DATASONDE MONITORING IN THE LOXAHATCHEE RIVER

TASK 2: FINAL REPORT

In Partial Fulfillment of PC P601858

For the Period

October 2005 through April 2006

Respectfully Submitted by

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October 23, 2006

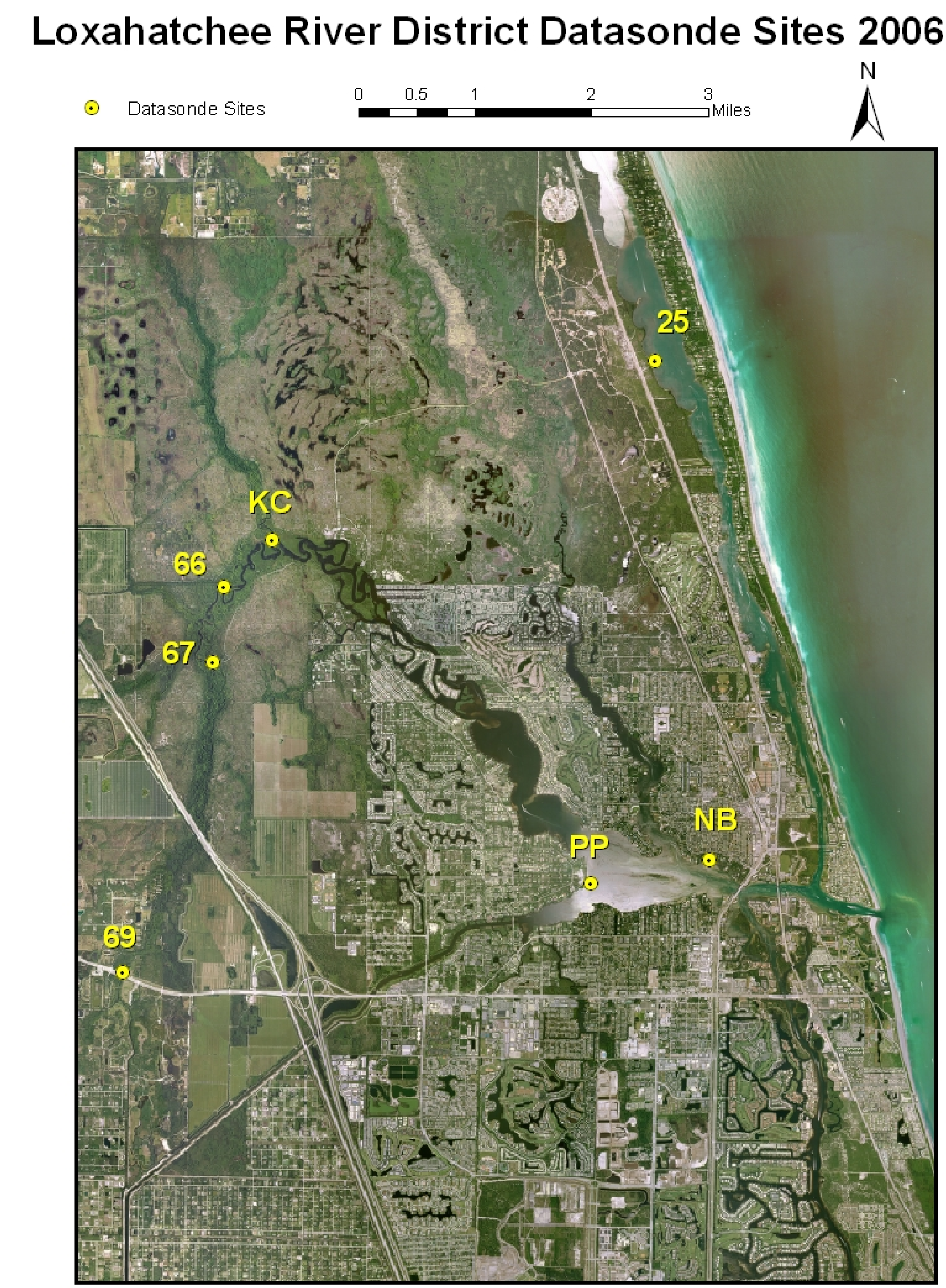


Figure 1. Datasonde sampling locations within the Loxahatchee River and southern Indian River Lagoon. See the text for sampling station names.

Introduction

Since January 2004, the Loxahatchee River District has partnered with the South Florida Water Management District to continuously monitor physical water quality parameters (i.e., temperature, salinity) within the Loxahatchee River Watershed. This monitoring program has several specific goals, and they include the following: (1) establishing baseline conditions in the Loxahatchee River and Estuary, (2) establishing the relationship between freshwater discharge (i.e., over Lainhart Dam and/or S-46) and salinity dynamics in the estuary and the river, (3) establish a better understanding of the daily salinity variability within the estuary and river, and (4) provide observational data on a nearly continuous basis that can be used to calibrate and validate salinity models. Results from the datasonde monitoring project already have been used to understand *why* seagrasses were so severely impacted by the storms of September 2004 and the resulting freshwater discharge (Ridler et al. 2006). Furthermore, as you will see below, these data go a long way towards achieving each of the goals stated above.

While this report primarily covers the data collected from October 2005 through September 2006, several of the graphics used to illustrate and define relationships between freshwater discharge and salinity dynamics are based on data from the entire period of record (April 2004 through September 2006). This report was designed to highlight some of the most important and relevant observations and findings that resulted from the datasonde monitoring. Goal 1 is addressed in the graphics in the appendix. Goals 2 and 3 are addressed in the body of the report. Goal 4 is not addressed in this report, and most likely can only be addressed by SFWMD staff in the Coastal Ecosystems Division.

Study Area

The Loxahatchee River Estuary encompasses approximately 400 ha and drains a watershed of approximately 700 km2 located in northeastern Palm Beach County and southeastern Martin County, Florida, USA. Freshwater discharges into the estuary from the North Fork, the Northwest Fork, and the Southwest Fork of the Loxahatchee River. The hydrology of the basin has been substantially altered by flood control efforts since the 1950s. Historically (pre-1950), most surface water runoff reaching the estuary originated in the Loxahatchee and Hungryland Sloughs and flowed gradually to the Northwest Fork. In the 1930s the Lainhart Dam, a small fixed-weir dam, was constructed in the Northwest Fork at river mile

14.5 to reduce "over" drainage of upstream reaches of the Northwest Fork during the dry season. In 1958 a major canal (C-18) and flood control structure (S-46) were constructed to divert flows from the Northwest Fork to the Southwest Fork, which increased the intensity and decreased the duration of storm-related discharge to the estuary. Furthermore, since 1947 Jupiter inlet, the eastern link to the ocean, has been kept permanently open through ongoing dredging projects, which increased saltwater intrusion into the primarily freshwater Northwest Fork. Ongoing restoration efforts seek to increase base flows into the Northwest Fork, while not compromising the ecological integrity of downstream reaches (i.e., estuary) nor impairing valued ecosystem components of the estuary such as oysters and seagrasses (SFWMD 2006).

During this study, datasondes were used to monitor physical water quality conditions at seven sites (Figure 1). Water quality monitoring occurred at three seagrass stations. These stations were North Bay (NB), Pennock Point (PP), and Station 25. North Bay (NB) and Pennock Point (PP) were located in the central embayment of the Loxahatchee River (Figure 1), while Station #25, which was only added in January 2006, was located 8 km north of Jupiter Inlet in the southern Indian River Lagoon. At each of these sampling locations, datasondes were used to monitor temperature, salinity, conductivity, and water depth.

Water quality monitoring also occurred at four locations in the Wild and Scenic segment of the Northwest Fork of the Loxahatchee River (Figure 1). These sites were Stations 69, 67, 66, and Kitching Creek (KC). Station 69 was the most upstream location and was located where Indiantown Road crosses the Loxahatchee River. Station 67 is at Trapper Nelson's dock. Station 66 is in the Loxahatchee River near the confluence of Hobe Grove ditch. The Kitching Creek (KC) site was in the Loxahatchee River at the confluence of Kitching Creek (see Figure 1). Note that two datasondes were deployed at Kitching Creek – one at the surface (0.5 m deep) and one in the middle of the channel approximately 20 cm off the bottom. At each of these monitoring locations in the Wild and Scenic River the following parameters were monitored: temperature, pH, DO, salinity, conductivity and water depth. It should be noted that stations 67 and 66 were added as a result of the extended drought observed during the monitoring period. These "supplemental" stations were added to help understand the dynamical movement of the salt wedge upstream into the Northwest Fork as a result of diminished freshwater discharge over Lainhart Dam.

