Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

1st Annual Progress Report
January 1979

[Editor's Note: The following report is an electronic reproduction of the original 1st annual progress report to the State Water Resources Control Board. The original text and structure of that report was left the same, however, the font styling and positioning of the figures within the report have been modified.]

Introduction

This is the first annual progress report on methods to estimate or otherwise determine flow and salinity conditions in the Sacramento-San Joaquin Delta. The report is required by Order No. 9 of the State Water Resources Control Board's Water Right Decision 1485. Specifically, Order No. 9 states:

> Permittees shall report to the Board by January 15, 1979, and annually thereafter, on the methods to be used in determining flows past Rio Vista and improving accuracy of Delta outflow estimates or on studies to be commenced by that date to determine such procedures. Permittees shall also report annually on methods for making more precise projections of salinity distribution in the Delta under varying inflow, outflow, and export conditions.

Flows at Rio Vista

The Decision 1485 fish and wildlife standards include a requirement for minimum net flows in the Sacramento River at Rio Vista to protect salmon migrations. The large tidal flows at Rio Vista preclude the use of conventional stage-flow relationships to determine river flow. Without direct measurements, the net flow at Rio Vista must be computed by estimating withdrawals and additions between Rio Vista and Sacramento. The river flow at Sacramento is measured by stage and backwater analysis but the measurements are not immediately available so a further estimate is required.

Present Method

The Division of Operations and Maintenance is currently using the following equations to estimate the daily flow at Rio Vista.

When the Delta Cross Channel is open;

QRV = .7QI - .333CD - 2050

When one gate of the Cross Channel is closed;

QRV = .7QI - .333CD - 1550

When Cross Channel is closed

QRV = .87QI - .333CD - 1000

Where:

QRV = Net flow at Rio Vista (cfs);
QI = Net flow at Sacramento at I Street (cfs); and
CD = Net Delta channel depletion (cfs).

The equations account for the diversion of water at the Delta Cross Channel and Georgiana Slough (.3I + 2050 for open gates), and for the withdrawal or addition due to channel depletion along the river (.333CD). The equations can be modified to account for inflow from the Yolo Bypass, but when bypass flows become significant, the flow at Rio Vista will be well above the standards.

The daily estimate of flow at the I Street Bridge in Sacramento (7 A.M.) is prepared by the Division of Flood Management. The estimate consists of the Sacramento River flow at Verona (based on stage-flow curves) plus the American River flow at Nimbus Dam less an estimate of average diversions between those points and I Street.

The daily estimate of channel depletion is based on values agreed to by DWR and USBR in 1969, also known as "MACO CD". These values are intended to represent average conditions including average precipitation.

Planned Improvements

A major improvement in the values used for flow at Sacramento is planned for early in 1979. An acoustical metering system is being installed near Freeport in connection with the regional sewage system. The flow measurements are planned to be telemetered directly to the Department.

Delta Cross Channel and Georgiana Slough diversions are based on historical tidal cycle measurements at these locations. These periodic tidal cycle measurements will be continued verify the flow-split relationships, particularly for the times when one or both of the Cross Channel gates are closed.

Delta Channel depletion (local use) values affect all flow and water quality determinations. This subject is discussed separately in the following section.

Channel Depletion

Four sets of average channel depletion values currently exist. These are:

1. **MACO Channel Depletion** – These values were developed in 1969 and agreed to by the USBR and the Department. MACO channel depletion is used in the calculation of the Delta Outflow Index.

2. **Central District Channel Depletion** – These values were developed in 1967 as a result of comprehensive field measurements, land use surveys and crop use studies performed by the Department. Central District channel depletion is used in the calculation of outflow values which are used in the Four-Agency fishery studies.

3. **Statewide Planning Channel Depletion** – These values were developed by the Department in 1976 using pervious field measurement information and updated land use and crop use studies. These values are used in the verification of the new Delta time-variable salinity model and are proposed for use in all Department operation studies.

4. **USBR Channel Depletion** – These values were mathematically developed in 1978 by USBR using measured 1976-77 Delta inflows, corresponding western salinities and math model steady-state salinity gradients. The mathematical technique employed makes assumptions that have not yet been verified. No consideration is given to errors that might be present in current salinity prediction methods. The USBR channel depletion values have been accepted by USBR officials only. The values have been used for the new CVP yield study, but have not been verified for historic hydrologic periods.

MACO, Central District, and Statewide Planning channel depletion values show comparable total annual Delta use values of approximately 1.1 MAF. USBR channel depletion has a much smaller annual Delta use of 0.8 MAF. Comparison of monthly values between the four channel depletion sets show differences larger than 1000 cfs.

To varying degrees, all four sets represent average channel depletion values derived from average Delta hydrologic conditions. The use of average channel depletion, and especially the use of average precipitation to adjust channel depletion values, is subject to inherent errors when applied to calculations involving extreme hydrologic conditions. As conditions begin to vary, all the factors affecting Delta channel depletion vary also.

These factors are applied irrigation water, irrigation drainage, evapotranspiration, seepage, changes in soil moisture, and precipitation. Since monthly channel depletion values are dependent on all these parameters, it is not accurate to apply average channel depletion values to the 1976-77 hydrology. All the factors affecting Delta channel depletion were not measured, therefore, it will be extremely difficult to quantify the changes that occurred during 1976-77.

The Division of Operation and Maintenance has initiated a special study of the changes in channel depletion that occur during drought conditions.

Delta Outflow

The 1976-77 drought provided the Department with the first set of records of sustained low flow conditions in the San Francisco Bay-Delta estuary since the start of project operations. These new records were, in part, a result of the Department’s comprehensive monitoring program implemented in conjunction with the SWRCB’s Decision 1379. Inspection of the new data allowed the Department to reevaluate current Delta outflow computation procedures. Some inconsistencies were found.

Starting in 1977 work was initiated to identify these inconsistencies, determine error sources, investigate the accuracy of current outflow calculations, and review alternative methods of outflow determinations. In 1978 the Department began coordinating a multiagency endeavor to assist with this work. The participating agencies were the USGS, DWR, USBR, SWRCB, and USCE. This group moved rapidly to select, fund and implement a test program by August 1978. This program focused on the best available alternative.

This alternative was a physical measurement of outflow using acoustic flow meters. Preliminary test results were available in October 1978 and looked promising. Currently, all testing has been completed and all test data is being evaluated. In June 1979, a USGS report will be completed outlining the results of the feasibility study. A decision regarding a permanent system will be made based on this report.

Inconsistencies in the 1976-1977 Flow and Quality Records

The major inconsistency found in the 1976-77 records was the relationship between western Delta salinity and computed outflows. During some months Delta salinity and outflows were both rising. It is known from previous work on outflow-salinity correlations that this condition is not possible for a sustained period. During other months the records of salinity and computed Delta outflow deviated from historic correlations beyond reasonable limits. Preliminary reviews showed the hydrologic balance equation used in the outflow calculations and the validity of salinity measurements to be well documented. Therefore, the error sources are traceable to the hydrologic values used to perform the outflow calculations and the current methods of predicting outflow-salinity relationships.

