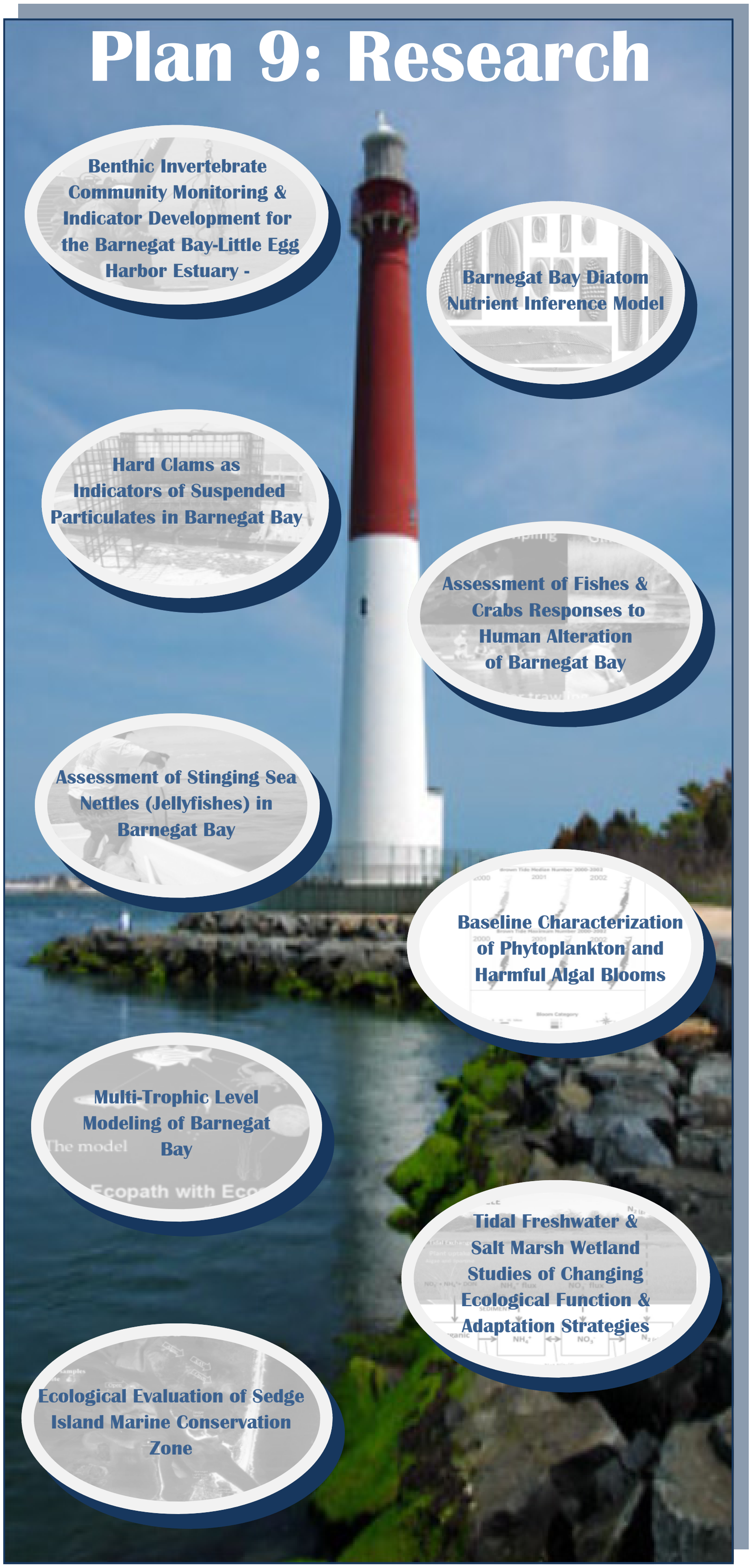
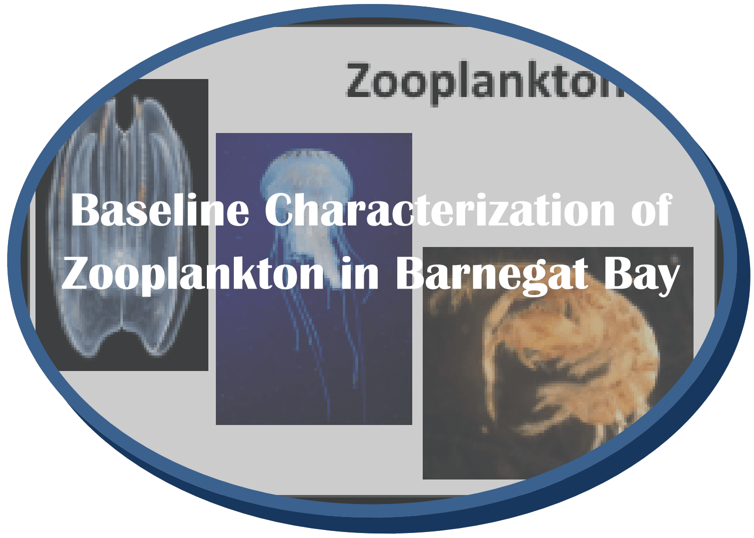


Barnegat Bay— Year 2



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June, 2015

BASELINE SURVEY OF ZOOPLANKTON OF BARNEGAT BAY

NJSG Project # 4904-0005 NJDEP # SR13-014
Sponsored by NJDEP Office of Science
Monmouth University
Urban Coast Institute

Final Report
June 2013 – May 2014

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2.0 ACKNOWLEDGMENTS

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NOAA research scientist J. Hare facilitated shipment of samples to Poland for sorting and identification.

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4.0 EXECUTIVE SUMMARY

The goal of this project was to gather information on the status of zooplankton populations in Barnegat Bay and to determine the distribution, abundance, and species composition of important plankters. This project was a cooperative venture between Monmouth University and the James J. Howard Marine Sciences Lab at Sandy Hook, NJ (SHL) which is part of the NOAA/NMFS Northeast Fisheries Science Center.

Zooplankton populations are subject to change due to natural and anthropogenic variations in environmental conditions. Biological conditions, physical conditions and environmental degradation in estuaries exert control over the composition, abundance, and distribution of zooplankton in estuaries and zooplankters must adapt to varying stresses associated with changing conditions. The environment of Barnegat Bay has changed considerably over the three decades since previous studies were conducted. According to the Barnegat Bay Estuary Program's Characterization Report, this back-bay ecosystem has been affected by an array of human impacts that potentially threaten its ecological integrity.

Assessing zooplankton populations in Barnegat Bay will provide updated information on the status of this important component of the bay's living resources that can be added to the bay's natural resource inventory and provide scientific information which could serve as an indicator of trends that may have taken place within the living resources of the bay. As such, this project is consistent with the overall goals and objectives of the monitoring program plans established for the BBNEP and will address a data gap identified in the Characterization Report prepared for the Bay.

Zooplankton samples were collected from the upper meter of the water column with horizontal surface net tows using bongo plankton nets. Samples were conducted monthly during the winter, and twice a month during spring, summer, and fall. Sites were located along a longitudinal transect in the bay, and corresponded with NJDEP water quality testing sites. Data were collected on the zooplankton community in the bay, including ichthyoplankton, gelatinous macrozooplankton, and important groups such as copepods, decapods, and bivalves. Results and recommendations for future work are presented in this report.

5.0 INTRODUCTION/PROBLEM STATEMENT

Plankton are organisms that live floating or suspended in marine and estuarine waters. Plankton range in size from very small microbes less than 0.05 mm to jellyfish and other gelatinous species that can exceed 1 m in diameter and have tentacles extending over 10 m (Kingsford and Battershill 2000). Phytoplankton include microscopic unicellular, colonial, or filamentous forms of primary producing algae. Zooplankton include both unicellular and multicellular planktonic animals. Zooplankton are typically categorized by life style and size. Zooplankton that spend their entire lives as plankton are known as holoplankton. Others, such as the larval stages of many benthic invertebrates, only spend part of their lives as plankton. These species are known as meroplankton (Johnson and Allen 2005, Kingsford and Battershill 2000).

In terms of classifying zooplankton by size, three categories are generally described – microzooplankton, mesozooplankton, and macrozooplankton. Microzooplankton are organisms that are classified as being approximately 20 to 202 μm in length, being at the smaller end of the size spectrum for zooplankton. The predominant microzooplankton include ciliate, flagellate, and amoeboid protozoa and copepod nauplii which float passively in the water column due to their limited abilities to move. Zooplankton in the 0.2 to 2.0 mm size range dominate the group known as mesozooplankton. Copepods are typically the most commonly encountered mesozooplankton. Other common mesozooplankton include rotifers, larval barnacles, crab zoeae, and mollusk veligers. The largest zooplankton are classified as macrozooplankton. Macrozooplankton include shrimps, larval fishes, and other large, mobile planktonic animals as well as ctenophores and jellyfish (Johnson and Allen 2005).

The most recent definitive studies of zooplankton in Barnegat Bay were conducted in the 1970's and summarized by Sandine (1984) and Kennish (2001). These studies indicate that, in general, macrozooplankton abundance peaks in the spring and summer months in response to phytoplankton food supply. In terms of species composition, as reported in Sandine (1984) and summarized by Kennish (2001), common macrozooplankton in the bay include hydromedusae (*Rathkea octopunctata*), shrimps (*Neomysis americana*, *Crangon septemspinosa*), larval crabs (*Neopanope texana*, *Panopeus herbstii*, *Rhithropanopeus harrisii*), amphipods (*Jassa falcata*), arrowworms (*Sagitta* spp.) and hydroids (*Sarsia* spp.). Ctenophores (*Mnemiopsis leidyi* and *Beroe* sp.) are also sometimes common, especially from summer to fall.

As the main herbivorous component of marine ecosystems, zooplankton play an important role in estuarine food webs. Macrozooplankton are particularly important because they are intermediaries in estuarine food chains, forming a link between smaller zooplankton and higher trophic levels, including many commercially and recreationally valuable fishes (Gewant and Bollens 2005). However, despite their importance in filling this niche, little is known about the distribution, abundance, and ecology of macrozooplankton in many coastal regions (Wilson et al. 2003). This is the case in the Barnegat Bay ecosystem. As noted by Kennish (2001), there has not been a detailed survey of zooplankton in the Barnegat Bay estuary since the 1970's. Furthermore, the most detailed of those studies (Tatham et al. 1977, 1978) focused on the central bay from Cedar Creek (Lanoka Harbor) south to Double Creek (Barnegat) (Sandine 1984).

Typically, in Mid-Atlantic and northeastern estuaries, short but intense blooms of ctenophores, primarily *Mnemiopsis leidyi*, occur in late summer and early fall (Kremer 1994); however, several recent studies have documented an expansion in ctenophore abundance and seasonal distribution to include spring and early summer blooms. This shift appears to be related to increasing average water temperatures (Sullivan et al. 2001, McNamara et al. 2009). If such a shift in the seasonal pattern and abundance of ctenophores is occurring in Barnegat Bay, it could have an impact on the abundance of other planktonic assemblages, as ctenophores are voracious predators on a variety of zooplankton, including bivalve veligers, copepods, and nauplii (Sullivan et al. 2001, McNamara et al. 2009).

Sea nettles (*Chrysaora quinquecirrha*) are becoming more abundant in Mid-Atlantic estuaries including Barnegat Bay, reaching peak numbers in mid to late summer. This phenomenon has apparently resulted from warmer summer water temperatures and increased eutrophication. Due to their severe sting, sea nettles are a nuisance and pose a hazard to recreational users of the bay. In Barnegat Bay, high summer concentrations of sea nettles have been observed north of the Toms River, which is included in the study area for this project, for several summers (BBNEP 2006). Documentation of the seasonal patterns of sea nettle distribution and abundance could also serve as an indicator of the health of the bay.

Updated information on ctenophore and sea nettle distribution and abundance may also assist scientists attempting to understand fishery declines in the bay since sea nettles, as well as some species of ctenophores such as *Mnemiopsis leidyi*, are known to prey on fish eggs and larval fishes (Purcell undated, Mills 2009).