Materials and Methods

At each station, LRD technicians employed a multi-parameter datasonde (either a HydroTech Data Sonde 3 or Data Sonde 4 or a YSI 600 OMS unit) to collect physical water quality parameters. We have included a brief description of how we employ datasondes. First, multi-parameter datasondes were used in both freshwater and marine waters. Datasondes were used to monitor temperature, depth, pH, conductivity/salinity and dissolved oxygen in freshwater, while only temperature, depth, and salinity were monitored in marine waters (e.g., NB). Typically, datasondes were placed within 25 cm of the bottom (see Kitching Creek surface site exception above), and observations were recorded every 15 minutes – though a 60 minute interval was used at Station 69.

Prior to datasonde deployment, an initial calibration was performed following the protocol described in the operating manual. Once the initial calibration was accomplished, the datasonde was programmed to begin collecting data at the appropriate start time and with a 15 minute interval between readings. Datasondes were deployed in an upright position, with the probes facing down, to minimize fouling of the probes. On a weekly basis, LRD technicians traveled to each of the datasonde sites and performed an *in situ* QC check by collecting an *in situ* comparison reading using an appropriately calibrated datasonde. This permited a comparison between results obtained from the field-deployed datasonde and the hand-held unit. Typically, datasondes were deployed for one week in marine waters or for two weeks in brackish and freshwaters. Upon collection, a final calibration was performed following the protocol described in the operating manual. In order for data to meet LRD's QA/QC acceptance criteria, weekly QC checks and final calibration data must have met the following criteria:

1. Dissolved Oxygen – difference ≤ 0.5 mg/L
2. Specific Conductance – difference ≤ 10%
3. pH – difference ≤ 0.5 pH units
4. Temperature – difference ≤ 0.5 °C

Data meeting the above criteria were accepted as valid, while data not meeting these criteria were rejected as unreliable and removed from the final (edited) dataset.

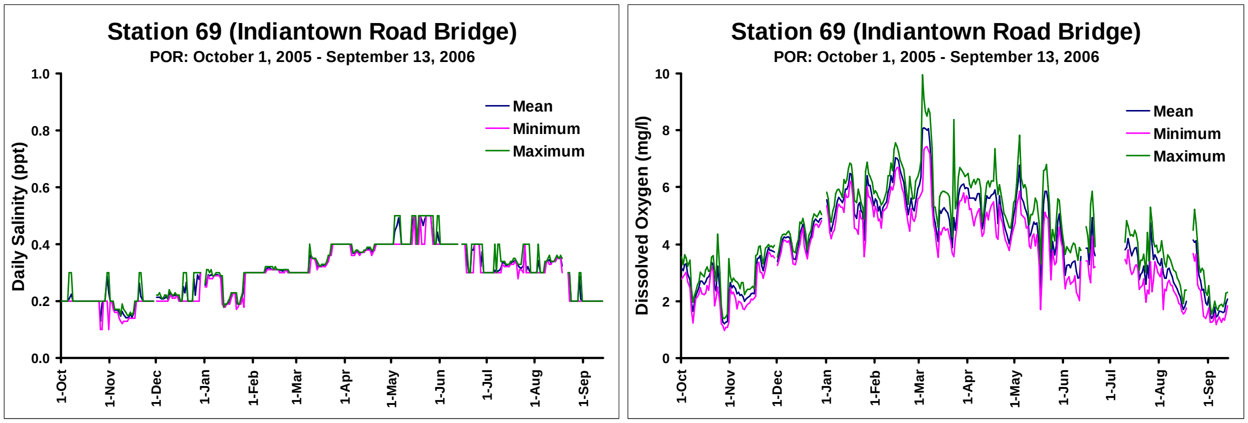


Figure 2. Salinity fluctuations at Station 69 (Indiantown Road bridge). This graph clearly shows the lack of saltwater intrusion at Station 69. Dissolved oxygen monitoring shows seasonally depressed values, which suggest biota may be impaired from August through November.

Results

Results from the datasonde monitoring project clearly show the daily and seasonal variability of the various monitored parameters (e.g., salinity, dissolved oxygen) within and among the monitored locations. For example, datasonde observations show substantial seasonal variability in dissolved oxygen at Station 69, with much of the summer and early fall having relatively low dissolved oxygen conditions (Figure 2). Similarly, Figure 3 shows the effects of saltwater intrusion. During the prolonged dry period (Feb. – Jun. 2006) daily salinities fluctuated between ~2 ppt to >16 ppt each day in the surface waters at the Kitching Creek monitoring site.

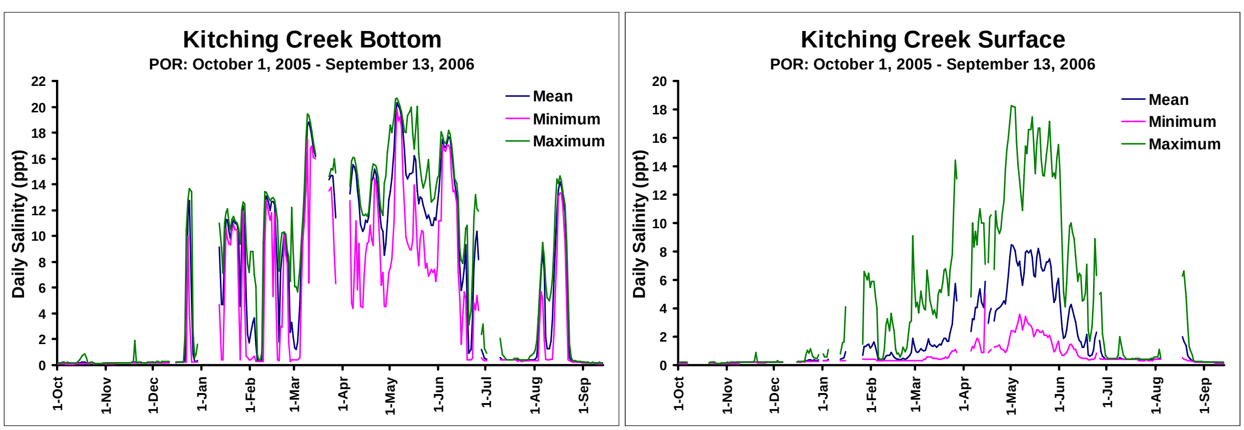
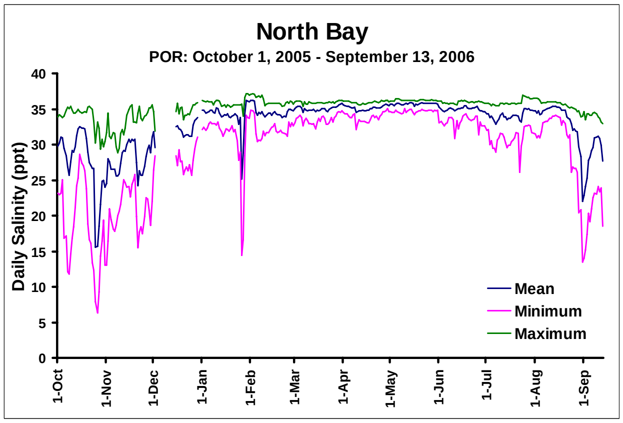
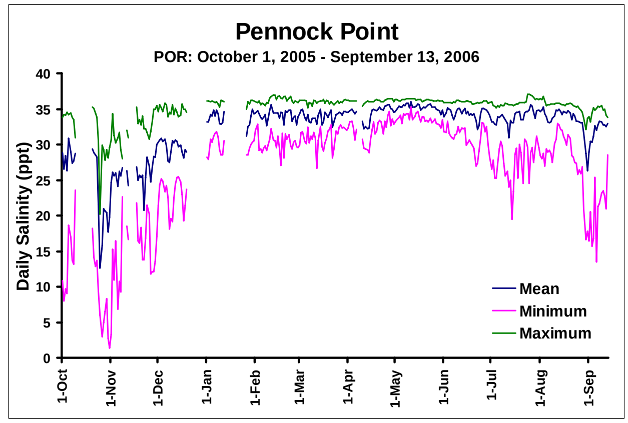


Figure 3. Daily and seasonal salinity fluctuations in the Loxahatchee River at the confluence with Kitching Creek. Observations are for both the bottom (left) and surface (right) datasondes. Note the excessive difference between daily minimum and maximum salinity values as recorded by the surface probe.





