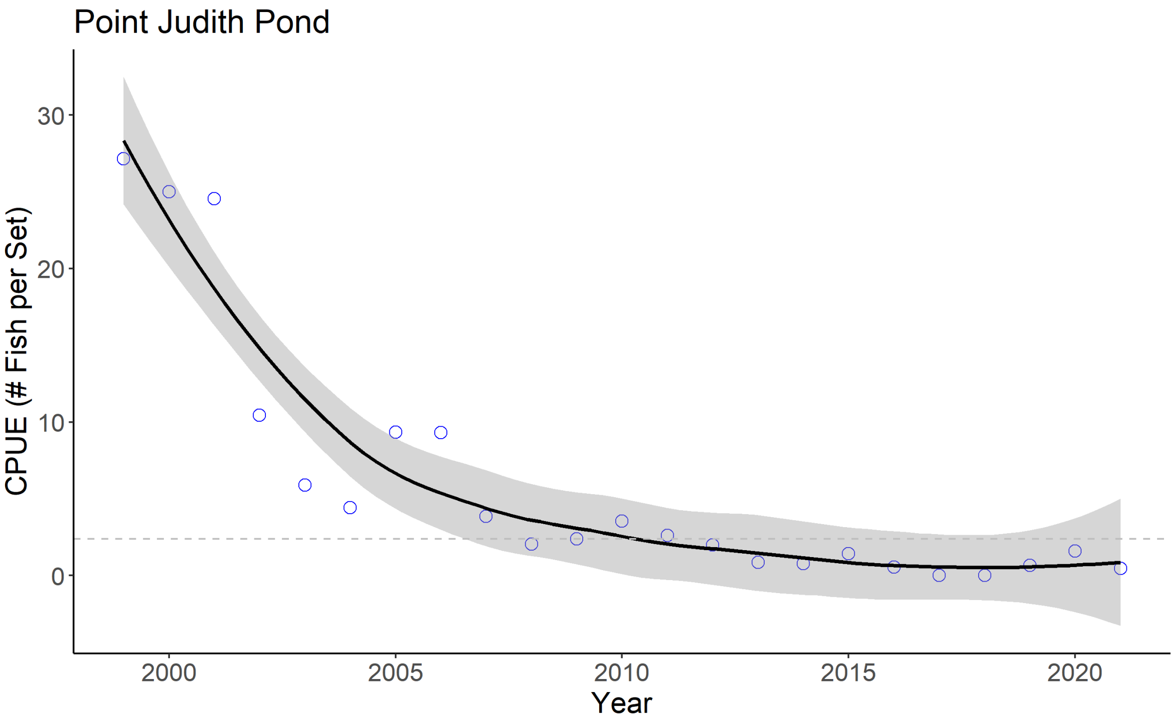


Figure 6 - WFL smoothed abundance index for Point Judith Pond. Gray dashed line is time series median; black line is time series Loess regression fit; and gray shaded area is the approximate 95% confidence limits for Loess regression fit.

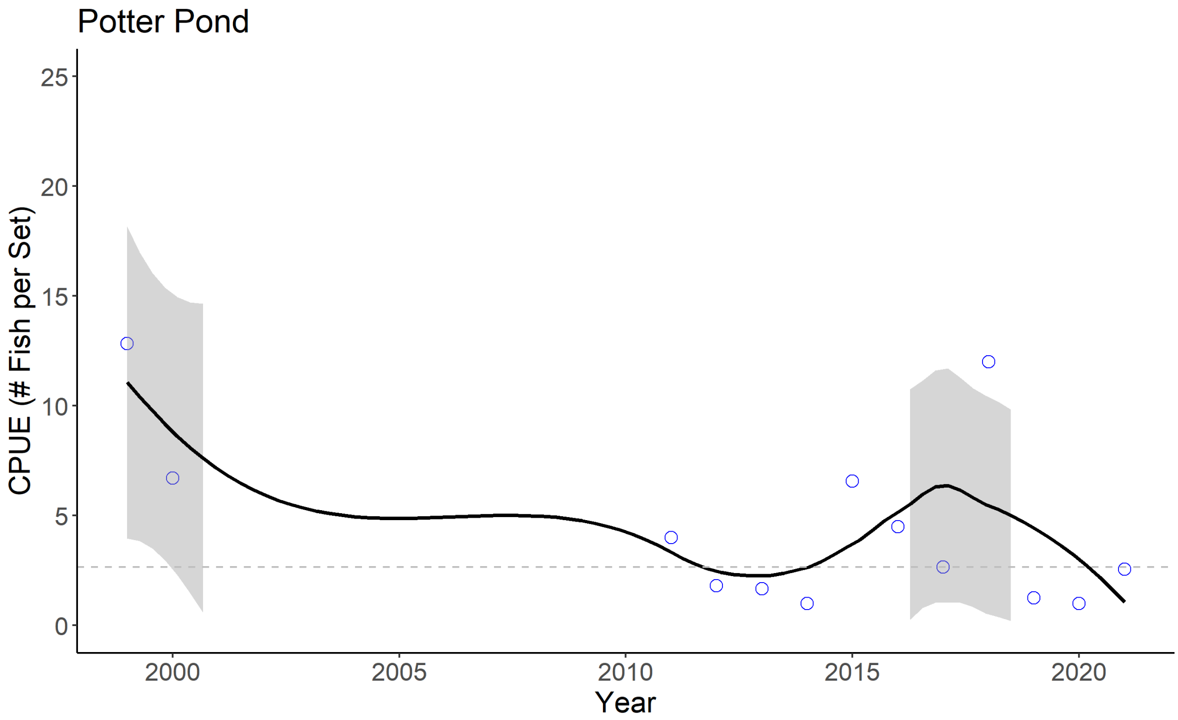


Figure 7 – Winter flounder smoothed abundance index for Potter Pond. Gray dashed line is time series median; black line is time series Loess regression fit; and gray shaded area is the approximate 95% confidence limits for Loess regression fit.

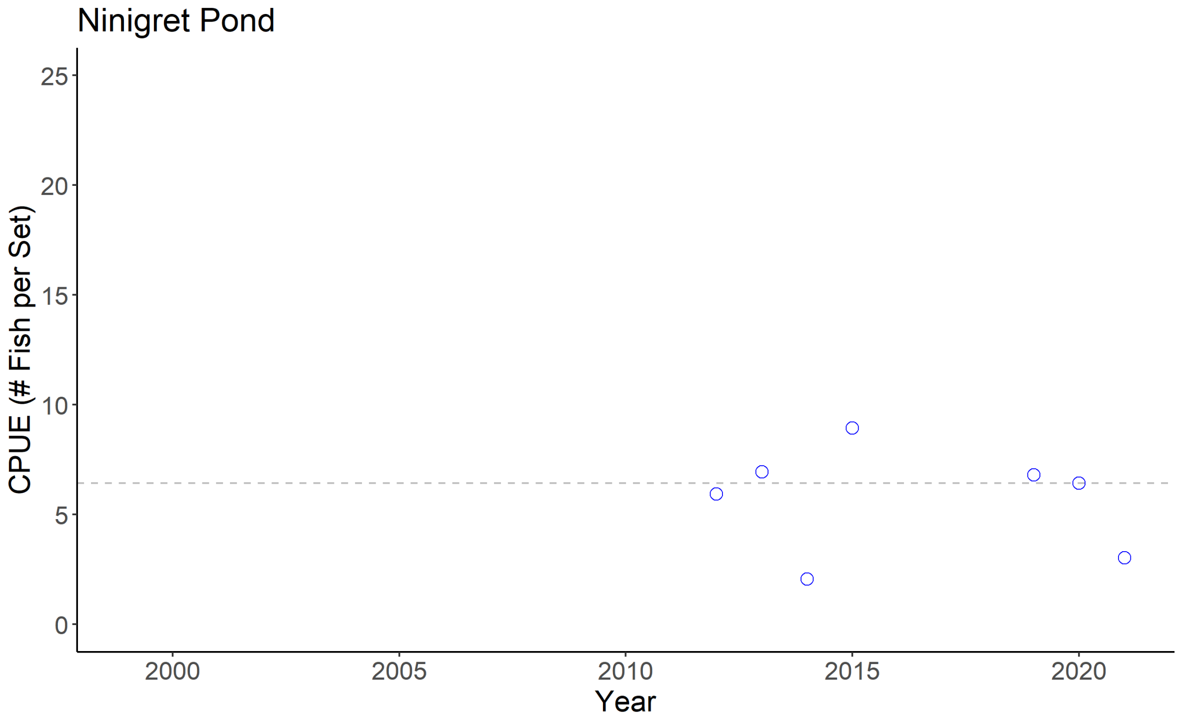


Figure 8 – Winter flounder smoothed abundance index for Ninigret Pond. Gray dashed line is time series median.

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, 2021 – December 31, 2021

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 2021

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.

2021 Fishery Data

In 2021, biomass within the management area reached the minimum 2 million pound threshold in mid-May and the commercial menhaden fishery inside the management opened at 120,000 pounds per vessel per day on May 17, 2021. The management area subsequently closed on June 9, 2021, as a result of the harvest cap being reached. State waters outside of the management area remained open even though RI had fully harvested its entire commercial quota, due to RI being approved to participate in the ASMFC Episodic Event Set-Aside (EESA) Program on June 8, 2021. Biomass inside the management area did not permit re-opening for the remainder of 2021. When the EESA program was closed, RI received a total of 1.6 million pounds of state-to-state quota transfers which allowed state waters outside the management area to remain open through October 18, 2021. A total of 40 contractor spotter flights were completed in 2021 to accurately monitor biomass levels of menhaden within the management area (Figure 1).

SUMMARY: The menhaden monitoring program in Narragansett Bay opened for approximately three weeks in mid-May during the 2021 fishing year as a result of high menhaden biomass. When the full harvest cap was reached, the menhaden management area closed and state waters outside the management area remained open through mid-October. RI fully harvested its initial 2021 commercial quota allocation, participated in the ASMFC EESA program, and received 1.6 million pounds in state-to-state quota transfers. Total landings for RI from all sources totaled over 3.5 million pounds.

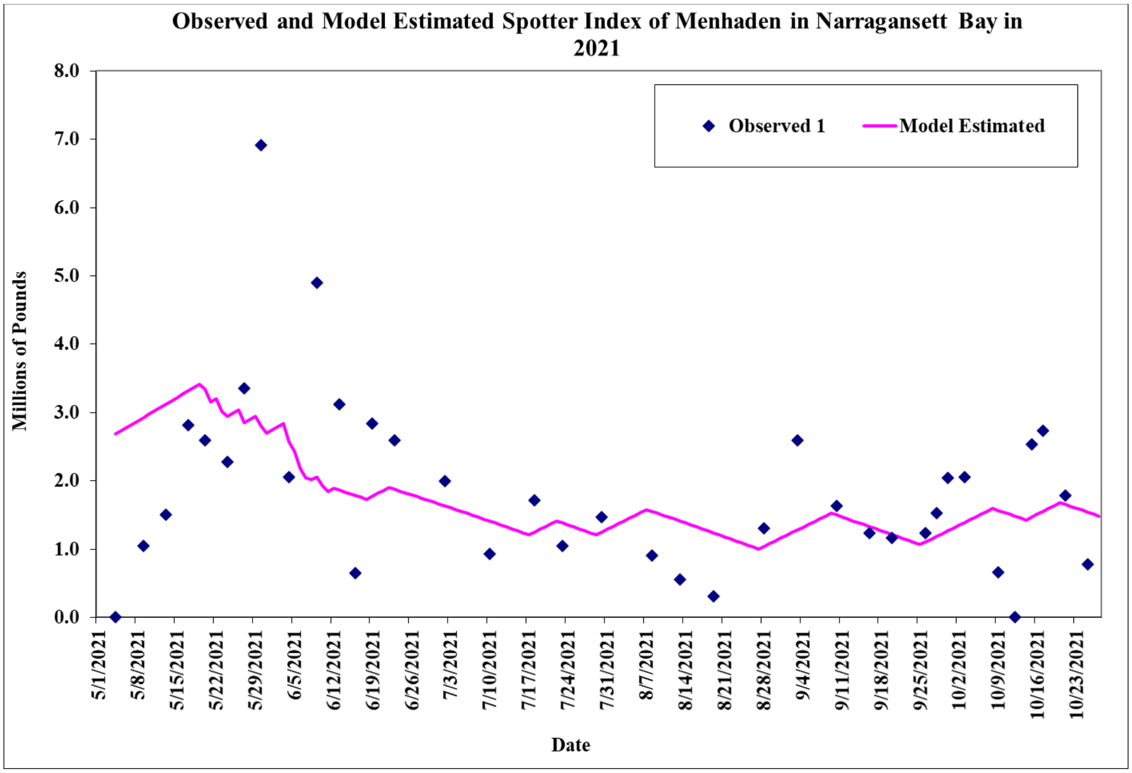

Figure 1. Predicted spotter pilot estimates and observed biomass in Narragansett Bay in 2021.

