FINAL REPORT

THE OCEAN MARGINS PROGRAM:
CAPE HATTERAS EXPERIMENT

US DEPARTMENT OF ENERGY GRANTS/CONTRACT
NUMBER: DE-FG05-95ER62035

PROJECT PI: Dr. L.J. PIETRAFESA

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1. Introduction

The central objectives of the Ocean Margins Program (OMP) were (1) to quantify the processes and mechanisms that affect the cycling, flux and storage of carbon and other biogenic elements at the land/ocean interface; (2) to define ocean-margin sources and sinks in the global biogeochemical cycle; and (3) to determine whether ocean margins, including continental shelves, are quantitatively significant in removing carbon dioxide from the atmosphere and isolating it via burial in sediments or by export to the interior ocean, or elsewhere. To achieve these objectives, OMP scientists designed and implemented an integrated multidisciplinary field program in 1996 to quantify the physical and biogeochemical processes affecting carbon fluxes, nutrient cycles, and ecological dynamics in shelf and slope waters from south of the Chesapeake Bay mouth to north of Diamond Shoals at Cape Hatteras, where carbon burial in sediments and carbon export to the interior ocean were expected to be maximal. This field program resulted in the most extensive, multidisciplinary set of observations ever obtained over an ocean margin.

Over seventy current meters and Seabird Electronics (SBE) 16 seacat CTD's were deployed twice during 1996. The first deployment consisted of 26 moorings placed during the February 1-16, 1996 cruise aboard the R/V OCEANUS. The majority of these instruments were recovered in May of 1996 and redeployed on 23 moorings in June of 1996. The second OMP deployment ended in October of 1996. Specific deployment and recovery dates are listed for each instrument in Appendices A and H.

2. Data Acquisition Systems

Array and Mooring Design

The OMP mooring array was designed so that a suite of biological, chemical, sedimentological, and physical processes could be measured on the shelf and slope between the Chesapeake Bay, Virginia and Cape Hatteras, North Carolina. The goal was to create a cross-shelf (diabathic) and along shelf (parabathic) grid with a high resolution observational cubical control volume (<15 km with a 10 km half diagonal) on the northern end of the array in 40 m of water. This volume included moorings 5,6,10,11, and 12. (see maps below) The mooring array then telescoped south towards Cape Hatteras to evaluate the spatial scales of coherency and temporal scales of duration over which oceanographic processes occurred during the periods of observation. Maps of both first and second deployment mooring arrays are shown in appendices A and H respectively.

Mooring Instrumentation

The instrumentation used in this experiment is summarized in tables in appendices A and H according to depth and mooring. The six types of current meters deployed are described in the following paragraphs.

SeaPac Model 2000 current meter (ACE or seapac)

Water velocity measurements are taken with a four inch diameter electromagnetic flow sensor manufactured by Marsh-McBirney, Inc. (MMI), Maryland. The MMI flow sensor is based on the Faraday principle of electromagnetic induction with an accuracy of ± 2 cm/sec. Along with flow over two axes, a Woods Hole Instrument Systems meter records compass heading, water temperature, x and y axis tilt, and conductivity. During both OMP deployments, in order to record conductivity these instruments did not record pressure.

S4 current meter by InterOcean systems, inc

Magnitude and direction of horizontal current motion is measured as a gradient in potential as water flows through a magnetic field created by the instrument (similar to *seapac*). Voltage is sensed by two pairs of titanium electrodes located symmetrically on the equator of the current meter's spherical case. Temperature, depth, and conductivity are stored with velocity data in solid state memory.

Aanderaa current meter (RCM - 4/5/7)

All the Aanderaa current meters measure current magnitude by rotor revolutions and direction by magnetic compass/potentiometer sensing shift in position of a vane. All RCM-4/5's are modified by NCSU MEAS with solid state data loggers (SSDL). The RCM-7 is equipped with a SSDL from the manufacturer. Temperature, depth, and conductivity are stored with velocity data in solid state memory.

RDI Acoustic Doppler Current Profiler (NarrowBand and Workhorse ADCP)

This instrument measures the Doppler frequency shift between the backscattered signal from transmitted acoustic pulses. The backscattering is caused by small particles that are presumed to be moving at the speed of the water. ADCP's with narrow band (NB) frequencies at 150, 300, 1200 Khz and broad band Workhorse (WH) ADCP were deployed. Velocities are averaged into vertical bins of different lengths depending on water depth at each mooring location.

BSCM

The current meters were built at FSU and are based on Geodyne 101 current meters with Pacer Systems, Inc. (previously Sea Data Corp.), Billerica, MA, electronics. They use a Savonius rotor to measure current speed, a vane and internal compass to measure direction, a thermistor to measure temperature, and an inclinometer to measure deviation from the vertical. Normally during a 32-second recording interval, the current meter senses the compass and vane settings every 4 seconds, and the number of 1/6th rotor revolutions over the previous 4 seconds. During the first 28 seconds of each interval, the average temperature is measured, and at the end of each interval time, the inclination of the meter from the vertical is measured and all the information (276 bits) is written on a 4-channel magnetic-tape cassette. The 32-second recording interval is repeated either continuously, or every 3.75 minutes, 7.5 minutes, ... 120 minutes. For this study, the sampling interval was repeated every 60 minutes. Because of their sampling scheme, the current meters are hereafter referred to as burst-sampling current meters (BSCM's). Stall speed of the rotor is about 2 cm/sec. One rotor revolution corresponds to 6 rotor counts. The vane and compass have a seven-bit ($\pm 2.8^\circ$) resolution. The inclinometer has a resolution of 5° over the range 0° to 35° . Time is measured by a quartz clock with an accuracy of $\pm 10^{-6}$ Hz, which translates to an accuracy of ± 2.63 seconds per month. The temperature sensor is a Yellow Springs Instrument Co., Yellow Springs, OH 45387 model 44032 thermistor and has a resolution of 0.0002°C with an absolute accuracy of $\pm 0.1^\circ\text{C}$.

SBE 16 Seacat

The seacats used during both deployments collected temperature and conductivity data. Manufactured by Seabird Electronics (SBE), the seacat uses a thermistor to sense temperature and an internal field glass cell to measure conductivity. Both sensors utilize SBE's 'ultra-stable' electronics for processing.

Standard meteorological data

Standard meteorological data were available from multiple National Data Buoy Center (NDBC) stations during both deployments. Recorded data include hourly averaged air temperature, sea surface temperature, sea level pressure, wind speed, wind direction, peak gust speed, significant

wave height, average wave period, dominant wave period, mean wave direction, and station visibility. The following stations frame the OMP study area.

<u>Station</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Water Depth (m)</u>
44014	36.6 N	74.8 W	47.5
chlv2	36.9 N	75.7 W	~15.0
dsln7	35.2 N	75.3 W	~15.0

3. Data Processing

Current Meter Data

Data reduction

The seapac current meter data is transferred to a DEC Alpha workstation. Here the data is converted to engineering units and velocity components are rotated to true North and East. T (temperature) and C (conductivity) conversions are performed using coefficients and equations from the manufacturer. Three hour and forty hour low pass filters are used on each data file using a Lanczos taper (Pietrafesa et al.,1978).

For the S4 current meters, the data is first processed using the manufacturers applications software (v 2.67) on a PC (IBM compatible personal computer). This creates a header and data file converted to engineering units. All further processing including the same filtering performed on the seapacs is done on DEC Alpha workstations.

The Aanderaa current meter data is converted to engineering units using coefficients and equations from the manufacturer on a PC. The data is then transferred to DEC Alpha workstations where further processing including the same filtering mentioned above is performed.

Both narrow band (NB) and workhorse wide band (WH) acoustic Doppler current profiler (ADCP) data are transferred to a PC for initial processing. The manufacturer's software converts data to engineering units. Again the data are transferred to DEC Alpha workstations where further processing and filtering is performed.

Seacat T and C data conversions are performed using coefficients and equations from the manufacturer on a PC. Again the data are transferred to DEC Alpha workstations where salinity (S) is calculated and filtering is performed.

Data relative to instruments from Florida State University (FSU) are transferred to NCSU after conversions to engineering units and S calculations have been done. These current meters include BSCM, WH ADCP, Seacat, and ACE (seapac) instruments. Lanczos filtering is performed on DEC Alpha workstations.

Calibration

For both NCSU and FSU instruments, further calibration of T and S are done using CTD casts made just after deployment and just prior to recovery (see Bignami et al., in preparation). A linear adjustment is made using the difference at the beginning and end of each of the two deployments.

4. Data Presentation

Appendices A through N contain a variety of maps, tables, and plots detailing the data collected during both OMP deployments. It should be noted that the titles for each map, plot, or table describe deployment, mooring, and depth information. Appendices A through G contain data from the first OMP deployment (OMP96A) and appendices H through N contain data from the second OMP deployment (OMP96B). All plots which do not mention Florida State University (FSU) were made with data from North Carolina State University.

<u>Appendix</u>	<u>Description</u>
A,H	mooring array map, table of instrument status, mooring diagrams
B,I	statistics
C,J	time series of 40 hour low pass data
D,K	scatter diagrams
E,L	progressive vector diagrams
F,M	auto-spectra
G,N	time series of winds

5. Acknowledgments

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6. References

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7. THE WINTER/SPRING 1996 OMP CURRENT, METEOROLOGICAL, SEA STATE AND COASTAL SEA LEVEL FIELD

The time series of atmospheric winds, coastal sea level, surface gravity waves, currents, water temperature, and salinity for the period February-May, 1996 across the OMP moored array defined a well-organized physical oceanographic system. The M2 tide, a frictionally modified Poincare wave, was manifested as a clockwise-rotating, elliptically polarized wave, with predominantly cross-shelf orientation of the ellipse, and an axis ratio of ~ 0.6 in upper layer waters and in offshore waters. However, bottom friction compressed and rotated the tidal ellipses in shallow and near-bottom waters. Elliptically polarized, clockwise-rotating motions were evident at near-inertial (~ 20 hours) and diurnal (~ 24 hours) periods. The wind field was dominated by 2-14 day events centered about 4-8 days. Due to the location and track of mesoscale atmospheric events, the wind field over the southern portion of the array was far more energetic than over the northern portion. The winds prior to 17 April had higher variances than after 17 April. Sub-diurnal frequency currents were dynamically responsive to the wind field at all locations and were stronger in the southern portion of the array. The shelf-wide, southward drift of Middle Atlantic Bight waters contributed to the weekly to monthly scales of motion. Shelf-wide, the record length means were generally southward, with an offshore component in near bottom waters. However, a significant finding was that near the 21 meter isobath on the north line of moorings, just south of the mouth of Chesapeake Bay, the mean flow was into the Bay, providing a means for the import of marine sediment into the estuary. In the southeastern-most corner of the array, north of Diamond Shoals in 36m of water, the flows were persistently directed offshore. Following southward wind events, an inability to propagate Kelvin waves northward along the coast traps a buildup of water against Diamond Shoals such that the only way for it to relax is through a geostrophically balanced offshore transport of shelf waters. The Chesapeake Bay Plume and Middle Atlantic Bight Waters often breached Diamond Shoals and invaded the South Atlantic Bight during the passage of northward-moving, but southward-directed wind events, particularly extra-tropical cyclones. Following the mid-April transition to persistent northward winds, Carolina Capes Water moved northward across Diamond Shoals and induced a transition from well-mixed wintertime to vertically stratified summertime hydrographic conditions.

The Ocean Margins Program (OMP) was designed to 1) quantify processes and mechanisms that affect the cycling, flux and storage of carbon and other biogenic elements at the land/ocean interface; 2) define ocean-margin sources and sinks in the global biogeochemical cycle; and 3) determine whether ocean margins, including continental shelves, are quantitatively significant in removing carbon dioxide from the atmosphere and isolating it via burial in sediments or via export to the interior ocean. To achieve these objectives, OMP scientists designed and implemented an integrated, multidisciplinary field program to quantify the physical, biological, geological and chemical processes affecting carbon fluxes, nutrient cycles, and ecological dynamics in shelf and slope waters from south of the Chesapeake Bay mouth to Diamond Shoals at Cape Hatteras. Underlying assumptions were that carbon burial in sediments and carbon export to the interior ocean were maximal in this, the southern apex of the Mid-Atlantic

Bight (MAB), as discussed by Verity et al. (2002). This field program resulted in the most extensive, multidisciplinary set of observations ever obtained over an ocean margin, and included an ambitious array of moored instruments. This manuscript describes the meteorological and physical oceanographic conditions affecting the oceanography of the OMP study area during the period February-May 1996.

MOORING ARRAY AND INSTRUMENTATION

The OMP moored instrument array (Figure 1) was designed so that a comprehensive suite of biological, chemical, sedimentological, meteorological, and physical oceanographic processes could be measured on the shelf and slope between the Chesapeake Bay, Virginia, and Cape Hatteras, North Carolina. The goal was to create a cross-isobath and along-isobath array of instruments with a high resolution control volume (<15 km with a 10 km half diagonal) on the northern end of the array in 40 m of water. The mooring array then telescoped south towards Cape Hatteras to evaluate the spatial scales of coherency and temporal scales of duration over which oceanographic processes occurred during the complete period of observation. The intent was to measure processes, both horizontally and vertically, from the smallest (~ 10 km) to largest (~ 135 km) scales of motion that were both practical and feasible within the study region. Consequently, the northern box array constituted the highest resolution component of the array while the northern and southern lines (NL and SL) defined the largest spatial scales within the constraints of the sampling scheme. The NL and SL provided input and output, i.e. along-isobath flow through cross-isobath lines, while an along-isobath picket fence of moorings was located along the 75m isobath to capture cross-isobath sources and sinks from or to the slope region. The NL consisted of eight moorings (#s 1-8) in waters ranging in depth from 13m to 850m. The SL line consisted of six moorings (#s 23-27) in waters ranging from 20m to 830m depth. There were seven moorings (#s 7, 13, 16, 17, 20, 22, 26) located along the 75m isobath. The array was deployed 1-16 February and recovered 08-16 May 1996, from the RV Oceanus.

OMP 96 Mooring Locations - 1st Deployment (Feb - May)

Figure 1

The physical oceanographic components of the OMP late winter/early spring 1996 moored array consisted of 162 current-meter, temperature, salinity, and pressure sensors. The first deployment (OMP I) consisted of 86 physical oceanographic instruments located on 39 bottom-mounted and/or taut wire moorings at 26 array moorings. The entire array was recovered in May 1996 and, considering modest instrument losses, was

re-deployed on 23 moorings in June 1996. The second OMP array (OMP II) had to be redesigned because of instrument losses incurred during OMP I, and consisted of the NL, the SL and the 75m along-shelf picket fence. Deployment was in early June, with recovery in October 1996. This paper addresses the physical processes observed during the first observational period. The description of the summer/fall physical oceanographic processes and the contrasts with the winter/spring processes can be found in Pietrafesa et al (2002b). The change in mooring design, as well as manuscript limitations, precludes a combination of the data sets.

The suite of instrumentation used in OMP I and discussed in the text and figures, along with locations and record length means of parameters measured, is presented in Table 1. All instruments used in this report were provided by North Carolina State University (NCSU), Florida State University (FSU), and the Brookhaven National Laboratory (BNL) (Table 1). A complete description of instrument characteristics is provided in a project technical report (Pietrafesa et al., 2001).

Standard meteorological data were available from multiple National Data Buoy Center (NDBC) buoy and coastal stations during both deployments. Recorded data include hourly averaged air temperature, sea-surface temperature, sea level, pressure, wind speed, wind direction, peak gust speed, significant wave height, average wave period, dominant wave period, mean wave direction, and station visibility. Coastal sea level was obtained from open-ocean stations to the north and south of the OMP mooring region, as well as within the study area, including Duck Pier and Cape Hatteras. The meteorological, wave gauge and sea -level station locations are given in Table 2.

Satellite Advanced Very High Resolution (AVHRR) sea-surface temperature data measured by the NOAA Polar Orbiting GOES series of satellites were downloaded in real time and processed at NCSU.

Edited, low-passed time series were created using 3 and 40 hour, half-power point Lanczos cosine taper filters following Janowitz and Pietrafesa (1979). Velocity components were rotated to true North (+v) and East (+u). Calibration of temperature and salinity were done using CTD casts made just after deployment and just prior to recovery.

ATMOSPHERIC FORCING AND SEA STATE

Atmospheric sampling sites were at the Chesapeake Lightship, the NDBC Buoy 44014, and the Diamond Shoals Lightship (Figure 1). The February-May winter/spring atmosphere of 1996 was marked by relatively different conditions prior to and following 17-20 April (Yeardays 108-111). Sea state displayed characteristics similar to those of the wind regimes. Both the means and variances of the two regimes were quite different in oceanographic effect, as seen below. The synoptic scale (2 to 10 day) wind-field was generally very coherent in terms of wind direction, if not magnitude, across the entire array. For efficiency, we only show the time series of wind velocity vectors measured at NDBC 41004 in Figure 2a. Two- to eight-day events are very evident throughout the time series. We next consider atmospheric wind particle motions via projection of the u , v wind vector components onto a horizontal hodograph plane.

The hodograph plane is basically a particle path description of the independent horizontal velocity vector (u , v) components as a function of time and frequency of motion. Rectilinear motion is straight, back- and forth-motion along a line at a specific period along a preferred orientation. Non-rectilinear motion is rotational, either clockwise or counter-clockwise, about an ellipse, aligned at a preferred orientation, at a specified period. At the Chesapeake Light Station (CLS) and NCDC 41004 sites, the hodograph descriptors (not shown) indicate very stable, clockwise-rotating atmospheric particle motion, rotating about an elongated ellipse with a minor to major axis ratio of 0.3, oriented at 20° west of north and east of south, at a near-diurnal period, ~24 hours. Over the 2-4 day period, there was stable, clockwise rotating elliptical motion aligned northeast/southwest. Over the 4-8 day period band and at bi-weekly to monthly and longer periods, stable atmospheric wind-vector motions were rectilinear and aligned more north-northeast/south-southwest, and north/south, respectively. However, at Diamond Shoals Light, the 4-8 day motions of the wind vector components were nearly circular and the vector was rotated counter-clockwise, with a slight preference for north/south orientation. Moreover, while atmospheric motions tended to be aligned nearly uniformly across the array, even though the size of the hodograph ellipse was considerably larger at the Diamond Shoals Light Station (DSL). This indicates a well-organized wind field.

Figure 2

In Figures 3a,b we see that the spectra of the energy of fluctuations in wind velocity, measured 10m above sea level, were very similar at frequencies higher than a cycle/day (c/d). However, at periods of 2-3 days, motions at DSL were 3 times more energetic than at the NCDC site, while for motions of periods 4-8 days, the zonal wind component was a half decade more energetic at DSL. This confirms that synoptic-scale winds were much higher over the southern part of the array than those over the northern part of the array, in keeping with the above finding of a north to south increase of the lengths of the wind vector hodograph axes.

Figure 3

From the regional meteorological data and an assessment of NOAA/NWS daily weather maps (not shown) the following general scenario is presented. Over the period February to mid-April, the atmospheric Icelandic Low Pressure system extended over the Middle Atlantic Bight and South Atlantic Bight, and was buffered by a weak atmospheric pressure system (the North American High) over the eastern North American continent, resulting in mean southward winds. During the February to early April period, cold, warm and stationary atmospheric fronts were often present and several extra-tropical cyclones (ETCs) passed over the array. There were seven periods of southward winds and eight periods of northward winds during this period. Each wind event lasted on the order of 3-8 days. Then, in mid-April the atmospheric Bermuda-Azores High Pressure system intensified, the Icelandic Low and North American High pressure systems both diminished, and the mean wind vectors rotated counter-clockwise, becoming northward thereafter. Thus following 17-20 April, the wind regime began a transition to a summertime mode in which winds became predominantly northward. While the period of the individual atmospheric events remained 3-8 days, the variance of the wind field was reduced from the first to the second atmospheric regime.

In summary, 2-day to 2-week synoptic-scale atmospheric events, centered about 4-8 days were characterized by winds of 5-15 m/s in the northern and middle portion of the array (Figure 2a), and 10-25 m/s over the southern portion. An important point to note here is that winds from the north generally carry cold, dry continental air masses into the area, while winds from the south carry warm, moist Gulf of Mexico (GOM) and SAB conditioned air masses into the area. In late winter to early spring, continental air masses extract latent and sensible heat from the coastal ocean, thus cooling shelf waters, while GOM and SAB air masses warm shelf waters (Pietrafesa et al, 1985a; Cione et al, 1992; Pietrafesa et al, 2002b).

Wave data from the NDBC buoy are provided in Figure 2b, coastal sea level data from the Duck and Cape Hatteras NOS stations are presented in Figure 2c, and the difference (Duck minus Cape Hatteras sea level) is shown in Figure 2d. Significant wave heights and coastal sea level fluctuations both dropped by more than 50% from the periods prior to and following the 17-20 April atmospheric transition. On an event basis, southward winds set sea level up at the coast in a frictional equilibrium mode and induced relatively high sea states during wind events occurring centered about year-days 33, 47, 60, 72, 79 and 90. Significant wave field heights reached 5, 5.5, 3, 5.5, 4, and 4m, respectively, while coastal sea-levels rose 50-60 cm during each event. Northward-directed wind events induced waves of 2-3m amplitudes.

In the sections to follow, the flow field is dynamically and kinematically decomposed and described.. First we consider the distribution of kinetic energy as a function of location

within the mooring array and phenomena observed. We then consider the anatomy of motions occurring in the diurnal-inertial-internal frequency band, followed by a discussion of sub-inertial motions across the array. Refer to Figure 1 for geographic perspective.

ENERGETICS OF PHYSICAL PROCESSES AND SHELF BANDING

We first consider the energy of the total flow field across and along the shelf. The total kinetic energy (KE) of the flow field decreased from near surface waters downward, and increased from north to south at similar levels in the vertical, across the entire domain. In addition, the distribution of energy as a function of frequency shifted across the shelf. Over the shelf, the southwestward movement contributed to the overall KE level which was modulated by synoptic to seasonal scale wind events.

At Mooring 1, 7m below the surface in 13m of water, the total variance was 629 (cm/sec)², with motions at frequencies of semi-diurnal or greater occupying but 10% of the total and 16% of the cross-shelf fraction. At Mooring 2, 8m below the surface in 21m of water, total variance was 380 (cm/sec)², with the sub-M2 tidal motions at 12% of the total and 33% of the across-shelf fraction. The more frequent presence of the Chesapeake Bay Plume at Mooring 1 contributed to the relatively higher level of total variance at this inner shelf site vs. that at Mooring 2. The kinetic energy at the lower level at Mooring 1 was comparable to the upper level at Mooring 2. At Moorings 4, 5, and 7, 7m below the surface in 23, 29 and 75m of water, respectively, the total variance shifts from 545 to 448 to 728 (cm/sec)², with the M2 and greater frequency motions occupying 29 (56)%, 41 (62)%, and 12 (16)% of the total (across-shelf) fraction, respectively. Thus, in the inner shelf, winds and the CBP dominated, while somewhat further offshore, in the inner to mid-shelf, the wind influence was maintained while the CBP influence diminished and inertial-tidal motions increase. In the mid shelf the winds maintained influence while the M2 tide peaked in relative contribution. On the outer shelf, represented by Mooring 7, the influence of the wind was retained, the M2 tide was greatly diminished, and the lateral influence of the Gulf Stream, though not significant relative to that of the wind-field, became evident.

Progressing south along the 30m isobath, from Mooring 5 to Moorings 14, 18 and 24, the total variance at 7m to 8m below the surface increased from 448 to 514 to 667 to 1056 (cm/sec)², which constitutes nearly a 2.5 fold increase in total variance from the north to the south line. At Mooring 14, 7m below the surface, the M2 and higher frequency motions occupied 28 (69)% of the total (across-shelf) variance (Figure 4a). This

represented a decrease in influence of the M2 relative to that at Mooring 5, a trend that continued to the south. A schematic of normalized variance for the near-surface instrument at Mooring 24 (Figure 4b) was clearly much larger than at Mooring 14. At Mooring 23, 8m below the surface in 20m of water, total variance was 925 vs. the $380(\text{cm/sec})^2$ value at Site 2, again 2.5 fold increase. At Moorings 25 and 26, 7m below the surface in 36 and 75m of water, respectively, total variances are 1241 and 3293 $(\text{cm/sec})^2$.