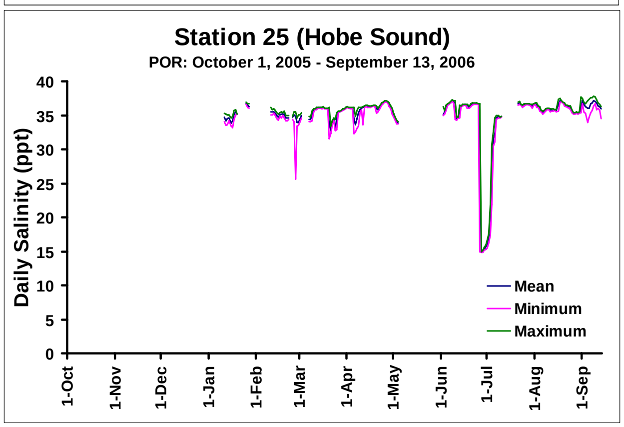


Figure 4. Daily and seasonal salinity fluctuations at the seagrass sampling sites. Note the near overlap among minimum, mean, and maximum daily salinity at Station 25, and then note the disparity among these same measures at North Bay and Pennock Point. It appears that the large daily salinity fluctuations in the Loxahatchee River are likely responsible for the dominance of *Halodule wrightii*.

Results from the datasonde project have already been used to understand *why* seagrasses were so severely impacted by the storms of September 2004 and the resulting freshwater discharge (Ridler et al. 2006). We believe the data resulting from the datasonde project are of utmost importance when understanding when and where seagrasses are stressed (i.e., experience physiologically stressful conditions). Figure 4 illustrates the salinity regime differences between the three datasonde monitoring sites associated with seagrasses. Previous work by LRD has clearly established that shoal grass (*Halodule wrightii*) is the dominant seagrass species in the Loxahatchee River Estuary, and it is known that this species is tolerant of broadly fluctuating salinity conditions. The datasonde data for North Bay and Pennock Point, presented in Figure 4, clearly show large daily salinity fluctuations in the Loxahatchee River Estuary, and furthermore, data from the datasonde at Station 25 (in the southern Indian River Lagoon) show the absence of such large daily salinity fluctuations. While not conclusive, these data are helping form our understanding of the conditions necessary for various seagrass species survival.

Furthermore, salinity data from the datasonde monitoring project have been used to understand how freshwater discharged into the Loxahatchee River Estuary (e.g., over Lainhart Dam and/or S-46) influence the daily salinity regime in the estuary and in particular at seagrass beds (Figure 5). It is both intuitive and immediately apparent that as freshwater flows (i.e., discharge into the system) increase, salinity values decrease. Nonetheless, datasonde data have been used to clearly describe the effect of discharge on minimum daily salinity, mean daily salinity, and maximum daily salinity values. Furthermore, this has been done for both the seagrass sites (NB and PP) as well as Kitching Creek surface and bottom sites (Figure 6). These curves document discharge–salinity relationships, and can be used to influence water management decisions (i.e., the amount of freshwater discharge that results in altered salinities at seagrass sites).

Data presented in Figure 7 clearly show that salinities in the southern Indian River Lagoon are not affected by freshwater discharged over Lainhart Dam and/or S-46. Furthermore, data in Figure 7 show the relatively stable nature of salinities at Station 25, which may help explain the high quality seagrass beds located at this site.

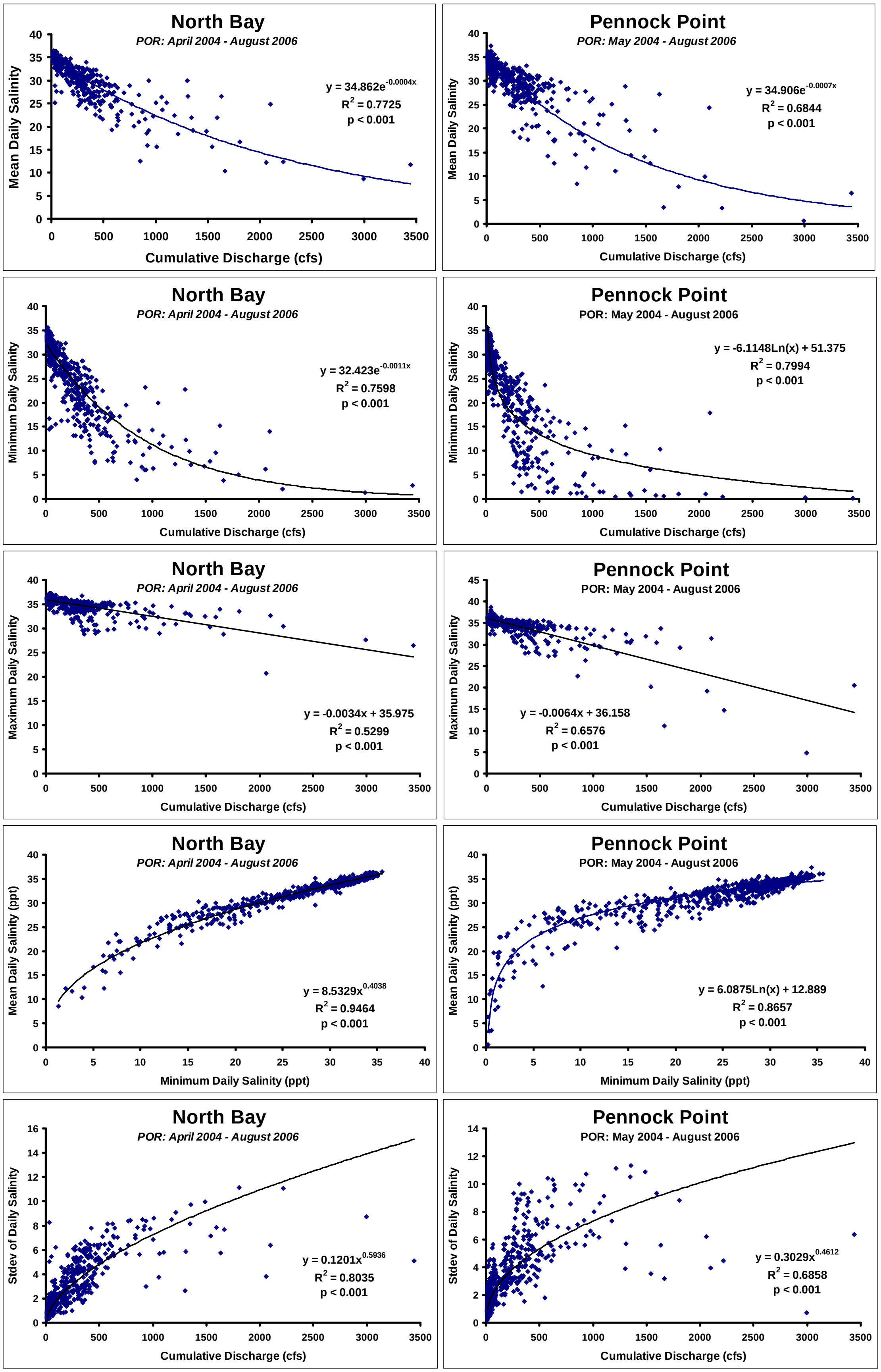


Figure 5. Statistical relationships between cumulative discharge (Lainhart flow + S-46 flow) and various measures of salinity at NB and PP. All regressions are significant at $p<0.001$.