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Narragansett Bay Ventless Pot Multi-Species Monitoring and Assessment Program

Ventless Fish Pot Survey

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Federal Aid in Sportfish Restoration
F-61-22

Performance Report: Job 12 March 2022

State: Rhode Island Project Number: F-61-R-22

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

Period Covered: January 1, 2021 – December 31, 2021

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: 2021 represented the first year of a new long-term ventless pot multi-species monitoring and assessment program. Only a subset of survey months was sampled in 2021 due to survey development logistics.

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 bottom trawl surveys.

To address this concern, Rhode Island's Division of Marine Fisheries (RIDMF) conducted an exploratory ventless fish pot (referred to alternately as 'pots' and 'traps' throughout and colloquially) survey in Narragansett Bay from 2013 through 2016 and again in 2019. Based on data gathered during the exploratory survey RIDMF designed a standardized monitoring and assessment survey of recreationally important finfish utilizing ventless fish pot gear and began the survey in 2021. The goal of this survey program is 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 was 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.

Fisheries:

Black sea bass, tautog, and scup are commercially and recreationally important species in RI. 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 ten-year time series, landings have shown generally stable (scup, tautog) or slightly increasing (black sea bass) 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 2021 tautog ASMFC stock assessment update, the Massachusetts-Rhode Island stock of tautog is not overfished and overfishing is not occurring (ASMFC 2021). A 3-year average F is 0.23 which is below the target F of 0.28. Spawning stock biomass in 2020 was estimated to be 14.9 million lbs, above the target spawning stock biomass of 10.9 million lbs. Similarly, for scup the 2021 management track stock assessment update indicated the stock is considered rebuilt and not experiencing overfishing, with 2019 SSB estimated at 389 million pounds, about two times the SSB target of 198 million pounds (ASMFC 2021).

Methods and Materials:

Seven sampling subareas are sampled within RI state waters: the Providence River including portions of the Upper Bay/Greenwich Bay, West Passage, East Passage, Mount Hope Bay including portions of the Upper Bay, Sakonnet River including the area from Land's End to Sakonnet Point, eastern RI Sound and western RI Sound. Each area is 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 when possible. The specific locations of structure were noted in the stations containing structural elements. At the start of the year three sampling stations are selected within each subarea and those stations are sampled each month through the year (Figure 1). A 'shallow', 'deep', and 'fixed' station are sampled within each subarea, with 'fixed' stations sampled in the same location every year. 'Shallow' and 'deep' stations are randomly selected each year.

In 2021 the survey was conducted monthly July to September. Traps fished are 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. Baited (frozen clam bellies) trawls of five traps are fished for an overnight soak (~24 hours) at each sampling station. After the 24-hour soak the trap sets were hauled, the catch processed, and gear either reset or removed from the water.

Upon hauling trap trawls, 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. Water temperature and salinity are collected using Star-Oddi loggers on each trawl. Major and minor bottom types present at each sampling station are noted each month based on data from an onboard Furuno transducer.

Results:

In 2021 a total of 61 trawl sets were sampled, totaling 305 individual fish pots set and processed. Twenty-three unique fish and invertebrate species were collected in 2021 with 1,863 fish and 1,915 invertebrates caught. Scup was the most caught fish species with 1,051 individuals trapped (56% of fish catch) (Table 7). Black sea bass were the second most caught fish species (719 individuals, 39% of fish catch) followed by tautog (39 individuals, 2% of total catch) These three species together accounted for over 97% of the total finfish catch. Spider crabs were the most frequently caught invertebrate representing over 80% of the total invertebrate catch (Table 8).

In 2021 black sea bass were caught in greatest abundance over structured bottom, while tautog and scup were caught in similar abundance over hard and soft bottom types (Figure 2). In general, black sea bass were caught in greater abundances at cooler bottom temperatures (10-14C) compared with scup (20-25C) (Figure 3). Likewise, black sea bass were caught in greatest abundances at moderate depths (50-75ft) compared with scup which were most common at shallow sampled depths (0-24ft) (Figure 4). Likely interrelated with depth and bottom temperature, black sea bass were caught in greatest abundance at more southern latitudes samples while scup were most common in the Upper Bay (Figure 5). Keep in mind, only July through September were sampled during the 2021 sampling season.

Discussion:

Results from 2021, the first year of the new long-term ventless pot multi-species monitoring and assessment program 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. Compared with the earlier exploratory studies, 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 across a whole sampling season of the new survey design in 2022 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 2022).

Year	Landings (lbs)	Value (dollars)
2010	241,886	779,001
2011	211,597	734,731
2012	204,360	735,346
2013	265,691	988,876
2014	267,702	884,332
2015	238,647	808,796
2016	294,343	1,091,990
2017	458,152	1,603,746
2018	374,637	1,433,963
2019	399,085	1,508,813
2020	553,749	1,332,448
Average	**326,796**	**1,082,004**

Table 2 - Commercial landings and value of tautog landed in Rhode Island by year (NMFS 2022).

Year	Landings (lbs)	Value (dollars)
2010	44,053	101,431
2011	47,426	124,738
2012	50,126	151,036
2013	53,427	168,478
2014	53,384	182,346
2015	47,140	172,693
2016	50,679	195,296
2017	52,844	194,379
2018	51,449	196,276
2019	46,561	168,046
2020	52,561	161,720
Average	**49,968**	**165,131**

Table 3 - Commercial landings and value of scup landed in Rhode Island by year (NMFS 2022).

Year	Landings (lbs)	Value (dollars)
2010	4,298,488	2,833,016
2011	6,335,920	3,311,831
2012	6,310,689	3,904,255
2013	7,345,771	3,666,438
2014	6,948,869	4,117,990
2015	6,793,853	4,278,298
2016	6,808,917	4,053,287
2017	5,973,305	3,077,933
2018	4,713,741	2,739,752
2019	4,583,835	2,570,825
2020	4,290,953	2,413,734
Average	**5,854,940**	**3,360,669**

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
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	21.2
2018	1,628,875	15.3
2019	1,225,058	16
2020	1,480,782	20.1

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
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
2020	853,470	19.2

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
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
2020	1,330,398	17.4

Table 7 – Fish catch from the ventless fish pot survey from 2021. Mean catch is number of individuals per trawl (5 trap string) ± standard error.

Species	Mean Catch ± SE	Total Catch
Scup	17.22 ± 2.33	1051
Black Sea Bass	11.78 ± 1.61	719
Tautog	0.64 ± 0.14	39
Cunner	0.26 ± 0.13	16
Conger Eel	0.21 ± 0.09	13
Oyster Toadfish	0.13 ± 0.04	8
Grey Triggerfish	0.05 ± 0.04	3
Red Hake	0.05 ± 0.03	3
Summer Flounder	0.05 ± 0.02	3
American Eel	0.03 ± 0.02	2
Atlantic Cod	0.03 ± 0.02	2
Smooth Dogfish	0.03 ± 0.02	2
Atlantic Menhaden	0.02 ± 0.01	1
Northern Puffer	0.02 ± 0.01	1

Table 8 – Invertebrate catch from the ventless fish pot survey from 2021. Mean catch is number of individuals per trawl (5 trap string) ± standard error.

Species	Mean Catch ± SE	Total Catch
Spider Crab	25.16 ± 5.5	1535
Channeled Whelk	2.54 ± 0.6	155
American Lobster	2.31 ± 0.6	141
Rock Crab	0.69 ± 0.6	42
Knobbed Whelk	0.39 ± 0.2	24
Jonah Crab	0.16 ± 0.1	10
Blue Crab	0.08 ± 0.1	5
Green Crab	0.03 ± 0.02	2
Quahog	0.02 ± 0.01	1

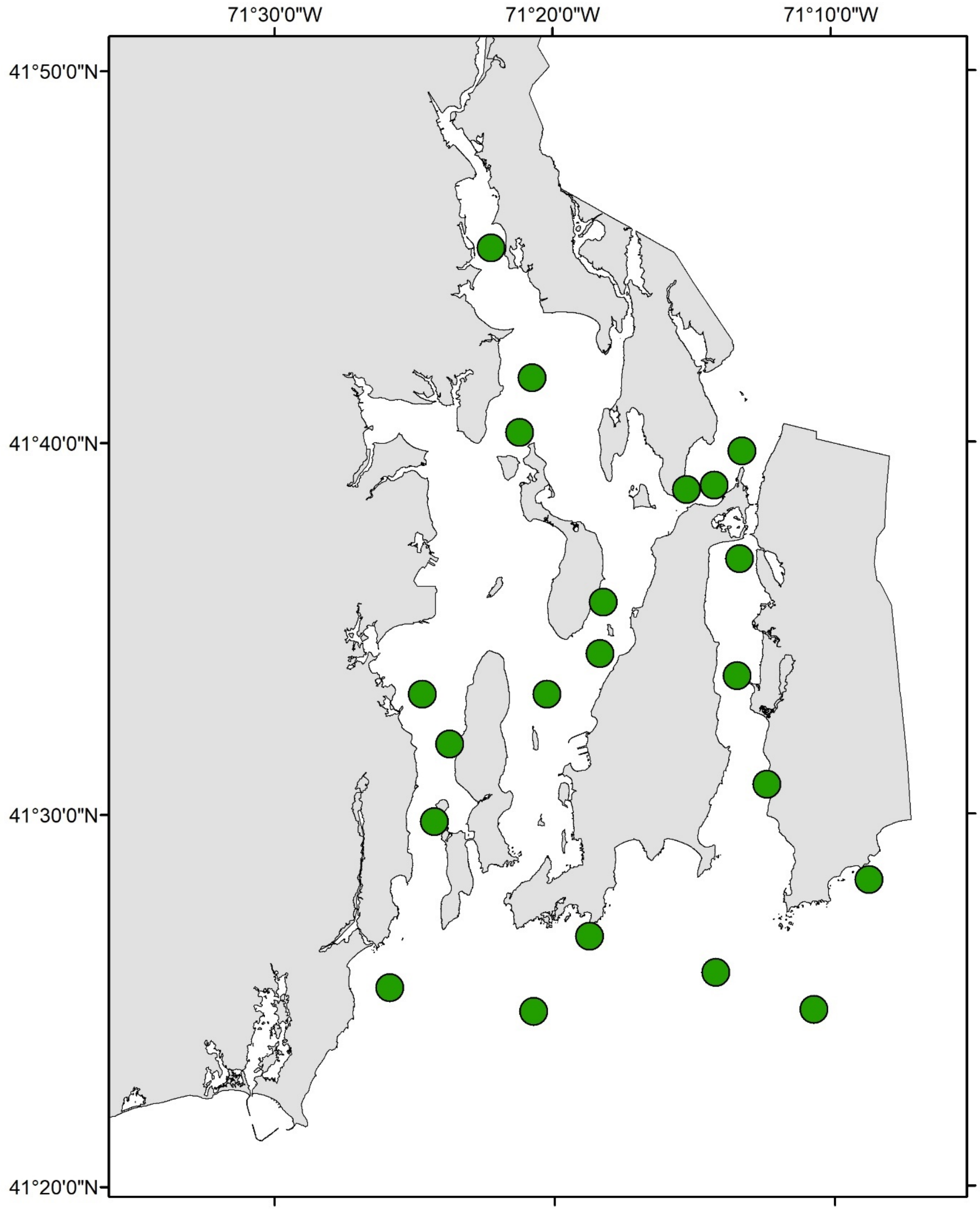

Figure 1 – Ventless pot multi-species monitoring and assessment program sampling locations 2021.

