UPSTREAM EXTENT OF SALINE WATER IN THE PASCAGOULA RIVER

Richard A. Rebich and Mark N. Landers
U. S. Geological Survey

Introduction

The Mississippi Gulf Coast region has undergone rapid industrial and municipal growth since the 1940's. A substantial part of this growth has centered in the Pascagoula-Moss Point metropolitan area (Bednar 1978, p.5). The development of the ground-water resources in this region has caused long-term declines in both water levels and water quality. As a consequence, the development of a surface-water supply has been proposed to help meet future demands. The surface-water source that has the greatest potential for development is the Pascagoula River, which has a mean annual discharge of about 12,200 ft3/s (cubic feet per second), or 7,870 Mgal/d (million gallons per day), in the study reach. The lower reaches of the river is tidally affected and has a fairly typical "wedge" of saline-water intrusion from the Mississippi Sound. This report describes a multiple-least-squares regression equation that can be used to estimate the upstream extent of saline water in the lower Pascagoula River, information that would be helpful to water-resources planners and managers.

In this report, the upstream extent of saline-water in the Pascagoula River is defined by a salinity (dissolved-solids concentration) value of 500 mg/L (milligrams per liter) throughout the entire depth. The value of 500 mg/L was used because it is the recommended limit for drinking water (U.S. Environmental Protection Agency 1986); it is also significantly greater than the concentration of dissolved solids in freshwater of the Pascagoula River, which typically is less than 100 mg/L. Water-quality data have been collected on the lower Pascagoula River on a nearly annual basis since 1972 (no data were collected in 1973) by the U.S. Geological Survey (USGS). Specific conductance, temperature, tide, and discharge records were analyzed to describe relations between salinity and explanatory variables.

Study Area

The Pascagoula River begins at the confluence of the Leaf and Chickasawhay Rivers and flows southward 81 river miles to the Mississippi Sound (fig. 1). The Pascagoula River basin drains approximately 9,700 square miles, of which about 94 percent is in Mississippi and 6 percent is in Alabama. The Leaf River basin drains 3,580 square miles and the Chickasawhay River basin drains 2,929 square miles. The largest tributary is the Escatawpa River, that drains 1,060 square miles and enters the Pascagoula River 7 miles upstream from the Mississippi Sound. Two other major tributaries are Red Creek and Black Creek.

The study area is the lower Pascagoula River along a reach extending from the mouth to about 20 miles upstream in Jackson County, Mississippi (fig. 2). This reach is a hydraulically complex system of tidally-inundated and interconnected streams. The channel bottom profile is a series of ridges and depressions, which can affect the movement of saline water in the Pascagoula River. During extreme conditions, water levels of the river can be tidally influenced to a distance of about 42 miles upstream of the mouth.

Methods

As part of ongoing data-collection activities of the USGS, water-quality data have been collected nearly annually in the study reach since 1972. These data were collected at high and low tide, near the date of the maximum tidal fluctuation each year. Water-quality data were collected at 1-mile intervals from the mouth of the Pascagoula River to the upstream extent of saline water on both the Pascagoula and Escatawpa Rivers. At each interval, specific conductance and temperature were measured at 5-foot depth increments. Specific conductance data were used in this analysis to determine salinity because few dissolved-solids data were available. Specific conductance can be converted to salinity using techniques described by Miller and others (1988 table 10).

Only the measurements at the mouth and above mile 7 on the Pascagoula River were used in this analysis. Tide data were collected at mile 7 for each sampling period. The tide records do not have a common elevation datum. Therefore, the position and direction of the tide cycle corresponding to each sampling time were generalized from plots of the time-stage data.

