

Distribution of Fishery Resources in Relation to Hydrographic Conditions in North Carolina Estuaries

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North Carolina has a unique shoreline. A sand bar, extending from the northern to the southern boundaries of the state—a distance of about 300 miles—separates the ocean from the largest system of sounds on the east coast of the United States, covering an area of between 2500 and 3000 square miles. These sounds differ widely in size, depth and other hydrographic conditions and therefore vary with respect to the fishery resources. The purpose of this paper is to describe the distribution of the state's fishery resources in relation to hydrographic conditions in the various sounds.

The northernmost sounds, Albemarle and Currituck (see Figure 1.), no longer have direct contact with the ocean as they did 100 or more years ago. Waters flowing down the Roanoke and Chowan Rivers and the numerous short, wide streams draining the surrounding lowlands must pass through Albemarle Sound, thence through Croatan or Roanoke Sound into the northern part of Pamlico Sound before reaching the ocean through Oregon Inlet. These sounds, because of their distance from the source of salt water, remain fresh except under certain conditions of wind and tide, when the eastern portion of Albemarle Sound becomes brackish.

The chief fisheries of this area are those concerned with the anadromous species, the herrings or alewives (*Pomolobus spp.*), striped bass or rockfish, and shad. Pound nets and gill nets are the principal types of gear used. Other species taken include the hickory shad, white perch, carp and catfish. There are no shellfish or shrimp taken commercially in Albemarle and Currituck Sounds.

Croatan and Roanoke Sounds are productive chiefly because of their location with respect to Oregon Inlet and Albemarle Sound. The anadromous fishes entering Oregon Inlet in search of fresh water must pass through one of these two sounds in order to reach the spawning grounds. Important fisheries for these species have naturally developed along this migration route. Inasmuch as the spawning runs take place in the spring, the fisheries are necessarily limited to the spring and early summer. Neither of these sounds produce shrimp. Oysters are found in limited quantities in Roanoke Sound.

Pamlico Sound covers approximately 1700 square miles. Its maximum depth is 24 feet, but because of extensive shoal areas, the average depth is probably less than 15 feet. This large shallow sound, receiving runoff waters from the Neuse and Pamlico Rivers and from Albemarle Sound, and salt water from the ocean through three inlets, offers a wide variety of habitats with respect to physical and chemical conditions. As a result, the fisheries are varied as to time and location.

The finfish, which are free to enter or leave the sound through the inlets as conditions change either to their liking or otherwise, are widely distributed throughout the sound during the spring, summer, and fall. Pamlico Sound provides a nursery area for the young of many species and fisheries for several commercial varieties. The anadromous species must pass through the sound

to reach the spawning grounds in the rivers. Fisheries for these species are concentrated in the northern part of the sound along the migration routes leading to Albemarle Sound. In earlier years, important shad fisheries existed along the south shore of Pamlico Sound and in both the Neuse and Pamlico Rivers but, with the general decline of shad along the Atlantic Coast, these fisheries have been reduced in number and importance.

