Abundance and Population Structure of Fishes in Cove Point Marsh

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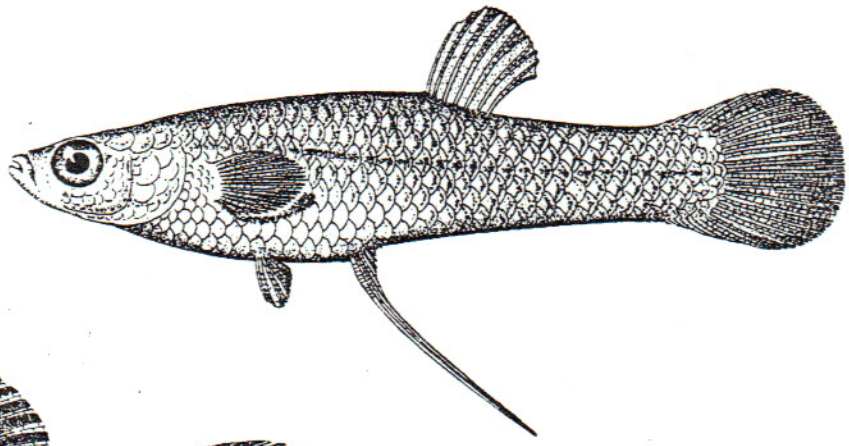
Eastern mosquitofish
Gambusia holbrooki Girard. 1859



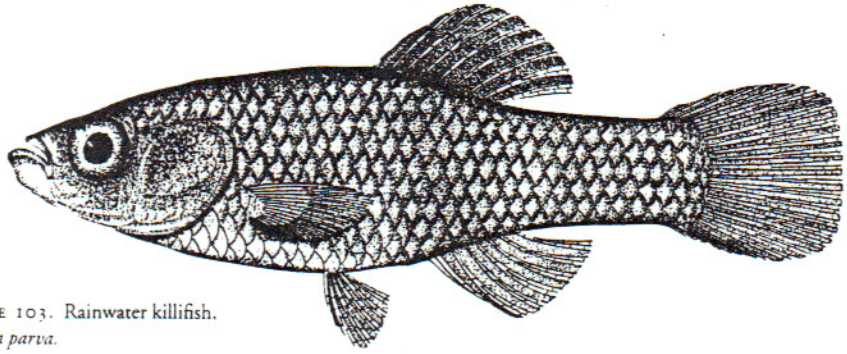
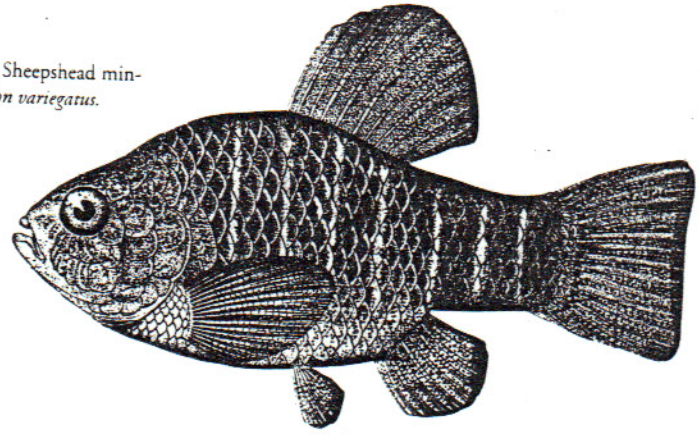


FIGURE 103. Rainwater killifish. *Lucania parva.*

FIGURE 102. Sheepshead minnow. *Cyprinodon variegatus.*



Introduction

Marshes and wetlands, both tidal and freshwater, often possess a great abundance of fishes. These habitats are characterized by high primary productivity (Odum, 1969; Turner, 1976) through an influx of plant nutrients, particularly nitrogen compounds. In tidal estuaries, the interface of surface freshwater and incoming subsurface salt water acts to trap nutrients within the estuary. Freshwater marshlands and wetlands often receive nutrient-rich water, and remove those nutrients through plant uptake as the water slowly passes through the marsh. This results in water purification before it reaches larger basins, while the extracted nutrients promote vascular plant growth and thus primary production.

High levels of available energy, trapped through plant primary production, allow heterotroph populations to grow abundantly. Tidal and freshwater marshes are important habitats for resident, anadromous and catadromous fishes. High productivity and sheltered, shallow waters make many wetland and marsh areas essential for spawning and the growth of juveniles (Turner, 1979). Estuarine marshes, while producing fish in high abundance, often have relatively low species diversity (Mitsch and Gosselink, 1986). Many species are physiologically unable to exploit environments where rapid changes in salinity, temperature and other water parameters are common. Inland freshwater marshes, as more stable systems, tend to have higher diversity of fishes.

At first inspection, Cove Point marsh seems likely to contain abundant and diverse fish populations. It is primarily a freshwater system, receiving water from runoffs, seeps and groundwater discharge. Storms and high tides bring occasional saltwater incursions from the Chesapeake Bay. It normally contains a larger body of open water as well as several smaller, isolated ponds and freshwater drainage streams. The open water areas are shallow, and permit the growth of submerged aquatic vegetation. The ponds are lined with emergents, such as cattail and *Phragmites australis*. This vegetation provides shelter and forage for fishes. The marsh has remained relatively undisturbed, which might benefit the fish community in two ways: as a refuge for rarer fishes and as a stable, good quality habitat for more common species. Common species are ecologically important, since they play roles as both predators and prey. Abundant populations of fishes can lead to "bottom up" influencing the abundance and diversity of many other organisms in the food web.

