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The efforts covered in this support period involved planning and execution of two cruise efforts. The first in fall 1988 included two legs aboard R/V Cape Hatteras to map the biological fields in a Gulf Stream meander. Funds in this contract covered the physical data collection and satellite real-time data support for the Hatteras. The second cruise in the spring of 1989 aboard R/V Columbus Iselin again mapped one wave length of a Gulf Stream meander. Both cruises were part of a multi-platform effort that also involved the R/V Endeavor and R/V Bartlett (spring only). The resulting data from the cruises is currently being analyzed as part of a current ONR contract.

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ONR Final Report

BioSYNOP: Biophysical Observations and Modeling

Grant Number: N00014-89-J-1536

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Abstracts

1989 Olson, D. B. Physical Aspects of Fishery Recruitment. In: Fishery Recruitment in Florida Water — Toward a Predictive Capability. G. S. Kleppel and William Seaman, Jr., Eds., February 15-17, 1989, Live Oak, Florida, Florida Sea Grant Technical Paper No. 57, 50 (abstract).

Olson, D. B. Physical Controls on Oceanic Productivity. Program of the Inaugural Meeting of The Oceanography Society, Monterey, CA, August 27-30, 1989 (Invited talk).

1990 Atwoods, D. K., G. L. Hitchcock, G. Knauer, R. H. Evans and D. B. Olson. Biogenic Carbon Export in Shelf Water Features Along the Gulf Stream Front. EOS Transactions, AGU (Abstract), 71(2), 190.

Hitchcock, G. L. and D. B. Olson. Phytoplankton Distribution in Gulf Stream Meanders. EOS Transactions, AGU (Abstract), 71(2), 176.

Napp, J. M., P. B. Ortner, D. B. Olson and C. S. Davis. Is Zooplankton Biomass Enhanced Within the Frontal Region of Gulf Stream Meaders? EOS Transactions, AGU (Abstract), 71(2), 177.

Hitchcock, G. L., A. J. Mariano and D. B. Olson. Mesoscale Pigment Fields in the Gulf Stream. EOS Transactions, AGU (Abstract), 71(43), 1403.

Cruise Reports

1988 Olson, D. B., Chief Scientist, BioSYNOP I, Leg 2, R/V Cape Hatteras CH08-88, 10-23 October 1988, N.W. Atlantic.

1989 Olson, D. B., Chief Scientist, BioSYNOP II, R/V Iselin, CI8903, March 30 - April 28, 1989, N.W. Atlantic.

Newsletters

1990 Olson, D. B., BIOSYNOP: Biophysical Studies of Gulf Stream Meanders. The Synoptician, 1(3), 2-3.

Presented at the Workshop on Fishery Recruitment in Florida Waters, Live Oak, Florida, February 14 - 16, 1989.

Physical Aspects of Fishery Recruitment

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Recruitment is dependent upon transfers between source regions for potential recruits and the final environment where an organism is going to exist in a given life stage. In the marine environment, this process is often controlled by the nature of flows found in given regimes and the degree of mixing that occurs between environments. This control may be direct as in the case of planktonic forms or indirect in the situation where an organism actively migrates but is stil dependent upon navigational ques which are effected by the fluid motion. While the drift of inert particles provides a first approximation to the redistribution of plankton, in general, behaviour is important in both of these types of interaction with the physical environment. The Florida marine environment can be separated into three distinct regimes; the pelagic environments of the Gulf of Mexico and Florida Current, the shelf and the semi-enclosed bays and rivers along the coast. Recruitment occurs in both directions between these regions. The physical mechanisms for exchange within and between these three regimes are briefly discussed along with some of the possible ways in which organisms can exploit or, alternatively, eliminate the effect of these processes. Finally, conditions in the Florida Environment are contrasted with the more completely understood conditions on the U.S. northeast and west coasts.

In: EOS Transactions, AGU (Abstract), 71(2), 190.

Biogenic Carbon Export in Shelf Water Features Along the Gulf Stream Front.