Figure 4

Minima in total variance were found at depth on Moorings 8 and 27, 827m and 822m from the surface respectively, where values of 29 and 5 (cm/sec)² were observed. Clearly these are very low energy sites and may even suggest a north to south decrease in what is already very low energy, in keeping with the notion of a zone of deposition on continental slope at these depth (Verity, et al., 2002).

In summary, the decomposition of variance across and along the OMP continental margin suggests the following banding of OMP waters. M2 tidal and higher frequency motions are most prominent in mid- to inner-shelf waters. Inertial and diurnal motions generally occupy less than 5% of the total, peaking at 12% of the total variance in near-surface waters at mid-shelf, in the central and northern portions of the array. The wind field is important inshore of the shelf break (~ 75m). The Gulf Stream, barely noticeable at the shelf break on the North Line (Mooring 7), became increasingly important to the south, and along the South Line, it was frequently evident in mid-shelf waters. Motions with periods in excess of 3 days tended to dominate the variance of the system throughout the array, save for the very deep (830-850m) sites where only longer period, low-energy motions of > 20 days were present. Wind-forced motions were far more energetic in the southern portions, relative to the middle and northern portion of the array, over the synoptic scale band of 2 days to 2 weeks. This finding is in keeping with the fact that wind motions over synoptic scales were more energetic in the southern portion of the array.

DIURNAL, INERTIAL, SEMI-DIURNAL AND HIGHER FREQUENCY MOTIONS

At Mooring 1, in 13m of water on the inner shelf on the North Line, sensors were placed at 3m and 6m above the bottom (or nominally, 7 and 10m below the surface). Here, at the shallowest mooring of the entire array, there was coherent, small, stable, elliptically polarized, clockwise rotating motion at periods of ~24, ~20, 12.42, 8, 6.2 and 4.1 hours, at both the upper and lower observational levels. The motions at these periods represent near-diurnal tidal, inertial, semi-diurnal (M2) tidal and tidal higher harmonics, respectively. The M2 tidal ellipse, aligned 40 degrees west of north and east of south, was

along-isobath with an eccentricity of 0.15 at the upper level and 0.0 (rectilinearly polarized) at the lower level. Thus, at the very shallow Mooring 1, the M2 tidal ellipse was very strongly frictionally compressed and rotated. At Mooring 3 in 23m of water, there were spectral energy peaks at 4.1, 12.42, and 20-25 hours, all with stable, clockwise rotary motions. There was a very broad-banded peak across the inertial-diurnal bands.

It is of note that in the OMP oceanographic region, near-diurnal motions are not significant contributors to the overall flow field dynamics. Inertial motions, while evident, had relatively low energy levels. However, the semi-diurnal or M2 tide was prominent throughout the array. The M2 tide is a frictionally modified Poincare wave on the shelf, as discussed by Pietrafesa et. al. (1985b). If the Poincare wave were pure or unaffected by bottom friction, the ratio of the minor to major axes would be the ratio of the M2 period to the local inertial period, or ~ 0.6 . For the SAB, Pietrafesa et. al. (1985b) demonstrated that the tidal ellipses are closer to theoretical predictions in near-surface and deeper waters, in general becoming more elongated and perpendicular to the coast in shallower and near-bottom waters. Battisti and Clark (1982) presented a thorough discussion of theory vs. reality for the U.S. Atlantic coast in which tidal motions reach their maximal amplitudes at mid-shelf on broad and shallow shelves.

In the northern region of the mooring array, from the 28m to the 75m isobaths, M2 tidal ellipses all displayed a minor to major axis ratio of ~ 0.6 at the near surface and interior levels. In the middle of the array, the tidal ellipse was slightly compressed (0.55) at the upper level at the 30m and 40m isobaths, but was 0.6 at the 75m isobath. In the southern part of the array, the ellipses were at 0.55, thus slightly compressed at the upper levels over the 30, 40 and 75m isobaths. Throughout, the ellipses remained aligned approximately on a WNW/ESE orientation. At Mooring 27 in 830m of water, the M2 axis ratio was 0.15 at 480m from the surface and 0.0 at 820m from the surface, with an E/W orientation in the interior and along topography (NNE/SSW) at the bottom level. On the 20m isobath, at Moorings 2 and 23, in the northern and southern portions of the array respectively, the M2 ellipse axes ratios were 0.4 at the upper level, 0.3 in the interior and 0.25 near bottom, in both cases aligned along-isobath.

The M2 tide and motions of higher frequencies are particularly important overall contributors to the energy of the currents in the northern and mid-shelf portion of the array. At Mooring 2, the variance of motions at semi-diurnal and higher frequencies contained 33% of the cross-isobath total. At mid-shelf Moorings 4 and 5, motions with frequencies equal to or greater than M2 contained 29% and 41% of the total variance, and 56% and 62% of the respective cross-isobath totals. At Mooring 14, M2 and higher frequency motions represented 28% of the total variance and 69% of the cross isobath component of variance. In summary, M2 tidal and super-tidal frequency motions

increased from the shelf-break, reached a maximum in mid-shelf waters, and then decreased both towards the coast and southward. For example, on the 30m isobath moving north to south, the variance of motions with periods shorter than or equal to the M2 period were $183(\text{cm/sec})^2$ at Mooring 5, $136(\text{cm/sec})^2$ at Mooring 14, $65(\text{cm/sec})^2$ at Mooring 18 and $52(\text{cm/sec})^2$ at Mooring 24. The influence of shelf narrowing in reducing the amplitude of tidal motions, following the theory of Battisti and Clark (1982), was quite evident. Clearly, at these northern and mid-shelf sites, the M2 tide occupied a significant portion of the cross-shelf variance.

While the M2 tide and motions at super-tidal frequencies may not affect the flux of particles to any appreciable extent, they can certainly contribute to the resuspension of bottom sediments in mid-shelf waters. This would allow for lower frequency current events to subsequently advect the tidally suspended particles long distances along and across the shelf.

SUB-INERTIAL FREQUENCY MOTIONS

At Mooring 1, the sub-inertial frequency currents were essentially bi-modal in direction and always aligned with the coastline, approximately NNW/SSE, with a preference for SSE-ward flow at both the upper and lower measurement levels. These flows were generally below 20 cm/sec in both directions, peaking at 80 cm/sec to the SSE, while never exceeding 40 cm/sec to the NNW. There also was very strong vertical shear along-isobath. In near-bottom waters the currents were more scattered, but there was a net counterclockwise shift relative to upper water column currents in that the flows were more toward the NW to WNW, and ESE. Near bottom current magnitudes were generally below 20 cm/sec and were always below 40 (60) cm/sec to the WNW (ESE). The flow field at this mooring site was rectilinear and driven by three different influences: 1) the along-shore component of the wind field; 2) the Chesapeake Bay Plume (CBP); and 3) the background southward drift over the shelf. Sub-inertial frequency motions tended to be concentrated in the 3-8 and 10-20 day bands, and aligned along an axis 30° (40°) west of north and east of south at the upper (lower) levels.

While the along-shelf motions at the inner shelf, Mooring 1, were very tightly coupled to the along-coast component of the wind, the current regime was also under the direct influence of the CBP. Assuming that over the period of observation, the along-isobath flows should have had the same background, southward flowing current of order 20 cm/s (Boicourt, 1973; Beardsley and Boicourt, 1981; Pietrafesa et al., 1994; Churchill and Berger, 1998), and assuming that the response to the winds should have been comparable

at both Moorings 1 and 4, the net difference between the moorings was ~ 10 cm/s. This component can be ascribed to be the flow field imbedded in the CBP. The along-shore flow field at Mooring 1 responded to the along-shore component of the wind in a frictionally modified barotropic, geostrophic manner, with southward (northward) winds setting waters up (down) at the coast, thereby driving an along-isobath current to the right (left) of the cross-isobath pressure gradient. Bottom friction or bottom-induced turbulence reduced the flow at the lower instrument, indicating that the current field was in coastal Ekman, frictional equilibrium balance. The observed cross-isobath flows were to the left of the wind, driven by mass conservation requirements. Coastal sea level appeared to be influenced by the CBP such that, when winds were southward, sea level at Duck initially built up more than at Cape Hatteras, reflecting the increased discharge of the CBP (Boicourt, 1973).

We see in Figures 2a, c, and d that when winds blew toward the south (north), sea level rose (fell) faster and higher (lower) at Duck than at Cape Hatteras. These findings were not in keeping with those of Janowitz and Pietrafesa (1979, 1994). Those authors found that sub-inertial frequency sea level rise and fall from Woods Hole, MA to Charleston, SC was tightly coupled to fluctuations in strength and persistence of the along-shore component of the synoptic-scale wind field. However, those studies did not focus on coastal sea level fluctuations immediately downstream, i.e. to the south of the mouth of Chesapeake Bay in the principal vicinity of the CBP. In effect, the southward wind case resulted in full plume presence at Duck much sooner than at Hatteras, and the coastal water level recorder sensed the additional water. The northward wind case removed much of the plume influence at Duck, but brought South Atlantic Bight (SAB) water to and across Diamond Shoals. Nominally, a 10m/s along-shore wind sets up an along-shore difference in water level up to ± 30 cm over the approximate distance of 100km between Duck and Hatteras. The effect was likely confined to the near-coastal region since the cross-shelf interior flows were related to bottom stress and mass conservation. Several excellent examples of the above scenarios occurred during the OMP period of observation.

At Mooring 1, when the winds blew southward (northward), currents 7m below the surface and 3 m above the bottom became more southward and offshore (northward and onshore), temperatures and salinity both dropped (rose) and coastal sea level rose (fell). This scenario is shown in Figure 5. The current, temperature, and salinity responses were observed to occur within 8-10 hours following the onset of the wind in keeping with the findings of Janowitz and Pietrafesa (1979) and Chao and Pietrafesa (1980). Thus the layer of water shallower than 7m from the surface flowed opposite to the interior, cross-isobath flow field. It is assumed that the water within the bottom three meters of the water column veered offshore (onshore) under southward (northward) wind forcing conditions. To conserve mass in this coastal Ekman system, the cross-isobath transport surface layer would have to have been comparable in magnitude to the vertical integral of

the interior, cross-isobath flow field. While cross-shelf and northward currents at the upper and lower levels were approximately equal in magnitude throughout the entire time series, southward along-isobath currents at the upper level were generally 15-20cm/sec greater than at the near bottom level, resulting in a vertical shear of 0.05s^{-1} - 0.07s^{-1} . This may be indicative of the suppression of vertical turbulence by stratification in this, the region of strongest influence of the CBP.

Figure 5

During southward wind events, water masses at Mooring 1 were dominated by a combination of CBP and Virginia Coastal Water (VCW) (Pietrafesa et al., 1994) when salinity ranged from 25 to 28. A combination of CBP/VCW and Middle Atlantic Bight Water (MABW) (Flagg et al, 2002) with salinity below 33, and Carolina Coastal Water (CCW) with salinity above 34, were often located to the south of the mooring prior to

northward wind events. Then, as a function of the strength and persistence of the northward wind, first the former, and then the latter were advected by the mooring during these wind events. When the flows were to the south, CBP water dominated the water column. On approximately 18 April, the hydrographic regime at this site transitioned from winter-time ($\sim 2^{\circ}\text{C}$) to summer-time ($8\text{--}11^{\circ}\text{C}$) conditions. However, the water column remained nearly vertically unstratified throughout the entire observational period.

Mooring 2 was deployed in 21m of water, with sensors located 3, 10, and 13m above the bottom ($\sim 18, 11,$ and 8m below the surface). At sub-diurnal periods the motions were aligned north/south with maximal speeds of $\sim 60\text{ cm/sec}$ in near surface waters, $\sim 40\text{ cm/sec}$ in the interior, and $\sim 20\text{ cm/sec}$ in near bottom waters. Vertical shears were thus nearly uniform. Over periods of 2-4 days, motions were clockwise-polarized, in keeping with wind-field motions at these periods. The response is more pronounced in the upper part of the water column. What is unusual about Mooring 2 was that its location could be either in the out-welling region of the CBP (as was Mooring 1), or in the path of along-shelf water mass transport from the north (both VCW and MABW), which occasionally was directed towards the mouth of the Bay. Although this finding may appear to be unusual, it is in keeping with the results reported by Boicourt (1981). Since the CBP was only occasionally evident at Mooring 2, the response of the currents to the wind would be expected to be more like that at Mooring 3. However, this was not the case.

In general, the flows at Mooring 2 were uniform in direction from top to bottom, display strong and near-constant vertical shear, and were tightly coupled to the along-shore component of the wind field. Currents, temperature and salinity at this mooring were controlled by dynamics similar to those at Mooring 1, with some differences. As mentioned above, the CBP was only occasionally present at this site, with the mooring generally located at or offshore of the eastern edge of the plume. This eliminated the net 10cm/sec drift of the plume itself from the composition of the total current field. The unexpected feature at Mooring 2 was the net movement of interior waters toward the north over the February-March observational period. A particle located at Mooring 1 would have moved decidedly south, some 600km at the 7m level and 80km at the 11m level. However, at Mooring 2 at the 7m level, a particle would have experienced a net 50km southeastward motion over the entire period of observation, while at the 11 and 18m levels, particles would have been advected about 200km to the north-northwest. Boicourt (1981) reported similar observations. In a theoretical study, Zhang et al. (1985) found that for the conditions of a southward (northward) flowing ambient shelf current, the CBP should turn right and flow southward (northward) after exiting the mouth of Chesapeake Bay. However, in both cases theory suggests there should be a compensatory inflow of shelf waters coming from the north, east, and southeast of the bay mouth. In keeping with the prior findings of Boicourt (1981) and the theory of Zhang et al. (1985), the observations from Mooring 2 appear to define the outer edge of the Chesapeake Bay

mouth bottom intake region. This has important implications for sediment fluxes in this region.

Consider the following scenario based upon an extra-tropical cyclone (ETC) event that moved rapidly northward over the MAB and the array on 12-14 February (Event A). Southeastward winds (Figure 2a) induced a 4m significant height wave field (Figure 2b), a 20cm rise in coastal sea level at Duck (Figure 2c), 20-25cm/sec currents and a 7 (6) drop in salinity at the 7(10)m level at Mooring 1 as the CBP moved down the coast. However, at Mooring 2, while near-surface currents were 10cm/sec southward and salinity dropped by 4.2, interior and near-bottom currents were northward and salinity dropped by only 0.7. This suggests that sediments that were either resuspended locally by the wind induced current and wave enhanced bottom shear stresses (Churchill et al, 1994), and being advected by Mooring 2, could subsequently be entrained into Chesapeake Bay, thus introducing marine sediments into the estuary. Meanwhile close to shore, Chesapeake Bay sediments were advected down the coast towards Cape Hatteras.

Mooring 3 was located in 23m of water 38 km offshore on the North Line, with sensors at 3m and 12m above the bottom (~ 20m and 11m below the surface). At the upper level, which was often in the interior, sub-tidal flows were either southward at speeds up to 60cm/sec or north-northeastward to east-northeastward at speeds up to 40cm/s. Here, the north to south drift in the MAB of 20cm/sec showed up very well in the overall average. The flows at the lower sensor were either north-northeastward or southward at speeds typically ranging from 10-22cm/sec. There was a net advection to the southeast at both levels, consisting of a series of northeastward flow periods, followed by stronger southward flow, creating a net displacement to the southeast of ~500km at the upper level, and 230km at the lower level. Sub-diurnal frequency along-isobath motions were an order of magnitude more energetic than were cross-isobath components. Again, stable, coherent, clockwise-polarized wavelike north/south aligned motions were very evident in the 2-3 day period band. At periods longer than 3 days, highly coherent motions in the 3-8 day range were rectilinear and aligned north/south. Like the across- and along-shelf coupled motions described for the currents at Moorings 1 and 2, northward (southward) flows were accompanied by onshore (offshore) interior flows at all observational levels. This suggests that the surface frictional Ekman layer was not observed in our sampling scheme. Temperature and salinity were very weakly stratified in the vertical, never exceeding 1°C and 1 salinity unit until 15 April when the temperature and the temperature differential both increased, reaching a vertical difference of >3°C by the first week in May. This vertical stratification did not occur at Moorings 1 and 2.

Mooring 4 was deployed 55 km offshore in 23m of water, with sensors at 3, 8, 14, and 17m above the bottom (~ 20, 15, 9 and 6m below the surface) on the north line (Figure

6). Currents, in general, exhibited a bi-modal directional distribution at every level. At the upper two instruments, the currents tended to be north-northeastward to east-northeastward at maximal speeds of 45 cm/sec, and southward to west-southwestward at maximal speeds 60 and 50cm/sec. For the lower two instruments, the currents tended to northward at speeds reaching 40cm/sec, or southward, with speeds reaching 55cm/sec to 40cm/s. The coherency, stability, degree of wavelike vs. rectilinear particle motions, and the relationships among east and north components, and the wind field, were identical to those at Mooring 3. Net particle excursions would have been 550, 500, 450, and 200kms to the south-southwest for the upper to lower levels over the period of observation. In the vertical, temperature and salinity were remarkably uniform from the beginning of the record through to 20 April. Then the salinity (temperature) at the lower (upper) two sensors became 1 unit (3.5°C) lower (higher) than the upper (lower) two sensors. Suddenly, the system had become vertically stratified.

Figure 6

The observations show that the currents and hydrographic properties from the mid-shelf moorings throughout the array followed the same basic pattern as reported for Mooring 4. This was true for currents and properties at moorings, 5, 6, 9, 10, 11, 12, 14, 15, 18, and 19 (Figure 1). The kinetic energy spectra and hodograph descriptors were essentially the same for all of these moorings at comparable levels in the water column. Representative hodograph descriptor plots of maximum and minimum coherence, tendency towards circular or rectilinear, clockwise or counter-clockwise polarization, stability, and principle axes orientations are presented for the upper level (6.3m below the surface) instrument at Mooring 4 in Figure 8. Velocities were correlated with the along-shore component of the wind; they were clockwise-rotating, and elliptically-polarized for motions with periods of 2-4 days, and rectilinear for motions with periods of 4-8 days. The basic differences between the time series at Mooring 4 with those at Mooring 23 (Figure 7) were in temperature and salinity . This is easily understood since southerly winds can drive CCW into the MAB just as MAB waters are often driven into the SAB (Pietrafesa et al., 1994). Examples of both types of events will be presented next.

OMP96A Mooring 23 : 40 Hr LP Data from Feb to May

Figure 7

Figure 8

During the period 11-14 March (yeardays 72-75; Event B), an ETC passed over the array, and southward winds (Figure 2a) induced 5m significant height amplitude waves (Figure 2b) and strong currents to the south at all sites, save for deep water Moorings 8, 26 and 27. Any sediments in the CBP, along with those coming from farther offshore on the shelf, both in the water masses being advected down-shelf and those locally resuspended, would have been carried south into the SAB, breaching Diamond Shoals as shown in the AVHRR satellite image in Figure 9a.

a:

b:

Figure 9

Alternatively, northward winds commencing on 13 April (yearday 105; Event C) and persisting for about two weeks, induced northward flow, dramatic increases in salinity and rises in temperature, accompanied by bursts of 3m amplitude waves. Over this period, highly saline, warmer CCW moved across Diamond Shoals into the MAB (cf. Figure 9b), penetrating as far north as Site 18. Not surprisingly, to the north of this

observational site, salinity was observed to drop, as low salinity inner shelf MAB waters were advected seaward across the shelf. Over this period there was a drop in coastal sea level at the coast (Figure 2c), but there was also a south to north, downward tilt in sea level (Figure 2d). The inability to propagate Kelvin Waves northward along the coast resulted in a trapping or a build-up of water against Diamond Shoals and the only way for it to relax was by way of a geostrophically balanced offshore transport of shelf waters. Here, northward winds induced an offshore flux of surface water via time-dependent Ekman forcing, and interior and near-bottom water fluxes via an alongshore pressure gradient.

Along the shelf break on the 75m isobath, currents were generally aligned, top to bottom, with the topography, based upon results from Moorings 7, 13, 16, and 17. At Mooring 20, the upper level currents were aligned with the topography, while the lower water column and near-bottom flows showed an offshore or counter-clockwise, southeasterly turning of the velocity vector with depth. This local effect may be due to a bend in the topography. While the flow at 9m below the surface had a sub-diurnal principle axis (PA) alignment of north/south, the flows at 56 and 71m from the surface were aligned towards the south-southeast. At Mooring 22, 24m below the surface, the PA was north/south; at 38m, the PA was south-southeast/north-northwest; and at 73m below the surface, the PA of the flow field was southeast/northwest. Curiously, at Mooring 22, there was evidence of a 3-4 day stable wave, with counter-clockwise polarization about an ellipse oriented north/south, with a minor to major axis ratio of 0.3. There was also evidence of rectilinear motion in the 4-8 day band. This suggests that either the synoptic scale 3-8 day wind forcing excited a wave-like response in the Gulf Stream Front (GSF), or that GSF waves at that period frequently passed by the mooring. The net result of the mean and oscillatory flows was that particles passed by Mooring 22 on a southeastward or offshore direction throughout the water column.

At Mooring 24 in 30m of water, the sub-diurnal flow field was locked into the alongshore component of the wind stress. Southward (northward) winds drove currents southward (northward) carrying low salinity, cold (high salinity, warm) waters from the MAB (SAB, specifically CCW) past the mooring. The PA of the sub-diurnal flow field was north/south. The east and north components of the horizontal flow field indicated that southward (northward) flows were accompanied by offshore (onshore) interior flows from 8m below the surface to 3m above the bottom.

Mooring 25, in 36m of water, exemplified the persistent export of shelf waters from the MAB to the continental slope. The mooring location was characterized by sub-diurnal currents that were wind dominated in the alongshore direction by the alongshelf component of the wind field. The PA of the flow fields at 7m, 17m and 33m below the

surface were aligned north-northeast/south-southwest., Alongshelf flows of magnitude 30 to 100 cm/sec at all levels were accompanied by robust cross shelf flows of 20 to 50 cm/sec. At 7m, 17m and 33m below the surface, northward (southward) flows also exhibited strong (relatively weak) offshore flows. The progressive vector diagrams for Mooring 25 (Figure 10) illustrate the strength of offshore flux at this location.

Figure 10

We now consider several events to demonstrate the well organized, shelf-wide response throughout the OMP domain. Many investigators assumed that the physical oceanography in this area was likely so chaotic and disorganized that it defied a measurement program that would produce meaningful results. Quite the contrary, the domain appears to be physically well organized, with very well defined processes, at least during the February/May 1996 experimental period.

Coastal sea level responded to the alongshore component of the wind field in the following way. Within 8-10 hours of the onset of a southward (northward) wind, sea level rose (fell) along the entire North Carolina/Virginia coastline. In general, the fluctuations in water level at Duck were larger and occurred sooner than did those at Cape Hatteras. The Chesapeake Bay Plume and Diamond Shoals, which extends offshore of Cape Hatteras, both appeared to play important roles in changing the response time, as well as the magnitude of response, of coastal sea level in this area. We found that southward (northward) winds built water up at (drove water away from) the coast via Ekman dynamics, drove the CBP to the south (north), while also building water levels up along Diamond Shoals. This then had a dual effect. Accompanying southward (northward) winds, sea level set up (dropped) not only at the coast, but particularly at Duck and the shoals. While Pietrafesa et al. (1994) showed that southward wind events were accompanied by excursions of MAB waters across Diamond Shoals, the shoals acted as a partial barrier to southward flow. When the southward (northward) winds subsided, sea level at the coast dropped (rose) at Duck with the freshwater Chesapeake Bay Plume retreating (advancing) from (into) the area. However at the shoals, water piled up. What becomes of this water?

