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Woods Hole Oceanographic Institution

Coastal Ocean Processes Inner-Shelf Study: Coastal and Moored Physical Oceanographic Measurements

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Carol A. Alessi, Steven J. Lentz, and Jay Austin

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Technical Report

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Approved for Distribution:

Philip L. Richardson, Chair
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Abstract

To improve our understanding of the physical and biological processes influencing planktonic larval distributions over the inner shelf, an interdisciplinary field program funded by the National Science Foundation's Coastal Ocean Processes program (CoOP) was conducted near Duck, North Carolina in the southern portion of the Middle Atlantic Bight. The field program took place from August to December, 1994 and included both moored and shipboard measurements of physical, biological and sedimentological variables.

This report summarizes the observations from one component of this field program, a moored array of physical oceanographic and meteorological instruments. This component of the field program consisted of a cross-shelf array of three surface/subsurface mooring pairs in 13 m, 20 m and 25 m of water supporting instruments to measure currents, temperature and conductivity, a suite of meteorological instruments on surface buoys at the 20 -m and 25 -m site, and an along-shelf array of temperature, conductivity and bottom pressure sensors mounted on jetted pipes along the 5-m isobath and on moorings along the 20-m isobath. The report includes descriptions of the cross-shelf and along-shelf arrays, the four types of instruments used (VAWRs, VMCMs, SeaCats, and SeaGauges), and the data return from the field program. Statistical and graphical summaries of the atmospheric (wind, air temperature, barometric pressure, relative humidity, short- and long-wave radiation), and oceanic (current, water temperature, conductivity and bottom pressure) measurements are presented.

1. Introduction

To improve our understanding of the physical and biological processes influencing planktonic larval distributions over the inner-shelf, an interdisciplinary field program funded by the National Science Foundation's Coastal Ocean Processes program (CoOP) was conducted in the southern portion of the Middle Atlantic Bight. Past studies of the relationships between physical processes and larval settlement have been hindered by limitations in measuring changes in planktonic larval distributions on the same time and space scales as the physics (Butman, 1987; Levin, 1990; GLOBEC, 1988, 1991a,b,c). Therefore this field program included two complementary observational approaches: deployment of a fixed array of biological and physical instruments, and detailed shipboard surveys of the region acquiring both biological and physical measurements. This study (referred to as the CoOP inner-shelf study in the remainder of this report) was planned and conducted by a group of seven principal investigators from five institutions representing the disciplines of biology, geology, and physical oceanography. The principal investigators and their technical responsibilities are listed in Table 1.

The CoOP inner-shelf field program was conducted on the North Carolina shelf between Chesapeake Bay and Oregon Inlet, focusing on the inner-shelf near Duck, from August to December 1994. The inner-shelf is defined as the portion of the continental shelf shoreward of where the surface and bottom boundary layers interact (about three surface Ekman layer depths, Mitchum and Clarke, 1986) and seaward of the surf zone, spanning water depths of roughly 5—30 m (Figure 1). The inner-shelf is most studied at its shoreward (surf zone) and seaward (traditional shelf studies) boundaries, with far fewer measurements in the depth range of 4 to 15 m.

In the CoOP inner-shelf field program the observations were concentrated between the 4-m and 25-m isobaths. The site near Duck was chosen for its relatively simple, straight shoreline and parallel isobaths which may minimize biological, hydrodynamical and sedimentological variation in the along-shelf direction. There were two intensive study periods representative of strong (August) and weak (October) stratification (Figure 2a, from Boicourt, 1973), when most of the shipboard surveys and the fixed array biological and bottom boundary layer measurements were made. Figure 2b shows two sections collected during the CoOP inner-shelf field program from the *R/V Cape Hatteras* during August 1994, representative of strong stratification, and Figure 2c shows data collected during October 1994, a period of weak stratification. The fixed array physical oceanography measurements spanned the intervening month of September to provide continuity between the two intensive study periods.

