Results Of Shrimp Research In North Carolina

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INTRODUCTION

THE SHRIMP FISHERY of North Carolina, worth about one and one-half million dollars annually, ranks second in value among the State's fisheries. Although the origin of the shrimp fishery was in the latter half of the nineteenth century, production was low until the otter trawl came into general use after the first World War. The catch, which was 371,000 pounds in 1908, had increased to 940,120 pounds in 1921. Today the catch is over 4 million pounds annually. This figure has roughly doubled in the last decade.

The North Carolina shrimp fishery is actually the sum of four separate fisheries located in three different parts of the State, each having a distinct but short productive season. Each of the four fisheries draws from a separate source of shrimp.

The areas within North Carolina that support shrimp fisheries are the environs of Cape Fear, especially the littoral zone southwest of the Cape; the waters adjacent to Carteret County, including Core and Back Sounds and the oceanic littoral zone from Bogue Inlet to Cape Lookout; and the vast inside waters of Pamlico Sound with its principal tributaries, the Neuse and Pamlico Rivers. Shrimp taken outside of these areas represent a small proportion of the State's catch.

The data reported in this paper were collected by the shrimp staff of the University of North Carolina Institute of Fisheries Research during the years 1948, 1949 and 1950. The author wishes to cite especially the work of Mr. Horace G. Loftin, Jr., who collected the data on commercial catches during the summers of 1949 and 1950.

SHRIMP OF COMMERCIAL IMPORTANCE

Three species of the genus Penaeus make up the shrimp catch of North Carolina. These are: *Penaeus aztecus* Ives; *Penaeus setiferus* (Linnaeus) and *Penaeus duorarum* Burkenroad. Three other peneids. *Xiphopenaeus kroyeri* (Heller), *Trachypenaeus constrictus* (Stimpson) and *Sicyonia brevirostris* (Stimpson), which appear in the catch are too seldom taken to be of commercial importance. Sampling of commercial catches during the years 1948 and 1949 has yielded data on the proportion in which the three species of *Penaeus* occur in North Carolina commercial shrimp catches during the months of the year. By applying these proportions to total catch statistics, an estimate of the proportion of each species in the total catch has been computed. In North Carolina, during the years 1948 and 1949, 68.3 per cent of all commercial shrimp taken were *P. aztecus. P. setiferus* contributed 17.3 per cent of the two-year catch and P. *duorarum* accounted for the remaining 14.4 per cent.

Each year the first species of shrimp to appear in commercial abundance in North Carolina is *P. duorarum.* This species, the spotted shrimp, supplies the first of the four shrimp fisheries, a spring fishery. In late May or early June

spotted shrimp are caught in Core and Back Sounds and in the littoral outside* waters from Cape Lookout to Bogue Inlet. These shrimp are first taken inside and later outside. The fishery, from its start until the latter half of June yields entirely *P. duorarum*. After mid-June, brown shrimp (*P. aztecus*) start to appear in the catch. These brown shrimp increase in relative abundance so that, during the first half of July, *P. duorarum* accounts for only one-third of the catch. After July, *P. duorarum* is infrequent in the inside catches until September. During the fall months of September, October and November, spotted shrimp supply about 10 to 20 per cent of the yield of a greatly decreased fishery. This species continues through the summer and fall in the outside catches, however, furnishing, after July, less than one-third of the shrimp taken.

Spotted shrimp are never important in the commercial catches from the Cape Fear region or from Pamlico Sound. They occur at Cape Fear in June and in November but comprise a negligible proportion of the catch.

During the June fishery in Core Sound and in the outside water adjacent to Carteret County, there is no evident growth of the spotted shrimp. During the spring run, starting late in May and ending early in July, *P. duorarum* taken in the inside waters average 107 mm. in total length. *P. duorarum* taken from the outside littoral zone during this same period average 112 mm. in length. These averages apply to all samples made from June 6 to July 6.

At the end of June and during the first week of July, *P. duorarum* females from the outer littoral zone, which average about 120 mm. in length, show signs of sexual maturity. The ovaries are enlarged and have taken on a blue-green color. At this time there is an increase in the proportion of females over males so that the percentage of females in the total population, which was less than 50 per cent during the first of the run, rises to greater than 50 per cent shortly before the end of the run. This phenomenon occurs shortly before the end of the period of maximum production in each of the North Carolina shrimp fisheries. Regardless of the species of shrimp caught, a predominance of females fortells decreased total yield.

