THE RHODE ISLAND CHAPTER OF THE NATURE CONSERVANCY

MULTI-GEAR FISHERIES SURVEY
EXTENSION PROJECT TO THE GREAT SALT POND STUDY

2018 Performance Report

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Project Title: "Multi-gear assessment to monitor commercially and recreationally important fishery resources in the Great Salt Pond (GSP), Block Island (BI), Rhode Island (RI)"

Reporting Period: January 1, 2018 – December 31, 2018

Approach:

The Nature Conservancy will collect, analyze, and summarize fish gear data from the Great Salt Pond, Block Island. The Nature Conservancy is committed to this long-term project as an extension of the larger Great Salt Pond study to monitor the pond over time.

Schedule and Work Tasks:

The work is part of an on-going monitoring program led by staff at the Block Island office of The Nature Conservancy. The work will be organized in the following tasks.

Task I. Methodology, Schedule, and Location of Sampling Stations

All methodology and sampling gear will be consistent with the standardized protocol outlined in the Narragansett Bay Ventless Pot, Multispecies Monitoring and Assessment Program (conducted as part of F-61-R-23, Job 12). Area of opportunity to improve the survey will be considered when appropriate and will involve input from our partners at the Rhode Island Department of Environmental Management, Division of Marine Fisheries. The Nature Conservancy samples a total of sixteen stations located in the Great Salt Pond watershed. Fish trap and eel pot hauls occur twice per week to allow for 6-day and 24-hour soak durations. All gear is hauled on the incoming tide during daylight from June to November. The fish traps are deployed and hauled via boat from a 28 ft outboard powered vessel. Eel pots are accessibly by land and water and are hauled manually. All species caught in gear are emptied into a bucket of sea water. Species are identified to genus and species, and total length is measured. All animals are released back into water at the collection site.

Task II. Data Analysis

All data collected in the field will be recorded and entered into the standard spreadsheet currently in use by The Nature Conservancy. A catch frequency table of all species by station in the Great Salt Pond for each year sampled will be presented. Monthly and yearly relative abundance indices will be calculated for the identified species of interest recorded and compared to the data available from previous seasons to develop time series on Block Island. Length frequency data for the species of interest will be prepared and presented. Monthly water temperature, salinity, and oxygen levels will be available upon request.

Task III. Reporting

Annual reports containing all sampling data and analysis will be submitted at the end of each sampling season. In addition to the report narrative, The Nature Conservancy will organize raw sample data in Excel and Microsoft Access format for the purpose of having shared use of the data and data products when necessary. Joint authorship on peer-reviewed, non-pier reviewed, and professional presentations will be recognized.

PROJECT TITLE: Multi-Gear Assessment of Commercially and Recreationally Important Fishery Resources in the Great Salt Pond, Block Island, Rhode Island

PERIOD COVERED: January 1, 2018 – December 31, 2018

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JOB OBJECTIVES: The goal of this project is to assess finfish and crustacean populations in the Great Salt Pond (GSP) to become more knowledgeable of the fishery resources as we look at changes in diversity and relative abundance of various stages of species in this offshore coastal lagoon. We obtain this goal by addressing the following objectives:

(1) Follow standardized sampling schedules and procedures to sustain time series dataset.
(2) Provide a comprehensive review of stock assessment data using time series indices to support best management projects targeting species of interest for RI fishery resources.

SUMMARY: This report summarizes all work conducted for this project between January 1 and December 31, 2018. During this period, we focused on aspects related to the objectives mentioned above.

To address Objective 1, we continued surveying the two stations for fish traps and the seven stations for eel pots as well as the additional 5 pots added this season to compliment the information collected for the time series. To address Objective 2, TNC followed the terms of reference (TOR) established at the inception of the project to successfully complete survey tasks and criteria for analyses.

In 2018, a total of 14 sites were sampled using fish traps and eel pots. The captures were shared with the Rhode Island Department of Environmental Management (RI DEM), Division of Marine Fisheries (DMF) and the Town of New Shoreham Harbors Department (TNS). Additional fish pot locations (Greenlee Dock, Champlain's Dock, Sullivan House, Mosquito Beach, Boat Basin) were added in 2018 to bridge spatial gaps in study area. A total of 192 trap checks were completed throughout June – November catching 12 species including 1,445 finfish and 3,467 crustaceans (Table 5). A total of 336 pot checks were completed in the same timeframe catching 20 species including 3,343 finfish and 4,500 crustaceans (Table 5).

TARGET DATE: December 31, 2018

DEVIATIONS: To address Objective 1, additional eel pots were added in 2018 to bridge spatial gaps in study area and to expand on the information collected for the time series. The five new locations were sampled from June – November.

RECOMMENDATIONS: We recommend continued sampling of fish gear and water quality monitoring at the designated sites. We also recommend continuing to work closely with RI Department of Environment Management (RI DEM) in view of our long-term commitment to monitoring fish populations, habitat, and environmental conditions in RI waters. We will be planning with our partners for how to proceed with the standardized project as we identify areas of opportunity to improve the survey.

Specific to fish traps (standard cube style gear), six of the target species were caught at varying numbers (American lobster, black sea bass, Jonah crab, scup, tautog, and winter flounder). We recommend investigating whether the current sampling method is adequately capturing the abundance of these species. If not, we suggest additional sampling techniques to be considered.

Specific to eel pots, six of the target species were caught at varying numbers (American eel, American lobster, black sea bass, blue crab, and tautog). Similar to the topic mentioned above, we recommend investigating the current sampling method to identify areas of opportunity to improve capturing the abundance of target species. If improvements are suggested, investigators will explore additional sampling techniques.

Specific to monitoring American lobster, we suggest additional assessments be completed to get a better handle on species presence in correlation to bottom temperature data. The potential impact of temperature on the size at which females reach sexual maturity could be assessed. Like the recommendations listed above, we recommend securing temperature dataloggers to a series of traps to record bottom temperature at the determined time interval. A thorough review of the literature is essential and will be incorporated in next stages of active planning sessions.

Specific to sampling strategies, we recommend reviewing the methodology for allocation of additional random sampling sites to compliment the information collected at fixed locations. A thorough review of standardized surveys, research methods, and input from cooperative project teams is necessary to follow through with this research recommendation. If improvements are relevant and tangible, investigators will develop a set of systematic methods to incorporate random sampling strategies in addition to the fixed-station methodology.

REMARKS: Investigators successfully sampled all stations for each gear type between June and November. The index value time series differentiates size structures of young of the year (YOY) and age 1+ finfish for consistent analyses (see Appendix C for species of interest by functional group).

INTRODUCTION

A common goal of fisheries research in estuaries is to estimate the density of fishes to project stock assessments. Enclosure traps are perhaps the most efficient gear types for estimating fishes in varying depths and estuarine habitats (Rozas and Minello 1997). Abundant populations of finfish, crustaceans, and other marine invertebrates are often associated with many estuarine systems (Steele et al. 2006). Assemblages of these species range from shallow areas, to extensive coves, and sloped areas (Allen et al. 2002).

Sound fisheries research is grounded in science-based research and utilizes different sampling methods and gear types to expand upon current knowledgebase (Hansen et al. 2007). While traditional gear, like seines and trawls, are commonly used for active sampling, fish traps are passive gear types well-suited for varying depths and area extents (Rozas and Minello 1997; Port et al. 2006).

The data presented in this report reflect the most current information available at the time the report was written. The 2018 report provides data collected between 2016 and 2018 in the GSP watershed. TNC is committed to long-term monitoring in the GSP to assess ecological function of this system as a critical nursery habitat. We plan to continue the standardized protocol and to collaborate with our partners as we move forward with our plans to identify areas of opportunity for the fisheries survey and greater extent of monitoring program.

APPROACH

The approach for each objective is described separately below.

Objective 1 – Overview

> Follow standardized sampling schedules and procedures to sustain time series dataset.

The purpose and scope of this objective is to focus on the statewide and regional approach to monitoring commercially and recreationally important fishery species. TNC's ability to monitor fishery resources is largely dependent upon the quality and extent of available data. The team strictly adheres to established protocols to strengthen quantitative information collected for the time series.

Objective 2 – Overview

> Provide a comprehensive review of stock assessment data using time series indices to support best management projects targeting species of interest for RI fishery resources.

To address Objective 2, TNC provides a complete review of time series indices standardized in the project. The creation of these indices helps fishery managers identify below-average recruitment. If persistent, examined trends serve as an early warning to managers of potential declines in the target species standing stock biomass. The time series dataset becomes more valuable with time as it increases the knowledge base for stock assessments. This approach allows us to provide reliable information about species assemblages in our efforts to fill informational gaps encountered in fisheries science.

STUDY AREA

Great Salt Pond

The GSP is a diverse body of water in the center of BI (see inset map in Appendix A). It is characterized as an estuarine habitat, or coastal salt pond – a body of salt water surrounded by salt water (Hale 2000). The GSP's low flushing rate, absence of major freshwater aquifers, and relatively small size creates a diverse mix of species and physical properties (Ketchum 1983; Shumway 2008). Rain falling on upland parts of the watershed also creates a salinity gradient combined with fresh water input from inner pond locations (Harbor and Trims Pond) (Shumway 2008).

The permanent breach way in GSP was constructed in 1895 (TNS Harbor Management Plan 2018). This change had broad-reaching effects on the ecosystem (Lee 1980; Katz 2000). The channel is dredged every two years for navigational purposes. Total acreage of the GSP is approximately 800 acres at mean low water (MLW). Close to 50-percent of the area is less than 4m at MLW. Maximum depth in the center of the pond reaches 17m (reference NOAA chart 13205).

Great Salt Pond Watershed

The GSP watershed is about 2,120 acres and covers about one-third of the island's total area. Approximately 25% of the land within the watershed is conserved (TNS Harbor Management Plan

2018). The area provides essential habitat for a wide array of estuarine species. It is composed of connective headwater systems and attract both anadromous and diadromous species (Rosenzweig et al. 2002).

METHODS

In 2018, two gear types were used for sampling: fish traps and eel pots. The fish traps targeted age 1+ species. The eel pots targeted juvenile, or age 0 species. Fixed station allocation was the methodology used for site planning.

The sampling season started the first week of June and ended the last week of November. Once gear was deployed, the monitoring schedule rotated between checks of 24-hour and 6-day soak durations. Once gear was checked on Tuesday, investigators checked gear 24 hours later. All gear was checked twice per week via boat or by land according to accessibly by site and gear type.

Species caught in gear were brought on board and transferred into a water-filled tote. Catch was sorted by species to obtain catch composition. All collected fishes and crustaceans were identified to genus or species. All finfish were measured to the nearest centimeter for total length (TL). All crustaceans were measured to the nearest millimeter for total carapace length (CL). A record of male/female ration was also kept to document sex ratios of the crabs caught in the gear. All specimens were enumerated and released back into the water at the collection site. Investigators also listed anecdotal information for incidental animal species.

Data on wind direction and speed, sea condition (tide, clarity, turbidity), water depth, air temperature, and cloud cover were recorded per station. Water parameters – temperature (°C), salinity (ppt), dissolved oxygen (mg/L) – were also recorded 1m below the surface using a Professional Plus handheld YSI multiparameter meter.

Fish Traps

Fish traps were deployed at 2 sites during the season. Two traps per site were monitored between June and November (Table 2). The traps were cube style and had dimensions of 43.5-inch length x 23-in width x 16-inch height, and 1.5-inch x 1.5-inch vinyl coated wire mesh. The traps contained a single mesh entry head and single mesh inverted parlor nozzle consistent with the traps used in the Narragansett Bay Ventless Pot, Multispecies Monitoring and Assessment Program (conducted as part of F-61-R-23, Job 12). Each trap contained two escape vents – one in the bottom vertical wall of the parlor section and one in the top vertical wall of the parlor section of the trap. Location of escape vents was based on known characteristic behaviors of the target species mentioned above; scup escape at the top and black sea bass escape at the bottom on the trap (Shepherd et al. 2002).

Two traps were tethered by line and secured 60m apart. The trawl was deployed by boat with the first trap set on high point of tidal flat and the second was set deeper to follow contour of the sloped gradient. They were left to soak for 6-day and 24-hour intervals and were unbaited. The depths at fish trap locations varied slightly by site and ranged between 3-11m at MLW. Both sites were situated on either side of the GSP channel and had enough water for the gear to be submerged at MLW.

Eel Pots

Eel pots were deployed at 12 sites during the season. The original seven sites located in the GSP watershed were consistently sampled from June – November, along with the additional site locations added this season (Figure 2). Pots were 24-inch length x 12-inch x wide x 12-inch height and are made of .5-inch x .5-inch 16-gauge vinyl coated wire. The pots had one entry way with a 2.5-inch funnel entrance.

One pot was deployed at each site. As previously stated, the new sites added to the study area were based on proximity to structure, potential recreational fishing locations (currently functional fish piers) and were easily accessible. The depth at the eel pot locations varied by site, especially in the upper estuary and connective habitat sites. The pots were set in areas where there was enough water for the gear to be submerged during all tidal stages. They were also left to soak for 6-day and 24-hour intervals and were left unbaited.

METRICS AND RATIONALE

Species of Interest

The following species were identified as species of interest to quantify for discussion of recreationally and commercially important species: American eel (demersal, multi-habitat), American lobster (demersal), black sea bass (pelagic, multi-habitat), blue crab (demersal, pelagic), Jonah crab (demersal), scup (pelagic, multi-habitat), tautog (demersal), and winter flounder (demersal) (see Appendix C for additional species of interest identified by functional group).

Juvenile cutoff sizes for species of interest were identified to compare species growth parameters. The following accepted values for YOY cutoff ranges were compiled from Bigelow and Schroeder (1953c): YOY winter flounder TL<120mm; YOY black sea bass TL<13cm; YOY scup TL<10cm; YOY tautog TL<12cm.

Analysis

Mean Shannon diversity and species richness were both compared by one-way ANOVAs (Shannon Diversity ~ Site; Richness ~ Site) for each gear type. Diversity was calculated using the "Shannon Index" (Shannon 1948), and richness was defined as the total number species caught. Diversity and richness were calculated for each haul and the mean values per haul were determined for each site sampled during the 2018 season.

To preliminarily evaluate difference in total catch across the sites and gear types a two-way ANOVA (Total Catch ~ Site + Gear 1 + Gear 2) was performed. All species were included in the analysis. JMP software was used for statistical computing,

As the data did not follow a normal distribution, attempts were made to normalize it. First, catch was regressed against soak time and the relationship was found to be non-linear. The Shapiro-Wilk test for normality was applied to catch in numbers, catch-per-unit-effort (CPUE) where effort was soak time, and catch in numbers transformed using $\sqrt{X + 0.5}$. The three types of data resulted in non-normal distributions. Therefore, non-parametric analyses of variance were used to compare catches.

The mean numbers of legal-size species of interest caught per haul were compared using the Kruskal-Wallis non-parametric ANOVA. If a significant difference among means was found, the Wilcoxon rank-sum test was applied to determine where significant differences were observed through a statistical pairwise comparison of means for the different trap sizes (Cody and Smith 1997).

Catch per rate was calculated using the following equation:

$$\text{CPUE} = \frac{\text{Total catch at site}}{\text{Number of soak days} * \text{Total samples by site}}$$

Number of soak days = Refer to Table 3
Total samples by site = Refer to Table 2
Total catch at site = Refer to Table 3

Catch rate and presence/absence of fish and crustacean species were compared by site and month (Figures 3-4 (month); Figures 5-6 (site); see Appendix B for presence/absence tables)). Percent of species of interest within total catch by sites was also compared (Figure 7). Histograms comparing frequency at length between gear types of the target species caught in both gear types showed differing size classes for comparable species (Figures 12-15).

RESULTS

In 2018, a total of 784 hauls were conducted across fish trap and eel pot sites. 12,759 individuals were identified and enumerated. A combined total of thirty-two species were caught in the fish gear. 4,788 finfishes were measured, and 7,971 crustaceans were measured. The various tables and figures differentiate between all species caught and only finfish.

All eight species of interest in this study were caught in the fish gear. Scup and black sea bass were the most abundant finfish species of interest caught across all fish traps at a catch per haul of 3.73 and 1.31, respectively. American eel and YOY black sea bass were the most abundant finfish species of interest caught across all eel pots at a catch per haul of 0.41 and 0.20, respectively.

Results of the two-way ANOVA testing the effect of site and gear type on total catch suggested significant difference between gear and sites (Total Catch ~ Site: $p=0.00457$; Total Catch ~ Gear 1: $p=0.0354$; Total Catch ~ Gear 2: $p=0.0463$). Total catch was log-transformed to satisfy assumptions of the ANOVA. A post-hoc Tukey's test showed catch at EP 5 was significantly different from EP 7 and EP 10.

Fish Traps

Coordinates were maintained for the fish trap sites (Table 1). A total of twelve species were caught in 2018, including 1,445 finfish and 3,467 crustaceans (Table 5). Beane Point had the highest overall catch rate (10 individuals/sampling effort), while FT 2 had the highest finfish catch rate (6 fish/sampling effort) (Figure 8). Spider crabs were the most abundant species caught (totnum: 3,298) and scup were the second most abundant (totnum: 732). Fish catch rate was highest in September and was mostly composed of scup and black sea bass (Figure 10).

Scup made up the highest percentage of the total finfish catch at the Beane Point site compared to the Coast Guard Station. Scup made up more than 63% of the total catch across the four traps. Black sea bass made up about 32% of the total catch, with most of the percentage accounted from FT 3 and FT 4.

Results of the one-way ANOVA testing the effect of site on species diversity was not significant (p-value>0.1; Diversity ~ Site: p=0.002). Results of the one-way ANOVA testing for the effect of site on species richness was also not significant (p-value>0.1; Richness ~ Site: p=0.024). Species richness was log-transformed to satisfy assumptions of the ANOVA.