Other inconsistencies uncovered during the drought better defined the error sources. Visual observations made in the field indicated that irrigation diversions started as early as January and February. This is inconsistent with the average channel depletion values currently used in the outflow calculations and mathematical salinity models. In addition, the 7 A.M. Sacramento River inflow values, computed for project operations, varied from the Sacramento River inflow values published by USGS. The Sacramento River inflow to the Delta is also used in outflow and salinity calculations.

The error sources causing the inconsistencies in the 1976-77 flow and quality records for the Delta are attributable to the severe nature of this drought condition. The 1977 Central Valley water supply was the most critical on record. The rainfall in January, February, and March of 1977 was far below normal creating dry soil conditions. This caused early season irrigation of Delta islands to increase the soil moisture content. This early application of water caused an appreciable shift in the average water use pattern in the first part of the year. The dry and warm climatic conditions of the drought may have caused higher than normal Delta consumptive use to occur in the first half of the irrigation season and less in the latter half. These probable changes from normal channel depletion patterns in the Delta were a major error source, causing inconsistencies between channel depletion values now used and those observed during the drought.

The error source associated with the Sacramento River inflow was drought-related. Increases in ground water pumpage and a decrease in ground water recharge caused lowered water tables along the Sacramento River. A direct result of this was a negative ground water accretion from the lower reach of the Sacramento River. This is an unusual situation and has not been encountered in the past 30 years. Historic records are not available to properly describe these negative accretions in current 7 A.M. Sacramento River inflow estimates used for project operations. Therefore, measured USGS Sacramento River flows at Sacramento (which are not available for use until 1 to 2 months after the fact) do not match the estimated inflows. To a much smaller extent, some uncertainty exists with the adjustment techniques used to correct USGS measured inflows.

Current Delta Outflow Accuracy

The inconsistencies and error sources uncovered during the 1976-77 drought generated some uncertainty about current Delta outflow accuracy. These uncertainties pertained to both types of computed outflow values presently being used. These types are:

1. **The Delta Outflow Index (D.O.I.)** – This index is computed by DWR project operators on a daily basis. The hydrologic data and computational procedure used to compute the D.O.I. is:

   DOI = QSAC + QSJR - CD - E

   Where:

   QSAC = Estimated daily Sacramento River inflow at Sacramento (7 a.m.) as described in "Flows at Rio Vista".

   QSJR = Measured San Joaquin River inflow at Vernalis (telemetered).

   CD = Average estimated historical Delta channel depletion including adjustment for average historical precipitation, known as MACO CD.

   E = Total Delta exports.

2. **The Central District Delta Outflow (DO)** – This outflow value is computed at a later date than the D.O.I. The calculations are done at the Department's Central District office. The data used in the computational procedure is not immediately available since it requires additional processing and some adjustment.

The hydrologic data and computational procedure used to compute this outflow is:

DO = QTI - CD - E

Where:

QTI = The total measured Delta inflow consisting of the Sacramento River, Yolo Bypass, San Joaquin River, Cosumnes River, Mokelumne River, Calaveras River, Bear Creek, Marsh Creek, Morrison Creek, Dry Creek, Stockton diversion canal, and French Camp Slough.

CD = Average estimated historical Delta channel depletion developed at Central District, adjusted for actual precipitation in the Delta.

E = Total Delta exports which consist of Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal, and miscellaneous exports.

The two methods of calculating outflow compare directly in their use of the basic hydrologic equation defining Delta outflow. This equation is:

Delta Outflow = Inflow - Exports - Channel Depletion

The Central District outflow method utilizes a more complete set of inflow values not available to the D.O.I. method on a daily computational schedule. This implies better accuracy.

The major differences between the two calculated outflow values can be traced to the Sacramento River inflow values, treatment of precipitation falling on Delta islands and the use of average channel depletion values. The Sacramento River inflow value used by the D.O.I. is computed, using estimated diversions not properly defined for the drought conditions. The extent of inaccuracies are unknown. The USGS Sacramento River inflow value used to compute the Central District outflows are measured and adjusted by computer program to account for the backwater effects of the tide. Investigation of this adjustment procedure indicated that the USGS values were more accurate and valid during sustained low flow conditions. Comparisons of the two inflow values showed differences of up to 1300 cfs.

The daily average precipitation used in D.O.I. calculations were another source of error since the actual precipitation occurring during the drought differed markedly from average values.

Comparisons of the different average channel depletion values used in the outflow calculations were covered in the previous section of this report.

Alternative Methods of Outflow Determination

Two types of solutions were investigated to resolve the uncertainties found during the drought. The solutions considered both mathematical applications and direct field measurements. Each alternative solution was reviewed according to criteria of total cost, time reliability, accuracy, and real-time results.

Mathematical Solution – A mathematical solution was evaluated by the Department according to the criteria listed. This type of solution was employed by USBR in development of their new Delta channel depletion values. A brief discussion of their method and associated problems is discussed in the previous section describing channel depletion values. Delta inflow, channel depletion, salinity measurements, and outflow-salinity correlations must all be used to correct the uncertainties in the 1976-77 Delta outflow values. A direct solution requires that three of the four parameters be held constant while the remaining parameter is adjusted to fit the other values. Consequently, all the error sources will be allocated on one source. Previous discussion have shown that unknown degrees of error exist in three of the four parameters. Therefore, some uncertainties will not be proerly addressed and accuracy not achieved. If more than one parameter is allowed to vary, a number of solutions will be possible. This creates questionable accuracy.

Since a mathematical solution was rejected, it was necessary to consider direct field measurements. Direct yearly measurements of one or more of the parameters in question would eliminate the uncertainties which currently exist. Field measurements could be made of parameters necessary to define channel depletion or outflow.

Channel Depletion Measurement – To determine channel depletion from direct field measurements it is necessary to monitor many parameters. These parameters include land use, crop unit use, precipitation, and changes in soil moisture. Measurements of changes in soil moisture present the most difficulties. In 1963 and 1964, the Department did collect these data through extensive field measurements. Determination of soil moisture changes required monthly monitoring of 500 sites with radioactive soil moisture probes which were installed on agricultural land and often subject to damage. Since technology has not advanced appreciably since this study was performed, it would be necessary to repeat this procedure on a yearly basis to eliminate the problems that occurred in 1976-77 by this process. This would incur substantial costs and the data obtained would required several months to evaluate; providing little assistance to day-by-day project operations. For these reasons, this measurement process was not pursued.

Delta Outflow Measurement – A direct measurement of Delta outflow proved to best meet the criteria listed for a successful alternative. Costs would be high yet all other criteria were feasible. Previous efforts to measure outflow by mechanical velocity meters encountered difficulties. However, advances in the technology of acoustic velocity meters showed new promise. Acoustic velocity systems have shown documented accuracy, and can be installed with a telemetering system to transmit instant results.

Delta Outflow Measurement Study – Recognizing the possibilities of an acoustic velocity system and the many benefits to Delta-related programs, the Department pursued interagency involvement and funding of this program. In 1978 commitments were obtained from USGS, USBR, SWRCB, and USCE. Meetings were arranged to exchange expertise and formulate a program to measure outflow at Chipps Island with joint funding. Meeting discussions identified benefits, previous efforts, potential problems, available technology, necessary testing, and expected costs.

