SEDIMENT OXYGEN DEMAND (SOD) STUDY
CALCASIEU RIVER ESTUARY
LAKE CHARLES, LOUISIANA
MAY 1984

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SURVEILLANCE AND ANALYSIS DIVISION
ATHENS, GEORGIA

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Environmental Protection Agency
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## Introduction

At the request of the Louisiana Department of Environmental Quality (LDEQ) through EPA, Region VI, Dallas, personnel of the EPA, Region IV, Environmental Services Division, Ecological Support Branch conducted a sediment oxygen demand (SOD) study on the Calcasieu River at Lake Charles, Louisiana. The purpose of the study was to determine sediment oxygen demand rates along the Calcasieu River for input and calibration of a wasteload allocation model being developed for the study area. With the assistance of LDEQ personnel, sampling station selection was accomplished during a reconnaissance on April 18, 1984 with field work accomplished during the period of May 7-14, 1984. A tabular presentation of SOD data has already been furnished to LDEQ.

## Study Area and Station Locations

The study area for SOD sampling was that portion of the Calcasieu River delimited upstream by Station 002 on the West Fork Calcasieu River and downstream to Calcasieu Lake and including Bayou d'Inde.

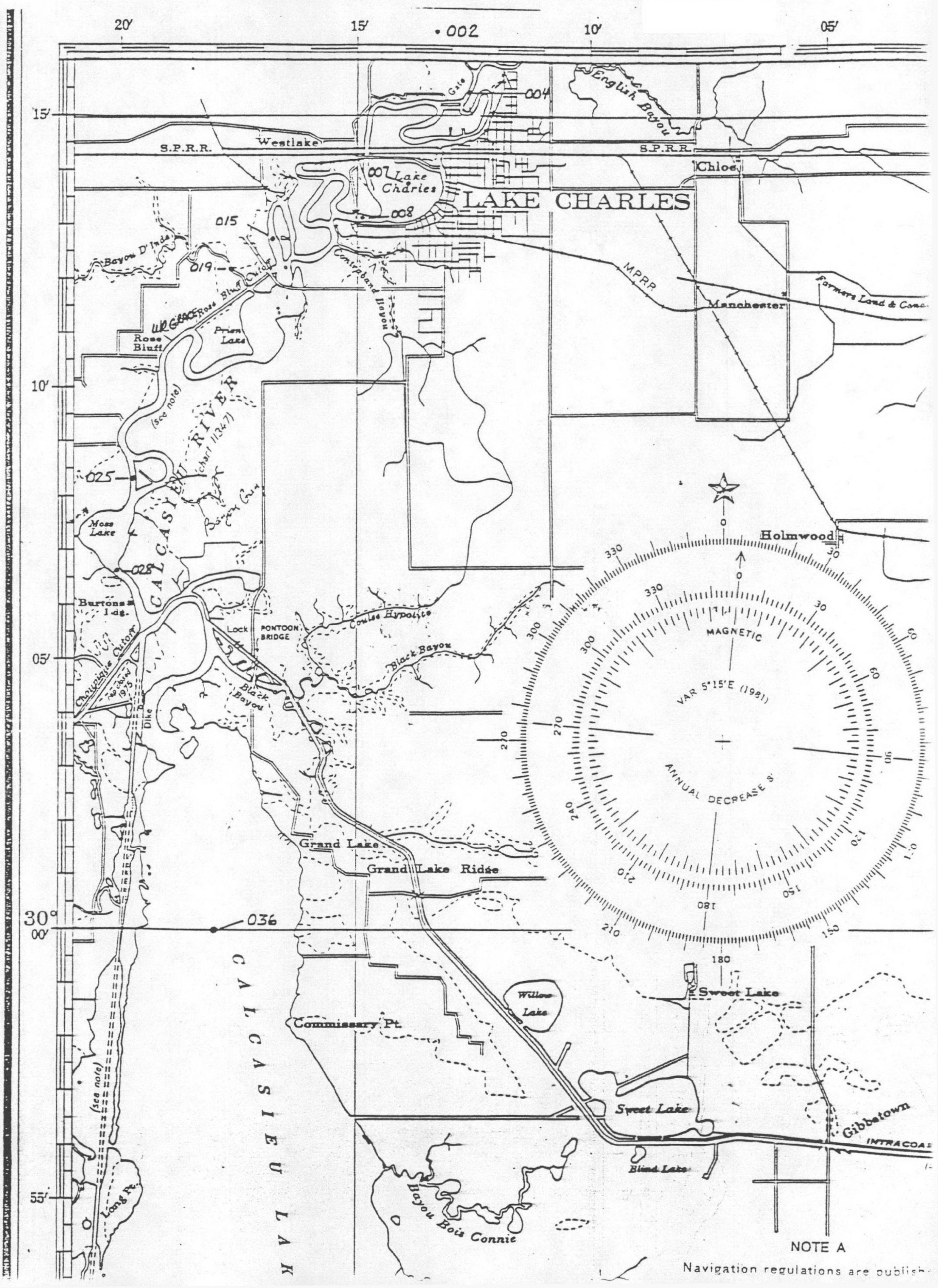
A total of eight (8) stations were studied along this reach with the numbering sequence corresponding to LDEQ station locations (Figure 1).

