New Jersey's Coastal Estuaries Inventory – Years 1-3
Closing the loop: connecting stakeholders, data, and managers for fisheries success



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Executive Summary

Elements frequently omitted from traditional fisheries surveys in an undergraduate setting include the collection of standardized, multi-seasonal data and meaningful stakeholder involvement. This project engaged Stockton University faculty and staff, students, as well as a local commercial fisher to collect year-round haul seine (10 sites, 2x month, May-Oct.; 1x month Nov.-Apr.) and seasonal fyke net (3x week, 1x month, Nov.–Apr.) data over a 3-year period (May 2016–Apr. 2019) in the Mullica River-Great Bay (MRGB) Estuary (NJ). In total, 485 haul seine (100' x 6' x ¼" mesh) samples inventoried 170,375 individual finfish (and select invertebrates) from 95 species. During the winter/spring, 212 fyke net (150' x 4' x 2.5" mesh leader; 25' x 4' x 2.5" wings; 25' x 2.5' x 2.5" mesh hoops) samples collected by a commercial partner inventoried 14,667 individuals from 39 species.

Numerically (both gear types), the dominant species were Atlantic menhaden (n=81,968), Atlantic silverside (n=41,234), bay anchovy (n=15,796), and white perch (n=14,641, target species of commercial partner). Young-of-the-year (YOY) tracking was possible for many species. For example, strength and timing of "split" (spring, summer) bluefish (n=1,252) cohorts was discernable from length frequency data. White perch was tracked from low salinity, shallow nursery grounds in summer (seine) to deeper bay environments in winter (fyke). With respect to ASMFC-managed species, striped bass (n=272) appeared in both gears with YOY-age 1 samples provided to colleagues for otolith microchemistry. Winter flounder (n=740) and summer flounder (n=1,244) exhibited complementary settlement patterns (inlet-bay, bay-river - respectively) and reliably appeared in both gear types (however, overall status was difficult to infer). Weakfish (n=3) was almost completely absent from both gear types. Of the managed herring species, alewife (n=426) dominated the winter/spring migration (fyke) and YOY summer recruitment (seine).

Surprisingly, seine collections did not reveal an abundance of southern and/or expatriated species (gag grouper, green goby, butterflyfishes). However, winter fyke catches were highlighted by species that typically migrate out of estuaries during the fall to the adjacent shelf (summer flounder) or warmer waters south (menhaden). The fyke net approach highlights the importance of pairing with experienced partners to sample during suboptimal, data-poor time periods.

Future applications of this dataset include "closing the loop" via linkages with additional life stages/gear types (i.e. Rutgers plankton net, otter trawl), temporal comparisons with historical data sets, cross-estuary spatial comparisons, and data sharing (e-DNA, otolith microchemistry).

Introduction / Problem Statement

Estuaries provide more than 30,000 km^2 of nursery habitat for over two-thirds of the economically important fish species along the East Coast of the United States (NOAA 1985, Able and Fahay 2010). A large percentage of these species are obligate users—they spawn in the ocean/lower estuary, enter estuaries as larvae, recruit as juveniles and (hopefully) survive to join the adult population. As a result, the composition, size, and abundance of estuarine juveniles function as important indicators of population status, especially if standardized, long-term data sets with broad coverage are available (Leggett and Frank 1997). The Mullica River Great Bay (MRGB) Estuary (NJ) is one such estuarine system in the Middle Atlantic Bight that provides a wide variety of Essential Fish Habitats (EFH) for estuarine-dependent species (USDOC 1996; Benaka 1999). Atlantic menhaden (*Brevoortia tyrannus*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), and blue crab (*Callinectes sapidus*) are notable commercially and recreationally important species that share critical links to New Jersey estuaries during early (and in most cases, adult) life.

One key element frequently omitted from traditional estuarine fish and invertebrate surveys in an academic setting is meaningful stakeholder involvement and direct, timely access to the data by fisheries professionals. This project explicitly engages Stockton University faculty and staff, undergraduate students, recent graduates, as well as local commercial fishers to collect seasonal seine and fyke net data from a variety of locations in the MRGB. Stockton University faculty and staff (Sullivan, Evert, and Stockton Marine Field Station technicians) have been collecting formal seine data on finfish and invertebrates since 2006 from a variety of locations in and around MRGB. This work extended into lower Barnegat Bay during the summer of 2012 for a Barnegat Bay Student Scholar project (Martin 2012 - 4,444 individuals collected over 33 species) and recently resulted in a Stockton academic distinction project synthesizing data from Graveling Point (Great Bay) spanning 8+ years and 100 seine hauls (Schkeeper 2015 - 19,131 individuals over 46 species). These datasets afforded students unparalleled, hands-on experience and training in the field, but did not always make the next leap to connecting the information to fishery managers. This project seeks to continue this tradition of hands-on research at Stockton University, but explicitly aims to make the data more standardized, multi-seasonal, and available to fisheries professionals in a timely fashion.

Project Design and Methods

Seine surveys

Seining is a versatile sampling technique that is frequently used to delineate Essential Fish Habitat (Hahn 2007). Examples of data that can be derived from seining include (but are not limited to): estimating total and relative abundance, calculating catch-per-unit-effort, collecting biological samples for further analysis, marking organisms for recapture, and sampling for species diversity/richness and other community-level variables. Seines can be used in a diversity of habitats effectively (rivers, estuaries, shallow coastal zone, beaches, etc.) and typically sample a large area in a short amount of time. Since the Fall of 2006, Stockton University's Marine Field Station has been accumulating formal fish and invertebrate data from standard seine collections in MRGB and portions of southern Barnegat Bay (Port Republic, Graveling Point, First Bridge-Tuckerton, Barrel Island, Southport Beach) as part of introductory Marine Science coursework ("Introduction to Marine Biology," "Introduction to Ichthyology"). Sullivan and Evert are well-versed in this dataset / collection technique over multiple shared courses together. Evert has conducted a variety of seining trips through Stockton since the late 1990s.

Seine collections from April – November were originally proposed across the MRGB salinity gradient (Little Egg Inlet to Lower Bank Bridge) along with synoptically collected environmental data using YSI's and longer-term buoy data loggers. As a result of a NJDEP/Stockton meeting on 10/13/15, the University proposed the following adjustment which formed the backbone of Year 1 sampling. This sampling scheme was continued for Year 2 & 3.

Seine Option: Add additional sampling months per NJDEP request at originally proposed 2x/month frequency (May-October) with only 1x/month in NJDEP added months (November – April).

- 6 months of the year at 2x/month
- 6 winter months 1x/month
- 180 samples/year and year-round component

Thus, ten seine sites were ultimately sampled in MRGB (**Fig. 1a, 2a**) using traditional haul seine methods every two weeks from May - October (once per month November – April) with a 100' x 6' x ¼" seine. Seine hauls were performed perpendicular to each beach / haul out location (**Fig. 1b,c**). For each seine haul, all organisms were sorted into bins of seawater (**Fig. 1c**) - identified, counted, and measured to fork, total length, or carapace width (for abundant species, only the first 50 individuals were measured and the remainder counted). Priority measurements were given to species with commercial and recreational value for return to the aquatic environment quickly. In addition, water temperature (**Fig. 2b**), salinity (**Fig. 2c**), dissolved oxygen, and pH were recorded with an YSI water quality instrument. The longer-term goal of the sampling design described above is to develop an easily transferrable project in part or whole for future years/estuaries.

Fyke surveys

New Jersey's commercial fyke net fishery runs from November 1 to April 30 – with the most common target species being winter flounder and, particularly in southern New Jersey rivers and tributaries, white perch. Although currently closed to all fishing, multiple herring species have been targeted in past years for the bait market. Fyke net sampling has a unique advantage over seine sampling - allowing cold weather sampling for adult and migratory species, while capturing size ranges (250 mm and up) that may avoid seine netting techniques and/or comprise schooling individuals easily missed by discrete sampling methods. Fyke nets have been used extensively in estuarine and river surveys for salmonid species and documented to provide valuable data on relative abundance as well as indices of stock abundance (O'Neal 2005). The PI's proposed the development of a long-term fyke net sampling program that could provide data to NJDEP that is rarely collected outside of ocean trawl samples (herring species in the spring, winter flounder, *Pseudopleuronectes americanus*, striped bass, *Morone saxatilis*). Almost all adult finfish entering areas of fyke net efforts would be encountered due to long soak times and bank-oriented sets.

Stockton has a strong history of working with the commercial fishing industry in the MRGB system. From 2012-2014, the University (Sullivan and Evert project co-PIs with Peter Straub) engaged four commercial crabbers through a NOAA Debris Removal Program funded project to locate and remove derelict crab pots from the system. This successful program broke down academic / scientist / commercial barriers - with additional funding approved through 2021. PI Evert has recently engaged the commercial shell fishing community, partnering with local oyster harvesters and farmers on a funded oyster restoration program through the Barnegat Bay Partnership. These partnerships demonstrate the University's interest in working with and supporting as appropriate all stakeholders. To this end, the PI's proposed funds within the budget to support a commercial fyke netter to assist with the setting and sampling of four rotating sites (**Fig. 1c, 4a**) using a fyke net with the following specifications (150' x 4' x 2.5" mesh leader; 25' x 4' x 2.5" wings; 25' x 2.5' x 2.5" mesh hoops to cod end).

As a result of the aforementioned 10/13/15 Stockton/NJDEP meeting it became apparent that the fyke net approach may have considerable benefits to the overall NJDEP project goals by providing a passive, low-mortality method of capturing estuarine and river fish over the reported gill net and seine size thresholds of ~250 mm standard individual length. The following adjustments to the fyke net section of Stockton's original proposal were as follows. This sampling scheme is being proposed for Year 2 & 3.

Fyke Option: Provides number of stations and standardized soak times at NJDEP request. Increases sample size and season but stays within regulatory season.

- Sampling frequency to be monthly during the regulatory fyke net season of November 1 – April 30.
- During each sampling month a week will be selected to work with icing and other considerations.
- Four sites will be established and used throughout the study period (2 bay and 2 river).
- Commercial netters will provide the set up and break down of nets each month. Stockton will tend the set nets every ~48 hours during each sampling week (3 events/month).
- Results in 12 days of commercial netter work.
- Requires equipment stipend to use commercial netters gear.

Sub-sampling and the collection of environmental parameters (**Fig. 4b**) follow procedures described above for the haul seine. Together, the seine and fyke components of this project have the potential to bring together local University scientists, fishery scientists, commercial fishers and undergraduate students to help better understand the population dynamics of a variety of commercially and recreationally important species.

Quality Assurance

A focal point of this project is collecting accurate as well as timely information. All sampling events deployed multiple faculty, technicians, and/or staff familiar with local species identification. Where necessary, unknowns or species that require microscopic identification techniques were brought back to the laboratory for keying out and/or preserved in ethanol. Environmental parameters were collected on-site and were additionally available from archived JCNERR monitoring buoys as back-ups. All handling of fishes conformed to protocols described by Jenkins et al. 2014 (American Fisheries Society – Guidelines for the Use of Fishes in Research). An official Quality Assurance Protocol (QAP) was submitted on 6/15/2016.

Results and Discussion

Elements frequently omitted from traditional fisheries surveys in an undergraduate setting include the collection of standardized, multi-seasonal data and meaningful stakeholder involvement. This project engaged Stockton University faculty and staff, students, as well as a local commercial fisher to collect year-round haul seine (10 sites, 2x month, May-Oct.; 1x month Nov.-Apr. **Fig. 1a,b, 2a**) and seasonal fyke net (3x week, 1x month, Nov.–Apr. **Fig. 1a, 4a**) data over a 3-year period (May 2016–Apr. 2019) in the Mullica River-Great Bay (MRGB) Estuary (NJ). In total, 485 haul seine (100’ x 6’ x ¼” mesh) samples inventoried 170,375 individual finfish (and select invertebrates) from 95 species. During the winter/spring, 212 fyke net (150’ x 4’ x 2.5” mesh leader; 25’ x 4’ x 2.5” wings; 25’ x 2.5’ x 2.5” mesh hoops) samples collected by a commercial partner inventoried 14,667 individuals from 39 species.

Numerically (both gear types), the dominant species were Atlantic menhaden, *Brevoortia tyrannus* (n=81,968), Atlantic silverside, *Menidia menidia* (n=41,234), bay anchovy, *Anchoa mitchilli* (n=15,796), and white perch, *Morone americana* (n=14,641, target species of commercial partner) (**Table 1**). Young-of-the-year (YOY) tracking was possible for many species. For example, strength and timing of “split” (spring, summer) bluefish, *Pomatomus saltatrix* (n=1,252) cohorts was discernable from length frequency data (**Fig. 3, Appendix B** poster). White perch, *Morone americana*, was tracked from low salinity, shallow nursery grounds in summer (seine, **Fig. 3, Appendix B** poster) to deeper bay environments in winter (fyke, **Fig. 5**). With respect to ASMFC-managed species, striped bass, *Morone saxatilis* (n=272) appeared in both gears (**Fig. 3,5, Appendix B** poster) with YOY-age 1 samples provided to colleagues for otolith microchemistry. Winter flounder, *Pseudopleuronectes americanus* (n=740) and summer flounder, *Paralichthys dentatus* (n=1,244) exhibited complementary settlement patterns (inlet-bay, bay-river - respectively) and reliably appeared in both gear types (however, overall status was difficult to infer) (**Fig. 3,5, Appendix B** multiple posters). Weakfish, *Cynoscion regalis* (n=3) was almost completely absent from both gear types (**Table 1**). Of the managed herring species, alewife, *Alosa pseudoharengus* (n=426) dominated the winter/spring migration (fyke, **Fig. 5**) and YOY summer recruitment (seine, **Fig. 3**).

Surprisingly, seine collections did not reveal an abundance of southern and/or expatriated species (i.e. gag grouper, *Mycteroperca microlepis*, green goby, *Microgobius thalassinus*, butterflyfishes, *Chaetodon* sp. **Table 1**). However, winter fyke catches were highlighted by species that typically migrate out of estuaries during the fall to the adjacent shelf (summer flounder, *Paralichthys dentatus* **Fig. 5**) or warmer waters south (Atlantic menhaden, *Brevoortia tyrannus* **Fig. 5**). The fyke net approach highlights the importance of pairing with experienced partners to sample during suboptimal, data-poor time periods.

Along these lines, sampling during winter months presented several challenges. Sampling was not attempted during bay-wide freezing events and/or during periods of intense wind or extended cold weather. Seasonal harbor seal haul outs in the vicinity of the Fish Island site resulted in reduced collections during certain winter/spring periods. Nevertheless, the number of samples collected mirrored the original goals of the project and provided a valuable window into dynamics occurring during the winter months.

A few caveats are important to consider with respect to the haul seine. Given the high volume of individuals collected (particularly with respect to Atlantic silversides, *Menidia menidia*, and mummichogs, *Fundulus heteroclitus*, n=48,577 total, **Table 1**), there is the possibility that rare, cryptic species were overlooked (i.e. rough silverside, *Membras martinica*, spotfin killifish, *Fundulus luciae*). Similarly, inland silversides, *Menidia beryllina*, and Atlantic silversides, *Menidia menidia*, were differentiated (preserved in 95% ETOH, frozen, ID'd in field) at the following mid-to-low salinity sites only due to the high volume of overall silverside catch: The Cuts, Parkway Bridge, Port Republic, Hog Island (**Fig. 3**). Finally, uncategorized individuals remain for subsets of the following groups: herrings (*Alosa* sp.), killifishes (*Fundulus* sp.), silversides (*Menidia* sp.), sunfishes (*Lepomis* sp.), mullets (*Mugil* sp.) (small, damaged, and/or otherwise problematic IDs). A final consideration, the seine only sampled beaches or low-lying marsh sites with suitable gear haul-out locations. Oyster beds and other heavily structured environments (peat reefs, jetties) were not sampled. This may help explain low numbers of species typically associated with reefs (spotfin butterflyfish, *Chaetodon ocellatus*, scup, *Stenotomus chrysops*, seaboard goby, *Gobiosoma ginsburgi*). In late summer 2018, a waterway closure due to high bacteria levels prevented sampling of the Port Republic site.

The usefulness of this dataset lies in its application. By itself, the data represents a three-year snapshot of finfishes and select invertebrates from a single estuary in southern New Jersey. Thus, it is difficult to draw conclusions about the overall conservation status of a given species (aside from obvious candidates such as weakfish, *Cynoscion regalis*). This work paralleled concomitant sampling by Rutgers University (plankton net, otter trawl, gill net). Thus, a unique opportunity exists to close the life history loop in the MRGB for select estuarine-dependent species via linkages with additional life stages/gear types. Temporal comparisons with historical data sets also offer the opportunity to investigate changes in assemblages over time (via New Jersey Department of Environmental Protection and Ichthyological Associates data from the 1970s). The Barnegat Bay Partnership collects bi-weekly seine data during portions of the year that could provide an interesting cross-estuary spatial comparison over similar time periods. Finally, numerous preserved specimens (initially used for ID confirmation / training) have been kept for future eDNA work, otolith microchemistry, and student training. As an additional layer to archival data mining projects and various modeling approaches, this project reflects the multiple benefits that can be realized from "natural history"-oriented projects that involve intensively sampling a single system.

Conclusions and Recommendations for Future Research

The original project objectives are re-included below, with comments on overall success.

- *Objective 1 – Foster engaged local stakeholders and colleagues through data collection, training, collaboration, and data transfer.* Collaboration with commercial fyke net partner Newt Sterling was particularly rewarding. Maintaining multiple, active fyke net sites during the winter months would have been difficult-to-impossible for Stockton staff (given highly variable weather conditions, teaching obligations, and other research commitments). Sterling constructed, tended/sampled, and repaired where necessary all fyke nets used in the project. On several occasions, Sterling was able to provide insightful ID advice for similar-looking species as well as a historical perspective on fluctuations in various local winter fisheries. Successful outreach opportunities (**Appendix B**) were incorporated through the Stockton Marine Field Station – including programs for high school students (Stockton Science Enrichment Academy – D. Furgione / Forsythe Environmental Education Intern Program – R. McClain) and Course Based Undergraduate Research Experiences (five Stockton courses – M. Sullivan - and Rowan College at Gloucester County Wetlands Field Ecology – J. DeGraff). In addition, samples were collected (**Appendix B**) for Rutgers University colleagues investigating striped bass migratory patterns (P. Lopez-Duarte) and alewife reproductive timing (K. Able, T. Grothues). Samples for eDNA analysis were shared with The Rockefeller University (M. Stoeckle).

● *Objective 2 – Collect accurate and comprehensive scientific data that is relevant to multiple life stages of commercial and recreational species managed by NJDEP / ASMFC.* This project collected data relevant to a variety of commercially and recreationally important regional species (see list of ASMFC managed species covered in **Table 1**). Of note was robust abundance and length frequency data in both seine and fyke net samples for Atlantic menhaden, alewife, striped bass, spot, summer flounder, and winter flounder.

● *Objective 3 – Produce timely reports that can be used immediately by fishery scientists in stock assessment model development.* Given the volume of data collected during this project, it was occasionally a challenge keeping pace with sampling, data entry, and the work-up of unknowns. Nevertheless, data is already being shared with local colleagues. In most cases, voucher specimens preserved in ethanol (see **Table 1**) are available for other researchers interested in fish early life history stages, eDNA work, and/or problematic IDs.

● *Objective 4 - Develop protocols that are transferable to other systems/estuaries in NJ.* The seine and fyke net components of this project are designed to be transferable to other systems or for continued use in the current system. A word of note, both gears collect high numbers of individuals. Projects should adequately account for the time involved in the field for sorting and in the lab for data entry / quality control.

Recommendations and Application and use by NJDEP

Since 1942, the Atlantic States Marine Fisheries Commission (ASMFC), in conjunction with federal partners such as NOAA (National Oceanic and Atmospheric Administration) and USFWS (United States Fish and Wildlife Service), has helped coordinate the interstate management of over 25 coastal / estuarine fish and invertebrate species. The State of New Jersey has benefited tremendously from this shared governance strategy. For example, the Atlantic Striped Bass Conservation Act (1984) represents one of the great early success stories of cooperative fisheries management in the Mid-Atlantic region. In this same spirit, the Atlantic States Marine Fisheries Commission 2014-2018 Strategic Plan (http://www.asmfc.org/fisheries-science/program-overview) is built around “ensuring that sound science is available to serve as the foundation for the Commission’s evaluation of stock status and adaptive management actions.”

The following strategies were recently identified by ASMFC to help reach this goal on a state and coast-wide level. Relevance of the current project to each goal is provided in italics.

● *Conduct stock assessments based on comprehensive data sources and rigorous technical analysis.* ~10 seining and 4 rotating fyke net sites (built around comprehensive historical sampling in the MRGB) were sampled.

● *Pro-actively address research priorities through cooperative state and regional data collection programs and collaborative research projects.* See below for collaborative component.

● *Facilitate stakeholder involvement in research initiatives and the stock assessment process.* The project engaged Stockton University faculty and staff, undergraduate students, recent graduates, local commercial fishers, and NJDEP scientists to “close the loop” between data collection in an academic setting and incorporation of results into fishery models.

● *Promote data collection and research to support ecosystem-based management.* Ecosystem-Based Fishery Management (Pikitch et al. 2004) explicitly acknowledges the connection between organisms and their physical environments, yet also recognizes that the livelihoods of commercial fishers are part of this balance as well. By bringing local fishers directly into the data collection process, fishery management decisions become less of a “black box” to individuals in industry.

● *Provide stock assessment training to improve the expertise and involvement of state and staff scientists.* The project trained undergraduate students and technicians in field / data inventory techniques frequently used by NJDEP Fish & Wildlife. Numerous Stockton University graduates have gone on to work for NJDEP in various capacities (**Appendix B**). Graduates that have hands-on field skills, as well as familiarity with data entry, statistical techniques, and GIS move more seamlessly into these positions.

Rutgers University bridgenetting

Stockton University seining

NJDEP ocean trawl

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Appendix A – Tables and Figures

Figure 1a

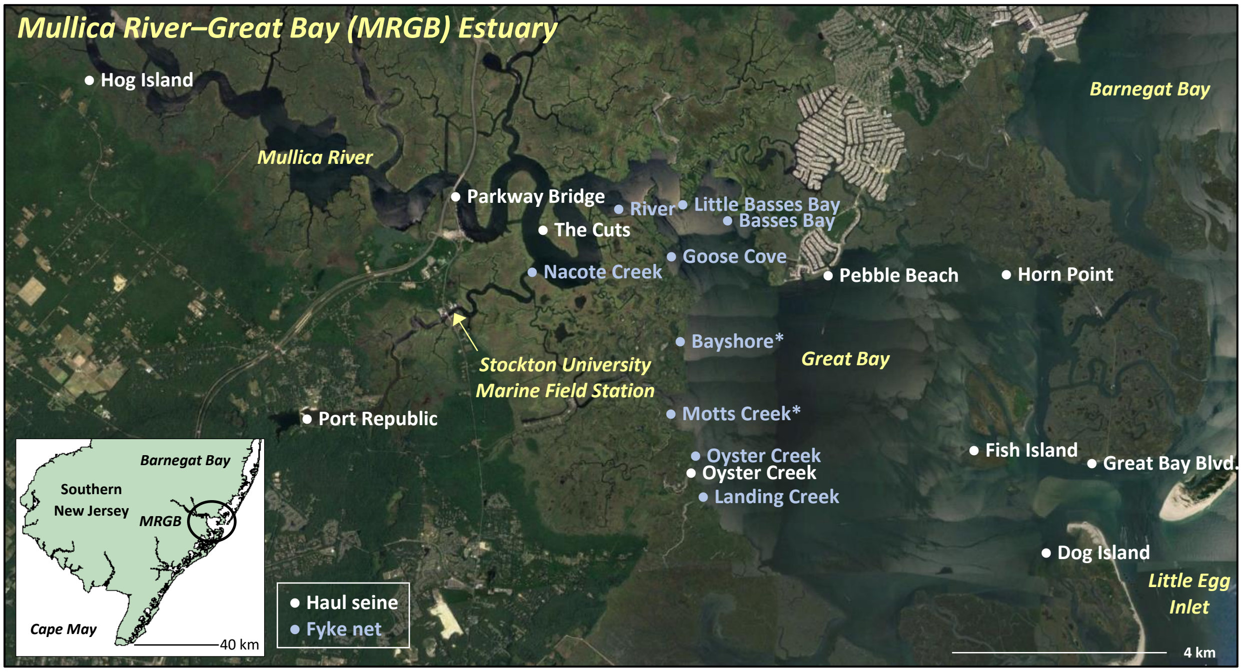


Figure 1b

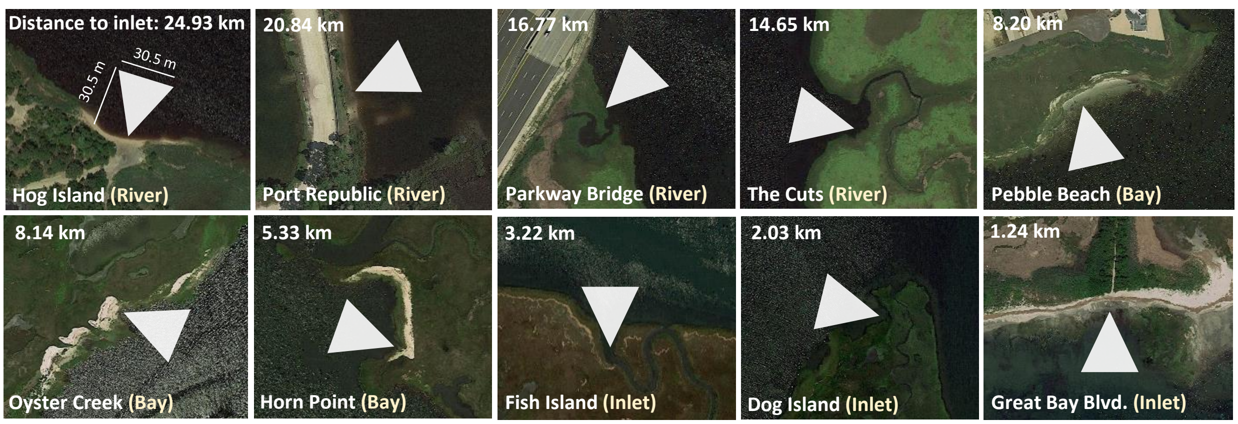


Figure 1c

Figure 1 – (a) Haul seine and fyke net sites within the Mullica River-Great Bay (MRGB) Estuary, NJ. Note: Motts Creek & Bayshore labels represent multiple fyke net sets depending on sampling time period. (b) Detail of seining sites depicting location and area sampled. (c) Field photos of seine and fyke net operations (drone image courtesy of TJ Johnson).

Table 1 – Combined species list from haul seine and fyke net collections in the MRGB. See individual species accounts for size criteria used (total length, fork length, disc width, carapace width). ASMFC = species managed through the Atlantic States Marine Fisheries Commission. Preserved = species with select individuals in 95% ethanol or frozen. Totals do not include subsets of unidentified specimens.

				Size (mm)			Gear			
Family	**Genus species**	**Common name**	**Count**	**Ave**	**Min**	**Max**	**Seine**	**Fyke**	**ASMFC**	**Preserved**
Odontaspididae	*Carcharias taurus*	sand tiger shark	1	1030	1030	1030	X		X	
Carcharhinidae	*Carcharhinus plumbeus*	sandbar shark	1	625	625	625	X		X	
	Mustelus canis	smooth dogfish	1	478	478	478	X		X	
Rajidae	*Leucoraja eglanteria*	clearnose skate	7	441	400	480	X	X		
	Leucoraja erinacea	little skate	1	270	270	270	X			
	Leucoraja ocellata	winter skate	1	300	300	300		X		
Dasyatidae	*Dasyatis americana*	southern stingray	2	531	500	600	X			
	Dasyatis centroura	roughtail stingray	1	790	790	790	X			
	Dasyatis say	bluntnose stingray	1	430	430	430	X			
Myliobatidae	*Rhinoptera bonasus*	cownose ray	20	835	640	1000	X			
Anguillidae	*Anguilla rostrata*	American eel	105	266	50	650	X	X	X	
Clupeidae	*Alosa aestivalis*	Blueback herring	11	173	54	310	X	X	X	X
	Alosa mediocris	Hickory shad	3	332	276	374	X			
	Alosa pseudoharengus	Alewife	426	166	42	290	X	X	X	X
	Alosa sapidissima	American shad	2	474	450	498		X	X	
	Brevoortia tyrannus	Atlantic menhaden	81968	98	0	390	X	X	X	X
	Clupea harengus	Atlantic herring	226	183	31	300	X	X	X	X
	Dorosoma cepedianum	gizzard shad	32	261	82	510	X	X		
Engraulidae	*Anchoa hepsetus*	striped anchovy	390	62	31	110	X			X
	Anchoa mitchilli	bay anchovy	15796	55	13	98	X			X
Esocidae	*Esox americanus*	redfin pickerel	1	79	79	79	X			
	Esox niger	chain pickerel	4	217	164	320	X			
Cyprinidae	*Notemigonus crysoleucas*	golden shiner	13	142	84	186	X			X
Ictaluridae	*Ameiurus catus*	white catfish	74	297	196	475	X	X		
	Ameiurus natalis	yellow bullhead	1	211	211	211	X			
	Ameiurus nebulosus	brown bullhead	3	184	38	327	X			
	Ictalurus punctatus	channel catfish	3	287	180	431	X	X		
Phycidae	*Urophycis regia*	spotted hake	28	139	55	345	X	X		X
Gadidae	*Pollachius virens*	pollock	22	48	36	73	X			X
Batrachoididae	*Opsanus tau*	oyster toadfish	83	71	19	250	X	X		X
Hemiramphidae	*Hyporhamphus meeki*	American halfbeak	5	181	126	219	X			
Belonidae	*Strongylura marina*	Atlantic needlefish	209	263	62	436	X			
Cyprinodontidae	*Cyprinodon variegatus*	sheepshead minnow	435	35	21	60	X			
	Fundulus diaphanus	banded killifish	716	65	20	110	X			X
	Fundulus heteroclitus	mummichog	7343	53	13	156	X	X		X
	Fundulus majalis	striped killifish	706	79	13	150	X			X
	Lucania parva	rainwater killifish	57	28	15	42	X			X
Atherinidae	*Menidia beryllina*	inland silverside	199	53	25	80	X			X
	Menidia menidia	Atlantic silverside	41234	70	11	152	X			X
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback	15	56	13	68	X			X
	Apeltes quadracus	fourspine stickleback	39	43	24	65	X	X		X
Syngnathidae	*Hippocampus erectus*	lined seahorse	12	96	63	125	X			
	Syngnathus fuscus	northern pipefish	309	134	49	244	X	X		
Triglidae	*Prionotus carolinus*	northern searobin	6	79	35	142	X			X
	Prionotus evolans	striped searobin	26	364	49	452	X	X		X
Moronidae	*Morone americana*	white perch	14641	190	12	392	X	X		X
	Morone saxatilis	striped bass	272	337	91	790	X	X	X	X
Serranidae	*Centropristis striata*	black sea bass	28	93	47	196	X	X	X	
Centrarchidae	*Enneacanthus obsesus*	banded sunfish	1	45	45	45	X			X
	Lepomis gibbosus	pumpkinseed	186	76	30	167	X			X
	Lepomis macrochirus	bluegill	56	48	22	135	X			X
	Micropterus salmoides	largemouth bass	5	284	79	414	X	X		
Percidae	*Etheostoma olmstedi*	tessellated darter	4	68	59	75	X			X
	Perca flavescens	yellow perch	1	72	72	72	X			
Pomatomidae	*Pomatomus saltatrix*	bluefish	1252	122	29	757	X	X	X	X
Rachycentridae	*Rachycentron canadum*	cobia	4	98	57	152	X		X	
Echeneidae	*Echeneis naucrates*	sharksucker	1	156	156	156	X			

Table 1 (continued)

Family	Genus species	Common name	Count	Size (mm)			Gear		ASMFC	Preserved
				Ave	Min	Max	Seine	Fyke		
Carangidae	*Carangoides bartholomaei*	yellow jack	1	137	137	137	X			X
	Caranx hippos	crevalle jack	18	59	31	121	X			X
	Selene vomer	lookdown	1	72	72	72	X			
	Trachinotus falcatus	permit	111	67	21	110	X			X
	Trachurus lathami	rough scad	1	49	49	49	X			X
Lutjanidae	*Lutjanus griseus*	gray snapper	3	62	32	111	X			
Gerreidae	*Eucinostomus* sp.	mojarras	30	54	30	86	X			X
Sparidae	*Archosargus probatocephalus*	sheepshead	3	79	26	108	X	X		X
	Lagodon rhomboides	pinfish	77	84	15	192	X	X		X
Sciaenidae	*Bairdiella chrysoura*	silver perch	7882	73	14	185	X			X
	Cynoscion regalis	weakfish	3	287	80	451	X	X	X	
	Leiostomus xanthurus	spot	475	74	15	184	X	X	X	X
	Menticirrhus saxatilis	northern kingfish	115	95	21	416	X	X		X
	Micropogonias undulatus	Atlantic croaker	23	60	30	172	X		X	X
	Pogonias cromis	black drum	82	146	76	260	X	X	X	
	Sciaenops ocellatus	red drum	2	61	58	64	X		X	X
Mullidae	*Upeneus* sp.	goatfish	1	54	54	54	X			
Chaetodontidae	*Chaetodon ocellatus*	spotfin butterflyfish	1	12	12	12	X			
Mugilidae	*Mugil cephalus*	striped mullet	116	117	28	246	X	X		X
	Mugil curema	white mullet	138	102	30	219	X			X
Labridae	*Tautoga onitis*	tautog	104	91	17	215	X	X	X	X
Blenniidae	*Hypsoblennius hentzi*	feather blenny	2	63	52	74	X			
Gobiidae	*Gobiesox strumosus*	skilletfish	11	35	28	71	X			X
	Gobiosoma bosc	naked goby	124	31	16	53	X			X
	Gobiosoma ginsburgi	seaboard goby	1	42	42	42	X			X
Sphyraenidae	*Sphyraena borealis*	northern sennet	18	117	58	185	X			
Stromateidae	*Peprilus triacanthus*	butterfish	2	117	39	195	X	X		
Paralichthyidae	*Etropus microstomus*	smallmouth flounder	14	75	51	96	X			X
	Paralichthys dentatus	summer flounder	1244	225	15	580	X	X	X	X
Scophthalmidae	*Scophthalmus aquosus*	windowpane flounder	23	225	56	313	X	X		
Pleuronectidae	*Pseudopleuronectes americanus*	winter flounder	740	99	22	443	X	X	X	X
Achiridae	*Trinectes maculatus*	hogchoker	708	69	25	295	X	X		X
Ostraciidae	*Lactophrys* sp.	trunkfish	1	12	12	12	X			X
Diodontidae	*Chilomycterus schoepfi*	striped burrfish	41	101	14	286	X			
Tetraodontidae	*Sphoeroides maculatus*	northern puffer	104	164	30	295	X	X		
Limulidae	*Limulus polyphemus*	Atlantic horseshoe crab	114	228	120	310	X	X	X	
Cancridae	*Cancer* sp.	rock / jonah crab	65	100	67	163	X	X	X	
Portunidae	*Callinectes sapidus*	blue crab	5258	54	5	251	X	X		
	Ovalipes ocellatus	lady crab	137	34	10	70	X			
	Carcinus maenas	green crab	19	47	27	68	X			