Benefits – In addition to eliminate trial and error SWP and CVP project operation methods, minimizing unnecessary reservoir releases and insuring compliance with D-1485 Delta water quality standards, other benefits of a direct outflow measurement were identified. These were:

1. Continuous outflow records to accurately verify physical and math Delta simulation models.

2. Continuous outflow records to accurately determine diversions from the Sacramento River and the Delta for water use surveys.

3. Long and short-term outflow information to establish better statistical correlations for numerous parameters being monitored throughout the Delta and, thereby, a more precise understanding of Delta environment.

Previous Efforts – Three methods have been used in attempts to measure Delta outflow at Chipps Island. Accuracy has been obtained for a short period only. Valuable flow records, technical information, and potential problems of a Delta outflow measurement have been gained by the previous efforts listed below:

1. DWR 1954 – A moving boat method was employed to eliminate inaccurate measurements of low flow encountered by mechanical velocity meters. Measurement techniques encountered difficulties and accuracy was questionable.

2. DWR 1963 – Savonious meters were installed on fixed supports. Accurate records were obtained yet problems of cost, maintenance, and continuous operation were encountered.

3. USGS 1967 – Acoustic velocity meters were used. Instrumentation was too primitive at that time, yet the method showed promising application.

Potential Problems – Problems identified by previous outflow measurement efforts are listed below:

1. Large tidal volumes to be measured, maximum flood or ebb tides are approximately 300,000 cfs.
2. Marine growth can be significant at the intended measurement site.
3. Wind and wave action is severe.
4. Possible thermal stratification from industrial discharges could affect acoustic velocity measurements.
5. Significant variations in salinity and water density occur in the channel at the site cross sections. This could affect acoustic velocity measurements.
6. Unsteady and two-layer flow phenomenon occur at the intended measurement site during times immediately before and after slack water conditions.
7. A ship channel is located in the main channel of the river, requiring permits or approval for any equipment or structure installation.
8. The total river width at the intended measurement site is approximately 3,000 feet. This width could attenuate an acoustic signal transmitted from bank to bank.
9. Possible riverbed movement which could restrict placing instrumentation near the riverbed.

Available Technology – Several sources were consulted to provide technical expertise and assist meeting discussions. In addition to technical information gained from previous outflow measurement studies, advances in technology and equipment were investigated through correspondence with: (1) Westinghouse Corp; (2) Ocean Research Engineering; and (3) Hydro-Instrumentation Department, Rijksweaterstaat Holland. Experts representing these organization were unable to cite any previous undertaking which matched the adverse conditions presented by the Delta outflow study. However, with the current advanced state of technology, the experts were optimistic that a system could be designed and implemented to accurately measure Delta outflow.

Feasibility Study – In August 1978 a feasibility study was agreed to by participating agencies. USGS was selected to act as lead agency for the testing based on their previous experience. Acoustic velocity equipment representing current technology was leased and installed at the Chipps Island site. Measurements were taken for approximately 60 days to provide documentation of the following:

1. Performance of current production acoustic transducers at the Chipps Island site.
2. Variations in acoustic transmission as related to the depth of the acoustic path.
3. Variations in acoustic transmission that may be caused by insolation or by cooling water discharges by industries in the Pittsburg area.
4. Variations in acoustic transmission resulting from salinity stratification.
5. Channel cross sections stability.

6. A detailed review of previous USGS work reported in USGS Water Supply Papers 1869-G and 1877.

Preliminary results became available in October 1978 and looked very promising. Evaluation of all test data is expected to be completed by June 1979. At that time a USGS report will be completed publishing the results of the feasibility study. A decision regarding a permanent system will be made at that time. If participating agencies approve the permanent system, it will be completed by 1981.

Costs – The test program will cost approximately $100,000. The permanent system cost is estimate at $1,000,000 with an annual operation and maintenance cost of roughly $50,000.

Salinity Predictions

Predictions of salinity concentrations and distributions in the Bay-Delta under various hydrologic conditions are used in the development and evaluation of water quality standards. The relationships between salinity and flow conditions are used to determine how much water is required to meet specific standards. This provides a measure of reasonable use based on the impact on the available supply. Predictions of salinity distribution provide information on how a water quality standard at one location affects the rest of the estuary.

The ability to predict salinities also is needed to plan the operation of the projects to meet the established standards.

Present Methods

To study the complex hydraulic and salinity relationships, the Department has developed several mathematical models on the Bay-Delta estuary. The three models presently in use are described in the following sections.

SALDIF – This model estimates salinity along the main channel of the estuary from the Golden Gate to Junction Point on the Sacramento River. The model considers both advective and dispersive transport of ocean salts between its seven channel segments. Land-derived salts are not considered in the model. The San Joaquin River is not included in the model, so that salinity in that portion of the western Delta must be estimated by correlations to predicted values at Sacramento River stations. Since the model assumes a single channel, the accuracy above the confluence of the Sacramento and San Joaquin Rivers (Collinsville) is questionable.

This model was described in detail during the hearing leading to D-1379. The model also was the basis for all evidence regarding outflow-salinity relationships presented by the Department during the hearing leading to D-1485.

PCSTAGE – This model estimates net flow and mean salinity at selected locations in the interior Delta. The flows are estimated by empirically derived formulas and the salinities are estimated by mass balance (no dispersion) at each location. The model input includes mean monthly inflows, channel deplections, exports, and boundary qualities. Quality at the western boundary is obtained by incorporating SALDIF as a subroutine. The effects of local drainage are incorporated as mean monthly salt loads that remain constant regardless of prior conditions or varying hydrology. The model output consists of mean monthly flows and qualities at a limited number of locations (about 15) in the interior Delta. Since the model is based on empirical relationships, it does not have the capability to analyze revised hydraulic conditions such as with the Peripheral Canal or other proposed facilities in the Delta.

This model was used to conduct the Delta routing portions of the operation studies for the 1980 level of development presented during the hearing leading to D-1485.

FLOSALT – This model estimates net flows and mean salinities throughout the interior Delta resulting from operation of the Peripheral Canal. The Delta is represented by a grid network of 88 channels and 64 junctions. The model accounts for the mass transport of salts brought into the Delta from upland tributaries as modified by local agricultural practices. The model does not consider ocean-derived salinity nor does it consider dispersive transfer of salts. The model consists of three major sections – an operation section that computes required releases from the Peripheral Canal based on predetermined criteria, a hydraulic section that estimates net flows in the Delta Channels based on a modified Hardy-Cross method, and a quality section that estimates mean salinities by mass balance using the net flows and a subroutine for the effects of local agricultural practices. Model input consists of mean monthly inflows, channel depletions, exports, and inflow qualities. The output consists of Canal releases and net flows and salinity at all points in the grid network. The model can only be used for conditions with the Peripheral Canal, and since it does not consider ocean salinity, the accuracy in the far western Delta is questionable.

This model was used to conduct the Delta routing portions of the operation studies for the 1990 level of development presented during the hearing leading to D-1485.

Present Studies

A new Bay-Delta salinity model (TVRK) is presently being developed by the Department to combine most of the desirable capabilities of the existing models while overcoming several of their limitations. The new model is currently operational, however, the verification, review, and documentation process has not been completed.