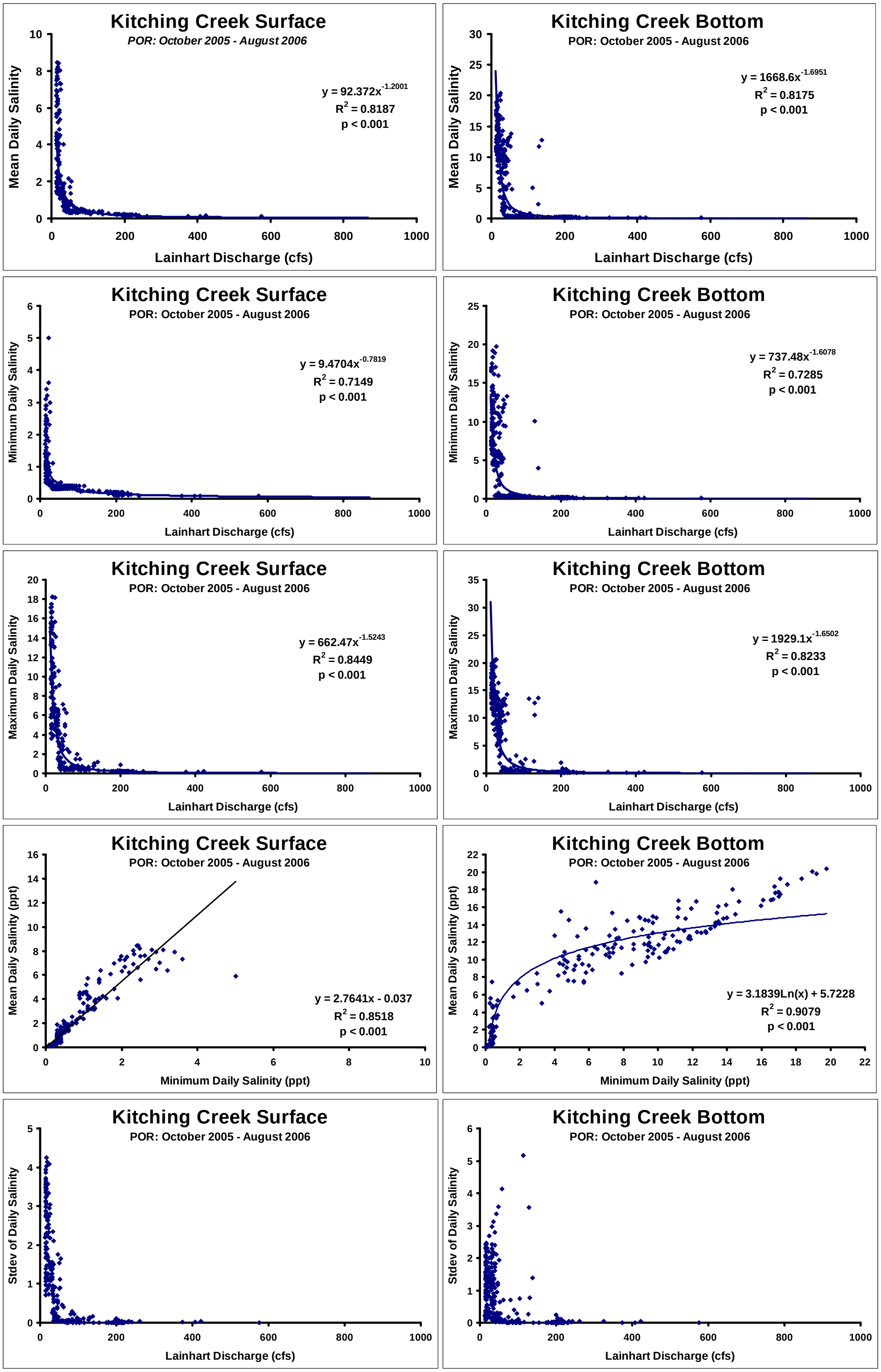


Figure 6. Statistical relationships between discharge over Lainhart Dam and various salinity measures at Kitching Creek. All regressions are significant at $p<0.001$.

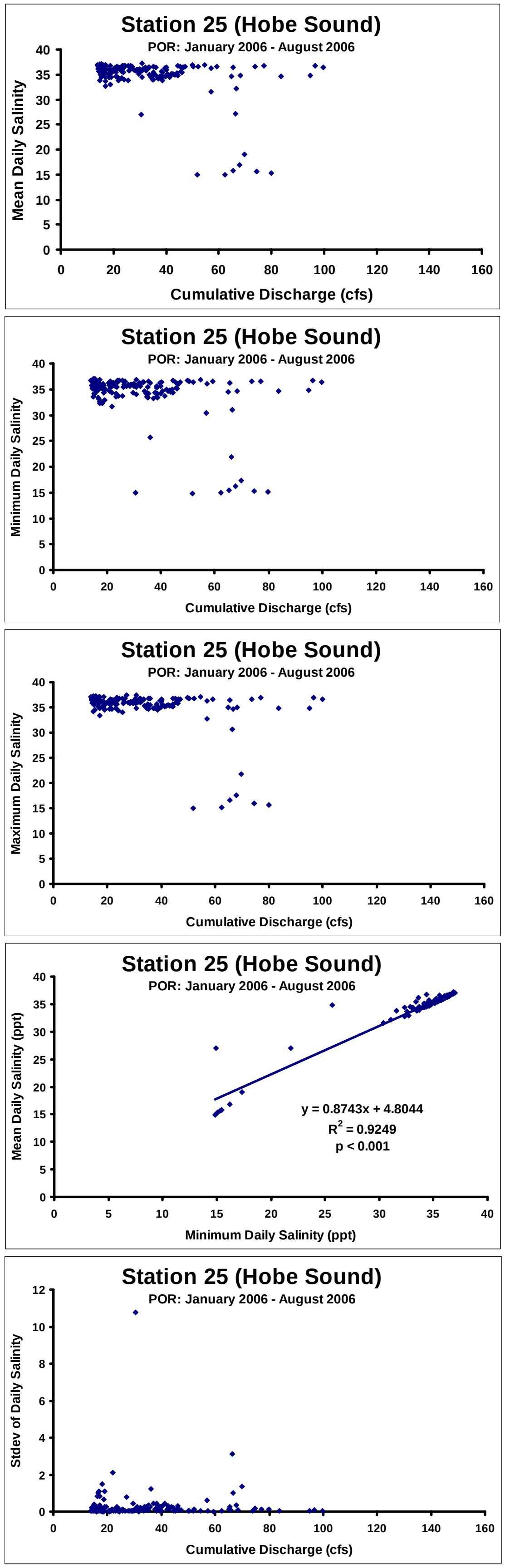


Figure 7. Statistical relationships between cumulative discharge (Lainhart flow + S-46 flow) and various salinity measures at Station 25. All regressions are significant at $p<0.001$.

Discussion

The goals of the datasonde monitoring project were to: (1) establish baseline conditions in the Loxahatchee River and Estuary, (2) establish the relationship between freshwater discharge and salinity dynamics in the estuary and the river, (3) establish a better understanding of the daily salinity variability within the estuary and river, and (4) provide observational data on a nearly continuous basis that can be used to calibrate and validate salinity models. Figures 2 through 6 as well as Appendix A clearly accomplish goal 1. That is, we are gaining a solid understanding of the pre-CERP physical water quality conditions in the Loxahatchee River and Estuary. Figures 5 and 6 clearly document the relationships between freshwater discharge and salinity conditions in the Loxahatchee River and Estuary (goal 2). Furthermore, these figures clearly document the statistical relationship between mean daily salinity (a parameter provided by the current salinity model) and minimum daily salinity (the salinity parameter suggested to be most important when trying to understand when seagrasses are stressed; Ridler et al. (2006)). The accomplishment of goal three is illustrated most effectively in Figures 3 and 4. Finally, at present LRD staff do not have the expertise to accomplish goal 4. However, we look forward to working collaboratively with SFWMD staff to accomplish this important goal.

