FLORIDA OUTFALLS SURVEY (FACE) CRUISE
OCTOBER 6th – 19th, 2006
DATA REPORT

Thomas P. Carsey[1]
Hector Casanova[1]
Courtney Drayer[4]
Charles Featherstone[1]
Charles Fischer[1]
Kelly D. Goodwin[1,3]
John R. Proni[5]
Amel Saied[2]
Chris D. Sinigalliano[2]
Jack Stamates[1]
Peter Swart[4]
Jia-Zhong Zhang[1]

1 Ocean Chemistry Division, Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida
2 Cooperative Institute for Marine and Atmospheric Sciences, University of Miami
3 NOAA Southwest Fisheries Science Center, La Jolla, California
4 Rosenstiel School of Marine and Atmospheric Sciences, University of Miami
5 Applied Research Center, Florida International University, Miami, Florida

National Oceanic and Atmospheric Administration
Atlantic Oceanographic and Meteorological Laboratory
Ocean Chemistry Division
Miami, Florida
March 2009

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

Issues of water use and treated-wastewater plant (TWWP) effluent discharge are of immense importance to the population of the fast-growing coastal Florida, and also to the adjoining coastal ecosystems. However, it was clear that the state of our knowledge of these ecosystems is lacking. Basic questions such as baseline chemical concentrations, location of inlet plumes, dilution of TWWP effluent plumes into the coastal ocean, the influence of inlet plumes, and the characterization of ocean currents in the receiving waters have not been adequately answered.

The FACE project originated as a NOAA response to the needs of government agencies and water and sewer authorities in south Florida in addressing these and other vital ecosystem management problems. FACE is a multi-year partnership of NOAA/AOML and other federal agencies, state and county ecosystem management agencies, county governments, municipal water and sewer authorities, and public environmentally concerned citizen groups. In 2006, the FACE program conducted a cruise on the NANCY FOSTER to obtain near-synoptic oceanographic, chemical, and biological sampling and measurements from all six treated-wastewater outfalls off of Florida's east coast. Tables 1 and 2 provide an overview of the six TWWP outfalls in southeast Florida.

2.0 OBJECTIVES

The primary objectives of the FACE cruise was to visit all six TWWP boils and the down-current plumes and produce a data set of acoustic, ocean currents, and ocean chemistry from those areas. The treated-water outfalls include South Central, Boca Raton, Hollywood, Broward, Miami North, and Miami Central. Some pertinent information on the outfalls is given in Tables 1 and 2.

Table 1. Overview of the treated-wastewater plant outfalls[1]

Name	Abb.	Latitude[2]	Longitude[2]	Outflow MGD	Depth m	Length km	Diam m	Ports
South Central[3]	SC	26°27.715N	80°2.525W	12.3	27.4	1.6	0.8	1
Boca Raton	BC	26°21.016N	80°3.243W	10.7	27.4	1.6	0.9	1
Broward-N	BR	26°15.083N	80°3.724W	36.5	32.6	2.2	1.4	1
Hollywood	HW	26°1.147N	80°5.156W	39.5	28.3	3.1	1.5	1
Miami-Dade-N	MN	25°55.203N	80°5.176W	80.6	32.9	3.6	2.3	12
Miami-Dade-C	MC	25°27.715N	80°5.158W	104.6	30.5	5.7	2.3	5

1. Source: Koopman *et al.,* 2006
2. Pipe end locations from multi-beam studies reported in this report.
3. The South Central TWWP is located in Delray Beach and sometimes goes by that name.

Table 2. Reported outgoing fluxes and concentrations from the TWWP outfalls[1]

Outfall	TN kg/day[N]	NH_4 kg/day[N]	N+N kg/day[N]	TP kg/day[P]	TSS mg/L	CBOD[2] mg/L	FCB[3] #/100ml
South Central	871	545	191	79	9	11	1
Boca Raton	685	425	134	28	6	3	3
Broward-N	2045	Nr	nr	180	7	4	14
Hollywood	2482	1779	179	164	17	8	7
Miami-Dade-N	5339	Nr	nr	519	10	6	nr
Miami-Dade-C	6652	Nr	nr	634	10	6	nr

1. Mass output computed from concentrations and averaged monthly flows from Koopman *op cit.*
2. CBOD: carbonaceous biochemical oxygen demand
3. FCB: fecal coliform bacteria counts

3.0 PARTICIPATING SCIENTISTS

The science team on the cruise is given in Table 3.

Table 3. Science personnel for the FACE cruise on the Nancy Foster.

NAME	TITLE	GENDER	LEGS	NAT.	AFFILIATION
Bishop, Joseph	Scientist	M	1,2,3	US	AOML[1]
Casanova, Hector	Scientist	M	1,2,3	US	NOAA Corps[1]
Carsey, Thomas	Scientist	M	1,2,3	US	AOML[1]
Featherstone, Charles	Scientist	M	1,2,3	US	AOML[1]
Stamates, Jack	Scientist	M	1,2,3	US	AOML[1]
Fischer, Charles	Scientist	M	2,3	US	AOML[1]
Goodwin, Kelly	Scientist	F	3	US	AOML[1]
Sinigalliano, Chris	Scientist	M	3	US	AOML[1]
Drayer, Courtney	Scientist	F	1,2,3	US	UM (RSMAS)[2]
Amel Saied	Scientist	F	3	US	UM (RSMAS)[2]

1. Atlantic Oceanographic and Meteorological Laboratory, 4301 Rickenbacker Cswy, Miami, FL 33149
2. Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Cswy, Miami, Florida 33149.

4.0 OPERATIONS

The cruise consisted of three Legs which are described below. Figures 1 and 2 show the location of sample collections, and ocean outfall and inlet locations.

4.1 LEG 1

Scientific equipment was loaded on the RV Nancy Foster on Friday October 6th, 2006 at the Miami Coast Guard Station located at the Port of Miami. All scientific equipment was setup and checked to see that all systems were properly functioning. On Saturday October 7th, 2006 an open house onboard the RV Nancy Foster was conducted for visitors.

4.2 LEG 2

The northward leg began on Sunday October 8th, 2006. The ship departed the Miami Coast Guard Station at 9am and proceeded to ~ 25° 46' N, 80° 8' W, to test the CTD system. The ship's multi-beam system was used to map each of the outfall pipes, beginning with Miami Central (MC). Upon arrival at the Boynton Inlet vicinity, the Shipek® bottom sampler was employed at the South Central (SC) outfall location for seafloor sediment sampling. The sampling regimen was as follows: Samples were obtained at 10 km east, 5km east, 2 km east, 1 km west, and 1 km north of each outfall. Samples were obtained ~100 m south, at the boil, and at 50, 100, 1nd 200 m north of the outfall, nominally, for a total of ten samples per outfall. Samples were obtained at additional sites between the Hollywood (HW) and Broward (BR) outfalls, near the latitude of the Port Everglades inlet (PE1-PE4).

4.3 LEG 3

The southward leg began on October 12th, 2006. The ship initiated an examination of each of the six treated-wastewater outfall plumes, beginning with the SC outfall plume. Each plume was examined using the following procedure: 1) The ship determined the location of the boil (using salinity-deficit measurements and visual information) and stop for an ADCP measurement. 2) The ship deployed the V-fin at the boil and maneuver to turn points east and west criss-crossing the plume, with increments of approximately 100 yards, and continuing northward until the plume can no longer be detected. 3) The ship deployed the CTD system at nine sites determined by the V-Fin results, three sets of three crossings of the plume at ~100 yards separation. The ship operated in the vicinity of each plume for a minimum of 24-36 hours. The ship returned to the Miami coast Guard Station on October 19th, 2006. A plot of Leg 2 and 3 of the cruise is given in Figure 1. Table 3 gives a summary of the daily activities of the cruise.

Table 3. Daily Activity Log for the Nancy Foster 2006 Cruise

	Day	October	Year Day	Activity
Leg 2	Sunday	8	281	Test of CTD, multibeam at all outfalls going N
	Monday	9	282	Shipek at SC, Shipek at BC (deepwater)
	Tuesday	10	283	Shipek at BR and at PE-1,2,3,4 and at HW
	Wednesday	11	284	Shipek at HW, MM1, MM2, transit to Boynton Inlet
Leg 3	Thursday	12	285	ADCP, CTD at Boynton; VFIN & CTD at SC
	Friday	13	286	VFIN & CTD at BC
	Saturday	14	287	VFIN & CTD at BR; CTD at C1-C2-C3
	Sunday	15	288	CTD at HW, Shipek samples. CTD at MC.
	Monday	16	289	CTD at MC
	Tuesday	17	290	VFIN & CTD at HW
	Wednesday	18	291	VFIN & CTD at MN, return

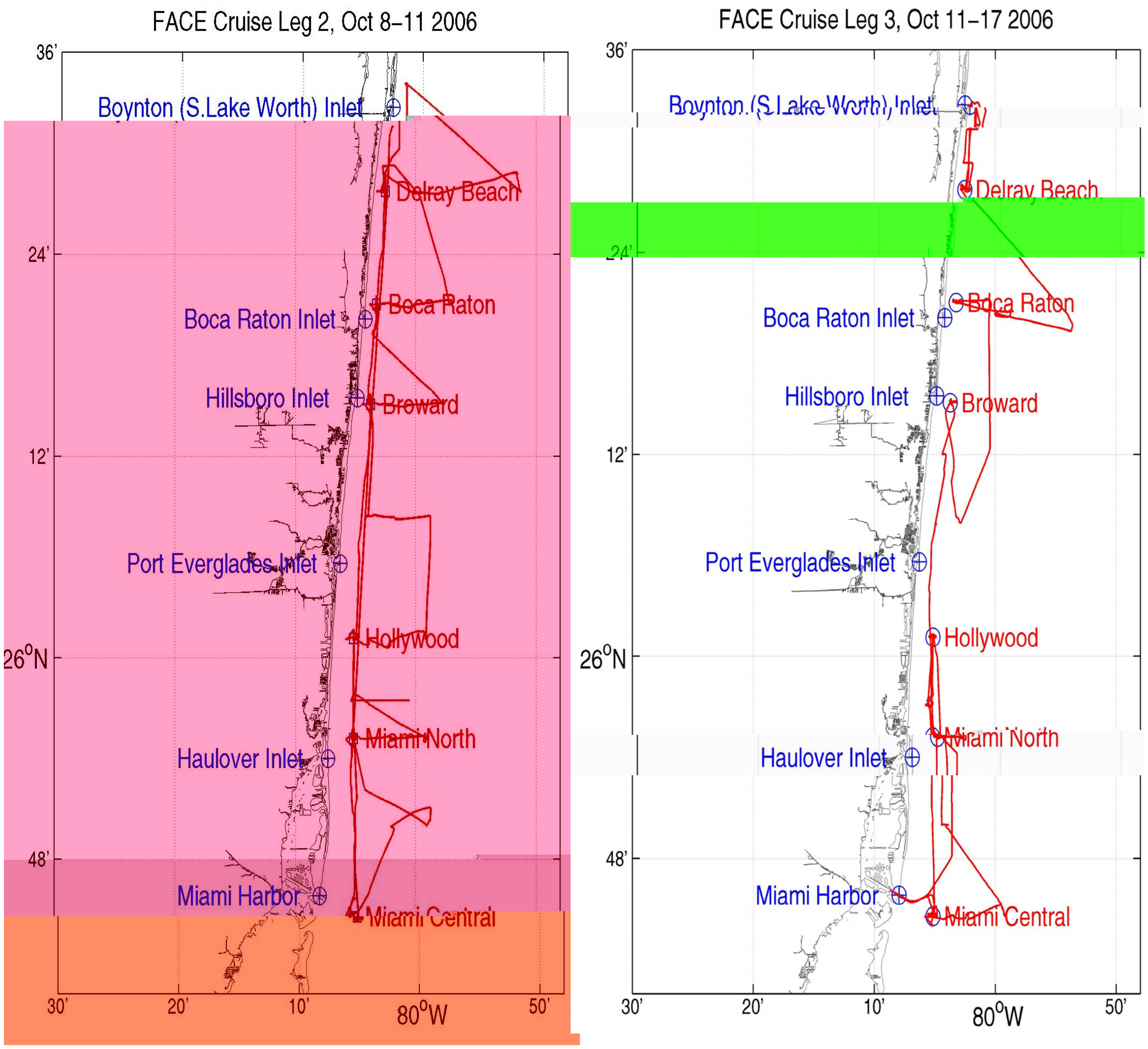


Figure 1: Map of Leg2 (left) and Leg 3 (right) of the FACE cruise on the R/V Nancy Foster. Major inlets are shown in blue, TWWP names and outfall terminus locations are given in red.

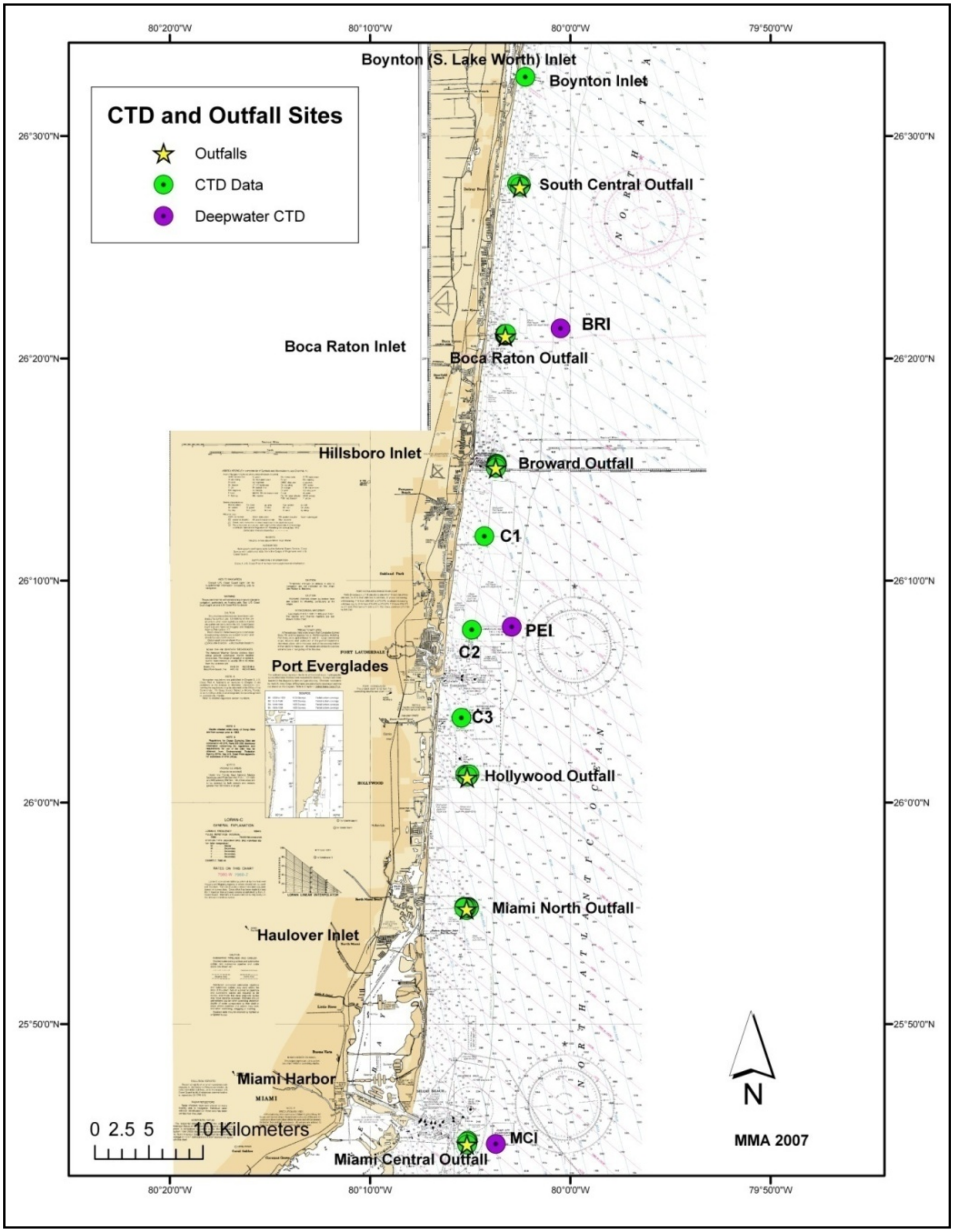


Figure 2: Map of the water sampling sites (CTD), outfalls and inlets during the Nancy Foster cruise. Sites "BRI", PEI", and "MCI" are deeper water cast sites. Sites C1, C2, and C3 are intermediary sites to provide data between the Hollywood and Broward sites.

5.0 SAMPLING METHODS

5.1 Water Sampling

Discrete water samples were collected for each station for the following parameters 1) nutrients, 2) dissolved organic carbon (DOC), 3) pH, 4) chlorophyll, 5) microbiology and 6) ^{15}N isotopes. A seabird 911 CTD and 12 2-L Niskin bottles were lowered by crane from the RV Nancy Foster to acquire a profile of temperature and salinity, and to collect discrete water samples for the above mentioned parameters at three depths (surface, mid and near bottom). Locations are shown in Figure 3 (right panel). Once the CTD and Niskin bottles were on board sample water was withdrawn from the appropriate Niskin bottle and placed in the proper sample storage container. Samples were either stored on board for later analysis back at AOML or analyses were carried out immediately in the laboratory on the RV Nancy Foster.

5.2 Sediment Sampling

Sediment samples were collected using a Teflon-coated Shipek sediment sampler (Model #214WA140). The exact location of the sampling was chosen to avoid hard-bottom areas. The Shipek unit was lowered to the sea floor by the ship's winch and cable, operated by the ship's deck department. Once the Shipek hit the seafloor the sampler closed collecting approximately 0.5 to 1 liter of sediment. The shipek was then brought back on board and sediment placed in the ship's refrigerated storage area for subsequent ^{15}N isotope analysis. Locations are shown in Figure 3 (left panel).

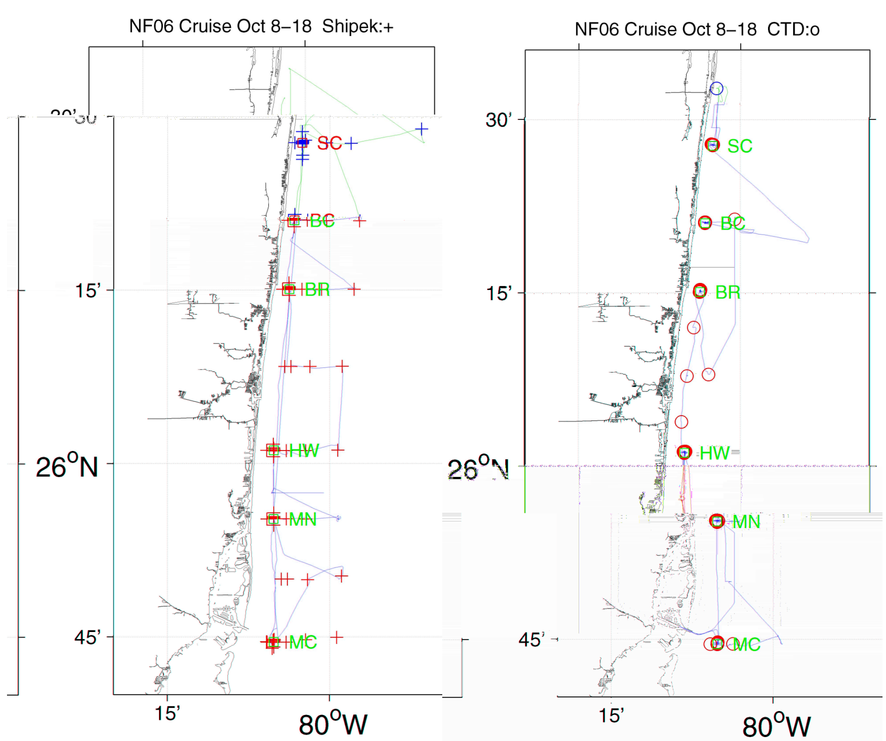


Figure 3: Map of the Shipek solid sampling sites and Leg 2 track (left), and of the CTD cast sites and Leg 3 track (right panel). Outfalls are denoted by abbreviations: SC is South

Central, BC is Boca Raton, BR is Broward, HW is Hollywood, MN is Miami (north), and MC is Miami (central) TWWP outfall locations.

5.3 Acoustic Current Doppler Profiler (ADCP)

A RDI 600-kHz ADCP (Teledyne RD Instruments, Poway, CA) was attached to a line and lowered off the side of the RV Nancy Foster for approximately 10 to 15 minutes. The ADCP was brought back on board and the data downloaded and processed immediately to determine the current direction and velocity of each outfall plume. The instrument was deployed ten times during the cruise.

The data from the dipped ADCP was processed by using the RDI quality control parameters to identify the data that had sufficient 3 or 4 beam solutions to be stable, had sufficient correlation and also to assure that the bottom was not influencing the data. Each ensemble was screened to look for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. The means, minima, maxima, and standard deviations of the data that passed the above-mentioned QC procedures were used for data analysis. A summary of the results is given in Appendix 1.

6.0 ANALYTICAL METHODS

6.1 Nutrient Analysis

Water samples are filtered through 0.45-εm membrane filters using a 50 ml syringe and collected in two 8ml polystyrene test tubes, one for Ammonia-N analysis and the other for Nitrate + Nitrite-N, Nitrite-N, Orthophosphate-P and Silica analysis. The filter was washed before use by passing 50 ml of sample water through the filter. Care must be taken to avoid the contamination of nutrient samples especially at low concentrations. Sample tubes were rinsed three times with sample water, shaking with the cap in place after each rinse. The sample tubes were then filled with sample water and preserved. Ammonia samples should be preserved by addition of 0.2% (V/V) of chloroform. All samples were analyzed on board the RV Nancy Foster after collection, using the following EPA methods.

Method 349.0 was used to determine the concentration of ammonia for each station (Zhang et al., 1997). This method uses automated gas segmented continuous flow colorimetry for the analysis of ammonia. Ammonia in solution reacts with alkaline phenol and NADTT at 60 ^{0}C to form indophenol blue in the presence of sodium nitroferricyanide as a catalyst. The absorbance of indophenol blue at 640 nm is linearly proportional to the concentration of ammonia in the sample.

Method 353.4 was used to determine the concentration of nitrate and nitrite for each station (Zhang et al., 1997). This method uses automated gas segmented continuous flow colorimetry for the analysis of nitrate and nitrite. In the method, samples are passed through a copper-coated cadmium reduction column. Nitrate is reduced to nitrite in a buffer solution. The nitrite is then determined by diazotizing with sulfanilamide and coupling with N-1-naphthylethylenediamine dihydrochloride to form a color azo dye.

The absorbance measured at 540 nm is linearly proportional to the concentration of nitrite + nitrate in the sample. Nitrate concentrations are obtained by subtracting nitrite values, which have been separately determined without the cadmium reduction procedure, from the nitrite + nitrate values.

Method 365.5 was used to determine the concentration of orthophosphate for each station (Zimmermann and Keefe, 1997; Zhang et al., 2001). This method uses automated calorimetric and continuous flow analysis for the determination of low-level orthophosphate concentrations. Ammonium molybdate and antimony potassium tartrate react in an acidic medium with dilute solutions of phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The absorbance measured at 800 nm is proportional to the phosphate concentration in the sample.

Method 366.0 was used to determine the concentration of silica for each station (Zhang and Berberian, 1997). This method uses automated gas segmented continuous flow colorimetry for the analysis of dissolved silicate concentration. In the method, β-molybdosilicic acid is formed by reaction of the silicate contained in the sample with molybdate in acidic solution. The β-molybdosilicic acid is then reduced by ascorbic acid to form molybdenum blue. The absorbance of the molybdenum blue, measured at 660 nm, is linearly proportional to the concentration of silicate in the sample.

Method 367.0 was used to determine the total phosphorus concentration for each station (Zhang et al, 1998). This method determines total dissolved phosphorus (TDP) concentration by autoclave promoted persulfate oxidation of organically bound phosphorus followed by a gas segmented continuous flow colorimetric analysis of digested samples. In this method, dissolved organic phosphorus (DOP) in the water reacts with persulfate in acidic media at elevated temperature and pressure. An autoclave is used to achieve a temperature of 120 ^{0}C and pressure of 2 atmospheres, which promote oxidation. After samples are cooled to room temperature, aliquot of ascorbic acid is added to remove the free chlorine formed in seawater during the digestion. Those autoclaved samples are then analyzed for phosphate concentrations by the molybdenum blue colorimetric method using a gas segmented continuous flow analysis by a Flow Solution Analyzer. In this method phosphate reacts with molybdenum (VI) and antimony (III) in an acidic medium to form an antimonyphosphomolybdate complex. This complex is subsequently reduced by hydrazine to form a blue complex and the absorbance measured at 710 nm. Undigested samples are analyzed separately to obtain the concentration of dissolved inorganic phosphate (DIP). Dissolved organic phosphorus is calculated as the difference between total dissolved phosphorus and dissolved inorganic phosphorus (DOP = TDP – DIP).

Total dissolved nitrogen was measured using the thermal decomposition/NO detection chemiluminescence method in a Shimadzu total organic carbon analyzer (Schimadzu, 2004). When a sample is introduced into the combustion tube (furnace temperature 720^{0}C), the TN in the sample decomposes to nitrogen monoxide. Nitrogen gas does not become nitrogen monoxide under these circumstances. The carrier gas, which contains the nitrogen monoxide, is cooled and dehumidified by the electronic dehumidifier. The gas then enters a chemiluminescence gas analyzer, where nitrogen monoxide is detected. The detection signal from the chemiluminescence gas analyzer generates a peak and the TN concentration in the sample can then be measured. All nutrient results are given in Appendix 2. Results from samples taken at the outfall boils are given in Appendix 3.

6.2 pH Analysis

pH was determined spectrophotometrically following the methods of Clayton and Byrne, (1993) and Mosley et al., (2004). A sulfonephthalein dye, -cresol purple, is added to the sample and absorbance readings measured at wavelengths 434 nm, 578 nm and 725 nm. Temperature and salinity are also recorded for each sample. The following equations will be used to calculate the pH of each sample,

$$\mathbf{p\mathit{K}'a\ (\mathit{m}CP) = 8.6353 - 0.3238S^{1/2} + 0.0807S - 0.01157S^{3/2} + 0.000694S^{2}}$$

$$\mathbf{pH = p\mathit{K}'a + \log \left(\frac{R - 0.0069}{2.222 - R0.133}\right)}$$

where S is the salinity, R is the ratio of two absorbance peaks of the indicator (wavelengths of 578 and 434 nm) after a baseline correction at 725 nm

(i.e. R = ${}_{578}A/{}_{434}A$), p a is the acid dissociation constant of the indicator and CP is the -cresol purple dye.

6.3 Chlorophyll Analysis

Water samples were filtered through 25 cm 0.45-εm glass fiber filters using a filter apparatus either attached to a hand pump or a vacuum pump. An aliquot of 200 ml of sample water was filtered. The filter was then folded in half by forceps and placed in a 2 ml polypropylene vial. A duplicate from the same sample is also filtered and placed in the same vial. Chlorophyll a was then extracted using a 60:40 mixture of acetone and dimethyl sulfoxide (Shoaf & Lium, 1976; Kelble et al., 2005). The fluorescence of each sample was measured before and after acidification in order to correct for phaeophytin on a Turner Designs model TD-700 fluorometer. The fluorescence values were calibrated using known concentrations of chlorophyll a to yield chlorophyll a concentrations in mg/m^{-3}.

6.4 N^{15} Isotope Analysis

Isotope analysis of sediment and algal samples was carried out by P. Swart and C. Drayer of the Stable Isotope Laboratory at the Rosenstiel School of Marine and Atmospheric Science. Their results are described in Swart and Drayer (2007), and will not be described in this report.

6.5 Microbiological Analysis

Culture-Based Analysis:
Viable Enterococci were enumerated by membrane filtration plate counts using EPA standard method 1600 and by the EPA-approved EnteroLert™ Chromogenic Substrate Assay (IDEXX, Inc.). Viable were enumerated by membrane filtration plate counts using EPA standard method 1603. Cryptosporidium oocysts and Giardia cysts were concentrated from 200 liter samples by the EPA-approved IDEXX Filtamax method (IDEXX, Inc.) and enumerated by immunomagnetic separation and immunofluorescent microscopy according to EPA standard method 1623. This protozoan cyst analysis was conducted by the NELAP-certified facilities of BSC Labs, Inc. Viable putative Bacteroides were enumerated by membrane filter method incubated on BBE agar under anaerobic conditions, Viable putative Staphylococci were enumerated by membrane filtration method incubated on Staphylococcus ChromAgar.

Molecular-Based Analysis:
One liter water samples for DNA extraction were collected onto 0.45 nitrate cellulose filters (Whatman), which were stored frozen until extraction. DNA was extracted and purified from filters with the FastDNA Spin Kit (Qbiogene – MPBiomedicals), according to manufacturer's recommendations.

Cycling conditions for all source-tracking qPCR assays were run on an MJ Research Chromo4 in 25-uL reaction volumes using QuantiTect Probe Mastermix (Qiagen, Inc.) with 0.125uL of each primer per reaction (from 100 εM stock) and 0.1uL of probe per reaction (from 100 εM stock). Samples were run in triplicate wells (with 1 well spiked with inhibition control) with the following cycling parameters: 15 min. denaturation at 95°C, followed by 45 cycles of 95°c for 15 sec and 60°C for 1 min with a fluorescent plate read at the end of each extension.

Quantitative PCR:
General Enterococci 23S rRNA gene
Forward primer: 5'-AGAAATTCCAAACGAACTTG-3'
Reverse primer: 5'-CAGTGCTCTACCTCCATCATT-3"
Probe: 5'-6FAM-TGGTTCTCTCCGAAATAGCTTTAGGGCTA-BHQ-3'

Total Control 16S rRNA gene
Forward primer: 5'-GCTGAAGGTTGGTACTTGTA-3'
Reverse primer: 5'-TCAGGTCGGCTATGTATCAT-3'
Probe: 5'-6FAM-TGGATGAGCAGCGAACGGGTGA-BHQ-3'

Human-source Bacteroides HF8 gene cluster marker
Forward primer: 5'-ATCATGAGTTCACATGTCCG-3'
Reverse primer: 5'-CAATCGGAGTTCTTCGTG-3'
Probe: 5'-6FAM-TCCGGTAGACGATGGGGATGCGTT-BHQ-3'

Human-source Bacteroides HuBac marker

As per Layton et al., 2005

Norovirus and enterovirus qPCR kits by Cepheid Inc. as per manufacturer's instructions (with some modifications – please contact Dr. Sinigalliano at AOML for details).

Non-Quantitative PCR:

Human-source Enterococci esp gene: As per Scott et al., 2005
Campylobacter jejuni gene: As per LaGier et al., 2004
Salmonella spp. gene: As per Kong et al., 2005
Pathogenic E. coli strain O157:H7 gene: As per Maurer et al., 1999
Staphylococcus aureus clfA gene: As per Mason et al., 2001
Human Adenovirus Hexon gene: As per He and Jiang, 2005
Additional analysis of viruses conducted by Dr. Jill Stewart of the Oceans and Human Health Center at Hollings Marine Lab.

Standards and Controls for quantitative PCR:

Quantitation standards for total bacteroides and human source bacteroides use purified genomic DNA from the culture , measured by fluorescence with a Qubit Fluorometer using the Molecular Probes Quant-It kit for dsDNA. Quantitation units for these qPCR assays are in genome equivalents (which can then be expressed as relative cell numbers with some assumptions/caveats about average target copy number in the environmental population of target cells). Quantitation standards for total and human-specific -containing enterococci are based on purified genomic DNA from a culture of that contains the marker (acquired from Dr. Troy Scott at BSC Laboratories). Quantitation units for these qPCR assays are in genome equivalents.

Extraction control: as above each sample is spiked before lysis and extraction with 10^5 cells of an enumerated control culture of . Variations in CT value of lactococcus indicate variations of extraction efficiency plus any potential inhibition. Variation due to inhibition is removed by comparing extraction controls to inhibition controls.

Inhibition controls: reactions of each sample run in triplicate, one replicate well of each sample gets spiked with known amount of target DNA. Variation in CT of spike corrected for background of unspiked for that sample indicate degree of inhibition.

DATA SUMMARY

7.0 MIAMI CENTRAL OUTFALL

7.1 Outfall Description

Miami Central ocean outfall is located approximately 5.7 km offshore Virgina Key at a depth of 30.5 meters and has an average discharge flow rate of 105 MGD (millions of gallons per day). Figure 4 shows the seas floor in the vicinity of the outfall. A careful analysis of this data resulted in a determination of the location of the outfall terminus at 25° 44.569'N, 80° 5.158'W (25.742817°N, 80.085967°W). Table 1 lists the CTD sample stations and sample depth. Table 2 lists the sediment sample locations and depth.

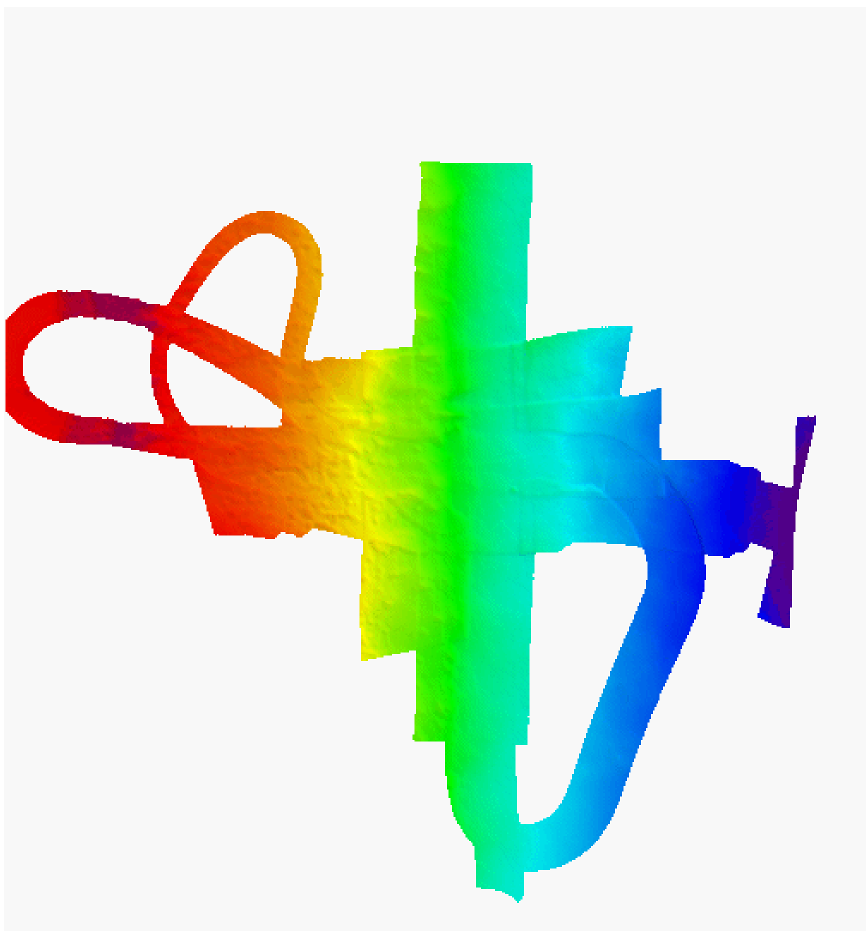


Figure 4: Sea floor view of the Miami-Central outfall vicinity.

Table 4: CTD sample locations for Miami Central Outfall.

Date	Station #		Latitude	Longitude	Depth (m)	Dist to pipe (m)
16-Oct	MC-	10a	25.7427	-80.0859	0	0.00
16-Oct	MC-	10b	25.7427	-80.0859	15.65	0.09
16-Oct	MC-	10c	25.7427	-80.0859	31.3	0.09
16-Oct	MC-	4a	25.7435	-80.0859	0	88.96
16-Oct	MC-	4b	25.7435	-80.0859	15.76	88.96
16-Oct	MC-	4c	25.7435	-80.0859	31.52	88.96
16-Oct	MC-	3a	25.7435	-80.0858	0	89.52
16-Oct	MC-	3b	25.7435	-80.0858	16.06	89.52
16-Oct	MC-	3c	25.7435	-80.0858	32.13	89.52
16-Oct	MC-	2a	25.7436	-80.0856	0	104.49
16-Oct	MC-	2b	25.7436	-80.0856	16.61	104.49
16-Oct	MC-	2c	25.7436	-80.0856	33.22	104.49
16-Oct	MC-	5a	25.7443	-80.0858	0	178.19
16-Oct	MC-	6a	25.7443	-80.0860	0	178.19
16-Oct	MC-	5b	25.7443	-80.0858	16.15	178.19
16-Oct	MC-	6b	25.7443	-80.0860	15.37	178.19
16-Oct	MC-	5c	25.7443	-80.0858	32.31	178.19
16-Oct	MC-	6c	25.7443	-80.0860	30.75	178.19
16-Oct	MC-	7a	25.7444	-80.0862	0	191.40
16-Oct	MC-	7b	25.7444	-80.0862	14.49	191.40
16-Oct	MC-	7c	25.7444	-80.0862	28.99	191.40
16-Oct	MC-	9a	25.7448	-80.0861	0	234.37
16-Oct	MC-	9b	25.7448	-80.0861	14.72	234.37
16-Oct	MC-	9c	25.7448	-80.0861	29.44	234.37
16-Oct	MC-	8a	25.7448	-80.0856	0	235.43
16-Oct	MC-	8b	25.7448	-80.0856	16.26	235.43
16-Oct	MC-	8c	25.7448	-80.0856	32.52	235.43
16-Oct	MC-	1a	25.7457	-80.0852	0	340.87
16-Oct	MC-	1b	25.7457	-80.0852	17.15	340.87
16-Oct	MC-	1c	25.7457	-80.0852	34.3	340.87

Table 5: Sediment sample locations for Miami Central Outfall and Miami Mid transect.

Date	Station	Latitude	Longitude	Depth (m)
15-Oct	MC10	25.7495	-79.9887	350.0
15-Oct	MC11	25.7458	-80.0369	251.7
15-Oct	MC12	25.7424	-80.0667	116.7
15-Oct	MC13	25.7429	-80.0963	14.1
15-Oct	MC13b	25.7424	-80.0959	14.1
15-Oct	MC14a	25.7428	-80.0863	31.0
15-Oct	MC14b	25.7337	-80.0880	19.8
15-Oct	MC14c	25.7335	-80.0882	18.6
15-Oct	MC15a	25.7418	-80.0860	31.3
15-Oct	MC15b	25.7418	-80.0871	23.7
15-Oct	MC15c	25.7422	-80.0867	26.5
15-Oct	MC16	25.7426	-80.0854	34.3
15-Oct	MC17a	25.7438	-80.0852	34.4
15-Oct	MC17b	25.7434	-80.0858	32.8
15-Oct	MC18a	25.7449	-80.0871	24.1
15-Oct	MC18b	25.7448	-80.0866	20.0
15-Oct	MC18c	25.7451	-80.0868	20.0
15-Oct	MC19	25.7455	-80.0857	32.5
15-Oct	MC19a	25.7448	-80.0858	32.5
16-Oct	MC19b	25.7448	-80.0856	32.9
16-Oct	MC19c	25.7448	-80.0854	32.5
16-Oct	MC19d	25.7448	-80.0854	33.2
16-Oct	MC19e	25.7455	-80.0852	33.2
16-Oct	MC20a	25.7465	-80.0860	29.1
16-Oct	MC20b	25.7465	-80.0858	30.6
16-Oct	MC20c	25.7465	-80.0856	7.4
16-Oct	MC20d	25.7467	-80.0854	32.6
16-Oct	MC21a	25.7352	-80.0859	29.9
16-Oct	MC21b	25.7352	-80.0859	29.9
15-Oct	MM3	25.8335	-80.0743	95.0
15-Oct	MM4	25.8334	-80.0646	149.0
11-Oct	MM1a	25.8335	-79.9853	294.1
11-Oct	MM1b	25.8379	-79.9813	287.7
11-Oct	MM2	25.8326	-80.0338	245.9

7.2 Nutrients

A total of 30 nutrient samples were collected during the CTD operations around the Miami Central outfall. These results are listed in Table 3 for concentrations in εM and in Table 4 for concentrations in mg/L. Results are presented graphically in Figure 5.

Table 6: Nutrient results in εM from the Miami Central Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
1a	1.8	0.57	0.32	4.01	0.47	1.01
1b	16.1	0.05	0	0.35	0.11	0.25
1c	32.2	0.07	0	0.58	0.12	0.17
2a	1.7	0.53	0.31	5.37	0.40	1.2
2b	12.8	0.55	0.33	5.61	0.44	1.11
2c	27.3	0.04	0	0.29	0.08	0.17
3a	3.1	1	0.61	10.97	0.70	2
3b	11.9	0.79	0.49	9.08	0.62	1.63
3c	25.7	0.05	0	0.23	0.14	0.12
4a	2.1	1.26	0.8	15.94	1.00	2.62
4b	13.4	0.14	0.05	1.61	0.21	0.39
4c	25.5	0.05	0	0.11	0	0.06
5a	1.6	0.66	0.41	11.42	0.57	1.73
5b	12.5	0.03	0	0.13	0.09	0.14
5c	25.9	0.19	0.01	0.11	0.02	0.17
6a	1.8	0.57	0.36	10.68	0.58	1.6
6b	12.0	0.28	0.15	4.64	0.24	0.87
6c	25.5	0.08	0.01	0.16	0.12	0.14
7a	1.5	0.48	0.29	8.92	0.47	1.36
7b	11.5	0.13	0.05	1.79	0.13	0.41
7c	27.8	0.07	0	0.24	0.01	0.17
8a	1.6	0.38	0.22	7.77	0.40	1.25
8b	12.6	0.01	0	0.11	0.11	0.17
8c	26.0	0.13	0.02	0.16	0.08	0.25
9a	1.8	0.27	0.16	6.41	0.36	1.11
9b	11.5	0.14	0.07	3.19	0.26	0.66
9c	23.9	0.12	0.01	0.32	0.10	0.2
10a	2.6	2.23	1.58	66.32	3.55	8.07
10b	12.2	0.57	0.37	15.94	1.48	2.11
10c	25.9	0.16	0.02	1.12	0.30	0.31

Table 7: Nutrient results in mg/L from the Miami Central Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1a	1.8	0.008	0.004	0.056	0.015	0.028
1b	16.1	0.001	0.000	0.005	0.003	0.007
1c	32.2	0.001	0.000	0.008	0.004	0.005
2a	1.7	0.007	0.004	0.075	0.012	0.034
2b	12.8	0.008	0.005	0.079	0.014	0.031
2c	27.3	0.001	0.000	0.004	0.002	0.005
3a	3.1	0.014	0.009	0.154	0.022	0.056
3b	11.9	0.011	0.007	0.127	0.019	0.046
3c	25.7	0.001	0.000	0.003	0.004	0.003
4a	2.1	0.018	0.011	0.223	0.031	0.073
4b	13.4	0.002	0.001	0.023	0.007	0.011
4c	25.5	0.001	0.000	0.002	0.000	0.002
5a	1.6	0.009	0.006	0.160	0.018	0.048
5b	12.5	0.000	0.000	0.002	0.003	0.004
5c	25.9	0.003	0.000	0.002	0.001	0.005
6a	1.8	0.008	0.005	0.150	0.018	0.045
6b	12.0	0.004	0.002	0.065	0.007	0.024
6c	25.5	0.001	0.000	0.002	0.004	0.004
7a	1.5	0.007	0.004	0.125	0.014	0.038
7b	11.5	0.002	0.001	0.025	0.004	0.011
7c	27.8	0.001	0.000	0.003	0.000	0.005
8a	1.6	0.005	0.003	0.109	0.012	0.035
8b	12.6	0.000	0.000	0.002	0.003	0.005
8c	26.0	0.002	0.000	0.002	0.002	0.007
9a	1.8	0.004	0.002	0.090	0.011	0.031
9b	11.5	0.002	0.001	0.045	0.008	0.018
9c	23.9	0.002	0.000	0.004	0.003	0.006
10a	2.6	0.031	0.022	0.928	0.110	0.226
10b	12.2	0.008	0.005	0.223	0.046	0.059
10c	25.9	0.002	0.000	0.016	0.009	0.009

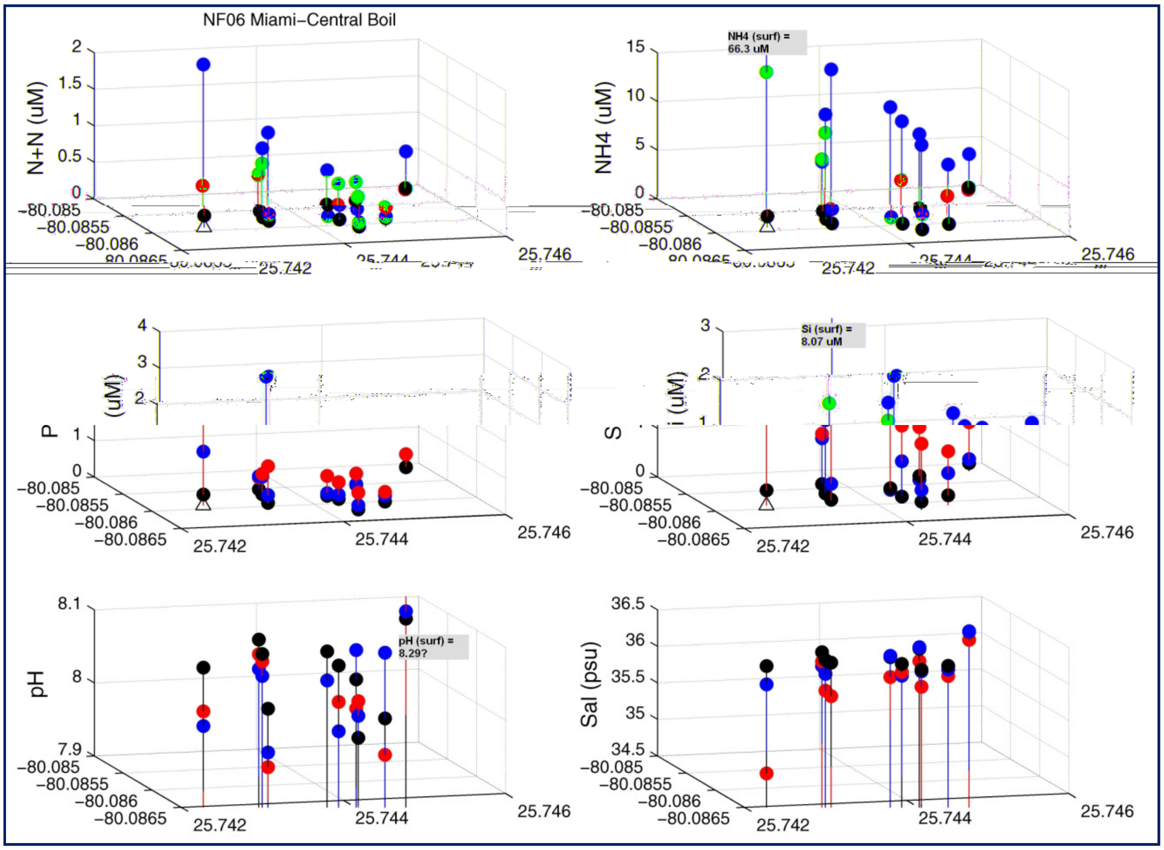


Figure 5. Three-dimensional presentation of N+N, NH_4, P, Si, pH and salinity data from CTD sampling around the Miami-Central outfall. Concentrations are denoted by height on the vertical axis. Red circles indicate concentrations obtained from the surface samples; blue circles indicate concentrations from the mid-level samples, and the black circles indicate concentration from the bottom-most samples. The black triangle denotes the location of the boil. Latitudes and longitudes are plotted in Cartesian space and do not indicate true geographical accuracy. The concentration of NH_4 in the surface sample was 66.3 µM; the vertical scale was chosen so that the other sample concentrations would be better viewed.

.

7.3 Chlorophyll and pH

A total of 30 chlorophyll and pH samples were collected during CTD operations around the Miami Central outfall. Table 5 list the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 8: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from Miami Central Outfall.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (ug/L)	Phaeopigments (ug/L)
1a	1.8	28.62	36.01	8.29	0.488	0.105
1b	16.1	28.64	36.12	8.09	0.475	0.110
1c	32.2	28.56	36.12	8.08	0.578	0.128
2a	1.7	28.66	36.00	8.06	0.416	0.096
2b	12.8	28.62	35.94	8.04	0.429	0.093
2c	27.3	28.59	36.13	8.08	0.526	0.123
3a	3.1	28.64	35.70	8.06	0.428	0.097
3b	11.9	28.65	35.93	8.04	0.596	0.121
3c	25.7	28.57	36.12	8.07	0.429	0.099
4a	2.1	28.63	35.67	7.92	0.429	0.099
4b	13.4	28.59	36.13	7.94	0.507	0.123
4c	25.5	28.57	36.13	8.00	0.545	0.126
5a	1.6	28.63	35.85	8.03	0.422	0.105
5b	12.5	28.65	36.14	8.03	0.403	0.093
5c	25.9	28.52	36.12	8.07	0.590	0.151
6a	1.8	28.64	36.01	8.01	0.399	0.096
6b	12.0	28.63	35.96	7.97	0.434	0.094
6c	25.5	28.56	36.12	8.06	0.550	0.133
7a	1.5	28.61	35.90	8.02	0.461	0.116
7b	11.5	28.62	36.11	8.00	0.451	0.095
7c	27.8	28.61	36.13	7.97	0.447	0.104
8a	1.6	28.64	35.95	7.98	0.411	0.089
8b	12.6	28.65	36.14	8.06	0.397	0.091
8c	26.0	28.52	36.12	8.02	0.662	0.206
9a	1.8	28.62	35.98	7.94	0.431	0.110
9b	11.5	28.64	36.07	8.08	0.386	0.107
9c	23.9	28.55	36.12	7.99	0.523	0.138
10a	2.6	28.63	34.65	8.00	0.461	0.128
10b	12.2	28.63	35.87	7.98	0.448	0.122
10c	25.9	28.53	36.12	8.06	0.527	0.173

7.4 CTD CAST

A total of 10 CTD casts were conducted at the Miami Central outfall. At each station the CTD obtained a sample near bottom, mid-point and near surface. MCB-1 has no profile information due to CTD failure. Figures 6-14 show the temperature, salinity and oxygen saturation for each station.

Figure 6: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-2.

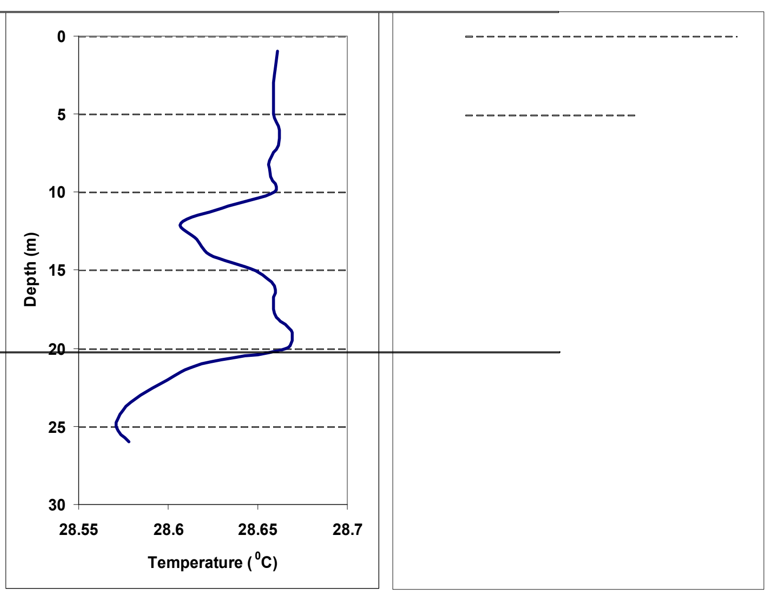


Figure 7: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-3.