A survey was initiated in the Spring of 1999 to determine the abundance, diversity and population structure of fishes in Cove Point marsh. It was designed to provide these data: 1) determination of the abundance and diversity of the fish community, 2) estimates of fish reproductive success, 3) estimates of major food types for fishes, 4) identification of common macroinvertebrates, and 5) measurements of water quality parameters and submerged aquatic vegetation. These data will help to determine both the status of fish populations and the overall ecological health of Cove Point marsh.

Materials and Methods

This study was done from April to November of 1999. Sampling times were once per month in April and May, twice per month in June, July, August, and September, and once per month in October and November. Sampling occurred during daylight hours, usually between 09:00 and 16:00.

Characterization of the fish community - The primary sampling device was a pop net. It consisted of two squares formed from ¾ in. PVC, each square with an area of 1 m^2. The PVC sections were joined by 1mm^2 netting, so that one square formed the base and the other the top of a cube, with the netting on the sides. The bottom square was not buoyant, and remained on the bottom of the marsh. The top square was buoyant. It was held attached to the bottom square with two galvanized nails, each slid through two swivels. String was attached to the nails and led 3-4 m away from the net. When the strings were pulled, the nails slid out of the swivels and the top square floated to the surface. This acted to trap all organisms within the 1 m^2 area of the net. Pop net sampling consisted of placing the nets on the marsh bottom in the morning, usually by 10:00. At least two hours was allowed for disturbance to settle. The nets were then popped at a 3-4 m distance. Caught organisms were removed from the popped net with three scoops of a rectangular net slightly smaller than the inside width of the pop net squares. Pop nets were set in five general areas: boardwalk pond, small pond, front marsh, back marsh, and south marsh (Fig. 1). These areas were chosen for their distance from each other and because there was access to a firm substrate. Removing fishes from the popped nets required standing on the bottom next to the net. A total of 25 pop nets were set over the course of the study.

Other sampling methods were also used. Minnow pots were set to collect small fishes in other areas of the marsh. Pots were baited with a mixture of algae-based and shrimp-based flake fish food wrapped in cheese cloth and placed in all sampling areas and Wilbur creek. Pots were left for at least two hours before retrieval. A small seine, about 1.5 m in length, was used to collect fishes in Wilbur and Gray's creek tributaries. This seine was also occasionally used to collect fish in the emergent vegetation. A larger, 50 ft seine was used at the south marsh sampling site and along the beach in the Chesapeake Bay.

For all fishes, identity, total counts and total length were recorded. Data from the pop nets were used to calculate abundance (# fishes/m^2) for the more common species. Data from all sampling methods were used to estimate the overall diversity of fishes in the marsh. Diversity was calculated using Simpson's diversity index (Simpson, 1949). Other observations, such as sexual maturity, pregnancy, or damage, were also recorded as noted.

Estimates of major food types for fishes - the minnow pots were employed in two sampling efforts to collect fishes for analysis of gut contents. Minnow pots were set in boardwalk and small ponds on July 31. Four individuals of the most common species – mosquito fish, sheepshead minnows, and rainwater killifish – were collected and gut contents examined. In addition, *one Fundulus heteroclitus* and one *Fundulus diaphanus* were examined. The collected fish were placed on ice for several hours, then in 10% formalin, then 70% ethanol until analysis.

Identification of common macroinvertebrates – Any macroinvertebrates caught in the pop nets or observed in the marsh were noted and identified when possible. Two dragonfly larvae were collected and saved in 10% formalin.

Physical characteristics of the marsh and aquatic vegetation types – Whenever a pop net or minnow pot was set, water depth, temperature, pH, and salinity were recorded at the sampling site. The overall water levels in the marsh were noted for each sampling day. The presence, type, and approximate distribution of aquatic vegetation throughout the marsh were also noted. On May 28, at the height of aquatic vegetation density, all plant material was collected from two 0.25 m^2 areas. The material was weighed in the laboratory to estimate biomass/m^2 in areas of dense and patchy vegetation.

Results

Characterization of the fish community – The survey identified eight different families and 14 species of fish within the Cove Point marsh and freshwater tributaries (Table 1). All species, except mudminnows, were salt-tolerant species and can be found in estuarine environments.

The most common species were *Gambusia holbrooki* (mosquito fish), *Cyprinodon variegatus* (sheepshead minnow) and *Lucania parva* (rainwater killifish). Sheepshead minnows were most common in the front marsh, where they congregated in large schools on sand flats created from the moving beach. Rainwater killifish were more common in the back marsh, where a soft mud substrate and dense vegetation were present. Mosquito fish were most common and found in all areas of the marsh, although highest densities occurred where submerged aquatic vegetation was present.

Abundance of these three species was high and varied over the course of the sampling season (Fig. 2), reaching a peak in July. Mosquito fish densities reached estimates of 81 individuals/m^2 in south marsh on July 16. Sheepshead minnows and rainwater killifish densities were estimated at 8 and 9 individuals/m^2, respectively, on this sampling date. Abundance dropped considerably in subsequent sampling efforts. Calculated densities at the end of August, a low point, were 8, 0.5, and 0.24 individuals/m^2 for mosquito fish, sheepshead minnows and rainwater killifish, respectively. This decline in fishes paralleled declines in water levels and aquatic vegetation.