The same scenario as that described above occurred at Cape Hatteras, but since water level at Hatteras was less affected by the CBP, it reacted with less magnitude than at Duck, though it did receive water from the SAB. The net result was that, when southward winds relaxed, there was no immediate mechanism to cause a flow of water to the north, such as Kelvin waves. A northward and offshore sea level pressure gradient force between Diamond Shoals and Duck was established, and water was driven offshore as a geostrophically balanced flow. This pressure gradient force not only moved CBP, VCW, and MABW offshore locally in the southern part of the array, for example at Mooring 25, but also into the middle of the array in the vicinity of Moorings 14 and 15. This created a temporary blockage in the along-shore transport while forcing an offshore flow at Moorings 14 to 15, to 20 and 22. These water masses then converged with waters headed eastward across the shelf in the southern part of the array near Mooring 25. It is of note that this scenario did not require a relaxation in the wind in order for offshore transport to occur, though that would certainly have enhanced its presence. The pressure gradient build-up against the shoals impacted the interior and near bottom waters, while the surface transport was shoreward in a surface Ekman layer. The pressure gradient force thus drove the interior waters offshore. When the wind subsided, a peculiar situation remained in which the elevation against the shoals could communicate with the shore because that would be in opposition to the direction of Kelvin wave propagation. Thus, the only way for the elevation to subside was through dissipation via offshore advection.

The wave measurements at the NDBC 44014 buoy showed, in general, that southward winds generated the largest surface gravity waves. Waves with significant wave height up to 6m were observed on at least three occasions, centered about 05 February, 17 February

and 12 March. All were associated with 2-8 day persistent southward winds of order 15-20m/s. Northward winds typically generated waves of significant wave height below 3m. While winds from both directions resuspended bottom sediments, southward winds clearly induced a surface gravity wave field of greater significant height and the observed down-shelf currents were larger in magnitude than their northward counterparts. The net effect was a much larger, more effective, bottom shear-stress during southward wind events, as compared to northward wind events, with maximal interaction between waves and currents.

VI. CONCLUSIONS

The time series of atmospheric winds, coastal sea level, surface gravity waves, currents, water temperature and salinity for the period February-May 1996 across the extensive and intensive OMP moored array defined a well-organized physical oceanographic system.

The M2 tide was very prominent across the array and was manifested as a clockwise-rotating, elliptically-polarized wave with predominantly cross-shelf orientation of the ellipse. It was a Poincare wave with an ellipse axis ratio of ~ 0.6 in upper layer waters and in offshore waters. However, bottom friction compressed and rotated the tidal ellipses in shallow and near-bottom waters. At the innermost mooring (in 13m of water) the tidal ellipse vanished near the bottom and the tidal motion became rectilinear along-isobath. Tidal harmonic motions were evident at mid-shelf moorings at periods of 4.1 hours, and robust elliptically-polarized, clockwise-rotating motions were also evident at near-inertial and diurnal periods.

The wind field was dominated by 2-14 day events centered about 4-8 days. Due to the location of continental and oceanic large-scale atmospheric systems and the pathways of winter storms in 1996, the synoptic-scale wind field at the southern portion of the array was far more energetic than in the north. Wind events with periods greater than 4 days, particularly in the 4-8 day period range, were very strongly rectilinear and aligned north/south. During the observational period, 5 February-17 April, the winds had higher variances than during the period following 17 April. Following 17 April, synoptic-scale winds were predominantly northward, with occasional northwestward to northeastward oscillations.

Sub-diurnal frequency currents were kinematically and dynamically responsive to the wind field at all locations, with several variations to the theme. Since the winds were more energetic in the southern portion of the OMP array, so were the wind-driven currents. The shelf-wide, southward drift of MAB waters also contributed to synoptic to seasonal scales of motion. Since the wind band ranged from 2 days to 2 weeks, centered about 4-8 day events, and given that wind events dominated the current field in waters out to 75 meters, the notion of an observational period length mean must be qualified. It is of note that the notion of the mean really has no dynamic or kinematic meaning other than to define the net record length motion at each mooring. However in 75m and deeper waters, the flows were persistently southward, resulting in an equally persistent offshore flow in the bottom boundary layer. Likewise, at Mooring 25 in 36m of water, the means

do have persistent meaning because the flows were persistently directed offshore. The record length mean current distributions at the upper and lower instruments across the array as well as the mean wind vector are shown in Figure 11.

Figure 11

Sea level at the southern end of the MAB played a very important role in the overall dynamics. Southward (northward) winds drove MAB (SAB) waters toward Diamond Shoals with the following results: 1) MAB (SAB) waters spilled across the shoals into the SAB (MAB); 2) MAB (SAB) waters piled up on (spread away from) the shoals; and 3) MAB waters piled up faster at the coast than farther offshore because of a shorter spin up time. Thus, within 8-10 hours of the onset of the wind, an alongshore, southward barotropic, geostrophic jet was established. For southward winds, interior flows were southward and offshore. Bottom flows were offshore as well. As the winds abated and reversed, water levels dropped away from the shoals. Sea level over the shoals remained more elevated because they received either SAB waters from the south or MAB water

from the north. Thus a northward pressure gradient force in the southern MAB was established. This pressure gradient blocked MAB waters from coming south to the shoals and caused MAB waters to veer southeastward and offshore from the middle of the OMP array down into the southeastern corner, just to the north of the shoals.

In Figure 11, the averages of the individual time integrals of the time series of current vectors collected at the upper and lower measurement levels across the mooring array during the February-May 1996 period of the OMP are presented. This figure also provides a perspective of where a depo-center might exist. Specifically the mean vectors in Figure 11 suggest that the most likely location of a depo-site area would be offshore of Moorings 22 and 25 (cf. Figure 1 for mooring locations), and probably in the vicinity of Mooring 27. The mean vectors at the bottom level at mooring 27 suggest a slow flow, of ~ 2.6 cm/s, to the west-southwest slightly across isobath. According to the topographic theory of Janowitz and Pietrafesa (1982), this would kinematically induce down-welling locally. Thus, as sediments move offshore and down-slope, they could be advected slowly south-southwestward, and also locally deposited as they are removed by gravity.

VII. ACKNOWLEDGEMENTS

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VIII. TABLES

Table 1. Listing of moorings and instruments for the first OMP deployment together with record means.

Moorings No. (Institution)	Inst Type	Inst Depth (Water Depth) meters	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° N	Longitude ° W	U (cm/sec) (MEAN)	V (cm/sec) (MEAN)	Temp (deg C) (MEAN)	S (psu) (MEAN)
1 (NCSU)	SP	7(13)	2/5	5/8	36 40.187	75 51.651	1.7	-7.9	5.6	30.0
	SP	10(13)	2/5	5/8	36 40.187	75 51.651	0.2	-0.9	5.6	30.8
2 (NCSU)	SP	8(21)	2/5	5/8	36 40.274	75 45.844	0.6	-0.3	5.4	31.6
	SP	11(21)	2/5	5/8	36 40.274	75 45.844	-0.2	1.5	5.5	32.1
	SP	18(21)	2/5	5/8	36 40.274	75 45.844	-0.3	1.7	5.4	32.0
3 (FSU)	ace	11(28)	2/6	5/8	36 40.30	75 28.05	3.1	-5.8	6.2	32.8
	ace	20(28)	2/6	5/8	36 40.30	75 28.05	1.4	-2.5	5.8	32.7
4 (NCSU)	SP	6(23)	2/8	5/8	36 40.463	75 17.396	-1.1	-6.5	6.6	33.0
	SP	9(23)	2/8	5/8	36 40.463	75 17.396	-1.9	-6.1	6.6	32.9
	SP	15(23)	2/8	5/8	36 40.463	75 17.396	-1.8	-4.3	6.3	33.1
	AA	20(23)	2/8	5/8	36 40.463	75 17.396	-1.8	-1.7	6.3	33.1
5 (FSU)	SC	10(29)	2/8	5/9	36 41.118	75 05.699			7.3	33.1
	SC	18(29)	2/8	5/9	36 41.118	75 05.699			6.9	33.2
	SC	24(29)	2/8	5/9	36 41.118	75 05.699			6.8	33.3
5* (FSU)	whadcp	29(29)	2/8	5/9	36 41.816	75 05.556	-0.5 (10m) 1.6 (18m) 1.6 (24m)	-4.0 (10m) -2.8 (18m) -2.2 (24m)		
6 (NCSU)	SC	10(40)	2/8	5/9	36 40.519	74 53.360			7.6	33.3
	SC	22(40)	2/8	5/9	36 40.519	74 53.360			7.2	33.4
	SC	37(40)	2/8	5/9	36 40.519	74 53.360			7.3	33.6
7 (NCSU)	S4	7(75)	2/6	5/16	36 40.231	74 45.917	-2.3	-18.8		
	SC	10(75)	2/6	5/16	36 40.231	74 45.917			7.9	33.5
	SC	22(75)	2/6	5/16	36 40.231	74 45.917			7.8	33.6
	SC	37(75)	2/6	5/16	36 40.231	74 45.917			8.0	33.8
	SC	72(75)	2/6	5/16	36 40.231	74 45.917			9.7	34.5
9 (FSU)	ace	7(39)	2/7	5/9	36 35.879	74 55.719	-1.4	-11.2	8.3	33.2
10 (FSU)	SC	23(39)	2/7	5/9	36 36.824	74 55.692			9.6	34.4
	SC	36(39)	2/7	5/9	36 36.824	74 55.692			7.2	33.5
11 (NCSU)	S4	8(37)	2/7	5/9	36 30.672	75 03.224	-2.1	-3.8	7.8	33.1
	SC	22(37)	2/7	5/9	36 30.672	75 03.224			7.3	33.4
	SC	34(37)	2/7	5/9	36 30.672	75 03.224			7.2	33.4
12* (FSU)	whadcp	40(40)	2/7	5/10	36 31.910	74 52.164	-0.8 (10m) 1.7 (20m) 0.6 (35m)	-12.7 (10m) -11.9 (20m) -9.3 (35m)		
13 (FSU)	bscm	17(76)	2/7	5/11	36 31.145	74 48.039	-4.8	-18.3	7.4	
	bscm	40(76)	2/7	5/11	36 31.145	74 48.039	-1.4	-18.8	7.3	33.6
	bscm	71(76)	2/7	5/11	36 31.145	74 48.039	0.0	-4.5	8.9	34.3
14 (NCSU)	S4	7(30)	2/12	5/12	36 15.398	75 14.328	-0.1	-6.4	7.3	33.5
	SC	22(30)	2/12	5/12	36 15.398	75 14.328			6.9	33.3
15 (NCSU)	SP	8(40)	2/12	5/12	36 15.432	75 04.422	-0.1	-6.1	8.0	
16 (FSU)	ace	7(76)	2/12	5/11	36 15.655	74 52.485	-0.4	-12.9	9.0	33.7
	bscm	23(76)	2/12	5/11	36 15.655	74 52.485	-2.5	-11.2	8.3	
	bscm	37(76)	2/12	5/11	36 15.655	74 52.485	-2.2	-10.8	7.5	33.8
17 (NCSU)	SP	7(75)	2/12	4/2	36 07.063	74 54.573	-1.0	-7.3	8.8	33.8
	SC	22(75)	2/12	4/2	36 07.063	74 54.573			9.2	31.0
	SC	37(75)	2/12	4/2	36 07.063	74 54.573			9.1	31.0
	SC	72(75)	2/12	4/2	36 07.063	74 54.573			9.4	31.5

18 (NCSU)	SP	8(31)	2/12	5/12	35 50.874	75 13.564	-0.2	-8.9	8.8	32.8
	SP	23(31)	2/12	5/12	35 50.874	75 13.564	-2.8	-8.4	7.7	33.3
	AA	28(31)	2/12	5/12	35 50.874	75 13.564	-1.0	-2.9	7.7	34.2
19 (FSU)	ace	8(41)	2/12	5/12	35 51.010	75 03.759			9.2	29.5
20 (FSU)	ace	9(76)	2/11	5/12	35 51.039	74 55.259	2.0	-11.0	11.0	33.8
	SC	38(76)	2/11	5/12	35 51.039	74 55.259			11.0	34.4
	SC	72(76)	2/11	5/12	35 51.039	74 55.259			9.6	34.4
20* (FSU)	whadcp	76(76)	2/11	5/12	35 51.039	74 55.259	-0.2 (16m) 0.1 (36m) 2.1 (71m)	-8.7 (16m) -7.4 (36m) -8.0 (71m)		
22 (FSU)	ace	9(77)	2/11	5/14	35 38.285	74 51.495	8.4	-5.5	12.7	
	bscm	24(77)	2/11	5/14	35 38.285	74 51.495	4.3	-4.3	14.2	33.9
	bscm	38(77)	2/11	5/14	35 38.285	74 51.495	3.4	-5.0	13.8	34.1
	bscm	73(77)	2/11	5/14	35 38.285	74 51.495	3.2	-5.9	11.6	34.0
23 (FSU)	ace	7(20)	2/10	5/13	35 27.029	75 23.954	-0.4	-6.2	10.1	32.0
	ace	16(20)	2/10	5/13	35 27.029	75 23.954	-1.6	0.9	10.8	32.7
24 (FSU)	ace	8(30)	2/10	5/13	35 27.035	75 14.470	3.0	-8.6	11.2	35.2
	SC	17(30)	2/10	5/13	35 27.035	75 14.470			12.0	33.7
	bscm	27(30)	2/10	5/13	35 27.035	75 14.470	1.1	1.3	12.3	34.4
25 (NCSU)	ace	7(36)	2/10	5/13	35 27.031	75 03.664	12.9	-3.8	13.0	34.2
	ace	17(36)	2/10	5/13	35 27.031	75 03.664	12.7	0.7	13.6	34.4
	S4	33(36)	2/10	5/13	35 27.031	75 03.664	6.1	2.9	13.0	34.4
26 (NCSU)	SP	7(75)	2/10	5/13	35 27.273	74 52.294	27.4	37.7	17.1	35.1
27 (NCSU)	AA	480(832)	2/10	5/13	35 27.238	74 47.409	-2.8	-2.2	6.1	34.9
	S4	730(832)	2/10	5/13	35 27.238	74 47.409	-1.8	-2.6	2.8	33.5
	AA	822(832)	2/10	5/13	35 27.238	74 47.409	-1.5	-2.2	4.5	34.9

SP	Seapac current meter	S4	InterOcean S4 Current Meter
AA	Aanderaa current meter	SC	SeaCat T,S sensors
whadcp	Workhorse acoustic Doppler current profiler	Ace	Ace Current Meter
nbadcp	Narrow band acoustic Doppler current profiler		

Table 2. Location of meteorological, sea-state, and sea-level observations.

<u>Station</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Water Depth (m)</u>
44014 Met, Sea-State	36.6 N	74.8 W	47.5
chlv2 Met	36.9 N	75.7 W	~15.0
dslv7 Met	35.2 N	75.3 W	~15.0
Duck Water Lvl	36.18 N	75.75 W	~0.0
Cape Hatteras Water Lvl	35.22 N	75.64 W	~0.0

IX. FIGURES

Figure 1. OMP February-May, 1996 Mooring Array

Figure 2. a. 40 Hour low passed (HLP) time series of the wind vector at NDBC Buoy 44014 with upward vectors indicating northward, b. Time series of significant wave heights at NDBC Buoy 44014, c. Time series of 40 HLP coastal sea level at the Duck Pier and at Cape Hatteras, d. Time series of differences of sea level at Duck and Cape Hatteras. Events A, B, C are discussed in the text.

Figure 3. Normalized kinetic energy of the east/west (+/- u) and north/south (+/-v) components of the wind vector at:

- a. NDBC Buoy 41004
- b. Diamond Shoals Light Station

Figure 4. Normalized kinetic energy of the east/west (+/-u) and north/south (+/-v) and total flow field at:

- a. Mid-shelf Mooring site 14, 7m below the surface
- b. Mid-shelf Mooring site 23, 7m below the surface

Figure 5. 40 HLP time series of u, v, S, T at Mooring 1

Events A, B, C are discussed in the text

Figure 6. 40 HLP time series of u, v, S, T at Mooring 4

Events A, B, C are discussed in the text

Figure 7. 40 HLP time series of u, v, S, T at Mooring 23

Events A, B, C are discussed in the text

Figure 8. Hodograph descriptor plot for currents from 6.3m below the surface at Mooring 4. Lower panel shows maximum and minimum coherence between orthogonal horizontal velocity components as a function of frequency. Middle panel shows the stability, axis ratio and circular vs. rectilinear tendencies of motion as well as clockwise vs. counter-clockwise polarization of particle motions as a function of frequency. Upper panel shows orientation of principle axis of flow as a function of frequency of motion.

Figure 9. AVHRR sea surface satellite images for:

- a. 13March
- b. 17 April

Figure 10. Progressive vector diagram plots of currents at Mooring 25.

Figure 11. Observational period-length, mean upper and lower level current and wind vectors.

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8. Springtime Hydrography of the Southern Middle Atlantic Bight and the Onset of Seasonal Stratification

The area surrounding Cape Hatteras represents one of the most complicated and yet important continental shelf regions in the world. In this locale there are several, generally distinct, water types which move back and forth, across and along the shelf, driven by density contrasts, winds, and the movement of the Gulf Stream and its associated eddies. The area has special significance from the point of view of shelf/ocean interaction as it forms the terminus of the extended equatorward coastal circulation that starts in the Labrador Sea, resulting in the export into the open ocean of the remnants of this flow together with its load of suspended and dissolved material. It was within this regime that the Department of Energy's Ocean Margins Program (OMP) attempted to document not only the export of water and material from the shelf, but also the local transformations that took place prior to and as the water left the shelf. In this paper, the hydrographic data from a series of late winter to summer cruises, and temperature and salinity data from a moored array are used to document the structure and spring transformation that occurs on the shelf between Chesapeake Bay and Cape Hatteras in this critical shelf water export region.

The southern end of the Middle Atlantic Bight (MAB) has received a lot of attention because of the widely documented cross shelf transport, partly because there is such a clear distinction between the cold, low salinity waters of the shelf and warmer temperatures and higher salinities of the slope and Gulf Stream, and partly because this is one of the few places where current records actually show significant cross-isobath flow. Ford's observations along the northern border of the Gulf Stream (Ford, 1952) are generally credited as the first to show a long drawn-out filament of low salinity of clear coastal origin. Since then there have been a number of studies reaffirming the existence of shelf waters along the Gulf Stream, typically showing it as a subsurface salinity minimum (eg. Fisher, 1972; Churchill, Cornillon, and Hamilton, 1989; Lillibridge et al., 1990). In addition to observing the shelf water as having been drawn off by the Gulf Stream directly, the role of Gulf Stream frontal eddies has also been documented (eg. Gawarkiewicz et al. 1996; Churchill and Berger, 1998). Churchill and Berger also made a distinction between the direct source of the water leaving the shelf and where along the shelf the departure occurs. The loci of exit routes for the shelf water is not confined to the immediate area of Cape Hatteras but can extend northward perhaps as far north as 39°N as a result of the meandering of the Gulf Stream and the interaction of relatively high salinity waters that have upwelled within the slope sea (Churchill and Cornillon, 1991b). This is shown nicely by Churchill and Cornillon (1991a) in some AVHRR data, which illustrates broad areas of shelf water, as well as narrow streamers, exiting the shelf between 36.5°N and 38.5°N. Flagg et al. (1998) showed a late spring departure of cold

band waters from the shelf over a wide latitude band, which organized itself into a series of cold, anticyclonic eddies. Churchill and Berger (1998) noted that the water is seen to depart the shelf from the shelf/slope frontal region over wide areas while the middle and inner shelf water departures are generally confined to the immediate area north of Cape Hatteras.

The southern end of the MAB not only loses water offshore, it is subject to sometimes large scale intrusions of Gulf Stream and Gulf Stream frontal eddy waters (Gawarkiewicz et al. 1992; Gawarkiewicz et al. 1996; Churchill and Berger, 1998) and waters that enter the shelf from the South Atlantic Bight (SAB) south of Cape Hatteras and Diamond Shoals (Stefansson, et al., 1971; Pietrafesa et al., 1994). These processes not only markedly alter the hydrographic characteristics of the southern MAB, they may also play a part in the discharge of the shelf waters to the slope.

In terms of the broad scale hydrographic characteristics of the southern MAB shelf itself, Boicourt (1973) carried out a very nice set of dense surveys with which he identified many of the significant features in the area. Included in this list are upwelling events along the coast, the summer cold band over the outer shelf, and S-max intrusions within the seasonal thermocline. One item that did not figure largely in that data set were intrusions from the south, partly because his surveys did not extend quite far enough south to capture some of the less dramatic events, and partly because of the necessarily limited sampling. To some extent, the study described here is an extension of these early 1970's observations, focusing on those processes that take place on the shelf rather than the off-shelf flow events. The advantage of this data set is that with moored observations, as well as a number of cruises, we are able to resolve the temporal development of the hydrographic structure.

The area of interest for OMP is shown in Figure 1, stretching from just south of the mouth of Chesapeake Bay, south 130km to a point about 20km north of Cape Hatteras, and from the coast, offshore past the shelf break to about the 75 m isobath. (The shelf break occurs along the ~50m isobath in this area.) A total of eight hydrographic cruises were made in this area, four in 1993 and 1994, preceding the main field program, and four more during the main 1996 field year. As shown in Figure 1, the cruises were significantly augmented by an array of 26 moorings which are discussed further below. A more thorough description of the moored array is contained in Kim, et al. (2001) and Pietrafesa, et al. (2001). This paper will be using the combined hydrographic data from the cruises and moored array to describe the processes that occur from late winter into early summer on the shelf as the shelf transitions from an unstratified to a stratified condition.

Figure 1

Data Sets and Methods

While the OMP sampling effort was concentrated in 1996, there were a number of preliminary cruises to the area between Cape Hatteras and Chesapeake Bay in 1993 and 1994. As a result, there were a total of eight hydrographic cruises from 1993 through 1996, three of which provide coverage of late winter/early spring conditions when there was minimal vertical stratification and five cruises show late spring and summer stratified conditions. The dates of the cruises are shown in Table 1. The temperature and salinity data discussed in this paper were collected using a Neil Brown Mark III (NBIS) CTD on all but the two RV Iselin cruises. On CI9404 and on about half of CI9408, casts were

made using the University of Miami's Sea Bird CTD. The NBIS CTD was sent to a calibration facility prior to each year's cruises and salinity calibration checks were provided by bottle samples. The performance of the CTD was also periodically checked during deep casts that extended into the deep slope water where salinities and temperatures are typically close to 34.95psu at 4°C. The accuracies of the temperature and salinity data are estimated to be $\pm 0.01^{\circ}\text{C}$ and ± 0.01 psu, respectively.

Table 1. Ocean Margin Program cruise dates

Cruises	Dates
RV Gyre 9306	May 10 - 14, 1993
RV C. Iselin 9402	March 26 - April 4, 1994
RV C. Iselin 9404	April 18 - May 1, 1994
RV C. Iselin 9408	June 22 - July 2, 1994
RV Endeavor 279	March 1 - 10, 1996
RV Endeavor 280	March 12 - 19, 1996
RV Seward Johnson 9607	July 19- August 2, 1996
RV Seward Johnson 9608	July 28 - August 4, 1996

The coverage of the cruises varied, Figure 2, however, all the cruises made at least two cross-shelf transects in the OMP study area, one along the northern boundary which varied between 36.5°N and 36.7°N, and, with the exception of CI9408, another along the southern boundary between 35.5°N and 35.7°N. Additional sections between the northern and southern boundaries and repeat sections were sometimes occupied on these cruises. On two of the cruises during 1996, EN280 and SJ9607, detailed and repeated casts were also made in an area along the northern boundary following groups of drifters during biological time-series sampling.

Figure 2

In addition to the CTD from the cruises, hydrographic data are also available from temperature and salinity sensors from the 26 moorings deployed during the spring (Kim et al., 2001; Pietrafesa et al., 2001). The moorings were deployed in early February and retrieved in mid-May, 1996. The moorings enclosed an area bounded by two cross-shelf lines from the coast out to the ~800 m isobath along 36.7°N and 35.5°N, connected by a series of moorings along the 75 m contour. In addition, there were four moorings in the interior and four more in a small area in the northeast corner of the array. The

instrumentation recording temperature and salinity included 64 current meters (RCM-4s, S4s, ACEs, and FSU/102s), plus 62 other instruments that variously monitored temperature and salinity, and sometimes additionally, dissolved oxygen or chlorophyll fluorescence (Seacats, YSI DO sensors, and BNL flurometers). The number of temperature/salinity sensors on each mooring varied from two on the shallow near-shore moorings, to as many as 10 on some of moorings in the northeast corner of the array. Instruments measuring different parameters were often grouped together, reducing the apparent vertical measurement density.