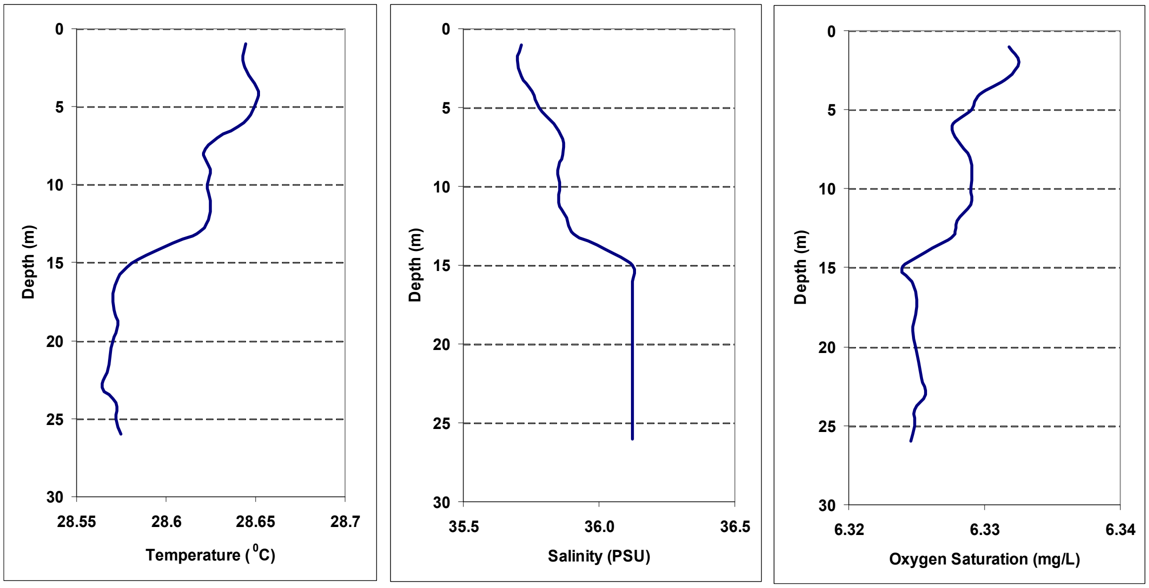


Figure 8: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-4.

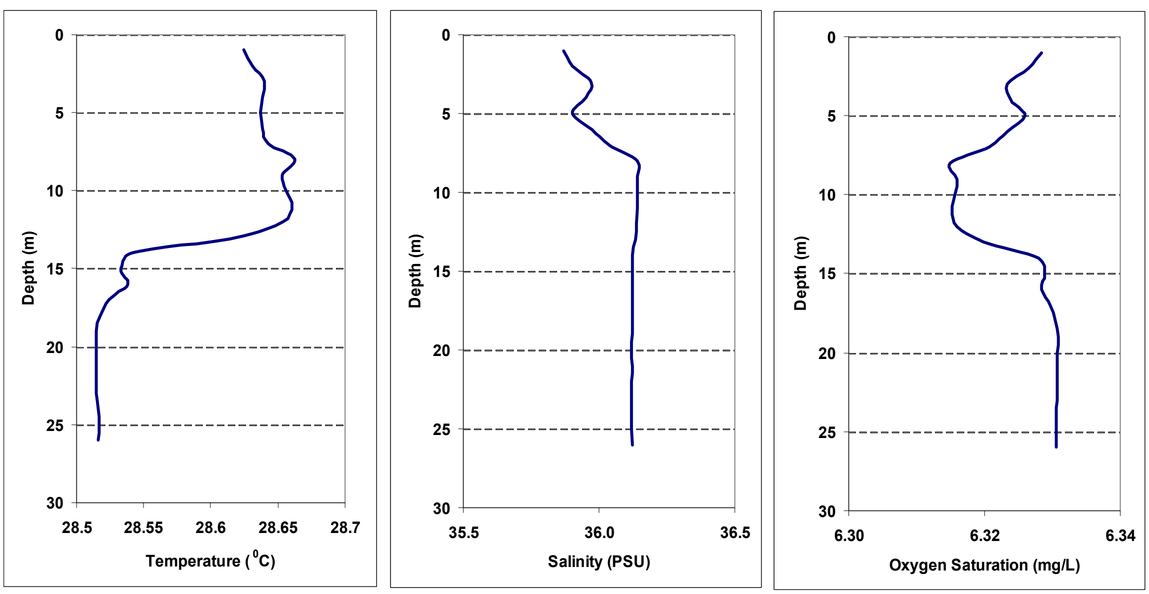


Figure 9: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-5.

Figure 10: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-6.

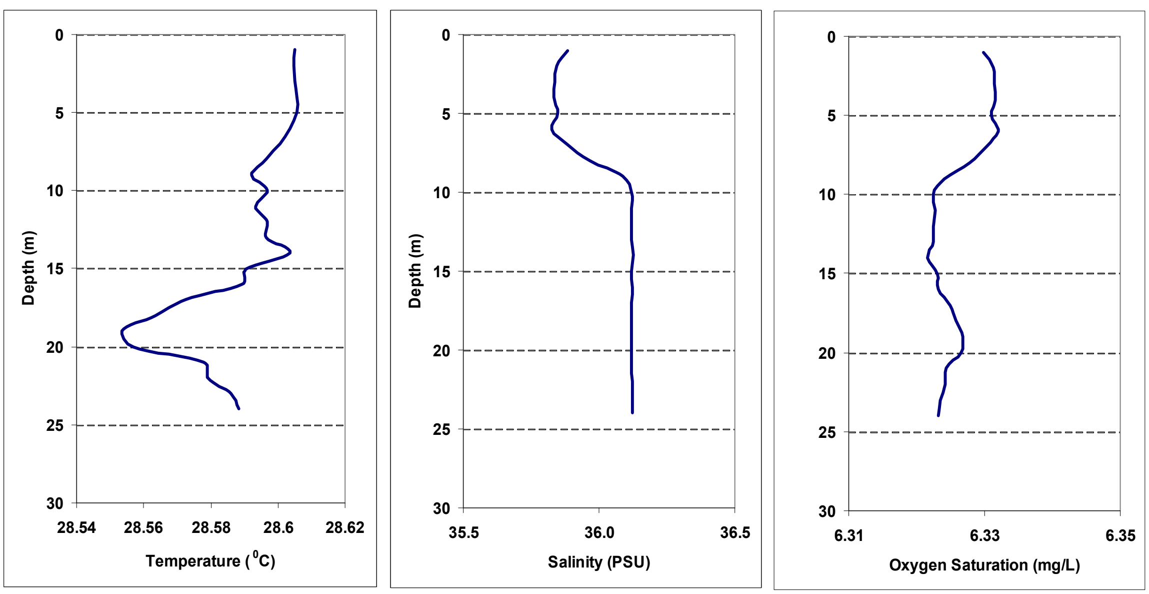


Figure 11: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-7.

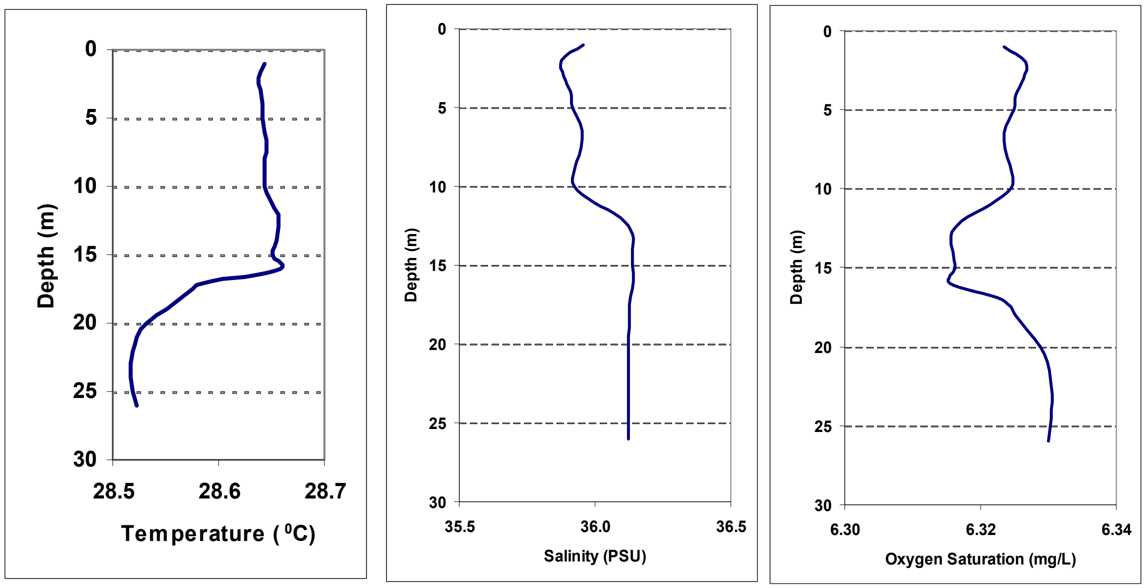


Figure 12: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-8.

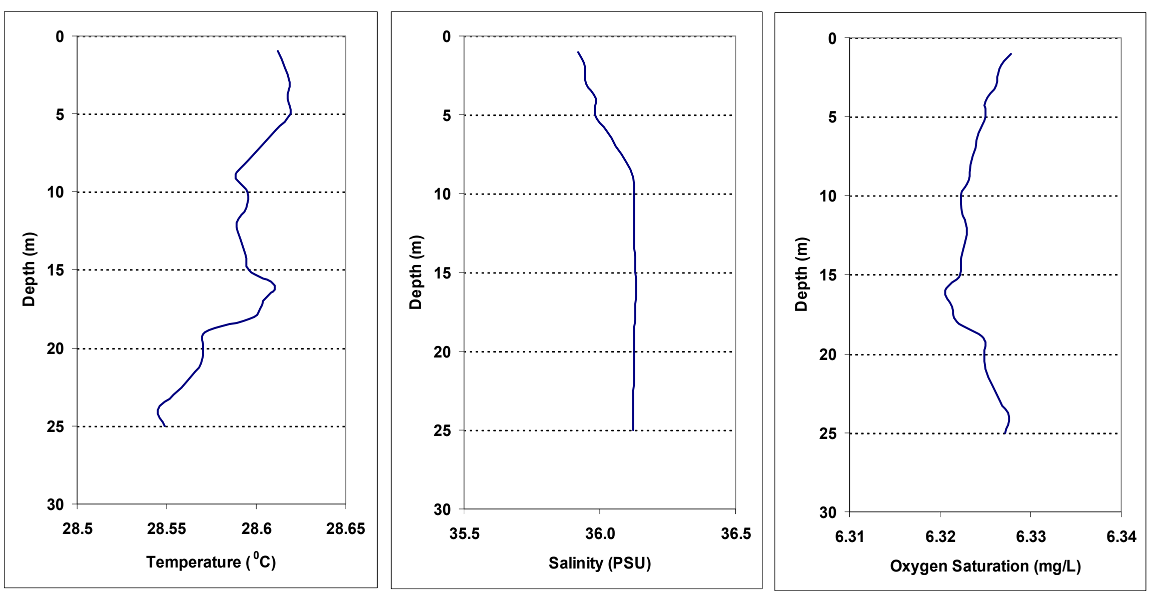


Figure 13: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-9.

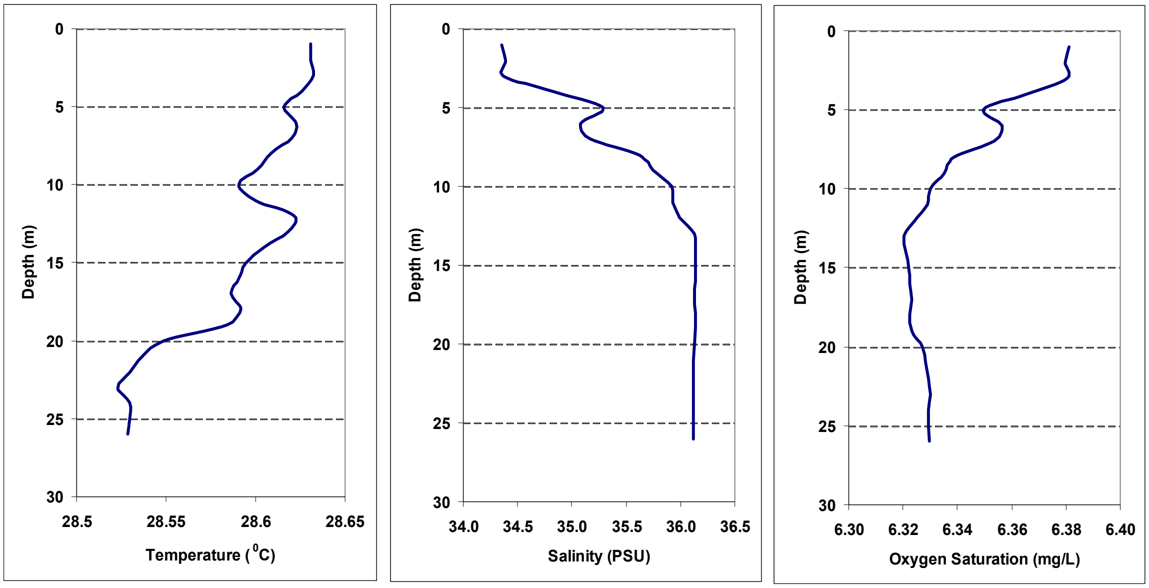


Figure 14: October 16th, 2006 temperature, salinity and oxygen concentration profile at station MCB-10.

7.5 Current Velocity and Direction

A RDI ADCP was dipped at the Miami Central outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. Table 9 lists the current velocity and direction data obtained from Miami Central outfall, while Figure 15 graphically depicts the data.

Table 9: Current velocity and direction for Miami Central outfall on October 8, 2006 at 10:00.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4	-16.24	-19.00	-12.90	2.11	-14.30	-19.00	-11.10	2.66	21.64	21.64	228.64
6	-11.87	-14.20	-9.20	1.88	-16.90	-20.10	-13.30	2.53	20.65	20.65	215.08
8	-9.87	-11.60	-7.90	1.14	-15.66	-17.50	-14.00	1.15	18.51	18.51	212.22
10	-8.11	-10.00	-6.70	1.04	-15.06	-16.50	-12.00	1.35	17.10	17.10	208.31

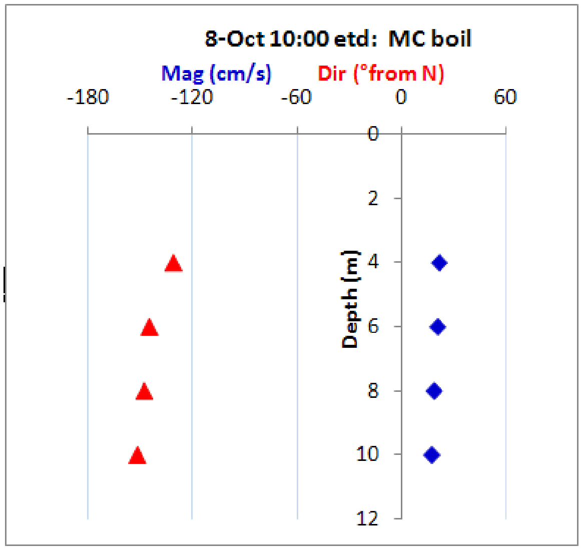


Figure 15: Current velocity and direction for Miami Central outfall on October 8, 2006 at 10:00.

8.6 V-Fin

On 16-October, a V-Fin (tow body with CTD) was towed behind the ship by the ship's A-frame in a crisscrossing track designed to intercept the surface expression of the Miami Central plume. It was expected that the plume would be detected by a deficit in salinity (because the plume is fresh water) and possibly in temperature. The mean location of the plume derived by these data was then used to fix the location of sites which were subsequently sampled by CTE-rosette casts and analyzed for a variety of parameters. While no ocean current measurements were made on this day, it had been noted that the mean current direction was north, so that the V-Fin operation took place north of the outfall location. Deployment of the V-Fin is shown in Figure 16.

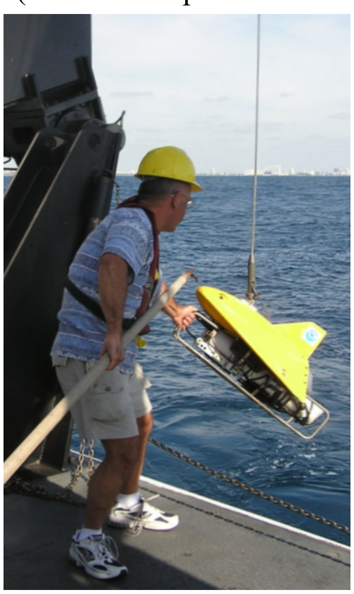


Figure 16: V-Fin being launched from the aft of the R/V Nancy Foster.

Figure 17 shows the track over the outfall plume and the salinity and temperature traces from the V-Fin instrumentation. The areas indicating the plume have been highlighted in differing colors. The data indicate that the plume was moving northward as expected. Clearly, the temperature deficit was minimal, with little or no change in temperature when the plume was encountered.

Because of an instrumentation problem, it was found that the V-Fin data time stamp had to be adjusted by 1.75 minutes to bring that data into conformity with the ship's time. This factor was applied to all V-Fin data sets reported in this document.

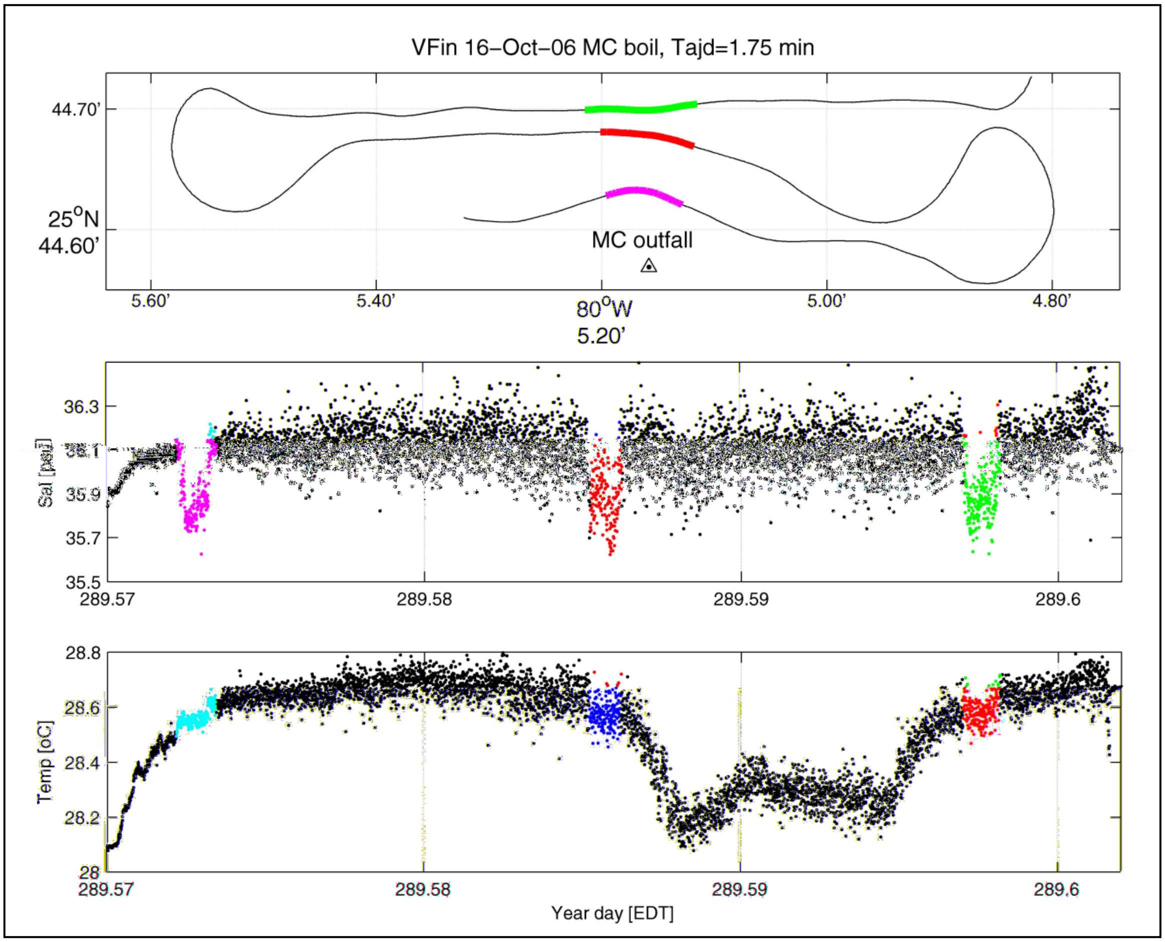


Figure 17: Upper panel: plot of the path of the V-Fin on 16-October, crossing the Miami Central outfall plume. The middle panel (salinity) and the bottom panel (temperature) are from the V-Fin CTD instrumentation. Plume indications as determined by salinity deficit are highlighted in magenta, red, and green.

9.0 Miami North Outfall

9.1 Outfall Description

Miami North ocean outfall is located approximately 3.6 km offshore the northern section of Miami Beach at a depth of 32.9 meters and has an average discharge flow rate of 80 MGD. Figure 18 shows the outfall pipe as recorded by the ship's multibeam system. From these data, a location of 25° 55.203'N, 80° 5.176'W (25.92005°N, 80.0862667°W) was determined. Table 7 lists the CTD sample stations and sample depth. Table 10 lists the sediment sample locations and depth.

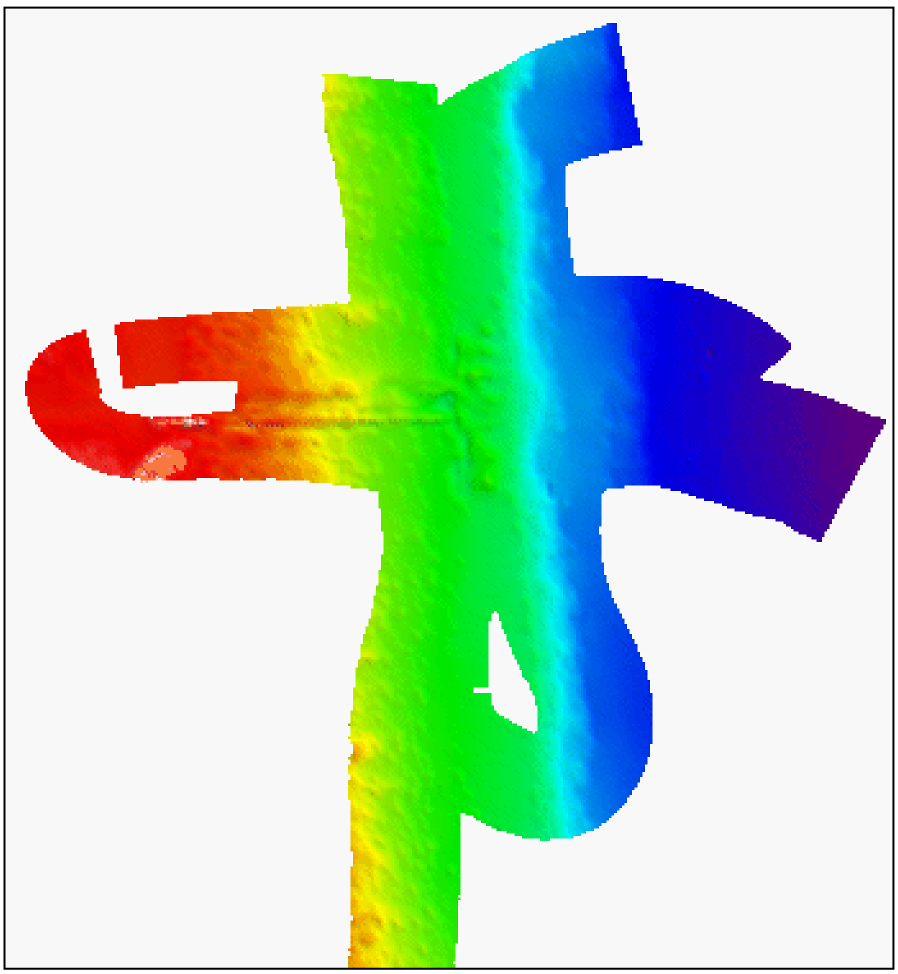


Figure 18: Multibeam data from the sea floor in the vicinity of the Miami North outfall.

Table 10: CTD sample locations for Miami North Outfall.

.

Date	Station #	Latitude	Longitude	Depth (m)	Dist to pipe (m)
17-Oct	MN- 2a	25.9196	-80.0863	44.5	0.0

Table 11: Sediment sample locations for Miami North Outfall.

Date	Station	Latitude	Longitude	Depth (m)
11-Oct	MN10	25.9202	-79.9863	253.0
11-Oct	MN10b	25.9194	-79.9889	257.0
11-Oct	MN10c	25.9233	-79.9871	257.0
11-Oct	MN11	25.9202	-80.0364	255.6
11-Oct	MN12	25.9203	-80.0664	140.9
11-Oct	MN13	25.9202	-80.0962	15.3
11-Oct	MN14a	25.9114	-80.0863	28.4
11-Oct	MN14b	25.9114	-80.0863	28.4
11-Oct	MN14c	25.9112	-80.0859	29.7
11-Oct	MN15	25.9112	-80.0862	30.6
11-Oct	MN16a	25.9202	-80.0862	27.6
11-Oct	MN16b	25.9202	-80.0858	32.6
11-Oct	MN16c	25.9203	-80.0858	32.7
11-Oct	MN17a	25.9210	-80.0864	30.6
11-Oct	MN17b	25.9220	-80.0857	32.1
11-Oct	MN17c	25.9220	-80.0857	32.1
11-Oct	MN18	25.9211	-80.0857	34.0
11-Oct	M18b	25.9211	-80.0857	34.0
11-Oct	MN19a	25.9228	-80.0858	33.4
11-Oct	MN19b	25.9228	-80.0858	33.4
11-Oct	MN19c	25.9228	-80.0859	36.9
11-Oct	MN20	25.9237	-80.0856	34.8
11-Oct	MN21	25.9291	-80.0856	35.5

9.2 Nutrients

A total of 31 nutrient samples were collected during the CTD operations around the Miami Central outfall. These results are listed in Table 12 for concentrations in εM and in Table 13 for concentrations in mg/L. Results for N+N are plotted in Figure 19.

Table 12: Nutrient results in εM from the Miami North Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
1a	1.4	29.00	1.00	12.85	0.78	3.24
1b	15.8	1.71	0.49	4.79	0.24	1.71
1c	28.1	0.26	0.14	0.02	0.03	0.62
2	24.3	2.81	1.77	26.10	1.71	5.78
3a	1.4	0.37	0.23	2.66	0.13	0.90
3b	15.9	0.08	0.02	0.00	0.00	0.36
3c	33.5	0.14	0.02	0.00	0.00	0.11
4a	1.2	0.21	0.12	1.36	0.06	0.44
4b	19.4	0.06	0.01	0.00	0.00	0.17
4c	34.1	0.10	0.01	0.00	0.00	0.11
5a	1.4	0.58	0.39	5.08	2.00	1.14
5b	15.6	0.04	0.02	0.00	0.00	0.11
5c	33.2	0.11	0.03	0.00	0.00	0.11
6a	2.8	0.76	0.50	6.02	0.42	1.63
6b	10.9	0.11	0.04	0.00	0.04	0.27
6c	23.6	0.30	0.04	0.00	0.06	0.25
7a	1.5	0.68	0.44	6.20	0.00	1.53
7b	13.6	0.10	0.03	0.00	0.00	0.13
7c	26.2	0.12	0.01	0.00	0.00	0.10
8a	1.5	0.13	0.01	0.00	0.00	0.10
8b	13.6	0.11	0.01	0.00	0.00	0.10
8c	25.4	0.19	0.02	0.12	0.00	0.21
9a	1.5	0.35	0.22	2.52	0.00	1.77
9b	8.6	0.34	0.20	3.12	0.00	1.34
9c	16.7	0.24	0.03	0.00	0.00	0.18
10a	1.4	0.08	0.04	0.00	0.00	1.24
10b	8.5	0.05	0.03	0.00	0.00	0.91
10c	17.0	0.21	0.02	0.00	0.00	0.29
11a	1.4	0.07	0.01	0.00	0.00	1.29
11b	9.3	0.00	0.00	0.00	0.00	0.02
11c	18.0	0.14	0.02	0.00	0.00	0.05

Table 13: Nutrient results in mg/L from the Miami North Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1a	1.4	0.406	0.014	0.180	0.024	0.091
1b	15.8	0.024	0.007	0.067	0.008	0.048
1c	28.1	0.004	0.002	0.000	0.001	0.017
2	24.3	0.039	0.025	0.365	0.053	0.162
3a	1.4	0.005	0.003	0.037	0.004	0.025
3b	15.9	0.001	0.000	0.000	0.000	0.010
3c	33.5	0.002	0.000	0.000	0.000	0.003
4a	1.2	0.003	0.002	0.019	0.002	0.012
4b	19.4	0.001	0.000	0.000	0.000	0.005
4c	34.1	0.001	0.000	0.000	0.000	0.003
5a	1.4	0.008	0.005	0.071	0.062	0.032
5b	15.6	0.001	0.000	0.000	0.000	0.003
5c	33.2	0.002	0.000	0.000	0.000	0.003
6a	2.8	0.011	0.007	0.084	0.013	0.046
6b	10.9	0.002	0.001	0.000	0.001	0.008
6c	23.6	0.004	0.001	0.000	0.002	0.007
7a	1.5	0.010	0.006	0.087	0.000	0.043
7b	13.6	0.001	0.000	0.000	0.000	0.004
7c	26.2	0.002	0.000	0.000	0.000	0.003
8a	1.5	0.002	0.000	0.000	0.000	0.003
8b	13.6	0.002	0.000	0.000	0.000	0.003
8c	25.4	0.003	0.000	0.002	0.000	0.006
9a	1.5	0.005	0.003	0.035	0.000	0.050
9b	8.6	0.005	0.003	0.044	0.000	0.038
9c	16.7	0.003	0.000	0.000	0.000	0.005
10a	1.4	0.001	0.001	0.000	0.000	0.035
10b	8.5	0.001	0.000	0.000	0.000	0.025
10c	17.0	0.003	0.000	0.000	0.000	0.008
11a	1.4	0.001	0.000	0.000	0.000	0.036
11b	9.3	0.000	0.000	0.000	0.000	0.001
11c	18.0	0.002	0.000	0.000	0.000	0.001

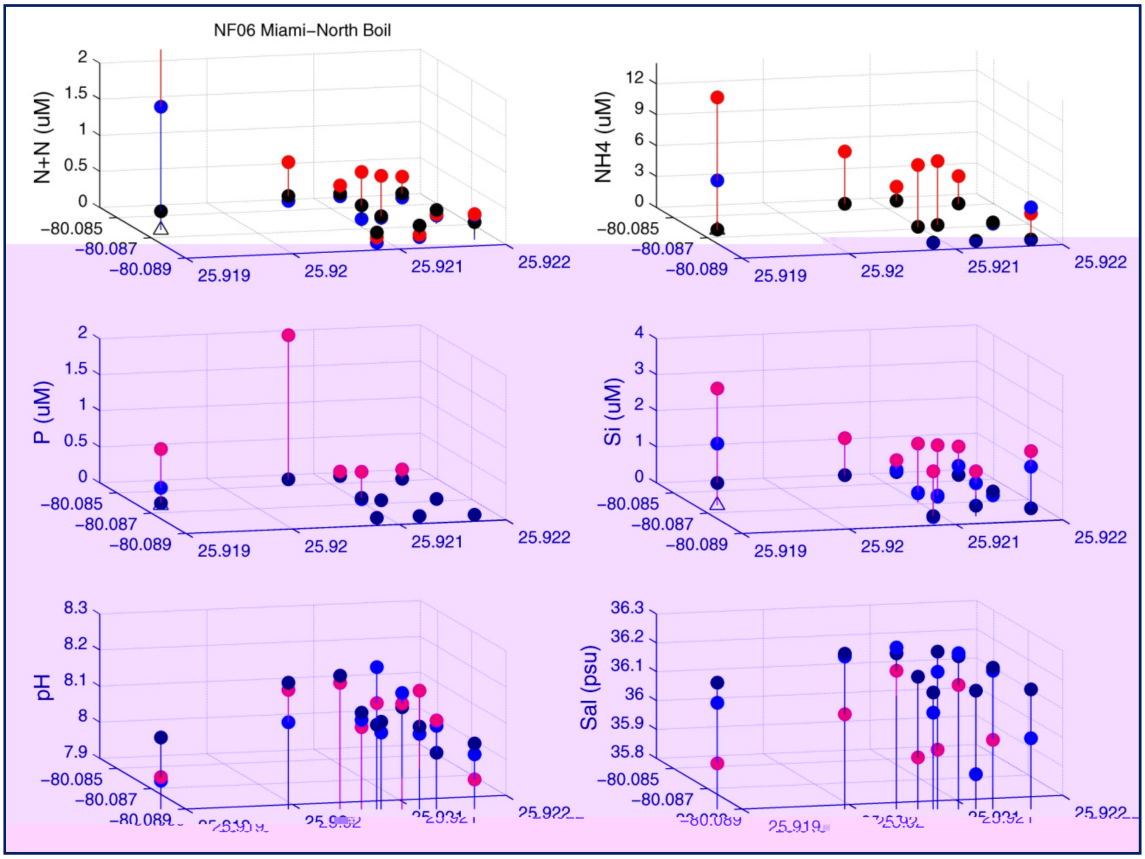


Figure 19. Three-dimensional presentation of N+N, NH_4, P, Si, pH, and salinity data from CTD sampling around the Miami-North outfall. Format follows that of Figure 5. The concentration of N+N at the boil was 29.0 µM.

9.3 Chlorophyll and pH

A total of 31 chlorophyll and pH samples were collected during CTD operations around the Miami North outfall. Table 14 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 14: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from Miami North Outfall.

Station	Depth (m)	Temperature (^0C)	Salinity (Units)	pH (Units)	Chlorophyll a (ug/L)	Phaeopigments (ug/L)
1a	1.4	28.5108	35.6215	7.92	0.778	0.200
1b	15.8	28.4938	36.0718	7.90	0.517	0.188
1c	28.1	28.4885	36.1389	8.02	0.845	0.279
2	24.3	28.5274	35.8575	7.91	0.642	0.189
3a	1.4	28.5563	36.0432	8.04	0.402	0.124
3b	15.9	28.5633	36.1522	8.07	0.468	0.141
3c	33.5	28.4687	36.1375	8.03	0.405	0.126
4a	1.2	28.5705	36.0779	8.09	0.398	0.124
4b	19.4	28.6013	36.1636	8.11	0.390	0.112
4c	34.1	28.5091	36.1422	8.11	0.408	0.164
5a	1.4	28.5757	35.9414	8.08	0.412	0.120
5b	15.6	28.5844	36.1405	7.99	0.384	0.115
5c	33.2	28.5572	36.1546	8.10	0.414	0.122
6a	2.8	28.5595	35.8654	8.04	0.560	0.112
6b	10.9	28.5486	36.1468	8.06	0.396	0.117
6c	23.6	28.5340	36.1469	8.08	0.430	0.119
7a	1.5	28.6667	35.8879	8.02	0.437	0.122
7b	13.6	28.6435	36.1631	8.02	0.530	0.136
7c	26.2	28.6990	36.2251	8.05	0.422	0.123
8a	1.5	28.7774	35.9242	8.05	0.417	0.128
8b	13.6	28.6286	36.1633	N/A	0.492	0.129
8c	25.4	28.6125	36.1695	7.96	0.433	0.139
9a	1.5	28.5961	35.6586	7.93	0.825	0.218
9b	8.6	28.7798	35.9815	8.00	0.687	0.177
9c	16.7	28.5995	36.1504	8.03	0.486	0.113
10a	1.4	28.5764	35.7034	8.18	0.874	0.265
10b	8.5	28.6966	35.8566	8.06	0.776	0.219
10c	17.0	28.6523	36.1472	8.08	0.479	0.156
11a	1.4	28.5659	35.6938	8.15	0.900	0.256
11b	9.3	28.9266	36.0818	8.25	0.594	0.169
11c	18.0	28.6524	36.1527	8.09	0.523	0.149

9.4 CTD CASTS

A total of 11 CTD casts were conducted at the Miami North outfall. At each station the CTD obtained a sample near bottom, mid-point and near surface. Figures 20-30 show the temperature, salinity and oxygen saturation for each station.

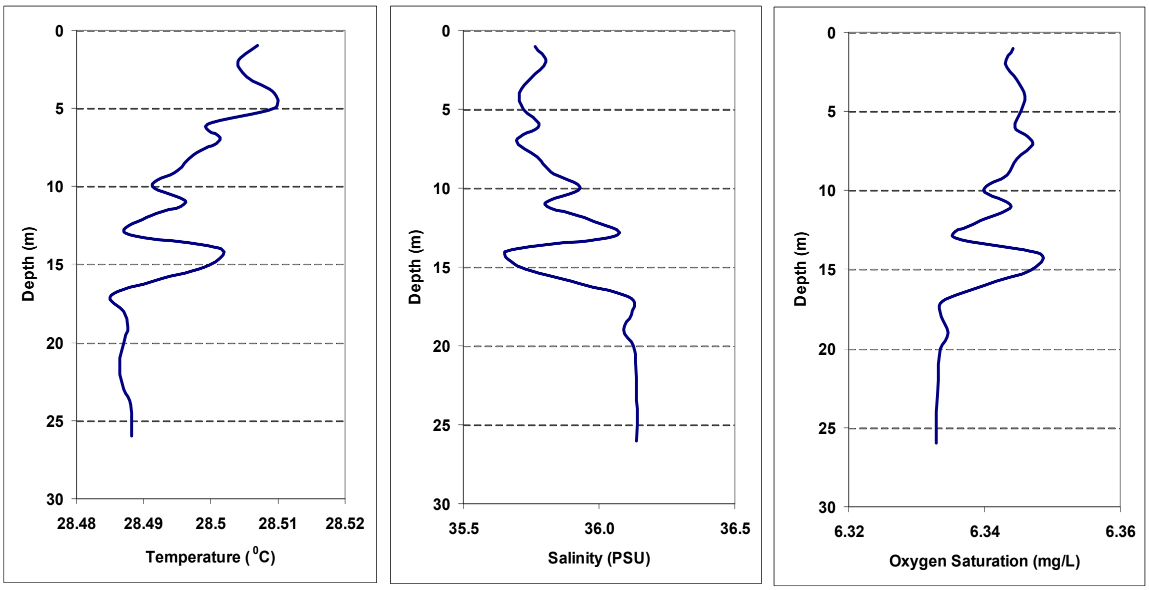


Figure 20: October 17th, 2006 temperature, salinity and oxygen concentration profile at station MNB-1.

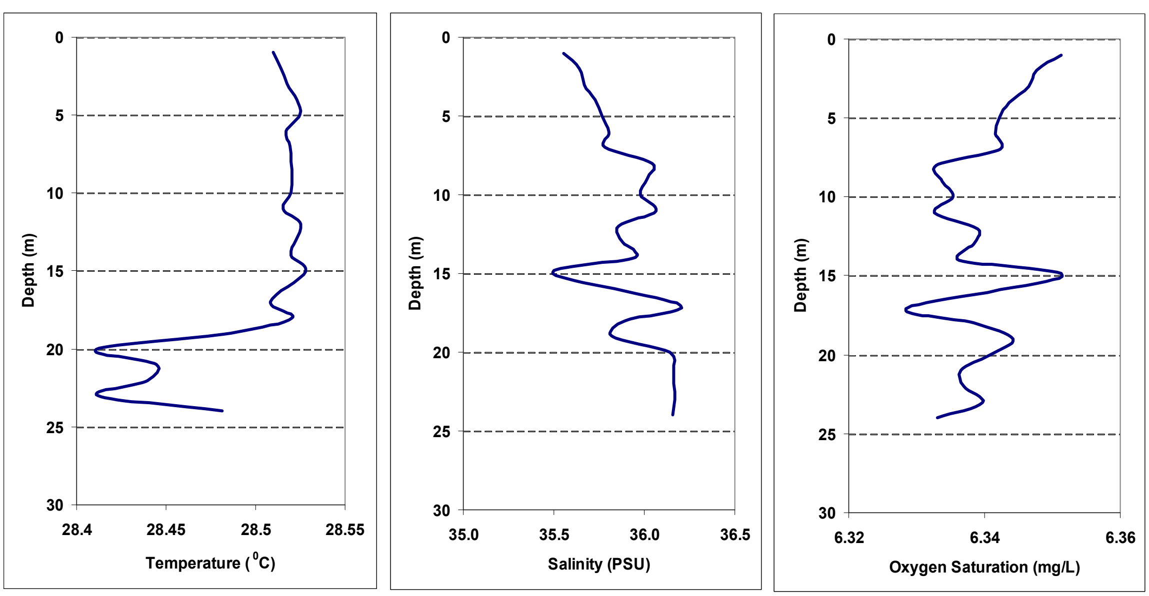


Figure 21: October 17th, 2006 temperature, salinity and oxygen concentration profile at station MNB-2.

Figure 22: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-3.

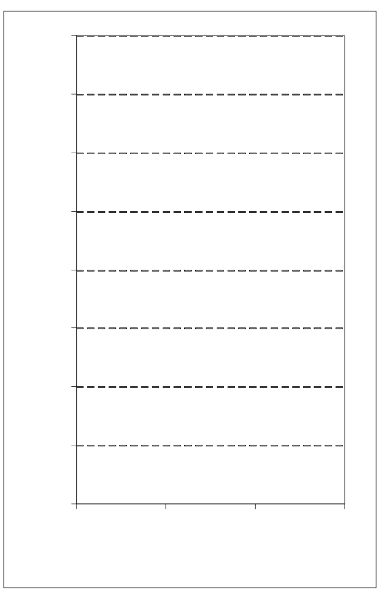


Figure 23: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-4.

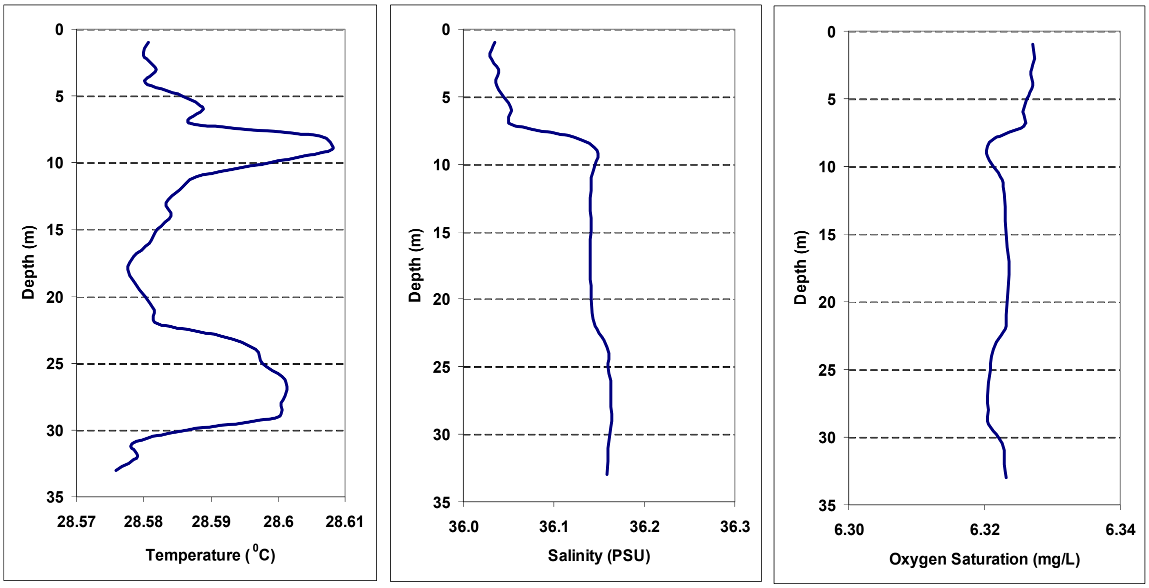


Figure 24: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-5.

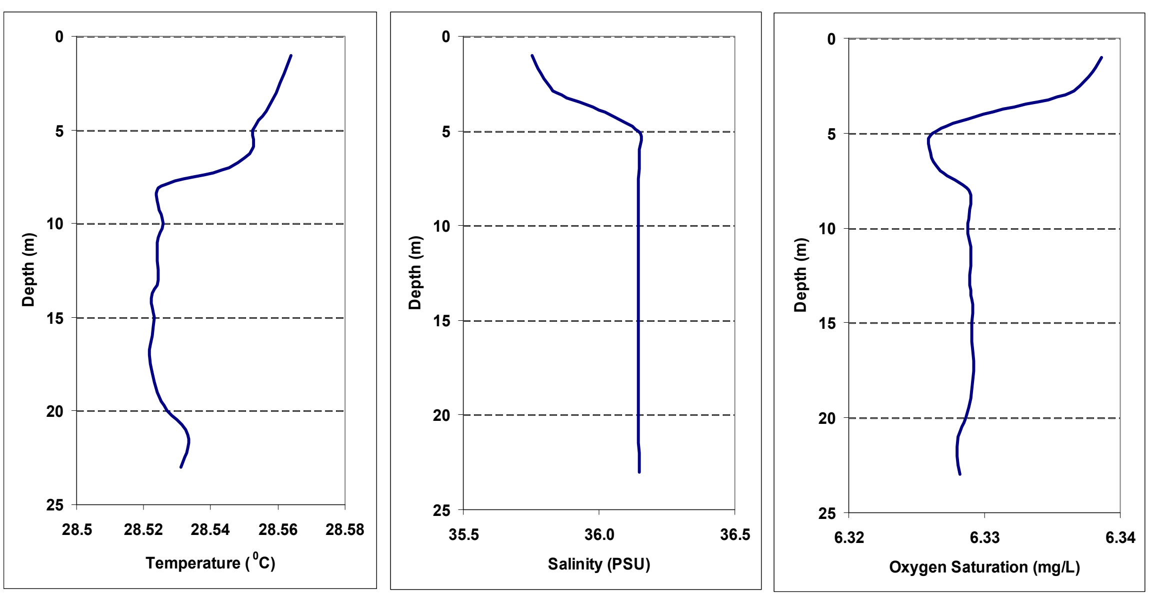


Figure 25: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-6.

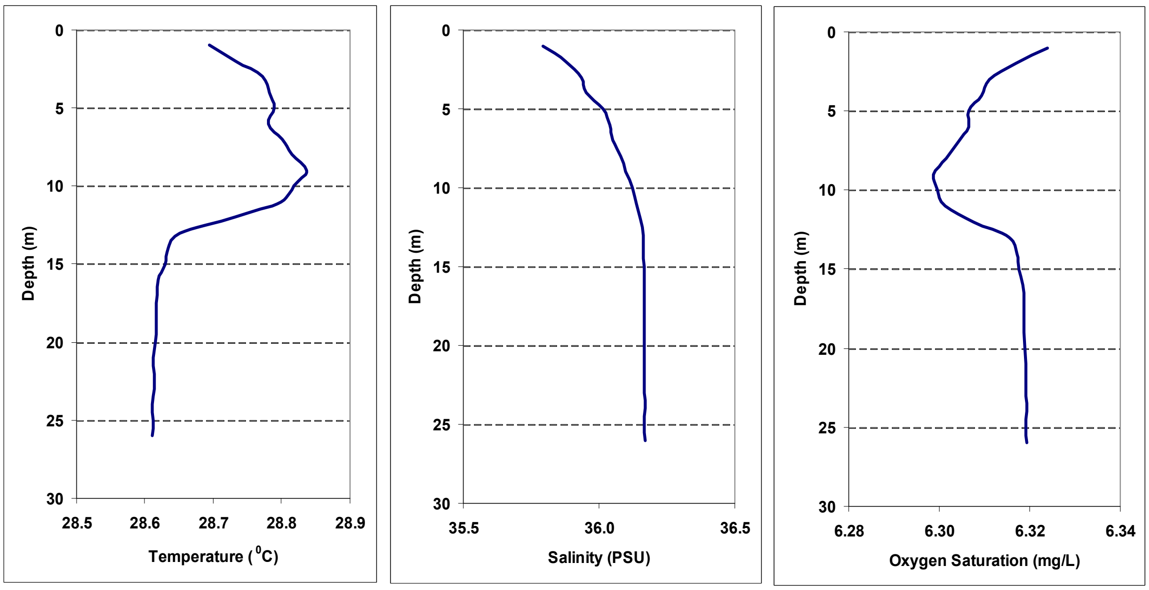


Figure 26: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-7.

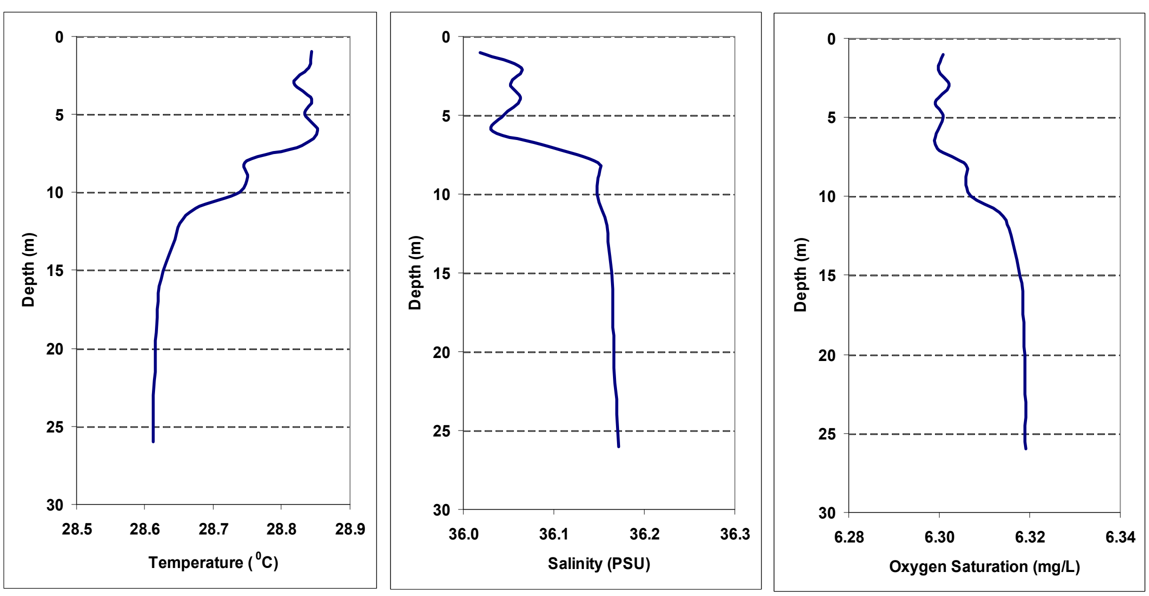


Figure 27: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-8.

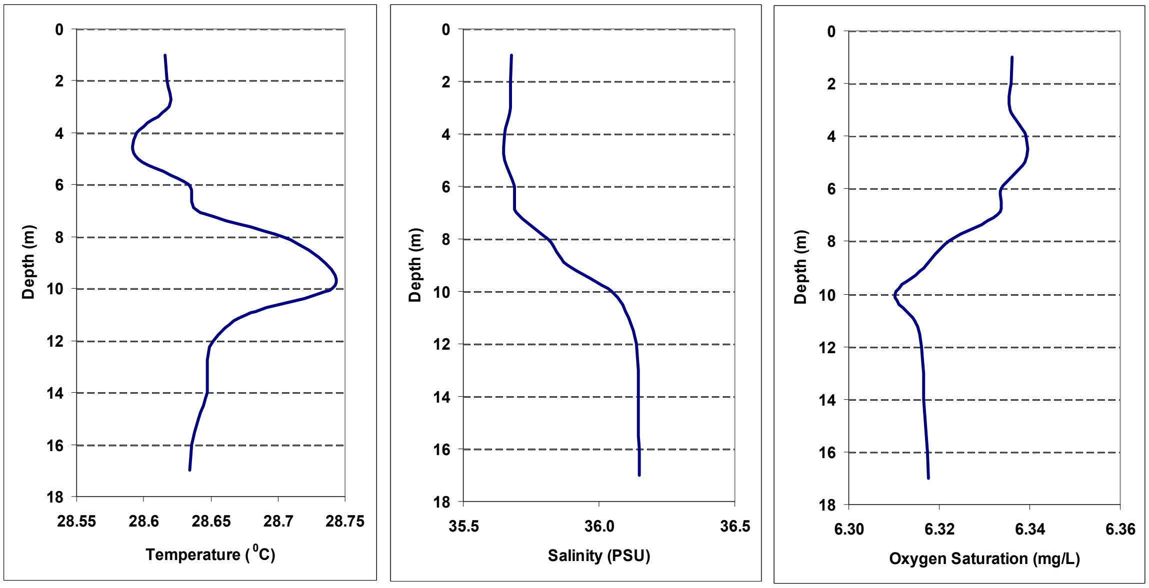


Figure 28: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-9.