Other fish species were less commonly encountered. A freshwater species, *Umbra pygmaea* (eastern mudminnow), was found in Wilbur creek and one tributary of Gray's creek. One clupeid, the bay anchovy (*Anchoa mitchilli*) was found in small numbers in front marsh. Two species of silversides, *Membras martinica* and *Menidia beryllina*, were found occasionally in the front and back marsh areas. Three killifish species, in the *Fundulus* genus, were occasionally found in the marsh , boardwalk pond and small pond. Although *Fundulus heteroclitus* is often the most abundant fish species in tidal marshes, its overall density in Cove Point marsh was low, with 10 individuals caught in 25 pop net sets (0.4 individuals/m^2). Other *Fundulus* species – *F. diaphanus*, and *F. confluentus* - were less common. A species appearing to be *Fundulus majalis* was observed, but no individuals were caught for identification. *Lepomis gibbosus* (pumpkinseed sunfish) was common in back marsh and boardwalk pond. Individuals

as large as 110 mm were collected. An adult pumpkinseed, guarding a nest, was observed in boardwalk pond on August 17. *Lepomis macrochirus* (bluegill sunfish) was found in Wilbur creek (juveniles) and boardwalk pond and was very abundant in the small reservoir above the marsh. *Cyprinus carpio* (carp) was observed in the back marsh on May 28. They were adults (estimated +50 cm). Carp were not observed again anywhere in Cove Point marsh. One species of pickerel (*Esox* sp.) was observed in boardwalk pond. It represents the only piscivorous fish found in the survey. Overall diversity of fish species was not high, as might be expected in an estuarine marsh. A Simpson's diversity index of 3.12 was calculated, based upon all fish collections made throughout the season.

Reproduction, in the form of collected young of the year, was observed for seven species. Mudminnow juveniles appeared on May 12 in Wilbur creek. Large individuals collected at that time showed ragged fins, evidence of aggressive behavior during courtship. Mosquito fish juveniles first appeared on May 28 throughout the marsh and small juveniles continued to be caught through July. Sheepshead minnow juveniles were first caught on June 25 in front and south marsh. Juveniles of this species were also caught in early October, after the marsh had refilled with fresh water. Rainwater killifish juveniles were first observed in south marsh on July 16. Inland silversides juveniles were found in south marsh on July 16. Pumpkinseed and bluegill sunfish juveniles first appeared on July 16 in back marsh and boardwalk pond. Juveniles from these species were not found later in the year.

The production of new juveniles was responsible for much of the rise in abundance seen in the three most common species. While abundance rose through July, the average size of fish caught (Fig. 3) declined. This reflects the increasing number of juvenile fish collected. This trend continued until the drought drastically reduced fish abundance. Sheepshead minnows showed a second size decline in September, indicative of a second reproductive period.

Estimates of major food types for fishes – four individuals of the three most common species – mosquito fish, sheepshead minnows and rainwater killifish – were dissected and gut contents examined to determine food types. The mosquito fish examined had eaten primarily backswimmers, filamentous algae and what appeared to be mosquito larvae or a related species. The sheepshead minnows had fed primarily on vascular plant material and filamentous algae. In the guts of rainwater killifish were small amphipods, backswimmers, and a small bit of plant

material. The gut contents of the single *Fundulus diaphaus* examined contained backswimmers and one caddisfly larvae. The gut of the *Fundulus heteroclitus* individual contained only filamentous algae.

Characterization of collected macroinvertebrates – The most abundant macroinvertebrates were grass shrimp (*Palaemonetes pugio*). They were found in all areas of the marsh, and were present in most pop net and minnow pot catches. They were found throughout the year, from May through November.

Blue crabs (*Callinectes sapidus*) were also observed and collected from all areas of the marsh. Both mature and juvenile males were observed in the main body of the marsh. Mature females were seen in front marsh and south marsh, and prepubertal premolt females were collected in front marsh. Male courtship displays toward a premolt female were observed in front marsh on May 28, 1999. The display lasted several minutes, after which the female moved away from the area.

Two dragonfly larvae were collected in pop nets. One was collected in front marsh on June 25, and the other in small pond on October 2. The most common aquatic insect collected in the nets were backswimmers (*Notonecta* sp.). They were found commonly throughout the marsh. Population peaks of high abundance were observed in small pond on June 25, and in south marsh on October 2.

Physical characteristics of the marsh and aquatic vegetation types – The year 1999 was characterized by a severe drought followed by heavy rains and hurricane Floyd. The main marsh area showed the greatest impact of no rain. The marsh was full of water at the beginning of the season, but by June 25 the water had begun to recede in the main marsh. By July 16 water had receded in the main marsh so that it was no longer possible to float a canoe from the beach or the back hillside. By the end of July the marsh had broken into three bodies of water – small pond, south marsh, and a narrow area of deeper water along the back hillside. By the end of August, after a night of heavy rain, the main marsh began to fill and the water again extended to the front marsh area. The main marsh was partly refilled by storm Dennis and completely filled by Floyd. Immediately after Floyd (9/17) water in the marsh was observed flowing in three channels into the Bay from the marsh.

Three areas, boardwalk pond, small pond and south marsh, showed little change in water volume. Small pond and south marsh seemed to receive groundwater input. Small pond did not greatly recede and remained fresh until Floyd overwashed into the area (Figure 4). South marsh was freshest near the beach, the probable site of groundwater discharge. There was a current of water flowing out of south marsh into the main marsh. Boardwalk pond appeared to receive some water from Wilbur creek, which remained flowing throughout the Summer.

Salinity increased in all areas of the marsh measured over the course of the Summer, except in small pond (Figure 4). Salinity climbed from zero in the Spring to 12 ppt by the end of August. After Floyd, salinity dropped to zero in the main marsh, but rose briefly to 8 ppt in small pond, due to overwash from the Bay. Water temperature climbed throughout the Summer, reaching 37° C in small pond in August (Fig. 5). Water temperatures fell after this, and dropped quickly after hurricane Floyd. pH readings throughout the marsh were generally consistent, reading 6-7 throughout the sampling season.