This report focuses on one component of the interdisciplinary CoOP inner-shelf field program, a moored array of physical oceanographic and meteorological instruments. This component of the field program consisted of a cross-shelf array of three surface/subsurface mooring pairs in 13, 20, and 25 m of water supporting instruments to measure currents, temperature and conductivity, a suite of meteorological instruments on surface buoys at the 20-m and 25-m site, and an along-shelf array of temperature, conductivity and bottom pressure sensors mounted on jetted pipes roughly along the 6-m isobath and on moorings along the 20-m isobath. The other major physical oceanographic components of the CoOP inner-shelf field program were an array of nearshore moorings and extensive shipboard hydrographic surveys (Table 1).

Table 1: Principal Investigators and Technical Responsibilities

		Physical Oceanography
S. J. Lentz	WHOI	Acquisition and analysis of the current, temperature, and conductivity measurements on the 13, 20, and 25 m moorings, and for the alongshelf array of bottom pressure/temperature/conductivity measurements.
J. Largier	SIO	Large-scale CTD surveys, anchor stations, and small boat CTD surveys.
R. T. Guza	SIO	All aspects of the current meters, pressure sensors, and thermistors in 8 m and shallower locations.
		Biological Oceanography
C. A. Butman	WHOI	Moored larval pumps and colonization tray.
A. L. Shanks	UO	Shipboard and pier larval pump sampling and beach surveys.
		Geological Oceanography and Ocean Engineering
L. D. Wright	VIMS	Bottom-boundary-layer instrumentation systems (tetrapods), and conducting surveys of bottom and substrate characteristics (e.g., side-scan sonar, coring, bottom photography, etc.)
O. S. Madsen	MIT	Modeling of wave current boundary layers.

Notes:

WHOI:	Woods Hole Oceanographic Institution	SIO:	Scripps Institution of Oceanography
MIT:	Massachusetts Institute of Technology	VIMS:	Virginia Institute of Marine Science
UO:	University of Oregon		

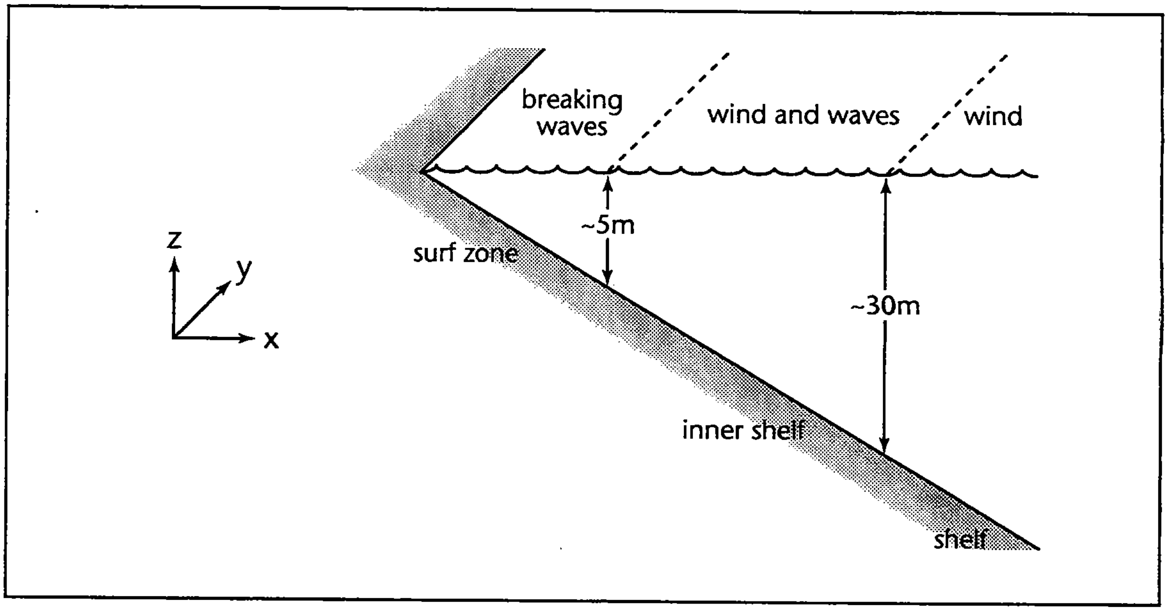

Figure 1: Cartoon showing various regions of the shelf and the principal driving forces of the flows in those regions. The coordinate system used is also shown.

