THE OCCURRENCE OF PRONOUNCED SALINITY VARIATIONS IN LOUISIANA COASTAL WATERS

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ABSTRACT

The chloride-ion contents of more than 700 sea water samples from the coastal waters of western Louisiana were converted to salinity values and were used in a study of the salinity characteristics. These data were gathered from seven drilling platforms during a period of 14 months in a zone paralleling the coast for about 60 miles, approximately 6 to 8 miles offshore and in depths varying between 40 and 50 feet. The chloride-ion content was determined by the standard chemical titration method in connection with quality control of salt water drilling mud used in the drilling of offshore oil wells.

An independent check of the validity of these data by means of salinity values derived from temperature and density determinations corroborate the existence of marked short and long range changes in salinity. In conclusion, it is pointed out that the existence of these salinity variations also means that other chemical and physical properties of sea water in the areas studied must be varying in essentially the same manner. Therefore, the marine organisms in these areas are subjected to a constantly changing ecological environment and must be continually making the physiological adjustments necessary to cope with these changes.

The analysis of the chloride-ion concentration data clearly demonstrates the existence of a wide salinity variation in any one area. The variations may be classified into long seasonal and shorter daily and even hourly types. A well defined correlation exists between the seasonal variations in salinity and the variations in the amount of water discharged by the Mississippi River. These data demonstrate that this is the major factor in determining the long term salinity characteristics of this area. However, available information also indicates that salinity variations in a given area are affected as well by local drainage patterns and current characteristics.

Results of the statistical summary show that the greatest variations occur from January through March and the least during summer months. This is further evidence in support of the argument that variation in the discharge of the Mississippi River is the major factor responsible for the pronounced long term salinity changes.

INTRODUCTION

It has long been suspected, and certain isolated bits of information have indicated, that the discharge of the Mississippi River and the westward moving littoral current are responsible for the marked decrease in salinity in the offshore coastal waters of Louisiana west of the delta. The only readily available published data on this subject are incorporated in papers by Riley (1937) and Parr (1935); for salinity

