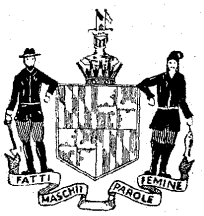
CHESAPEAKE BIOLOGICAL LABORATORY

MARYLAND

DEPARTMENT OF RESEARCH AND EDUCATION

EFFECT OF SUSQUEHANNA RIVER STREAM FLOW ON CHESAPEAKE BAY SALINITIES AND HISTORY OF PAST OYSTER MORTALITIES ON UPPER BAY BARS

G. FRANCIS BEAVEN



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EFFECT OF SUSQUEHANNA RIVER STREAM FLOW ON CHESAPEAKE BAY SALINITIES AND HISTORY OF PAST OYSTER MORTALITIES ON UPPER BAY BARS.[1]

G. FRANCIS BEAVEN

It has long been recognized that an area of extensive oyster rocks in Upper Chesapeake Bay, north of Kent Island, is characterized by erratic production, slow growth and occasional heavy oyster mortality. These Upper Bay bars once supplied large quantities of small stock for the steam houses in Baltimore when Cove Oysters were canned. Quantities of the small round single oysters, which at times are abundant, have been utilized by both private industry and the State as seed oysters for planting further down the Bay. At rare intervals, the upper Bay oysters make good growth and produce a quantity of acceptable market oysters for the shucking houses.

The proper management of these bars presents different problems from those encountered in the rest of the State and has evoked considerable discussion and debate. Although the adverse effect of fresh water in this area is generally recognized, the fact that an extensive mortality in 1943 occurred at a time when local precipitation was known to be deficient, as was true also in other instances, gave rise to other theories concerning the cause of the oyster losses. A "blight," pollution from Baltimore, and the opening of the bars to commercial dredging in certain years have been suggested as possible reasons for oyster losses occurring on the bars.

Far too little factual data is available concerning past oyster mortalities. Even as late as 1943 no observations on these bars were made until several months after a severe mortality had occurred. Since that year, the bars have been kept under continuous observation and extensive studies have been made during the past two years by the Fish and Wildlife Service.[2]

The possibility of a "blight" or oyster disease being a causative agent in an extensive mortality extending some distance down below Kent Island during 1916 was investigated by the Bureau of Fish-

[1] Read at the meeting of the National Shellfisheries Association, New York City, June 5-7, 1946.
[2] Engle, James B., 1946. Commercial Aspects of the Upper Chesapeake Bay Oyster Bars in Light of the Recent Oyster Mortalities. U. S. Fish and Wildlife Service.

eries. At that time no conclusions as to the exact agency responsible for the oyster deaths were reached. Examination of oysters then and in other more recent instances failed to disclose any recognized parasite in unusual abundance. Observations of the dispersal of industrial pollutants from Baltimore and the fact that the intensity of the mortalities observed has been greater on bars above and to the eastward than on those nearest to the approaches to Baltimore offer no support to the theory that pollution from Baltimore has caused the extensive losses observed. Continuous examination for the presence of both parasites and pollutants must, nevertheless, be continued since they constitute a potential danger which may vary from year to year.

The proximity of the upper Bay bars to the entrance of the Susquehanna River (Fig. 1) and the frequent references in past conservation reports to destructive floods from that River have prompted a study of available records for the purpose of organizing the data and determining what relationship exists between Susquehanna stream flow, Chesapeake salinities and past oyster mortalities.

The Chesapeake Bay is a drowned valley and comprises the largest inland waterway along the Atlantic Coast of the United States. It has been formed by the flooding of the lower stream system of the Susquehanna River as a result of coastal subsidence. Its salinity varies from slightly below that of the open ocean at the Virginia Capes to fresh water on the Susquehanna flats. An average outward flow of about three tenths of a knot was calculated by Wells, Bailey and Henderson in their 1929 publication. The outward flow of the fresher and lighter water at the surface is accompanied by a slow movement of denser salt water up the Bay in the deeper channels. Deflection of currents toward their right by the earth's rotation together with greater stream flow from the western shore of the Bay have resulted in slightly higher salinities on the eastern side than on the western. The normal heavier run-off from the land during the spring months causes an annual salinity fluctuation with lowest salinities occurring in the spring and highest in the fall. Seasonal variations in evaporation, precipitation, and wind direction and velocity all influence the salinity pattern of the Bay.

