THE DELAWARE CENTER FOR THE INLAND BAYS

INSHORE FISH AND BLUE CRAB SURVEY OF REHOBOTH BAY, INDIAN RIVER AND BAY, AND LITTLE ASSAWOMAN BAY FOR 2013

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ABSTRACT

Sites along the shoreline of the Inland Bays were sampled in the last half of April and each half of each month from May through October. The sampling effort was a single 100-ft seine haul made parallel to shore with a 30-ft long bag seine. This unit of effort has been used throughout the study.

A total of 208 samples at 16 sites yielded 50 different species of fish, 30,681 total fish and crabs, and CPUE of 128.71 fish per seine. The CPUE for 2013 was lower than the CPUE for the previous two years of the survey, however, 2013 had a greater number of species than either of the previous years. The most abundant species of 2013 were mummichog, Atlantic silverside, striped killifish, white mullet and summer flounder which represented 87% of the overall fish catch.

Catches of the 14 target species: Atlantic croaker, Atlantic menhaden, Atlantic silverside, bay anchovy, bluefish, mummichog, silver perch, spot, striped bass, striped killifish, summer flounder, weakfish, white mullet, and winter flounder, were examined individually.

The blue crab catch of 3,909 crabs, consisted of 2,282 small (0 – 40 mm carapace length), 1,497 medium (41 – 140 mm), and 130 large specimens (>141 mm). CPUE was 18.79 crabs per seine in 2013, less than the CPUE of 2012 (24.21).

INTRODUCTION

The 2013 Inshore Fish and Blue Crab Survey was the third annual volunteer seining study of the near-shore areas of Rehoboth Bay, Indian River and Bay, and Little Assawoman Bay, sponsored through the Delaware Center for the Inland Bays.

Shallow, inshore areas are important to survey as they may be preferentially utilized by juvenile fish and crabs. While the Delaware Natural Resources and Environmental Control (DNREC) offshore bottom trawl surveys are informative, and are the more accurate method for assessing populations for many species, they may miss the forage species which prefer the inshore areas. Likewise, they may miss out on the young-of-year juveniles for species which inhabit the inshore shallow waters until they reach maturity. It is
therefore important to survey both the deeper waters of the Inland Bays, and the inshore areas, in order to accurately assess species populations. This survey represents the first comprehensive, long-term survey of these inshore areas in the Inland Bays.

The objectives of the study are to generate comparative average catch data for all species, with emphasis on 14 target fish species (seven forage and seven predator species) as well as blue crab. From these data, changes in species abundance and distribution for each species can be monitored.

The annual Inland Bays reports are distributed to state and federal regulatory organizations, academic institutions, and interested environmental organizations. Summary data are available to the above entities and the public through the annual reports. Complete data sets are available by request to the Center for the Inland Bays.

METHODS AND MATERIALS

A total of 208 inshore seine samples were collected at 16 sites on Indian River and Bay, Rehoboth Bay, Little Assawoman Bay and tributaries (Figure 1) during April through early November. Site descriptions are listed in Table 1. One set was collected during the second half of April, while two sets were collected in each month from May through October: one during the first half of the month and one in the second half.

Each study site needed to be in close proximity to a road or parking lot for ease of access by volunteers in motor vehicles. To qualify as a sampling site, there had to be an open shoreline area of at least 100 feet in length, with a flat bottom and substrate that was not too soft to safely sample at all tidal stages. Four sites are located on Rehoboth Bay, while seven are on Indian River and Bay, and five are on Little Assawoman Bay and tributaries (Figure 1).

Each sample was collected with a 30-foot long by 4-foot high bag seine with ¼-inch mesh. The bag is 4-foot long, 4-foot wide and 4-foot deep, located in the center of the net. The net was drawn, fully extended, parallel to the shore for 100 feet, swung onto shore and emptied. The only exception to this procedure was at Rosedale Beach (Site No. 6), where two 50-foot hauls were made due to the fact that a pier, too low to walk under, is located across the middle of the area. All fish were removed from the net, identified and counted. At least 25 specimens of each fish species were placed in buckets of water as quickly as possible to be measured to the nearest millimeter. Fish to be measured are selected in a haphazard fashion. The first 25 fish of each species which are scooped out of the holding bucket are measured. This may slightly
bias measurements towards the largest fish of each haul, because the larger fish have less chance of avoiding the dip net and being removed from the holding bucket. All other fish and all crabs were immediately counted and returned to the water to minimize mortality. When air temperature was extremely high, bottles of frozen water and aerators were placed in the buckets to reduce mortality for those specimens retained for measurement. Blue crabs were counted and recorded as small (less than 40 mm carapace width, less than 1-year old), medium (41-140 mm, 1-2 years old) or large (greater than 140 mm, adults more than 2 years old).

Fish were identified to the species level. The senior author was present for most of the surveys to verify identifications. When questionable species were encountered in other samples, pictures or preserved specimens were transmitted to the senior author for identification or verification.