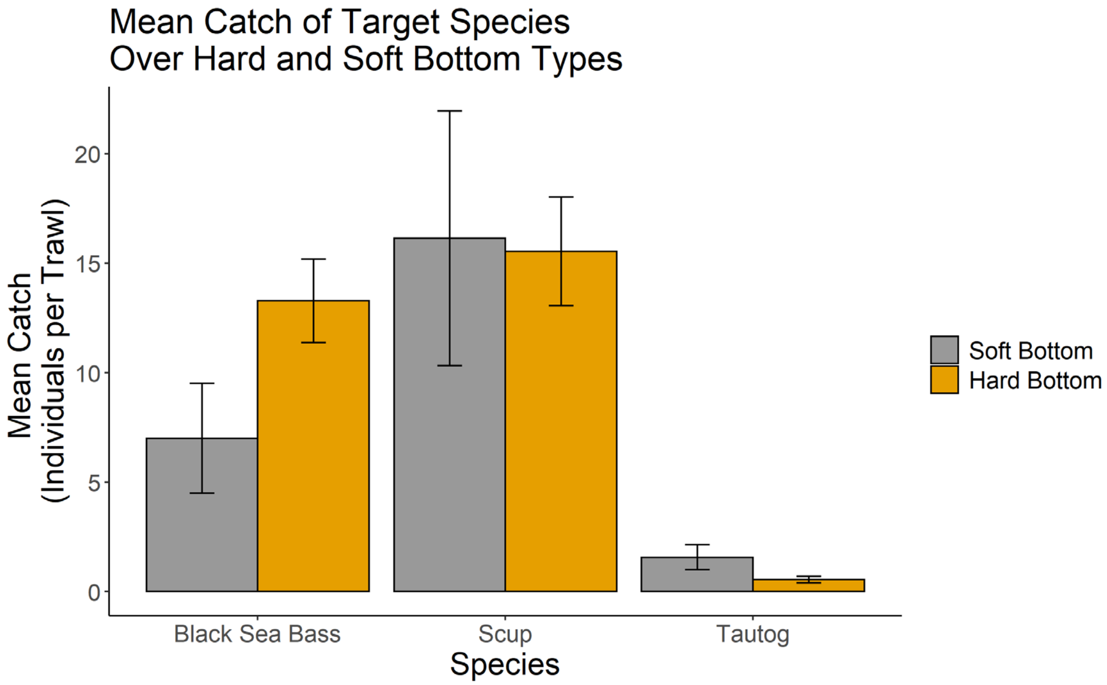

Figure 2 – Target fish species mean catch over hard and soft bottom types. Bars represent mean catch and error bars represent standard error.

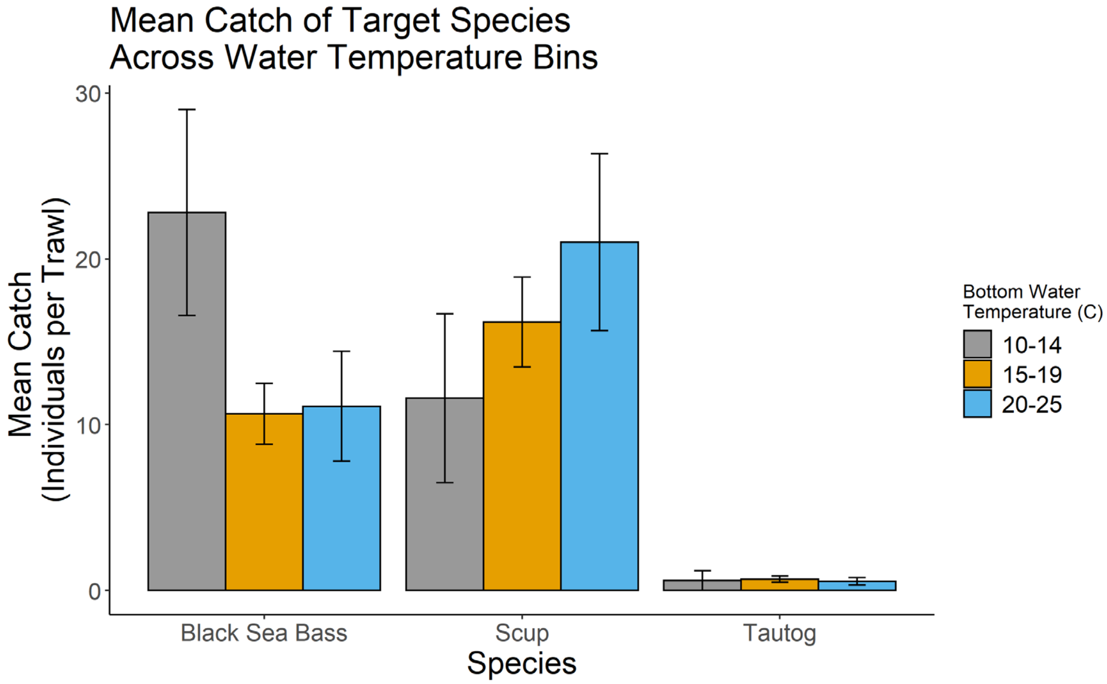

Figure 3 – Target fish species mean catch across bottom temperature bins. Bars represent mean catch and error bars represent standard error.

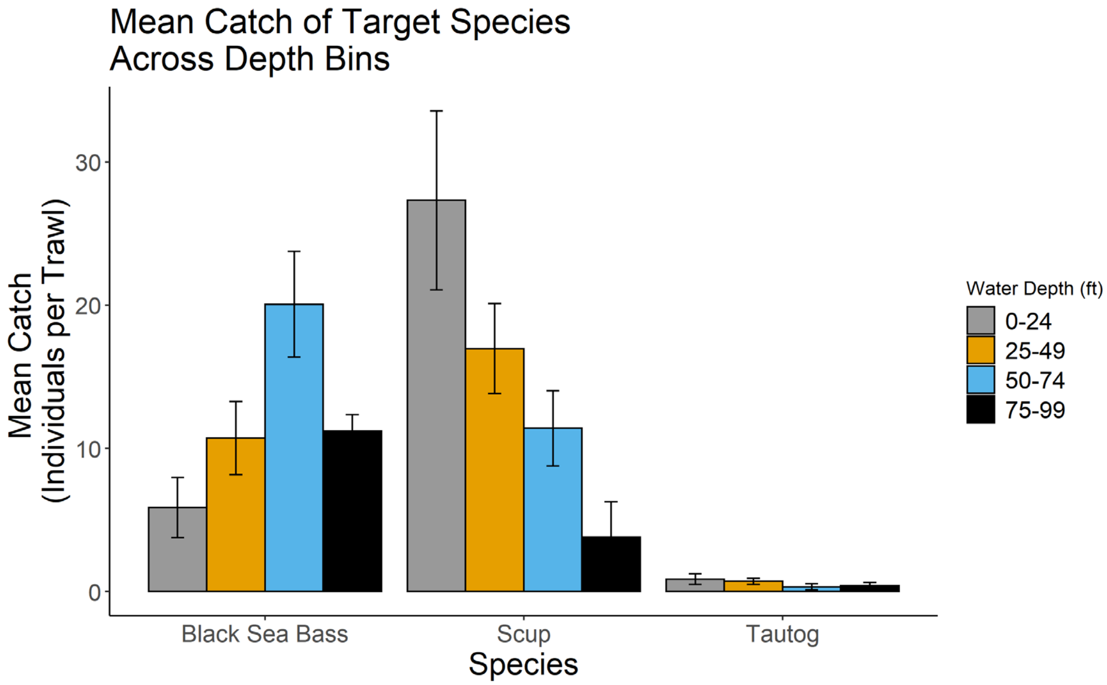

Figure 4 – Target fish species mean catch across bottom depth bins. Bars represent mean catch and error bars represent standard error.

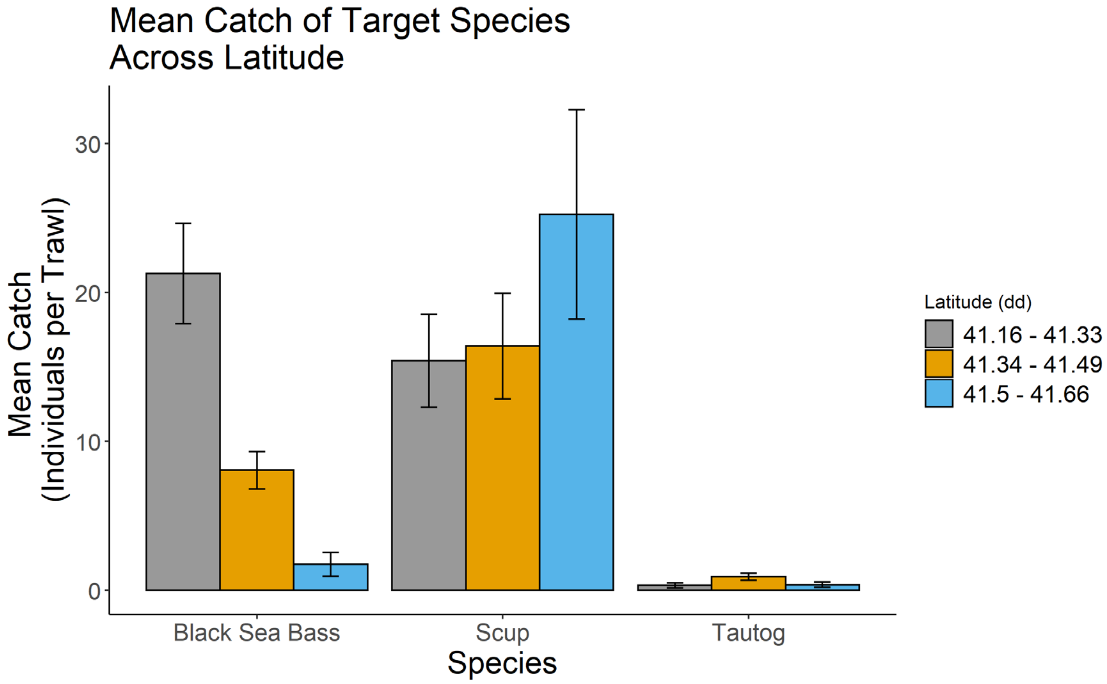

Figure 5 – Target fish species mean catch across latitude bins. Bars represent mean catch and error bars represent standard error.

ASSESSMENT OF RECREATIONALLY IMPORTANT FINFISH STOCKS IN RHODE ISLAND COASTAL WATERS

2021 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 2022

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, 2021 – December 31, 2021

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 for this project (January 1, 2014 – December 31, 2019) (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 2021 (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 reported to be observed by entities other than RIDMF, either recently or historically. Of these 284 species, a total of 100 species will be illustrated, including 5 species with both sexes illustrated, for a total of 105 illustrations. There were 86 species observed rarely and 98 species never observed in RIDMF surveys but were reported to be observed by other sources (184 species total) 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, 2021 – December 31, 2021), a total of 10 species illustrations were completed by the illustrator (Robert Jon Golder) with 2 other illustrations near completion. There have been numerous email correspondences (≈30) and two (2) in-person meetings with the illustrator during this report period when completed illustrations and invoices were delivered to RIDMF and additional frozen fish specimens were provided for illustration reference (Table 4).

TARGET DATE: December 31, 2024

SIGNIFICANT DEVIATIONS: None

RECOMMENDATIONS: Continue into the next grant segment reporting period.

REMARKS:

- The marine fish illustrations part of the job is now on schedule.
- One (1) species (*Serranus scriba*) was removed from inclusion in the book, as it was determined to be a misapplied name to the species *Sebastes norvegicus*.

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 segment reporting period, January 1, 2021 - December 31, 2021 with total number completed* (January 1, 2014 – December 31, 2021*) and total number required (* includes previous grant award).

Book Sections	**Number completed 1/1/2021-12/31/2021**	**Total Number Completed***	**Total Number Required***
Family Descriptions	18	109	117
Cover page	0	1	1
Table of Contents	0	1	1
Acknowledgements	0	1	1
Dedication	0	1	1
Introduction	0	1	1
Description of Data Sources	0	7	7
Survey sampling maps	0	7	7
Survey activity photos	0	4	4
Tables	0	6	6
Glossary	0	In progress	1
Taxonomic Index	0	1	1
Common / Species Name	0	284	284
Other Name(s)	55	272	284
RI Sportfish Record	0	284	284
All-Tackle Record	0	284	284
Species ID / Description	47	250	284
General / Local Distribution	46	249	284
Diet	46	251	284
Importance	50	253	284
Management	55	270	284
Illustrations	10 (10 species)	72 (100 species)	105 (100 species)
Species - text completed	46	253	284
Species - text incomplete	31	-	-

Table 3. Summary of book sections completed by species and illustration status for previous grant award (January 1, 2014 - December 31, 2019; x, done), current grant award (January 1, 2020 - December 31, 2024; **X**, **done**) and current segment reporting period (January 1, 2021 - December 31, 2021; **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	**done**
Anchoa hepsetus	x	x	x	x	x	x	x	x	x	x	done	YES	done
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	x	x	X	X	X	X	X	**done**	YES	**done**
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	**done**
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	X	X	x	X	X	**done**	YES	
Centropristis striata (M)	X	x	x	x	x	X	X	x	X	X	**done**	YES	
Citharichthys arctifrons	X	x	X	x	x	X	X	X	X	X	**done**	YES	**done**
Clupea harengus	x	x	x	x	x	x	x	x	x	x	done	YES	**done**
Conger oceanicus	x	x	x	x	x	x	x	x	x	x	done	YES	
Cynoscion regalis	X	x	X	x	x	X	X	X	X	X	**done**	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
Decapterus punctatus	x	x	x	x	x	X	X	X	X	x	**done**	YES	
Dorosoma cepedianum	x	x	x	x	x	x	x	x	x	x	done	YES	done
Enchelyopus cimbrius	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	**done**
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