D K Atwood, G L Hitchcock (Both at: NOAA/AOML, 4301 Rickenbacker Cswy, Miami, FL 33149; 305-361-4397; GTE Telemail G.HITCHCOCK)
G Knauer (Center for Marine Science, University of Southern Mississippi, Stennis Space Center, MS 39529; 601-688-3177; GTE Telemail USM.CMS)
R H Evans, D B Olson (Both at: RSMAS, University of Miami, 4600 Rickenbacker Cswy, Miami, FL 33149; 305-361-4770; GTE Telemail R.EVANS)

The entrainment of shelf water along the northern edge of the Gulf Stream occurs as an intermittent process northeast of Cape Hatteras. The low salinity 'Ford Water' is often identified as surface or subsurface jets 5 to 10 km wide and 10 to 50 m thick along the shoreward edge of the Gulf Stream surface front. CZCS imagery (August, 1985) has shown the surface jets may coincide with plumes of high pigment concentrations extending 100 km offshore of Cape Hatteras. Daily productivity rates (350 - 600 mg C m^{-2} d^{-1}) and chlorophyll standing stocks (20 - 30 mg m^{-2}) within Ford Water features are similar to those in the contiguous Slope Waters. A drifting sediment trap array deployed in July, 1988 indicated that 97% of total carbon sedimenting from a low-salinity surface feature was organic matter (86.4 mg m-2 d-1), but the major flux of particulate matter was inorganic (mass flux = 552 mg m^{-2} d^{-1}). The level of 'new' production was estimated to 18% of total daily production. The daily offshore export of biogenic carbon within Ford Water features during the summer is estimated to be equivalent to the productivity witnin 10 to 20 km^2 of Shelf waters near Cape Hatteras.

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9. C.
10.

In: Eos Transactions, 71(2), AGU (Abstract), 176.

Phytoplankton Distribution in Gulf Stream Meanders

G L Hitchcock (NOVA University, Department of Oceanography, 8000 North Ocean Drive, Dania, FL 33004; 305-361-4397; GTE Telemail G.HITCHCOCK)
D B Olson (Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Cswy, Miami, FL 33149; 305-361-4074; GTE Telemail D.OLSON)
(Sponsor: D. B. Olson)

Distributions of chlorophyll with respect to Gulf Stream meanders are discussed with the use of synoptic shipboard and satellite (CZCS) data and in the context of simple advection/diffusion models for a meandering current. The field data include two multiple ship experiments, one in Fall 1988 and another in Spring 1989. Cross-stream transects show a shallower pigment maximum at the inflow to an anticyclonic meander crest than in the outflow. The isotherm structure also indicated a shallower mixed layer on the inflow side, with surface isotherms and velocity vectors suggesting a region of divergence. In the outflow region, in contrast, the isotherm structure indicated convergence, with deeper pigment maxima. An isopycnal float deployed within the thermocline also deepened upon entering a cyclonic meander, supporting the observed distributions of isotherms and pigments. The effect of these vertical motions on the phytoplankton population is discussed. A simple model for the time history of a phytoplankton population following a path through a meander is used to infer the important factors governing the development of the biomass distributions in the Gulf Stream edge.

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   exp. 3/91
   Donald B. Olson
9. C
10. Schedule paper before Napp, Ortner, Olson and Davis, "Zooplankton Biomass Enhanced within the Frontal Region of Gulf Stream Meanders?"
11. No

In: EOS Transactions, 71(2), AGU (Abstract), 177.

Is Zooplankton Biomass Enhanced Within the Frontal Region of Gulf Stream Meanders?

J.M. Napp, P.B. Ortner, and D.B. Olson (All at: University of Miami, RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149; 305-361-4131; GTE Telemail P.Ortner, D.Olson).
C.S. Davis (Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543; 508-548-1400)

Frontal enhancement of zooplankton biomass in Gulf Stream meanders is hypothesized to occur via two mechanisms: 1)growth and reproduction downstream of upwelling caused by stream flow divergence in the anticyclonic portion of the meander; and 2)passive concentration caused by stream flow convergence (downwelling) in the cyclonic portion of the meander. As one component of the BioSYNOP program, mesoscale surveys of macrozooplankton (fall and spring) and microzooplankton (spring, only) biomass were conducted across the front in Gulf Stream meanders to examine the above hypothesis. In addition to presenting the specific relationship between zooplankton biomass and several indices of frontal intensity, we will discuss the general horizontal and vertical distributions of macrozooplankton biomass in the meander and the water masses surrounding it.