Streamflow data were obtained from 1972 through 1988 at continuous gaging stations operated by the USGS in Mississippi on the main stem of the Pascagoula River near Merrill and on the principal tributaries to the Pascagoula River downstream of Merrill (fig. 2). Almost 94 percent of the flow into the lower Pascagoula River study reach is measured by these gages. For each sampling period, 3- and 7-day average discharges were calculated for each gaging station to determine antecedent-flow conditions in the study reach. The period from which average discharges were computed at the gages was adjusted for estimated times-of-travel from the gages to the study reach. The 3- and 7-day average discharges were each summed for Red Creek at Vestry, Black Creek near Wiggins, and Pascagoula River at Merrill to determine the flow from main-stem Pascagoula River into the study reach for each sampling period. The 3- and 7-day average discharges for the Escatawpa River near Agricola were considered separately because the Escatawpa River affects only the lower 7 miles of the study reach.

Discussion

The data were analyzed to provide quantitative information relating the upstream extent of saline water to other measured variables. Tide stage was not statistically significant to saline intrusion for the sample set. Temperature was relatively constant and was not statistically significant in the sample set. The effect of the 3- and 7-day average discharges from the Escatawpa River on the upstream extent of saline water in the Pascagoula River was not statistically significant. The 3-day average discharges from the Pascagoula River were slightly more significant than the 7-day averages; however, the 7-day averages were used because low-flow quantity more commonly is reported as a 7-day average. Generally, the extent of saline water moves upstream as salinity increases at the mouth of the Pascagoula River (fig. 3) and as freshwater discharge decreases (fig. 4).

Multiple-least-squares linear regression was used to develop an equation to estimate upstream extent of saline water. The regression variables are specific conductance at the mouth of the Pascagoula River and the 7-day average discharge. The equation is as follows:

$$E = 9.99 + 0.000142\,(K) - 0.000248\,(Q) \quad (1)$$

where:

E is estimated location of upstream extent of saline water, in river miles upstream from the mouth of the Pascagoula River;

K is specific conductance at the mouth of the Pascagoula River, in microsiemens per centimeter at 25 degrees Celsius; and

Q is 7-day average discharge in the study reach of the main-stem Pascagoula River, in cubic feet per second.

The statistical fit of equation 1 is fair with 81.7 percent of the observed variance being explained. The standard error of this equation is +11 percent. Observed and estimated values are shown in figure 5. The equation is representative of the conditions under which the sample data were collected, and does not represent abnormal conditions such as hurricane-induced tidal surges.

The upstream extent of saline water for extreme conditions was evaluated using this equation. The maximum upstream extent of saline water would occur during conditions of high salinity in the Mississippi Sound and lowflow conditions in the Pascagoula River. A maximum value (51,200 microsiemens per centimeter at 25 degrees C) of specific conductance at the mouth of Pascagoula River was estimated by averaging maximum specific conductance values collected from tide gages located in or near the Mississippi Sound (Eleuterius 1976). Low-flow values were obtained from statistical analyses of gaging station records. The 7Q10 (7-day, 10-year low flow) represents the minimum average 7-day discharge which has a 10 percent chance of occurring in any given year. The 7Q10 value for main-stem Pascagoula River inflow was obtained from the gages on the contributing streams (table 1). These values are preliminary (P.A. Telis, U.S. Geological Survey, oral commun. 1990).

Using these values in equation 1, the maximum upstream extent of saline water on Pascagoula River for the above defined extreme set of conditions is estimated as:

$$E = 9.99 + 0.000142\ (51{,}200) - 0.000248\ (1120) = 17$$ miles.

This value (17 miles) is in close agreement with that actually measured (17.3 miles) during field conditions similar to those described previously.

Summary

Multiple-least-squares techniques were used to develop an equation to estimate saline intrusion in the lower Pascagoula River. This equation can be used in evaluations of the potential development of the Pascagoula River as a surface-water supply. The two significant explanatory variables are salinity at the mouth of the river and the 7-day average discharge. Tide stage and direction, temperature, and Escatawpa River inflow were not statistically significant to the location of the upstream extent of saline water. The maximum extent of salinity was estimated to be 17 miles upstream of the mouth of the Pascagoula River using the equation and extreme values of the explanatory variables (high salinity in the river mouth and 7-day, 10-year low flow).