Description – The major characteristics that were incorporated into TVRK included:

1. A grid network that represents the entire Bay-Delta estuary as shown in Figure 1. This grid is the same as that used for the hydrodynamic model DYNFLOW.
2. Time-variable simulation of salinity conditions.
3. Simultaneous consideration of both ocean and land-derived salinity.
4. Consideration of both advective and dispersive transport of salt.
5. Consideration of the salinity effects of local agricultural practices.
6. Capability for analyzing existing conditions or modified flow patterns resulting from new facilities or other changes in channel configurations.

Verification – The model was initially calibrated using 1964 historical conditions and checked for verfication against historical conditions in 1966, 1968, 1970, and 1972. The verification results were excellent, including simulation of the salinity effects of the 1972 Andrus Island levee failure. Following the 1976-77 drought, final verification of the model was attempted using the hydrology of those two years. The model simulation for these critical low flow conditions was not good.

The model was recently modified by adding Mayberry Slough to the grid network (channel 343 on Figure 1). This channel connects the Sacramento and San Joaquin Rivers via the inundated portion of western Sherman Island. The importance of this channel in transferring water and salinity between the two rivers was not recognized until the drought conditions were analyzed. With this modification the model produces reasonably good simulation of the 1976 and 1977 conditions. The 1968 conditions also were reverified, but the other years have not been rerun. Figures 2 through 10 illustrate the comparison of historical salinities and model simulation with and without Mayberry Slough for 1968, 1976, and 1977 at Antioch, Emmaton, and Jersey Point.

Planned Improvements

No further major modification of the model are planned for the immediate future. During the calibration and verification of the model for 1976 and 1977 conditions, several problems were encountered that reflected on the validity of the estimated and measured prototype data used as input to the model. At present the model appears to produce results that are within the accuracy of the input data. This is particularly true of estimated Delta outflow, which is dependent on estimated Delta use (channel depletion). Future modifications of the model will be based on either: (1) recommendations resulting from the review of the model by outside experts, or (2) improvements in prototype hydrologic data resulting from the studies described in this report or other studies.

Assuming adequate manpower and funds, the following steps in the development and use of the model are planned for the coming year.

Verifications – The model verification will be completed for the historical years of 1964, 1966, 1970, and 1972. No problems are anticipated, but this process could indicate the need for further modification of the model.

Review – The model development, calibration, and verification will be comprehensively reviewed by outside experts. Such review will include sensitivity tests of the model. The model has been used for comparative analyses for the Interagency Drainage Program. In connection with this work, Dr. Hugo Fischer was contracted by the Board to review the models that had been used. Dr. Fischer's written report is pending, but his oral presentations were favorable to the TVRK model.

Documentation – The model development, calibration, and verification will be formally documented. A user's manual will be prepared also. A report on the review and sensitivity tests will be required of the outside consultants.

Use – The model will be used initially to develop new salinity-outflow relationships. These will be replacements for DWR Exhibits 7a and 7b from Phase I of the hearing leading to D-1485. The second use will be to develop new export-outflow relationship similar to DWR Exhibits 8 and 9 from Phase I of the hearings, but for additional locations.

Future uses of the model will include evaluations of alternative facilities and modes of operation, analyses of planned or accidental changes in the channel configurations, and modification of existing models. This latter use is desirable because the new model is considerably more expensive to run than the existing models.

[Editor's Note: Figure 1 was missing from the hard copy of report used to reconstruct this electronic copy. Only a portion of Figure 6 was found in the hard copy, but the portion of Figure 6 that was found is presented here.]

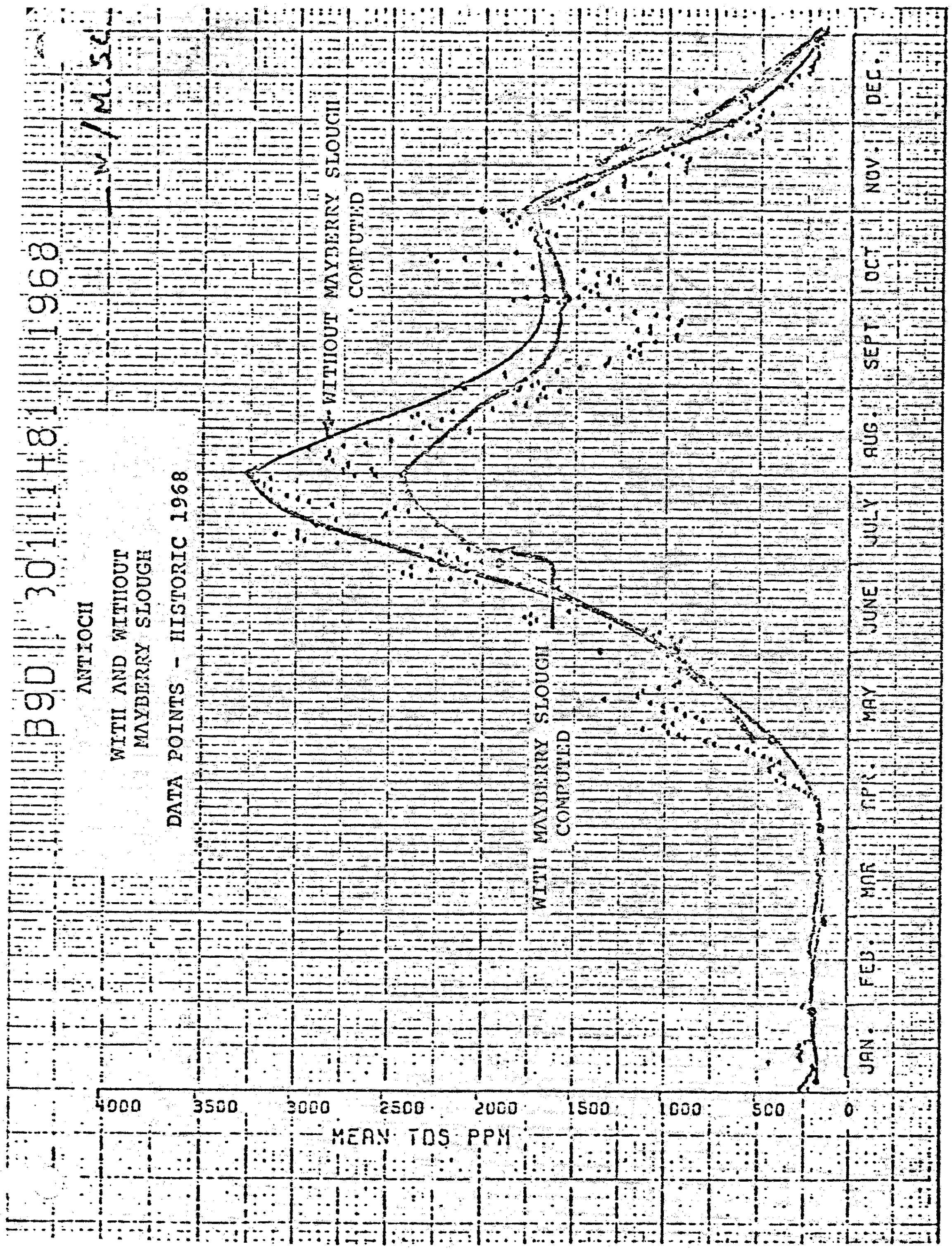

Figure 2: Observed and FLOSALT Salinity with and without Mayberry Slough at Antioch in 1968.