Ripe or ripening females disappear from the catch during the latter half of July. At the same time there is a decrease in the average size of the spotted shrimp so that *P. duorarum* taken in North Carolina during the latter half of July, August and September average from 97.6 to 103.2 mm. in total length. The percentage of the sexes is variable during these summer months.

In early October an increase in average size of spotted shrimp from the littoral zone occurs. This increase continues through November. A general increase of the population mean of 10 mm. every two weeks occurs through mid-November, by which time commercial shrimp fishing has ended. The increase in mean length is accompanied by the reappearance of blue-roed females. Degrees of coloration varying from opaque white to deep blue-green are found in these ovaries. These shrimp average 120 mm. in mid-October and 140 mm. by mid-November. There is a preponderance of females during October and November.

During the past few years, *P. aztecus*, the brown shrimp, has been by far

* The terms "inside," "outside," "inshore," and "offshore" as used here are defined:
Inside: describes bodies of water which are inside the outer banks or other natural shoreline.
Outside: describes ocean waters.
Inshore: pertaining to the littoral zone of the ocean or outside waters.
Offshore: pertaining to ocean waters having a depth of more than 10 fathoms.

the most important commercial shrimp of North Carolina. Is occurs in all parts of the State and furnishes two summer fisheries, one in the Pamlico Sound and Beaufort Inlet areas and one in the Cape Fear area.

P. aztecus first appears in commercial catches in late June in the inside and outside waters around Carteret County. Brown shrimp are found first here only because catches of spotted shrimp are being made in these waters before fishing starts in other parts of the State. Small (80-90 mm.) brown shrimp have been taken by the author from inside waters at Cape Fear as early as June. Although the winter and spring occurrence of small shrimp has not been studied in North Carolina, it seems unreasonable to assume that other areas later to produce brown shrimp do not have populations of small *P. aztecus* in June. By early July, brown shrimp contribute two-thirds of the catch at Beaufort Inlet and continue to make up from two-thirds to three-fourths of the catch through November.

In July, as the inside run of spotted shrimp ends, the focus of the North Carolina fishery is directed to the Pamlico Sound—Neuse River area. Here a summer fishery, lasting from the last half of July through mid-September, yields more shrimp than any other North Carolina fishery. The shrimp taken during this period in Pamlico Sound are 93 to 98 per cent *P. aztecus*. During September, there is a decline in the abundance of brown shrimp in the inside waters and a corresponding decrease in the proportion of them in the fishery. The September catches yield about 75 per cent brown shrimp. After September, except for a late run of white shrimp, there is little commercial activity in Pamlico Sound and accurate percentage figures are not available.

A summer fishery at Cape Fear produces 90 to 99 per cent brown shrimp during July and August. There is a change in the Cape Fear population during late August so that September production of brown shrimp at Cape Fear is only 1.4 per cent of the total catch. This reversal is an expression of both the disappearance of brown shrimp and the appearance on the grounds of white shrimp. After the end of August brown shrimp constitute a negligible proportion of the catch until the white shrimp disappear in mid-November when the proportion, although not the actual number, of brown shrimp rises as the fishery decreases.

P. aztecus enter the North Carolina fishery at Beaufort Inlet at an average size of 104 to 107 mm. in late June. The increment in mean size is slight through August, at which time the population average is 118 mm. In the inside area, however, brown shrimp which average 113 mm. in early July, average 140 mm. a month later and 150 mm. by the end of August. In September, there is a decrease in average size of brown shrimp in the sounds. September means from inside areas vary from 103.2 mm. to 139.6 mm. By October the average size of brown shrimp from Beaufort Inlet, however, has increased to 125 or 130 mm. By mid-November, brown shrimp in the greatly decreased catches at Beaufort Inlet average 137 to 140 mm.

At Cape Fear, brown shrimp are always smaller than those from the sounds. Early July *P. aztecus* from Cape Fear average 115 mm. Late August samples of this species average 125 mm. These shrimp are believed to be not migrants from or to Pamlico Sound but a separate stock.

The larger females *P. aztecus* found in the late August and early September catches show signs of sexual maturity. These shrimp are from 155 to 160 mm. in length. The ovaries are enlarged and pigmented various shades: opaque

white, yellow, tan or gray. Shrimp taken inside seldom have tan or gray ovaries, while those from outside show all degrees of coloration.