References

Bednar, G.A., 1978, Quality of water in Pascagoula and Escatawpa Rivers, Jackson, County, Mississippi: U.S. Geological Survey Open-file Report 78-913, 91 p.

Eleuterius, C.K., 1976, Mississippi Sound: Salinity distribution and indicated flow patterns: Sea Grant Publication MASG-26-023, 128 p.

Miller, R.L., Bradford, W.L., and Peters, N.E., 1988, Specific conductance: Theoretical considerations and application to analytical quality control: U.S. Geological Survey Water-Supply Paper 2311, 16 p.

U.S. Environmental Protection Agency, 1986, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 587-590.

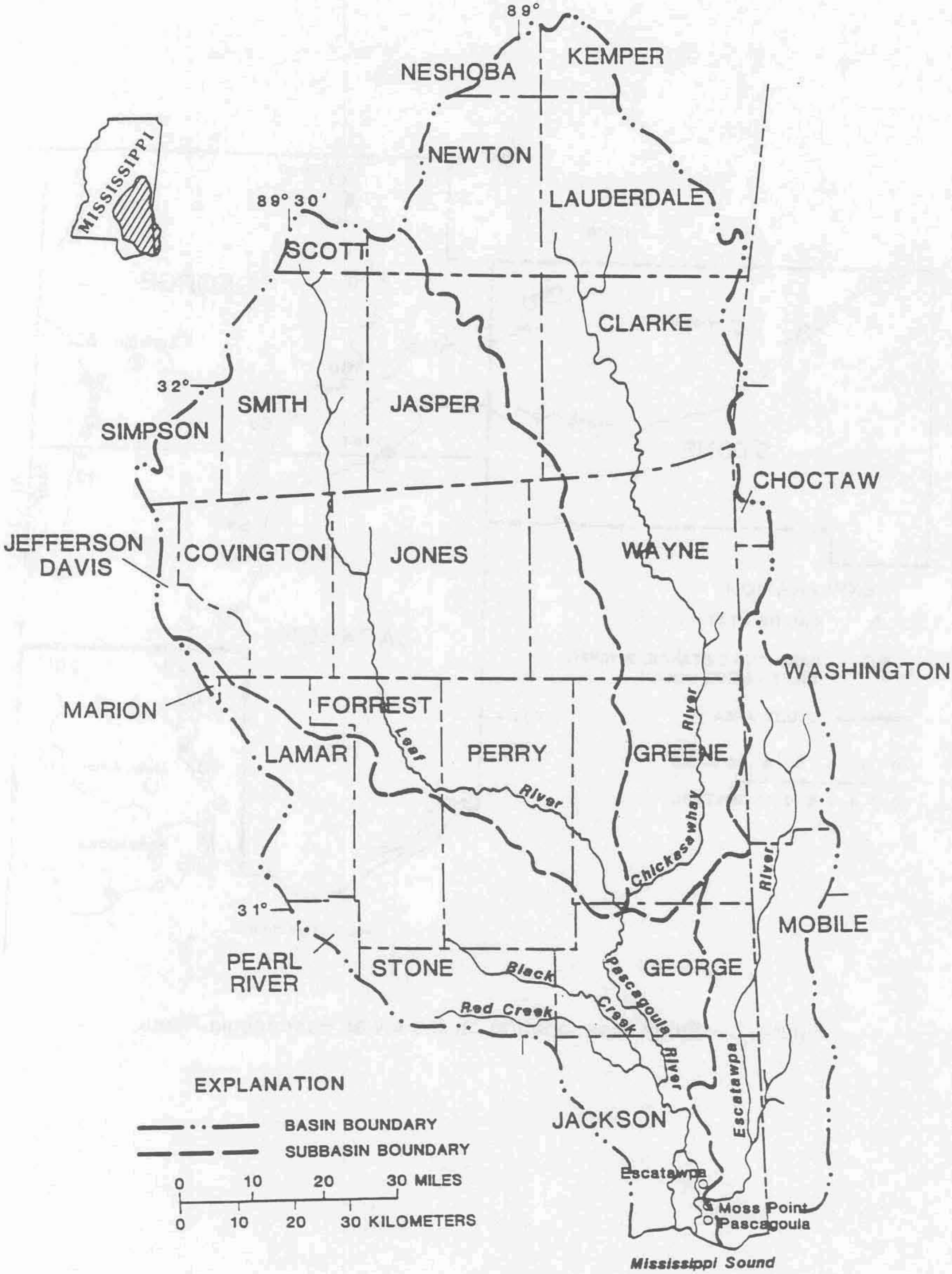

Figure 1.--Location and major drainage of the Pascagoula River basin.