Each seine sample was designated as one unit of effort. Rosedale beach, which is surveyed with two 50-ft hauls, was combined, and counted as one unit of effort, since both hauls take place within minutes of each other, and because a pier separates the two hauls, neither haul is likely to influence the other. Catch-per-unit-effort (CPUE) was calculated for each species for all bays, and each bay individually, by dividing the total catch of that species in 2013 by the total number of seines for all bays (208), or each bay (Rehoboth Bay 52, Indian River Bay 91, Little Assawoman Bay 65). CPUE was also calculated for all fish by dividing the total catch of 2013 by the total number of seines (208). Percentage calculations for each species of fish do not include crabs in the calculation of total catch, and are therefore the percentage each species comprises of the overall fish catch.

The 14 target fish species chosen for individual results and discussion sections included seven important forage species which occur throughout the Inland Bays, and seven recreationally and commercially caught species in Delaware and other states. These species include: Atlantic croaker, Atlantic menhaden, Atlantic silverside, bay anchovy, bluefish, mummichog, silver perch, striped bass, striped killifish, summer flounder, weakfish, white mullet, and winter flounder. Blue crab were also considered a target species. Individual analyses were performed for all 15 target species.

Physical parameters of water temperature (measured to 0.1 degree centigrade, °C), dissolved oxygen (to 0.1 milligram per liter, mg/l), and salinity (to 0.1 part per thousand, ppt) were measured with either a YSI 85 or a YSI Pro 2030 meter at the beginning of each survey. The weather and wind conditions were noted for each sample as well as the stage of the tide. Tidal stages were categorized as low ebb or low flood if sampling began within 2 hours of low tide, mid-flood or mid-ebb if sampling began within 2 to 4 hours of low or high tide, and high ebb or high flood if sampling began within 2 hours of high tide.
Results

Overall Catch

The overall catch for 2013 consisted of 26,772 fish of 50 species and 3,909 blue crabs. The catch per unit effort (CPUE) was 128.71 fish per seine. The most abundant fishes were Atlantic silverside (35.7% of the total fish catch), mummichog (34%), striped killifish (9.5%), white mullet (5.1%), and bay anchovy (3.7%), which accounted for 88% of the overall catch. The most abundant species in each month was Atlantic menhaden in April, mummichog from May through July, and Atlantic silverside from August through October. Ten species collected for the first time in 2013 were Atlantic moonfish, bluegill, gizzard shad, lookdown, pollock, redfin pickerel, skilletfish, smallmouth flounder, striped searobin, and windowpane. July and August were the most productive months, with the greatest number of fish caught (Figure 2).

The blue crab catch consisted of 2,282 small, 1,497 medium, and 130 large specimens. June and July had the greatest number of crabs caught (Figure 3).

Rehoboth Bay

The overall catch from Rehoboth Bay (sites 1-4) was comprised of 33 fish species, with a total of 5,172 fish, and 418 crabs. Rehoboth bay sites had a CPUE of 99.5 fish per seine. The five species with the highest catches were Atlantic silverside (2,088; 40% of the overall fish catch), striped killifish (1,495; 28.9%), mummichog (494; 9.5%), white mullet (352; 6.8%), and sheepshead minnow (278; 5.3%). These species accounted for 90.5% of the overall catch. The overall catch for Rehoboth Bay was dominated by the 4,066 specimens collected at Kayak Launch which accounted for 78.6% of the total.

The blue crab catch consisted of 226 small, 170 medium, and 22 large specimens.

Physical/chemical parameters in Rehoboth Bay during 2013 were relatively consistent across the sites. The average ranges across the sites were 5.4 – 5.9 mg/l for dissolved oxygen, 26.0 – 28.6 ppt for salinity, and 20.7 – 22.6 °C for water temperature. Dissolved oxygen generally was high in April, lower in May, within a relatively narrow range of 5.0 – 6.6 mg/l from June through September (except for 3.7 mg/l at Kayak Launch during July), and higher in
October. Monthly average salinities were very consistent within a range of 24.6 – 29.5 ppt. Monthly temperature increased from a low range of 13.9 – 15.8 °C in April to highs of 25.9 – 29.4 °C in July, and decreased to 17.8 – 19.2 °C during October.

**Indian River and Bay**

The overall catch from Indian River and Bay (sites 5 – 13) was comprised of 35 fish species, 16,337 total fish, and 2,852 blue crabs. Indian River and Bay sites had a CPUE of 179.52 fish per seine. Then five most abundant fish species were mummichog (6,385 specimens; 39.1% of the total catch), Atlantic silverside (5,607; 34.3%), white mullet (996; 6.1%), summer flounder (679; 4.1%), and bay anchovy (624; 3.8%). These species accounted for 87.4% of the total fish catch.

Indian River and Bay had the most productive sites of 2013, with respect to both the total number of fish caught (Site 5, Peninsula), and total number of species caught (Site 6, Rosedale Beach) (Figure 4,5). Sites 5, 6, and 8 were the most diverse and were all located on the Indian River.

The blue crab catch (2,852) was comprised of 1,660 small, 1,121 medium, and 71 large specimens. The vast majority of crabs collected in 2013 were caught at sites on the Indian River (Figure 8).

