(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.

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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

Much of the present-day oyster industry of Florida is centered in estuaries which do not provide a constant and uniform salinity. Variations exist not only seasonally, but daily and tidally.

Biologists and producers alike would be benefitted by a knowledge of the magnitude of variation which oysters can tolerate in Florida's sub-tropical waters, and what degree of variation can be considered optimal for reproduction, deposition of glycogen, maximum growth, etc. The present study was carried out to establish, if possible, the critical values for salinity variations as they affect oyster well-being.

Procedure

Salinity studies (by hydrometer) were made on a series of habitats ranging from the poorest to the best with regard to commercial production. Density was obtained for other stations frequently, and there were several sets of paired readings run on consecutive high and low tides. In some instances salinity tests were run on bottom and top samples hourly for a 24-hour period. The studies were carried on for a period of eighteen months (February, 1949, to July, 1950). Where practical, frequent correlative glycogen studies were made on oysters from habitats under observation.

Results

As was expected, substantial variations in salinity were observed seasonally and weekly. The variations found intertidally and hourly were surprisingly large in certain cases.

In Figure 1, seasonal salinity variation (as standard deviation) and oyster

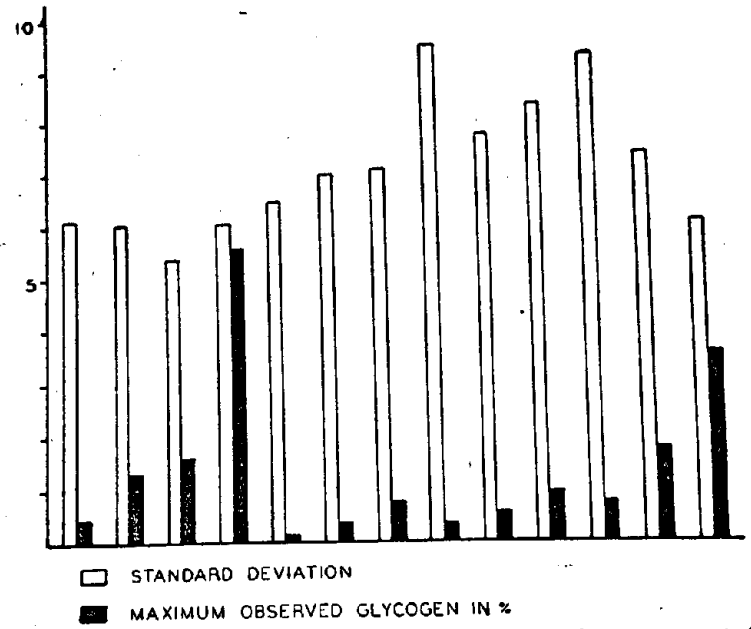

FIGURE 1—Seasonal salinity variation correlated with observed glycogen content. Stations from left to right are as follows: Cat Point, Porter's Bar, Green Point, Indian Pass, Goose Island, Pilot's Cove, East Slough, Paradise Flat, Cabbage Lump, St. Vincent's, Miller's 13 Mile, Nick's Hole, and Sebastian.

condition are shown together. Eighteen month ranges of salinity for various stations in Apalachicola Bay are shown in Figure 2, which is a haligraph modified after the suggestion of Stauber (1943). Maximum weekly ranges of salinity for all stations are indicated in Figure 3. In Figure 4, maximum ranges intertidally are provided.

Results of 24-hour studies are shown graphically in Figures 5 and 6 for Porter's Bar and St. Vincent's Reef, respectively.

A summary of all data gathered is presented in Table I.

Discussion

The oysters of Apalachicola Bay, from the standpoint of salinity variation, live in a rigorous habitat. During their development to marketable size they are