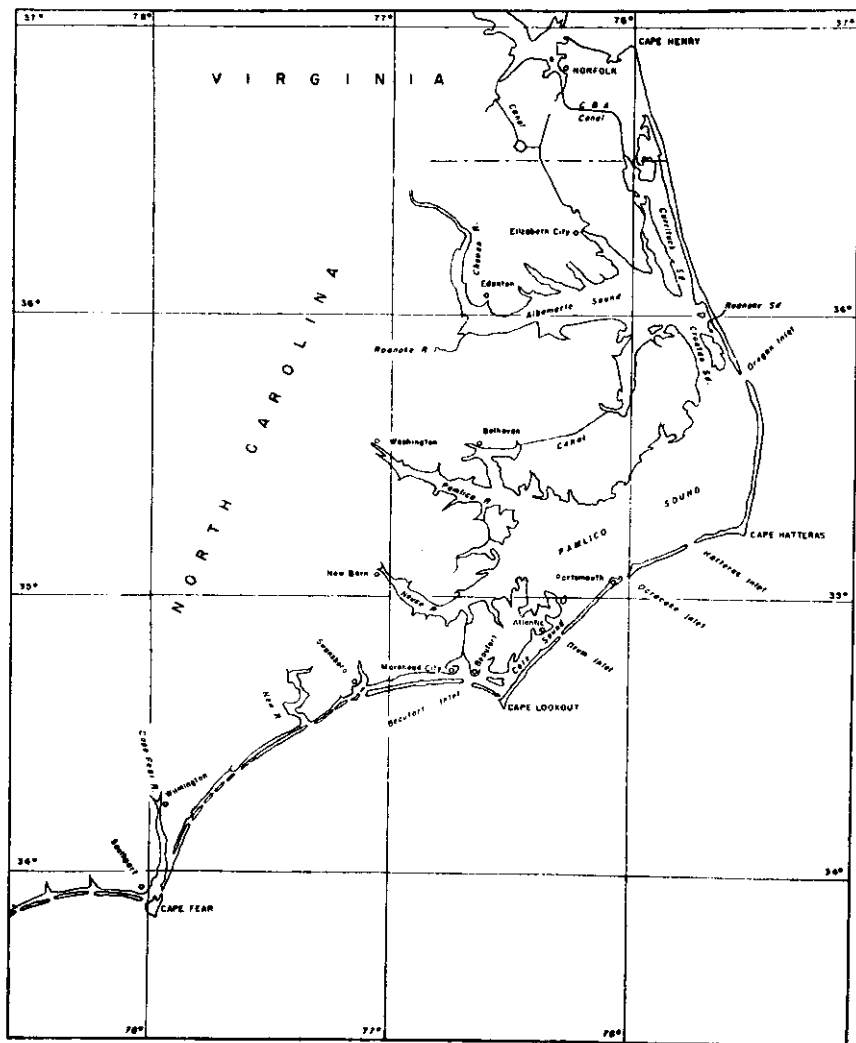


FIGURE 1. Map of the coastal region of North Carolina.

Mullet (*Mugil* spp.) are taken in the western portion of the sound in the bays between the Neuse and Pamlico Rivers. Trout and flounders are found in various parts of the sound but particularly in the Pamlico River area. Large

croakers were taken in the sound in earlier years but have not been taken in quantity since about 1930. Their disappearance from Pamlico Sound coincides with an increase in the commercial catch in Chesapeake Bay. Although no data are available, it seems possible that some change in hydrographic conditions in the sounds caused the movement of the adult croaker population. Pamlico Sound contains large numbers of small croakers each summer but the large "jumbo" croakers have not entered the sound for several years.

Movements of fish in and out of the sound are associated with water temperature. During the fall, when water temperatures fall below 10°C., most of the fish move out of the sound and return in the spring when the water temperature reaches 10 to 12°C. The dates when these water temperatures are reached vary from year to year, but as a general rule the sound is barren of fish from December to April, except for the earliest shad which may enter in January or February. A number of trawl hauls have been made during January and February, when the water temperatures were as low as 5.5° to 7.5° and no fish have been taken.

In a hydrographic study of Pamlico Sound, undertaken by the Institute and continued over a four-year period, it has been observed that the water temperature in the open sound follows the air temperature very closely. This is undoubtedly a result of the shallowness of the sound and the almost constant mixing of surface and subsurface waters by the wind. It has also been observed that waters entering the inlets on flood tides during the winter are considerably warmer (4.5°C) than the sound waters. This difference explains why many small fish can be found in the shallow waters off the ocean beach during the winter and not inside the sounds.

The distribution of shellfish in Pamlico Sound seems more closely associated with salinity than with temperature. Oysters, for example, are found most abundantly along the western and northwestern shores of the sound, the areas having the lowest salinities (ranging from 6.0 to 20.8 parts per thousand). Some oysters are found along the eastern shore where salinities range from 10.5 to 30.9 but these oyster rocks are not extensive. There are, of course, factors other than salinity which determine the location of productive oyster beds. There are, perhaps, few places in Pamlico Sound in which the salinity is unsuitable for oyster growth, but in the entire open portion of the sound the nature of the bottom is believed to be a limiting factor. Much of the bottom is soft mud, the rest is sand. But because of the shallowness of the water and the location of the long axis of the sound in the direction of the prevailing winds, the bottom is unstable and, even though oyster beds are formed in this area, their continued success can not be assured. Some small oyster beds have been maintained for a period of years in close proximity to some of the larger and relatively stable shoals.

In the vicinity of the three inlets the salinity is high and less variable than in the sound proper. Here clams and bay scallops are found. Clams are marketed from Ocracoke Inlet, but those from the other inlets are less plentiful and generally serve only to supply the small communities on the outer banks.

The Pamlico Sound shrimp fishery is well known for its economic importance to the state (about one-half of the State's production comes from Pamlico Sound and its tributaries). But there is as yet no evidence linking the distribu-

tion and movements of shrimp with specific hydrographic conditions. There are three species of commercial shrimp in the Pamlico Sound area: the brown spotted shrimp, *Penaeus duorarum*; the brown shrimp, *P. aztecus*; and the white shrimp, *P. setiferus*. The fisheries take adult shrimp, i.e. individuals which are sexually mature or nearing maturity, and which are enroute to the ocean waters, presumably for spawning. Seasonally, the spotted shrimp appear first, usually in May and June; the brown shrimp moves through the sounds in July and August; and the white shrimp follows in September and October. These migrations, occurring over a six to seven month period do not seem to be associated with hydrographic conditions but rather with the development cycle peculiar to each species.