## Methods

Determination of SOD rates was accomplished by diver deployment of opaque acrylic chambers over bottom sediments and recording the decay rate of oxygen inside the chambers over a time period. During the course of the experiment, water within the chamber was circulated continuously at approximately 0.1 foot per second.

A detailed presentation of the methods employed are contained in the Ecological Support Branch's, Standard Operation Procedures manual and accompany this report (Appendix A).

Figure 1
Station Locations
Calcasieu River SOD Study



## Result and Discussion

Within the study reach, SOD chambers were deployed over a variety of habitats which included river run channel, dredged ship channel, bayou, lake, and near shore submerged mud flats. Figure 2 presents a non-scaled schematic drawing of station locations relative to the varying hydrologic and benthic character of the study area.

River run sampling location were located above the saltwater barrier and are represented by Stations 002 and 004. Although substrate differences, based on diver observations, were evident between the two stations, SOD rates were very similar with mean rates of 0.0270 and 0.0265 $gO_2/m^2/hr$ at Stations 002 and 004, respectively (Table 1). Extended to a 24-hour (day) respiration rate, each of these stations averaged 0.65 $gO_2/m^2/day$.

SOD experiments in the dredged ship channel are represented by rates associated with Stations 025 and 008. Station 025 exhibited a mean rate of 0.0272 $gO_2/m^2/hr$ (Table 1) or 0.65 $gO_2/m^2/day$, similar to the upstream river run stations. Although rate determinations were conducted at Station 008, they are not included in Table 1 due to the following qualifications. At Station 008, initial dissolved oxygen concentrations at the water/sediment interface were so suppressed (0.5 mg/L) that experiments had to be terminated at considerably shorter incubation times than normal. Accordingly, due to the initial DO concentrations near zero (0) and the short observation time, rates obtained at this station may be somewhat less reliable than those obtained at all other stations. Since rates obtained under such circumstances are questionable, SOD experiments conducted under such conditons are outside EPA, Region IV, ESD standard operating procedure. For these reasons, Station 008 rates are not included in Table 1. However, for discussion purposed only, a mean SOD rate of 0.0205 $gO_2/m^2/hr$ (based on four replicates) or 0.50 $gO_2/m^2/day$ was observed at Station 008.

Lake station SOD rates are represented by Station 007 in Lake Charles and Station 036 in Calcasieu Lake. Both stations were characterized by open, shallow water (7 to 8 feet) and soft, fine substrate. A mean SOD rate of 0.0264 $gO_2/m^2/hr$ was observed at Station 007 in Lake Charles, which is consistent with the rates reported above for river run and ship channel stations. Rates in Calcasieu Lake were slightly greater than those in Lake Charles. Station 036 in the northern section of Calcasieu Lake exhibited a mean SOD rate of 0.0348 $gO_2/m^2/hr$ (Table 1) or 0.84 $gO_2/m^2/day$.