Eel Pots

Coordinates were maintained for the eel pot sites and five new sites were added based on depth, ease of access, different habitat types, and presence of fishing piers (Table 1). A total of twenty species were caught in 2018, including 3,343 finfish and 4,500 crustaceans (Table 5). The connective stream and culvert site found in the inner pond, EP 7, had the highest overall catch rate (4 individuals/sampling effort) as well as the site with the highest finfish catch rate (3 individuals/sampling effort) (Figure 9). Green crabs were the most abundant species caught (totnum: 4,442) and mummichogs were second most abundant (totnum: 1,678). Fish catch rate was highest in September and was mostly composed of cunners, mummichogs, and striped killifish (Figure 11).

Mummichogs made up the highest percentage of the total finfish catch. The species was mostly caught in August and September at EP 7. Striped killifish and mummichogs made up 74% of total finfish catch across all sites. Black sea bass accounted for about 17% of total finfish catch.

Results of the one-way ANOVA testing the effect of site on species diversity was partially significant (p-value>0.1; Diversity ~ Site: p=0.586). Results of the one-way ANOVA testing for the effect of site on species richness was significant (p-value>0.1); Richness ~ Site: p=1.820). Species richness was log-transformed to satisfy assumptions of the ANOVA.

DISCUSSION

Results from the comparison across sites and gear types reveals certain sites support different amounts of finfish and crustaceans depending on the time of the season. Investigators were cautious to draw conclusions about the lower catch at EP 5 (Mill Pond tributary) compared to other sites, because it is situated in the freshwater system at the upper reaches of the watershed. EP 5 was the site where investigators collected anadromous species such as the American eel. While relative abundance was low at EP 5, researchers noted interesting comparisons between presence of species across all sites due to habitat features and location within the greater study area. Future sampling will inform the study as the dataset becomes more robust with each year.

Six of the eight target species were caught in the fish traps (American lobster, black sea bass, Jonah crab, scup, tautog, and winter flounder). Scup prefer smooth to rocky bottom and tend to hug the coast to stay inshore during the summer months, which results in a very local distribution and a further explanation of their more abundant numbers off the tidal flats of Beane Point (Bigelow and Schroeder 2002). Historically, the tidal flats off Beane Point (the site area for FT 1-2) supported a diverse and abundant volume of flora and fauna (Livermore 1877). Extensive eelgrass beds in this area of the GSP persisted into the 19th century (Jeffries et al. 1988; Katz 2000); and it was historically known as a highly productive site regarding commercial forage fish species (Olsen and Stevenson 1975).

Six of the eight target species were caught in eel pots (American eel, American lobster, black sea bass, blue crab, tautog, and winter flounder). Blue crabs exhibited a trend of presence in finger-cove and inner pond locations (EP 4, EP 6, EP 7). YOY tautog were almost exclusively found off dock pilings.

Both gear types supported presence of black sea bass. Abundance varied by site and time of sampling season. Juvenile and adult black sea bass habitat preferences are well known and qualitatively explain presence at certain sites. Black sea bass are a structure seeking species, so it was interesting for investigators to verify certain sites with available structure correlating with the presence of age 1+ individuals found on the slopes off the Coast Guard Station as well as the dock pilings where YOY individuals were collected (ASMFC 2009). Wood piling habitats are more complex than other sampled habitats in the survey. Pilings interfere with pursuit and lower probability of predator encounter (Scharf et al. 2001). More complex habitats reduce predation risk and increased survival for YOY black sea bass (Miller et al. 2016); thereby, these types of habitats tend to have higher prey densities, which may be associated with the more abundant numbers of black sea bass at these sites (Connell and Jones 1991).

While these sites provide qualitative reasoning to help explain some disparity across sampling sites, additional benthic monitoring is recommended. To make better distinctions between presence of year 0-1+ individuals and habitat types, it may also be beneficial for investigators to establish categorical parameters to describe the habitat setting to complement data collected per site and survey area. Future analysis is expected to combine water quality, benthic substrate, and fish assemblage to explicate variability in species of interest abundances.

CONCLUSION

The intention of adding fish gear to the sampling regime was to sample presence of fish and other marine invertebrates at stages not typically captured in the beach seine survey (F-61-R-21, Job 3). Visual inspection of histograms comparing frequency at length between gear types of the target species caught in both gear types showed differing size class for all comparable species (Appendix A; Figures 13a-17a). While these results support survey expectations, continued comparisons of gear size selection should be made to confirm the results across multiple sampling years.

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TABLES

Table 1. Geographic coordinates for fish trap and eel pot placements.

	Site	Trap ID	Lat	Long
Fish Traps	Beane Pt	FT #1	41.195572	-71.584276
	Beane Pt	FT #2	41.195314	-71.584165
	Coast Guard	FT #3	41.193632	-71.587370
	Coast Guard	FT #4	41.193633	-71.586998
Eel Pots	Coast Guard Dock	EP #1	41.194548	-71.588334
	Block Island Club Dock	EP #2	41.196157	-71.574171
	Hog Pen Dock	EP #3	41.180225	-71.572898
	Harris Point	EP #4	41.193588	-71.57396
	Town Hall/Mill Pond	EP #5	41.172457	-71.564737
	Power Plant Culvert	EP #6	41.176055	-71.570120
	Kimberly's Culvert	EP #7	41.174102	-71.563578
Additional pots added in 2018	Greenlee Dock	EP #8	41.188839	-71.590862
	Champlain's Dock	EP #9	41.184570	-71.582101
	Sullivan House	EP #10	41.183803	-71.568819
	Mosquito Beach	EP #11	41.189522	-71.569869
	Boat Basin	EP #12	41.182879	-71.577705
Eel Ramp	Town	ER	41.172457	-71.564737
HOBO	Coast Guard Dock	DL #1	41.194525	-71.588337
	Block Island Club Dock	DL #2	41.196133	-71.574212
	Hog Pen Dock	DL #3	41.180277	-71.572845

Table 2. Summary of sampling effort for GSP fisheries survey, 2018.

Fish Traps		Jun	Jul	Aug	Sep	Oct	Nov	Total samples by site
Beane Point	FT #1	8	6	9	8	10	8	49
Beane Point	FT #2	8	6	9	8	10	8	49
Coast Guard	FT #3	8	6	9	8	10	8	49
Coast Guard	FT #4	8	6	9	8	10	8	49
Total samples per month		32	24	36	32	40	32	**196**

Eel Pots		Jun	Jul	Aug	Sep	Oct	Nov	Total samples by site
Coast Guard Dock	EP #1	8	6	9	8	10	8	49
Block Island Club Dock	EP #2	8	6	9	8	10	8	49
Hog Pen Dock	EP #3	8	6	9	8	10	8	49
Harris Point	EP #4	8	6	9	8	10	8	49
Town Hall/Mill Pond	EP #5	8	6	9	8	10	8	49
Power Plant Culvert	EP #6	8	6	9	8	10	8	49
Kimberly's Culvert	EP #7	8	6	9	8	10	8	49
Greenlee Dock	EP #8	8	6	9	8	10	8	49
Champlain's Dock	EP #9	8	6	9	8	10	8	49
Sullivan House	EP #10	8	6	9	8	10	8	49
Mosquito Beach	EP #11	8	6	9	8	10	8	49
Boat Basin	EP #12	8	6	9	8	10	8	49
Total samples per month		96	72	108	96	120	96	**588**

Table 3. Summary of fishing effort for GSP fisheries survey, 2018.

Gear type	Start	End	# trips made	Total # hauls	# days on ground (hrs)	Total soak duration (hrs)	Total # of species	CPUE
Fish Trap	6/5/2018	11/28/2018	25	192	600	4248	4912	8.58
Eel Pot	6/5/2018	11/28/2018	26	336	624	4272	7847	12.27

Table 4. Common, scientific, and family names of all species collected in fish traps and eel pots, 2018.

Fish Traps

2018		
Common Name	**Scientific Name**	**Family**
American Lobster	*Homarus americanus*	Nephropidae
Atlantic Rock Crab	*Cancer irroratus*	Cancridae
Black Sea Bass	*Centropristis striata*	Serranidae
Conger Eel	*Conger conger*	Congridae
Grey Triggerfish	*Balistes capriscus*	Balistidae
Lesser Amberjack	*Seriola fasciata*	Carangidae
Jonah Crab	*Cancer borealis*	Cancridae
Scup	*Stenotomus chrysops*	Sparidae
Spider Crab	*Macrocheira kaempferi*	Majidae
Summer Flounder	*Paralichthys dentatus*	Paralichthyidae
Tautog	*Tautoga onitis*	Labridae
Winter Flounder	*Pseudopleuronectes americanus*	Pleuronectidae

Eel Pots

	2018	
Common Name	**Scientific Name**	**Family**
American Eel	*Anguilla rostrata*	Anguillidae
American Lobster	*Homarus americanus*	Nephropidae
Brown Bullhead Catfish	*Ameiurus nebulosus*	Ictaluridae
Black Sea Bass	*Centropristis striata*	Serranidae
Blue Crab	*Callinectes sapidus*	Portunidae
Common Sea Star	*Asterias rubens*	Asteroidea
Conger Eel	*Conger conger*	Congridae
Cunner	*Tautogolabrus adspersus*	Labridae
Doctorfish	*Acanthurus chirurgus*	Acanthuridae
Foureye Butterflyfish	*Chaetodon capistratus*	Chaetodontidae
Green Crab	*Carcinus maenas*	Portunidae
Mummichog	*Fundulus heteroclitus*	Cyprinodontidae
Oyster Toadfish	*Opsanus tau*	Batrachoididae
Sheepshead Minnow	*Cypinodon variegatus*	Cyprinodontidae
Snowy Grouper	*Hyporthodus niveatus*	Serranidae
Spotfin Butterflyfish	*Chaetodon ocellatus*	Chaetodontidae
Striped Killifish	*Fundulus majalis*	Cyprinodontidae
Tautog	*Tautoga onitis*	Labridae
Winter Flounder	*Pseudopleuronectes americanus*	Pleuronectidae
Yellowfin Grouper	*Mycteroperca venenosa*	Serranidae

Table 5. Common, scientific names, and abundances of all species collected in fish traps and eel pots, 2018.

Fish Traps

2018		
Common Name	**Scientific Name**	**Abundance**
Spider Crab	*Macrocheira kaempferi*	3298
Scup	*Stenotomus chrysops*	732
Tautog	*Tautoga onitis*	302
Black Sea Bass	*Centropristis striata*	257
Conger Eel	*Conger conger*	82
Jonah Crab	*Cancer borealis*	82
Grey Triggerfish	*Balistes capriscus*	65
American Lobster	*Homarus americanus*	51
Atlantic Rock Crab	*Cancer irroratus*	36
Winter Flounder	*Pseudopleuronectes americanus*	4
Summer Flounder	*Paralichthys dentatus*	2
Lesser Amberjack	*Seriola fasciata*	1

Eel Pots

2018		
Common Name	**Scientific Name**	**Abundance**
Green Crab	*Carcinus maenas*	4442
Mummichog	*Fundulus heteroclitus*	1678
Cunner	*Tautogolabrus adspersus*	856
Striped Killifish	*Fundulus majalis*	309
American Eel	*Anguilla rostrata*	240
Black Sea Bass	*Centropristis striata*	117
Tautog	*Tautoga onitis*	92
Blue Crab	*Callinectes sapidus*	55
Oyster Toadfish	*Opsanus tau*	21
Conger Eel	*Conger conger*	13
Sheepshead Minnow	*Cypinodon variegatus*	7
Common Sea Star	*Asterias rubens*	4
American Lobster	*Homarus americanus*	3
Winter Flounder	*Pseudopleuronectes americanus*	3
Foureye Butterflyfish	*Chaetodon capistratus*	2
Brown Bullhead Catfish	*Ameiurus nebulosus*	1
Doctorfish	*Acanthurus chirurgus*	1
Snowy Grouper	*Hyporthodus niveatus*	1
Spotfin Butterflyfish	*Chaetodon ocellatus*	1
Yellowfin Grouper	*Mycteroperca venenosa*	1

Table 6. Total number caught by site with calculated total catch rate and finfish catch rate by site.

Species	FT 1	FT 2	FT 3	FT 4	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	Total
American Eel							11	95	13	78	5		8	4	2	24	**240**
American Lobster	3	29	2	16	3								1				**54**
Atlantic Rock Crab	5	2	8	21													**36**
Black Sea Bass	12	92	35	118	27	53	19									18	**374**
Brown Bullhead Catfish									1								**1**
Blue Crab								6		22	11	1		8	7		**55**
Common Sea Star					1	2	1										**4**
Conger Eel	10	47	5	25	3	4							1				**95**
Cunner					104	411	260			42						39	**856**
Doctorfish												1					**1**
Foureye Butterflyfish					1								1				**2**
Green Crab					663	521	852	596	2	706	370	103	156	120	215	138	**4442**
Grey Triggerfish	6	59															**65**
Lesser Amberjack		1															**1**
Jonah Crab	12	45	7	18													**82**
Mummichog								73		492	981			132			**1678**
Oyster Toadfish							18							3			**21**
Sheepshead Minnow								7									**7**
Scup	210	356	52	114													**732**
Snowy Grouper													1				**1**
Spider Crab	864	1938	123	373													**3298**
Spotfin Butterflyfish													1				**1**
Striped Killifish											123			186			**309**
Summer Flounder				2													**2**
Tautog	167	22	45	68	9	31	24						3			25	**394**
Winter Flounder			1	3		2								1			**7**
Yellowfin Grouper													1				**1**
Total	**1289**	**2591**	**278**	**758**	**811**	**1024**	**1185**	**777**	**16**	**1340**	**1490**	**105**	**173**	**454**	**224**	**244**	
Catch Rate	**14.87**	**29.89**	**3.21**	**8.74**	**9.35**	**11.81**	**13.67**	**8.96**	**0.18**	**15.46**	**17.19**	**1.21**	**2.00**	**5.24**	**2.58**	**2.81**	
Finfish Catch Rate	4.67	6.66	1.59	3.81	1.66	5.78	3.83	1.18	0.16	7.06	12.79	0.01	0.17	0.69	0.02	1.22	
Crustacean Catch Rate	10.20	20.38	1.61	4.94	7.69	6.03	9.83	7.79	0.02	8.40	4.39	1.20	1.48	3.00	2.56	1.59	

FIGURES

Figure 1. Map extent to show sampling site locations in the GSP and OH. Red dots represent HOBO dataloggers. Yellow dots represent eel pots. Blue dots indicate the eel ramp. Green dots represent fish traps (ArcMap 2018).