The drainage area of the Bay system (Fig. 2) is about 64,900 square miles with the Susquehanna River comprising approximately 43% of the total. Stream flow from the Susquehanna represents over 85% of all contributions north of the Potomac and over 95% of that above the Patapsco. Variations in the flow of the Susquehanna River would thus be expected to have a major influence on salinities in the upper part of Chesapeake Bay, with its effects being marked as far down as the entrance of the Potomac.

Fig. 1. Charted Oyster Bars of the Chesapeake Bay and Tributaries.

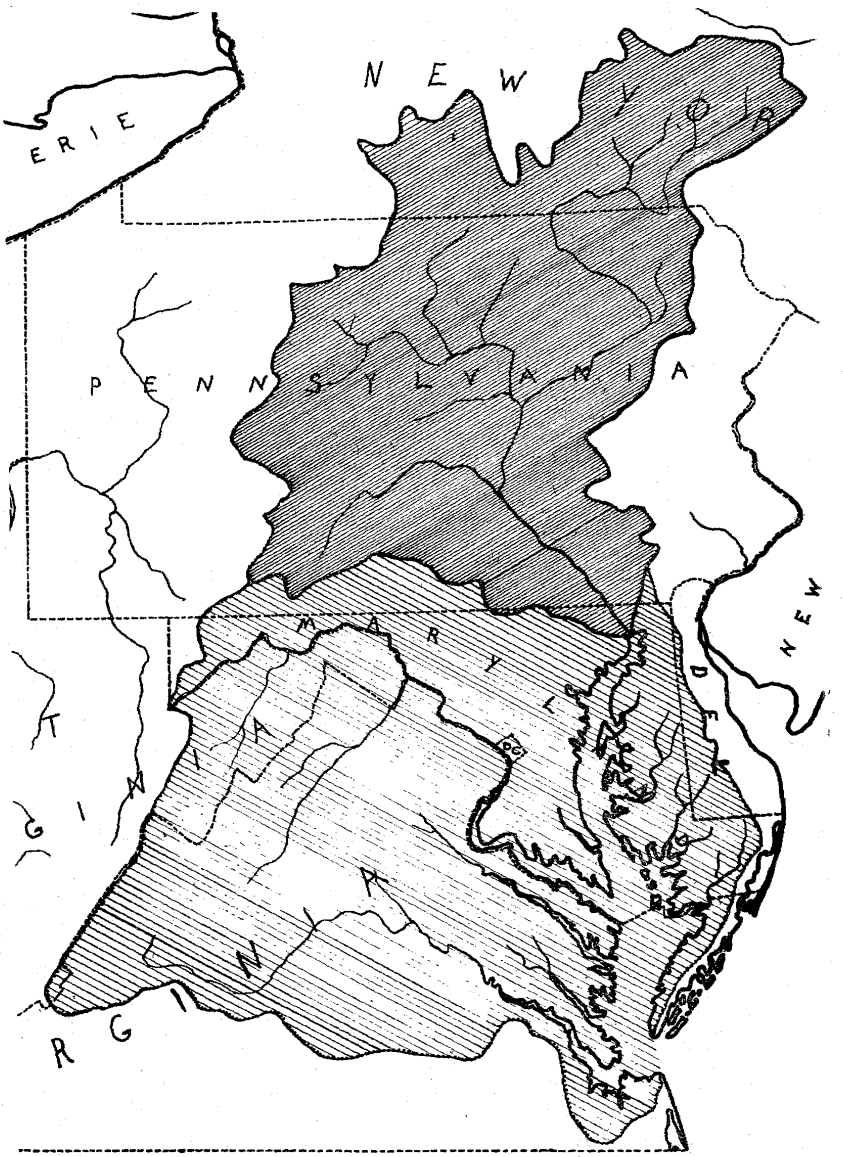


Fig. 2. Drainage Basin of the Chesapeake Bay. Susquehanna River drainage basin shown in darker shading.