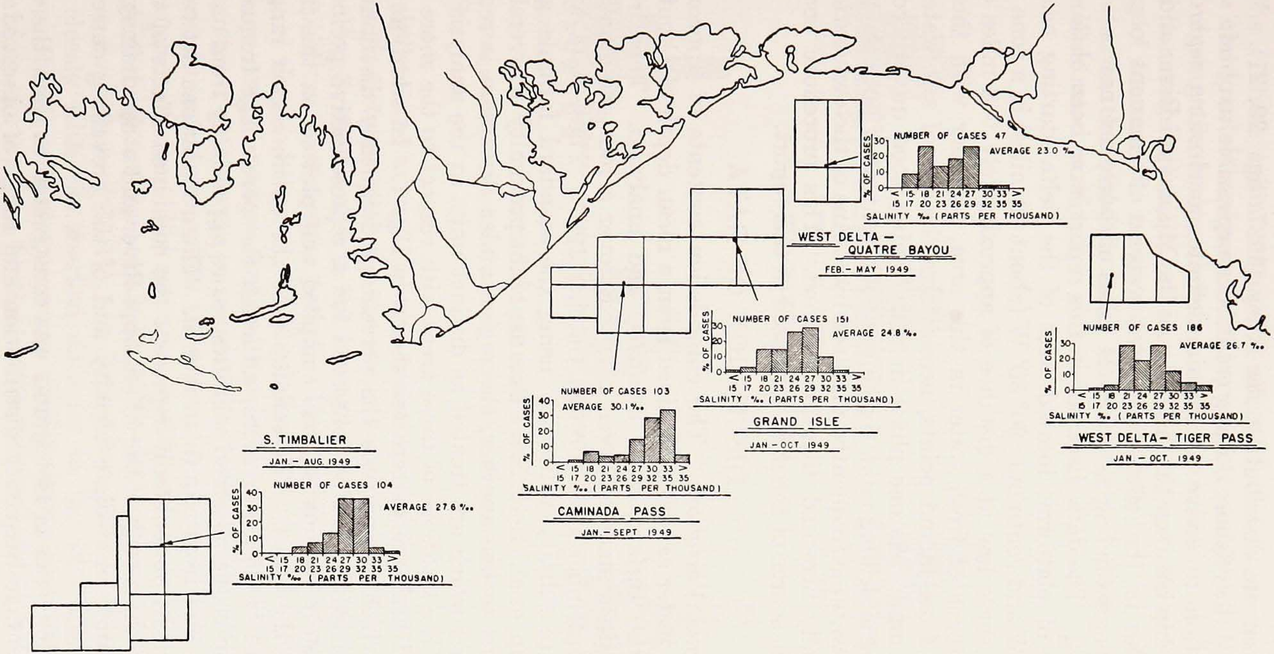

Figure 1. Frequency distribution of salinity values at drilling locations in Grand Isle District.

and phosphate distribution, see Riley (1937: figs. 20, 21). With the advent of the offshore drilling era it became feasible to obtain sufficient information to arrive at certain definite conclusions regarding the relationship between the discharge of the Mississippi River and salinity variations in the offshore coastal waters. Permanent observation platforms, extending as far as 24 miles offshore, are now available in this area. The data discussed in this report have been obtained from a series of platforms located west of the delta starting near Long. 89° 30′ W and continuing 90° 30′ W (about 60 miles) in a zone paralleling the shore line at a distance of approximately 6–8 miles offshore. The absence of fresh water in this area, together with the cost of barging from inland points, necessitates the use of salt water in the drilling mud. As one phase in maintaining good quality control of this type of drilling mud, the chloride-ion content of both the mud and the sea water is frequently analyzed by means of the conventional and universally accepted titration method. This procedure constitutes the basic source of the data discussed in this report.

DISCUSSION OF DATA

Seasonal Variations. The chloride-ion contents of approximately 700 sea water samples, obtained from a mean depth of about 10 feet below the surface, were compiled and analyzed. They represent observations made at seven platforms over a fourteen-month period from September 1948 through October 1949. These data were converted to salinity values by using the standard formula given by Sverdrup, et al. (1946: 51). Because of the proximity of several of these platforms to one another, the region under discussion is reduced to five areas which are treated as distinct units in the analysis of these data. The locations of these areas with respect to the shore line and the land drainage pattern are shown in Fig. 1. In addition, a histogram, which summarizes the percentage frequency distribution and range of salinity values observed for a representative period of approximately 10 months, was compiled and plotted on this figure for each of the areas. The salinity over the entire region ranges from about 14 to 35‰ or more, although the percentage frequency distribution of the observed salinities varies appreciably from one area to another and from month to month. These variations between areas and months undoubtedly represent the combined effects of the proximity to the mouth of the Mississippi River and other drainage outlets in the more immediate vicinity and of the prevailing current characteristics.

Another series of histograms was constructed to show the variation of percentage frequency distribution and range of observed salinities by months. These again reflect the effect of the above mentioned factors. The greatest range in salinity, varying from 14 to 38°/₀₀, is observed during the spring months, whereas in June and July, for example, the range is limited between 21 and 37°/₀₀. Thus, with the beginning of summer the range not only decreases but the values are concentrated in the higher salinity class intervals. These relationships are illustrated in Fig. 2.

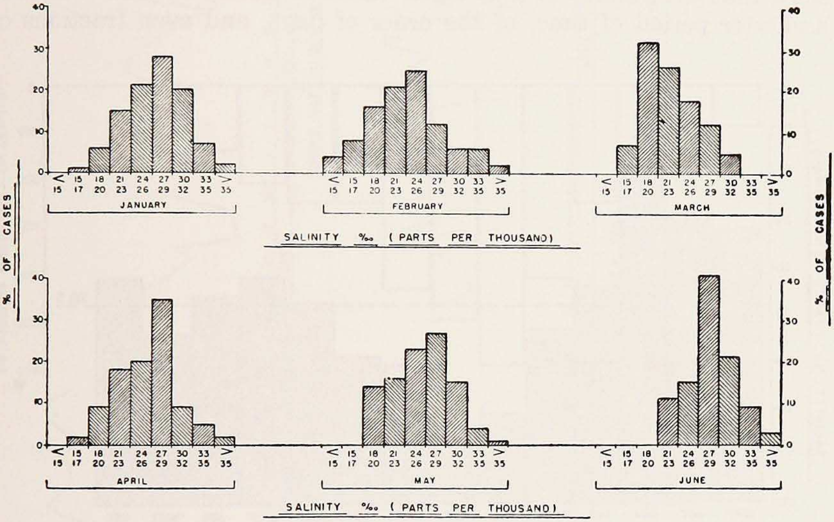

Figure 2. Frequency distribution of salinity values for a six-month interval in the Grand Isle District.