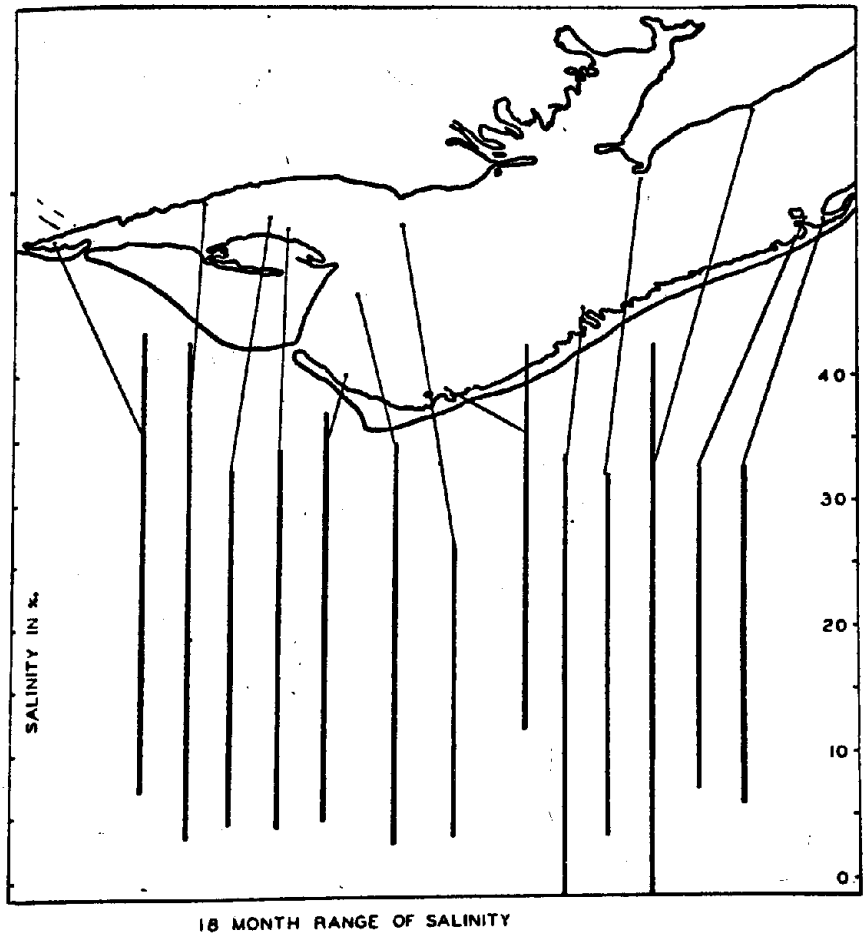

FIGURE 2—18 Month Range of Salinity. Stations from left to right are as follows: Indian Pass, Miller's 13 Mile, Paradise Flat, Cabbage Lump, Government Dock, St. Vincent's, Green Point, Pilot's Cove, Nick's Hole, Cat Point, Porter's Bar, Goose Island, and East Slough.

Station	18 MONTHS No. Obs.	Range	Standard Deviation	Ave. Sal.	INTERTIDAL No. Obs.	Greatest Range	Ave. Range	WEEKLY No. Obs.	Greatest Range	Ave. Range	Produc.	Highest Obs. Gly.
Pilot's Cove	68	11.9—42.4	7.0	24.5				20	20.5—35.6	8.3	Small	0.3
Cat Point	144	0.0—32.1	6.2	15.6	10	8.0—23.0	4.8	61	0.0—22.2	7.1	Medium	0.4
Porter's Bar	158	0.0—42.5	6.1	19.8	9	9.2—13.1	1.9	56	15.4—42.5	7.7	Heavy	1.3
Green Point	57	3.2—26.5	5.4	14.2	6	16.0—21.4	3.8	13	13.6—26.5	5.7	Heavy	1.6
Indian Pass	143	16.1—43.8	6.1	27.2	11	25.0—33.3	3.1	54	10.7—35.0	5.9	Heavy	5.6
Paradise Flat	36	4.3—32.8	9.5	16.3	4	5.4— 7.0	0.8	7	5.4—27.4	10.6	Heavy	0.3
Cabbage Lump	77	4.3—34.5	7.7	16.3	9	13.1—30.0	4.8	17	9.9—33.0	11.0	Heavy	0.5
St. Vincent's	197	2.6—34.9	8.3	22.1	14	14.1—30.2	6.6	21	10.8—34.0	12.0	None	0.9
Miller's 13	113	3.3—43.8	9.4	20.6	5	5.0—22.7	6.7	49	3.5—33.7	10.2	None	0.7
Nick's Hole	83	0.0—33.6	7.3	17.5	2	7.2—15.6	6.9	20	0.0—20.3	7.4	Small	1.7
Goose Island	33	7.0—32.7	6.5	20.6				11	10.7—26.0	4.7	None	
East Slough	28	5.9—32.9	7.1	21.6				11	11.4—24.2	4.8	None	
Govt. Dock	49	4.8—42.8	7.4	22.2				37	16.7—42.8	9.2	None	