In conclusion, the datasonde project has resulted in the compilation of an amazing amount of data that has a very direct relevance to ongoing research, monitoring, and restoration in the Loxahatchee River and Estuary. However, our work is not done. More work needs to be accomplished, and more specifically, more datasonde data needs to be collected. Specifically, datasonde data needs to be collected in the vicinity of the existing oyster reefs in the Loxahatchee River. We look forward to continuing this cost-effective collaboration.

Literature Cited

Ridler, M. S., R. C. Dent and D. A. Arrington. 2006. Effects of two hurricanes on *Syringodium filiforme*, manatee grass, within the Loxahatchee River Estuary, Southeast Florida. Estuaries and Coasts 29: *In Press*.

(1) COORDINATES OF THE MONITORING SITES

Coordinates are provided in decimal degrees using the WGS84 Datum Coordinate System.

Station	Latitude	Longitude	Period of Record
69	26.937309460	-80.176155231	10/1/05 – 9/13/06
KC	26.991137909	-80.155045620	10/1/05 – 9/13/06
25	27.013308183	-80.101452568	1/1/06 – 9/13/06
NB	26.950903312	-80.094306194	10/1/05 – 9/13/06
PP	26.948131888	-80.110831491	10/1/05 – 9/13/06
66	26.985330292	-80.161806702	3/21/06 – 7/10/06
67	26.976002794	-80.163348247	3/21/06 – 7/10/06

(2) DESCRIPTION OF PROBE CALIBRATION AND Q/A Q/C PROCEDURES

See the interim report submitted by LRD.

(3) FORMULAS FOR PARAMETER CONVERSION AND CALCULATION

See the interim report submitted by LRD.

(4) DISCUSSION OF DATA ACCURACY

The accuracy of the data can be defined by the limits set in the QA/QC Acceptance Criteria found in the LRD Standard Operating Procedures (see item (2) above). Data that do not meet QA/QC Acceptance Criteria were deleted from the record and not reported in the data (spreadsheet) files. Nonetheless, we also have provided raw data files, which are the direct downloads of the datasondes and have not been edited for QC.

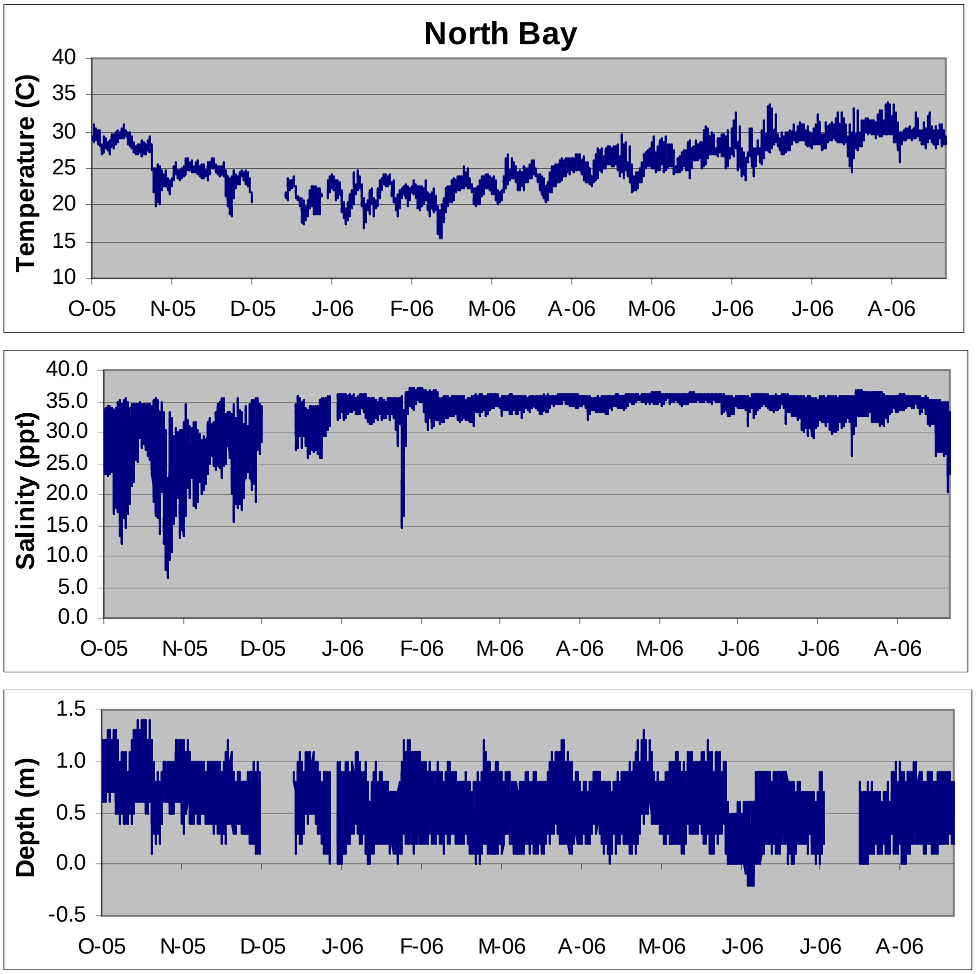
(5) LIST OF DATA PROVIDED

In addition to this written report, a CD-ROM has been provided that contains electronic files of the report and all data (original and converted) in MS Excel spreadsheets. The CD is structured with three main folders (Data, Location, and Report). The Data folder contains a folder (1 All Stations Composite Data) that contains all QA/QC data, and a separate folder for each sampling site (e.g., 25, 69, KC, NB, and PP) that contains all raw data for the site. Again, the "Raw Data" have not been edited for quality assurance or quality control. The data in the folder "1 All Stations Composite Data" represent our working data. These data do not contain any data that do not meet QA/QC acceptance criteria.

The Datasonde QA/QC procedures and calibration are on the CD in the File Report:

- LRD Standard Operating Procedures (printed in report)
- DEP Standard Operating Procedures (printed in report)
- Hydrolab Corporation Operating Manual Part 3 Maintenance and Calibration
- The Datasonde Formulas for Parameter Conversion and Calculation
- Hydrolab Corporation Operating Manual Part 5 Technical Notes
- YSI Incorporated 6-Series Environmental Monitoring Systems Manual (includes formulas for parameter conversion and calculation)

APPENDIX: Composite graphics for each datasonde site showing the relevant period of record (10/1/05 – 9/13/06).



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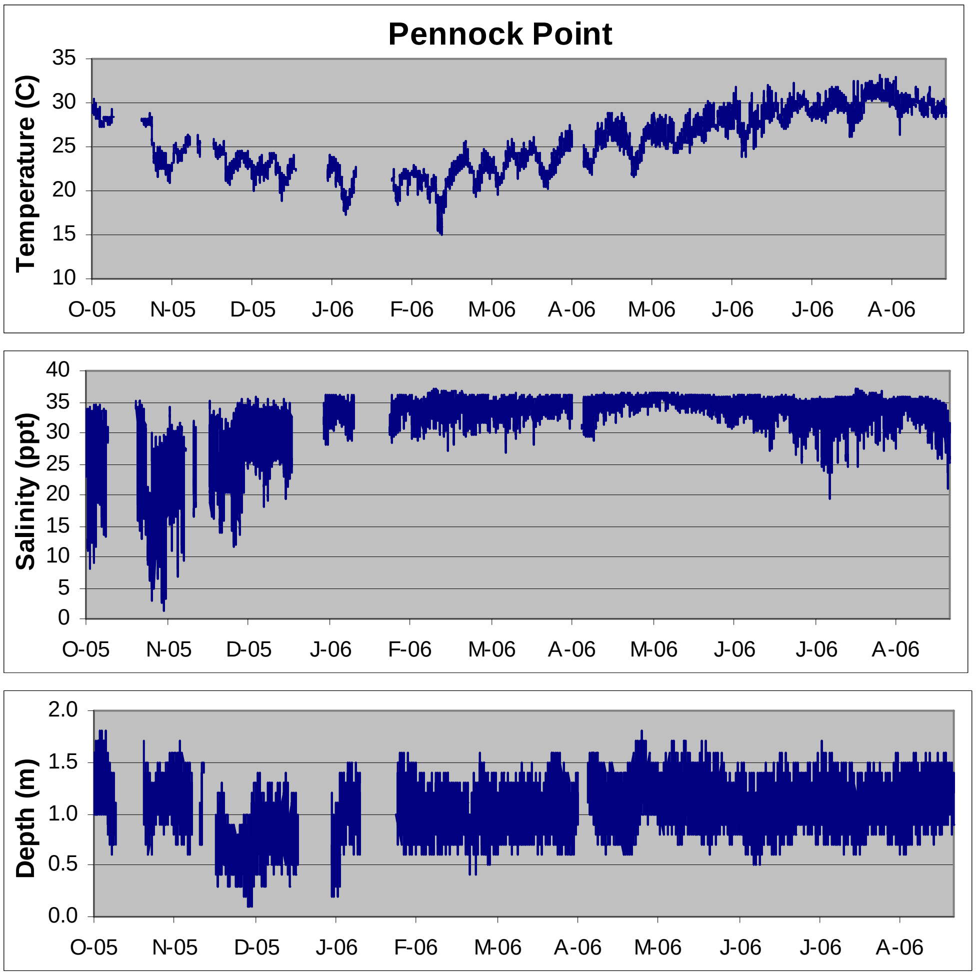