6.0 PROJECT DESIGN AND METHODS

Zooplankton were collected from the upper meter of the water column with horizontal surface net tows using bongo plankton nets, with one 500 μ and one 202 μ paired sample. Nets were rigged with a flow meter to determine the volume of flow in order to calculate catch per unit effort (CPUE). Abiotic parameters were collected using a YSI meter and Secchi disc. Gelatinous macrozooplankton disintegrate when stored in a fixative, so they were processed fresh in the laboratory. Ichthyoplankton were removed before the zooplankton sample was preserved, and stored in 95% ethanol. Ichthyoplankton were retained at Monmouth University, and were identified with the assistance of the ichthyoplankton laboratory at Rutgers University Marine Field Station, Tuckerton, NJ. The remaining zooplankton were preserved in 5% formalin. The 202 μ samples were separated in the laboratory with a 500 μ and a 202 μ sieve to produce a 200 – 500 μ fraction. This was designated the "200 μ" sample. One each of a 500 μ and 200 μ sample for each site at each sampling event was selected randomly for transport to a sorting laboratory, Morski Instytut Rybacki - Państwowy Instytut Badawczyi (MIR), Zakład Sortowania i Oznaczania Planktonu (ZSIOP) in Poland. This laboratory has sorted plankton as a NOAA contractor for almost 40 years.

Data collected on the ctenophores *Mnemiopsis leidyi* and *Beroe ovata* included total volume per tow, total count per tow, and lengths of 20 haphazardly selected individuals from each sample. Catch per unit effort (CPUE) was calculated by incorporating volume of flow collected from the flow meters attached to the plankton nets. Length of the bell was measured longitudinally from apex to the top of the lobes; length was not measured to the bottom of the lobes as the lobes may break off during collection and handling. Data collected on sea nettle *Chrysaora quinquecirrha* included total volume per tow, total count per tow, and bell width.

One sample set was collected at each of the five sites, 2, 5a, 7a, 10, and 12 from June 2013 through May 2014. A sample set was defined as a replicate pair of 500 µm and a replicate pair of 202 µm plankton samples collected at a site, accompanied by the abiotic parameters water temperature, salinity, conductivity, dissolved oxygen (DO) mg/l, DO %saturation (%sat), pH, Secchi depth, and water depth. A sampling event was the collection of sample sets at all sites, typically over a one- or two-day period. Sampling events occurred twice monthly during March – September, and once monthly during October – January. Samples were not collected during February 2013 due to weather and vessel mechanical issues. Two 24 hr sampling events were conducted, one each in October 2013 and April 2014.

7.0 QUALITY ASSURANCE

A Quality Assurance Project Plan was approved by NJDEP for this study. Samples totaling 10% of the total number of processed samples for the study year were randomly selected (random number generator), single-blinded, then sent to ZSIOP for reprocessing for QA/QC (Appendix 1).

8.0 RESULTS AND DISCUSSION

A total of 19 regular sampling events occurred at Sites 2, 5a, 7a, 10, and 12 during June 2013 – May 2014. Two intensive 24 hr sampling events were conducted in October 2013 and April 2014 at Site 5a. Samples were collected every four hours during the 24 hr period. Abiotic data were collected during all regular and intensive sampling events. Microzooplankton were collected during all regular and intensive sampling events and were subsequently processed for shipment to the sorting lab. Targeted gelatinous macrozooplankton were collected at all regular and intensive sampling events and processed at Monmouth University.

Data from the first year of this study, May 2012 – May 2013, were already presented and discussed in that study's final report. However, those data are included in all figures in the current report so interannual trends may be better visualized.

8.1 Abiotic Data

Water temperature during the June 2013 – June 2014 study period followed trends expected with seasonal changes. Water temperature trends were similar across all five stations (Fig 1a), although there was a slight elevation in temperature at Site 5a during the summer of 2013. The winter of 2013-2014 was abnormally cold in New Jersey; this was reflected in the low water temperatures observed in December 2013 and January 2014. Salinity remained higher at BB7a, 10, and 12 throughout the sampling period, although there was a slight decrease at Site 10 in

December 2013. Salinity is lower in the northern bay (Sites 2 and 5a) due to riverine input (Fig 1b). Dissolved oxygen (DO) levels were very high in winter 2013-2014, as they were in winter 2012-2013. It is likely that the high DO levels are due to the decrease in temperature, as cold water holds more oxygen than warm water. However, a dip seen in December 2012 is not repeated in December 2013; the lower DO may be due to the dense copepod bloom observed in that time period (Fig 1c). Secchi transparency (water clarity) is inversely related to turbidity, which is often due to particulates in the water column. Wind may mix particulate organic matter (POM) in the water column, or biological factors such as phytoplankton or zooplankton blooms may increase turbidity. Water clarity was variable over much of this study period, but was surprisingly high in Fall 2013 (Fig 1d). Although there was a large zooplankton bloom in Fall 2012, the bloom was conspicuously absent in Fall 2013, which may have contributed to the high level of clarity at the time (refer to Section 8.2 Zooplankton). However, water clarity was quite low at Sites 10 and 12 in December 2013; as zooplankton levels were low at the time, the increased turbidity may have been due to a phytoplankton bloom, or to mixing of the water column and concomitant resuspension of POM due to winter winds. The spring 2014 bloom did appear, and water clarity, although variable, was quite low at times.

Abiotic parameters were sampled during all 24 hr intensive sampling events. Temperature changed only slightly over each 24 hr period (Fig 2a). As expected, temperature was highest during the July sampling event. The water was considerably warmer (+6-7°C) in October 2012 than in October 2013, even though the latter sampling event was only two weeks later in the year. All intensive sampling events except for October 2013 exhibited a change in salinity indicative of tidal flow (Fig 2b). Unexpectedly, DO was lowest in October 2012, not when water was warmest in July. Low DO during this period is likely due to the intense zooplankton bloom that occurred at this time (see Section 8.2 Zooplankton).

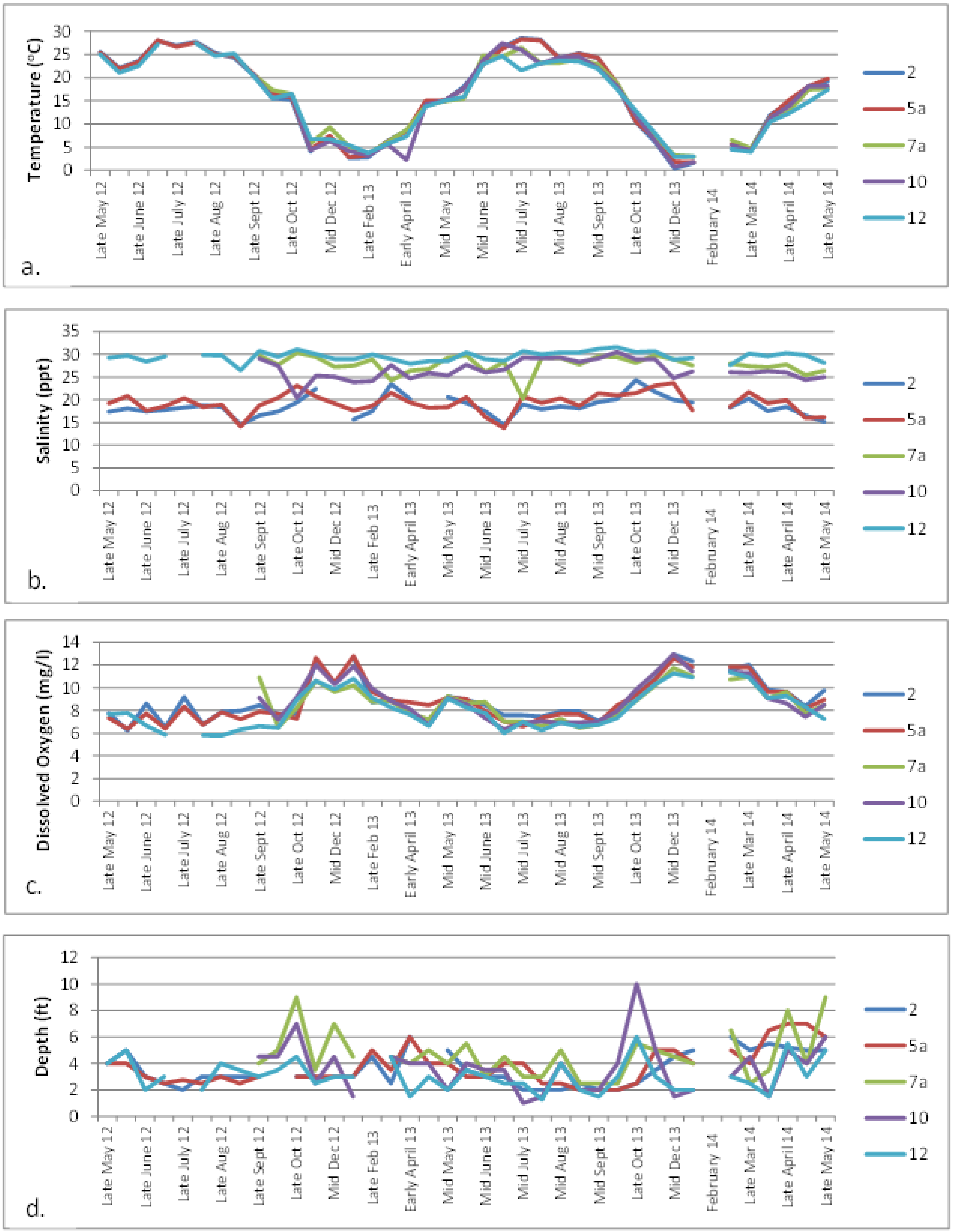


Figure 1. Abiotic data collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. a. temperature (°C); b. salinity (ppt); c. dissolved oxygen (mg/l); Secchi transparency (ft). Sites 7a and 10 were added in late September 2012.