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6. N/A
7. 25% at 1989 TOS Mtg.
8. $50 check enclosed
9. C
10. Schedule after G.L. Hitchcock and D.B. Olson, "Phytoplankton Distribution in Gulf Stream Meanders" /BioSYNOP
11. No

Mesoscale Pigment Fields in the Gulf Stream

G L Hitchcock, A J Mariano and D B Olson (All at: Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL 33149; 305-361-4131; Omnet Telemail G.HITCHCOCK)

In September/October, 1988 and April, 1989 a series of transects were completed across the Gulf Stream front during the Anatomy of a Meander/Biosynop experiment. One of the main objectives of this program is to relate the spatial distribution of chlorophyll to the physical fields of Gulf Stream Meanders. The fall 1988 cruise concentrated on repeated Lagrangian sampling of a meander crest, while the spring 1989 cruise sampled a meander trough. Chlorophyll distributions were derived from CTD/fluorescence profiles calibrated with discrete pigment samples collected from bottles at several depths at each station.

Objective Analysis (OA) maps and vertical sections, in stream coordinates, of chlorophyll were constructed on density, pressure and temperature surfaces. It is evident from the OA maps that the chlorophyll distribution is strongly related to the structure of the Gulf Stream front. For example, during the Fall 1988 cruise, maximum chlorophyll concentrations were wrapped around a warm core ring during a strong stream-ring interaction. Characteristic length scales of chlorophyll distribution determined from the horizontal and temporal correlation function are the same order (50-100 km) as the dynamical fields.

The maximum chlorophyll concentrations in the vertical are at 25-50 m depth on the western flank of the meander crest and deepen to 75-100 m depth on the eastern flank. This coincides with the deepening of the 25.7 σ_θ on the eastern flank of the meander crest. Although during the spring cruise the maximum chlorophyll concentrations were also found at depths from 25-75 m, there are no clear distinctions between the western and eastern transects of a relatively weak trough. A set of Lagrangian biophysical models are used to explore the underlying dynamics behind the distributions.

1. **1990 Fall Meeting**
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BIOSYNOP Leg II

R/V Cape Hatteras CH08-88 10-23 October, 1988

The second leg of the fall BIOSYNOP effort left WHOI mid-morning on October 10th. The first day was spent in transit to the upstream quadrant of the target Gulf Stream meander. A portion of the second day was lost due to weather conditions in the region. As the weather moderated, a mesoscale survey of the meander was begun. The pattern used was a truncated version of the original plan. To speed up the survey, the cross frontal sections were reduced to 3 to 4 MOCNESS tows. A shallow CTD cast was taken at each station to provide flourometer profiles. The MOCNESS tows were done to 1000 m except in one case where battery limitations forced a limitation on the depth to 300 m. Some problems with charging the MOCNESS battery pack between the stations was encountered. This was finally remedied by adding 5 volts worth of batteries to the MOCNESS. Heavy weather and problems with flying the net in the high current shears encountered in the Gulf Stream core led to tearing in several nets during one of the cross sections.

The mesoscale survey was completed in four and a half days. It was followed by a section out to the Sargasso Sea side of the stream where a daylight period in situ primary productivity station was occupied. The drift during this station carried the ship approximately a half wave length of the meander to the east. Thermocline isotherm depth decreases, observed between the end of the mesoscale survey and the end of the Sargasso productivity station, suggested the meander was collapsing. Gale force winds and limitations of steaming time did not allow the ship to follow the evolution of the stream to the east of the meander. Instead the ship proceeded westward to the original inlet region of the meander surveyed as part of BIOSYNOP and the meander experiment.

The remainder of the cruise was spent completing stream core and slope water primary productivity stations and a fine scale cross section across the now linear Gulf Stream at the location of the previous meander crest. The Gulf Stream in situ incubation led to drift through an entire meander wave length during the twelve hour station. The ship steamed back upstream to the the final MOCNESS cross section which was done with shallow 300 m tows to maximize the ground truth return for the ADCP biomass volume estimates. The original plan was to do the slope water productivity station just north of the survey area. Weather conditions did not permit this. Time constraints forced the ship to steam westward where the final productivity station took place following moderation of the seas. Weather deteriorated to the worst conditions of the cruise following the final productivity stations. Both the Lamont and Bigelow drifters were successfully recovered in near gale conditions and limited visibility. Despite gale conditions, the ship managed to proceed southward and arrive in Beaufort a half day early.

The second leg was overall very successful. Weather cost approximately three and a half days of station time and the forced relocation of the slope water phytoplankton work described above. The captain and crew of the Cape Hatteras are to be complimented on a very professional job. In particular, the ship handling by the captain on the buoy recoveries was superb. T. Boynton did a commendable job of maintaining the ship's equipment and provided crucial help with the communications and solving the MOCNESS power problem. The galley is definitely the best on any research vessel in the chief scientist's experience.