No continuous daily record of salinities in the upper Bay proper is available. At Solomons, some 65 miles below the affected bars, the average daily surface salinity is a little less than 14 p.p.t. or approximately double the normal salinity on the upper Bay oyster bars. It ranges from a normal of 10.3 about May 1 to 17.3 in early November. A comparison of intermittent salinity records from the upper Bay with those at Solomons shows that both follow the same general trend with abrupt fluctuations more smoothed at Solomons than up the Bay. Extensive surface and bottom samples on oyster bars have further shown that surface salinity fluctuations correlate closely with those occurring in the slightly higher salinities of the bottom water.

Salinities at Solomons have been plotted and compared with graphs of the precipitation recorded for the Maryland-Delaware section by the U. S. Weather Bureau. Monthly average salinities at Solomons and monthly average precipitation during the past five years are shown by the accompanying graph. (Fig. 3). There is some general relationship shown between recorded salinities and local

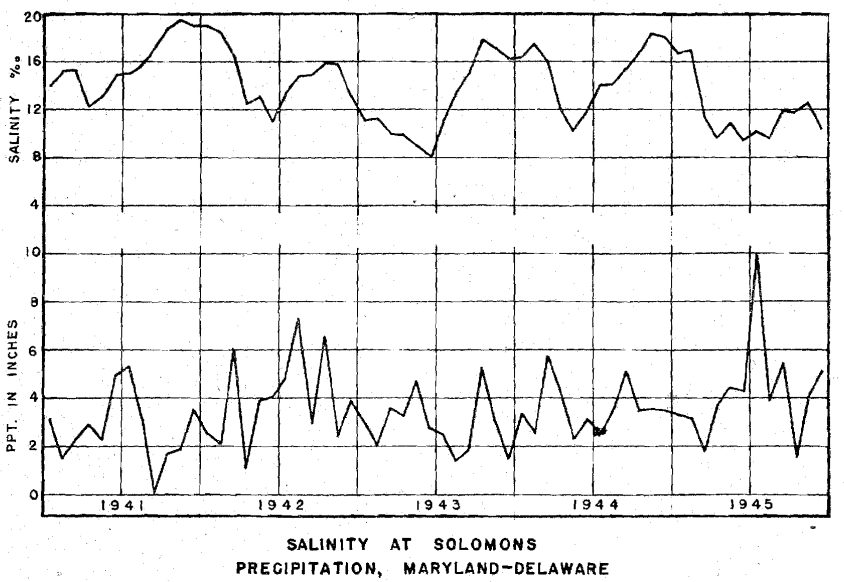


Fig. 3. Relationship between the Maryland-Delaware precipitation and the salinity at Solomons, Maryland.

precipitation but no well-defined correlation exists. The marked low salinity which occurred in 1943 is not accompanied by above normal precipitation for the same period. This lack of correlation might be expected from the relatively small portion of fresh water which is contributed to the upper Bay by local run-off.

Accurate records of Susquehanna River stream flow have been kept near its mouth at Conowingo Dam since 1933 by the Susquehanna Electric Company. These have been studied and plotted in several ways for the entire period. Relationship of stream flow, precipitation and salinity at Solomons are shown graphically for the year 1945 (Fig. 4), a year of marked precipitation and stream flow peaks. No noticeable effect of local rainfall on salinity can be found except a slight dip following record breaking rains in mid-July. This same period also showed a moderate rise in stream flow from the Susquehanna. The graph of daily stream flow at Conowingo, however, shows a definite relationship to daily salinity. Each marked peak of flow is followed by a trough of low salinity. The interval of time ranges from five to about fourteen days and is usually slightly less than one week. However, the effect of periods of high stream flow is cumulative so that when salinity is depressed it does not recover fully for a period of weeks or months.