TABLE I

Summary of salinity observations taken daily, weekly, and tidally correlated with production estimate and maximum observed glycogen. Salinity figures refer to parts per thousand.

exposed to a range of salinity extending from fresh water, or nearly so, to ten or more parts per thousand more than is found in ocean water.

More frequent changes of salinity of substantial magnitude are endured. Tidally, variations of 8-10 parts per thousand are not uncommon. In one instance (Cat Point) a variation of 15°/₀₀ was observed in an area of high productivity.

Occasional weekly variations of approximately 25°/₀₀ do not seem to interfere with the development to marketable size and quality. Indian Pass consistently had the best oysters of the Bay during the winter of 1949-1950, yet the average weekly salinity change for that station was 5.9°/₀₀ (maximum 24.3°/₀₀).

A correlation between magnitude of salinity change per unit of time and oyster quality (based upon glycogen and production) does not give conclusive results. Apparently, oysters in one habitat can stand a tidal variation of 10.6°/₀₀

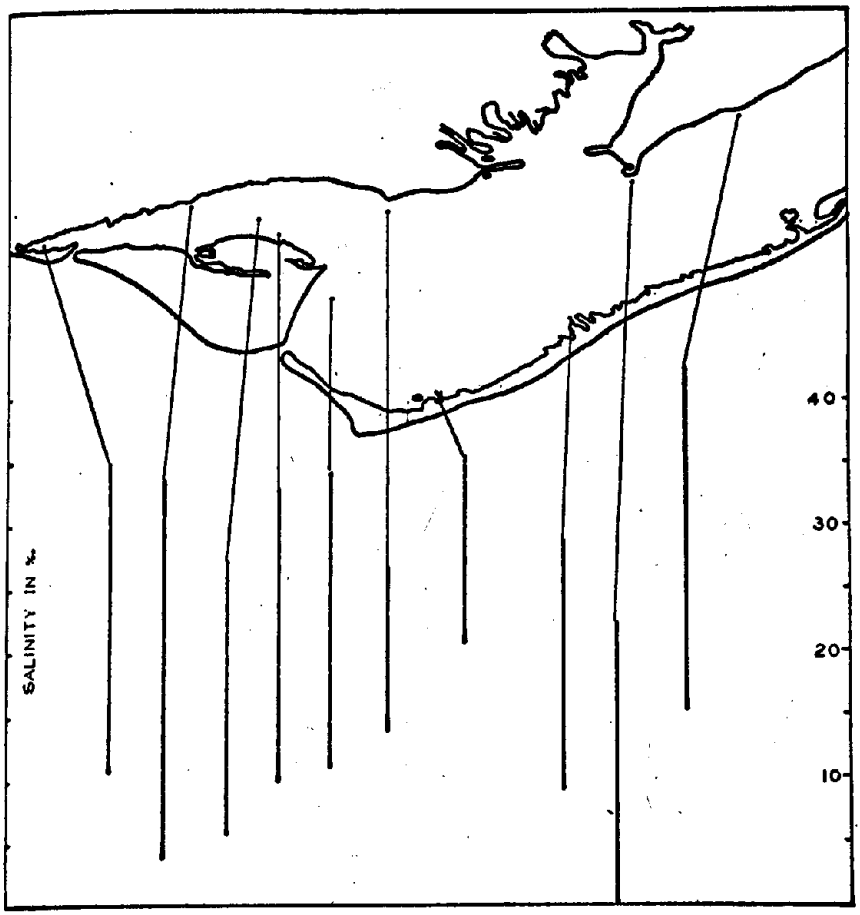

FIGURE 3—Maximum weekly salinity range. Stations from left to right are as follows: Indian Pass, Miller's 13 Mile, Paradise Flat, Cabbage Lump, St. Vincent's, Green Point, Pilot's Cove, Nick's Hole, Cat Point, and Porter's Bar.

as an average and still be of marketable quality (Indian Pass). This lack of correlation is also noticed in weekly and seasonal changes.