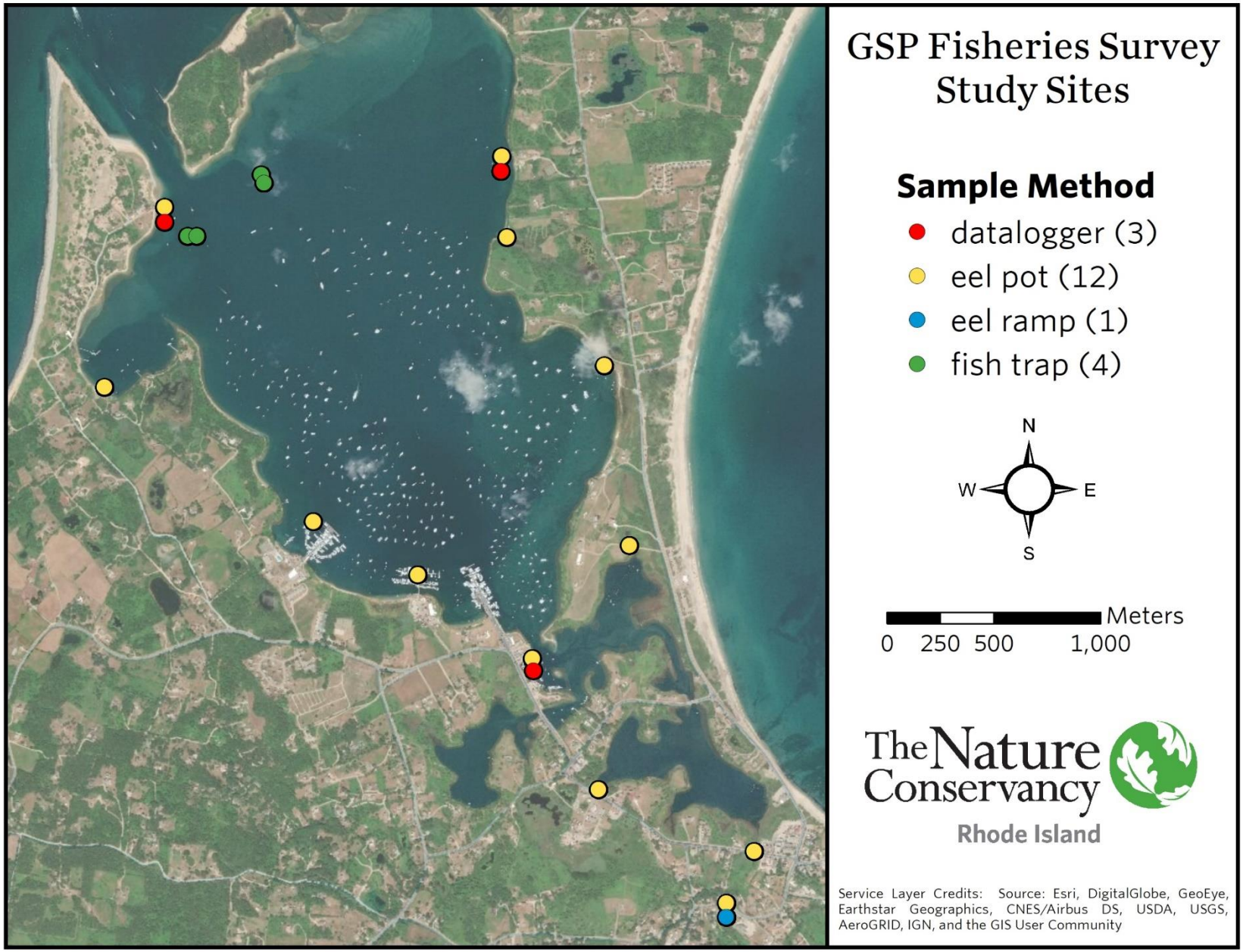
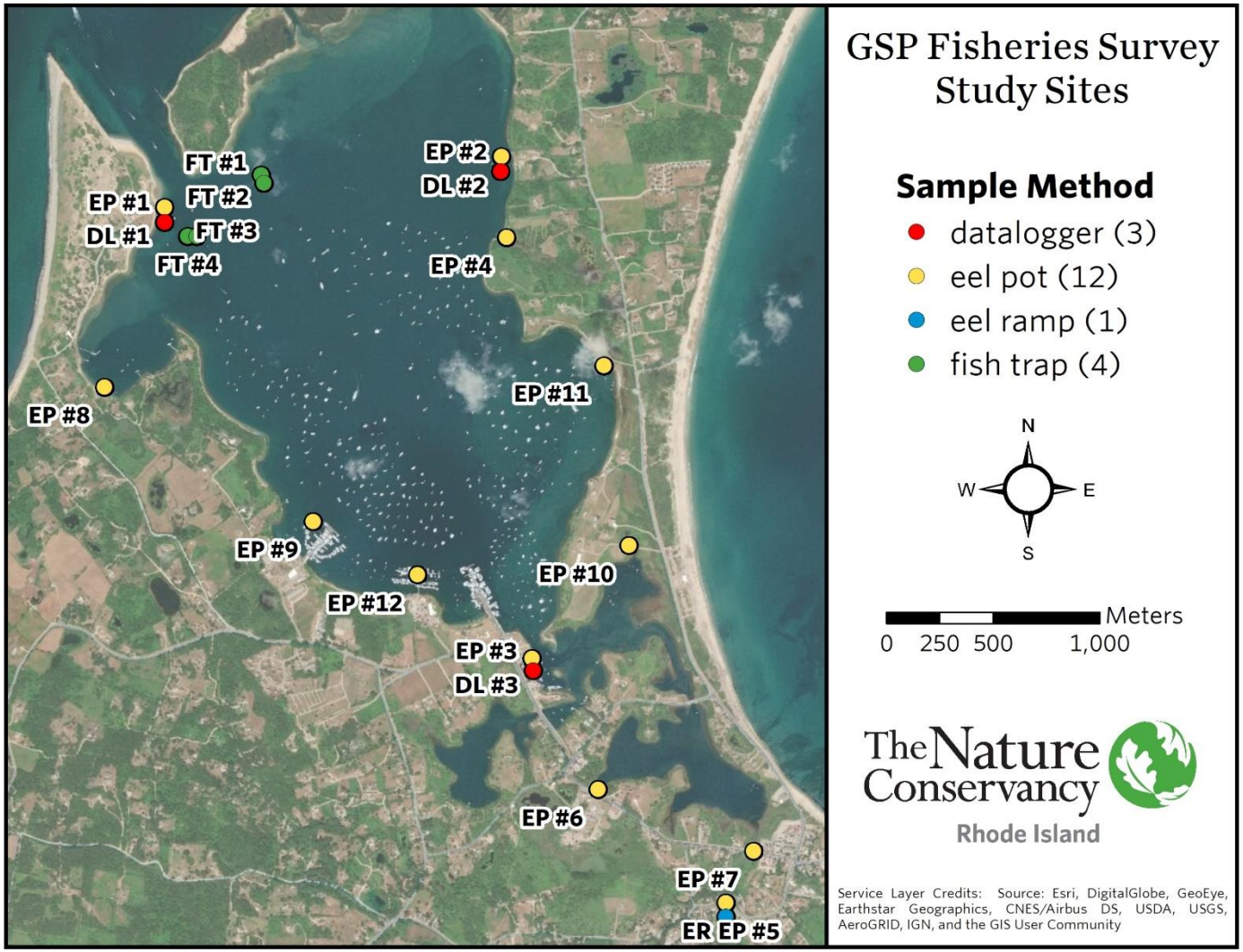


Figure 2. Map depicting sampling site locations within the Great Salt Pond watershed (ArcMap 2018).



Buoy/Channel/Slope:
- FT #1-4

Permanent Dock:
- EP #1-3, *EP #8, 9, 12
- DL #1-3

Rocky Intertidal:
- *EP #11

Marsh Edge:
- EP #6

Cove:
- EP #4,10

Tributary:
- EP #5, 7, ER

**Gear added in 2018*

Figure 3. Total catch rate by month for fish traps in 2018 (stacked). CPUE = Total fish caught/(Number of hauls*Number of soak days). All hauls were based on one trap per haul.

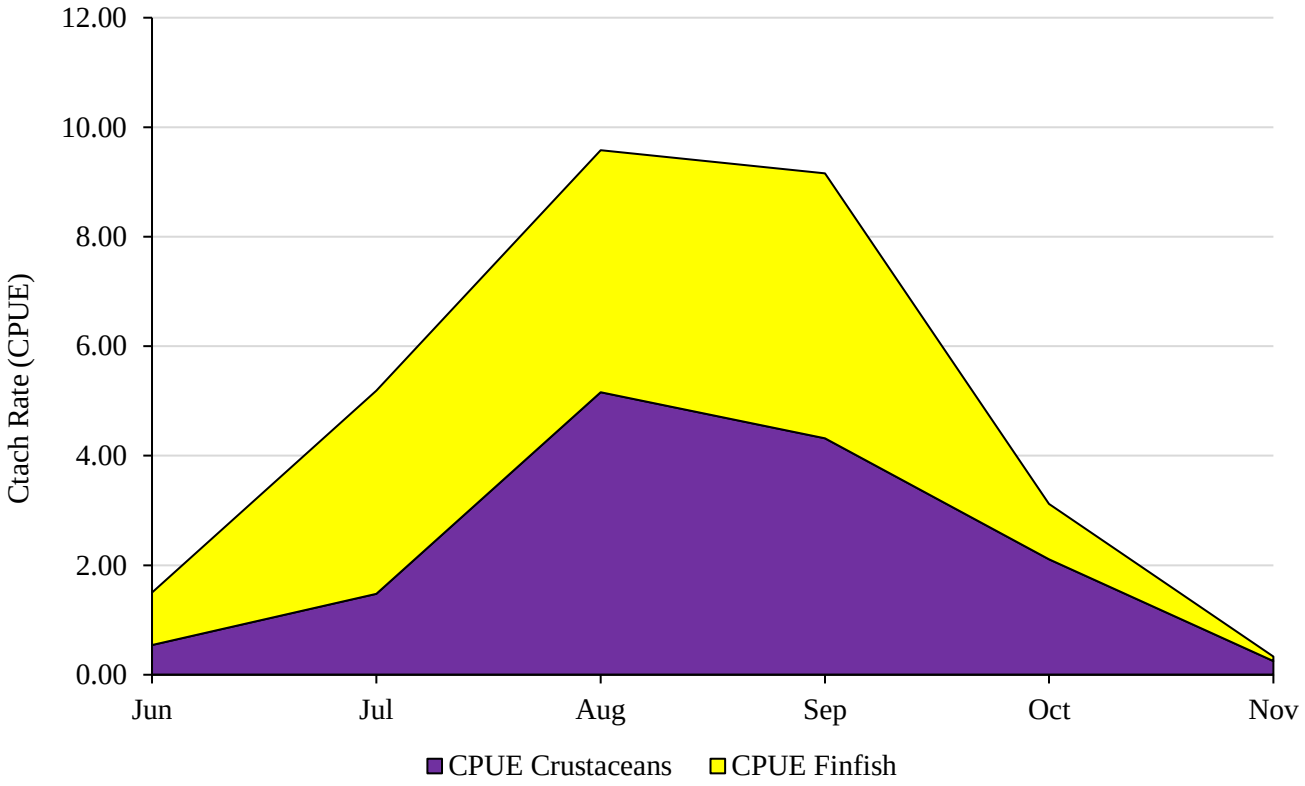


Figure 4. Total catch rate by month for eel pots (staked). CPUE = Total fish caught/(Number of hauls*Number of soak days). All hauls were based on one trap per haul.

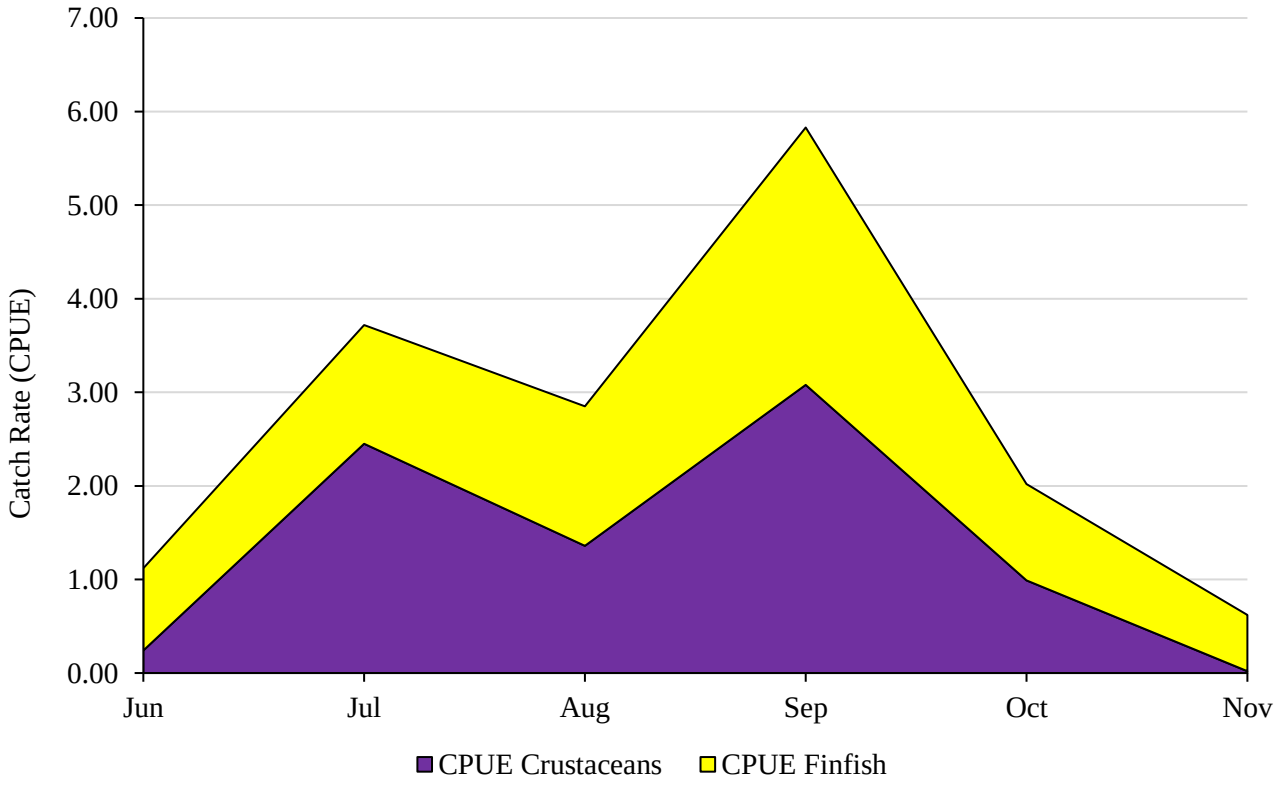


Figure 5. Total catch rate by site for fish traps in 2018 (staked). CPUE = Total fish caught/(Number of hauls*Number of soak days). All hauls were based on one trap per haul.

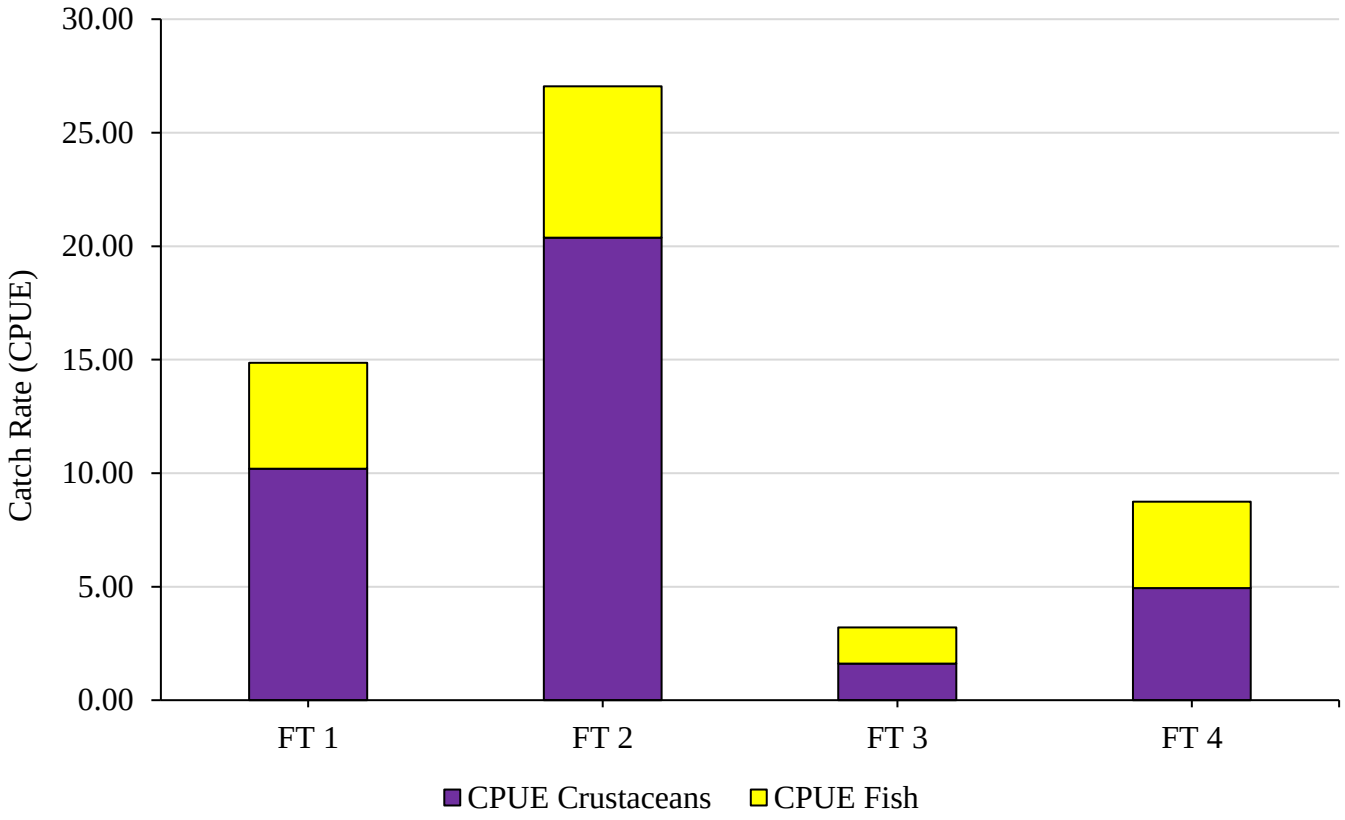


Figure 6. Total catch rate by site for eel pots in 2018 (staked). CPUE = Total fish caught/(Number of hauls*Number of soak days). All hauls were based on one trap per haul.

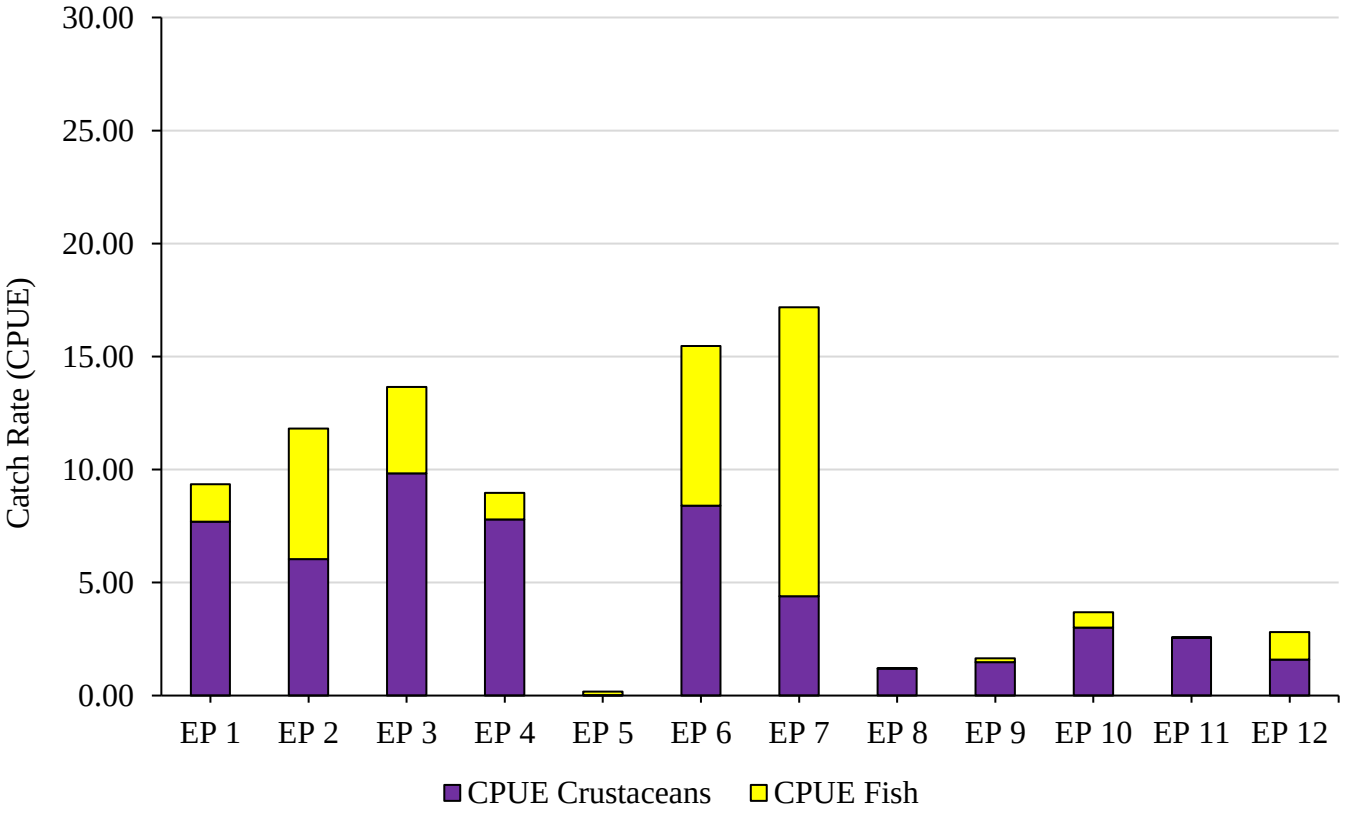


Figure 7. Percent of finfish and crustaceans caught at each site in the 2018 season (stacked).