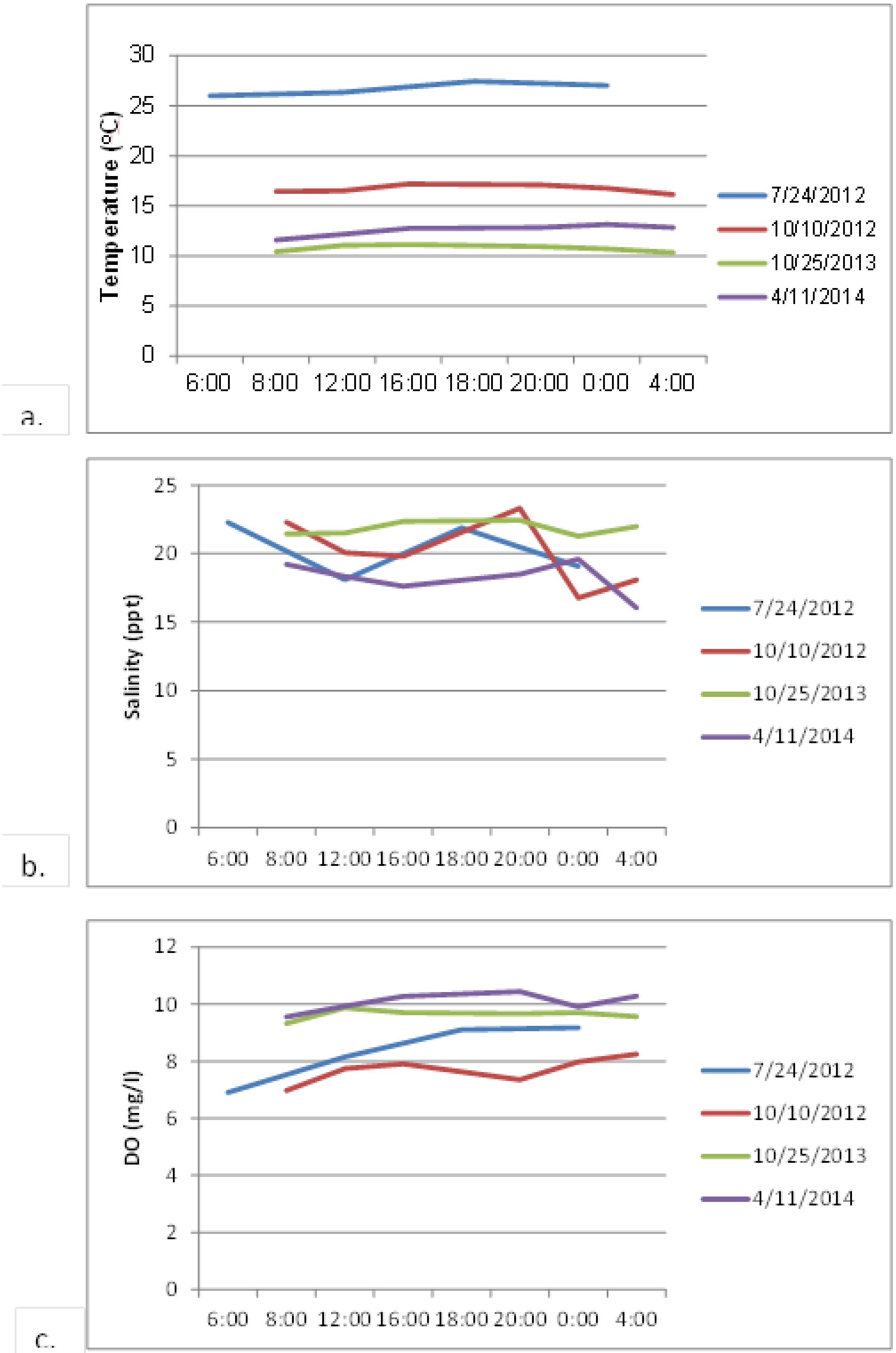
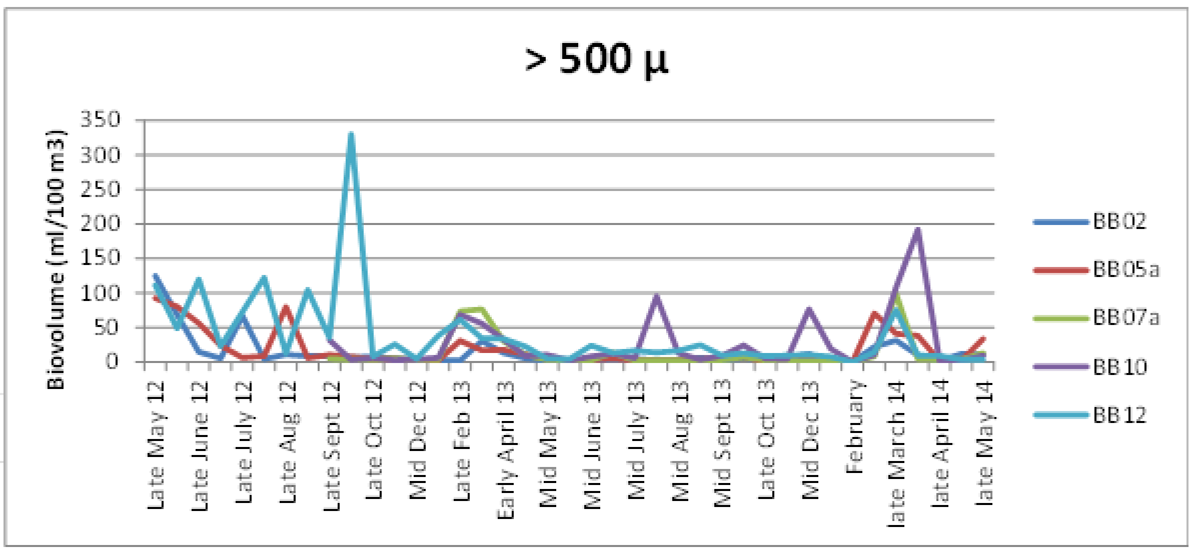


Figure 2. Abiotic data collected at Site BB-5a during intensive sampling events in July 2012, October 2012, October 2013, and April 2014. Samples were collected every 6 hr in July, and every 4 hr for all subsequent sampling event. A)temperature, b) salinity, c) dissolved oxygen.

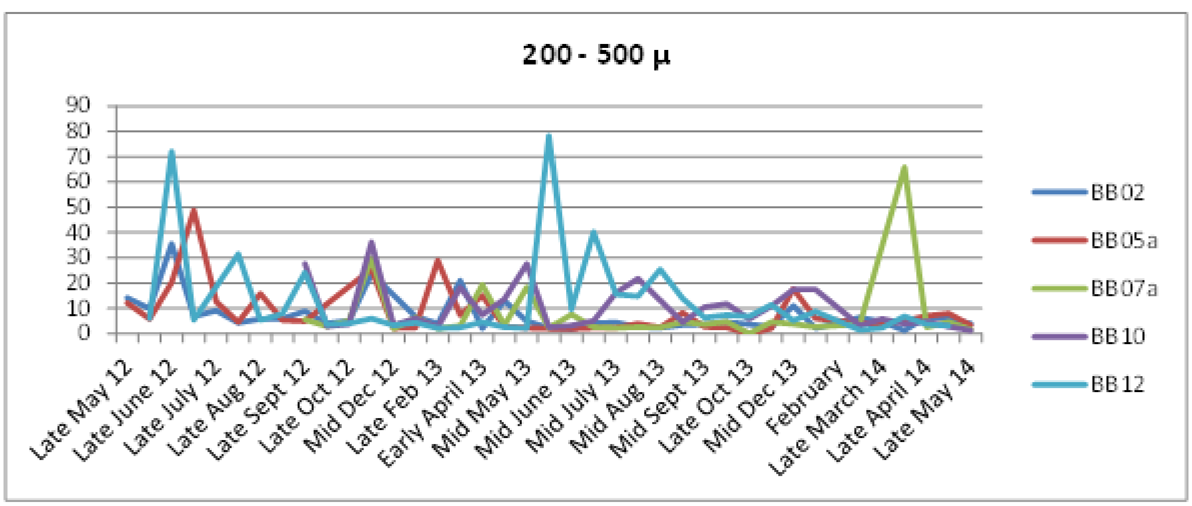
8.2 Zooplankton

Biovolume is a measure of the overall content of a plankton sample and is useful in discerning patterns of abundance. Biovolume in the > 500 µ size class was variable throughout the Year 2 sampling period, with the greatest values occurring during Spring 2014, associated with the spring bloom (Fig 3a). In Year 2, blooms of the > 500 µ size class also occurred several times at Site 10. Abundance of smaller plankton in the 200 – 500 µ size fraction was high in the winter of 2013/2014. The largest bloom for this size class occurred in Summer 2013 at Site 12; another large bloom occurred at Site 7a in Spring 2014 (Fig 3b).

Although it appears that the 200 – 500 µ size class undergoes a spring bloom every year, it is at a much lower level than that of the >500 µ size class, when compared on the same scale (Fig 4a and b).

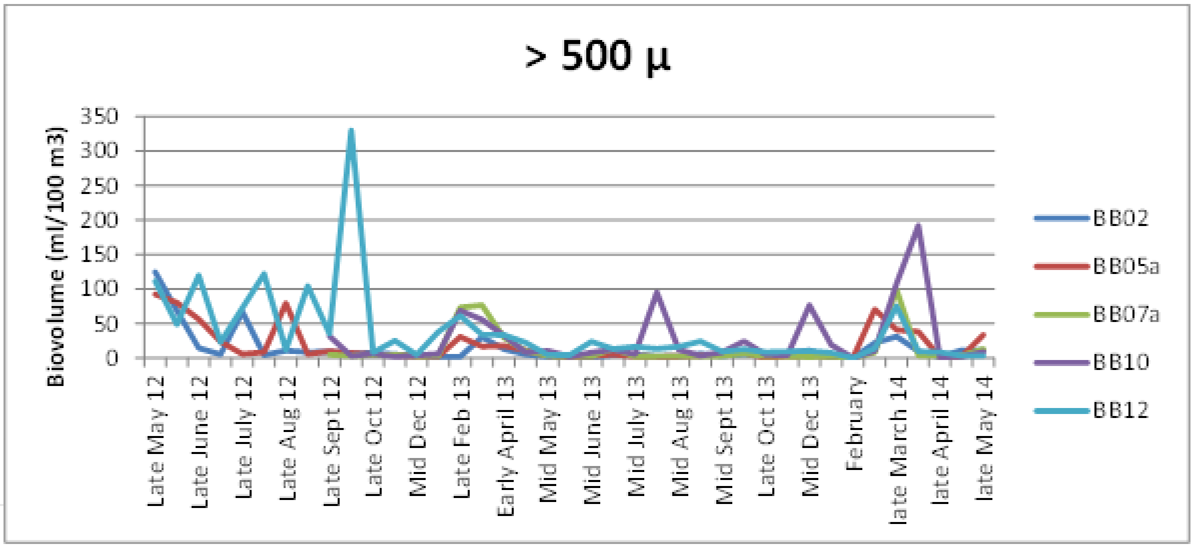


a.

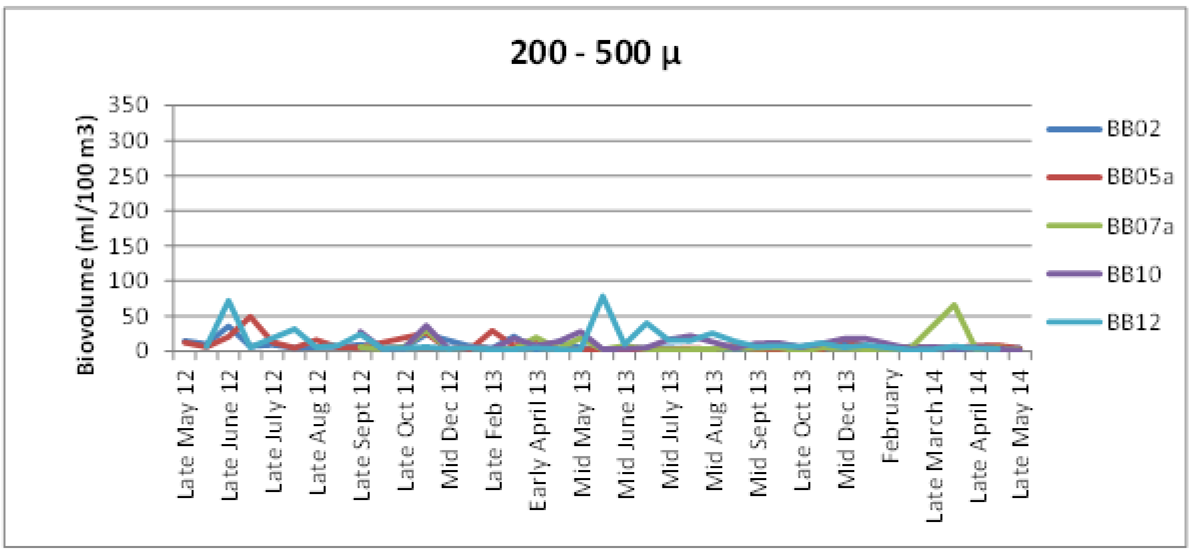


b.

Figure 3. Biovolume collected in 500 µ and 202 µ nets at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. a. Samples from 500 µ net. b. Samples from 202 µ net, which were filtered to separate and process the 200 – 500 µ fraction. Note that the y-axis is *not* on the same scale for both figures.



a.



b.

Figure 4. Biovolume collected in 500 µ and 202 µ nets at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. a. Samples from 500 µ net. b. Samples from 202 µ net, which were filtered to separate and process the 200 – 500 µ fraction. Note that the y-axis *is* on the same scale for both figures.

Copepods are an integral component of the holoplankton. The estuarine genus *Acartia* is very abundant throughout the bay, especially associated with the spring and fall blooms. *Acartia* was very abundant from September 2012 through May 2013, but numbers have declined dramatically since then (Fig 5a, 6a). NOAA monitors several common coastal species in the mid-Atlantic bight, including *Temora longicornis, Calanus finmarchicus, Pseudocalanus minutus, Centropages hamatus*, and *Centropages typicus*. Although these species are common along the coast, they are not as abundant in Barnegat Bay. When they do occur, it is most often associated with the spring bloom (Fig 5b – f, 6b - f). *Temora longicornis* was equally as abundant as *Acartia* during the spring bloom of 2014 (Fig 6a and b), especially at Site 12.