There are also differences in the distribution of the species. The brown spotted shrimp occurs only in the extreme southern portion of Pamlico Sound (it is much more abundant in Core Sound which contains waters of higher salinity) whereas the other two species are distributed quite generally throughout the sound. We do not know enough about the distribution of the larval stages of the three species to know whether this distribution of the adults represents a "preference" for higher salinities on the part of the brown spotted shrimp, or whether the distribution of larval forms might determine the adult distribution. Research along this line is in progress.

Blue crabs are abundant in Pamlico Sound throughout most of the year although there is little commercial production during the winter months. The bulk of blue crab production occurs in the western part of the sound, the low salinity areas, but this is undoubtedly due to the fact that the only markets for crabs are located there. There is only a limited demand for blue crabs and the western area of the sound is able to supply that demand. No special studies of blue crabs have been made in North Carolina, but observations by the Institute personnel indicate that there is a large supply of crabs throughout the sound. Pearson (1951) points out the inverse relationship between North Carolina production and Chesapeake Bay production, and further states that this relationship exists because of economic rather than biological reasons. There is no doubt that the blue crab fishery in Pamlico Sound could be increased several-fold if the demand warranted such an increase.

Core Sound contains water of higher salinity than Pamlico Sound (19.0 - 35.8 p.p.t.), and the higher salinity is reflected by the fisheries. Clams are quite generally distributed throughout the sound and provide a valuable fishery. Bay scallops, which suffered a serious decline in the early 1930's as they did along the entire east coast, have made a comeback during the last few years. Long haul seines are used in the sound for taking a variety of finfish.

There is an important and unique shrimp fishery in Core Sound. The spotted shrimp is the principal species involved. This species is active during the hours of darkness and can be taken in commercial quantities only at that time. This characteristic habit of the spotted shrimp was unknown until 1949, and since that time the North Carolina laws, which previously prohibited night shrimping, have been changed so that this shrimp could be utilized by the industry.

An interesting change took place in the Core Sound fisheries following the reopening of Drum Inlet by a storm in 1933. Prior to that time there were extensive oyster beds in the Sound, particularly in the northern end. After the opening of Drum Inlet and the resultant increase in salinity in northern Core

Sound, oysters decreased in abundance and the clams extended their range to include the northern part of the sound.

Perhaps the best example of the relationship between hydrographic conditions and distributions of fishery resources is the growth of Core Sound scallops in relation to distance from the inlet. Gutsell (1930) pointed out such a relationship by showing that scallops grew faster and larger near Beaufort Inlet than in Core Sound and western Bogue Sound. Scallops are not found at present in many of the areas which Gutsell studied, but are found principally in Core Sound. Barden Inlet, at the extreme southern end of Core Sound (see Figure 1), has developed since Gutsell's study and is responsible for higher salinities in that area than existed prior to the formation of the inlet. Fahy and Chestnut of the University of North Carolina Institute of Fisheries Research (unpublished manuscript) report a progressive diminution in growth rate and size of scallops with distance from the inlet. It is not known whether the differential size and growth rate is the result of the effect of salinity or currents, both of which decrease with distance from the inlet. Gutsell (op.cit.) advanced the hypothesis that currents had the greater influence because of their transport of food and oxygen into the area; and of products of metabolism and decay away from the area. This hypothesis however has not been proved.

Temperature is also an important factor in scallop survival. Fahy and Chestnut report a high mortality in an otherwise successful year class following the extremely high temperatures of June and July, 1952. They observed further that scallops in those areas of deeper water near the inlet, where cooler ocean waters periodically moved in, suffered less mortality than those in the very shallow flats some distance from the inlet.

The exact way in which the various hydrographic conditions (salinity, currents, and temperature) effect scallop growth, size and survival is not known, but it is evident that these conditions act directly or indirectly to limit the scallop range and cause the differences of size and growth within that range.

The remaining sounds, Bogue, Stump, Topsail, Middle, Masonboro, and Myrtle, are small and relatively unimportant in the over-all fisheries picture. There are numerous small inlets in this southern area causing relatively high salinities except in the areas supplied with fresh water from the streams. Clams, oysters, scallops and shrimp are taken in various localities, and these small fisheries provide at least part of the livelihood of the small communities bordering the sounds.

From the above discussion it will be noted that the North Carolina sounds provide a variety of hydrographic conditions and a variety of fishery resources. Some of these are intimately related to specific hydrographic conditions whereas others tolerating a wide range of conditions, show a lesser relationship.

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