The inter-calibration of this instrumentation was not a simple matter despite pre-deployment calibrations. Post deployment calibration was generally not carried out as the instruments were onshore for only a brief period before a subsequent summer deployment. Thus, the only calibration method available was to compare the records with CTD profiles taken near the moorings at the time of deployment and recovery and to those casts taken near the moorings during EN280 in mid-March. As so often happens in these circumstances, there was sufficient stratification during the deployment and recovery cruises, even during the winter, that comparisons made then are of little value. Luckily, a major storm occurred just prior to the EN280 cruise causing well-mixed conditions enabling reasonable comparisons for a select number of stations. Unfortunately, a single calibration point, even when available, is not sufficient to guarantee the quality of the data for a span of three months.

As a result, an adhoc approach was adopted which relied on relatively few "reference" instruments, primarily Seacats, and took advantage of the occasional periods of vertically homogeneous conditions to force all the errant instruments into periodic agreement. This is a method that only works if there is sufficient confidence in the reference instruments and a sufficient number of vertically homogeneous periods are distributed through the records. The Seacats appeared to perform uniformly well during the spring deployment, showing no sign of biofouling which would normally show up as a gradual salinity decrease as the build-up continued. Temperature measurements throughout appeared to be fairly good, usually requiring, where there was disagreement, a simple offset correction. For salinity, the behavior of instruments relative to the Seacats indicated a much more complicated calibration pattern. For the YSI dissolved oxygen probes there was often a "burn-in" period at the beginning of the record followed by a more gradual drift. The other instruments had less consistent but also less severe apparent errors. By examining the difference between each sensor relative to a reference sensor, it was almost always possible to fit a correction function to the anomalous behavior based upon the periods of vertical uniformity, and thereby generate a corrected record. When this had been completed for all the instruments on a mooring, the density profiles were then checked to make sure that the water column remained at least neutrally stable. For a couple of moorings that did not have a Seacat, a reference instrument from a nearby mooring was used, usually with rather good results. At the end of the process, the records were then compared to CTD casts from EN280 where possible with surprisingly good agreement. To some extent, the method is necessarily subjective. Each record was examined separately and if the "discomfort" level with the results was

sufficient, either some portion or the entire record was discarded. A total of 126 temperature and 118 salinity records were calibrated in this manner.

Results

Hydrographic data from cruises

Hydrographically, the southern Mid-Atlantic Bight is quite complex because of the confluence of five, not always distinct, water types. From the north come the waters of the central Middle Atlantic Bight shelf (MABW). In the winter these waters are cold ($<8^{\circ}\text{C}$) and of intermediate salinity (~ 31.5 to 34.5 psu). In summer months, the salinity range is about the same but surface temperatures reach as high as 18°C to 20°C . Offshore to the east are the waters of the upper slope region (USW), a result of the sometimes incomplete mixing of shelf, Labrador, and upwelled Gulf Stream waters, marked by a salinity range between that of the shelf and Gulf Stream, ie >34.5 psu and $\sim <36.0$ psu. Because of the depth of the slope region, temperatures of the slope waters undergo a reduced seasonal fluctuation, with near surface waters rarely getting colder than 15°C during the winter. Impinging on the area from the southeast are the waters from the upper Gulf Stream (GSW) with salinities generally greater than 36 psu. From the southwest come the waters formed in the South Atlantic Bight (SABW). These waters are marked by warmer temperatures than those of the northern continental shelf, with salinities typically between those of the northern shelf waters and the high salinity GSW. The last water type, the Virginia coastal waters (VCW) originates from the outflow of the Chesapeake Bay but with some contribution from Delaware Bay and other estuaries of the MAB. The VCW emerges from the Bays with highly variable salinities, usually less than ~ 28 psu, that quickly mix with shelf waters so that in the OMP region it is usually marked by salinities less than 30 to 31 psu. Because of the shallow source region of the VCW, winter temperatures can be less than 5°C while summertime temperatures easily exceed 20°C .

The interplay of the various water masses can sometimes be illustrated best using temperature and salinity diagrams. The composite T/S diagrams for each of the primary cross-shelf transects, $\sim 36.7^{\circ}\text{N}$, 36.0°N , and 35.5°N , are shown in Figure 3 in which a distinction is made between summer and winter conditions. The northern section had the most consistent coverage while the 36.0°N section was occupied the fewest times. The diagrams indicate that there are substantial differences in the relative importance of the various water masses even within the restricted alongshelf extent of the OMP area. The deep T/S distribution off the edge of the shelf has characteristics typical of those found all along the MAB beginning with the tight distribution at $\sim 4^{\circ}\text{C}$ and ~ 34.95 psu in the Deep Slope Water (DSIW), warming up to 12°C to 15°C and >35.0 psu at the depth of the shelf break. Above this level the competing influences of seasonal heating and cooling, the freshening from the coast, and the salting from waters of ultimately Gulf Stream origin, give the region its characteristic property distribution. To help in the understanding the regional and seasonal differences, a schematic T/S diagram was devised to differentiate, to the extent possible, the five water masses that typically interact in the area. Water mass differentiation in this area is not an exact process and is

partially based upon characteristics of source regions, partially on location, and materially effected by season and degree of mixing. Winter conditions are indicated in the figure by the shaded areas. During the cold months the water properties and spatial distribution are such that fairly clear boundaries between water masses can be determined. Based primarily upon location, breaks between VCW and MABW, and between MABW and Upper Slope Water (USIW) occur at salinities of ~ 31.5 psu and ~ 34.5 psu, respectively. After seasonal warming takes effect and relative density differences are altered, some of these distinctions can become somewhat more arbitrary as indicated in the schematic of **Figure 3** by the dashed lines. The biggest water mass overlap occurs between the SABW with salinities typically greater than 34.5 psu but less than those of GSW, and the generally colder waters of the offshore portion of the shelf/slope front indicated as USIW on the schematic. Generally a distinction can be made between these waters based upon location. A clear distinction between the summertime SABW, MABW, and VCW is not always possible as these waters grade into each other and can be found horizontally or vertically adjacent depending upon conditions. Lastly, it should be noted that water mass conditions north of Diamond Shoals are generally more complicated than those found south of the shoals and this is reflected in the relative complexity of the T/S diagram presented here compared to that suggested by Pietrafesa et al. (1985) which only showed three , fairly distinct, water masses.

Figure 3

With this brief background we can examine the results of the hydrographic sampling program completed during the OMP program. Eight hydrographic cruises occupied a series of transects between Cape Hatteras and the offing of Chesapeake Bay. Three (CI9402, EN279 and EN280) were conducted during the late winter and early spring when stratification over the region was at a minimum, two cruises (GY9306 and CI9404) took place in mid to late spring after the onset of seasonal stratification, and three cruises (CI9408, SJ9607 and SJ9608) took place in early to mid-summer after stratified conditions were well established. During these cruises, an attempt was made to collect data along three main cross-shelf transects, nominally along 35.5°N, 36.0°N, and 36.7°N, providing repeated snapshots of the hydrographic conditions in the area. The temperature and salinity data from those sections are shown in Figures 4, 5, and 6.

Figure 4a

Figure 4b

Figure 4c

Figure 5a

Figure 5b

Figure 5c

Figure 6a

Figure 6b

Figure 6c

Winter hydrographic conditions on the shelf are typically the easiest to understand as the winter's strong wind-forced mixing tends to produce nearly vertically homogeneous conditions and a near two-dimensional distribution of properties, at least in the northern half of the OMP area. Examination of the late winter data from the northern section, **Figure 4**, shows the general validity of that statement as the middle shelf temperatures for all three winter cruises (CI9402, EN270 and EN280) exhibit vertically mixed conditions. In the offshore direction, temperature increases gradually from $<5^{\circ}\text{C}$ near-shore to 7°C to 8°C at the shelf break before reaching the shelf slope front where it increases to typical winter slope conditions of $> 12^{\circ}\text{C}$. Despite the minimal thermal stratification over this area of the shelf, the outflow from the Chesapeake generally maintains a plume of low salinity water flowing along the coast to the south. At times of low wind stress, this plume exists as a shallow feature with quite low salinities as during CI9402, at other times vertical mixing causes the plume to extend to the bottom, while at yet other times conditions are such that the low salinity water is nearly absent altogether, as during EN280. EN280 occurred just after a major, two day long period of southwestward winds, **Figure 9**, which stalled the outflow from Chesapeake Bay while driving the fresh water that was on the shelf further south. This low salinity water showed up in the sections taken further south, **Figures 5 and 6**.

As one proceeds further south, the hydrographic conditions become more complex, even over the mid-shelf and even during winter. The winter cruise of 1994, CI9402, exemplifies the complexity that can arise during a collision of the various water types. In this case, a Gulf Stream frontal eddy drove up onto the shelf from the south and southeast. AVHRR satellite photos show that the source of the highest salinity waters began with a cyclonic Gulf Stream frontal eddy in mid-April which over-ran a portion of the shelf, the effects of which lasted until early May. The impact of the intrusion at the southern end of the Bight can be seen by the presence of 36.0psu waters found along the 35.5°N section, **Figure 6**. The northward extent of this water of Gulf Stream origin is unclear from the north-south spacing of these sections. However, there was a significant amount of relatively warm water along 36.0°N below 15 to 20m with salinities between 33.5 and 35.0 psu, salinities substantially less than those of the Gulf Stream intrusion. This water appears to fit the description of SABW, that is, intermediate in both temperature and salinity. A CTD-TOYO section taken along the 40m isobath subsequent to the three cross-shelf sections on this cruise, **Figure 7**, showed a strong subsurface cross-shelf front in both temperature and salinity at the limit of the intrusion's northward penetration. Southward across this subsurface front, salinities increased from ~ 33.2 psu to > 34.2 psu and temperatures from 8°C to 13°C . There was a nearly coincident surface front, particularly in salinity, marking the alongshore boundary between the less saline and lower density VCW and the MABW. Thus, this is a clear example of the complex interplay of four of the five water types found in this area in which the presence of the high salinity GSW diverted the warm intermediate salinity SABW northward underneath the VCW and up against the colder, lower salinity, but slightly denser, MABW. An important aspect of this water mass interaction is that it imposes a substantial degree of often long-lasting stratification in the vicinity of Cape Hatteras which can facilitate the

onset of the spring bloom by restricting vertical mixing and increasing the available sunlight for photosynthetic activity.

Figure 7

Even without the dramatic effect of the intrusion of Gulf Stream water witnessed during CI9402, the presence of the high salinity GSW is almost always evident along 35.5°N. Notice the location of the 34.5 psu isohaline, an indication of the center of the shelf/slope front, along the southern section, **Figure 6**, during EN280, as compared to its location along the middle and northern sections in **Figures 4 and 5**. The water column was generally well mixed everywhere on the shelf with little vertical stratification and yet salinities of >36.0 psu were found at the edge of the shelf and the 34.5 psu isohaline itself was pushed up to the ~40m isobath.

At the other seasonal extreme when stratified conditions prevail over most of the shelf, some significant differences appear, in addition to the obvious changes in vertical structure. Three of the cruises, CI9408, SJ9607, and SJ9608, took place during summer. First consider the 1996 summer cruises, SJ9607 and SJ9608, separated by about a week. The northern section from both cruises is characteristic of shelf summertime conditions removed from the direct influence of high salinity intrusions from the south. Visible in the northern sections is a strong thermocline overlying the cold near bottom "cold band" water over the outer shelf and upper slope. The cold band during these late July cruises contained waters of less than 10°C and salinities of 32.5 psu to 34.0 psu. These properties are characteristic of much of the bottom water all along the outer Mid-Atlantic Bight. The low near bottom temperatures resulted from the southward advection of cold water into the area from the north (Houghton, et al. 1982). It is interesting to note that the near bottom salinities are approximately the same as those found in this area during the winter whereas the surface salinities are substantially reduced. The halocline is generally coincident with the thermocline over the central shelf but upper isohalines slope to the surface further offshore over the shelf break. Near-shore there is clear evidence of even fresher waters within the Chesapeake Bay plume. In fact, during the summer months the whole area is capped by waters with salinities that are characteristic of the VCW soon after it is formed near the mouth of the Chesapeake. During the summer months the magnitude of the winds are much reduced compared to the winter while the predominant wind direction shifts from northwest to south and southwest. This has the effect of slowing the southward transport of the VCW and driving it northward and offshore within the surface Ekman layer. As a result, very low salinity waters can be found all along the outer shelf northward almost to the latitude of Delaware Bay as shown by some earlier data collected during the SEEP-II program (Flagg, Houghton, and Pietrafesa, 1994). A significant side effect of the presence of this low salinity surface layer is that the stratification in this region is much stronger than one would expect simply as a result of seasonal solar insulation and air/sea heat flux. It also has the effect of restricting the depth penetration of the heating, increasing the maximum surface temperature and maximum water column Brunt-Vaisala frequency. An important result of the strong stratification is that it severely limits vertical exchange thereby reducing the supply of nutrients to the upper mixed layer.

The summer 1994 cruise, CI9408, occurred when a major intrusion of Gulf Stream water covered much of the southern two thirds of the OMP area and illustrates another aspect of summer conditions of the region. AVHRR satellite photos show that relatively cold MABW occupied almost the entire shelf southward to about 35.7°N at the end of May. Shortly thereafter, a series of cyclonic Gulf Stream frontal eddies caused warm waters to overflow much of the southern half of the OMP area, a condition that lasted at least a month and through the late June time period of the cruise. The impact of this intrusion was such that it drove a substantial amount of >35.0 psu water onto the shelf in the area of the northern section at 36.5°N, Figure 4. Figure 5 shows that along the 36.0°N section in the middle of the area, Gulf Stream waters with salinities greater than 36.0 psu occupied the outer two thirds of the shelf producing a near homogeneous warm high salinity layer down to a depth of 30 to 40 meters. The low salinity near surface waters and the intermediate salinity subthermocline waters that normally exist in this area appear to have been pushed northward into the northern section producing a patchy cross-shelf subthermocline salinity distribution. Nutrient levels in the warm saline intrusion were uniformly low and what primary production that took place, did so under reduced light conditions near the bottom.

While the distinct differences between winter and summer conditions are well known phenomena, exactly how this transition occurred is difficult to follow from individual and sporadically collected transects. This is especially so within the complicated regime of the OMP area. As the sections in Figures 4 thru 6 show, each year seems to undergo slightly different progressions so that an description of the process in three dimensions and with great temporal resolution serves to enlighten us to potential complexities. This is the purpose of the next section based upon the time series data from the OMP moored array.

Hydrographic Time Series

The temperature and salinity time series data from the moored array offer a rare opportunity to follow the three-dimensional evolution of the hydrographic structure in this complex region during the transition from the sometimes near homogeneous winter conditions in some areas, to the stratified summer conditions. Temperature, salinity, and sigma-t time series for representative regions are first shown followed by areal maps depicting the time/space development of the seasonal stratification.

To illustrate the different responses to the seasonal transition, near surface and near bottom temperature, salinity, and sigma-t records from moorings 2, 4, 11, 18, and 24 are shown in Figure 8. Mooring 2 was deployed near the offshore boundary of the low salinity Chesapeake Bay plume while the other moorings were all deployed near mid-shelf progressing from north to south. We start with a general description and then return to discuss the implications for seasonal heating.

Figure 8a

Figure 8b

Figure 8c

The records from these sites indicate rather different responses to the seasonal changes taking place. Mooring 2 is located about 13 km from the coast and is often directly impacted by the low salinity plume during the early spring, at which time salinity can drop from ~32 psu to between 28 and 30 psu. These offshore plume meanders, or spreading events, appear to be correlated with the wind such that low salinities at Mooring 2 follow peak easterly and/or northerly wind-stress events, **Figure 9**. Concentrating on the higher salinities in the record which indicate the presence of near-shore MABW, there is a clear indication of a general seasonal freshening of these waters by almost 1 psu reaching a minimum salinity of ~31.5 psu by mid April. Beginning with this seasonal minimum, salinity increases rapidly regaining all the lost salt in about 25 days. Despite the long term salinity changes and the major salinity fluctuations due to the intruding low salinity plume, temperatures throughout the water column at this location maintained a remarkably steady increase of ~0.07°C/day through the entire 90 day deployment, starting at ~2.5°C on February 6th and ending at ~9°C by May 7th.

Figure 9

Further offshore at Mooring 4 located near mid-shelf and also somewhat further offshore at Mooring 11, temperature and salinity showed a rather different behavior. At both locations temperature remained steady or increased but slightly during the first half of the record. Beginning in late March temperatures throughout the water column at both sites decreased by 1 to 2°C reaching the a minimum of ~6°C in early to mid-April. At this point, temperatures at the mid to outer shelf were ~1°C colder than those of the near shore waters. This minimum at Mooring 11 was clearly the annual minimum for that location although the annual minimum at Mooring 4, < 5°C, appears to have occurred in early February. After the mid-April temperature minima, temperatures increased at both moorings throughout the water column. Shortly however, stratification

began to have an impact such that beginning about on April 19th, the near surface and bottom temperatures began to diverge. At this point near surface temperatures increased at $\sim 0.3^{\circ}\text{C}/\text{day}$ while those near bottom increased at $\sim 0.08^{\circ}\text{C}/\text{day}$. Salinity at mid-shelf, as shown by Mooring 4, decreased steadily by ~ 0.01 psu/day, aside from some minor low salinity intrusions from onshore, from the beginning of the record through the time of the temperature minimum until salt also became stratified beginning on April 21st. Even after the water column became stratified by both salinity and temperature, the near bottom salinity continued to decrease at the same rate as before. The stratification in salt occurred rather abruptly within a day after the surface and bottom temperatures began to diverge. At Mooring 11 a similar behavior occurred although the salinities were initially a little higher than those further onshore and the seasonal salinity decrease was not as uniform. Minimum salinities at Mooring 11, which were ~ 33 psu, occurred in mid-April, or about two weeks later than at Mooring 2, which was almost 1 psu less than in mid-winter. As at Mooring 4, salinity stratification set in abruptly at Mooring 11 also on April 21st. In fact, this pattern of an abrupt transition to stratified salinity conditions happened at nearly all the moorings offshore of the near shore zone, represented by Moorings 1 and 2, and included the outer portion of the cross-shelf array extending southward to Moorings 19 and 20. The timing, however, was not the same everywhere. The transition occurred on April 21st for Moorings 4, ~ 5 , 11, 14, 19, and 20, and on approximately April 24th at Moorings 6, 7, 9, 10, 13, 15, and 16. Thus, it appears that there was an extended plume of low salinity water that penetrated south over the inner half of the shelf that subsequently moved relatively quickly offshore impacting first the mid-shelf moorings and then the outer moorings. This movement does not appear to be correlated with any significant wind event, Figure 9.

Mooring 18, plus those along the southern line, showed a rather different behavior during the spring transition, one in which alternating intrusions of low salinity VCW, intermediate salinity SABW, and high salinity water of more direct Gulf Stream origin, produced large fluctuations in both temperature and salinity. The record from Mooring 24 at mid-shelf along 35.5°N shows that there was a very high correlation between temperature and salinity and that the water column was usually well mixed except during a few instances when warm, high salinity water intruded along the bottom. Some 20 km further north Mooring 18 lies in a transition zone showing intermittent behavior characteristic of the areas to both the north and south. Salinity is generally higher at Mooring 18 than further north with the impact of salinity intrusions from the south generating stratified conditions in late winter when things are homogeneous to the north. Aside from the periods effected by intruding waters, temperature shows a fairly steady increase, not as much as at Mooring 2, but more than at the northern mid-shelf moorings. The salinity during this period was between 33 and 34 psu, indicative of SABW, showing that the seasonal heating was occurring throughout the whole region. Stratification in both temperature and salinity started fairly gradually around April 11th at Mooring 18, about 10 days before it happened further north. At Mooring 24 on the southern line, the water never did become stratified in either temperature or salinity.

It is of particular interest to note that a large and long lasting intrusion of warm high salinity water appeared at Mooring 24 on April 21st, the same day that the large area

of low salinity water over-ran many of the northern mid-shelf moorings. This intrusion of saline water was clearly visible at Moorings 23 through 26 along the southern line. The maximum salinities that reached the southern line were 35.7 and 36.0 psu at 18°C to 19°C, **Figure 8**. As the T/S diagrams of **Figure 3** illustrate, these temperatures and salinities mark these waters as originating in the SAB. A series of AVHRR images (not shown) illustrate the progression from the southward flood of cold water which peaked around April 20th, through the period when the intrusion from the south and southwest of warm/saline pushed into the area south of ~36.0°N. The images show that at its maximum extent on April 17th, the cold water had moved just south of Cape Hatteras, there were no Gulf Stream frontal eddies in the area, and the Gulf Stream itself was proceeding smoothly to the northeast. By the next day, a slight undulation had formed on Gulf Stream's northern boundary, which expanded over the next few days to follow the shelf break isobaths northward around Cape Hatteras. On the shelf, this meander was accompanied by water not quite as warm as the Gulf Stream itself, flooding onto the southern MAB shelf. This warm, and saline as **Figure 8b** shows, gradually moved northward until it reached ~36.0°N. This SABW remained in the area, gradually giving way to the south until by the 10th it was confined south of ~35.5°N and some of the low salinity and cooler coastal plume had again reached the Cape.

While the individual hydrographic time series from the moorings and the AVHRR images give a good idea of which water masses were involved in the seasonal progression, it is still difficult to get a complete three-dimensional picture of what is happening. The spatial and temporal coverage afforded by the moored array makes it possible to address this need through a mapping of the observations onto a three-dimensional grid using optimal interpolation. The 126 temperature and 118 salinity observations are spread somewhat unevenly on the 26 moorings spread across the shelf to the north and south, along a picket fence of observations at the shelf break, together with a few moorings filling in over the middle and outer shelf. Recently, an interpolation scheme has been devised for shelf application (Lynch and McGillicuddy, 2001) but it requires an estimate of the regional flow field, which unfortunately, we do not have with sufficient detail or confidence. Thus, the optimal interpolation scheme used here is that of Hendry and He (1996) which is a direct implementation of the Bretherton et al (1976) algorithm for a scalar quantity with provision for anisotropic scaling and kd tree and nearest neighbor data searching. The 4D correlation model used in the interpolation is that of Hendry and He:

$$C_{uu} = (1 + r + r^2/3) e^{-r},$$

where r is the pseudo distance given by:

$$r_{jk} = \{ \sum [((x_{ij} - x_{ik})/a_i)^2] \}^{1/2},$$

and a_i is the appropriate scale distance along the i th axis. The horizontal scaling is further modified for shelf application such that the alongshelf scaling is increased and the cross-shelf scaling decreased with bottom slope at the shelf edge.

The success of the method depends upon a measurement density that fully resolves the scalar fields, that is, the scales of variability need to be significantly larger than the spacing between observations. To determine the temperature and salinity spatial scales, zero time-lagged correlations were calculated in the across and alongshelf

directions, **Figure 10**. There is considerable scatter in the results but it appears that the horizontal scales of temperature are greater than 150km in the alongshelf direction and about 80km in the cross-shelf direction. The comparable scales for salinity are about 100km and 40km, respectively. The vertical scale for both temperature and salinity was about 60m. Thus, the density of observations is generally quite sufficient to meet the interpolation requirements.

Figure 10a

Figure 10b

The initial interpolated fields were quite acceptable over most of the area with the exception of the near-shore region, approximately mid-way between the northern and southern lines. In particular, the low salinity coastal plume tended to vanish in the plots even though it showed up clearly in the data from Moorings 1, 2, and 23. To address this problem and make the plots conform to the character of the observations seen during the hydrographic cruises, two "ghost" moorings with instruments at 7 m were inserted near

the coast as extensions of the two cross-shelf lines consisting of Moorings 14, 15, and 16, and Moorings 18, 19, and 20. The temperature and salinity values used at these ghost sites were distance-weighted means from Moorings 1, 23, and either Mooring 14 or 18. The interpolation time scale for all the plots was 5 days.