The scientific objectives of the physical oceanographic component include determining:

- the role of the wind stress, waves, and pressure gradients in the along-shelf momentum balance as a function of cross-shelf position;
- the processes influencing the vertical and cross-shelf structure of the cross-shelf velocity field; and
- the processes influencing the temporal evolution and vertical and cross-shelf structure of the density field.

The objective of this report is to present statistical and graphical summaries of data from the physical oceanography component of the CoOP inner-shelf study. This includes the 13-m, 20-m, and 25-m mooring sites and the along-shelf array of temperature, conductivity and bottom pressure instruments. This report is organized in the following way:

- Section 2 gives a description of the cross-shelf and along-shelf array design, the placement of instruments at the various measurement sites, associated data return, and problems affecting the data return.

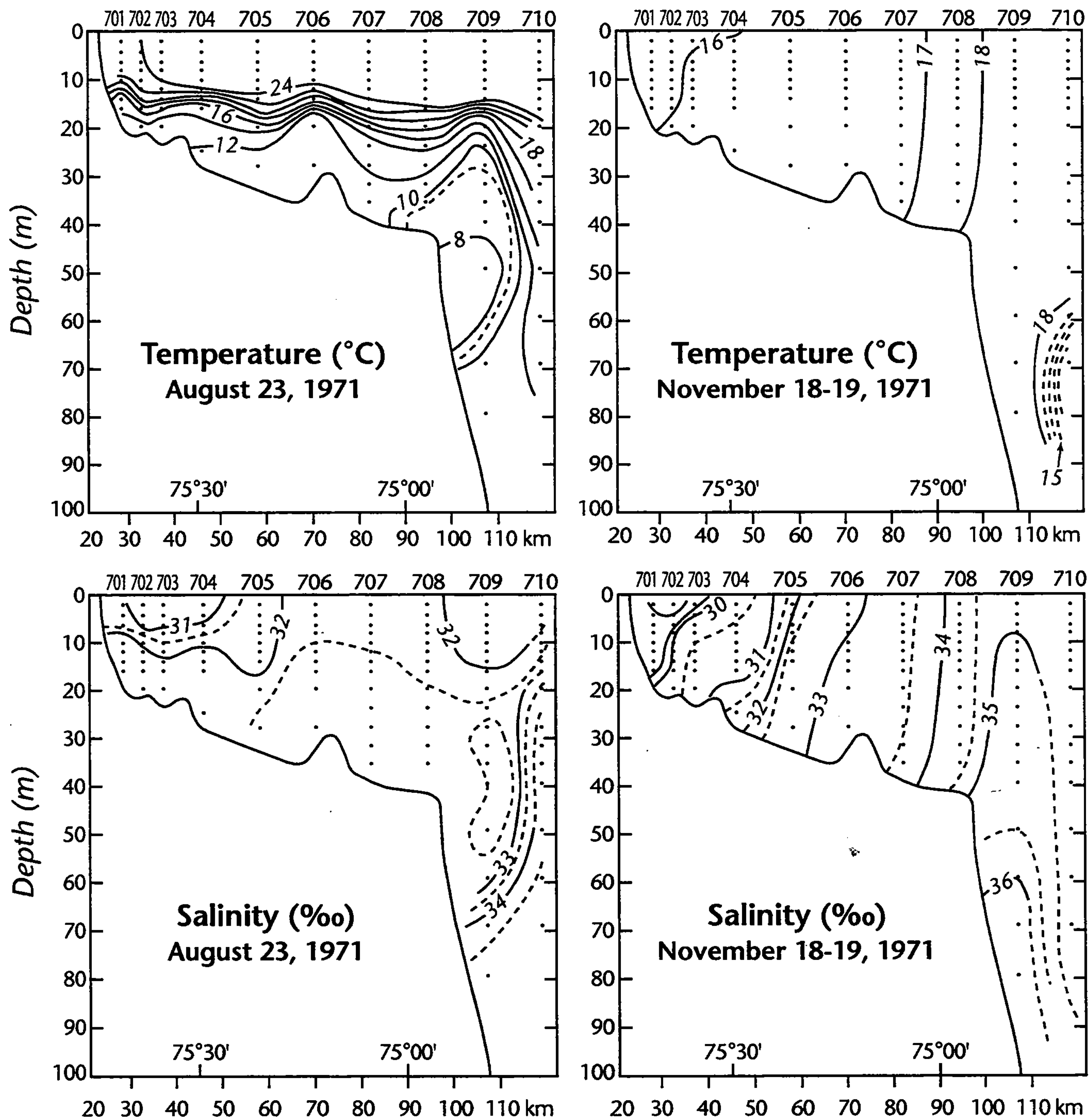

Figure 2a: Temperature/Salinity transects near Duck, NC (Boicourt, 1973) showing the temperature and salinity structure out to 120 km offshore.