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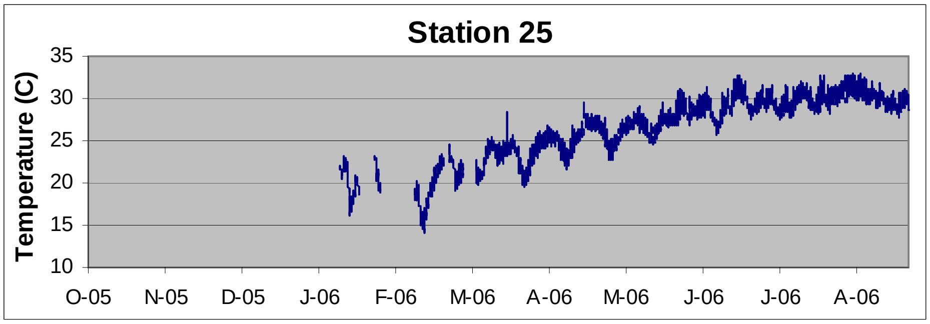

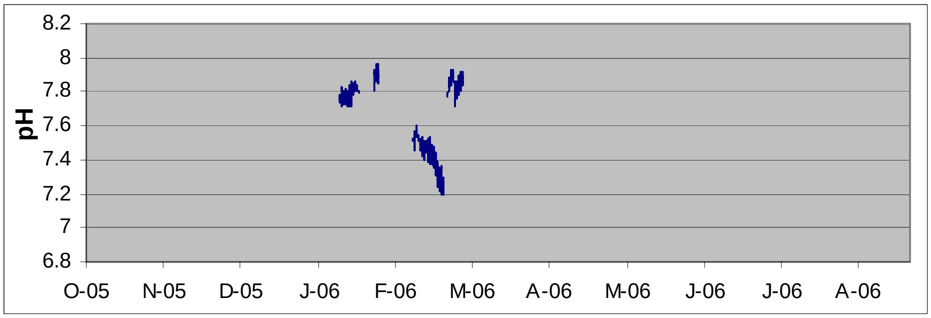

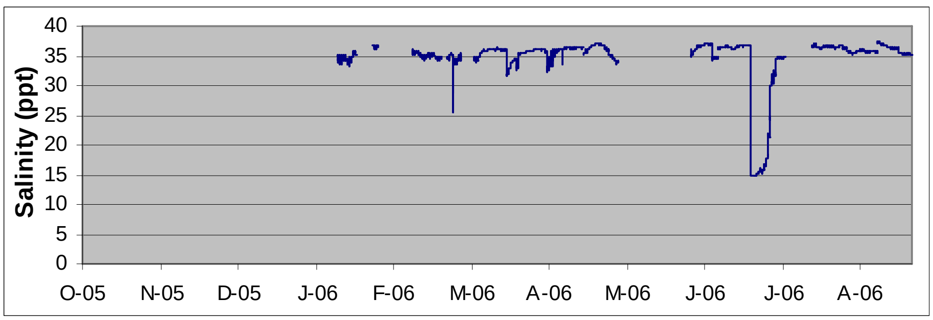

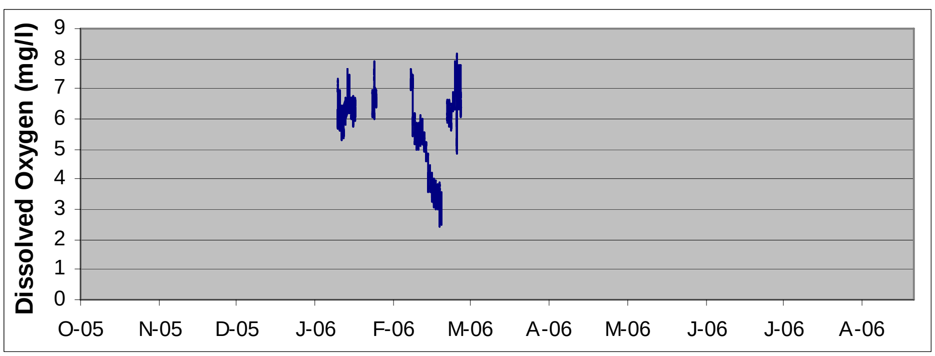

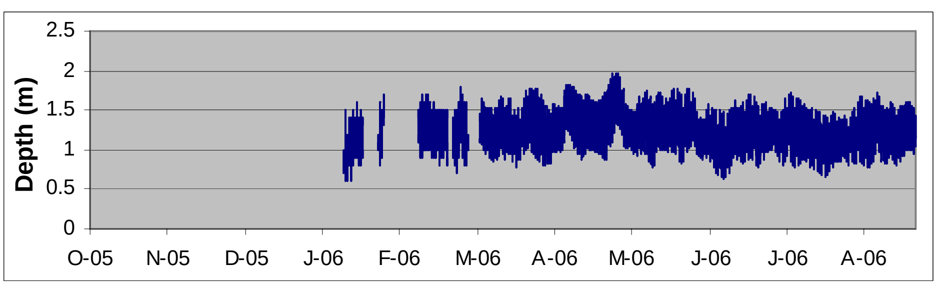

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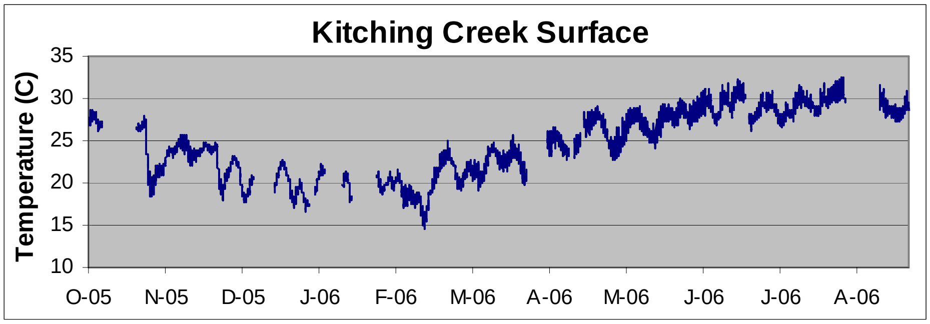