There is one aspect of the ship's performance which could be improved, namely communications, although this did not jeopardized the scientific effort. The limitations of the Cape Hatteras communication facilities were well understood before the cruise and steps were taken to surmount them. Of the two items put on board from Miami to improve communications, only the PACKRAT modem proved to be of use. Until a lightning strike to the ship's antennas late in the cruise, the PACKRAT was used to obtain files through ATS with fair success. Gulf Stream positions during other times were passed to the ship via voice using a phone patch through Beaufort. As a general comment, UNOLS needs to think about ship communications. The current trend to move to MARSAT is a solution, although an expensive one. Other solutions to replace ATS should be explored.

BIOSYNOP CRUISE

R/V Cape Hatteras Log
September 21 - October 21, 1988

Leg 1

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
21 Sep 88	02:18:55	35°55.4 N	74°26.1 W	CTD 1
21 Sep 88	14:25:59	37°35.8 N	73°12.1 W	CTD 2 St. 1
21 Sep 88	15:11:01	37°35.2 N	73°12.8 W	Light profile (failed)
21 Sep 88	15:36:40	37°34.8 N	73°13.4 W	MOCNESS (MOC 01) in water
21 Sep 88	16:11:11	37°34.25N	73°14.76W	FORAM tow 1
21 Sep 88	16:35:50	37°33.93N	73°15.74W	MOC 01 at bottom
21 Sep 88	16:51:50	37°33.06N	73°19.08W	MOC surface
21 Sep 88	18:58	37°33.90N	73°09.91W	Underway system resumed
21 Sep 88	19:33	37°34.52N	73°03.27W	XBT 1
21 Sep 88	20:32	37°32.69N	72°56.37W	CDT 3 St. 2
21 Sep 88	21:05	37°32.8 N	73°00.00W	MOC 02 in water
21 Sep 88	21:52	37°32.31N	72°54.38W	MOC 02 at bottom
21 Sep 88	23:19	37°31.34N	72°50.68W	MOC 02 at surface
21 Sep 88	23:58	37°31.46N	72°46.17W	XBT 2
22 Sep 88	00:41:20	37°30.16N	72°39.66W	CTD 4 St. 3
22 Sep 88	01:44:37	37°31.65N	72°39.09W	MOC 03 in water
22 Sep 88	02:29:27	37°32.99N	72°39.36W	MOC 03 at bottom
22 Sep 88	03:45	------	------	MOC 03 at surface
22 Sep 88	05:10	37°27.85N	72°31.65W	XBT 3 (first probe tried failed to load)
22 Sep 88	05:45	37°27.14N	72°24.76W	CTD 5 St. 4
22 Sep 88	06:25	37°28.6 N	72°23.2 W	MOC 04 in water
22 Sep 88	07:14	37°28.9 N	72°21.1 W	MOC 04 at depth
22 Sep 88	08:20	37°29.57N	72°18.76W	MOC 04 at surface
22 Sep 88	09:44	37°25.5 N	72°12.5 W	XBT 4 (file _5.DAT)
22 Sep 88	11:02	37°22.77N	71°59.06W	CTD 6 St. 5
22 Sep 88	11:08:18	37°23.13N	71°58.74W	FORAM tow 2
22 Sep 88	11:50	37°25.6 N	71°56.9 W	MOC 05 surface
22 Sep 88	12:04	37°26.11N	71°56.68W	FORAM tow 3
22 Sep 88	12:42	37°27.45N	71°55.99W	MOC 05 bottom
22 Sep 88	14:14	37°28.97N	71°53.31W	Underway Chlorophyll
22 Sep 88	13:59	37°28.94N	71°54.37W	MOC 05 surface
22 Sep 88	14:59	37°29.49N	71°55.18W	XBT 5
22 Sep 88	17:00	37°41.4 N	71°56.78W	Light sensor
22 Sep 88	17:26	37°41.4 N	71°56.78W	MOC 06 launch
22 Sep 88	17:45	37°41.95N	71°56.00W	FORAM tow 4
22 Sep 88	18:13	37°42.32N	71°54.64W	MOC 06 bottom
22 Sep 88	19:07	------	------	MOC 06 surface
22 Sep 88	21:15	37°44.48N	72°00.01W	XBT 6
22 Sep 88	22:45	37°53.35N	71°59.61W	CTD 8
22 Sep 88	23:05	37°54.24N	71°59.30W	MOC 7 over
22 Sep 88	23:11	37°54.48N	71°59.27W	FORAM tow 5
23 Sep 88	00:38:11	37°58.5 N	71°58.4 W	MOC 07 at depth
23 Sep 88	01:59:14	38°02.77N	71°56.53W	MOC 07 at surface