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 heteroclitus (F)	x	x	x	x	x	x	x	x	x	x	done	YES	done
Fundulus heteroclitus (M)	x	x	x	x	x	x	x	x	x	x	done	YES	
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	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	done
Leiostomus xanthurus	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	**in progress**
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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	YES	
Leucoraja ocellata	**X**	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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	

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
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	
Paralichthys oblongus	X	x	X	x	x	X	X	X	X	X	done	YES	done
Peprilus triacanthus	X	x	X	x	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	done
Pollachius virens	x	x	x	x	x	X	X	X	X	x	done	YES	done
Pomatomus saltatrix	X	x	X	x	x	X	X	X	X	X	done	YES	done
Pomoxis nigromaculatus	x	x	x	x	x	X	X	X	X	x	done	YES	done
Priacanthus arenatus	X	x	X	x	x	X	X	X	X	x	done	YES	
Prionotus carolinus	X	x	X	x	x	X	X	X	X	X	done	YES	done
Prionotus evolans	X	x	X	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	YES	
Rhinichthys atratulus	x	x	x	x	x	x	x	x	x	x	done	YES	done
Salmo salar	X	x	X	x	x	X	X	X	X	X	done	YES	done
Salmo trutta	X	x	X	x	x	X	X	X	X	X	done	YES	done
Salvelinus fontinalis	X	x	X	x	x	X	X	X	X	X	done	YES	done
Scomber scombrus	X	x	X	x	x					X		YES	done
Scophthalmus aquosus	X	x	X	x	x	X	X	X	X	X	done	YES	done
Selene setapinnis	x	x	x	x	x	X	X	X	X	x	done	YES	done
Selene vomer	x	x	x	x	x	X	X	X	X	x	done	YES	done
Sphoeroides maculatus	x	x	x	x	x	X				x		YES	done
Sphyraena borealis	X	x	X	x	x	X	X	X	X	X	done	YES	in progress
Squalus acanthias	X	x	X	x	x	X	X	X	X	X	done	YES	
Stenotomus chrysops	x	x	x	x	x	X	x	X	X	x	done	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	done
Trinectes maculatus	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
Upeneus parvus	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	**done**
Urophycis chuss	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Urophycis regia	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	YES	
Urophycis tenuis	**X**	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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

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
Brosme brosme	x	x	x	x	x	**X**	**X**	**X**	**X**	x	**done**	NO	N/A
Calamus bajonado	x	x	**X**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	NO	N/A
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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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
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**	x	x	**X**	**X**	**X**	**X**	**X**	**done**	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
Engraulis eurystole	x	x	x	x	x	x	x	x	x	x	done	NO	N/A
Epinephelus niveatus	**X**	x	**X**	x	x			**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	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	NO	N/A
Heteropriacanthus cruentatus	X	x	X	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	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	x	x	X	X	X	X	X	done	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	x							NO	N/A
Mycteroperca phenax	X	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	x	x	X	X	X	X	X	done	NO	N/A
Peristedion miniatum	X	x	X	x	x	X	X	X	X	X	done	NO	N/A
Pogonias cromis	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
Prionace glauca	x	x	x	x	x	X	X	X	X	X	**done**	NO	N/A
Prionotus rubio	X	x	x	x	x		X	X	X	X		NO	N/A
Pristigenys alta	X	x	X	x	x	X	X	X	X	x	**done**	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	x	x	X	X	X	X	X	**done**	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	x							NO	N/A
Sarda sarda	X	x	X	x	x	X	X	X	X	X	**done**	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	x	X	X	X	X	x	**done**	NO	N/A
Scomber colias	X	x	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	x	x					X		NO	N/A
Scomberomorus regalis	X	x	X	x	x							NO	N/A
Scyliorhinus retifer	x	x	x	x	x				x	x		NO	N/A
Sebastes norvegicus	X	x	X	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	x	x					X		NO	N/A
Sphyraena guachancho	X	x	X	x	x					X		NO	N/A
Sphyrna lewini		x	x	x	x					X		NO	N/A
Sphyrna tiburo		x	x	x	x					X		NO	N/A
Sphyrna zygaena		x	x	x	x					X		NO	N/A
Squatina dumeril		x		x	x							NO	N/A
Stegastes leucostictus	X	x	X	x	x	X	X	X	X	X	**done**	NO	N/A
Stegastes partitus	X	x	X	x	x	X	X	X	X	X	**done**	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**	x	x					**X**		NO	N/A
Thunnus albacares	**X**	x	**X**	x	x					**X**		NO	N/A
Thunnus obesus	**X**	x	**X**	x	x					**X**		NO	N/A
Thunnus thynnus	**X**	x	**X**	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	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 (January 1, 2020 - December 31, 2024; **X**, **done**), current grant period (January 1, 2021 - December 31, 2021; **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 (x, done).

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	X	X	X	X	X	X	done	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	X	X	X	X	X	X	done	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	X	X	X	X	X	X	done	Marine Fishes of RI
Etropus microstomus	Smallmouth flounder	X	X	X	X	X	X	done	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	X	X	X	X			in progress	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	X	X	X	X	X	X	done	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	X	done	Marine Fishes of RI
Selene setapinnis	Atlantic moonfish	X	X	X	X	X	X	done	Marine Fishes of RI
Sphoeroides maculatus	Northern puffer	X	X	X	X	X	X	done	Marine Fishes of RI
Sphyraena borealis	Northern sennet	X	X	X	X	X		in progress	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	X	X	X	X	X	X	done	Marine Fishes of RI
Upeneus parvus	Dwarf goatfish	X	X	X	X	X	X	done	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
2021

PERFORMANCE REPORT
F-61-R SEGMENT 21
JOB 14

Jeremy Collie, PhD
Professor of Oceanography
March 2022

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, 2021 – December 31, 2021.

TARGET DATE: December 2021

SCHEDULE OF PROGRESS: On schedule.

SIGNIFICANT DEVIATIONS: None

RECOMMENDATIONS: Continuation of the weekly trawl survey into 2022; 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 2021. 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 2021 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

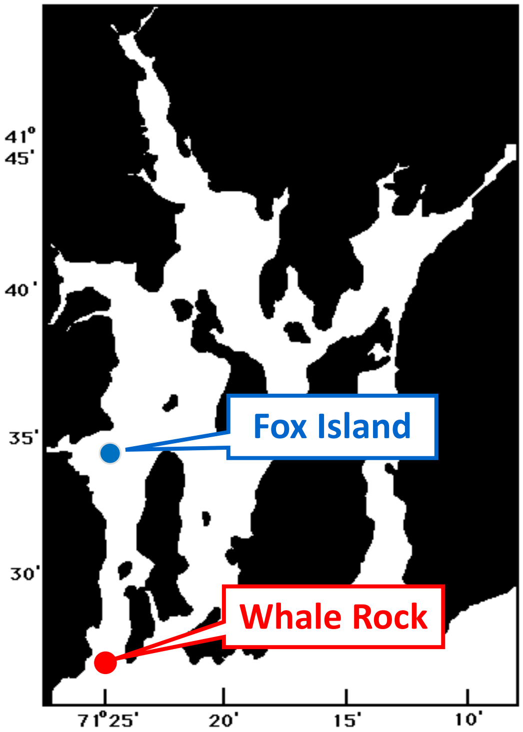


Figure 1. Location of trawl stations in Narragansett Bay.

(For more information about the GSO fish trawl go https://web.uri.edu/gso/research/fish-trawl/)

Results:

51 weekly tows were made at both the bay (Fox Island) and sound (Whale Rock) stations. One week of sampling was missed in December because of a positive case of Covid-19. Neither station was sampled that week.

Environmental conditions

Weekly water temperatures at both stations were overall comparable to the historic average throughout the year (Figure 2), with the fall and winter slightly warmer. Surface temperature at Whale Rock was not measured for one week in July because of an equipment issue.

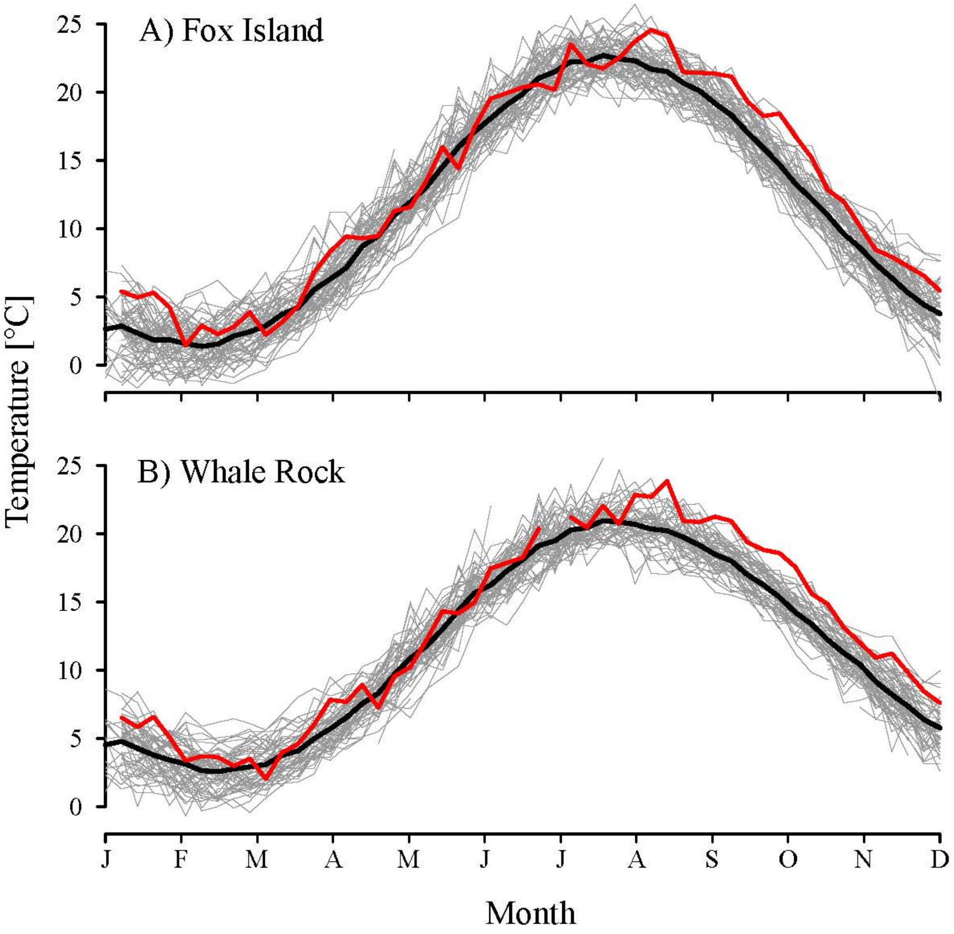


Figure 2. Weekly sea surface temperature of Narragansett Bay at each sampling station. The gray lines represent the seasonal temperature cycle for each previous year. The black line is the average temperature over all years. The most recent year, 2021, is labeled red.

Summary catch statistics

Table 3. Total catch by species at Fox Island (FI) and Whale Rock (WR) for the top 25 species caught in 2021.

Species	**FI**	**WR**	**Total**
SCUP (*Stenotomus chrysops*)	8980	3276	12256
ATLANTIC MOONFISH (*Selene setapinnis*)	6764	279	7043
LONGFIN SQUID (*Doryteuthis peali*)	945	4892	5837
BUTTERFISH (*Peprilus triacanthus*)	382	1775	2157
ATLANTIC ROCK CRAB (*Cancer irroratus*)	29	1386	1415
SUMMER FLOUNDER (*Paralichthys dentatus*)	330	148	478
LITTLE SKATE (*Leucoraja erinacea*)	17	439	456
SPIDER CRAB (*Libinia emarginata*)	229	153	382
WEAKFISH (*Cynoscion regalis*)	23	228	251
ATLANTIC SILVERSIDE (*Menidia menidia*)	157	68	225
STRIPED SEAROBIN (*Prionotus evolans*)	60	143	203
WINTER FLOUNDER (*Pseudopleuronectes americanus*)	38	154	192
BLUE MUSSEL (*Mytilus edulis*)	178	0	178
BLUE CRAB (*Callinectes sapidus*)	110	61	171
NORTHERN SEAROBIN (*Prionotus carolinus*)	9	151	160
SILVER HAKE (*Merluccius bilinearis*)	3	156	159
SMOOTH DOGFISH (*Mustelus canis*)	123	33	156
HERMIT CRAB (*Pagurus pollicaris*)	136	9	145
CONCH (*Busycon canaliculatum* & *B. carica*)	114	5	119
MENHADEN (*Brevoortia tyrannus*)	7	110	117
BAY ANCHOVY (*Anchoa mitchilli*)	44	65	109
SPOTTED HAKE (*Urophycis regia*)	8	101	109
SAND SHRIMP (*Crangon septiemspinosa*)	39	41	80
ATLANTIC HERRING (*Clupea harengus*)	29	40	69
SMALLMOUTH FLOUNDER (*Etropus microstomus*)	10	58	68
Total	**18764**	**13771**	**32535**

The top 10 species caught in 2021 (and the station where they were most numerous) were: Scup (FI), Moonfish (FI), Squid (WR), Butterfish (WR), Rock crab (WR), Summer flounder (FI), Little skate (WR), Spider crabs (FI), Weakfish (WR), and Silverside (FI).