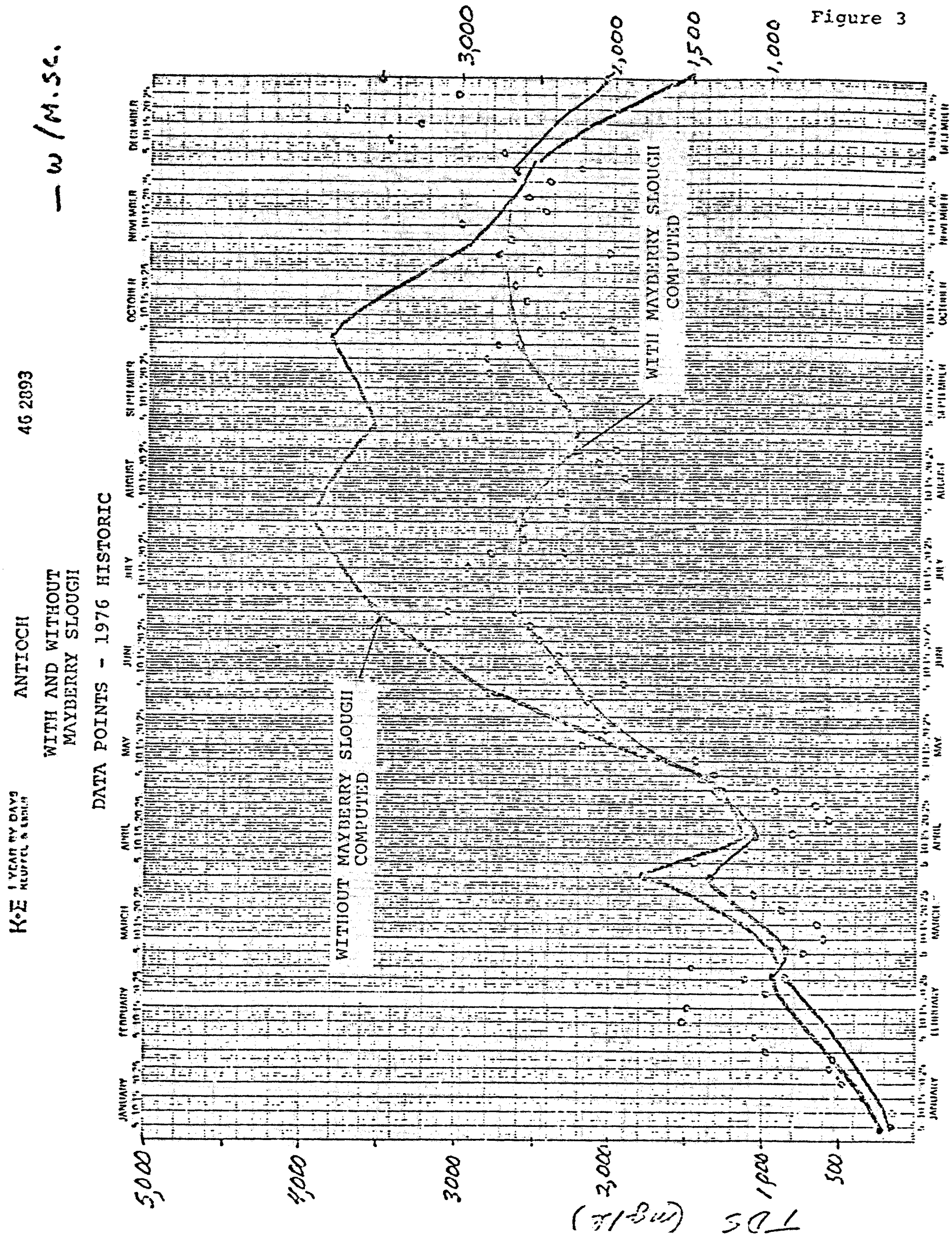

Figure 3: Observed and FLOSALT Salinity with and without Mayberry Slough at Antioch in 1976.

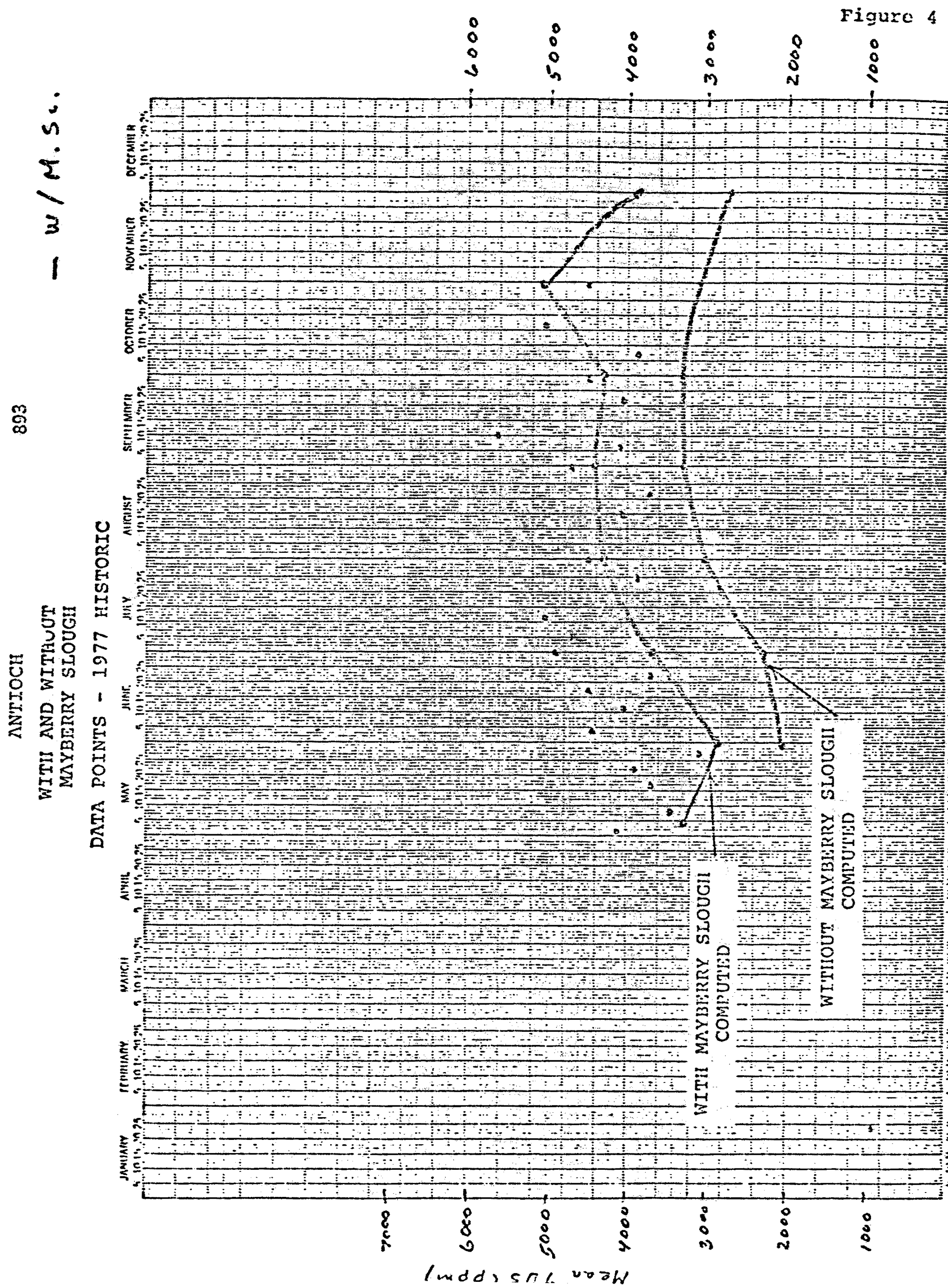

Figure 4: Observed and FLOSALT Salinity with and without Mayberry Slough at Antioch in 1977.