An analysis of the average salinity values by months for September 1948 through October 1949 for the entire region is shown in the bar graph in Fig. 3; shown also is the average monthly discharge of the Mississippi River for the same period. This graph demonstrates that the effect of the discharge of the Mississippi River on the salinity of the offshore coastal waters dominates salinity characteristics of the entire region. For example, a minimum average salinity of 22.6°/₀₀ is observed during March when the river is carrying off the melting snows and spring rains. The average monthly salinity then continues to increase throughout the remainder of the late spring and summer, reaching a maximum of 34.1°/₀₀ in November. These changes correspond closely with the marked decrease in the discharge of the Mississippi River, reflecting summer rainfall and runoff conditions. Although data for only a portion of the second year's record are available, it is evident from Fig. 3 that the cycle is beginning to repeat itself, although the absolute values are somewhat less.

Short Term Variations. The evidence presented thus far demonstrates that a wide variation in salinity occurs in these coastal waters each year and that this variation shows pronounced seasonal effects which reflect primarily the seasonal variations in the amount of water discharged by the Mississippi. The remainder of the discussion will show that the salinity in this region varies markedly in each area over a shorter period of time, of the order of days, and even fractions of

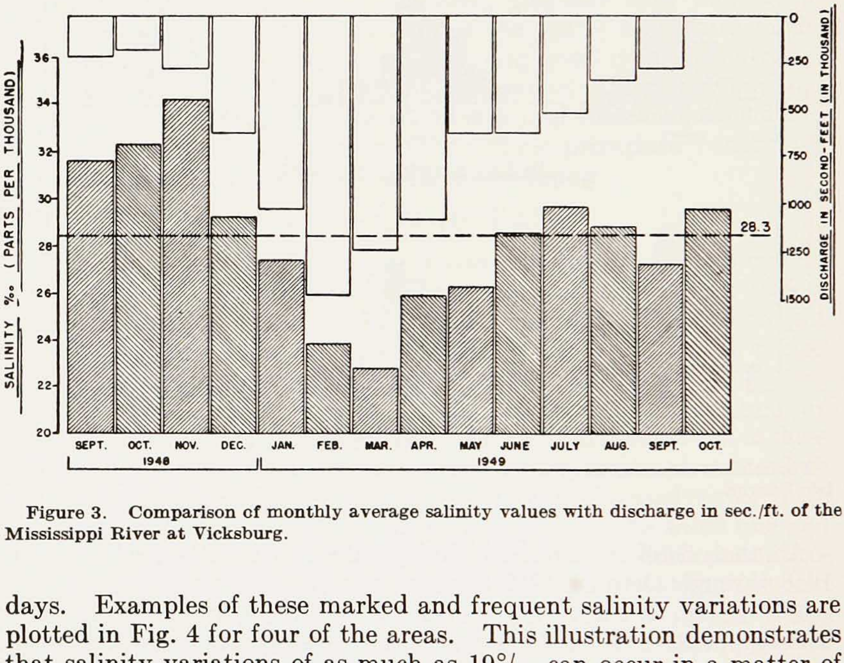

Figure 3. Comparison of monthly average salinity values with discharge in sec./ft. of the Mississippi River at Vicksburg.

days. Examples of these marked and frequent salinity variations are plotted in Fig. 4 for four of the areas. This illustration demonstrates that salinity variations of as much as 19‰ can occur in a matter of one to two days. These occurrences are characteristic of the areas studied rather than isolated. In addition to the marked short period variations, the seasonal trends are also evident in these graphs.