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
23 Sep 88	02:58	37°59.53N	71°59.57W	XBT 7
23 Sep 88	02:58	37°59.53N	71°59.57W	Underway Chlorophyll
23 Sep 88	03:53	38°07.03N	72°00.09W	CTD 9
23 Sep 88	04:31:15	38°07.84N	72°00.39W	MOC 08 in water
23 Sep 88	05:32:30	38°09.35N	72°00.48W	MOC 08 at bottom
23 Sep 88	06:36:30	38°10.94N	72°00.74W	MOC 08 at surface
23 Sep 88	08:07:11	38°00.72N	72°52.18W	XBT 8
23 Sep 88	09:10	37°55.24N	71°44.72W	CTD 10
23 Sep 88	09:50	37°57.09N	71°41.19W	MOC 09 over
23 Sep 88	10:25	37°59.00N	71°39.24W	FORAM tow 6
23 Sep 88	11:36	38°02.73N	71°35.9 W	MOC 09 bottom
23 Sep 88	12:48	38°04.38N	71°37.03W	ADCP to 1 min
23 Sep 88	13:05	38°04.92N	71°37.31W	MOC 09 surface
23 Sep 88	16:08	37°49.7 N	71°37.1 W	XBT 9 (whales sighted)
23 Sep 88	17:11	37°44.14N	71°30.03W	CTD 11
23 Sep 88	18:12	37°45.6 N	71°27.22W	Test Taylor produc
23 Sep 88	18:25	37°46.14N	71°26.09W	Photometer
23 Sep 88	21:08	37°42.24N	71°32.58W	MOC 10
23 Sep 88	21:19	37°42.32N	71°31.95W	FORAM tow 7
23 Sep 88	22:26:[illegible]	37°42.83N	71°28.06W	MOC 10 at bottom
23 Sep 88	01	37°36	71°19	XBT 10 failed
24 Sep 88	01:59:52	37°33.19N	71°15.07W	CTD 12
24 Sep 88	04:01:55	37°31.26N	71°18.79W	MOC 11 over
24 Sep 88	04:58:20	37°32.2 N	71°18.7 W	MOC 11 at depth
24 Sep 88	05:59:25	37°32.6 N	71°19.2 W	MOC 11 at surface
24 Sep 88	09:00	37°50	71°05	XBT 11
24 Sep 88	10:35	37°41.95N	70°54.42W	CTD 13
24 Sep 88	11:16	37°42	70°56.8 W	MOC 12A launch
24 Sep 88	12:28	37°43	70°58	MOC 12A abort
24 Sep 88	13:58	37°42	70°57	MOC 12 launch
24 Sep 88	---	---	---	MOC 12 down
24 Sep 88	---	---	---	MOC 12 up
24 Sep 88	14:15	37°42.26N	70°57.31W	FORAM tow 8
24 Sep 88	15:08	37°42.55N	70°58.09W	MOC 12 bottom
24 Sep 88	16:45	37°42.7 N	70°58.7 W	MOC 12 at surface
24 Sep 88	18.22	37°48	70°46.11W	XBT 12
24 Sep 88	19:32	37°54.09N	70°35.52W	CTD 14
24 Sep 88	19:59:00	37°53.21N	70°34.16W	MOC 13 over
24 Sep 88	21:11:45	37°50.54N	70°31.35W	MOC 13 bottom
24 Sep 88	22:40:25	37°47.26N	70°27.97W	MOC 13 at surface
25 Sep 88	00:57	37°59.0 N	70°27.07W	XBT 13
25 Sep 88	01:56	38°03.98N	70°17.52W	CTD 15
25 Sep 88	02:54	38°03.06N	70°17.50W	MOC 14 over
25 Sep 88	04:32	37°58.1 N	70°14.1 W	MOC 14 at bottom
25 Sep 88	06:11	37°53.14N	70°10.63W	MOC 14 surface
25 Sep 88	08:50	38°07.5 N	70°11.0 W	XBT 14
25 Sep 88	09:30	38°10.64N	70°05.36W	Surface front/underway sample
25 Sep 88	09:48	38°10.53N	70°04.20W	CTD 16
25 Sep 88	11:21	38°13.22N	70°07.12W	MOC 15 start
25 Sep 88	11:45	38°13.13N	70°05.72W	FORAM tow 9
25 Sep 88	12:23	38°12.90N	70°04.23W	MOC 15 bottom
25 Sep 88	13:47	38°12.66N	70°01.09W	MOC 15 surface