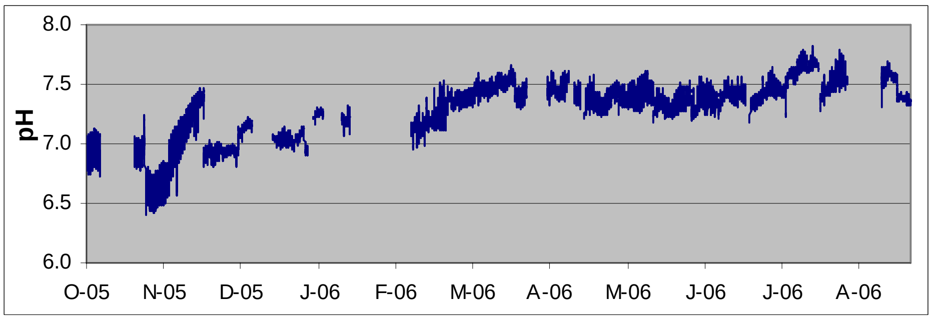

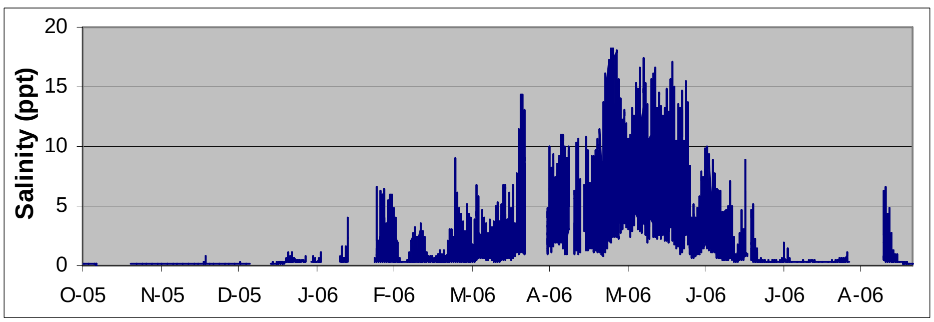

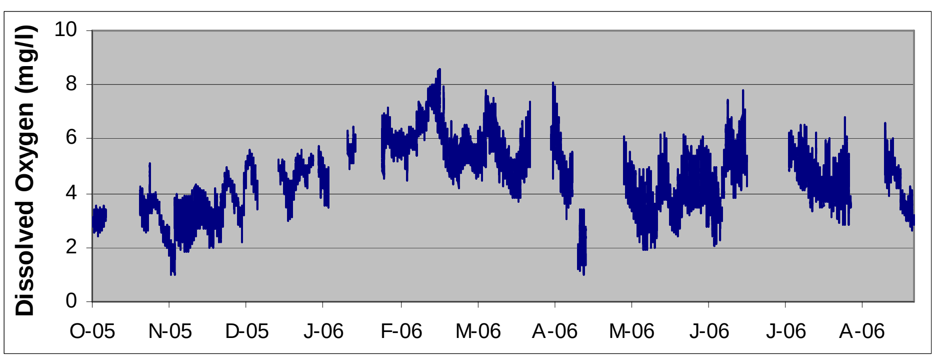

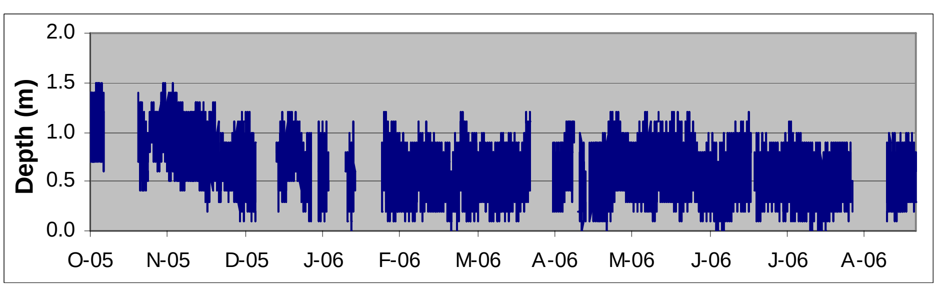

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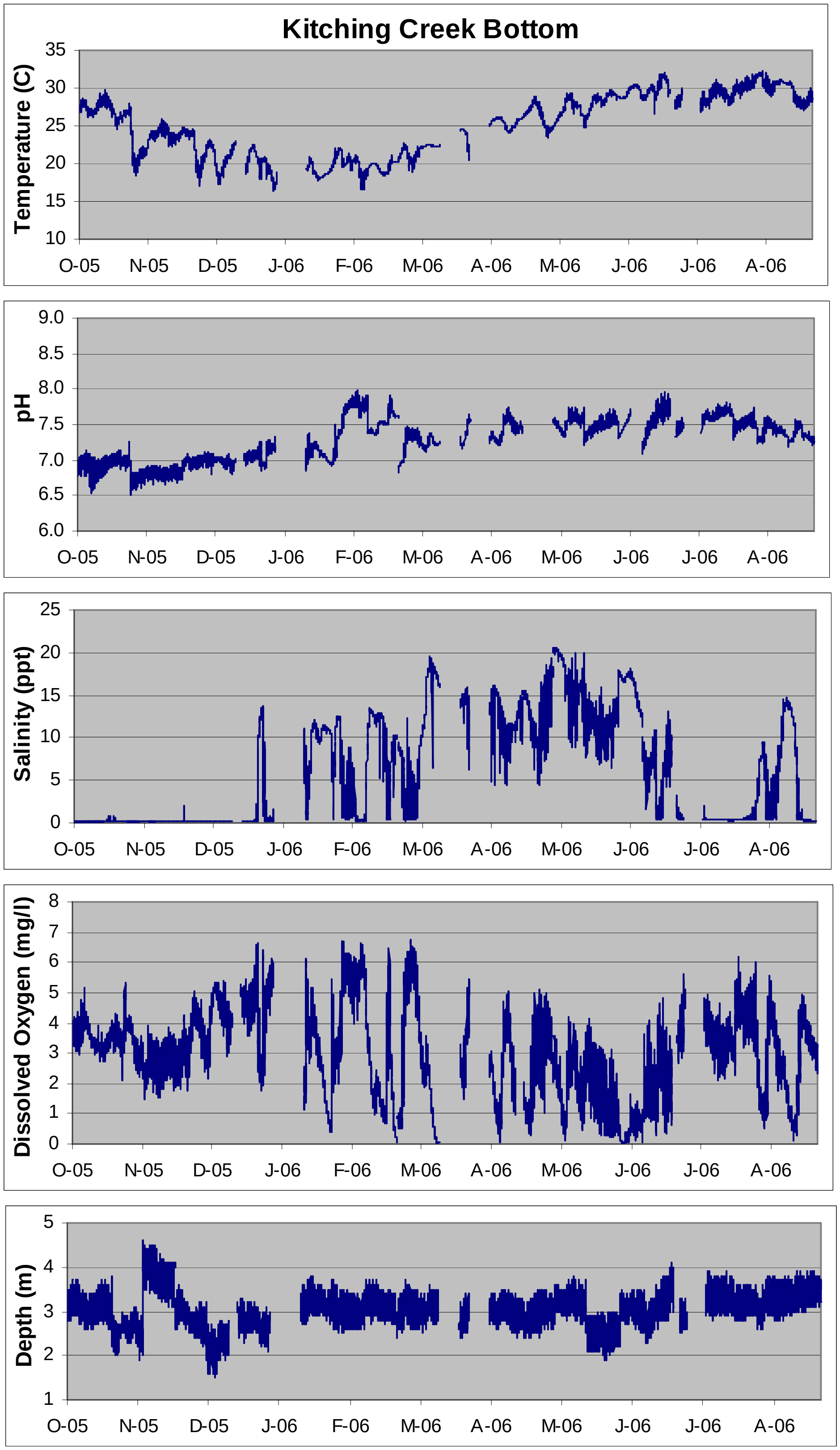

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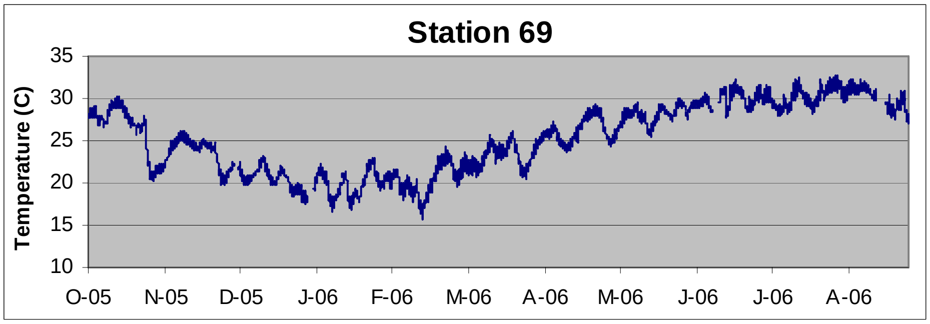