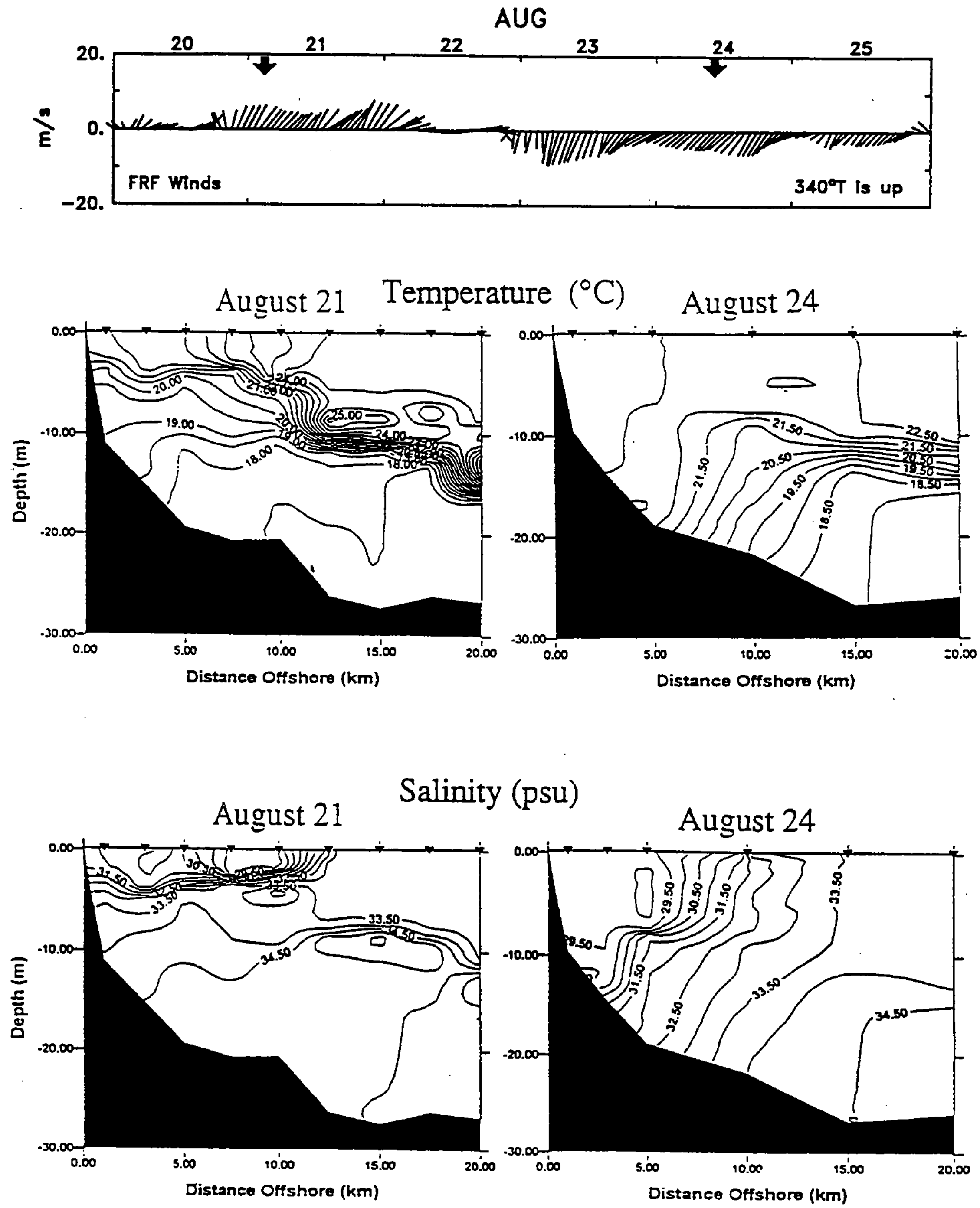

Figure 2b: Temperature/Salinity sections out to 20 km along the central line from shipboard surveys taken on August 21 (lefthand figures) and August 24 (righthand figures). For reference, a time series of wind vectors from the FRF pier is shown at the top. A vector toward the top of the page indicates alongshore winds toward 340°T. Bold arrows indicate when sections were taken.