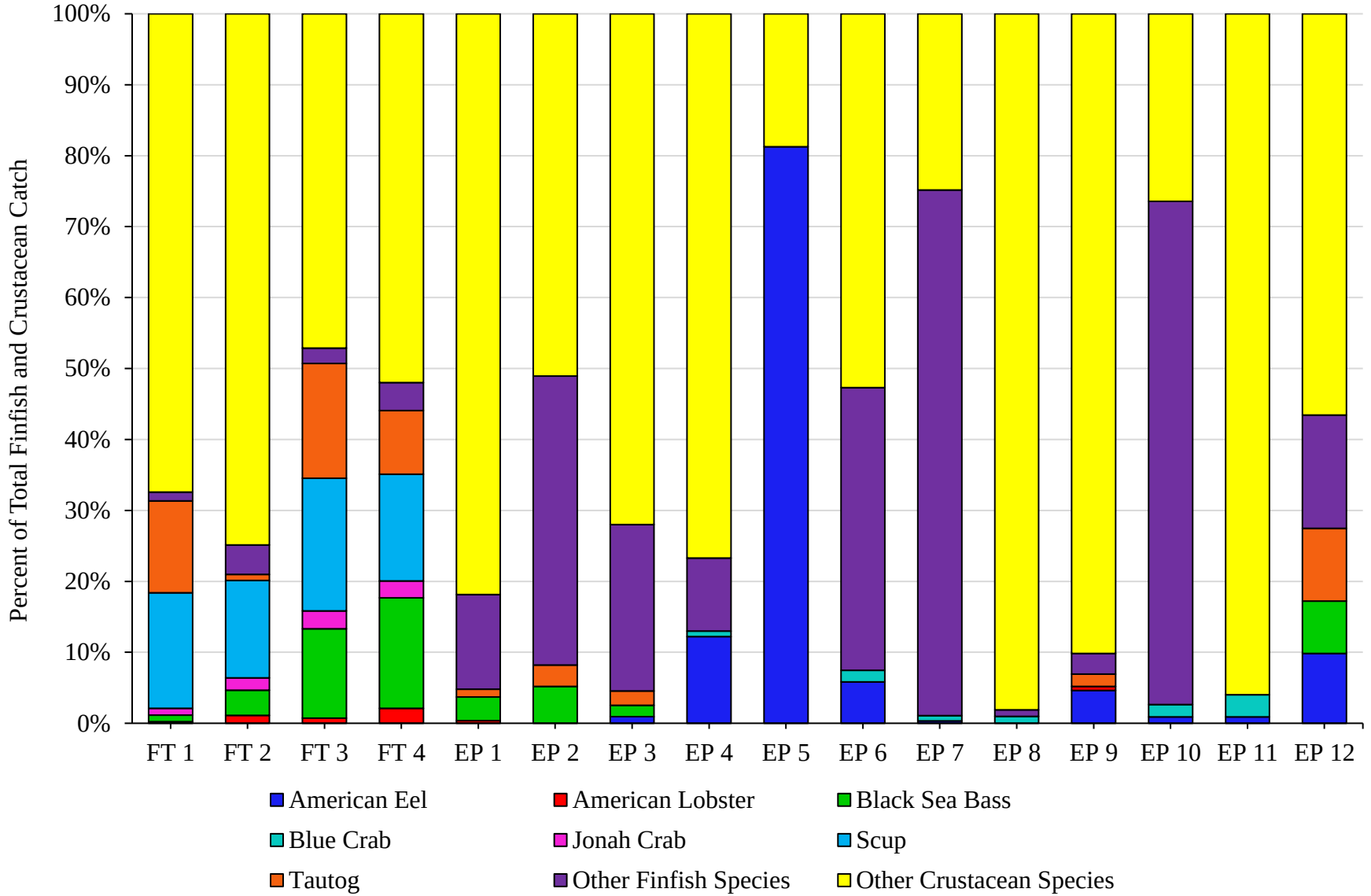


Figure 8. Mean abundance finfish and crustaceans ± SE across fish trap sites in 2018.

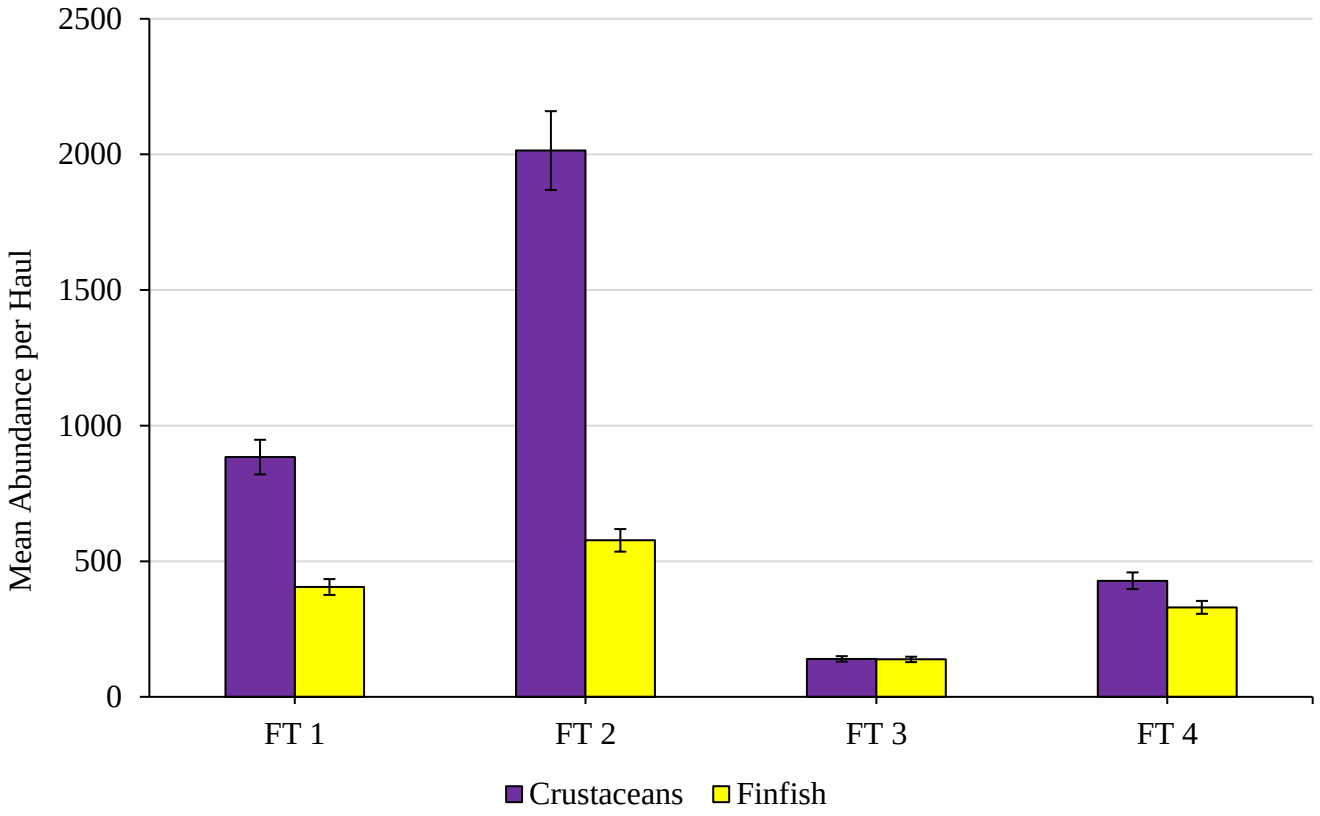


Figure 9. Mean abundance finfish and crustaceans ± SE across eel pot sites in 2018.

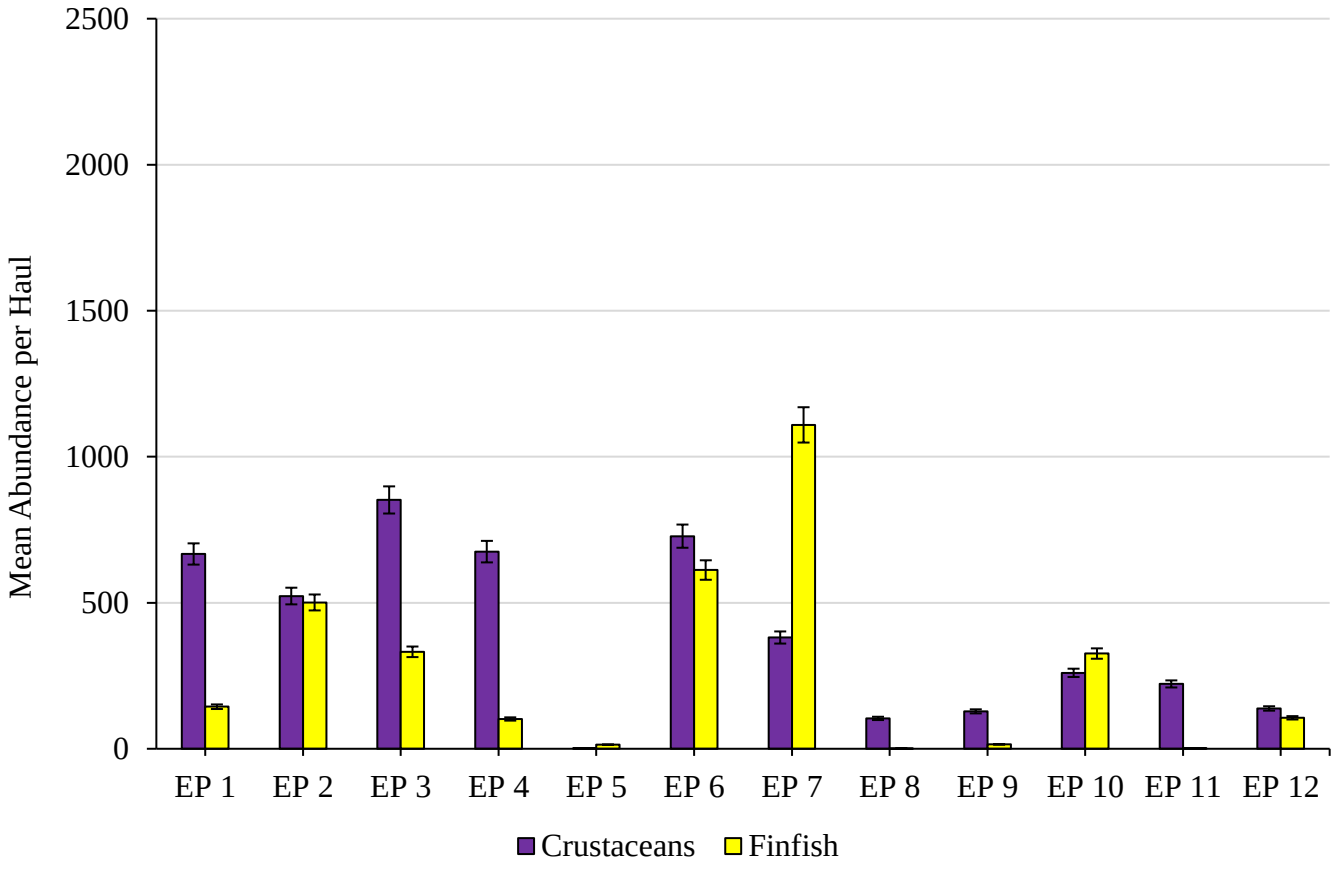


Figure 10. Mean finfish abundance ± SE across fish traps in 2018.

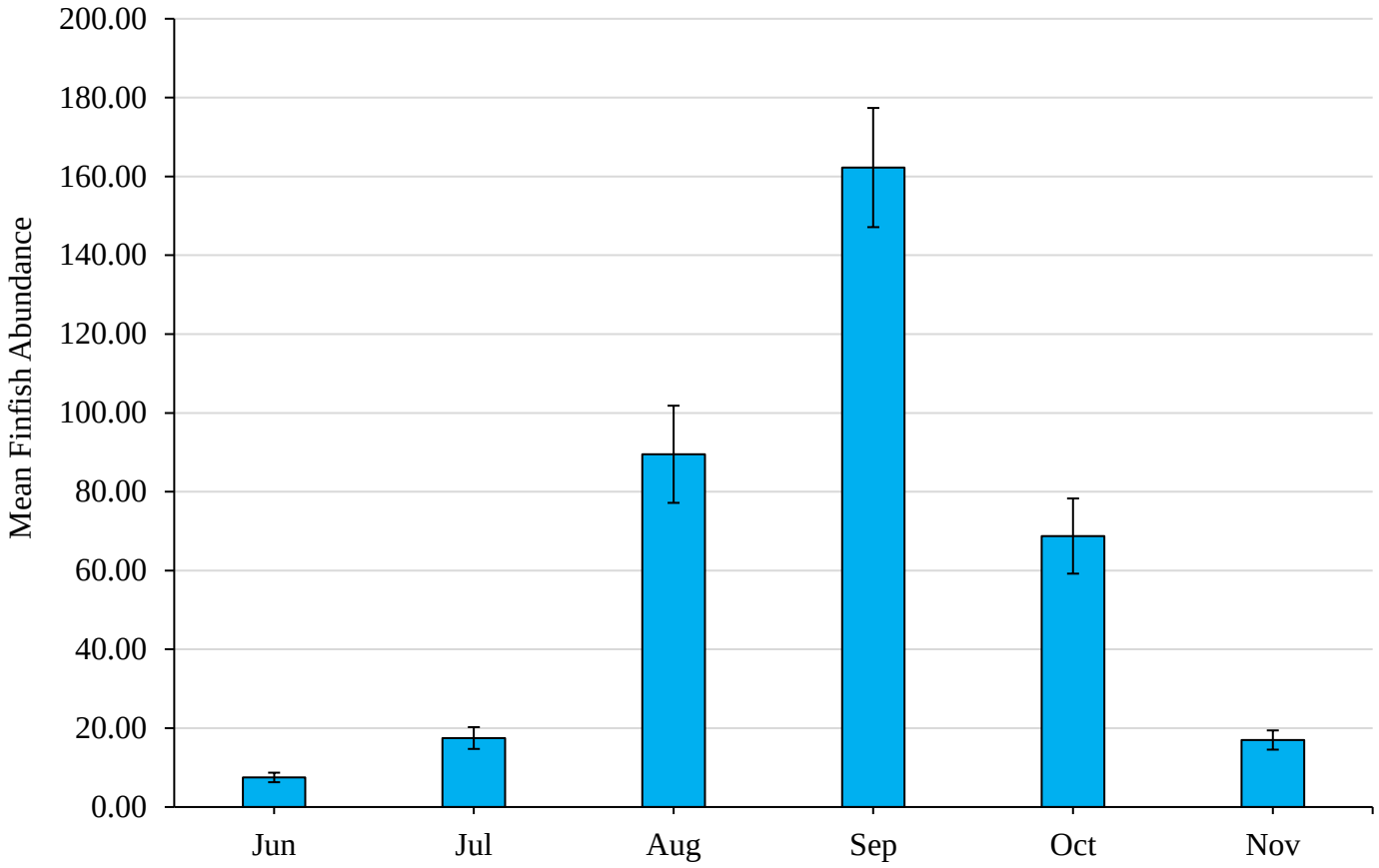
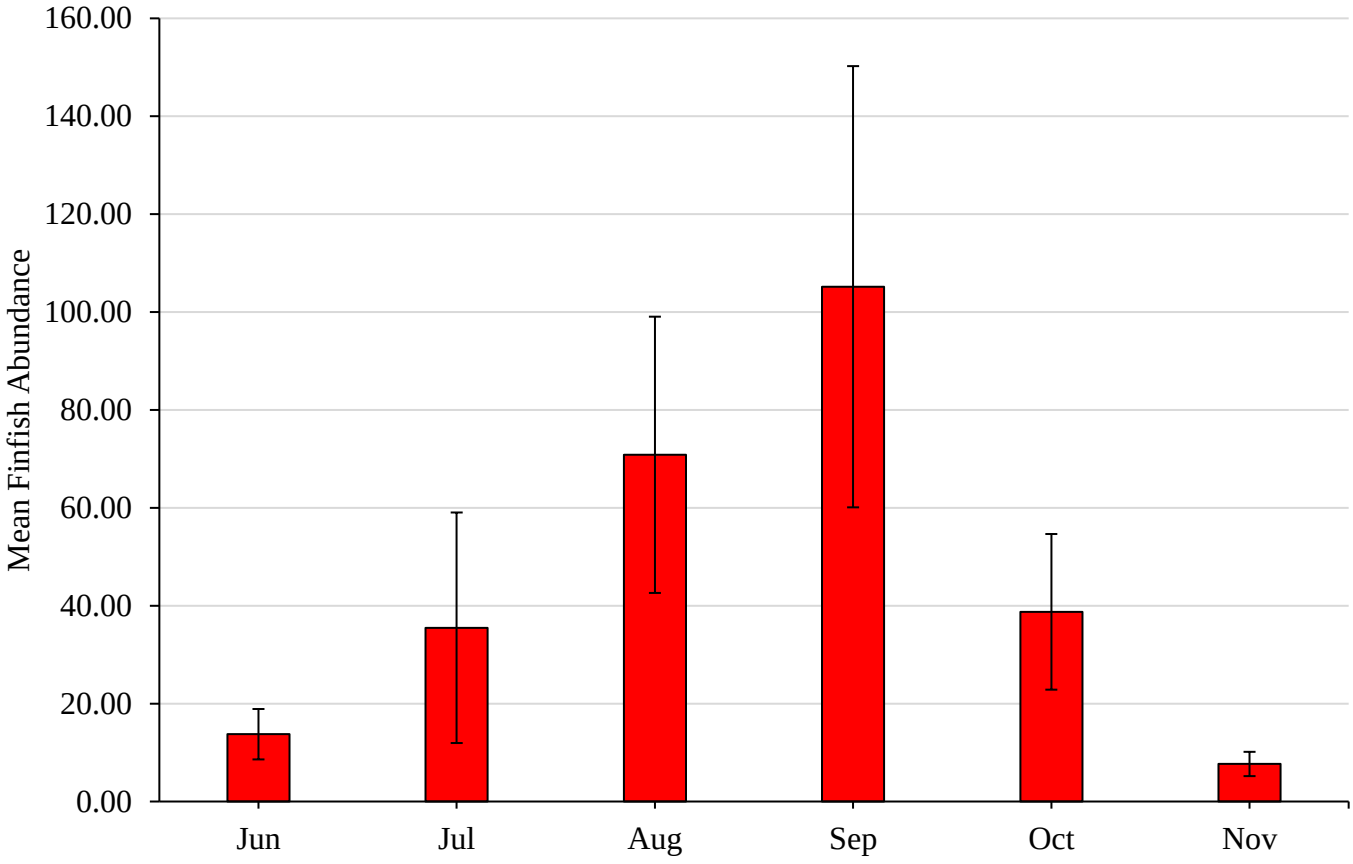


Figure 11. Mean abundance finfish ± SE across eel pot sites in 2018.