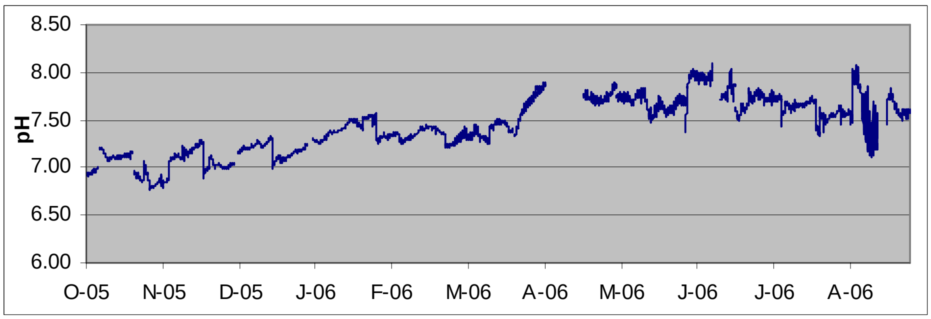

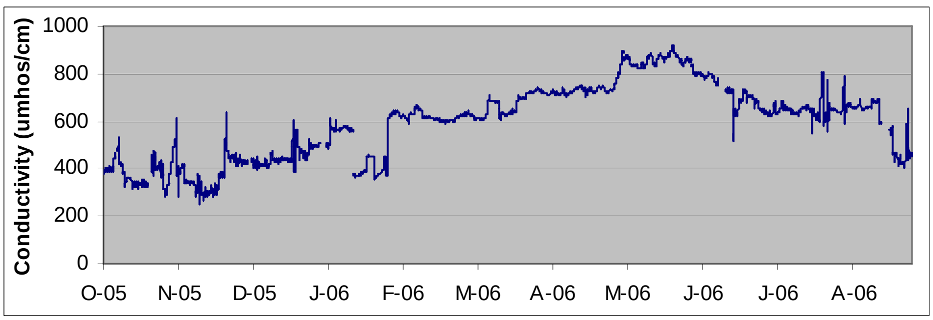

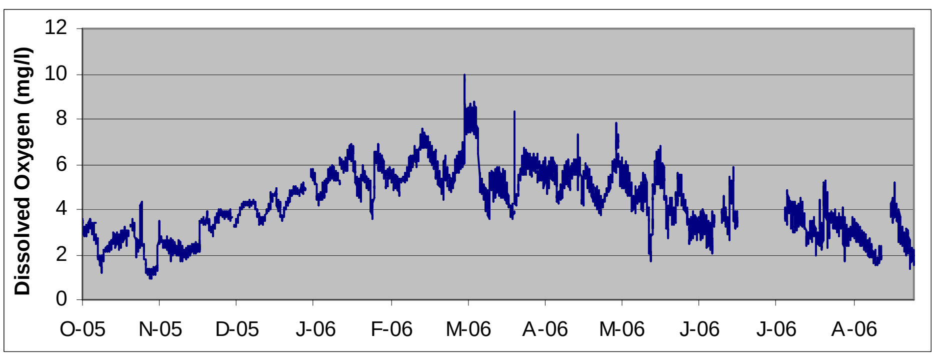

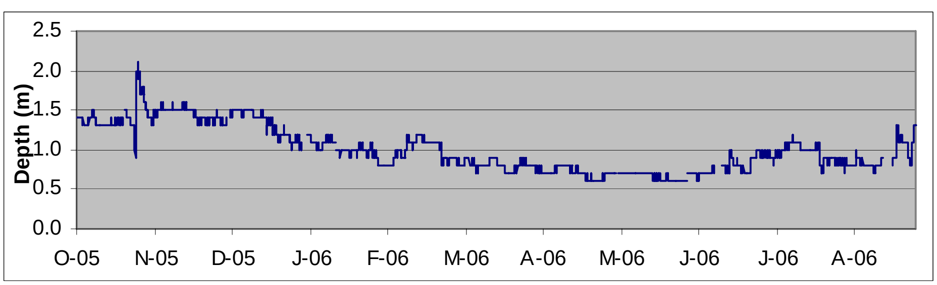

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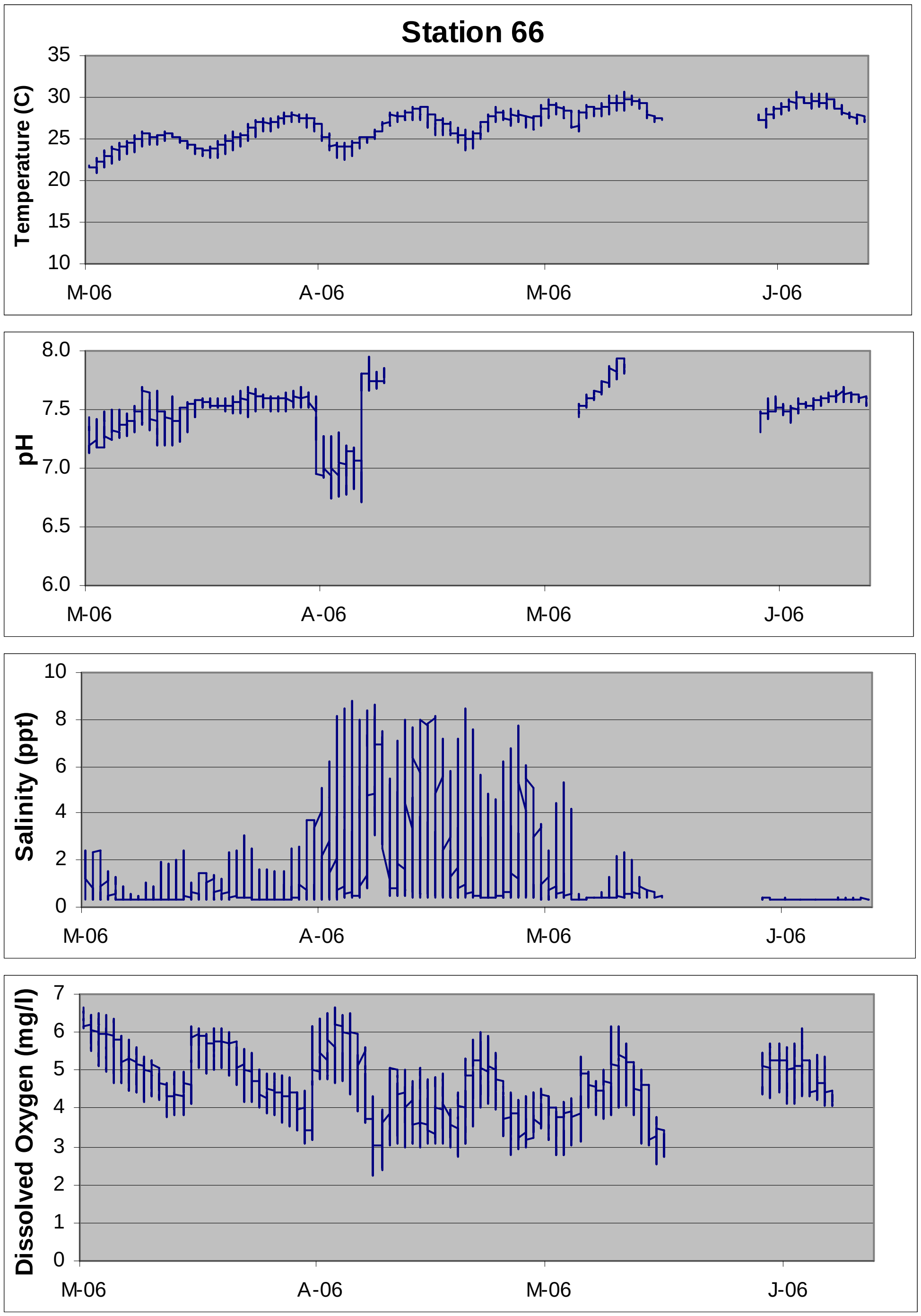

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