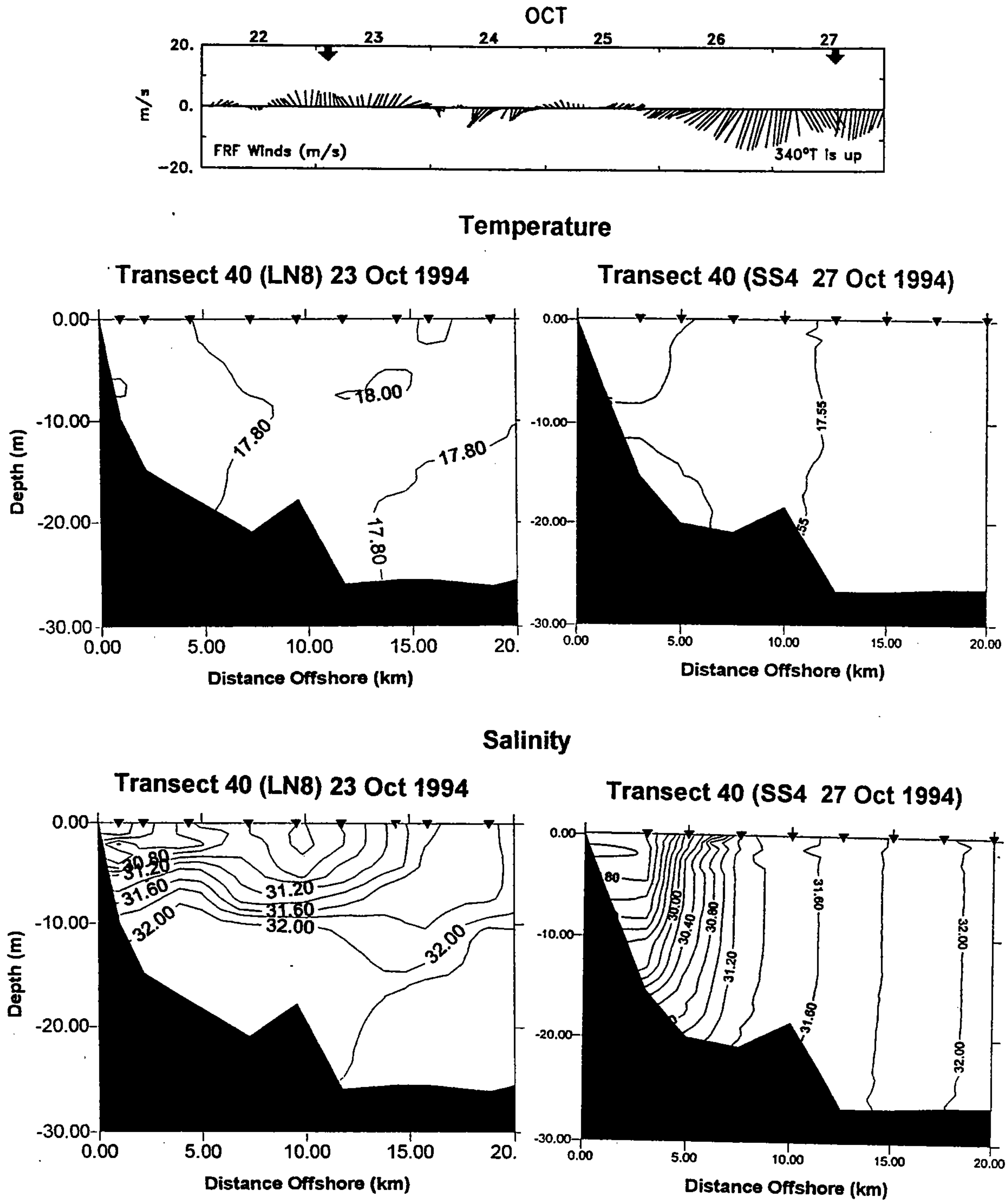

Figure 2c: Temperature/Salinity sections out to 20 km along the central line from shipboard surveys taken on October 23 and October 27. For reference, a time series of wind vectors from the FRF pier is shown at the top. Bold arrows indicate when sections were taken.

- Section 3 gives a description of the four types of instruments used in the WHOI physical oceanography cross-shelf and along-shelf arrays including accuracy specifications.
- Section 4 describes general processing of the data including the coordinate system used, and a description of the meteorological and oceanic data analysis procedures. This includes comparisons made with other instruments collecting the same type of data to detect any systematic errors.
- Section 5 contains a description of the time series data presentation.
- The basic statistics of the hourly-averaged data covering the entire time period for each record are presented in Section 6.
- Time series plots for each instrument are presented in Section 9. This includes the coastal and moored meteorological measurements, moored velocity measurements, and the temperature, conductivity, and salinity measurements.

2. Description of the Inner-Shelf Arrays

The focal point of the physical oceanographic component of the CoOP inner-shelf study was a cross-shelf three-element array of surface/subsurface mooring pairs measuring winds, currents, temperature, and conductivity (discussed in Section 2.1), and an along-shelf array of temperature, conductivity, and bottom pressure sensors mounted on jetted pipes along the shore and deeper sensors mounted on surface moorings (Section 2.2). A location map of the cross-shelf moored array sites is shown in Figure 3 along with the sea level and coastal wind stations and the along-shelf array. The U.S. Army Corps of Engineers CERC Field Research Facility (FRF) is located at Duck. Collaboration with FRF allowed access to supplementary data on winds, waves, inshore currents, and accurate bathymetric surveys. Listed in Table 2 are the locations of various sites, abbreviated station names, water depths, and positions.