To illustrate the seasonal changes for the entire OMP area, surface temperatures and salinities, and surface to bottom density differences are shown in **Figures 11 a-c**. The panels are spaced at ten-day intervals for the first three quarters of the record and then at two day intervals from April 20th until the end of the record in early May. The surface temperature maps show a cold wedge of water occupying all but the southeast corner of the area through mid-April. Along the shelf break there were some broad intrusions of warm water of Gulf Stream origin from the slope penetrating to about the 40 m isobath. Note that on April 10th the entire area was flooded by cold water. This corresponds to the time of the wide spread temperature minimum shown in the time series of **Figure 8a**. (The extension of the cold plume out over the slope in the figure may be an artifact of the interpolation.) Shortly after this flood of cold water, the area around the south mooring line north to about 35.6°N warms considerably while the surface waters to the north begin to warm more gradually. The warming seems to begin in the south and move northward and offshore leaving the near-shore waters along the north line as the coldest in the area by the end of the records.

Figure 11a

Figure 11b

Figure 11c

The corresponding salinity maps show a different seasonal development. Initially, the cold and low salinity plume (<30psu) from the Chesapeake dominated the near coastal region with higher salinity waters found offshore (~33 to 33.5psu) and to the south (>34.5psu). Prior to the general warming and the onset of stratification there were occasional periods when the near surface low salinity plume moved onto the mid-shelf, as indicated for March 1st, but generally it was confined near shore. The overall impression of conditions during the late winter is of a cross-shelf distribution of properties and fairly high salinity MABW over at least the northern half of the area. The cold flood of water that reached its maximum extent on April 10th extended all the way south to the southern line of moorings over the middle and outer shelf. Beginning on about April 20th this intermediate salinity water began to be replaced by low salinity water (~31.5 to 32 psu) over much of the shelf as high salinity (>34.5psu) water from the south pushed north into the area. Ultimately, the high salinity, high temperature, waters reached about 36.0°N before they began to recede during the last few days of the record. Of particular note is that the near surface intermediate salinity waters that dominated the northern half of the moored array in the late winter had been replaced by waters with 1 to 1.5 psu lower salinities and that the characterization of the region switched from cross-shelf salinity gradients, to north-south gradients in both salinity and temperature. Although it is not shown, a striking feature of the seasonal development was the change in sign of the north-south near surface density gradient. Initially the densest surface waters were the cold intermediate salinity waters of the mid shelf. By the end of the period, the surface shelf waters had undergone a dramatic change in salinity as well as warmed with the result that the shelf water had become lighter than the warm but high salinity waters that intruded into the region from the south.

These seasonal temperature and salinity transformations are reflected in the development of the areal surface to bottom stratification, **Figure 11c**. Initially, there was little stratification over the shelf except within the low salinity coastal plume and that stratification existed only under fairly low wind stress conditions. During the late winter and early spring stratification appeared intermittently and usually reflected a presence of relatively low salinity near surface waters as shown for March 1st in the middle of the region and near-shore along the southern line. The cold flood of northern water that reached its maximum extent in the first half of April also marked the end of the period of generally well mixed, minimal stratified conditions. With the offshore movement of low salinity water accompanying the northward push of high salinity GSW around April 20th, the mid portion of the moored array was the first area to become stratified. The stratified conditions pushed further north past the north line of moorings by the end of the record. The stratified conditions were a combination of surface warming and an offshore and northward spreading of low salinity VCW. As for the vertical density contrast, salinity changes in the near surface waters appear to have been about twice as effective as temperature in establishing the initial seasonal stratification. At Mooring 11 the top to bottom temperature and salinity differences were ~3.5°C and ~1 psu by May 5th (**Figures 8a and b**) which individually would have been responsible for density contrasts of ~0.5 kg m⁻³ and ~1.3 kg m⁻³, respectively, accounting for the observed ~2 kg m⁻³ total vertical density contrast. As the season progressed into the summer, temperature kept increasing while minimum salinities over the mid and outer shelf are limited. By mid summer the

surface to bottom temperature differences reached values of $\sim 12^{\circ}\text{C}$ (see **Figure 4a**), so that by temperature effects on the vertical density contrast outweighed those of salinity by about a factor of two.

Discussion

Estimates of the effects of air-sea heat flux and thermal insolation can be gained from the time histories of temperature from the moorings. While neither short- nor longwave radiation measurements were made within the OMP area during the program, daily-averaged, photosynthetically active radiation (400 to 700 nm) was measured by Tom Fisher at the Horn Point Laboratory in Maryland. Using a long-term record, he has established a close relationship between PAR and shortwave radiation ($r^2 = 0.998$) (Fisher et al., 2001) which was used to convert his measurements to daily averaged shortwave radiation for the period. While this site is more than 200 km north of the OMP area, it is within the same general weather regime and should be generally representative over the time scale of the spring transition. We were not so fortunate with longwave radiation and needed to resort to the net monthly climatic mean longwave radiation estimates in the Bunker atlas (Isemer and Hasse, 1987). Longwave back radiation is usually only about a quarter of the shortwave radiation so that errors in assuming climatic means should be relatively small for this time of the year. Estimates of sensible and latent heat fluxes were possible using NDBC buoy 44014 wind stress, air and water temperatures. This was accomplished using the Fairall et al. (1996) algorithms as implemented by the MATLAB Air-Sea toolbox code of R. Beardsley (URL: sea-mat.whoi.edu). Since humidity was not recorded on the buoy, we have had to assume a constant humidity of 80 percent to estimate the latent heat flux.

Through the entire deployment, temperatures at Mooring 2, and Mooring 1 as well, showed a nearly linear increase of $\sim 0.07^{\circ}\text{C}/\text{day}$, **Figure 8**, amounting to an average heat gain over the period of $\sim 73 \text{ m}^2\text{sec}^{-1}$, **Figure 12a**. Further offshore at Mooring 4 there was relatively little heat gain until stratification began, **Figure 12a**. After about April 11th, the entire water column at Mooring 4 began to warm at a rate of $\sim 0.08^{\circ}\text{C}/\text{day}$ for a net heating rate of $\sim 87 \text{ Jm}^2\text{sec}^{-1}$. After April 18th and the appearance of stratified conditions, heating of the upper portion of the water column accelerated to $\sim 0.3^{\circ}\text{C}/\text{day}$ and the overall net heat flux into the water doubled to $\sim 204 \text{ Jm}^2\text{sec}^{-1}$. At Mooring 11 there was actually a net heat loss from the beginning of the record through about April 3rd, particularly during the last three weeks of March when the heat loss amounted to about $-170 \text{ Jm}^2\text{sec}^{-1}$. Beginning on about April 4th, the waters around Mooring 11 experienced a net heat gain of $\sim 280 \text{ Jm}^2\text{sec}^{-1}$, quickly replacing earlier losses. The thermal history at Mooring 11, that is the net heat loss during the first two thirds of the deployment and the thermal recovery during the last third, was quite representative of all the moorings offshore of Mooring 4 on the north line, and extending southward to include the shelf edge Moorings 19 and 20, **Figure 12a**.

Figure 12

There are two possible causes for the extended cooling period between approximately March 7th and April 6th. The first is that there was sufficient heat loss through the air/sea interface. Figures 12 b and c show an estimate of the cumulative, radiative, sensible, and latent heat fluxes for the period. The longwave radiative loss estimated from the Bunker atlas are of necessity, assumed to be fairly constant, accounting for a not loss of only $-50 \text{ J m}^{-2} \text{ s}^{-1}$ over the 90 day deployment period. Shortwave radiative heat gain starts out slowly but increases as the maximum daily solar angle increases. The total net radiative influx for the spring was large, $\sim 1000 \times 10^6 \text{ J m}^{-2}$, and more than offset the latent heat losses. For the first month of the deployment, air

temperature was generally less than water temperature causing a steady but relatively small heat loss. For the next month air and sea temperatures were nearly the same with little net sensible heat flux either way. After about April 11th air temperature exceeded water temperature and there was an influx of sensible heat at about $20 \text{ J m}^{-2} \text{ s}^{-1}$. The latent heat losses were the most significant, having the greatest effect over the first 30 or so days, averaging $-58 \text{ J m}^{-2} \text{ s}^{-1}$. The total estimated cumulative heat flux through the air/sea interface is shown in Figure 12a for comparison with the vertically integrated water column thermal energies at the moorings. The main features of the total surface heat flux are that there was little net heating or cooling during the first half of the spring, with radiative fluxes balanced by sensible and latent heat losses. Then after mid-March, the shortwave radiation, and to a lesser extent, the sensible heat, resulted in a steady heat influx. From mid-March to the end of the period to total net air/sea heat influx amounts to $\sim 165 \text{ J m}^{-2} \text{ s}^{-1}$. This heat influx at the end of the record agrees rather well with the heat gain over the last 30 days for all the moorings with the exception of the near-shore Mooring 2. The one feature of the thermal records at the moorings that cannot be accounted for by the surface heat fluxes is the period of overall heat loss during March.

A potential explanation for the thermal energy loss during March comes from an examination of the current records from the moorings. These show a prolonged period of strong southerly flow over much of the shelf coinciding with the energy losses, Figure 13. The north-south components of progressive vector diagrams bear a remarkable similarity to the thermal energy plots of Figure 12a. So also does the cumulative alongshelf wind stress. This suggests that advection of colder water from the northern shelf played an important role in the apparent heat losses over the mid to outer shelf within the OMP area. The southward alongshore displacements during the cooling period range from $\sim 230 \text{ km}$ at Mooring 5, to $\sim 400 \text{ km}$ at Moorings 3, 4, and 15, to as much as $\sim 1000 \text{ km}$ within the shelf/slope frontal jet represented by Mooring 13. Moorings 1, 2, 3, and to a lesser extent Mooring 4, showed almost no effect of the advective cooling while Moorings 5 and 15 were significantly impacted despite seemingly similar levels of advection. Throughout the area, the mid and outer shelf reached minimum temperatures of between 6 and 7°C in mid-April rather than the in late winter as one would normally expect. It appears that some preconditioning of shelf waters must have occurred north of the OMP area, perhaps as a result of widely distributed sensible and latent heat loss as described above. Apparently, during this process the usual wintertime positive offshore thermal gradient was replaced by a large area of near homogeneous temperatures of $\sim 6^\circ \text{C}$. The alongshore extent of this preconditioning was clearly quite extensive. The 1000 km displacement observed at Mooring 13 places the source waters somewhere in the vicinity of Cape Cod while the $\sim 200 \text{ km}$ displacement observed at the near-shore Mooring 2 suggests a source near Delaware Bay. The more southerly source for the near-shore waters and that some of it may have been mixed with Delaware and Chesapeake Bay waters may account for the absence of the colder waters seen further offshore.

Figure 13

Conclusions

We have presented results from a number of hydrographic cruises together with those from one of the most extensive moored data sets collected anywhere within the MAB. The purpose has been to describe the spring transition at this terminus of southwestward flowing waters of the MAB, the interaction between the various water masses, and how these effected the response to the seasonal changes in air/sea heat flux. The eight cruises that took place during OMP have provided a number of short-term pictures of the water mass structure and distribution during the late winter to summer transition. Substantial water mass transformations take place during this period, reducing some of the density and property contrasts. In addition, the relatively simple, usually two-dimensional, wintertime distribution becomes more complex as the water masses ride over one another producing a layered three-dimensional structure. This is further complicated by fluctuations along the southern and southeastern boundaries caused by Gulf Stream frontal eddies. As the results from 1996 showed, the sudden onset of widespread stratified conditions seems to have been instigated by the appearance of one of the frontal eddy which drive intruding water north almost to 36.0°N . In addition to

flooding the area with warm, high salinity water, the intrusion appears to have stopped the southward flow of the VCW. This event, combined with the reversal of alongshore windstress which turned around in mid-April, pushed the near surface low salinity waters VCW northward and offshore. This change in the wind field was also coincident with the slowing, and in some cases reversing the previous southward currents. With the slowing of the alongshore flow and increased residence time in the area, the local air/sea heat fluxes were able to make a noticeable impact, strengthening the stratification that initially resulted from the flooding of the area by the VCW.

The seasonal warming of 1996 obviously continued past the events documented by the moored array. However, by the end of July during the last cruises to the area, many of the same basic structures observed at the end of the spring remained. Thus, to the north the cold band waters remained along the outer shelf over which spread the continually warming, low salinity VCW out to the shelf break. The southward penetration of the VCW, as defined here, was confined to a very narrow region near the coast south of $\sim 36.0^{\circ}\text{N}$. The body of the shelf water was met from the south, at least during the period of the 1996 cruises, by the intermediate salinity waters of the SAB and deflected offshore into the existing flow field along the Gulf Stream's north wall.

The exiting near surface water during this period is the lightest of any of the surrounding water masses and thus stays on the surface as it leaves the shelf. The lower thermocline and cold band waters, on the other hand, has a density of $\sim 25 \text{ kg m}^{-3}$, which is usually equal to or greater than that of the other water masses at the same depth. Because of their densities, these deeper waters leave the shelf and settle at an intermediate depth as has been observed by Lillibridge et al. (1990), and others. While the near surface water has been stripped of much of its nutrients and suspended material, the thermocline and cold band waters carry a significant portion of the shelf's net productivity. When these waters leave the shelf at the southern terminus in this manner, they are permanently gone from the shelf, including the dissolved and suspended material with them.

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Figure Captions

Figure 1. Chart of the Ocean Margins Program area between Chesapeake Bay and Cape Hatteras. Also shown are the locations of the moorings deployed between February 8 and May 12, 1996 and the NDBC's meteorological buoy 44014.

Figure 2. Charts showing the hydrographic stations, solid circles, occupied during the Ocean Margins Program within the southern portion of the Middle Atlantic Bight. The dates of the cruises were: GY9306, 5/10/93-5/14/93; CI9402, 3/26/94-4/4/94; CI9404, 4/18/94-5/1/94; CI9408, 6/22/94-7/2/94; EN279, 3/1/96-3/10/96; EN380, 3/12/96-3/19/96; SJ9607, 7/19/96-7/26/96; and SJ9608, 7/28/96-8/4/96. The location of the moorings deployed during the late winter and spring of 1996 are shown as diamonds. The heavy line running north-south in the plot for CI9402 indicates the location of the TOYO section of Figure 7.

Figure 3. Temperature and salinity diagrams for each of the cross-shelf sections shown in Figures 2-4. Winter data is shown as open diamonds while late spring and summer data is shown as open circles. Also shown is a schematic of the property distributions of the winter and summer regional water masses, the Middle Atlantic Bight Water (MABW), Virginia Coastal Water (VCW), South Atlantic Bight Water (SABW), Gulf Stream Water (GSW), and Deep and Upper Slope Waters (DSIW and USIW).

Figure 4. Hydrographic cross-shelf sections of a) temperature, b) salinity, and c) sigma-t, along the northern boundary of the OMP area between 36.5°N and 36.7°N.

Figure 5. As in Figure 2, but for the central section approximately along 36.0°N.

Figure 6. As in Figure 2, but for the southern section approximately along 36.5°N.

Figure 7. North-south TOYO section showing temperature, salinity, and sigma-t, along approximately the 40m isobath obtained on April 2-3, 1994 during the CI9402 cruise. Horizontal resolution varied from ~ 0.5 km near the surface and bottom to ~0.25 km at mid-depth while vertical resolution was ~0.5m.

Figure 8. Time series plots of a) temperature, b) salinity, and c) sigma-t from near surface and near bottom (dashed) records on Moorings 2, 4, 11, 18, and 24 (see Figure 1).

Figure 9. Meteorological and sea surface data from the NDBC buoy 44014 located in the northeast corner of the OMP array at 36.58°N, 74.83°W in 48m of water. The top three panels show the wind stress, the third panel shows air (+5m) and sea water (-1m) temperatures while the lower panel shows an estimate of the sensible and latent heat fluxes, computed using the algorithms of Fairall et al., (1996).

Figure 10. Spatial correlations at zero temporal lags computed between recorded temperature and salinity series from the moorings. The cross-shelf and alongshelf correlations were computed between all records within ±10km alongshelf or cross-shelf,

Phd. Dissertations:

1) Satellite Oceanography of Sea-Ice Variability over the Greenland Shelf and Sea-level Adjustment to Gulf Stream Motions in the Middle Atlantic Bight, Emanuele Bohm.

Dr. L.J. Pietrafesa co-chair

Dr. T.S. Hopkins co-chair

2) Classic Hydrography and Air-Sea Interaction Methodologies Applied to Coastal Oceanography : The Northeast Water Polynya(Northeast Greenland) and the North Carolina Continental Shelf, Francesco Bignami.

Dr. J. Janowitz co-chair

Dr. T. S. Hopkins co-chair

3) The Climatology of Western North Atlantic Extra-Tropical Cyclone Tracks and Their Effects on Mass Flux in the Middle Atlantic Bight, Xiao Feng Li.

Dr. Leonard J. Pietrafesa, Chair

Appendix A

OMP 96 Mooring Locations - 1st Deployment (Feb - May)

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
1 (NCSU)	SeaPac current meter (SP)	u,v,t,s	15	7(13)	50060	Mooring recov'd one km from station	2/5	5/8	36 40.187	75 51.651	NCSU
	SP	u,v,t,s	15	10(13)	50066		2/5	5/8	36 40.187	75 51.651	NCSU
2 (NCSU)	SP	u,v,t,s	15	8(21)	50059		2/5	5/8	36 40.274	75 45.844	NCSU
	SP	u,v,t,s	15	11(21)	50064		2/5	5/8	36 40.274	75 45.844	NCSU
	SP	u,v,t,s	15	18(21)	50065		2/5	5/8	36 40.274	75 45.844	NCSU
3 (FSU)	ace	u,v,t,s	15	11(28)	61		2/6	5/8	36 40.30	75 28.05	FSU
	ace	u,v,t,s	15	20(28)	51		2/6	5/8	36 40.30	75 28.05	FSU
4 (NCSU)	SP	u,v,t,s	15	6(23)	50058		2/8	5/8	36 40.463	75 17.396	NCSU
	SP	u,v,t,s	15	9(23)	50057		2/8	5/8	36 40.463	75 17.396	NCSU
	SP	u,v,t,s	15	15(23)	50046		2/8	5/8	36 40.463	75 17.396	NCSU
	Aanderaa current meter (AA)	u,v,t,s,p	20	20(23)	11109		2/8	5/8	36 40.463	75 17.396	NCSU
5 (FSU)	SC	t,s	20	10(29)	82		2/8	5/9	36 41.118	75 05.699	FSU
	SC	t,s	20	18(29)	83		2/8	5/9	36 41.118	75 05.699	FSU
	SC	t,s	20	24(29)	84		2/8	5/9	36 41.118	75 05.699	FSU
5* (FSU)	Work Horse acoustic doppler current profiler (whadcp)	u,v	20	29(29)	17		2/8	5/9	36 41.816	75 05.556	FSU
6 (NCSU)	SC	t,s	15	10(40)	2010		2/8	5/9	36 40.519	74 53.360	NCSU
	SC	t,s	15	22(40)	2011		2/8	5/9	36 40.519	74 53.360	NCSU
	SC	t,s	15	37(40)	2012		2/8	5/9	36 40.519	74 53.360	NCSU

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
6* (NCSU)	300 kHz narrow band adcp (nbadcp)			40(40)	442	Corrupted data file			36 41.155	74 52.912	NCSU
7 (NCSU)	S4 current meter (S4)	u,v,t,s,p	30	7(75)	765	Mooring recov'd 16 mi SSW of station 5/16	2/6	5/16	36 40.231	74 45.917	NCSU
	SC	t,s	15	10(75)	2013		2/6	5/16	36 40.231	74 45.917	NCSU
	SC	t,s	15	22(75)	2014		2/6	5/16	36 40.231	74 45.917	NCSU
	SC	t,s	15	37(75)	2015		2/6	5/16	36 40.231	74 45.917	NCSU
	SC	t,s	15	72(75)	2016		2/6	5/16	36 40.231	74 45.917	NCSU
7* (NCSU)	whadcp	u,v	15	73(73)	29		2/6	5/9	36 40.514	74 46.100	NCSU
8a (FSU)	bscm		20	50(850)	20	No data, flooded	2/6	10/15	36 40.179	74 37.492	FSU
	bscm	u,v,t,s	20	500(850)	30		2/6	10/15	36 40.179	74 37.492	FSU
8b (FSU)	bscm	u,v,t	20	710(830)	22	Bad C values	2/6	10/11	36 40.571	74 37.738	FSU
	bscm	u,v,t,s	20	827(830)	11		2/6	10/11	36 40.571	74 37.738	FSU
9 (FSU)	ace	u,v,t,s	20	7(39)	54		2/7	5/9	36 35.879	74 55.719	FSU
10 (FSU)	SC	t,s	20	23(39)	87		2/7	5/9	36 36.824	74 55.692	FSU
	SC	t,s	20	36(39)	89		2/7	5/9	36 36.824	74 55.692	FSU
11 (NCSU)	S4	u,v,t,s,p	30	8(37)	848		2/7	5/9	36 30.672	75 03.224	NCSU
	SC	t,s	15	22(37)	2018		2/7	5/9	36 30.672	75 03.224	NCSU
	SC	t,s	15	34(37)	2019		2/7	5/9	36 30.672	75 03.224	NCSU
11* (NCSU)	1200 kHz nbadcp			37(37)	145	No data, magnetic tape drive failed			36 30.894	75 03.130	NCSU

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
12 (FSU)	SC		20	22(40)	85	Lost, fisherman			36 31.413	74 52.292	FSU
	SC		20	37(40)	81	Short record, recovered by fisherman			36 31.413	74 52.292	FSU
12* (FSU)	whadcp	u,v	20	40(40)	wh13		2/7	5/10	36 31.910	74 52.164	FSU
13 (FSU)	bscm	u,v,t	20	17(76)	13	No C data after early March, Cond. case took water	2/7	5/11	36 31.145	74 48.039	FSU
	bscm	u,v,t,s	20	40(76)	16		2/7	5/11	36 31.145	74 48.039	FSU
	bscm	u,v,t,s	20	71(76)	6	Rotor stalled in April, everything else okay	2/7	5/11	36 31.145	74 48.039	FSU
14 (NCSU)	S4	u,v,t,s,p	30	7(30)	2121		2/12	5/12	36 15.398	75 14.328	NCSU
	SC	t,s	15	22(30)	2020		2/12	5/12	36 15.398	75 14.328	NCSU
	AA	u,v,t,s,p	20	27(30)	1905		2/12	5/12	36 15.398	75 14.328	NCSU
15 (NCSU)	SP	u,v,t	15	8(40)	50048	No C data, Cond. cell lost, hit by ship	2/12	5/12	36 15.432	75 04.422	NCSU
	AA	u,v,t,s,p	20	22(40)	1906		2/12	5/12	36 15.432	75 04.422	NCSU
	AA	u,v,t,s,p	20	37(40)	1907		2/12	5/12	36 15.432	75 04.422	NCSU

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
16 (FSU)	ace	u,v,t,s	20	7(76)	41		2/12	5/11	36 15.655	74 52.485	FSU
	bscm	u,v,t	20	23(76)	25	No C data after early March, Cond case took water	2/12	5/11	36 15.655	74 52.485	FSU
	bscm	u,v,t,s	20	37(76)	31		2/12	5/11	36 15.655	74 52.485	FSU
	bscm		20	72(76)	27	No data, cm flooded (fisherman)	2/12	5/11	36 15.655	74 52.485	FSU
17 (NCSU)	SP	u,v,t,s	15	7(75)	50049	Dragged up by trawler 4/96	2/12	4/2	36 07.063	74 54.573	NCSU
	SC	t,s	15	22(75)	2021	Dragged up by trawler 4/96	2/12	4/2	36 07.063	74 54.573	NCSU
	SC	t,s	15	37(75)	2022	Dragged up by trawler 4/96	2/12	4/2	36 07.063	74 54.573	NCSU
	SC	t,s	15	72(75)	2023	Dragged up by trawler 4/96	2/12	4/2	36 07.063	74 54.573	NCSU
17* (NCSU)	whadcp			75(75)	10	No data, battery pack leaked. Recov'd by HBOI 10/96	2/12	10/96	36 06.721	74 54.591	NCSU
18 (NCSU)	SP	u,v,t,s	15	8(31)	50056		2/12	5/12	35 50.874	75 13.564	NCSU
	SP	u,v,t,s	15	23(31)	50050		2/12	5/12	35 50.874	75 13.564	NCSU
	AA	u,v,t,s,p	20	28(31)	2127		2/12	5/12	35 50.874	75 13.564	NCSU
19 (FSU)	ace	t,s	20	8(41)	45	bad compass	2/12	5/12	35 51.010	75 03.759	FSU
	bscm	u,v,t,s	20	23(41)	29		2/12	5/12	35 51.010	75 03.759	FSU
	bscm	u,v,t,s	20	37(41)	33		2/12	5/12	35 51.010	75 03.759	FSU