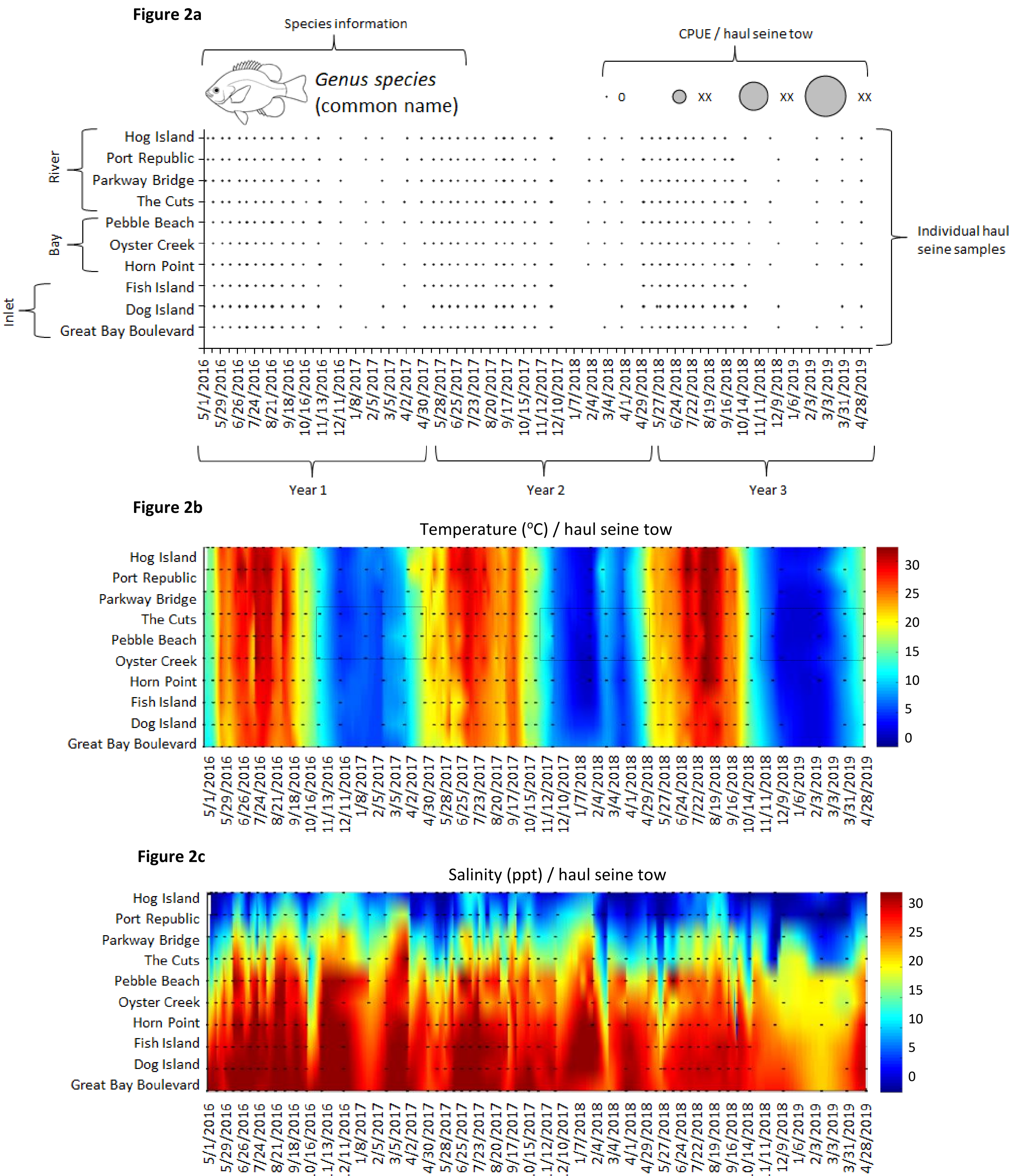
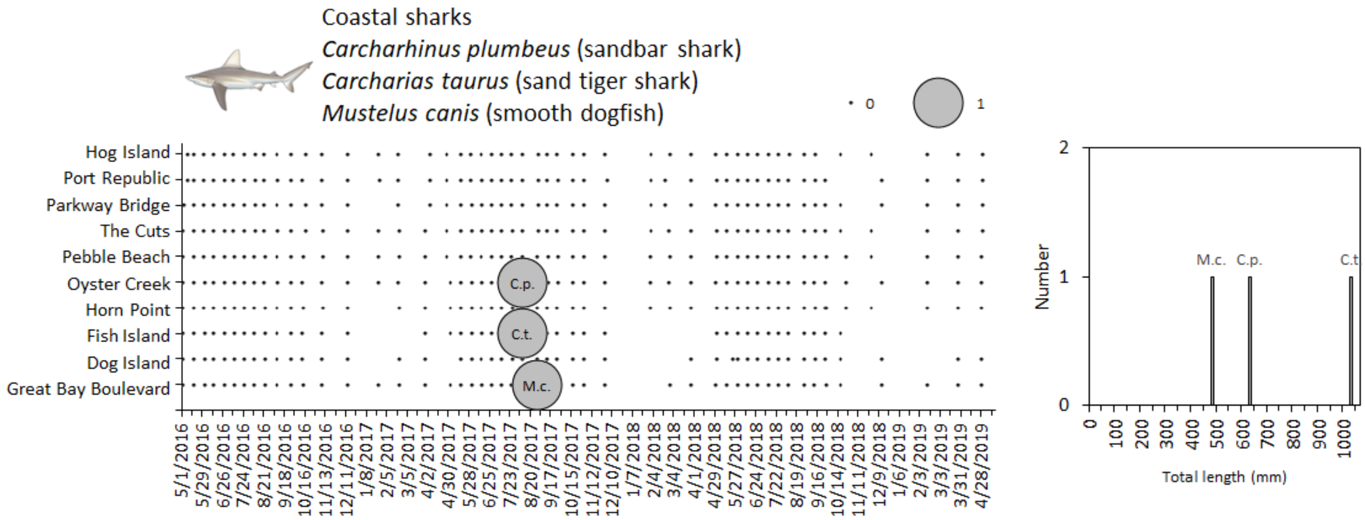
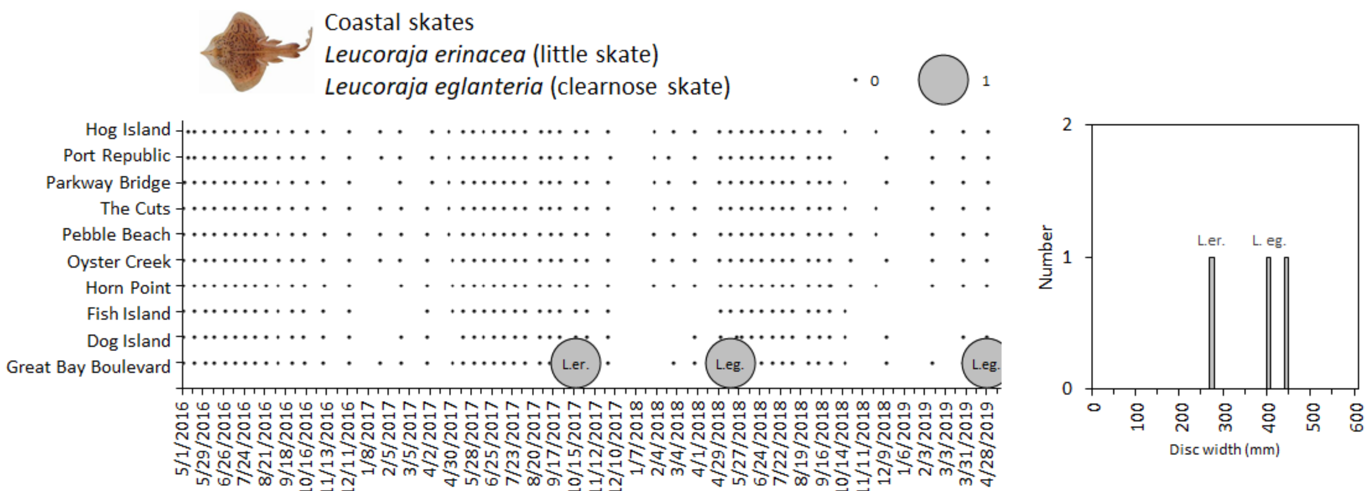
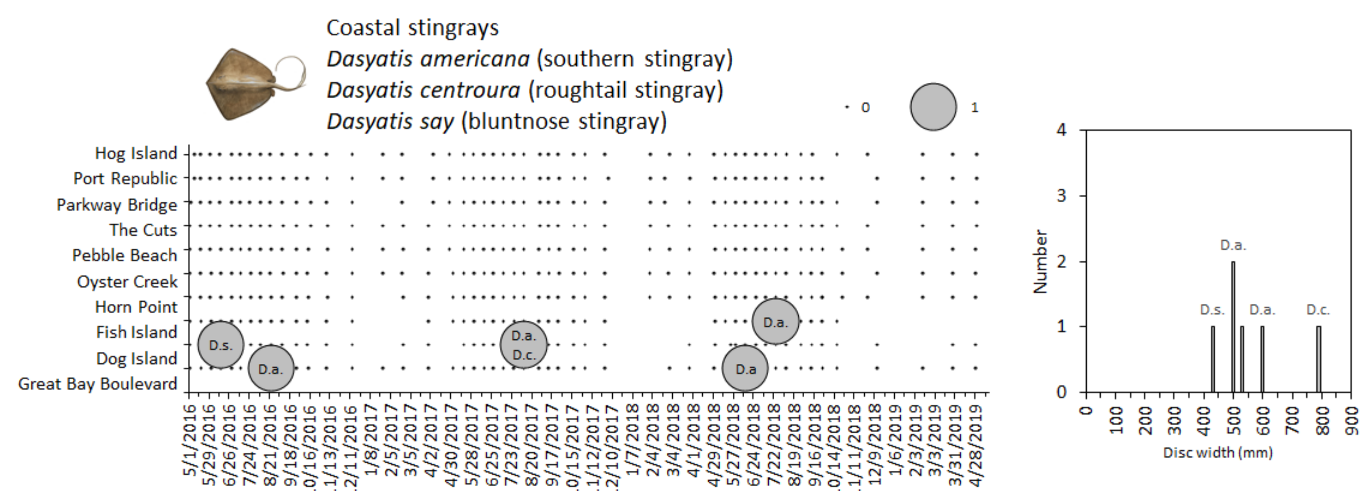


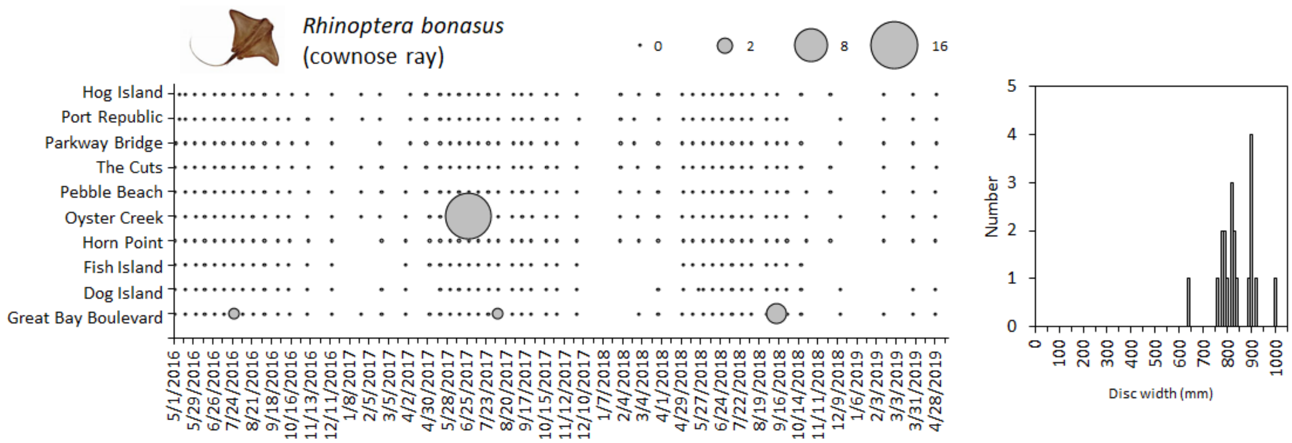
Figure 2 – (a) Schematic of general haul seine plot used throughout Figure 3. (b) Temperature and (c) salinity contour plots derived from water quality data collected at each site. Rectangles in (b) represent data used in Figure 4b.

Figure 3 (61 species plots derived from haul seine, "*" = genera with unconfirmed IDs remaining)

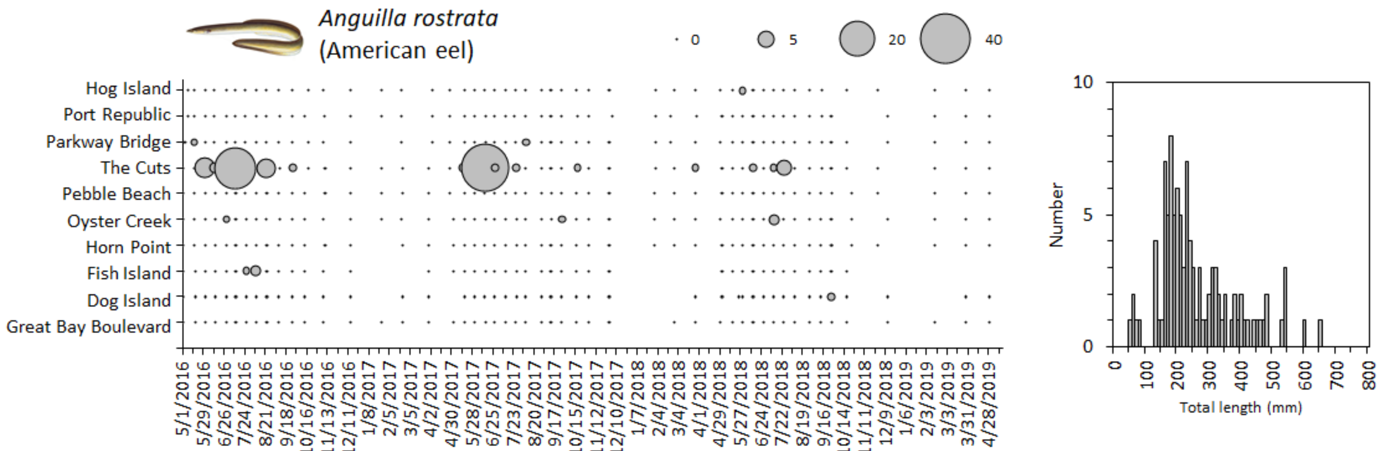


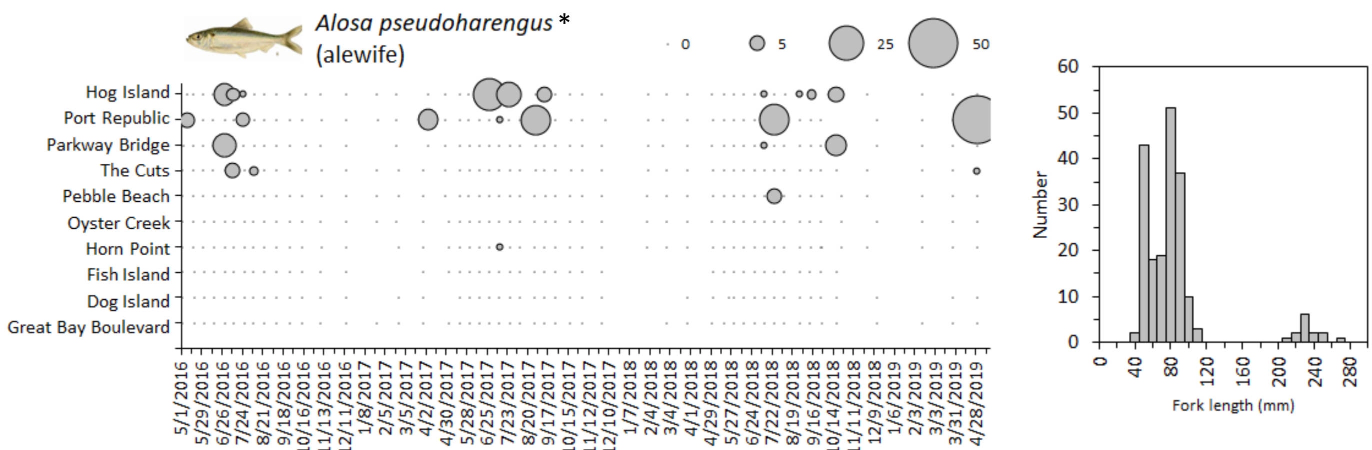


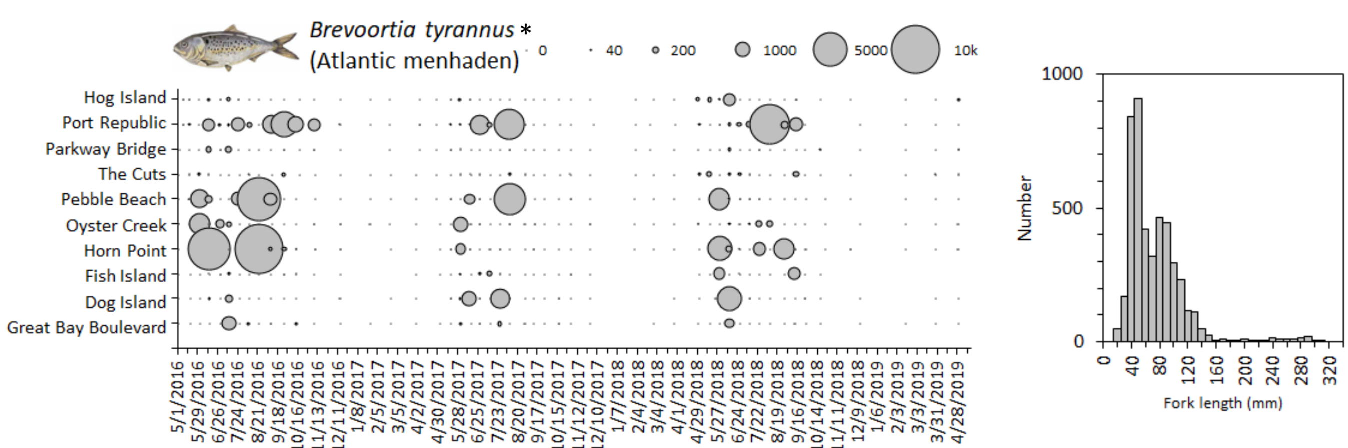


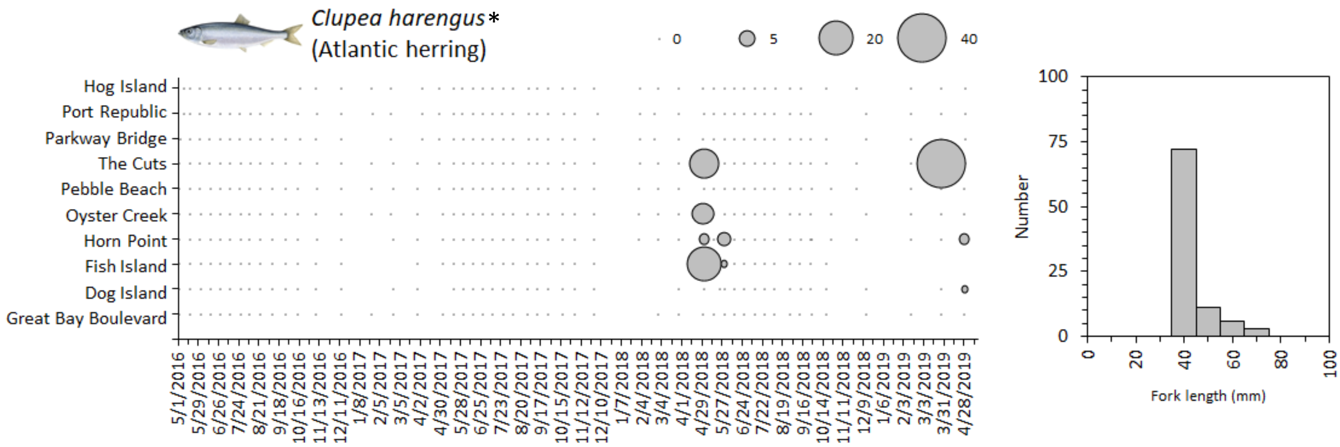


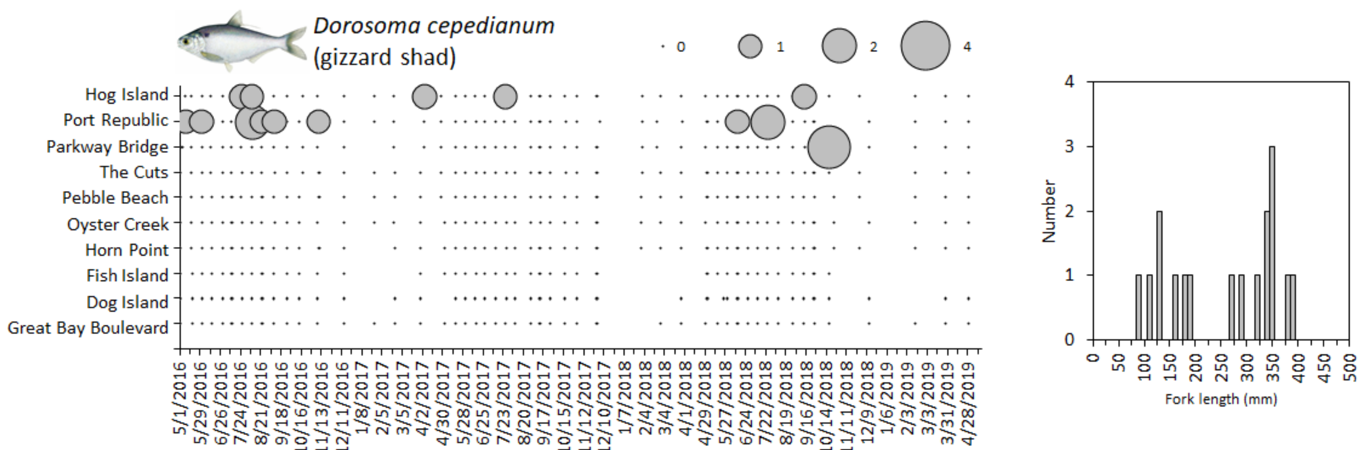
Rhinoptera bonasus
(cownose ray)
0
2
8
16
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Disc width (mm)

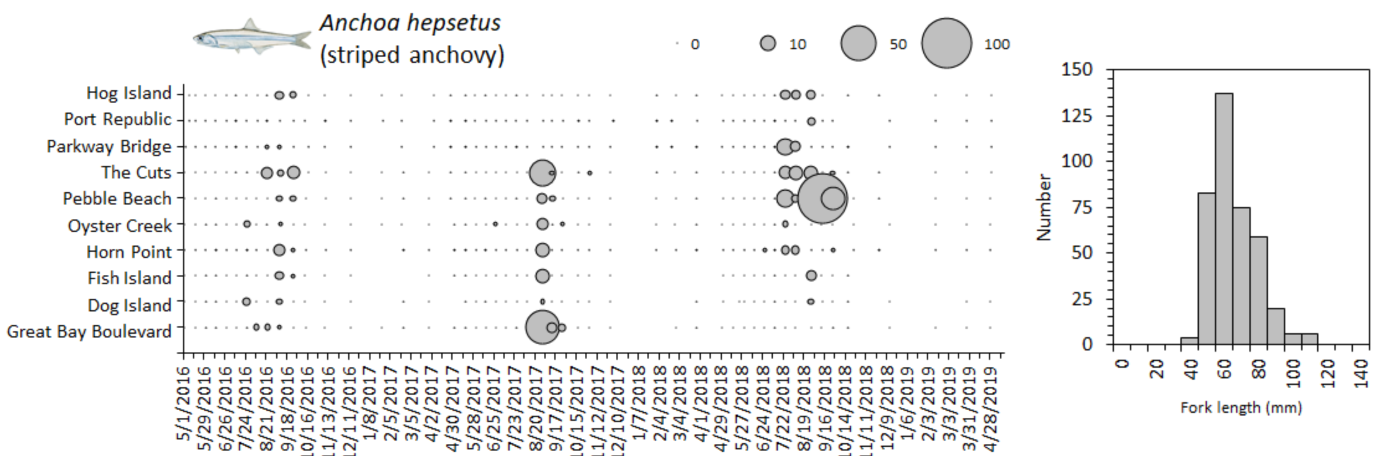

Anguilla rostrata
(American eel)
0 5 20 40
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10
0 100 200 300 400 500 600 700 800
Total length (mm)

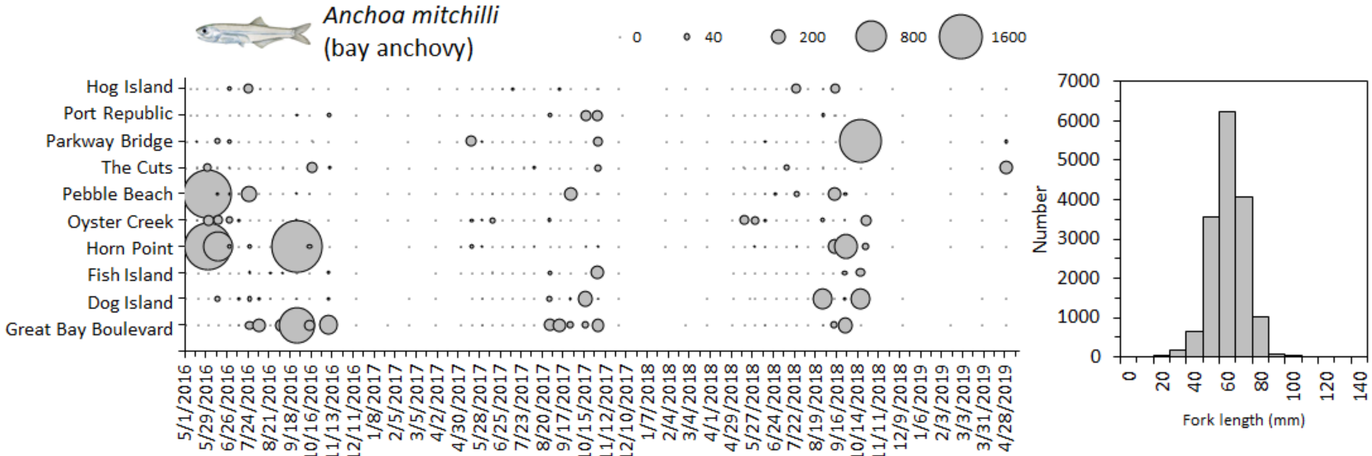

Alosa pseudoharengus *
(alewife)
0 5 25 50
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 10 20 30 40 50 60
0 40 80 120 160 200 240 280
Fork length (mm)

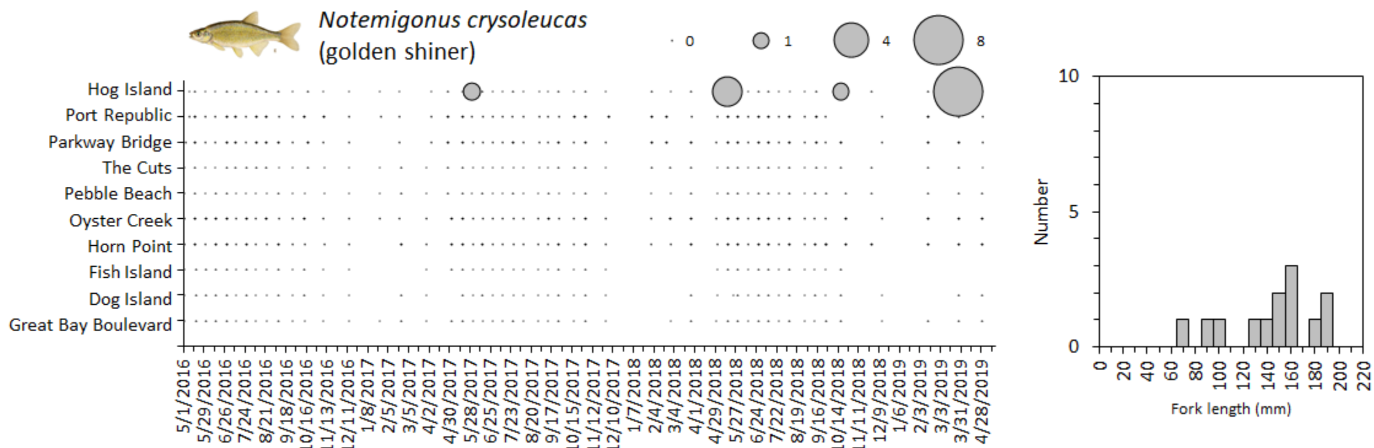

Brevoortia tyrannus *
(Atlantic menhaden)
0 40 200 1000 5000 10k
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 500 1000
0 40 80 120 160 200 240 280 320
Fork length (mm)

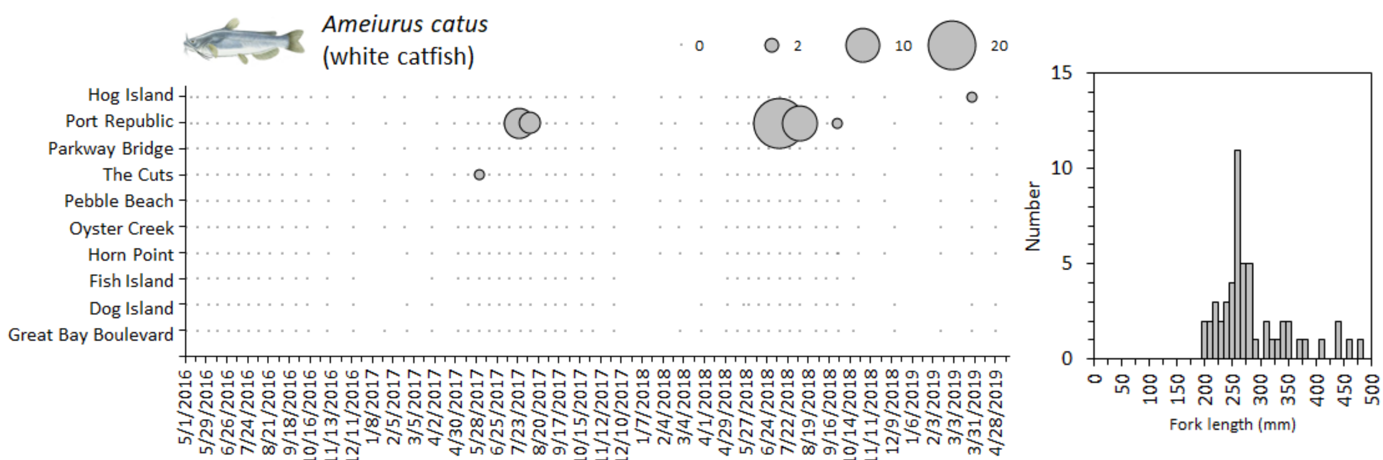

*Clupea harengus**
(Atlantic herring)
0
5
20
40
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Fork length (mm)
100
75
50
25
0
0
20
40
60
80
100

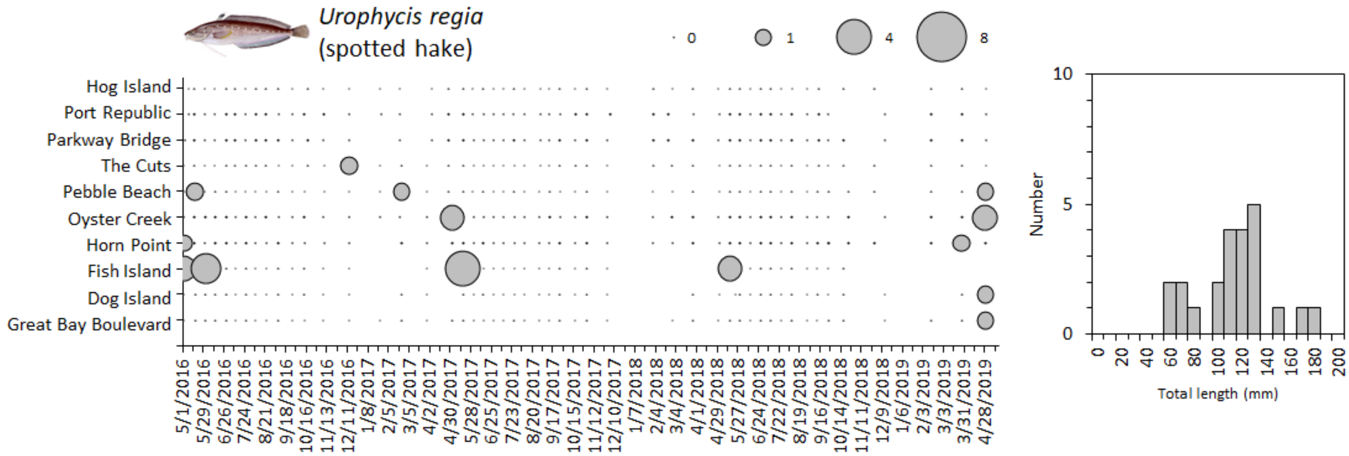

Dorosoma cepedianum
(gizzard shad)
0
1
2
4
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Fork length (mm)
4
3
2
1
0
0
50
100
150
200
250
300
350
400
450
500