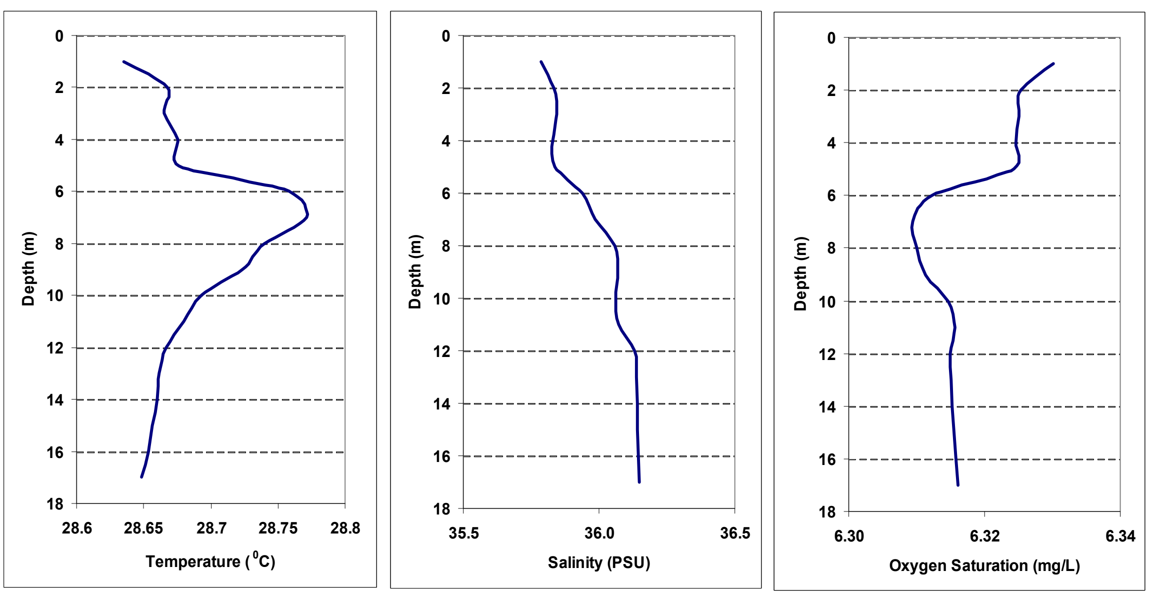


Figure 29: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-10.

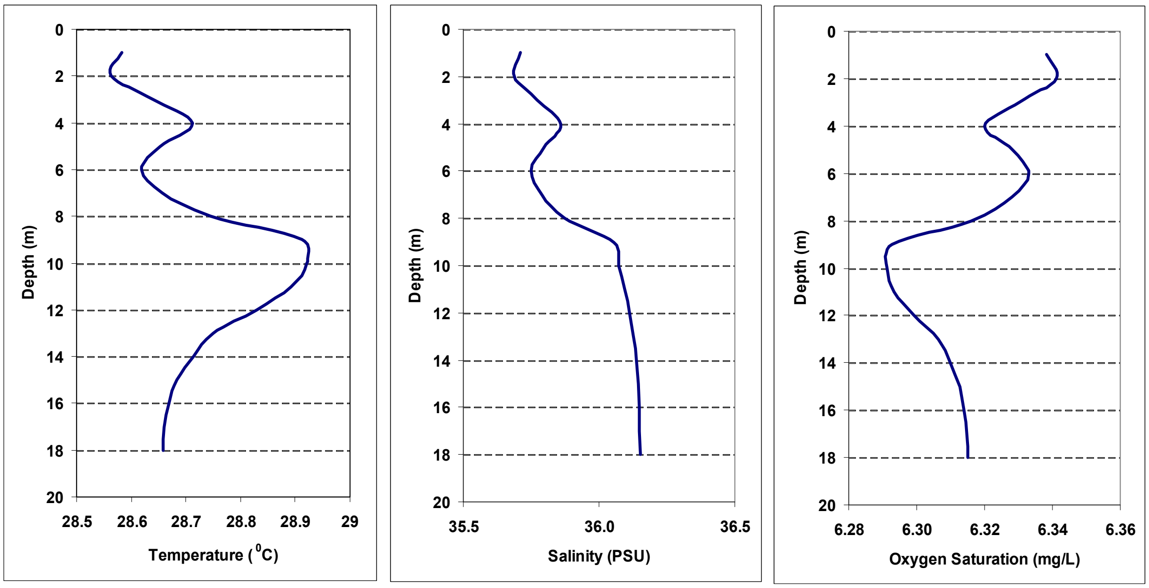


Figure 30: October 18th, 2006 temperature, salinity and oxygen concentration profile at station MNB-11.

9.5 Current Velocity and Direction

A RDI ADCP was dipped at the Miami North outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. A total of four measurements were collected. Tables15-18 list the current velocity and direction data obtained from Miami North outfall, while Figures 31- 34 graphically depict the data.

Table 15: Current velocity and direction for Miami North outfall on October 11, 2006 at 14:00 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4	0.93	-1.80	2.70	1.56	-6.05	-9.70	-2.70	2.28	6.12	6.12	171.31
6	0.61	-2.40	5.10	2.57	-3.69	-5.20	-1.90	1.20	3.74	3.74	170.57
8	1.63	-0.10	2.70	0.80	-3.94	-6.10	-1.40	1.38	4.26	4.26	157.57
10	1.95	0.40	5.00	1.42	-4.03	-9.10	-0.40	2.62	4.47	4.47	154.15
12	1.69	-1.20	3.70	1.59	-2.71	-6.10	0.90	2.66	3.19	3.19	148.11
14	1.03	-0.90	3.20	1.42	-2.19	-6.30	1.90	2.65	2.42	2.42	154.89
16	0.94	-0.40	2.40	1.02	-1.31	-3.40	1.30	1.72	1.61	1.61	144.46
18	0.54	-1.40	3.20	1.48	-0.99	-2.70	2.00	1.68	1.12	1.12	151.44
20	0.11	-2.30	2.40	1.55	0.19	-1.40	1.90	1.11	0.22	0.22	30.96
22	-0.88	-2.10	0.70	1.15	1.93	-0.40	3.30	1.07	2.11	2.11	335.56
24	-2.66	-3.80	-1.40	0.87	3.99	2.90	4.80	0.60	4.79	4.79	326.27
26	-3.48	-3.90	-2.50	0.44	4.48	3.60	5.50	0.83	5.67	5.67	322.17
28	-4.15	-5.50	-2.90	0.97	4.15	2.80	5.40	1.05	5.87	5.87	315.00

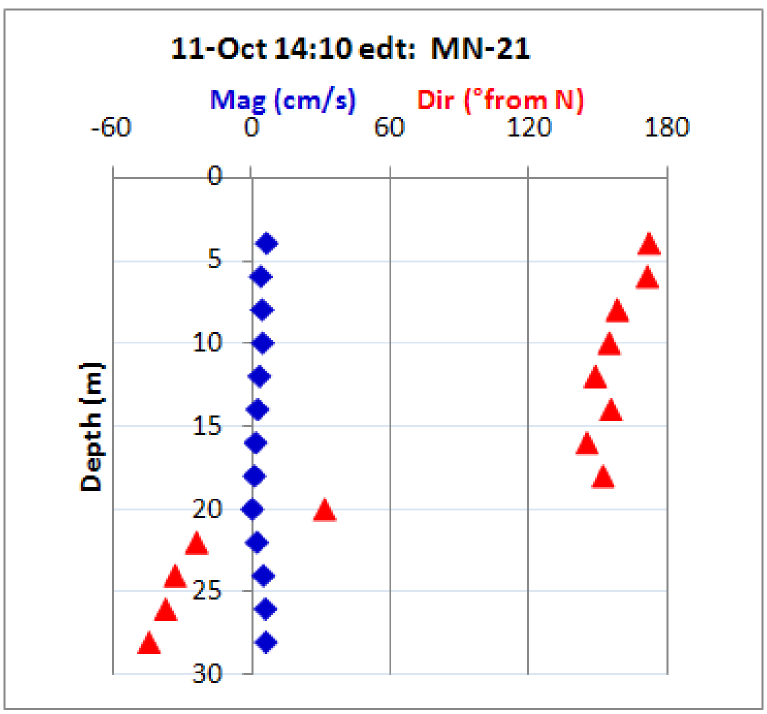


Figure 31: Current velocity and direction for Miami North outfall on October 11, 2006 at 14:00.

Table 16: Current velocity and direction for Miami North outfall on October 11, 2006 at 20:20 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4	0.78	-1.20	3.50	2.01	-5.72	-12.70	0.20	5.47	5.77	5.77	172.23
6	3.16	2.00	6.10	1.71	-4.90	-8.60	0.20	3.81	5.83	5.83	147.18
8	3.28	1.40	5.90	1.96	-4.14	-7.30	0.30	3.11	5.28	5.28	141.61
10	2.86	0.80	5.00	1.76	-4.82	-7.70	-2.50	2.13	5.60	5.60	149.32
12	2.62	1.50	4.10	1.16	-7.54	-13.30	-3.10	3.99	7.98	7.98	160.84
14	3.46	1.60	4.90	1.33	-7.84	-14.50	-4.80	3.86	8.57	8.57	156.19
16	3.14	1.50	4.10	1.07	-8.04	-13.80	-2.50	4.26	8.63	8.63	158.67
18	3.80	2.80	4.90	0.89	-9.40	-14.60	-3.90	4.31	10.14	10.14	157.99
20	3.60	1.70	6.00	1.57	-9.74	-14.20	-4.40	4.28	10.38	10.38	159.72
22	3.62	1.80	7.60	2.28	-10.56	-13.70	-3.50	4.35	11.16	11.16	161.08
24	3.76	2.50	6.80	1.77	-10.08	-14.00	-4.80	3.57	10.76	10.76	159.54
26	3.90	2.10	6.60	1.73	-10.42	-14.70	-6.30	3.30	11.13	11.13	159.48

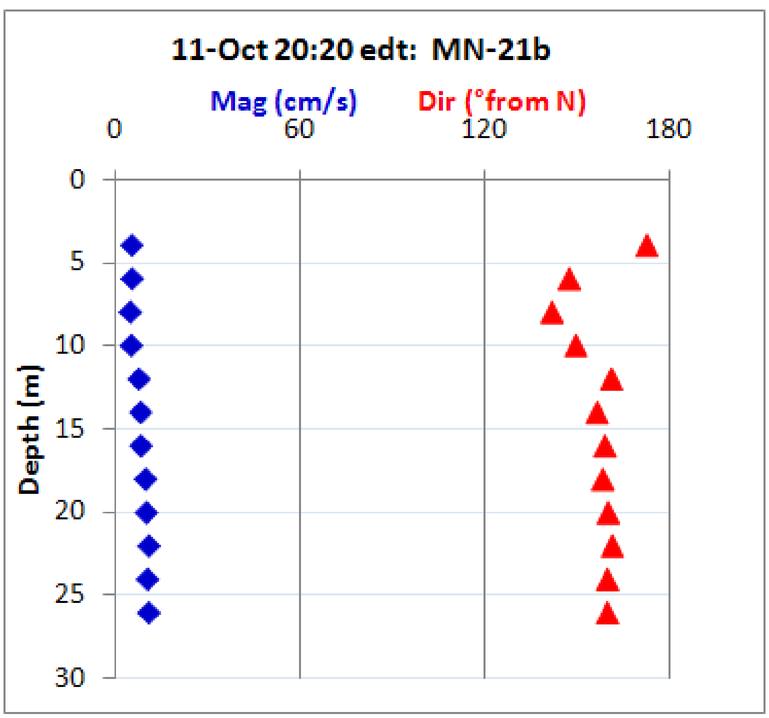


Figure 32: Current velocity and direction for Miami North outfall on October 11, 2006 at 14:00.

Table 17: Current velocity and direction for Miami North outfall on October 17, 2006 at 19:00 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4.25	17.17	11.50	23.10	5.80	-18.17	-20.80	-14.50	3.27	24.99	24.99	136.62
6.25	16.67	14.20	19.50	2.67	-11.37	-15.00	-8.40	3.35	20.17	20.17	124.29
8.25	17.60	10.00	23.50	6.91	-4.03	-7.90	3.20	6.27	18.06	18.06	102.91
10.25	21.00	7.70	32.00	12.31	-4.50	-8.40	1.20	5.05	21.48	21.48	102.09
12.25	31.70	19.80	39.10	10.41	-7.67	-11.30	-5.60	3.16	32.61	32.61	103.60
14.25	40.07	32.80	47.40	7.30	-7.63	-11.90	-0.80	5.98	40.79	40.79	100.79
16.25	38.43	32.90	43.00	5.12	-7.27	-11.70	1.40	7.51	39.11	39.11	100.71
18.25	38.70	32.70	42.20	5.22	-6.27	-10.70	-2.30	4.22	39.20	39.20	99.20
20.25	34.50	34.10	34.80	0.36	-5.87	-9.70	-3.00	3.45	35.00	35.00	99.65
22.25	22.43	17.00	25.30	4.71	0.07	-5.20	4.90	5.06	22.43	22.43	89.83
24.25	16.00	12.90	19.10	3.10	1.53	-4.90	5.10	5.58	16.07	16.07	84.53
26.25	12.97	9.50	16.40	3.45	-4.90	-8.90	-2.10	3.56	13.86	13.86	110.70

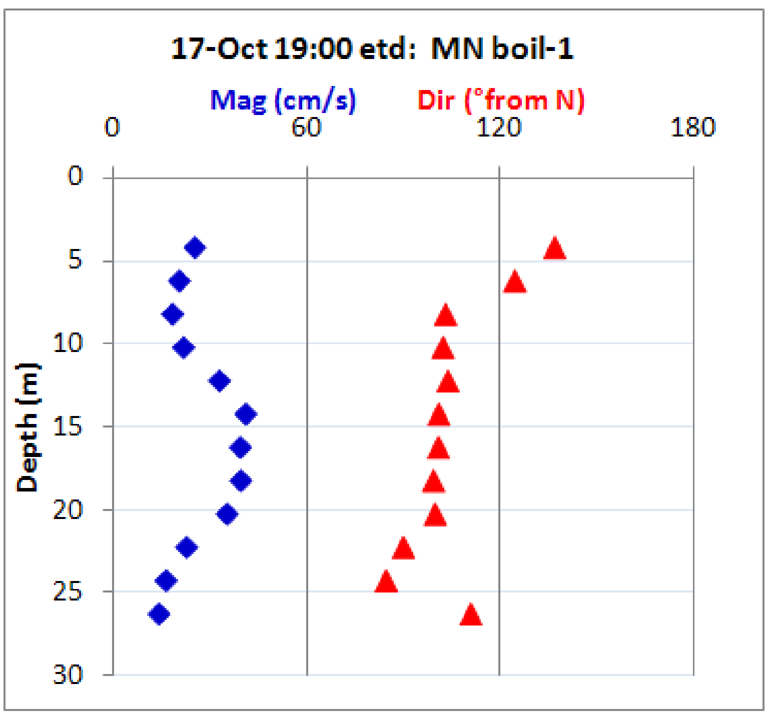


Figure 33: Current velocity and direction for Miami North outfall on October 17, 2006 at 19:00.

Table 18: Current velocity and direction for Miami North outfall on October 18, 2006 at 07:40 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4.3	-4.22	-6.80	-1.60	1.75	8.97	5.50	12.70	2.75	9.91	9.91	334.81
6.3	-4.33	-6.60	1.70	3.09	7.42	2.00	10.70	3.35	8.59	8.59	329.70
8.3	-3.48	-7.00	-1.70	1.90	7.68	3.80	12.50	3.48	8.44	8.44	335.61
10.3	-2.12	-4.60	-0.20	1.78	9.25	4.00	13.40	3.37	9.49	9.49	347.11
12.3	-2.58	-6.40	-0.20	2.54	10.95	7.00	14.40	2.76	11.25	11.25	346.73
14.3	-3.38	-7.10	-1.30	2.34	11.92	9.70	14.30	1.83	12.39	12.39	344.15
14.3	-2.67	-6.00	-0.20	2.25	11.78	9.00	15.20	2.69	12.08	12.08	347.25
16.3	-2.83	-4.70	-1.40	1.34	10.98	8.50	13.40	2.27	11.34	11.34	345.53
18.3	-2.45	-4.20	-1.10	1.12	11.62	10.40	13.10	1.07	11.87	11.87	348.09
20.3	-2.65	-4.70	-0.60	1.47	11.27	9.50	12.30	1.01	11.57	11.57	346.76
22.3	-3.10	-5.30	-1.20	1.51	11.32	10.40	12.00	0.60	11.73	11.73	344.68
24.3	-2.63	-4.90	0.10	1.72	11.48	9.80	12.80	1.13	11.78	11.78	347.08
26.3	-1.75	-3.50	2.40	2.13	11.42	10.60	12.20	0.60	11.55	11.55	351.29
28.3	-1.55	-2.40	0.60	1.09	9.00	7.70	11.60	1.42	9.13	9.13	350.23

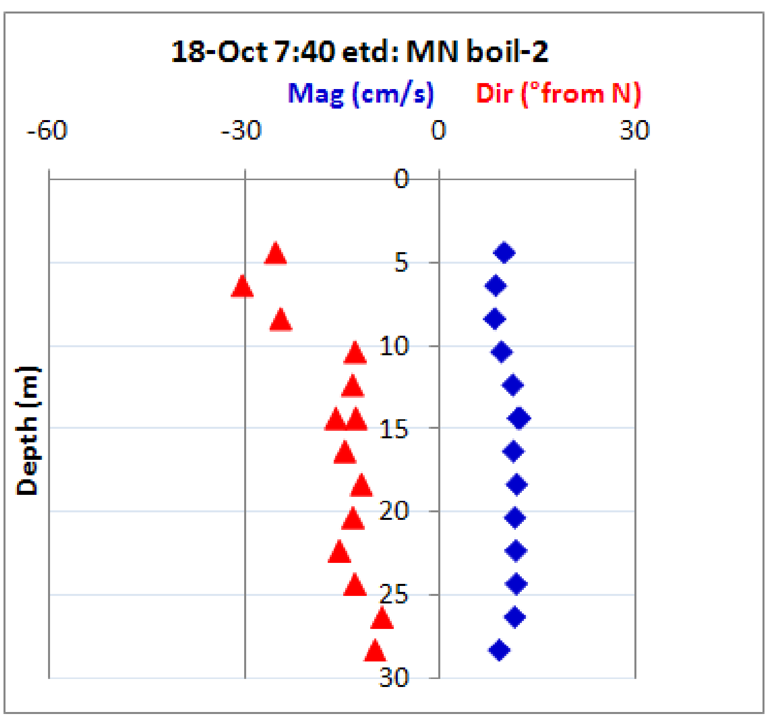


Figure 34: Current velocity and direction for Miami North outfall on October 18, 2006 at 07:40.

9.6 V-Fin

No V-Fin data collected.

10.0 HOLLYWOOD OUTFALL

10.1 Outfall Description

Hollywood ocean outfall is located approximately 3.1 km offshore the southern section of Broward County at a depth of 28.3 meters and has an average discharge flow rate of 40 MGD. Figure 35 shows the outfall pipe as recorded by the ship's multibeam system. From these data, a location of 26° 1.147 'N, 80° 5.156 'W (26.019117°N, 80.089533°W) was determined. Table 16 lists the CTD sample stations and sample depth. Table 17 lists the sediment sample locations and depth.

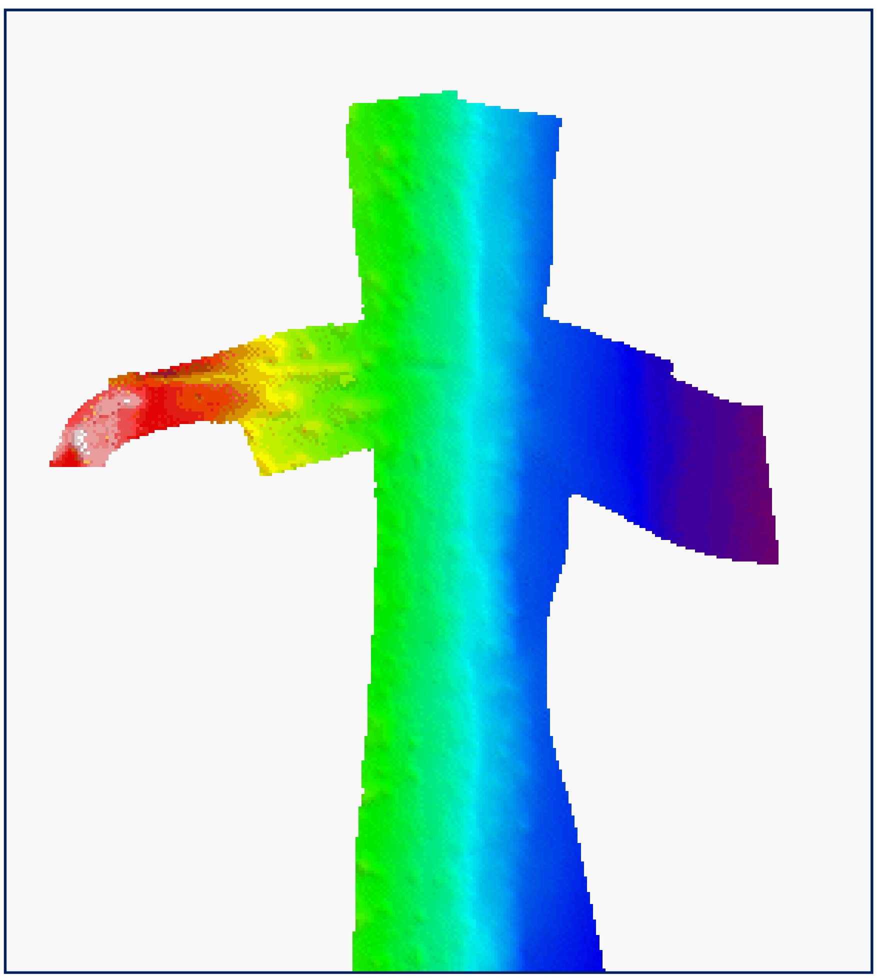


Figure 35. Multibeam view of the sea floor in the vicinity of the Hollywood outfall pipe. The structure can be seen as the yellow line in the left arm of the view.

Table 19: CTD sample locations for Hollywood Outfall.

Date	Station #		Latitude	Longitude	Dist to pipe (m)	Depth (m)
17-Oct	HW-	10a	26.0197	-80.0856	0.0	0.0
17-Oct	HW-	1ab	26.0203	-80.0868	137.2	0.0
17-Oct	HW-	2a	26.0203	-80.0856	66.7	0.0
17-Oct	HW-	3a	26.0203	-80.0846	120.1	0.0
17-Oct	HW-	4a	26.0208	-80.0845	164.4	0.0
17-Oct	HW-	5a	26.0207	-80.0857	111.6	0.0
17-Oct	HW-	6a	26.0207	-80.0871	186.6	0.0
17-Oct	HW-	7a	26.0211	-80.0874	237.9	0.0
17-Oct	HW-	8a	26.0212	-80.0856	166.8	0.0
17-Oct	HW-	9a	26.0213	-80.0840	239.2	0.0
17-Oct	HW-	10b	26.0197	-80.0856	0.0	14.3
17-Oct	HW-	1bb	26.0203	-80.0868	137.2	10.1
17-Oct	HW-	2b	26.0203	-80.0856	66.7	13.8
17-Oct	HW-	3b	26.0203	-80.0846	120.1	17.1
17-Oct	HW-	4b	26.0208	-80.0845	164.4	17.3
17-Oct	HW-	5b	26.0207	-80.0857	111.6	13.4
17-Oct	HW-	6b	26.0207	-80.0871	186.6	8.0
17-Oct	HW-	7b	26.0211	-80.0874	237.9	7.7
17-Oct	HW-	8b	26.0212	-80.0856	166.8	13.8
17-Oct	HW-	9b	26.0213	-80.0840	239.2	18.6
17-Oct	HW-	11	26.0186	-80.0861	132.1	25.2
17-Oct	HW-	10c	26.0197	-80.0856	0.0	28.5
17-Oct	HW-	1cb	26.0203	-80.0868	137.2	20.2
17-Oct	HW-	2c	26.0203	-80.0856	66.7	27.5
17-Oct	HW-	3c	26.0203	-80.0846	120.1	34.2
17-Oct	HW-	4c	26.0208	-80.0845	164.4	34.6
17-Oct	HW-	5c	26.0207	-80.0857	111.6	26.8
17-Oct	HW-	6c	26.0207	-80.0871	186.6	16.0
17-Oct	HW-	7c	26.0211	-80.0874	237.9	15.4
17-Oct	HW-	8c	26.0212	-80.0856	166.8	27.5
17-Oct	HW-	9c	26.0213	-80.0840	301.1	37.1

Table 20: Sediment sample locations for Hollywood Outfall.

Date	Station	Latitude	Longitude	Depth (m)
10-Oct	HW10	26.0193	-79.9869	262.0
10-Oct	HW11	26.0189	-80.0363	234.0
10-Oct	HW12	26.0189	-80.0663	135.8
10-Oct	HW13	26.0190	-80.0966	26.0
10-Oct	HW14	26.0280	-80.0863	22.7
10-Oct	HW14b	26.0280	-80.0863	22.7
10-Oct	HW15	26.0227	-80.0862	22.9
10-Oct	HW16	26.0219	-80.0860	24.3
10-Oct	HW16b	26.0219	-80.0862	24.0
10-Oct	HW16c	26.0219	-80.0862	23.0
10-Oct	HW16d	26.0219	-80.0858	26.4
10-Oct	HW17	26.0210	-80.0860	25.2
10-Oct	HW17b	26.0210	-80.0856	28.1
10-Oct	HW18	26.0201	-80.0855	28.5
10-Oct	HW19	26.0192	-80.0855	29.0
10-Oct	HW19a	26.0192	-80.0855	29.0
10-Oct	HW19b	26.0192	-80.0853	29.8
10-Oct	HW19c	26.0191	-80.0853	29.8
10-Oct	HW19d	26.0191	-80.0853	29.8
10-Oct	HW20	26.0182	-80.0854	29.4
10-Oct	HW21	26.0100	-80.0859	28.5
10-Oct	HW21b	26.0100	-80.0860	28.1

10.2 Nutrients

A total of 31 nutrient samples were collected during the CTD operations around the Hollywood outfall. These results are listed in Table 21 for concentrations in εM and in Table 22 for concentrations in mg/L.

Table 21: Nutrient results in εM from the Hollywood Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
1ab	2.6	0.25	0.03	0.55	0.13	0.63
1bb	6.8	0.20	0.02	0.01	0.04	0.57
1cb	16.3	0.24	0.02	0.20	0.00	0.54
2a	1.5	0.59	0.32	2.03	0.08	0.87
2b	11.4	0.70	0.42	1.97	0.04	1.01
2c	22.9	0.25	0.00	0.06	0.00	0.43
3a	2.3	1.26	0.81	3.31	0.09	1.54
3b	15.3	0.08	0.00	0.00	0.00	0.40
3c	31.6	0.09	0.00	0.00	0.00	0.35
4a	1.7	0.08	0.00	0.00	0.00	0.52
4b	18.7	0.13	0.00	0.33	0.00	0.49
4c	32.4	0.19	0.02	0.10	0.00	0.43
5a	1.4	0.23	0.09	0.59	0.00	0.52
5b	12.2	0.18	0.04	0.36	0.00	0.43
5c	24.1	0.26	0.02	0.00	0.00	0.38
6a	1.5	0.18	0.01	0.00	0.00	0.38
6b	9.4	0.21	0.01	0.00	0.00	0.40
6c	13.5	0.19	0.01	0.00	0.00	0.38
7a	1.3	0.23	0.03	0.00	0.00	0.43
7b	7.1	0.21	0.02	0.06	0.00	0.38
7c	12.3	0.18	0.02	0.00	0.00	0.32
8a	1.2	0.64	0.34	2.20	0.00	0.96
8b	12.3	0.16	0.03	0.12	0.00	0.43
8c	24.6	0.15	0.01	0.07	0.00	0.49
9a	1.5	0.03	0.00	0.15	0.00	0.35
9b	18.7	0.03	0.00	0.00	0.00	0.35
9c	35.6	0.13	0.01	0.11	0.00	0.32
10a	1.5	0.77	0.46	3.17	0.00	1.32
10b	13.8	0.16	0.01	0.54	0.00	0.40
10c	25.8	0.12	0.01	0.23	0.00	0.40
11	35.8	5.95	4.56	30.22	0.83	8.26

Table 22: Nutrient results in mg/L from the Hollywood Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1ab	2.6	0.004	0.000	0.008	0.004	0.018
1bb	6.8	0.003	0.000	0.000	0.001	0.016
1cb	16.3	0.003	0.000	0.003	0.000	0.015
2a	1.5	0.008	0.004	0.028	0.002	0.024
2b	11.4	0.010	0.006	0.028	0.001	0.028
2c	22.9	0.004	0.000	0.001	0.000	0.012
3a	2.3	0.018	0.011	0.046	0.003	0.043
3b	15.3	0.001	0.000	0.000	0.000	0.011
3c	31.6	0.001	0.000	0.000	0.000	0.010
4a	1.7	0.001	0.000	0.000	0.000	0.015
4b	18.7	0.002	0.000	0.005	0.000	0.014
4c	32.4	0.003	0.000	0.001	0.000	0.012
5a	1.4	0.003	0.001	0.008	0.000	0.015
5b	12.2	0.003	0.001	0.005	0.000	0.012
5c	24.1	0.004	0.000	0.000	0.000	0.011
6a	1.5	0.003	0.000	0.000	0.000	0.011
6b	9.4	0.003	0.000	0.000	0.000	0.011
6c	13.5	0.003	0.000	0.000	0.000	0.011
7a	1.3	0.003	0.000	0.000	0.000	0.012
7b	7.1	0.003	0.000	0.001	0.000	0.011
7c	12.3	0.003	0.000	0.000	0.000	0.009
8a	1.2	0.009	0.005	0.031	0.000	0.027
8b	12.3	0.002	0.000	0.002	0.000	0.012
8c	24.6	0.002	0.000	0.001	0.000	0.014
9a	1.5	0.000	0.000	0.002	0.000	0.010
9b	18.7	0.000	0.000	0.000	0.000	0.010
9c	35.6	0.002	0.000	0.002	0.000	0.009
10a	1.5	0.011	0.006	0.044	0.000	0.037
10b	13.8	0.002	0.000	0.008	0.000	0.011
10c	25.8	0.002	0.000	0.003	0.000	0.011
11	35.8	0.083	0.064	0.423	0.026	0.231

10.3 Chlorophyll and pH

A total of 31 chlorophyll and pH samples were collected during CTD operations around the Hollywood outfall. Table 20 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 23: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from Hollywood Outfall.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
1ab	2.6	28.6116	36.1626	7.93	0.406	0.114
1bb	6.8	28.6109	36.1634	7.93	0.409	0.111
1cb	16.3	28.6123	36.1632	7.98	0.430	0.118
2a	1.5	28.5924	36.0571	8.00	0.475	0.129
2b	11.4	28.5956	36.0453	7.95	0.480	0.125
2c	22.9	28.5912	36.1493	8.01	0.460	0.120
3a	2.3	28.6017	35.9236	8.00	0.494	0.115
3b	15.3	28.2869	36.1464	8.00	0.509	0.122
3c	31.6	28.5853	36.1457	8.03	0.493	0.124
4a	1.7	28.6932	36.1801	8.03	0.335	0.076
4b	18.7	28.5969	36.1621	7.96	0.473	0.068
4c	32.4	28.5637	36.1507	8.02	0.483	0.108
5a	1.4	28.6457	36.1449	8.05	0.373	0.081
5b	12.2	28.6239	36.1577	8.07	0.371	0.091
5c	24.1	28.6058	36.1593	8.03	0.397	0.095
6a	1.5	28.6047	36.1499	8.03	0.439	0.103
6b	9.4	28.5937	36.1492	8.02	0.462	0.101
6c	13.5	28.5949	36.1493	8.05	0.453	0.098
7a	1.3	28.5403	36.1414	8.04	0.507	0.117
7b	7.1	28.5539	36.1442	7.97	0.480	0.107
7c	12.3	28.5899	36.1525	8.05	0.550	0.094
8a	1.2	28.6595	36.0769	8.03	0.365	0.086
8b	12.3	28.6502	36.1656	7.95	0.357	0.082
8c	24.6	28.7289	36.1648	7.93	0.394	0.096
9a	1.5	28.7606	36.1687	8.04	0.177	0.058
9b	18.7	28.7151	36.1734	8.03	0.238	0.059
9c	35.6	28.588	36.1598	7.97	0.470	0.098
10a	1.5	28.7331	36.0112	7.96	0.333	0.046
10b	13.8	28.7489	36.1735	8.05	0.244	0.064
10c	25.8	28.6679	36.1725	8.03	0.384	0.096
11	35.8	28.7138	13.777	7.93	0.214	0.065

10.4 CTD CAST

A total of 11 CTD casts were conducted at the Hollywood outfall. At each station the CTD obtained a sample near bottom, mid-point and near surface. Figures 36-47 show the temperature, salinity and oxygen saturation for each station.

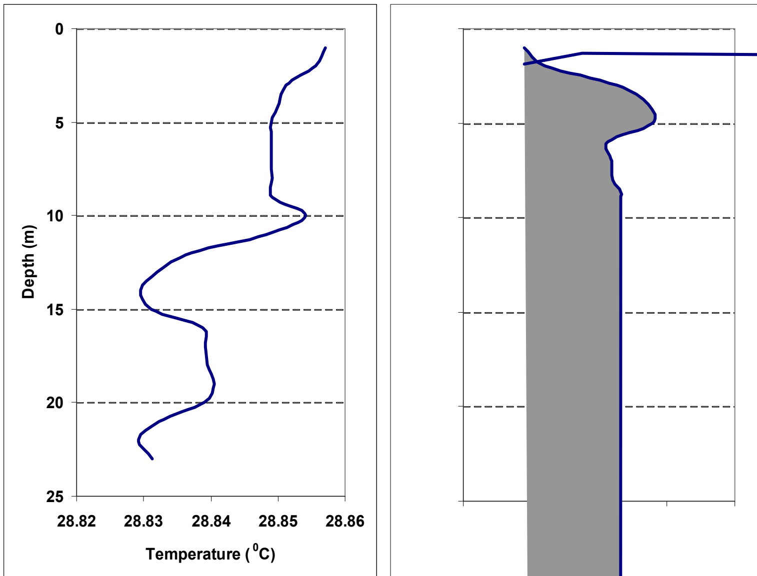


Figure 36: October 17th, 2006 temperature, sal[illegible]d oxygen concentration profile at station HWB-1.

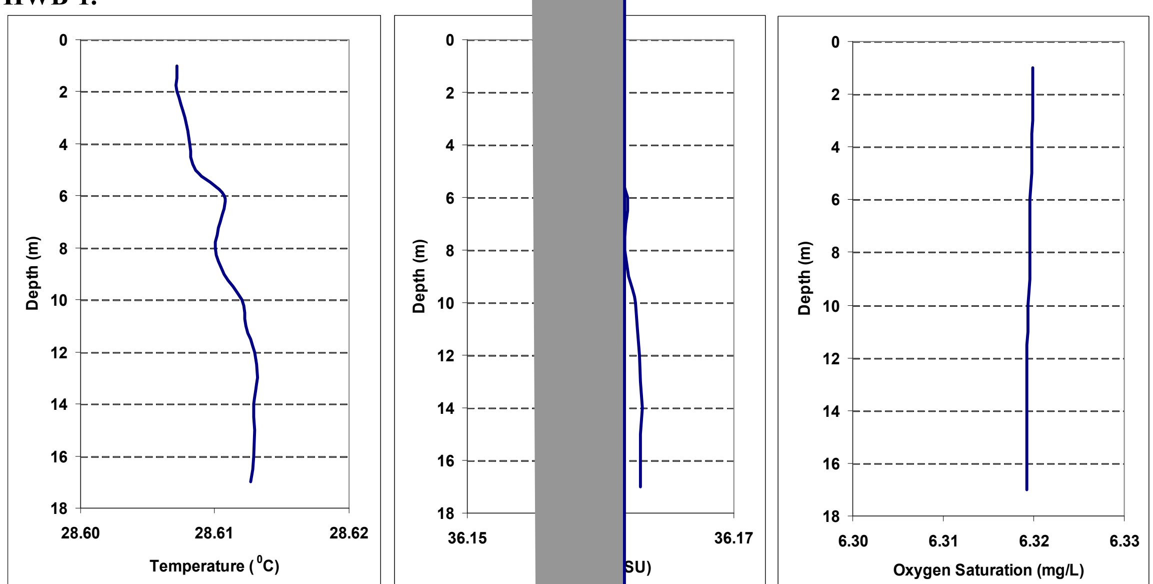


Figure 37: October 17th, 2006 temperature, sal[illegible]d oxygen concentration profile at station HWB-1B.

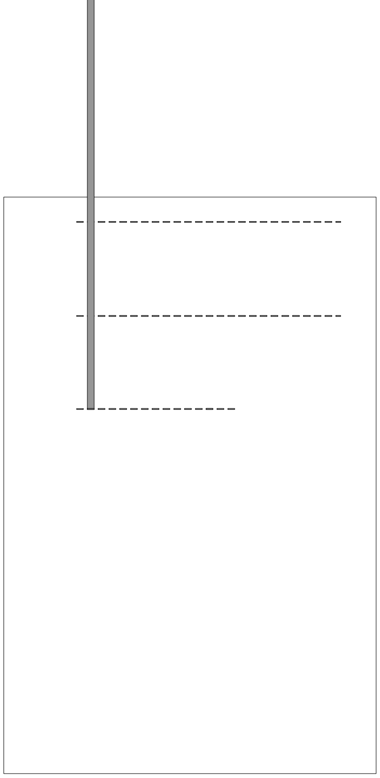


Figure 38: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-2.

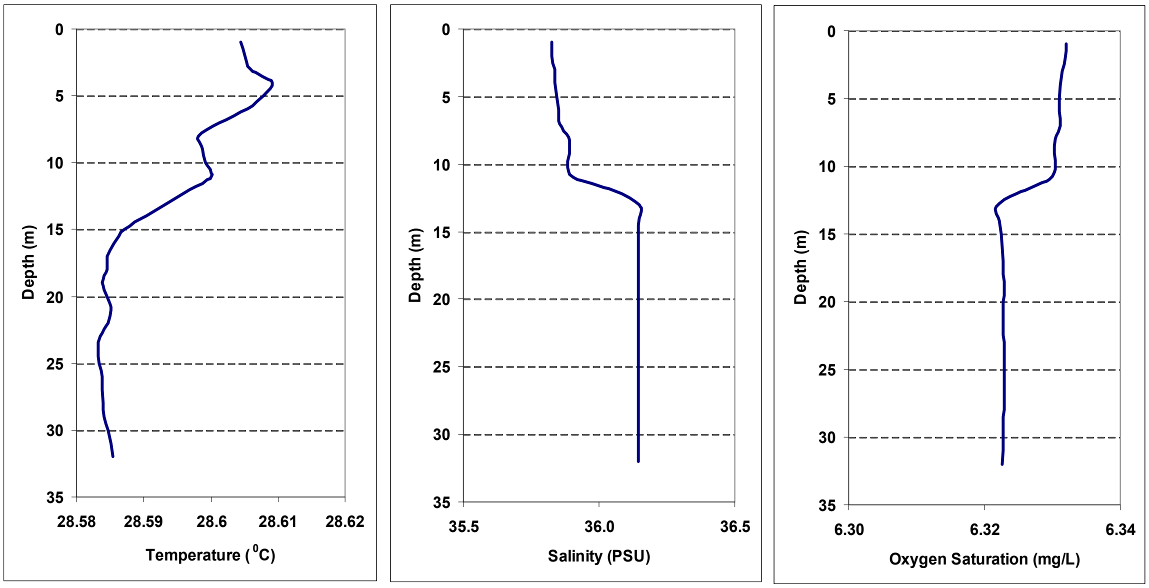


Figure 39: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-3.

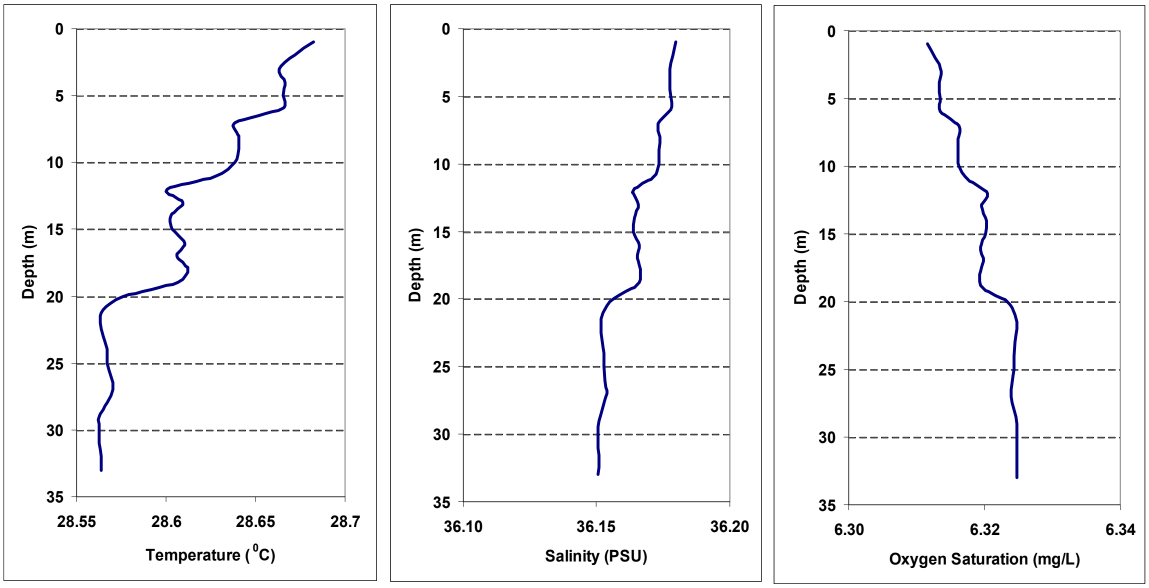


Figure 40: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-4.

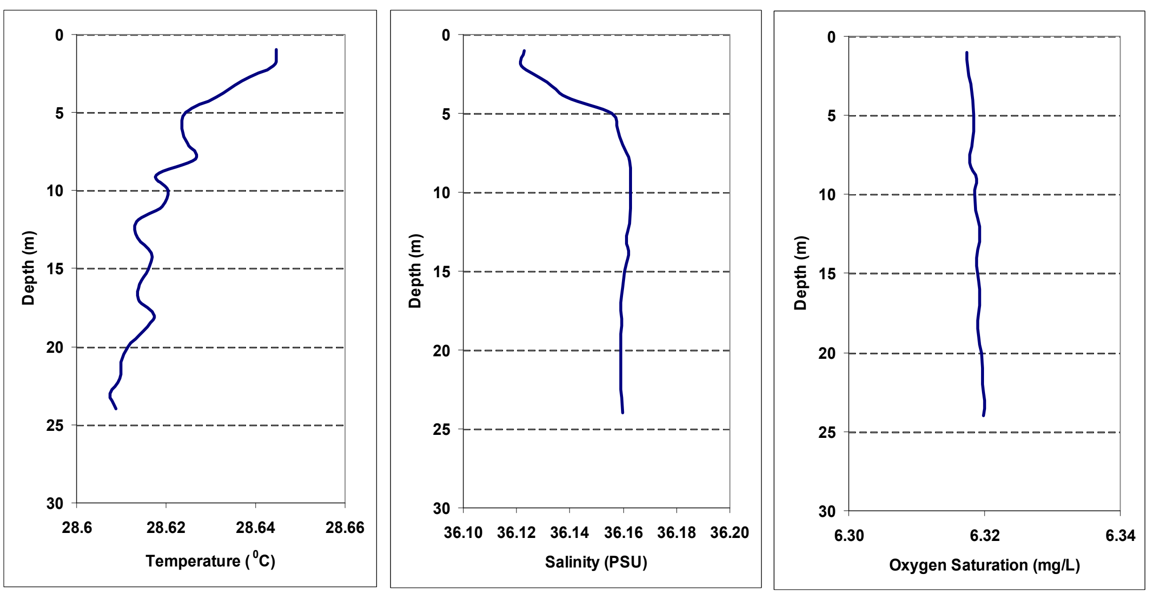


Figure 41: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-5.

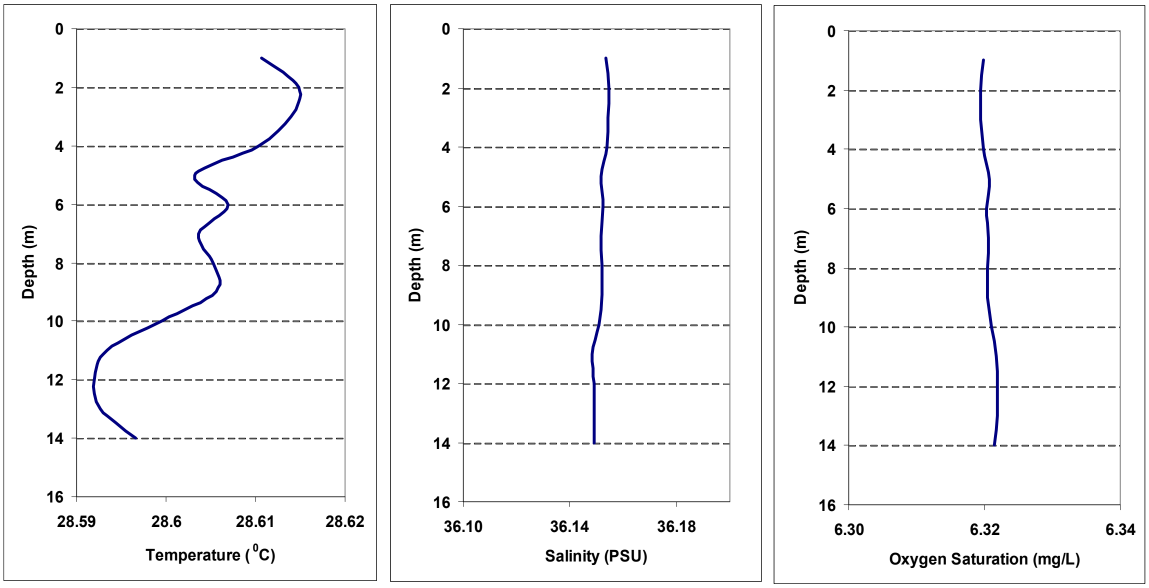


Figure 42: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-6.

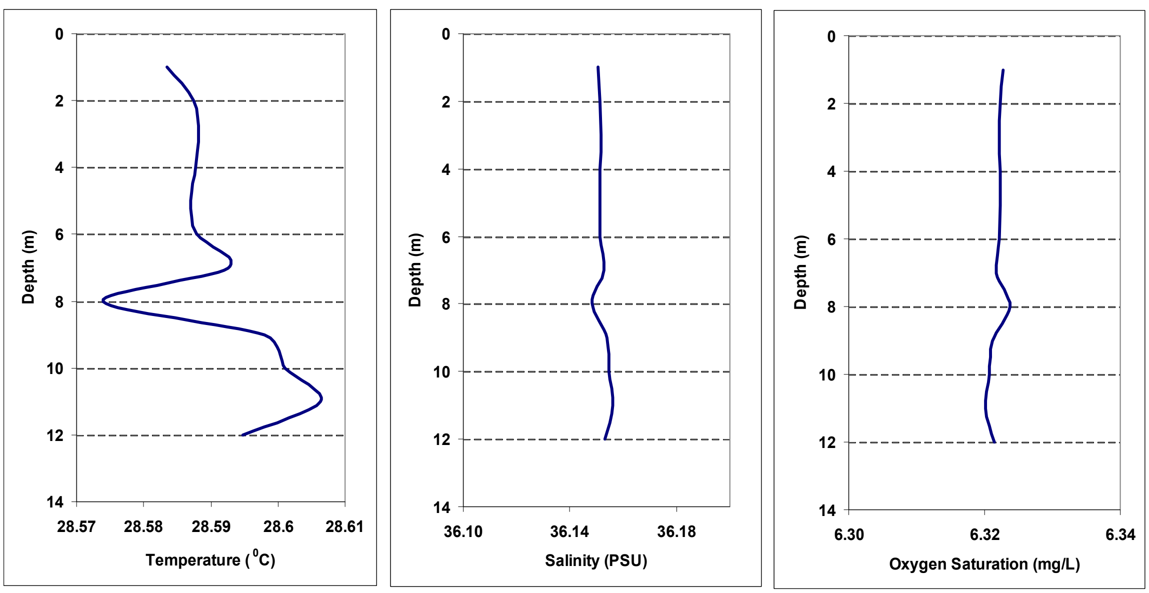


Figure 43: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-7.

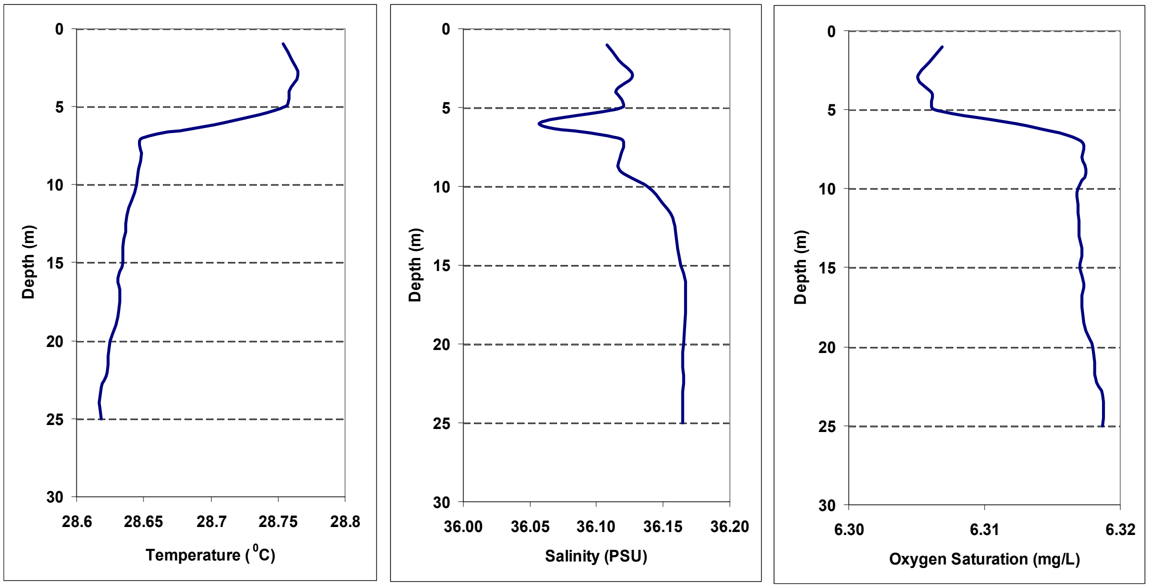


Figure 44: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-8.

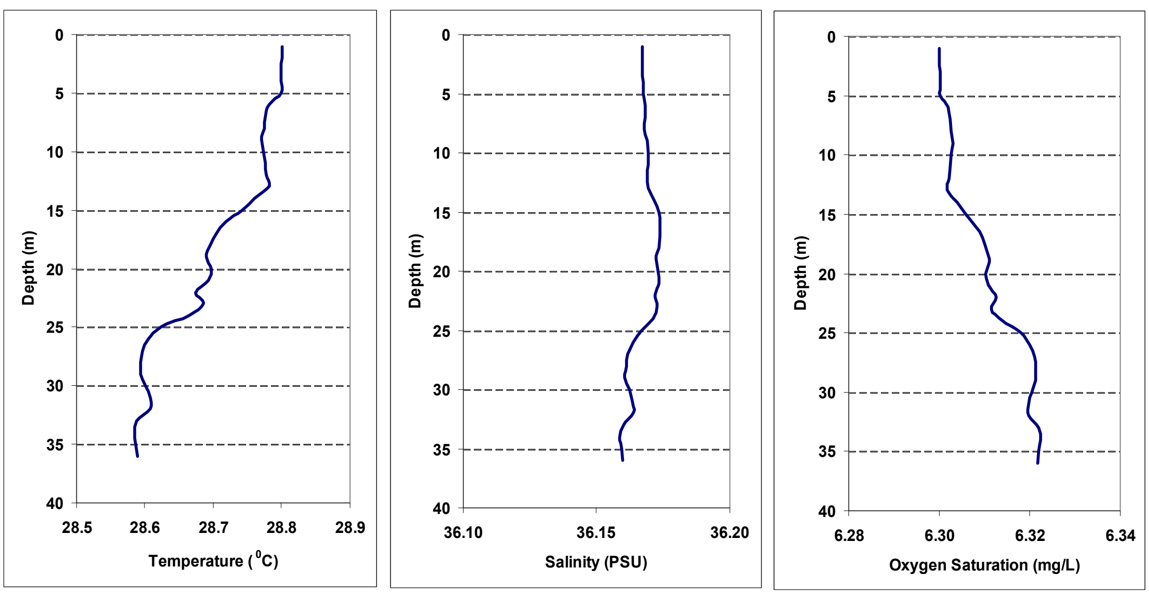


Figure 45: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-9.