The overall average physical/chemical values for Indian River and Bay were 6.1 mg/l for dissolved oxygen, 22.5 ppt for salinity, and 22.5 °C for water temperature. Dissolved oxygen generally was highest in April and May, lower in June through August, and high in September and October. A notable exception to this pattern was at Sandy Beach, the farthest upstream site in the Indian River system. Oxygen there averaged unusually high levels of 9.0 mg/l in June and 7.9 mg/l during August while oxygen was unusually low (4.2 mg/l) during October. Salinity measurements ranged from 4.2 ppt in August at Sandy Beach to 29.6 ppt at Bethany Bay during May. Water temperature readings ranged from 12.0 °C to 30.7 °C. The monthly pattern was typical of the Inland Bays, with the lowest temperatures in April and early May, highest temperatures during late June through July, and a gradual decrease through August, September, and October.

**Little Assawoman Bay**
The overall catch at Little Assawoman sites (numbers 15-20) included 5,263 fish of 27 species, and 639 blue crabs. Little Assawoman Bay sites had a CPUE of 80.96 fish per seine. The most abundant fish species were mummichog (2,238; 42.5% of the overall catch), Atlantic silverside (1,865; 35.4%), striped killifish (451; 8.5%), bay anchovy (301; 5.7%), and sheepshead minnow (211; 4.0%), which accounted for 96.1% of the catch.

The blue crab catch consisted of 396 small, 206 medium, and 37 large specimens.

The overall physical/chemical averages for Little Assawoman Bay during 2013 were 6.4 mg/l for dissolved oxygen, 19.7 ppt for salinity, and 22.7 °C for water temperature. Individual dissolved oxygen readings ranged from 2.9 to 10.6 mg/l, but only three values were less than 4.3 mg/l. Monthly averages were 4.9 – 10.6 mg/l. Oxygen levels generally were highest in April and May, lowest during June through July, and high in September and October. Salinity levels were much more variable with the high frequency of substantial rainfall events throughout most of the sampling season. Individual readings ranged from 6.6 to 31.1 ppt while the monthly range was 10.6 – 30.7 ppt. Individual water temperature readings ranged between 14.3 and 31.6 °C. Monthly average temperatures were low in April and May and highest in June and July. Temperatures declined monthly thereafter to lowest values in October.

Discussion

The overall fish catch of 26,772 for 2013 was substantially lower than the 50,883 for 2011, and 46,096 for 2012 (Kernehan et al. 2012, 2014). Likewise, 2013 had the lowest CPUE of the three survey years. The overall average dissolved oxygen for 2013 (6.1 mg/l) was higher than the averages for 2011 (5.3 mg/l) and 2012 (5.4 mg/l). The average water temperature for 2013 (22.5 °C) was intermediate between the averages for 2011 and 2012 (23.6 and 19.1 °C). Salinity was the lowest of the 3 years but, all were very similar (22.5 ppt, 22.6 ppt and 23.5 ppt). However, there were substantial short-term fluctuations between many samples during 2013. For example, at Rosedale Beach, the average difference between salinity values for individual samples was 20.3%. These higher fluctuations in salinity may help explain why 2013 had fewer total fish. Many fish species may have moved farther away from shore to slightly deeper waters where salinities are more stable, leaving the range of the seine nets, and therefore not being captured by the techniques utilized in this study.
Despite the lower CPUE and number of fish caught, 2013 was the most diverse year yet. The 50 species collected in 2013 was higher than the 41 species collected in 2011, and the 37 species collected in 2012.

The monthly pattern of fish abundance did not follow either monthly pattern seen over the last two years. 2013 had a peak number of fish in June and July (Figure 2). 2012 had a peak in May and a steady decline after, while 2011 had a peak in September. These differing patterns in peak fish abundance could be driven by many factors, including weather, water temperature, and differing success of spawning stocks for individual species.

The most abundant species in 2013 were the Atlantic silverside, mummichog, and striped killifish. As in the previous two years, these three species accounted for a bulk of the total fish caught. Mummichog and Atlantic silversides appear to be fairly well distributed across all 16 sites. Striped killifish were also found at all sites surveyed, indicating their wide distribution in the Inland Bays, however, a majority (55%) of the striped killifish were caught at a single site (Kayak Launch) in 2013 (Figure 6). Since the start of this survey in 2011, Kayak Launch has been responsible for the majority of all striped killifish catches. It is unclear why this site has such a large number of striped killifish present. Out of all the sites surveyed by this study, Kayak Launch has been on the lower end of both temperature and dissolved oxygen, and on the higher end of salinity. Kayak Launch also has Spartina sp. along a majority of the seine haul, although this is not entirely unique in our survey. Further investigation is needed to determine the exact reasons why this site has such a large abundance of striped killifish.

As in the two previous years, the most productive sites in terms of both total fish caught and greatest number of species caught were registered at sites in Indian River. The Peninsula (Site 5), Rosedale Beach (Site 6), and Sandy Beach (Site 8) have consistently been top producers for fish and crabs in the Inland Bays (Figure 4, 5). These three sites all have some form of structure that extends into the water. At Rosedale and Sandy beach there are piers which form the end of the seine haul. Likewise, Peninsula has two small jetties which flank the seine haul. These elements of structure are somewhat unique to the sites surveyed for this study. It is possible that the structure these sites provide acts as an attractive to both fish and crabs, providing refuge from predators, and a more complex habitat than flat bottom.
With only two years of crab data, it is difficult to conclude whether 2013 was a below average year for crabs, or whether 2012 was an above average year. Regardless, June has been the peak crab month for both years that crabs have been tallied, with July as the second highest month (Figure 3). The relatively low numbers of large crabs is not unexpected based on the methods employed by this study. Larger crabs utilize structure, and inhabit deeper waters. This study focuses entirely on inshore habitat, often in water less than two feet deep. While this method is likely successful at catching small crabs, large crabs are likely better assessed through deeper water trawls as conducted by DNREC.