There is some reason for believing that range of salinity variation may be a more critical factor for oyster production in Florida than the high temperatures they experience. Fast growing, high quality (ave. gly. 3.5%) oysters are found consistently in commercial quantities 154 miles north of Miami in the Indian River. The daily temperature of the water in that area during December, 1949, January, and February of 1950, averaged 24.3° C. During the three month observation period, however, the change of salinity from day to day averaged only 1.7°/$_{oo}$. There are no appreciable tides in the area.

It was observed that the quality of the Indian River oyster was the same during the entire winter. The quality of oysters from the best area of Apalachicola Bay did not remain constant during this period although the average

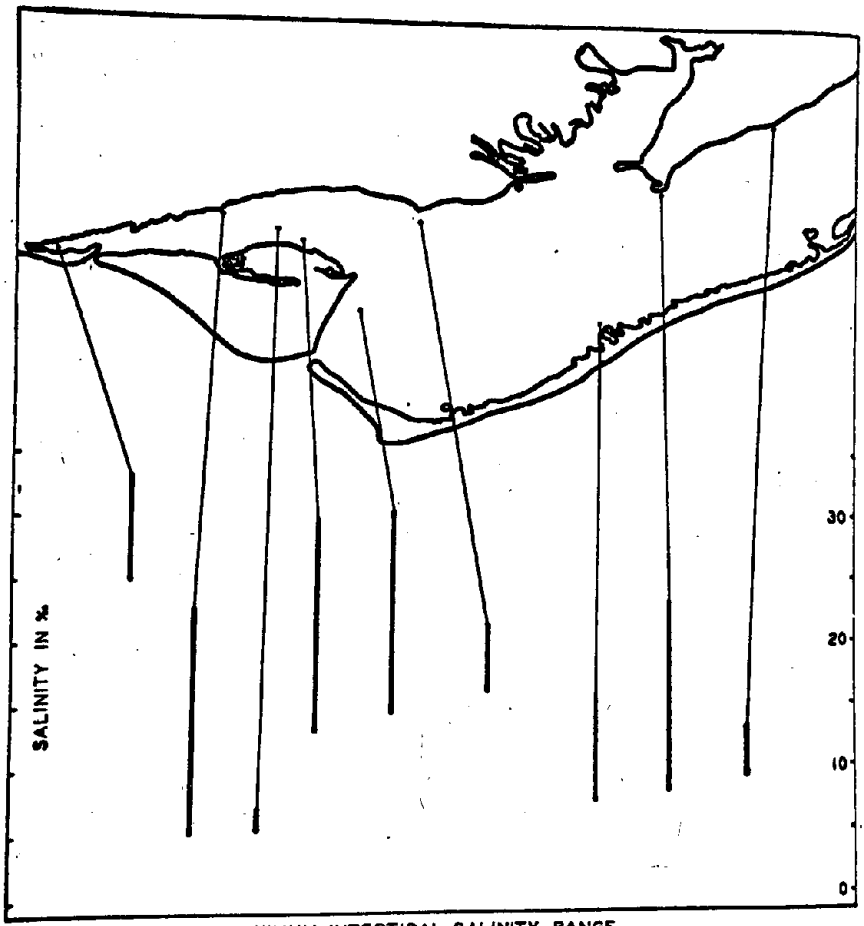

FIGURE 4—Maximum intertidal salinity range. Stations from left to right are as follows: Indian Pass, Miller's 13 Mile, Paradise Flat, Cabbage Lump, St. Vincent's, Green Point, Nick's Hole, Cat's Point, and Porter's Bar.

temperature was lower than that of the Indian River. The average water temperature during December, 1949, January, and February of 1950, was 18.9°C. for Apalachicola Bay. This figure is based upon 45 observations taken during that period at widely isolated parts of the estuary.