By the end of May, aquatic vegetation grew densely in all shallow areas of the marsh. The most abundant species was *Ruppia maritima* (widgeon grass), although *Myriophyllum spicatum* (water milfoil) and bladderwort (*Utricularia* sp.) were also observed. On May 28, widgeon grass biomass was 2 kg/meter^2 wet weight in areas of dense growth. By July 16, vegetation was disappearing from the main marsh and what remained was heavily fouled. South marsh and small pond, where water was not receding, showed similar declines in vegetation. In the main marsh, where water had receded, widgeon grass was replaced by spike rush (*Eleocharis* sp.), and eventually in some areas by saltmarsh hay (*Spartina patens*). By July 31 aquatic vegetation was absent from the marsh in all areas except boardwalk pond. South marsh and small pond, which maintained water levels, lost all vegetation by this time. Water in these areas was turbid. Exposed areas throughout the marsh were covered by spike rush. Widgeon grass was observed growing in the re-flooded main marsh on December 17.

In addition to these observations, casual notes were made of any organisms seen in the marsh over the course of the sampling season. This list is shown in Table 2.

Discussion

The Cove Point marsh fish community contains populations of high abundance yet shows relatively low diversity. This pattern is typical of estuarine rather than freshwater marshes.

Cove Point provides habitat for population growth and constraints upon the kinds of fishes exploiting the habitat.

Several factors influence fish abundance. For much of the year, the marsh is freshwater. Shallow, clear water supports a dense growth of submerged aquatic vegetation, which in turn provides the primary productivity for an abundant fish community. The vegetation also provides shelter and food. With no open passage, anadromous and marine fishes cannot enter the marsh. Thus, the list of resident fishes is quite different from that of the adjacent estuary. Common fishes such as menhaden, some silversides (*Menidia menidia*), naked gobies and flounder appear absent from the marsh. Mummichogs (*Fundulus heteroclitus*), usually very abundant in estuaries, are relatively rare. Anadromous species, such as striped bass and white perch, are also excluded from the marsh. These fish are piscivores, which means that fishes in Cove Point marsh are likely under less predation pressure than tidal marshes open to the Bay.

Seasonal changes in water depth, quality and salinity appear to restrict fish diversity. Although freshwater for much of the year, salinity climbs in Summer as rain and groundwater discharge slow. The marsh must receive increasing volumes of water from the Chesapeake Bay, although there is no open water passage between the marsh and the Bay. The rise in salinity in the Summer likely restricts the fish species that can exist in the marsh. Strictly freshwater species are not present in the marsh. All fishes collected were to some degree salt tolerant, with the exception of mudminnows. However, these fishes were found only in the freshwater tributaries of Wilber and Gray's creeks. One adult mudminnow was also caught in boardwalk pond, which receives water from Wilbur creek.

Within these constraints, the marsh may provide a refuge for fishes subject to disturbance in other areas. Two individuals were collected by minnow pot from the main marsh on August 13, of which one was kept. It has tentatively been identified as a marsh killifish (*Fundulus confluentus*). This species, although common in coastal marshes further south, has not been reported in Maryland and has been reported in the Chesapeake Bay only from one location in Lynnhaven Bay near Norfolk, Virginia (Hildebrand and Schroeder, 1928). Recent attempts to find this species in the Chesapeake Bay have been unsuccessful (Murdy *et al.*, 1997). The specimen is currently in the laboratory of Dr. Lynn Parenti at the National Museum of Natural History, where its identity will be confirmed. It is likely that *Fundulus confluentus* is a rare,

permanent resident of the marsh. For Maryland species existing on the edge of their natural range, undisturbed areas such as Cove Point may be essential for their continued survival.

It was interesting to observed the extensive use of the marsh by blue crabs. With no opening to the Bay, crabs must have crossed the beach to enter the marsh. Males and females, both juveniles and adults, were observed, as well as courtship behaviors. The marsh, with its extensive beds of widgeon grass, represents a functional grass bed, and the only one of its size along the Western Shore from Rosehaven in the north south to the Patuxent River (Orth *et al.*, 1998). As such, Cove Point marsh may be an important habitat for blue crab growth and reproduction.

As a grass bed, Cove Point marsh supports the abundant animal populations commonly found in such habitats. Over the 1999 sampling season, however, the grasses disappeared, and with them much of the fishes. The reason for vegetation disappearance is unknown. It can be attributed in part to receding waters, but the grasses also vanished in south marsh and small pond, which retained water all Summer. With no vegetation, the water became turbid, water quality undoubtedly deteriorated, and fish collections declined.

Recommendations

Long term monitoring of the marsh is important to track changes that may affect the abundance and diversity of life in the marsh. With a drought and hurricane, the marsh experienced extreme changes in hydrology and a severe drop in fish abundance and perhaps diversity. Continued monitoring is necessary to determine if 1999 was a typical or abnormal year, and if the resident fish populations can fully recover. The beach is receding in many areas, and the marsh will likely experience more frequent saltwater incursions in the future and may eventually open to the Bay. Conversion of the marsh from an essentially freshwater system to a tidal marsh will entail large changes, including increases in turbidity, higher salinity levels and the introduction of anadromous fishes. The vegetation may change or in some areas be eliminated. This will likely change the species composition of the marsh.

Addition fish surveys could also examine some of the more remote areas of the site, such as part of Gray's creek and some small pond in the southern area of the marsh. Surveying fishes using nets has several advantages, such as the non-invasive nature of the technique and the ability to obtain quantitative estimates of fish density and diversity. However, even with

repetitive sampling pop nets may miss some species, particularly those with larger or rarer individuals. It would be useful to survey a few areas, particularly the creeks, with additional methods such as a backpack electroshocker. This technique, while probably more stressful to the fish than nets, does no harm and allows for a more complete survey than nets alone, particularly in areas of dense vegetation and structure.