Bayou D' Inde receives large volumes of heated industrial discharge as well as domestic waste water. Additionally, much of its shoreline and adjacent land consists of brackish water marshland. Diver observation of the Bayou D' Inde substrate revealed it to be a finely divided soft substrate underneathe a more chunky, irregular, large fragment layer. The substrate surface probably reflects the input of wetland material and eroding banks along the narrow channel. The water column of Bayou D' Inde was heated but well oxygenated. Benthic respiration rates at Station 019 in Bayou D' Inde averaged 0.0550 $gO_2/m^2/hr$ (Table 1) or 1.32 $gO_2/m^2/day$, nearly twice those reported in river run and ship channels (Table 1). Based on previous studies throughout the southeast, the increased water temperature was likely the prevailing influence elevating SOD rates in Bayou D' Inde along with the different substrate character.

Originally, SOD experiments were planned for the ship channel at Station 015, Coon Island loop (Figure 2). On-site, however, it was decided that SOD rates determine shoreward of the channel, in the shallow flats, would be more representative of the Coon Island loop area than the channel proper. Additionally, pending ship movements made deployment in the channel uncertain. At this location, diver observation revealed light penetration to the shallow bottom to be adequate for the possible existence of a microscopic plant community normally associated with marsh muds and adjacent shallow water zones. The enhanced metabolic activity of this zone was reflected in the highest mean SOD rate observed in the project area, 0.0690 g $O_2/m^2/hr$ or 1.66 g $O_2/m^2/day$. The higher SOD rate exhibited by this shallow water, non-channel, wetland associated zone should receive thorough consideration in defining the oxygen budget of this portion of the Calcasieu River estuary. Since it represents only one mean rate, based on five replicate observations, expansion of the rate to other zones in the study area should be done with caution. However, since much of the study area is probably represented by this type of benthic community (sediment and hydrographic mapping could determine the ratio of shallow water to dredge channel area), and since in every case non-channel SOD rates were greater than in-channel rates any modeling effort should be cognizant of and take into account the rate increases associated with shallow, wetland associated benthic communities versus deep channel areas.

Table . Sediment Oxygen Demand (SOD) Rates (Replicates and Means), Calcasieu River, Lake Charles, Louisiana, May 1984.

| Station | Rep | Avg. Rate of Change (mg/L/min) | Adjusted Avg.[1] mg/L/min | Respiration (R) or SOD g $O_2/m^2/hr$ | Mean R or SOD g $O_2/m^2/hr$ | $s$[2] | C[3] | Water Column Respiration (mg/L/min | Water Temp (°C) |
|---|---|---|---|---|---|---|---|---|---|
| 002 | 1 | .00205 | .00205 | .029 | .0270 | .0054 | 20.1 | -0- | 24.0 |
| | 2 | .00218 | .00218 | .031 | | | | | |
| | 4 | .00136 | .00136 | .019 | | | | | |
| | 5 | .00204 | .00204 | .029 | | | | | |
| 004 | 2 | .00158 | .00158 | .023 | .0265 | .0087 | 32.8 | -0- | 24.0 |
| | 3 | .00270 | .00270 | .039 | | | | | |
| | 4 | .00178 | .00178 | .025 | | | | | |
| | 5 | .00132 | .00132 | .019 | | | | | |
| 007 | 1 | .00313 | .00186 | .027 | .0264 | .0058 | 22.0 | .00127 | 24.2 |
| (Lake | 2 | .00313 | .00186 | .027 | | | | | |
| Charles) | 3 | .00294 | .00167 | .024 | | | | | |
| | 4 | .00259 | .00132 | .019 | | | | | |
| | 5 | .00369 | .00242 | .035 | | | | | |
| 015 | 1 | .00452 | .00429 | .061 | .0690 | .0096 | 13.9 | .00023 | 24.2 |
| | 2 | .00464 | .00441 | .063 | | | | | |
| | 3 | .00601 | .00578 | .083 | | | | | |
| | 4 | .00464 | .00441 | .063 | | | | | |
| | 5 | .00547 | .00524 | .075 | | | | | |

[1] Adjusted avg. obtained by subtraction of water column R from avg. rate of change (SOD) at mg/L/min level.