A number of species of recreational importance were collected during 2021 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.

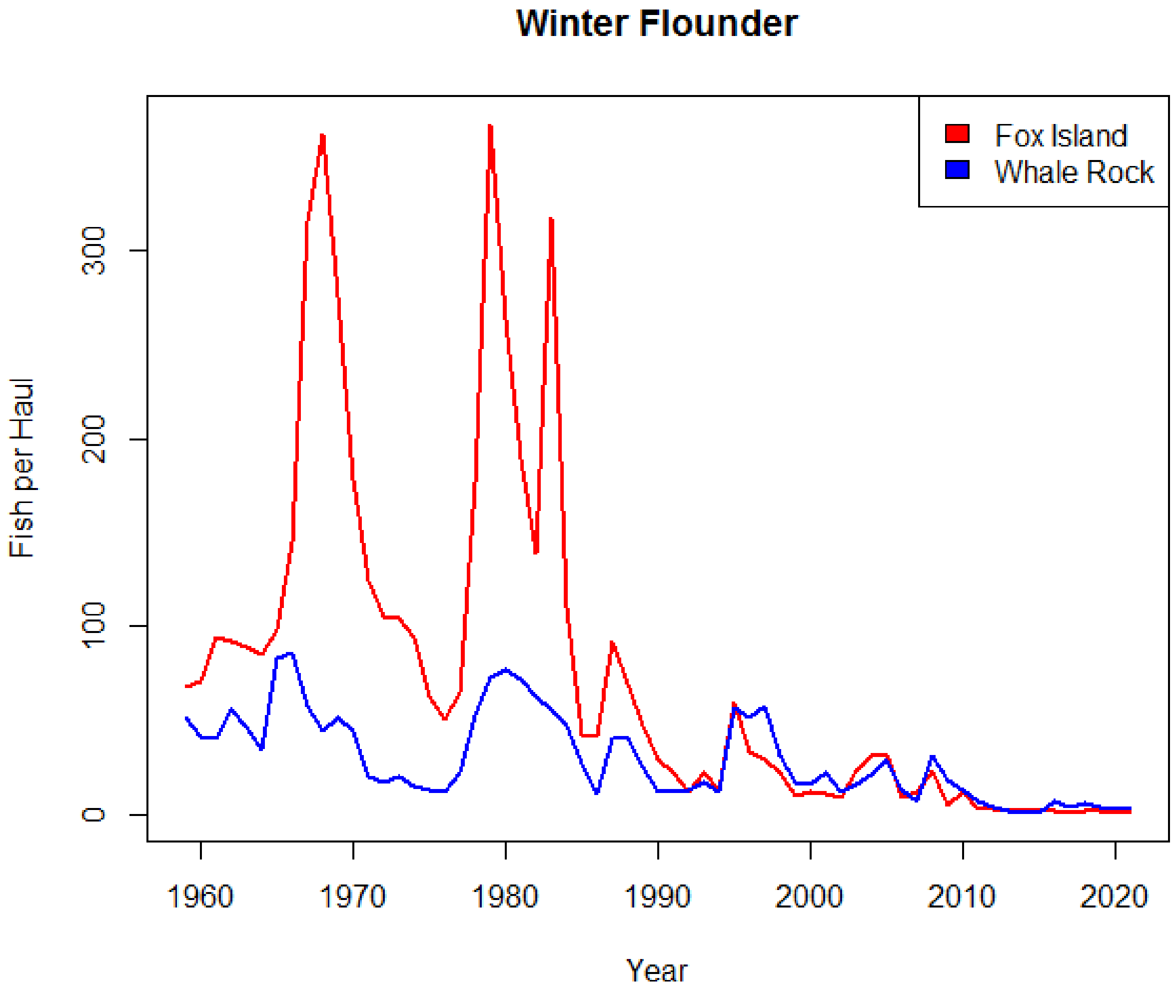


Figure 3 – Survey data for entire time series for winter flounder at both sampling stations (Fox Island and Whale Rock).

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.

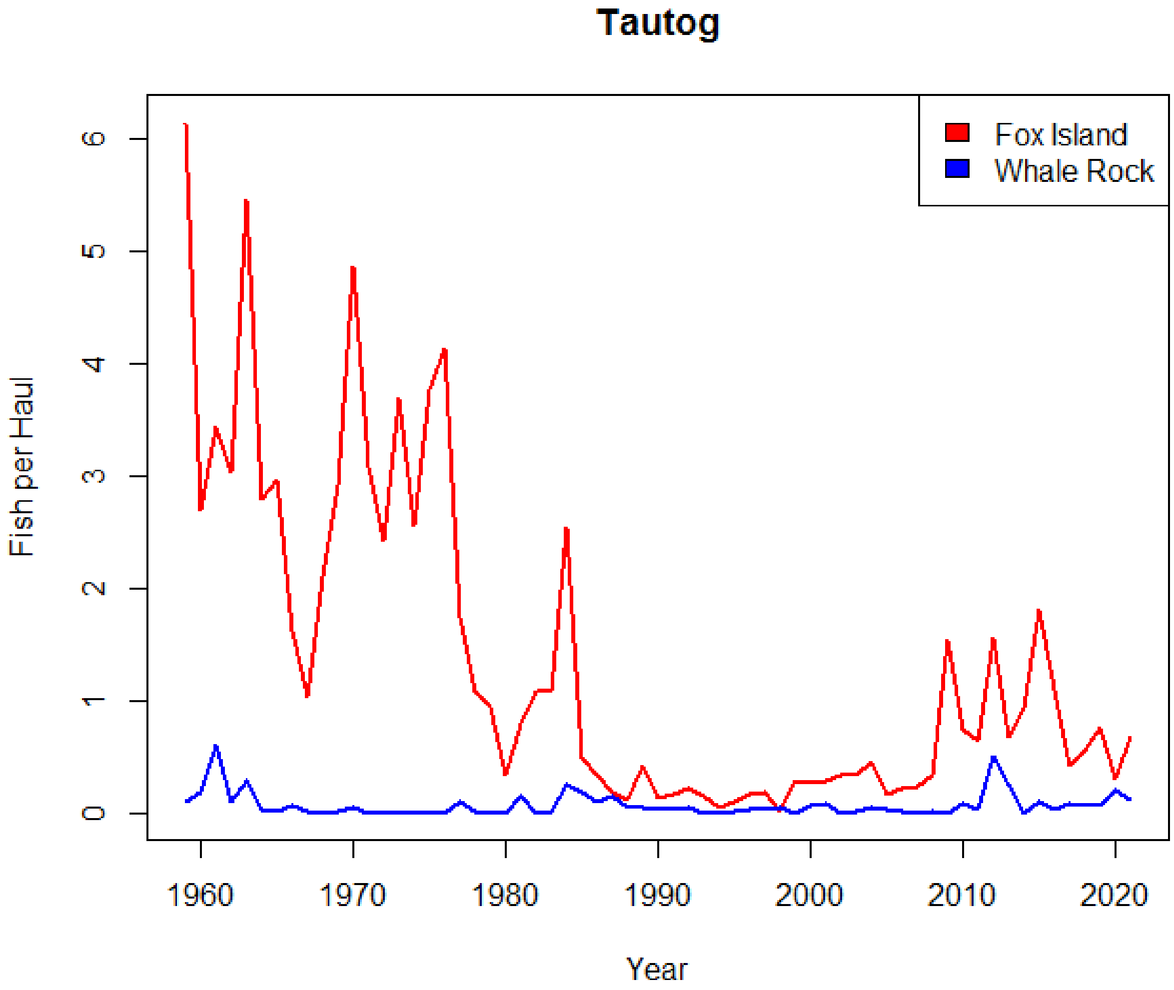


Figure 4 – Survey data for entire time series for tautog at both sampling stations (Fox Island and Whale Rock).

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 show a fair amount of variability in the most recent time period (Figure 5). Summer flounder are caught at both sampling stations consistently, although 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.

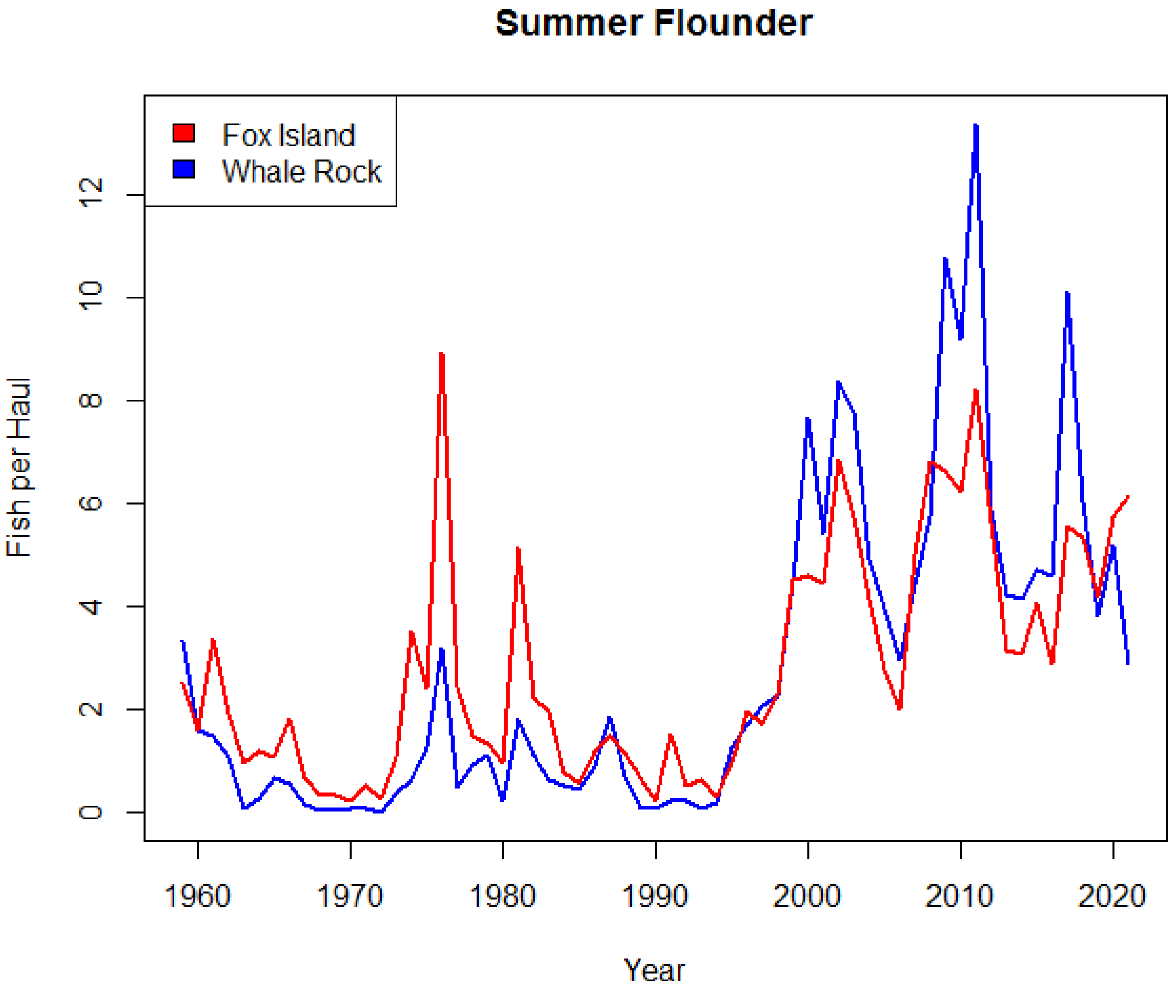
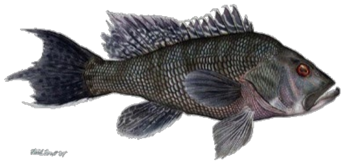


Figure 5 – Survey data for entire time series for summer flounder at both sampling stations (Fox Island and Whale Rock).



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 fairly consistently.