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
25 Sep 88	14:40	38°15	69°53	XBT 15
25 Sep 88	16:00	~38°18	~69°52	CTD 17
25 Sep 88	16:32	38°17.53N	69°53.55W	MOC 16 start
25 Sep 88	16:47	38°17.78N	69°53.14W	FORAM tow 10
25 Sep 88	17:21	38°18.25N	69°52.30W	MOC 16 bottom
25 Sep 88	17:23	38°18.30N	69°52.22W	FORAM tow 11
25 Sep 88	18:40	38°19.68N	69°50.38W	MOC 16 surface
25 Sep 88	19:27	38°19.03N	69°51.71W	CTD 18
25 Sep 88	20:54	38°11	69°52	XBT 16
26 Sep 88	22:29	38°03.41N	69°51.7 W	CTD 19
26 Sep 88	01:22	37°56	69°52	XBT 17
26 Sep 88	02:04	37°41	69°52	XBT 18
26 Sep 88	02:48	37°49	69°52	XBT 19
26 Sep 88	03:30	37°34	69°52	XBT 20
26 Sep 88	04:30	37°35	69°42	XBT 21
26 Sep 88	05:19	37°36	69°31	XBT 22
26 Sep 88	06:20	37°36.87N	69°89.6 W	XBT 23B (25 in files)
26 Sep 88	07:27	37°38	69°06	XBT 24 (26 in files)
26 Sep 88	08:39	37°39	68°53	XBT 25 (27 in files)
26 Sep 88	09:45	37°40	68°4	XBT 26
26 Sep 88	11:26	37°39.33	68°52.99	
26 Sep 88	12:06	37°78.06N	68°53.34W	
26 Sep 88	12:20	37°38.33N	68°53.00W	FORAM two 12
26 Sep 88	12:57	37°38.98N	68°52.03W	MOC 17 bottom
26 Sep 88	14:20	37°40.62N	68°50.57W	MOC 17 surface
26 Sep 88	17:47	37°36.83N	69°18.70W	CTD 21
26 Sep 88	19:34	37°36.12N	69°19.8 W	MOC 18 start
26 Sep 88	20:56	37°34.2 N	69°15.1 W	MOC 18 at bottom
26 Sep 88	21:24	37°33.7 N	69°14.8 W	MOC 18 start up
26 Sep 88	22:20	~37°31.0N	69°14.1 W	MOC 18 at surface
27 Sep 88	04:35	37°40.76N	69°49.89W	CTD 22
27 Sep 88	05:17	37°42.7 N	69°53.1 W	MOC 19 in water
27 Sep 88	06:10	37°42.8 N	69°50.5 W	MOC 19 at depth
27 Sep 88	07:25	37°42.1 N	69°45.8 W	MOC 19 at surface
27 Sep 88	11:30	38°03.89N	69°51.21W	CTD 23
27 Sep 88	12:27	38°05.48N	69°46.20W	CTD 24
27 Sep 88	15:34	38°05.69N	69°48.10W	MOC 20 launch
27 Sep 88	16:55	38°04.66N	69°42.08W	MOC 20 bottom
27 Sep 88	23:47	37°54.40N	70°15.4 W	underway Chlorophyll
28 Sep 88	12:36	37°19	71°54	CTD 25
28 Sep 88	13:57:16	37°17.62N	71°56.90W	XBT 27
28 Sep 88	14:33:20	37°16.25N	71°59.90W	XBT 28
28 Sep 88	15:30	37°14:4 N	72°03.5 W	CTD 26
28 Sep 88	16:30:00	37°17.55N	72°05.16W	XBT 29
28 Sep 88	16:56	37°20.45N	72°07.56W	XBT 30
28 Sep 88	17:41	37°26.5 N	72°11.92W	CTD 27
28 Sep 88	17:15	37°23.44N	72°10.00W	XBT 31
28 Sep 88	18:11	37°26.59N	72°11.45W	FORAM low 13 algae bloom ?Trichodesimian at surface
28 Sep 88	18:13	37°26.59N	72°11.45W	light cast
28 Sep 88	18:52	37°26.63N	72°10.73W	SID light test
28 Sep 88	18:52	37°26.63N	72°10.73W	CTD 28
28 Sep 88	20:15	37°23.30N	72°07.04W	XBT 32