Results and Discussion – Target Species

Target species are species of special concern, either due to their importance for commercial or recreational fishermen, or due to their importance as food for larger species. A total of 14 fish species (7 predators and 7 forage species) have been defined as target species; Atlantic croaker, Atlantic menhaden, Atlantic silverside, bay anchovy, bluefish, mummichog, silver perch, spot, striped bass, striped killifish, summer flounder, weakfish, white mullet, and winter flounder. Blue crabs have also been designated as a target species based on their importance for recreational and commercial interests. While this survey has gathered a large amount of data thus far, reliable trends in populations cannot yet be assessed. Without trend information, we can only report on anecdotal information for each target species such as monthly peaks, and whether a particular site was more productive than the others for a target species. Each target species was analyzed separately to investigate any potential site or monthly biases.

Atlantic croaker

A total of 57 specimens were collected at six sites in 2013. The annual catch was intermediate between 2012 (5) and 2011 (103). Most of the Atlantic croakers collected during the 3 years were small young (19-57mm) taken during October. This time of collection corresponds with the fall and early winter oceanic spawning period of croaker which utilize the Inland Bays as nursery grounds as reported by Wang and Kernehan (1979). Most croakers were collected at Sandy Beach (74%) for 2013. All croaker were collected over soft substrate which agrees with results from 2012 and 2011 sampling. The spatial distribution of the croaker catch in 2013 and 2012, was markedly different from
2011. 91% and 100% were collected in Indian River and Bay in 2013 and 2012 respectively, but 83% were collected in Little Assawoman Bay in 2011. This indicates that the distribution of Atlantic croaker is highly variable from year to year.

Atlantic menhaden

The 405 specimens collected in 2013 was the lowest total of the 3 sampling years (1,429 in 2012; 765 in 2011). Four of the five sites where this species was collected are located in Indian River and Bay. Catches at Sandy Beach (360 specimens) yielded 88% of the overall catch. Sandy Beach has been the most productive site for Atlantic menhaden each year of the study. All sites with substantial catches have soft substrate which is probably preferred by menhaden food items.

The temporal pattern of menhaden catches in 2013 differed slightly from the previous 2 years. In 2013, 85% of the catch was taken in April whereas 72.9% and 66.4% of the 2011 and 2012 catches were taken in May.

Atlantic silverside

The 2013 catch of 9,560 specimens was nearly twice as high as in 2012 (5,304) but less than half of the 2011 total (22,901). The highest catches in 2013 were recorded at The Peninsula (2,247), and Kayak Launch (1,374), but the Atlantic silverside appears well distributed in the Inland Bays (Figure 6).

While August was the most productive month for silversides in 2013, no monthly pattern is visible over the last three years.

The rebound in Atlantic silverside catches in 2013 was a positive event after the puzzling drop in 2012 catches from the 2011 levels. The 2012 catch was 77% lower than the 2011 catch. The dramatically higher abundance of silversides in a year within the Inland Bays is not unprecedented. Pacheco and Grant (1973) found dramatic differences in the annual numbers of early life stages of silversides collected in Indian River Inlet sampling during flood tides in 1959-1961. Their catch in 1958-59 was only 194 as opposed to 1,491 in 1959-60 and 18,259 in 1960-61. The percentage of silverside recruitment in the Inland Bays from spawning in the Ocean is unknown. Substantial spawning activity has been reported in the Inland Bays (Wang and Kernehan 1979).

Bay anchovy
The bay anchovy catch of 989, was almost double the levels of 2012 (570) and 2011 (512). Bay anchovy catches were highest at Pools Point (360), which accounted for 36% of the total catch. The bay anchovy appears well distributed throughout the Inland Bays, with catches at 15 of the 16 sites in 2013. All of the most productive Bay anchovy sites each year, except Coastal Kayak, have soft substrate. This type of habitat is undoubtedly favorable for the zooplankton which are the dominant food type for bay anchovy.

September was the most productive month for anchovy catches. The higher September catch in 2013 was composed of young-of-the-year bay anchovy; 50% were 19-26 mm in length while 37% were 30-55 mm (most of the larger specimens were collected in October).

**Bluefish**

The 2013 catch of 78 bluefish was substantially higher than for either 2011 (41) or 2012 (41). The highest catches were recorded at Kayak Launch (21), but Bluefish appear fairly well distributed across the Inland Bays (Figure 7).

The majority of the bluefish catch was taken during May through July in 2013 (82%), 2012 (100%) and 2011 (80.5%). The methods employed in this study are more conducive to catching juvenile bluefish rather than adults, and as a result the overwhelming majority of bluefish captured in this study are juveniles. Therefore, these peaks in juvenile catches during May through July suggest that these specimens were probably spawned in the early part of the spawning season which has been reported to begin in May off North Carolina (Smith et al. 1994; Berrien and Sibunka 1999).