The values plotted in Fig. 4 are primarily one-a-day observations. However, for one location a series of observations is available for a two-month period during which the chloride-ion content was measured as often as three times a day. These data, plotted in Fig. 5, indicate that even shorter period variations of the order of several hours exist in addition to the seasonal and daily variations of salinity.

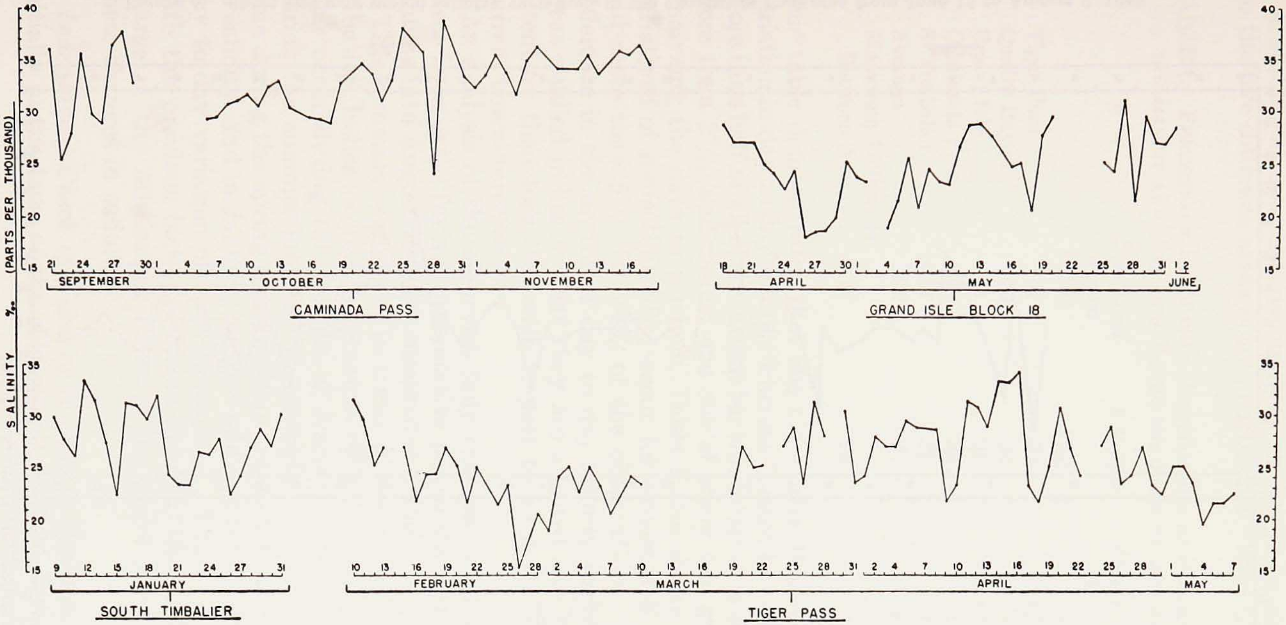

Figure 4. Example of frequent salinity variations in the Grand Isle District, 1948–1949.