APPENDICES

Appendix A

Figure 1a. Map depicting the area extent for the Great Salt Pond watershed, ArcMap 2017.

Figure 2a. Mean Shannon diversity of all species across sites for fish traps and eel pots in 2018.

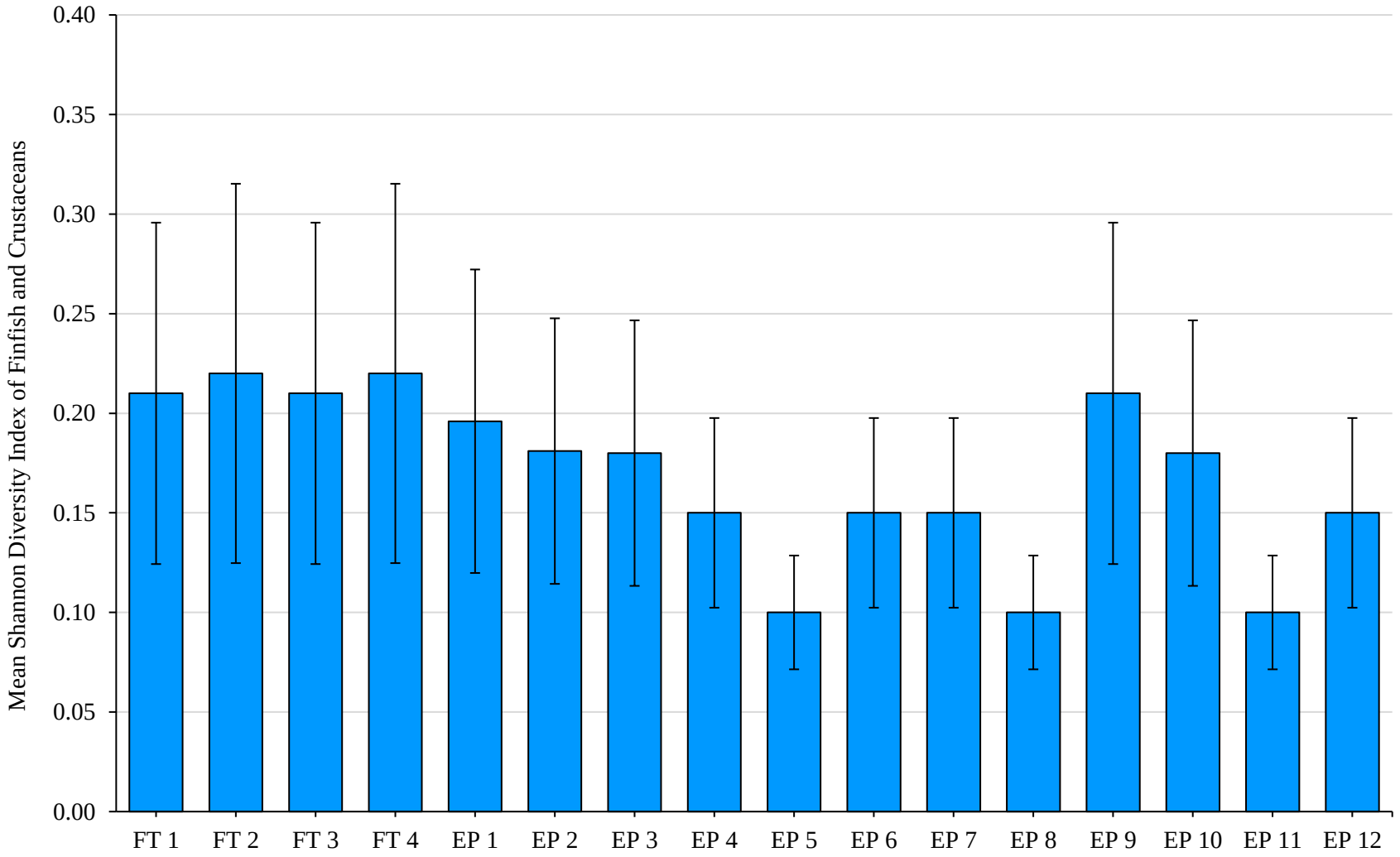


Figure 3a. Mean Shannon diversity of finfish across sites for fish traps and eel pots in 2018.

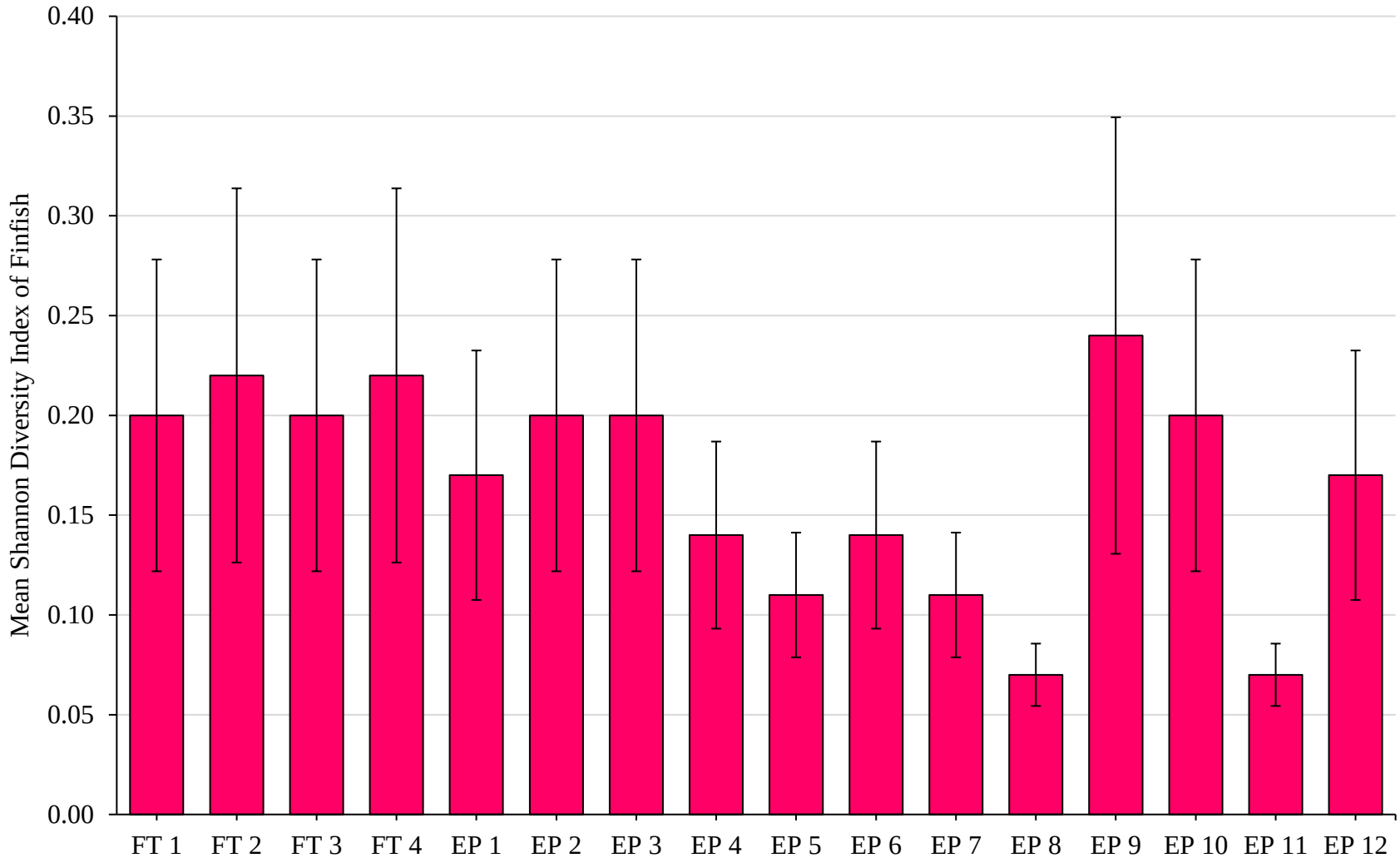


Figure 4a. Percent of effort for species of interest caught in fish traps, 2018. First axis displays number of individuals. Second axis displays percent of effort.

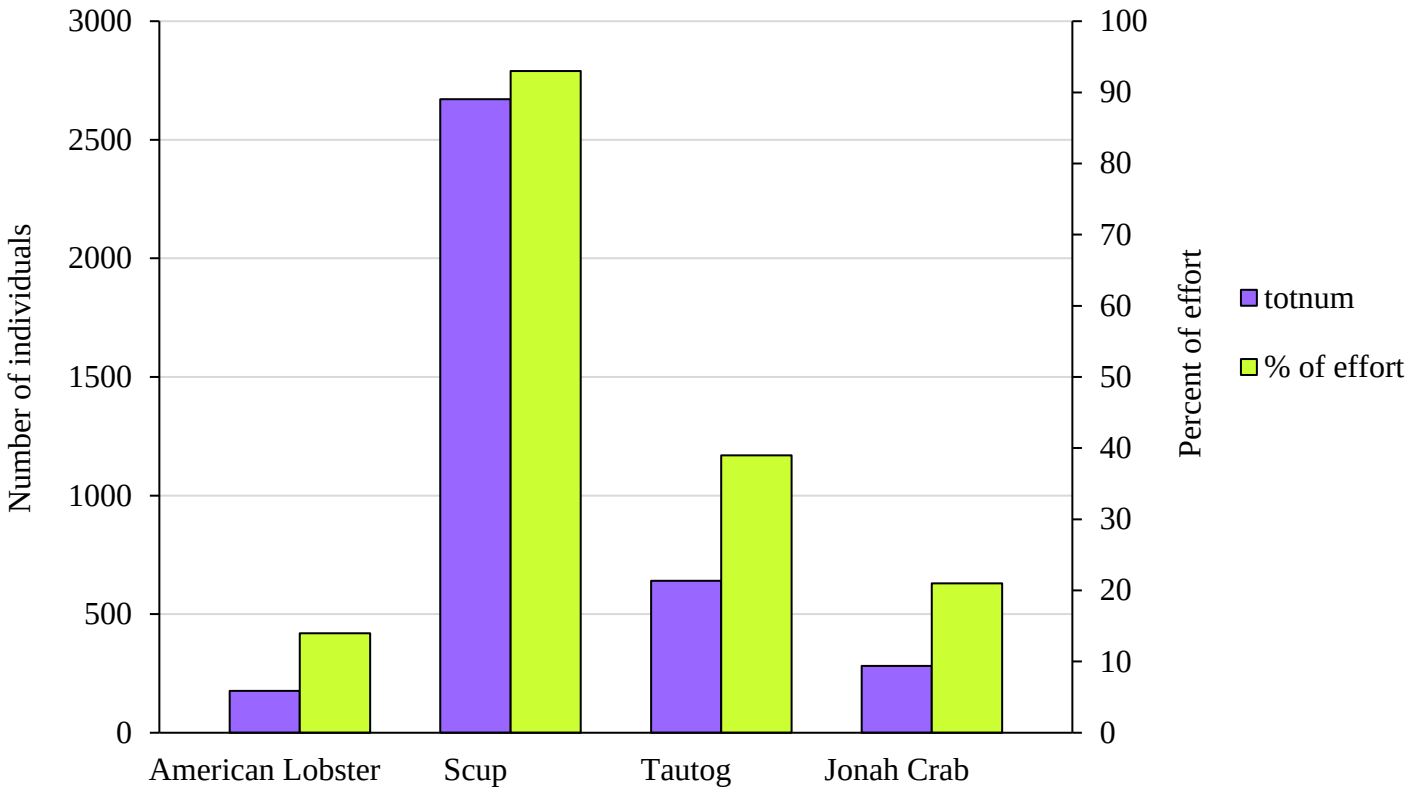


Figure 5a. Percent of effort for additional age 1+ species of interest caught in fish traps, 2018. First axis displays number of individuals. Second axis displays percent of effort.

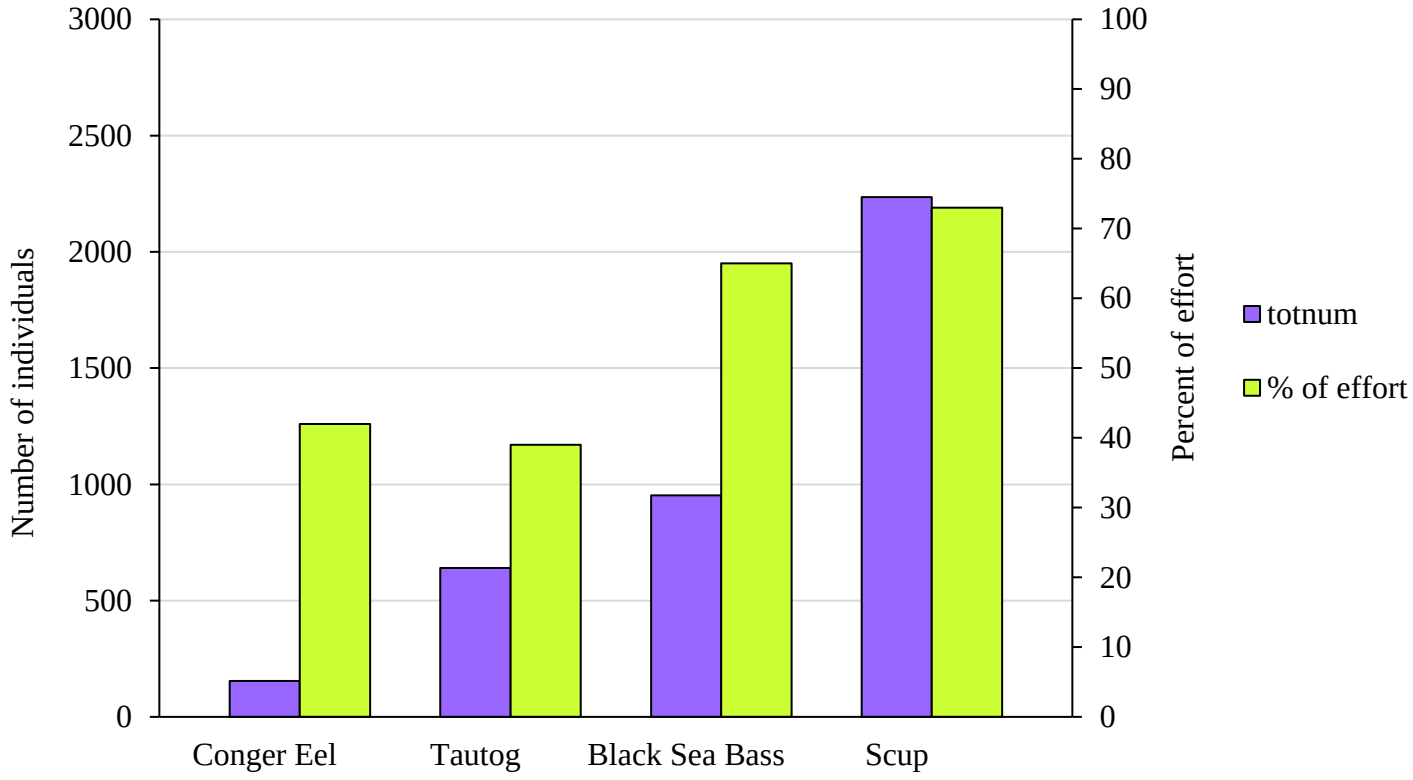


Figure 6a. Catch per unit effort of scup, black sea bass, tautog, and conger eel caught in fish traps, 2018. Data reflects age 1+ caught between the two sites, Beane Point and Coast Guard.