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
20 (FSU)	ace	u,v,t,s	20	9(76)	62		2/11	5/12	35 51.039	74 55.259	FSU
	SC	t,s	20	38(76)	80		2/11	5/12	35 51.039	74 55.259	FSU
	SC	t,s	20	72(76)	86		2/11	5/12	35 51.039	74 55.259	FSU
20* (FSU)	whadcp	u,v	20	76(76)	wh45		2/11	5/12	35 51.039	74 55.259	FSU
21			20			Not set, faulty release					
22 (FSU)	ace	u,v,t	20	9(77)	53		2/11	5/14	35 38.285	74 51.495	FSU
	bscm	u,v,t,s	20	24(77)	14		2/11	5/14	35 38.285	74 51.495	FSU
	bscm	u,v,t,s	20	38(77)	21		2/11	5/14	35 38.285	74 51.495	FSU
	bscm	u,v,t,s	20	73(77)	26		2/11	5/14	35 38.285	74 51.495	FSU
23 (FSU)	ace	u,v,t,s	20	7(20)	55		2/10	5/13	35 27.029	75 23.954	FSU
	ace	u,v,t,s	20	16(20)	52		2/10	5/13	35 27.029	75 23.954	FSU
24 (FSU)	ace	u,v,t,s	20	8(30)	63		2/10	5/13	35 27.035	75 14.470	FSU
	SC	t,s	20	17(30)	88		2/10	5/13	35 27.035	75 14.470	FSU
	bscm	u,v,t,s	20	27(30)	19		2/10	5/13	35 27.035	75 14.470	FSU
25 (NCSU)	ace	u,v,t,s	20	7(36)	44		2/10	5/13	35 27.031	75 03.664	FSU
	ace	u,v,t,s	20	17(36)	42		2/10	5/13	35 27.031	75 03.664	FSU
	AA	u,v,t,s,p	20	23(36)	5762		2/10	5/13	35 27.031	75 03.664	NCSU
	S4	u,v,t,s,p	30	33(36)	2071		2/10	5/13	35 27.031	75 03.664	NCSU
26 (NCSU)	SP	u,v,t,s	15	7(75)	50047		2/10	5/13	35 27.273	74 52.294	NCSU
26* (NCSU)	whadcp					Not deployed, unit failed on deck					NCSU

OMP DEPLOYMENT I
5 February 1996 - 9 May 1996

Status of Instruments and Data

Mooring No. (Owner)	Inst Type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude ° ' " North	Longitude ° ' " West	Responsible Party
27 (NCSU)	150 kHz nbadcp			280(832)	261	adcp on float oriented upwards	2/10	5/13	35 27.238	74 47.409	NCSU
	AA	u,v,t,s,p	20	480(832)	3140		2/10	5/13	35 27.238	74 47.409	NCSU
	S4			730(832)	2122	no data	2/10	5/13	35 27.238	74 47.409	NCSU
	AA	u,v,t,s,p	20	822(832)	2256		2/10	5/13	35 27.238	74 47.409	NCSU
28 (NCSU)	meteorological buoy			0(78)		Buoy hijacked	2/10	6/96 in St. Thomas	35 26.820	74 52.657	NCSU

Appendix B

OMP96A RCM-11109 m4-20

BIN	MEAN	ST DEV	MIN	MAX
U(cm/sec)	-1.805	8.285	-37.764	20.573
V(cm/sec)	-1.658	12.675	-57.470	47.232
T(° C)	6.264	0.952	4.406	9.348
C(mS/cm)	32.901	0.692	31.148	35.123
S(psu)	33.087	0.304	31.962	33.786

~/ompa96/aanderaa/raw/files/11109raw

OMP96A RCM-1905 M14-26.9

BIN	MEAN	ST DEV	MIN	MAX
U	0.284	10.781	-42.057	53.619
V	1.054	8.358	-50.635	30.983
T	6.825	0.886	4.519	11.040
C	34.678	0.874	32.484	38.955
P	28.664	0.266	27.811	29.649
S	33.588	0.363	32.777	34.336

1905cal

OMP96A RCM-1906 M15-22.0

BIN	MEAN	ST DEV	MIN	MAX
U	4.957	19.259	-64.069	48.516
V	-3.563	17.679	-55.996	47.000
T	7.534	1.140	5.116	13.462
C	35.917	1.152	33.359	42.062
P	23.302	0.309	22.334	25.002
S	33.744	0.442	32.331	34.968

1906cal

OMP96A RCM-1907 M15-36.9

BIN	MEAN	ST DEV	MIN	MAX
U	-6.279	8.806	-37.903	29.072
V	-0.982	7.811	-53.130	31.860
T	7.407	1.125	5.144	13.382
C	35.529	1.275	32.923	42.260
P	39.762	0.375	38.803	41.306
D	39.762	0.375	38.803	41.306
S	33.845	0.414	32.927	35.372

1907cal

OMP96A RCM-2127 M18-28

BIN	MEAN	ST DEV	MIN	MAX
U	-0.987	7.817	-38.409	33.801
V	-2.892	10.347	-80.172	35.411
T	7.723	2.178	4.913	19.059
C	35.250	2.869	31.058	48.806
P	30.756	0.228	29.574	31.817
S	34.168	0.972	31.891	36.707

~/ompa96/aanderaa/raw/files/2127raw

OMP96A RCM-2256 M27-822

BIN	MEAN	ST DEV	MIN	MAX
U	-1.491	2.374	-12.331	9.365
V	-2.250	1.474	-15.231	2.442
T	4.471	0.171	3.896	5.022
C	31.496	0.365	30.410	32.283
P	878.046	0.218	877.891	878.471
S	34.891	0.144	34.185	35.039

2256cal

OMP96A RCM-3140 M27-480

BIN	MEAN	ST DEV	MIN	MAX
U	-2.634	8.816	-29.439	30.956
V	-2.238	5.218	-30.905	22.458
T	6.076	0.443	5.104	9.001
C	35.311	0.312	34.615	37.089
P	536.327	2.303	533.676	554.950
S	34.895	0.244	33.649	35.510

3140cal

OMP96A RCM-5762 M25-23

BIN	MEAN	ST DEV	MIN	MAX
U	11.954	24.248	-63.376	75.806
V	-6.358	16.899	-67.027	88.784
T	13.698	5.242	5.447	22.710
C	41.751	5.896	32.805	52.782
S	34.927	1.067	31.657	40.120

~/ompa96/aanderaa/raw/files/5762raw

OMP96A SEAPAC-50046 M4-15.1

BIN	MEAN	ST DEV	MIN	MAX
U	-1.815	12.923	-44.315	42.578
V	-4.289	18.489	-93.665	52.462
T	6.269	1.077	4.363	12.202
C	32.914	0.774	31.223	37.312
S	33.098	0.329	31.913	33.750

/d3/users/jim/ompa96/seapac/raw/files/50046raw

OMP96A SEAPAC-50056 M18-7.6

BIN	MEAN	ST DEV	MIN	MAX
U	-0.152	12.164	-85.483	63.508
V	-8.939	26.051	-122.974	77.637
T	8.832	3.902	3.855	20.541
C	35.007	4.210	29.160	49.919
S	32.816	1.017	29.796	36.341

/d3/users/jim/ompa96/seapac/raw/files/50056raw

OMP96A SEAPAC-50057 M4-9.2

BIN	MEAN	ST DEV	MIN	MAX
U	-1,890	15.278	-64.588	56.571
V	-6.139	20.662	-84.525	63.009
T	6.645	1.778	4.381	12.780
C	33.068	1.261	30.481	37.612
S	32.909	0.455	31.268	33.691

/d3/users/jim/ompa96/seapac/raw/files/50057raw

OMP96A SEAPAC-50058 M4-6.3

BIN	MEAN	ST DEV	MIN	MAX
U	-1.095	15.593	-86.253	53.906
V	-6.501	20.462	-92.851	58.255
T	6.621	2.025	4.057	12.833
C	33.110	1.454	29.497	37.773
S	32.981	0.538	30.779	33.863

/d3/users/jim/ompa96/seapac/raw/files/50058raw

OMP96A SEAPAC-50059 M2-7.9

BIN	MEAN	ST DEV	MIN	MAX
U	0.658	9.359	-44.953	53.845
V	-0.282	19.107	-92.364	76.670
T	5.437	1.890	2.154	12.272
C	30.874	1.974	25.935	36.370
S	31.578	0.969	27.919	33.271

/d3/users/jim/ompa96/seapac/raw/files/50059raw

OMP96A SEAPAC-50047 M26-7.0

BIN	MEAN	ST DEV	MIN	MAX
U	27.412	32.584	-92.652	167.046
V	37.670	53.713	-106.157	230.899
T	17.090	4.903	5.664	24.799
C	45.298	6.317	30.446	54.552
S	35.068	1.538	29.985	38.254

/d3/users/jim/ompa96/seapac/raw/files/50047raw

OMP96A SEAPAC-50048 M15-7.7

BIN	MEAN	ST DEV	MIN	MAX
U	-0.055	13.220	-55.067	54.696
V	-6.107	20.233	-93.803	67.538
T	8.056	1.986	5.114	13.607
C	2.063	14.008	-4.177	35.533
S	5.550	12.449	0.003	34.196

/d3/users/jim/ompa96/seapac/raw/files/50048raw

OMP96A SEAPAC-50049 M17-6.9

BIN	MEAN	ST DEV	MIN	MAX
U	-1.050	16.280	-77.005	64.673
V	-7.332	27.055	-177.504	87.099
T	8.809	2.500	6.038	18.288
C	35.832	2.852	31.458	47.691
S	33.757	0.738	30.587	36.287

/d3/users/jim/ompa96/seapac/raw/files/50049raw

OMP96A SEAPAC-50050 M18-22.5

BIN	MEAN	ST DEV	MIN	MAX
U	-2.852	13.553	-60.183	62.024
V	-8.370	22.741	-113.174	55.147
T	7.709	2.229	4.512	19.282
C	34.450	2.621	30.201	48.613
S	33.334	0.645	31.501	36.858

/d3/users/jim/ompa96/seapac/raw/files/50050raw

OMP96A SEAPAC-50056 M18-7.6

BIN	MEAN	ST DEV	MIN	MAX
U	-0.152	12.164	-85.483	63.508
V	-8.939	26.051	-122.974	77.637
T	8.832	3.902	3.855	20.541
C	35.007	4.210	29.160	49.919
S	32.816	1.017	29.796	36.341

/d3/users/jim/ompa96/seapac/raw/files/50056raw

OMP96A SEAPAC-50057 M4-9.2

BIN	MEAN	ST DEV	MIN	MAX
U	-1.890	15.278	-64.588	56.571
V	-6.139	20.662	-84.525	63.009
T	6.645	1.778	4.381	12.780
C	33.068	1.261	30.481	37.612
S	32.909	0.455	31.268	33.691

/d3/users/jim/ompa96/seapac/raw/files/50057raw

OMP96A SEAPAC-50058 M4-6.3

BIN	MEAN	ST DEV	MIN	MAX
U	-1.095	15.593	-86.253	53.906
V	-6.501	20.462	-92.851	58.255
T	6.621	2.025	4.057	12.833
C	33.110	1.454	29.497	37.773
S	32.981	0.538	30.779	33.863

/d3/users/jim/ompa96/seapac/raw/files/50058raw

OMP96A SEAPAC-50059 M2-7.9

BIN	MEAN	ST DEV	MIN	MAX
U	0.658	9.359	-44.953	53.845
V	-0.282	19.107	-92.364	76.670
T	5.437	1.890	2.154	12.272
C	30.874	1.974	25.935	36.370
S	31.578	0.969	27.919	33.271

/d3/users/jim/ompa96/seapac/raw/files/50059raw

OMP96A SEAPAC-50060 M1-6.8

BIN	MEAN	ST DEV	MIN	MAX
U	1.729	15.971	-49.308	103.349
V	-7.923	22.351	-115.396	55.331
T	5.626	2.414	1.087	14.331
C	29.650	2.819	22.415	35.947
S	30.038	2.243	22.835	32.768

/d3/users/jim/ompa96/seapac/raw/files/50060rawa

OMP96A SEAPAC-50064 M2-10.8

BIN	MEAN	ST DEV	MIN	MAX
U	-0.165	8.161	-40.618	44.973
V	1.511	16.878	-83.145	69.322
T	5.520	1.830	2.239	11.700
C	32.301	1.274	29.009	36.374
S	32.072	0.721	28.321	33.685

50064cal

OMP96A SEAPAC-50065 M2-18.1

BIN	MEAN	ST DEV	MIN	MAX
U	-0.292	5.675	-40.388	41.268
V	1.687	11.232	-66.879	46.428
T	5.414	1.669	2.535	10.936
C	31.238	1.455	27.904	35.951
S	32.025	0.572	29.249	33.260

/d3/users/jim/ompa96/seapac/raw/files/50065raw

OMP96A SEAPAC-50066 M1-10.1

BIN	MEAN	ST DEV	MIN	MAX
U	0.185	14.535	-42.659	86.293
V	-0.917	14.039	-98.666	50.944
T	5.575	2.245	1.337	12.684
C	30.264	2.382	23.493	35.793
S	30.784	1.899	23.840	32.996

/d3/users/jim/ompa96/seapac/raw/files/50066raw

OMP96A S4-765 m7-7

BIN	MEAN	ST DEV	MIN	MAX
u	-2.293	12.530	-45.551	57.329
v	-18.833	25.976	-76.244	66.588
t	45.000	0.000	45.000	45.000
c	70.000	0.000	70.000	70.000
p	14.352	2.372	6.742	18.249
s	32.464	0.000	32.463	32.466

/d3/users/jim/ompa96/s4/raw/files/s4ompa765.raw

OMP96A S4-848 M11-8.0

BIN	MEAN	ST DEV	MIN	MAX
U	-2.079	14.583	-49.646	48.312
V	-3.786	19.632	-71.668	58.653
T	7.852	1.707	5.028	13.195
C	34.034	1.162	31.680	37.550
P	4.554	0.425	3.029	6.336
S	33.139	0.595	31.198	34.250

848cal

OMP96A S4-2071 m25-33

BIN	MEAN	ST DEV	MIN	MAX
u	6.063	7.259	-20.940	40.318
v	2.905	19.786	-76.604	85.304
t	12.999	5.072	4.849	21.882
c	40.554	5.669	32.090	51.270
p	35.172	0.413	33.716	37.053
s	34.440	1.420	30.515	36.766

/d3/users/jim/ompa96/s4/raw/files/s4ompa2071.raw

OMP96A S4-2101 m13-7

BIN	MEAN	ST DEV	MIN	MAX
u	-0.632	16.633	-51.569	57.507
v	-21.433	26.901	-94.345	70.415
t	8.061	1.387	6.002	14.389
c	34.208	1.301	31.970	41.960
p	7.633	1.556	5.432	22.096
s	32.795	0.664	31.259	34.691

/d3/users/jim/ompa96/s4/raw/files/s4ompa2101.raw

OMP96A S4-2121 M14-7.9

BIN	MEAN	ST DEV	MIN	MAX
U	-0.105	13.285	-47.775	38.790
V	-6.400	21.312	-80.126	66.370
T	7.336	2.860	3.459	14.637
C	33.502	1.842	27.600	38.560
P	8.364	0.471	6.409	10.316
S	33.474	1.151	28.652	35.338

2121cal

OMP96A S4-2122 m27-730

BIN	MEAN	ST DEV	MIN	MAX
u	-1.845	4.456	-22.304	15.210
v	-2.602	7.979	-28.820	20.445
t	2.805	0.136	2.468	3.240
c	32.802	0.162	32.370	33.220
p	789.351	0.600	788.439	791.796
s	36.176	0.075	35.980	36.365

/d3/users/jim/ompa96/s4/raw/files/s4ompa2122.raw

OMP96A SEACAT-2010 M6-10

BIN	MEAN	ST DEV	MIN	MAX
T	7.573	1.235	5.372	11.853
C	34.250	1.000	32.095	36.642
S	33.308	0.562	31.559	34.331

/d3/users/jim/ompa96/seacat/raw/files/2010raw

OMP96A SEACAT-2011 M6-22 T,C,S

BIN	MEAN	ST DEV	MIN	MAX
T	7.228	0.836	5.380	10.922
C	34.063	0.932	32.104	36.579
S	33.425	0.431	31.951	34.607

/d3/users/jim/ompa96/seacat/raw/files/2011raw

OMP96A SEACAT-2012 M6-37

BIN	MEAN	ST DEV	MIN	MAX
T	7.340	0.980	5.384	10.692
C	34.312	1.218	32.083	38.580
S	33.573	0.422	32.603	34.829

/d3/users/jim/ompa96/seacat/raw/files/2012raw

OMP96A SEACAT-2013 M7-10

BIN	MEAN	ST DEV	MIN	MAX
T	7.943	1.387	5.514	16.606
C	34.737	1.521	31.981	44.956
S	33.461	0.543	31.693	35.635

/d3/users/jim/ompa96/seacat/raw/files/2013raw

OMP96A SEACAT-2014 M7-22

BIN	MEAN	ST DEV	MIN	MAX
T	7.770	1.389	5.615	17.632
C	34.724	1.689	32.128	46.664
S	33.600	0.513	32.226	36.007

/d3/users/jim/ompa96/seacat/raw/files/2014raw

OMP96A SEACAT-2015 M7-37

BIN	MEAN	ST DEV	MIN	MAX
T	8.034	1.409	5.987	16.414
C	35.161	1.774	32.506	45.503
S	33.803	0.539	32.591	36.058

/d3/users/jim/ompa96/seacat/raw/files/2015raw

OMP96A SEACAT-2016 M7-72

BIN	MEAN	ST DEV	MIN	MAX
T	9.722	1.842	5.987	12.495
C	37.437	2.365	32.585	40.990
S	34.529	0.691	32.217	35.636

/d3/users/jim/ompa96/seacat/raw/files/2016raw

OMP96A SEACAT-2018 M11-22

BIN	MEAN	ST DEV	MIN	MAX
T	7.298	0.843	5.084	10.969
C	34.098	0.835	32.035	36.999
S	33.397	0.415	32.216	34.355

/d3/users/jim/ompa96/seacat/raw/files/2018raw

OMP96A SEACAT-2019 M11-34

BIN	MEAN	ST DEV	MIN	MAX
T	7.240	0.758	5.117	10.363
C	34.062	0.882	32.034	37.980
S	33.405	0.385	32.763	34.534

/d3/users/jim/ompa96/seacat/raw/files/2019raw

OMP96A SEACAT-2020 M14-22

BIN	MEAN	ST DEV	MIN	MAX
T	6.866	0.872	4.638	11.011
C	33.603	0.851	31.562	38.200
S	33.273	0.296	32.722	34.206

/d3/users/jim/ompa96/seacat/raw/files/2020raw

OMP96A SEACAT-2021 M17-22

BIN	MEAN	ST DEV	MIN	MAX
T	9.201	3.084	5.515	20.955
C	32.858	10.661	0.041	48.531
S	30.952	9.724	0.027	36.491

/d3/users/jim/ompa96/seacat/raw/files/2021raw

OMP96A SEACAT-2022 M17-37

BIN	MEAN	ST DEV	MIN	MAX
T	9.074	2.717	5.444	21.330
C	32.764	10.561	0.004	47.529
S	30.986	9.785	0.005	36.530

/d3/users/jim/ompa96/seacat/raw/files/2022raw

OMP96A SEACAT-2023 M17-72

BIN	MEAN	ST DEV	MIN	MAX
T	9.437	2.406	5.389	21.054
C	33.663	9.771	0.172	42.045
S	31.480	9.095	0.122	35.560

/d3/users/jim/ompa96/seacat/raw/files/2023raw

OMP96A WH-29 M7-73

BIN	MEAN	ST DEV	MIN	MAX
U7	-6.634	19.068	-74.000	63.000
V7	-15.664	24.384	-115.000	117.000
U35	-8.291	13.731	-53.000	52.000
V35	-14.867	23.364	-87.000	79.000
U61	-4.305	10.288	-46.000	35.000
V61	-13.175	21.505	-73.000	63.000

wh7.gf

OMP96A ACE-41 M16-7

BIN	MEAN	ST DEV	MIN	MAX
U	-0.453	13.375	-123.327	48.222
V	-12.955	24.317	-102.628	86.316
T	8.976	2.116	6.801	20.036
S	33.739	0.606	29.797	36.685

41cal

OMP96A FSU ACE-42 M25-17

BIN	MEAN	ST DEV	MIN	MAX
U	12.691	15.568	-47.640	67.045
V	0.670	33.309	-132.193	131.748
T	13.590	5.461	4.860	22.690
S	34.404	1.459	30.833	36.465

~/fsu/ompa96/ace/raw/files/42raw

OMP96A FSU ACE-44 M25-7

BIN	MEAN	ST DEV	MIN	MAX
U	12.854	18.293	-43.380	98.585
V	-3.817	33.441	-158.338	140.206
T	12.978	5.599	3.940	22.650
S	34.222	1.544	30.315	36.997

~/fsu/ompa96/ace/raw/files/44raw

OMP96A FSU ACE-45 M19-8

BIN	MEAN	ST DEV	MIN	MAX
U	3.469	19.771	-79.427	77.822
V	-0.210	15.226	-77.584	78.568
T	9.191	3.679	4.370	20.250
S	29.511	0.852	26.244	32.578

~/fsu/ompa96/ace/raw/files/45raw

OMP96A FSU ACE-51 M3-20

BIN	MEAN	ST DEV	MIN	MAX
U	1.359	8.290	-29.605	28.711
V	-2.534	17.241	-77.703	49.380
T	5.781	1.299	3.500	8.780
S	32.673	0.312	30.847	33.282

~/fsu/ompa96/ace/raw/files/51raw

OMP96A FSU ACE-52 M23-16

BIN	MEAN	ST DEV	MIN	MAX
U	-1.584	9.580	-40.277	42.614
V	0.889	20.956	-87.038	68.452
T	10.769	5.185	3.940	20.210
S	32.700	1.751	28.681	35.804

~/fsu/ompa96/ace/raw/files/52raw

OMP96A ACE-53 M22-9

BIN	MEAN	ST DEV	MIN	MAX
U	8.445	18.471	-62.361	86.719
V	-5.506	24.496	-96.964	101.001
T	12.727	4.710	3.880	22.258
S	0.000	0.000	0.000	0.000

53cal

OMP96A ACE-54 M9-7

BIN	MEAN	ST DEV	MIN	MAX
U	-1.379	17.217	-50.428	65.364
V	-11.183	20.680	-84.412	62.351
T	8.341	1.660	6.209	13.881
S	33.174	0.675	31.326	34.318

54cal

OMP96A FSU ACE-55 M23-7

BIN	MEAN	ST DEV	MIN	MAX
U	-0.382	9.133	-41.683	41.113
V	-6.153	31.240	-100.533	84.296
T	10.138	5.050	3.720	20.040
S	32.021	1.947	27.933	35.917

~/fsu/ompa96/ace/raw/files/55raw

OMP96A FSU ACE-61 M3-11

BIN	MEAN	ST DEV	MIN	MAX
U	3.119	10.958	-35.545	43.432
V	-5.802	18.957	-83.271	50.008
T	6.218	2.101	2.980	13.100
S	32.836	0.581	30.706	33.769

~/fsu/ompa96/ace/raw/files/61raw

OMP96A ACE-62 M20-9

BIN	MEAN	ST DEV	MIN	MAX
U	2.007	13.828	-71.469	61.715
V	-11.032	27.083	-109.231	73.516
T	10.955	3.582	6.524	21.473
S	33.791	1.226	30.099	37.077

62cal

OMP96A FSU ACE-63 M24-8

BIN	MEAN	ST DEV	MIN	MAX
U	3.051	13.949	-42.154	56.784
V	-8.566	32.125	-129.372	106.717
T	11.158	5.328	4.100	21.120
S	35.229	6.330	30.452	94.580