About the middle of August, there is an increase in the population of females over males in the inside waters and at Cape Fear similar to the increase of the percentage of female spotted shrimp described above.

The white shrimp *P. setiferus* is of commercial importance chiefly in the Cape Fear area in North Carolina. It supplies the fourth, or fall, fishery. *P. setiferus* first appears in May when a run of sexually mature shrimp of about 160 to 165 mm. in length is fished west of Cape Fear. This run lasts through June with a steady decrease in total yield of the fishery and in average size of the shrimp. A few of these large white shrimp are taken at Beaufort Inlet during the same period. *P. setiferus* is only found occasionally in catches of brown and spotted shrimp during July and August.

In August small white shrimp may be found in the back waters of Pamlico Sound and in the Cape Fear River. Because of their small size and the availability of brown shrimp at this time, these shrimp do not appear in the commercial catches. In late August small white shrimp enter the Cape Fear fishery. As the brown shrimp disappear, the white shrimp enter the fishing grounds. During September, while the species of shrimp caught at Cape Fear is changing, the total catch decreases slightly. The shrimp fishery at Cape Fear has its peak of production during October when 98 per cent of the catch is white shrimp. There is a decline in the yield during November and the fishery ends before December.

In Pamlico Sound white shrimp do not become important until mid-October. Following the decrease in the sound catches of brown shrimp there is a period of inactivity when vessels spread out as the yield from the productive grounds of the summer fishery decreases. In October, schools of white shrimp are encountered in Pamlico Sound and are followed by vessels as they move to the inlets. This fall migration has earned *P. setiferus* the local name of "school shrimp" in the North Carolina sounds. This disappearance of "school shrimp" from Pamlico Sound ends the inside shrimp fishery.

After a summer's absence, white shrimp reappear at Beaufort Inlet during October. They contribute an increasing percentage to the fishery through its end in November. At that time about 20 per cent of the shrimp taken are *P. setiferus*.

White shrimp re-enter the Cape Fear fishery in August at an average length of 140 mm. They increase in number and in average size through the end of October, at which time the mean length is 155 mm. During November the average size decreases as the catches diminish.

White shrimp taken in tributaries of Pamlico Sound in August average 140 mm. in length. Those found at Beaufort Inlet in October average between 150 and 155 mm. There is a decrease in average size during November.

The spring white shrimp encountered at Cape Fear and at Beaufort Inlet have ovaries of the olive drab color described by King (1948). The ovaries of fall *P. setiferus* are undeveloped. At Cape Fear a predominance of female white shrimp occurs in late September or early October.

SHRIMP OFFSHORE OF NORTH CAROLINA

Sampling of offshore shrimp has revealed the presence of *P. setiferus* in the environs of Diamond Shoals and of *P. duorarum* in the vicinity of Cape Lookout Shoals during the winter months. Shrimp found were generally larger than