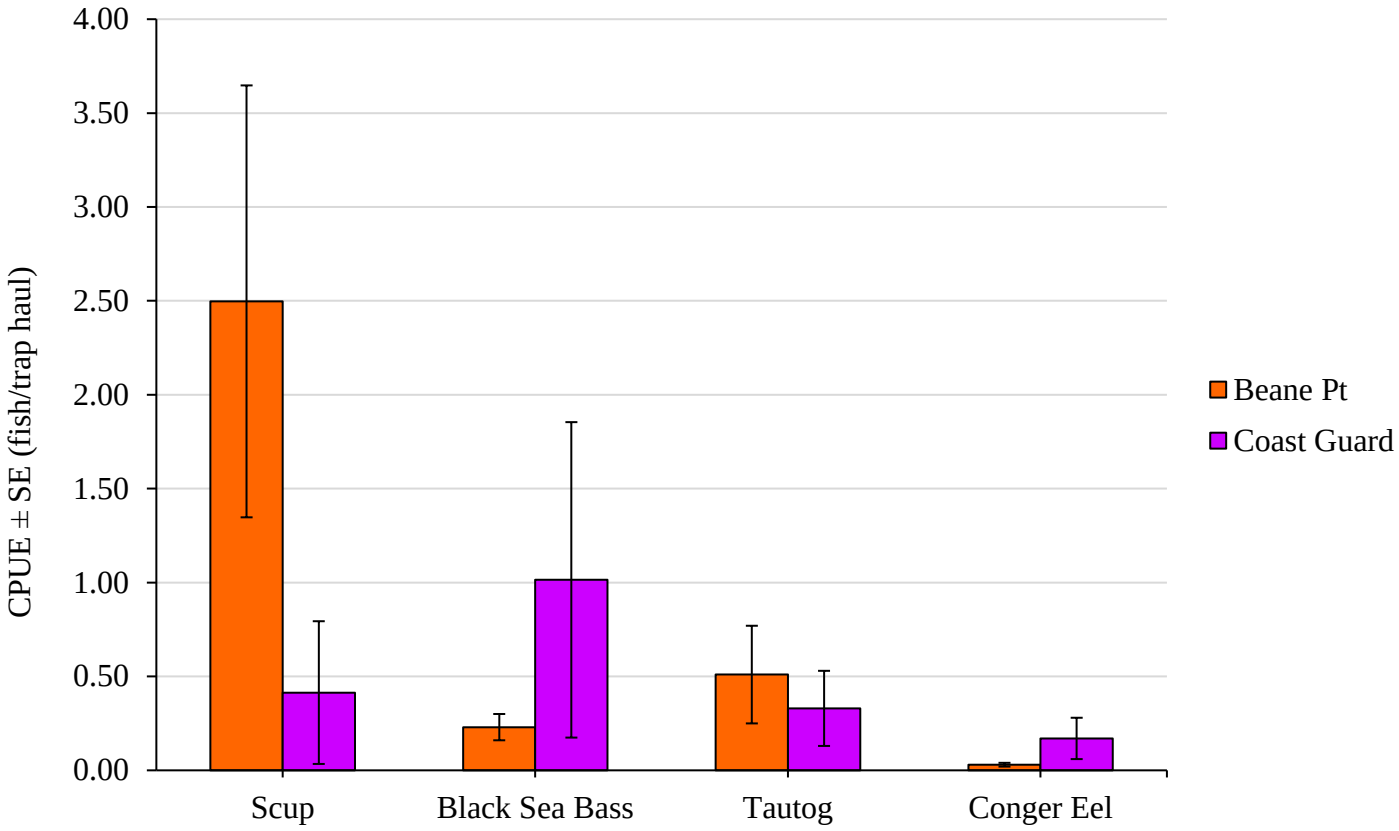


Figure 7a. CPUE ± SE scup caught in fish traps, 2016-2018. Migration patterns of scup are seasonal and have both a north-south and an inshore-offshore component. The bar plot illustrates this pattern where they migrate inshore late spring and remain there until the fall when the reverse migration occurs.

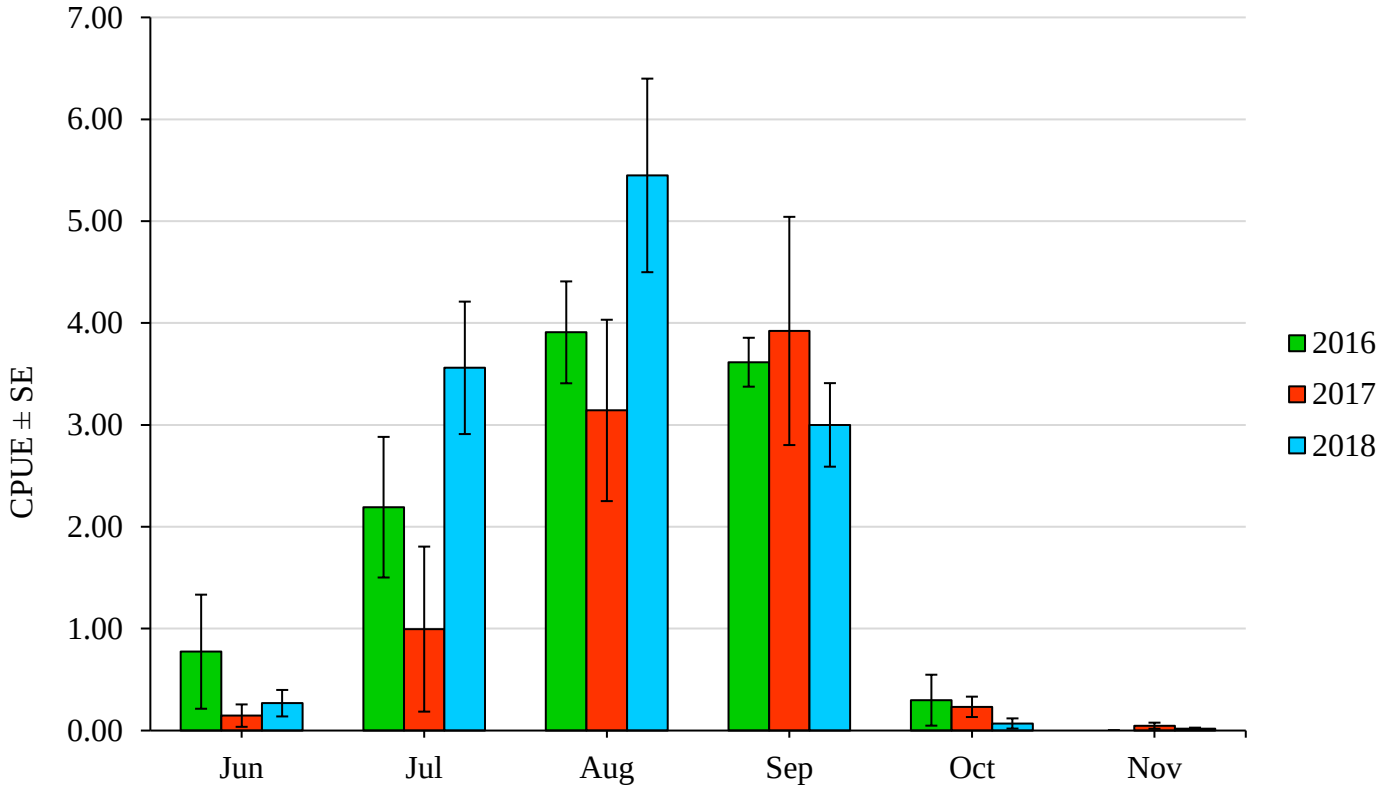


Figure 8a. CPUE black sea bass caught in fish traps, 2016-2018.

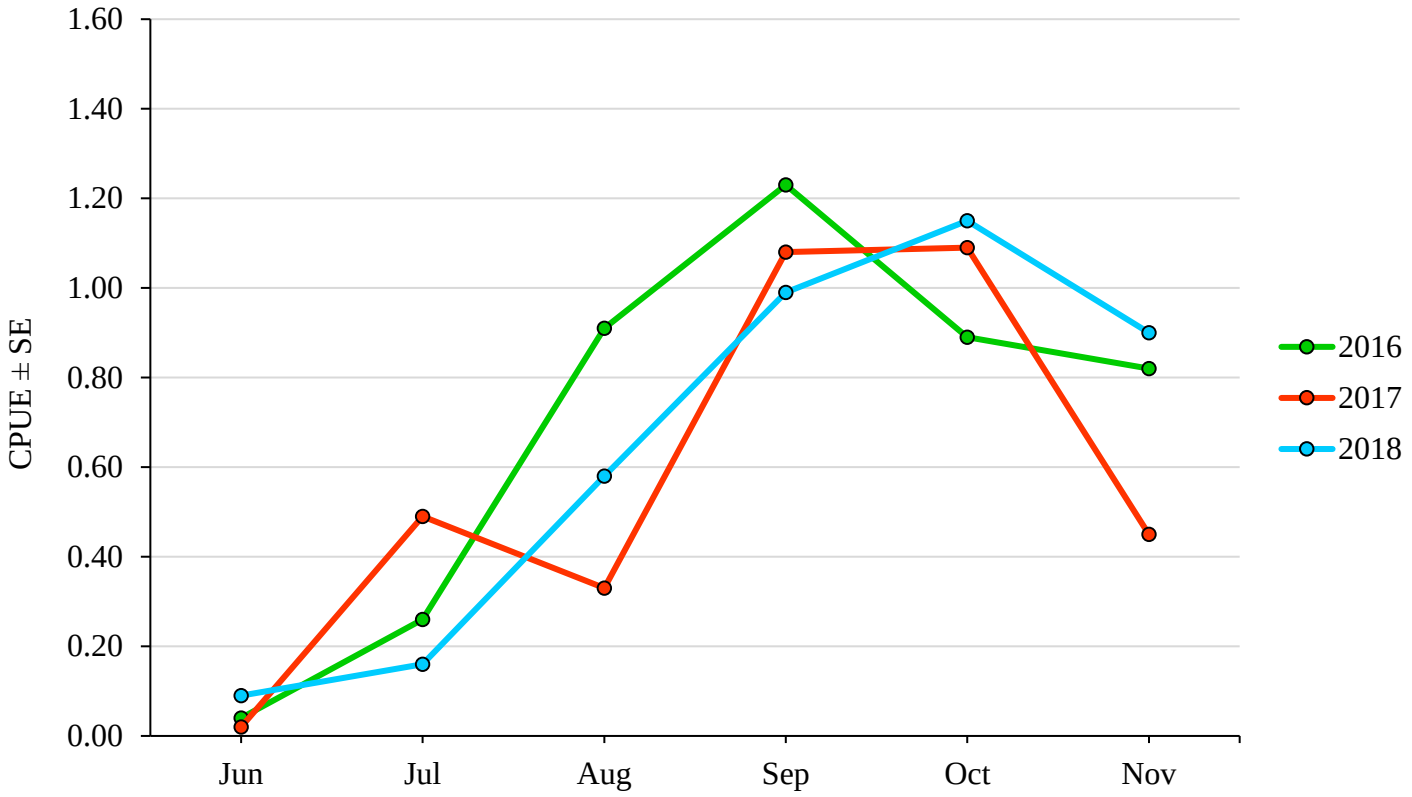


Figure 9a. CPUE YOY black sea bass caught in eel pots, 2016-2017.

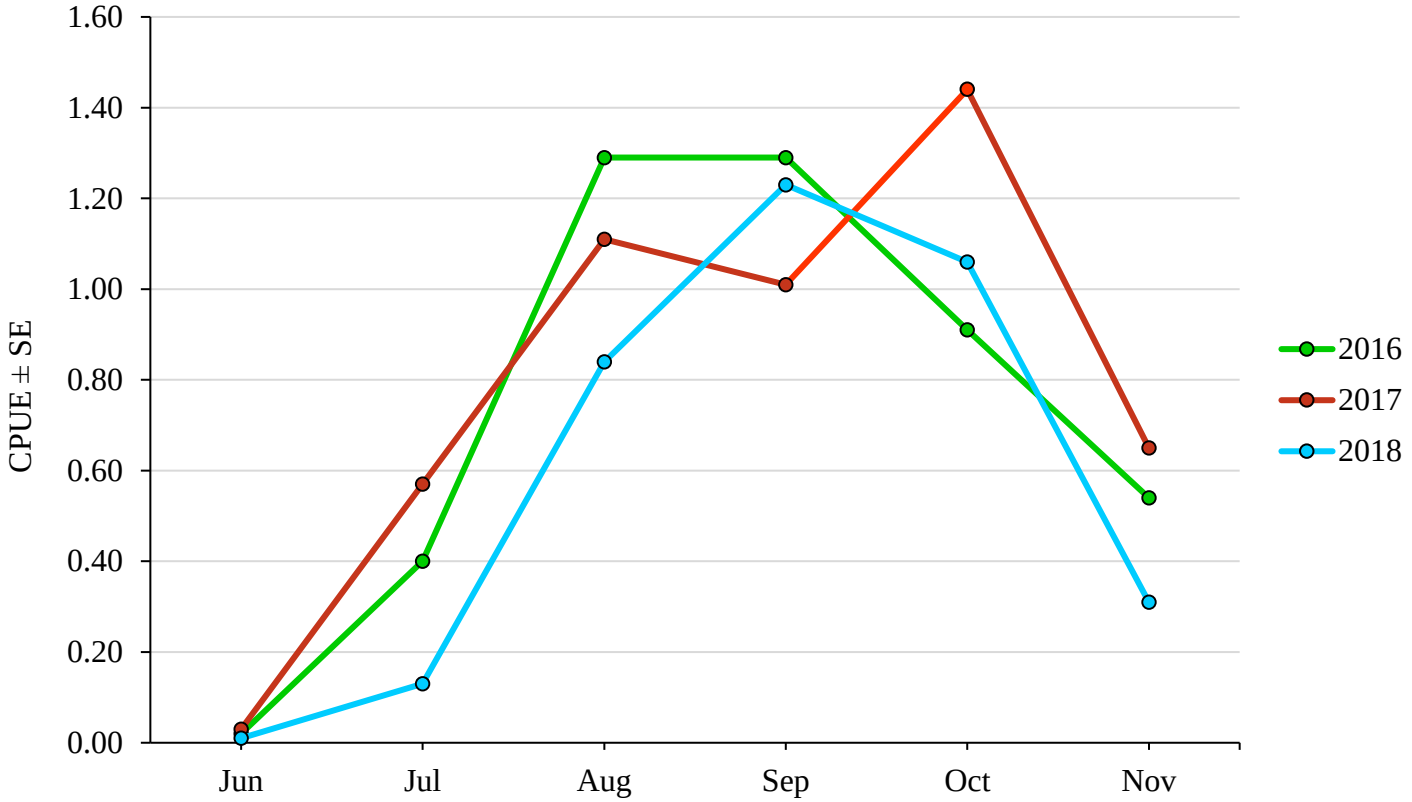


Figure 10a. YOY black sea bass found in eel pots, 2016-2018. Note the general habitat types associated with each eel pot site.

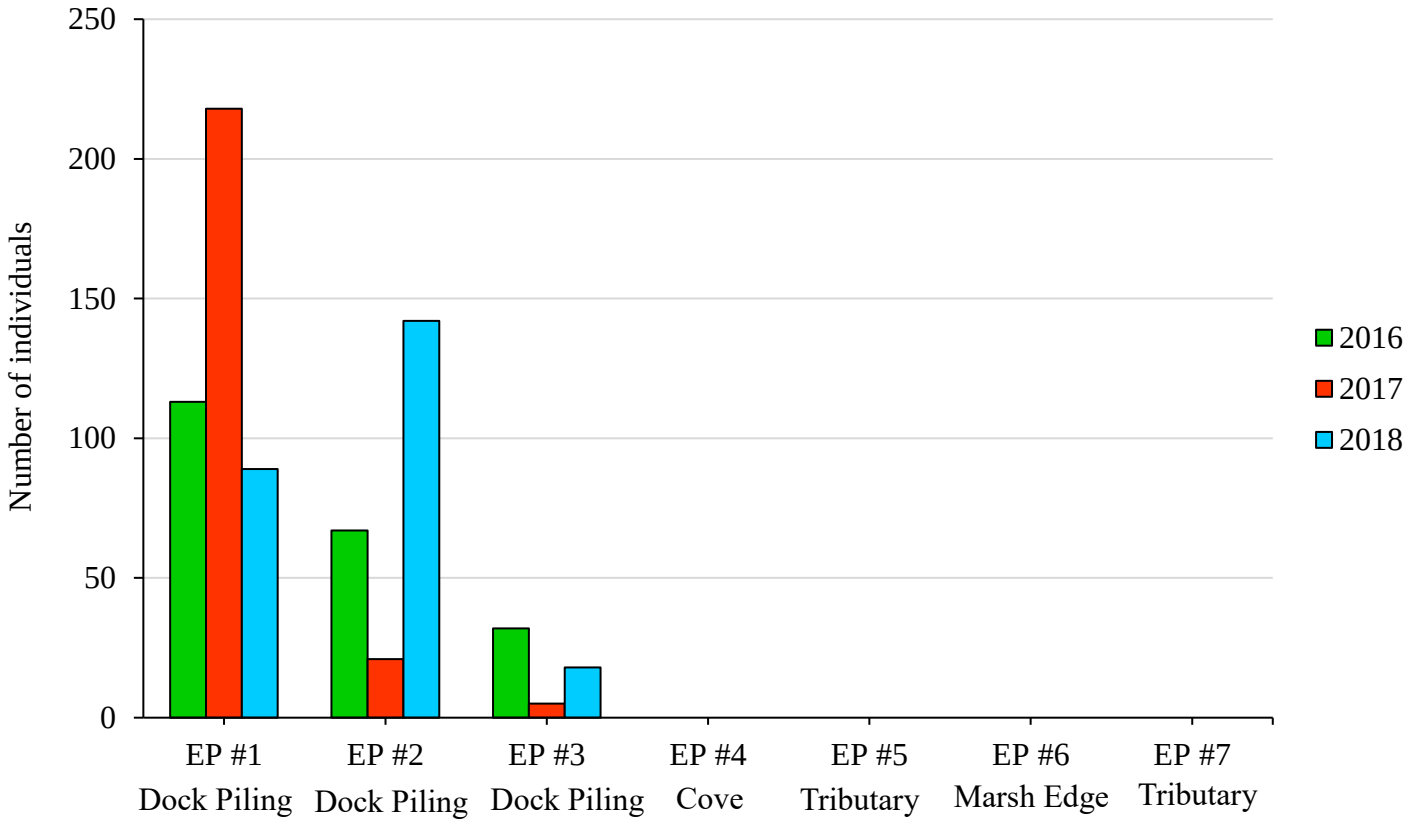


Figure 11a. Juvenile green crabs caught across eel pot sites, 2016-2018.