Exposure to a brief period of low salinity seems to have little permanent effect upon oysters, but long or frequently repeated exposure may result in serious damage. Thus, salinities averaged over a monthly period are more significant than the daily extremes. At the bottom of the graph, the monthly average salinity at Solomons is plotted with low figures at the top and high ones at the bottom so that peaks of low salinity will parallel peaks of high stream flow. In order to smooth out and show the cumulative effect of stream flow, the monthly average, three month progressive average and six month progressive average daily flow are plotted. The six month progressive average curve appears to correspond more closely with that of monthly salinity than do the others. Several years were plotted in similar manner and the same general relationships were found to hold. Other periods of progressive average flow were tried, but the six month period seemed to follow general salinity trends best as illustrated by the five-year graph shown (Fig. 5).

Salinity records at Solomons do not extend back enough years to cover earlier periods of recorded oyster mortalities at the Head-of-the-Bay nor do the stream flow records at Conowingo. Daily salinity records at Fort McHenry in Baltimore Harbor have been kept by the Coast and Geodetic Survey since 1914. Solomons records were considered best for preliminary analysis since they are at the mouth of a long and broad tidal estuary and are little affected by local stream flow while those at Baltimore are likely to be more influenced by local Patapsco River conditions. When both, however, are plotted together, a high degree of correlation is shown generally. Records of Susquehanna stream flow extending back to 1890 have been kept at Harrisburg by the Coast and Geodetic Survey. When daily flows at Harrisburg and Conowingo are plotted in parallel a very high correlation is found. Records of peak floods showed that