**Mummichog**

The overall mummichog catch (9,117 specimens) for 2013 was substantially lower than in 2012 (17,239) and 2011 (13,206). Mummichogs were well distributed (Figure 6), and were found at all 16 sites. Sandy Beach was the most productive site, with 28% of the total catch. Sites where mummichogs were found in large numbers have vascular plants abutting the sampling areas. The bases of the plants are under water at higher tide stages. These areas are favored by mummichogs at higher tide stages but they have to move to the adjacent beaches at lower tide stages.

May or June was the month with the highest monthly totals in each year. The substantial decline in catches after July is likely due to cessation of
extensive spawning activity which reduces the number of large aggregations of mummichog in inshore areas.

**Silver perch**

A total of 117 silver perch were collected in 2013. This was substantially less than the total catches in 2012 (647) and 2011 (1,756). Nearly 50% of the specimens were collected in August.

Juvenile silver perch did not exhibit specific habitat preference since sites with hard and soft substrates were rated within the top five for catch levels. Silver perch were collected throughout the Rehoboth and Indian River systems with the highest catches in mid to high salinity waters. Only 15 specimens were collected during the 3 years at Little Assawoman Bay sites. The population size of silver perch in the Little Assawoman system appears to be much lower than in the Indian River system with little successful spawning.

**Spot**

The 146 spot collected in 2013 was almost twice as many as the 74 collected in 2011, but far less than the 8,219 from 2012 when a very strong year class was generated from this species’ offshore spawning, and survival of larvae. Able and Fahay (2010) reported that spot has exhibited dramatic fluctuations in annual abundance of young. Pacheco and Grant (1973) reported the collection of planktonic spot in Indian River Inlet during 1958-59 was 117 times higher than the average of 1959-60 and 1960-61. These large fluctuations may help explain the patterns seen in this study.

Sites on Indian River (Sandy and Rosedale beaches) and close to it (The Peninsula) have been preferred sites for spot in each of the 3 years. All of these sites have soft substrate in all or part of the sampling area. June and July were the peak times for Spot.

**Striped bass**

37 striped bass were collected in 2013. This is greater than in 2012 (22), but lower than in 2011 (43). The location of striped bass catches have been variable from year to year. Over 50% of the 2013 catches were in Little Assawoman Bay, while all catches in 2012 were in the Indian River and Bay. Striped bass have semi-buoyant eggs which need flowing freshwater or very low salinity water to remain suspended until they hatch. Spring rainfall was
abundant in 2011 and 2013 which allowed successful spawning in the Little Assawoman system, but drought during the spring of 2012 likely prevented it. The Little Assawoman system does not have a substantial source of above ground freshwater as the Indian River system does from Millsboro Pond. This factor limits successful spawning of striped bass in Little Assawoman to years with abundant rainfall in early spring.

The majority of striped bass were collected during July through September, a pattern which has been observed the last three years.

**Striped killifish**

Striped killifish catch totals were dramatically lower in 2013 than either of the previous years. Furthermore, while striped killifish have been caught at all 16 sites, Kayak Launch comprised the majority of striped killifish caught (Figure 6). This site appears to be very important to striped killifish populations year after year. Further investigation is needed as to why striped killifish are so abundant at this site, and not at others. Monthly catches in 2013 were well distributed.

**Summer flounder**

Summer flounder catches were substantially higher in 2013 (756 overall) than in 2012 (62) and 2011 (49). Bottom trawl samples in Indian River and Rehoboth bays during 2013 by DNREC also observed a greater number of summer flounder per tow in 2013 than the 2011-2012 average (Greco 2014). Our results combined with DNREC’s indicate that 2013 was a strong year class for summer flounder in the Inland Bays.

Interestingly, while DRNEC bottom trawls saw an increase in summer flounder, the increase observed in this study was much higher. This may indicate that inshore seine samples are a better method for assessing the year class strength of summer flounder.

Sites along the Indian River had the bulk of summer flounder catches (Figure 7). The average salinity for the summer flounder catch was 16.7 ppt. The preference for mid-salinity waters differs from the preference for high salinity waters that Able and Fahay (2010) found in New Jersey estuaries. April and May were the most productive months for summer flounder.

**Weakfish**
The 2013 catch consisted of only two specimens collected at Peninsula during July. Weakfish catches have been low for our study all three years. DNREC trawl samples have had better success with an average of 4.47 weakfish per tow in 2013 (Greco 2014). The radical difference in abundance results between the two studies indicates that the inshore habitats sampled in our study are not heavily utilized by weakfish.

White mullet

The white mullet catch for 2013 (1,365) was higher than 2012 (474) and 2011 (527). 63.5% of the 2013 catch was at Peninsula, and the most productive month was July.

Winter flounder

Like summer flounder, winter flounder abundance was substantially higher in 2013 (419 specimens) than 2012 or 2011, with May being the most productive month. DNREC bottom trawls also reported higher catches per tow in 2013 than in 2011-2012 (Greco 2014). However, no young-of-year winter flounder were collected in the Delaware Bay portion of the DNREC study during 2013. As was the case with summer flounder, inshore seine samples appear to be more effective than offshore bottom trawl samples for monitoring year class strength of winter flounder. In support of this, Sogard and Able (1991) reported that juvenile winter flounder larger than 25 mm in length were found to be most abundant in waters of 1-3 m, the area captured by our seining methodology.