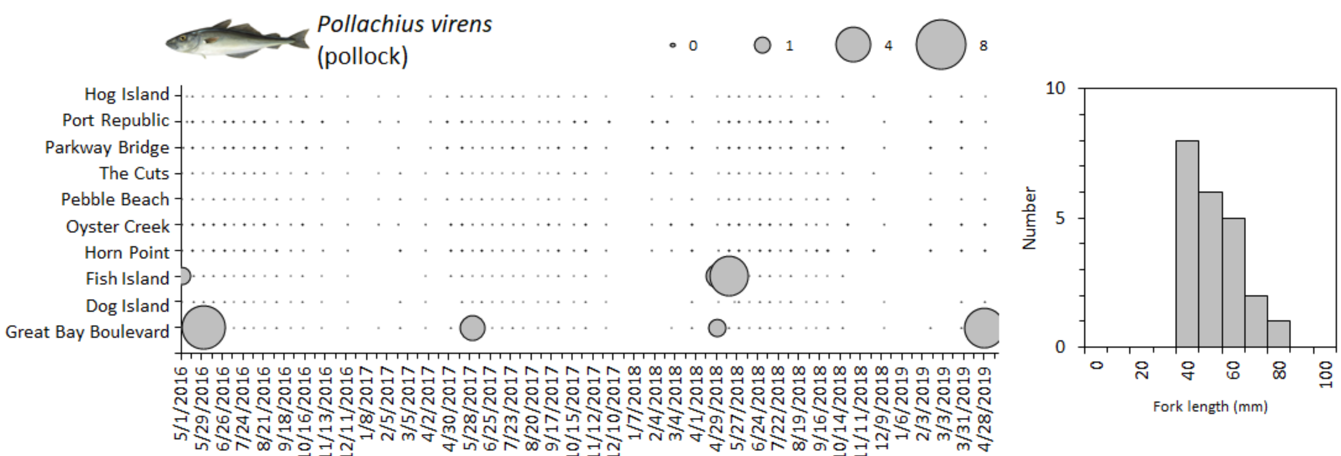

Anchoa hepsetus
(striped anchovy)
0
10
50
100
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Fork length (mm)
150
125
100
75
50
25
0
0
20
40
60
80
100
120
140

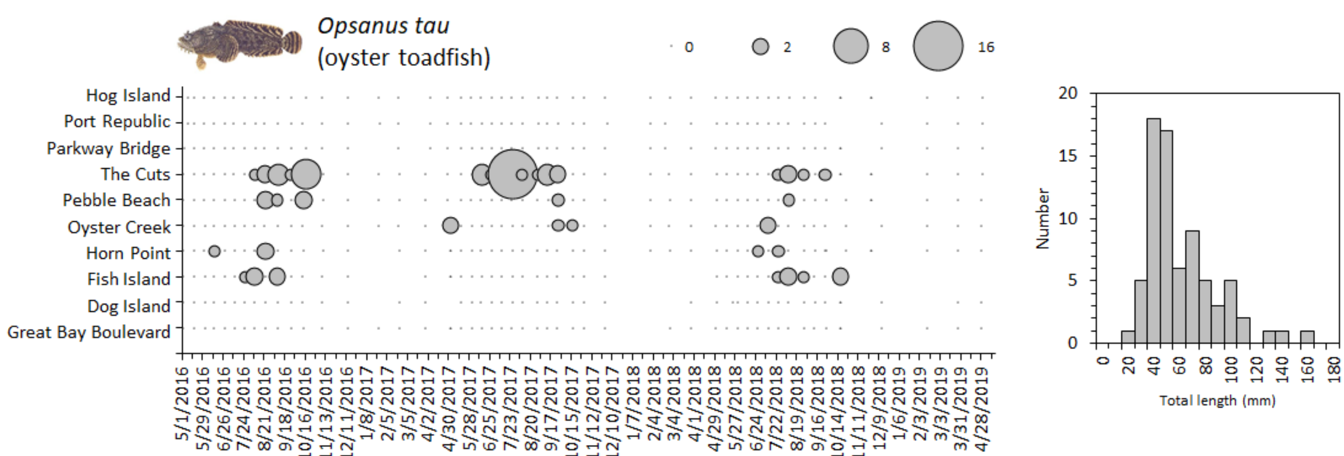

Anchoa mitchilli
(bay anchovy)
0 40 200 800 1600
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 1000 2000 3000 4000 5000 6000 7000
0 20 40 60 80 100 120 140
Fork length (mm)

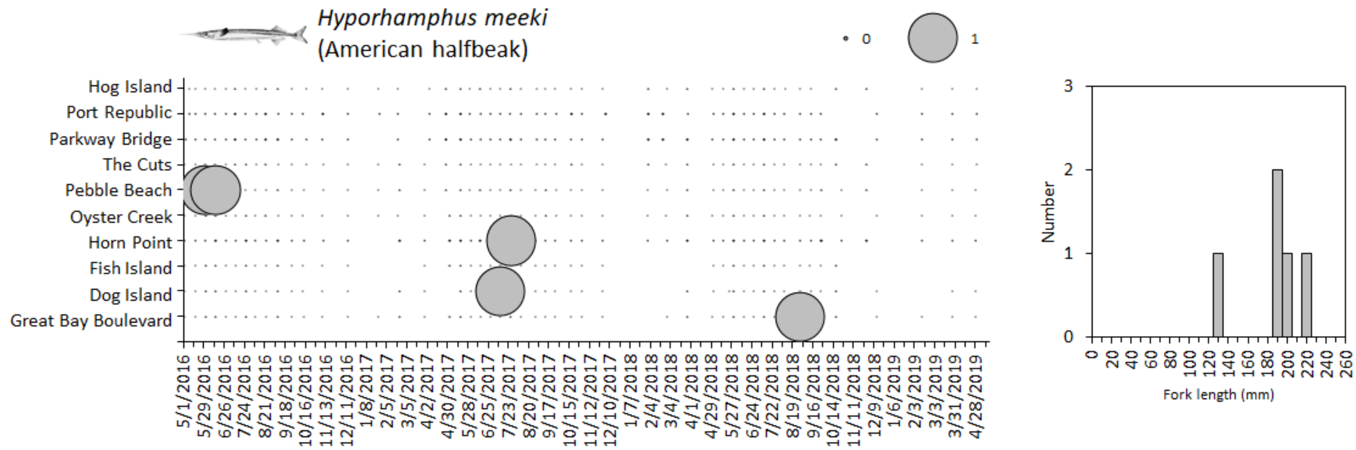

Notemigonus crysoleucas
(golden shiner)
0 1 4 8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10
0 20 40 60 80 100 120 140 160 180 200 220
Fork length (mm)

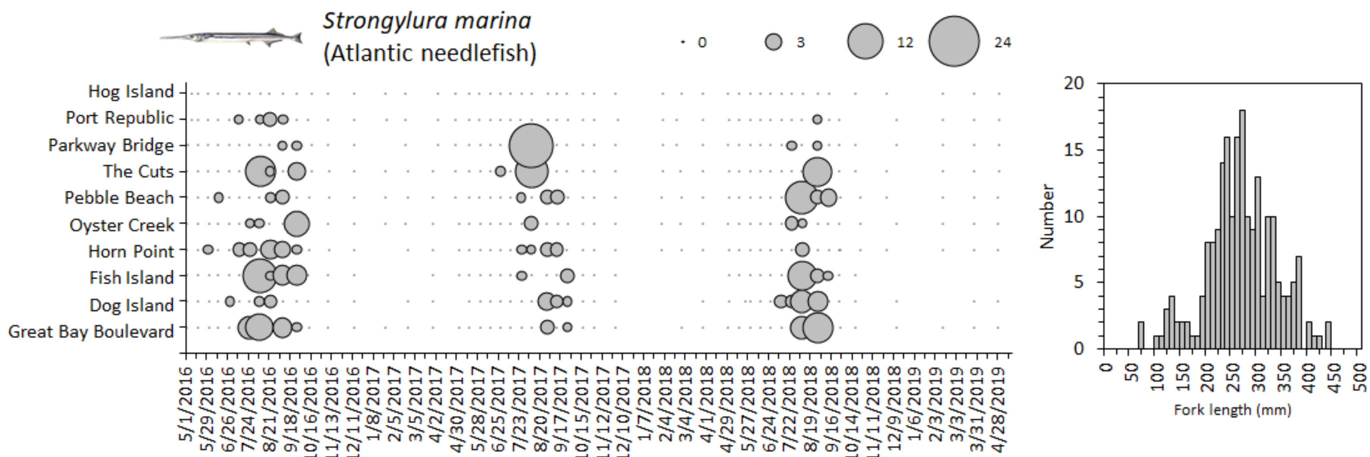

Ameiurus catus
(white catfish)
0 2 10 20
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10 15
0 50 100 150 200 250 300 350 400 450 500
Fork length (mm)

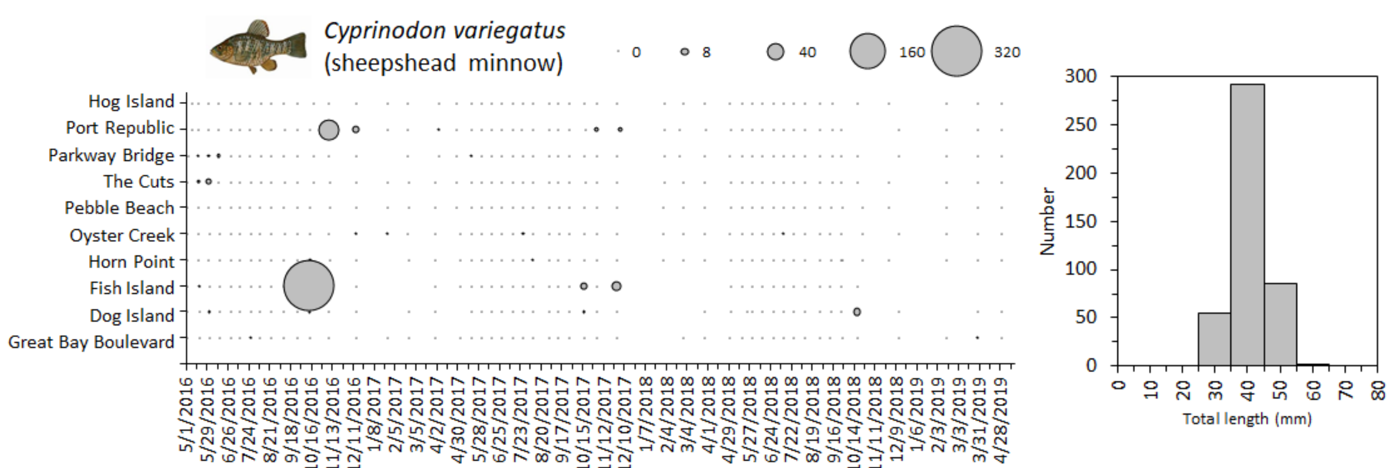

Urophycis regia
(spotted hake)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0
5
10
0 20 40 60 80 100 120 140 160 180 200
Total length (mm)


Pollachius virens
(pollock)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0
5
10
0 20 40 60 80 100
Fork length (mm)

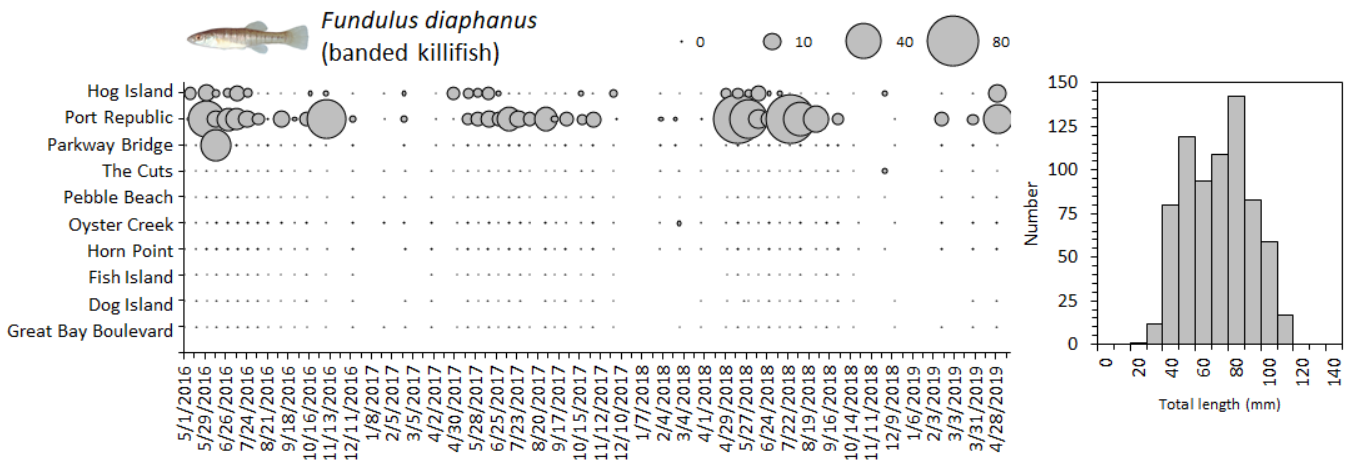

Opsanus tau
(oyster toadfish)
0
2
8
16
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0
5
10
15
20
0 20 40 60 80 100 120 140 160 180
Total length (mm)

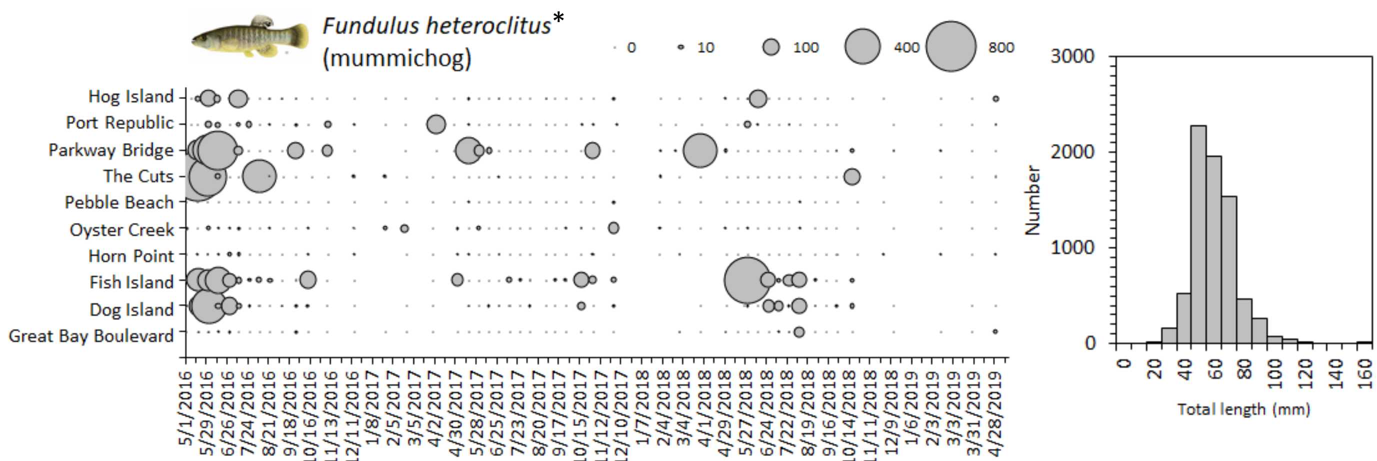

Hyporhamphus meeki
(American halfbeak)
0
1
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

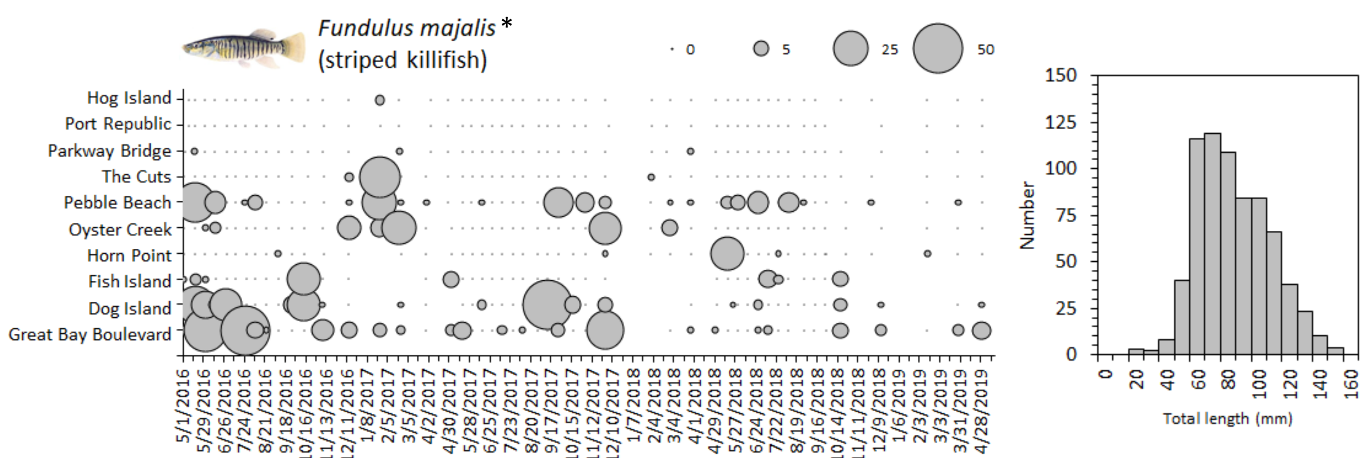

Strongylura marina
(Atlantic needlefish)
0
3
12
24
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

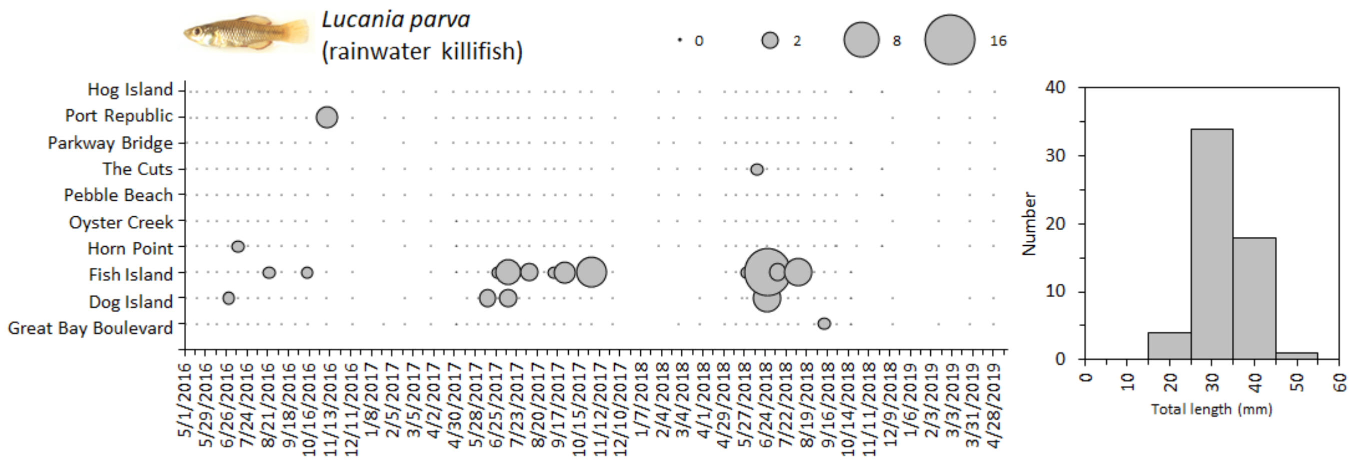

Cyprinodon variegatus
(sheepshead minnow)
0
8
40
160
320
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Total length (mm)

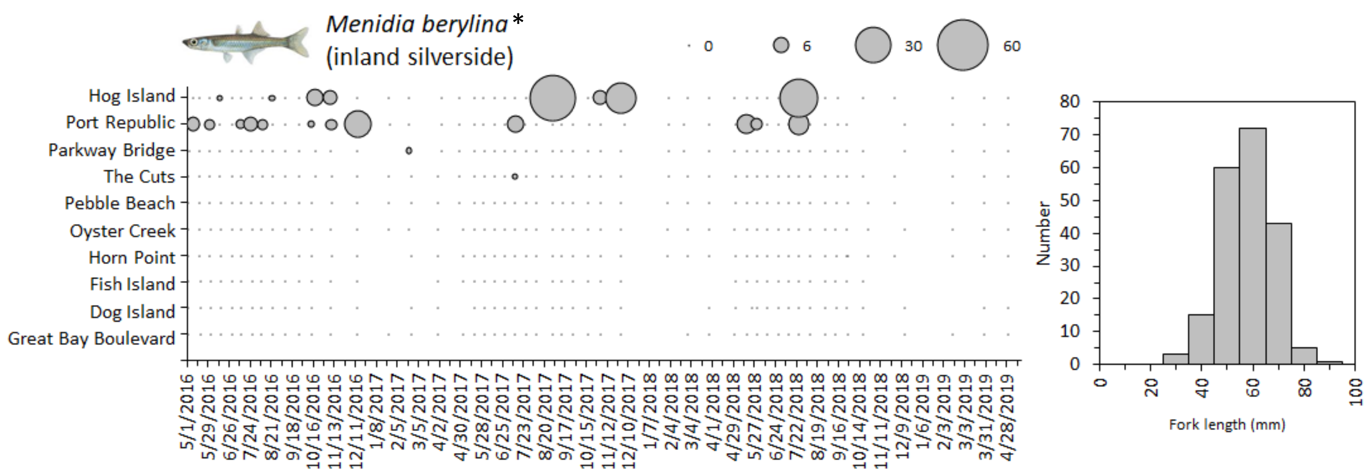
NJDEP Inventory Haul Seine Data (2016-2019)

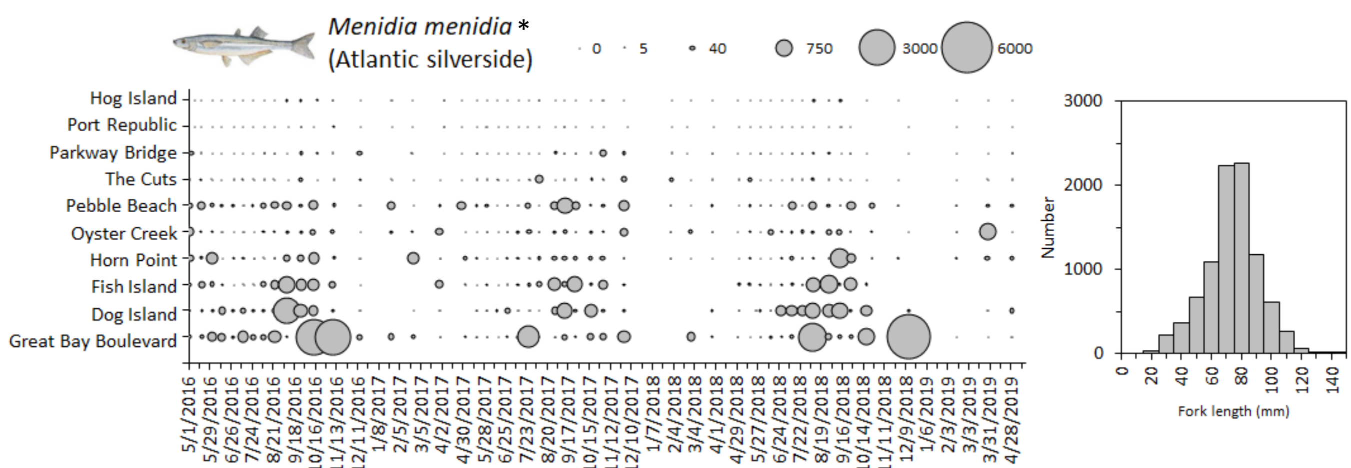


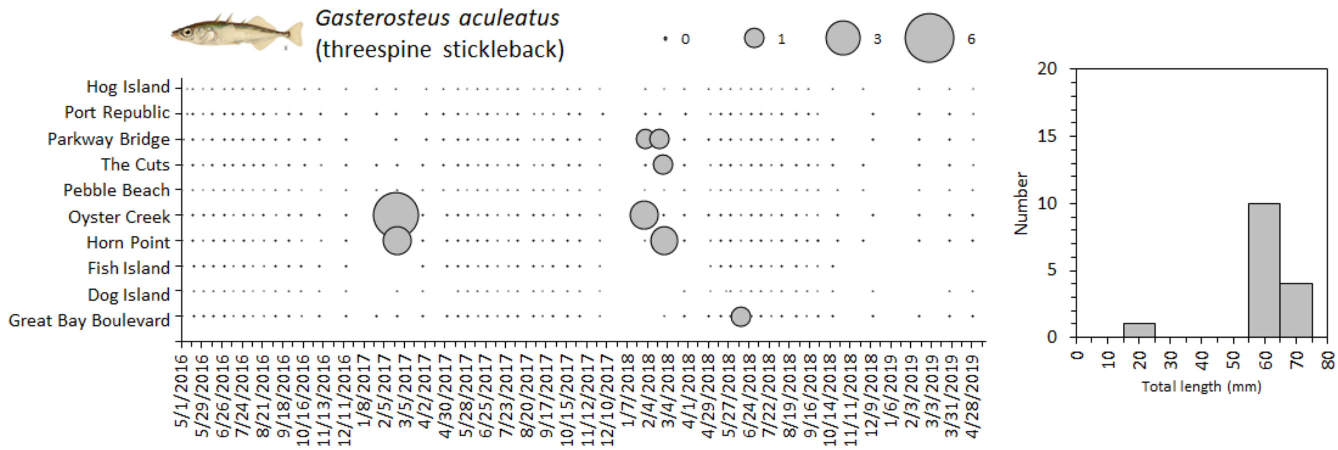


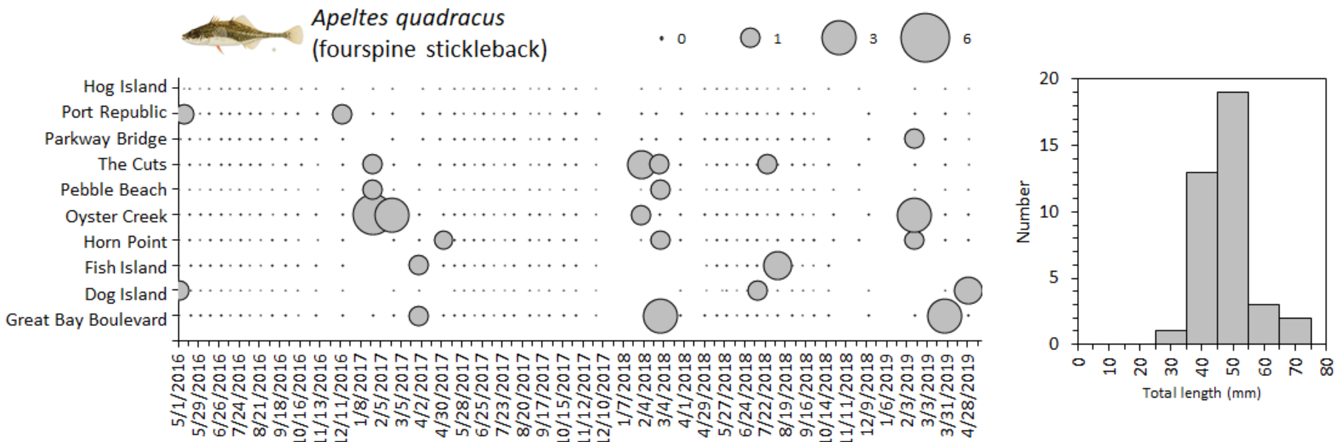


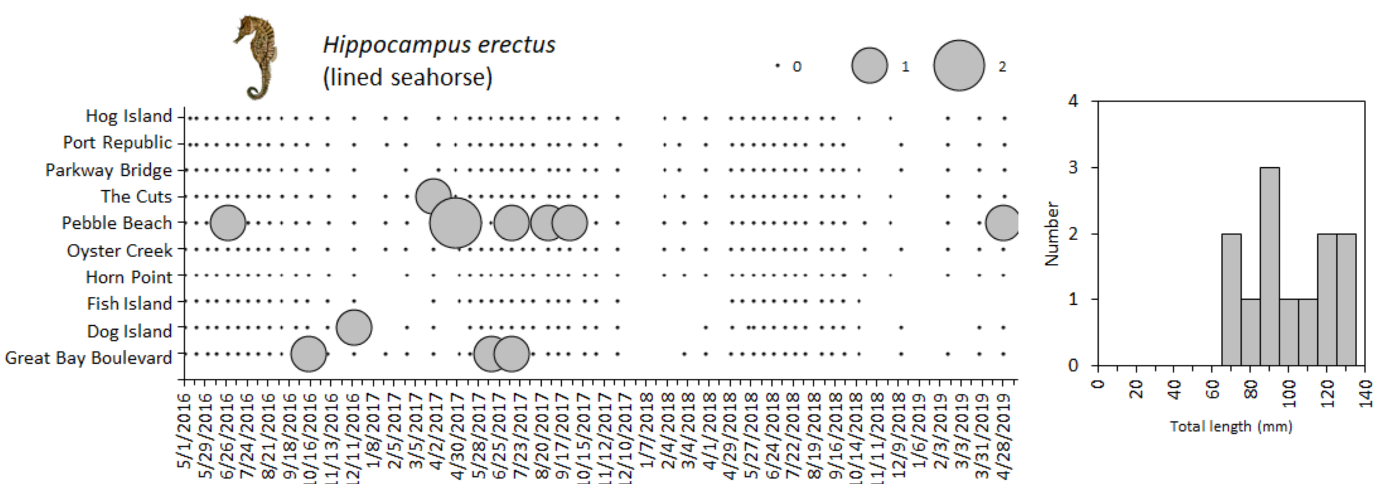

Lucania parva
(rainwater killifish)
0
2
8
16
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Total length (mm)

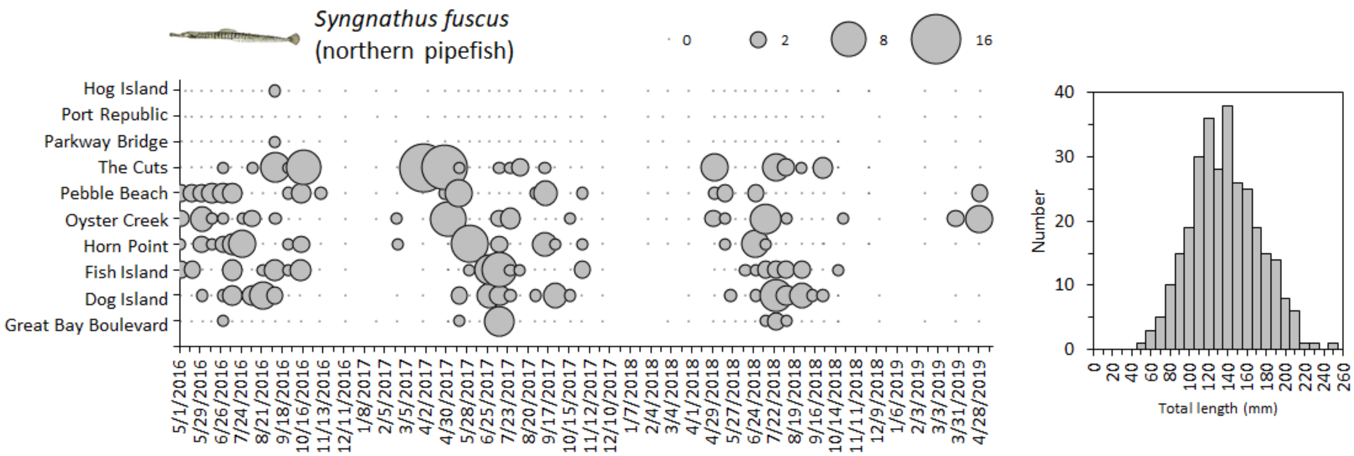

*Menidia berylina**
(inland silverside)
0
6
30
60
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

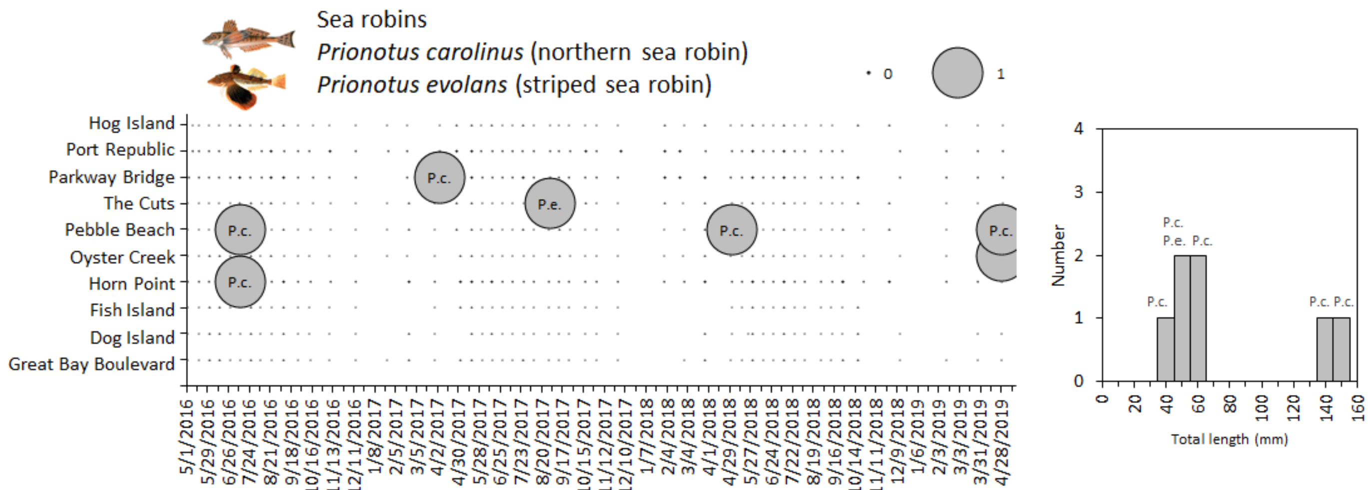

*Menidia menidia**
(Atlantic silverside)
0
5
40
750
3000
6000
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