Figure 5

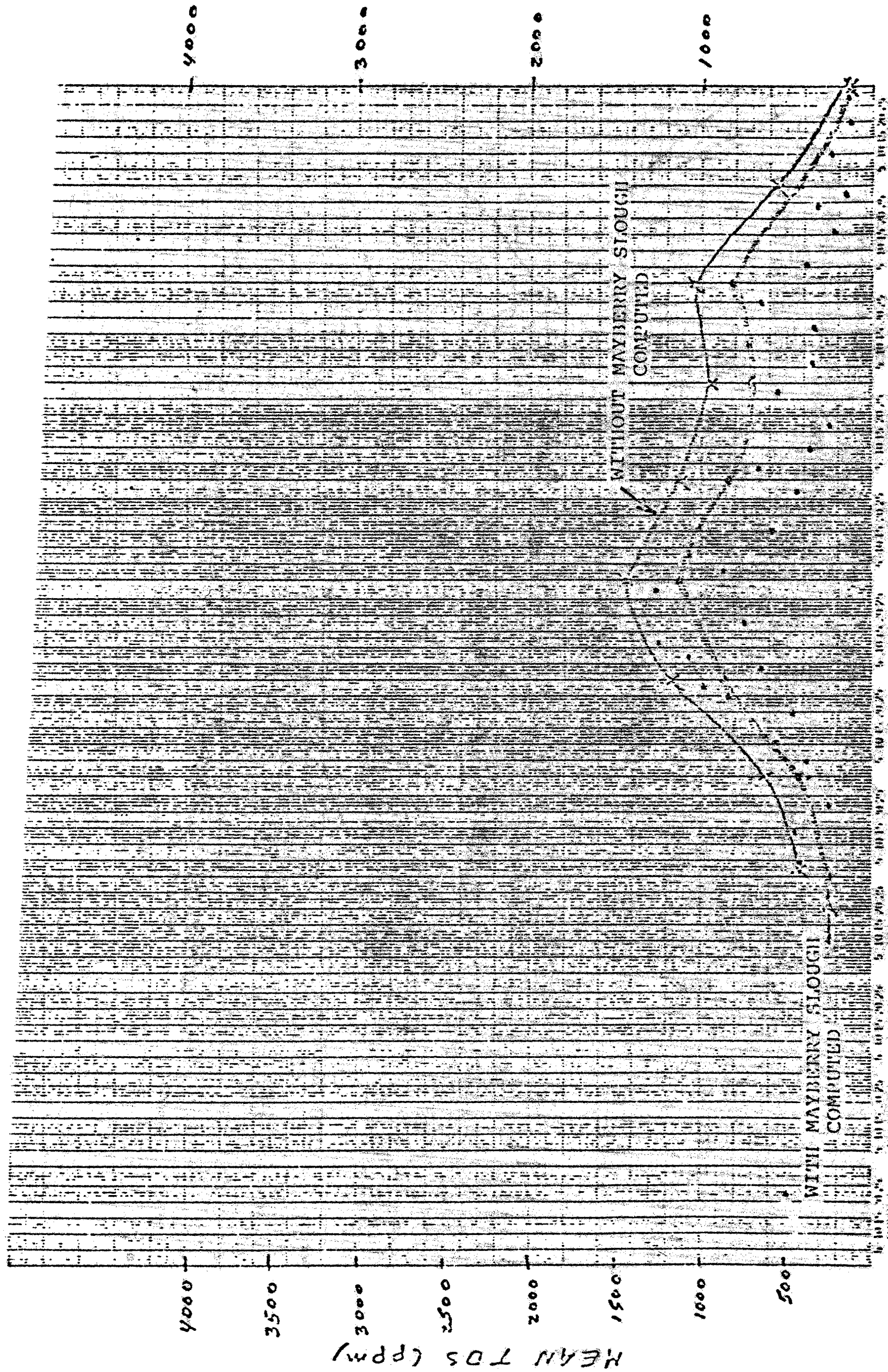

Figure 5: Observed and FLOSALT Salinity with and without Mayberry Slough at Emmaton in 1968.

[Editor's Note: Only a portion of Figure 6 was photocopied. Although largely incomplete, the surviving portion is shown below.]

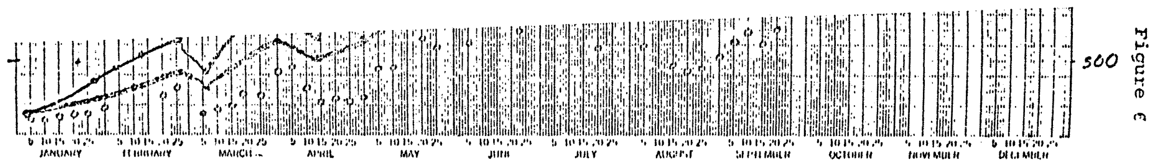

Figure 6: Observed and FLOSALT Salinity with and without Mayberry Slough at Emmaton in 1976.