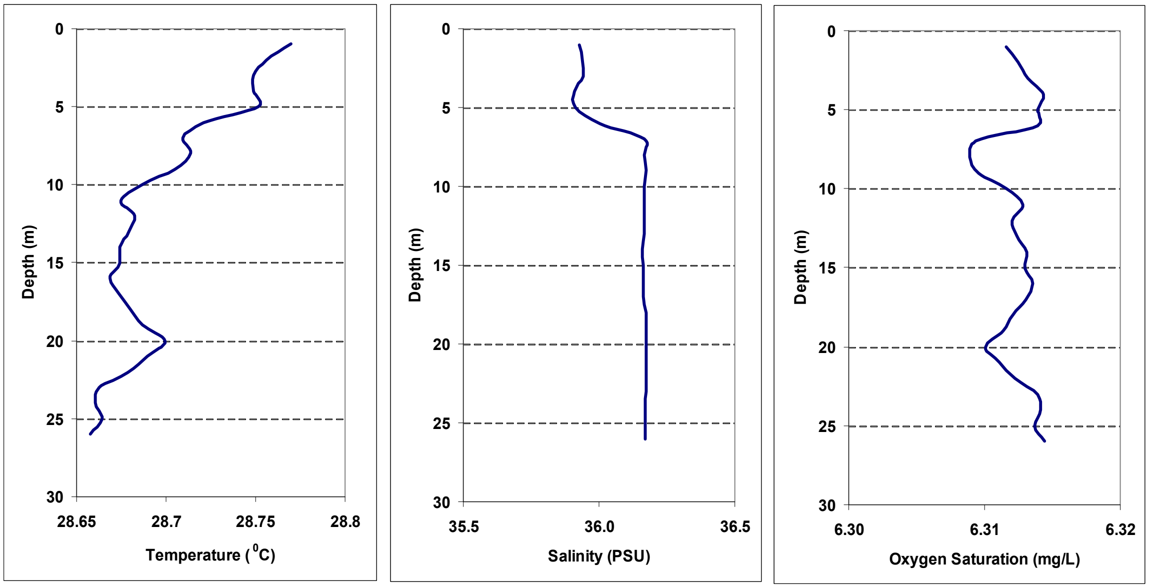


Figure 46: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-10.

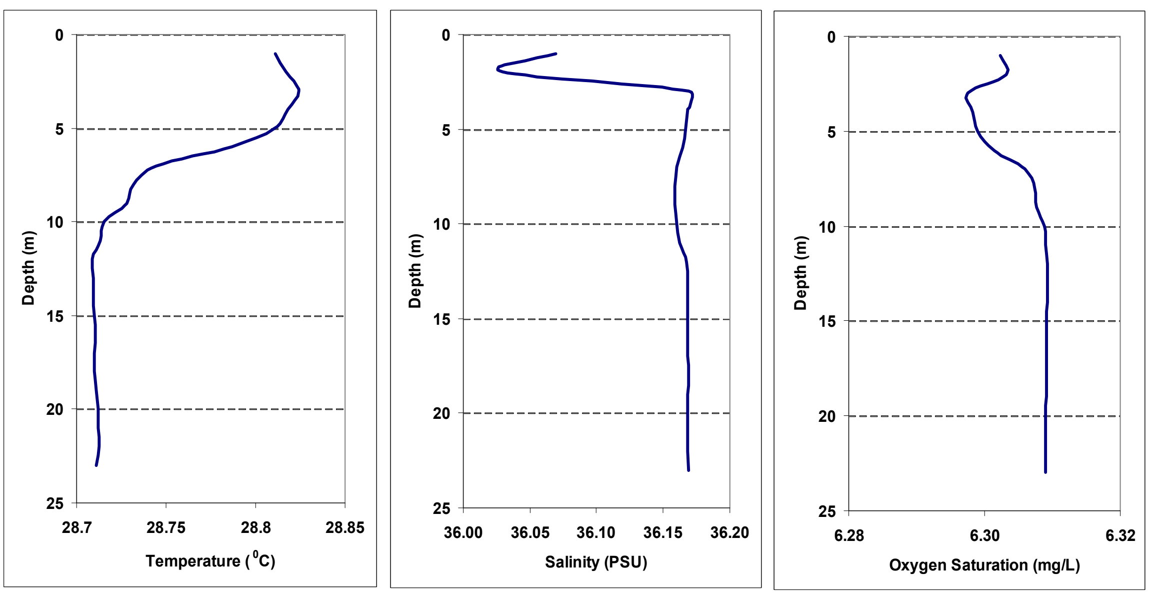


Figure 47: October 17th, 2006 temperature, salinity and oxygen concentration profile at station HWB-11.

10.5 Current Velocity and Direction

A RDI ADCP was dipped at the Hollywood outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. A total of two measurements were collected. Tables 24 and 25 list the current velocity and direction data obtained from Hollywood outfall, while Figures 48 and 49 graphically depict the data.

Table 24: Current velocity and direction for Hollywood outfall on October 10, 2006 at 21:00 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4.25	-6.79	-9.80	-2.60	2.21	-36.92	-42.20	-32.80	3.16	37.54	37.54	190.42
6.25	-4.97	-10.60	1.90	3.74	-34.84	-37.20	-31.90	2.00	35.20	35.20	188.11
8.25	-5.47	-11.80	-2.40	3.33	-32.78	-36.90	-30.70	1.96	33.23	33.23	189.47
10.25	-4.06	-8.80	-0.30	2.82	-31.20	-33.80	-26.80	2.03	31.46	31.46	187.41
12.25	-3.21	-6.00	0.60	2.51	-29.57	-33.80	-26.10	2.15	29.74	29.74	186.20
14.25	-1.10	-3.90	5.50	3.04	-28.36	-31.80	-23.30	2.34	28.38	28.38	182.22
16.25	1.19	-2.50	8.10	3.50	-26.82	-28.50	-20.10	2.67	26.85	26.85	177.46
18.25	1.56	-1.60	7.50	3.28	-24.14	-26.80	-18.10	2.55	24.19	24.19	176.31
20.25	1.47	-2.60	4.90	2.81	-22.81	-24.90	-20.90	1.71	22.86	22.86	176.32

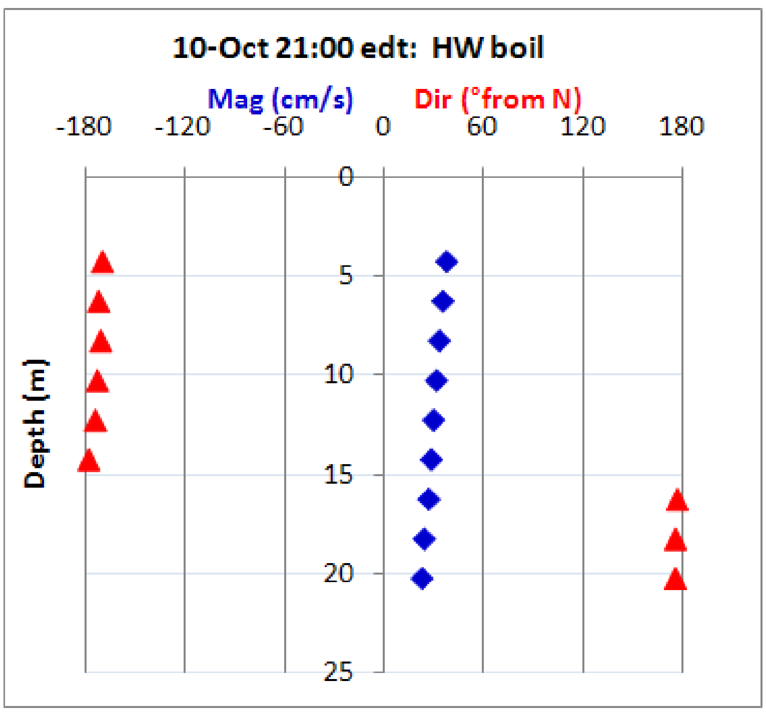


Figure 48: Current velocity and direction for Hollywood outfall on October 10, 2006 at 21:00.

Table 25: Current velocity and direction for Hollywood outfall on October 17, 2006 at 08:30 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4.6	-19.63	-27.50	-8.80	7.03	9.99	4.70	17.20	4.94	22.02	22.02	296.97
6.6	-17.91	-24.90	-6.30	7.88	10.53	2.40	19.70	5.29	20.78	20.78	300.44
8.6	-13.44	-23.50	-2.70	7.20	13.55	9.10	19.50	4.07	19.08	19.08	315.24
10.6	-8.18	-15.80	2.20	6.51	17.49	12.10	22.40	3.45	19.30	19.30	334.95
12.6	-4.05	-13.50	0.60	4.90	22.24	17.90	27.30	3.64	22.60	22.60	349.68
14.6	-2.99	-9.30	0.90	3.82	25.39	21.10	30.50	3.33	25.56	25.56	353.29
16.6	-2.08	-5.30	0.60	2.20	26.95	24.00	29.70	1.99	27.03	27.03	355.60

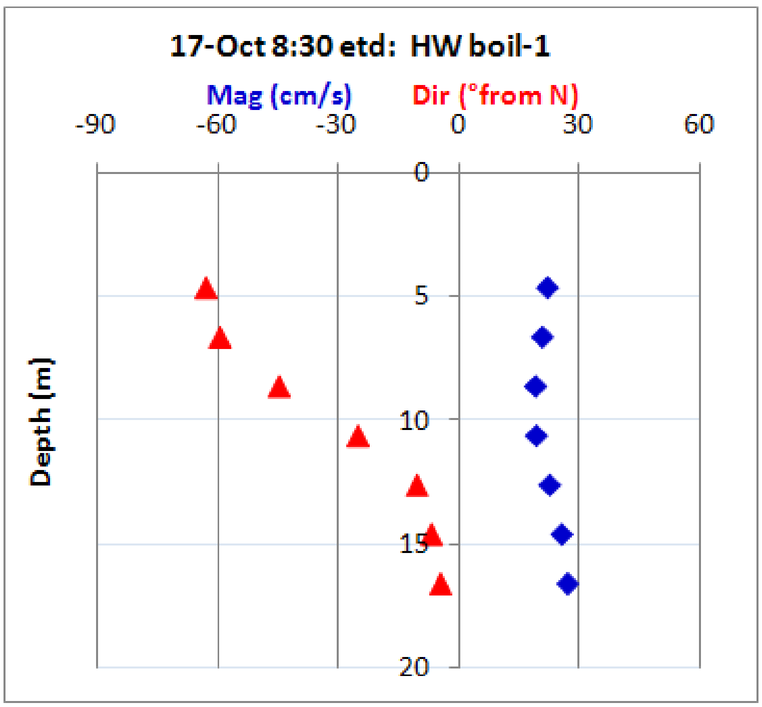


Figure 49: Current velocity and direction for Hollywood outfall on October 17, 2006 at 08:30.

10.6 V-Fin

A V-Fin (tow body with CTD) was lowered via A-frame behind the ship to crisscross the outfall to obtain additional information on the salinity and temperature to determine the location of the plume. Figure 50 shows the track over the outfall plume as well as the temperature and salinity deficits encountered when the plume was sampled. The areas indicating the plume have been highlighted in differing colors.

Figure 50: V-Fin CTD data for 17-October-06 showing the track of the ship during the V-Fin experiment. Plume encounters, determined by salinity deficits, are noted in magenta, red, and green. No temperature deficit was found.

11.0 BROWARD OUTFALL

11.1 Outfall Description

Broward ocean outfall is located approximately 2.2 km offshore the northern section of Broward County at a depth of 32.6 meters and has an average discharge flow rate of 36 MGD. Figure 51 shows the outfall pipe as recorded by the ship's multibeam system. From these data, a location of 26° 15.083 'N, 80° 3.724'W (26.25138°N, 80.062067°W) was determined. Table 26 lists the CTD sample stations and sample depth. Table 27 lists the sediment sample locations and depth.

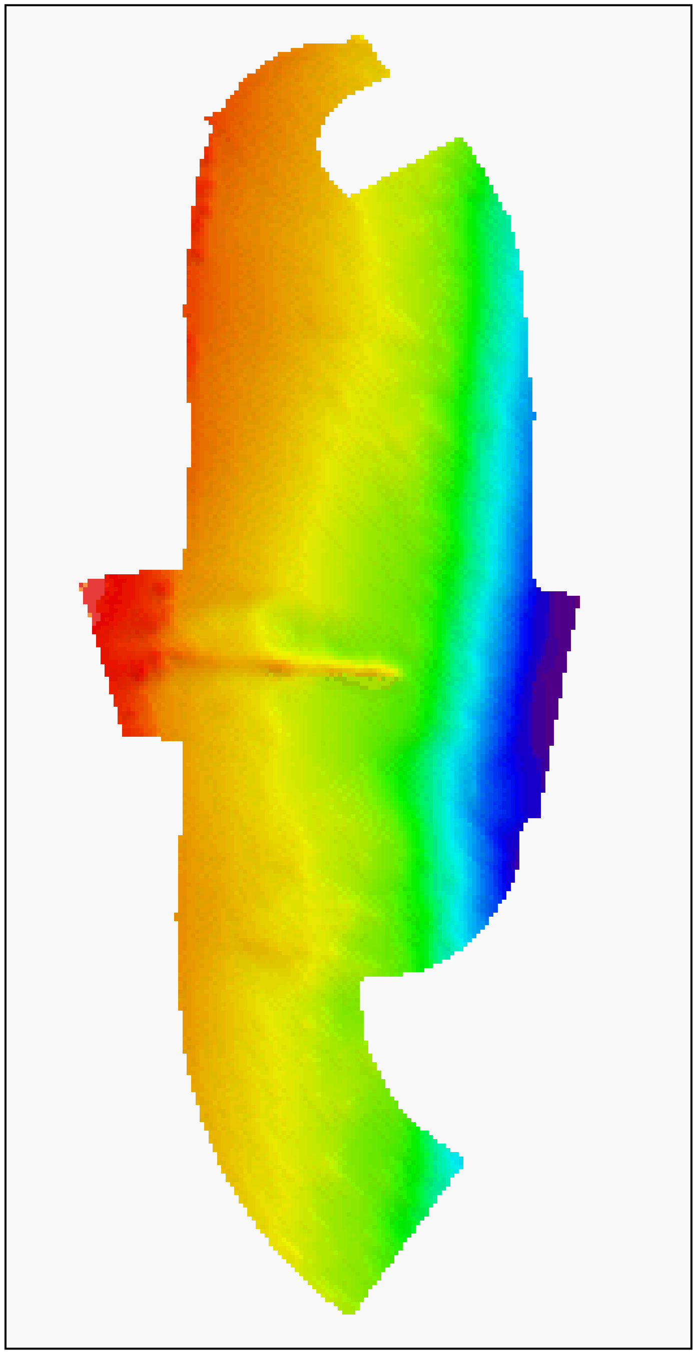


Figure 51. Multibeam data from the vicinity of the Hollywood outfall.

Table 26: CTD sample locations for Broward Outfall.

Date	Station #		Latitude	Longitude	Dist to pipe (m)	Depth (m)
14-Oct	BR-	1a	26.2524	-80.0618	0.0	0.0
14-Oct	BR-	1b	26.2524	-80.0618	0.0	16.8
14-Oct	BR-	1c	26.2524	-80.0618	0.0	33.5
14-Oct	BR-	4a	26.2529	-80.0616	59.1	0.0
14-Oct	BR-	7a	26.2529	-80.0620	59.1	0.0
14-Oct	BR-	4b	26.2529	-80.0616	59.1	17.3
14-Oct	BR-	7b	26.2529	-80.0620	59.1	16.2
14-Oct	BR-	4c	26.2529	-80.0616	59.1	34.5
14-Oct	BR-	7c	26.2529	-80.0620	59.1	32.4
14-Oct	BR-	10a	26.2529	-80.0613	74.7	0.0
14-Oct	BR-	10b	26.2529	-80.0613	74.7	18.9
14-Oct	BR-	10c	26.2529	-80.0613	74.7	37.8
14-Oct	BR-	11a	26.2514	-80.0619	111.6	0.0
14-Oct	BR-	11b	26.2514	-80.0619	111.6	17.1
14-Oct	BR-	11c	26.2514	-80.0619	111.6	34.2
14-Oct	BR-	6a	26.2538	-80.0618	155.7	0.0
14-Oct	BR-	6b	26.2538	-80.0618	155.7	16.5
14-Oct	BR-	6c	26.2538	-80.0618	155.7	32.9
14-Oct	BR-	3a	26.2538	-80.0615	158.5	0.0
14-Oct	BR-	3b	26.2538	-80.0615	158.5	17.6
14-Oct	BR-	3c	26.2538	-80.0615	158.5	35.2
14-Oct	BR-	9a	26.2537	-80.0611	160.5	0.0
14-Oct	BR-	9b	26.2537	-80.0611	160.5	19.2
14-Oct	BR-	9c	26.2537	-80.0611	160.5	38.4
14-Oct	BR-	5a	26.2546	-80.0618	244.6	0.0
14-Oct	BR-	5b	26.2546	-80.0618	244.6	16.3
14-Oct	BR-	5c	26.2546	-80.0618	244.6	32.6
14-Oct	BR-	8a	26.2545	-80.0610	246.8	0.0
14-Oct	BR-	8b	26.2545	-80.0610	246.8	19.4
14-Oct	BR-	8c	26.2545	-80.0610	246.8	38.8
14-Oct	BR-	2a	26.2547	-80.0613	260.6	0.0
14-Oct	BR-	2b	26.2547	-80.0613	260.6	17.5
14-Oct	BR-	2c	26.2547	-80.0613	260.6	35.0

Table 27: Sediment sample locations for Broward Outfall.

Date	Station	Latitude	Longitude	Depth (m)
10-Oct	BR10	26.2514	-79.9617	246.0
10-Oct	BR11	26.2514	-80.0120	198.8
10-Oct	BR12	26.2513	-80.0420	37.7
10-Oct	BR13	26.2514	-80.0720	16.5
10-Oct	BR14	26.2423	-80.0620	40.7
10-Oct	BR15b	26.2506	-80.0620	33.9
10-Oct	BR15c	26.2506	-80.0620	33.9
10-Oct	BR15d	26.2507	-80.0621	33.9
10-Oct	BR15e	26.2507	-80.0618	36.7
10-Oct	BR16	26.2514	-80.0621	31.0
10-Oct	BR16b	26.2516	-80.0620	33.8
10-Oct	BR16c	26.2516	-80.0621	33.8
10-Oct	BR17	26.2522	-80.0621	32.9
10-Oct	BR18	26.2532	-80.0622	32.3
10-Oct	BR19a	26.2541	-80.0621	32.8
10-Oct	BR19b	26.2541	-80.0619	32.8
10-Oct	BR20	26.2549	-80.0621	32.6
10-Oct	BR21	26.2604	-80.0622	31.0
10-Oct	BR21b	26.2604	-80.0622	31.0

11.2 Nutrients

A total of 33 nutrient samples were collected during the CTD operations around the Broward outfall. These results are listed in Table 28 for concentrations in εM and in Table 29 for concentrations in mg/L. A three-dimensional plot for N+N is shown below.

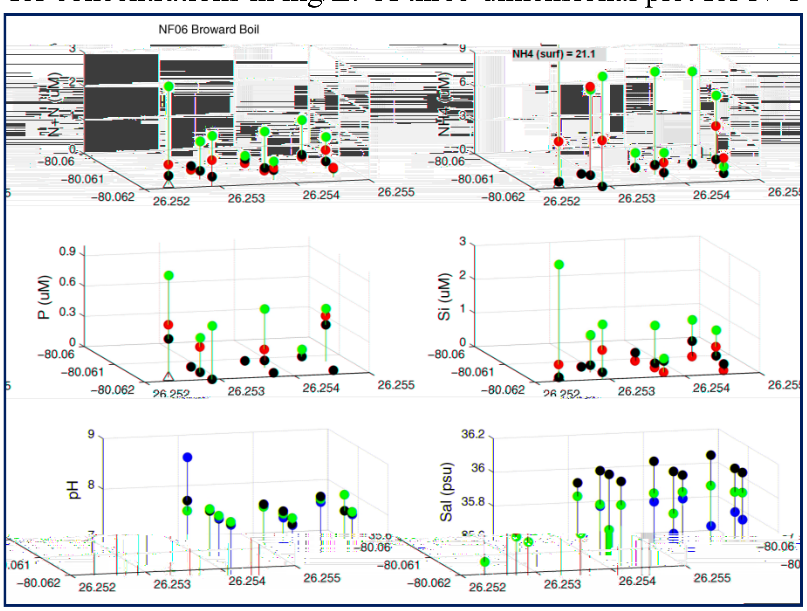


Figure 52. Three- Three-dimensional presentation of N+N, NH_4, P, and Si data from CTD sampling around the Miami-Central outfall. Format is similar to Figure 5.

Table 28: Nutrient results in εM from the Broward Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
1a	1.5	2.91	2.22	21.09	1.01	3.35
1b	13.7	0.59	0.38	3.82	0.52	0.38
1c	27.9	0.26	0.05	0.24	0.38	0.00
2a	1.2	0.93	0.66	6.49	0.52	0.92
2b	13.8	0.54	0.33	3.75	0.45	0.43
2c	29.5	0.20	0.02	0.78	0.36	0.16
3a	1.4	1.28	0.95	9.17	0.58	1.25
3b	14.4	0.12	0.01	0.82	0.18	0.00
3c	29.5	0.20	0.02	0.88	0.07	0.13
4a	1.1	1.13	0.82	7.97	0.34	1.11
4b	15.0	1.12	0.80	8.24	0.25	1.09
4c	30.3	0.25	0.06	0.36	0.00	0.21
5a	1.3	0.26	0.06	0.98	0.00	0.00
5b	13.3	0.29	0.14	1.73	0.00	0.00
5c	27.2	0.27	0.07	0.36	0.00	0.19
6a	1.3	0.55	0.29	2.42	0.00	0.43
6b	13.1	0.36	0.15	1.55	0.00	0.02
6c	27.2	0.29	0.09	0.66	0.00	0.35
7a	1.1	1.50	1.05	9.79	0.53	1.63
7b	14.7	0.78	0.50	4.10	0.00	0.87
7c	29.0	0.29	0.06	0.00	0.00	0.21
8a	1.2	1.29	0.91	8.20	0.07	1.09
8b	17.0	0.20	0.04	0.00	0.00	0.00
8c	34.1	0.26	0.07	0.00	0.00	0.46
9a	1.2	0.36	0.21	1.33	0.00	0.00
9b	19.4	0.14	0.03	0.00	0.00	0.00
9c	34.4	0.26	0.07	0.03	0.00	0.24
10a	1.2	0.12	0.03	0.00	0.00	0.00
10b	16.6	0.13	0.05	0.00	0.00	0.00
10c	33.9	0.24	0.03	0.00	0.00	0.00
11a	1.2	0.24	0.07	0.00	0.00	0.00
11b	15.9	0.39	0.22	1.28	0.00	0.00
11c	30.2	0.25	0.08	0.00	0.00	0.00

Table 29: Nutrient results in mg/L from the Broward Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1a	1.5	0.041	0.031	0.295	0.031	0.094
1b	13.7	0.008	0.005	0.053	0.016	0.011
1c	27.9	0.004	0.001	0.003	0.012	0.000
2a	1.2	0.013	0.009	0.091	0.016	0.026
2b	13.8	0.008	0.005	0.053	0.014	0.012
2c	29.5	0.003	0.000	0.011	0.011	0.004
3a	1.4	0.018	0.013	0.128	0.018	0.035
3b	14.4	0.002	0.000	0.011	0.006	0.000
3c	29.5	0.003	0.000	0.012	0.002	0.004
4a	1.1	0.016	0.011	0.112	0.010	0.031
4b	15.0	0.016	0.011	0.115	0.008	0.031
4c	30.3	0.004	0.001	0.005	0.000	0.006
5a	1.3	0.004	0.001	0.014	0.000	0.000
5b	13.3	0.004	0.002	0.024	0.000	0.000
5c	27.2	0.004	0.001	0.005	0.000	0.005
6a	1.3	0.008	0.004	0.034	0.000	0.012
6b	13.1	0.005	0.002	0.022	0.000	0.001
6c	27.2	0.004	0.001	0.009	0.000	0.010
7a	1.1	0.021	0.015	0.137	0.017	0.046
7b	14.7	0.011	0.007	0.057	0.000	0.024
7c	29.0	0.004	0.001	0.000	0.000	0.006
8a	1.2	0.018	0.013	0.115	0.002	0.031
8b	17.0	0.003	0.001	0.000	0.000	0.000
8c	34.1	0.004	0.001	0.000	0.000	0.013
9a	1.2	0.005	0.003	0.019	0.000	0.000
9b	19.4	0.002	0.000	0.000	0.000	0.000
9c	34.4	0.004	0.001	0.000	0.000	0.007
10a	1.2	0.002	0.000	0.000	0.000	0.000
10b	16.6	0.002	0.001	0.000	0.000	0.000
10c	33.9	0.003	0.000	0.000	0.000	0.000
11a	1.2	0.003	0.001	0.000	0.000	0.000
11b	15.9	0.005	0.003	0.018	0.000	0.000
11c	30.2	0.004	0.001	0.000	0.000	0.000

11.3 Chlorophyll and pH

A total of 33 chlorophyll and pH samples were collected during CTD operations around the Broward outfall. Table 30 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 30: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from Broward Outfall.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
1a	1.5	28.8701	35.6520	9.24	0.940	0.166
1b	13.7	28.9107	36.0409	8.18	1.050	0.137
1c	27.9	28.7886	36.1204	8.38	0.649	0.157
2a	1.2	28.8611	35.8460	??	0.772	0.193
2b	13.8	28.8778	35.9675	8.18	0.804	0.112
2c	29.5	28.7962	36.1143	7.86	0.459	0.125
3a	1.4	28.8721	35.7618	7.85	0.774	0.243
3b	14.4	28.8897	35.8769	7.93	1.408	0.490
3c	29.5	28.7765	36.1255	7.98	0.452	0.035
4a	1.1	28.8378	35.7741	7.94	0.850	0.185
4b	15.0	28.8162	35.8111	7.98	0.732	0.146
4c	30.3	28.6882	36.1449	7.92	0.380	0.060
5a	1.3	28.8642	35.8649	7.97	1.209	0.355
5b	13.3	28.8059	36.0246	8.02	0.779	0.140
5c	27.2	28.6731	36.1411	8.00	0.397	0.112
6a	1.3	28.7655	36.0022	7.81	0.869	0.185
6b	13.1	28.7895	36.0428	7.95	0.692	0.149
6c	27.2	28.6121	36.1420	7.83	0.317	0.105
7a	1.1	28.8369	35.7764	7.94	0.699	0.226
7b	14.7	28.7978	36.0009	8.00	0.511	0.130
7c	29.0	28.6768	36.1407	7.97	0.391	0.113
8a	1.2	28.9019	35.7417	7.94	1.001	0.403
8b	17.0	28.9278	35.9769	8.00	1.148	0.385
8c	34.1	28.5733	36.1559	8.05	0.345	0.077
9a	1.2	29.0195	35.9111	6.69	1.072	0.438
9b	19.4	28.9493	35.9575	7.93	1.107	0.364
9c	34.4	28.5957	36.1491	7.98	0.482	0.121
10a	1.2	29.0735	35.9165	8.01	1.093	0.556
10b	16.6	28.9655	35.9339	8.01	1.210	0.725
10c	33.9	28.6929	36.1275	7.97	0.579	0.107
11a	1.2	29.0216	35.8943	8.00	1.811	1.039
11b	15.9	28.8925	35.6807	7.95	1.137	0.448
11c	30.2	28.7653	36.1116	8.31	0.628	0.148

11.4 CTD CAST

A total of 15 CTD casts were conducted at the Broward outfall. At each station except (BRB-12 thru 15) the CTD obtained a sample near bottom, mid-point and near surface. Figures 53-67 show the temperature, salinity and oxygen saturation for each station.

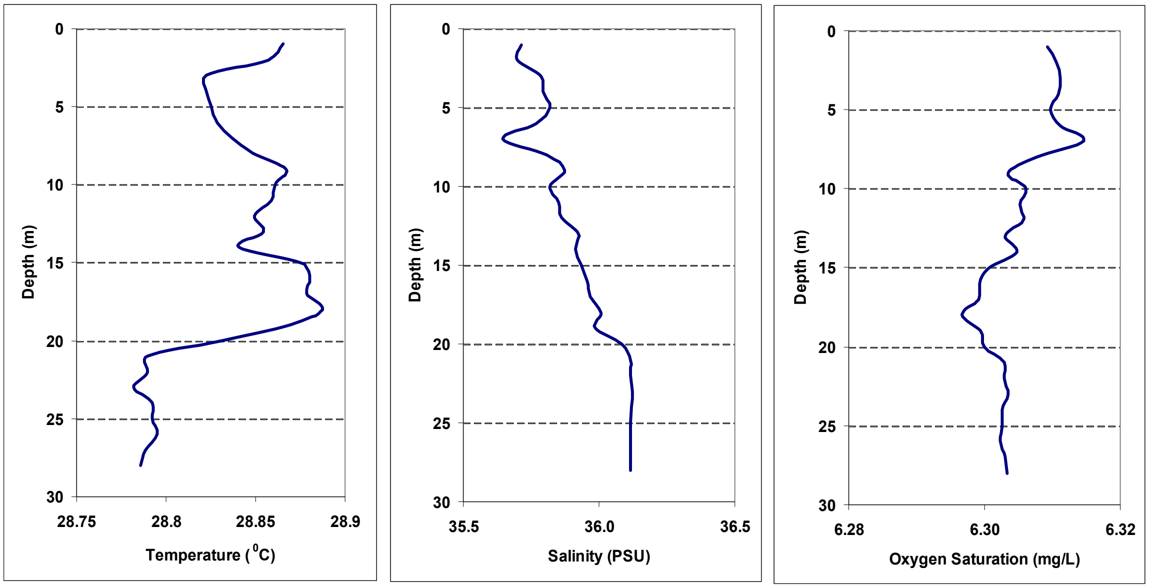


Figure 53: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-1.

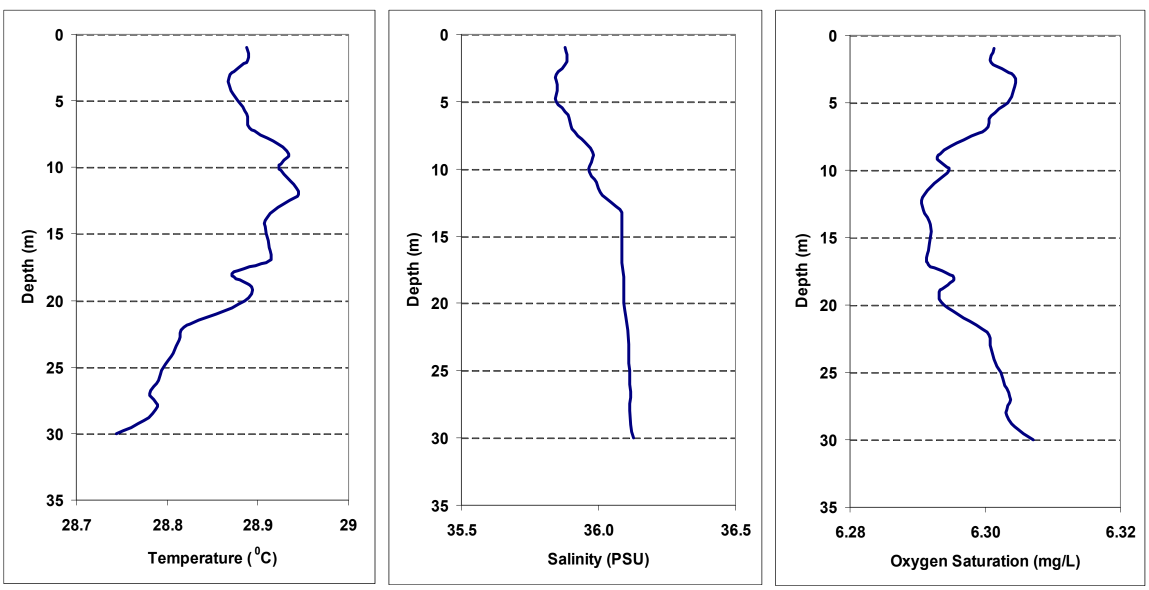


Figure 54: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-2.

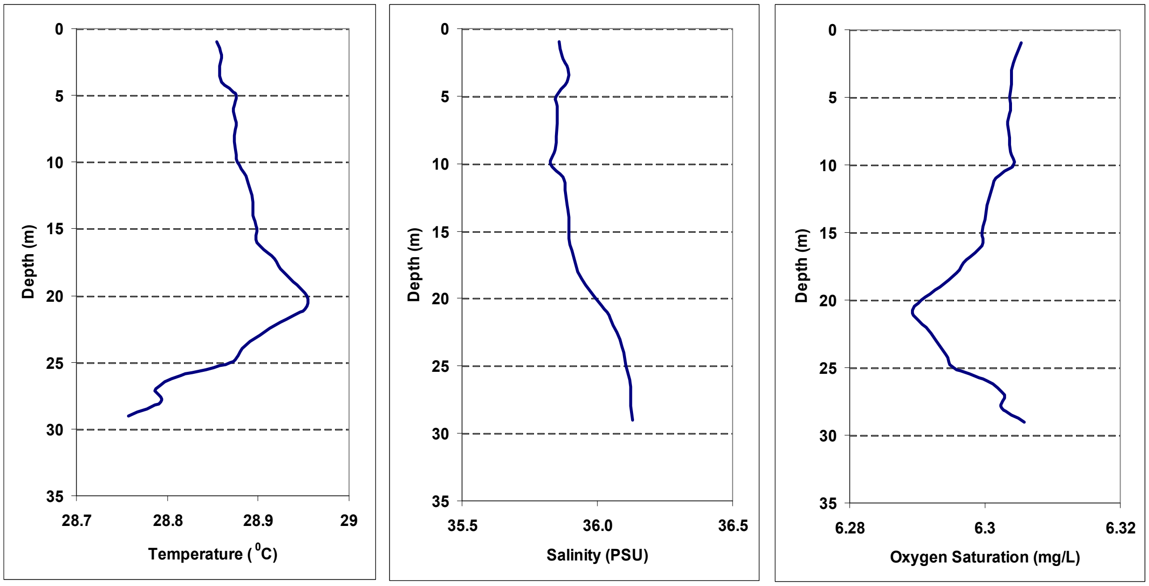


Figure 55: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-3.

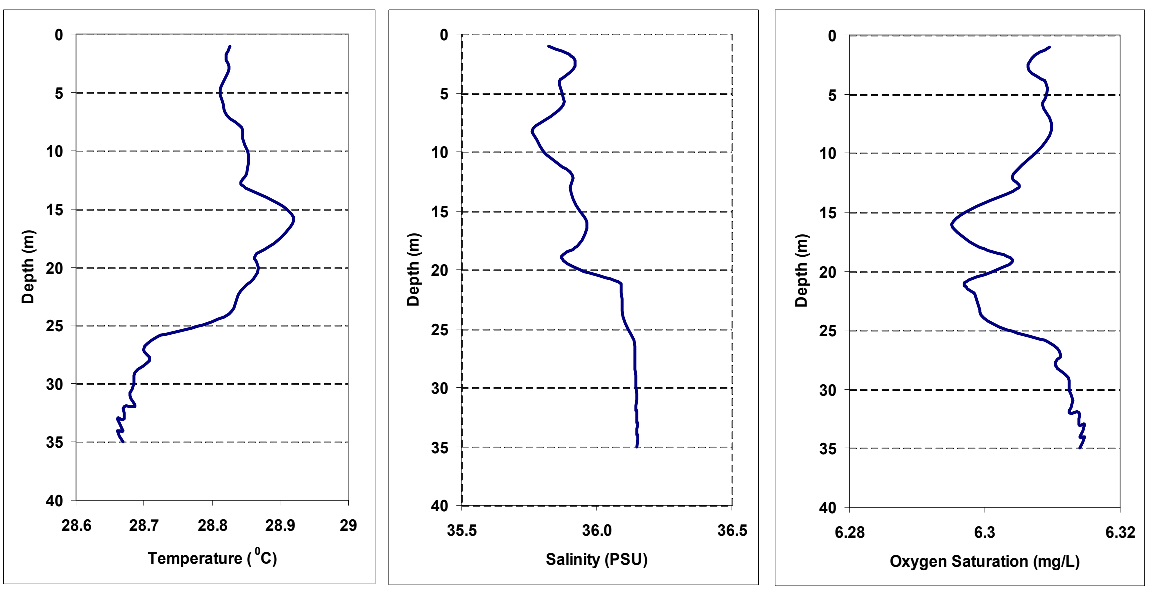


Figure 56: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-4.

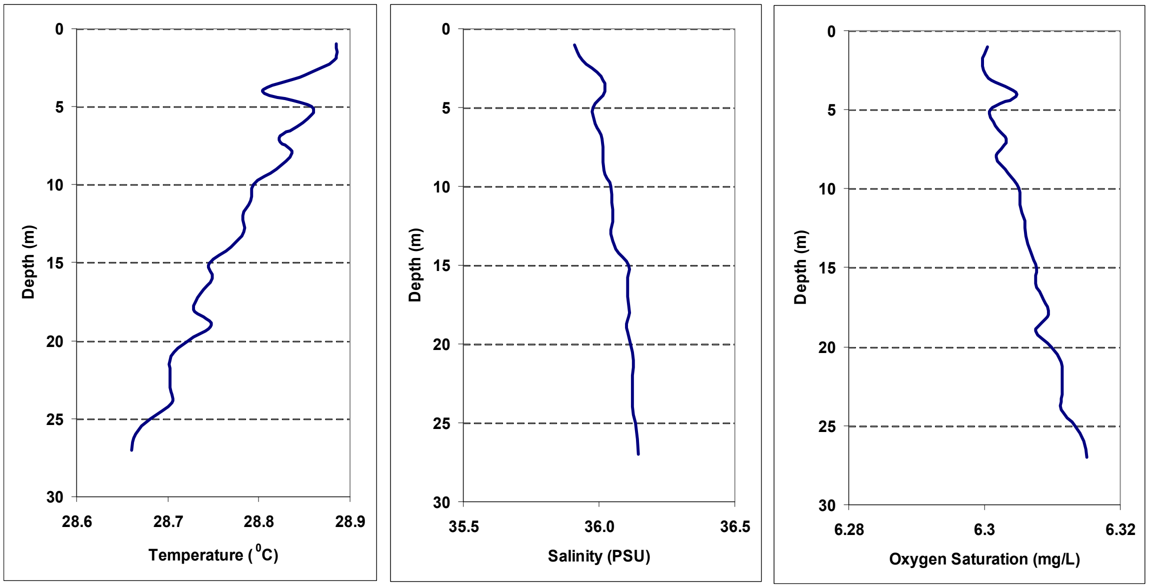


Figure 57: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-5.

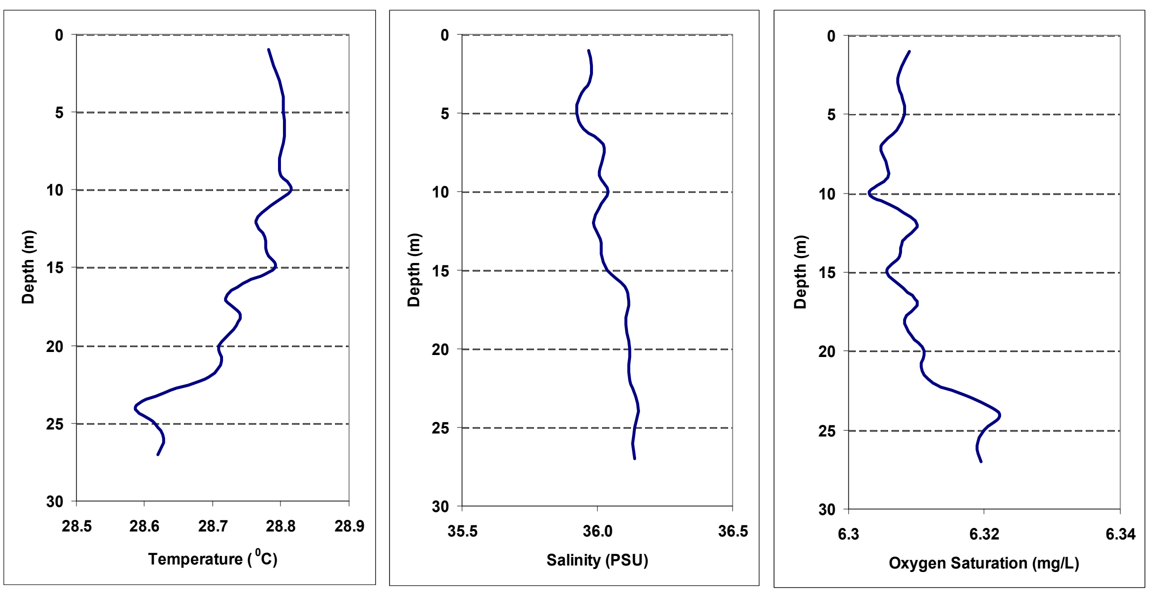


Figure 58: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-6.

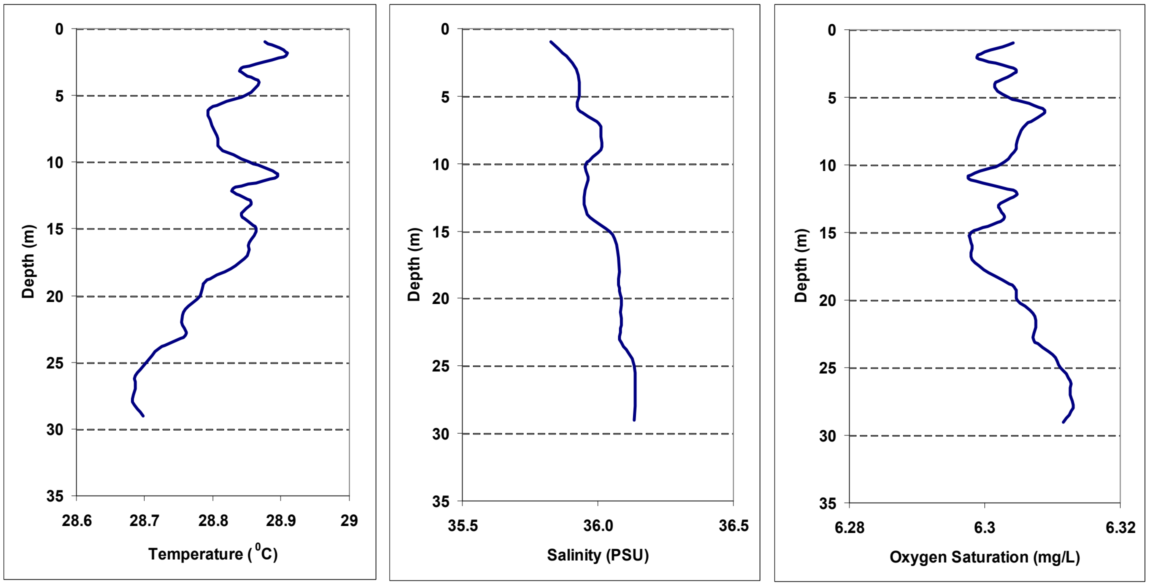


Figure 59: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-7.

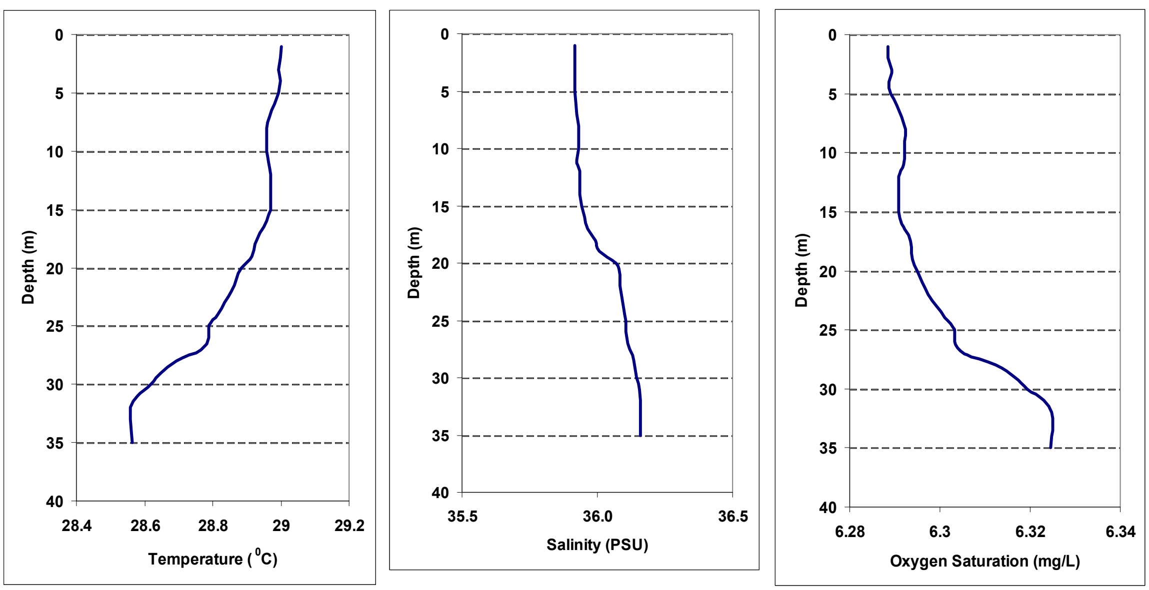


Figure 60: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-8.

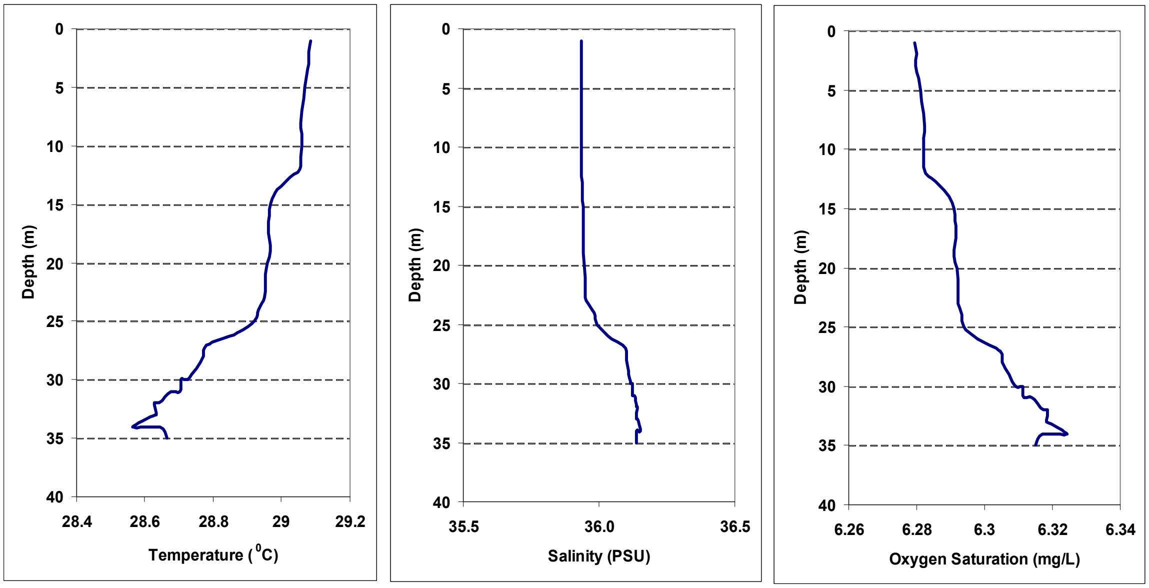


Figure 61: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-9.

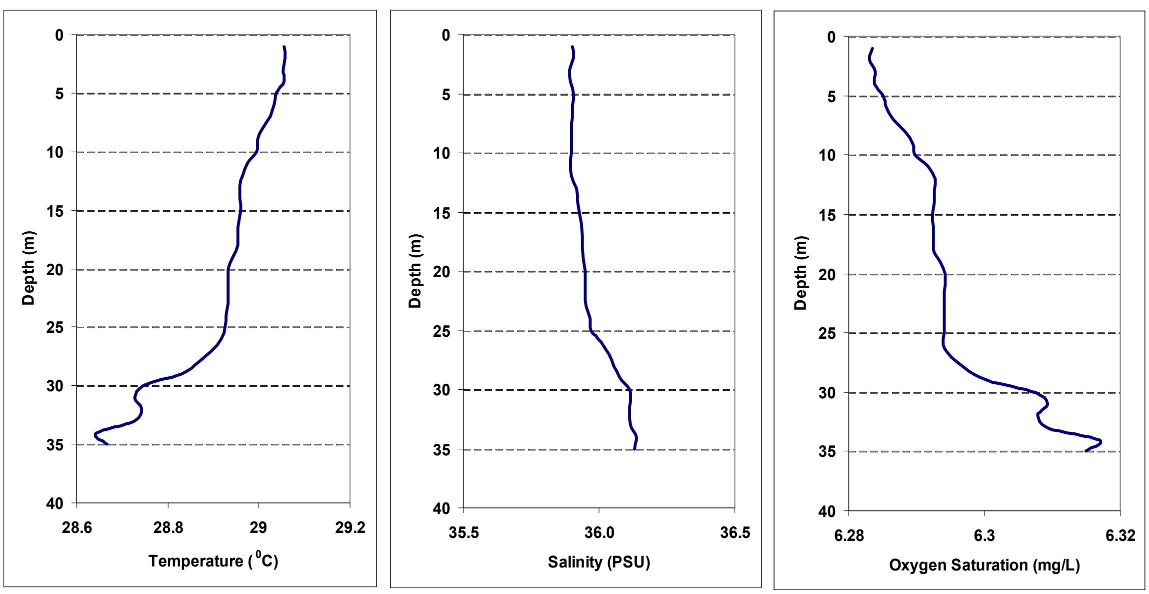


Figure 62: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-10.

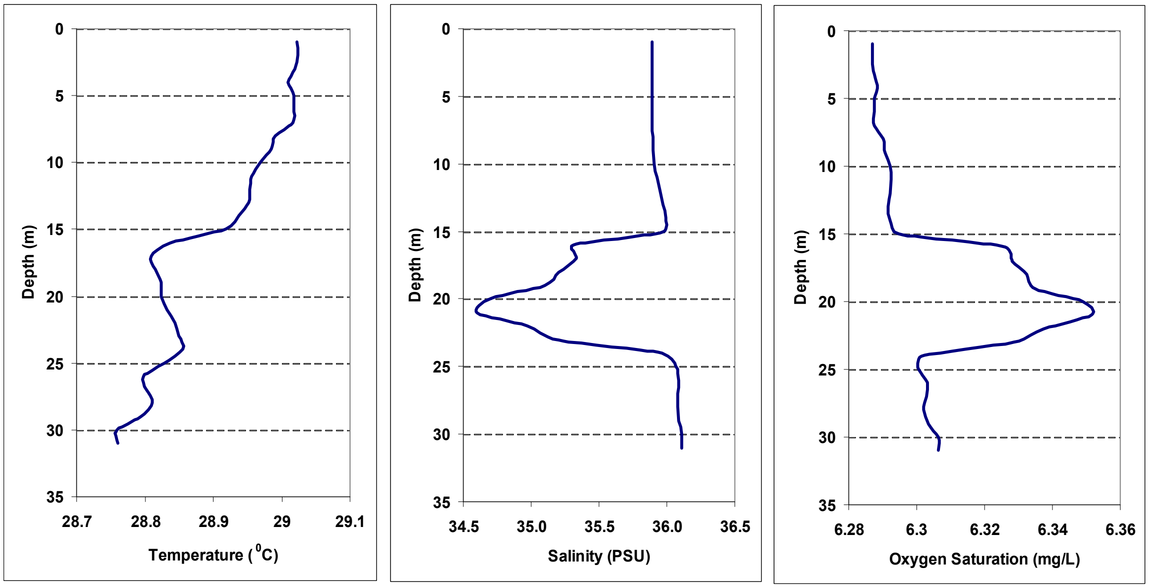


Figure 63: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-11.