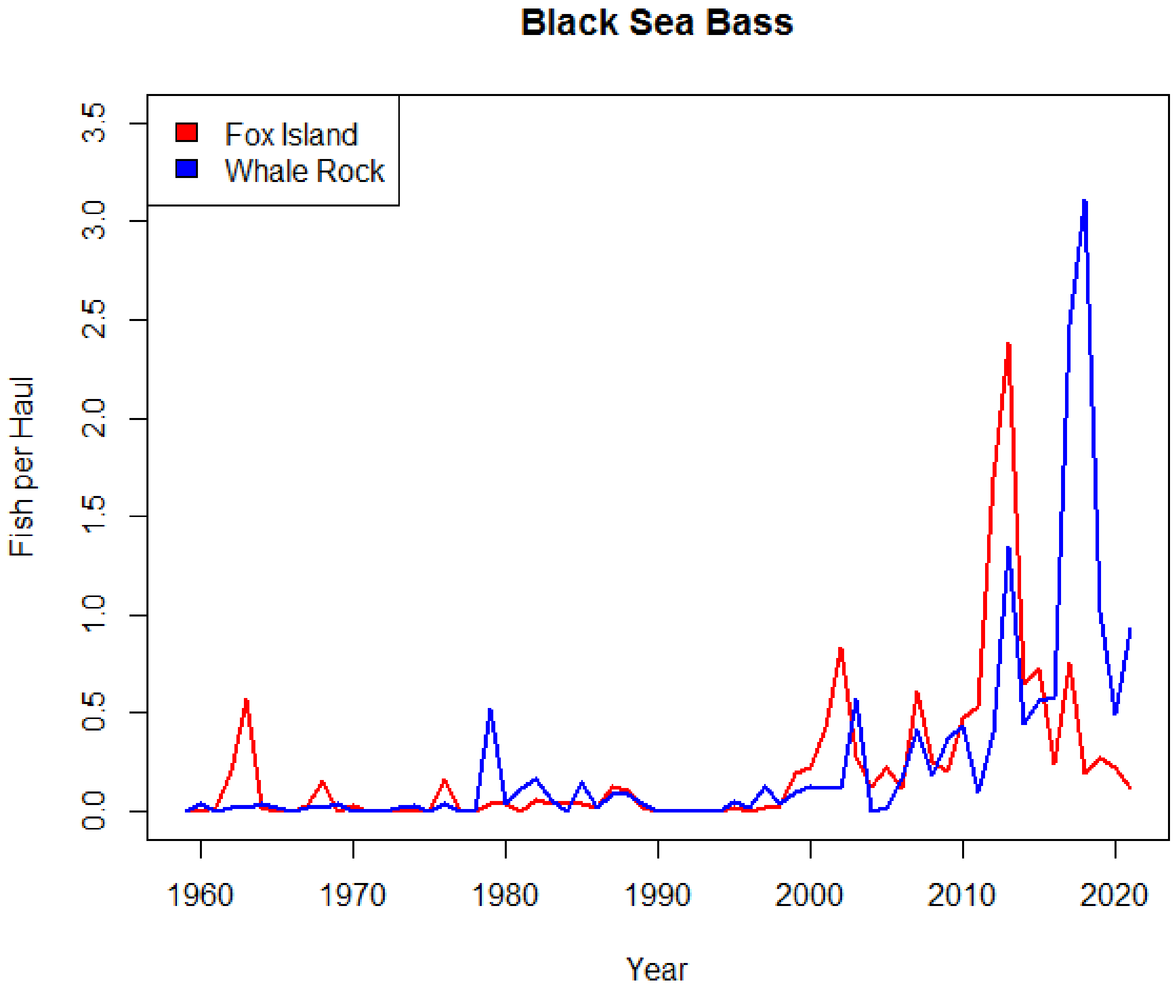
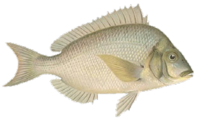


Figure 6 – Survey data for entire time series for black sea bass at both sampling stations (Fox Island and Whale Rock).



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 consistently, although 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.

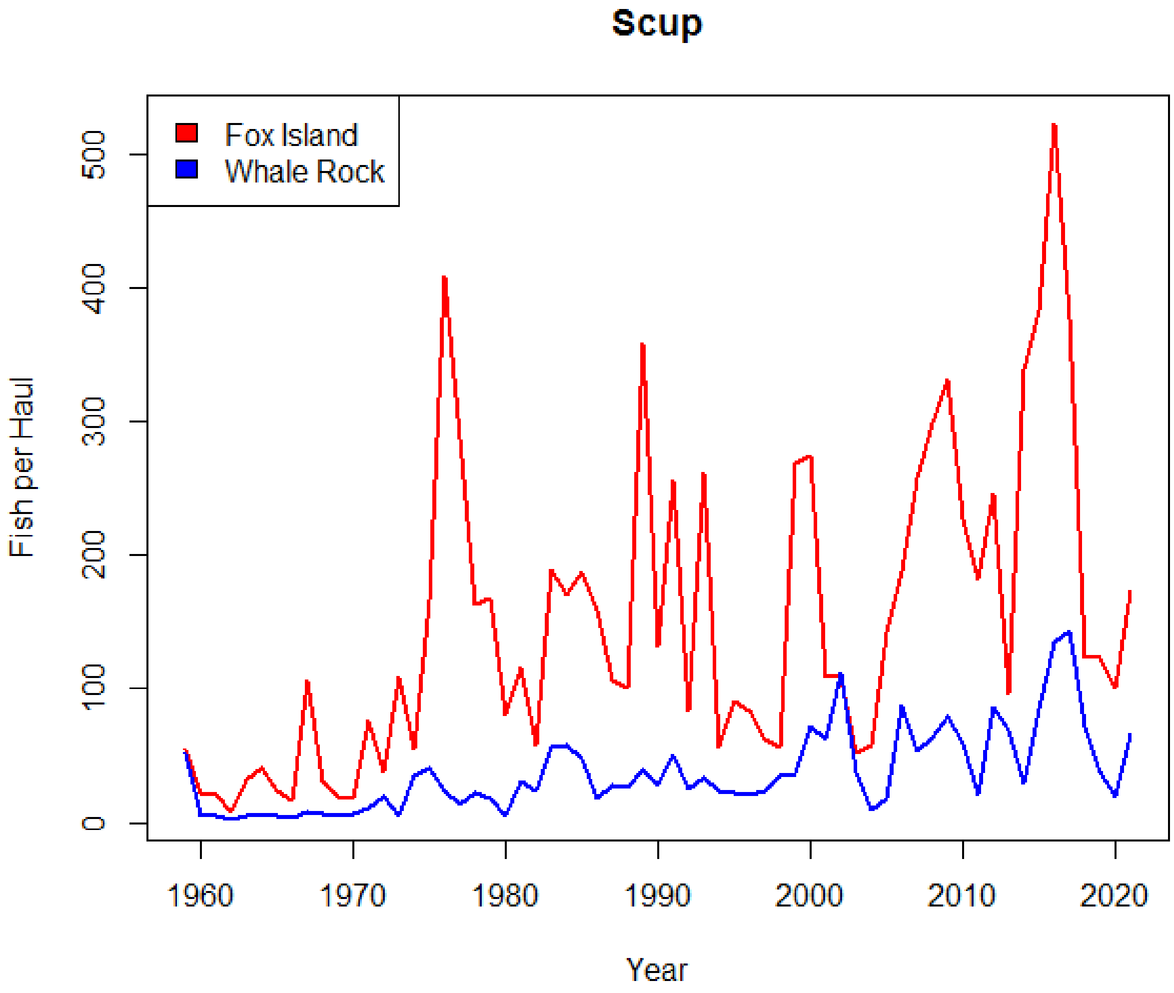


Figure 7 – Survey data for entire time series for scup at both sampling stations (Fox Island and Whale Rock).

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 fairly consistently.

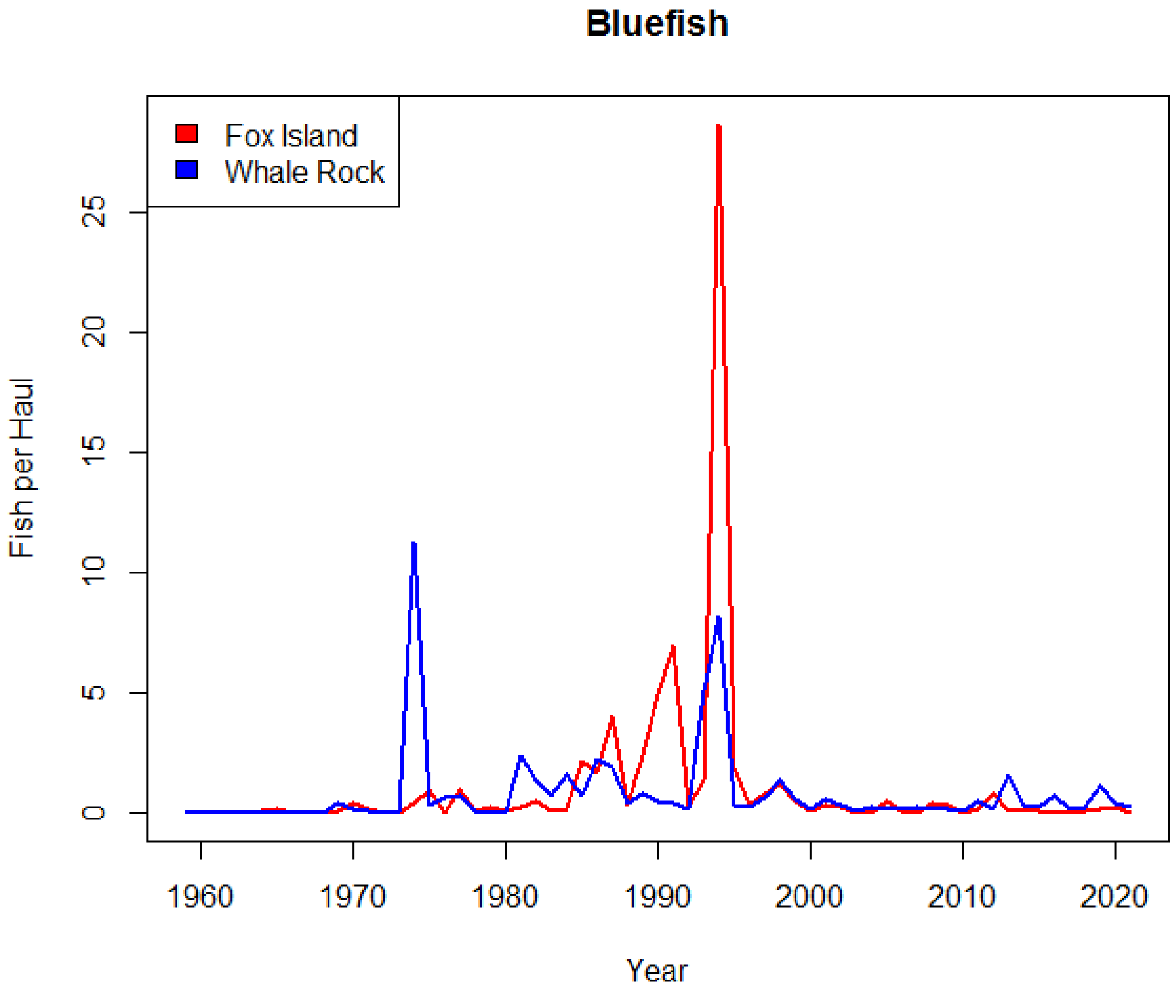
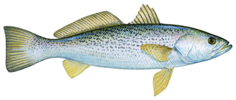


Figure 8 – Survey data for entire time series for bluefish at both sampling stations (Fox Island and Whale Rock).



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 fairly consistently.