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
28 Sep 88	20:35	37°22.06N	72°02.57W	XBT 33
28 Sep 88	20:59	37°20.19N	71°58.13W	XBT 34
28 Sep 88	27:25	37°17.44N	71°53.44W	BIOCTD 1
29 Sep 88	01:09	37°15.5 N	71°52.9 W	BIOCTD 1
29 Sep 88	05:09	37°17.63N	71°57.83W	MOC 21 in water
29 Sep 88	05:31	37°18.42N	71°57.17W	MOC 21 at bottom
29 Sep 88	06:13	37°20.0 N	71°56.3 W	MOC 21 at surface
29 Sep 88	07:23	37°18.56N	71°56.36W	CAM 01 in water
29 Sep 88	07:52	37°19.9 N	71°55.3 W	CAM 01 at surface
29 Sep 88	10:07	37°14.78N	71°59.75W	CTD 29
29 Sep 88	11:30	37°18.83N	71°53.95W	Grazing chain test
29 Sep 88	22:10	38°01	71°12	CTD 30
29 Sep 88	23:12	38°01	71°12	Triangle 2 begins
29 Sep 88	23:31	38°02.74N	71°15.51W	XBT 35
29 Sep 88	23:58	38°04.98N	71°19.66W	XBT 36
30 Sep 88	00:04	38°07.35N	71°24.21W	XBT 37
30 Sep 88	00.37			CTD 31
30 Sep 88	01:25	38°09.46N	71°27.33W	BIOCTD going down
30 Sep 88	01:40	38°09.38N	71°27.01W	BIOCTD bottom
30 Sep 88	01:44	38°09.29N	71°26.64W	BIOCTD surface
30 Sep 88	01:59	38°09.11N	71°25.55W	BIOCTD bottom
30 Sep 88	02:06	38°09.06N	71°25.05W	BC 06 surface
30 Sep 88	02:08	38°09.02N	71°24.81W	BC 07 surface
30 Sep 88	02:20:45	38°08.96N	71°23.84W	BC 07 bottom
30 Sep 88	02:27:13	38°08.98N	71°23.34W	BC 07 surface
30 Sep 88	02:29.58	38°08.99N	71°23.12W	BC 08 surface
30 Sep 88	02:45.40	38°09.00N	71°21.60W	XBT 38
30 Sep 88	02:48:00	38°09.00N	71°21.40W	BC 08 bottom
30 Sep 88	02:55:32	38°09.02N	71°20.70W	BC 08 surface
30 Sep 88	02:59:75	38°09.01N	71°20.33W	BC 09 surface
30 Sep 88	03:16:30	38°09.00N	71°18.61W	BC 09 bottom
30 Sep 88	03:24:20	38°09.01N	71°17.85W	BC 09 surface
30 Sep 88	03:27:45	38°09.01N	71°17.50W	BC 10 surface
30 Sep 88	03:42:25	38°09.04N	71°15.97W	XBT 39
30 Sep 88	03:42:31	38°09.04N	71°15.95W	BC 10 bottom
30 Sep 88	03:50:00	38°09.05N	71°15.20W	BC 10 surface
30 Sep 88	03:53:20	38°09.05N	71°14.86W	BC 11 surface
30 Sep 88	04:12:40	38°09.04N	71°12.82W	BC 11 bottom
30 Sep 88	04:20:40	38°09.02N	71°11.99W	BC 11 surface
30 Sep 88	04:23:59	38°09.01N	71°11.58W	BC 12 surface
30 Sep 88	04:38:00	38°09.00N	71°10.08W	XBT 40
30 Sep 88	04:41:26	38°09.00N	71°09.65W	BC 12 bottom
30 Sep 88	04:49:47	38°09.01N	71°08.83W	BC 12 surface
30 Sep 88	04:54:57	38°09.02N	71°08.25W	BC 13 surface
30 Sep 88	05:[illegible]:20	38°09.56N	71°06.07W	BC 13 bottom
30 Sep 88	05 [illegible]2:58	38°09.93N	71°05.17W	BC 13 surface end
30 Sep 88	06:27	38°07.42N	71°06.94W	XBT 41
30 Sep 88	06:57	38°04.01N	71°09.87W	XBT 42
30 Sep 88	07:13:47	38°03.65N	71°10.68W	MOC 22 start
30 Sep 88	07:36:21	38°04.03N	71°11.58W	MOC 22 bottom
30 Sep 88	08:33	38°05.19N	71°13.67W	MOC 22 at surface
30 Sep 88	09:19	38°03.30N	71°13.4 W	CAM 02 in water
30 Sep 88	09:53	38°03.88N	71°14.86W	CAM 02 at surface
30 Sep 88	11:50	37°58.02N	[illegible]	CTD [illegible]