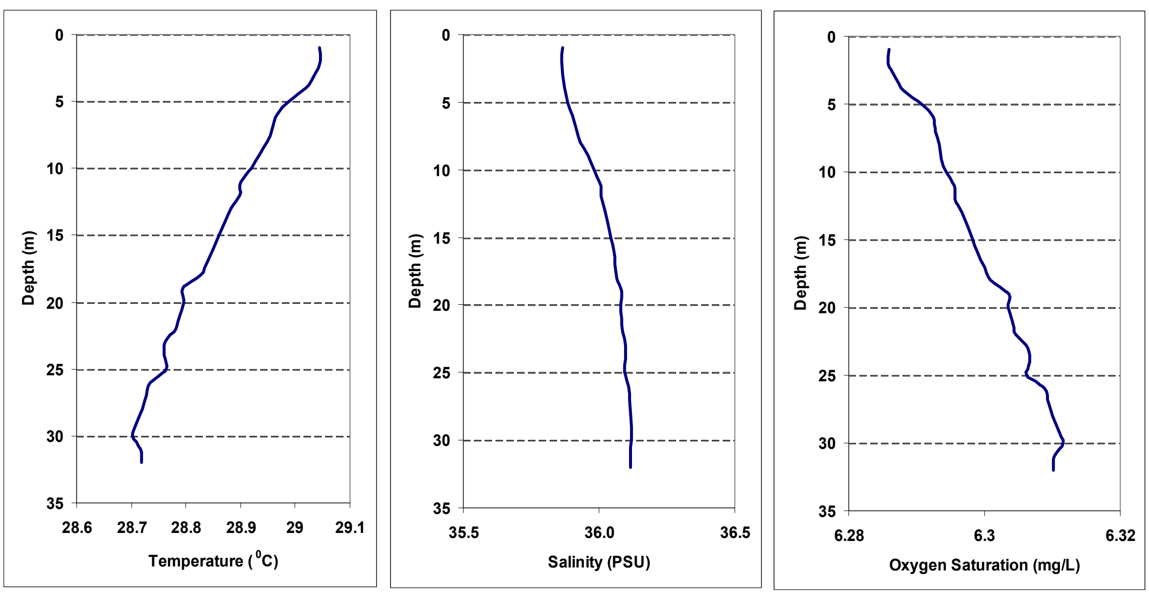


Figure 64: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-12.

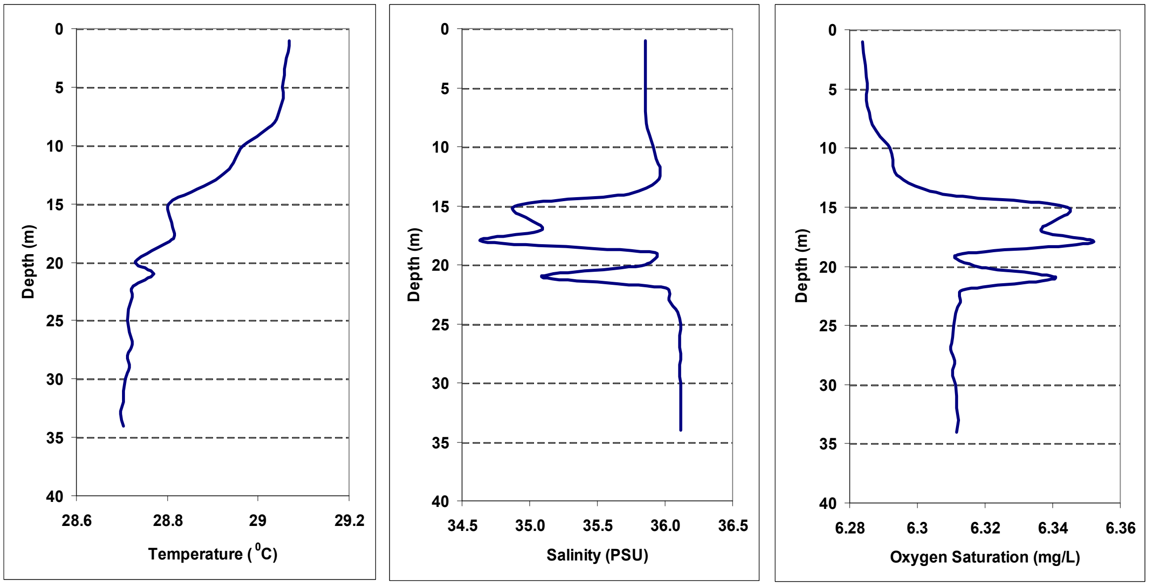


Figure 65: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-13.

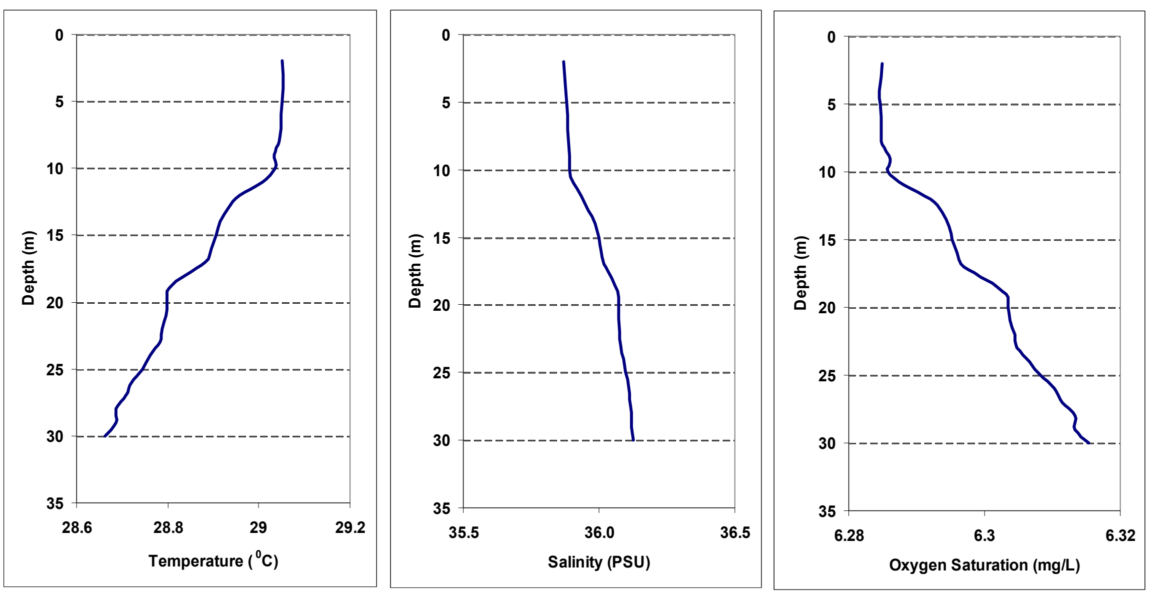


Figure 66: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-14.

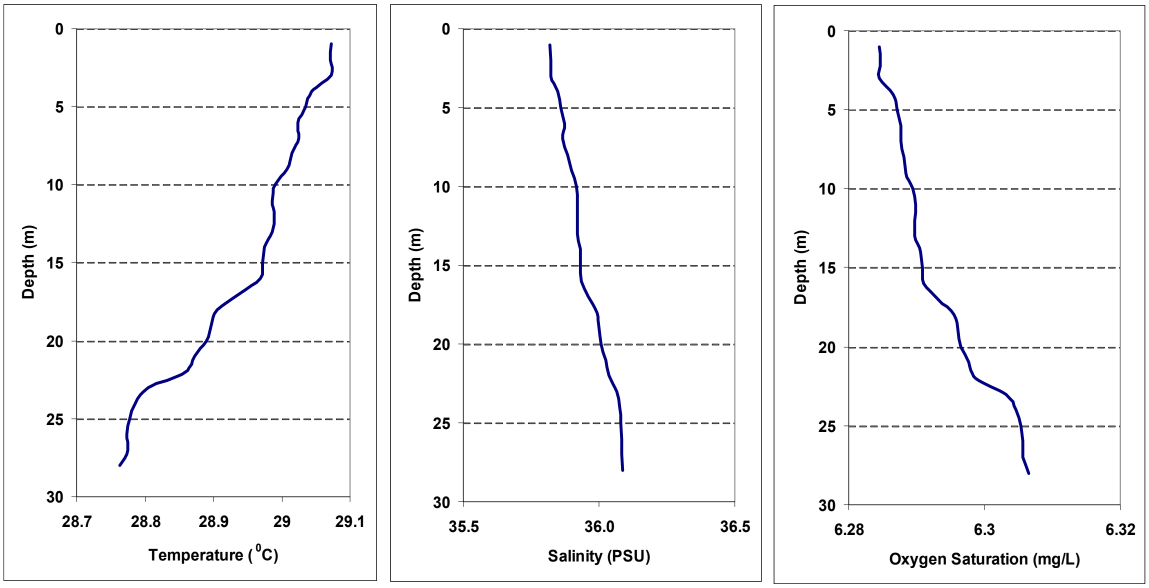


Figure 67: October 14th, 2006 temperature, salinity and oxygen concentration profile at station BRB-15.

11.5 Current Velocity and Direction

A RDI ADCP was dipped at the Broward outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. Table 31 lists the current velocity and direction data obtained from Broward outfall, while Figure 68 graphically depicts the data.

Table 31: Current velocity and direction for Broward outfall on October 14, 2006 at 07:40 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
3.75	15.57	9.70	21.40	3.97	31.46	24.10	36.10	3.63	35.10	35.10	26.34
5.75	13.93	7.80	20.90	5.39	33.34	29.90	36.30	2.37	36.14	36.14	22.67
7.75	8.71	-1.70	16.40	7.51	33.43	30.40	37.50	2.54	34.55	34.55	14.61
9.75	2.67	-5.70	9.20	5.85	36.09	33.00	40.50	2.63	36.18	36.18	4.23
11.75	-0.34	-5.20	5.10	3.80	36.53	34.90	39.20	1.60	36.53	36.53	359.46
13.75	-0.84	-4.90	2.00	2.85	35.01	32.70	38.90	2.18	35.02	35.02	358.62
15.75	0.76	-3.20	3.90	3.01	33.53	31.60	36.90	1.92	33.54	33.54	1.29
17.75	1.89	-1.30	5.20	2.36	31.94	29.70	35.20	2.17	32.00	32.00	3.38
19.75	1.46	-1.00	5.00	2.43	30.76	27.30	36.70	3.24	30.79	30.79	2.71
21.75	-0.60	-1.90	1.90	1.44	27.99	19.40	35.30	4.82	27.99	27.99	358.77

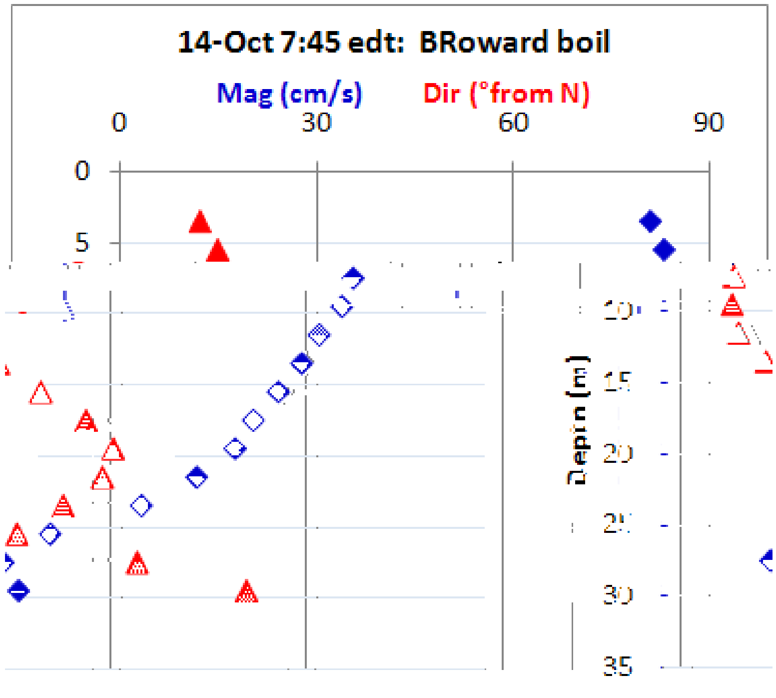


Figure 68: Current velocity and direction for Broward outfall on October 14, 2006 at 07:40.

11.6 V-Fin

No V-Fin data collected

12.0 BOCA RATON OUTFALL

12.1 Outfall Description

Boca Raton ocean outfall is located approximately 1.6 km offshore the southern section of Palm Beach County at a depth of 27.4 meters and has an average discharge flow rate of 11 MGD. Figure 69 shows the outfall pipe as recorded by the ship's multibeam system. From these data, a location of 26° 21.016 'N, 80° 3.243'W (26.350267°N, 80.05405°W) was determined. Table 32 lists the CTD sample stations and sample depth. Table 30 lists the sediment sample locations and depth.

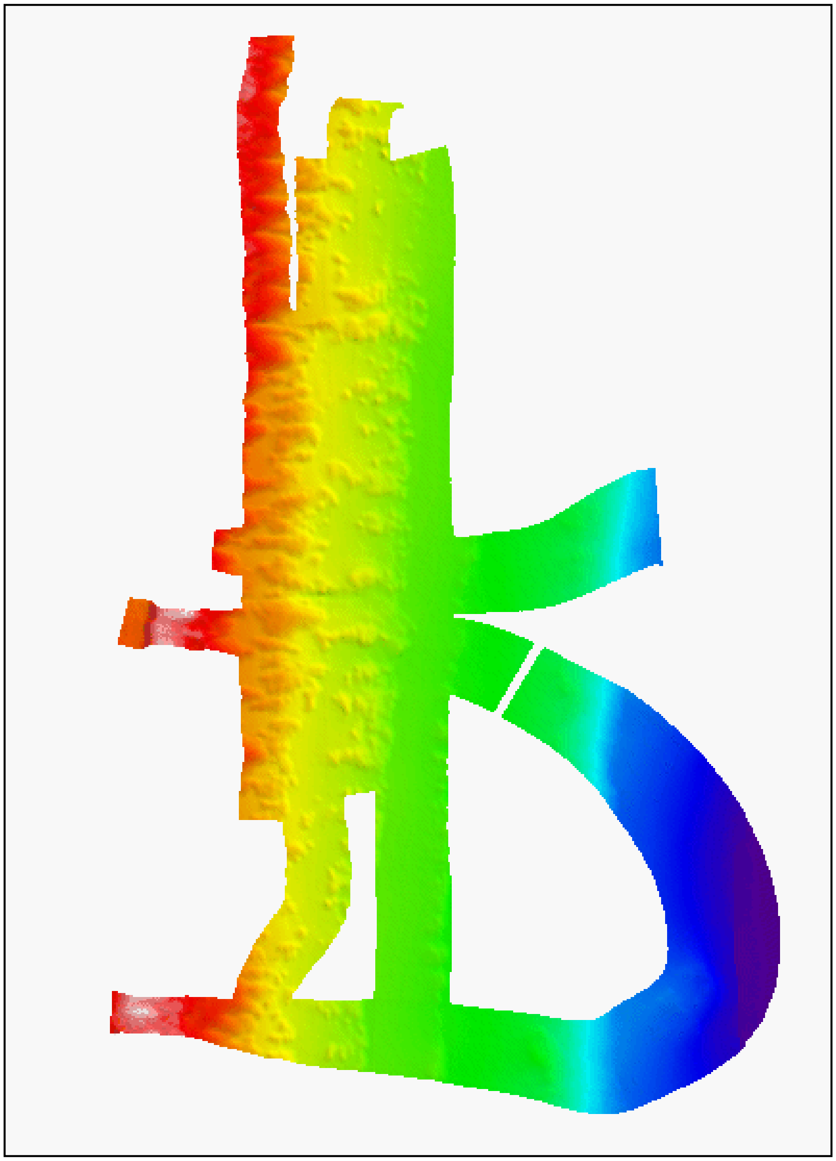


Figure 69. Multibeam data from the vicinity of the Hollywood outfall. Structure is the small horizontal line near the center of the view.

Table 32: CTD sample locations for Boca Raton Outfall.

Date	Sample #		Latitude	Longitude	Dist to pipe (m)	Depth (m)
13-Oct	BC-	1a	26.3506	-80.0540	0.0	0.0
13-Oct	BC-	1b	26.3506	-80.0540	0.0	13.7
13-Oct	BC-	1c	26.3506	-80.0540	0.0	27.4
13-Oct	BC-	3a	26.3512	-80.0541	67.5	0.0
13-Oct	BC-	3b	26.3512	-80.0541	67.5	13.6
13-Oct	BC-	3c	26.3512	-80.0541	67.5	27.2
13-Oct	BC-	4a	26.3511	-80.0536	68.4	0.0
13-Oct	BC-	4b	26.3511	-80.0536	68.4	14.7
13-Oct	BC-	4c	26.3511	-80.0536	68.4	29.3
13-Oct	BC-	2a	26.3511	-80.0546	81.6	0.0
13-Oct	BC-	2b	26.3511	-80.0546	81.6	12.7
13-Oct	BC-	2c	26.3511	-80.0546	81.6	25.4
13-Oct	BC-	6a	26.3515	-80.0538	102.0	0.0
13-Oct	BC-	6b	26.3515	-80.0538	102.0	13.9
13-Oct	BC-	6c	26.3515	-80.0538	102.0	27.9
13-Oct	BC-	5a	26.3515	-80.0543	104.4	0.0
13-Oct	BC-	5b	26.3515	-80.0543	104.4	12.7
13-Oct	BC-	5c	26.3515	-80.0543	104.4	25.3
13-Oct	BC-	7a	26.3515	-80.0535	111.8	0.0
13-Oct	BC-	7b	26.3515	-80.0535	111.8	14.6
13-Oct	BC-	7c	26.3515	-80.0535	111.8	29.3
13-Oct	BC-	9a	26.3520	-80.0538	156.9	0.0
13-Oct	BC-	9b	26.3520	-80.0538	156.9	13.7
13-Oct	BC-	9c	26.3520	-80.0538	156.9	27.5
13-Oct	BC-	8a	26.3520	-80.0543	158.5	0.0
13-Oct	BC-	8b	26.3520	-80.0543	158.5	13.0
13-Oct	BC-	8c	26.3520	-80.0543	158.5	26.0
13-Oct	BC-	10a	26.3520	-80.0534	166.8	0.0
13-Oct	BC-	10b	26.3520	-80.0534	166.8	14.6
13-Oct	BC-	10c	26.3520	-80.0534	166.8	29.3
13-Oct	BRI-	a	26.3561	-80.0081		0
13-Oct	BRI-	b	26.3561	-80.0081		30
13-Oct	BRI-	c	26.3561	-80.0081		60
13-Oct	BRI-	d	26.3561	-80.0081		90
13-Oct	BRI-	e	26.3561	-80.0081		120
13-Oct	BRI-	f	26.3561	-80.0081		150

Table 33: Sediment sample locations for Boca Raton Outfall.

Date	Station	Latitude	Longitude	Depth (m)
9-Oct	BC10	26.3498	-79.9534	237.0
9-Oct	BC11	26.3496	-80.0039	182.0
9-Oct	BC12	26.3507	-80.0341	118.0
9-Oct	BC13	26.3503	-80.0638	11.0
9-Oct	BC13b	26.3503	-80.0638	11.0
9-Oct	BC14	26.3411	-80.0539	29.5
9-Oct	BC14b	26.3412	-80.0542	29.5
9-Oct	BC15	26.3503	-80.0541	26.6
9-Oct	BC16	26.3512	-80.0541	26.9
9-Oct	BC17	26.3521	-80.0541	26.4
9-Oct	BC18	26.3530	-80.0541	26.1
9-Oct	BC18b	26.3532	-80.0539	26.1
9-Oct	BC19c	26.3532	-80.0539	25.7
9-Oct	BC20a	26.3591	-80.0542	23.2
9-Oct	BC20b	26.3591	-80.0539	24.5

12.2 Nutrients

A total of 30 nutrient samples were collected during the CTD operations around the Boca Raton outfall. These results are listed in Table 35 for concentrations in εM and in Table 36 for concentrations in mg/L. A presentation of the results is given below.

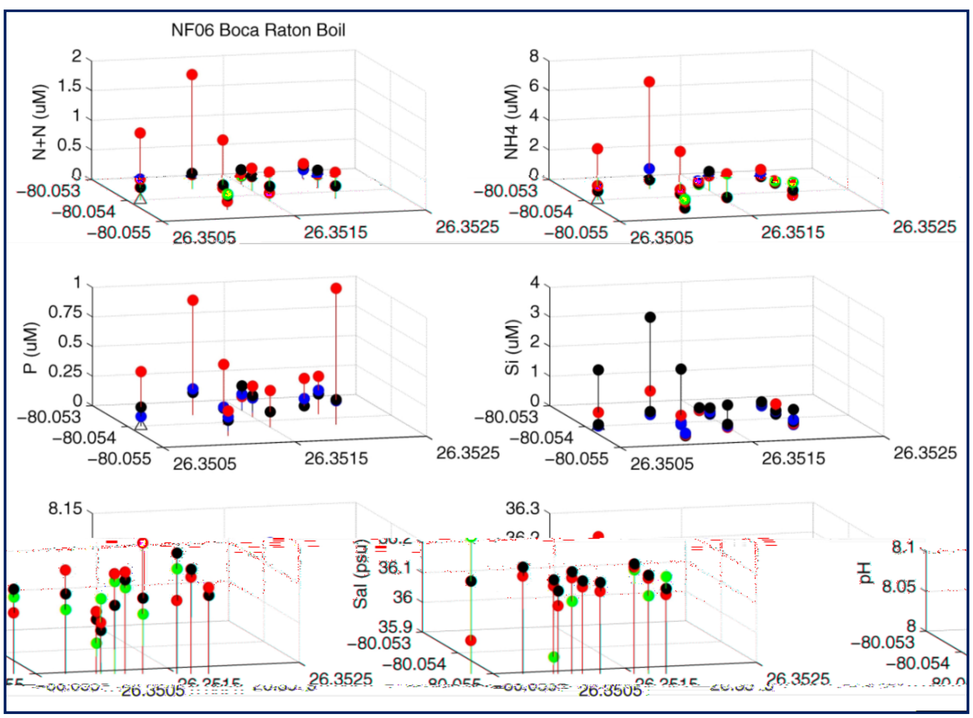


Figure 70. Three-dimensional presentation of the nutrient results from CTD casts near the Boca Raton outfall. Labeling is the same as in Figure 5.

Table 35: Nutrient results in εM from the Boca Raton Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)		
1a	1.2	1.13	1.30	3.45	0.46	1.90		
1b	13.6	0.35	0.03	0.96	0.08	0.00		
1c	24.2	0.21	0.05	0.60	0.16	0.00		
2a	4.5	0.26	0.04	0.70	0.21	0.00		
2b	11.9	0.14	0.08	0.56	0.16	0.00		
2c	22.5	0.24	0.07	0.11	0.13	0.01		
3a	2.4	0.99	1.11	3.18	0.51	1.88		
3b	12.4	0.18	0.09	0.61	0.15	0.01		
3c	24.0	0.23	0.08	0.33	0.14	0.00		
4a	0.9	1.93	2.12	7.22	0.97	3.30		
4b	13.5	0.24	0.09	1.35	0.22	0.01		
4c	26.0	0.26	0.11	0.61	0.19	0.04		
5a	1.1	0.49	0.46	1.85	0.31	0.75		
5b	11.4	0.14	0.10	0.24	0.13	0.04		
5c	22.3	0.25	0.10	0.26	0.13	0.04		
6a	0.9	0.38	0.38	1.29	0.26	0.30		
6b	13.0	0.24	0.17	1.00	0.16	0.09		
6c	24.2	0.25	0.11	1.30	0.18	0.04		
7a	0.8	0.15	0.10	0.00	0.12	0.00		
7b	13.2	0.14	0.09	0.23	0.14	0.00		
7c	25.6	0.25	0.10	0.09	0.21	0.00		
8a	1.3	0.44	0.38	1.08	1.15	0.51		
8b	12.5	0.21	0.16	0.21	0.20	0.00		
8c	23.0	0.21	0.10	0.55	0.21	0.04		
9a	1.2	0.22	0.13	0.48	0.32	0.00		
9b	13.0	0.23	0.10	0.42	0.20	0.00		
9c	24.5	0.30	0.13	0.33	0.17	0.00299	-1.26953./b	0

Table 36: Nutrient results in mg/L from the Boca Raton Outfall.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1a	1.2	0.005	0.000	0.013	0.002	0.000
1b	13.6	0.016	0.018	0.048	0.014	0.053
1c	24.2	0.003	0.001	0.008	0.005	0.000
2a	4.5	0.004	0.001	0.010	0.007	0.000
2b	11.9	0.002	0.001	0.008	0.005	0.000
2c	22.5	0.003	0.001	0.002	0.004	0.000
3a	2.4	0.014	0.016	0.045	0.016	0.053
3b	12.4	0.003	0.001	0.009	0.005	0.000
3c	24.0	0.003	0.001	0.005	0.004	0.000
4a	0.9	0.027	0.030	0.101	0.030	0.092
4b	13.5	0.003	0.001	0.019	0.007	0.000
4c	26.0	0.004	0.002	0.009	0.006	0.001
5a	1.1	0.007	0.006	0.026	0.010	0.021
5b	11.4	0.002	0.001	0.003	0.004	0.001
5c	22.3	0.004	0.001	0.004	0.004	0.001
6a	0.9	0.005	0.005	0.018	0.008	0.008
6b	13.0	0.003	0.002	0.014	0.005	0.003
6c	24.2	0.004	0.002	0.018	0.005	0.001
7a	0.8	0.002	0.001	0.000	0.004	0.000
7b	13.2	0.002	0.001	0.003	0.004	0.000
7c	25.6	0.004	0.001	0.001	0.006	0.000
8a	1.3	0.006	0.005	0.015	0.036	0.014
8b	12.5	0.003	0.002	0.003	0.006	0.000
8c	23.0	0.003	0.001	0.008	0.006	0.001
9a	1.2	0.003	0.002	0.007	0.010	0.000
9b	13.0	0.003	0.001	0.006	0.006	0.000
9c	24.5	0.004	0.002	0.005	0.005	0.000
10a	1.0	0.004	0.003	0.010	0.007	0.002
10b	13.9	0.002	0.001	0.005	0.002	0.000
10c	26.3	0.003	0.002	0.003	0.000	0.000

12.3 Chlorophyll and pH

A total of 30 chlorophyll and pH samples were collected during CTD operations around the Boca Raton outfall. Table 37 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 37: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from Boca Raton Outfall.

Station	Depth (m)	Temperature (^0C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
1a	1.2	29.68	36.29	8.07	0.706	0.209
1b	13.6	28.99	35.94	8.05	0.714	0.191
1c	24.2	28.88	36.14	8.08	0.561	0.204
2a	4.5	29.16	36.09	8.08	0.734	0.246
2b	11.9	29.12	36.09	8.05	1.446	0.424
2c	22.5	28.90	36.14	8.04	N/A	N/A
3a	2.4	29.13	35.88	8.01	0.774	0.243
3b	12.4	28.98	36.12	8.05	0.745	0.208
3c	24.0	28.87	36.14	8.04	0.561	0.182
4a	0.9	29.12	35.69	8.04	0.699	0.197
4b	13.5	28.96	36.12	8.09	0.696	0.137
4c	26.0	28.86	36.15	8.06	0.603	0.190
5a	1.1	29.26	35.65	8.05	0.644	0.176
5b	11.4	29.14	36.11	8.14	0.608	0.214
5c	22.3	28.93	36.14	8.07	0.617	0.165
6a	0.9	29.01	34.93	8.07	0.475	0.174
6b	13.0	29.16	36.09	8.09	0.587	0.159
6c	24.2	29.09	36.11	8.08	0.681	0.151
7a	0.8	29.34	36.02	8.07	0.388	0.126
7b	13.2	29.17	36.10	8.08	0.666	0.245
7c	25.6	29.02	36.12	8.04	0.639	0.186
8a	1.3	29.16	36.15	8.08	0.618	0.187
8b	12.5	29.16	36.09	8.08	0.619	0.156
8c	23.0	29.09	36.11	8.07	0.653	0.201
9a	1.2	29.09	36.05	8.08	0.619	0.206
9b	13.0	29.08	36.11	8.08	0.575	0.215
9c	24.5	29.07	36.12	8.09	0.594	0.176
10a	1.0	29.05	36.11	8.08	0.752	0.233
10b	13.9	28.98	36.12	8.04	0.607	0.230
10c	26.3	28.94	36.13	8.10	0.630	0.226

12.4 CTD CAST

A total of 10 CTD casts were conducted at the Boca Raton outfall. At each station the CTD obtained a sample near bottom, mid-point and near surface. Figures 71-80 show the temperature, salinity and oxygen saturation for each station.

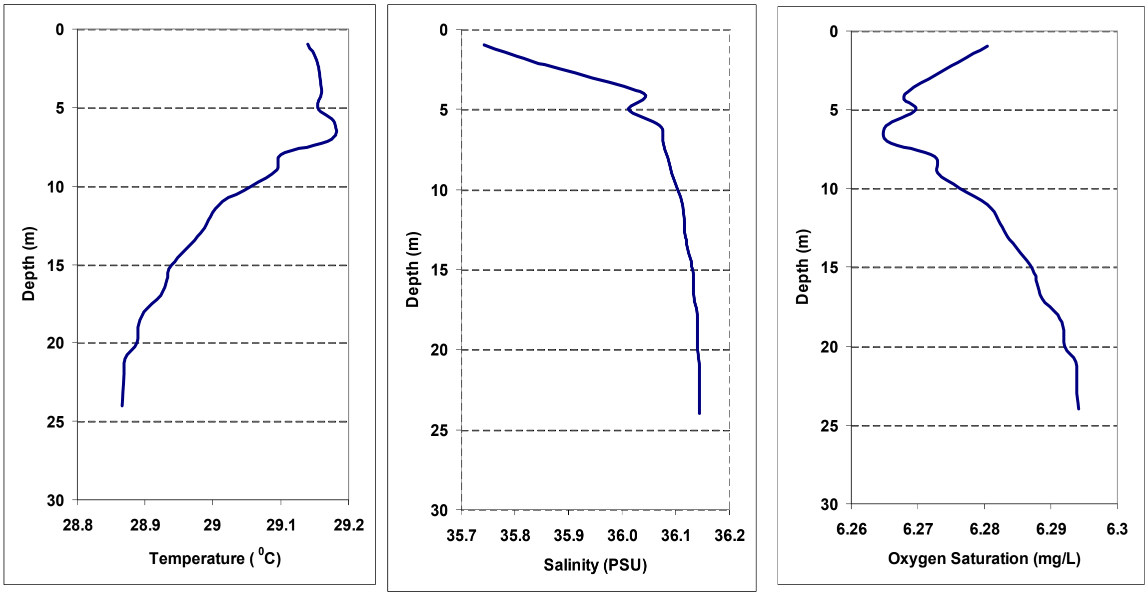


Figure 73: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-3.

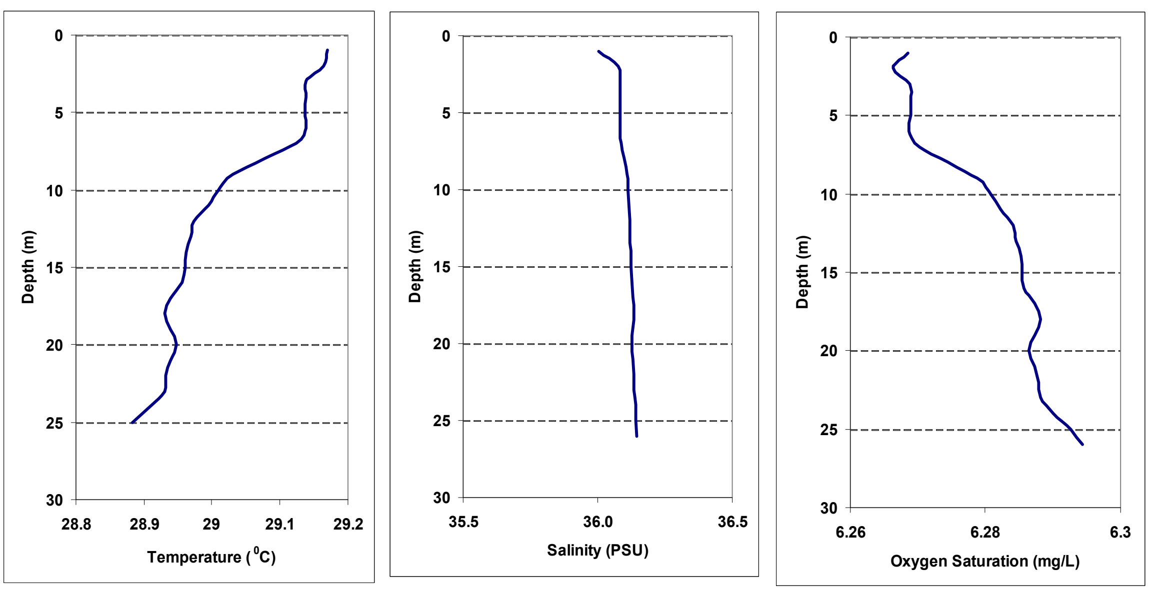


Figure 74: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-4.

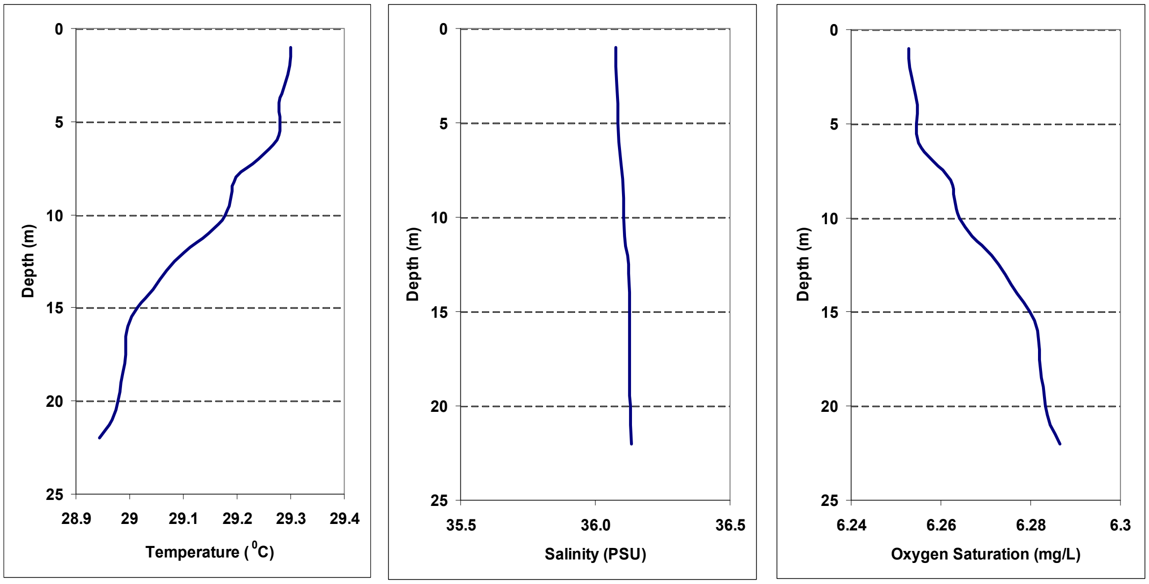


Figure 75: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-5.

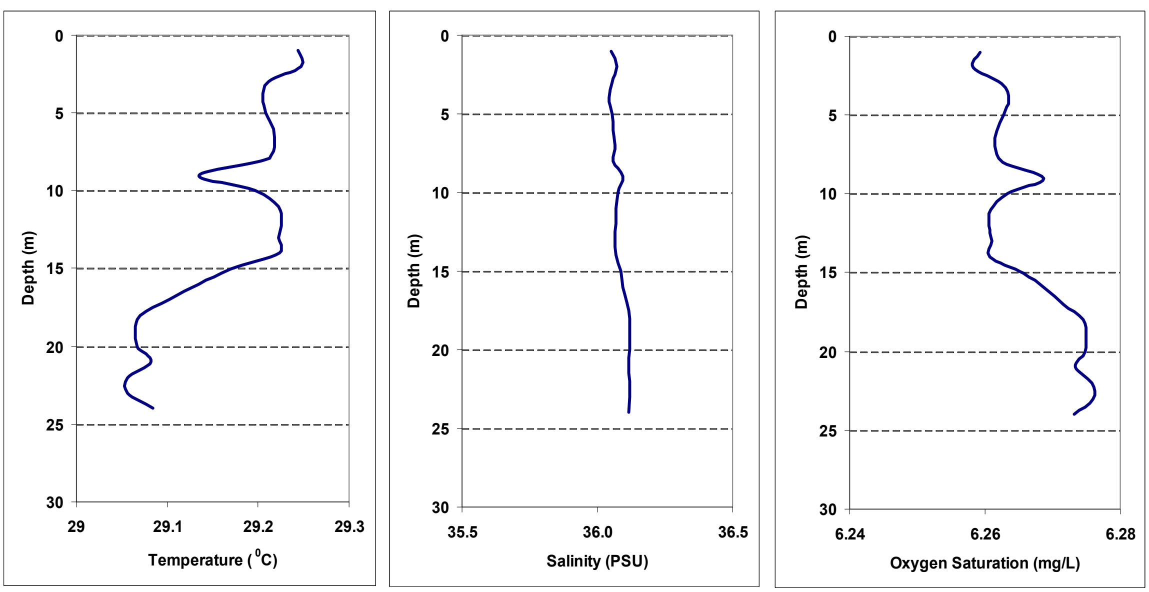


Figure 76: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-6.

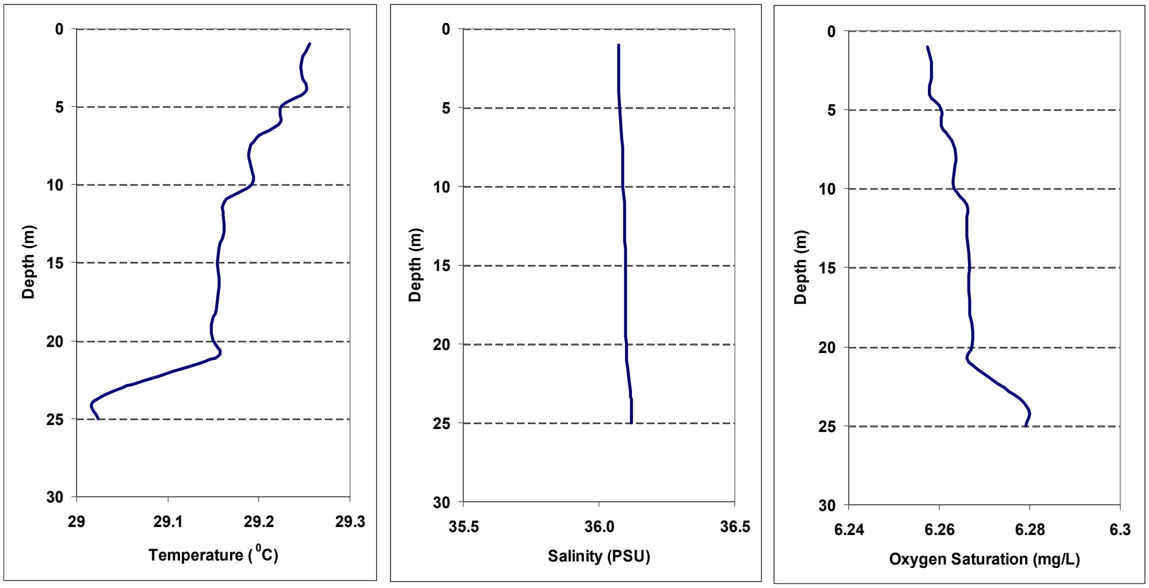


Figure 77: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-7.

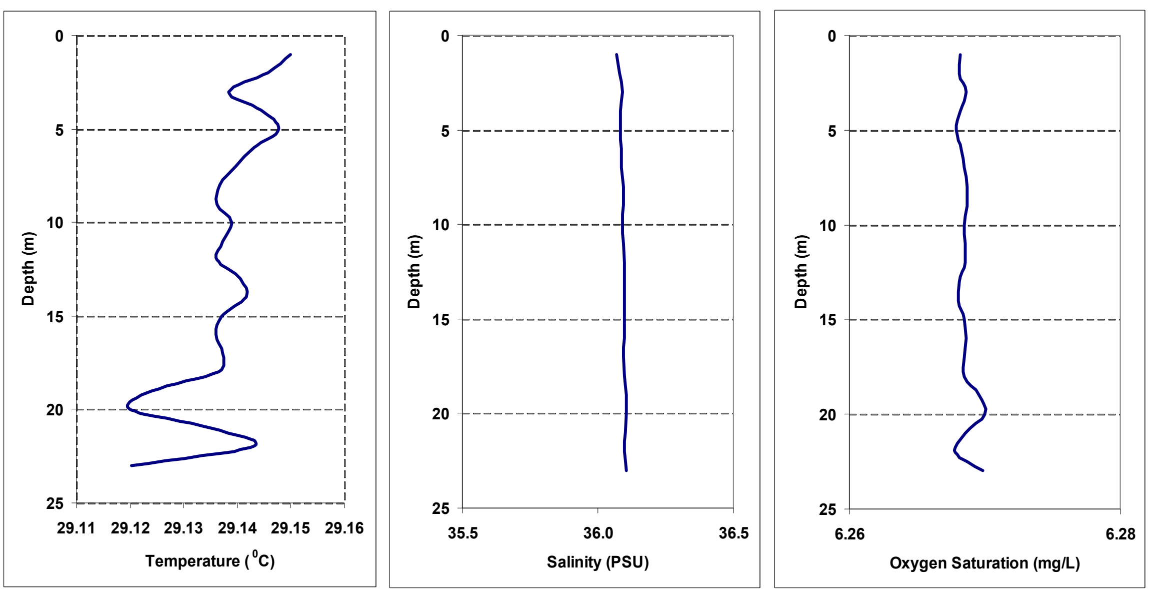


Figure 78: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-8.

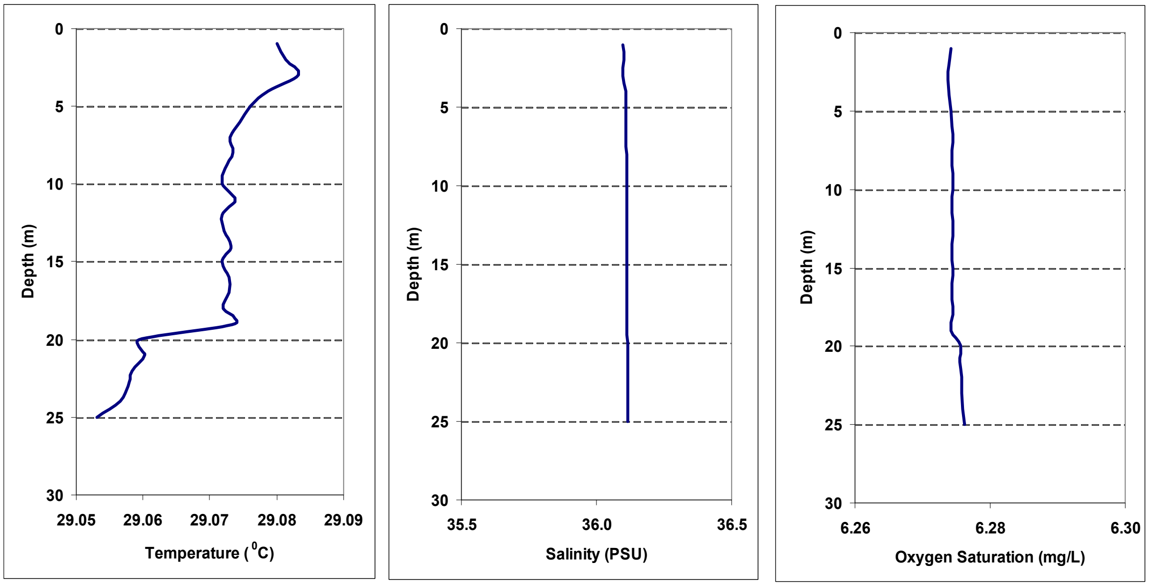


Figure 79: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-9.

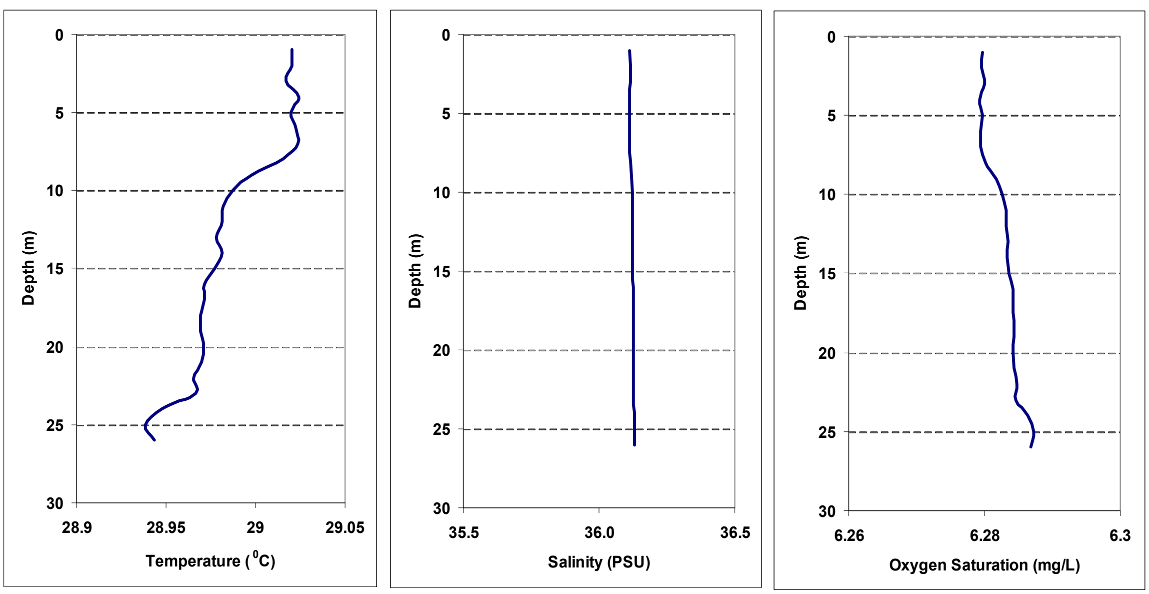


Figure 80: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BCB-10.

12.5 Current Velocity and Direction

A RDI ADCP was dipped at the Boca Raton outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. Table 38 lists the current velocity and direction data obtained from Boca Raton outfall, while Figure 81 graphically depicts the data.

Table 38: Current velocity and direction for Boca Raton outfall on October 13, 2006 at 07:45 EDT.

Bin Z (m)	U mean	U min	U max	U Std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
3.25	-1.48	-2.70	-0.60	1.01	-11.90	-13.80	-10.30	1.81	11.99	11.99	187.07
5.25	-0.68	-1.70	0.30	0.90	-14.08	-14.80	-12.90	0.88	14.09	14.09	182.75
7.25	-3.80	-5.60	-1.00	2.02	-13.95	-16.60	-12.50	1.83	14.46	14.46	195.24
9.25	-5.40	-7.60	-2.60	2.26	-14.68	-16.70	-12.40	1.78	15.64	15.64	200.20
11.25	-7.23	-9.20	-6.00	1.39	-15.48	-16.40	-14.00	1.09	17.08	17.08	205.03
13.25	-8.53	-10.40	-7.00	1.64	-16.78	-17.40	-15.80	0.74	18.82	18.82	206.94
15.25	-9.43	-11.40	-7.00	2.01	-16.78	-17.40	-15.40	0.93	19.24	19.24	209.33
17.25	-9.40	-10.70	-7.70	1.54	-17.13	-18.00	-16.20	0.86	19.54	19.54	208.76
19.25	-9.55	-10.80	-8.70	0.91	-16.65	-18.20	-15.10	1.30	19.19	19.19	209.84
21.25	-8.28	-8.60	-7.80	0.36	-15.33	-16.20	-14.60	0.80	17.42	17.42	208.37

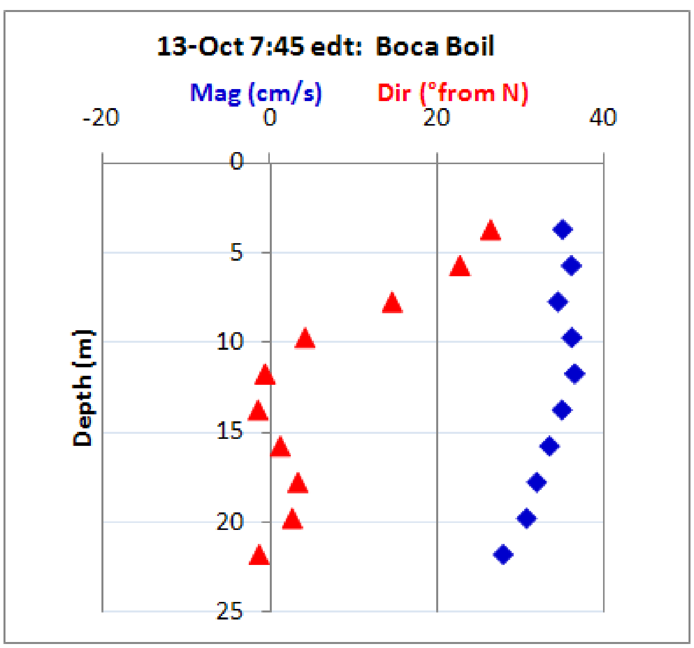


Figure 81: Current velocity and direction for Boca Raton outfall on October 10, 2006 at 11:40.

12.6 V-Fin

A V-Fin (tow body with CTD) was lowered via A-frame behind the ship to crisscross the outfall to obtain additional information on the salinity and temperature to determine the location of the plume. Figure 82 shows the track over the outfall plume as well as the salinity and temperature deficits. The plume was clearly identified by salinity deficit but, as observed in other plumes, the temperature deficit was negligible. The plume development as seen in Figure 81 supports the northerly current direction seen above.

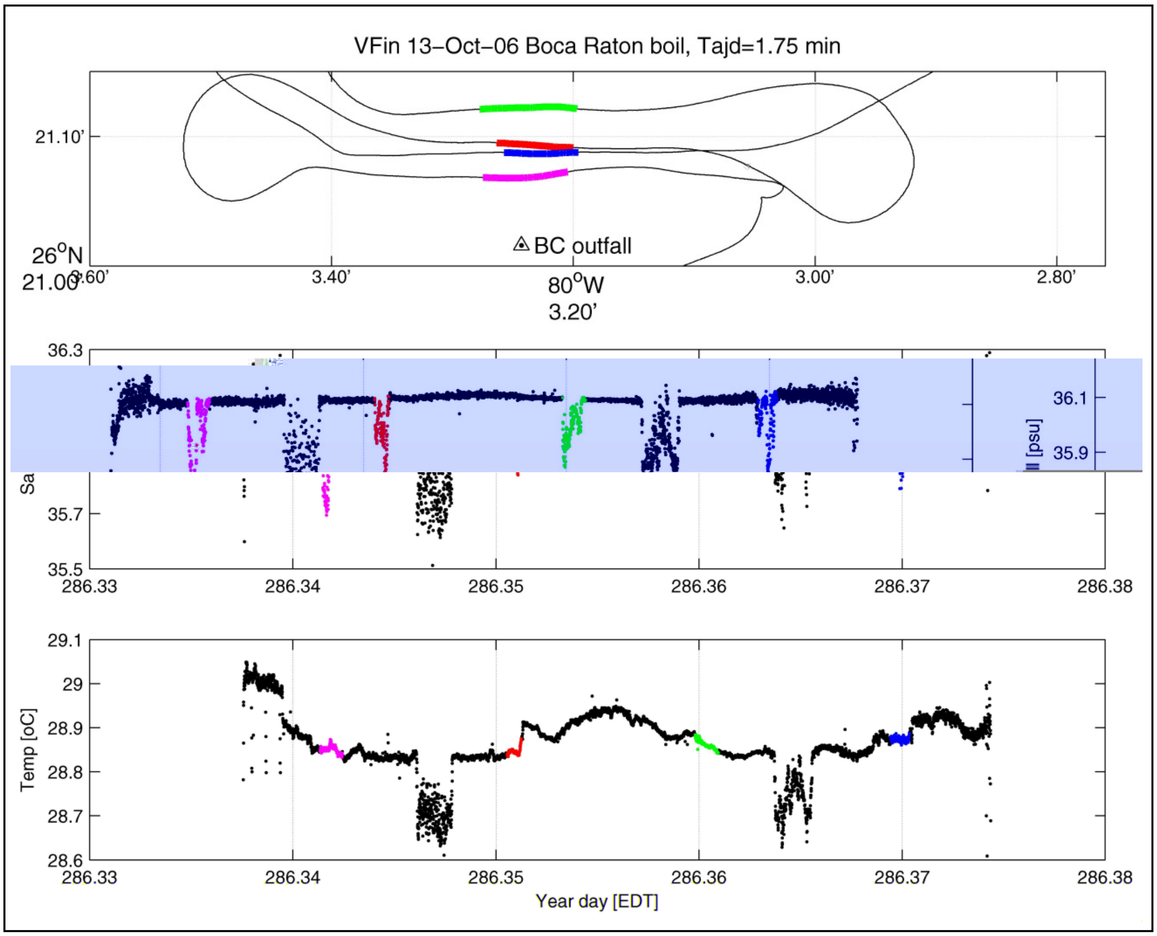


Figure 82: V-Fin tracking map of the Boca Raton outfall plume on 13-October. Plume indications are highlighted in magenta, green, red, green and blue.