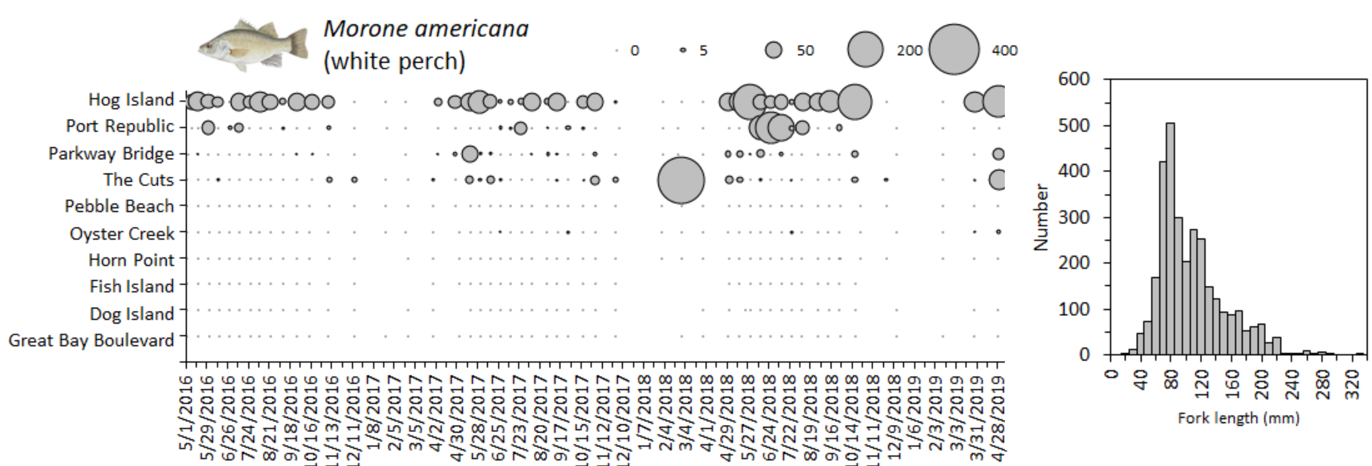

Gasterosteus aculeatus
(threespine stickleback)
0
1
3
6
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
5
10
15
20
0
10
20
30
40
50
60
70
80
Total length (mm)


Apeltes quadracus
(fourspine stickleback)
0
1
3
6
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
5
10
15
20
0
10
20
30
40
50
60
70
80
Total length (mm)

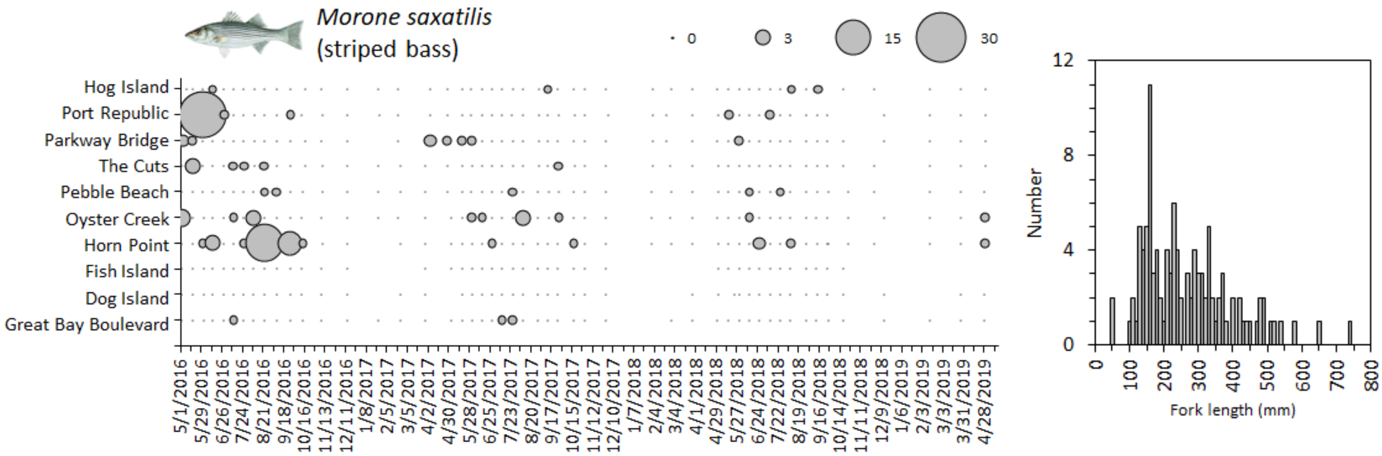

Hippocampus erectus
(lined seahorse)
0
1
2
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
1
2
3
4
0
20
40
60
80
100
120
140
Total length (mm)

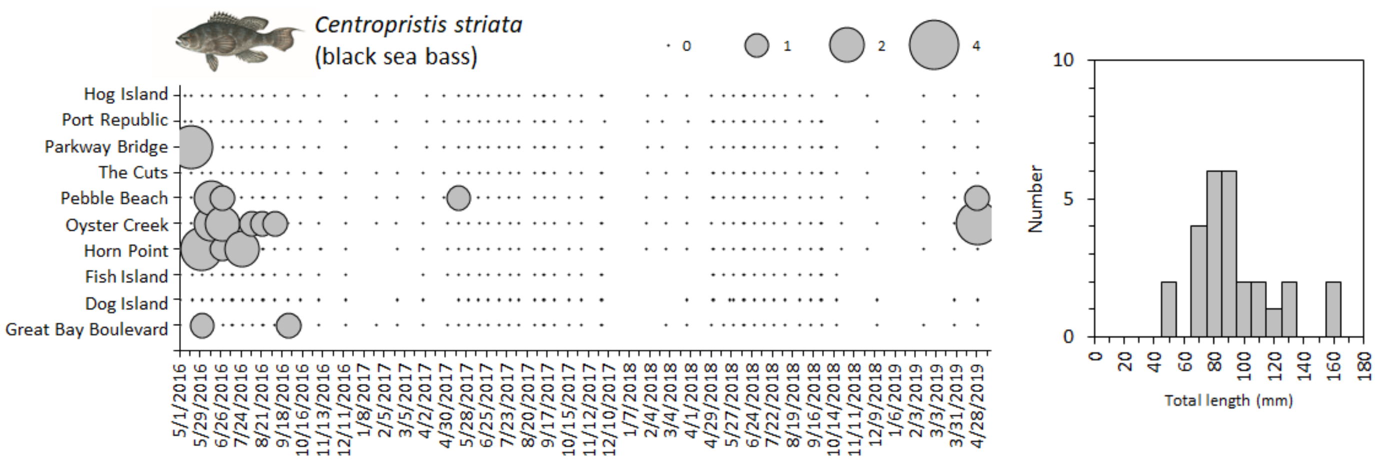

Syngnathus fuscus
(northern pipefish)
0
2
8
16
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 10 20 30 40
0 20 40 60 80 100 120 140 160 180 200 220 240 260
Total length (mm)

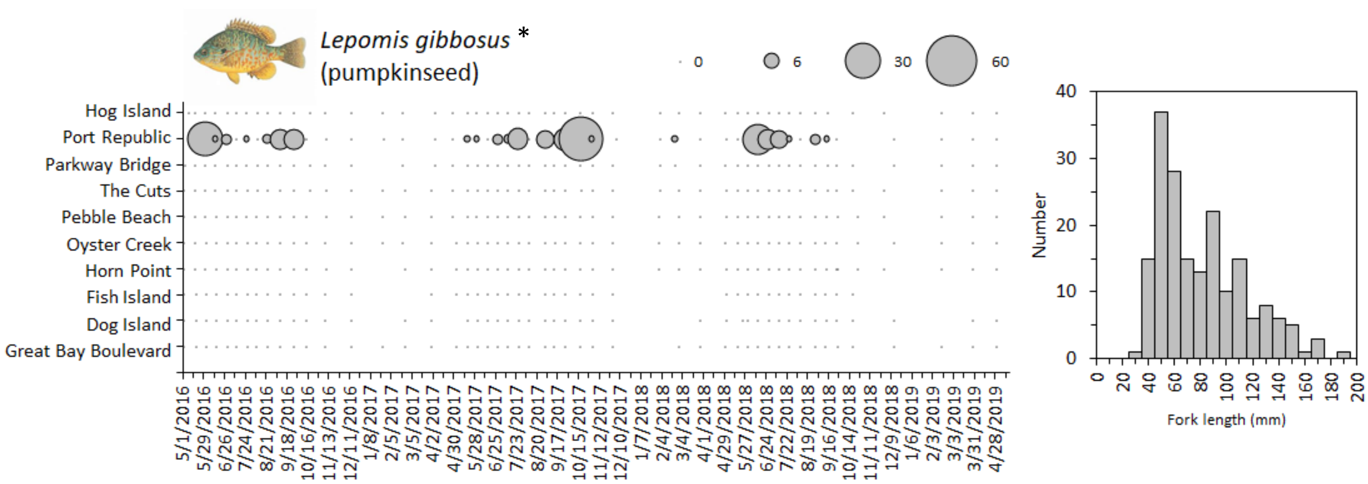

Sea robins
Prionotus carolinus (northern sea robin)
Prionotus evolans (striped sea robin)
0
1
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
P.c.
P.e.
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 1 2 3 4
0 20 40 60 80 100 120 140 160
Total length (mm)

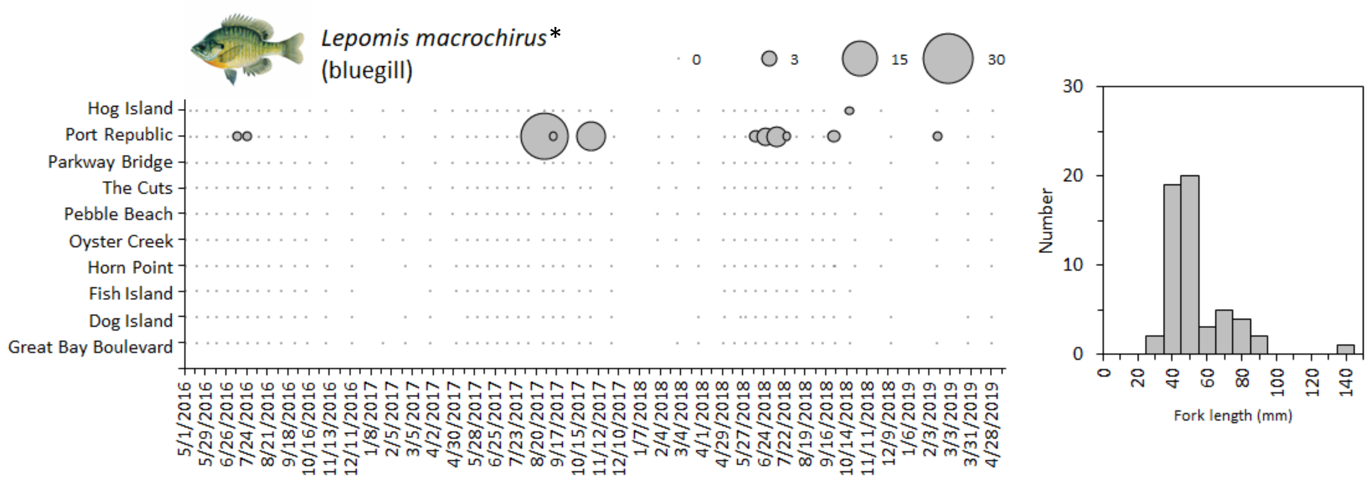

Morone americana
(white perch)
0
5
50
200
400
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 100 200 300 400 500 600
0 40 80 120 160 200 240 280 320
Fork length (mm)

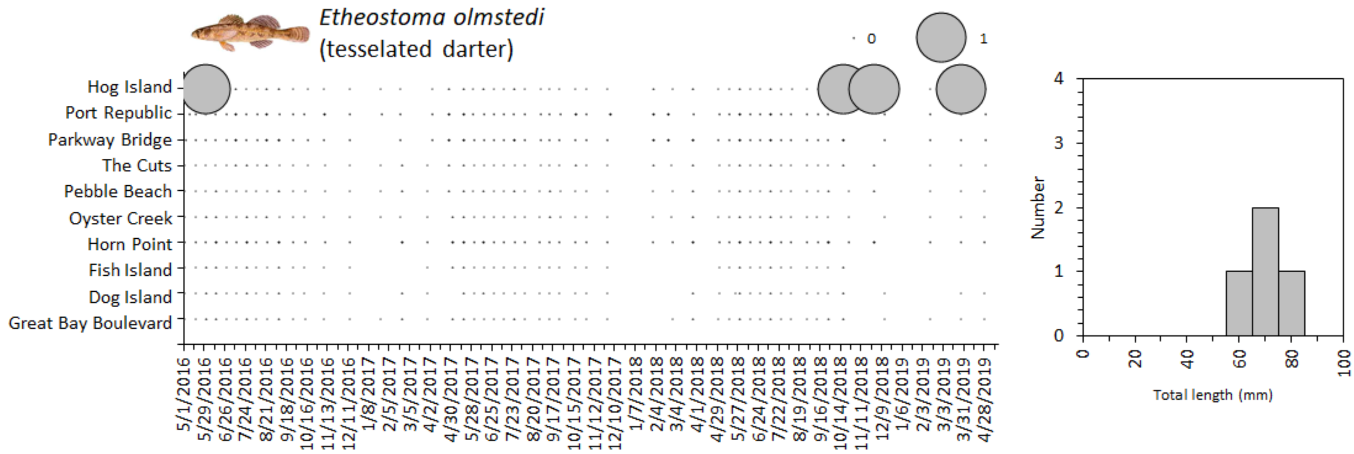
NJDEP Inventory Haul Seine Data (2016-2019)

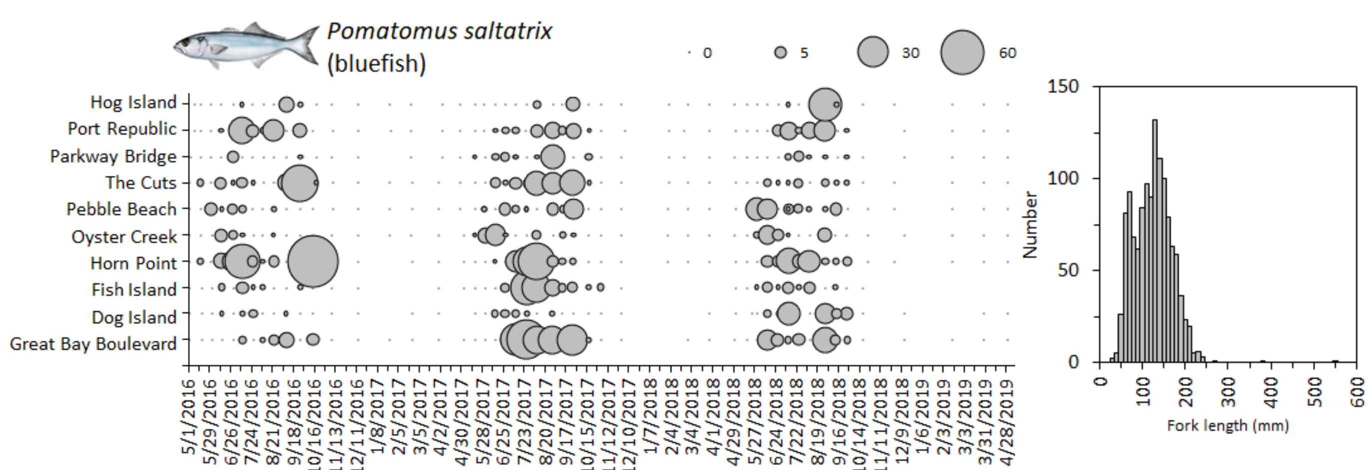


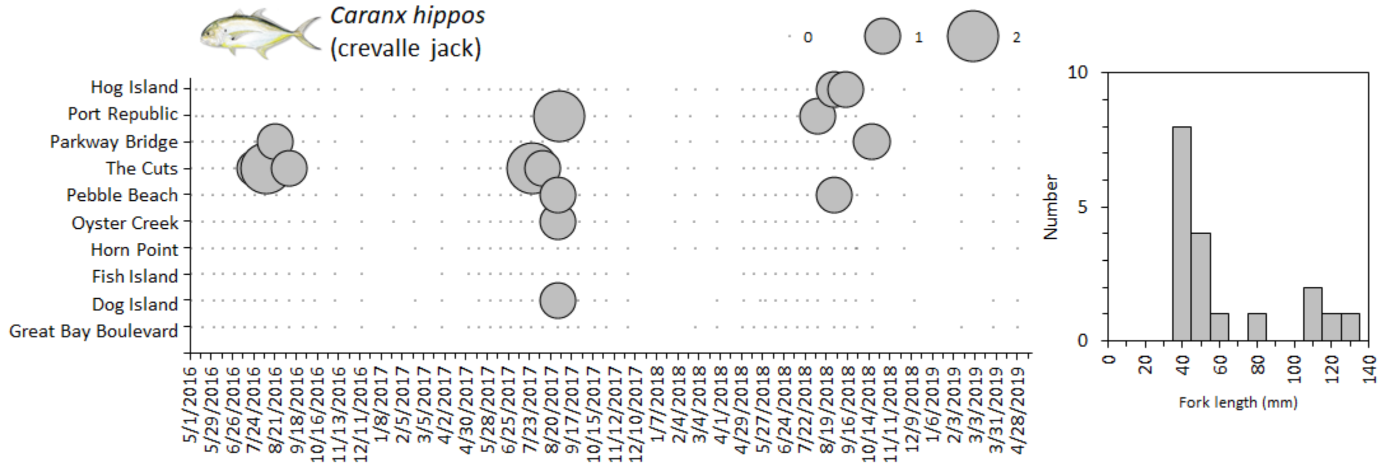


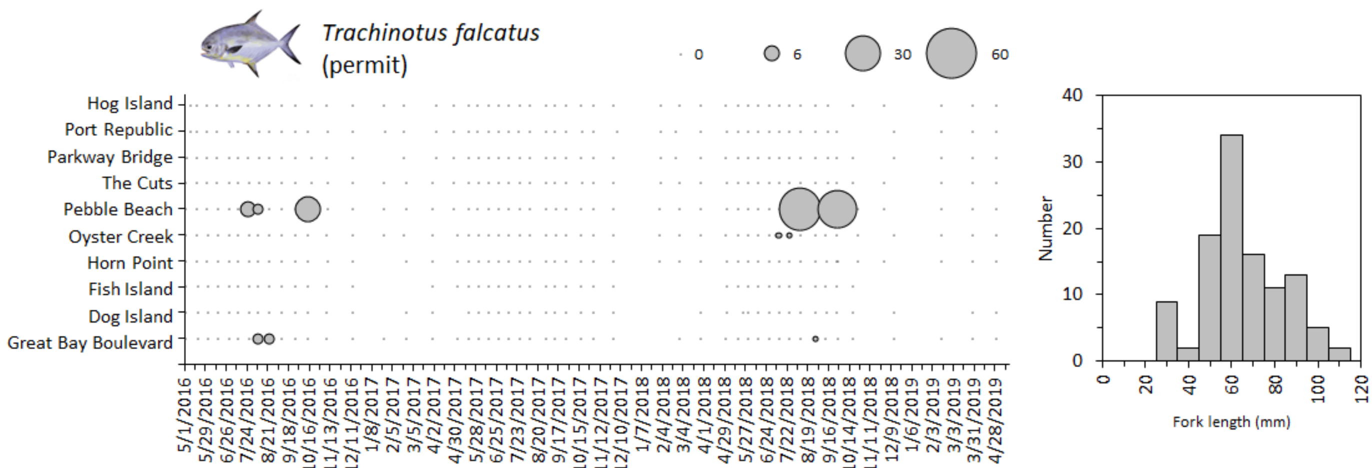


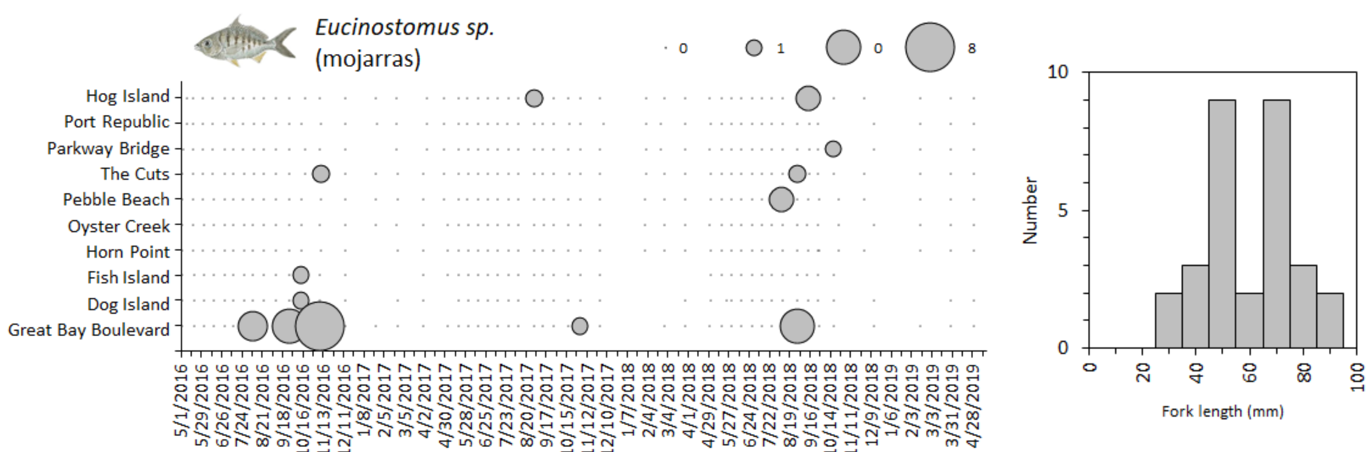

*Lepomis macrochirus**
(bluegill)
0
3
15
30
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

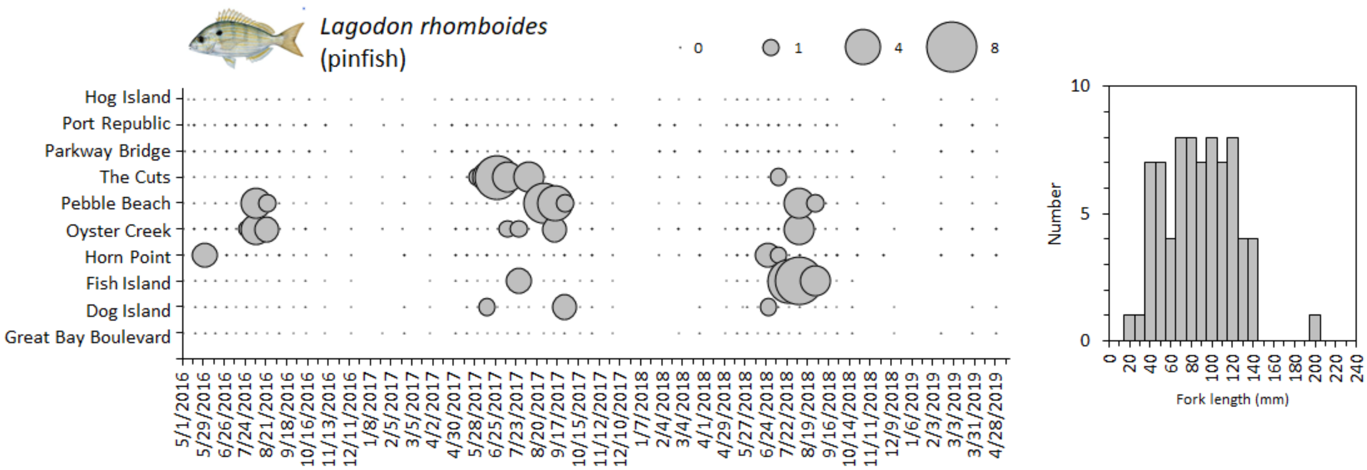

Etheostoma olmstedi
(tesselated darter)
0
1
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Total length (mm)

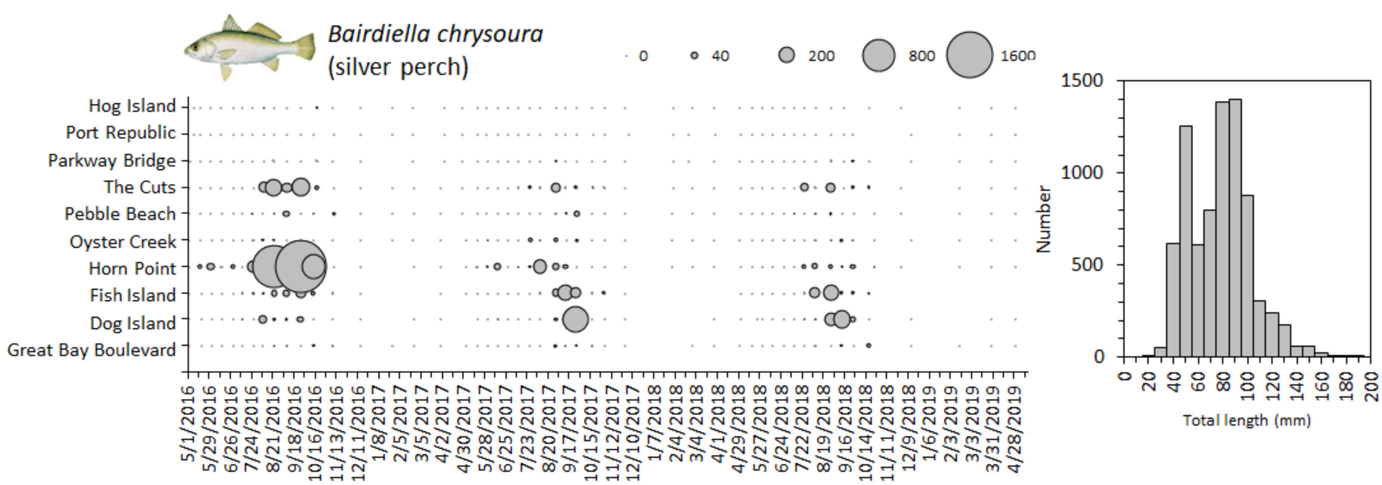

Pomatomus saltatrix
(bluefish)
0
5
30
60
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Fork length (mm)

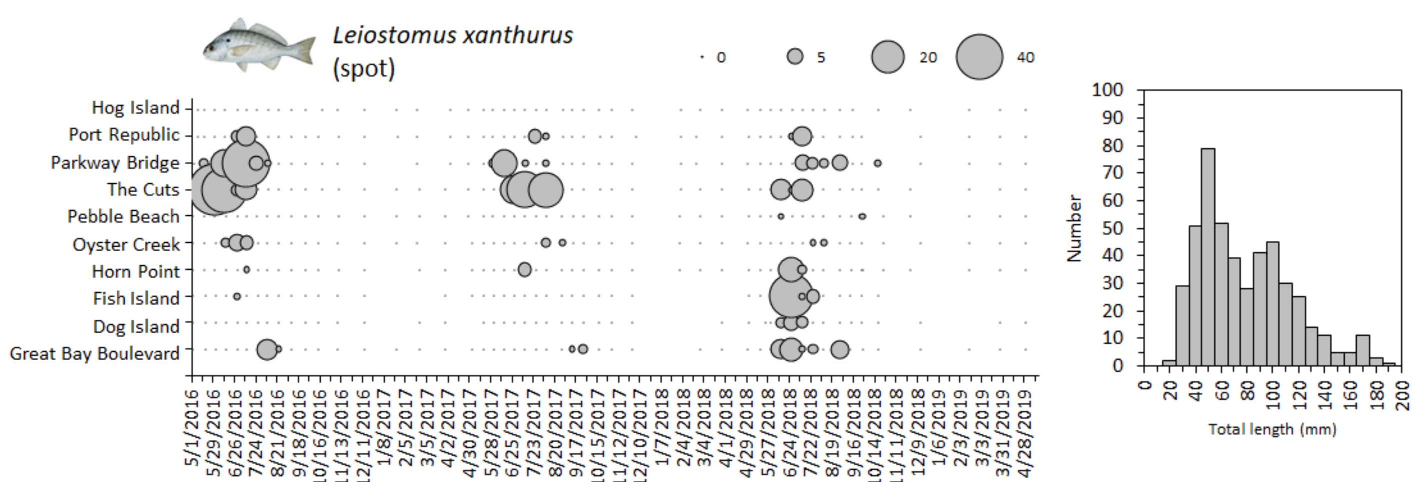

Caranx hippos
(crevalle jack)
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Fork length (mm)

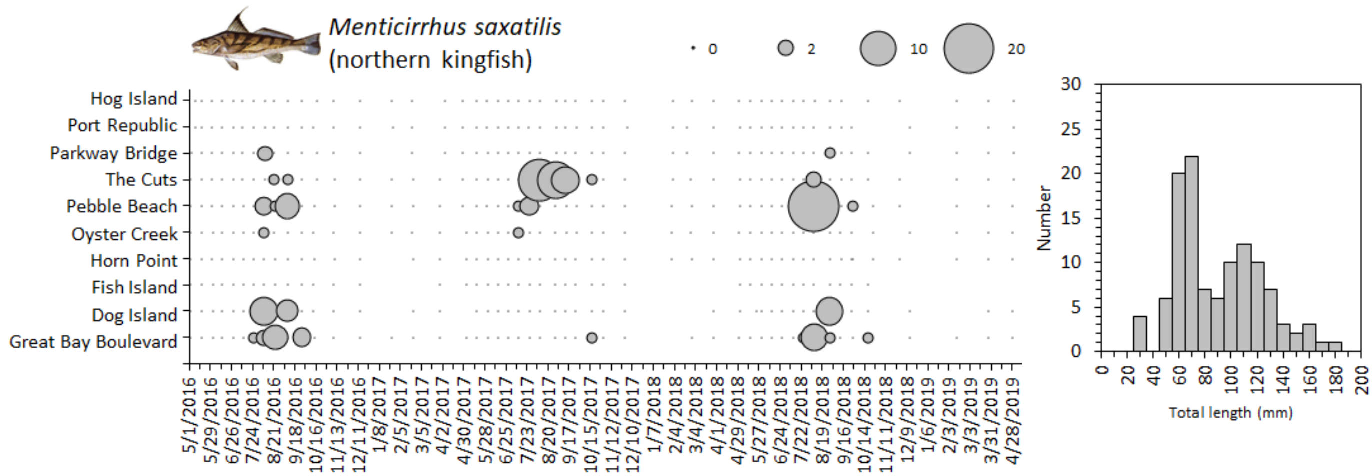

Trachinotus falcatus
(permit)
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Fork length (mm)

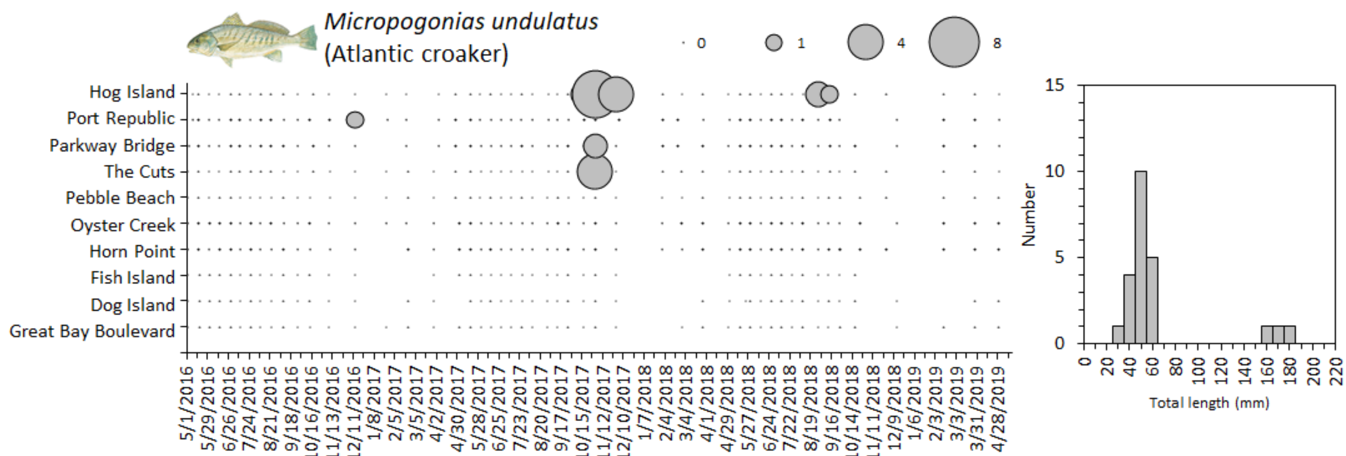

Eucinostomus sp.
(mojarras)
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Fork length (mm)

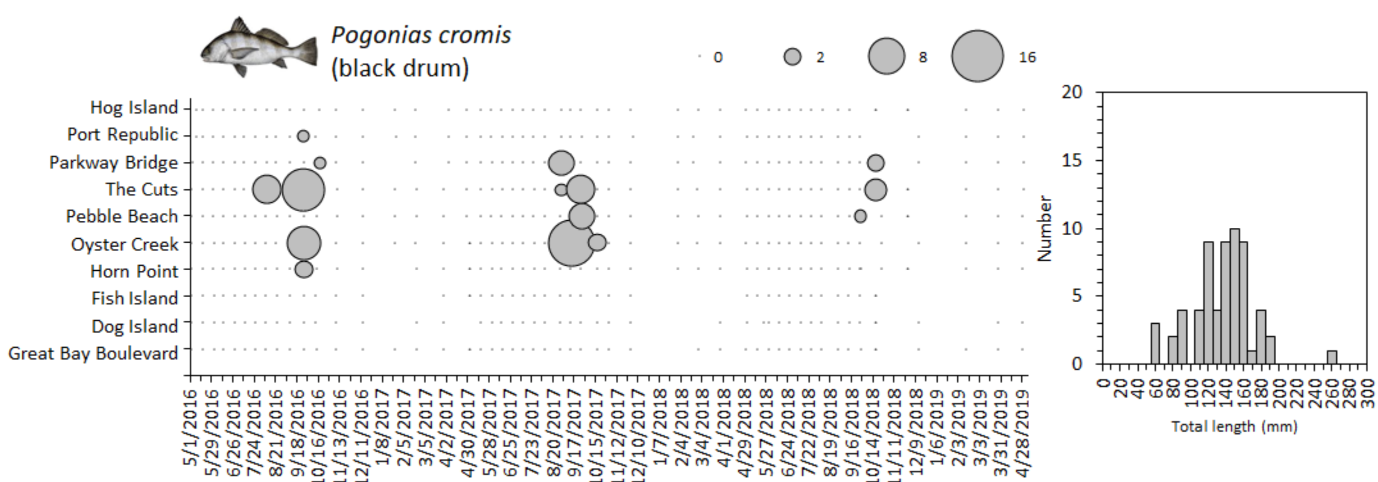

Lagodon rhomboides
(pinfish)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10
Fork length (mm)
0 20 40 60 80 100 120 140 160 180 200 220 240