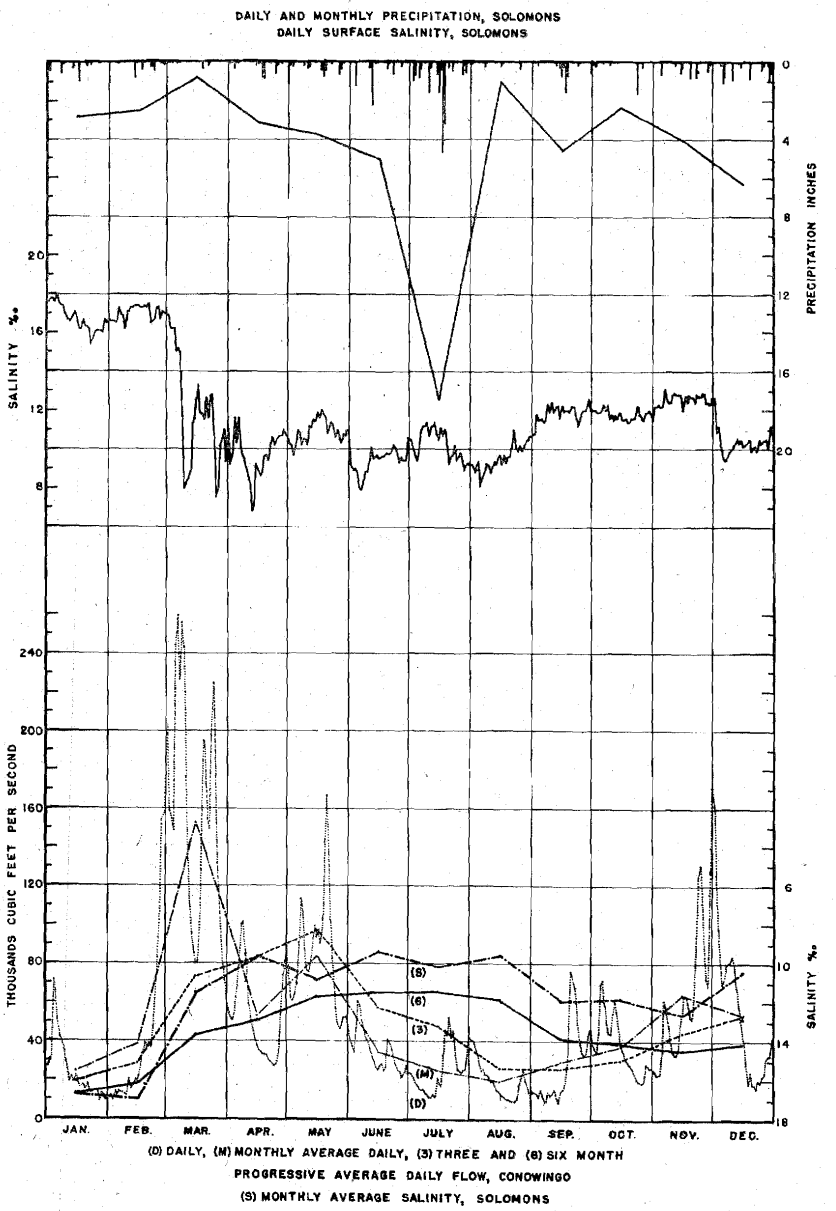
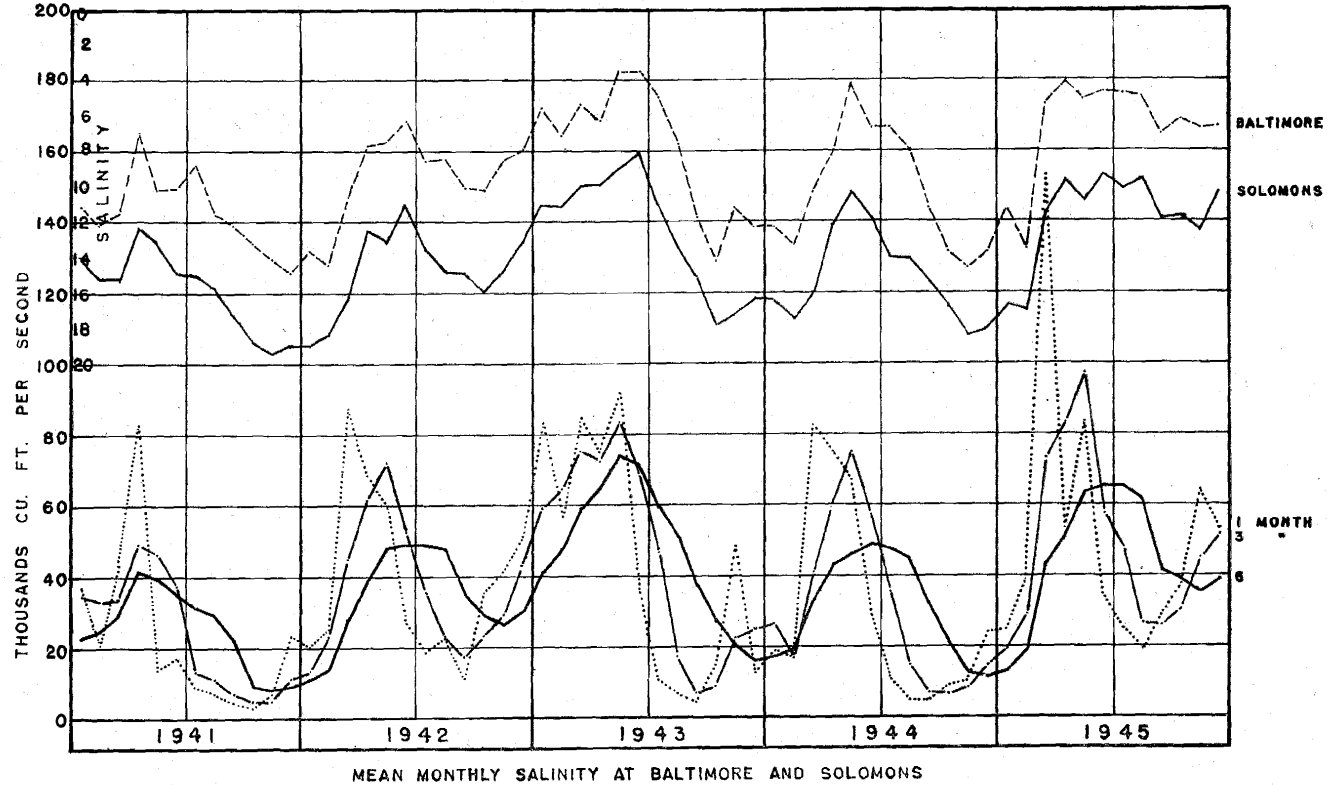