Lastly, any evaluation of the resident fish community or overall biodiversity in the marsh must take into extent the size and health of the submerged aquatic vegetation beds. Decline in grasses was correlated with decline in all fish populations. The reasons for vegetation decline in areas that still held open water are unknown, but predation from herbivores may well have contributed. The marsh contains at least two non-indigenous species that could eat submerged grasses - mute swans and carp. Any future monitoring should also examine temporal changes in submerged aquatic vegetation, and the causes that lead to its decline during the Summer season.

References

Hildebrand, S.F. and W.C. Schroeder. 1928. *Fishes of Chesapeake Bay. Bulletin of the U.S. Bureau of Fisheries* 43(1):1-366.

Mitsch, W.J. and J.G. Gosselink. 1986. *Wetlands*. Van Reinhold:New York.

Murdy, E.O., R.S. Birdsong And J.A. Musick. 1997. *Fishes of Chesapeake Bay*. Smithsonian Institution Press, Washington.

Odum, E.P. 1969. The strategy of ecosystem development. Science 164:262-270

Orth, R.J., J.F. Nowak, D.J. Wilcox, J.R. Whiting and L.S. Nagey. 1998. Distributions of submerged aquatic vegetation in the Chesapeake Bay and tributaries and the coastal bays-1997. *VIMS Special Scientific Report*, number 138.

Simpson, E.H. 1949. Measurement of diversity. *Nature*, 163:688.

Turner, R.E., 1976. Geographic variations in salt marsh macrophyte production. *Contrib. Mar. Sci*. 20:47-147.

Turner, R.E. 1979. A simple model of the seasonal growth of *Spartina alterniflora* and *Spartina patens*. *Contrib. Mar. Sci*. 22:137-147.

Figure 1. Sketch of Cove Point marsh. Sampling areas are labeled. "X" represents the approximate sampling site for each area.

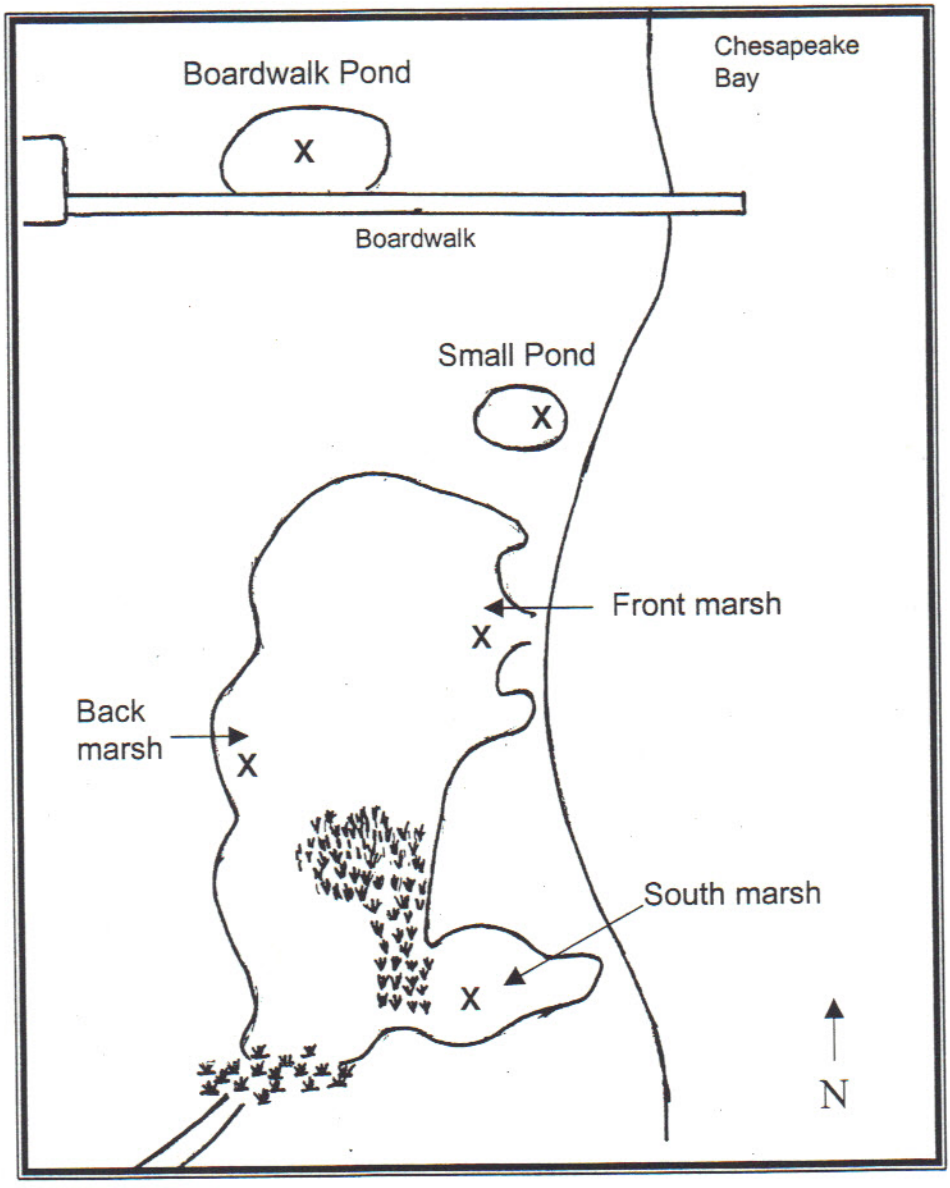


Table 1. Listing of all fish species observed in Cove Point Marsh

Name	Common name	Total #
Clupeidae	bay anchovy	21
Anchoa mitchilli		
Cyprinidae		
Cyprinus carpio	grass carp	5 (est.)
Umbridae		
Umbras pygmaea	eastern mudminnow	28
Esocidae		
Esox sp.	pickerel	1
Cyprinodontidae		
Cyprinodon variegatus	sheepshead minnow	114
Fundulus heteroclitus	mummichog	10
Fundulus diaphanus	banded killifish	6
Fundulus confluentus	marsh killifish	2
Lucania parva	rainwater killifish	78
Poeciliidae		
Gambusia holbrooki	mosquito fish	397
Atherinidae		
Membras martinica	rough silverside	34
Menidia beryllina	inland silverside	30
Centrarchidae		
Lepomis gibbosus	pumpkinseed	19
Lepomis macrochirus	bluegill	4