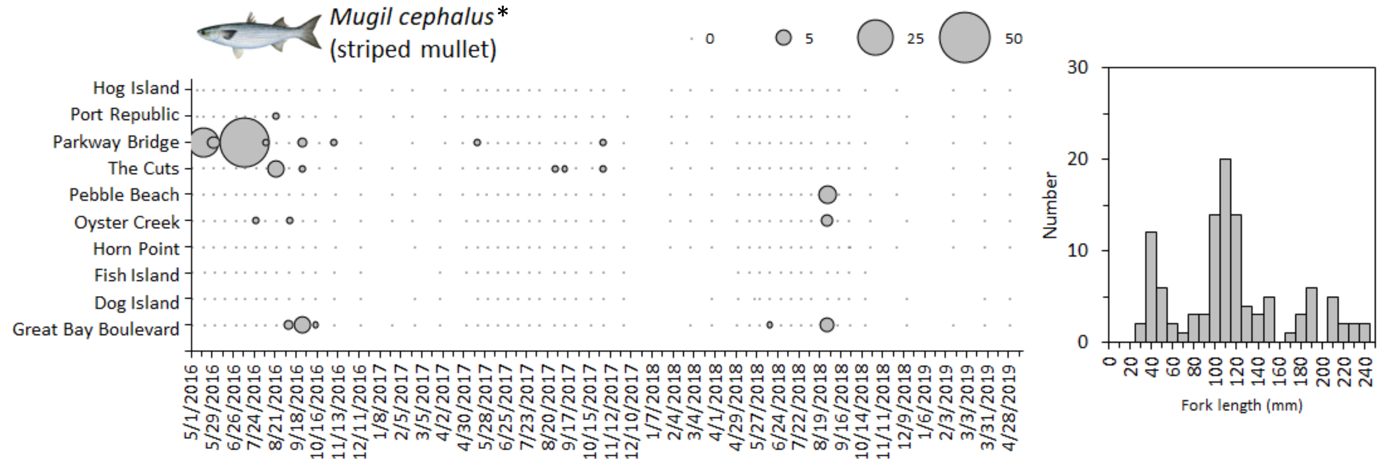

Bairdiella chrysoura
(silver perch)
0
40
200
800
1600
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 500 1000 1500
Total length (mm)
0 20 40 60 80 100 120 140 160 180 200

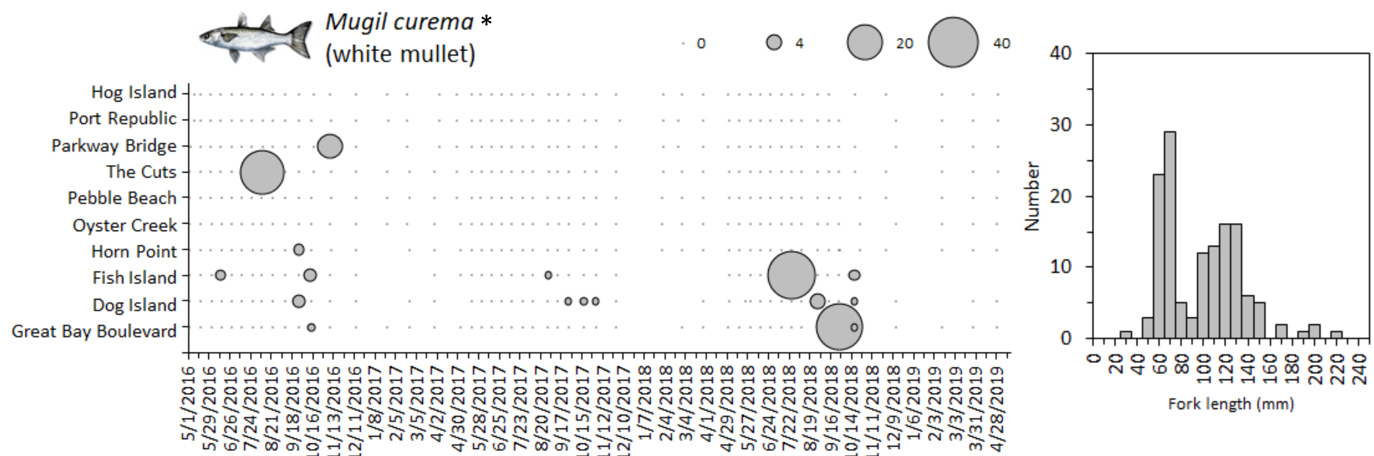

Leiostomus xanthurus
(spot)
0
5
20
40
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 10 20 30 40 50 60 70 80 90 100
Total length (mm)
0 20 40 60 80 100 120 140 160 180 200

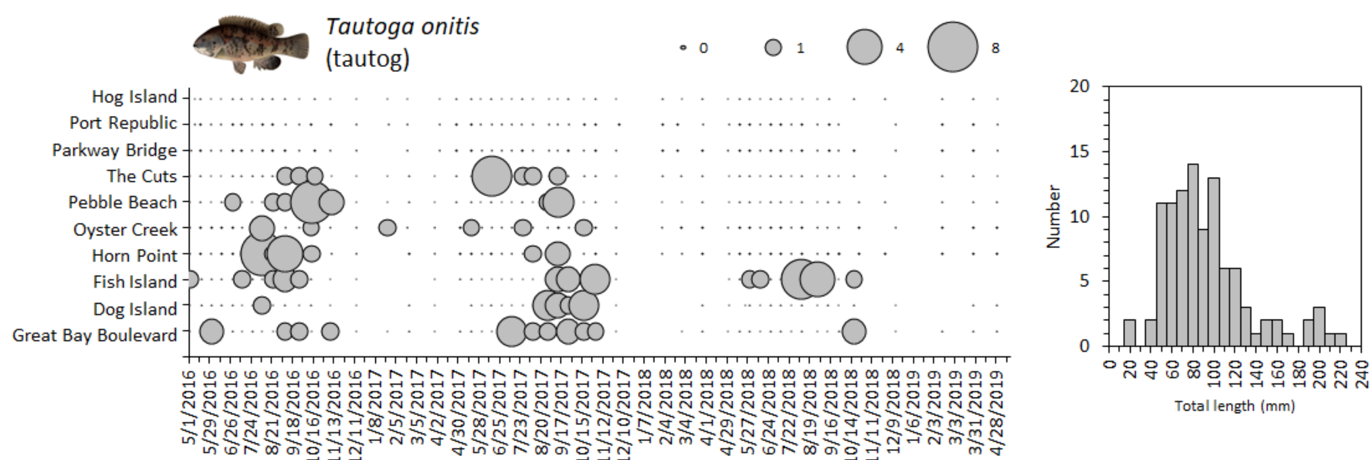

Menticirrhus saxatilis
(northern kingfish)
0
2
10
20
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10 15 20 25 30
0 20 40 60 80 100 120 140 160 180 200
Total length (mm)

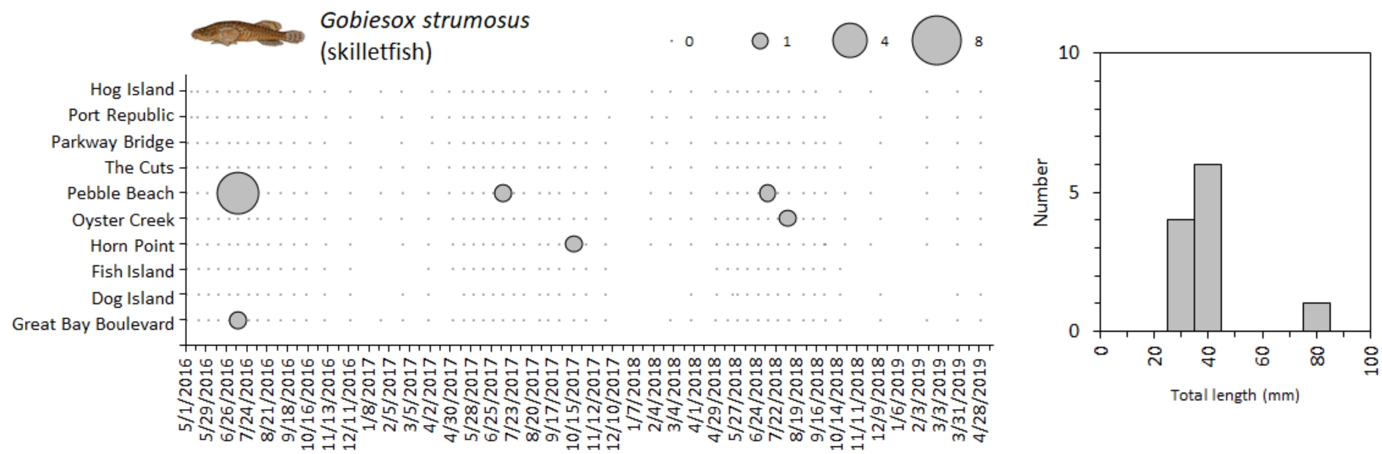

Micropogonias undulatus
(Atlantic croaker)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10 15
0 20 40 60 80 100 120 140 160 180 200 220
Total length (mm)

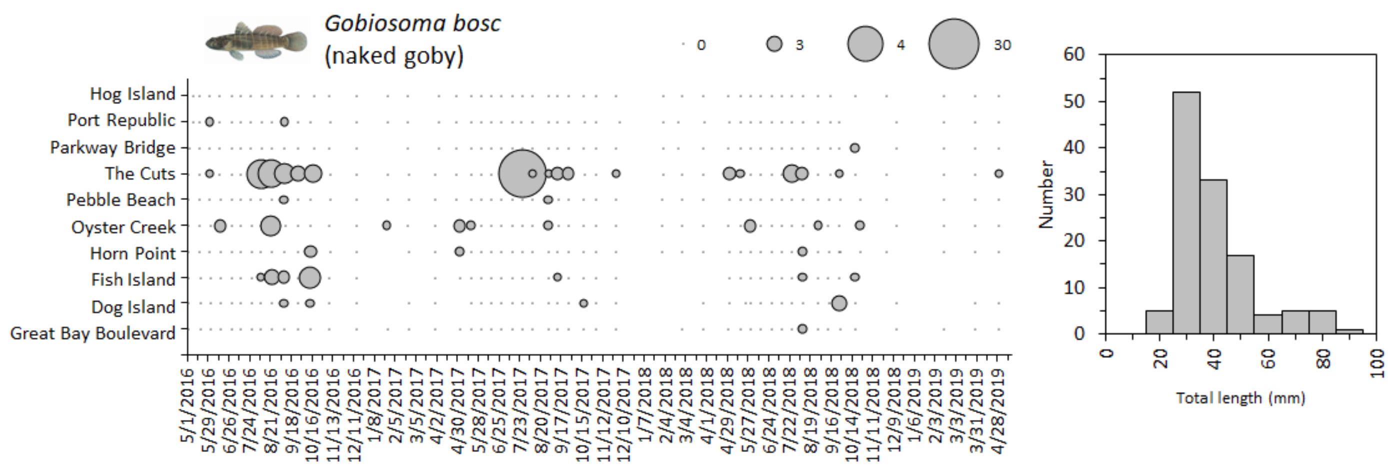

Pogonias cromis
(black drum)
0
2
8
16
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10 15 20
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Total length (mm)

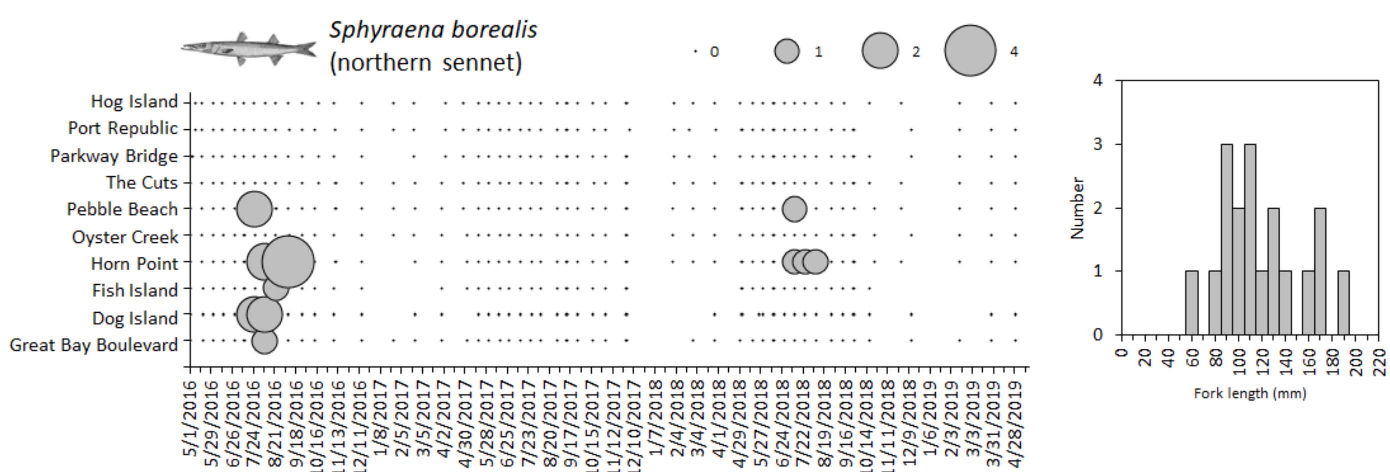

*Mugil cephalus**
(striped mullet)
0
5
25
50
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Fork length (mm)


Mugil curema *
(white mullet)
0
4
20
40
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Fork length (mm)

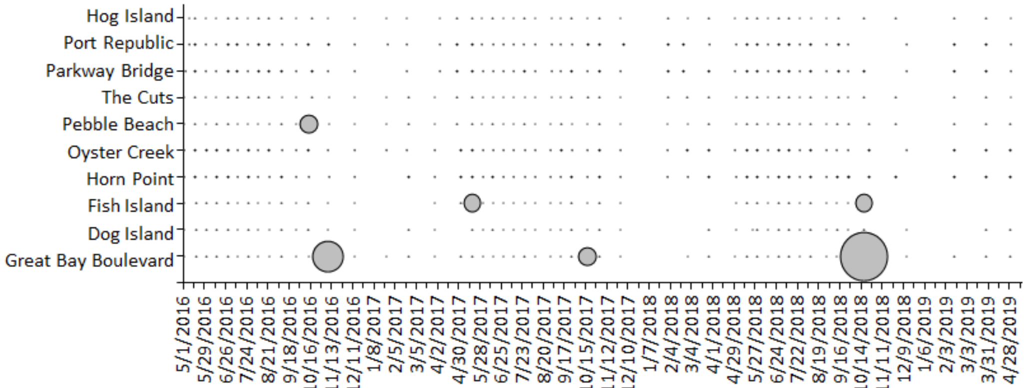

Tautoga onitis
(tautog)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Total length (mm)

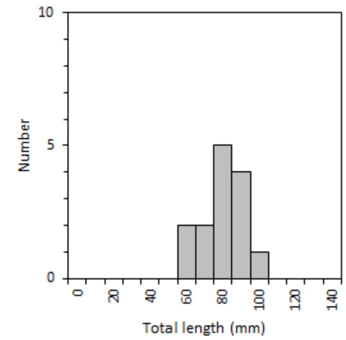

Gobiesox strumosus
(skilletfish)
0 1 4 8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10
0 20 40 60 80 100
Total length (mm)


Gobiosoma bosc
(naked goby)
0 3 4 30
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 10 20 30 40 50 60
0 20 40 60 80 100
Total length (mm)

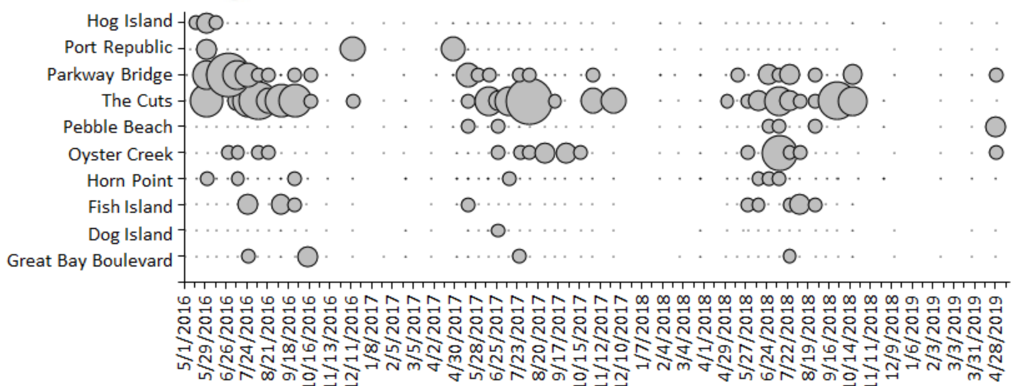

Sphyraena borealis
(northern sennet)
0 1 2 4
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 1 2 3 4
0 20 40 60 80 100 120 140 160 180 200 220
Fork length (mm)

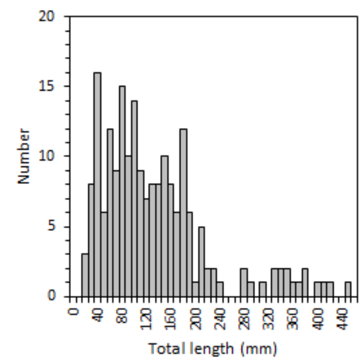
Etropus microstomus
(smallmouth flounder)



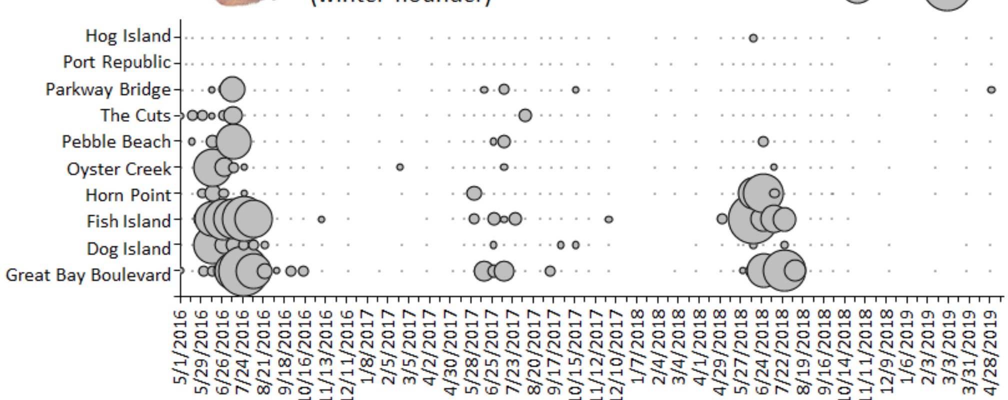


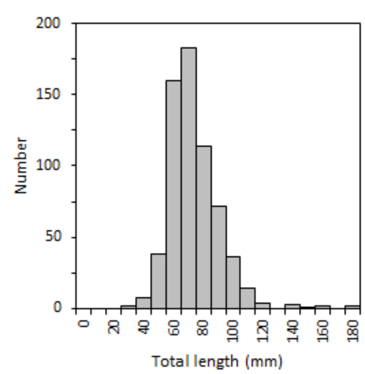
Paralichthys dentatus
(summer flounder)

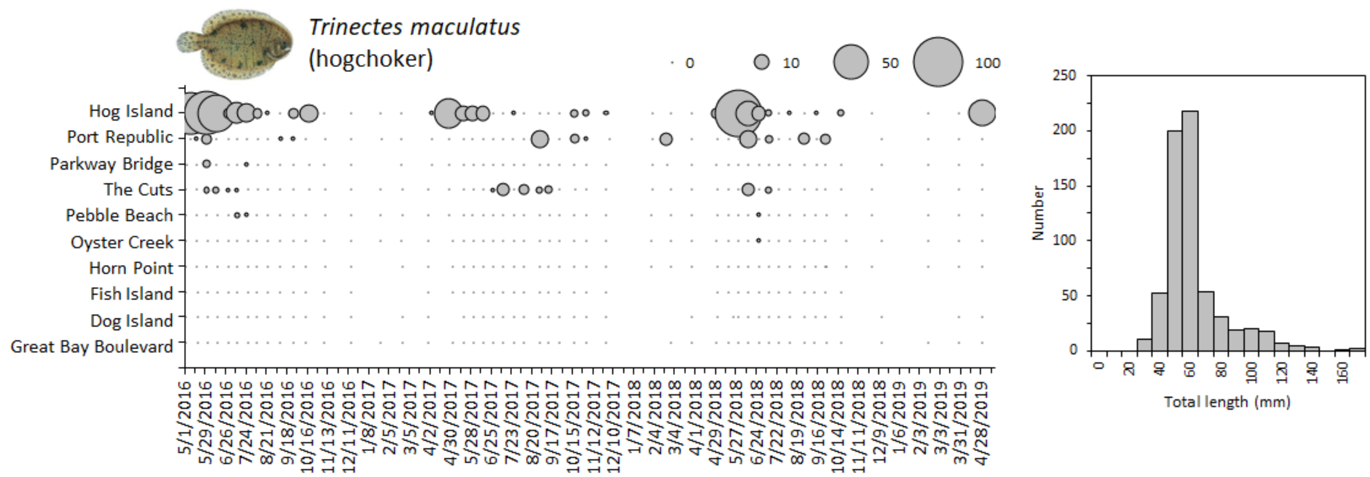


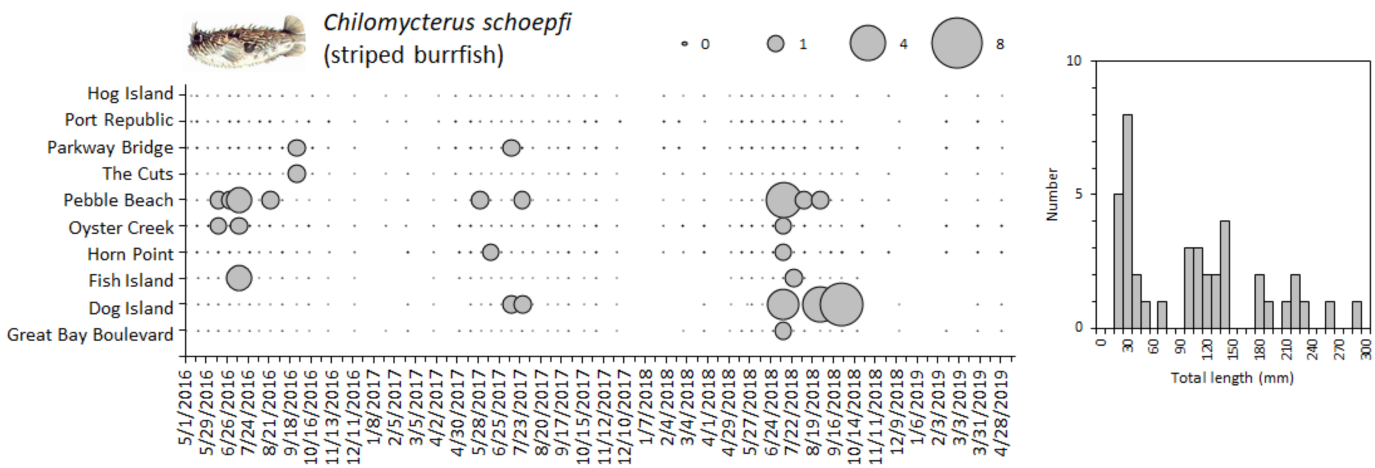


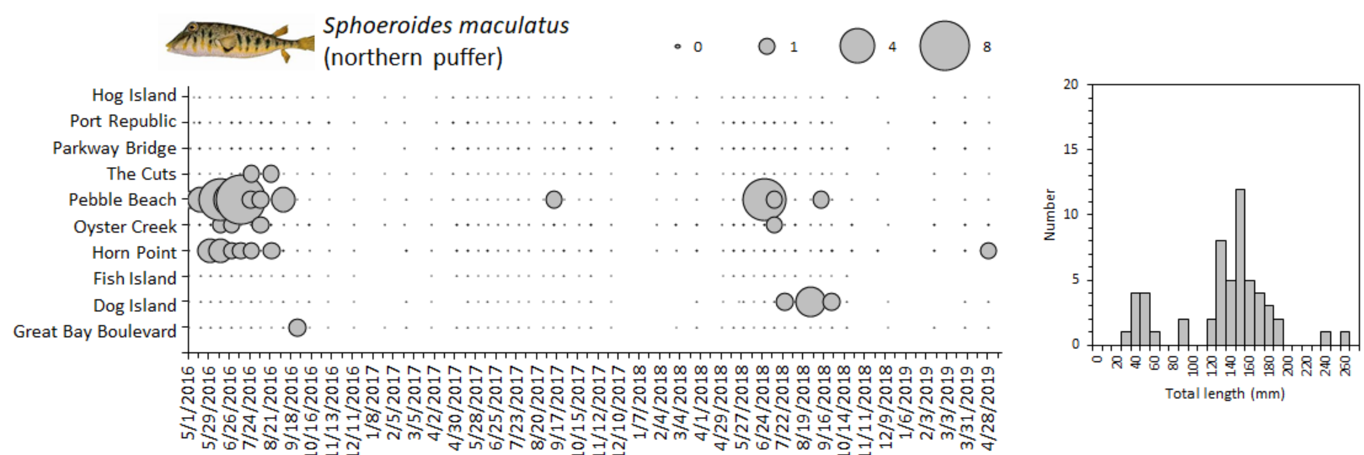
Pseudopleuronectes americanus
(winter flounder)

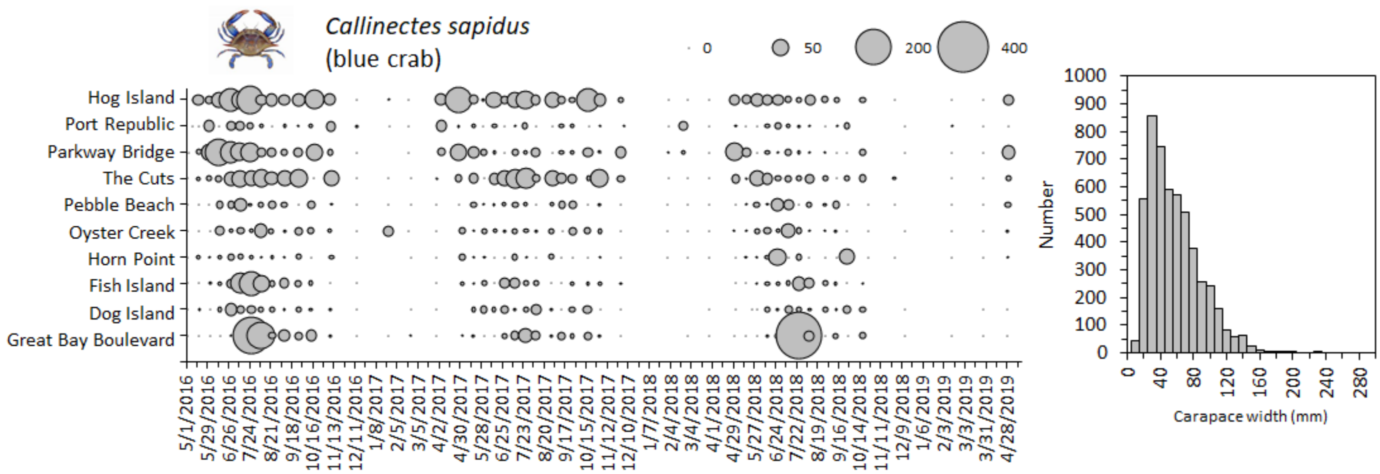


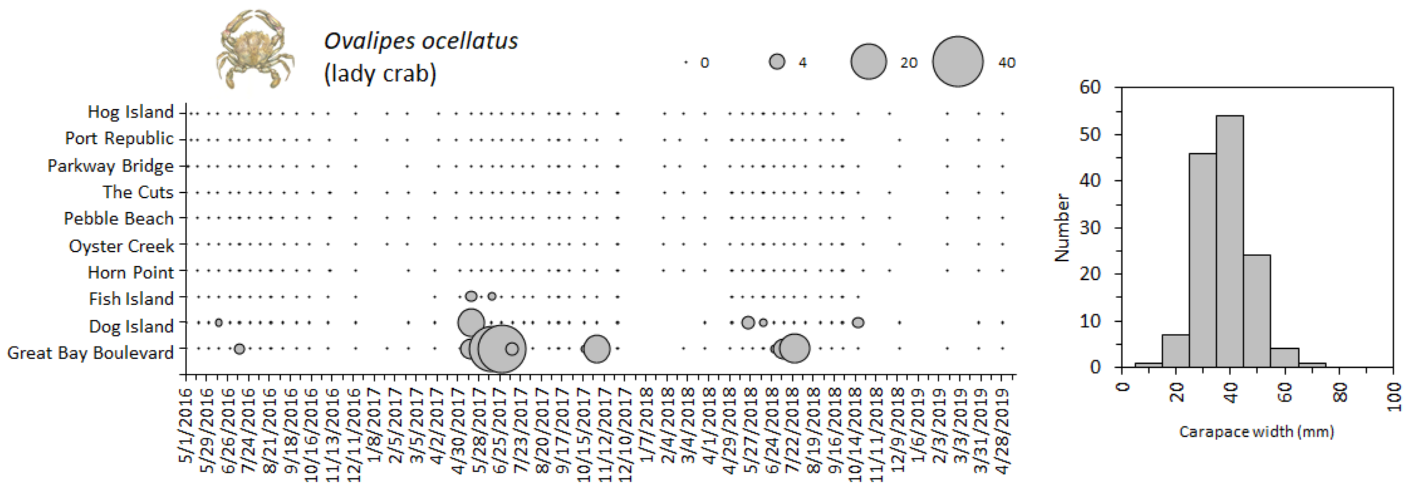


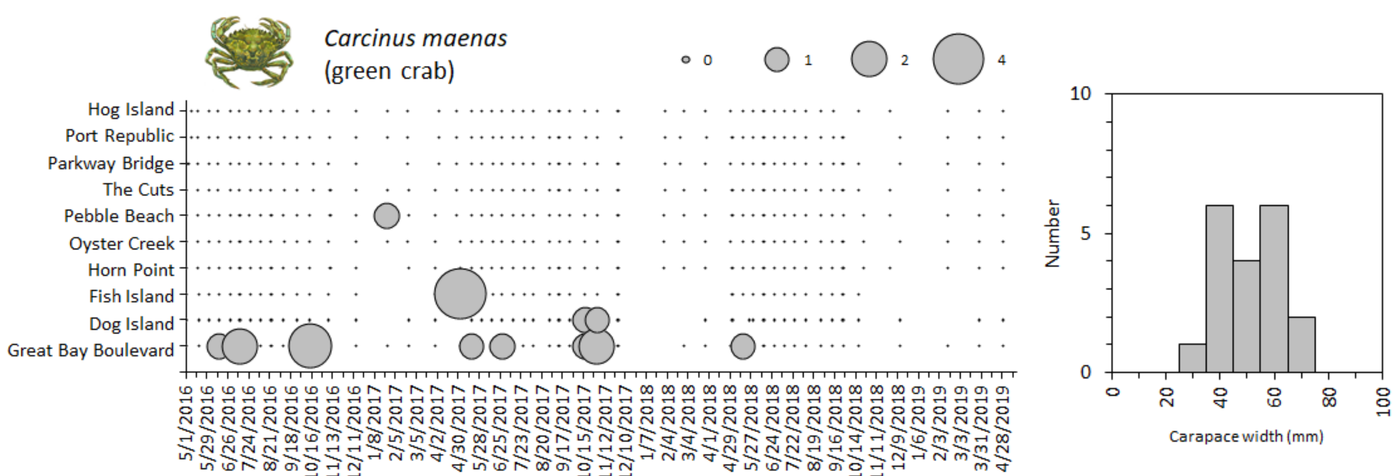

Trinectes maculatus
(hogchoker)
0
10
50
100
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 50 100 150 200 250
0 20 40 60 80 100 120 140 160
Total length (mm)


Chilomycterus schoepfi
(striped burrfish)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10
0 30 60 90 120 150 180 210 240 270 300
Total length (mm)


Sphoeroides maculatus
(northern puffer)
0
1
4
8
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
0 5 10 15 20
0 20 40 60 80 100 120 140 160 180 200 220 240 260
Total length (mm)


Callinectes sapidus
(blue crab)
0
50
200
400
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Carapace width (mm)


Ovalipes ocellatus
(lady crab)
0
4
20
40
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Carapace width (mm)


Carcinus maenas
(green crab)
0
1
2
4
Hog Island
Port Republic
Parkway Bridge
The Cuts
Pebble Beach
Oyster Creek
Horn Point
Fish Island
Dog Island
Great Bay Boulevard
Number
Carapace width (mm)

Haul seine species notes:

Menidia berylina differentiated from *Menidia menidia* at the following mid-to-low salinity sites only (due to high volume of overall *Menidia* catch): The Cuts, Parkway Bridge, Port Republic, Hog Island.

Length-frequency histograms extrapolated from sub-samples (i.e. 50 individuals measured expanded to entire catch at a given site) for all species except *Menidia menidia* and *Brevoortia tyrannus*.

Uncategorized individuals remain for subsets of the following: *Alosa* sp., *Fundulus* sp., *Menidia* sp., *Lepomis* sp., *Mugil* sp. (small, damaged, or otherwise problematic IDs).