[2] $s$ = standard deviation

[3] C = coefficient of variation as percent

Table (continued)

| Station | Rep | Avg. Rate of Change (mg/L/min) | Adjusted Avg.[1] mg/L/min | Respiration (R) or SOD g $O_2/m^2$/hr | Mean R or SOD g $O_2/m^2$/hr | 2 | C[3] | Water Column Respiration (mg/L/min) | Water Temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|
| 019 (Bayou d'Inde) | 1 | .00600 | .00420 | .060 | .0550 | .0150 | 27.3 | .00180 | 26.0 |
| | 2 | .00447 | .00267 | .038 | | | | | |
| | 3 | .00690 | .00510 | .073 | | | | | |
| | 5 | .00523 | .00343 | .049 | | | | | |
| 025 | 1 | .00178 | .00178 | .025 | .0272 | .0061 | 22.3 | -0- | 24.5 |
| | 2 | .00170 | .00170 | .024 | | | | | |
| | 3 | .00262 | .00262 | .038 | | | | | |
| | 4 | .00175 | .00175 | .025 | | | | | |
| | 5 | .00166 | .00166 | .024 | | | | | |
| 036 (Calcasieu Lake) | 1 | .00333 | .00238 | .034 | .0348 | .0051 | 14.6 | .00095 | 23.0 |
| | 2 | .00333 | .00238 | .034 | | | | | |
| | 3 | .00333 | .00238 | .034 | | | | | |
| | 4 | .00392 | .00297 | .043 | | | | | |
| | 5 | .00295 | .00200 | .029 | | | | | |