13.0 SOUTH CENTRAL OUTFALL

13.1 Outfall Description

South Central ocean outfall is located approximately 1.6 km offshore Delray Beach at a depth of 27.4 meters and has an average discharge flow rate of 12 MGD. Figure 83 shows the outfall pipe as recorded by the ship's multibeam system. From these data, a location of 26° 27.715 'N, 80° 2.525'W (26.461917°N, 80.042083°W) was determined. Table 39 lists the CTD sample stations and sample depth. Table 40 lists the sediment sample locations and depth.

Figure 83: Multibeam data from the vicinity of the South Central outfall pipe.

Table 39: CTD sample locations for South Central Outfall.

Date	Sample #		Latitude	Longitude	Dist to pipe (m)	Depth (m)
12-Oct	SC-	1	26.4627	-80.0420	0.0	0.0
12-Oct	SC-	11a	26.4623	-80.0420	44.5	0.0
12-Oct	SC-	1b	26.4623	-80.0420	44.5	0.0
12-Oct	SC-	11b	26.4623	-80.0420	44.5	14.7
12-Oct	SC-	11c	26.4623	-80.0420	44.5	29.4
12-Oct	SC-	6a	26.4631	-80.0417	53.6	0.0
12-Oct	SC-	6b	26.4631	-80.0417	53.6	15.0
12-Oct	SC-	6c	26.4631	-80.0417	53.6	30.0
12-Oct	SC-	4a	26.4631	-80.0424	59.7	0.0
12-Oct	SC-	4b	26.4631	-80.0424	59.7	13.6
12-Oct	SC-	4c	26.4631	-80.0424	59.7	27.1
12-Oct	SC-	7a	26.4636	-80.0424	107.7	0.0
12-Oct	SC-	7b	26.4636	-80.0424	107.7	13.8
12-Oct	SC-	7c	26.4636	-80.0424	107.7	27.6
12-Oct	SC-	5a	26.4630	-80.0431	114.5	0.0
12-Oct	SC-	5b	26.4630	-80.0431	114.5	12.0
12-Oct	SC-	5c	26.4630	-80.0431	114.5	24.0
12-Oct	SC-	3a	26.4638	-80.0416	128.6	0.0
12-Oct	SC-	3b	26.4638	-80.0416	128.6	15.2
12-Oct	SC-	3c	26.4638	-80.0416	128.6	30.4
12-Oct	SC-	8a	26.4637	-80.0411	142.8	0.0
12-Oct	SC-	8b	26.4637	-80.0411	142.8	15.8
12-Oct	SC-	8c	26.4637	-80.0411	142.8	31.6
12-Oct	SC-	9a	26.4642	-80.0427	180.8	0.0
12-Oct	SC-	9b	26.4642	-80.0427	180.8	11.5
12-Oct	SC-	9c	26.4642	-80.0427	180.8	23.0
12-Oct	SC-	2a	26.4642	-80.0434	217.4	0.0
12-Oct	SC-	2b	26.4642	-80.0434	217.4	10.6
12-Oct	SC-	2c	26.4642	-80.0434	217.4	21.1
12-Oct	SC-	10a	26.4642	-80.0442	275.3	0.0
12-Oct	SC-	10b	26.4642	-80.0442	275.3	9.8
12-Oct	SC-	10c	26.4642	-80.0442	275.3	19.7

Table 40: Sediment sample locations for South Central Outfall.

Date	Station	Latitude	Longitude	Depth (m)
9-Oct	SC10	26.4622	-79.8554	345.0
9-Oct	SC10	26.4817	-79.8583	220.0
9-Oct	SC11	26.4612	-79.9669	203.0
9-Oct	SC12	26.4617	-80.0052	156.0
9-Oct	SC13	26.4781	-80.0421	22.7
9-Oct	SC14	26.4657	-80.0375	27.1
9-Oct	SC15	26.4646	-80.0421	28.0
9-Oct	SC16a	26.4637	-80.0422	N/A
9-Oct	SC16b	26.4632	-80.0421	N/A
9-Oct	SC16c	26.4633	-80.0421	N/A
9-Oct	SC17	26.4629	-80.0420	29.3
9-Oct	SC18	26.4620	-80.0537	8.5
9-Oct	SC19	26.4611	-80.0421	29.8
9-Oct	SC19	26.4611	-80.0421	29.8
9-Oct	SC20	26.4379	-80.0423	30.0
9-Oct	SC21	26.4440	-80.0419	41.8
9-Oct	SC21b	26.4601	-80.0426	41.8
9-Oct	SC22	26.4620	-80.0422	28.5

13.2 Nutrients

Nutrient samples were collected but the data was lost due to computer failure.

13.3 Chlorophyll and pH

A total of 33 chlorophyll and pH samples were collected during CTD operations around the South Central outfall. Table 41 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 41: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from South Central Outfall.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
1a	0.5	28.8474	35.8623	N/A	N/A	N/A
1b	15.5	28.8438	36.1418	N/A	N/A	N/A
2a	1.1	28.9830	36.0996	8.28	0.343	0.111
2b	11.4	28.9102	36.1466	N/A	0.424	0.104
2c	20.3	28.8011	36.1608	8.23	0.316	0.144
3a	1.9	29.0463	35.9955	8.15	0.422	0.121
3b	19.5	28.8524	36.0616	8.15	0.518	0.204
3c	28.8	28.7028	36.1673	8.05	0.433	0.170
4a	1.8	28.6877	35.8053	8.36	0.402	0.126
4b	13.6	28.8923	36.1528	8.02	0.434	0.137
4c	25.3	28.8365	36.1634	N/A	0.419	0.148
5a	1.2	29.0360	36.1167	8.07	0.398	0.126
5b	11.7	28.8085	36.1514	N/A	0.406	0.132
5c	20.4	28.8076	36.1588	8.06	0.429	0.138
6a	1.2	29.0340	36.0460	N/A	0.403	0.115
6b	14.1	28.9418	36.1614	8.34	0.407	0.128
6c	28.0	28.7763	36.1623	8.26	0.416	0.133
7a	1.3	29.0645	36.0543	8.23	0.362	0.094
7b	13.5	28.9387	36.1438	8.23	0.437	0.122
7c	24.4	28.8353	36.1572	8.04	0.387	0.134
8a	1.2	29.1314	35.9803	N/A	0.439	0.119
8b	15.6	28.9980	36.1510	N/A	0.231	0.075
8c	28.6	28.9018	36.1417	N/A	0.481	0.196
9a	1.2	29.1017	35.9733	N/A	0.422	0.134
9b	11.8	29.0219	36.1370	8.03	0.418	0.129
9c	22.8	28.8908	36.1524	N/A	0.412	0.139
10a	1.0	29.1505	35.8912	N/A	0.455	0.129
10b	7.9	29.1160	36.1324	8.25	0.533	0.145
10c	16.5	28.8692	36.1539	8.29	0.486	0.135
11a	1.2	29.0963	36.0886	8.27	0.279	0.084
11b	15.1	28.9632	36.1459	8.06	0.214	0.074
11c	27.4	28.8939	36.1445	8.31	0.517	0.179

13.4 CTD CAST

A total of 11 CTD casts were conducted at the South Central outfall. At each station the CTD obtained a sample near bottom, mid-point and near surface. No profiles are available due to error with the CTD.

13.5 Current Velocity and Direction

A RDI ADCP was dipped at the South Central outfall to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. A total of three measurements were collected. Tables 42-44 list the current velocity and direction data obtained from South Central outfall, while Figures 84-86 graphically depicts the data.

Table 42: Current velocity and direction for South Central outfall on October 9, 2006 at 10:40 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4	-2.30	-4.40	1.20	2.39	-7.68	-9.80	-5.10	1.72	8.02	8.02	196.67
6	-3.86	-6.30	-2.90	1.40	-9.58	-10.60	-8.70	0.73	10.33	10.33	201.95
8	-3.56	-8.90	-1.50	3.05	-9.92	-11.50	-8.80	0.99	10.54	10.54	199.74
10	-1.42	-3.90	0.10	1.51	-11.12	-12.20	-9.80	1.09	11.21	11.21	187.28
12	0.78	0.20	1.30	0.50	-11.64	-12.00	-11.00	0.39	11.67	11.67	176.17
14	3.76	2.60	4.80	0.96	-11.56	-12.50	-10.10	1.12	12.16	12.16	161.98
16	5.82	4.00	7.00	1.45	-11.52	-12.80	-10.20	1.05	12.91	12.91	153.20
18	5.88	5.40	6.30	0.43	-8.48	-10.70	-7.00	1.49	10.32	10.32	145.26

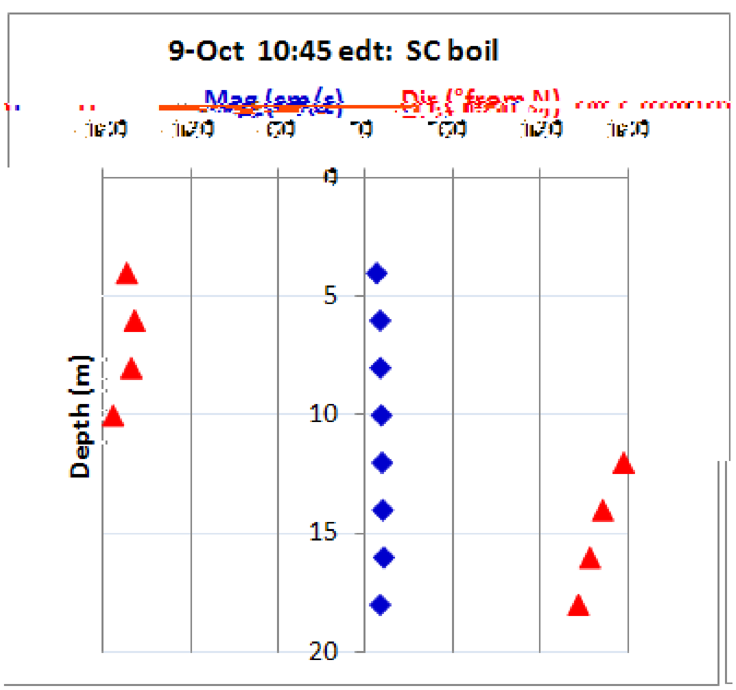


Figure 84: Current velocity and direction for South Central outfall on October 9, 2006 at 10:40.

Table 43: Current velocity and direction for South Central outfall on October 12, 2006 at 11:00.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4	1.63	-2.40	6.20	2.49	36.95	33.00	41.40	2.24	36.99	36.99	2.52
6	-3.09	-8.40	1.70	3.50	36.63	33.50	41.70	2.37	36.76	36.76	355.18
8	-6.73	-12.90	1.00	4.28	37.22	34.50	42.80	2.32	37.82	37.82	349.76
10	-8.11	-14.40	-1.00	4.23	36.78	32.10	40.20	2.08	37.67	37.67	347.57
12	-9.32	-14.00	-3.80	3.53	35.39	30.10	39.60	2.82	36.60	36.60	345.25
14	-9.42	-14.30	-5.60	2.99	33.54	28.70	39.70	3.94	34.84	34.84	344.32
16	-9.59	-14.90	-6.00	3.06	31.40	24.70	37.50	4.94	32.83	32.83	343.01
18	-9.33	-13.90	-5.20	3.18	29.54	21.70	37.40	6.17	30.98	30.98	342.48
20	-9.23	-13.20	-4.50	2.90	27.14	18.60	35.80	6.71	28.67	28.67	341.21
22	-9.72	-13.30	-5.30	2.59	25.93	15.20	37.00	6.97	27.69	27.69	339.46

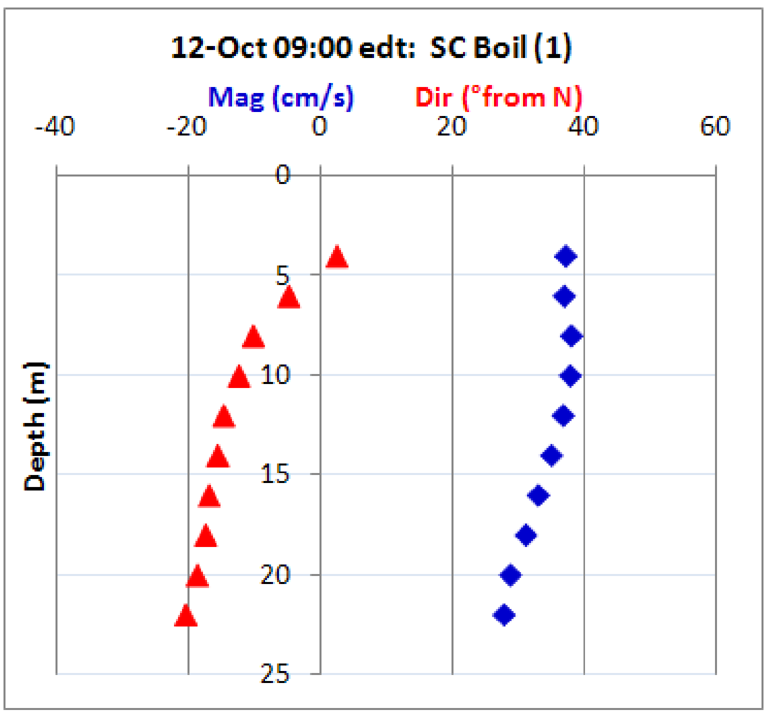


Figure 85: Current velocity and direction for South Central outfall on October 12, 2006 at 11:00.

Table 44: Current velocity and direction for South Central outfall on October 12, 2006 at 17:00 EDT.

Bin Z (m)	U mean	U min	U max	U std	V mean	V min	V max	V std	MAG Mean	MAG 2	Dir
4.25	-12.22	-19.90	-4.80	4.12	23.92	9.00	36.60	7.58	26.86	26.86	332.94
6.25	-7.94	-16.00	-1.50	2.98	19.45	10.00	31.40	6.65	21.01	21.01	337.78
8.25	-6.52	-11.10	-1.10	2.29	19.62	10.60	32.20	6.35	20.67	20.67	341.61
10.25	-5.76	-11.20	-1.30	2.16	19.83	13.90	28.70	4.51	20.65	20.65	343.80
12.25	-4.12	-9.10	0.20	2.74	20.36	15.70	26.60	3.52	20.77	20.77	348.57
14.25	-3.72	-10.60	0.90	3.23	20.38	16.10	27.70	3.23	20.71	20.71	349.66
16.25	-3.58	-8.30	2.00	3.07	19.37	11.80	25.90	4.10	19.70	19.70	349.52
18.25	-4.30	-9.20	0.90	3.28	18.46	13.90	24.10	3.48	18.95	18.95	346.87
20.25	-4.83	-10.20	1.30	3.32	18.06	11.20	25.10	3.62	18.70	18.70	345.02
22.25	-4.78	-10.50	-0.80	2.71	15.94	10.70	21.10	3.23	16.64	16.64	343.31

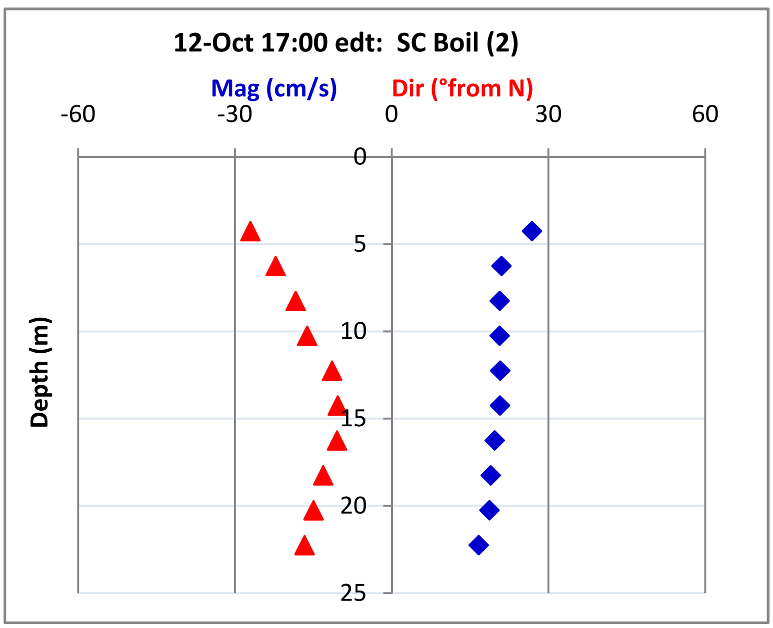


Figure 86: Current velocity and direction for South Central outfall on October 12, 2006 at 17:00.

13.6 V-Fin

As has been reported above at other outfalls, a V-Fin (tow body with CTD) was towed by the ship across the expected surface expression of the South Central outfall plume on 12-October. The resulting salinity and temperature data was then used to define the plume and allow sampling sites to be located for water sampling of the plume. Figure 87 shows the track over the outfall plume, and salinity and temperature deficits for the three plume encounters denoted in magenta, red, and blue. In this experiment only, there is a noted temperature response to the plume, particularly for the third (blue colored) pass.

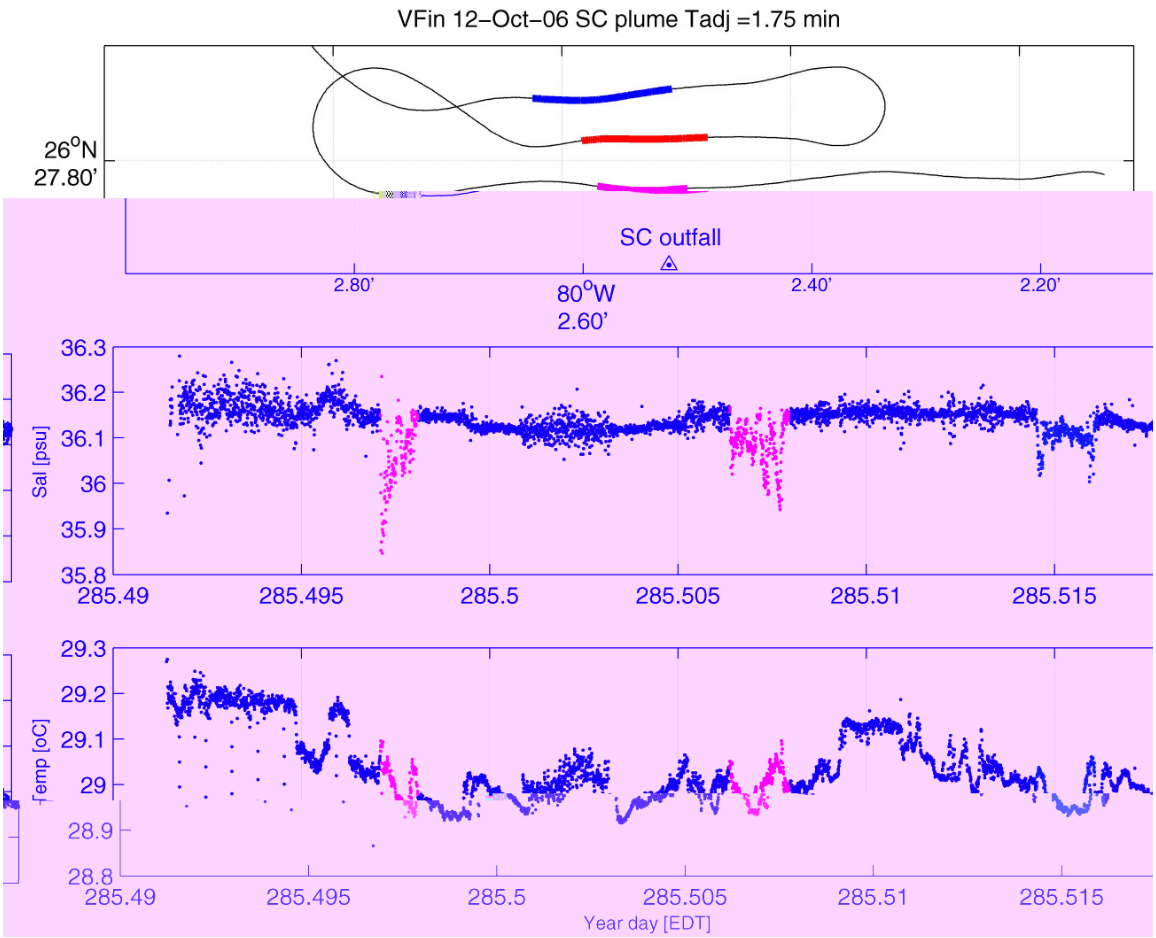


Figure 87: V-Fin CTD data for 12-October showing the changes in the salinity and temperature as the South Central plume was crossed.

It is observed here (and in other V-Fin data presented earlier) that there is a conspicuous 'edge effect', in which the salinity is lower at the edges of the plume while the temperature is higher (Figure 88), as if the plume was more concentrated in those regions. This observation, which is counterintuitive (as we expect mixing with the ambient waters to be maximal on the plume boundaries), was noted on most of the plume passes during the cruise.

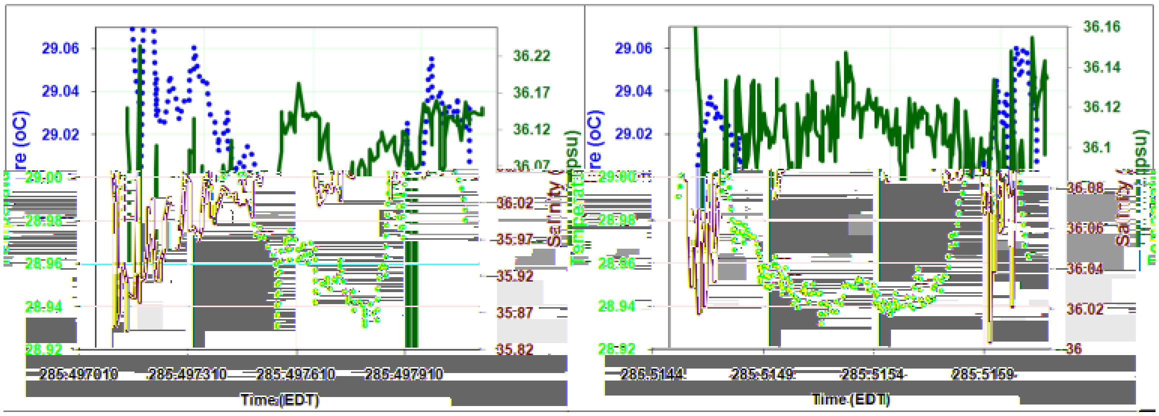


Figure 88: V-Fin data for 12-October showing the temperature (dotted line) and salinity (solid line) during the first and third passes through the South Central plume. Note that the temperature and salinity are anti-correlated, and that the maximum change occurs at the edge of the plume.

14.0 BOYNTON INLET

14.1 Station Location

The Boynton Inlet is the southernmost outlet for the Lake Worth Lagoon. The inlet is approximately 61 m wide and 3.7 m deep. One CTD cast was conducted outside the inlet but within the inlet plume. Table 45 lists the station location and depth of the CTD cast.

Table 45: CTD cast outside Boynton Inlet.

Date	Station	Latitude	Longitude	Depth (m)
2-Oct	BI-1a	26.5445	-80.0375	3.9
12-Oct	BI-1b	26.5445	-80.0375	5.6

14.2 Nutrients

Nutrient samples were collected but the data was lost due to a computer failure.

14.3 Chlorophyll and pH

A total of 2 chlorophyll and pH samples were collected during CTD operations around the Boynton Inlet. Table 46 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 46: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from outside the Boynton Inlet.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
1a	3.9	28.6051	35.7111	7.99	0.844	0.371
1b	5.6	28.6147	35.7273	8.09	0.855	0.377

14.4 CTD Cast

A total of 1 CTD cast was conducted outside the Boynton Inlet. At each station the CTD obtained a sample near bottom and near surface. No profiles are available due to error with the CTD.

14.5 Current Velocity and Direction

A RDI ADCP was dipped outside the Boynton Inlet to obtain current direction and velocity. The data was processed by using the RDI quality control parameters to identify that the data had sufficient 3 or 4 beam stable solutions, sufficient correlation and to assure the bottom was not influencing the data. Each ensemble was screened for evidence of the ship's propulsion in the data. If there were any ensembles that significantly deviated in the upper water column, those ensembles were eliminated from the average. Table 47 lists the current velocity and direction data obtained from outside the Boynton Inlet, while Figure 89 graphically depicts the data.

Table 47: Current velocity and direction outside the Boynton Inlet on October 12, 2008 at 07:40 EDT.

Bin Z (m)	U mean	U min	U max	U std	V Mean	V min	V max	V std	MAG Mean	MAG 2	Dir
3.8	12.20	7.90	17.20	3.14	9.73	5.40	15.50	3.63	15.60	15.60	51.44
5.8	5.86	3.80	7.30	1.17	5.69	2.80	7.10	1.39	8.17	8.17	45.87

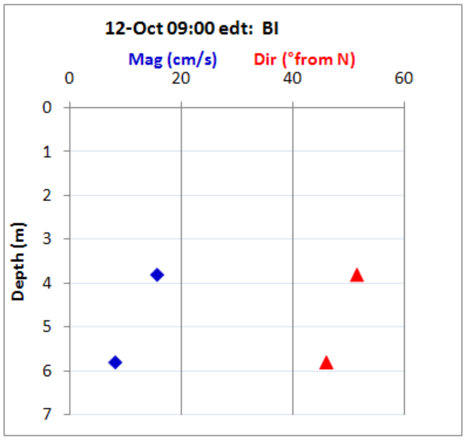


Figure 89: Current velocity and direction outside the Boynton Inlet on October 12, 2006 at 07:40.

14.6 V-Fin

No V-Fin operations were conducted outside the Boynton Inlet.

15.0 C1-C2-C3 TRANSECT

15.1 Station Locations

Three CTD casts were conducted offshore Broward County spanning the area between north of the Hollywood outfall to south of the Broward outfall (Figure 1). Table 48 lists the station locations and depth of the CTD casts. Table 49 lists the sediment sample locations and depth.

Table 48: CTD cast sample location and depth.

Date	Station	Latitude	Longitude	Depth (m)
14-Oct	C-1a	26.2002	-80.0715	1.4
14-Oct	C-1b	26.2002	-80.0715	3.8
14-Oct	C-1c	26.2002	-80.0715	11.4
14-Oct	C-2a	26.1300	-80.0820	1.5
14-Oct	C-2b	26.1300	-80.0820	9.4
14-Oct	C-2c	26.1300	-80.0820	17.6
14-Oct	C-3a	26.0639	-80.0906	1.1
14-Oct	C-3b	26.0639	-80.0906	11.1
14-Oct	C-3c	26.0639	-80.0906	18.3

Table 49: Sediment sample location and depth.

Date	Station	Latitude	Longitude	Depth (m)
10-Oct	PE1	26.1400	-80.0687	58.8
10-Oct	PE2	26.1400	-80.0592	128.6
10-Oct	PE3	26.1401	-80.0299	200.0
10-Oct	PE4	26.1403	-79.9802	237.9

15.2 Nutrients

A total of 9 nutrient samples were collected during the CTD operations of the C1-C2-C3 transect. These results are listed in Table 50 for concentrations in εM and in Table 51 for concentrations in mg/L.

Table 50: Nutrient results in εM from the C1-C2-C3 transect.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
1a	1.4	0.10	0.06	0.00	0.00	0.00
1b	3.8	0.13	0.08	0.00	0.00	0.00
1c	11.4	0.15	0.04	0.00	0.00	0.00
2a	1.5	0.14	0.05	0.00	0.00	0.00
2b	9.4	0.12	0.04	0.00	0.00	0.00
2c	17.6	0.23	0.05	0.00	0.00	0.00
3a	1.1	0.08	0.04	0.00	0.00	0.00
3b	11.1	0.24	0.05	0.00	0.00	0.06
3c	18.3	0.22	0.04	0.00	0.00	0.09

Table 51: Nutrient results in mg/L from the C1-C2-C3 transect.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
1a	1.4	0.001	0.001	0.000	0.000	0.000
1b	3.8	0.002	0.001	0.000	0.000	0.000
1c	11.4	0.002	0.001	0.000	0.000	0.000
2a	1.5	0.002	0.001	0.000	0.000	0.000
2b	9.4	0.002	0.001	0.000	0.000	0.000
2c	17.6	0.003	0.001	0.000	0.000	0.000
3a	1.1	0.001	0.001	0.000	0.000	0.000
3b	11.1	0.003	0.001	0.000	0.000	0.002
3c	18.3	0.003	0.001	0.000	0.000	0.003

15.3 Chlorophyll and pH

A total of 9 chlorophyll and pH samples were collected during CTD operations for the C1-C2-C3 transect. Table 52 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled.

Table 52: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from the C1-C2-C3 transect.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (ug/L)	Phaeopigments (ug/L)
1a	1.4	29.0681	35.8406	7.81	1.568	1.158
1b	3.8	29.0670	35.8059	8.36	1.704	1.471
1c	11.4	29.0041	35.9402	7.85	1.427	0.594
2a	1.5	29.1216	35.9315	7.81	1.657	0.519
2b	9.4	29.1088	35.9441	7.99	1.537	0.636
2c	17.6	28.9017	36.0678	7.90	1.192	0.361
3a	1.1	29.1326	35.4243	8.00	1.403	0.563
3b	11.1	29.1540	36.0310	7.82	1.166	0.569
3c	18.3	29.0360	36.0779	7.85	0.849	0.225

15.4 CTD Casts

A total of 3 CTD casts were conducted at the C1-C2-C3 transect. At each station the CTD obtained a sample near bottom, mid-point and near surface. Figures 90-92 show the temperature, salinity and oxygen saturation for each station.

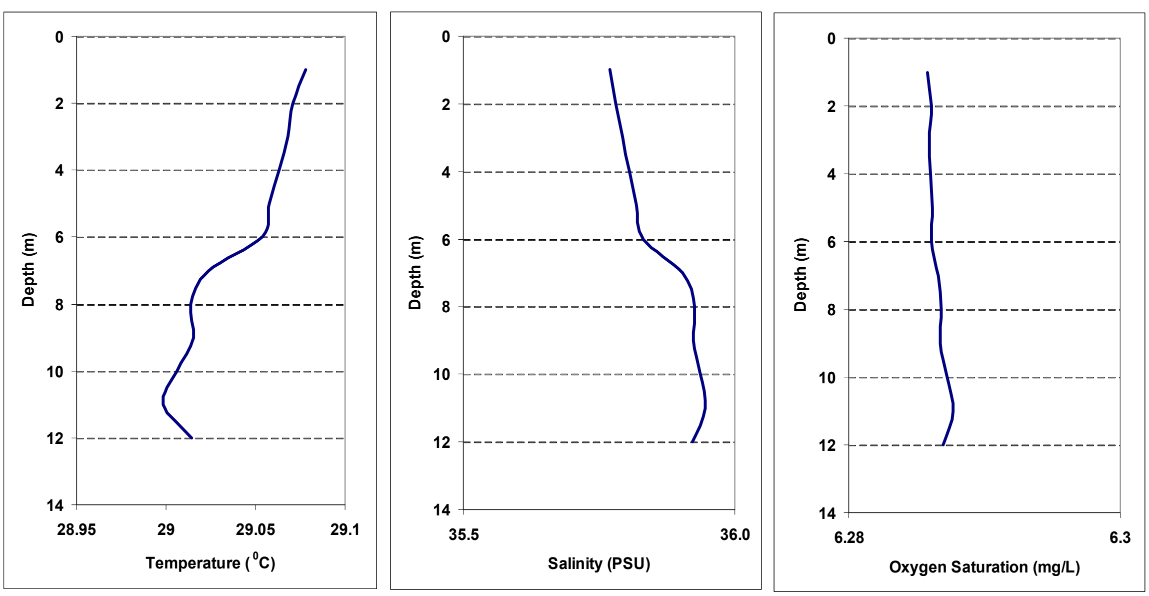


Figure 90: October 14th, 2006 temperature, salinity and oxygen concentration profile at station C-1.

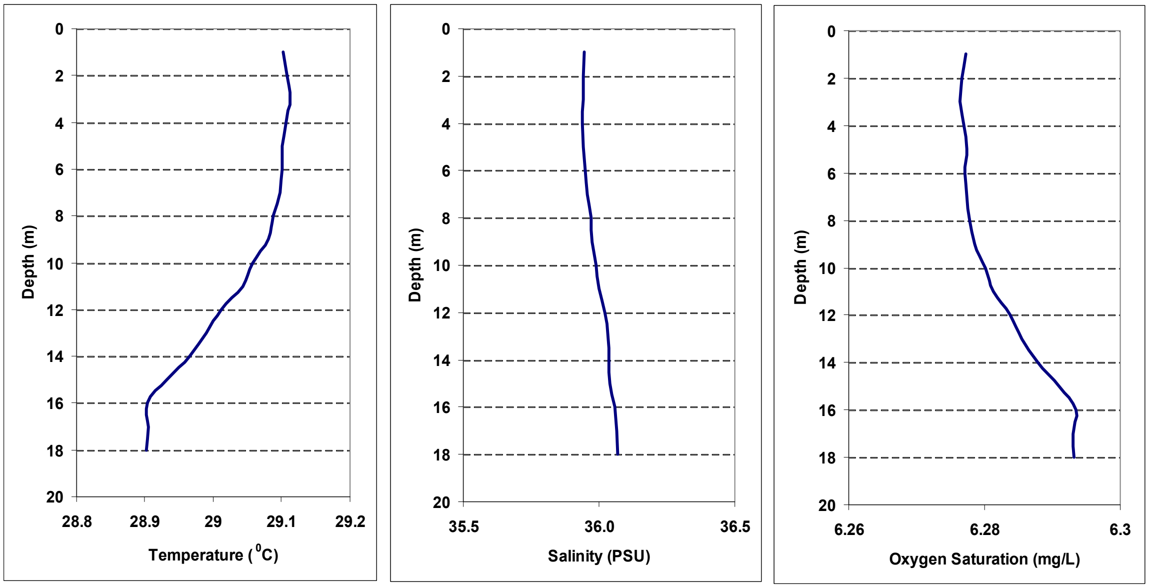


Figure 91: October 14th, 2006 temperature, salinity and oxygen concentration profile at station C-2.

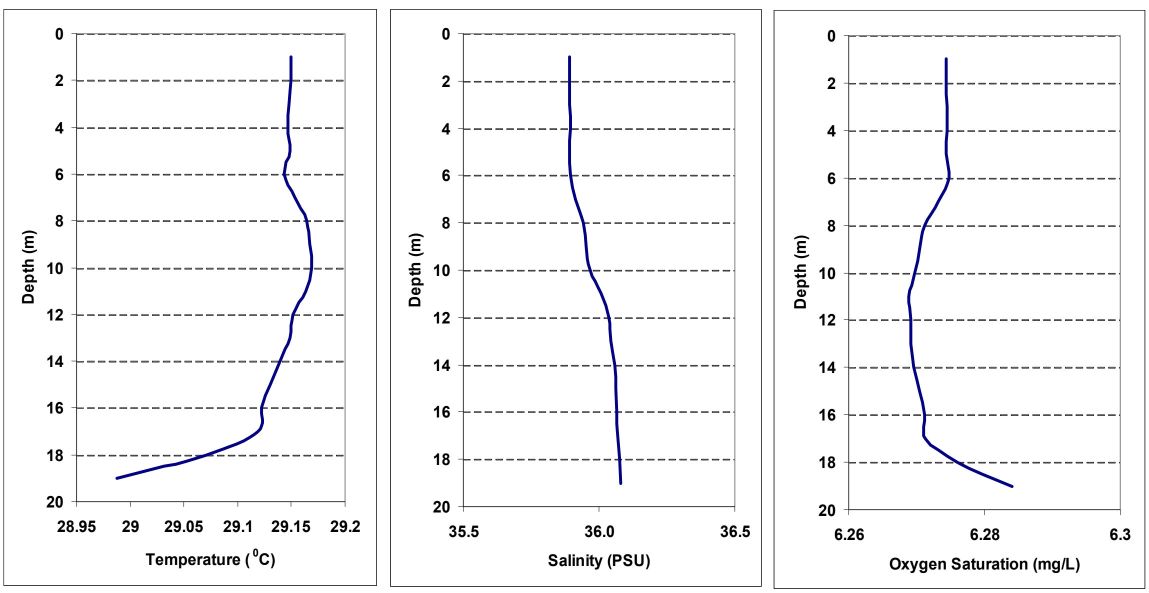


Figure 92: October 14th, 2006 temperature, salinity and oxygen concentration profile at station C-3.

15.5 Current Velocity and Direction

No ADCP operations were carried out for the C1-C2-C3 transect.

15.6 V-Fin

No V-Fin operations were conducted out for the C1-C2-C3 transect.

16.0 DEEPWATER STATIONS

16.1 Station Locations

CTD cast were conducted at three deepwater sites (BRI = Boca Raton, PEI = Port Everglades and MCI = Miami Central), shown in Figure 2 and Figure 93. A total of five depths were sampled for each cast. These casts were conducted to collect information about the upwelled deep water that occurs at irregular times during the year. Table 53 lists the CTD sample locations and depths of the deepwater casts.

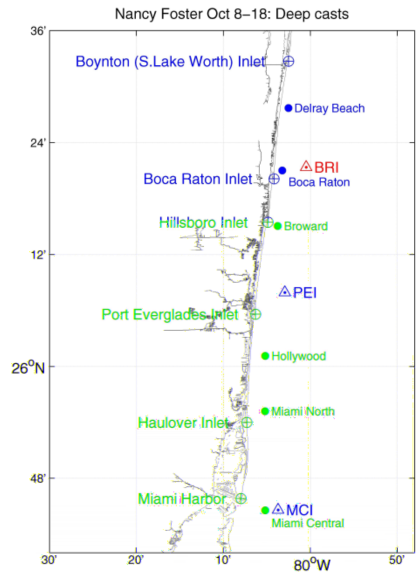


Figure 93: Location of deep water CTD cast sites.

Table 53: CTD cast sample location and depth of the three deepwater sites.

Date	Station	Latitude	Longitude	Depth (m)
13-Oct	BRI-a	26.3561	-80.0081	1.1
13-Oct	BRI-b	26.3561	-80.0081	30.6
13-Oct	BRI-c	26.3561	-80.0081	61.0
13-Oct	BRI-d	26.3561	-80.0081	93.9
13-Oct	BRI-e	26.3561	-80.0081	127.6
13-Oct	BRI-f	26.3561	-80.0081	157.1
13-Oct	PEI-a	26.1323	-80.0488	2.0
13-Oct	PEI-b	26.1323	-80.0488	28.9
13-Oct	PEI-c	26.1323	-80.0488	55.7
13-Oct	PEI-d	26.1323	-80.0488	83.7
13-Oct	PEI-e	26.1323	-80.0488	125.4
13-Oct	PEI-f	26.1323	-80.0488	155.4
15-Oct	MCI-a	25.7432	-80.062	2.1
15-Oct	MCI-b	25.7432	-80.062	36.6
15-Oct	MCI-c	25.7432	-80.062	70.5
15-Oct	MCI-d	25.7432	-80.062	102.1
15-Oct	MCI-e	25.7432	-80.062	120.3
15-Oct	MCI-f	25.7432	-80.062	133.2

15.2 Nutrients

A total of 15 nutrient samples were collected during the CTD operations of the deepwater sites. These results are listed in Table 54 for concentrations in εM and in Table 55 for concentrations in mg/L and in Figure 94. Locations of the sites are shown in Figure 2.

Table 54: Nutrient results in εM from the deepwater sites.

Station	Depth (m)	NO_3-N+NO_2-N (μM)	NO_2-N (μM)	NH_4-N (μM)	P (μM)	Si (μM)
BRI-a	1.1	0.10	0.00	0.00	0.00	0.22
BRI-b	30.6	0.00	0.00	0.00	0.00	0.19
BRI-c	61.0	0.10	0.10	0.00	0.00	0.61
BRI-d	93.9	1.38	0.22	0.00	0.00	1.37
BRI-e	127.6	7.97	0.07	0.00	0.39	5.20
BRI-f	157.1	13.92	0.02	0.00	1.03	8.02
PEI-a	2.0	0.20	0.01	0.00	0.00	0.64
PEI-b	28.9	0.01	0.00	0.00	0.00	0.50
PEI-c	55.7	0.03	0.01	0.00	0.00	0.77
PEI-d	83.7	2.43	0.27	0.00	0.03	2.20
PEI-e	125.4	6.56	0.06	0.00	0.38	4.26
PEI-f	155.4	14.56	0.02	0.00	1.27	9.38
MCI-a	2.1	0.09	0.04	0.00	0.05	0.46
MCI-b	36.6	0.05	0.03	0.00	0.03	0.30
MCI-c	70.5	0.28	0.26	0.00	0.04	0.54
MCI-d	102.1	2.91	0.25	0.00	0.25	2.20
MCI-e	120.3	8.25	0.09	0.00	0.64	4.65
MCI-f	133.2	10.88	0.04	0.64	1.44	6.52

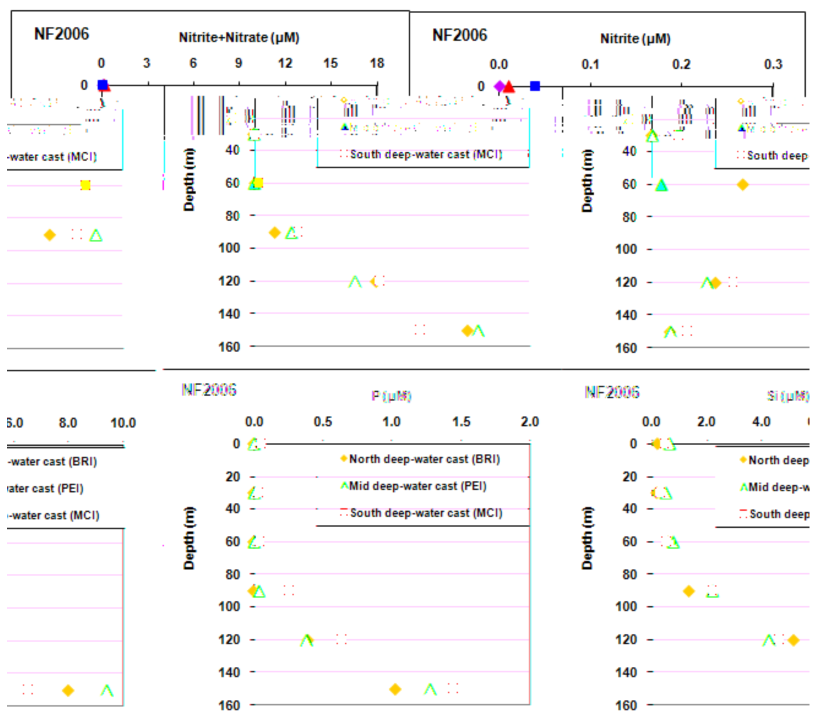


Figure 94: Nutrient results (N+N, nitrate, orthophosphate, and silica) in μM from the three deep-water sites, versus depth.

Table 55: Nutrient results in mg/L from the deepwater sites.

Station	Depth (m)	NO_3-N+NO_2-N (mg/L)	NO_2-N (mg/L)	NH_4-N (mg/L)	P (mg/L)	Si (mg/L)
BRI-a	1.1	0.001	0.000	0.000	0.000	0.006
BRI-b	30.6	0.000	0.000	0.000	0.000	0.005
BRI-c	61.0	0.001	0.001	0.000	0.000	0.017
BRI-d	93.9	0.019	0.003	0.000	0.000	0.038
BRI-e	127.6	0.112	0.001	0.000	0.012	0.146
BRI-f	157.1	0.195	0.000	0.000	0.032	0.225
PEI-a	2.0	0.003	0.000	0.000	0.000	0.018
PEI-b	28.9	0.000	0.000	0.000	0.000	0.014
PEI-c	55.7	0.000	0.000	0.000	0.000	0.022
PEI-d	83.7	0.034	0.004	0.000	0.001	0.062
PEI-e	125.4	0.092	0.001	0.000	0.012	0.119
PEI-f	155.4	0.204	0.000	0.000	0.039	0.263
MCI-a	2.1	0.001	0.001	0.000	0.002	0.013
MCI-b	36.6	0.001	0.000	0.000	0.001	0.008
MCI-c	70.5	0.004	0.004	0.000	0.001	0.015
MCI-d	102.1	0.041	0.004	0.000	0.008	0.062
MCI-e	120.3	0.116	0.001	0.000	0.020	0.130
MCI-f	133.2	0.152	0.001	0.009	0.045	0.183

15.3 Chlorophyll and pH

A total of 9 chlorophyll and 15 pH samples were collected during CTD operations for the deepwater sites. Table 56 lists the results for the chlorophyll and pH samples collected along with the salinity and temperature for each depth sampled; data are also shown in Figure 95.

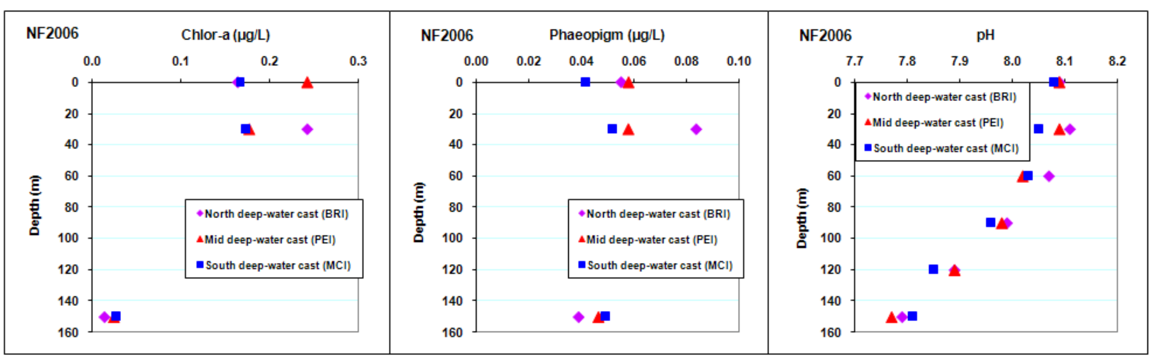


Figure 95: Chlorophyll-a, phaeopigments (in µg/L), and pH from the three deep-water sites, versus depth.

Table 56: Temperature, Salinity, pH, Chlorophyll and Phaeopigments from the deepwater sites.

Station	Depth (m)	Temperature (^{0}C)	Salinity (Units)	pH (Units)	Chlorophyll a (µg/L)	Phaeopigments (µg/L)
BRI-a	1.1	29.3044	36.0569	8.09	0.164	0.055
BRI-b	30.6	28.9832	36.1533	8.11	0.242	0.084
BRI-c	61.0	27.9131	36.2246	8.07	N/A	N/A
BRI-d	93.9	23.4851	36.4453	7.99	N/A	N/A
BRI-e	127.6	18.3494	36.2073	7.89	N/A	N/A
BRI-f	157.1	14.9514	35.9399	7.79	0.014	0.039
PEI-a	2.0	29.1569	36.0478	8.09	0.242	0.058
PEI-b	28.9	28.9823	36.1557	8.09	0.177	0.058
PEI-c	55.7	28.2374	36.1973	8.02	N/A	N/A
PEI-d	83.7	24.8913	36.3565	7.98	N/A	N/A
PEI-e	125.4	19.4595	36.3179	7.89	N/A	N/A
PEI-f	155.4	14.4923	35.8583	7.77	0.025	0.046
MCI-a	2.1	28.8677	36.1793	8.08	0.166	0.042
MCI-b	36.6	28.8789	36.1827	8.05	0.173	0.052
MCI-c	70.5	28.0473	36.2047	8.03	N/A	N/A
MCI-d	102.1	22.7022	36.3879	7.96	N/A	N/A
MCI-e	120.3	18.1155	36.2493	7.85	N/A	N/A
MCI-f	133.2	16.5492	36.1187	7.81	0.026	0.049

15.4 CTD Casts

A total of 3 CTD casts were conducted at deepwater sites. At each station the CTD obtained a sample near bottom, (3) mid-water and near surface. Figures 97-99 show the temperature, salinity and oxygen saturation for each station.

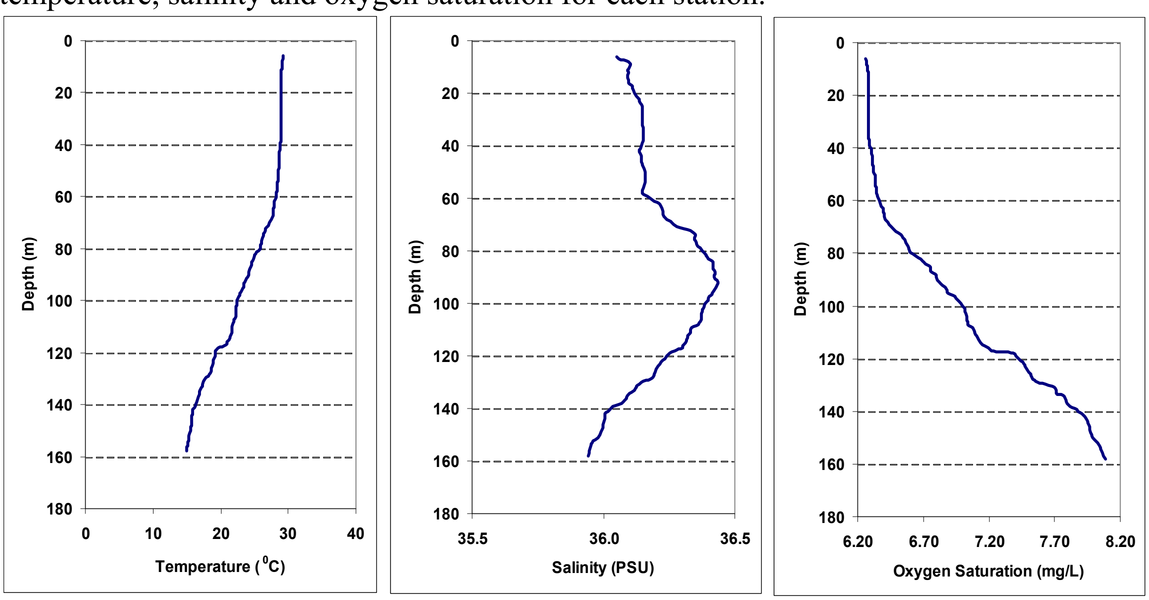


Figure 97: October 13th, 2006 temperature, salinity and oxygen concentration profile at station BRI.

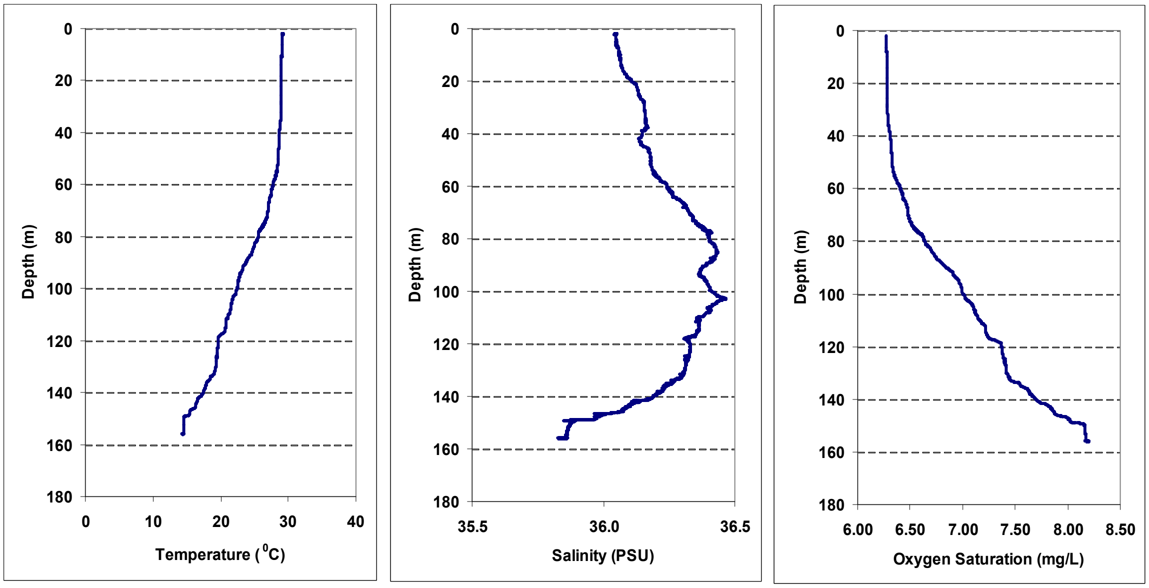


Figure 98: October 14th, 2006 temperature, salinity and oxygen concentration profile at station PEI.