Additional fish species collected in haul seine (n $\leq$ 4, not presented in plots):

*Alosa aestivalis** (blueback herring) (4)
Alosa mediocris (hickory shad) (3)
Esox americanus (redfin pickerel) (1)
Esox niger (chain pickerel) (4)
Ameiurus natalis (yellow bullhead) (1)
Ameiurus nebulosus (brown bullhead) (3)
Ictalurus punctatus (channel catfish) (1)
Enneacanthus obsesus (banded sunfish) (1)
Micropterus salmoides (largemouth bass) (4)
Perca flavescens (yellow perch) (1)
Rachycentron canadum (cobia) (4)
Echeneis naucrates (sharksucker) (1)
Carangoides bartholomaei (yellow jack) (1)
Selene vomer (lookdown) (1)
Trachurus lathami (rough scad) (1)
Lutjanus griseus (gray snapper) (3)
Archosargus probatocephalus (sheepshead) (2)
Cynoscion regalis (weakfish) (2)
Sciaenops ocellatus (red drum) (2)
Upeneus sp. (goatfish) (1)
Chaetodon ocellatus (spotfin butterflyfish) (1)
Hypsoblennius hentzi (feather blenny) (2)
Gobiosoma ginsburgi (seaboard goby) (1)
Peprilus triacanthus (butterfish) (1)
Scophthalmus aquosus (windowpane flounder) (2)
Lactophrys sp. (trunkfish) (1)
Limulus polyphemus (Atlantic horseshoe crab) (4)
Cancer irroratus (rock crab) (4)

Figure 4a

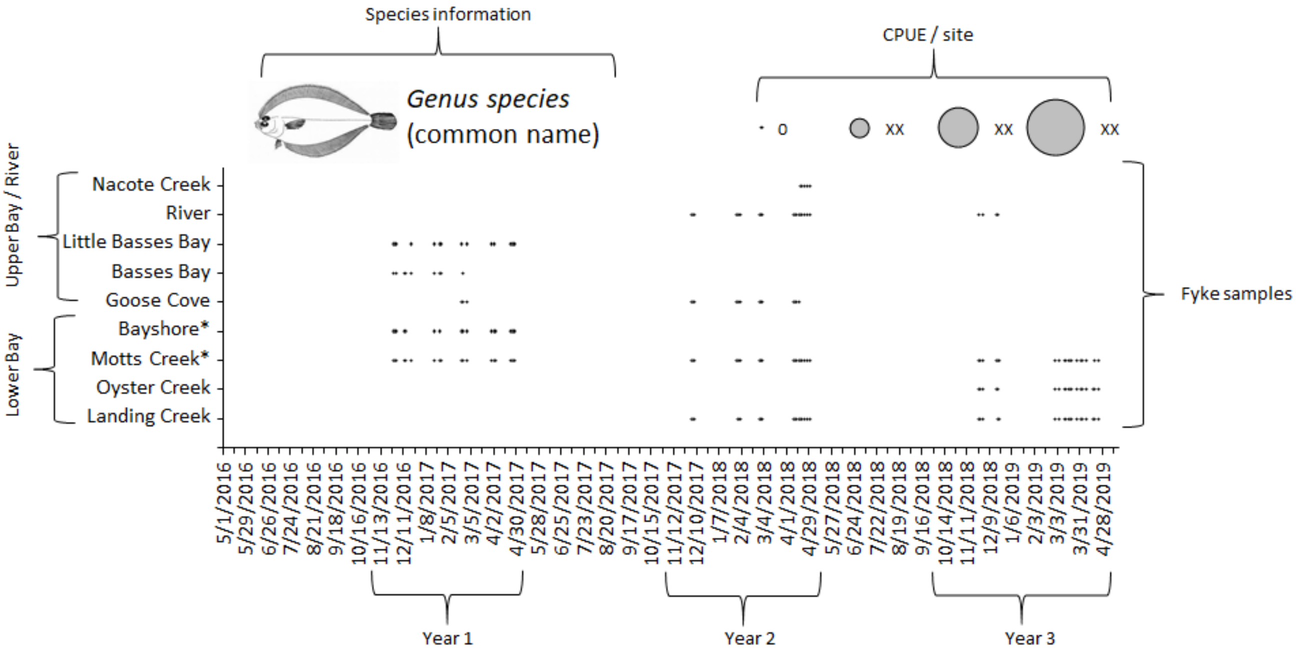


Figure 4b

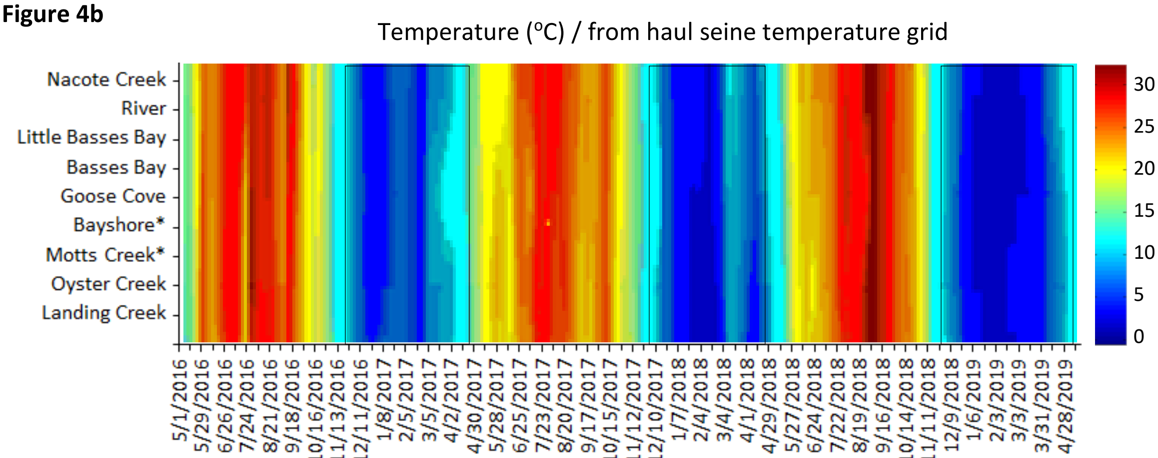
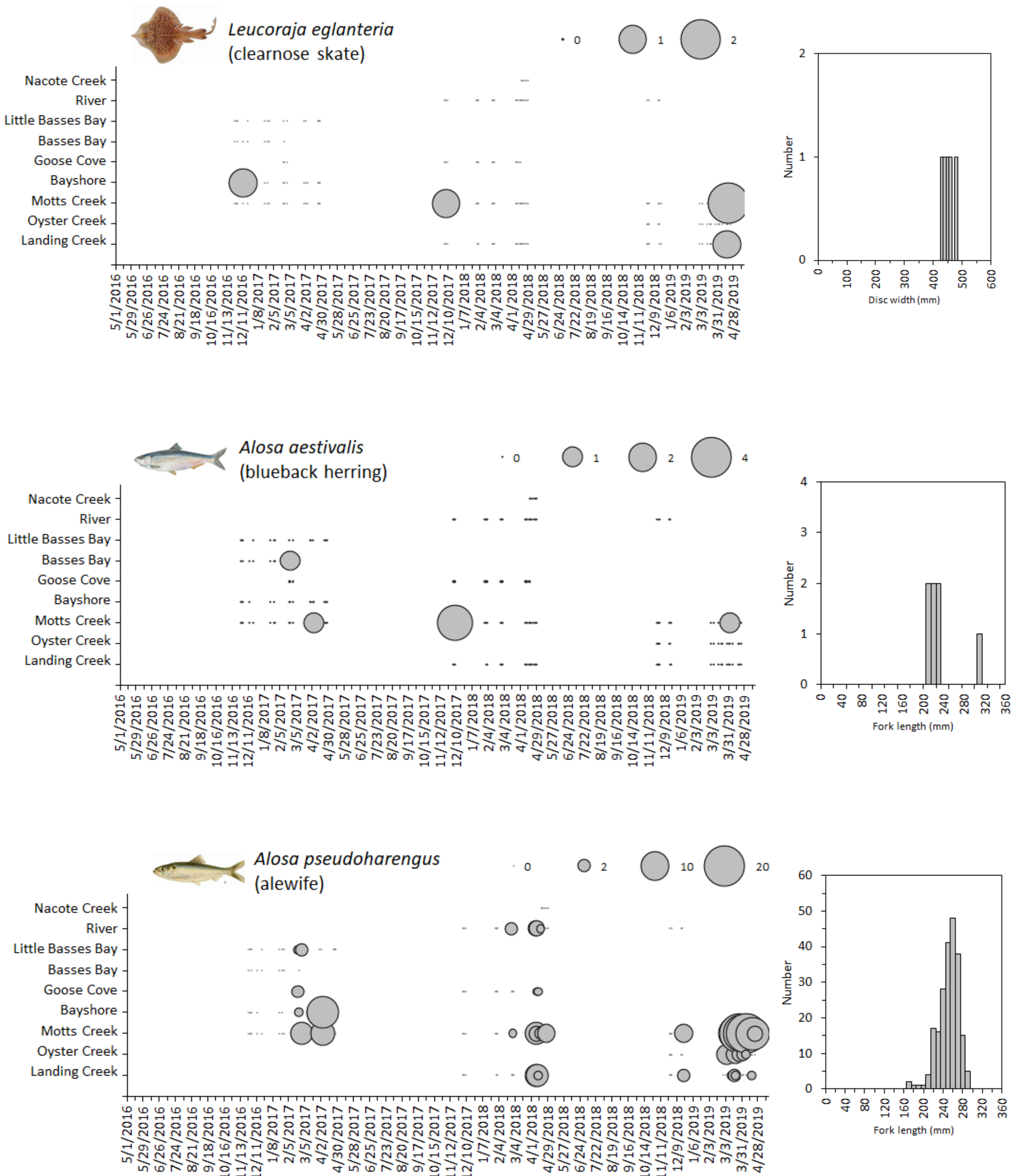
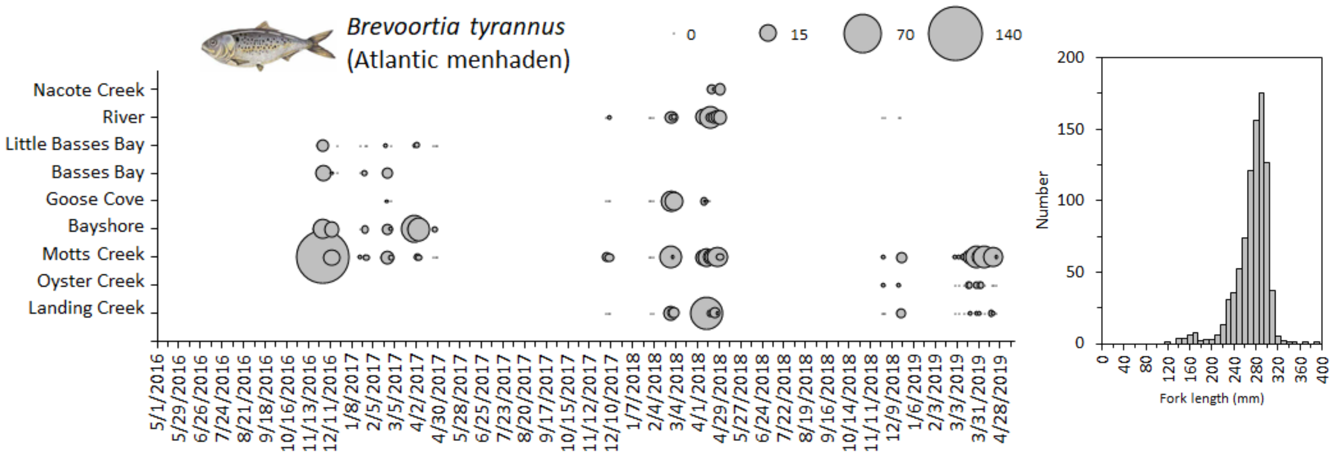
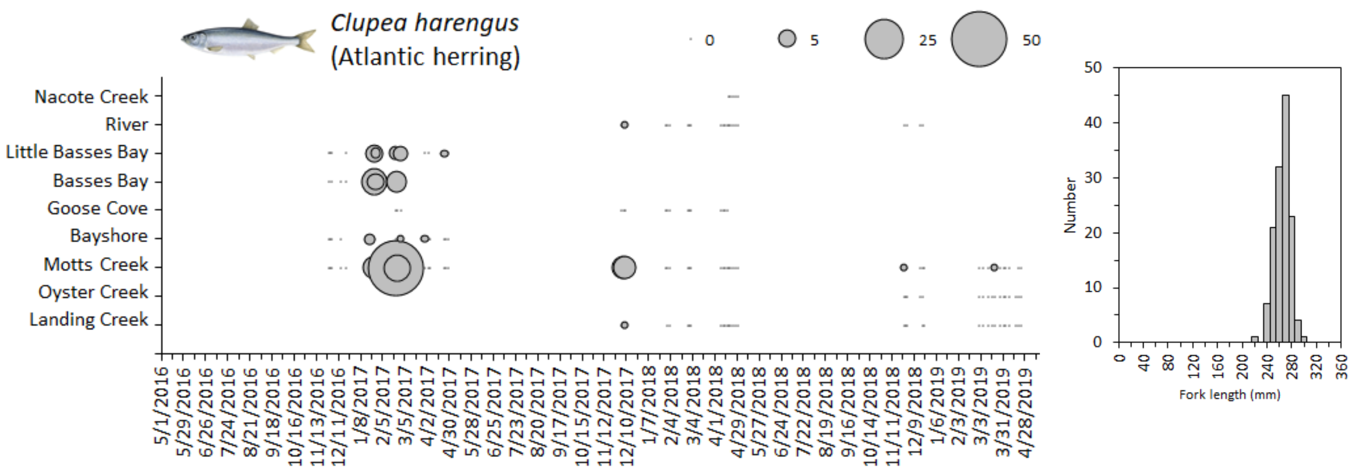


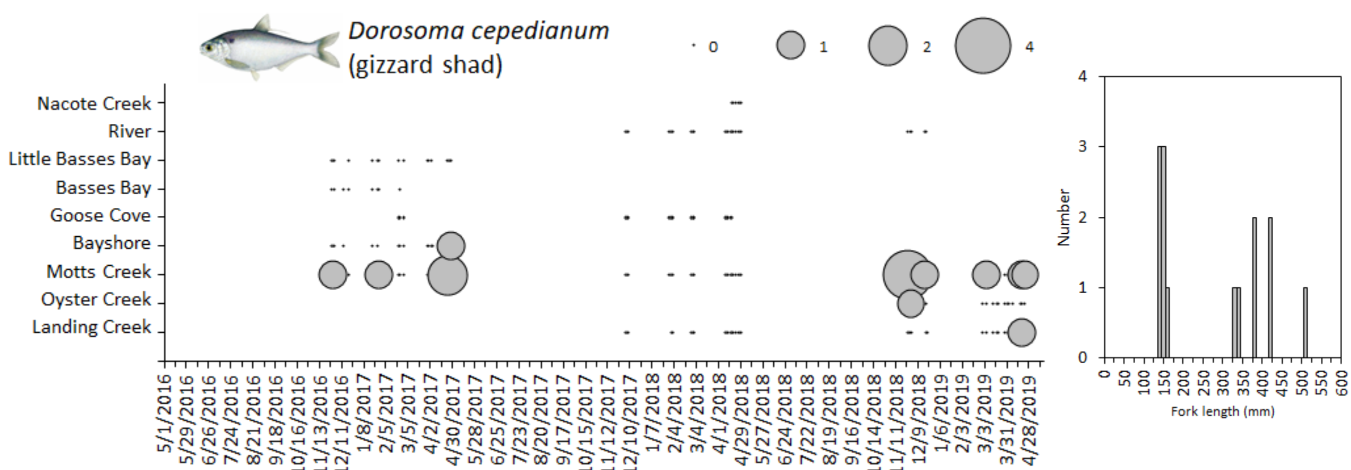
Figure 4 – (a) Schematic of general fyke net plot used throughout Figure 5. (b) Temperature contour plot derived from water quality data (note: winter haul seine data from Oyster Creek, Pebble Beach, and The Cuts used for contouring purposes – see Figure 2b).

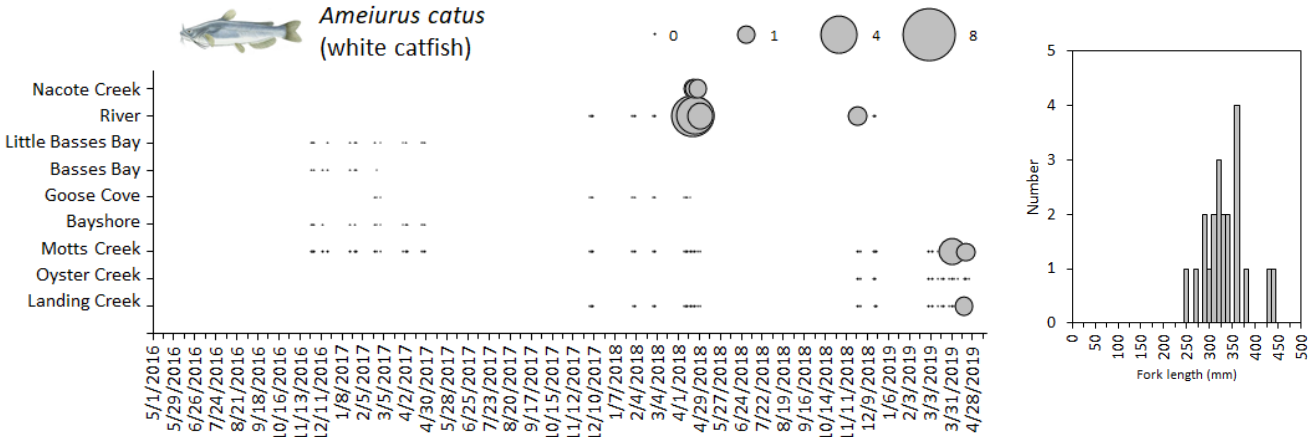
Figure 5 (24 species plots derived from fyke net)

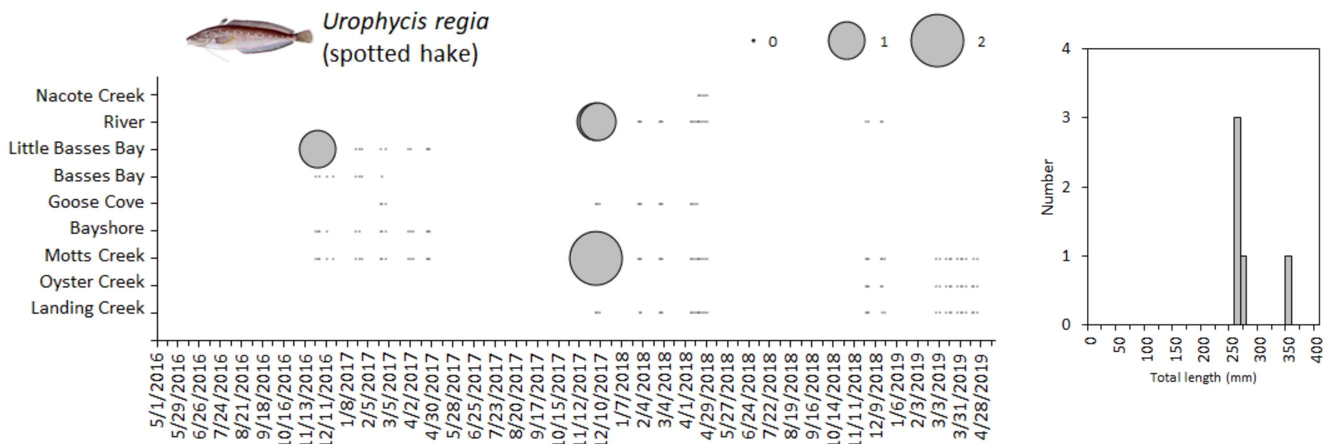


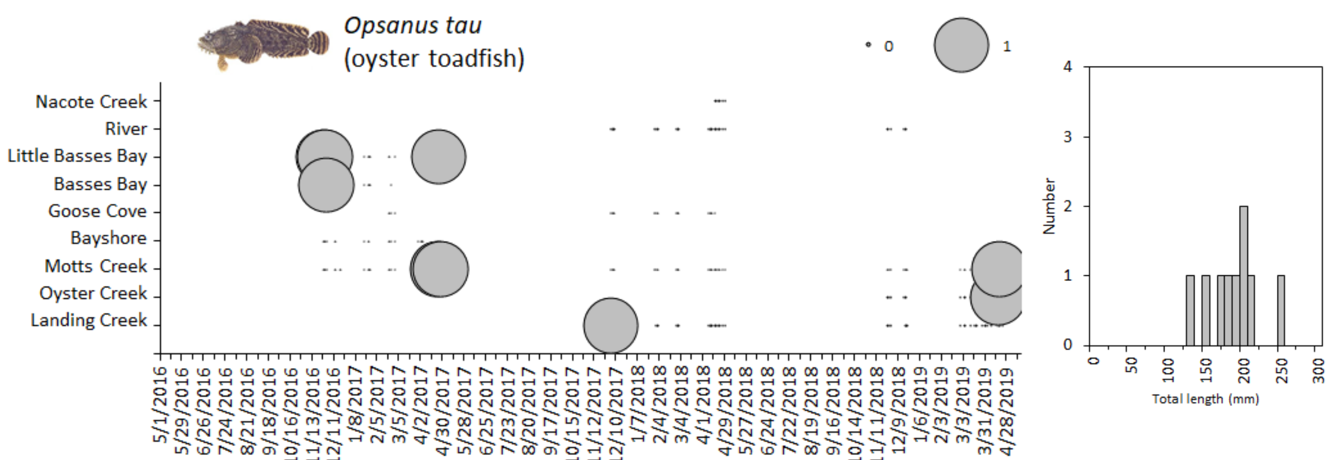

Brevoortia tyrannus
(Atlantic menhaden)
0
15
70
140
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)
0 50 100 150 200
0 40 80 120 160 200 240 280 320 360 400

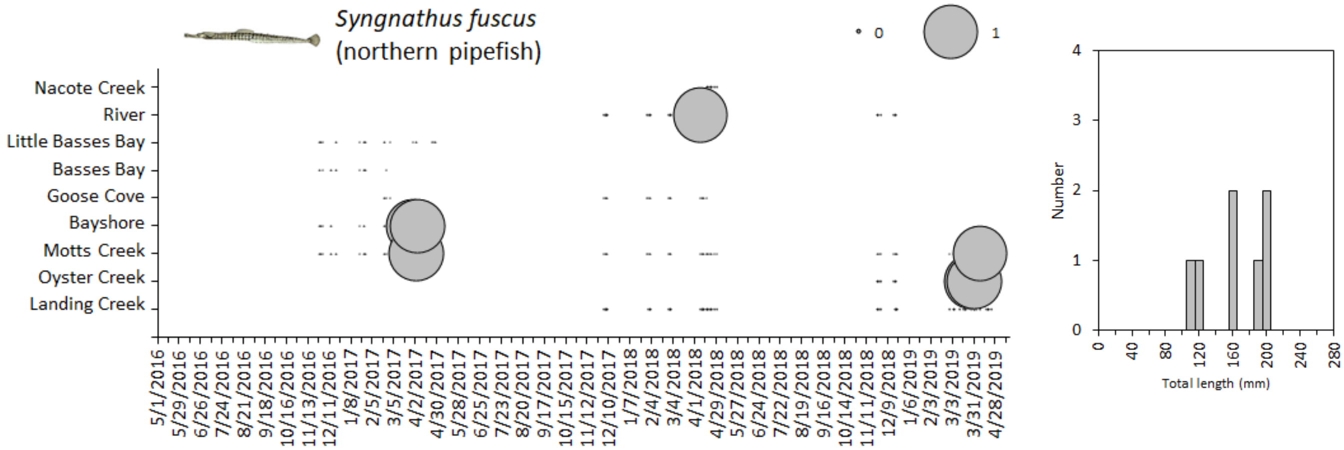

Clupea harengus
(Atlantic herring)
0
5
25
50
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)
0 10 20 30 40 50
0 40 80 120 160 200 240 280 320 360

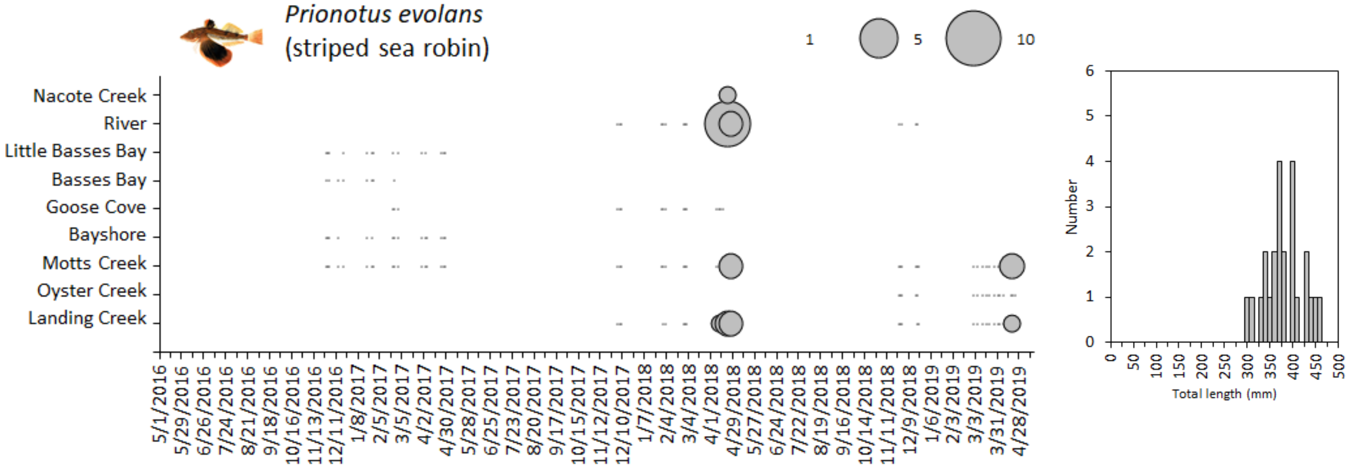

Dorosoma cepedianum
(gizzard shad)
0
1
2
4
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)
0 1 2 3 4
0 50 100 150 200 250 300 350 400 450 500 550 600

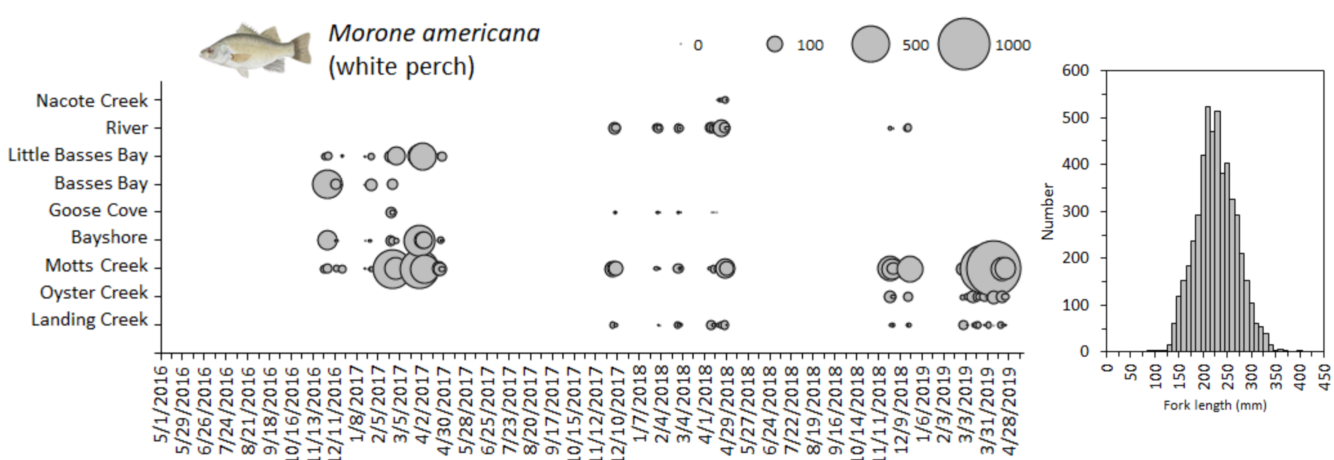

Ameiurus catus
(white catfish)
0
1
4
8
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
Fork length (mm)

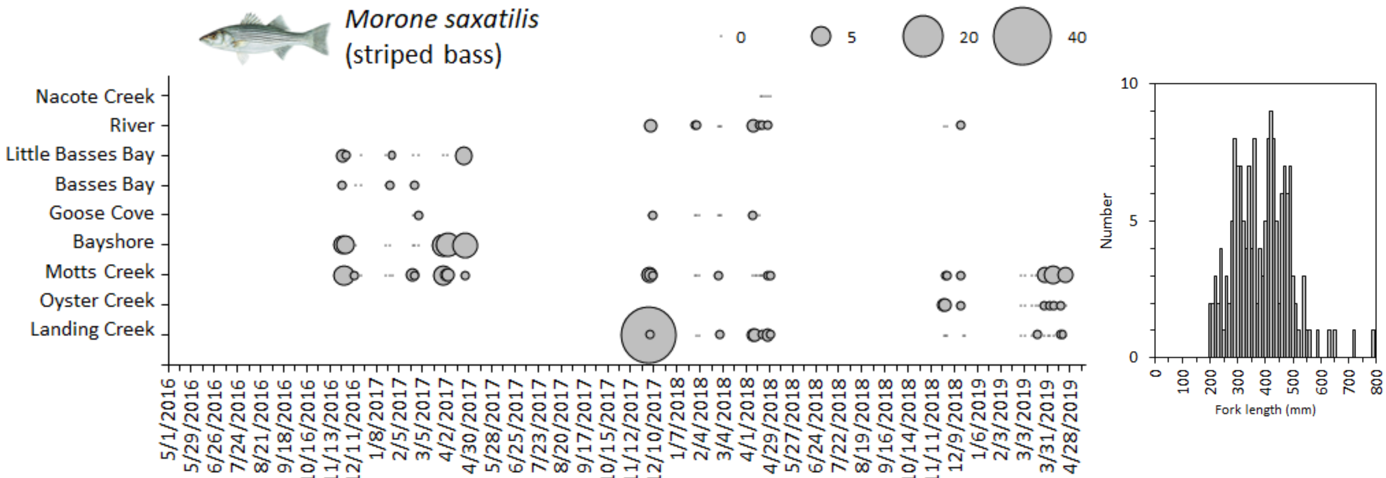

Urophycis regia
(spotted hake)
0
1
2
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
Number
Total length (mm)

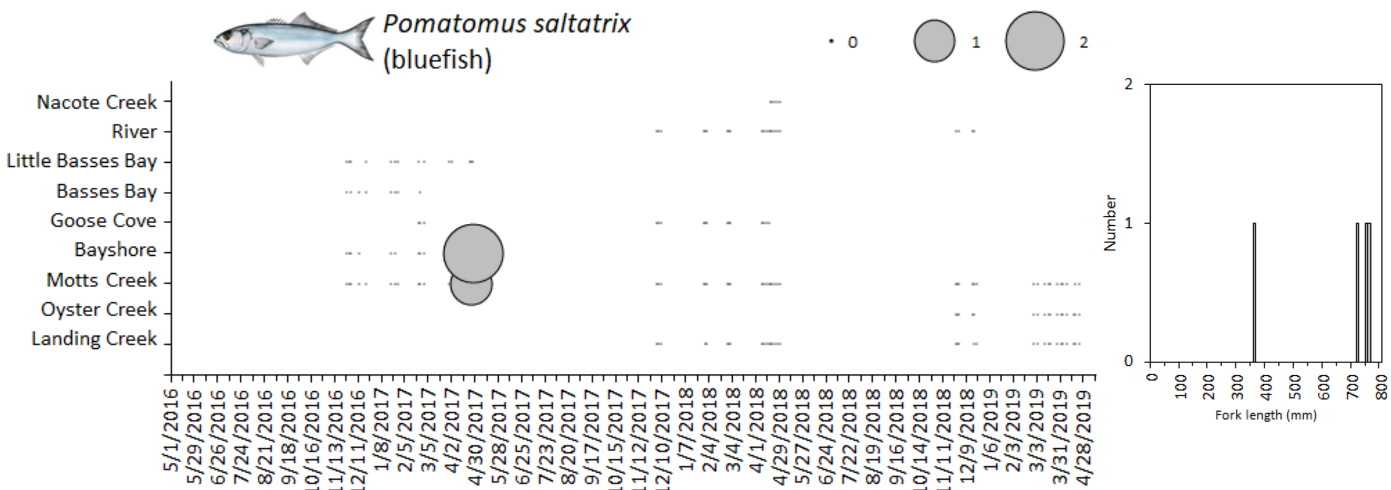

Opsanus tau
(oyster toadfish)
0
1
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
Number
Total length (mm)

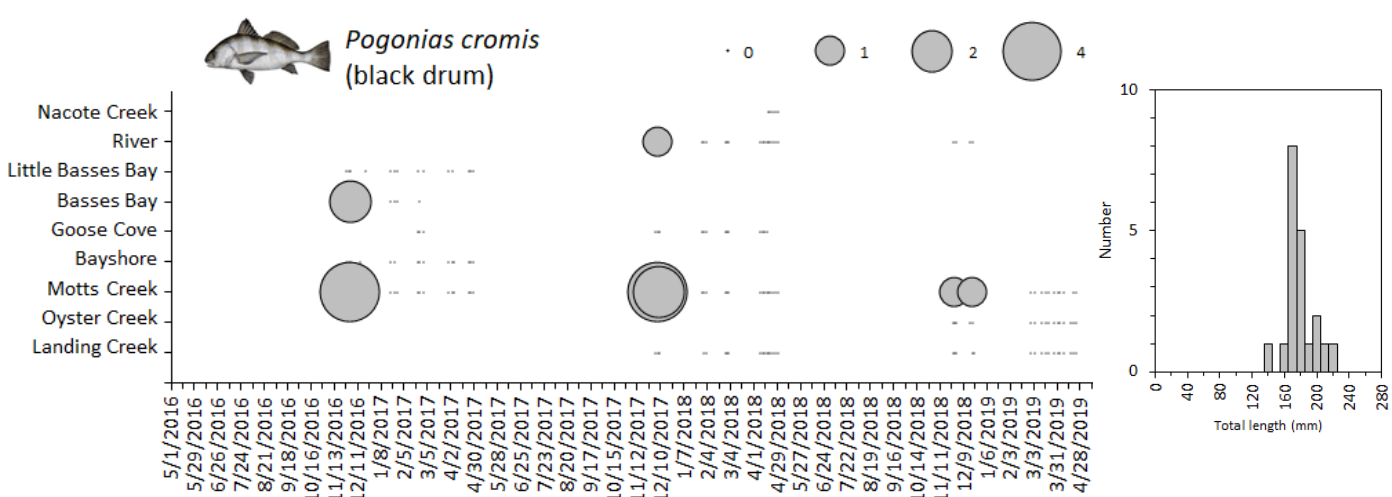

Syngnathus fuscus
(northern pipefish)
0
1
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
1
2
3
4
0
40
80
120
160
200
240
280
Total length (mm)


Prionotus evolans
(striped sea robin)
1
5
10
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
1
2
3
4
5
6
0
50
100
150
200
250
300
350
400
450
500
Total length (mm)