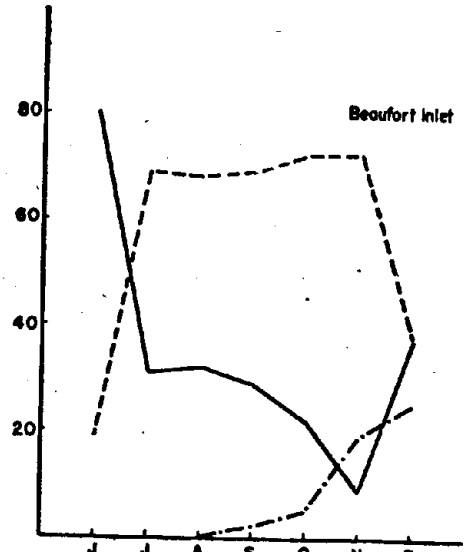

FIGURE 1

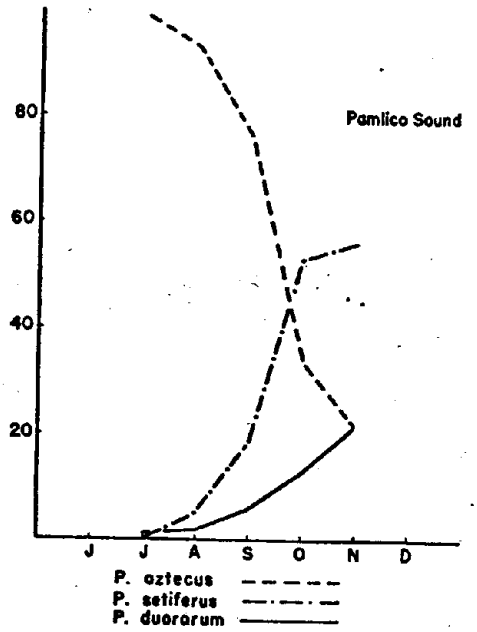

FIGURE 2

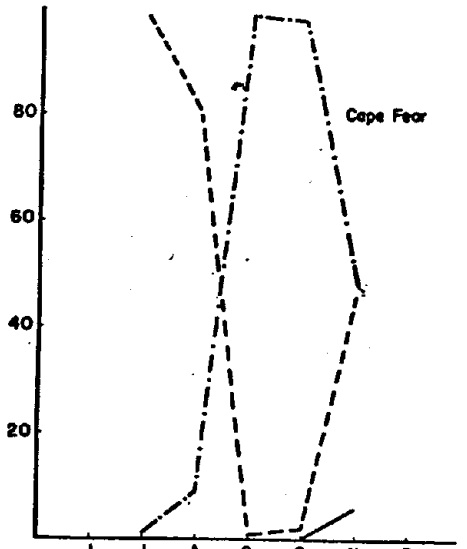

FIGURE 3

Composition of total catch by species, Beaufort Inlet, Pamlico Sound and Cape Fear.

in the straits between Harkers Island and Beaufort, North Carolina, and which employs a stationary "submarine" net as a tide trap. This fishery, the earliest productive fishery of North Carolina, lasts from late May through early July. It produces shrimp only during the hours of darkness and only on an ebb tide when the shrimp, swimming "presumably to sea," are carried into the net by the tide.

Samplings from the catch of the channel net fishery have been made during 1949 and 1950. The yield of the channel net is similar, species-wise, to that of the trawl fishery at Beaufort Inlet during the same period. The channel net shrimp average 105 to 110 mm. in length from the start of the season until late June. During this time the channel net yields only *P. duorarum*. In late June *P. aztecus* of about 100 mm. in length enter the catch. By the first week of July *P. aztecus* accounts for two-thirds of the shrimp taken by the channel net. Channel nets are not used after the first half of July.

THE NORTH CAROLINA SHRIMP FISHERY

The statistics assembled by the North Carolina Department of Conservation and Development most readily lend themselves to an analysis of the North Carolina shrimp fishery. These figures are based upon returns from tax tag sales which are rendered monthly by localities and may be converted into pounds of shrimp shipped from all parts of the State. Sampling of catches landed at fish houses in all the important shrimp landing ports has given percentage data on species composition of the catch. The species composition of total catch for each of the three main shrimp producing areas may be illustrated graphically. (See Figures 1, 2, and 3).

By plotting the per cent of the total catch per month landed in each of the three areas, the multi-seasonal aspect of the North Carolina shrimp fishery may be illustrated. It will be noted that the three production peaks fall in June, August and October, the periods of peak production for the three species of commercial shrimps.

RECENT TRENDS IN THE NORTH CAROLINA SHRIMP FISHERY

If the percentage of the annual catch landed each month over a five-year period is plotted against time, the period of maximum production of the North Carolina shrimp fishery as a whole is illustrated. Such production figures for the five-year period from 1941 to 1945 show a peak of production in October. The same figures for the period from 1945 to 1949, however, show the production peak to be in August.

This shift in time of the season of maximum production is a result of the opening of the Pamlico Sound fishery and the increase in the proportion of brown shrimp in the catch.

past decade indicates that the present level of brown shrimp production is of recent origin. Species composition percentages are not available to apply to catch statistics for the years before 1948. The seasonal occurrence of the mass