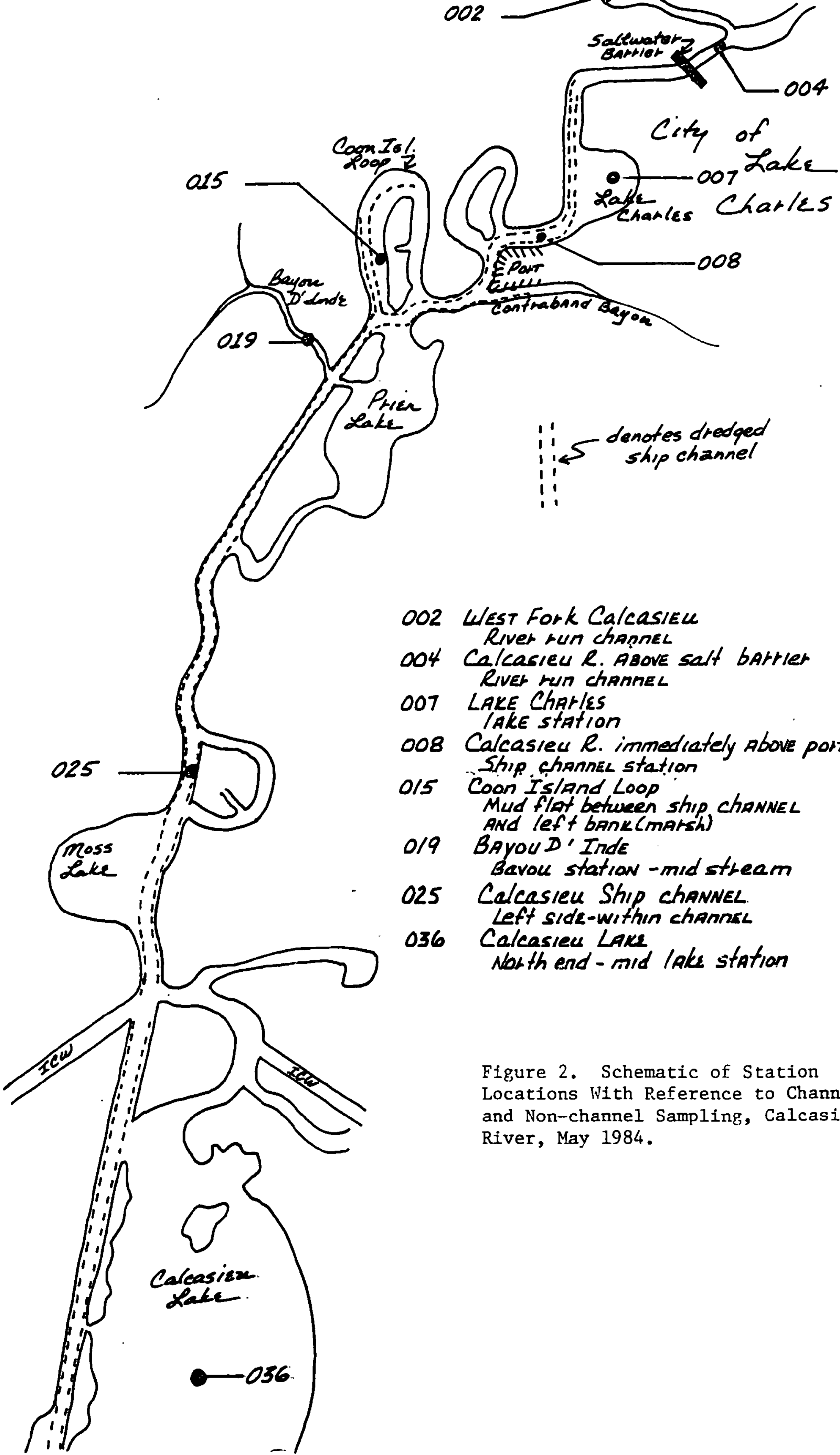



Figure 2. Schematic of Station Locations With Reference to Channel and Non-channel Sampling, Calcasieu River, May 1984.

APPENDIX A

- SOD Chamber
- Photometer
- Pyranograph
- Dissolved oxygen meters and Winkler chemicals
- Salinometer
- Conductivity meter
- Thermistor
- KCl solution
- BOD bottles
- Corer
- Collection bags for vegetation

2.12.9.2 Procedures

- Investigators should calibrate dissolved oxygen meters (Winkler method) and other monitoring equipment such as salinometers, conductivity meters, and recorders; DO probe should be self-stirring.

- Then team should begin recording daily solar intensity if benthic primary production rates are desired and obtain vertical profile of dissolved oxygen, light extinction, and other desired parameters such as temperature, salinity and conductivity; continue procedures by checking delivery of power and operation of circulation pump.

- After preliminary checks and information gathering are completed, team should deploy chamber with lid open gently lowering the chamber with rope. When chamber is on the bottom, placement, positioning, and securing of seal and lid closure should be done by divers. The chamber used for monitoring water column respiration (called a "blank" since it is isolated from the sediment by a glass bottom) should be deployed first and purged with bottom water for at least 15 minutes prior to sealing. Other chambers can be deployed while this process occurs. Be sure that purge valve is closed after purging.

- Approximately 15 minutes should be allowed for settlement of any resuspended materials; then team should start pump and place monitoring probes in chamber. Ambient probes should be lowered to dome level and approximately one foot above bottom; record initial monitoring data. (Note: If used in fresh water, salt solution can be injected into pump discharge port at this time if desired).

  In conjunction with use of the "blank" chamber to assess respiration of the water column, bottle (dark) experiments are advised as back-up source of data since only one "blank" chamber is used. The dark bottle experiments should begin at this time positioned at same depth as chamber. A minimum of two bottles should be filled with bottom water collected adjacent to chambers and deployed alongside the chambers for incubation during the course of the SOD experiments.

- Team should record monitoring data either continuously or at 15-minute intervals. If 15-minute intervals are used, probe stirrer may be turned off between readings but should be turned on a sufficient time (approximately 1 minute) before reading so meter can reach stabilization; check zero and power output (red line) of DO meter frequently; continue experiment for approximately 1 hour. Oxygen readings at 15-minute intervals during the period will provide sufficient data points for analysis.

