Studies on the Vertical Distribution of Setting of Oysters in North Carolina

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In many oyster producing areas of the southeastern states of the Atlantic coast, concentrations of oysters grow in the intertidal zone, frequently with no adult oysters found below the low water level. The influence of water currents and a differential mortality rate caused by fouling organisms have been offered as a partial explanation for the vertical distribution of adult oysters. This has led to studies of the vertical distribution of setting in some localities. The possible significance of such studies has been pointed out by Galtsoff (1930) who wrote, "the knowledge of the exact location of the setting zone is as important to the oyster culturist as is the knowledge of the time of setting".

In a review of the studies on the vertical distribution of setting of the eastern oyster (*Crassostrea virginica*) there are considerable variations in the location of the zone of heaviest setting. Galtsoff and Prytherch (1927) reported that the peculiar distribution of oyster beds in South Carolina, Georgia and North Carolina is due to the setting of oysters between tide levels and postulated that the current is probably the prime factor controlling the distribution of the natural beds. This was followed by experiments in other areas. At Milford Harbor, Connecticut, Prytherch (1929) found that oysters set at all levels from the bottom of the channel to two feet above low water level with the heaviest setting near the bottom, but in Great South Bay, Long Island, setting occurred from the bottom to the approximate high water mark. Later, Prytherch (1934) correlated setting with current velocity and copper content to explain the vertical distribution of setting in Milford Harbor. Loosanoff and Engle (1940) confirmed the findings of Prytherch that the zone of heaviest setting in Milford Harbor was on the bottom.

Galtsoff and Luce (1930) studied the vertical distribution of setting in Georgia by stacking pairs of shell bags. They found the zone of heaviest setting to be above the low water level. Studies in Massachusetts by Galtsoff (1930) showed that the zone of heaviest setting in Wareham River was above the low water level. At Onset, Massachusetts, he found that setting occurred from the bottom of the channel to two feet above low water level, with no setting at the high water mark. The maximum set was from one and one-half feet to two feet above low water. Needler (1931) found the heaviest setting in Bideford River, Malpeque Bay, to occur from two to three feet below the low water level. These studies by Galtsoff in Massachusetts and Needler in Canada were made by placing bags of shells on the bottom, beginning at the high water mark, through the low water level to the channel and are not actual vertical distribution studies as made by other investigators.

Loosanoff (1932) studied the vertical distribution of setting in three localities in Virginia using a cement coated pole as cultch. In the James and Corrotoman rivers the zone of heaviest setting was found near the bottom. At Wachapreague, Virginia the heaviest setting was from one and one-half feet to three feet above the low water level. Mackin (1946) repeated the studies at Wachapreague and found the heaviest setting from the low water level to two feet above low water.

MacDougall (1943) in studying the attachment of sessile marine invertebrates at Beaufort, North Carolina, found the heaviest set of oysters to occur near the bottom. Recent studies in South Carolina reported by McNulty (1953) show that the maximum setting in three localities was from one foot below low water to one foot above low water.

Studies of the vertical distribution of setting of other species of oysters have shown equally diversified results. Seki and Tanaka (1931) found the greatest number of oyster spat of *Ostrea denselamellosa* near the bottom. McMillan and Bonnet (1931) point out the advantages of suspended oyster culture in California waters with *Crassostrea gigas*, writing that a maximum set is obtained on suspended tarred ropes. Ota (1948), cited by Cahn (1950), found in Hiroshima and Kumamoto prefectures that the zone of heaviest setting in shallow water for *Crassostrea gigas* was at a depth of 40 to 100 cms above the bottom to the low low water level, but in deeper waters the zone of heaviest setting was from 0 to 100 cms above low low water level.

Bonnot (1936) writes that spat collectors for *Ostrea lurida* in California are laid on the bottom or suspended from logs or floats. Hopkins (1937) suspended baskets of shells at various levels from a float to study the vertical distribution of setting of O. *lurida* in Puget Sound and found that the heaviest setting takes place from 6 to 30 inches below the surface.

Cole and Knight-Jones (1939) found that the spat of *Ostrea edulis* were evenly distributed in intensity from the bottom to the surface on the inner surfaces of their tanks at Conway. Experimental shells placed in the tanks just below the surface, at mid-depth, and near the bottom showed the heaviest setting on the shells near the surface. Korringa (1940) clearly demonstrated in field experiments that the heaviest setting of *Ostrea edulis* in the Oosterschelde occurs near the bottom. Experiments by Cole and Knight-Jones (1949) of the vertical distribution of setting in the Helford River, Cornwall, confirmed the findings of Korringa, but they found conflicting results in the tanks at Conway.

In the studies of the vertical distribution of setting two of the investigators present some evidence of the mortalities that may take place. Mackin (1946) found that 75 to 83 percent of the spat at Wachapreague, Virginia, were killed by oyster drills between June and December. Test panels used in the studies by MacDougall (1943) were left overboard with attached oyster spat from August 15 to December 27. No oysters remained below low water level, and MacDougall concluded that the heavy growths of hydroids, sponges, tunicates and other encrusting organisms smothered the young oysters.