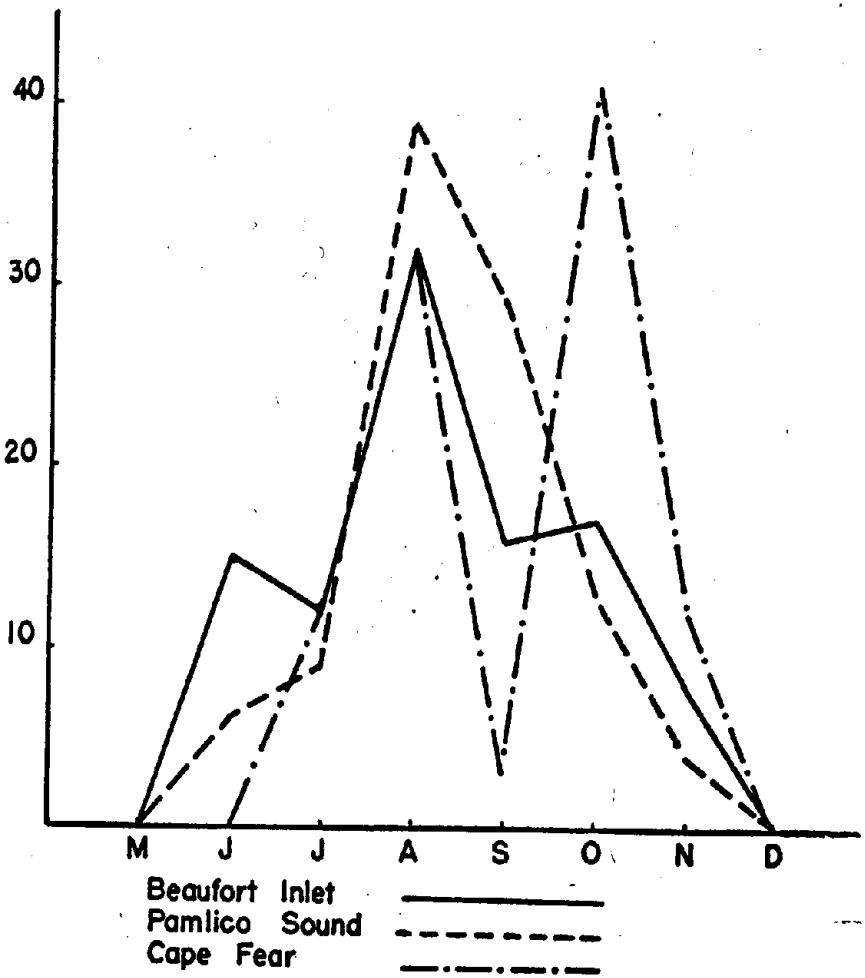

FIGURE 4

Monthly percentage of total catch for each of the three principal shrimp producing areas of North Carolina.

of the population of each species, however, is sufficiently distinct to allow treatment of June shrimp as largely *P. duorarum*, of August shrimp as largely *P. aztecus*, and of October shrimp as largely *P. setiferus*. The 1945-1949 figures, therefore, show not only an increase in *P. aztecus* over the 1941-1945 figures but also an increase in the proportion of *P. duorarum*.

The Pamlico Sound fishery is, in a large part, responsible for this increase in the proportion of brown shrimp in the North Carolina catch. Although there is little agreement among North Carolina fishermen concerning who first shrimped in North Pamlico Sound, there is general accord that no one did much before 1940. An accelerated market for shrimp paid the highest prices in history during the second World War. This demand resulted in exploration and opening up of North Carolina's inside waters by shrimp fishermen. Burkenroad (1949) has suggested an increase in the relative abundance of grooved shrimp. From interviews with fishermen from all parts of the State, such seems most certainly to be the case. There was then an increased demand which coincided in time with the opening of a new area when shrimp of the sort inhabiting that area were becoming increasingly abundant. The result of these fortuitous circumstances is an inside fishery—the only one of its kind on the Atlantic Coast—which produces in a period of two months half of North Carolina's annual catch.

King (1948) described field characters by which the degree of maturity of *P. setiferus* could be judged. Present observations of degrees of pigmentation of ovaries of grooved shrimps suggest that such characters may also exist for *P. duorarum* and *P. aztecus*.