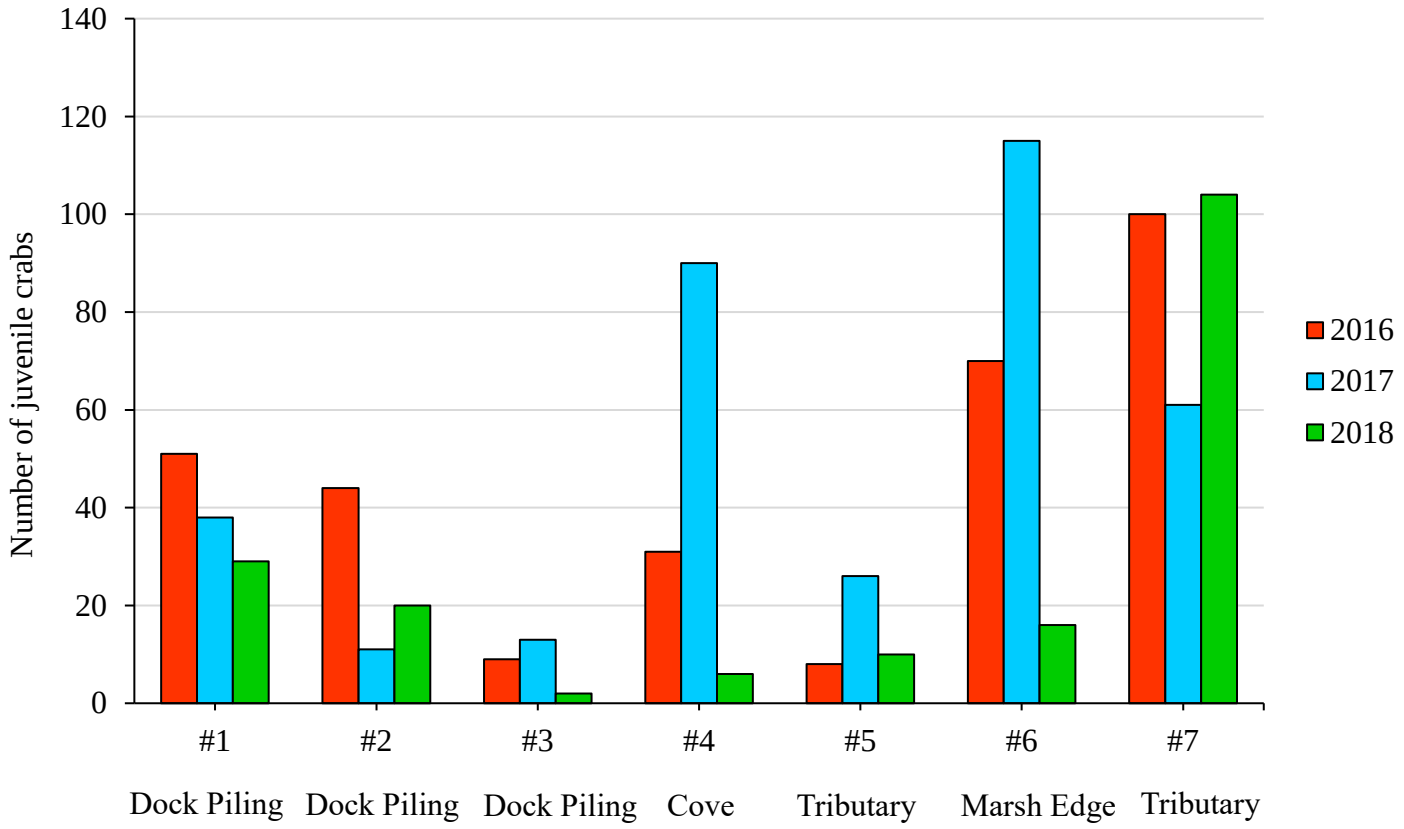


Figure 12a. Adult green crabs caught in eel pots, 2018. Green crabs of nearly all possible sizes, from juveniles ≤ mm CL up to adult males of 80mm CL, were found across all sites in the GSP. Crabs larger than 5cm were more commonly found this year compared to years sampled thus far. About 83.4-91.2% of crabs observed were sexually mature (individuals ≥ 1-2 years old and with ≥ 15mm). The proportion of mature crabs and mean overall crab sizes (17-26mm CL) were higher than previous years.

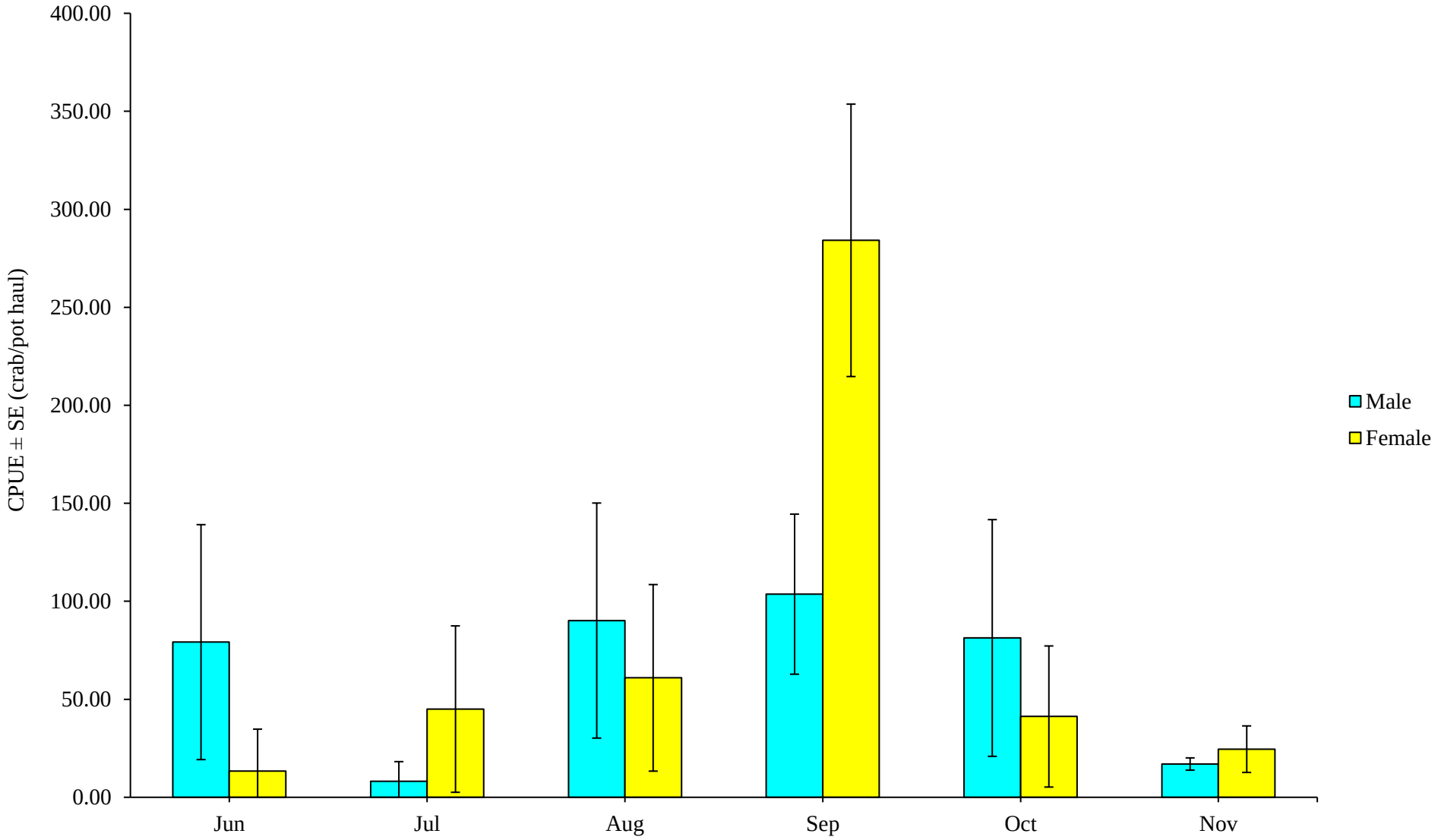


Figure 13a. Histogram of black sea bass caught in the fish traps set off Beane Point and Coast Guard Station in 2018. Black sea bass were measured by TL. The dotted line represents the recreational legal size (15 inches by TL).

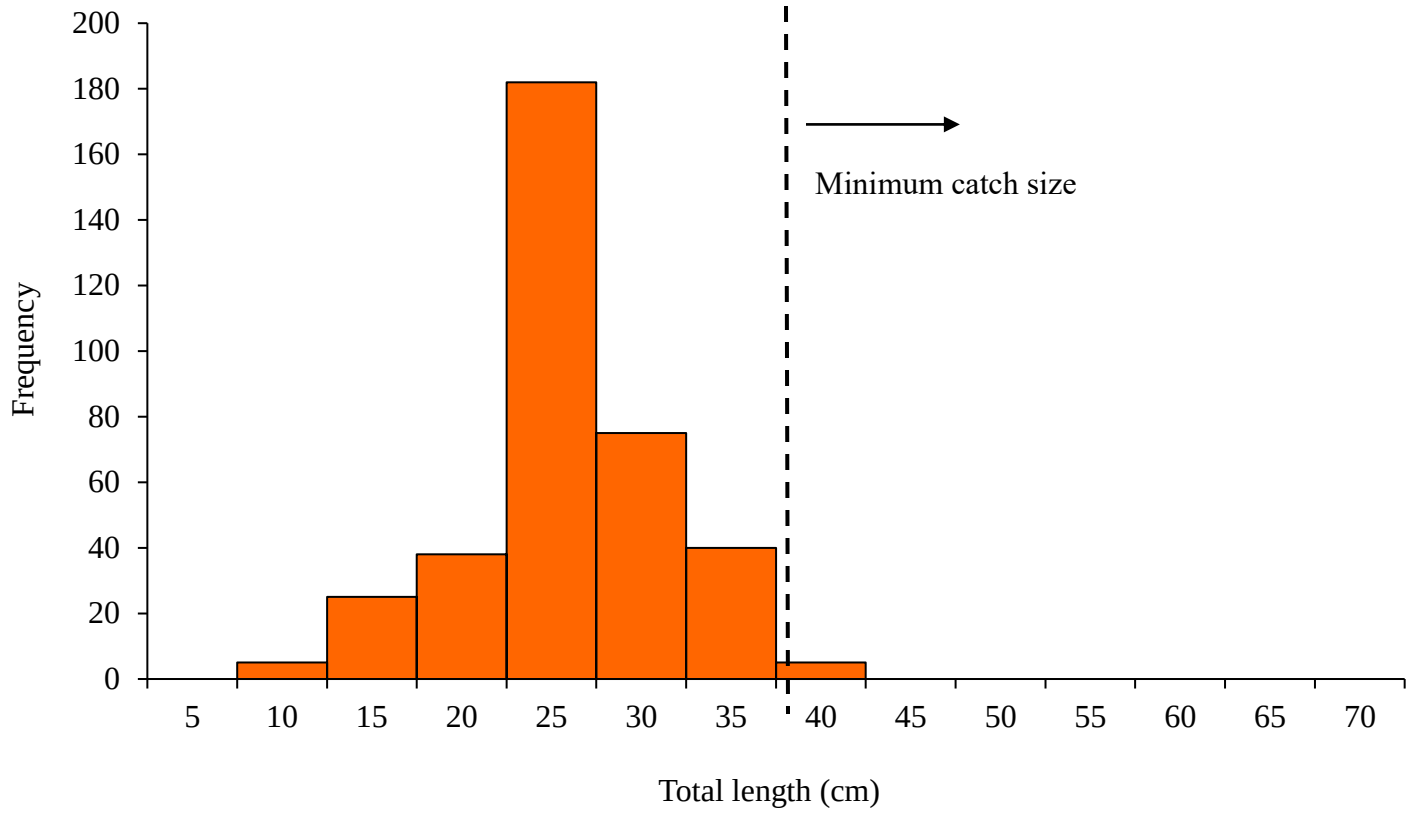


Figure 14a. Histogram of YOY black sea bass caught in eel pots, 2018. Black sea bass were measured by TL. The dotted line represents the YOY cutoff (TL<13cm). This number is not a strict cutoff as YOY guidelines for black sea bass vary by region due to size being highly dependent on temperature and localized environmental conditions (Bigelow and Schroeder 1953c).

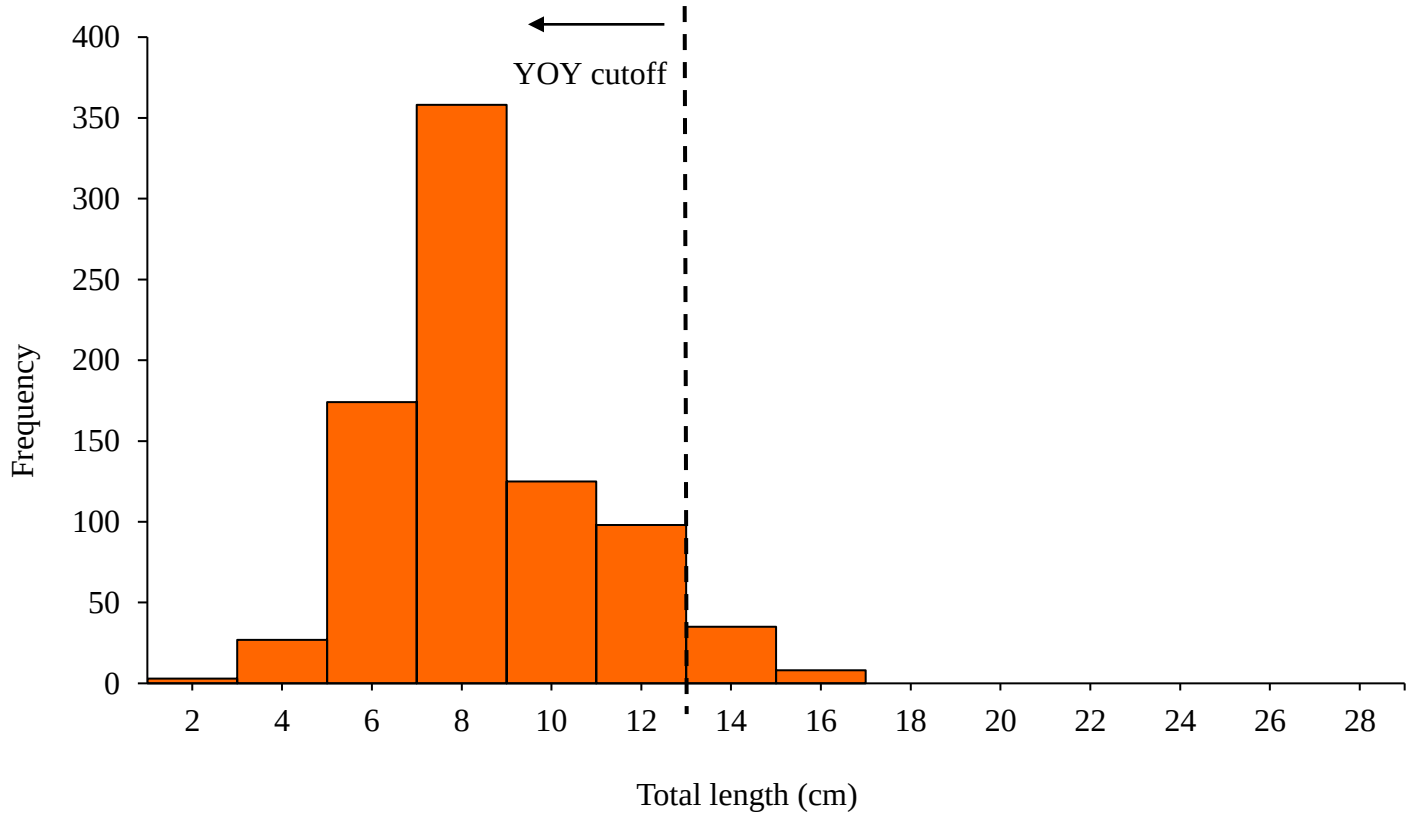


Figure 15a. Histogram of American lobster caught in fish traps, 2018. American lobsters were measured from the rear of the eye socket to the rear of the carapace on a line parallel to the center line of the body shell for carapace length (mm). The dotted line indicates minimum catch size 3-3/8" by carapace length.