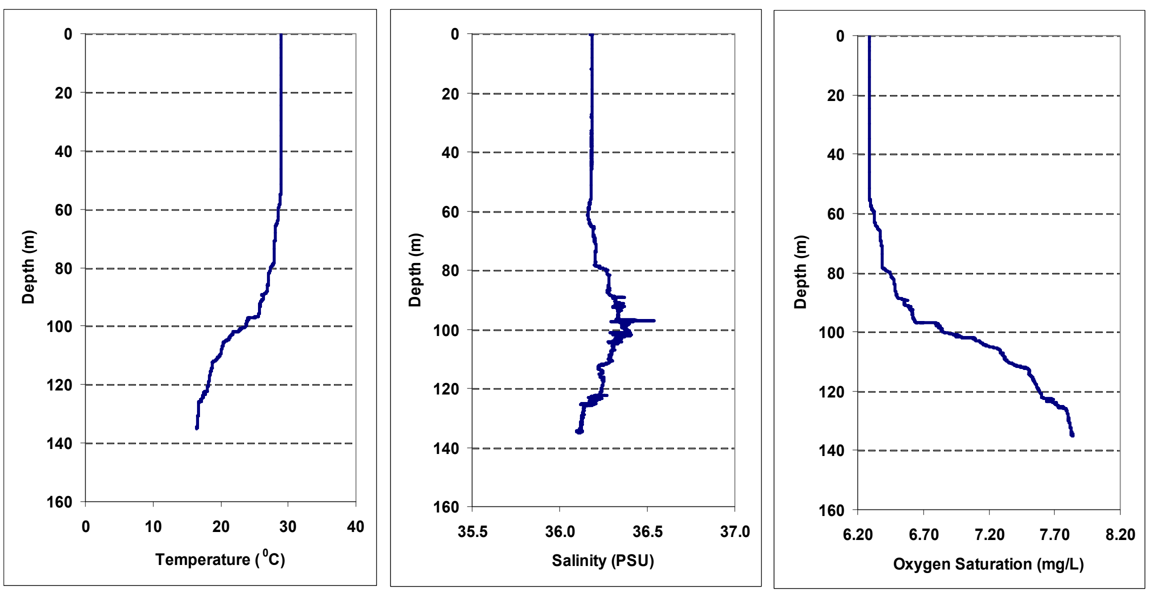


Figure 99: October 15th, 2006 temperature, salinity and oxygen concentration profile at station MCI.

15.5 Current Velocity and Direction

No ADCP operations were carried out for the deepwater sites.

15.6 V-Fin

No V-Fin operations were carried out for the deepwater sites.

17.0 SEA GRASS DIVE PROJECT

A companion project to the cruise was a project to obtain samples of seagrass and sediments from various locations near the six ocean outfalls. This project was accomplished with the assistance of various diving organizations in the area. Figure 100 is a graphic presentation of the locations of the sample sites. Location data is provided in Appendix 4. Results are reported in Swart and Drayer (2007).

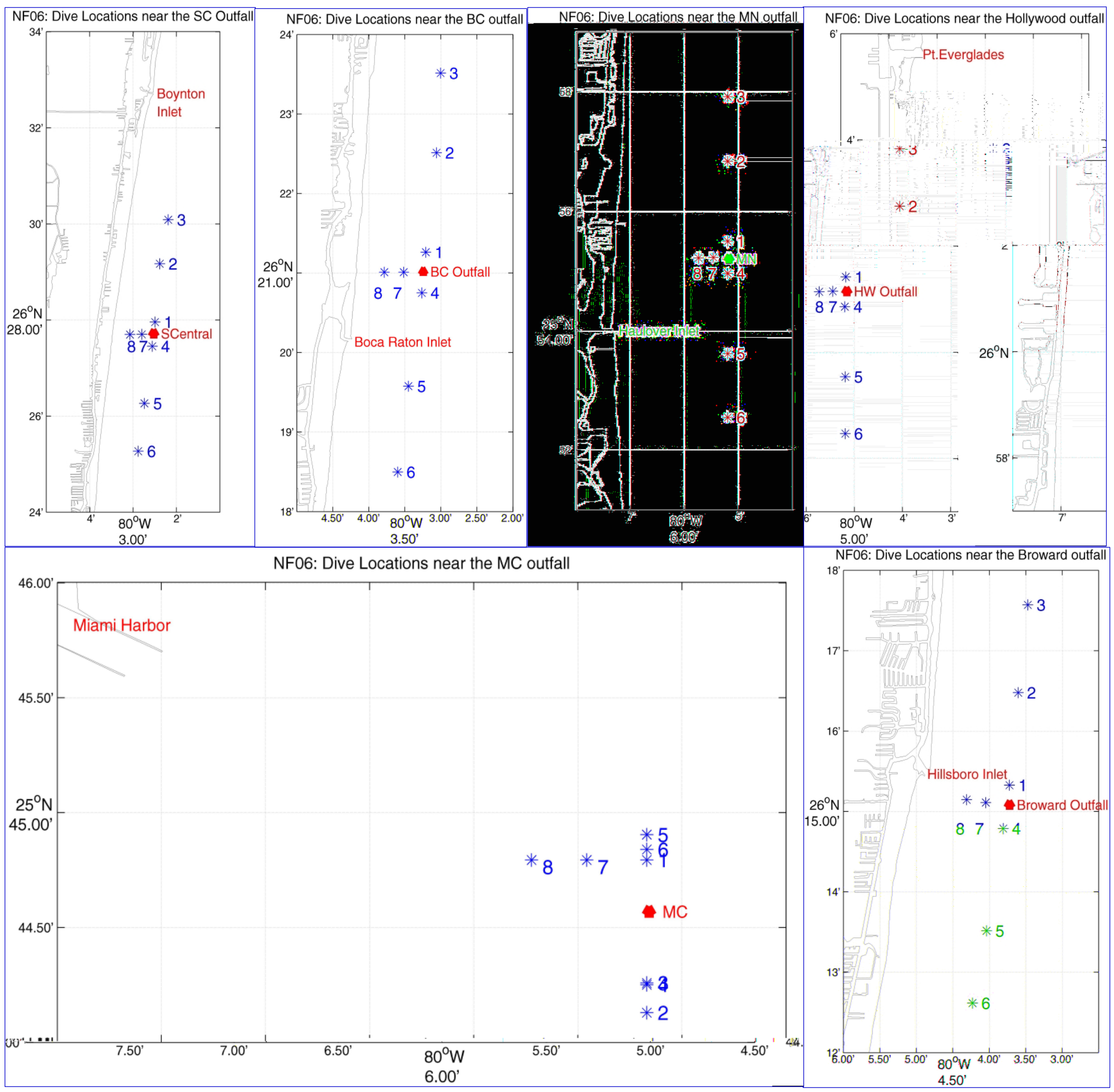


Figure 100: Location of dives to obtain seagrass and sediment samples.

18 AUXILIARY DATA

18.1 ADCP data from GSR-N.

An acoustic Doppler current profiler (ADCP) was installed at a site at the north end of the Gulf Stream Reef (GSRN) on 25-July 2006, at a depth of 52 feet below means sea level, at the location 26° 31.247'N, 80° 1.939'W; a second unit, GSRS, was installed on 29-September 2006, at 26°29.272'N, 80° 2.350'W (see Figure 101). A subset of this data, which includes the time period of the Nancy Foster Cruise, is shown in Figure 102 (GSRN) and Figure 103 (GSRS).

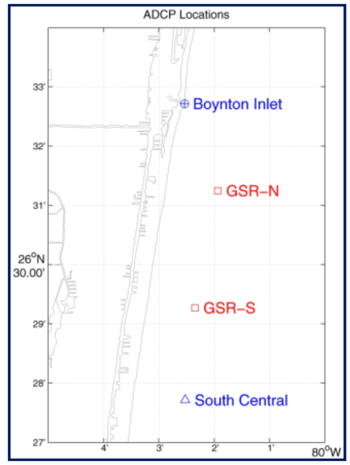


Figure 101: Location of ADCPs in the Cruise area.

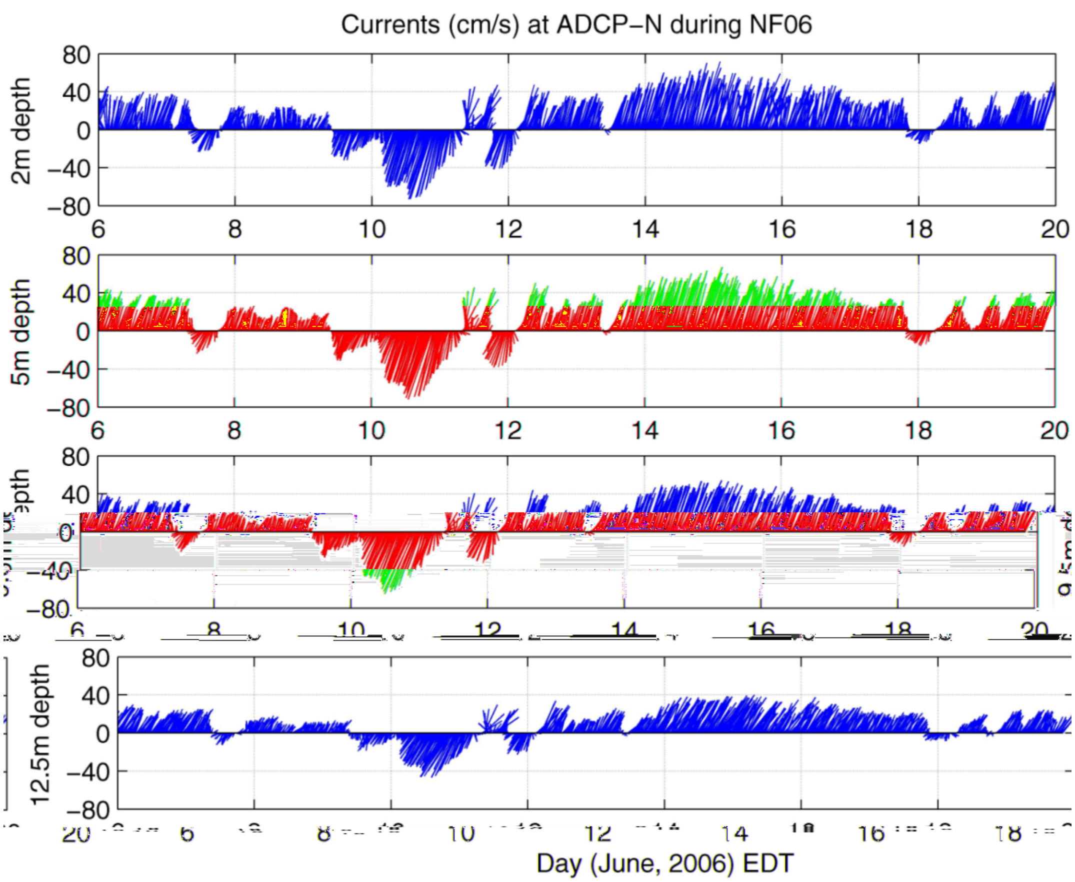


Figure 102: Stick plots of current data from the GSR-N ADCP instruments at depths near the surface (upper panel) to lower depths (lower panels). During most of Leg 3 (beginning on 12-October), where the water sampling occurred, the ocean current at GSR-N was northerly.

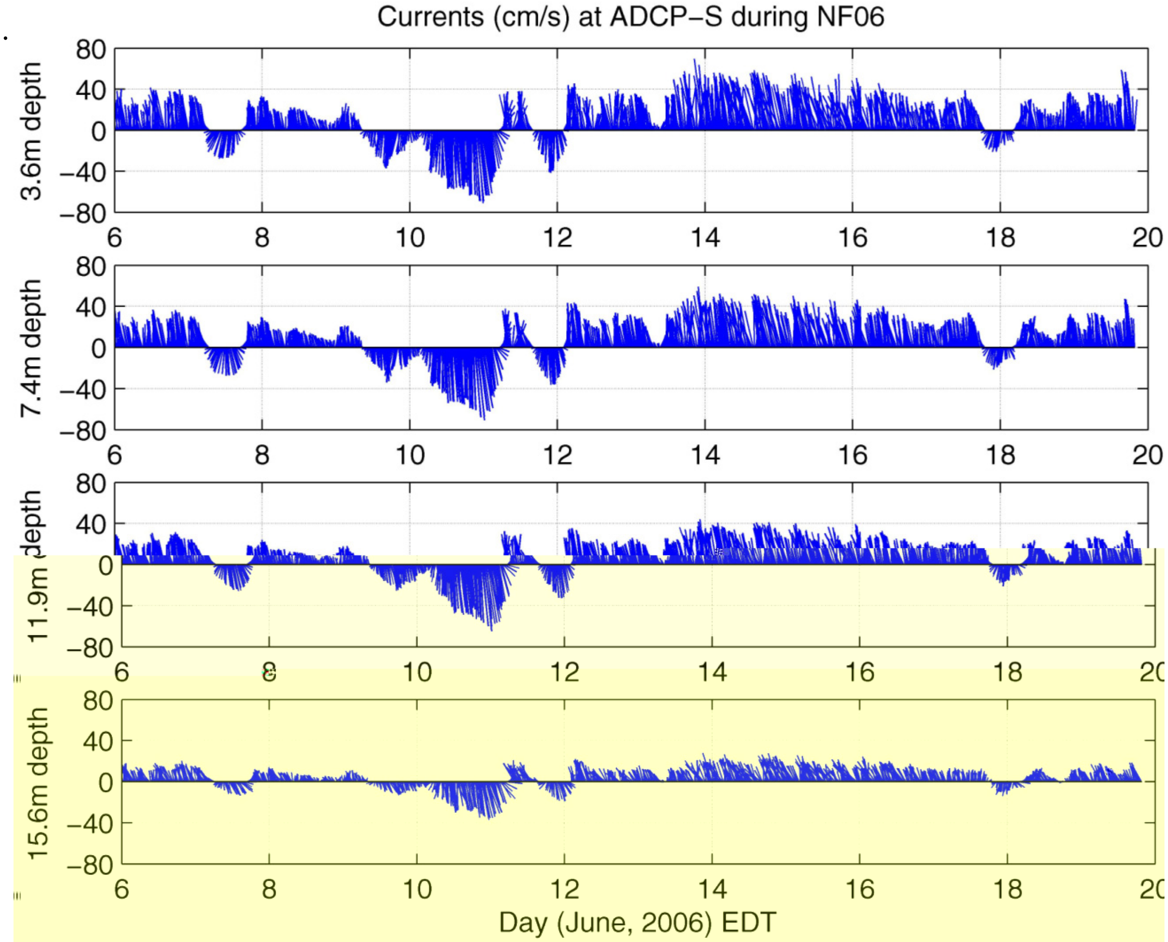


Figure 103: Stick plots of current data from the GSR-S ADCP instruments at depths near the surface (upper panel) to lower depths (lower panels). As with GSRN, the current at GSR-S was northerly.

18.2 LKWF1 meteorological Data

Meteorological data is continuously recorded from the C-MAN station LKWF1, Lake Worth, Florida, 26°36'42" N 80°2'0" W, stored at the NOAA National Data Buoy Center (http://www.ndbc.noaa.gov/station_page.php?station=LKWF1). The data for the cruise dates is shown in Figure 104 below.

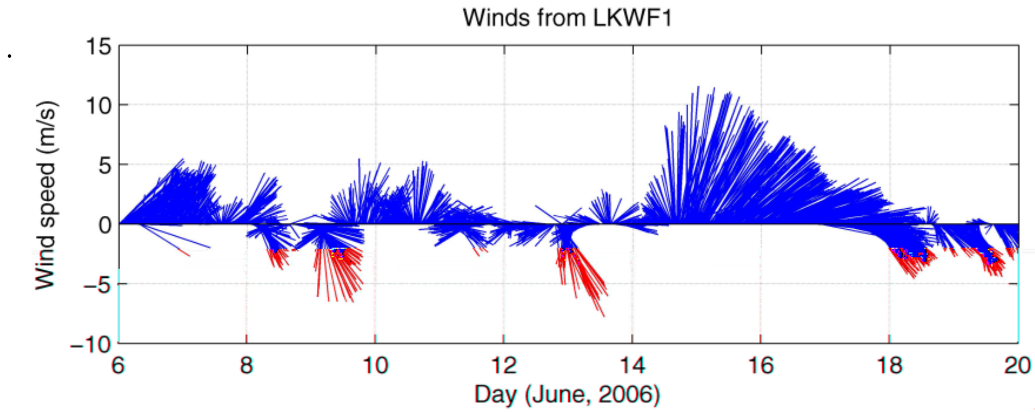


Figure 104: Wind speed (green) and wind direction (blue) from station LKWF1, Lake Worth, FL. This station is north of the Boynton Inlet.

18.3 Ship's Meteorological Data

The Nancy Foster records a suite of meteorological data. A subset of this data, the ship's true wind, is shown in Figure 105, for the days of Leg 3 of the cruise.

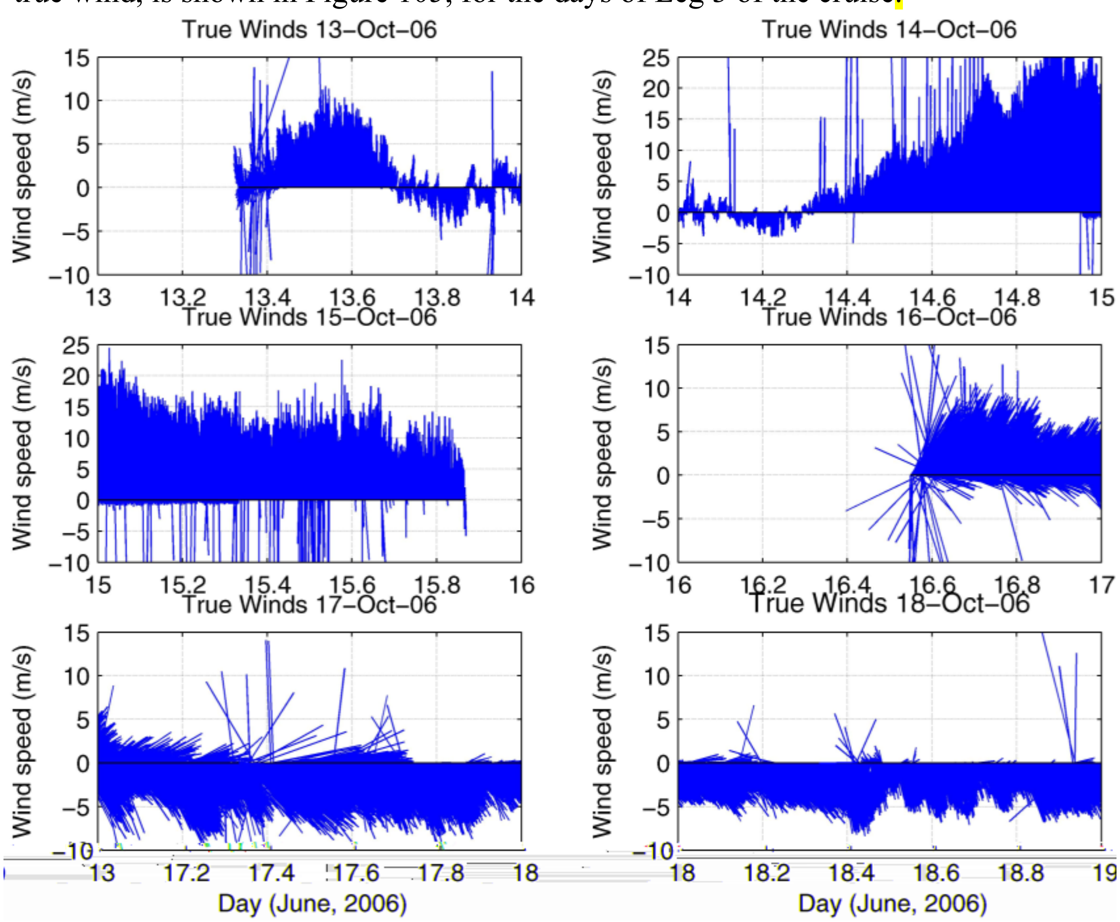


Figure 105: Ship's true wind speed as wind barbs. This data is obtained by correcting mast wind speed and direction for ship's orientation and motion.

19. OVERVIEW AND SUMMARY

We are in a position to compare results from the six outfalls examined in the cruise.

19.1 Boil measurements.

We begin with the nutrients at the boils. Figure 106 and Appendix 3 provide the nutrient concentrations from the TWWP boils (no data is available for South Central). In agreement with expectations, the concentrations are higher at the surface, as the TWWP effluent is fresh water and thus is positively buoyant with respect to the receiving marine waters. The relative concentrations of the nutrients are roughly in agreement with the TWWP nutrient fluxes as reported by Koopmans et al (2006) (Table 2).

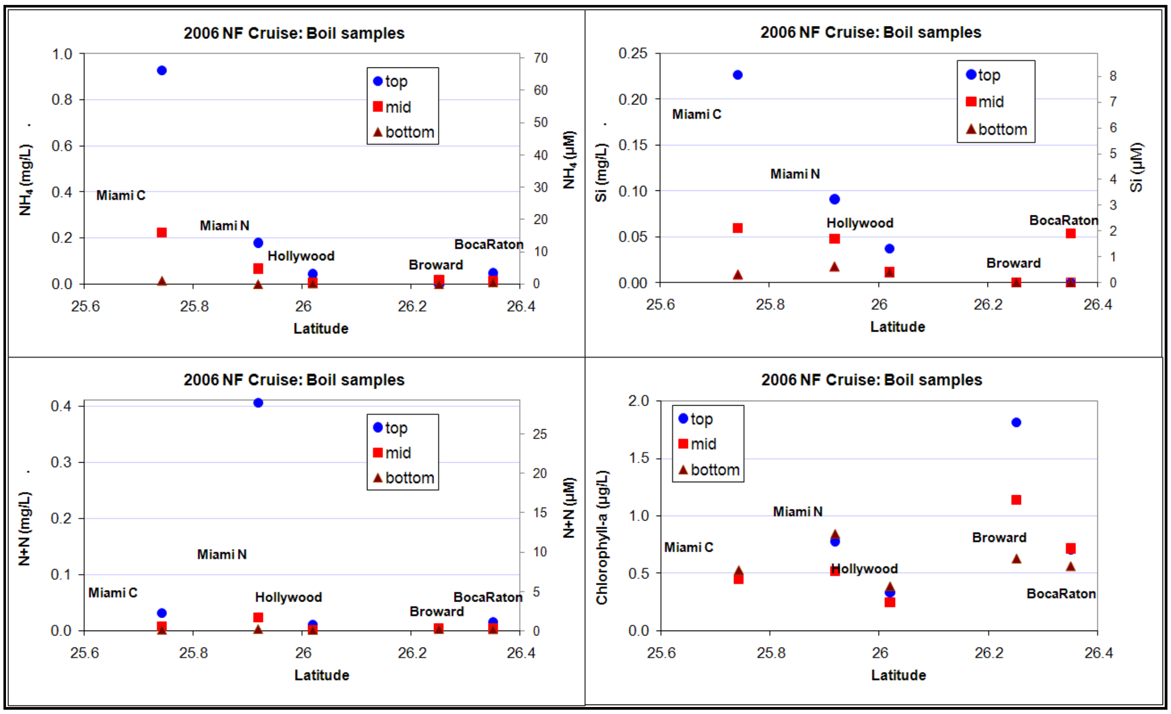


Figure 106: Nutrient results from boil samples from the five outfalls (results are not available for South Central) for NH_4 (top left), N+N (bottom left), and Si (to right, plotted versus the latitude of the outfall. Units are given as mg/L (left vertical axis) and in µM (right vertical axis). Bottom right panel shows chlorophyll-a results (µg/L).

19.2 Plume characteristics

At each TWWP effluent plume, measurements were obtained as described above and given in Appendix 2. What do these data indicate about the dilution of the plume with distance down-current of the boil?

To answer the question, we desired to distinguish which of the three samples taken during a crossing of the plume represented the plume maxima in the surface, mid, and deep levels. For each crossing of the plume, the sample with the maximum in the all (or most) analytes was found (not always at the same location comparing surface, mid, and bottom samples).

The nutrient concentrations from these chosen locations are plotted versus distance from the plume. Clearly, the surface data versus distance regression is strongly negative for most analytes and most outfall plumes.

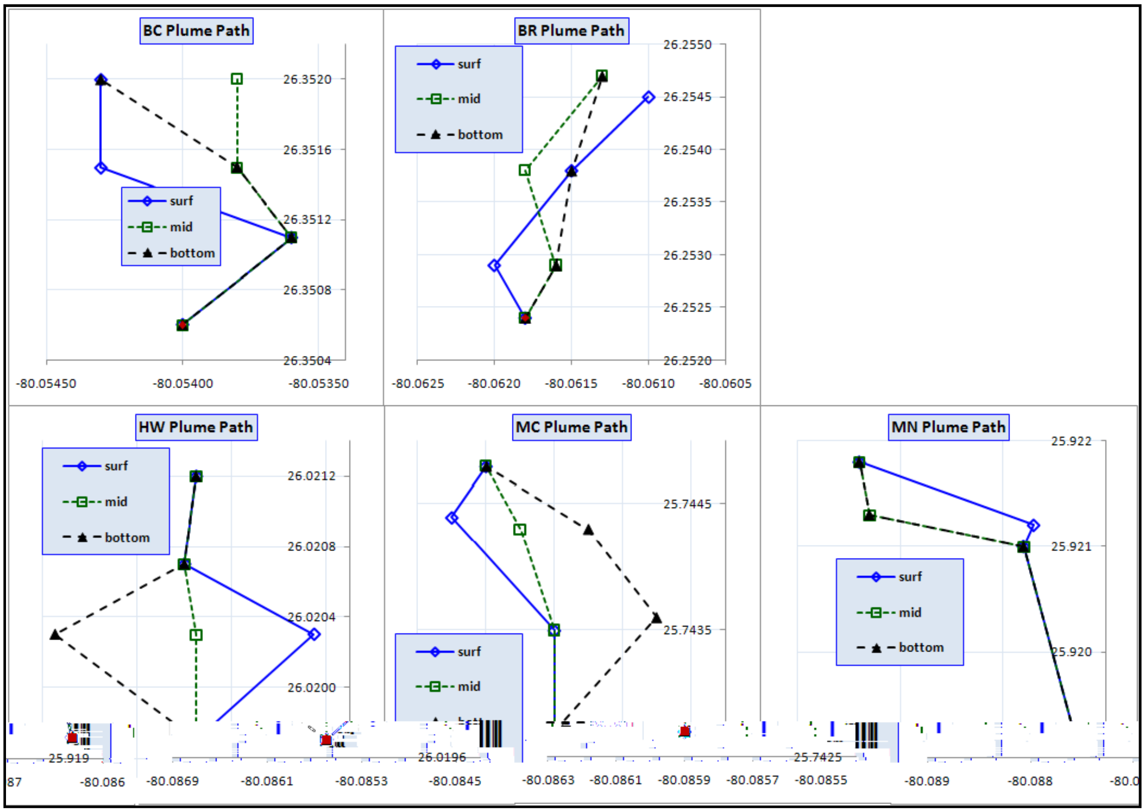


Figure 107: Location of plume maxima for surface (blue), mid (green), and bottom (black) sample depths from the five sampled outfalls. The boil is denoted in red.

Because each plume measurement depth level was considered separately in the above analysis, a question arises as to the whether the plume maxima (as determined by the sample with maxima of concentrations of "most" analytes) is the same for the surface, mid, or deep samples. In Figure 107 above are plotted the plume maxima for the five analyzed outfalls. The plots are not plotted to geographic scale. These data again demonstrate the highly inhomogeneous nature of the plume as it is becomes dispersed into the receiving waters.

19.3 Comparison of Outfall Characteristics

The six TWWP outfalls described in Tables 1 and 2 and investigated in this study differ considerably in daily flow and nutrient output. How is this reflected in the relative effect on the receiving waters?

We begin by computing an average concentration of each species at each depth and across a single crossing of the plume (there were always three crossings of the plume with three stops for CTD-rosette sampling at each outfall). A cast that attempted to sample right at the boil was also performed (distance from boil = zero). These data are shown in figures 97-101 for the five outfalls (recall that no data was obtained at South Central).

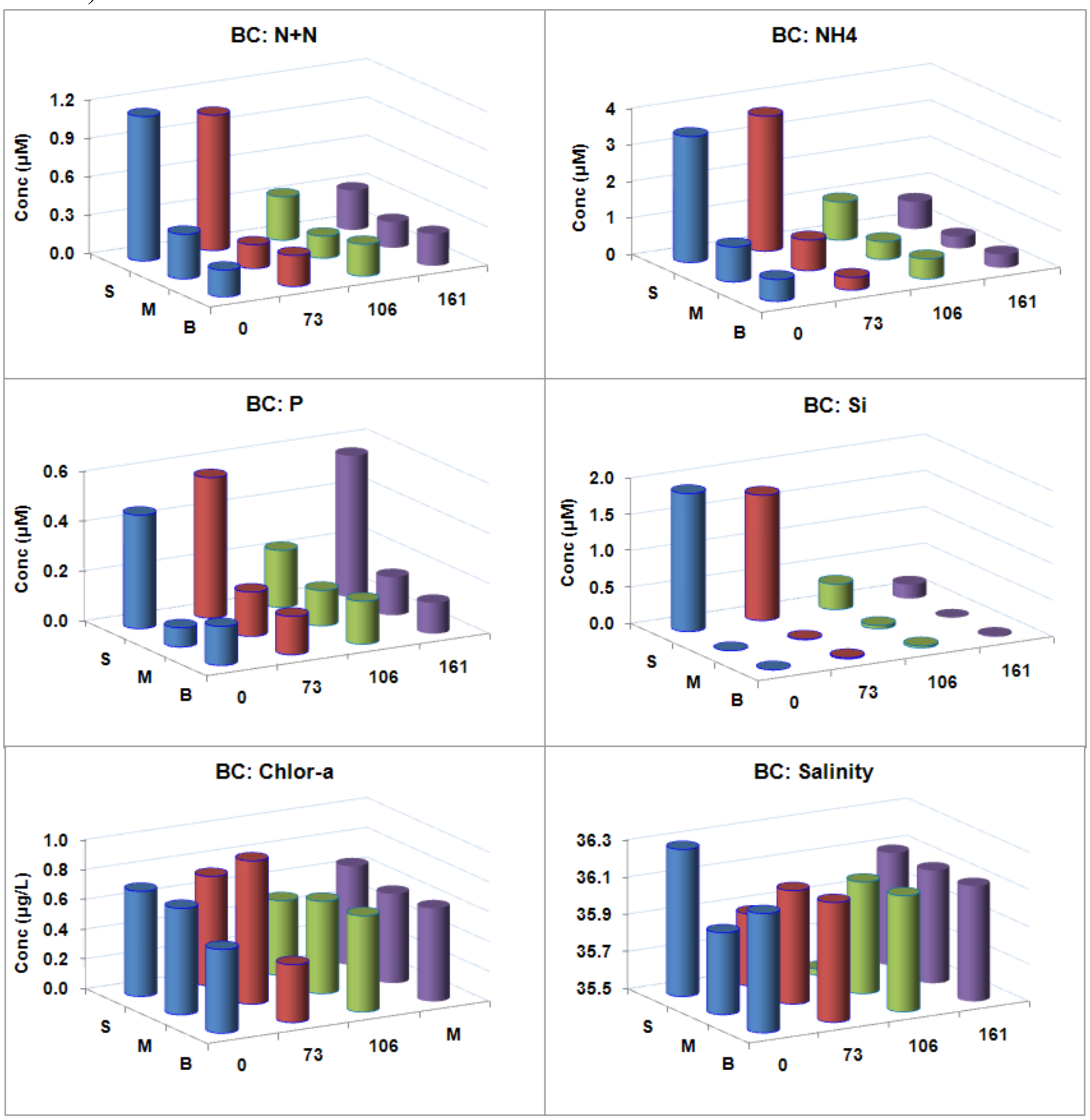


Figure 97. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Boca Raton outfall study, plotted versus average distance and depth (S=surface, M=middle, B=bottom samples). Horizontal axis is distance from the boil in meters. Note decline in concentration of nutrients with distance, without substantial increase in concentrations from samples at deeper

depths. Comparing with other outfalls, it is likely that the heart of the boil was missed in the cast denoted as zero distance.

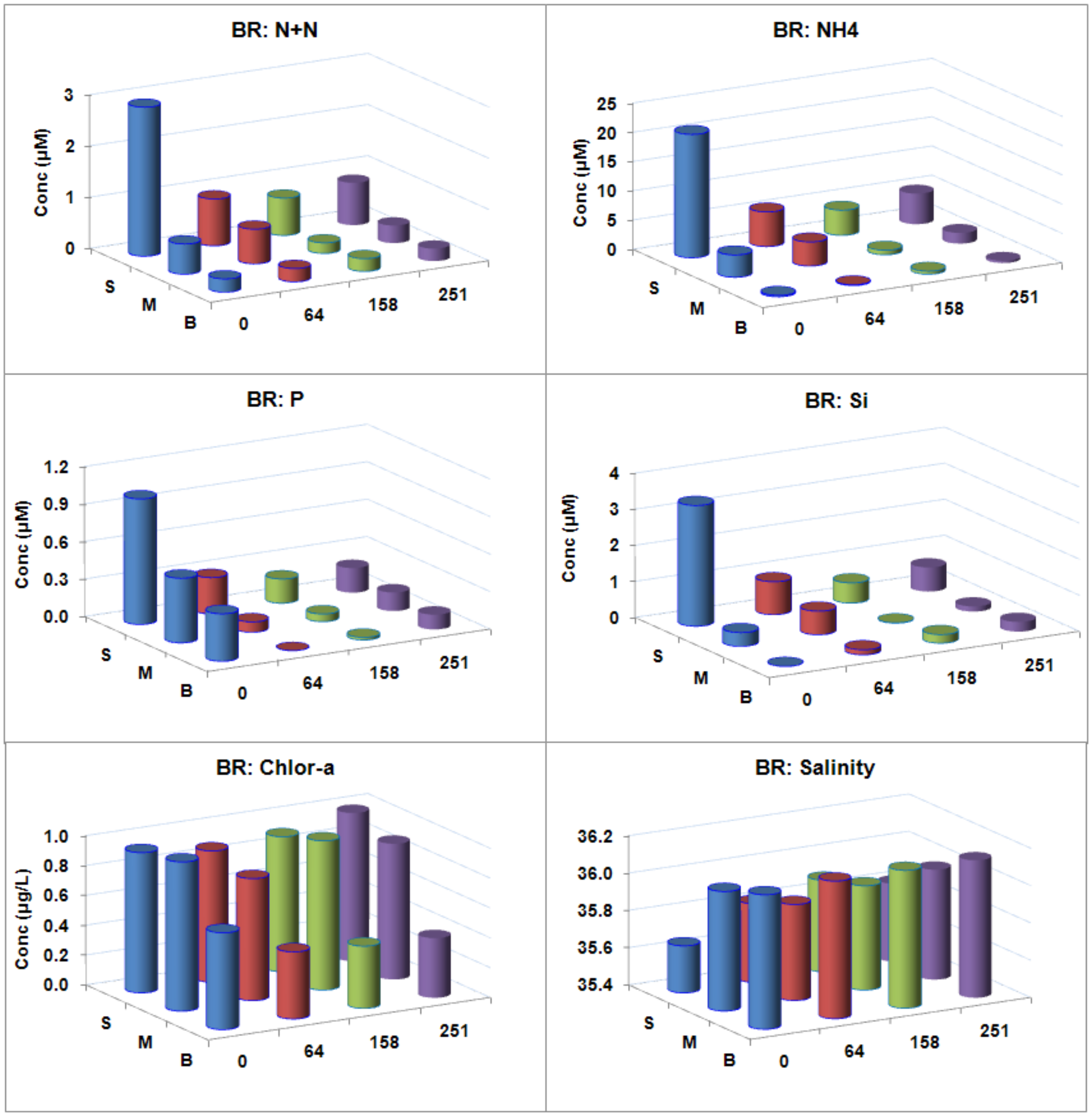


Figure 98. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Broward outfall study. Format is the same as in Figure 97.

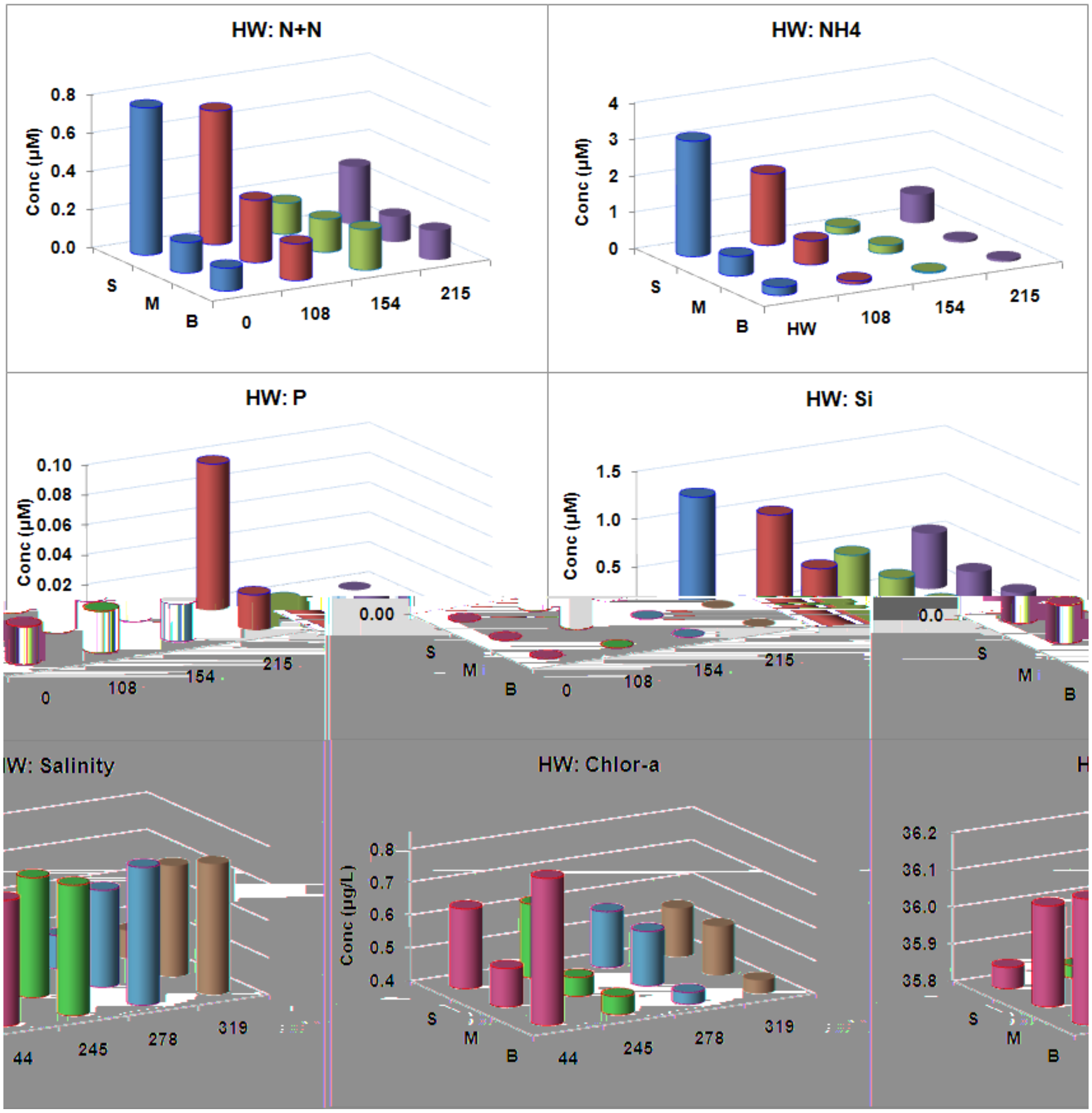


Figure 99. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Hollywood outfall study. Format is the same as in Figure 97.

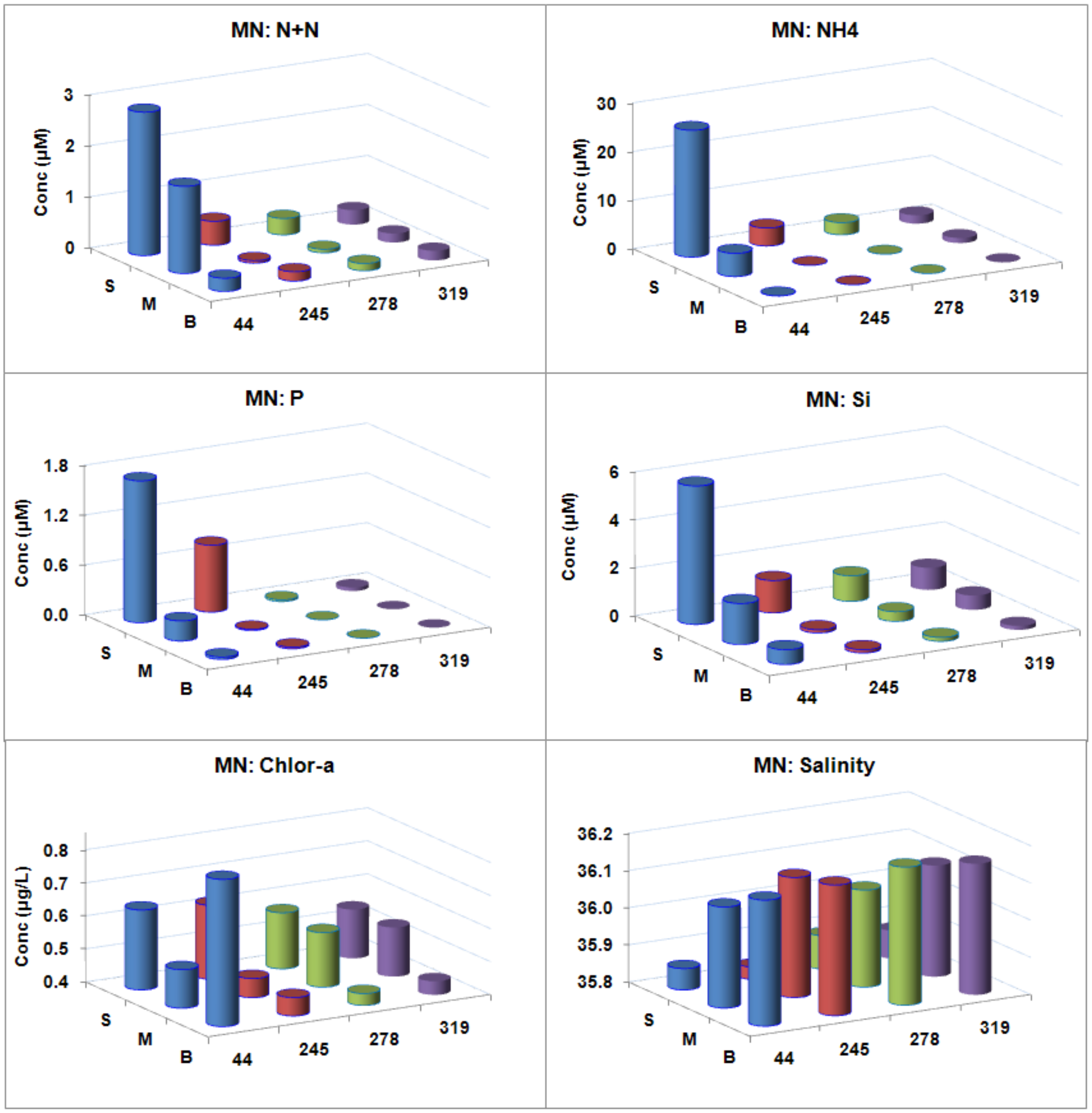


Figure 100. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Miami-North outfall study. Format is the same as in Figure 97.

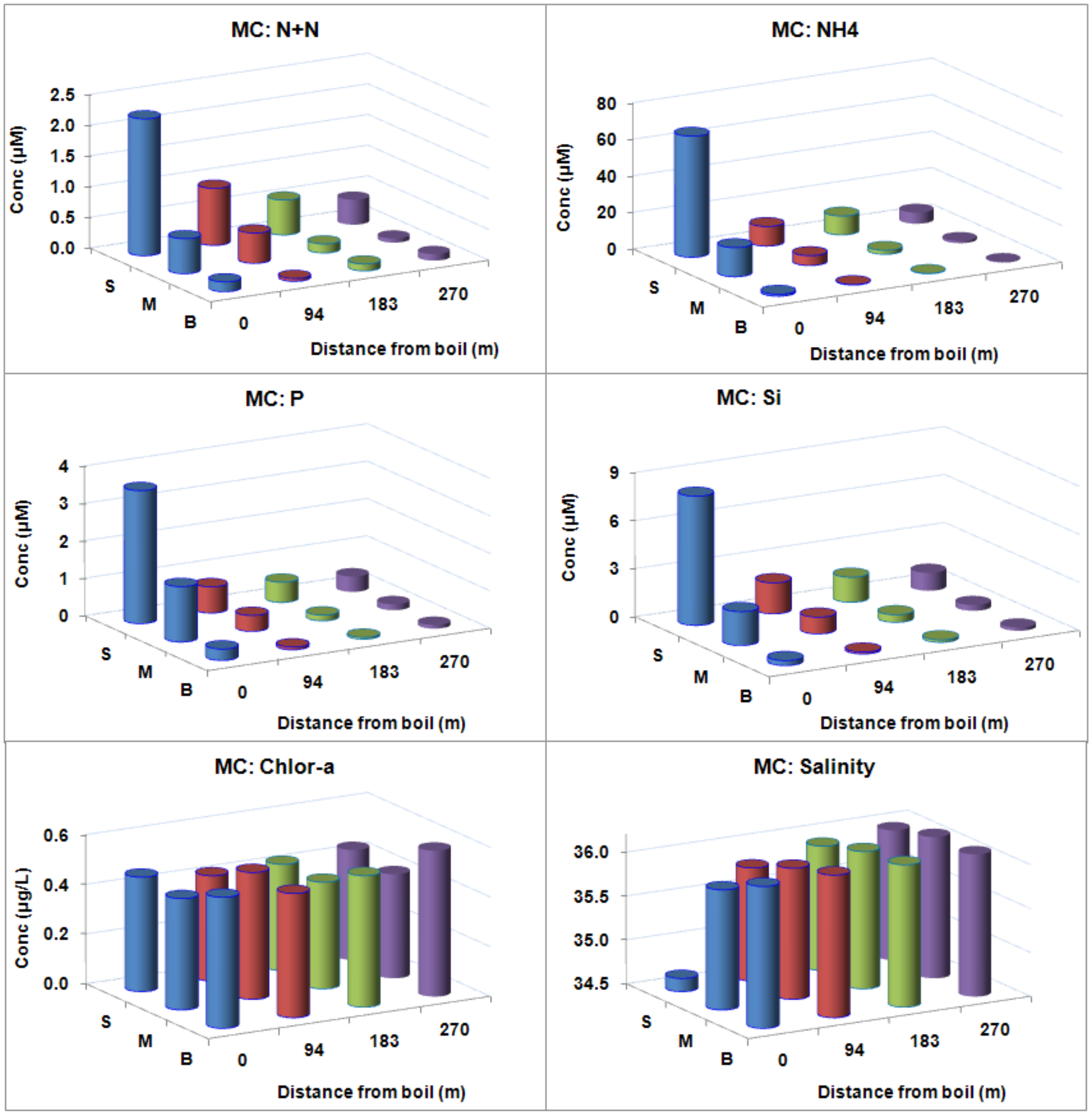


Figure 101. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Miami-North outfall study. Format is the same as in Figure 97.

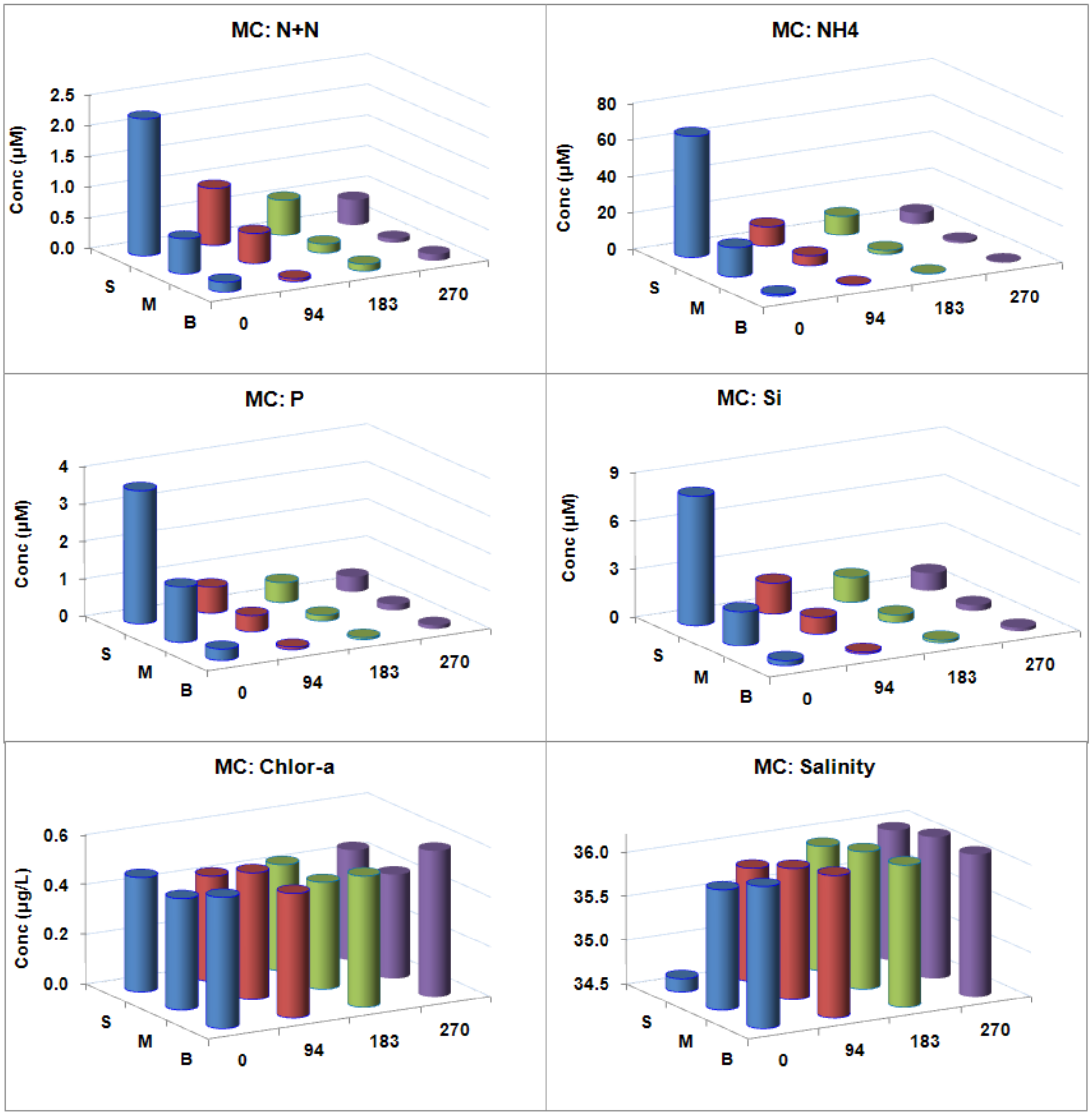


Figure 102. Averaged nutrient and chlorophyll-a concentrations and salinity data from the Miami-Central outfall study. Format is the same as in Figure 97.

Figures 97-102 provide qualitatively support for these points:

1. Highest concentrations among the five analytes was ammonium, especially in Broward, Miami-North, and Miami-Central.

2. In almost every case, there is observed a rapid diminution of nutrient concentration with distance, implying that the concentrations are indistinguishable from background concentrations within less than a kilometer. This situation did not obtain with chlorophyll-a and phaeopigments (not shown), where there was no consistent impact of the plume at any depth.

3. There was no substantial increases noted in bottom concentrations, implying that plume spread was primarily horizontal, with little vertical mixing occurring in these studies.

4. Salinity was found to be lower in the boil and increasing with distance (because the outfall plumes are fresh) in contrast to the nutrients. However, within a few hundred meters the salinity deficit had essentially disappeared.