~/fsu/ompa96/ace/raw/files/63raw

OMP96A BSCM-06 M22-24

BIN	MEAN	ST DEV	MIN	MAX
U	-0.023	6.288	-33.162	47.198
V	-4.480	14.426	-68.777	45.644
T	8.930	1.960	5.621	12.777
S	34.291	0.558	32.807	35.878

nctp06cal

OMP96A BSCM-13 M22-24

BIN	MEAN	ST DEV	MIN	MAX
U	-4.829	14.478	-51.426	45.145
V	-18.351	23.914	-86.087	73.342
T	7.451	1.343	5.301	17.752
S	19.389	20.212	-10.000	35.228

nctpl3cal

FSU OMP96A BSCM-14 M22-24

BIN	MEAN	ST DEV	MIN	MAX
U	4.314	13.777	-42.908	63.858
V	-4.300	20.975	-81.873	63.611
T	14.211	4.861	5.264	23.252
S	33.854	1.062	29.473	37.681

~/fsu/ompa96/bscm/raw/files/nctp14raw

OMP96A BSCM-16 M22-24

BIN	MEAN	ST DEV	MIN	MAX
U	-1.454	11.708	-44.828	55.712
V	-18.773	23.849	-97.398	67.223
T	7.271	1.423	5.194	16.320
S	33.617	0.443	32.049	37.125

nctp16cal

OMP96A BSCM-19 M24-27

BIN	MEAN	ST DEV	MIN	MAX
U	1.132	8.047	-27.682	41.333
V	1.325	18.259	-80.933	75.517
T	12.254	5.555	3.715	21.812
S	34.365	1.314	30.263	36.533

nctp19cal

FSU OMP96A BSCM-21 M22-38

BIN	MEAN	ST DEV	MIN	MAX
U	3.385	12.831	-33.234	53.420
V	-5.017	19.605	-74.562	56.244
T	13.767	4.237	6.702	22.696
S	34.102	0.939	31.489	37.884

~/fsu/ompa96/bscm/raw/files/nctp21raw

OMP96A BSCM-25 M16-23

BIN	MEAN	ST DEV	MIN	MAX
U	-2.553	11.410	-47.708	41.938
V	-11.200	22.553	-97.855	60.032
T	8.279	1.829	6.396	18.464
S	6.030	25.523	-9.351	319.975

nctp25cal

FSU OMP96A BSCM-26 M22-73

BIN	MEAN	ST DEV	MIN	MAX
U	3.216	11.660	-39.454	61.347
V	-5.949	12.586	-57.278	38.285
T	11.638	2.181	7.016	19.091
S	34.009	0.652	32.426	37.559

~/fsu/ompa96/bscm/raw/files/nctp26raw

OMP96A BSCM-31 M16-37

BIN	MEAN	ST DEV	MIN	MAX
U	-2.159	10.230	-33.619	51.844
V	-10.766	21.723	-91.210	61.278
T	7.457	1.496	5.570	16.893
S	33.755	0.474	32.050	36.613

nctp31cal

OMP96A SEACAT-80 M20-38

BIN	MEAN	ST DEV	MIN	MAX
U	11.001	3.404	6.853	20.773
V	34.433	0.908	32.425	37.283

80cal

FSU OMP96A SEACAT 82 M5-10

BIN	MEAN	ST DEV	MIN	MAX
T	7.343	1.786	4.979	13.092
S	33.145	0.552	31.221	34.201

~/fsu/ompa96/seacat/raw/files/82raw

FSU OMP96A SEACAT 83 M5-18

BIN	MEAN	ST DEV	MIN	MAX
T	6.889	0.882	4.979	10.730
S	33.252	0.405	31.360	34.196

~/fsu/ompa96/seacat/raw/files/83raw

FSU OMP96A SEACAT 84 M5-24

BIN	MEAN	ST DEV	MIN	MAX
T	6.835	0.763	4.978	8.861
S	33.269	0.372	32.320	34.195

~/fsu/ompa96/seacat/raw/files/84raw

OMP96A SEACAT-86 M20-71

BIN	MEAN	ST DEV	MIN	MAX
U	9.597	2.004	6.206	15.838
V	34.382	0.733	32.999	36.022

86cal

FSU OMP96A SEACAT 87 M10-23

BIN	MEAN	ST DEV	MIN	MAX
T	7.249	0.829	5.470	10.590
S	33.413	0.419	32.104	34.447

~/fsu/ompa96/seacat/raw/files/87raw

FSU OMP96A SEACAT 88 M24-17

BIN	MEAN	ST DEV	MIN	MAX
T	12.048	5.429	4.541	21.789
S	33.684	1.616	29.434	36.383

~/fsu/ompa96/seacat/raw/files/88raw

FSU OMP96A SEACAT 89 M10-36

BIN	MEAN	ST DEV	MIN	MAX
T	7.219	0.823	5.471	9.663
S	33.500	0.392	32.374	34.467

~/fsu/ompa96/seacat/raw/files/89raw

FSU OMP96A WH-13 M12

BIN	MEAN	ST DEV	MIN	MAX
u10	-0.853	16.830	-51.230	73.667
v10	-12.693	20.050	-92.808	78.965
u20	-1.726	14.567	-46.584	58.556
v20	-11.937	20.053	-82.280	69.451
u30	-0.157	12.637	-42.070	54.494
v30	-11.086	19.026	-80.406	67.245
u35	0.658	10.825	-28.711	49.888
v35	-9.295	16.064	-74.899	48.947

~/fsu/ompa96/adcp/raw/files/13raw

FSU OMP96A WH-17 M12

BIN	MEAN	ST DEV	MIN	MAX
u10	-0.531	15.583	-49.590	46.310
v10	-4.036	18.592	-295.477	65.815
u18	-1.609	14.043	-45.541	40.704
v18	-2.780	16.688	-69.850	49.210
u24	-1.609	11.548	-38.851	35.054
v24	-2.202	13.721	-60.348	41.926

~/fsu/ompa96/adcp/raw/files/17rawa

FSU OMP96A WH-45 M20-76

BIN	MEAN	ST DEV	MIN	MAX
u16	-0.210	10.263	-37.354	187.723
v16	-8.681	23.157	-113.472	131.974
u36	0.143	8.684	-40.531	27.213
v36	-7.446	23.458	-95.866	61.167
u56	2.230	8.983	-30.941	43.080
v56	-7.381	22.179	-89.902	62.243
u71	2.148	8.589	-31.290	50.674
v71	-8.062	17.953	-118.135	36.943

~/fsu/ompa96/adcp/raw/files/45rawa

Appendix C

OMP96A Mooring 1 : 40 Hr LP Data from Feb to May

OMP96A Mooring 2 : 40 Hr LP Data from Feb to May

Salinity and Temperature calibrated with CTD casts (jme 10/97)

OMP96A Mooring 3 : 40 Hr LP Data from Feb to May

OMP96A Mooring 4 : 40 Hr LP Data from Feb to May

OMP96A Mooring 5 : 40 Hr LP Data from Feb to May

FSU OMP96A WH-17 M5-29 40HR LOW PASS DATA FROM FEB TO MAY

CURRENT AT 10 METERS

CURRENT AT 18 METERS

CURRENT AT 24 METERS

FSU OMP96A WH-17 M5-29 u10,v10,u18,v18,u24,v24 40LP FEB-MAY 96

~/fsu/ompa96/adcp/filter/files/17.40lp

OMP96A Mooring 6 : 40 Hr LP Data from Feb to May

OMP96A Mooring 7 : 40 Hr LP Data from Feb to May

OMP96A WH-29 M7-73 40HR LOW PASS DATA FROM FEB TO MAY

CURRENT AT 7 METERS

CURRENT AT 35 METERS

CURRENT AT 61 METERS

OMP96A WH-29 M7-73 U7,V7,U35,V35,U61,V61 40LP FEB-MAY 96

~/ompa96/adcp/whorse/filter/files/wh7.40lp

OMP96A Mooring 8 : 40 Hr LP Data from Feb to May

Florida State University Mooring

Salinity and Temperature calibrated with CTD casts (jme 1/98)

OMP96A Mooring 9 : 40 Hr LP Data from Feb to May

OMP96A Mooring 10 : 40 Hr LP Data from Feb to May

OMP96A Mooring 11 : 40 Hr LP Data from Feb to May

Salinity and Temperature calibrated with CTD casts (jme 10/97)

FSU OMP96A WH-13 M12-40 40HR LOW PASS DATA FROM FEB TO MAY

CURRENT AT 10 METERS

CURRENT AT 20 METERS

CURRENT AT 35 METERS

OMP96A Mooring 13 : 40 Hr LP Data from Feb to May

OMP96A Mooring 14 : 40 Hr LP Data from Feb to May

Salinity and Temperature calibrated with CTD casts (jme 10/97)

OMP96A Mooring 15 : 40 Hr LP Data from Feb to May

Salinity and Temperature calibrated with CTD casts (jme 10/97)

OMP96A Mooring 16 : 40 Hr LP Data from Feb to May

OMP96A Mooring 17 : 40 Hr LP Data from Feb to May

OMP96A Mooring 18 : 40 Hr LP Data from Feb to May

OMP96A Mooring 19 : 40 Hr LP Data from Feb to May

OMP96A Mooring 20 : 40 Hr LP Data from Feb to May

FSU OMP96A WH-45 M20-76 40HR LOW PASS DATA FROM FEB TO MAY

CURRENT AT 16 METERS

CURRENT AT 36 METERS

CURRENT AT 71 METERS

FSU OMP96A WH-45 M20-76 u16,v16,u36,v36,u56,v56,u71,v71 40LP FEB-MAY 96

~/fsu/ompa96/adcp/filter/files/45.40lp

OMP96A Mooring 22 : 40 Hr LP Data from Feb to May

OMP96A Mooring 23 : 40 Hr LP Data from Feb to May

OMP96A Mooring 24 : 40 Hr LP Data from Feb to May

OMP96A Mooring 25 : 40 Hr LP Data from Jun to Oct

OMP96A Mooring 26 : 40 Hr LP Data from Feb to May

OMP96A Mooring 27 : 40 Hr LP Data from Feb to May

Salinity and Temperature calibrated with CTD casts (jme 10/97)

Appendix D

OMP96A Mooring 1 : 40 Hr LP Data from Feb to May

OMP96A Mooring 2 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 3 : 40 Hr LP Data from Feb to May

OMP96A Mooring 4 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 5 : 40 Hr LP Data from Feb to May

OMP96A Mooring 7 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 8 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 9 : 40 Hr LP Data from Feb to May

OMP96A Mooring 11 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 12 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 13 : 40 Hr LP Data from Feb to May

OMP96A Mooring 14 : 40 Hr LP Data from Feb to May

OMP96A Mooring 15 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 16 : 40 Hr LP Data from Feb to May

OMP96A Mooring 17 : 40 Hr LP Data from Feb to May

OMP96A Mooring 18 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 19 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 20 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 22 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 23 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 24 : 40 Hr LP Data from Feb to May

OMP96A Mooring 25 : 40 Hr LP Data from Feb to May

OMP96A Mooring 26 : 40 Hr LP Data from Feb to May

OMP96A Mooring 27 : 40 Hr LP Data from Feb to May

Appendix E

OMP96A Mooring 1 : 40 Hr LP Data from Feb to May

OMP96A Mooring 2 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 3 : 40 Hr LP Data from Feb to May

OMP96A Mooring 4 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 5 : 40 Hr LP Data from Feb to May

10 m

18 m

24 m

OMP96A Mooring 7 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 9 : 40 Hr LP Data from Feb to May

OMP96A Mooring 11 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 12 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 13 : 40 Hr LP Data from Feb to May

OMP96A Mooring 14 : 40 Hr LP Data from Feb to May

OMP96A Mooring 15 : 40 Hr LP Data from Feb to May

7.7 m

22.0 m

36.9 m

100 Km

FSU OMP96A Mooring 16 : 40 Hr LP Data from Feb to May

OMP96A Mooring 17 : 40 Hr LP Data from Feb to May

6.9 m

North

100 Km

OMP96A Mooring 18 : 40 Hr LP Data from Feb to May

7.6 m

22.5 m

27.9 m

FSU OMP96A Mooring 19 : 40 Hr LP Data from Feb to May

8 m

23 m

37 m

↑
North

100 Km

FSU OMP96A Mooring 20 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 22 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 23 : 40 Hr LP Data from Feb to May

FSU OMP96A Mooring 24 : 40 Hr LP Data from Feb to May

OMP96A Mooring 25 : 40 Hr LP Data from Feb to May

OMP96A Mooring 26 : 40 Hr LP Data from Feb to May

OMP96A Mooring 27 : 40 Hr LP Data from Feb to May

Appendix F

OMP96A Mooring 1 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

OMP96A Mooring 2 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 3 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

OMP96A Mooring 4 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 5 : 3 Hr LP Data from Feb to May

— : U Spectrum - - - : V Spectrum

OMP96A Mooring 7 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96 Mooring 8 : 3 Hr LP Data from Feb to Oct

— : U Spectrum : V Spectrum

FSU OMP96A Mooring 9 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

OMP96A Mooring 11 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 12 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 13 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

OMP96A Mooring 14 : 3 Hr LP Data from Feb to May

— : U Spectrum - - - : V Spectrum

OMP96A Mooring 15 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

FSU OMP96A Mooring 16 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

OMP96A Mooring 17 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

OMP96A Mooring 18 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 19 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

FSU OMP96A Mooring 20 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 22 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

FSU OMP96A Mooring 23 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

FSU OMP96A Mooring 24 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

OMP96A Mooring 25 : 3 Hr LP Data from Feb to May

— : U Spectrum : V Spectrum

OMP96A Mooring 26 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

OMP96A Mooring 27 : 3 Hr LP Data from Feb to May

— : U Spectrum ---- : V Spectrum

Appendix G

Appendix H

OMP 96 Mooring Locations - 2nd Deployment (Jun - Oct)

DEPLOYMENT II
June 25, 1996-October 11, 1996

Mooring No. (Owner)	Inst type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude o' ' ' North	Longitude o' ' ' West	Responsible Party
1 (NCSU)	SeaPac CM (SP)	uvst	15	7(13)	50048		6/23	10/9	36 40.112	75 51.264	NCSU
	SP	uvst	15	10(13)	50066		6/23	10/9	36 40.112	75 51.264	NCSU
2 (NCSU)	SP	uvst	15	8(18)	50046	Mooring struck by ship 8/96	6/25	8/30	36 40.255	75 39.979	NCSU
	SP		15	11(18)	50050	destroyed	6/25		36 40.255	75 39.979	NCSU
	SP	uvst	15	15(18)	50065	recovered	6/25	1/16/97	36 40.255	75 39.979	NCSU
3 (FSU)	ace	uvst	20	11(28)	ace 62		6/23	10/11	36 40.419	75 27.747	FSU
	ace	uvst	20	20(28)	ace51		6/23	10/11	36 40.419	75 27.747	FSU
4 (NCSU)	SP	uvst	15	6(23)	50058		6/25	10/11	36 40.447	75 17.409	NCSU
	SP	uvst	15	9(23)	50059		6/25	10/11	36 40.447	75 17.409	NCSU
	SP	uvst	15	15(23)	50064		6/25	10/11	36 40.447	75 17.409	NCSU
	Aanderaa CM (AA)	uvstp	15	20(23)	11109		6/25	10/11	36 40.447	75 17.409	NCSU
5 (FSU)	Seacat (SC)	st	20	9(29)	84	not turned on	6/25	10/10	36 41.140	75 05.692	FSU
	SC	st	20	18(29)	87	not turned on	6/25	10/10	36 41.140	75 05.692	FSU
	SC	st	20	24(29)	82	not turned on	6/25	10/10	36 41.140	75 05.692	FSU
5* (FSU)	Work Horse adcp	uv	20	(29)	wh17		6/25	10/10	36 41.837	75 05.550	FSU
6 (NCSU)	(SC)	st	15	10 (40)	2019		6/25	10/10	36 40.750	74 53.291	NCSU
	SC	st	15	22 (40M)	2011		6/25	10/10	36 40.750	74 53.291	NCSU
	SC	st	15	37 (40)	2018		6/25	10/10	36 40.750	74 53.291	NCSU
6* (NCSU)	300 KHz narrow band adcp	uv		(40)	442		6/25	10/10	36 40.516	74 53.361	NCSU

DEPLOYMENT II
June 25, 1996-October 11, 1996

Mooring No. (Owner)	Inst type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude o' ' North	Longitude o' ' West	Responsible Party
7 (NCSU)	S4 CM			8(75)	765	Lost	6/24		36 40.164	74 45.861	NCSU
	SC			10(75)	2015	Lost	6/24		36 40.164	74 45.861	NCSU
	SC			22(75)	2024	Lost	6/24		36 40.164	74 45.861	NCSU
	SC			37(75)	2020	Lost	6/24		36 40.164	74 45.861	NCSU
	SC			72(75)	2022	Lost	6/24		36 40.164	74 45.861	NCSU
7* (NCSU)	whadcp			(73)	29	lost			36 40.455	74 45.763	NCSU
8a (FSU)	bscm			50(850)	20	Depl. Feb-Oct, flooded-no data, subsurface float at 50M	2/6	10/15	36 40.179	74 37.492	FSU
	bscm	uvst	20	500(850)	30	Depl. Feb-Oct	2/6	10/15	36 40.179	74 37.492	FSU
8b (FSU)	bscm	uvt	20	710(830)	22	Depl. Feb-Oct, bad Cond. values, subsurface float at 600M	2/6	10/11	36 40.571	74 37.738	FSU
	bscm	uvst	20	827(830)	11	Depl. Feb-Oct	2/6	10/11	36 40.571	74 37.738	FSU
9 (FSU)	ace	uvst	20	9(39)	44		6/24	10/11	36 35.874	74 55.757	FSU
10 (FSU)	SC			23(39)	80	not turned on	6/24		36 36.817	74 55.673	
	SC			36(39)	83	not turned on	6/24				
11 (NCSU)	S4	uvstp	30	8(37)	848		6/24	10/11	36 30.675	75 03.178	NCSU
	SC	st	15	22(37)	2014		6/24	10/11	36 30.675	75 03.178	NCSU
	SC	st	15	34(37)	2016		6/24	10/11	36 30.675	75 03.178	NCSU
12 (FSU)	S4	uvstp	30	7(75)	2071		6/24	10/11	36 31.527	74 52.524	NCSU
12* (FSU)	whadcp			(40)	wh13	not recovered	6/24		36 32.158	74 52.398	FSU

DEPLOYMENT II
June 25, 1996-October 11, 1996

Mooring No. (Owner)	Inst type	Parameters available	Sample interval minutes	Inst Depth (Water Depth) meters	S/N	Notes/Inst Status	Date Deploy'd 1996	Date Recov'd 1996	Latitude o ' " North	Longitude o ' " West	Responsible Party
13 (FSU)	S4			7(76)	2101	lost	6/24		36 32.158	74 52.398	NCSU
	bscm			23(76)	9	not recovered	6/24		36 31.052	74 47.834	FSU
	bscm			37(76)	7	not recovered	6/24		36 31.052	74 47.834	FSU
	bscm	uvst	20	71(76)	15		6/24	10/12	36 31.052	74 47.834	FSU
16 (FSU)	ace	uvt	20	9(76)	43	short salinity record	6/28	10/12	36 15.730	74 52.591	FSU
	bscm	uvst	20	23(76)	35	rotor died	6/28	10/12	36 15.730	74 52.591	FSU
	bscm	uvt	20	37(76)	32	no salinity	6/28	10/12	36 15.730	74 52.591	FSU
	bscm	uvst	20	72(76)	34		6/28	10/12	36 15.730	74 52.591	FSU
17 (NCSU)	SP	uvst	15	7 (75)	50060		6/28	10/12	36 06.293	74 54.756	NCSU
	SC	st	15	22 (75)	2010		6/28	10/12	36 06.293	74 54.756	NCSU
	SC	st	15	37 (75)	2021		6/28	10/12	36 06.293	74 54.756	NCSU
	SC	st	15	72 (75)	2023		6/28	10/12	36 06.293	74 54.756	NCSU
17* (NCSU)	whadcp	uv		75 (75)	71		6/28	10/12	36 06.649	74 75.545	NCSU
18 (NCSU)	SP	uvst	15	8(38)	50049	Mooring struck by ship 10/96.	6/28	10/15	36 30.442	75 03.220	NCSU
	SP	uvst	15	26(38)	50056	recovered	6/28	12/20/97	36 30.442	75 03.220	NCSU
	AA	uvstp	15	35(38)	2127	recovered	6/28	12/20/97	36 30.442	75 03.220	NCSU
20 (FSU)	ace	uvst	20	9(76)	63		6/28	10/12	35 51.045	74 55.264	FSU
	SC			23(76)	88	not turned on	6/28	10/12	35 51.045	74 55.264	FSU
	SC			38(76)	86	not turned on	6/28	10/12	35 51.045	74 55.264	FSU
	SC			72(76)	81	not turned on	6/28	10/12	35 51.045	74 55.264	FSU
20* (FSU)	whadcp	uv	20	(76)	45		6/28	10/14	35 51.626	74 55.391	FSU

DEPLOYMENT II

June 25, 1996-October 11, 1996

22 (FSU)	ace	uvst	20	9(77)	54		6/27	10/14	35 39.347	74 51.655	FSU
	bscm	uvf	20	24(77)	1	no salinity data	6/27	10/14	35 39.347	74 51.655	FSU
	bscm	st	20	39(77)	3	bad compass	6/27	10/14	35 39.347	74 51.655	FSU
	bscm	uvst	20	73(77)	19		6/27	10/14	35 39.347	74 51.655	FSU
23 (FSU)	ace	uvst	20	7(20)	55		6/27	10/15	35 27.048	75 23.949	FSU
	ace	uvst	20	16(20)	45		6/27	10/15	35 27.048	75 23.949	FSU
24 (FSU)	ace	uvst	20	8(30)	61		6/27	10/14	35 27.052	75 14.473	FSU
	SC			17(30)	89	not turned on	6/27	10/14	35 27.052	75 14.473	FSU
	bscm	uvst	20	27(30)	17		6/27	10/14	35 27.052	75 14.473	FSU
25 (NCSU)	ace	uvst	20	7(38)	42		6/27	10/13	35 27.065	75 03.895	FSU
	ace	uvst	20	17(38)	52		6/27	10/13	35 27.065	75 03.895	FSU
	AA	uvstp	15	23(38)	1907		6/27	10/13	35 27.065	75 03.895	NCSU
	S4	uvstp	30	33(38)	2121		6/27	10/13	35 27.065	75 03.895	NCSU
26 (NCSU)	SP			7 (75)	50057	Mooring is lost.	6/27		35 27.069	74 52.538	NCSU
27c (NCSU)	150 KHz nbadcp	uv		270 (820)	261	subsurface float at 250M	6/27	10/13	35 27.292	74 47.345	NCSU
	AA	uvstp	15	470(820)	3140		6/27	10/13	35 27.292	74 47.345	NCSU
	S4			720(820)	2122	clk. batt. failed.	6/27	10/13	35 27.292	74 47.345	NCSU
	AA	uvstp	15	812(820)	2256		6/27	10/13	35 27.292	74 47.345	NCSU

Appendix I

OMP96B RCM-11109 m4-20

BIN	MEAN	ST DEV	MIN	MAX
u(cm/sec)	-1.094	7.817	-40.195	27.091
v(cm/sec)	-1.610	7.649	-32.276	50.120
t((C)	14.471	3.080	10.021	20.947
c(mS/cm)	38.134	1.833	34.039	42.784
p(dbar)	20.170	1.117	17.862	24.560
s(psu)	32.634	0.773	27.315	34.014

~/ompb96/aanderaa/sal_cal/raw/11109cal

OMP96B RCM-1907 M25-23

BIN	MEAN	ST DEV	MIN	MAX
U	7.435	13.443	-36.203	42.667
V	-3.364	12.575	-37.915	53.568
T	22.399	4.664	10.540	28.708
C	48.989	5.489	36.367	56.203
P	23.780	0.479	22.250	26.478
S	33.665	1.641	27.680	37.298

~/ompb96/aanderaa/sal_cal/raw/1907cal

OMP96B RCM-2127 M18-35

BIN	MEAN	ST DEV	MIN	MAX
U	-3.728	5.361	-22.202	17.984
V	-0.031	2.925	-18.334	10.159
T	11.588	1.807	7.859	16.569
C	37.636	1.662	34.021	43.548
P	34.708	0.238	33.500	35.183
S	33.053	0.548	31.546	35.475