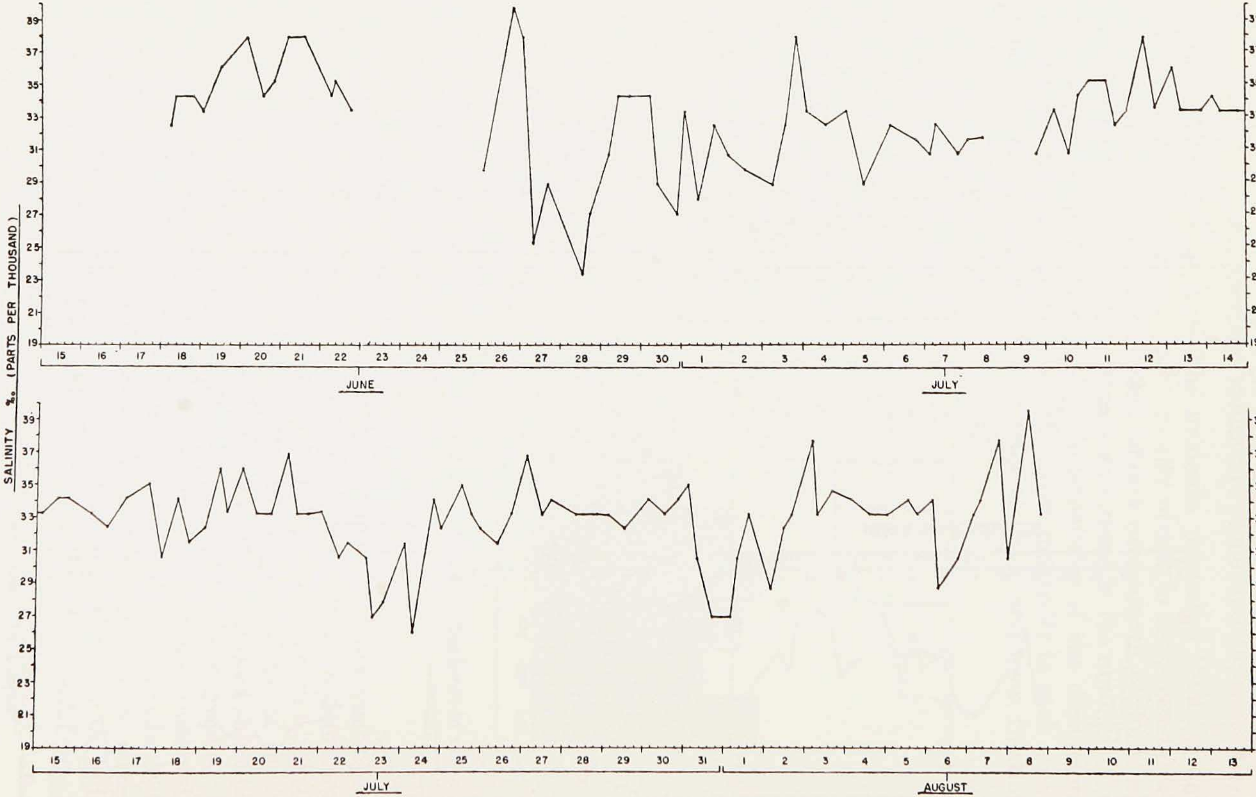

Figure 5. Short and long period salinity variations in the Caminada Pass area from June 18 to August 9, 1949.

A statistical quantitative analysis of the daily salinity variations for the five different areas is summarized in Table I.

TABLE I. Percentage Frequency Distribution of Observed Daily Changes in Salinity and Maximum Range for Each of the Areas Studied

Area	*Less Than 2 ppm* (%)	*2–5 ppm* (%)	*Greater Than 5 ppm* (%)	*Maximum Range* (*ppm*)
Tiger Pass	57	30	13	11
Quatre Bayou	43	38	19	10
Grand Isle	61	25	14	10
Caminada Pass	64	25	11	19
S. Timbalier	57	31	12	12
Average	56	30	14	12
Maximum Difference Between Areas	18	13	8	9

This table demonstrates that the Caminada Pass area has the least variation in day to day salinity whereas Quatre Bayou has the greatest. More than half of all observations for this latter area show variations of more than $2°/_{oo}$ and almost one out of every five greater than $5°/_{oo}$. Analyzing the data as a whole, Table I also shows that day to day variations of more than $2°/_{oo}$ occur for almost half the observations and more than $5°/_{oo}$ for 14% of the observations. The appreciable difference in the degree of day to day salinity variations for the five areas studied indicates that they are affected also to an appreciable extent by their locations with respect to local drainage patterns and current characteristics.

An analysis of the observed daily changes in salinity for all of the areas by months for a representative period starting in June and continuing into August 1949 is presented in Table II.

This summary, expressed in terms of the percentage frequency distribution, indicates that the greatest variations with respect to time of year occur during the months of January through March, the least during the summer months; for example, for at least one-half of the time during the spring months there are variations of more than $2°/_{oo}$ in salinity, and in January one out of every four observations shows a day to day variation of more than $5°/_{oo}$. This is again in agreement with the previous facts demonstrating that the variation in the discharge of the Mississippi River is the major factor responsible for these changes in salinity.