To examine the effect of distance on concentration further, we computed regression statistics of individual concentration values versus distance for each of the five outfalls. In Table 57, the slope and x-intercept of each regression is shown, for nutrients Si, N+N, NH4, P, and NO2. The correlation coefficients were not high. This was undoubtedly because it was difficult to obtain an adequate sampling of a highly transitory plume. The data show qualitatively that Miami Central and Broward plumes had the highest initial concentrations slopes.

The x-intercept of the regression line provides an estimate of when the concentration becomes theoretically zero (i.e., becoming indistinguishable from the background concentrations). In all cases but one, this result is obtained within a few hundred meters. The exception is orthophosphate (P) found at the Boca Raton outfall, which had an outlier concentration of 1.15 εM which highly affected the statistics. Also, in Appendix 6a and 6b, concentration maxima from each passing are plotted versus distance; again, a rapid diminution of concentration with distance is observed.

Table 57. X-intercepts for regressions of surface nutrients versus distance

Outfall name	Analyte	Slope	X-intercept (m)	Outfall name	Analyte	Slope	X-intercept (m)
BC	**Si**	**-0.014**	**163**	MN	**Si**	**-0.006**	**461**
	N+N	**-0.007**	**194**		**N+N**	**-0.083**	**291**
	NH4	**-0.025**	**183**		**NH4**	**-0.036**	**354**
	P	0.000	21074		P	-0.002	401
	NO2	-0.008	176		NO2	-0.003	364
BR	**Si**	**-0.006**	**306**	MC	**Si**	**-0.016**	**305**
	N+N	**-0.004**	**378**		**N+N**	**-0.005**	**338**
	NH4	**-0.034**	**341**		**NH4**	**-0.130**	**278**
	P	-0.002	313		P	-0.007	288
	NO2	-0.004	342		NO2	-0.003	320
HW	**Si**	**-0.008**	**225**				
	N+N	**-0.007**	**194**				
	NH4	**-0.025**	**183**				
	P	-0.001	501				
	NO2	-0.008	176				

20 ACKNOWLEDGEMENTS

We would like to thank the captain and crew of the RV Nancy Foster for their help with operations and data collection.

21 REFERENCES

Bernhard, A.E., and K.G. Field. 2000. Appl. Environ. Microbiol. 66:4571-4574.

Clayton, T.D. and Byrne, R.H. 1993. Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of -cresol purple and at-sea results. Deep Sea Research 40 (10): 2115-2129.

Koopman, B., J. P. Heaney, F. Y. Cakir, M. Rembold, P. Indeglia, and G. Kini, 2006. Ocean Outfall Study, Final Report prepared for the Florida Department of Environmental Protection, Tallahassee, Florida.

Dick, L.K., M.T. Simonich, K.G. field, 2005. Appl. Environ. Microbiol. 71:3179-3183.

Haughland, R.A., S.C. Siefring, L.J. Wymer, K.P. Brenner, A.P. Dufour, 2005. Water Research 39:559-568.

He, J.W., S. Jiang, 2005. Appl. Environ. Microbiol. 71:2250-2255.

Kelble, C.R., Ortner, P.B., Hitchcock, G.L. and Boyer, J.N., 2005. Attentuation of Photosynthetically Available Radiation (PAR) in Florida Bay: Potential for Light Limitation of Primary Producers. Estuaries 28 (4): 560-572.

Kildare, B.J., C.M. Leutenegger, B.S. McSwain, D.G. Bambic, V.B. Rajal, S.Wuertz, 2007. Water Research 41:3701-3715.

Kong, R. Y. C., S. K. Y. Lee, T. F. W. Lee, S. H. W. Law, and R. S. S. Wu., 2002. Wat. Res. 36:2802-2812.

LaGier, M. J., L. A. Joseph, T. V. Passaretti, K. A. Musser, and N. M. Cirino., 2004. Mol. Cell Probes 18:275-282.

Layton, A., C. Kay, D. Williams, V. Garret, Gentry, R, G. Sayler, 2006. Appl. Environ. Microbiol. 72:4214-4224.

Mosley, L.M., Husheer, S.L.G. and Hunter, K.A, 2004. Spectrophotometric pH measurement in estuaries using tymol blue and -cresol purple. Marine Chemistry 91: 175-186.

Mason, W. J., J. S. Blevins, K. Beenken, N. Wibowo, N. Ojha, and M. S. Smeltzer, 2001. J. Clin. Microbiol. 39:3332-3338.

Maurer, J. J., D. Schmidt, P. Petrosko, S. Sanchez, L. Bolton, and M. D. Lee., 1999. Appl. Environ. Microbiol. 65:2954-2960.

Scott, T.M., T.M. Jenkins, J. Lukasik, J.B. Rose, 2005. Environ. Sci. Technol. 39:283-287.

Shimadzu Users Manual, 2004. Total Organic Carbon Analyzer V-CPH/CPN.

Shoaf, W.T. and Lium, B.W., 1976. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. Limnology and Oceanography 21: 926-928.

Swart, P.K. and Drayer, C., 2007. 1st Year Report, Sampling of Nitrogen Compounds for Determination of Isotopic Values in Benthic Macroalgae, Sediment Organics, and Seawater, Division of Marine Geology and Geophysics, Annual Report, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

Zhang, Jia-Zhong and Berberian, G.A., 1998. Determination of Dissolved Silicate in Estuarine and Coastal Waters by Gas Segmented Flow Colorimetric Analysis, EPA Method 366.0.

Zhang, Jia-Zhong, Fischer, C.J. and Ortner, P.B., 1998. Determination of Total Phosphorus in Estuarine and Coastal Waters by Autoclave Promoted Persulfate Oxidation. EPA Method 367.0.

Zhang, Jia-Zhong, Fischer, C.J. and Ortner, P.B., 2001. Continuous Flow Analysis of Phosphate in Natural Waters Using Hydrazine as a Reductant. Intern. J. Environ. Anal. Chem. 80(1): 61-73.

Zhang, Jia-Zhong, Ortner, P.B. and Fischer, 1997. C.J. Determination of Nitrate and Nitrite in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis, EPA Method 353.4.

Zhang, Jia-Zhong, Ortner, P.B., Fischer, C.J and Moore, L.D., 1997. Determination of Ammonia in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis, EPA Method 349.0.

Zimmermann, C.F. and Keefe, C.W.. 1997. Determination of Orthophosphate in Estuarine and Coastal Waters by Automated Colorimetric Analysis, EPA Method 365.5.

Appendix 1. Ocean current measurements from the dipped ADCP .

Station ID	D (m)	Date/Time	Description
MC 10	4	10/8/2006 10:00	South current mag decreases from 21.5 cm/sec near surf to 17 cm/sec near bottom
SC 13	4	10/9/2006 10:40	South current low flow velocities
BR 20	3.25	10/10/2006 11:40	South current, max velocity at 17.25m
HW 21`	4.25	10/10/2006 21:00	South current mag decreases from 37 cm/sec near surf to 23 cm/sec near bottom
MN 21	4	10/11/2006 14:10	Shear in water column South from near surface to 20m then shifts to NNW from 20m to near bottom. Mag minimum at shear inflection point.
MN 21b	4	10/11/2006 20:20	South flow
Boynton Inlet	3.8	10/12/2006 7:40	NNE current
SC BOIL 1	3.8	10/12/2006 11:00	North current
SC BOIL 2	4.25	10/12/2006 17:00	North current. Flow speed decreasing with depth 37-28 cm/sec
BC BOIL	3.75	10/13/2006 7:45	North current, flow speed decreasing with depth.
BR BOIL	3.5	10/14/2006 7:40	North current, max flow near surf decreasing to minimum flow near bottom
HW BOIL	4.6	10/17/2006 8:30	North current, more NNW at surface Min flow at 8.6m , max flow near bottom
MN BOIL 1	4.25	10:17 19:00	East current with max flow at 14.25 m
MN BOIL 2	4.3	10/18/2006 7:40	North current, max velocity at 14.3m

Appendix 2. All Nutrient Results

	Date	Samp desig	Dep m	Chlor. µg/L	Phae. µg/L	N+N µM	NO_2 µM	NH_4 µM	P µM	Si µM	N+N mg/L[N]	NO_2 mg/L[N]	NH_4 mg/L[N]	P mg/L[P]	Si mg/L[Si]
SC	12-Oct	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	2a	0	0.343	0.111	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	3a	0	0.422	0.121	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	4a	0	0.402	0.126	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	5a	0	0.398	0.126	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	6a	0	0.403	0.115	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	7a	0	0.362	0.094	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	8a	0	0.439	0.119	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	9a	0	0.422	0.134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	10a	0	0.455	0.129	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	11a	0	0.279	0.084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	1b	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	2b	10.6	0.424	0.104	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	3b	15.2	0.518	0.204	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	4b	13.6	0.434	0.137	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	5b	12	0.406	0.132	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	6b	15	0.407	0.128	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	7b	13.8	0.437	0.122	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	8b	15.8	0.231	0.075	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	9b	11.5	0.418	0.129	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	10b	9.84	0.533	0.145	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	11b	14.7	0.214	0.074	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	2c	21.1	0.316	0.144	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	3c	30.4	0.433	0.170	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	4c	27.1	0.419	0.148	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	5c	24	0.429	0.138	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	6c	30	0.416	0.133	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	7c	27.6	0.387	0.134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	8c	31.6	0.481	0.196	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	9c	23	0.412	0.139	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

SC	12-Oct	10c	19.7	0.486	0.135	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC	12-Oct	11c	29.4	0.517	0.179	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BI	12-Oct	1a	0	0.844	0.371	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BI	12-Oct	1b	8	0.855	0.377	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BC	13-Oct	1a	0	0.706	0.209	1.13	1.3	3.45	0.455	1.9	0.016	0.0182	0.048	0.014	0.053
BC	13-Oct	2a	0	0.734	0.246	0.26	0.04	0.7	0.212	0	0.0036	0.0006	0.0098	0.0066	0.0000
BC	13-Oct	3a	0	0.774	0.243	0.99	1.11	3.18	0.508	1.88	0.0139	0.0155	0.0445	0.0157	0.0526
BC	13-Oct	4a	0	0.699	0.197	1.93	2.12	7.22	0.969	3.3	0.0270	0.0297	0.1011	0.0300	0.0924
BC	13-Oct	5a	0	0.644	0.176	0.49	0.46	1.85	0.31	0.75	0.0069	0.0064	0.0259	0.0096	0.0210
BC	13-Oct	6a	0	0.475	0.174	0.38	0.38	1.29	0.256	0.3	0.0053	0.0053	0.0181	0.0079	0.0084
BC	13-Oct	7a	0	0.388	0.126	0.15	0.1	0	0.121	0	0.0021	0.0014	0.0000	0.0038	0.0000
BC	13-Oct	8a	0	0.618	0.187	0.44	0.38	1.08	1.15	0.51	0.0062	0.005	0.015	0.036	0.014
BC	13-Oct	9a	0	0.619	0.206	0.22	0.13	0.48	0.315	0	0.0031	0.002	0.007	0.010	0.000
BC	13-Oct	10a	0	0.752	0.233	0.27	0.2	0.68	0.234	0.07	0.0038	0.003	0.010	0.007	0.002
BC	13-Oct	1b	13.7	0.714	0.191	0.35	0.03	0.96	0.077	0	0.005	0.0004	0.0134	0.0024	0.0000
BC	13-Oct	2b	12.7	1.446	0.424	0.14	0.08	0.56	0.163	0	0.00196	0.0011	0.0078	0.0051	0.0000
BC	13-Oct	3b	13.6	0.745	0.208	0.18	0.09	0.61	0.15	0.01	0.0025	0.0013	0.0085	0.0047	0.0003
BC	13-Oct	4b	14.7	0.696	0.137	0.24	0.09	1.35	0.221	0.01	0.0034	0.0013	0.0189	0.0069	0.0003
BC	13-Oct	5b	12.7	0.608	0.214	0.14	0.1	0.24	0.131	0.04	0.0020	0.0014	0.0034	0.0041	0.0011
BC	13-Oct	6b	13.9	0.587	0.159	0.24	0.17	1	0.155	0.09	0.0034	0.0024	0.0140	0.0048	0.0025
BC	13-Oct	7b	14.6	0.666	0.245	0.14	0.09	0.23	0.141	0	0.0020	0.001	0.003	0.004	0.000
BC	13-Oct	8b	13	0.619	0.156	0.21	0.16	0.21	0.204	0	0.0029	0.002	0.003	0.006	0.000
BC	13-Oct	9b	13.7	0.575	0.215	0.23	0.1	0.42	0.197	0	0.0032	0.001	0.006	0.006	0.000
BC	13-Oct	10b	14.6	0.607	0.230	0.17	0.1	0.33	0.059	0	0.0024	0.001	0.005	0.002	0.000
BC	13-Oct	1c	27.4	0.561	0.204	0.21	0.05	0.6	0.156	0	0.0029	0.0007	0.0084	0.0048	0.0000
BC	13-Oct	2c	25.4	0.000	0.000	0.24	0.07	0.11	0.132	0.01	0.0034	0.0010	0.0015	0.0041	0.0003
BC	13-Oct	3c	27.2	0.561	0.182	0.23	0.08	0.33	0.14	0	0.0032	0.0011	0.0046	0.0043	0.0000
BC	13-Oct	4c	29.3	0.603	0.190	0.26	0.11	0.61	0.191	0.04	0.0036	0.0015	0.0085	0.0059	0.0011
BC	13-Oct	5c	25.3	0.617	0.165	0.25	0.1	0.26	0.131	0.04	0.0035	0.0014	0.0036	0.0041	0.0011
BC	13-Oct	6c	27.9	0.681	0.151	0.25	0.11	1.3	0.177	0.04	0.0035	0.0015	0.0182	0.0055	0.0011
BC	13-Oct	7c	29.3	0.639	0.186	0.25	0.1	0.09	0.209	0	0.0035	0.001	0.001	0.006	0.000
BC	13-Oct	8c	26	0.653	0.201	0.21	0.1	0.55	0.206	0.04	0.0029	0.001	0.008	0.006	0.001
BC	13-Oct	9c	27.5	0.594	0.176	0.3	0.13	0.33	0.165	0	0.0042	0.002	0.005	0.005	0.000
BC	13-Oct	10c	29.3	0.630	0.226	0.24	0.13	0.21	0	0	0.0034	0.002	0.003	0.000	0.000

BRI	13-Oct	a	0	0.164	0.055	0.1	0	0	0	0.22	0.001	0.000	0.000	0.000	0.006
BRI	13-Oct	b	30	0.242	0.084	0	0	0	0	0.19	0.000	0.000	0.000	0.000	0.005
BRI	13-Oct	c	60	N/A	N/A	0.1	0.1	0	0	0.61	0.001	0.001	0.000	0.000	0.017
BRI	13-Oct	d	90	N/A	N/A	1.38	0.22	0	0	1.37	0.019	0.003	0.000	0.000	0.038
BRI	13-Oct	e	120	N/A	N/A	7.97	0.07	0	0.394	5.2	0.112	0.001	0.000	0.012	0.146
BRI	13-Oct	f	150	0.014	0.039	13.92	0.02	0	1.027	8.02	0.195	0.000	0.000	0.032	0.225
PEI	13-Oct	a	0	0.242	0.058	0.2	0.01	0	0	0.64	0.003	0.000	0.000	0.000	0.018
PEI	13-Oct	b	30	0.177	0.058	0.01	0	0	0	0.5	0.000	0.000	0.000	0.000	0.014
PEI	13-Oct	c	60	N/A	N/A	0.03	0.01	0	0	0.77	0.000	0.000	0.000	0.000	0.022
PEI	13-Oct	d	90	N/A	N/A	2.43	0.27	0	0.034	2.2	0.034	0.004	0.000	0.001	0.062
PEI	13-Oct	e	120	N/A	N/A	6.56	0.06	0	0.377	4.26	0.092	0.001	0.000	0.012	0.119
PEI	13-Oct	f	150	0.025	0.046	14.56	0.02	0	1.27	9.38	0.204	0.000	0.000	0.039	0.263
C1-3	14-Oct	1a	0	1.568	1.158	0.1	0.06	0	0	0	0.001	0.001	0.000	0.000	0.000
C1-3	14-Oct	1b	9.35	1.704	1.471	0.13	0.08	0	0	0	0.002	0.001	0.000	0.000	0.000
C1-3	14-Oct	1c	18.7	1.427	0.594	0.15	0.04	0	0	0	0.002	0.001	0.000	0.000	0.000
C1-3	14-Oct	2a	0	1.657	0.519	0.14	0.05	0	0	0	0.002	0.001	0.000	0.000	0.000
C1-3	14-Oct	2b	11.3	1.537	0.636	0.12	0.04	0	0	0	0.002	0.001	0.000	0.000	0.000
C1-3	14-Oct	2c	22.6	1.192	0.361	0.23	0.05	0	0	0	0.003	0.001	0.000	0.000	0.000
C1-3	14-Oct	3a	0	1.403	0.563	0.08	0.04	0	0	0	0.001	0.001	0.000	0.000	0.000
C1-3	14-Oct	3b	11.3	1.166	0.569	0.24	0.05	0	0	0.06	0.003	0.001	0.000	0.000	0.002
C1-3	14-Oct	3c	22.5	0.849	0.225	0.22	0.04	0	0	0.09	0.003	0.001	0.000	0.000	0.003
BR	14-Oct	1a	0	0.940	0.166	2.91	2.22	21.09	1.005	3.35	0.041	0.031	0.295	0.031	0.094
BR	14-Oct	2a	0	0.772	0.193	0.93	0.66	6.49	0.524	0.92	0.013	0.009	0.091	0.016	0.026
BR	14-Oct	3a	0	0.774	0.243	1.28	0.95	9.17	0.582	1.25	0.018	0.013	0.128	0.018	0.035
BR	14-Oct	4a	0	0.850	0.185	1.13	0.82	7.97	0.337	1.11	0.016	0.011	0.112	0.010	0.031
BR	14-Oct	5a	0	1.209	0.355	0.26	0.06	0.98	0	0	0.004	0.001	0.014	0.000	0.000
BR	14-Oct	6a	0	0.869	0.185	0.55	0.29	2.42	0	0.43	0.008	0.004	0.034	0.000	0.012
BR	14-Oct	7a	0	0.699	0.226	1.5	1.05	9.79	0.533	1.63	0.021	0.015	0.137	0.017	0.046
BR	14-Oct	8a	0	1.001	0.403	1.29	0.91	8.2	0.068	1.09	0.018	0.013	0.115	0.002	0.031
BR	14-Oct	9a	0	1.072	0.438	0.36	0.21	1.33	0	0	0.005	0.003	0.019	0.000	0.000
BR	14-Oct	10a	0	1.093	0.556	0.12	0.03	0	0	0	0.002	0.000	0.000	0.000	0.000
BR	14-Oct	11a	0	1.811	1.039	0.24	0.07	0	0	0	0.003	0.001	0.000	0.000	0.000
BR	14-Oct	1b	16.8	1.050	0.137	0.59	0.38	3.82	0.517	0.38	0.008	0.005	0.053	0.016	0.011
BR	14-Oct	2b	17.5	0.804	0.112	0.54	0.33	3.75	0.446	0.43	0.008	0.005	0.053	0.014	0.012

BR	14-Oct	3b	17.6	1.408	0.490	0.12	0.01	0.82	0.184	0	0.002	0.000	0.011	0.006	0.000
BR	14-Oct	4b	17.3	0.732	0.146	1.12	0.8	8.24	0.249	1.09	0.016	0.011	0.115	0.008	0.031
BR	14-Oct	5b	16.3	0.779	0.140	0.29	0.14	1.73	0	0	0.004	0.002	0.024	0.000	0.000
BR	14-Oct	6b	16.5	0.692	0.149	0.36	0.15	1.55	0	0.02	0.005	0.002	0.022	0.000	0.001
BR	14-Oct	7b	16.2	0.511	0.130	0.78	0.5	4.1	0	0.87	0.011	0.007	0.057	0.000	0.024
BR	14-Oct	8b	19.4	1.148	0.385	0.2	0.04	0	0	0	0.003	0.001	0.000	0.000	0.000
BR	14-Oct	9b	19.2	1.107	0.364	0.14	0.03	0	0	0	0.002	0.000	0.000	0.000	0.000
BR	14-Oct	10b	18.9	1.210	0.725	0.13	0.05	0	0	0	0.002	0.001	0.000	0.000	0.000
BR	14-Oct	11b	17.1	1.137	0.448	0.39	0.22	1.28	0	0	0.005	0.003	0.018	0.000	0.000
BR	14-Oct	1c	33.5	0.649	0.157	0.26	0.05	0.24	0.38	0	0.004	0.001	0.003	0.012	0.000
BR	14-Oct	2c	35	0.459	0.125	0.2	0.02	0.78	0.355	0.16	0.003	0.000	0.011	0.011	0.004
BR	14-Oct	3c	35.2	0.452	0.035	0.2	0.02	0.88	0.065	0.13	0.003	0.000	0.012	0.002	0.004
BR	14-Oct	4c	34.5	0.380	0.060	0.25	0.06	0.36	0	0.21	0.004	0.001	0.005	0.000	0.006
BR	14-Oct	5c	32.6	0.397	0.112	0.27	0.07	0.36	0	0.19	0.004	0.001	0.005	0.000	0.005
BR	14-Oct	6c	32.9	0.317	0.105	0.29	0.09	0.66	0	0.35	0.004	0.001	0.009	0.000	0.010
BR	14-Oct	7c	32.4	0.391	0.113	0.29	0.06	0	0	0.21	0.004	0.001	0.000	0.000	0.006
BR	14-Oct	8c	38.8	0.345	0.077	0.26	0.07	0	0	0.46	0.004	0.001	0.000	0.000	0.013
BR	14-Oct	9c	38.4	0.482	0.121	0.26	0.07	0.03	0	0.24	0.004	0.001	0.000	0.000	0.007
BR	14-Oct	10c	37.8	0.579	0.107	0.24	0.03	0	0	0	0.003	0.000	0.000	0.000	0.000
BR	14-Oct	11c	34.2	0.628	0.148	0.25	0.08	0	0	0	0.004	0.001	0.000	0.000	0.000
MCI	15-Oct	a	0	0.166	0.042	0.09	0.04	0	0.05	0.46	0.001	0.001	0.000	0.002	0.013
MCI	15-Oct	b	30	0.173	0.052	0.05	0.03	0	0.032	0.3	0.001	0.000	0.000	0.001	0.008
MCI	15-Oct	c	60	N/A	N/A	0.28	0.26	0	0.043	0.54	0.004	0.004	0.000	0.001	0.015
MCI	15-Oct	d	90	N/A	N/A	2.91	0.25	0	0.253	2.2	0.041	0.004	0.000	0.008	0.062
MCI	15-Oct	e	120	N/A	N/A	8.25	0.09	0	0.636	4.65	0.116	0.001	0.000	0.020	0.130
MCI	15-Oct	f	150	0.026	0.049	10.88	0.04	0.64	1.444	6.52	0.152	0.001	0.009	0.045	0.183
MCI	16-Oct	10a	0	0.461	0.128	2.23	1.58	66.32	3.552	8.07	0.031	0.022	0.928	0.110	0.226
MCI	16-Oct	2a	0	0.416	0.096	0.53	0.31	5.37	0.402	1.2	0.007	0.004	0.075	0.012	0.034
MCI	16-Oct	3a	0	0.428	0.097	1	0.61	10.97	0.704	2	0.014	0.009	0.154	0.022	0.056
MCI	16-Oct	4a	0	0.429	0.099	1.26	0.8	15.94	0.995	2.62	0.018	0.011	0.223	0.031	0.073
MCI	16-Oct	5a	0	0.422	0.105	0.66	0.41	11.42	0.573	1.73	0.009	0.006	0.160	0.018	0.048
MCI	16-Oct	6a	0	0.399	0.096	0.57	0.36	10.68	0.579	1.6	0.008	0.005	0.150	0.018	0.045
MCI	16-Oct	7a	0	0.461	0.116	0.48	0.29	8.92	0.467	1.36	0.007	0.004	0.125	0.014	0.038
MCI	16-Oct	8a	0	0.411	0.089	0.38	0.22	7.77	0.403	1.25	0.005	0.003	0.109	0.012	0.035

MCI	16-Oct	9a	0	0.431	0.110	0.27	0.16	6.41	0.356	1.11	0.004	0.002	0.090	0.011	0.031
MCI	16-Oct	1a	0	0.488	0.105	0.57	0.32	4.01	0.474	1.01	0.008	0.004	0.056	0.015	0.028
MCI	16-Oct	10b	15.7	0.448	0.122	0.57	0.37	15.94	1.48	2.11	0.008	0.005	0.223	0.046	0.059
MCI	16-Oct	2b	16.6	0.429	0.093	0.55	0.33	5.61	0.443	1.11	0.008	0.005	0.079	0.014	0.031
MCI	16-Oct	3b	16.1	0.596	0.121	0.79	0.49	9.08	0.624	1.63	0.011	0.007	0.127	0.019	0.046
MCI	16-Oct	4b	15.8	0.507	0.123	0.14	0.05	1.61	0.21	0.39	0.002	0.001	0.023	0.007	0.011
MCI	16-Oct	5b	16.2	0.403	0.093	0.03	0	0.13	0.087	0.14	0.000	0.000	0.002	0.003	0.004
MCI	16-Oct	6b	15.4	0.434	0.094	0.28	0.15	4.64	0.235	0.87	0.004	0.002	0.065	0.007	0.024
MCI	16-Oct	7b	14.5	0.451	0.095	0.13	0.05	1.79	0.134	0.41	0.002	0.001	0.025	0.004	0.011
MCI	16-Oct	8b	16.3	0.397	0.091	0.01	0	0.11	0.111	0.17	0.000	0.000	0.002	0.003	0.005
MCI	16-Oct	9b	14.7	0.386	0.107	0.14	0.07	3.19	0.255	0.66	0.002	0.001	0.045	0.008	0.018
MCI	16-Oct	1b	17.2	0.475	0.110	0.05	0	0.35	0.112	0.25	0.001	0.000	0.005	0.003	0.007
MCI	16-Oct	10c	31.3	0.527	0.173	0.16	0.02	1.12	0.304	0.31	0.002	0.000	0.016	0.009	0.009
MCI	16-Oct	2c	33.2	0.526	0.123	0.04	0	0.29	0.078	0.17	0.001	0.000	0.004	0.002	0.005
MCI	16-Oct	3c	32.1	0.429	0.099	0.05	0	0.23	0.144	0.12	0.001	0.000	0.003	0.004	0.003
MCI	16-Oct	4c	31.5	0.545	0.126	0.05	0	0.11	0	0.06	0.001	0.000	0.002	0.000	0.002
MCI	16-Oct	5c	32.3	0.590	0.151	0.19	0.01	0.11	0.02	0.17	0.003	0.000	0.002	0.001	0.005
MCI	16-Oct	6c	30.8	0.550	0.133	0.08	0.01	0.16	0.12	0.14	0.001	0.000	0.002	0.004	0.004
MCI	16-Oct	7c	29	0.447	0.104	0.07	0	0.24	0.011	0.17	0.001	0.000	0.003	0.000	0.005
MCI	16-Oct	8c	32.5	0.662	0.206	0.13	0.02	0.16	0.076	0.25	0.002	0.000	0.002	0.002	0.007
MCI	16-Oct	9c	29.4	0.523	0.138	0.12	0.01	0.32	0.098	0.2	0.002	0.000	0.004	0.003	0.006
MCI	16-Oct	1c	34.3	0.578	0.128	0.07	0	0.58	0.118	0.17	0.001	0.000	0.008	0.004	0.005
HW	17-Oct	10a	0	0.333	0.046	0.77	0.46	3.17	0	1.32	0.011	0.006	0.044	0.000	0.037
HW	17-Oct	1ab	0	0.406	0.114	0.25	0.03	0.55	0.129	0.63	0.004	0.000	0.008	0.004	0.018
HW	17-Oct	2a	0	0.475	0.129	0.59	0.32	2.03	0.076	0.87	0.008	0.004	0.028	0.002	0.024
HW	17-Oct	3a	0	0.494	0.115	1.26	0.81	3.31	0.091	1.54	0.018	0.011	0.046	0.003	0.043
HW	17-Oct	4a	0	0.335	0.076	0.08	0	0	0	0.52	0.001	0.000	0.000	0.000	0.015
HW	17-Oct	5a	0	0.373	0.081	0.23	0.09	0.59	0	0.52	0.003	0.001	0.008	0.000	0.015
HW	17-Oct	6a	0	0.439	0.103	0.18	0.01	0	0	0.38	0.003	0.000	0.000	0.000	0.011
HW	17-Oct	7a	0	0.507	0.117	0.23	0.03	0	0	0.43	0.003	0.000	0.000	0.000	0.012
HW	17-Oct	8a	0	0.365	0.086	0.64	0.34	2.2	0	0.96	0.009	0.005	0.031	0.000	0.027
HW	17-Oct	9a	0	0.177	0.058	0.03	0	0.15	0	0.35	0.000	0.000	0.002	0.000	0.010
HW	17-Oct	10b	14.3	0.244	0.064	0.16	0.01	0.54	0	0.4	0.002	0.000	0.008	0.000	0.011
HW	17-Oct	1bb	10.1	0.409	0.111	0.2	0.02	0.01	0.035	0.57	0.003	0.000	0.000	0.001	0.016

HW	17-Oct	2b	13.8	0.480	0.125	0.7	0.42	1.97	0.035	1.01	0.010	0.006	0.028	0.001	0.028
HW	17-Oct	3b	17.1	0.509	0.122	0.08	0	0	0	0.4	0.001	0.000	0.000	0.000	0.011
HW	17-Oct	4b	17.3	0.473	0.068	0.13	0	0.33	0	0.49	0.002	0.000	0.005	0.000	0.014
HW	17-Oct	5b	13.4	0.371	0.091	0.18	0.04	0.36	0	0.43	0.003	0.001	0.005	0.000	0.012
HW	17-Oct	6b	8	0.462	0.101	0.21	0.01	0	0	0.4	0.003	0.000	0.000	0.000	0.011
HW	17-Oct	7b	7.71	0.480	0.107	0.21	0.02	0.06	0	0.38	0.003	0.000	0.001	0.000	0.011
HW	17-Oct	8b	13.8	0.357	0.082	0.16	0.03	0.12	0	0.43	0.002	0.000	0.002	0.000	0.012
HW	17-Oct	9b	18.6	0.238	0.059	0.03	0	0	0	0.35	0.000	0.000	0.000	0.000	0.010
HW	17-Oct	11	25.2	0.214	0.065	5.95	4.56	30.22	0.83	8.26	0.083	0.064	0.423	0.026	0.231
HW	17-Oct	10c	28.5	0.384	0.096	0.12	0.01	0.23	0	0.4	0.002	0.000	0.003	0.000	0.011
HW	17-Oct	1cb	20.2	0.430	0.118	0.24	0.02	0.2	0	0.54	0.003	0.000	0.003	0.000	0.015
HW	17-Oct	2c	27.5	0.460	0.120	0.25	0	0.06	0	0.43	0.004	0.000	0.001	0.000	0.012
HW	17-Oct	3c	34.2	0.493	0.124	0.09	0	0	0	0.35	0.001	0.000	0.000	0.000	0.010
HW	17-Oct	4c	34.6	0.483	0.108	0.19	0.02	0.1	0	0.43	0.003	0.000	0.001	0.000	0.012
HW	17-Oct	5c	26.8	0.397	0.095	0.26	0.02	0	0	0.38	0.004	0.000	0.000	0.000	0.011
HW	17-Oct	6c	16	0.453	0.098	0.19	0.01	0	0	0.38	0.003	0.000	0.000	0.000	0.011
HW	17-Oct	7c	15.4	0.550	0.094	0.18	0.02	0	0	0.32	0.003	0.000	0.000	0.000	0.009
HW	17-Oct	8c	27.5	0.394	0.096	0.15	0.01	0.07	0	0.49	0.002	0.000	0.001	0.000	0.014
HW	17-Oct	9c	37.1	0.470	0.098	0.13	0.01	0.11	0	0.32	0.002	0.000	0.002	0.000	0.009
MN	17-Oct	1a	0	0.778	0.200	29	1	12.85	0.78	3.24	0.406	0.014	0.180	0.024	0.091
MN	17-Oct	2a	0	0.642	0.189	2.81	1.77	26.1	1.708	5.78	0.039	0.025	0.365	0.053	0.162
MN	18-Oct	3a	0	0.402	0.124	0.37	0.23	2.66	0.13	0.9	0.005	0.003	0.037	0.004	0.025
MN	18-Oct	4a	0	0.398	0.124	0.21	0.12	1.36	0.064	0.44	0.003	0.002	0.019	0.002	0.012
MN	18-Oct	5a	0	0.412	0.120	0.58	0.39	5.08	2	1.14	0.008	0.005	0.071	0.062	0.032
MN	18-Oct	6a	0	0.560	0.112	0.76	0.5	6.02	0.421	1.63	0.011	0.007	0.084	0.013	0.046
MN	18-Oct	7a	0	0.437	0.122	0.68	0.44	6.2	0	1.53	0.010	0.006	0.087	0.000	0.043
MN	18-Oct	8a	0	0.417	0.128	0.13	0.01	0	0	0.1	0.002	0.000	0.000	0.000	0.003
MN	18-Oct	9a	0	0.825	0.218	0.35	0.22	2.52	0	1.77	0.005	0.003	0.035	0.000	0.050
MN	18-Oct	10a	0	0.874	0.265	0.08	0.04	0	0	1.24	0.001	0.001	0.000	0.000	0.035
MN	18-Oct	11a	0	0.900	0.256	0.07	0.01	0	0	1.29	0.001	0.000	0.000	0.000	0.036
MN	17-Oct	1b	15.3	0.517	0.188	1.708	0.49	4.79	0.243	1.71	0.024	0.007	0.067	0.008	0.048
MN	18-Oct	3b	18.6	0.468	0.141	0.08	0.02	0	0	0.36	0.001	0.000	0.000	0.000	0.010
MN	18-Oct	4b	19	0.390	0.112	0.06	0.01	0	0	0.17	0.001	0.000	0.000	0.000	0.005
MN	18-Oct	5b	19	0.384	0.115	0.04	0.02	0	0	0.11	0.001	0.000	0.000	0.000	0.003

MN	18-Oct	6b	14	0.396	0.117	0.11	0.04	0	0.041	0.27	0.002	0.001	0.000	0.001	0.008
MN	18-Oct	7b	14.8	0.530	0.136	0.1	0.03	0	0	0.13	0.001	0.000	0.000	0.000	0.004
MN	18-Oct	8b	14.4	0.492	0.129	0.11	0.01	0	0	0.1	0.002	0.000	0.000	0.000	0.003
MN	18-Oct	9b	10.2	0.687	0.177	0.34	0.2	3.12	0	1.34	0.005	0.003	0.044	0.000	0.038
MN	18-Oct	10b	10.4	0.776	0.219	0.05	0.03	0	0	0.91	0.001	0.000	0.000	0.000	0.025
MN	18-Oct	11b	13.6	0.594	0.169	0	0	0	0	0.02	0.000	0.000	0.000	0.000	0.001
MN	17-Oct	1c	30.7	0.845	0.279	0.26	0.14	0.02	0.029	0.62	0.004	0.002	0.000	0.001	0.017
MN	18-Oct	3c	37.2	0.405	0.126	0.14	0.02	0	0	0.11	0.002	0.000	0.000	0.000	0.003
MN	18-Oct	4c	38	0.408	0.164	0.1	0.01	0	0	0.11	0.001	0.000	0.000	0.000	0.003
MN	18-Oct	5c	38	0.414	0.122	0.11	0.03	0	0	0.11	0.002	0.000	0.000	0.000	0.003
MN	18-Oct	6c	28.2	0.430	0.119	0.3	0.04	0	0.061	0.25	0.004	0.001	0.000	0.002	0.007
MN	18-Oct	7c	29.6	0.422	0.123	0.12	0.01	0	0	0.1	0.002	0.000	0.000	0.000	0.003
MN	18-Oct	8c	28.8	0.433	0.139	0.19	0.02	0.12	0	0.21	0.003	0.000	0.002	0.000	0.006
MN	18-Oct	9c	20.4	0.486	0.113	0.24	0.03	0	0	0.18	0.003	0.000	0.000	0.000	0.005
MN	18-Oct	10c	20.8	0.479	0.156	0.21	0.02	0	0	0.29	0.003	0.000	0.000	0.000	0.008
MN	18-Oct	11c	27.2	0.523	0.149	0.14	0.02	0	0	0.05	0.002	0.000	0.000	0.000	0.001

Appendix 3. Nutrient Results from boil samples.

	Date	Depth (m)	Chlor. a (µg/L)	Phaeo. (µg/L)	N+N (µM)	NO2 (µM)	NH4 (µM)	P (µM)	Si (µM)	N+N (mg/L)	NO_2 (mg/L)	NH_4 (mg/L)	P (mg/L)	Si (mg/L)
SC	12-Oct	0												
BC	13-Oct	0	0.71	0.21	1.13	1.30	3.45	0.455	1.9	0.016	0.018	0.048	0.002	0.000
BC	13-Oct	13.71	0.71	0.19	0.35	0.03	0.96	0.077	0	0.005	0.000	0.013	0.014	0.053
BC	13-Oct	27.43	0.56	0.20	0.21	0.05	0.60	0.156	0	0.003	0.001	0.008	0.005	0.000
BR	14-Oct	0	1.81	1.04	0.24	0.07	0.00	0	0	0.003	0.001	0.000	0.000	0.000
BR	14-Oct	17.08	1.14	0.45	0.39	0.22	1.28	0	0	0.005	0.003	0.018	0.000	0.000
BR	14-Oct	34.17	0.63	0.15	0.25	0.08	0.00	0	0	0.004	0.001	0.000	0.000	0.000
HW	17-Oct	0	0.33	0.05	0.77	0.46	3.17	0	1.32	0.011	0.006	0.044	0.000	0.037
HW	17-Oct	14.25	0.24	0.06	0.16	0.01	0.54	0	0.4	0.002	0.000	0.008	0.000	0.011
HW	17-Oct	28.5	0.38	0.10	0.12	0.01	0.23	0	0.4	0.002	0.000	0.003	0.000	0.011
MN	17-Oct	0	0.78	0.20	29.00	1.00	12.85	0.78	3.24	0.406	0.014	0.180	0.024	0.091
MN	17-Oct	15.33	0.52	0.19	1.71	0.49	4.79	0.24	1.71	0.024	0.007	0.067	0.008	0.048
MN	17-Oct	30.66	0.84	0.28	0.26	0.14	0.02	0.03	0.62	0.004	0.002	0.000	0.001	0.017
MC	16-Oct	0	0.46	0.13	2.23	1.58	66.32	3.55	8.07	0.031	0.022	0.928	0.110	0.226
MC	16-Oct	15.65	0.45	0.12	0.57	0.37	15.94	1.48	2.11	0.008	0.005	0.223	0.046	0.059
MC	16-Oct	31.3	0.53	0.17	0.16	0.02	1.12	0.30	0.31	0.002	0.000	0.016	0.009	0.009

Appendix 4. Sea grass sampling locations

Name	D(m)	d	min	d	min	Name	D(m)	d	min	d	Min
SC-1	95	26°	27.9583	80°	2.4945	BC-1	89	26°	21.2625	80°	3.2079
SC-2	75	26°	29.1716	80°	2.3854	BC-2	89	26°	22.5127	80°	3.0590
SC-3	79	26°	30.0875	80°	2.1898	BC-3	95	26°	23.5147	80°	3.0032
SC-4	95	26°	27.4531	80°	2.5582	BC-4	89	26°	20.7506	80°	3.2638
SC-5	92	26°	26.2655	80°	2.7414	BC-5	98	26°	19.5780	80°	3.4499
SC-6	92	26°	25.2684	80°	2.8814	BC-6	79	26°	18.4983	80°	3.5988
SC-7	66	26°	27.7021	80°	2.7991	BC-7	59	26°	21.0112	80°	3.5151
SC-8	36	26°	27.6980	80°	3.0708	BC-8	36	26°	21.0112	80°	3.7849
BR-1	118	26°	15.3269	80°	3.7249	HW-1	112	26°	1.4216	80°	5.1787
BR-2	105	26°	16.4779	80°	3.6050	HW-2	98	26°	2.7522	80°	5.1887
BR-3	105	26°	17.5690	80°	3.4731	HW-3	85	26°	3.8327	80°	5.1887
BR-4	112	26°	14.7874	80°	3.8088	HW-4	112	26°	0.8614	80°	5.1987
BR-5	98	26°	13.5166	80°	4.0366	HW-5	112	25°	59.5408	80°	5.1887
BR-6	95	26°	12.6173	80°	4.2284	HW-6	105	25°	58.4703	80°	5.1887
BR-7	82	26°	15.1111	80°	4.0486	HW-7	85	26°	1.1515	80°	5.4488
BR-8	52	26°	15.1471	80°	4.3123	HW-8	69	26°	1.1415	80°	5.7289
MN-1	115	25°	55.4987	80°	5.1970	MC-1	115	25°	44.7940	80°	5.1688
MN-2	138	25°	56.8378	80°	5.1970	MC-2	112	25°	44.1298	80°	5.1688
MN-3	102	25°	57.9197	80°	5.1970	MC-3	98	25°	44.2588	80°	5.1688
MN-4	105	25°	54.9600	80°	5.1970	MC-4	112	25°	44.2511	80°	5.1688
MN-5	115	25°	53.6157	80°	5.1970	MC-5	118	25°	44.9045	80°	5.1688
MN-6	118	25°	52.5478	80°	5.1970	MC-6	125	25°	44.8395	80°	5.1688
MN-7	75	25°	55.2270	80°	5.4600	MC-7	95	25°	44.7940	80°	5.4570
MN-8	66	25°	55.2173	80°	5.7337	MC-8	79	25°	44.7940	80°	5.7221

Appendix 5. Microbiological Data

Table 57: Microscopy and Culture-Based Microbiological Data Summary for All Outfall Boils.

Site ID/ Date collected	Site Description	Enterococci mEI filter plate count	Enterococci IDEXX	E. coli MFC filter Plate count	Staphylococcus filter plate count	Bacteroides filter plate count	Cryptosporidium Oocyst count (done by BSC Labs, Inc.)	Giardia Cyst count (done by BSC Labs, Inc.)
Units Ÿ		cfu/100mL	cfu/100mL	cfu/100mL	cfu/100mL	cfu/100mL	Cysts/100 liters	Cysts/100 liters
SC19	South Central Boil Sediment		<1					
BC15	Boca Raton Boil Sediment		<1					
BRI5e	Broward Boil Sediment		665.3					
HW19a	Hollywood Boil Sediment		1					
MN1BC	Miami North Boil Sediment		1					
BI	Boynton Inlet Surface (mix from surface and CTD)	1.2 (7/600mL)	5	TNTC confluent	TNTC confluent	0	not analyzed - not in report from BSC Labs	not analyzed - not in report from BSC Labs
SCB1	South Central Boil Surface (bucket)	<1 (2/900mL)	<1	TNTC	>2.2 (200/900mL)	0		
SCB11	South Central Boil Bottom (CTD)	0	<1	TNTC confluent	TNTC (>900 cfu / 900mL)	0		
BCB	Boca Raton Boil Surface (bucket)	0	<1	TNTC	<1 (4/2.1L)	0	<1.1	<1.1
BCB1	Boca Raton Boil Bottom (CTD)	0	3.1	TNTC	<1 (18/2.1L)	0		
BRI	Boca Raton Inlet Control (surface)	0	<1	>17 (>200/1.2L)	~1 (11/1.2L)			
PEI	Port Everglades Inlet Control	0	<1	>0.54 (65/1.2L)	~1 (12/1.2L)			

Appendix 4: Continued

Table 57: Continued

Site ID/ Date collected	Site Description	Enterococci mEI filter plate count	Enterococci IDEXX	E. coli MFC filter Plate count	Staphylococcus filter plate count	Bacteroides filter plate count	Cryptosporidium Oocyst count (BSC Labs, Inc.)	Giardia Cyst count (BSC Labs, Inc.)
Units Ÿ		cfu/100mL	cfu/100mL	cfu/100mL	cfu/100mL	cfu/100mL	Cysts/100 liters	Cysts/100 liters
BRB	Broward Boil Surface (bucket)	<1 (1 per 1.2L)	1	TNTC confluent	1 (15/1.5L)	0	7.5	1.5
HWB	Hollywood Boil Surface (bucket)	5.2 (62/1.2L)	<1	TNTC confluent	TNTC almost confl.	3 (36/1.2L)	55	67.5
MCI	Miami Central Inlet Control (surface)	<1 (1/1.2L)	<1	TNTC Not conflu.	<1 (7/1.2L)			
MC16	Miami Central Boil Sediments		10					
MCB	Miami Central Boil Surface (bucket)	0	<1	>48 (>580/1.2L)	4.6 (56/1.2L)	0	235	145.5
MCB-B	Miami Central Boil Bottom (CTD)	<1 (8/1.2L)	<1	TNTC Confluent				
HWB2	Hollywood Boil 2 Surface (bucket)	<1 (9/1.2L)	<1	>25 (>300/1.2L)	4.5 (53/1.2L)	0	17.3	19.1
HWBII-B	Hollywood Boil 2 Bottom (CTD)	4 (47/1.2L)	20.5	TNTC not confl.	TNTC not confl.	<1 (4/1.2L)		
NMB2D-B	North Miami Boil Bottom (CTD)	<1 (4/1.2L)	10	TNTC confluent	TNTC confluent	<1 (1/1.2L)		
NMB	North Miami Boil	0	5	TNTC not conflu.	TNTC almost confl.	0	8.3	120.1

(“TNTC” = colonies too numerous to count)

Appendix 5: Continued

Table 58: Molecular (PCR) Based Microbiological Data Summary of Fecal Indicator Bacteria and Microbial Source Tracking Markers for All Outfall Boils (Presence/Absence Detection).

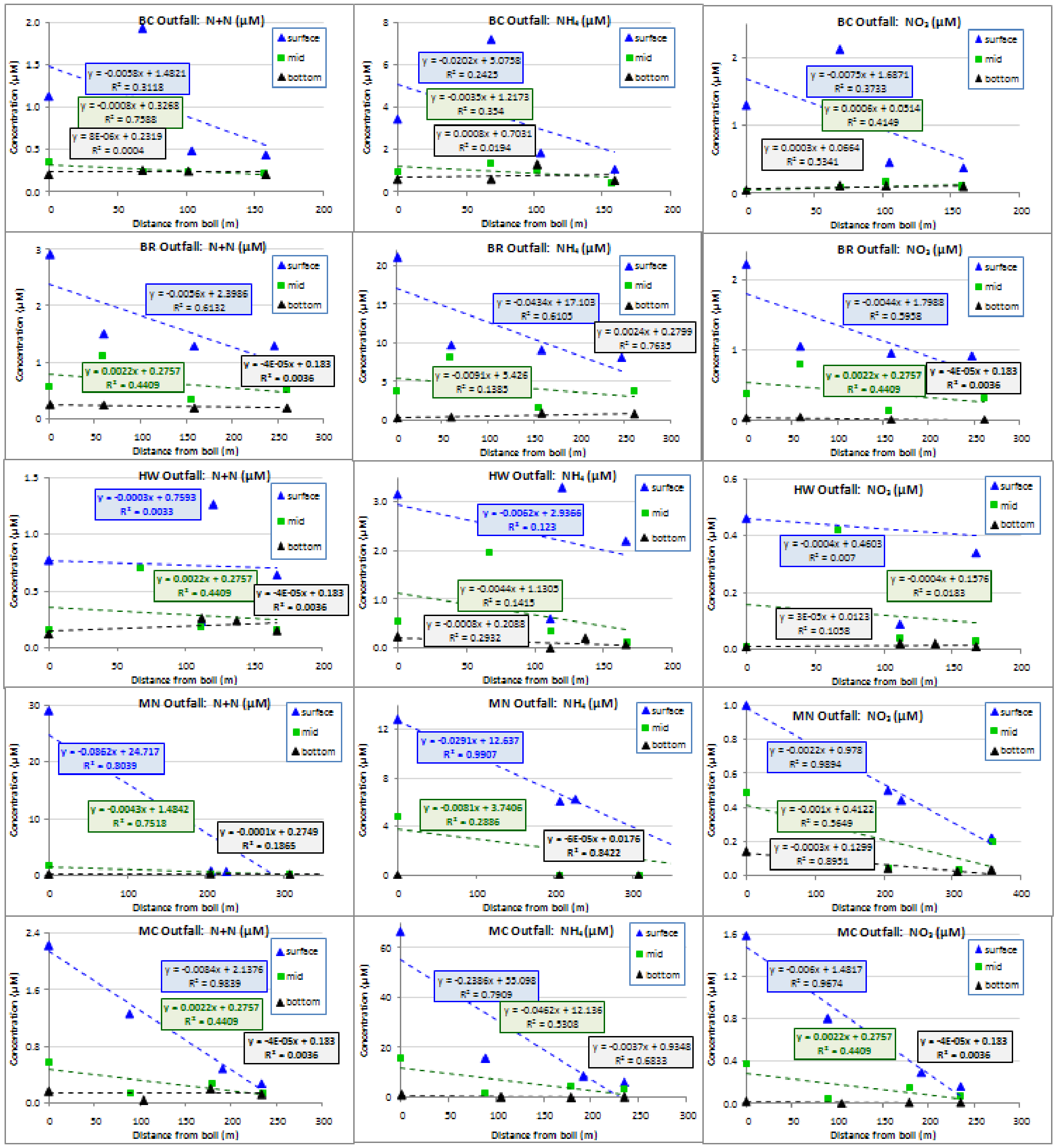
Site ID/ Date collected	Site description	Enterococci 23S rRNA gene	Human-specific Enterococci esp marker	Human-specific Bacteroides (HF8 gene cluster marker)	Human-specific Bacteroides (HuBac marker)	Human-specific Methanobrevibacter smithii (done by NOAA Hollings Marine Lab)	Human Adenovirus hexon gene marker	Human-associated Coliphage MS2
SCB1	South Central Boil Surface (bucket)	-	-	-	-	-	+	-
SCB11	South Central Boil Bottom (CTD)	-	-	-	-		-	
BCB	Boca Raton Boil Surface (bucket)	-	-	-	-	+	-	-
BCB1	Boca Raton Boil Bottom (CTD)	-	-	-	-		-	
BRB	Broward Boil Surface (bucket)	-	-	-	-	+	-	-
HWB	Hollywood Boil Surface (bucket)	+	-	+	+	+	+	+
MCB	Miami Central Boil Surface (bucket)	+	+	+	+	+	+	+
MCB-B	Miami Central Boil Bottom (CTD)	-	+	-	+		+	
HWB2	Hollywood Boil 2 Surface (bucket)	+	-	-	-	+	+	+
HWBII-B	Hollywood Boil 2 Bottom (CTD)	-	-	-	-		-	
NMB2D-B	North Miami Boil Bottom (CTD)	-	+	-	+		-	
NMB	North Miami Boil	+	-	-	-	+	-	+

Appendix 5: Continued

Table 59: Molecular (PCR) Based Microbiological Data Summary of Selected Microbial Pathogens for All Outfall Boils (Presence/Absence Detection).

Site ID/ Date collected	Site description	Salmonella sp. (IpaB gene)	Escherichia coli strain O157:H7 (rfb gene)	Campylobacter jejuni (HipO gene)	Staphylococcus aureus (clfA gene)	Noroviruses (with Cephied commercial scorpion-probe qPCR kit)	Noroviruses (done by NOAA Hollings Marine Lab)	Enteroviruses (Cephied commercial scorpion-probe qPCR kit)
SCB1	South Central Boil Surface (bucket)	-	-	-	-	-	-	-
SCB11	South Central Boil Bottom (CTD)	-	-	-	-	-	-	-
BCB	Boca Raton Boil Surface (bucket)	-	-	-	-	-	-	-
BCB1	Boca Raton Boil Bottom (CTD)	-	-	-	-	-	-	-
BRB	Broward Boil Surface (bucket)	-	-	-	-	-	-	+
HWB	Hollywood Boil Surface (bucket)	-	-	-	-	-	-	+
MCB	Miami Central Boil Surface (bucket)	-	-	-	+	+	+	+
MCB-B	Miami Central Boil Bottom (CTD)	+	-	-	+	+	+	+
HWB2	Hollywood Boil 2 Surface (bucket)	-	-	-	-	-	-	+
HWBII-B	Hollywood Boil 2 Bottom (CTD)	-	-	-	-	-	+	+
NMB2D-B	North Miami Boil Bottom (CTD)	-	-	-	+	+	+	+
NMB	North Miami Boil	-	-	-	+	+	-	+

Appendix 6a: Dilution of nutrients at plume center with distance from boil. Results for N+N, NH_4, and NO_3.



Appendix 6b: Dilution of nutrients at plume center with distance from boil. Results for P, Si, and chlorophyll-a.