~/ompb96/aanderaa/raw/files/2127raw

OMP96B RCM-2256 M27-812

OMP96B RCM-2256 M27-812

BIN	MEAN	ST DEV	MIN	MAX
U	-2.888	1.588	-12.832	-0.733
V	-2.721	1.431	-12.249	-0.361
T	4.402	0.156	3.885	4.888
C	31.528	0.352	30.410	32.378
P	837.428	0.204	837.302	840.781
S	35.376	0.107	34.829	35.562

~/ompb96/aanderaa/sal_cal/raw/2256cal

OMP96B RCM-3140 M27-470

BIN	MEAN	ST DEV	MIN	MAX
U	-3.543	4.550	-20.618	12.777
V	-2.128	2.734	-15.986	13.245
T	5.731	0.355	4.849	7.264
C	35.481	0.256	34.796	36.205
P	503.175	1.064	501.194	513.731
S	35.191	0.197	34.426	35.624

~/ompb96/aanderaa/sal_cal/raw/3140cal

OMP96B S4-848 m11-8

BIN	MEAN	ST DEV	MIN	MAX
u	-3.463	15.975	-65.538	66.558
v	-3.589	13.943	-51.561	59.582
t	22.487	1.999	15.891	25.563
c	44.415	2.054	38.000	51.840
p	4.367	0.406	2.312	5.913
s	30.339	0.841	28.063	34.630

/d3/users/jim/ompb96/s4/raw/files/s4ompb848.raw

OMP96B S4-2071 m25-33

BIN	MEAN	ST DEV	MIN	MAX
u	-2.905	17.345	-69.115	85.578
v	-13.612	16.159	-61.734	66.574
t	21.371	1.925	13.675	24.528
c	44.090	1.717	37.420	51.280
p	7.746	0.412	5.255	9.814
s	30.881	0.750	29.740	35.201

/d3/users/jim/ompb96/s4/raw/files/s4ompb2071.raw

OMP96B S4-2121 M25-33

BIN	MEAN	ST DEV	MIN	MAX
U	2.712	7.570	-41.342	33.768
V	1.926	11.368	-26.936	55.218
T	19.445	4.768	10.446	28.117
C	45.073	5.271	32.600	55.800
P	35.325	0.530	33.693	36.929
S	33.175	1.844	24.161	36.277

~/ompb96/s4/sal_cal/raw/2121cal

OMP96B SEAPAC-50046 M2-8

BIN	MEAN	ST DEV	MIN	MAX
U	1.289	12.667	-52.545	51.285
V	1.101	14.982	-64.978	66.949
T	18.924	4.094	12.974	26.071
C	42.395	2.940	38.100	47.683
S	31.352	1.086	25.657	33.827

/d3/users/jim/ompb96/seapac/raw/files/50046raw

OMP96B SEAPAC-50048 M1-7

BIN	MEAN	ST DEV	MIN	MAX
U	0.289	12.267	-48.026	65.644
V	-2.162	16.266	-87.495	67.154
T	19.867	3.854	13.105	25.776
C	40.873	2.629	33.576	46.493
S	29.470	1.825	22.748	32.759

/d3/users/jim/ompb96/seapac/raw/files/50048raw

OMP96B SEAPAC-50049 M18-7.6

BIN	MEAN	ST DEV	MIN	MAX
U	-2.529	19.360	-68.601	73.905
V	-3.556	16.907	-63.496	61.790
T	23.099	1.482	17.422	25.401
S	30.062	0.952	28.603	34.591

~/ompb96/seapac/sal_cal/raw/50049cal

OMP96B SEAPAC-50056 M18-25.5

BIN	MEAN	ST DEV	MIN	MAX
U	-6.711	15.926	-81.159	47.399
V	-1.453	15.763	-61.066	57.254
T	12.719	2.080	7.983	20.335
C	37.827	1.782	34.034	47.751
S	32.253	0.493	29.814	35.940

/d3/users/jim/ompb96/seapac/raw/files/50056raw

OMP96B SEAPAC-50058 M4-6.3

BIN	MEAN	ST DEV	MIN	MAX
U	-3.603	16.408	-52.386	66.184
V	-4.637	18.509	-82.214	72.179
T	22.516	1.945	17.895	25.280
C	45.410	1.636	41.487	48.910
S	31.084	0.469	29.218	37.264

/d3/users/jim/ompb96/seapac/raw/files/50058raw

OMP96B SEAPAC-50059 M4-9

BIN	MEAN	ST DEV	MIN	MAX
U	-2.957	15.054	-56.366	50.069
V	-4.615	16.815	-66.161	64.888
T	21.643	2.136	13.141	25.300
C	44.795	1.749	38.158	47.814
S	31.235	0.484	29.326	33.952

/d3/users/jim/ompb96/seapac/raw/files/50059raw

OMP96B SEAPAC-50060 M17-7

BIN	MEAN	ST DEV	MIN	MAX
U	1.739	19.751	-62.990	92.256
V	-11.995	20.072	-83.389	69.449
T	22.721	2.323	16.221	26.532
C	46.231	2.536	40.666	56.032
S	31.563	1.178	29.729	36.165

/d3/users/jim/ompb96/seapac/raw/files/50060raw

OMP96B SEAPAC-50064 M4-15

BIN	MEAN	ST DEV	MIN	MAX
U	-3.292	15.985	-61.320	49.080
V	-6.065	15.992	-62.656	54.605
T	16.000	3.318	10.058	24.709
C	40.355	2.534	35.679	47.211
S	31.861	0.618	30.039	35.373

/d3/users/jim/ompb96/seapac/raw/files/50064raw

OMP96B SEAPAC-50065 M2-15

BIN	MEAN	ST DEV	MIN	MAX
U	1.191	7.237	-22.914	28.738
V	1.140	8.676	-28.135	35.278
T	13.991	0.817	12.930	17.631
C	38.725	0.659	37.887	41.123
S	32.029	0.171	31.163	32.276

/d3/users/jim/ompb96/seapac/raw/files/50065raw

OMP96B SEAPAC-50066 M1-10

BIN	MEAN	ST DEV	MIN	MAX
U	0.246	9.990	-40.043	58.259
V	-0.654	9.546	-71.841	37.012
T	19.232	3.974	13.132	25.847
C	41.061	2.557	34.780	46.061
S	30.073	1.701	23.059	32.203

/d3/users/jim/ompb96/seapac/raw/files/50066raw

OMP96B SEACAT-2010 M17-22

BIN	MEAN	ST DEV	MIN	MAX
T	15.293	3.667	7.525	26.330
C	40.484	4.053	33.646	55.963
S	32.479	0.977	29.416	36.681

/d3/users/jim/ompb96/seacat/raw/files/2010raw

OMP96B SEACAT-2011 M6-22

BIN	MEAN	ST DEV	MIN	MAX
T	12.866	3.149	6.650	23.472
C	37.868	2.693	32.668	48.257
S	32.157	0.458	28.111	35.984

/d3/users/jim/ompb96/seacat/raw/files/2011raw

OMP96B SEACAT-2014 M11-22

BIN	MEAN	ST DEV	MIN	MAX
T	14.231	2.650	8.380	22.880
C	39.111	2.378	34.387	51.352
S	32.170	0.583	29.636	38.472

/d3/users/jim/ompb96/seacat/raw/files/2014raw

OMP96B SEACAT-2016 M11-34

BIN	MEAN	ST DEV	MIN	MAX
T	12.340	2.465	7.860	18.956
C	37.494	1.936	33.983	42.763
S	32.263	0.500	30.806	34.914

/d3/users/jim/ompb96/seacat/raw/files/2016raw

OMP96B SEACAT-2018 M6-37

BIN	MEAN	ST DEV	MIN	MAX
T	10.018	2.367	6.370	17.878
C	35.477	1.853	32.556	41.792
S	32.309	0.437	31.052	34.528

/d3/users/jim/ompb96/seacat/raw/files/2018raw

OMP96B SEACAT-2019 M6-10

BIN	MEAN	ST DEV	MIN	MAX
T	18.858	3.275	7.212	23.951
C	44.214	2.288	36.287	49.541
S	31.347	0.517	29.694	34.680

~/ompb96/seacat/sal_cal/raw/2019cal

OMP96B SEACAT-2021 M17-37

BIN	MEAN	ST DEV	MIN	MAX
T	11.182	2.717	6.497	24.017
C	36.820	2.842	32.736	52.550
S	32.582	0.794	31.168	36.712

/d3/users/jim/ompb96/seacat/raw/files/2021raw

OMP96B SEACAT-2023 M17-72

BIN	MEAN	ST DEV	MIN	MAX
T	8.711	1.774	6.592	13.887
C	35.027	2.346	31.096	42.406
S	32.987	0.872	30.390	35.527

/d3/users/jim/ompb96/seacat/raw/files/2023raw

OMP96B NB-261 M27-300

BIN	MEAN	ST DEV	MIN	MAX
U288	-3.445	19.182	-96.400	43.100
V288	2.375	10.640	-30.000	55.400
U168	-21.299	38.959	-153.200	46.000
V168	13.513	24.589	-36.300	116.700
U40	-53.745	40.170	-176.400	42.200
V40	44.299	30.181	-18.400	156.000
T	8.903	0.800	7.110	12.880

m27.raw

OMP96B NB-442 M6-40

BIN	MEAN	ST DEV	MIN	MAX
U29	1.249	7.394	-20.300	35.900
V29	-6.974	8.538	-39.400	24.000
U16	-1.461	9.179	-40.900	29.800
V16	-8.066	10.365	-41.300	34.600
U3	-0.513	10.752	-33.700	45.200
V3	-7.559	10.727	-48.400	34.500
T	9.797	2.349	6.290	18.030

mo6.raw

OMP96B WH-71 M17-73

BIN	MEAN	ST DEV	MIN	MAX
U7	-1.992	16.636	-88.000	87.000
V7	-10.789	18.884	-86.000	88.000
U35	-1.384	10.418	-36.000	45.000
V35	-8.141	17.457	-73.000	71.000
U61	-1.022	9.278	-42.000	37.000
V61	-3.557	11.991	-49.000	39.000

wh17.raw

OMP96B FSU ACE-42 M25-7

BIN	MEAN	ST DEV	MIN	MAX
U	7.068	20.792	-70.965	96.655
V	-2.969	22.550	-83.580	97.966
T	24.565	2.447	18.740	28.960
S	33.021	2.097	29.625	36.291

~/fsu/ompb96/ace/raw/files/42raw

OMP96B FSU ACE-43 M16-9

BIN	MEAN	ST DEV	MIN	MAX
U	-1.292	16.308	-65.657	78.438
V	-11.994	19.420	-79.194	72.717
T	22.415	2.754	13.739	27.963
S	19.251	84.506	-10.000	7229.036

~/fsu/ompb96/ace/sal_cal/raw/43cal

OMP96B ACE-44 M9-9

BIN	MEAN	ST DEV	MIN	MAX
U	-2.835	20.827	-69.474	77.712
V	-12.332	18.191	-75.233	79.816
T	20.319	2.482	10.022	24.504
S	21.993	17.244	-10.000	39.676

44cal

OMP96B ACE-45 M23-16

BIN	MEAN	ST DEV	MIN	MAX
U	0.169	9.726	-57.021	34.310
V	-0.137	16.704	-62.123	98.631
T	23.191	2.675	18.992	29.158
S	30.645	2.178	26.583	34.180

45cal

OMP96B FSU ACE-51 M3-20

BIN	MEAN	ST DEV	MIN	MAX
U	1.316	7.427	-32.196	27.682
V	-1.952	12.897	-64.755	52.939
T	15.898	3.464	10.640	22.290
S	31.657	0.596	30.040	32.389

/d3/users/jim/fsu/ompb96/ace/raw/files/51raw

OMP96B FSU ACE-52 M25-17

BIN	MEAN	ST DEV	MIN	MAX
U	9.526	17.317	-46.895	75.840
V	0.121	23.502	-67.541	94.784
T	22.962	3.999	10.560	28.750
S	34.229	1.966	29.954	38.895

/d3/users/jim/fsu/ompb96/ace/raw/files/52raw

OMP96B FSU ACE-54 M22-9

BIN	MEAN	ST DEV	MIN	MAX
U	4.654	16.995	-73.968	78.184
V	-3.965	19.264	-72.325	66.147
T	24.004	2.675	16.710	29.060
S	32.925	2.042	29.626	36.521

/d3/users/jim/fsu/ompb96/ace/raw/files/54raw

OMP96B FSU ACE-55 M23-7

BIN	MEAN	ST DEV	MIN	MAX
U	-3.516	9.202	-37.579	26.407
V	-3.735	23.802	-85.527	94.849
T	23.498	1.965	17.780	26.810
S	26.830	8.342	0.863	36.094

/d3/users/jim/fsu/ompb96/ace/raw/files/55raw

OMP96B FSU ACE-61 M24-8

BIN	MEAN	ST DEV	MIN	MAX
U	0.600	12.635	-59.058	51.973
V	-7.198	22.120	-87.669	87.904
T	24.085	1.947	18.600	28.340
S	32.111	1.946	28.575	36.271

/d3/users/jim/fsu/ompb96/ace/raw/files/61raw

OMP96B FSU ACE-62 M3-11

BIN	MEAN	ST DEV	MIN	MAX
U	-0.728	14.460	-51.128	65.367
V	-3.195	17.382	-80.329	70.955
T	20.715	3.244	13.550	25.580
S	30.988	0.637	28.504	32.845

/d3/users/jim/fsu/ompb96/ace/raw/files/62raw

OMP96B ACE-63 M20-9

BIN	MEAN	ST DEV	MIN	MAX
U	1.685	17.338	-57.558	94.590
V	-11.422	20.115	-80.051	87.318
T	23.279	2.231	16.528	26.488
S	31.812	1.548	29.495	36.105

63cal

OMP96B BSCM-1 M22-24

BIN	MEAN	ST DEV	MIN	MAX
U	3.504	13.599	-70.501	55.077
V	-1.141	14.785	-63.273	67.476
T	19.818	4.755	7.533	28.920
S	-10.000	0.000	-10.000	-10.000

1cal

OMP96B BSCM-3 M22-39

BIN	MEAN	ST DEV	MIN	MAX
U	-3.543	14.730	-61.842	65.818
V	0.470	14.612	-65.845	65.490
T	15.269	4.623	6.766	28.162
S	33.607	1.553	30.888	39.467

3cal

OMP96AB BSCM-11 M8A-827

BIN	MEAN	ST DEV	MIN	MAX
U	1.508	4.378	-19.030	20.986
V	-1.063	3.679	-23.828	15.923
T	4.490	0.661	3.779	16.280
S	34.968	0.195	31.388	35.051

11cal

OMP96B BSCM-15 M13-71

BIN	MEAN	ST DEV	MIN	MAX
U	-1.280	8.455	-40.520	30.321
V	-7.557	10.393	-39.844	31.924
T	7.779	1.662	4.600	16.878
S	32.652	0.675	31.542	35.017

15cal

OMP96B BSCM-17 M24-27

BIN	MEAN	ST DEV	MIN	MAX
U	0.472	7.083	-47.052	31.045
V	-1.441	9.973	-51.751	61.045
T	20.331	3.217	14.258	28.117
S	33.765	1.866	29.383	40.604

17cal

OMP96B BSCM-19 M22-73

BIN	MEAN	ST DEV	MIN	MAX
U	1.855	9.461	-32.418	33.037
V	-3.944	9.793	-36.116	28.174
T	11.679	1.800	7.095	20.052
S	33.605	0.800	31.703	36.951

19cal

OMP96AB BSCM-22 M8A-710

BIN	MEAN	ST DEV	MIN	MAX
U	-0.206	4.287	-37.756	35.784
V	-0.573	4.385	-64.705	30.685
T	4.799	0.639	4.120	16.221
S	38.344	3.657	11.936	52.446

22cal

OMP96AB BSCM-30 M8A-500

BIN	MEAN	ST DEV	MIN	MAX
U	-0.898	5.153	-21.391	49.137
V	-4.877	9.420	-44.297	30.771
T	5.627	0.317	4.943	15.460
S	35.018	0.052	31.761	37.654

30cal

OMP96B BSCM-32 M16-37

BIN	MEAN	ST DEV	MIN	MAX
U	-1.836	10.420	-159.181	50.297
V	-11.831	17.565	-61.478	73.498
T	10.212	3.079	5.776	21.693
S	-10.000	0.000	-10.000	-10.000

32cal

OMP96B BSCM-34 M16-72

BIN	MEAN	ST DEV	MIN	MAX
U	0.354	8.123	-30.343	53.318
V	-4.234	9.745	-43.998	32.553
T	7.365	1.626	5.193	15.708
S	33.019	0.988	30.361	35.849

34cal

OMP96B BSCM-35 M16-23

BIN	MEAN	ST DEV	MIN	MAX
U	0.186	5.895	-41.604	46.841
V	-0.654	9.703	-48.008	71.430
T	15.213	7.068	7.963	630.180
S	32.750	0.929	-9.152	38.231

35cal

FSU OMP96B WH-17 M5-29

BIN	MEAN	ST DEV	MIN	MAX
u10	-1.535	15.830	-47.217	57.245
v10	-5.149	15.479	-77.466	69.224
u18	-0.453	16.518	-64.999	56.150
v18	-1.858	15.383	-59.730	53.114
u24	-1.863	13.960	-53.704	35.372
v24	-0.587	11.238	-47.614	36.325

17raw

FSU OMP96B WH-45 M20-76 u16,v16,u36,v36,u56,v56,u71,v71

BIN	MEAN	ST DEV	MIN	MAX
u16	-0.169	12.695	-52.564	61.866
v16	-7.159	16.753	-61.438	70.812
u36	0.018	9.982	-32.706	35.076
v36	-6.466	17.412	-65.192	62.312
u56	0.563	8.591	-34.775	32.830
v56	-3.060	15.433	-47.937	51.539
u71	1.240	8.073	-26.856	34.135
v71	-5.530	18.843	-52.644	60.505

45raw

Appendix J

OMP96B Mooring 1 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 2 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 3 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 4 : 40 Hr LP Data from Jun to Oct

Salinity and Temperature calibrated with CTD casts (11/97 jme)

FSU OMP96B WH-17 M5-29 40HR LOW PASS DATA FROM JUN TO OCT

CURRENT AT 10 METERS

CURRENT AT 18 METERS

CURRENT AT 24 METERS

FSU OMP96B WH-17 M5-29 u10,v10,u18,v18,u24,v24 40LP JUN-OCT 96

~/fsu/ompb96/adcp/filter/files/17.40lp

OMP96B Mooring 6 : 40 Hr LP Data from Jun to Oct

OMP96B NB-442 M6-40 40HR LOW PASS DATA FROM JUN TO OCT

CURRENT AT 3 METERS

CURRENT AT 16 METERS

CURRENT AT 33 METERS

OMP96B NB-442 M6-40 U33,V33,U16,V16,U3,V3,T 40LP JUN-OCT 96

~/ompb96/adcp/nband/filter/files/mo6.40lp

OMP96B Mooring 8 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 9 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 11 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 13 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 16 : 40 Hr LP Data from Jun to Oct

Florida State University Mooring

Salinity and Temperature calibrated with CTD casts (jme 12/97)

OMP96B Mooring 17 : 40 Hr LP Data from Jun to Oct

OMP96B WH-71 M17-75 40HR LOW PASS DATA FROM JUN TO OCT

CURRENT AT 7 METERS

CURRENT AT 35 METERS

CURRENT AT 61 METERS

OMP96B WH-71 M17-75 U7,V7,U35,V35,U61,V61 40LP JUN-OCT 96

~/ompb96/adcp/whorse/filter/wh17.40lp

OMP96B Mooring 18 : 40 Hr LP Data from Jun to Oct

Salinity and Temperature calibrated with CTD casts (11/97 jme)

OMP96B Mooring 20 : 40 Hr LP Data from Jun to Oct

FSU OMP96B WH-45 M20-76 40HR LOW PASS DATA FROM JUN TO OCT

CURRENT AT 16 METERS

CURRENT AT 36 METERS

CURRENT AT 71 METERS

OMP96B Mooring 22 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 23 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 24 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 25 : 40 Hr LP Data from Jun to Oct

OMP96B Mooring 27 : 40 Hr LP Data from Jun to Oct

Salinity and Temperature calibrated with CTD casts (11/97 jme)

OMP96B NB-261 M27-300 40HR LOW PASS DATA FROM JUN TO OCT

CURRENT AT 40 METERS

CURRENT AT 168 METERS

CURRENT AT 288 METERS

OMP96B NB-261 M27-300 U288,V288,U168,V168,U40,V40,T 40LP JUN-OCT 96

~/ompb96/adcp/nband/filter/files/m27.40lp

Appendix K

OMP96B Mooring 1 : 40 Hr LP Data from June to Oct

OMP96B Mooring 2 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 3 : 40 Hr LP Data from June to Oct

OMP96B Mooring 4 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 5 : 40 Hr LP Data from June to Oct

OMP96B Mooring 6 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 8 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 9 : 40 Hr LP Data from June to Oct

OMP96B Mooring 11 : 40 Hr LP Data from June to Oct

OMP96B Mooring 12 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 13 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 16 : 40 Hr LP Data from June to Oct

OMP96B Mooring 17 : 40 Hr LP Data from June to Oct

OMP96B Mooring 18 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 20 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 22 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 23 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 24 : 40 Hr LP Data from June to Oct

FSU OMP96B Mooring 25 : 40 Hr LP Data from June to Oct

OMP96B Mooring 27 : 40 Hr LP Data from June to Oct

Appendix L

OMP96B Mooring 1 : 40 Hr LP Data from June to October

OMP96B Mooring 2 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 3 : 40 Hr LP Data from June to October

OMP96B Mooring 4 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 5 : 40 Hr LP Data from June to October

OMP96B Mooring 6 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 9 : 40 Hr LP Data from June to October

OMP96B Mooring 11 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 13 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 16 : 40 Hr LP Data from June to October

OMP96B Mooring 17 : 40 Hr LP Data from June to October

OMP96B Mooring 18 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 20 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 23 : 40 Hr LP Data from June to October

FSU OMP96B Mooring 24 : 40 Hr LP Data from June to October

OMP96B Mooring 25 : 40 Hr LP Data from June to October

OMP96B Mooring 27 : 40 Hr LP Data from June to October

Appendix M

OMP96B Mooring 1 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

OMP96B Mooring 2 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

FSU OMP96B Mooring 3 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

OMP96B Mooring 4 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

FSU OMP96B Mooring 5 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

OMP96B Mooring 6 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

FSU OMP96B Mooring 9 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

OMP96B Mooring 11 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

OMP96B Mooring 12 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

FSU OMP96B Mooring 13 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

FSU OMP96B Mooring 16 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

OMP96B Mooring 17 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

OMP96B Mooring 18 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

FSU OMP96B Mooring 20 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

FSU OMP96B Mooring 22 : 3 Hr LP Data from June to Oct

— : U Spectrum - - - : V Spectrum

FSU OMP96B Mooring 23 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

FSU OMP96B Mooring 24 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

OMP96B Mooring 25 : 3 Hr LP Data from June to Oct

— : U Spectrum ---- : V Spectrum

OMP96B Mooring 27 : 3 Hr LP Data from June to Oct

— : U Spectrum : V Spectrum

Appendix N

OMP96 NOAA/NDBC BUOY 44014 40 HR LOW PASS DATA FROM JUNE TO OCT

OMP96 NOAA/NDBC BUOY 44014 40 HR LOW PASS DATA FROM JAN - DEC 1996

~/ompa96/wind_data/filter/files/44014.40lp

OMP96 CHESAPEAKE LIGHT 40 HR LOW PASS DATA FROM JUNE TO OCT

OMP96 CHESAPEAKE LIGHT 40 HR LOW PASS DATA FROM JAN - DEC 1996

~/ompa96/wind_data/filter/files/chlv2.40lp

OMP96 DIAMOND SHOALS LIGHT 40 HR LOW PASS DATA FROM JUNE TO OCT

OMP96 DIAMOND SHOALS LIGHT 40 HR LOW PASS DATA FROM JAN - DEC 1996

~/ompa96/wind_data/filter/files/dsl7.40lp