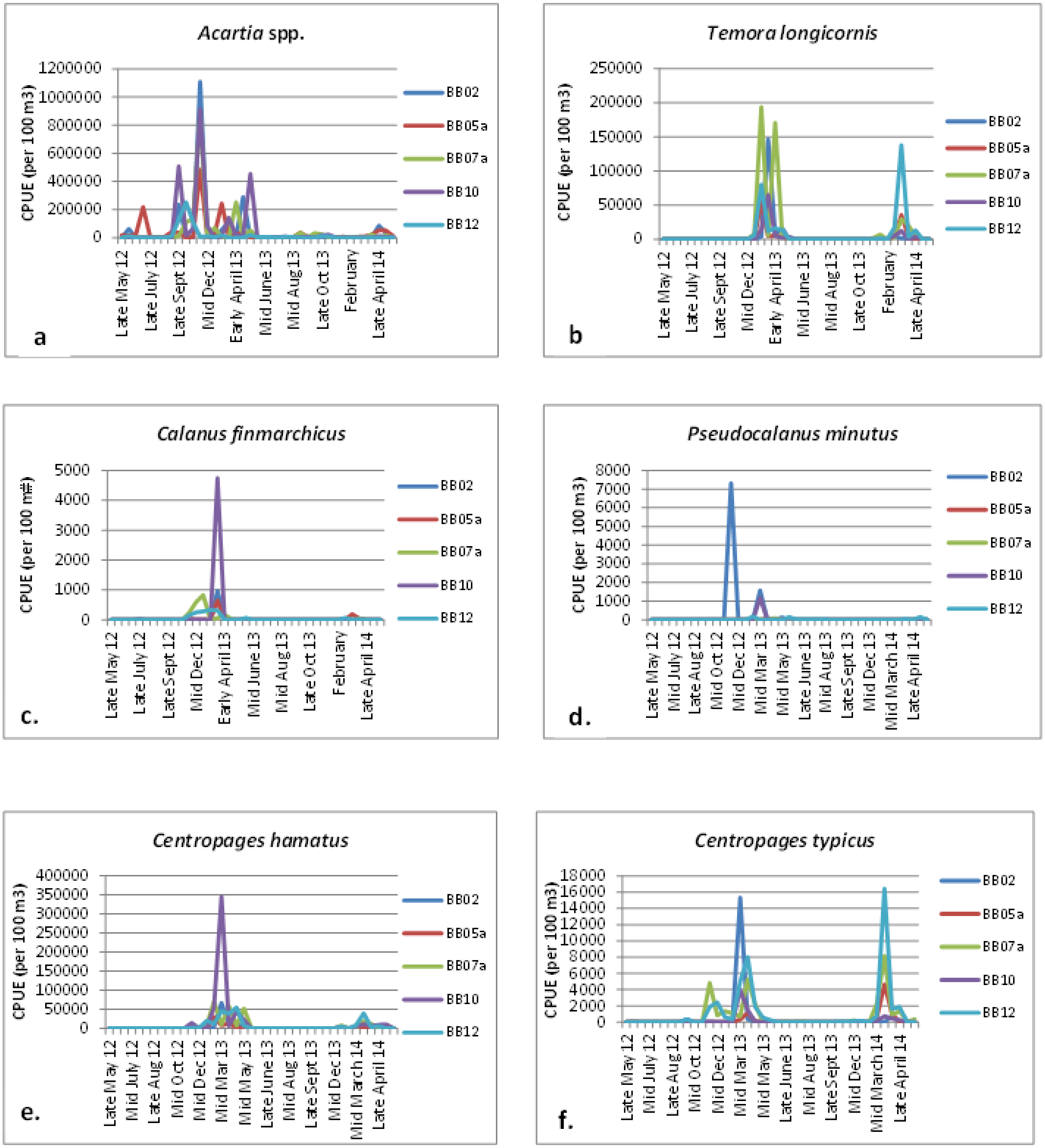


Figure 5. Abundance of copepod species collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012. a) *Acartia* spp. b) *Temora longicornis*. c) *Calanus finmarchicus* d) *Pseudocalanus minutus* e) *Centropages hamatus* f) *Centropages typicus*.

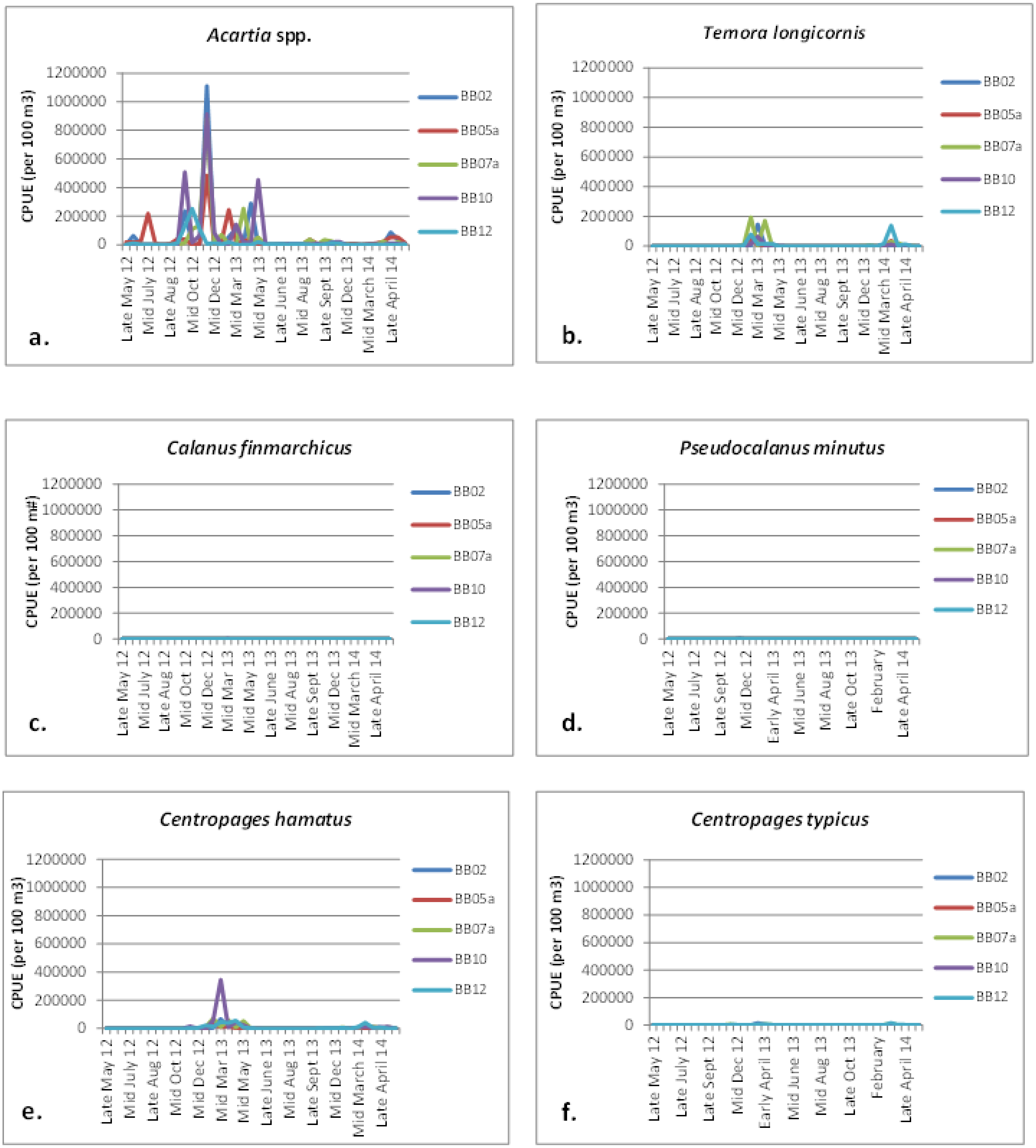


Figure 6. Abundance of copepod species collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012. Y axis is standardized to the *Acartia* figure for comparison. a) *Acartia* spp. b) *Temora longicornis*. c) *Calanus finmarchicus* d) *Pseudocalanus minutus* e) *Centropages hamatus* f) *Centropages typicus*.

Although decapod and bivalve specimens have not been identified to species, the overall trend in both taxonomic groups shows highest abundances in the spring and summer (Fig. 7 and 8). Peak abundance of decapod larvae occurred in Summer 2013 and Spring 2014. Greatest abundance of bivalve larvae occurred one month after Superstorm Sandy, with an extremely large bloom evident in November, and a smaller one in January. This bloom was at the station closest to Barnegat Inlet, so it is unclear whether these bivalve larvae are from the bay or from coastal populations.

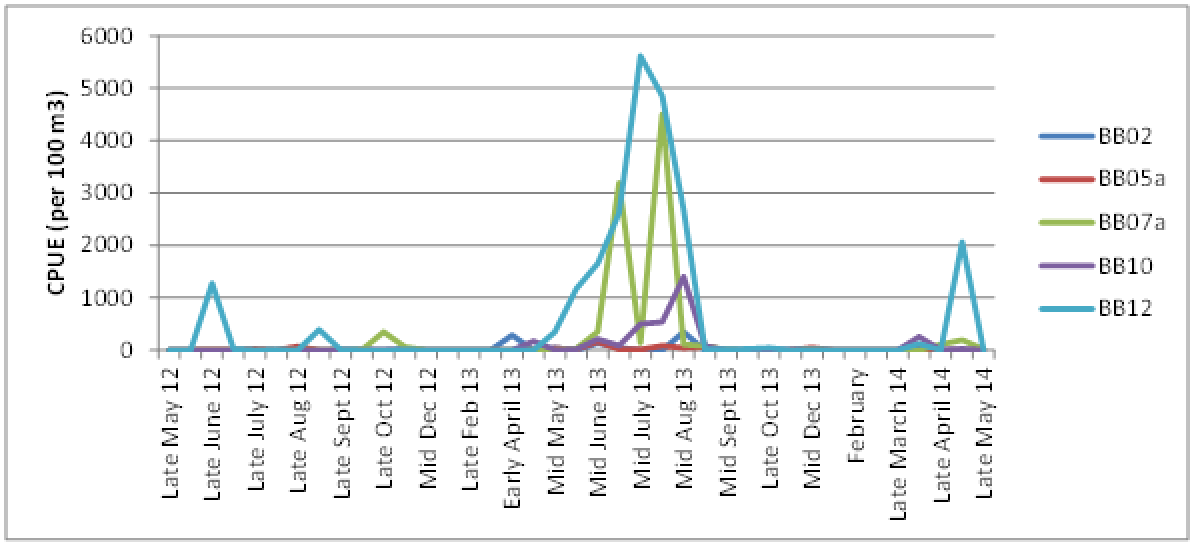


Figure 7. Abundance of decapod larvae (zoeae and megalopae) collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012.