The effectiveness of the channel net has been interpreted by Burkenroad

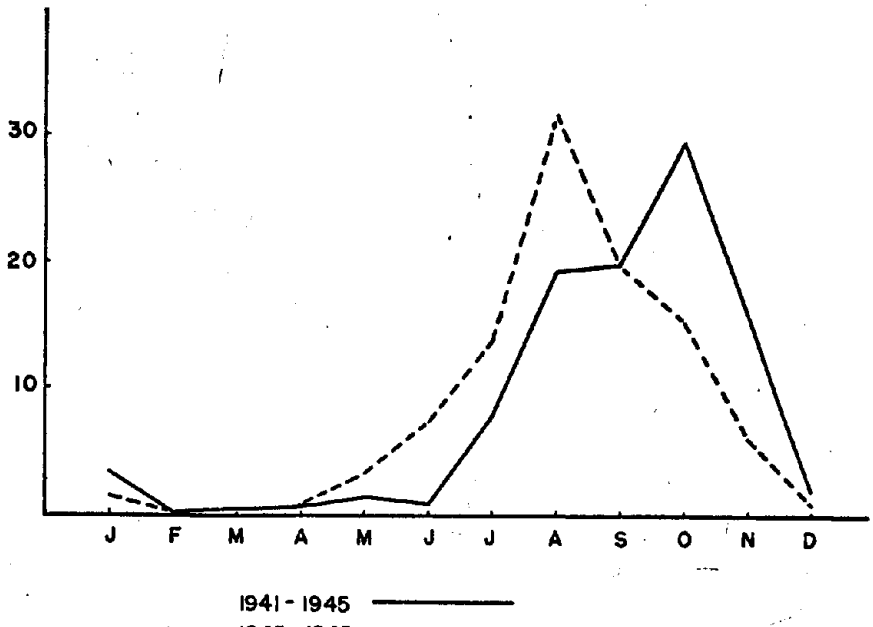

FIGURE 5

Percentage of the North Carolina shrimp catch landed each month. Five-year average.

(1949) as the interception of shrimp swimming off the bottom and "presumably to sea." Fishermen of Carteret County have long noted that heavy catches of spotted shrimp at Beaufort Inlet follow a night of heavy catches in the channel nets in Back Sound. A slightly greater average size of *P. duorarum* from Beaufort Inlet than from Back Sound during June and the stability of these averages through the spring suggest that these are two stations at which a seaward and offshore migration is being sampled. The presence of females with pigmented roe at Beaufort Inlet in late June, with a few such blue-roed females coming from the channel nets relates this migration to approaching sexual maturity.

The fall reappearance of blue-roed *P. duorarum* females may represent a portion of an offshore breeding stock driven in by conditions coincident with the changing of the season. This behavior is at variance with Burkenroad's (1939) observation that, in Louisiana, *P. duorarum* "retires permanently to deeper waters after a littoral youth."

The presence of yellow and tan-roed female *P. aztecus* in the late August catches suggest the September disappearance of this species is related to approaching maturity. If the migrations that remove grooved shrimps from the North Carolina littoral zone may be thus related to spawning activity, then the observed increase in the proportion of females in the catch may be interpreted as differential behavior of the sexes at the approach of sexual maturity. The high percentage of female white shrimp in the October population at Cape Fear, however, cannot be related to such macroscopically observable indications of approaching maturity.

BIBLIOGRAPHY

ANDERSON, W. W.; M. J. LINDNER and J. E. KING, 1949, *The shrimp fishery of the southern United States,* U. S. Fish and Wildlife Service, Commercial Fisheries Review, 11 No. 2, 1-17.

BURKENROAD, M. D., 1939, *Further observations on Penaeidae of the northern Gulf of Mexico,* Bull. Bingham Oceanog. Coll., 6, 1-62.

BURKENROAD, M. D., 1949, *Occurrence and life histories of commercial shrimp,* Science, 110, 688-689.

KING, J. E., 1948, *A study of the reproductive organs of the common marine shrimp,* Penaeus setiferus (*Linnaeus*), Biol. Bull., 94, 244-262.

WEYMOUTH, F. W., M. J. LINDNER and W. W. ANDERSON, 1933, *Preliminary report on the life history of the common shrimp,* Penaeus setiferus (*Linnaeus*), Bull. U. S. Bur. Fish., 48, 1-26.

Variation In Salinity And Its Relation To The Florida Oyster

Salinity Variations In Apalachicola Bay*

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SEVERAL OF THE ESTUARIES of Florida are not well protected. Water from the rivers many times enters the Gulf and Atlantic abruptly and without an opportunity to become uniformly mixed.

*Contribution No. 46 from Marine Laboratory, University of Miami