Studies on setting of oysters were started in North Carolina at the Institute of Fisheries Research in June, 1948. Spat collectors placed on the bottom at the Institute pier in Bogue Sound in depths of eighteen to twenty feet showed that heavy sets of oysters occur at the bottom in an area where adult oysters are found only in the intertidal zone. Some preliminary studies were made in 1951 to determine the vertical distribution of oyster setting using clam shells strung on a wire at foot intervals. Setting of oysters was found to occur at all levels. This was followed by studies in 1952 to determine the vertical distribution and intensity of setting at foot levels in five different areas (see Figure 1).

Description of areas:

The distribution of adult oysters at three of the stations, Cape Lookout, Pivers Island and Institute pier is generally limited to the intertidal zone. In Bay River and Core Creek oysters are found growing on the bottom and distributed vertically along piling and similiar structures.

The tidal fluctuation, except in Bay River where there are no periodic tides, is from two and one-half feet to four feet at the four stations. In Bay River the slight rise and fall of water level is governed by the prevailing winds. The depth of water at the various stations was eight feet at Pivers Island and in Bay River, thirteen feet in Core Creek, sixteen feet at Cape Lookout, and eighteen feet at the Institute pier.

Water temperatures at the five stations during the period the studies were made ranged from 24.0°C to 32.8°C. At the Institute pier, Pivers Island and Cape Lookout the salinities ranged from 30.0 parts per thousand to 36.3 p.p.t. The greatest fluctuation in salinity was at the Core Creek station where readings from 18.4 p.p.t. to 37.0 p.p.t. were recorded.The salinities in Bay River ranged from 14.2 p.p.t. to 18.4 p.p.t.

The station at Cape Lookout was located in the bight at the government pier. At Pivers Island the series of shells was suspended from the U.S. Fish and Wildlife Service dock. At Core Creek the studies were made from a small pier adjacent to the north side of the highway bridge across the Intracoastal Waterway. In Bay River the shells were suspended from a group of piling on the south shore of the river at Bell Point.

Methods:

Small wire baskets, eight inches square, were constructed of one inch hexagonal mesh wire. Clam *(Venus)* shells of uniform size, measuring approximately three and one-half by three inches in length and width were used as spat collectors. Two pairs of shells were placed in each basket with each pair facing in opposite directions. The baskets were wired at foot intervals to a length of chain anchored with a cement block, and suspended from a pier. The shells were changed at weekly intervals, and counts were made of the oyster spat attached to the inner surfaces of the shells.

Results:

The results presented here are from studies made during the months of June, July and August, 1952. Table 1 contains the average counts of spat per shell at each station for three weekly series of studies.

TABLE 1

VERTICAL DISTRIBUTION OF OYSTER SPAT AT FIVE LOCALITIES IN NORTH CAROLINA. FIGURES REPRESENT AVERAGE SPAT-PER-SHELL COUNTS FOR THREE WEEKS.

Depth	Cape Lookout	Institute Pier	Core Creek	Pivers Island	Bay River
3	0.4			0	
2	0.4	0	0	0	
1	3.	1	1	0.2	
LW	12.	10	1	4.	8
— 1	40.	10	2	12.	53
— 2	35.	10	3	13.	132
— 3	44.	7	2	22.	204
— 4	45.	14	4	52.	243
— 5	55.	16	4	128.	341
— 6	53.	20	4		280
— 7	74.	25	3		232
— 8	89.	27	5		
— 9	123.	24	4		
—10	244.	36	4		
—11	530.	24			
—12		34			
—13		42			
—14		34			
—15		33			