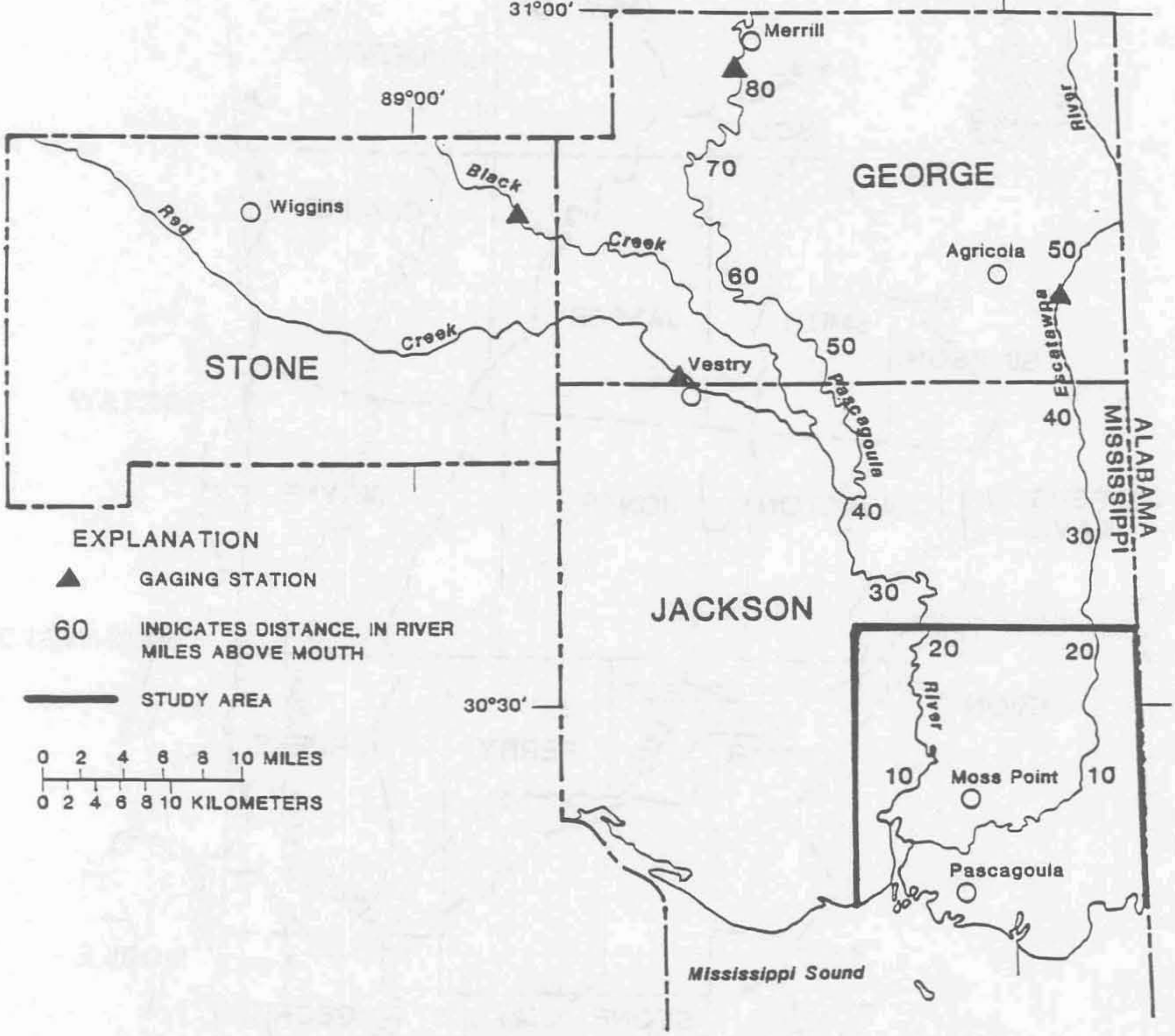

Figure 2.--Study area location on the lower Pascagoula River.

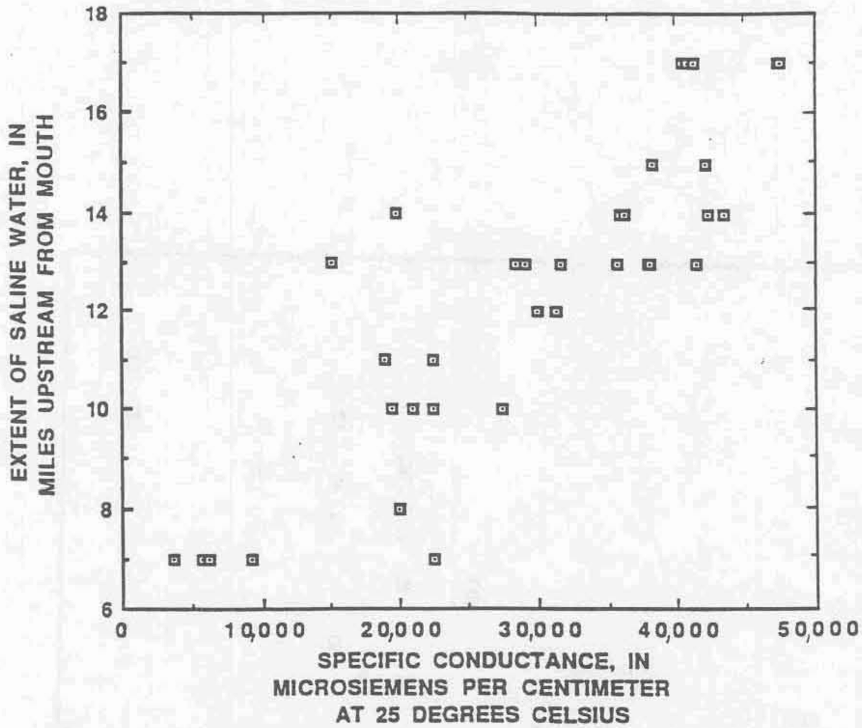

Figure 3.--Relation between specific conductance at the mouth of the Pascagoula River and extent of saline water upstream from the mouth.