Fig. 4. Daily, monthly, 3-month and 6-month progressive average daily flow at Conowingo and the monthly average salinity at Solomons.



MEAN MONTHLY SALINITY AT BALTIMORE AND SOLOMONS

MONTHLY, 3 AND 6 MONTH PROGRESSIVE AVERAGE DAILY FLOW AT CONOWINGO

Fig. 5. Salinity at Baltimore and Solomons and the monthly, 3-month, and 6-month progressive average daily flow at Conowingo.

the average time interval for a peak to travel from Harrisburg to Conowingo is eight hours. The narrow gorge of the Susquehanna and the maintenance of a continuous high head of water back of the dams gives them little if any flood control effect. Stream flow records at Harrisburg thus furnish a reliable index of the water discharge into the upper Bay by the Susquehanna River (Fig. 6).

Publications of various agencies in Maryland dealing with oysters have been searched for records of general mortalities occurring at the Head-of-the-Bay. It is found that such losses when occurring in spring or summer were sometimes unreported until the rocks were visited after Christmas so that records of such loss may be given in the following year. There is also evidence that oysters weakened by spring floods, followed by below-normal salinities during the summer, may succumb the following winter when environmental conditions are unfavorable. The following major mortalities and no others were found to have been reported during the period for which records are available: 1908-1909, estimated at 55% on the Tea Tables and 62% on Man O' War Shoals; 1916, only an occasional living oyster could be found above Swan Point and the Patapsco River; 1928, an 80% mortality of up-Bay oysters; 1936, a heavy mortality from freshets down to Swan Point and Sandy Point; 1943, 97% loss on Tea Tables ranging to little loss at Swan Point and Sandy Point; 1945-46, extensive mortality decreasing down the Bay below Love Point.[2]

The six-month progressive average daily flow of the Susquehanna River at Harrisburg for the period of recorded mortalities has been plotted together with the existing monthly average salinity records from Baltimore (Fig. 7). Mortality years are marked on the graph by an "M". These six mortality periods correspond with the six highest sustained periods of cumulative run-off from the Susquehanna. The five mortality periods reported since Baltimore salinities were available correspond with five of the seven recorded periods when salinities remained below five for three months or longer. These records thus afford excellent evidence that the recorded major oyster mortalities at the Head-of-the-Bay have all been associated with and probably are principally the direct result of low salinities caused by periods of high run-off from the Susquehanna River.

[1] Loc. cit. Engle, James B. 1946.