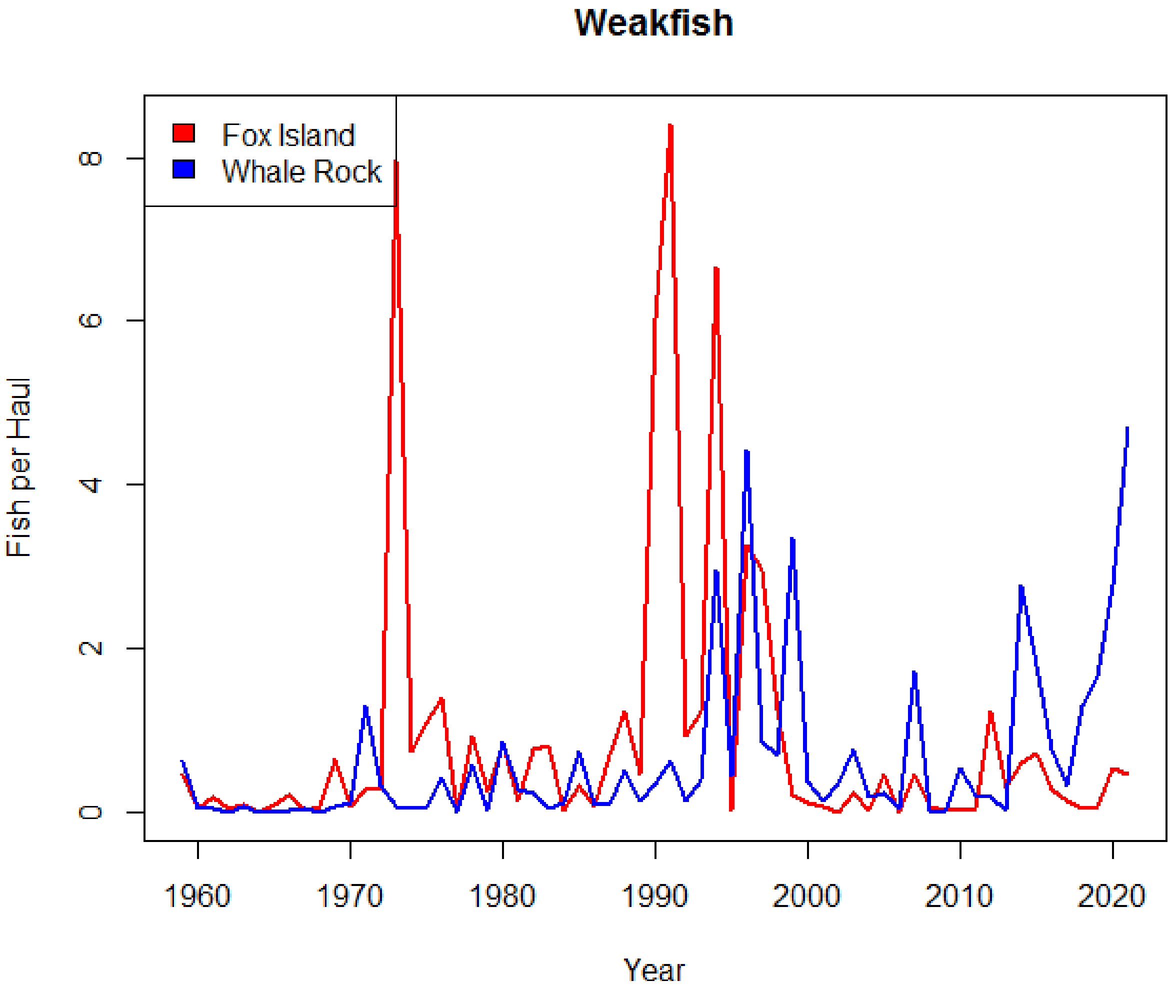


Figure 9 – Survey data for entire time series for weakfish at both sampling stations (Fox Island and Whale Rock).

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 (Figure 10), but the survey catches both juveniles and adults. Striped bass are caught in greater abundance and frequency at Fox Island than at Whale Rock.

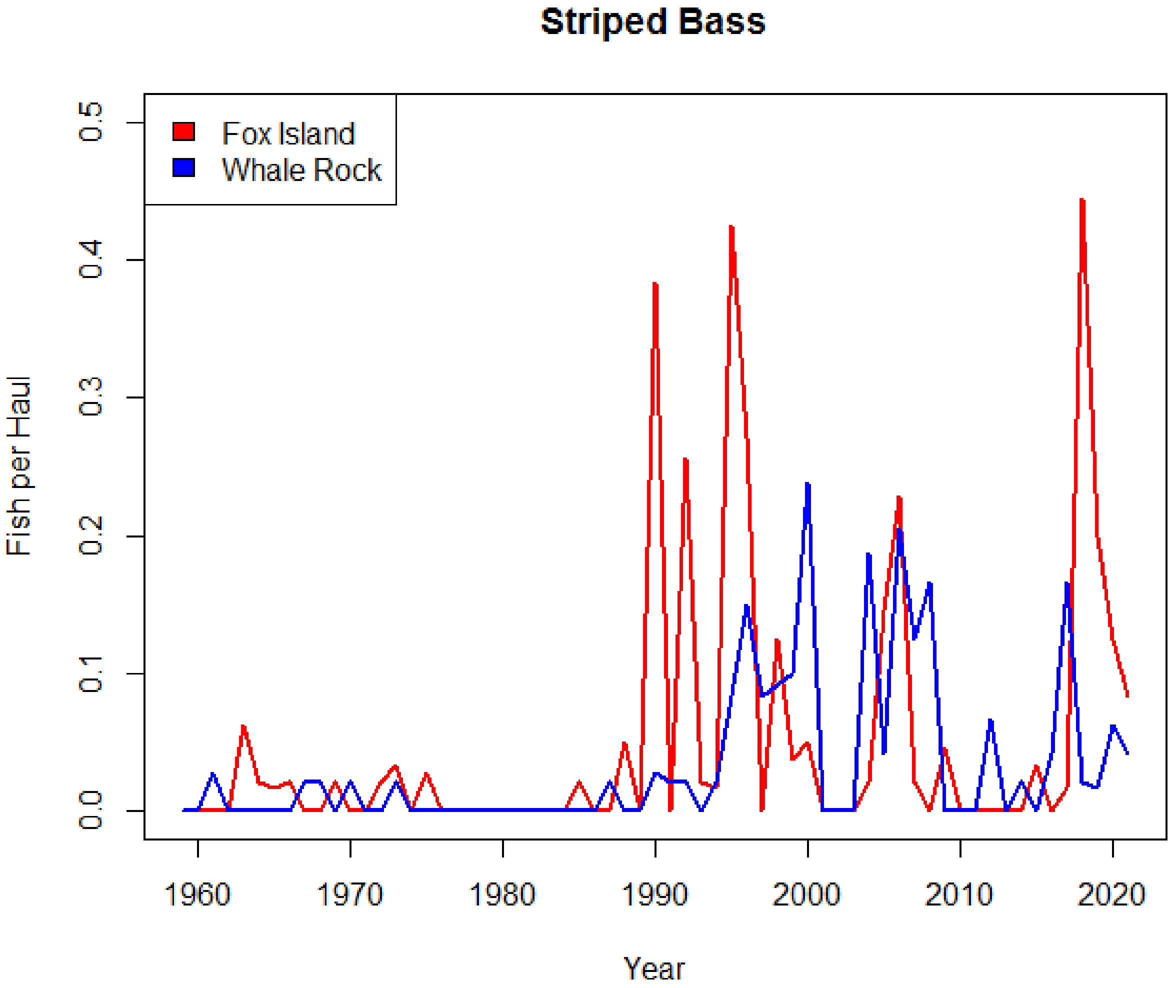


Figure 10 – Survey data for entire time series for striped bass at both sampling stations (Fox Island and Whale Rock).

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 (Figure 11), but the survey mainly catches juveniles. 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.

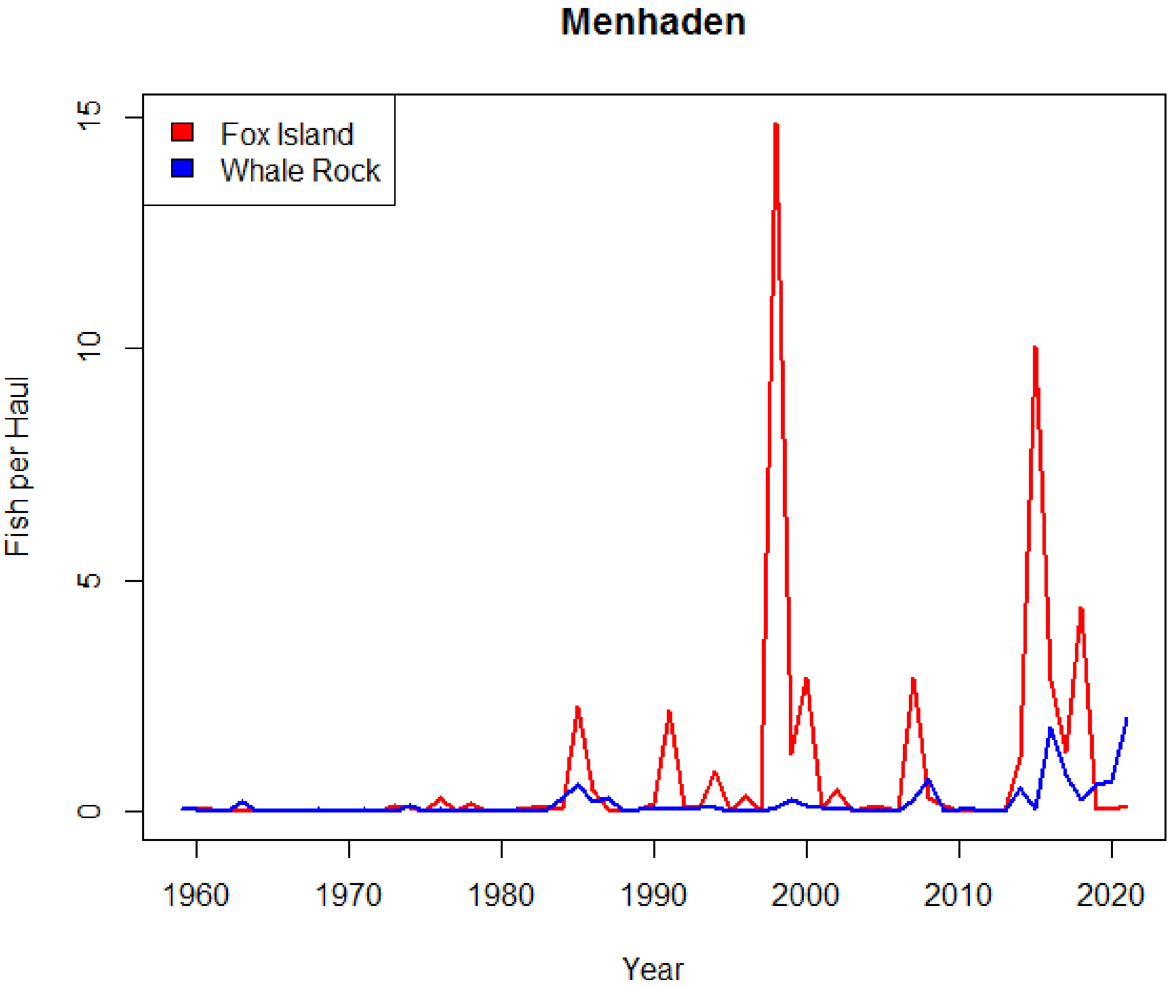


Figure 11 – Survey data for entire time series for menhaden at both sampling stations (Fox Island and Whale Rock)

Special Projects

During summer of 2021, quality-control queries were performed on the database to detect and correct any data-entry errors. Additionally, the URI GSO Fish Trawl website (https://web.uri.edu/gso/research/fish-trawl/) was updated to include data through 2020.

Undergraduate Research Assistants

Undergraduate assistants were recruited from URI for the spring, summer, and fall semesters to gain experience and provide extra assistance on the Fish Trawl Survey. 2021 Undergraduate assistants included: Coral Aiello, Tina Munter, Gwen Riendeau, and Keaghan Murray.

List of references that have used the GSO Fish Trawl Survey data:

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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 2022

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

Project Title: Recreational Coastal Sharks Monitoring

Period Covered: January 1, 2021 – December 31, 2021

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 state waters using tagging technologies.

Significant Deviations: Tag Deployment Breakdown To-Date: 22 of 24 Vemco V-16 acoustic tags purchased are now deployed, and 5 of 10 SPOT tags purchased are now deployed.

Justification and Objective:

Coastal pelagic sharks of the North Atlantic Ocean are keystone species in regulating lower tropic levels, serving as an important service in marine ecosystems. As top predators and larger fish, these species have also been long sought after by recreational harvesters 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 New England. 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) and charter captains, the objective of this work is to initiate a coastal shark monitoring for recreationally significant species to the state of Rhode Island. Data from this project are intended to provide information on these species use of state waters, the habitat they are associated with, and more broadly to be available for use in informing their sustainability. Given shark abundance data is often sparse within state waters (particularly for northeast U.S. states), we hope to improve this data gap through this tagging endeavor.

Progress Summary:

ASI supported eight research trips for shark tagging purposes in 2021 (Table 1). Of the 24 Vemco V-16 acoustic tags purchased in 2020, 18 were deployed in 2021. This results in 22 of the 24 total purchased acoustic tags as a part of this five-year grant now having been deployed on coastal sharks (Table 2). The metadata 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 receive those detections. We will also be checking to see if we get any detections on the preexisting RIDEM DMF-ASI receiver array. In 2021, five SPOT tags were also deployed within the same study region (Table 3).