The Peninsula was responsible for 77% of the total winter flounder catch (Figure 7). Interestingly, unlike summer flounder which showed a preference for mid salinity waters, the average salinity for samples which yielded winter flounder in 2013 was 26.7 ppt.

Blue crab

A total of 130 large, 1497 medium, and 2282 small crabs were caught in 2013, for a total of 3,909 blue crabs. This was substantially less than the 4,884 captured during 2012. Crabs of all three size classes were mostly caught along the Indian River sites (Figure 8). The difference in the number of crabs caught from each size class is likely due to the inherent bias of seining. Seine samples were taken in shallow flat bottom areas, and nets were often dragged over macro algal beds. Epifanio et al. (2003) reported that macro algal beds serve as
an important nursery area for small crabs (less than 30mm) in the Inland Bays. Other authors have also reported that shallow, muddy areas in estuaries were very valuable habitats for juvenile crabs (Seitz et al. 2003 and 2005; King et al. 2005; Lipcius et al. 2005). Furthermore, juvenile blue crab abundance and survival is enhanced in shallow, unstructured habitats (Lipcius et al. 2007). It is therefore not surprising that our study captures so many small crabs, because we sample areas which are heavily utilized by them.

Oppositely, large crabs prefer areas with structure (Hines 2007). This study catches few large crabs because the habitats these crabs utilize are largely not sampled. In support of this, the only sites where large vertical structures (piers, docks, jetties) are present, are sites where we found the greatest number of large crabs (Figure 8).

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LITERATURE CITED


Figure 1. All 16 sites surveyed in 2013.
Fig 2. Total fish caught by month for 2013. July and August had the greatest number of fish caught.
Figure 3. Total crabs caught by month for 2013. June and July saw the greatest number of crabs caught.
Figure 4. Total number of fish caught by site. Peninsula (Site 5) had the greatest number of fish caught in 2013.
Figure 5. Number of species caught at each site for 2013. Rosedale Beach (Site 6) was the most diverse site, with 26 species caught. Indian River had the three most diverse sites (5, 6, 8).
Figure 6. Percentage of the total catch of the three most abundant species, for 2013, at each site. Each species sums to 100% percent separately. Mummichog and Atlantic silverside catches were fairly well distributed, with a slightly higher percentage caught along the Indian River. A majority of striped killifish were caught at Kayak Launch.
Figure 7. Percentage of the total catch of three managed species, for 2013, at each site. Each species sums to 100% percent separately. A majority of summer and winter flounder were caught at Indian River sites. Bluefish catches were well distributed throughout our sites.
Figure 8. Percentage of the total catch of each size class, for 2013 at each site. Each size category sums to 100% separately. A majority of large, medium, and small crabs were caught along the Indian River.
Table 1. Description of sampling sites for CIB Inshore Fish Survey - 2013

Site 1. Kayak Launch Site (Latitude 38.6165, Longitude -75.0704) – Delaware Seashore State Park launch site located behind the Indian River North Marina off Inlet Rd. on Rehoboth Bay. The seine haul is made from east to west starting at 100-ft to the east of the dock at the launch area. Substrate is sand and the shore is *Spartina* marsh grass, which is submerged at high tide, for the first 70 ft while the remainder of the shore is sand beach.

Site 2. Tower Road – Bay Side (Lat. 38.6752, Long. -75.0739) – located at the Delaware Seashore State Park, Tower Road – Bay Area off Rt. 1 South on Rehoboth Bay south of Dewey Beach. The seine haul is made from north to south starting from 100-ft north of the center parking area. The substrate is sand.

Site 3. Rehoboth Country Club (Lat. 38.6896, Long. -75.107) – located behind (south of) the 19th tee of Rehoboth Country Club off East Side Drive on Rehoboth Bay. The seine haul is made from west to east starting at 100-ft west of the small jetty at the end of the Country Club property. The substrate is sand while the shore is large slabs of concrete.

Site 4. Herring Landing (Lat. 38.6457, Long. -75.1278) – located at the end of the trail in the State wildlife area on the end of Camp Arrowhead Rd. The seine haul is made from west to east on Rehoboth Bay starting 100-ft west of the end of the trail. The substrate is sand around numerous drowned juniper stumps.

Site 5. The Peninsula (Lat. 38.607, Long. -75.1551) – located in The Peninsula development at the end of Bay Farm Rd. in the embayment on the east side of the pier off Indian River Bay. The seine haul is made from east to west starting at 100-ft east of the end of the embayment next to the pier. Substrate is sand near shore and mud out to the rip rap jetties (which are separated by 50-ft) that separate the embayment from the Bay. A large area of marsh grass is adjacent to the end of the east jetty and extends back into Lingo Creek.

Site 6. Rosedale Beach (Lat. 38.5916, Long. -75.2119) – located adjacent to the State boat launch ramp on Indian River. Two 50-foot seine hauls are made at this site due to the pier located close to the east side of the launch ramp. The first haul is made from east to west starting 50-ft east of the pier. The second haul is started at the west side of the pier and extends 50-ft to the sheet piling wall of the ramp. The substrate of the entire area is mud. The shoreline along
the first seine area is marsh grass bordered by a 6-inch mussel-covered drop-off. The shoreline of the second haul is a sandy beach.