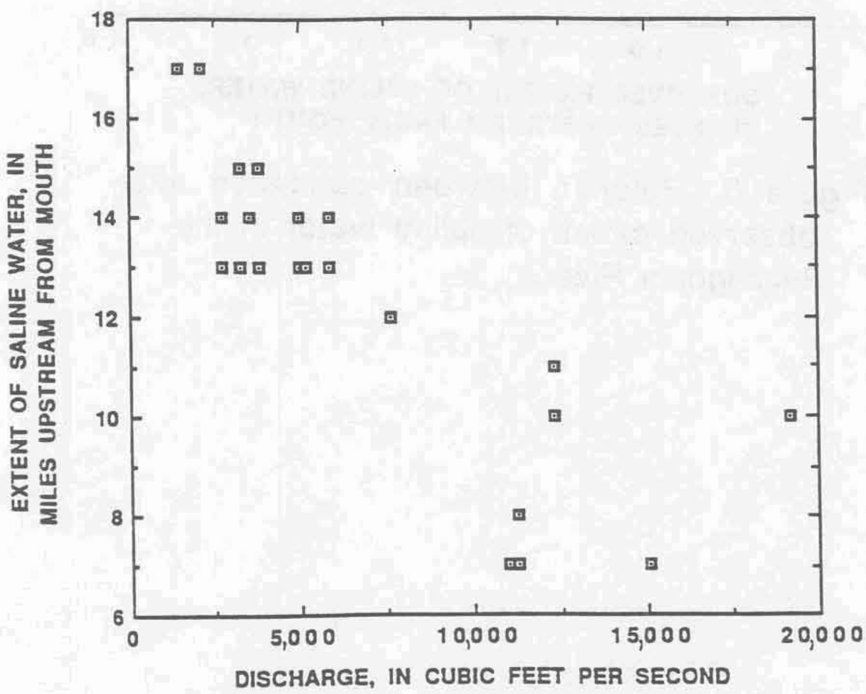

Figure 4.--Relation between 7-day average discharge of the Pascagoula River and the extent of saline water.

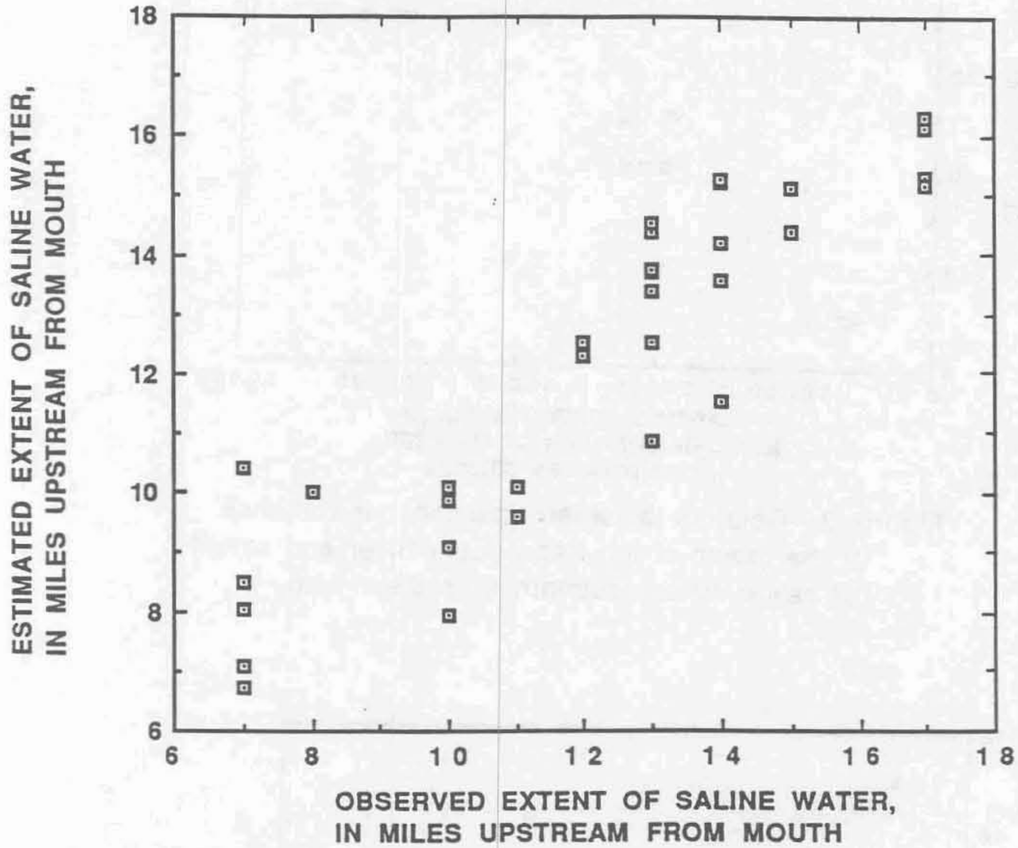

Figure 5.--Relation between estimated and observed extent of saline water in the Pascagoula River.