Figure 7

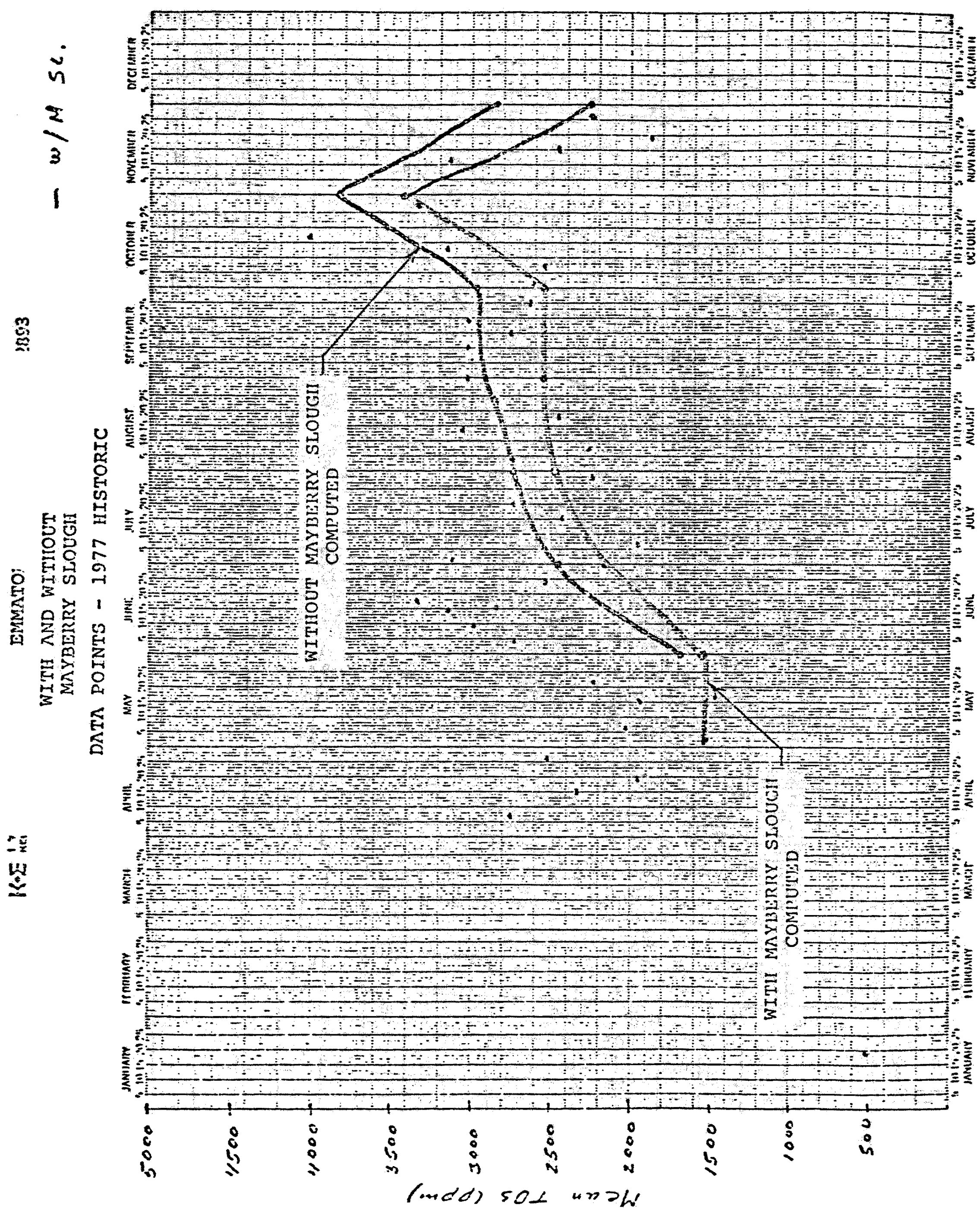

Figure 7: Observed and FLOSALT Salinity
with and without Mayberry Slough at Emmaton in 1977.

Figure 8

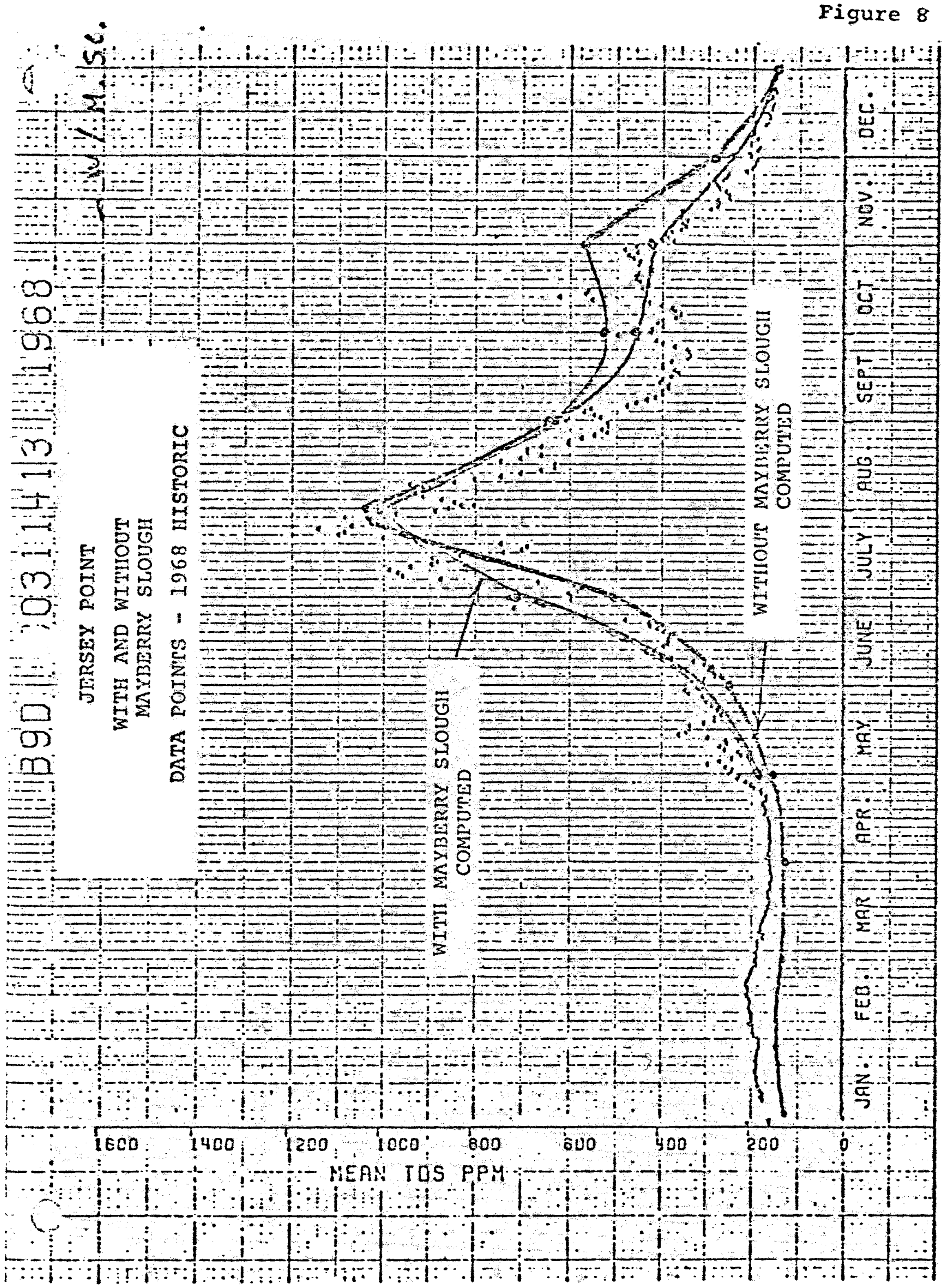

Figure 8: Observed and FLOSALT Salinity
with and without Mayberry Slough at Jersey Point in 1968.