All tags to-date have been deployed in southern New England waters that Rhode Island recreational shark fishermen operate in, and/or are adjacent to Rhode Island state waters. From the acoustic tags, 17 were deployed on shortfin mako sharks, four were deployed on blue sharks, and one was deployed on a common thresher shark. Of the five SPOT tags deployed in 2021, four were deployed on blue sharks (2 males and 2 females), and one was deployed on a male shortfin mako (Table 3). The shortfin mako with the SPOT tag also represents one of the makos tagged with an acoustic tag; the double-tagged nature of this shark will provide a direct comparison of the two data types for the species.

To date, detections from five of the sharks tagged with the acoustic tags have been reported: one thresher, one blue shark, and three shortfin makos. Detections for the five sharks ranged from 12 to 29 over time periods of a single day to months. Of the 105 total detections, 57 came from shortfin makos, 25 from the blue shark, and 23 from the thresher shark. Detections ranged from southern New England to the Gulf of Maine and Nova Scotia. The inferred movement paths will be further analyzed for these and the other acoustically tagged sharks as more data become available. The next MATOS data push will occur in March 2022, at which time we believe many more detections will be provided for these and the other sharks. More sophisticated movement analyses will be presented in the next report.

Movement paths are provided for two of the SPOT tagged sharks. The first is of the shortfin mako that was tagged in October of 2021 (Figure 1). The shark has moved southward and is currently in the southeast U.S. The second is a female blue shark tagged in July 2021. We have not received detections from this shark since August 2021, but the data highlight the value of these tags in identifying when the species may move into state waters (Figure 2).

Table 1. Description of shark tagging trips conducted in 2021.

Date	Location
7/14/2021	Tuna Ridge
6/17/2021	Tuna Ridge
7/27/2021	Tuna Ridge
7/29/2021	The Claw
8/8/2021	Butterfish Hole
8/4/2021	Butterfish Hole
8/13/2021	Butterfish Hole
10/6/2021	Butterfish Hole

Table 2. Sharks tagged with Vemco V-16 acoustic transmitters with their corresponding tagging date, species common name, size, and sex (F=female;M=male;U=unknown). Last MATOS push of data to researchers was October 2021.

Date	Species	Total Length (in)	Sex
8/28/2020	Blue Shark	108	M
7/1/2021	Shortfin Mako	60	U
7/1/2021	Shortfin Mako	66	M
7/1/2021	Shortfin Mako	70	F
6/15/2021	Thresher	168	M
8/6/2021	Shortfin Mako	60	F
7/24/2020	Shortfin Mako	70	F
7/1/2021	Shortfin Mako	66	M
7/29/2021	Shortfin Mako	66	F
9/3/2021	Shortfin Mako	72	U
10/4/2020	Blue Shark	86	M
10/4/2020	Shortfin Mako	79	F
10/6/2021	Shortfin Mako	90	M
6/24/2021	Blue Shark	102	M
6/24/2021	Blue Shark	90	M
6/17/2021	Shortfin Mako	63	F
6/24/2021	Shortfin Mako	66	F
7/8/2021	Shortfin Mako	66	U
7/14/2021	Shortfin Mako	78	F
7/8/2021	Shortfin Mako	60	M
7/8/2021	Shortfin Mako	72	M
7/8/2021	Shortfin Mako	60	F

Table 3. Sharks tagged with SPOT satellite tags with their corresponding tagging date, species common name, size, and sex. Date of last detection are also presented (as indicated on 3/9/2022)

Date	Species	Total Length (in)	Sex	Date of Last Detection
10/6/2021	Shortfin Mako Shark	90	M	3/9/2022
10/6/2021	Blue Shark	126	M	2/21/2022
10/6/2021	Blue Shark	102	M	3/9/2022
7/29/2021	Blue Shark	72	F	8/28/2021
7/29/2021	Blue Shark	72	F	9/19/2021

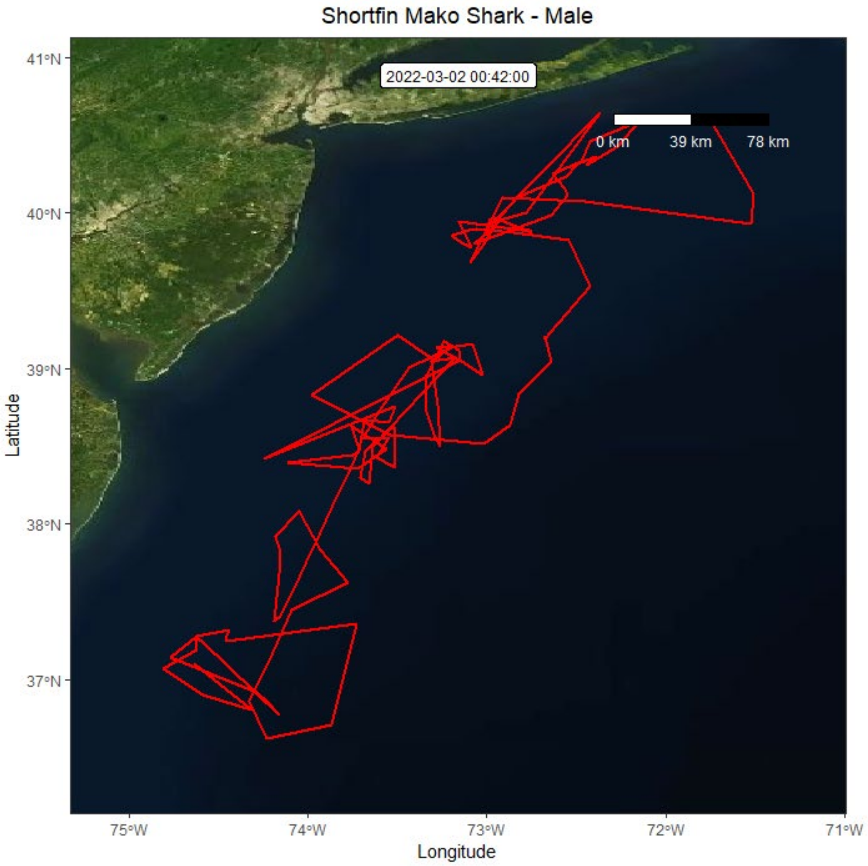

Figure 1. Movement path for the shortfin mako tagged with a SPOT tag from southern New England in October 2021 to the southeast U.S. in March 2022. See Table 3 for further description. Positions represent daily time steps.

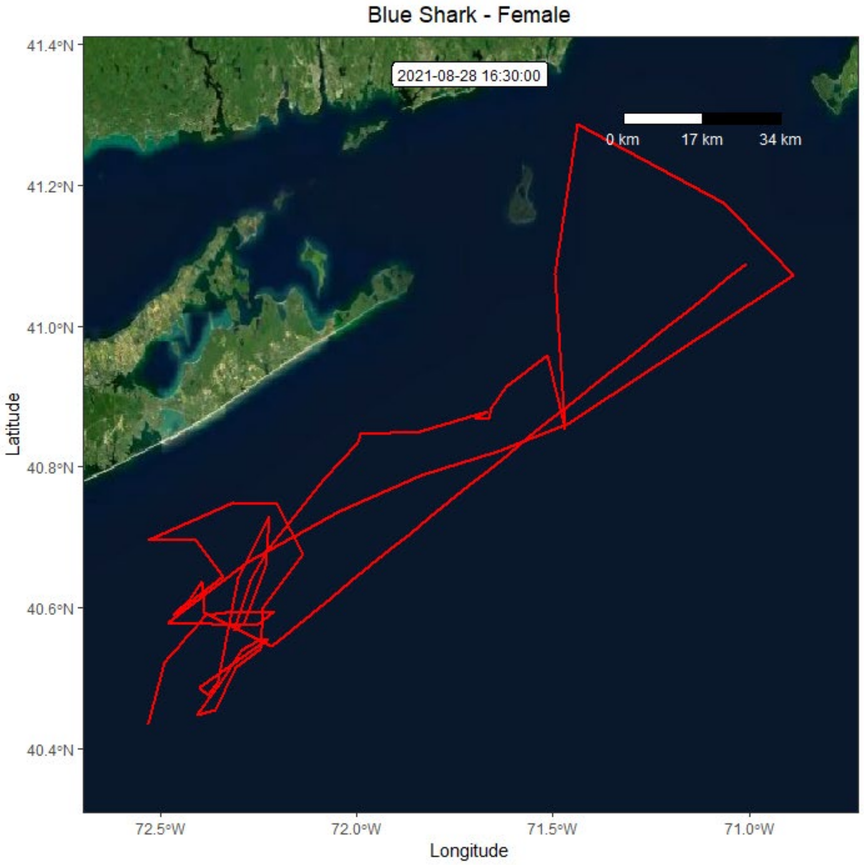

Figure 2. Movements of a female blue shark tagged with a SPOT tag from southern New England in July 2021 through August 2021. See Table 3 for further description. Positions represent 8-hr time steps.

Enhancements to MRIP Data Collection

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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, 2021 – 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 202 RIDMF APAIS was able to add on 393 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 2021 due to the COVID – 19 pandemic. RIDEM only conducted the NOAA base level of head boat samples. RIDMF APAIS was not able to complete all of our shore, private/rental, and party/charter mode assignments during 2021 due to staffing issues. We lost several staff at the end of wave 4 and could not re-hire resulting in 4 missed assignments. 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 2021 MRIP estimates are available on the NOAA Fisheries web site. A detailed summary of the total 2021 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 2016-2021 by wave. While survey rates were on par with previous years 2021 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 with our samplers.

Table 1. APAIS Interview Statistics from 2021 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
2021	2	PR	21	40	8	6	10	1.9
2021	2	SH	24	95	18	16	19	3.96
2021	3	CH	46	311	462	5	103	6.76
2021	3	HB	6	69	46	0	0	11.5
2021	3	PR	65	430	139	94	151	6.62
2021	3	SH	55	332	98	64	132	6.04
2021	4	CH	75	523	807	31	305	6.97
2021	4	HB	16	268	131	34	0	16.75
2021	4	PR	97	611	279	82	184	6.3
2021	4	SH	41	226	98	74	82	5.51
2021	5	CH	50	191	377	32	72	3.82
2021	5	HB	10	110	66	32	0	11
2021	5	PR	73	488	186	87	131	6.68
2021	5	SH	54	199	91	105	84	3.69
2021	6	CH	15	75	224	15	32	5
2021	6	HB	4	41	22	4	0	10.25
2021	6	PR	15	14	6	4	0	0.93
2021	6	SH	26	95	29	2	52	3.65
2021			**693**	**4118**	**3087**	**687**	**1357**	**5.94**

Table 2. Summary of APAIS interview Statistics from 2016 – 2021 assignments by wave.

Year	Wave	Completed	Refused	Missed	Percent Refused	Percent Complete
2016	2	116	63	3	8	35.20%
2016	3	396	549	66	65	58.10%
2016	4	857	1157	190	260	57.45%
2016	5	665	557	101	143	45.58%
2016	6	111	61	41	4	35.47%
2016		**2145**	**2387**	**401**	**480**	**53.00%**
2017	2	124	15	8	13	10.79%
2017	3	759	579	128	146	43.27%
2017	4	1908	1011	217	629	34.64%
2017	5	901	518	37	267	36.50%
2017	6	149	94	36	37	38.68%
2017		**3841**	**2217**	**416**	**1092**	**36.60%**
2018	2	149	46	14	19	23.59%
2018	3	782	532	114	277	40.49%
2018	4	1740	989	151	704	36.24%
2018	5	1058	583	150	434	35.53%
2018	6	199	147	70	87	42.49%
2018		**3928**	**2297**	**499**	**1521**	**36.90%**
2019	2	199	63	31	31	24.05%
2019	3	1001	460	142	142	31.49%
2019	4	1659	765	147	147	31.56%
2019	5	1044	354	182	182	25.32%
2019	6	140	75	27	27	34.88%
2019		**4043**	**1717**	**529**	**529**	**29.81%**
2020	2	46	12	8	17	20.69%
2020	3	661	426	128	227	39.19%
2020	4	1463	1082	147	486	42.51%
2020	5	1115	522	155	261	31.89%
2020	6	118	105	7	41	47.09%
2020		**3403**	**2147**	**445**	**1032**	**38.68%**
2021	2	135	26	29	29	16.15%
2021	3	1142	745	163	386	39.48%
2021	4	1628	1315	221	571	44.68%
2021	5	988	720	256	287	42.15%
2021	6	225	281	25	84	55.53%
2021		**4118**	**3087**	**687**	**1357**	**42.85%**

Recreational Fisheries Management Support

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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, 2021 – 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 in 2021 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 in 2021 as well. The Division is hopeful that as the pandemic eases in 2022 that outreach activities can begin again and continue as in the past.