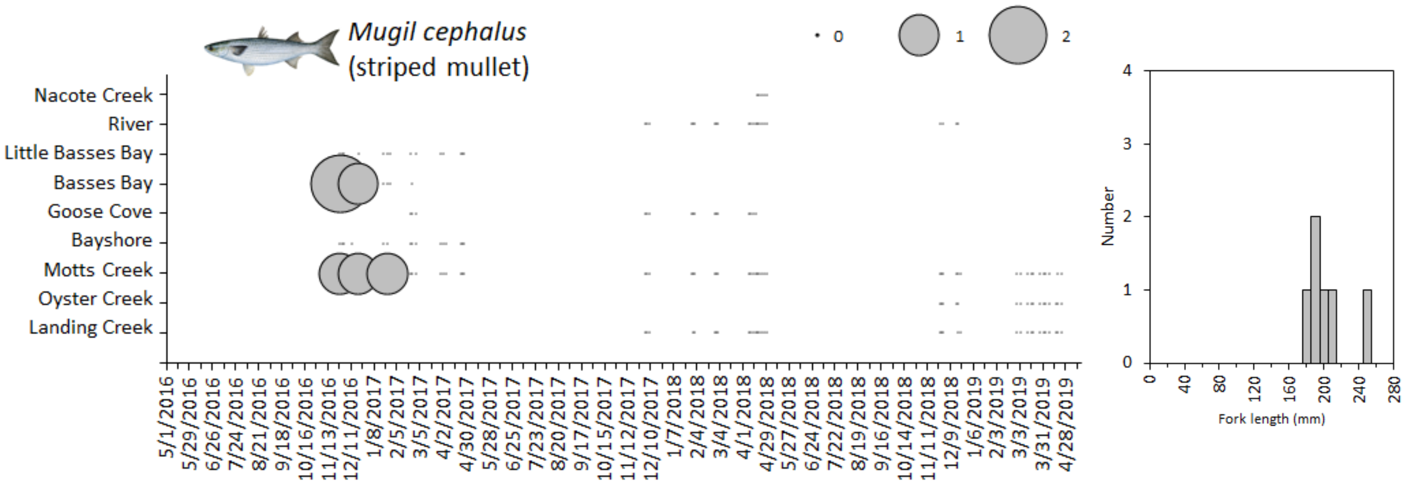

Morone americana
(white perch)
0
100
500
1000
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016
5/29/2016
6/26/2016
7/24/2016
8/21/2016
9/18/2016
10/16/2016
11/13/2016
12/11/2016
1/8/2017
2/5/2017
3/5/2017
4/2/2017
4/30/2017
5/28/2017
6/25/2017
7/23/2017
8/20/2017
9/17/2017
10/15/2017
11/12/2017
12/10/2017
1/7/2018
2/4/2018
3/4/2018
4/1/2018
4/29/2018
5/27/2018
6/24/2018
7/22/2018
8/19/2018
9/16/2018
10/14/2018
11/11/2018
12/9/2018
1/6/2019
2/3/2019
3/3/2019
3/31/2019
4/28/2019
Number
0
100
200
300
400
500
600
0
50
100
150
200
250
300
350
400
450
Fork length (mm)

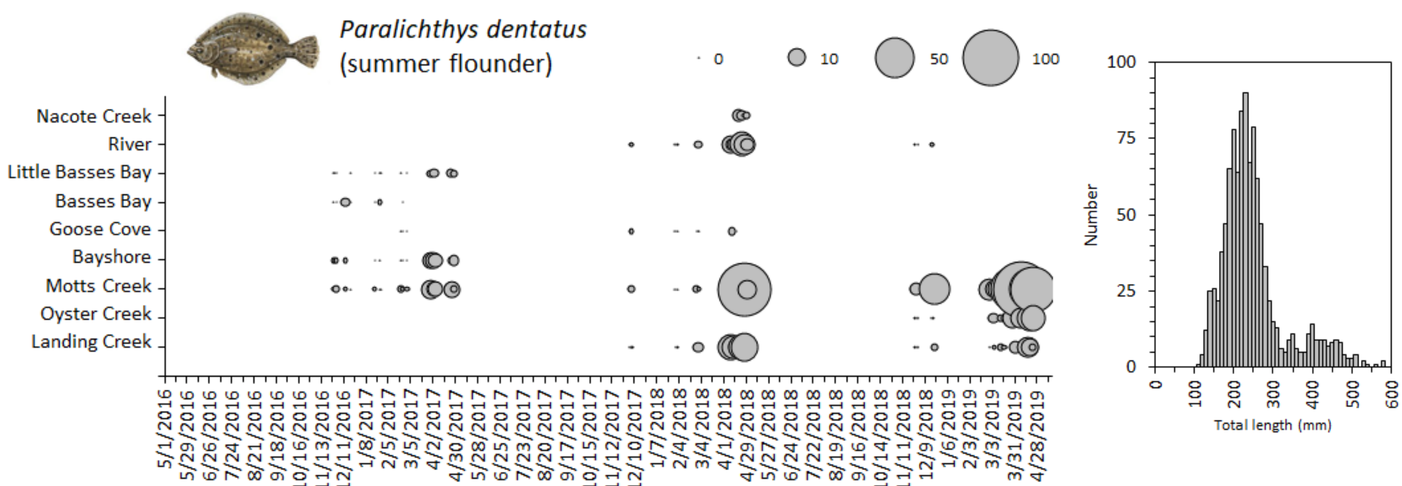

Morone saxatilis
(striped bass)
0
5
20
40
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)

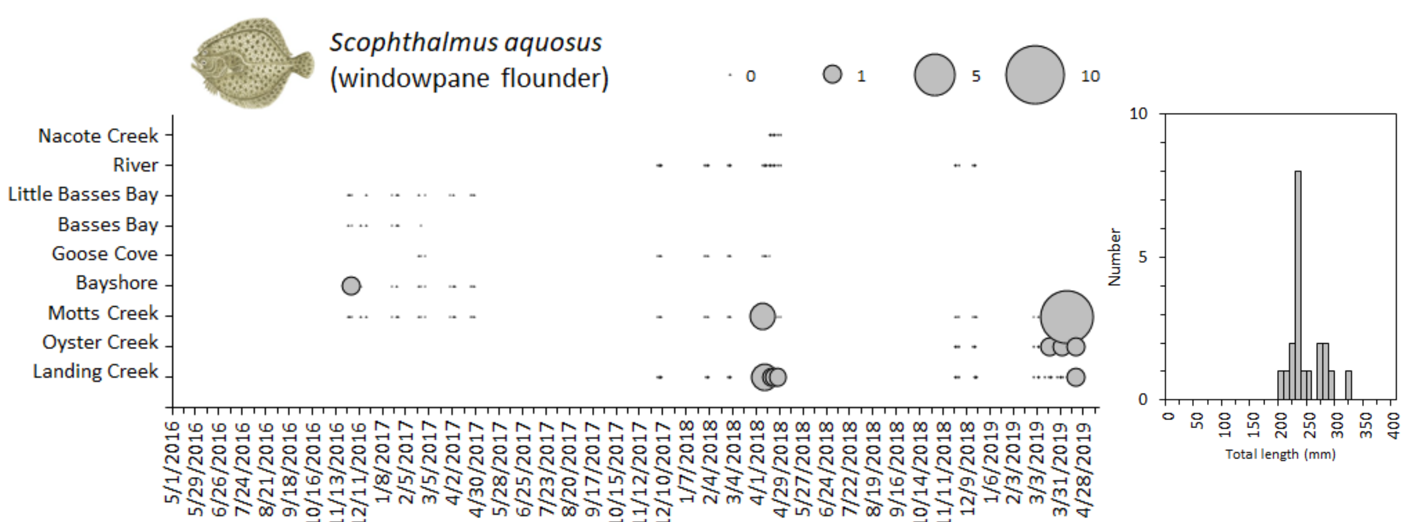

Pomatomus saltatrix
(bluefish)
0
1
2
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Fork length (mm)


Pogonias cromis
(black drum)
0
1
2
4
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
5/1/2016 5/29/2016 6/26/2016 7/24/2016 8/21/2016 9/18/2016 10/16/2016 11/13/2016 12/11/2016 1/8/2017 2/5/2017 3/5/2017 4/2/2017 4/30/2017 5/28/2017 6/25/2017 7/23/2017 8/20/2017 9/17/2017 10/15/2017 11/12/2017 12/10/2017 1/7/2018 2/4/2018 3/4/2018 4/1/2018 4/29/2018 5/27/2018 6/24/2018 7/22/2018 8/19/2018 9/16/2018 10/14/2018 11/11/2018 12/9/2018 1/6/2019 2/3/2019 3/3/2019 3/31/2019 4/28/2019
Number
Total length (mm)

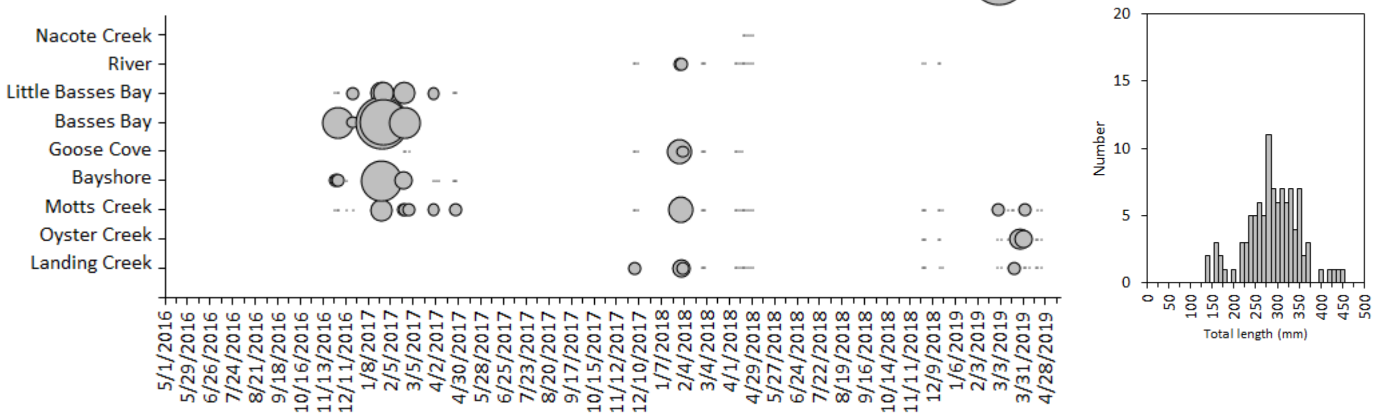
NJDEP Inventory Fyke Net Data (2016-2019)



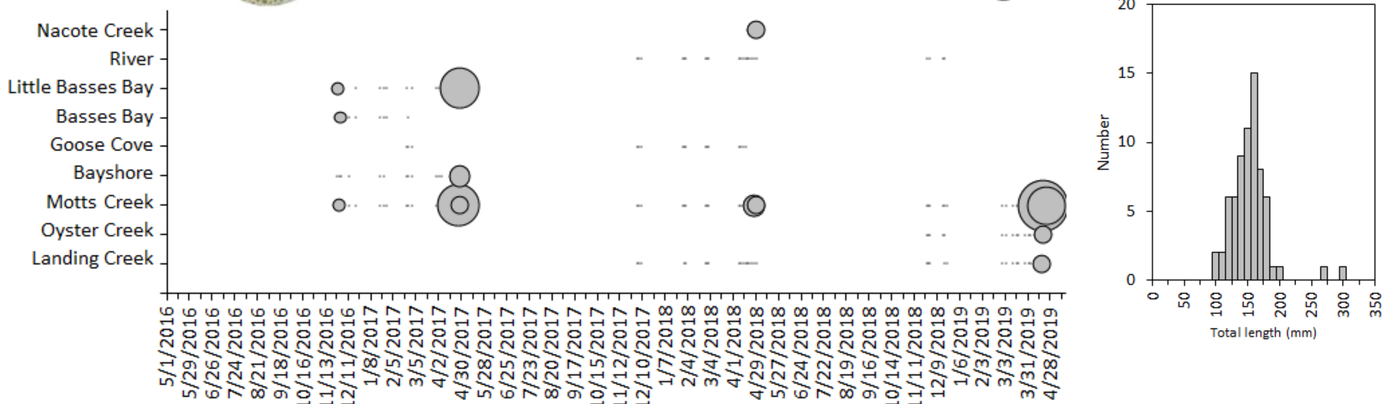




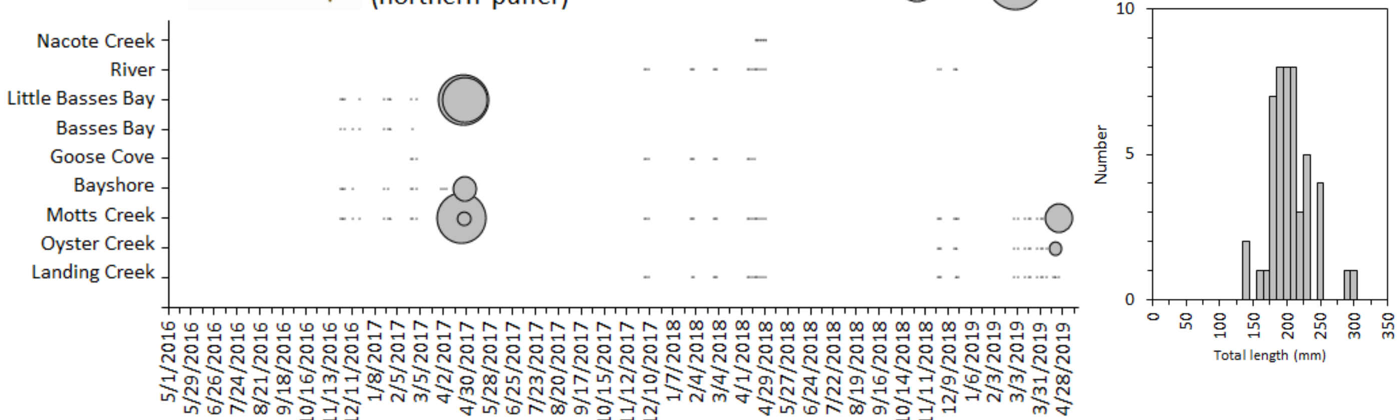
Pseudopleuronectes americanus
(winter flounder)

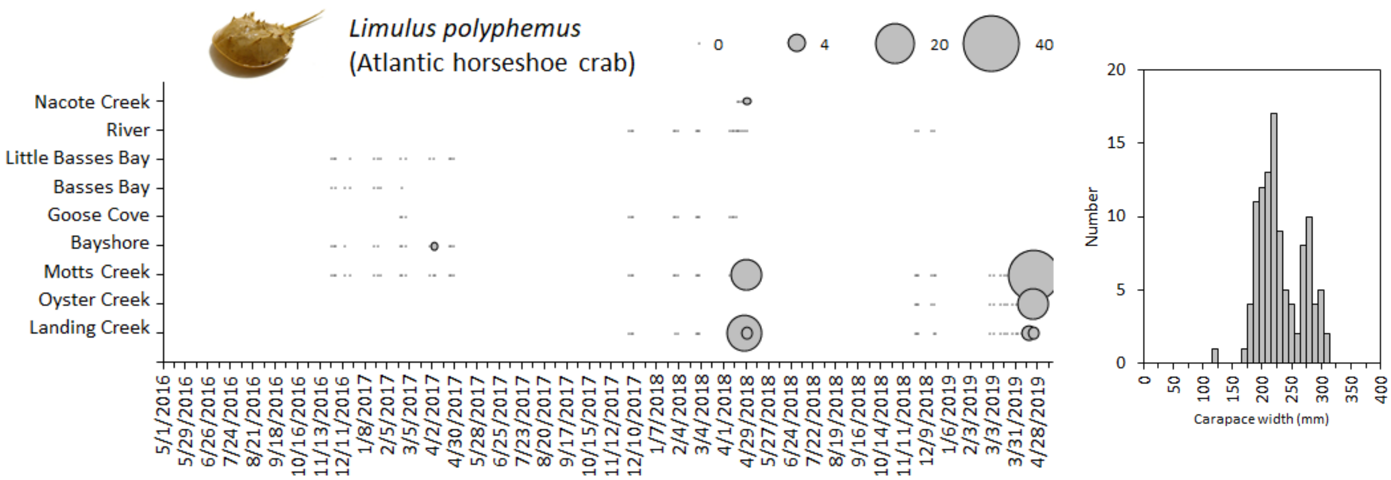


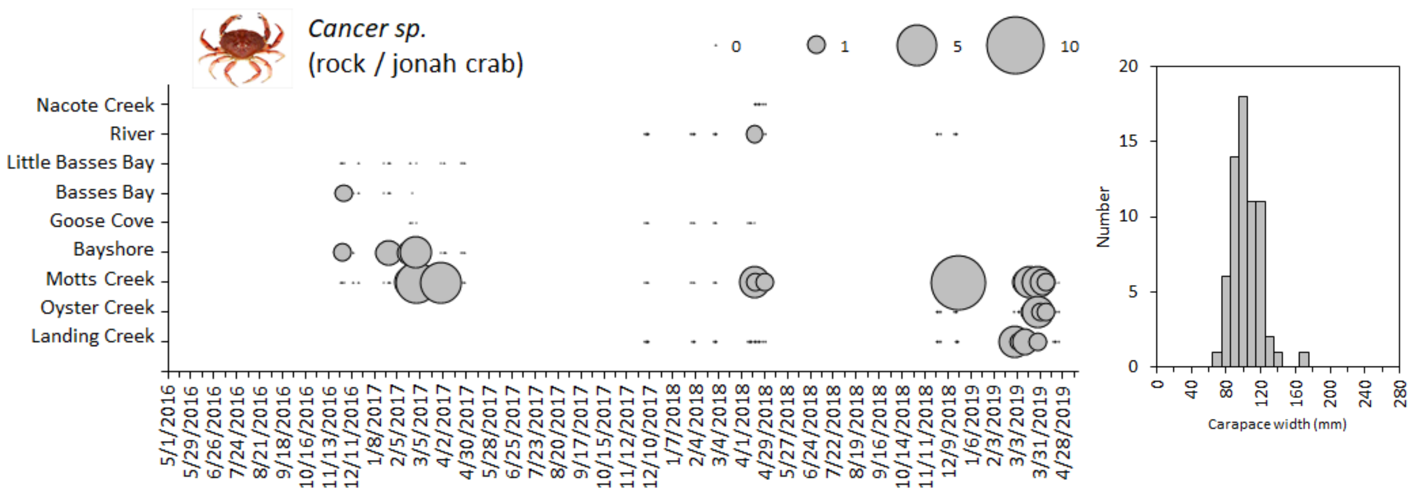
Trinectes maculatus
(hogchoker)

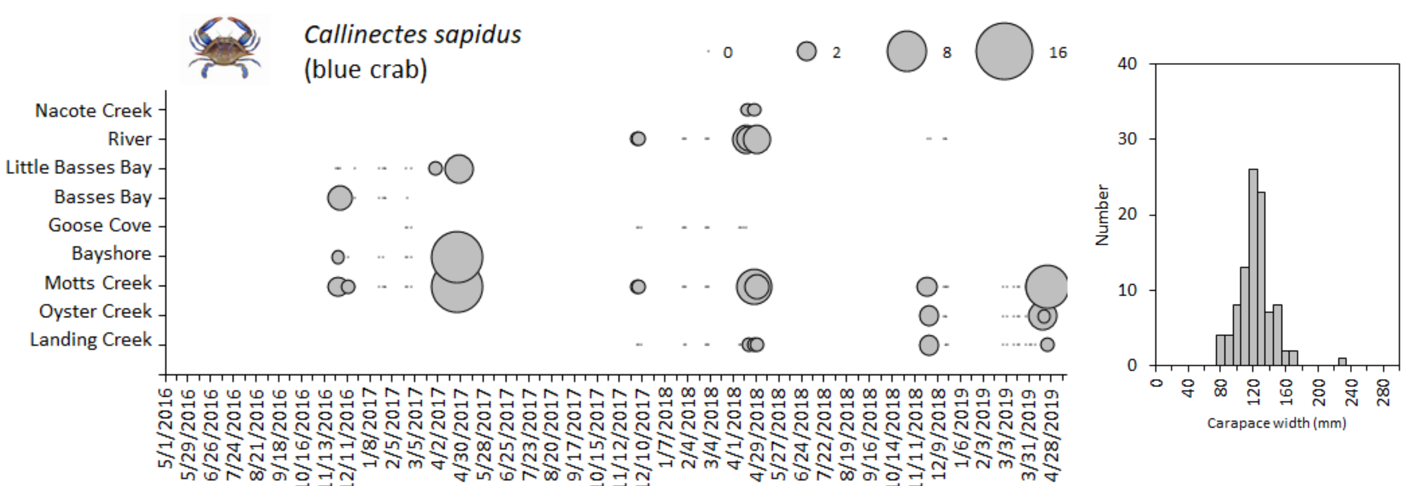


Sphoeroides maculatus
(northern puffer)




Limulus polyphemus
(Atlantic horseshoe crab)
0
4
20
40
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
Number
Carapace width (mm)


Cancer sp.
(rock / jonah crab)
0
1
5
10
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
Number
Carapace width (mm)


Callinectes sapidus
(blue crab)
0
2
8
16
Nacote Creek
River
Little Basses Bay
Basses Bay
Goose Cove
Bayshore
Motts Creek
Oyster Creek
Landing Creek
Number
Carapace width (mm)

Fyke net species notes:

Alosa pseudoharengus and *Alosa aestivalis* differentiated primarily by gut peritoneum color.

Length-frequency histograms extrapolated from sub-samples (i.e. 50 individuals measured expanded to entire catch at a given site) for all species except *Morone americana*.

Additional fish species collected in fyke net (n $\leq$ 4, not presented in plots):

Leucoraja ocellata (winter skate) (1)
Anguilla rostrata (American eel) (2)
Alosa sapidissima (American shad) (2)
Ictalurus punctatus (channel catfish) (2)
Fundulus heteroclitus (mummichog) (1)
Apeltes quadracus (fourspine stickleback) (1)
Centropristis striata (black sea bass) (1)
Micropterus salmoides (largemouth bass) (1)
Lagodon rhomboides (pinfish) (1)
Archosargus probatocephalus (sheepshead) (1)
Cynoscion regalis (weakfish) (1)
Leiostomus xanthurus (spot) (1)
Menticirrhus saxatilis (northern kingfish) (1)
Tautoga onitis (tautog) (2)
Peprilus triacanthus (butterfish) (1)

Appendix B – Project Outcomes (2016-2019)

Presentations

Sullivan, M., S. Evert, D. Ambrose, C. Beck, M. Nguyen, and J. Citro. New Jersey's coastal estuaries inventory: Connecting stakeholders, data, and managers for fisheries success. **148th Annual American Fisheries Society Meeting**, Atlantic City, NJ, August 2018 and **Atlantic Estuarine Research Society Fall Meeting**. Stockton University, October 2018.

Sullivan, M. and S. Evert. New Jersey's coastal estuaries inventory: Connecting stakeholders, data, and managers for fisheries success. **New Jersey Department of Environmental Protection Marine Fisheries Research Seminar**, Trenton, NJ, March 2017.

Sullivan, M, S. Evert, C. Capri, D. Ambrose, N. Robinson, E. Zimmermann, T. Fuchs, S. Crowley, T. Johnson, and C. Barber. New Jersey's coastal estuaries inventory: Preliminary seine results from the Mullica River-Great Bay Estuary, NJ. Poster, Mid-Atlantic Chapter of the American Fisheries Society Annual Meeting, Bordentown, NJ, October 2016.

Outreach Publications

Sullivan, M. and S. Evert. What's in Your Estuary? Stockton School of Natural Sciences and Mathematics Essential Elements E-zine. Summer 2018.

Data / Sample Sharing

Parry, D., P. Lopez-Duarte, J. Valenti, K. Able, and O. Jensen. Distinguishing juvenile **striped bass** habitats and spawning sites using otolith microchemistry. Poster presentation. 148th Annual American Fisheries Society Meeting, Atlantic City, NJ, August 2018.

Able, K. and T. Grothues. **Alewife** spawning and nursery areas in a sentinel estuary. Draft ms.

Stoeckle, M. Barnegat Bay fish environmental DNA localized in space (samples used: **rainwater killifish, feather blenny**). Program for the Human Environment, The Rockefeller University.

Panyi, A. Insights into food web dynamics through trophically-transmitted parasites (samples used: **Atlantic silverside, Mummichog**). MS thesis, University of Southern Mississippi.

Stockton University Undergraduate / Graduate Student Mentoring

Kooker, J. and J. Anzalone. Web-based portal development for coastal inventory seine data (DSSA 5302 Data Practicum). Stockton University Data Science and Strategic Analytics Master's Degree (Advisors: Dr. Russell Manson, M. Sullivan). Summer 2019.

Kehoe, L. Habitat mapping of juvenile winter and summer flounder (*Pseudopleuronectes americanus*, *Paralichthys dentatus*) in the Mullica River-Great Bay Estuary (NJ) with progress towards a habitat suitability index using ArcMap. NAMS Research Symposium, Stockton University, April 2019.

Risch, K. Evaluation of bluefish (*Pomatomus saltatrix*) cohort-splitting from a fishery independent seine survey in the Mullica River-Great Bay Estuary (NJ). NAMS Research Symposium, Stockton University, April 2019.

Belardo, A., **B. Ritchie**, **J. Anzalone**, **L. Kehoe**, **A. Esteves**, **K. Wiegel**, **R. Buchan**, and **A. Kilic**. Assessing white perch (*Morone americana*) and Atlantic striped bass (*Morone saxatilis*) abundance through cooperative fisheries research in Great Bay, New Jersey. NAMS Research Symposium, Stockton University, April 2018.

Anglero, A., **J. Dominick**, and **K. McLean**. Shifting migration patterns in Great Bay, NJ summer flounder (*Paralichthys dentatus*): here to stay or just a fluke? NAMS Research Symposium, Stockton University, April 2017.

25+ individual student field technicians and volunteers (current status of select participants below)

Colby Capri – R/V Seawolf, Stony Brook University
Taylor Fuchs – New Jersey Aquaculture Innovation Center
Chase Barber – NJ Fish & Wildlife Access Point Angler Intercept Survey (APAIS)
Collen Beck - NJ Fish & Wildlife Access Point Angler Intercept Survey (APAIS)
Joe Citro – NJ Fish & Wildlife Freshwater Fisheries Technician
Michael Nguyen – Monmouth U. Research Experiences for Undergraduates (REU)
Liam Kehoe – Gulf of Maine Research Institute (GMRI) REU
Kevin Risch - NJ Fish & Wildlife Marine Fisheries Technician
Stephanie Ball – Stockton SEAS Program student liaison
Clare Maloney–Undergraduate, UMASS-Amherst Dept. of Environmental Conservation

Stockton University Course-Based Undergraduate Research Experiences (CURE)

MARS 1200 - Introduction to Marine Biology (2016-2018): Annual multi-day project sampling (seine), data entry, introductory data analysis with Pivot Tables, lab report (**82 students**, Instructor: M. Sullivan).

MARS 3307 - Fisheries Science and Management (2017-2019): Annual multi-day project sampling (fyke), group project with data analysis (2017), written student reflection (**69 students**, Instructor: M. Sullivan).

MARS 3340 - Introduction to Ichthyology (2016-2018): Annual multi-day project sampling (seine) w/ emphasis on species and family-level identification for course practical exam, multi-media student reflection (**83 students**, Instructor: M. Sullivan). Annual single day project sampling and data sharing with Rowan College at Gloucester County (RCGC) Marine Biology and Wetlands Field Ecology students (**18 students**, RCGC lead: Dr. Jessica DeGraff).

MARS 3746 – New Jersey Field Ichthyology (2018): Multi-day project sampling (fyke), data entry, data analysis, final group project, written student reflection (**8 students**, Instructor: M. Sullivan).

GNM 1123 - Honor's Fisheries in Crisis (2019): Single day project sampling, group project on industry-science collaborations in fisheries (fyke net) (**14 students**, Instructor: M. Sullivan).

New Jersey High School Student Training

Stockton University Science Enrichment Academy (SEAS) (2016-2018): Annual single-day project sampling (fyke) with talented high-school students entering their senior year, data entry, introductory data analysis, final project (**42 students**, SEAS lead: David Furgione).

Edwin B. Forsythe National Wildlife Refuge Environmental Education Internship (2018): Single day project sampling (seine) with high school summer interns (**4 students**, Forsythe lead: Robin McClain).

Stockton School of Natural Sciences and Mathematics (NAMS) Research Symposium posters

Shifting migration patterns in Great Bay, NJ summer flounder (*Paralichthys dentatus*): here to stay or just a fluke?

Stockton University undergraduate students: Angelica Anglero (ENVL), Jessie Dominick (MARS), Kathleen McLean (MARS)

Abstract:

Fishery independent studies are critical to document abundance trends in commercially and recreationally important finfish as well as formulate testable hypotheses for future work. Given its recent controversial stock status, summer flounder (*Paralichthys dentatus*) is one such species that invites further examination. Summer flounder inhabit sandy bottoms of bays and estuaries in summer and typically move offshore to the shelf in fall. Using a combination of haul seines and fyke nets, this study conducted a basic inventory to track cohorts of summer flounder (and other finfish) in the Mullica River–Great Bay Estuary, NJ. Abundance and length by site were collected with physical parameters to better understand estuarine distribution of summer flounder. Contrary to expectation, young-of-the-year and older juveniles remained in the estuary during winter. Several hypotheses are suggested to help understand the mechanisms behind these observations.

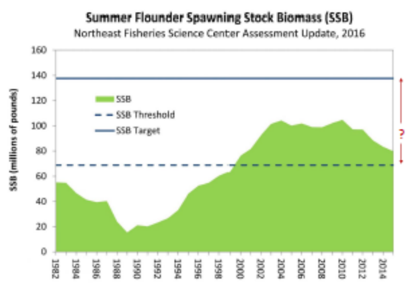


Fig. 1 – Summer flounder spawning stock biomass (SSB) from 1982-2015. The dotted line represents the SSB threshold, if crossed the sustainability of the stock is threatened. In 1988, the population fell drastically. The population has since rebounded, but is not considered fully rebuilt to the SSB target (ASMFC 2015).

Fig. 2 – Seine (blue) and fyke (orange) net sampling locations in the Mullica River-Great Bay Estuary.

Introduction:

- The Mullica River-Great Bay Estuary (MRGB) is a drowned river valley that provides nursey habitat for a variety of commercially and recreationally important finfish species.
- Recently, the Atlantic States Marine Fisheries Commission (ASMFC) approved a 34% reduction in the state's recreational quota for summer flounder (*Paralichthys dentatus*) due to low recruitment in recent years (NJDEP 2017).
- Fishery independent surveys are critical to help better document these fluctuating trends in abundance and formulate testable hypotheses for future work (Able 2016).
- In Great Bay, NJ, summer flounder inhabit sandy bottoms of bays and estuaries in summer - as fall comes to a close they typically move offshore to the shelf (Able et. al. 1990).
- This study uses fishery independent surveys to track summer flounder seasonally in the MRGB.

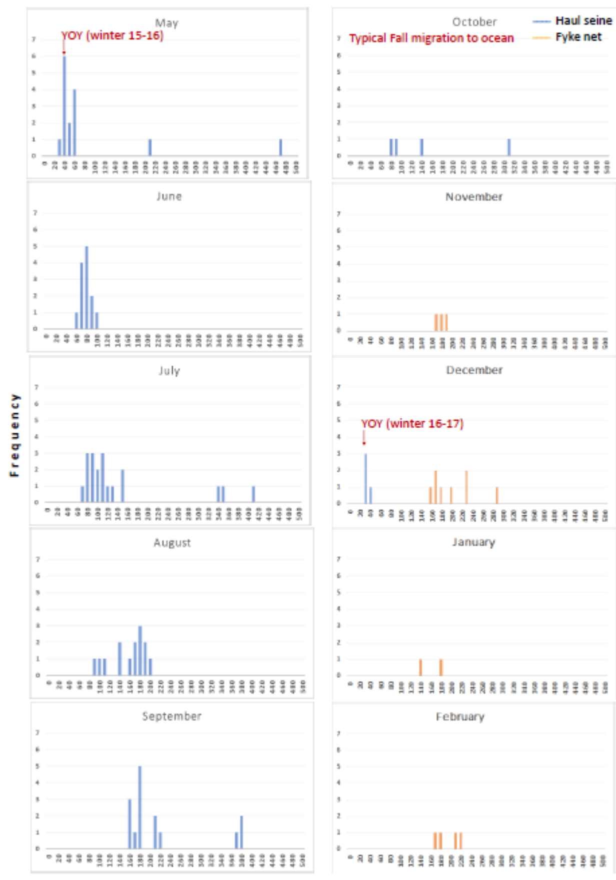


Fig. 3– Summer flounder length frequencies inventoried over two gear types - seine (blue) and fyke (orange) in the MRGB.

Fig. 4– (left – photo credit, TJ Johnson) 100 foot haul seine deployment (middle – photo credit, D Ambrose) Sorting a fyke net catch (right – photo credit, E Zimmermann) Typical fyke net catch (summer flounder visible in lower right).

Methods

- Haul seines were conducted bimonthly through summer-fall (once per month in winter-spring). Fyke net sets were conducted once per month in winter-spring (with a commercial fyke net partner).
- All finfish were identified, counted, and measured to fork or total length.
- Water temperature, salinity, dissolved oxygen, and pH recorded with a YSI.
- Data entered into Microsoft Excel, quality controlled, and assembled into one database.
- Microsoft Excel PivotTable function used to filter data for summer flounder.

Acknowledgements: *Stockton University Principal Investigators:* Mark Sullivan, Steve Evert; *Stockton University Marine Field Station support:* Colby Capri, David Ambrose, Nathan Robinson, Elizabeth Zimmermann; *Commercial partner (fyke net collections):* Newt Sterling; *Stockton University course student support:* Fall 2016 Introduction to Ichthyology, Fall 2017 Fisheries Science and Management; *Funding generously provided by:* NJ Department of Environmental Protection.

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ASMFC. 2015. Summer Flounder stock status; http://www.asmfc.org/uploads/file//560c5737SummerFlounderStockStatus_2015.pdf
Able, K.W. 2016. Natural history: an approach whose time has come, passed, and needs to be resurrected. ICES J. Mar. Sci. 73(9).
Able, K.W. et. al. 1990. Patterns of summer flounder early life history in the Mid-Atlantic Bight and New Jersey estuaries. Fish. Bull. 88.
Rountree, R.A. 2001. Retrieved from Fish Ecology.org; http://www.fishecology.org/diets/flukesem.htm

Results:

- Few juvenile summer flounder were expected based on recent stock assessments.
- Two summer flounder YOY cohorts were successfully tracked over the two gear types.
- All sites were not equal, juveniles (and several adults) were caught primarily at two mid-estuary sites.
- Likely offshore migration was observed in October, however, (contrary to expectation) larger juveniles remained in the estuary during the winter months.

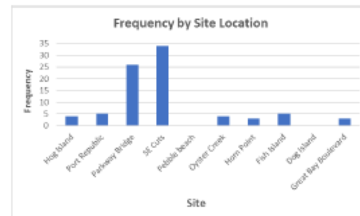

Fig. 5 – Total catch of summer flounder across all seine haul sites.

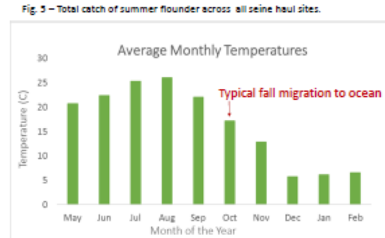

Fig. 6 – Average monthly water temperatures across all sites sampled.

Conclusions and Future Work:

- Inventory studies are critical for assessing stocks and developing testable hypotheses for future work.
- Although few summer flounder were expected to be caught in the estuary during the winter months, juveniles remained in the estuary based on fyke net collections.