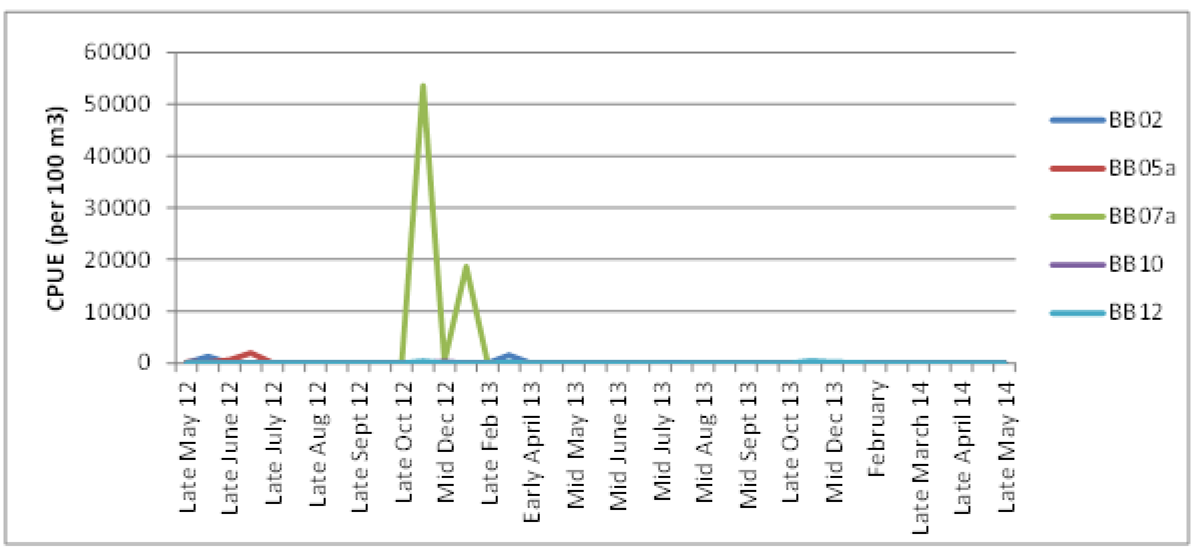
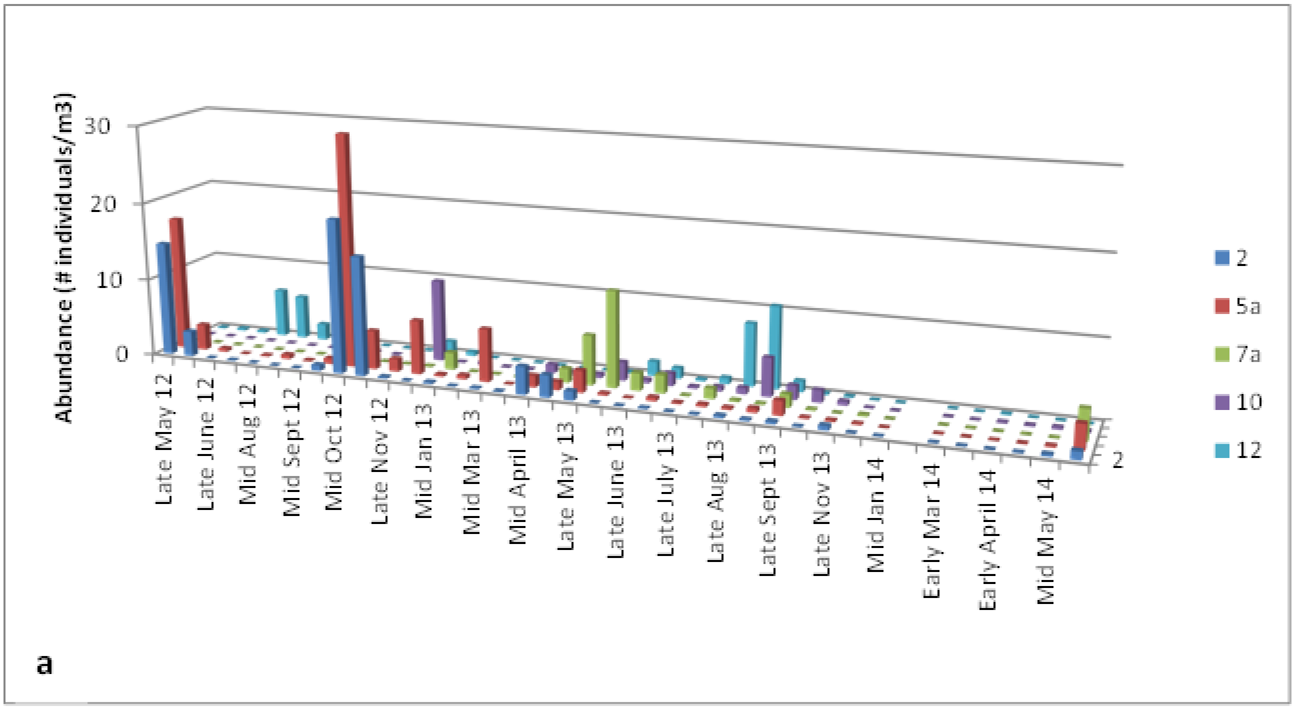


Figure 8. Abundance of pelecypod (bivalve) veliger larvae collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012.

8.3 Gelatinous Macrozooplankton

Targeted gelatinous macrozooplankton included the ctenophores *Mnemiopsis leidyi* and *Beroe ovata*, as well as the cnidarian scyphozoan *Chrysaora quinquecirrha*. These species appeared infrequently in the plankton tows during this sampling period: although M. leidyi was seasonally abundant in the bay in 2012-2013, considerably fewer were collected in the current sampling period (Fig 9). High abundance in Spring 2013 coincided with the spring bloom, while abundance in Fall 2013, although much lower than in Fall 2012, coincided with the smaller fall zooplankton bloom. Abundance declined as Fall 2013 progressed; low zooplankton abundance may have contributed to this trend, as ctenophores are voracious predators of other zooplankton. Winter 2013-2014 was substantially colder than the previous winter, potentially resulting in high mortality for any resident stock of *M. leidyi* overwintering in the bay. Greatest abundance was seen at Site 12 during Summer 2013, which is surprising since *M. leidyi* prefers water of lower salinity than is found in the southern bay.

Ctenophore size distribution was variable across the bay, with more larger individuals found in the northern sampling sites (Figs 10 – 14). Larger specimens tended to be found in the southern bay in the previous sampling year.



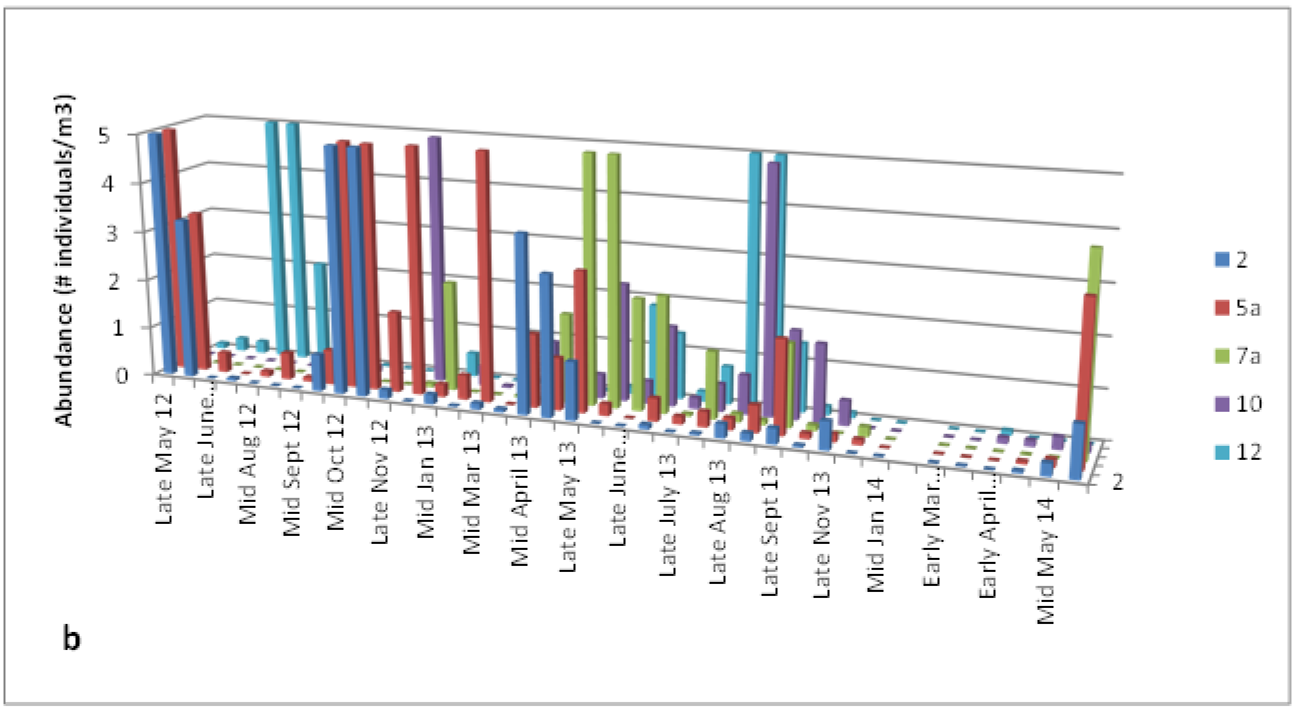


Figure 9. Abundance of *Mnemiopsis leidyi* collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012. Graphs are presented at two resolutions as the large values prevent a finer-scale assessment of lower abundances. a. coarse resolution. b. fine resolution (note differences in y axis between the two graphs).

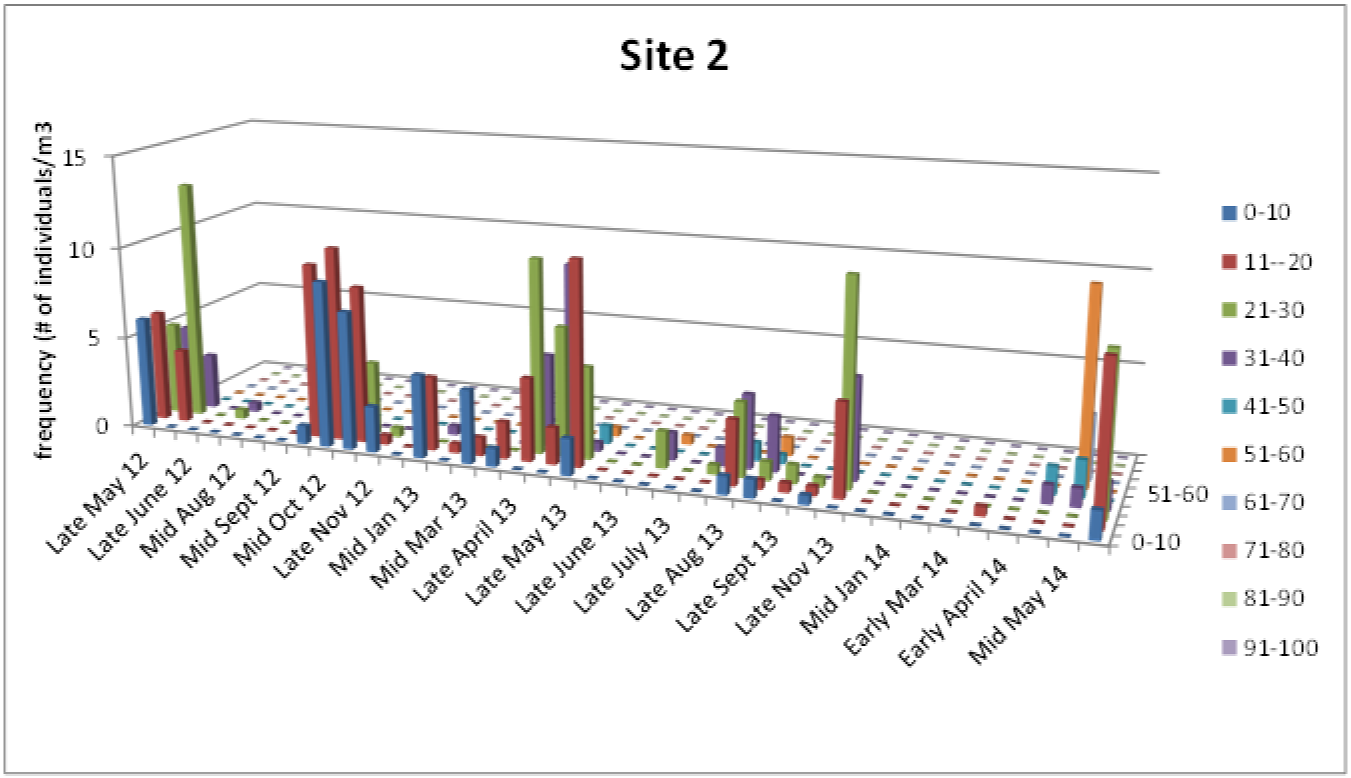


Figure 10. Frequency ditribution of *Mnemiopsis leidyi* at Site BB02 collected May 2012 – May 2014.