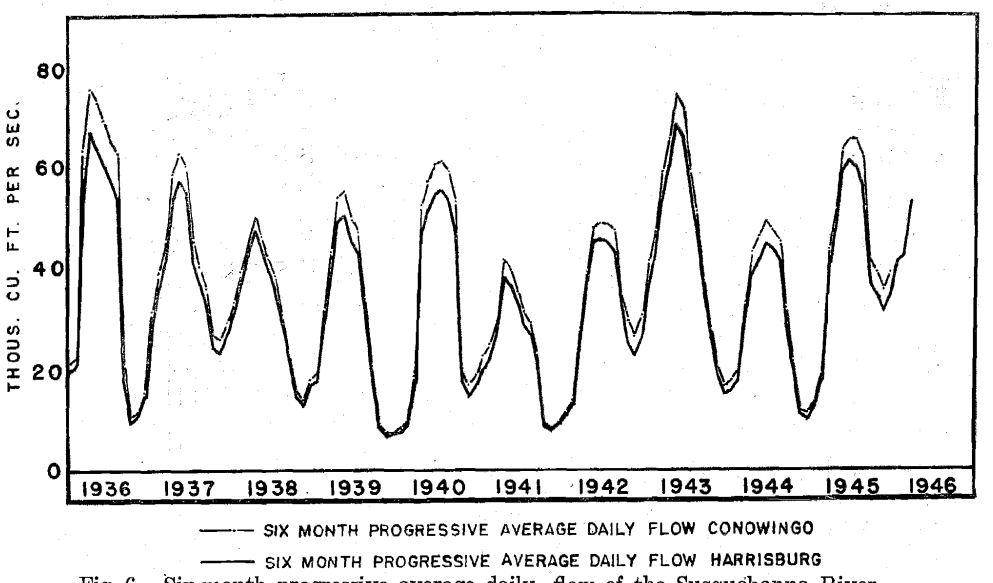


Fig. 6. Six-month progressive average daily flow of the Susquehanna River.

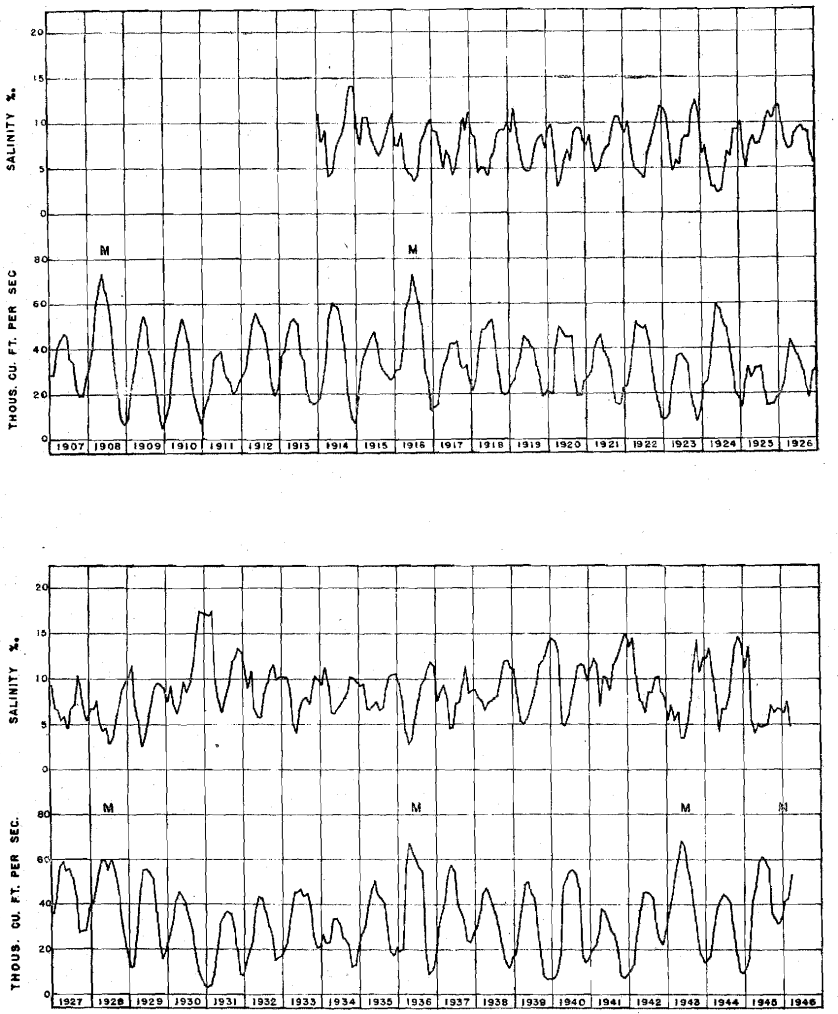


Fig. 7. Relationship between the six-month progressive average daily flow at Harrisburg and the salinity at Baltimore, 1907 to 1946.