Independent Check of Validity of Data. These data were obtained initially in the form of the chloride-ion content of sea water and were

TABLE II. AVERAGE SALINITY, PERCENTAGE FREQUENCY DISTRIBUTION OF OBSERVED DAILY CHANGES IN SALINITY, AND MAXIMUM RANGE BY MONTHS FOR JANUARY–AUGUST 1949 FOR ALL AREAS

Month	*Average Salinity (ppm)*	*Less Than 2 ppm (%)*	*2–5 ppm (%)*	*Greater Than 5 ppm (%)*	*Maximum Range (ppm)*
January	27.3	47	27	26	19
February	23.9	57	31	12	9
March	22.6	44	42	14	10
April	25.9	58	26	16	11
May	26.2	59	27	14	13
June	28.4	64	23	13	10
July	29.6	67	33	0	5
August	28.7	72	21	7	10
Average	26.6	58	28	14	
Maximum Difference	7.0	33	21	26	

converted to salinities by the standard conversion formula. This is the first appreciable amount of information available from this region and it is characterized by pronounced as well as rapid short and long period variations. It was felt, therefore, that a verification of these phenomena with evidence obtained by an entirely different method would add significantly to the validity of the observations and their interpretation. An official U. S. Coast and Geodetic Survey tide gauge station is located on the Grand Isle platform, and at this station daily reports are made of the temperature and density of a sample of sea water taken from or near the surface. These observations for a representative two-month period were converted to salinity values by the standard method discussed by Adams (1942: 585). The corresponding salinities were then plotted as illustrated in Fig. 6. The same characteristics as those found in the other graphs (Figs. 4, 5) are evident. Thus, two independent lines of corroborative evidence are available.

CONCLUDING REMARKS

In view of the frequent and marked salinity changes, other chemical and physical properties of the sea water must be changing also in essentially the same manner. This statement is based on the fact that the salinity changes actually reflect the movement of water masses as a unit rather than as a specific isolated change of one particular physical characteristic. Thus, if the salinity changes at one location, then the whole water mass changes in that area, such change being attended by variations in other factors such as oxygen and

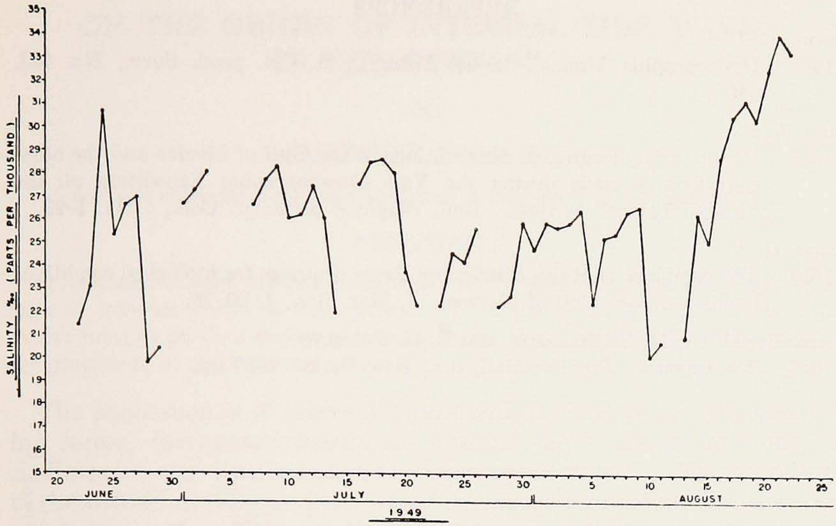

Figure 6. Salinity data for Grand Isle platform computed from hydrometer and temperature measurements of sea water at surface.

hydrogen-ion content and in nutrient material, i. e. phosphates, nitrates, and nitrites, necessary for the life of marine organisms. Therefore, any attached marine organisms living in the areas from which these salinity data have been obtained are constantly subjected to a changing ecological environment and must be making continual physiological adjustments to cope with these changes. It is hoped that additional information may be obtained in the future, possibly including some of the other physical characteristics of the water masses.

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