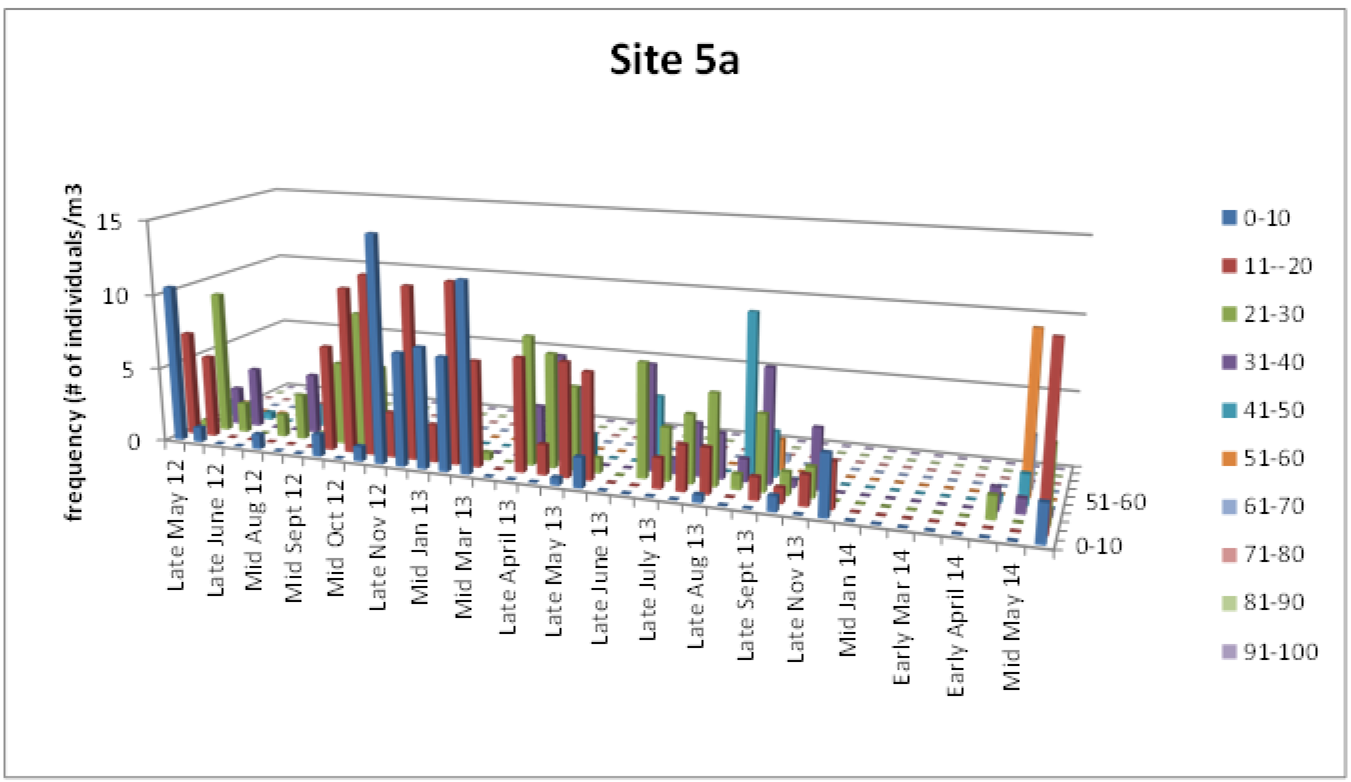


Figure 11. Frequency ditribution of *Mnemiopsis leidyi* at Site BB05a collected May 2012 – May 2014.

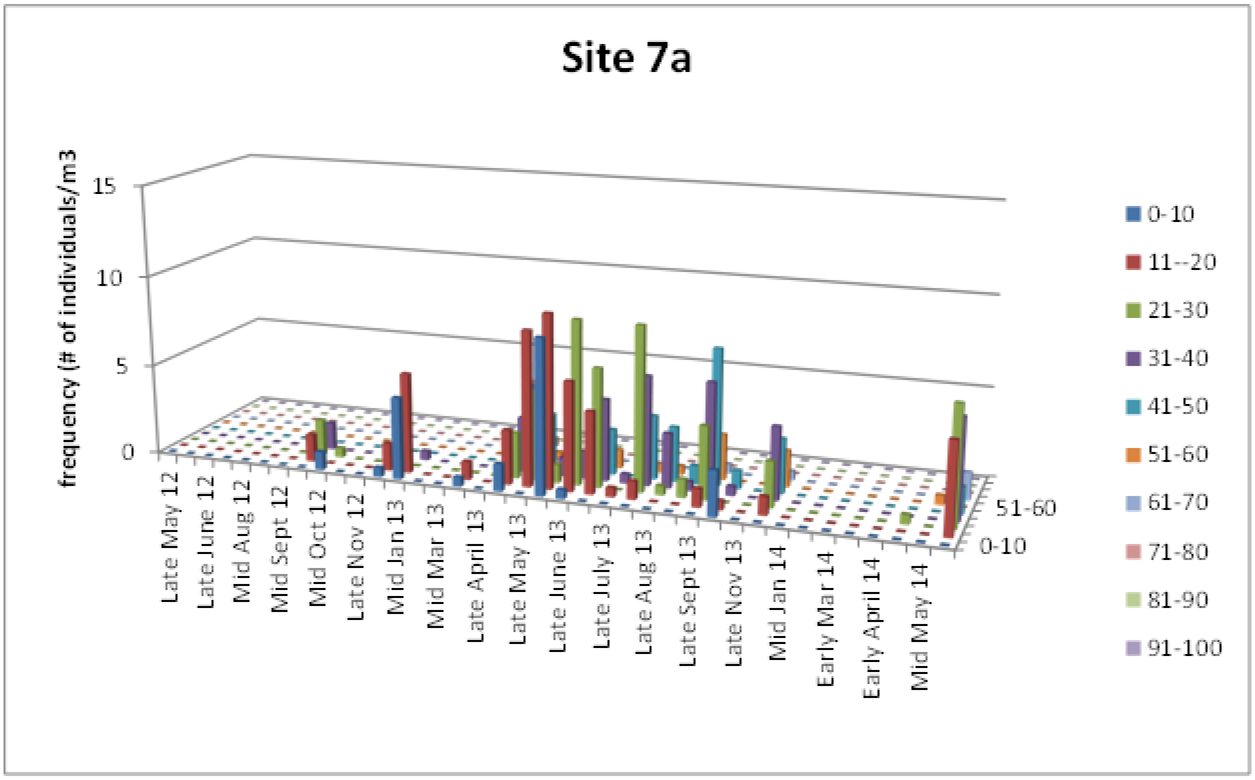


Figure 12. Frequency distribution of *Mnemiopsis leidyi* at Site BB07a collected September 2012 – May 2014.

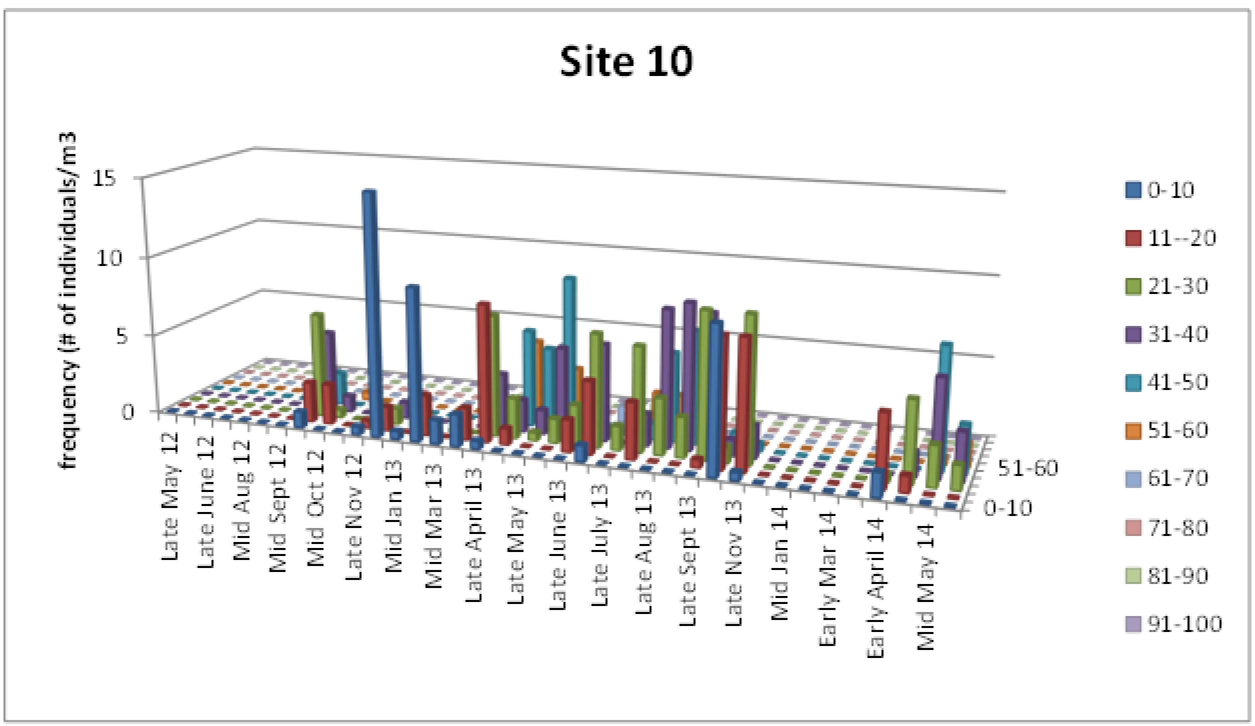


Figure 13. Frequency distribution of *Mnemiopsis leidyi* at Site BB10 collected September 2012 – May 2014.

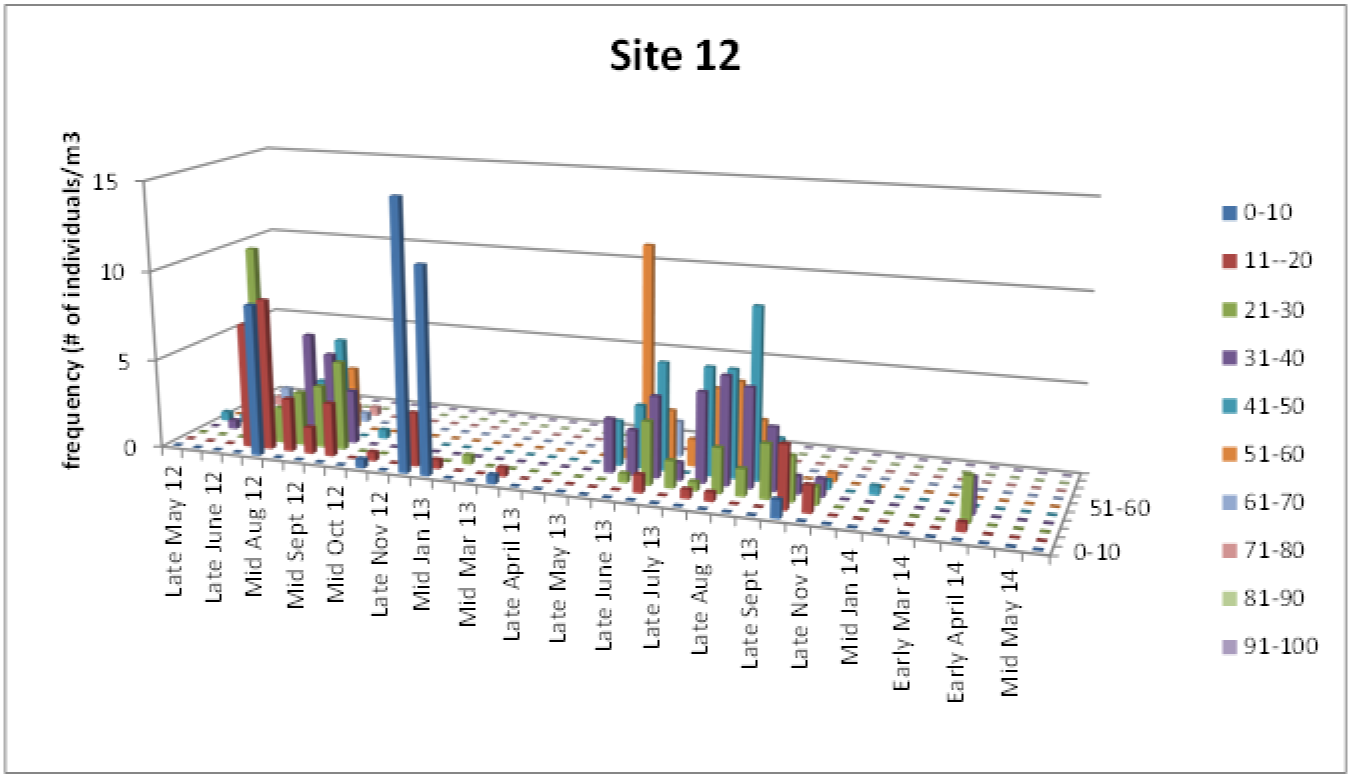


Figure 14. Frequency distribution of *Mnemiopsis leidyi* at Site BB10 collected September 2012 – May 2014.