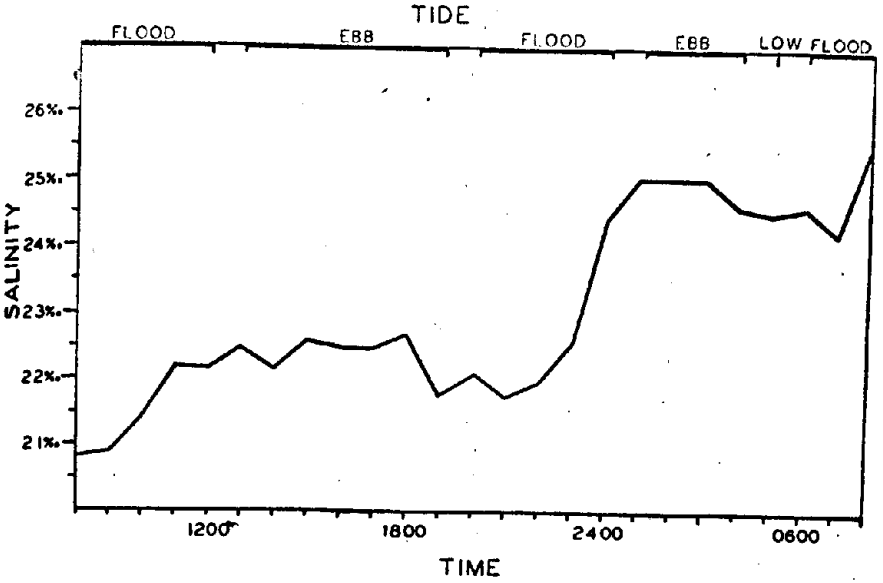

FIGURE 5—24 hour surface salinity observation at Porter's Bar.

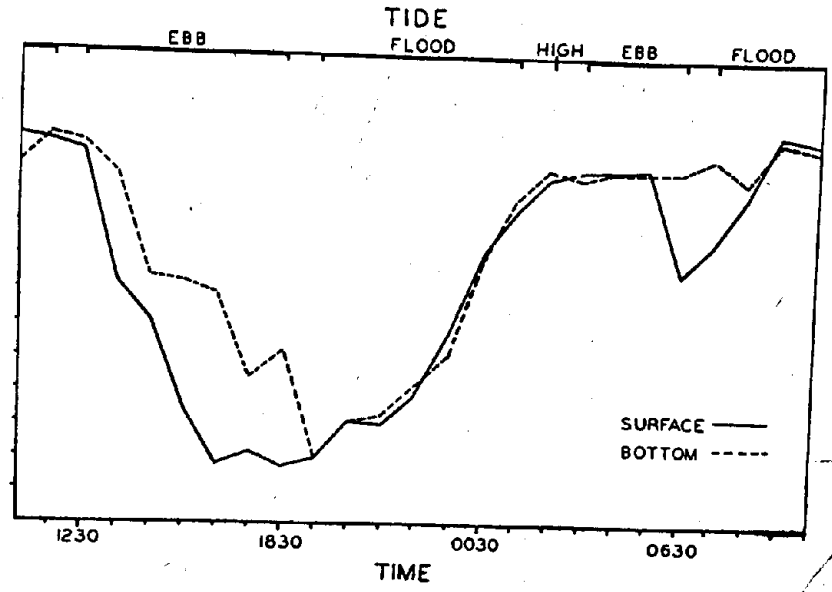

FIGURE 6—24 hour surface and bottom salinity observations at St. Vincent's Reef.

Summary

1. An eighteen month survey of salinity conditions has been made of Apalachicola Bay, present center of Florida's oyster industry.
2. Annual variations in salinity from fresh water to 42.5°/$_{oo}$ are not only tolerated by the indigenous oysters, but commercial production is present where those conditions exist.
3. Marketable oysters in Apalachicola Bay are found in habitats which experience weekly salinity changes averaging 11°/$_{oo}$.
4. Commercial production of oysters is possible in habitats showing an average tidal salinity variance of 4.8°/$_{oo}$.
5. Growth rate studies carried on simultaneously with the salinity investigation indicate that growth under the salinity variations mentioned above is extremely rapid. One inch in length is achieved in five weeks, and 2.6 inches in 16 weeks.
6. In general, Apalachicola oysters are not of superior quality. It is suggested that the low glycogen content might be due to the great ranges of salinity to which they are exposed.

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