- After obtaining a sufficient number of data points, monitoring probes should be removed from dome and calibration checked.

- Immediately after the experiment, team should collect sediment core and vegetation biomass from within dome placement if so desired.

- Of the five replicates attempted, a minimum of three should be determined successful, on-site, or else the experiments repeated.

- Sealing of chamber to substrate should be conducted and confirmed by divers in both salt and fresh water. Additionally, in fresh waters a concentrated salt solution may be injected into the chamber and conductivity monitored. Any decline in conductivity after equilibrium would indicate intrusion of outside ambient water.

- Pump operation should be determined prior to chamber deployment and confirmed by divers prior to securing the lid to the chamber.

- Resuspension should be visually checked by divers in waters with sufficient clarity, but in all cases a 10-minute time delay is observed prior to beginning pump operation to allow time for settlement. Plotting of observed data points during and after experiments also should be accomplished to determine resuspension and its effect on SOD rates.

- Between and post experiment calibration checks should be accomplished by removing DO probes from chambers during relocation or retrieval and positioning the chamber probes adjacent to the ambient probe. Similarity in probe measured DO concentrations (less than 0.5 mg/L deviation) indicates adequate calibration maintenance. Deviation in concentrations beyond the above dictates recalibration via Winkler method.

- All light and dark bottle DO concentrations should be determined generally according to Standard Methods (1980).

2.12.9.3 SOD Rate Calculations and Data Assessment

During in-situ SOD rate determinations, the decay or production rate of oxygen is recorded as the instantaneous dissolved oxygen concentration at specific time intervals, usually 10 or 15 minutes. The specified interval must be adhered to throughout each individual experiment.

Rate calculations are accomplished by solving the equation:

$$\beta \cdot \frac{.06v}{A} = g\ O_2/m^2/hr$$

where,

$\beta$ = rate of change in DO as mg $O_2$/L/min

v = chamber volume in liters

A = chamber area in meters square

.06 = constant

Beta ($\beta$) is determined by calculation of the average rate of change in DO (mg $O_2$/L/minute) for each recorded interval. Negative rates represent respiration (R) of the benthic community while positive rates, obtained only in the clear chamber, represent net primary production (NPP).

All rates should be adjusted for water column metabolic functions at the mg $O_2$/L/min level before being extended to the hourly rate. Light and dark bottle (water column NPP and R) values should be determined by simple division of the average change in DO concentration within each set of bottles by the incubation period.

2.12.9.4 Precision (see section 2.11.2)

2.12.9.5 Quality Control Checks with Acceptable Limits When/Where Applicable

- All DO meters should be calibrated via the Winkler method (Standard Methods, 1980) prior to determination of dissolved oxygen profile and initiation of SOD experiment. Salinometer and conductivity meters should be calibrated electronically.

- Sealing of chamber to substrate should be conducted and confirmed by divers in both salt and fresh water. Additionally, in fresh waters a concentrated salt solution may be injected into the chamber and conductivity monitored. Any decline in conductivity after equilibrium would indicate intrusion of outside ambient water.

- Pump operation should be determined prior to chamber deployment and confirmed by divers prior to securing the lid to the chamber.

- Resuspension should be visually checked by divers in waters with sufficient clarity, but in all cases a 10-minute time delay is observed prior to beginning pump operation to allow time for settlement. Plotting of observed data points durinng and after experiments also should be accomplished to determine resuspension and its effect on SOD rates.

- Between and post experiment calibration checks should be accomplished by removing DO probes from chambers during relocation or retrieval and positioning the chamber probes adjacent to the ambient probe. Similarity in probe measured DO concentrations (less than 0.5 mg/L deviation) indicates adequate calibration maintenance. Deviation in concentrations beyond the above dictates recalibration.

- All light and dark bottle DO concentrations should be determined via Standard Methods (1980).