The ctenophore predator on *M. leidyi*, *Beroe ovata*, occurred rarely in the bay, but was collected in very small numbers in the northern bay during Summer 2013 (Fig 15). Another predator of *M. leidyi*, the sea nettle *Chrysaora quinquecirrha* was abundant mostly in the northern bay in Summer 2013, but was also found at Site 12 in the southern bay in Summer 2013 and Spring 2014.

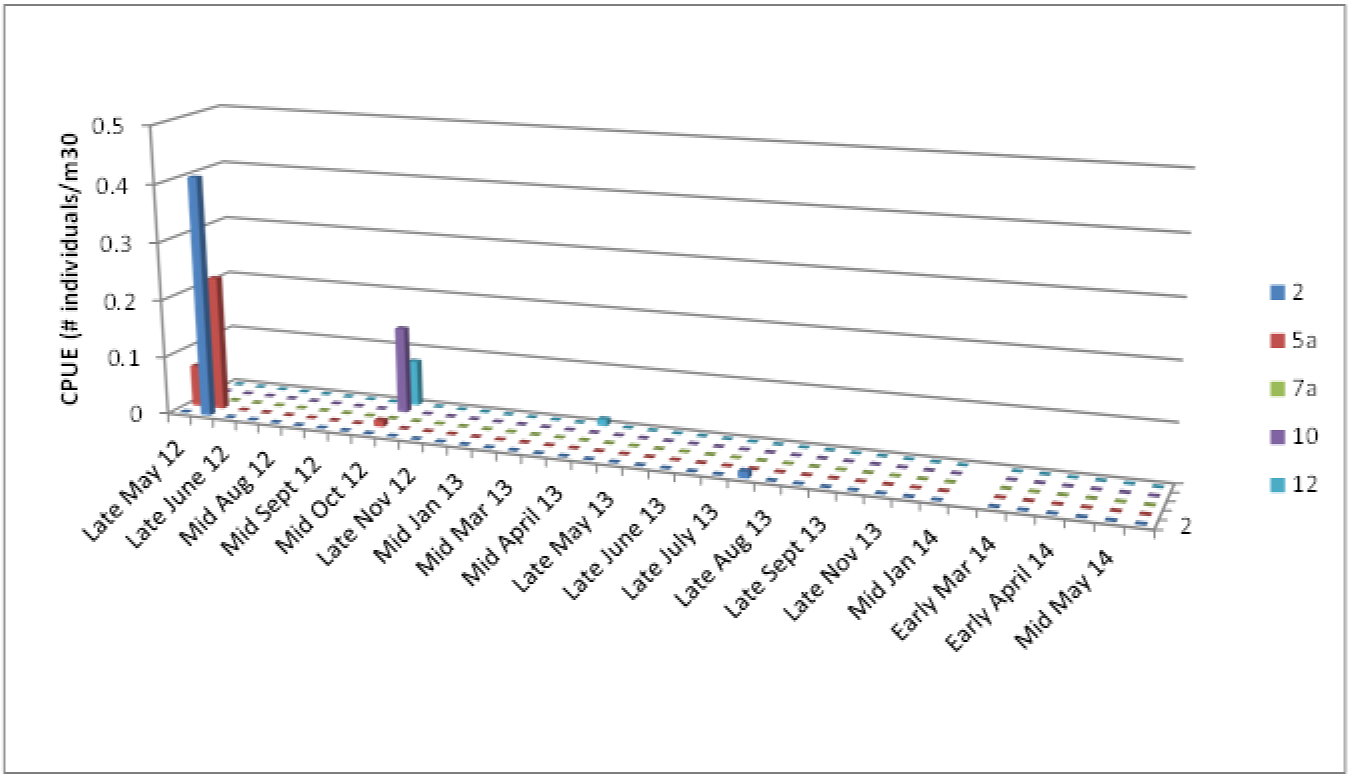


Figure 15. Abundance of *Beroe ovata* collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012.

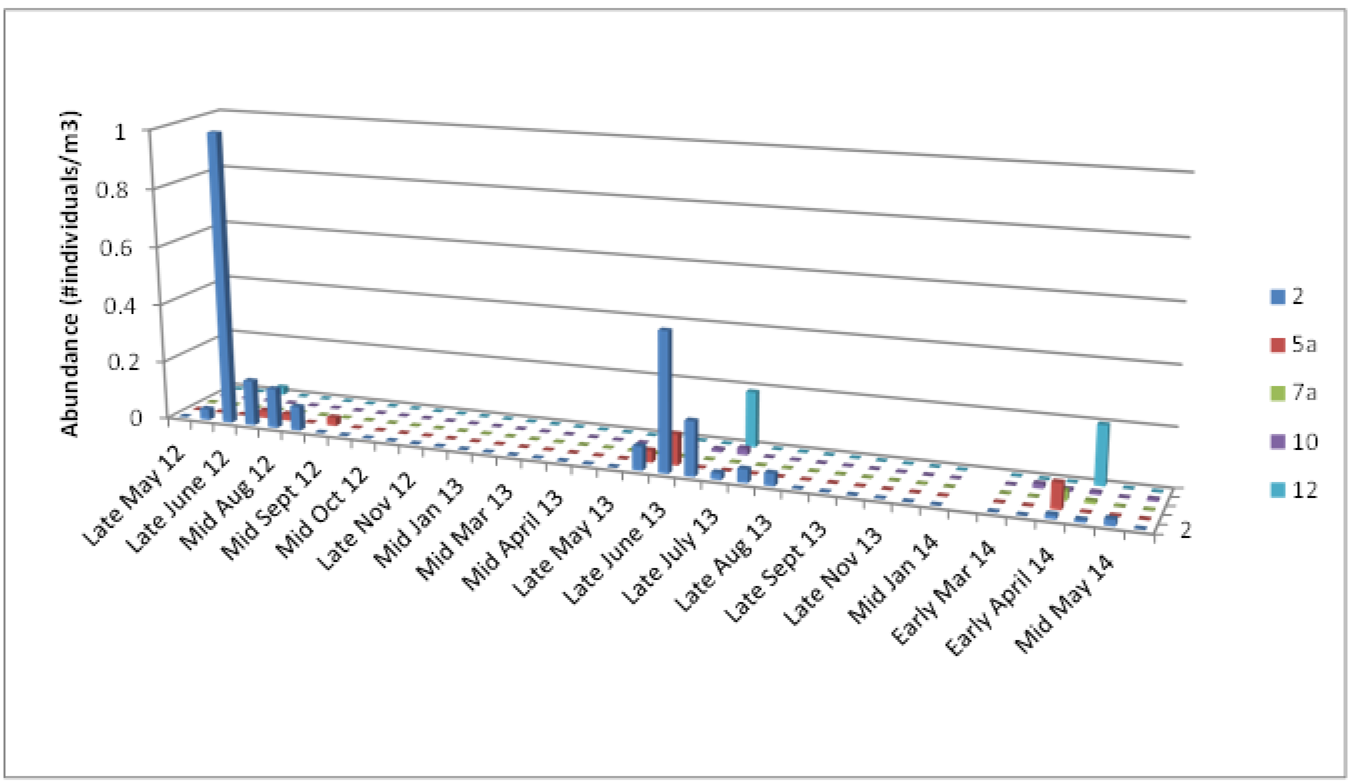


Figure 16. Abundance of *Chrysaora quinquecirrha* collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – May 2014. Sites BB7a and BB10 were added in late September 2012.

8.4 Ichthyoplankton

Ichthyoplankton were removed from fresh samples and preserved in 95% ETOH for later identification. All larval specimens were mid-Atlantic estuarine and coastal species, indicative of the fact that the bay is a nursery for these species. Atlantic silverside was the most abundant species in Year 1 samples, comprising 56% of the total number collected. That species, along with winter flounder and northern pipefish, made up almost 88% of the entire Year 1 sample (Table 1). Although Atlantic silverside was again very abundant in the Year 2 collection, the species only comprised 4% of the total number of fish larvae collected. The majority of ichthyoplankton collected were winter flounder, primarily during the April 2014 intensive sampling event. Winter flounder larvae made up 91% of the Year 2 ichthyoplankton collection.

Table 1. Ichthyoplankton collected in Barnegat Bay, NJ in Year 1 and Year 2. Values are raw abundance data and have not been corrected for tow volume.

Common Name	Scientific Name	Year 1	Year 2
American Eel	*Anguilla rostrata*	1	6
Atlantic Croaker	*Micropogonias undulatus*	7	0
Atlantic Menhaden	*Brevoortia tyrannus*	9	17
Atlantic Needlefish	*Strongylura marina*	2	0
Atlantic Silverside	*Menidia menidia*	1019	498
Anchovy, Bay	*Anchoa mitchilli*	88	94
Anchovy, Striped	*Anchoa hepsetus*	34	105
Black Sea Bass	*Centropristis striata*	2	1
Feather Blenny	*Hypsoblennius hentz*	4	3
Herring spp	*Clupeidae*	0	43
Lined Seahorse	*Hippocampus erectus*	40	26
Mummichog	*Fundulus heteroclitus*	0	3
Northern Pipefish	*Syngnathus fuscus*	115	84
Northern Puffer	*Sphoeroides maculatus*	3	93
Sand Eels	*Ammodytes sp.*	9	67
Striped Mullet	*Mugil cephalus*	1	0
Summer Flounder	*Paralichthys dentatus*	1	0
Tautog	*Tautoga onitis*	1	0
Windowpane	*Scophthalmus aquosus*	1	2
Winter Flounder	*Pseudopleuronectes americanus*	470	12317
Unidentified		23	176
Total		**1830**	**13535**

Four intensive sampling events were conducted during 2012 – 2014. Ichthyoplankton collected during the July 2012 sampling event exhibited nocturnal vertical migration, as most were collected during the midnight tow (Fig 17). Although a few unidentified specimens were seen in the 8 am sample during the October 2012 event, the majority were collected in the 8 pm (20:00) and 4 am samples, not the midnight one (Fig 18). Species differed between the October 2012 and October 2013 (Fig 19) intensive events. Water temperature was warmer during Fall 2012, which may have impacted spawning by certain species in the bay or along the coast. During the April 2014 event, winter flounder *Pseudopleuronectes americanus* began to rise to the surface late in the afternoon, then was collected in large numbers in the plankton tows through early morning (Fig 20).

Some specimens were not identified due to damage. In the first three intensive sampling events, the majority of specimens were Atlantic silverside *Menidia menidia*, an important prey species in the bay. However, winter flounder abundance was an order of magnitude greater in the April 2014 sampling event.