Simpson's Diversity Index = 3.12

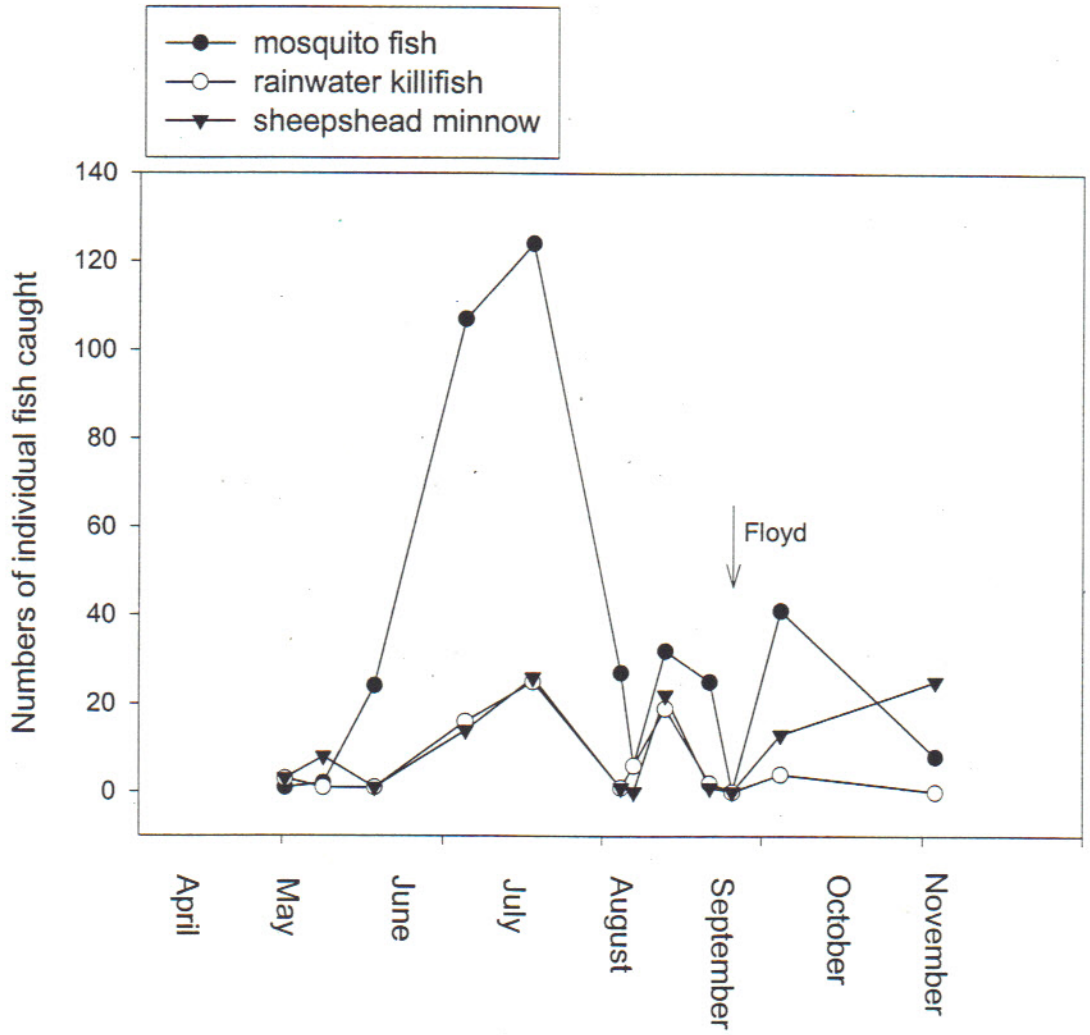


Figure 2. Total number of three most abundant fish species collected in Cove Point marsh.