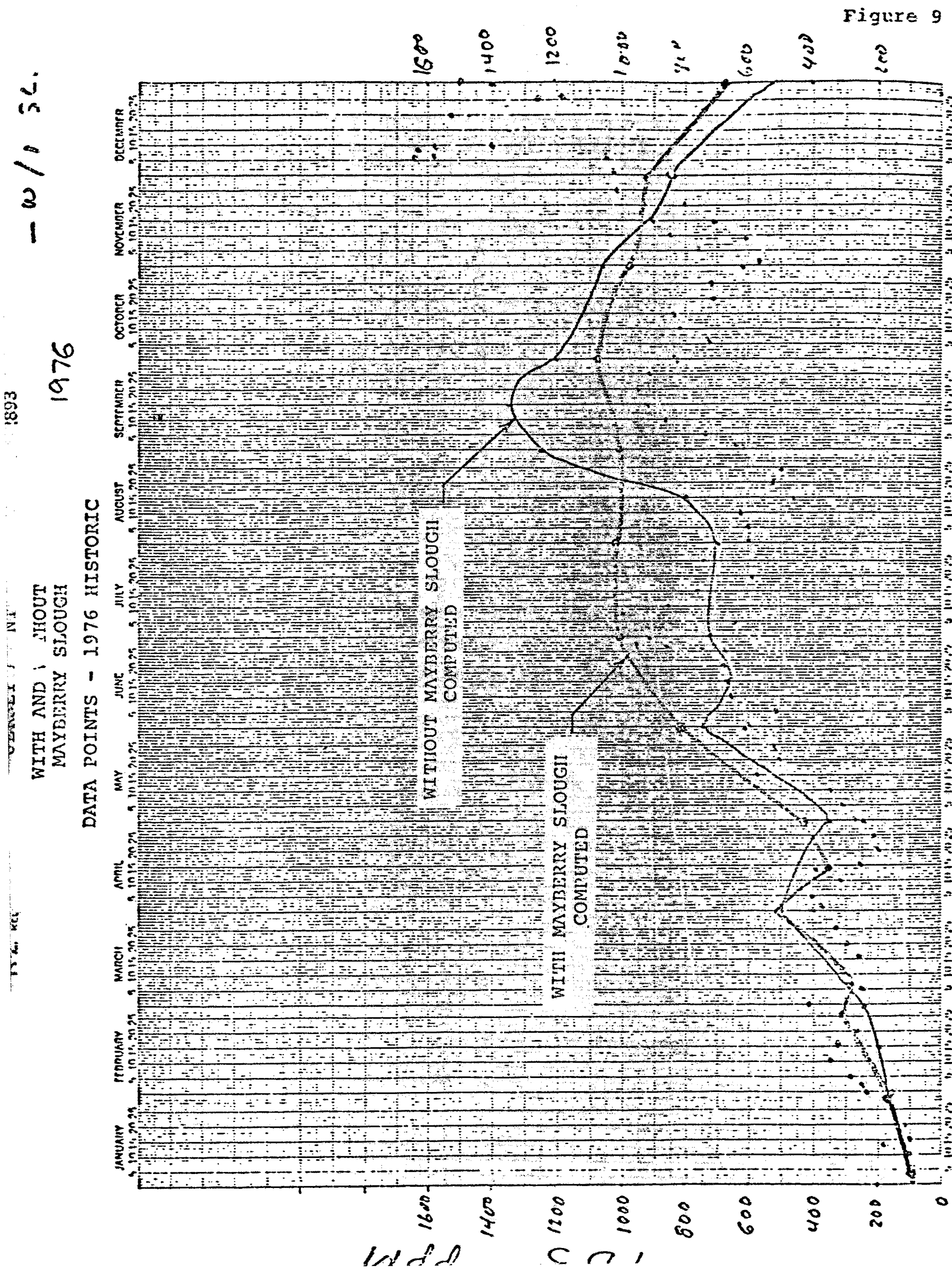

Figure 9: Observed and FLOSALT Salinity with and without Mayberry Slough at Jersey Point in 1976.

Figure 10

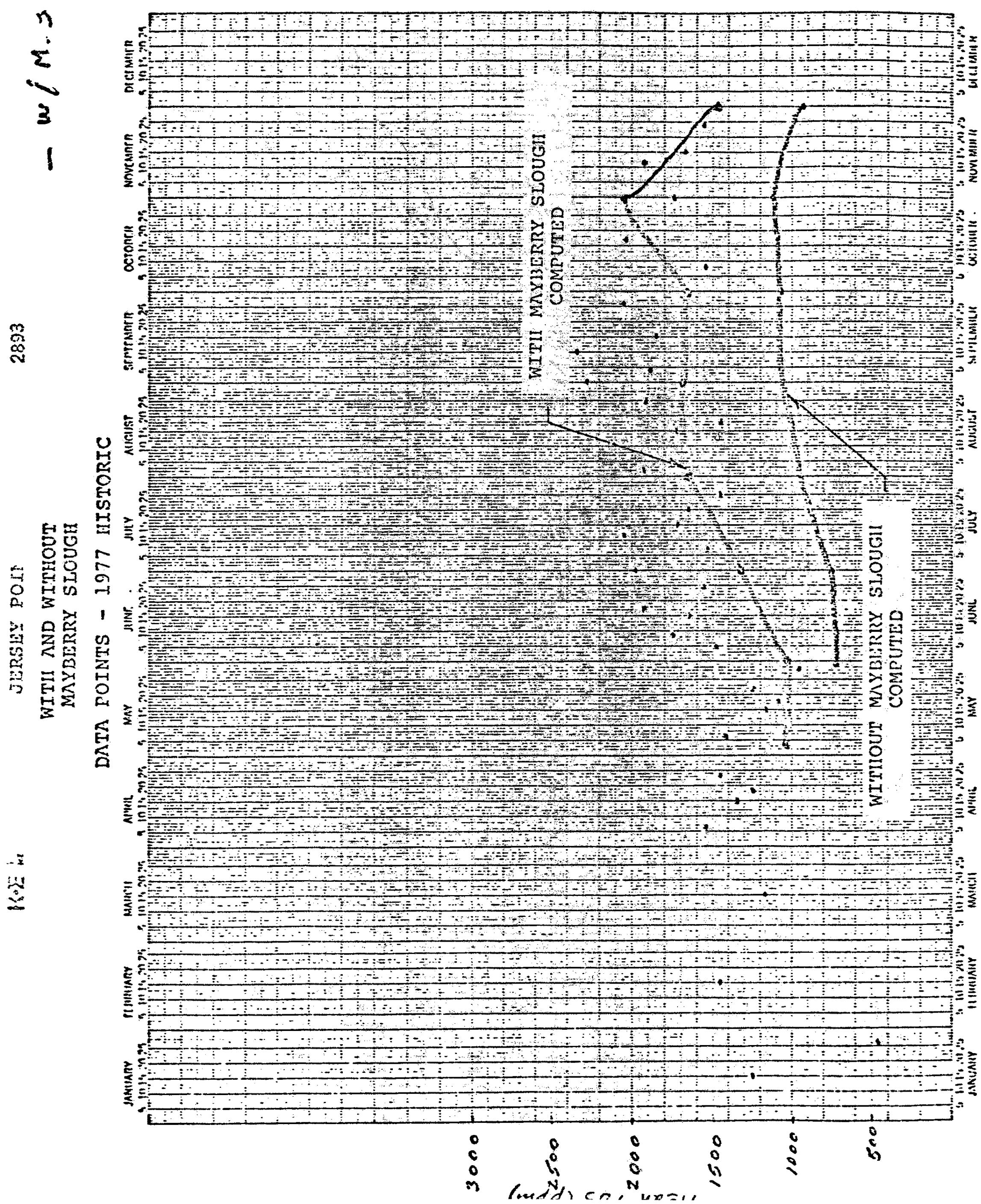

Figure 10: Observed and FLOSALT Salinity with and without Mayberry Slough at Jersey Point in 1977.