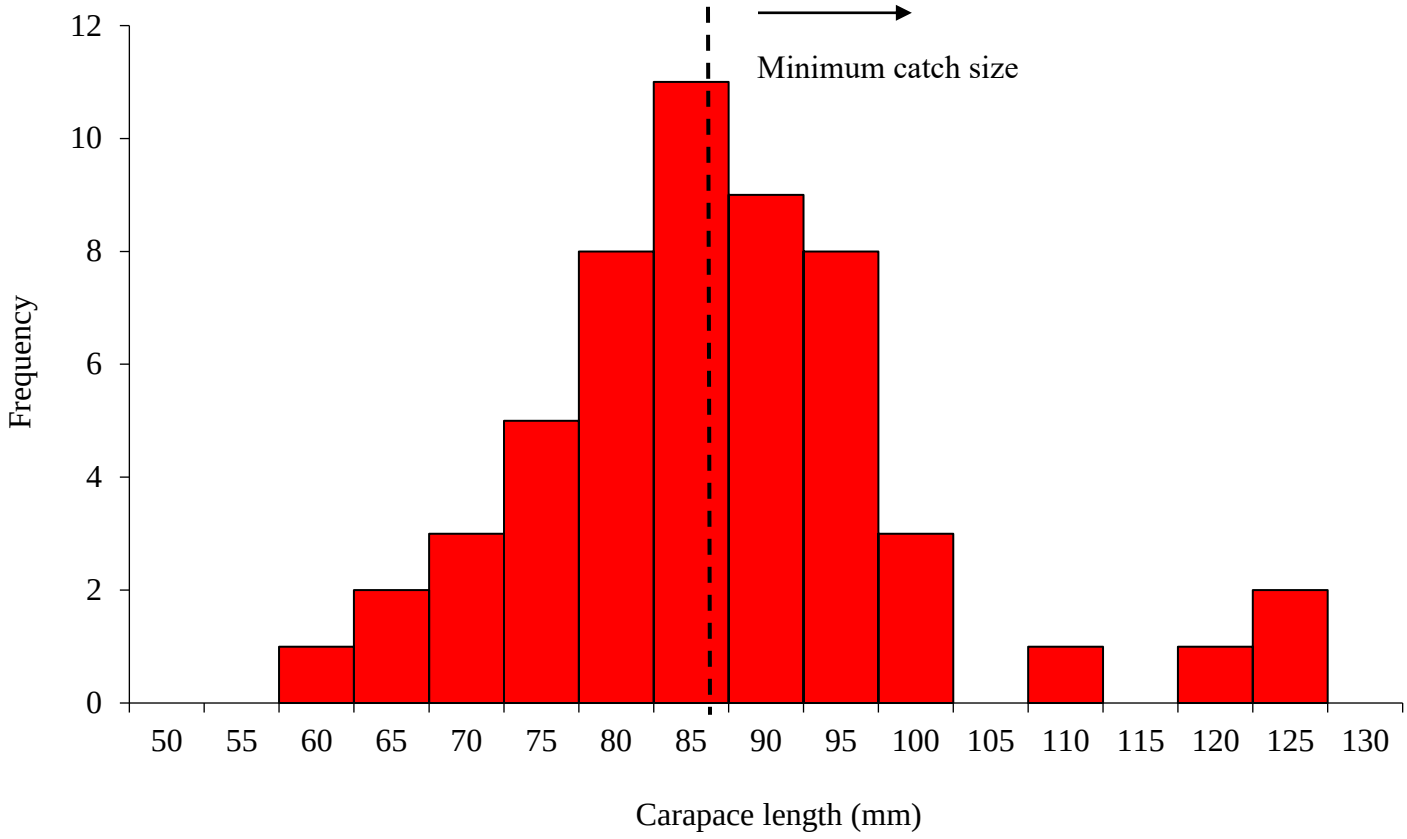


Figure 16a. Histogram of male and female American lobster caught in fish traps, 2018. The light blue shade represents overlap. The dotted line indicates minimum catch size 3-3/8-inches by carapace length.

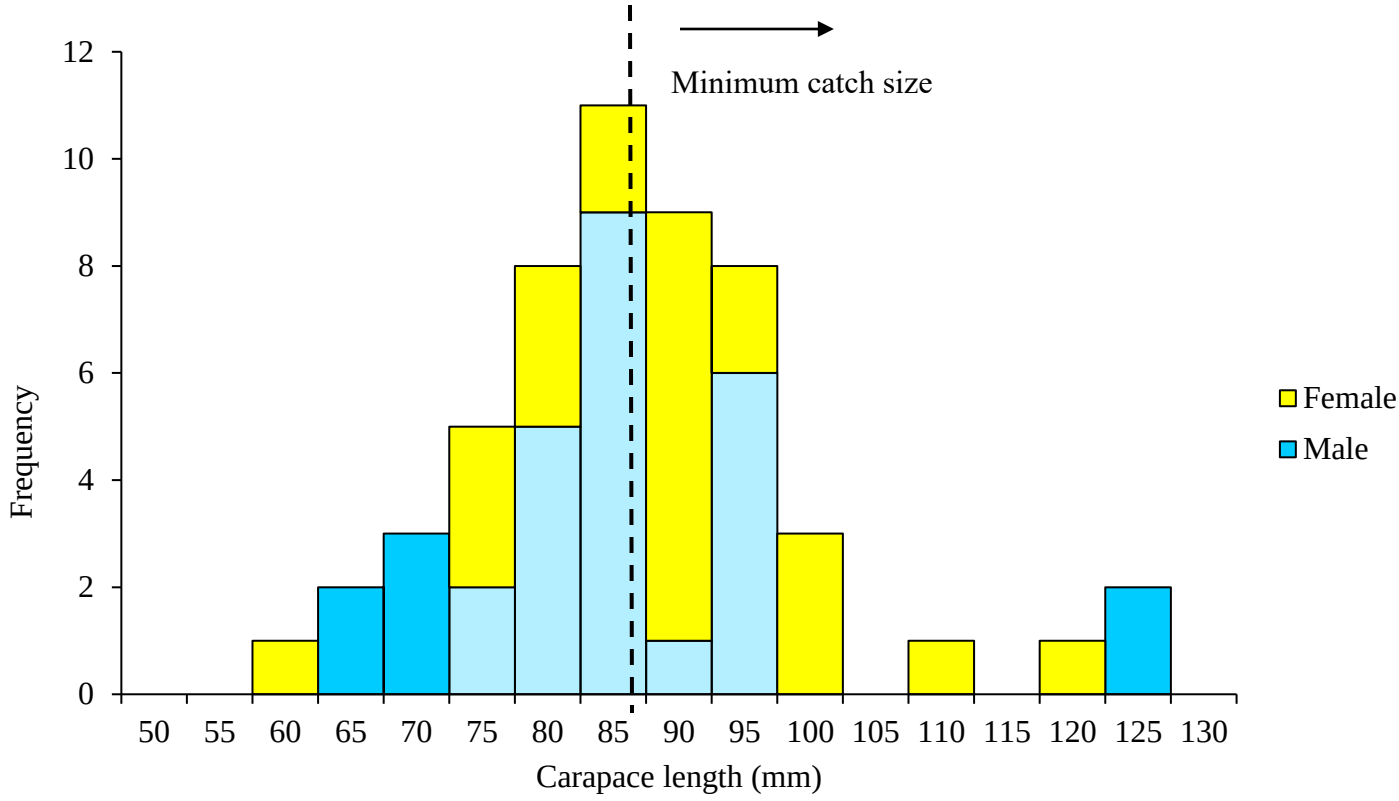
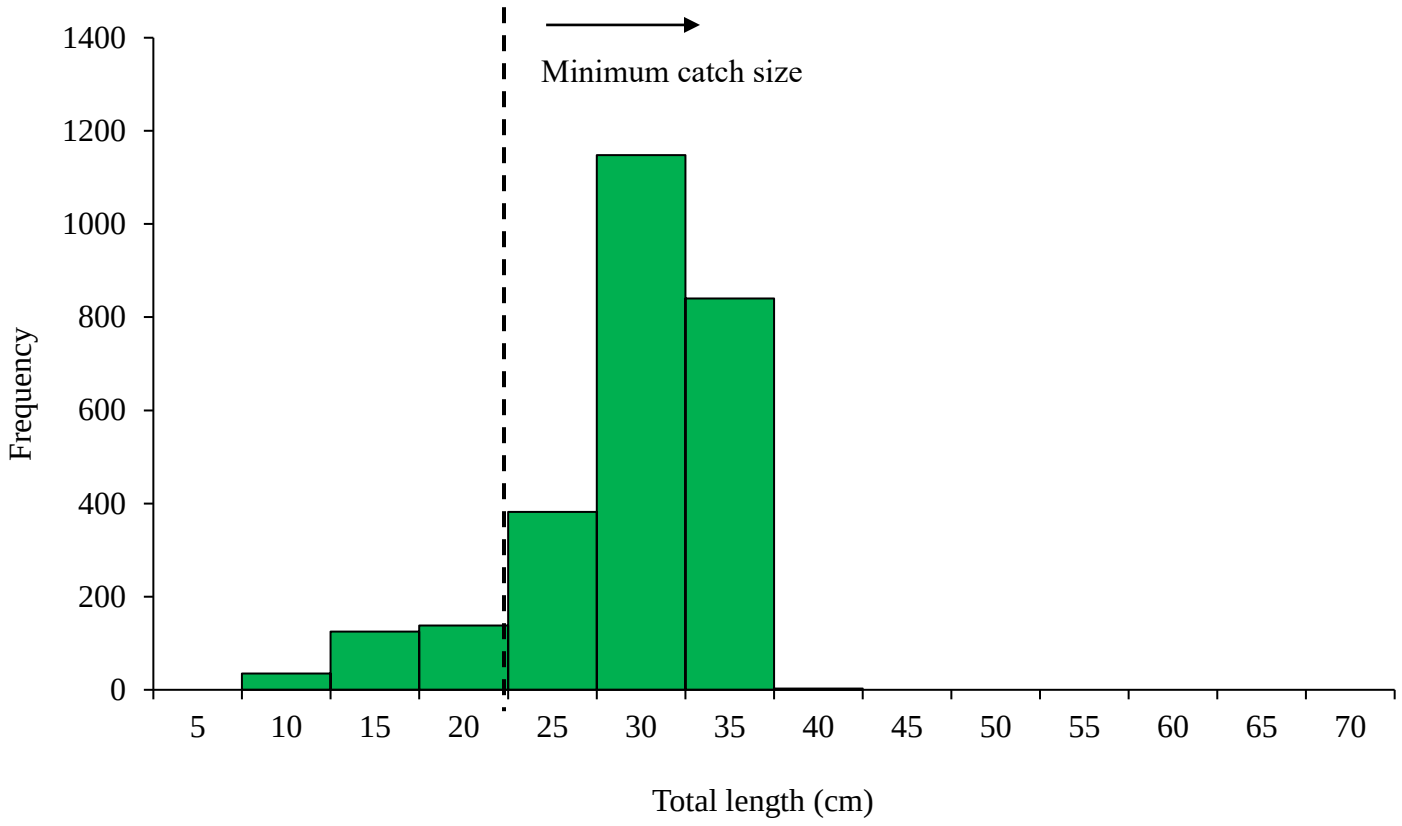


Figure 17a. Histogram of scup caught in fish traps, 2018. The dotted line indicates minimum catch size 9 inches by TL. This histogram showed a strong showing of age 7-8 individuals caught in traps. While the age structure of the represented stock may be highly truncated, investigators view the histogram as an indicative measure of missing recruits at age 0 due to the proper gear type or methods not being utilized in current survey design.



Appendix B

Table 1b. Species presence by site in June 2018 fish traps.

JUNE	Site				
Species	FT 1	FT 2	FT 3	FT 4	**Total out of 10**
American Lobster		1	1	1	**3**
Atlantic Rock Crab	1	1	1	1	**4**
Conger Eel		1	1	1	**3**
Grey Triggerfish	1	1			**2**
Jonah Crab	1	1	1	1	**4**
Scup	1	1	1	1	**4**
Spider Crab	1	1	1	1	**4**
Summer Flounder				1	**1**
Tautog	1	1		1	**3**
Winter Flounder		1		1	**2**

Table 2b. Species presence by site in June 2018 eel pots.

JUNE	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	**Total out of 9**
American Eel			1	1	1	1	1		1	1	1	1	**9**
American Lobster			1										**1**
Common Sea Star		1											**1**
Conger Eel	1												**1**
Cunner	1	1	1										**2**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Tautog			1						1				**2**
Winter Flounder		1											**1**

Table 3b. Species presence by site in July 2018 fish traps.

JULY	Site				
Species	FT 1	FT 2	FT 3	FT 4	**Total out of 11**
American Lobster	1	1			**2**
Atlantic Rock Crab	1		1		**2**
Black Sea Bass				1	**1**
Conger Eel	1	1		1	**3**
Grey Triggerfish	1	1			**2**
Lesser Amberjack				1	**1**
Jonah Crab			1	1	**2**
Scup	1	1	1	1	**4**
Spider Crab	1	1	1	1	**4**
Tautog		1		1	**2**
Winter Flounder				1	**1**

Table 4b. Species presence by site in July 2018 eel pots.

JULY	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	**Total out of 14**
American Eel			1	1	1	1	1		1	1	1	1	**9**
American Lobster									1				**1**
Black Sea Bass		1	1									1	**3**
Blue Crab				1			1						**2**
Common Sea Star			1										**1**
Conger Eel	1	1											**2**
Cunner	1	1	1			1							**4**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Oyster Toadfish			1							1			**2**
Sheepshead Minnow				1									**1**
Striped Killifish							1			1			**2**
Tautog	1	1	1						1				**4**
Winter Flounder		1											**1**

Table 5b. Species presence by site in August 2018 fish traps.

AUGUST	Site				
Species	FT 1	FT 2	FT 3	FT 4	**Total out of 9**
American Lobster	1	1			**2**
Atlantic Rock Crab	1			1	**2**
Black Sea Bass	1	1	1	1	**4**
Conger Eel		1		1	**2**
Grey Triggerfish	1				**1**
Jonah Crab		1			**1**
Scup	1	1	1	1	**4**
Spider Crab	1	1	1	1	**4**
Tautog	1	1		1	**3**

Table 6b. Species presence by site in August 2018 eel pots.

AUGUST	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	**Total out of 13**
American Eel			1	1	1	1	1		1	1	1	1	**9**
American Lobster	1								1				**2**
Brown Bullhead Catfish					1								**1**
Black Sea Bass	1	1	1									1	**4**
Blue Crab				1		1	1	1		1	1		**6**
Conger Eel	1												**1**
Cunner	1	1	1			1						1	**5**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Oyster Toadfish			1							1			**2**
Sheepshead Minnow				1									**1**
Striped Killifish							1						**1**
Tautog	1	1	1						1			1	**5**

Table 7b. Species presence by site in September 2018 fish traps.

SEPTEMBER	Site				
Species	FT 1	FT 2	FT 3	FT 4	Total out of 9
American Lobster		1			**1**
Atlantic Rock Crab		1		1	**2**
Black Sea Bass	1	1	1	1	**4**
Conger Eel		1		1	**2**
Jonah Crab		1	1		**2**
Scup	1	1	1	1	**4**
Spider Crab	1	1	1	1	**4**
Tautog		1		1	**2**
Winter Flounder				1	**1**

Table 8b. Species presence by site in September 2018 eel pots.

SEPTEMBER	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	Total out of 12
American Eel			1	1		1	1		1	1		1	**7**
Black Sea Bass	1	1	1									1	**4**
Blue Crab				1			1			1			**3**
Conger Eel	1	1											**2**
Cunner	1	1	1			1						1	**5**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Oyster Toadfish			1										**1**
Striped Killifish							1			1			**2**
Tautog	1	1	1										**3**
Winter Flounder										1			**1**
Yellowfin Grouper									1				**1**

Table 9b. Species presence by site in October 2018 fish traps.

OCTOBER	Site				
Species	FT 1	FT 2	FT 3	FT 4	**Total out of 7**
American Lobster		1			**1**
Black Sea Bass	1	1	1	1	**4**
Conger Eel		1		1	**2**
Jonah Crab				1	**1**
Scup	1	1	1		**3**
Spider Crab	1	1	1	1	**1**
Tautog		1			**1**

Table 10b. Species presence by site in October 2018 eel pots.

OCTOBER	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	**Total out of 10**
American Eel			1	1		1	1			1		1	**6**
Black Sea Bass	1	1	1									1	**4**
Blue Crab										1			**1**
Cunner	1	1	1			1						1	**5**
Foureye Butterflyfish	1												**1**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Snowy Grouper									1				**1**
Striped Killifish							1			1			**2**
Tautog	1	1	1						1				**4**

Table 11b. Species presence by site in November 2018 fish traps.

NOVEMBER	Site				
Species	FT 1	FT 2	FT 3	FT 4	Total out of 3
Black Sea Bass	1	1	1	1	**4**
Scup	1	1			**2**
Spider Crab	1	1	1	1	**4**

Table 12b. Species presence by site in November 2018 eel pots.

NOVEMBER	Site												
Species	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9	EP 10	EP 11	EP 12	Total out of 10
Black Sea Bass	1	1	1									1	**4**
Common Sea Star			1										**1**
Cunner	1	1	1			1							**4**
Doctorfish								1					**1**
Green Crab	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Mummichog				1		1	1			1			**4**
Snowy Grouper									1				**1**
Spotfin Butterflyfish									1				**1**
Striped Killifish									1				**1**
Tautog	1	1	1										**3**

Appendix C

Additional Species of Interest by Functional Group

Bait: Killifish (Rainwater, Striped, Mummichog, Sheepshead Minnow)

Pelagic (multi-habitat): Scup, Spot, Atlantic Croaker White Perch, Grey Triggerfish, Amberjacks (American, Greater, Lesser), Doctorfish, Butterflyfish (Foureye, Spotfin), Bluefish

Demersal: Tautog, Black Sea Bass, Oyster Toadfish, Cunner, Striped Sea Robin, American Eel (mostly demersal), Conger Eel, Summer Flounder, Winter Flounder, Smooth Dogfish, Hogchoker, Grouper (Snowy, Yellowfin), Catfish (Brown Bullhead)

Crustaceans (mobile invertebrates, shrimp): American Lobster, Jonah Crab, Blue Crab, Green Crab, Mud Crab, Lady Crab, Atlantic Rock Crab, Spider Crab, Mantis Shrimp, Common Shore Shrimp.

Mollusks: Moon Snail, Common Slipper Shell Snail

Echinoderms: Common Sea Star, Sea Urchin