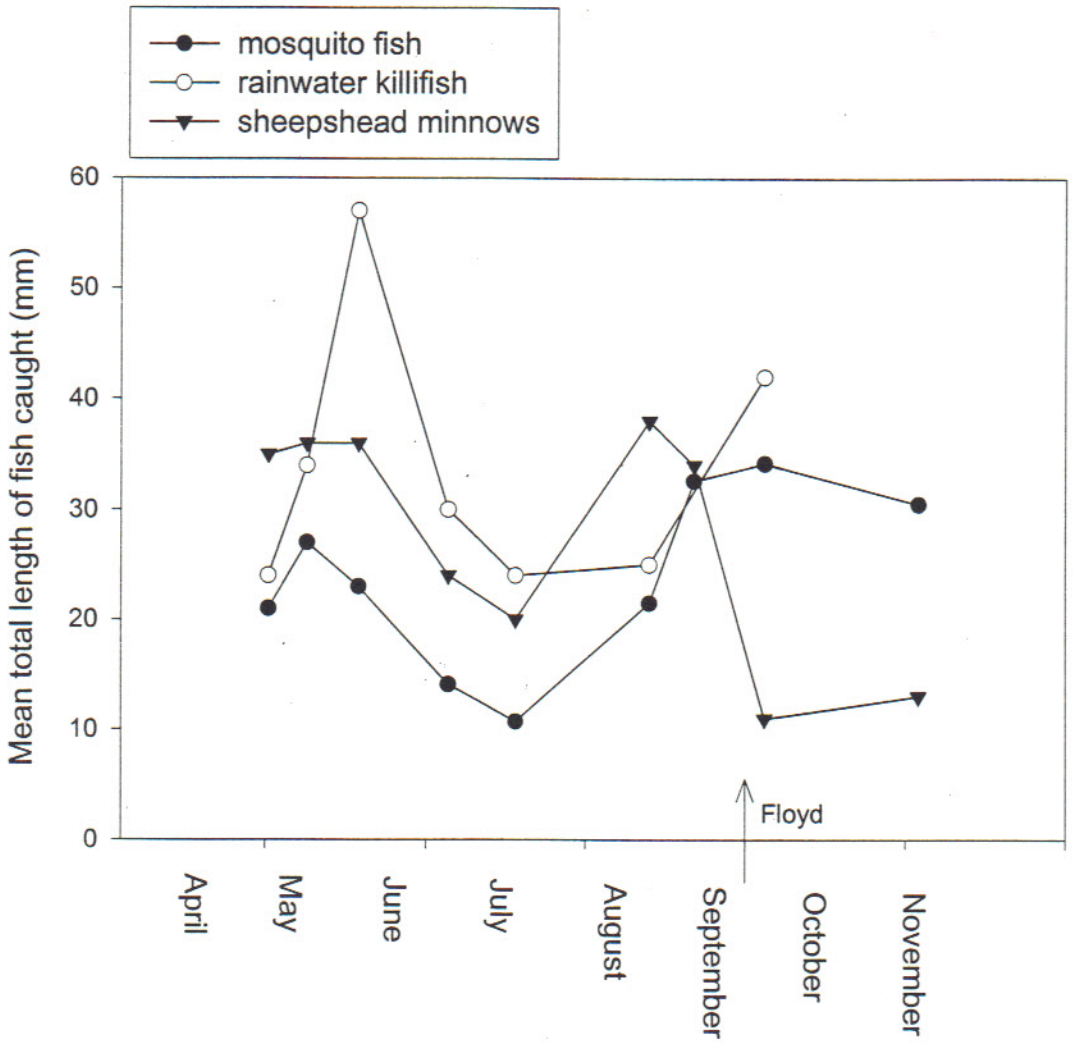


Figure 3. Mean total length of three most abundant fish species collected in Cove Point marsh.

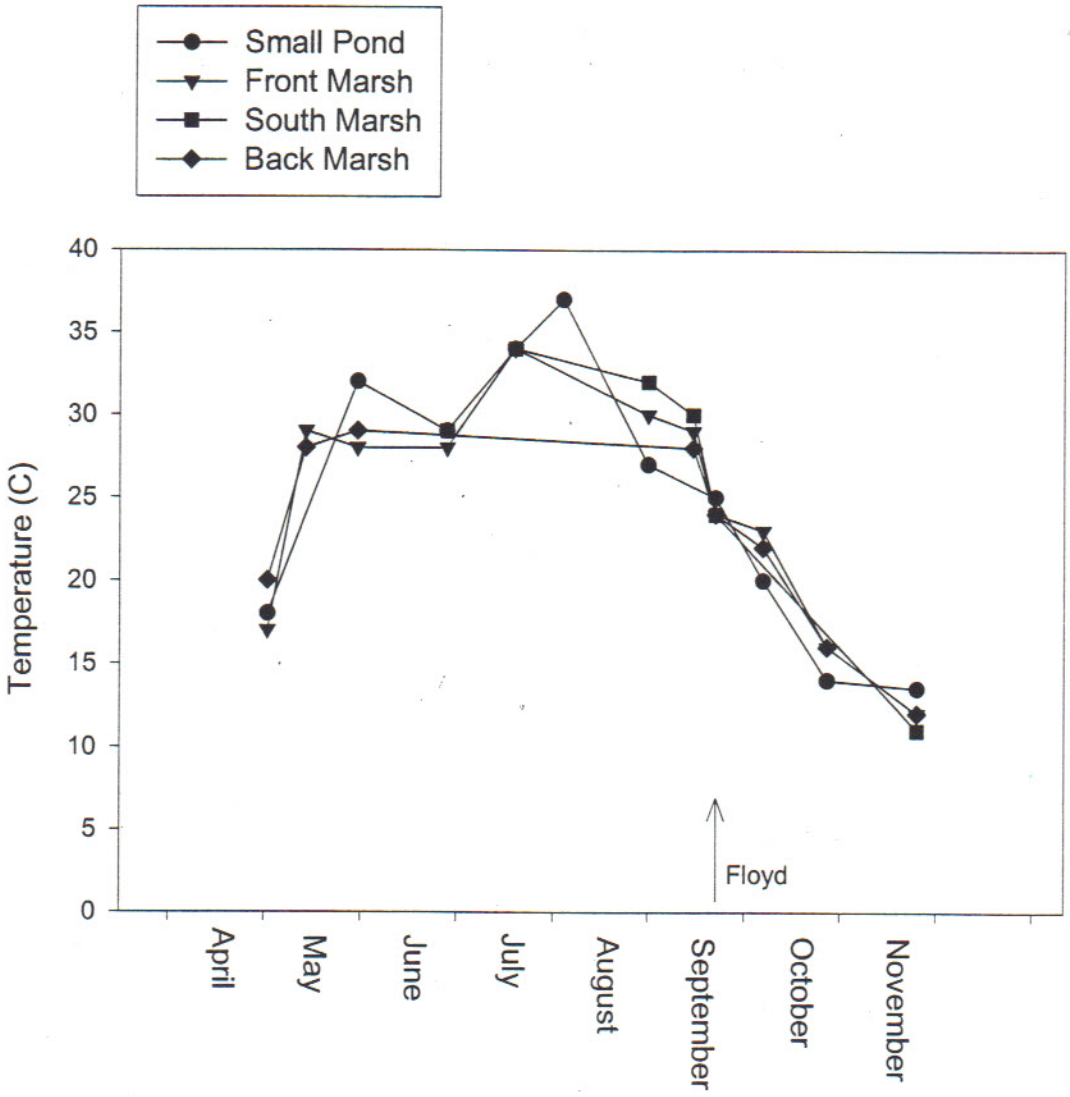


Figure 4. Water temperature changes at four sampling sites in Cove Point marsh.