Site 8. Sandy Beach (Lat. 38.5834, Long. -75.2535) – located at the end of Sandy Beach Drive off the end of Thorogoods Rd. The seine haul is made from west to east on Indian River starting 100-ft west of the dock. The net is pulled up onto the launch ramp next to the dock to unload the catch. The substrate is mud.

Site 10. Pools Point (Lat. 38.5682, Long -75.1876) – located at the intersection of Dogwood and Pepper Creek roads on Pepper Creek at the confluence with Indian River Bay. The seine haul is made from northwest to southeast starting at 100-ft northwest of the end of the trail from the parking area to the beach. Substrate is sand near shore and mud offshore.

Site 11. Holts Landing State Park (Lat. 38.5925, Long. -75.1288) – located off the west end of the parking lot at the end of Holts Landing Rd. on Indian River Bay. The seine haul is made from 100-ft west of and into the embayment at the end of the trail from the parking lot to the Bay. The bottom is a mixture of sand and mud. The shoreline is marsh grass and a rip rap jetty separates the embayment from the Bay. A narrow sand bar delineates the eastern end of the embayment.

Site 12. Bethany Bay (Lat. 38.5709, Long. -75.0987) – located in the development of Bethany Bay at the end of Railway Rd. Seining is conducted in front of Building No. 30474 at the end of the access trail on White Creek. The seine haul is made from east to west starting at 100-ft east of the end of the trail. The substrate is a mixture of mud and sand with abundant algae usually present. The shoreline is marsh grass for the first 70% of the seine haul with a sandy beach comprising the balance.

Site 13. Cedar Shores (Lat. 38.5762, Long. -75.0919) – located in the development of Cedar Shores at the end of Sandy Rd. on the confluence of White Creek and Indian River Bay. The site is located off the lawn in front of the development. The seine haul is made from east to west beginning 100-ft to the east of the stairs leading to the beach. The substrate is sand and the shore is rip rap.

Site 15. Fenwick Island State Park (Lat. 38.4975, Long. -75.0561) – Assawoman Recreation Area – located on the west side of Rt. 1 between South Bethany and
the Kings Grant development on Little Assawoman Bay. The seine haul is made from north to south starting at 100-ft north of the center of the parking lot. Substrate is sand.

Site 16. Coastal Kayak (Lat. 38.4723, Long. -75.0528) – located on the west side of Rt. 1 approximately 1-mile north of Fenwick Island city limits on Little Assawoman Bay. The seine haul is made from north to south starting at 100-ft north of the center of the beach in front of the Kayak building. The substrate is sand.

Site 17. Bayville Shores (Lat. 38.4821, Long. -75.0821) - located at the end of Bayville Shores Dr., Ocean Vista Dr and the end of Sunset Ct. in the Bayville Shores development. The site is located to the northwest of the parking area at the end of Sunset Ct. on the confluence of Dirickson Creek and Little Assawoman Bay. The seine haul is made from east to west starting 100-ft north of the end of the access trail onto the beach. Substrate is a narrow band of sand along the shore and mud offshore.

Site 18. Sassafras Landing (Lat. 38.4995, Long. -75.0845) - located in Assawoman Wildlife Area at the kayak launch beach of Sassafras Landing on Miller Creek. The seine haul is made from east to west beginning 100-ft east of the launch beach. Substrate is sand.