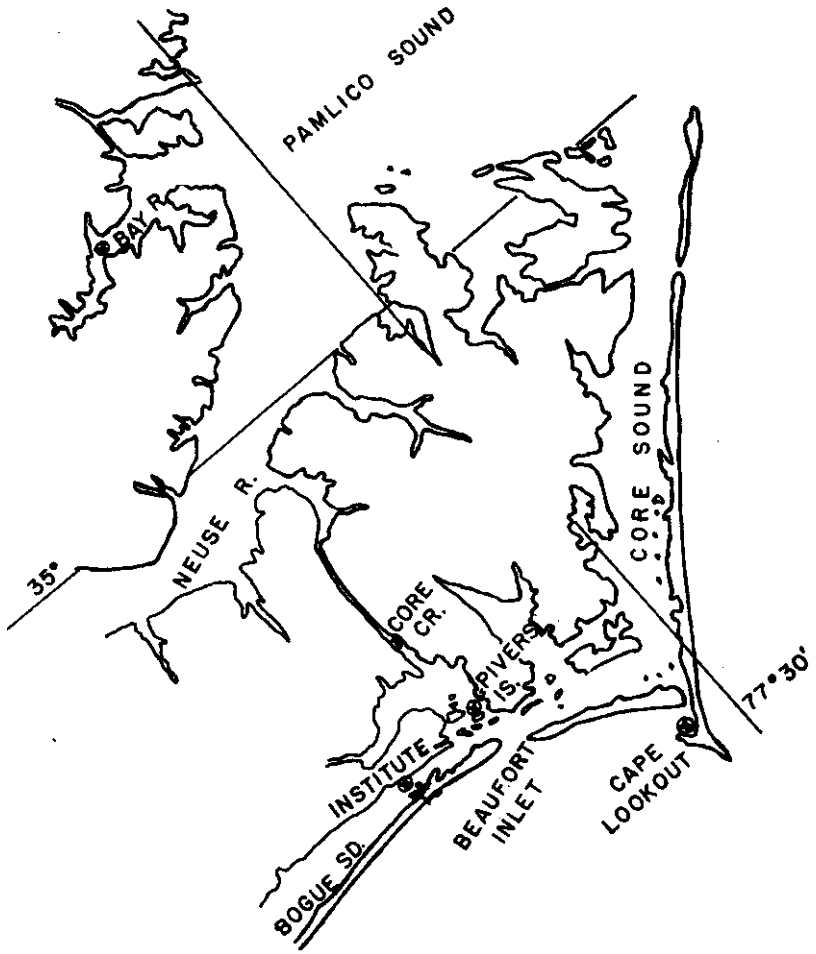

FIGURE 1. Map of portion of eastern North Carolina showing the location (✱) of each station for vertical distribution studies.

From the data, a trend of increased setting intensity is noted nearer the bottom. This is particularly evident at the stations at Cape Lookout and Pivers Island. Both of these stations are located in sheltered areas away from the influence of strong currents. In Bay River, the currents are sluggish of negligible, but the average count shows that the maximum setting occurred three feet above the bottom. During the three week interval when these data were collected in Bay River, the level of maximum set varied among the lower three series of shells. The heaviest set during the week of July 28 to August 4 was on the bottom series of shells with an average of 344 spat per shell, and in the following week the heaviest set was two feet above the bottom with an average set of 375 spat per shell.

At the Institute pier and Core Creek setting intensity was light in comparison to the other stations, but the trend of heavier setting near the bottom was

still evident. These series of shells, at the two stations, were exposed to the direct effects of the strong water currents that flow by the piers.

The intensity of setting above low water level was markedly reduced at those stations located in areas where the tidal fluctuations occur. No oysters were found attached to the shells placed at the high water level, but light sets of barnacles were frequently found on the shells.

TABLE 2

SETTING INTENSITY OF OYSTERS ON SHELLS EXPOSED FOR ONE MONTH, PIVERS ISLAND

Depth	Spat/Shell	Number Drilled
2	0	0
1	8	0
LW	24	0
—1	14	0
—2	17	0
—3	25	1
—4	41	15
—5	5	57

A series of shells was left overboard for one month (July-August) at Pivers Island to determine the rate of mortality. These results are presented in Table 2. After a month of exposure the shells were heavily encrusted with growths of bryozoa, hydroids, barnacles and tunicates. Many of the oysters had died, and those with both shells intact in many cases showed evidence of mortality caused by oyster drills. The heaviest set was on the shells two feet above the bottom, and a marked increase in the number of spat at the low water level was noted. The intensity of fouling organisms on the shells at low water level was not as great as on those shells below low water. The greatest mortality was on the shells near the bottom.

In the high salinity areas, at Cape Lookout, Pivers Island and the Institute pier, spat less than a week old were found killed by oyster drills. In one weekly series at the Institute pier 23 spat from a total of 516 spat were found drilled on the shells nearest the bottom. At the three stations in the high salinity areas, evidence of drill damage was seen in each weekly series. The greatest mortality was always on the spat attached to the shells nearest the bottom, but the shells which were two and three feet above the bottom also contained spat that had been killed by oyster drills.

Summary:

The studies presented were primarily designed to determine the vertical distribution of oyster setting at several stations with particular emphasis on the intensity of setting in those areas where concentrations of adult oysters are growing in the intertidal zone. It was found that the intensity of setting below low water level was far in excess of the set above low water. Some evidence was collected of the high rate of mortality below low water level which may offer a partial explanation of the peculiar distribution of adult oysters in the intertidal zone.

The direct effects of predators such as oyster drills and secondary effects of heavy growths of various sessile organisms, which compete for space and may cause additional mortalities, has been noted. The rate of mortality caused by oyster drills may be greater than these results indicate because the use of a chain to which the baskets were attached would hinder the ascent of drills.

The light sets of oysters at Core Creek and the Institute pier compared to the heavy sets at the other stations suggest the possible influence of currents upon setting. At the Institute pier the set of oysters in the vertical distribution series was light compared to the sets obtained along the shore in the intertidal zone, where daily and weekly data are collected. The average set of oysters along the shore during the same period was nearly five times greater than the set at any level of the vertical distribution studies.

The need for further studies of the effects of current upon setting and the effects of predators and fouling organisms upon survival is evident before an explanation can be made of the limited distribution of adult oysters to the intertidal zone.

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