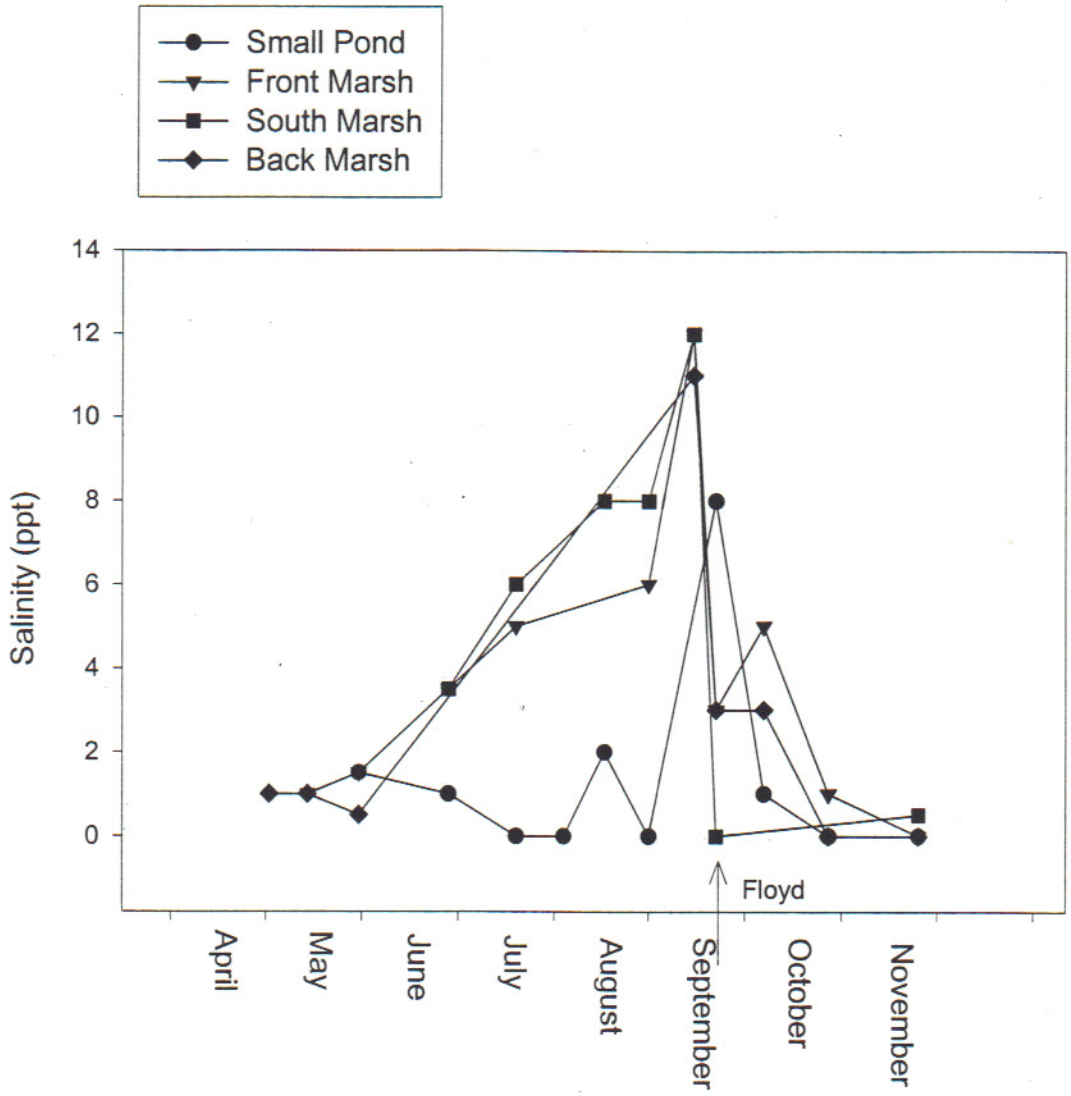


Figure 5. Salinity changes at four sampling sites in Cove Point marsh.

Table 2. Animals observed in Cove Point marsh throughout the Summer of 1999.

Animals observed	Comments
Crustaceans	
grass shrimp	very common in marsh
blue crab	courtship observed, seen throughout Summer
Amphibians	
spotted salamander	Found in hillsides above marsh
tadpoles	Common until salinity rose. Remained in Boardwalk Pond
bull frog	Seen in Front marsh in early Summer. Salinity was low.
Reptiles	
snapping turtle	Seen throughout marsh. Mating observed 9/17
painted turtles	Seen throughout marsh
musk turtle	Seen in small pond 7/16
spotted turtle	Seen in front marsh 5/28
water snake	Seen in back marsh 5/28
Birds	
mute swans (family)	In small pond, then moved to main marsh. Present all Summer.
osprey	Occaisonal sightings all year.
great blue heron	Present throughout Summer
kingfisher	Present throughout Summer
coot	Seen in marsh 11/19
black duck	Very large flock seen 11/19
mallard duck	Present throughout Summer
Canada goose	Seen 10/22
unk. shorebirds	Seen in marsh 10/22
Mammals	
grey fox	Seen on beach (ran into *Phragmites*) 7/31