- The following null hypotheses warrant further investigation:
- **Null Hypothesis 1:** No difference in summer flounder juvenile growth rates between warm and cold winters within estuary.
- **Null Hypothesis 2:** No significant difference in summer flounder juvenile growth rates between estuarine and shelf habitats.

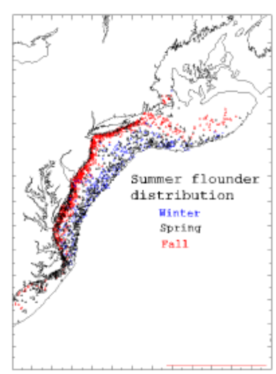

Fig. 7 – Summer flounder distribution by season (Rountree 2001).

Assessing White Perch (*Morone americana*) and Atlantic Striped Bass (*Morone saxatilis*) Abundance Through Cooperative Fisheries Research in Great Bay, New Jersey

Stockton University students: Anna Belardo (MARS), Brieanne Ritchie (MARS), Joshua Anzalone (PHYS, MATH, BIOL), Liam Kehoe (MARS)
Amanda Esteves (MARS), Kylie Wiegel (MARS), Rachel Buchan (ENVL), Ayshe Kilic (MARS, PHYS)

Abstract:

Fishery independent research is critical to document abundance trends in commercially and recreationally important finfish as well as formulate testable hypotheses for future work. Using an array of fyke nets tended cooperatively by a commercial fisher, this research conducted a winter / spring inventory of white perch (*Morone americana*) and Atlantic striped bass (*Morone saxatilis*) abundance in Great Bay, NJ from November 2016 - April 2018. Abundance and length information were collected and combined with YSI water quality data and archived weather data to better understand the distribution of these two moronid species during a seasonally under-sampled time period. Abundance and environmental data suggest lower numbers of white perch in 2017/18 may be the result of a bay-wide freezing event coupled with higher-than-average snowfall / precipitation. Future work is needed to test the mechanisms behind these initial observations.

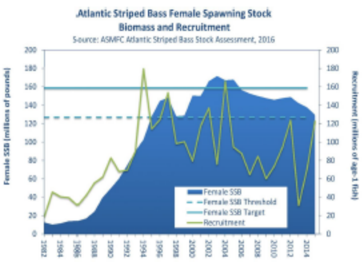

Fig. 1 – Female spawning stock biomass and recruitment from 1982-2015 for *Morone saxatilis*. Graph courtesy of the Atlantic States Marine Fisheries Commission.

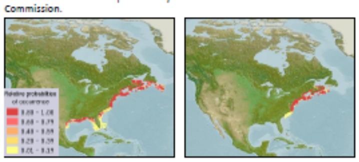

Fig. 2 – Distribution probabilities along the US East Coast for *Morone saxatilis* (left) and *Morone americana* (right). Images courtesy of FishBase.

Introduction:

- The Mullica River-Great Bay Estuary (MRGB) is a drowned river valley that provides nursery and adult habitat for a variety of commercially and recreationally important finfish species.
- Fishery independent surveys are critical to help better document these fluctuating trends in abundance and formulate testable hypotheses for future work (Able 2016).
- *Morone americana* and *Morone saxatilis* (two migratory moronids – Fig. 2) are mobile predators present in Great Bay, NJ during the winter / spring months, yet frequently under-sampled by scientists.
- Formal stock assessment information for *M. americana* is absent from this region while *M. saxatilis* female spawning stock biomass has been declining in recent years (Fig. 1; ASMFC 2016).
- Both species were successfully sampled by a local commercial fyke net partner from 2016-2018.

Fig. 3 – Fyke net sampling locations and continuous water quality station in Great Bay, NJ (2016-2018). Data produced with Google Earth.

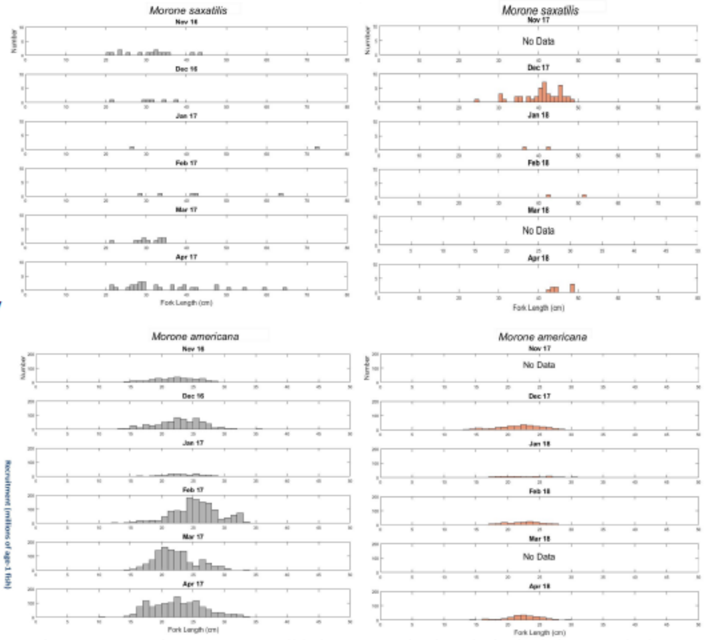

Fig. 4 – Length-frequency histograms for *Morone saxatilis* (top) and *Morone americana* (bottom) during winter/spring 2016-2017 (gray) and winter/ spring 2017-2018 (orange). No data collected during November 2017 and March 2018.

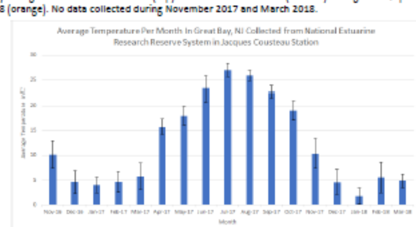

Fig. 5 – Average monthly water temperature (°C) at the Chestnut Neck Boatyard (Mullica River-Great Bay Estuary, NJ) from November 2016 to March 2018. Data downloaded from the National Estuarine Research Reserve Centralized Data Management Office.

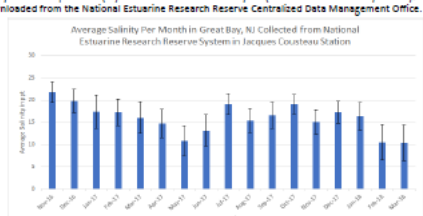

Fig. 6 – Average monthly salinity (ppt) at the Chestnut Neck Boatyard (Mullica River-Great Bay Estuary, NJ) from November 2016 to March 2018. Data downloaded from the National Estuarine Research Reserve Centralized Data Management Office.

Fig. 7 – (L-R) Students on Stockton's R/V Skimmer. YSI water quality data collection. A catch of *Morone americana*. Fyke net operations (background).

Methods

- Fyke net sets (upper, mid-bay) were conducted 3 days per week/once per month in winter-spring with a commercial fyke net partner supported by NJ Department of Environmental Protection (Figs. 3, 7, 8).
- All finfish were identified, counted, and measured to fork or total length (Fig. 7).
- Water temperature (°C), salinity (ppt), dissolved oxygen (mg/l), and pH recorded with a YSI (Fig. 7).
- Data entered into Microsoft Excel and quality controlled. Fish length frequencies plotted with MATLAB.
- Additional water quality data (collected at the Chestnut Neck Boatyard) downloaded from the National Estuarine Research Reserve Centralized Data Management Office (Fig. 3).
- Corresponding atmospheric data at Atlantic City, NJ downloaded from Weather Underground.

Results:

- *M. americana* catch was lower between winter/spring sampling periods (2016-17, 2017-18). *M. saxatilis* catch was of a similar magnitude between sampling periods, with consistently higher abundance in November / December and March / April (Fig. 4).
- Great Bay froze in early January 2018 due to 3°C lower than average water temperatures (Fig. 5).
- Average salinity was lower in February and March 2018 compared to previous sampling period (Fig. 6).
- Data from Weather Underground indicate total precipitation in February 2017 was 34.79 mm compared to 163.32 mm in February 2018.
- Lower salinity in February and March 2018 may have resulted from a high influx of fresh water due to precipitation and ice melt.

Fig. 8 – Winter/spring 2016-2017 sampling operations (high abundance of *M. americana* visible in fish tote).

Conclusions and Future Work:

- Inventory studies are critical for assessing stocks and developing testable hypotheses for future work.
- Additional data is needed to determine a mechanism driving the lower observed abundance of *M. americana*.
- *M. americana* is semi-anadromous, undergoing migrations related to temperature and salinity cues (Murdy et al. 2013).
- *M. americana* typically occupies temperatures between 4.7-18.2°C with a mean of 10.2°C.
- During winter/spring 2017-18, *M. americana* may have sought refuge in deeper, thermally stable water outside of fyke net range. Similarly, migratory behavior may have been triggered by changes in salinity.
- Future research using expanded fyke net stations and/or acoustic tracking could be implemented to test these hypotheses.

Acknowledgements:

Special thanks: David Ambrose (NJDEP Inventory lead technician) and Newt Sterling (commercial fyke net partner); *Stockton Principal Investigators*: Mark Sullivan, Steve Evert; *Stockton Marine Field Station support*: Nathan Robinson, Elizabeth Zimmermann, Colby Capri; *Stockton course student support*: Spring 2018 NJ Field Ichthyology, Spring 2018/Spring 2017 Fisheries Science and Management, Spring 2017 Independent Study Students: Angelica Anglero, Jessie Dominick, Kathleen McLean; *Funding generously provided by:* NJ Department of Environmental Protection.

References:

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Evaluation of bluefish (*Pomatomus saltatrix*) cohort-splitting from a fishery independent seine survey in the Mullica River-Great Bay Estuary (NJ)

Stockton University undergraduate student: Kevin Risch (ENVL)

In fulfillment of ENVL 4800 senior project. Faculty mentor: Dr. Mark Sullivan; ENVL project coordination: Dr. Emma Witt

Abstract:

Fishery independent surveys are useful for monitoring fish population trends over time (in combination with landings data from recreational and commercial efforts). Over three years, a 100-foot haul seine was used to survey 10 sites in the Mullica River-Great Bay Estuary (New Jersey) as part of a broader state coastal inventory project. One common economically and ecologically important species collected through this effort is bluefish (*Pomatomus saltatrix*). Bluefish juveniles exhibit bimodal or "split" cohort patterns (spring, summer spawned) within multiple estuaries along the U.S. East Coast. Various hypotheses have been proposed to explain the observed variability in these cohorts (water temperature, physical oceanography, cannibalism). Length and abundance data from bluefish collected in the present study were used to evaluate two main questions related to bluefish "cohort splitting": 1) Are multiple cohorts detectable within this survey design? 2) If so, which cohort is dominant? Given the relatively short time series available, future work is proposed to evaluate the factors driving cohort timing and abundance trends in this survey.

Fig. 1 – Example of a spring-spawned bluefish collected in September.

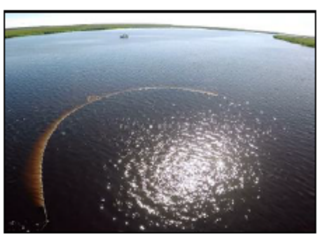

Fig. 2 – 100-foot haul seine deployed at Hog Island site (drone credit: TJ Johnson).

Introduction:

- The Mullica River-Great Bay Estuary (MRGB) is a drowned river valley that provides nursey habitat for a variety of commercially / recreationally important fish species.
- Bluefish (Fig. 1) are estuarine habitat generalists and typically arrive in two separate young-of-the-year cohorts along the US East Coast (Fig. 5).
- Multiple hypotheses have been proposed to address variability in cohort timing and abundance (growth rate, ocean temperature, wind direction, cannibalism by spring spawners).
- Identifying presence / absence of two cohorts within a sampling program is an important first step for evaluating underlying recruitment mechanisms.

Bluefish young-of-the-year abundance / length frequency by year

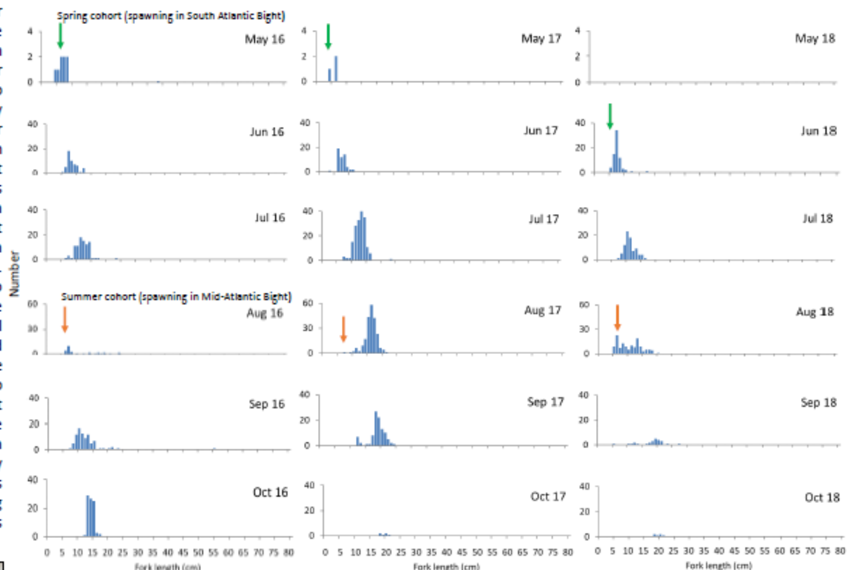

Fig. 3 – Bluefish young-of-the-year length frequencies (cm, all other tables in mm) over all sampling locations from 2016-2018 (May-October). Initiation of spring (green) and summer (orange) spawned cohorts are noted with arrows. Cohorts are based on length designations from Wuenschel et al. 2012.

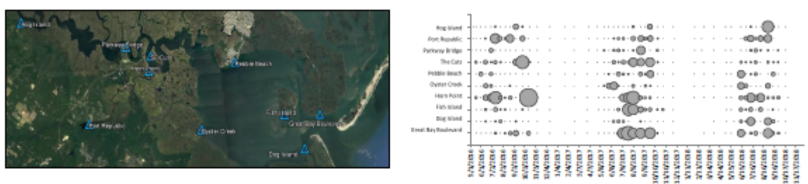

Fig. 4 – (left) Sampling locations within the Mullica River-Great Bay Estuary (NJ). (right) Relative catch-per-unit effort of young-of-the-year bluefish by location (largest shaded circle = 81 individuals; smallest circles = sampled, no bluefish collected).

2016

	Spring	Summer
MAY	8	0
JUNE	52	0
JULY	90	0
AUGUST	13	71
SEPTEMBER	18	69
OCTOBER	5	82
TOTAL	186	168

2017

	Spring	Summer
MAY	3	0
JUNE	54	0
JULY	176	0
AUGUST	213	2
SEPTEMBER	90	9
OCTOBER	6	0
TOTAL	542	11

2018

	Spring	Summer
MAY	0	0
JUNE	72	0
JULY	84	0
AUGUST	69	61
SEPTEMBER	20	6
OCTOBER	6	0
TOTAL	245	67

Table 1 - Spring and summer spawned cohort assignments (2016-2018) based on length designations from Wuenschel et al. 2012.

SPRING (AVERAGE FL BY MONTH)

	2016	2017	2018
JUNE	77.71	70.20	68.60
JULY	111.47	121.27	105.19
AUGUST	175.17	154.45	130.65
SEPTEMBER	170.31	187.71	192.75

SPRING (AVERAGE GROWTH BY MONTH)

	2016	2017	2018
JULY	33.76	51.08	36.59
AUGUST	63.70	33.18	25.46
SEPTEMBER	-4.86	33.26	62.10

SUMMER (AVERAGE FL BY MONTH)

	2016	2017	2018
JUNE	0	0	0
JULY	0	0	0
AUGUST	65.94	68.00	63.95
SEPTEMBER	104.58	116.78	100.50

SUMMER (AVERAGE GROWTH BY MONTH)

	2016	2017	2018
JULY	0	0	0
AUGUST	0	0	0
SEPTEMBER	38.64	48.78	36.55

Table 2 – Average FL (mm) and growth rate (difference between months) by spring and summer cohort.

Methods:

- 100 ft haul seines (Fig. 2, Fig. 4) conducted bimonthly through late spring-fall.
- All finfish identified, counted, and measured to fork or total length.
- Water temperature, salinity, dissolved oxygen, and pH recorded with a YSI.
- Data entered into Microsoft Excel, quality controlled, and assembled into one database.
- Designation of spring or summer spawned cohorts assigned from Wuenschel et al. 2012 (Table 3).

Acknowledgements: *Stockton University Principal Investigators:* Mark Sullivan, Steve Evert; *Stockton University Marine Field Station support:* David Ambrose, Nathan Robinson, Elizabeth Zimmermann, Colby Capri; *Stockton University course student support:* multiple individual students, Introduction to Marine Biology, Introduction to Ichthyology, Fisheries Science and Management courses; *Funding generously provided by:* NJ Department of Environmental Protection.

References:

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McBride, R. S., & Conover, D. O. (1991). Recruitment of young-of-the-year bluefish *Pomatomus saltatrix* to the New York Bight: Variation in abundance and growth of spring- and summer-spawned cohorts. *Marine Ecology Progress Series,78*, 205-216. doi:10.3354/meps078205

Munch, S. B., & Conover, D. O. (2000). Recruitment dynamics of bluefish (*Pomatomus saltatrix*) from Cape Hatteras to Cape Cod, 1973–1995. *ICES Journal of Marine Science,57*(2), 393-402. doi:10.1006/jmsc.1999.0636

Taylor, D. L., & Able, K. W. (2006). Cohort dynamics of summer-spawned bluefish as determined by length-frequency and otolith microstructure analyses. *Transactions of the American Fisheries Society,135*(4), 955-969. doi:10.1577/t05-109.1

Wuenschel, M. J., Able, K. W., Buckel, J. A., Morley, J. W., Lankford, T., Branson, A. C., . . . Stormer, D. (2012). Recruitment patterns and habitat use of young-of-the-year bluefish along the United States East Coast: Insights from coordinated coastwide sampling. *Reviews in Fisheries Science,20*(2), 80-102. doi:10.1080/10641262.2012.660999

Results:

- Spring and summer spawned cohorts positively identified over all three years of sampling (Fig. 3).
- Early stage bluefish collected over all sites within study area (Fig. 4).
- Spring cohort abundant over all three years of sampling (Table 1).
- Summer cohort abundant in 2016, virtually absent in 2017, low 2018.
- Average FL by September for spring and summer cohorts consistent over all three years (Table 2).

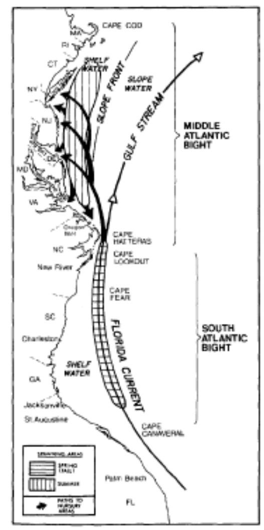

Fig. 5– South Atlantic Bight and Middle Atlantic Bight spawning areas and transport pathways for bluefish (Fig. 1 from Kendall & Wolford 1979).

Mid-monthly cohort length cut-offs (FL in mm) used in the length-frequency analysis (also shown as shaded regions in Figures 3–8)

	Spring cohort		Summer cohort	
	Minimum FL (mm)	Maximum FL (mm)	Minimum FL (mm)	Maximum FL (mm)
January	0	25	0	0
February	0	25	0	0
March	0	50	0	0
April	0	75	0	0
May	0	125	0	0
June	20	175	0	20
July	50	210	0	50
August	90	230	0	90
September	140	260	0	140
October	160	270	10	160
November	170	275	20	170
December	180	280	50	180

Note: Individual bluefish were assigned to a given cohort when FL was greater than or equal to the minimum FL but less than the maximum FL for the month of capture. See "Methods" section for further explanation on cohort assignment and calculation of cohort specific CPUE.

Table 3 – Values used to make cohort determinations based on FL (Table 2 from Wuenschel et al. 2012).

Conclusions and Future Work:

- Inventory studies are critical for assessing stocks and developing testable hypotheses for future work.
- Size structure and abundance of early stage bluefish determined over 3 years of sampling at 10 sites in the Mullica River–Great Bay Estuary (NJ).
- Additional work needed to better understand mechanisms.
- Otolith microstructure analysis (growth rates), archived wind speed data (transport), gut content analysis (cannibalism) may shed light on variability in strength and size structure of cohorts.

Habitat mapping of juvenile winter and summer flounder (*Pseudopleuronectes americanus, Paralichthys dentatus*) in the Mullica River-Great Bay Estuary (NJ) with progress towards a habitat suitability index using ArcMap

Stockton University Undergraduate Student: Liam Kehoe (MARS), *Advisors:* Dr. Mark Sullivan (MARS) and Dr. Weihong Fan (ENVL)

Abstract:

Fishery independent surveys are useful for monitoring fish population trends over time (in combination with landings data from recreational and commercial efforts). Over three years, a 100-foot haul seine was used to survey 10 sites in the Mullica River-Great Bay Estuary (New Jersey) as part of a broader state coastal inventory project. One potential application of this work is using the results to predict habitat use patterns in future collections and/or new locations. Juvenile fish abundance (CPUE), sediment distribution (% sand), temperature (C), and distance from inlet (km) were used to establish a baseline set of preferred environmental parameters for two commercially / recreationally important species of flatfish: winter flounder (*Pseudopleuronectes americanus)* and summer flounder (*Paralichthys dentatus)*. Using a GIS map algebra framework (ArcMap spatial analyst function), habitat ratings were assigned for each species using a matrix constructed from the three environmental parameters (higher rating = higher likelihood of being collected at a given location). This simple model can be expanded upon for new species and/or sets of parameters to help better understand habitat-use patterns of commercially and recreationally important finfish species in this system.

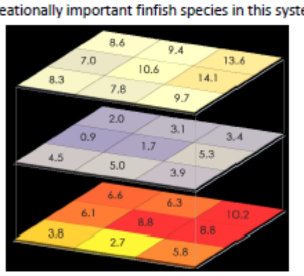

Fig. 1 –Map algebra is a spatial analysis tool in GIS used to perform raster calculations from multiple layers to create a single output layer.

Introduction:

- The Mullica River-Great Bay Estuary (MRGB) is a drowned river valley that provides nursery habitat for a variety of commercially and recreationally important fish species.
- Fishery independent surveys are critical to help document abundance trends over time, while formulating testable hypotheses for future work.
- Winter flounder *(Pseudopleuronectes americanus)* and summer flounder (*Paralichthys dentatus)* are estuarine dependent bottom dwellers that utilize the Mullica River-Great Bay Estuary as nursery habitat (Fig. 2).
- This study uses juvenile CPUE in combination with a simple suite of environmental variables to develop a predictive model of abundance within this system using GIS map algebra (Fig. 1).

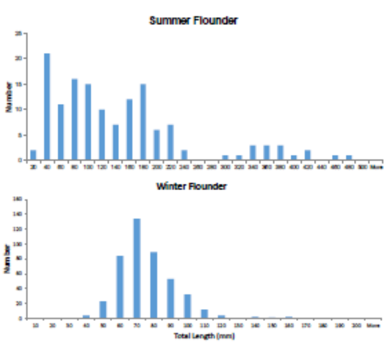

Fig. 2 – Length frequency histograms for both species over the entire dataset. The majority of specimens collected were young-of-the-year juveniles.

Summer Flounder

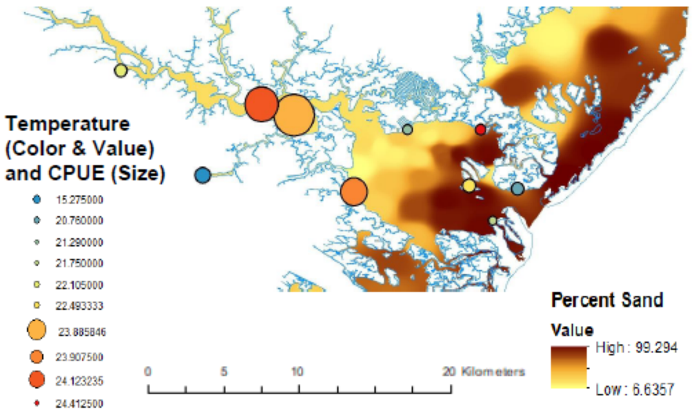

Fig. 3 – Multiple layers of summer flounder / environmental data for 10 sites in the Mullica River–Great Bay Estuary. Marker size scaled for catch-per-unit-effort. Marker color denotes average temperature (C) at each site when specimens present. Percent sand displayed for entire system (average values within a set radius around each site used for habitat analysis). Distance from inlet for each site calculated as straight lines over water only.

Winter Flounder

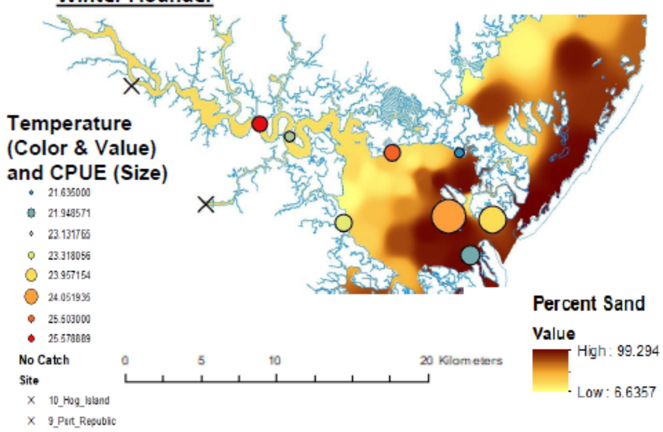

Fig. 4 – Multiple layers of winter flounder / environmental data for 10 sites in the Mullica River–Great Bay Estuary. Marker size scaled for catch-per-unit-effort. Marker color denotes average temperature (C) at each site when specimens present. Percent sand displayed for entire system (average values within a set radius around each site used for habitat analysis). Distance from inlet for each site calculated as straight lines over water only.

Fig. 5 – 100 foot haul seine operations in the Mullica River – Great Bay Estuary (NJ): deployment, sorting, measurement.

Methods

- 100 foot haul seines (Fig. 5) were conducted bimonthly summer-fall (once per month winter-spring)
- All finfish identified, counted, and measured to fork or total length.
- Water temperature, salinity, dissolved oxygen, and pH recorded with a YSI.
- Data entered into Microsoft Excel, quality controlled, and assembled into one database.
- Microsoft Excel PivotTable function used to filter data for summer and winter flounder.
- ArcMap (Fig. 3, 4) used to plot site locations providing the distance from a central point in the inlet.
- Catch per unit effort (CPUE) was calculated using the total catch for each site.
- Temperature data calculated using a weighted average of each site at time of sample collection.
- Percent sand calculated from raster data supplied by Stockton Coastal Research Center (courtesy of B. Smith). An 150 foot radius was constructed and averaged to assign values for each site.

Results:

- Juvenile summer flounder were associated with the following parameters (Fig. 6):
- Between 9,500 and 20,000 meters from inlet entrance
- Lower percentages of sand between 22%-26%.
- Temperatures between 23 and 24.5 degrees Celsius.
- Juvenile winter flounder were associated with the following parameters (Fig. 6):
- Between 4,500 and 9,500 meters from inlet entrance.
- Higher percentages of sand between 60%-90%.
- Temperatures between 23 and 24.5 degrees Celsius.

Summer Flounder

Site	Site Preference Rank	Sample Count	Temperature (c)	Percent Sand	Distance From Inlet (m)
1_Great_Bay_Boulevard	5	4	20.76	63.78849	2750
2_Dog_Island	2	1	21.75	97.61094	3500
3_Fish_Island	6	6	22.49333	88.15513	4500
4_Horn_Point	4	4	24.4125	66.36264	7000
5_Oyster_Creek	8	12	23.9075	26.04021	9600
6_Pebble _Beach	3	2	21.29	29.03447	8900
7_SE_Cuts	**10**	**65**	**23.88585**	**22.84757**	**14000**
8_Parkway_Bridge	9	34	24.12324	23.94856	15500
9_Port_Republic	7	8	15.275	29.62194	20000
10_Hog_Island	5	4	22.105	28.52912	22750

Winter Flounder

Site	Site Preference Rank	Sample Count	Temperature (c)	Percent Sand	Distance From Inlet (m)
1_Great_Bay_Boulevard	9	130	23.95715	63.78849	2750
2_Dog_Island	8	42	21.94857	97.61094	3500
3_Fish_Island	**10**	**155**	**24.05194**	**88.15513**	**4500**
4_Horn_Point	3	14	21.635	66.36264	7000
5_Oyster_Creek	7	36	23.31806	26.04021	9600
6_Pebble _Beach	6	28	25.503	29.03447	8900
7_SE_Cuts	4	17	23.13176	22.84757	14000
8_Parkway_Bridge	5	18	25.57889	23.94856	15500
9_Port_Republic	0	0	No Data	29.62194	20000
10_Hog_Island	0	0	No Data	28.52912	22750

Fig. 6 – Summary table of data used to create GIS maps and rank preferred sites and variables.

Conclusions and Future Work:

- Inventory studies are critical for assessing stocks and developing testable hypotheses for future work.
- Current technique can be applied to other species in the Mullica River – Great Bay Estuary system.
- Map algebra used in future work to evaluate new collections and/or sites within system.
- Environmental parameters measured at new locations can be used to evaluate likely presence and level of abundance for a given species.
- Low sample sizes (<3 years of data) make predictions difficult at this point.
- Statistical tests needed to determine significance of relationships uncovered.
- Future results could be used to identify priority habitats for protection or future hypothesis driven research.

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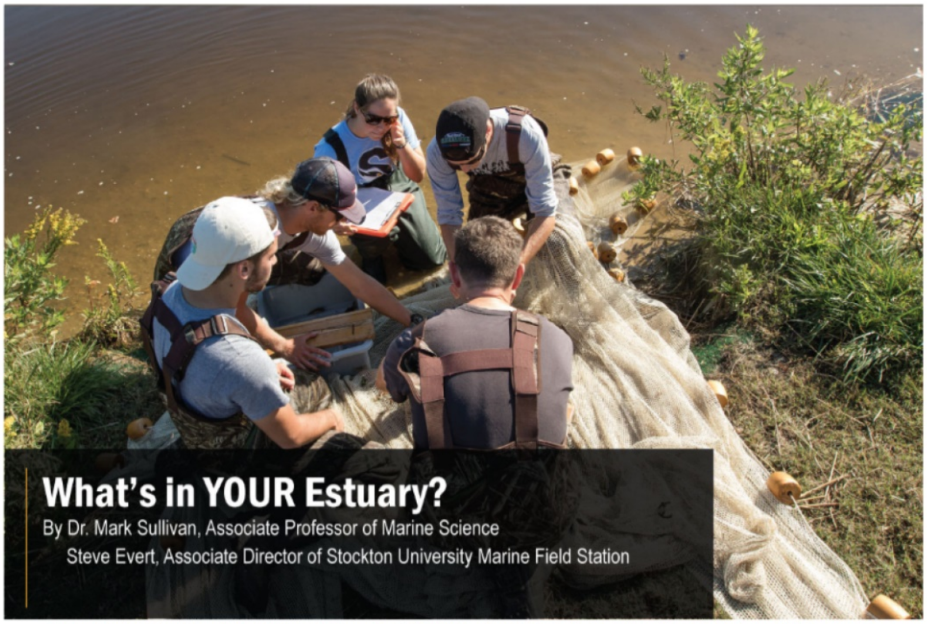

(Bottom to Top): Stockton University Marine Science faculty member Dr. Mark Sullivan, Joseph Citro, Professional Science Master's in Environmental Science graduate student, Marine Field Station technician David Ambrose, Marine Science '14, undergraduate student Caroline Bowman, Biology and Teacher Education student, and Stockton alumnus Sean Lynch, Marine Science '17, sort a seine net catch in Port Republic, N.J. (Photo credit: Susan Allen).

Estuaries ("where the river meets the sea…") provide more than 30,000 km^2 of nursery habitat for over two-thirds of the economically important fish species along the East Coast of the United States. A large percentage of these species are "estuarine-dependent" - they reproduce in the ocean/lower estuary/river, enter estuaries as very young fish, survive to become juveniles, and (hopefully) join the adult population. As a result, the composition, size and numbers of young fish in estuaries function as important indicators of population health, particularly if standardized data with broad coverage are available. The Mullica River-Great Bay (MRGB) estuary is one such system on the East Coast that provides a wide variety of habitats for estuarine-dependent species. Summer flounder ("fluke"), winter flounder, bluefish, black sea bass, and tautog are notable economically and ecologically important species that share critical links to New Jersey estuaries during early and, in many cases, adult life.

Stockton University's Nacote Creek Marine Field Station is located 15 minutes from Galloway campus and has supported undergraduate course-based fish sampling for over two decades, primarily using seine nets deployed from land or vessel and hauled back to shore by students.

This work was recently synthesized in a Marine Science Program Distinction project by Caroline Schkeeper, Marine Science '15, spanning eight-plus years, 100 seine hauls and 19,131 individual fish. Overall, these collections afforded students hands-on experience and training, but did not always connect the data with fishery managers. In 2016, the New Jersey Department of Environmental Protection generously funded a three-year project that continues this tradition of immersive field experiences at Stockton University, but also aims to make the data more standardized, multi-seasonal and available to fishery managers.

A cryptic juvenile hogchoker – a type of flatfish easily mistaken for leaf litter - sampled with a seine net in Port Republic, N.J. (Photo credit: Susan Allen).

Since May 2016, twice-per-month seine collections from May–November (monthly from November–April) have been conducted in the MRGB from Little Egg Inlet to upriver beyond the Garden State Parkway bridge. In addition, a local commercial waterman, Newt Sterling, has been engaged to collect monthly fyke (a long, stationary, cylindrical net) data for highly migratory species (striped bass, river herring) in Great Bay during the winter and spring months. By the close of year one, 238 samples were completed across the two gear types collecting 90,424 individual fish from 66 different species. To date, over 100 students have gained direct hands-on experience from this funded project through independent study work, volunteer opportunities, four undergraduate courses (Introduction to Marine Biology, Fisheries Science and Management, Introduction to Ichthyology, and New Jersey Field Ichthyology) as well as programs for high school students Stockton University Science Enrichment Academy - (SEAS).

A key take-home message from this project for the undergraduate students is simply - take the time to "look." In the rush to test complicated hypotheses, sometimes students (and faculty alike) overlook the critical first step in the scientific method – record observations. Along these lines, project scientists have learned that members of the commercial fishing community often have the most complete data sets available, collected over a lifetime of observations. Thus, data from this project is helping to answer the question "What's in *YOUR* estuary?", while providing key observations from multiple sources that may help propose and answer interesting questions in the future.

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