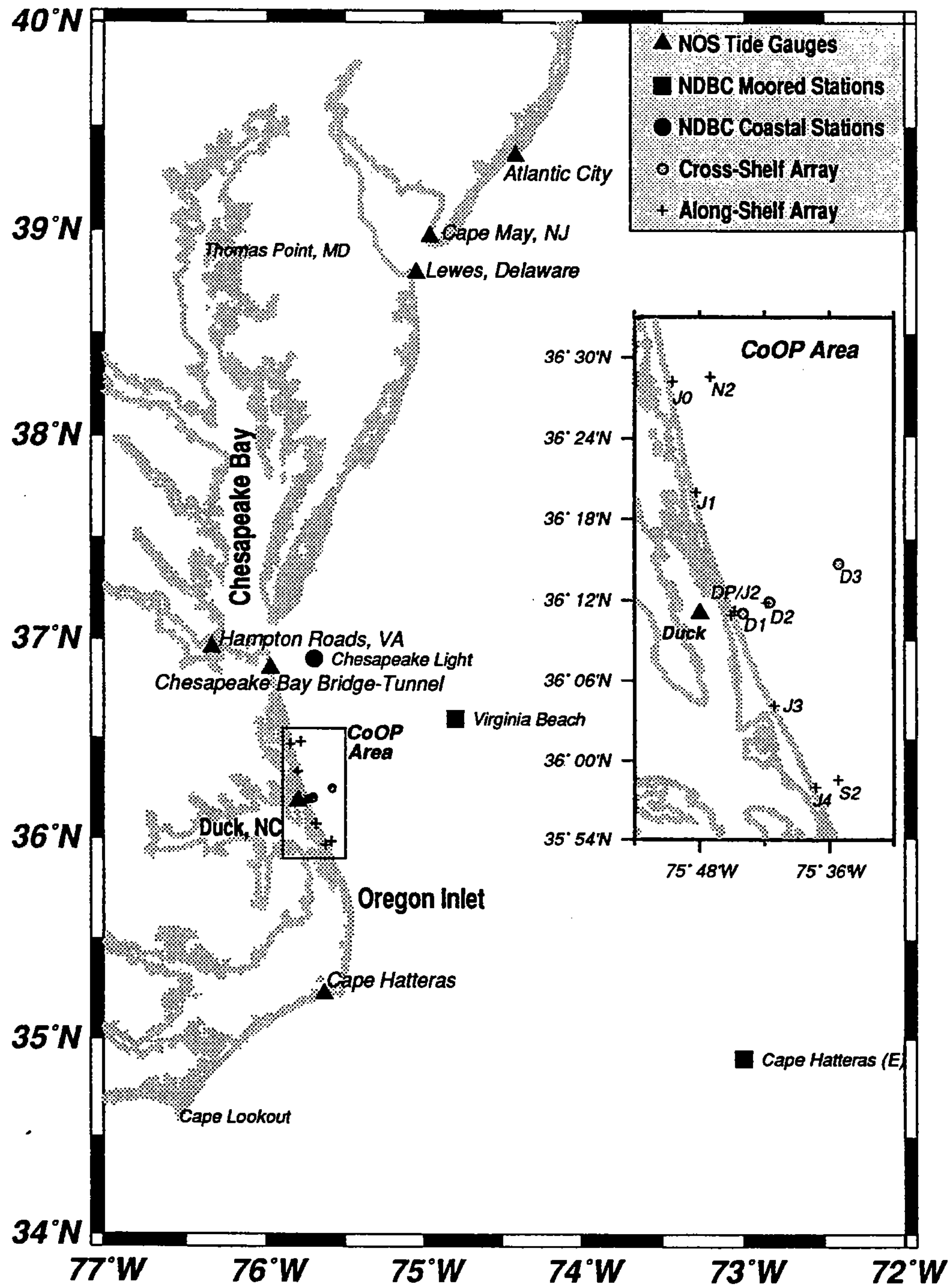

Figure 3: Location Map of the cross- and along-shelf array sites, sea level and coastal wind stations. The inset shows the cross-shelf mooring pairs deployed along the central-line, perpendicular to the coast near Duck (labelled D1, D2 and D3), and the bottom pressure sites (labelled J0, J1, J2, J3, and J4). The FRF pier (located at Duck) extends 500m offshore.