Site 20. Strawberry Landing (Lat. 38.5012, Long. -75.0726) - located in Assawoman Wildlife Area on the south side of Miller Creek. The seine haul is made from 30-m to the west of the west end of the bulkhead along the front of Strawberry Landing. The haul is continued for 100-ft along the shoreline. The substrate is sand.
Table 2. Common and scientific names of fishes and blue crab in addition to months of collection during 2013.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Months of Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alewife</td>
<td><em>Alosa pseudoharengus</em></td>
<td>June-August</td>
</tr>
<tr>
<td>American eel</td>
<td><em>Anguilla rostrate</em></td>
<td>May, July-October</td>
</tr>
<tr>
<td>Atlantic croaker</td>
<td><em>Micropogonias undulatus</em></td>
<td>June-August, October</td>
</tr>
<tr>
<td>Atlantic menhaden</td>
<td><em>Brevoortia tyrannus</em></td>
<td>April-September</td>
</tr>
<tr>
<td>Atlantic moonfish</td>
<td><em>Selene setapinnis</em></td>
<td>August</td>
</tr>
<tr>
<td>Atlantic needlefish</td>
<td><em>Strongylura marina</em></td>
<td>July, August</td>
</tr>
<tr>
<td>Atlantic silverside</td>
<td><em>Menidia menidia</em></td>
<td>April-October</td>
</tr>
<tr>
<td>Banded killifish</td>
<td><em>Fundulus diaphanus</em></td>
<td>April</td>
</tr>
<tr>
<td>Bay anchovy</td>
<td><em>Anchoa mitchilli</em></td>
<td>April-October</td>
</tr>
<tr>
<td>Blackcheek tonguefish</td>
<td><em>Symphurus plagiusa</em></td>
<td>June</td>
</tr>
<tr>
<td>Black drum</td>
<td><em>Pogonias cromis</em></td>
<td>July-October</td>
</tr>
<tr>
<td>Bluefish</td>
<td><em>Pomatomus saltatrix</em></td>
<td>May-September</td>
</tr>
<tr>
<td>Bluegill</td>
<td><em>Lepomis machocharus</em></td>
<td>July</td>
</tr>
<tr>
<td>Bluntnose stingray</td>
<td><em>Dasyatis say</em></td>
<td>June</td>
</tr>
<tr>
<td>Cownose ray</td>
<td><em>Rhinoptera bonasus</em></td>
<td>August-September</td>
</tr>
<tr>
<td>Crevalle jack</td>
<td><em>Caranx hippos</em></td>
<td>July, September, October</td>
</tr>
<tr>
<td>Florida pompano</td>
<td><em>Trachinotus carolinus</em></td>
<td>June, June</td>
</tr>
<tr>
<td>Fourspine stickleback</td>
<td><em>Apeltes quadracus</em></td>
<td>June</td>
</tr>
<tr>
<td>Fish</td>
<td>Scientific Name</td>
<td>Month(s)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Gizzard shad</td>
<td><em>Dorosoma cepedianum</em></td>
<td>October</td>
</tr>
<tr>
<td>Hogchoker</td>
<td><em>Trinectes maculatus</em></td>
<td>July, September</td>
</tr>
<tr>
<td>Largemouth bass</td>
<td><em>Micropterus salmoides</em></td>
<td>July</td>
</tr>
<tr>
<td>Lookdown</td>
<td><em>Selene vomer</em></td>
<td>June</td>
</tr>
<tr>
<td>Mummichog</td>
<td><em>Fundulus heteroclitus</em></td>
<td>April-October</td>
</tr>
<tr>
<td>Naked goby</td>
<td><em>Gobiosoma bosc</em></td>
<td>April-July, Sept., Oct.</td>
</tr>
<tr>
<td>Northern kingfish</td>
<td><em>Menticirrhus saxatilis</em></td>
<td>July-October</td>
</tr>
<tr>
<td>Northern pipefish</td>
<td><em>Sygnatus fuscus</em></td>
<td>June-Septemver</td>
</tr>
<tr>
<td>Oyster toadfish</td>
<td><em>Opsanus tau</em></td>
<td>May, July-Septemver</td>
</tr>
<tr>
<td>Permit</td>
<td><em>Trachinotus falcatus</em></td>
<td>July</td>
</tr>
<tr>
<td>Pinfish</td>
<td><em>Lagodon rhomboides</em></td>
<td>June-October</td>
</tr>
<tr>
<td>Pollock</td>
<td><em>Pollachius virens</em></td>
<td>May</td>
</tr>
<tr>
<td>Rainwater killifish</td>
<td><em>Lucania parva</em></td>
<td>June, October</td>
</tr>
<tr>
<td>Redfin pickerel</td>
<td><em>Esox americanus</em></td>
<td>June</td>
</tr>
<tr>
<td>Sheepshead minnow</td>
<td><em>Cyprinodon variegatus</em></td>
<td>Apr-Oct</td>
</tr>
<tr>
<td>Silver perch</td>
<td><em>Bairdiella chrysoura</em></td>
<td>July-Oct</td>
</tr>
<tr>
<td>Smallmouth flounder</td>
<td><em>Etropus microstomus</em></td>
<td>Apr, Jul</td>
</tr>
<tr>
<td>Spot</td>
<td><em>Leiostomus xanthurus</em></td>
<td>Apr-Oct</td>
</tr>
<tr>
<td>Spotfin mojarra</td>
<td><em>Eucinostomus argenteus</em></td>
<td>Aug, Oct</td>
</tr>
<tr>
<td>Spotted hake</td>
<td><em>Urophycis regia</em></td>
<td>May</td>
</tr>
<tr>
<td>Striped anchovy</td>
<td><em>Anchoa hepsetus</em></td>
<td>June-Aug, Oct</td>
</tr>
<tr>
<td>Striped bass</td>
<td><em>Morone saxatilis</em></td>
<td>July-Sept</td>
</tr>
<tr>
<td>Fish</td>
<td>Scientific Name</td>
<td>Season</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Striped killifish</td>
<td><em>Fundulus majalis</em></td>
<td>April-October</td>
</tr>
<tr>
<td>Striped mullet</td>
<td><em>Mugil curema</em></td>
<td>June-August, October</td>
</tr>
<tr>
<td>Striped searobin</td>
<td><em>Prionotus evolans</em></td>
<td>August</td>
</tr>
<tr>
<td>Summer flounder</td>
<td><em>Paralichthys dentatus</em></td>
<td>April-October</td>
</tr>
<tr>
<td>Weakfish</td>
<td><em>Cynoscion regalis</em></td>
<td>July</td>
</tr>
<tr>
<td>White mullet</td>
<td><em>Mugil cephalus</em></td>
<td>June-October</td>
</tr>
<tr>
<td>White perch</td>
<td><em>Morone americana</em></td>
<td>July-October</td>
</tr>
<tr>
<td>Windowpane</td>
<td><em>Scophthalmus aquosus</em></td>
<td>May</td>
</tr>
<tr>
<td>Winter flounder</td>
<td><em>Pseudopleuronectes americanus</em></td>
<td>May-July, October</td>
</tr>
<tr>
<td>Blue crab</td>
<td><em>Callinectes sapidus</em></td>
<td>April-October</td>
</tr>
</tbody>
</table>