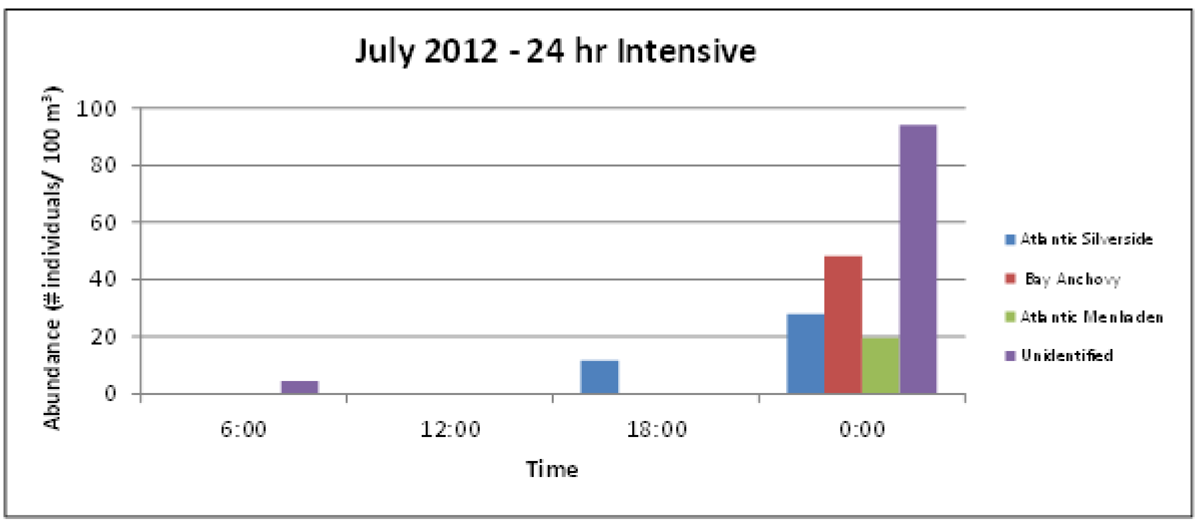


Fig 17. Abundance of ichthyoplankton collected at Site 5a over a 24 hr intensive sampling event in July 2012. Samples were collected every 6 hr.

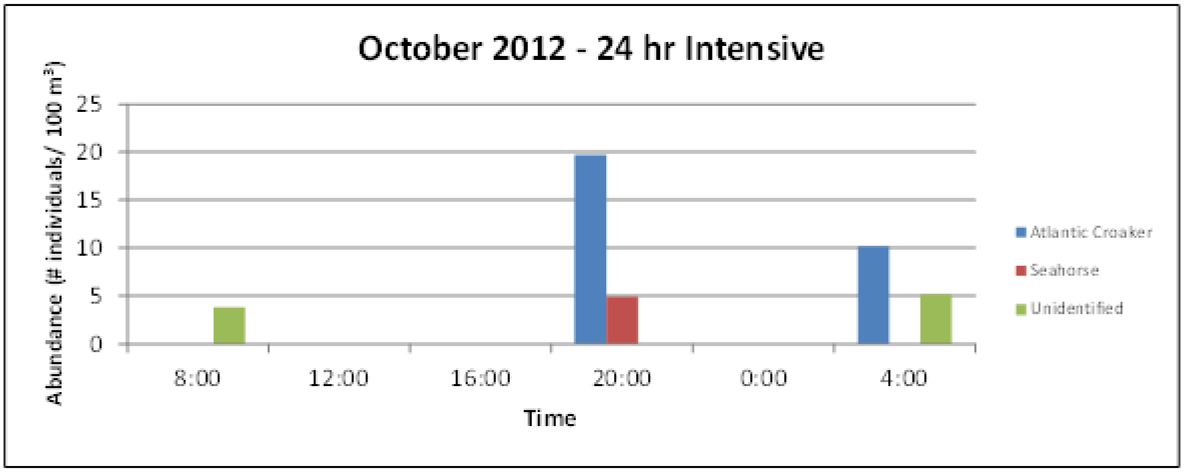


Fig 18. Abundance of ichthyoplankton collected at Site 5a over a 24 hr intensive sampling event in October 2012. Samples were collected every 4 hr.

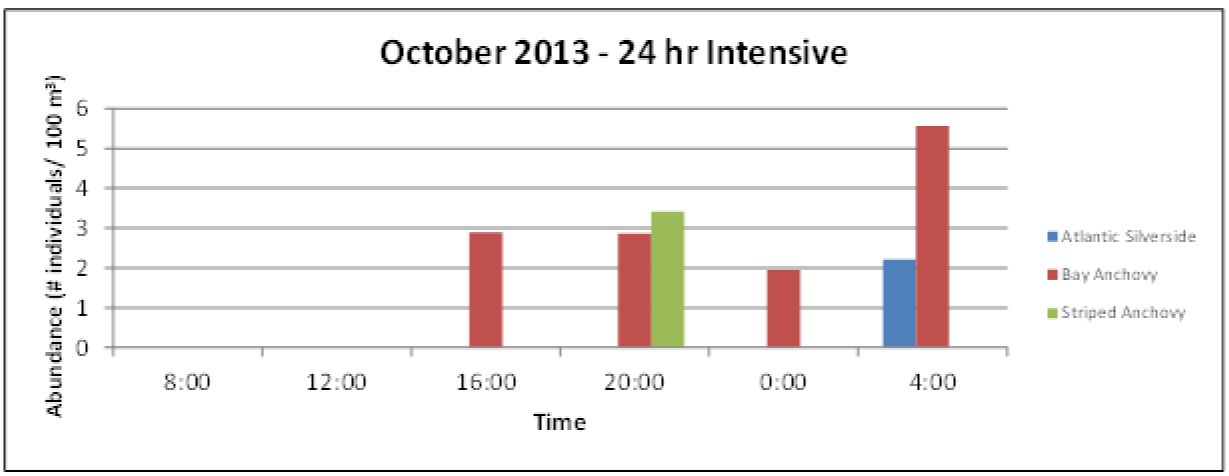
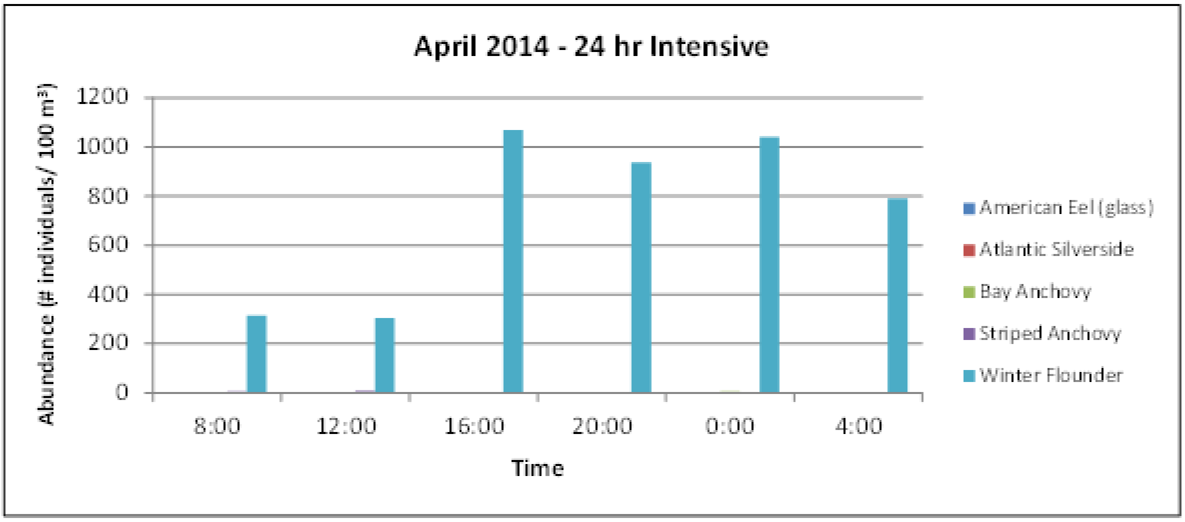
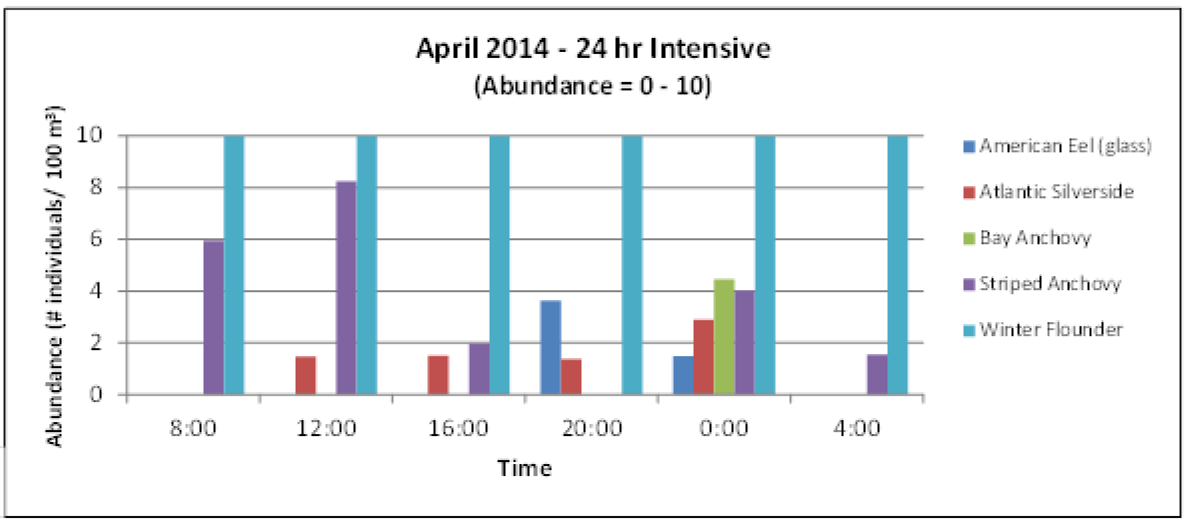


Fig 19. Abundance of ichthyoplankton collected at Site 5a over a 24 hr intensive sampling event in October 2013. Samples were collected every 4 hr.



a.



b.

Fig 20. Abundance of ichthyoplankton collected at Site 5a over a 24 hr intensive sampling event in April 2014. Samples were collected every 4 hr. a.) normal scale on y-axis b.) maximum value on y-axis set to 10 so detail of abundance values for other species is visible.

9.0 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Temporal and spatial trends in Barnegat Bay zooplankton community structure were characterized in the second year of a three year study. Zooplankton such as copepods are important components of the zooplankton during spring and fall blooms throughout the bay. Groups such as decapods (crabs) and bivalves exhibit discrete spawning pulses during certain times of the year, and are almost absent from the plankton otherwise. Ctenophores were not abundant during this sampling year, although they were very abundant in the preceding year. Gelatinous macrozooplankton exhibited few obvious trends in distribution and abundance, although sea nettles were most abundant in the summer. Ichthyoplankton were most abundant during the Spring 2014 intensive sampling event, where the samples were dominated by winter flounder larvae. All ichthyoplankton exhibited nocturnal vertical migratory behavior

Although a number of trends in distribution and abundance of Barnegat Bay zooplankton were observed in this study, many species did not exhibit obvious patterns. Information on abiotic and biotic factors not examined in this study could help to discern subtle trends and linkages between communities. As herbivorous zooplankton abundance is tied to phytoplankton production, evaluating phytoplankton community structure in conjunction with that of zooplankton will undoubtedly be important. Zooplankton may be subject to transport due to currents, tides, and wind, so examining a hydrodynamic model of the bay in conjunction with this study may help to further elucidate patterns in zooplankton distribution and abundance.

The Final Report for the third and final year of this project will examine all data from the project, May 2012 through April 2015. The comprehensive analysis will include an assessment of linkages between phytoplankton and zooplankton, to provide an overview of zooplankton patterns in the bay. The Year 3 Final Report will also include a comparison with historic (1970s) Barnegat Bay zooplankton data, as well as an evaluation of any observed changes in the zooplankton community structure.

10.0 RECOMMENDATIONS AND APPLICATION AND USE BY NJDEP

NJDEP is currently providing funding for studies on phytoplankton, larger ichthyoplankton, a trophic model, and a hydrodynamic model. Communication has already been established with all of these groups, and zooplankton data have been provided to the group modeling trophic structure. It is recommended that NJDEP continues to facilitate communication among these groups and provide a platform (such as the annual workshop) for ongoing results to be discussed.

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Appendix 1: NOAA Quality Assurance/Quality Control Documentation