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
30 Sep 88	12:55	37°59.05N	71°15.84W	SIO 1 deployed
30 Sep 88	13:00	37°59.16N	71°15.78W	SIO 1: incub #1
30 Sep 88	14:10	38°00.85N	71°14.47W	SIO 1: incub #2
30 Sep 88	15:20	38°02.05N	71°13.24W	SIO 1: incub #3
30 Sep 88	16:34	38°02.93N	71°11.50W	SIO 1, ts
30 Sep 88	16:55	38°00.60N	71°07.41W	XBT 43
30 Sep 88	17:17	37°58.66N	71°03.70W	XBT 44
30 Sep 88	17:47	37°56.18N	71°00.63W	XBT 45
30 Sep 88	18:48	37°55.7 N	70°53.4 W	CAM 03 at depth
30 Sep 88	19:15	37°56.3 N	70°50.9 W	CAM 03 at surface
01 Oct 88	01:07	37°48.07N	71°07.08W	CAM 04 surface
01 Oct 88	01:49	37°51.54N	71°04.53W	CAM 04 end
01 Oct 88	02:25	37°53.01N	71°04.04W	MOC 23 start
01 Oct 88	02:56	37°54.1 N	71°01.6 W	MOC 23 at bottom
01 Oct 88	03:46	37°54.92N	70°57.60W	MOC 23 at surface
01 Oct 88	04:33	37°55.33N	70°56.21W	Grazing chamber
01 Oct 88	07:29	37°51.95N	70°55.78W	Egg tow 1 & 2
01 Oct 88	08:03	37°53.27N	70°53.83W	Zoopl. tow (202μm)
01 Oct 88	08:34	37°53.5 N	70°55 W	XBT 46
01 Oct 88	08:53	37°57.28	70°57.03W	XBT 47
01 Oct 88	09:09	38°00.5 N	70°49.75W	XBT 48
01 Oct 88	10:00	38°00.5 N	70°56	XBT 49
01 Oct 88	10:45	38°00.3 N	71°01.7 W	XBT 50
01 Oct 88	11:20	37°59.96N	71°06.15W	XBT 51
01 Oct 88	11:50	37°57.5 N	71°00.5 W	XBT 52
01 Oct 88	12:03	37°56.05N	70°57.61W	XBT 53
01 Oct 88	13:02	37°51.29N	70°55.74W	MOC 24
01 Oct 88	13:17	37°51.55N	70°54.20W	FORAM tow 14
01 Oct 88	13:26	37°51.68N	70°53.36W	MOC 24 bottom
01 Oct 88	13:40	37°52.28N	70°52.42W	FORAM tow 15
01 Oct 88	14:36	37°55.23N	70°52.60W	MOC 24 surface
01 Oct 88	15:28	37°54.07N	70°53.8 W	CAM 05 launch
01 Oct 88	16:05	37°56.03N	70°51.26W	CAM 05 sal.
01 Oct 88	17:07	37°56.08N	70°50.24W	Grazing chamber
01 Oct 88	18:30	~37°59 N	~70°40 W	CTD 34
01 Oct 88	19:01	37°59.92N	70°41.52W	CTD 35
01 Oct 88	21:45	~38°5.09	~70°34.1W	SIO 2 (finish)
02 Oct 88	01:16	37°53.67N	70°54.66	CAM 06 launch
02 Oct 88	01:25	37°54.27N	70°53.87W	CAM 06 bottom
02 Oct 88	01:50	37°55.87N	70°52.77W	CAM 06 surface
02 Oct 88	02:31	37°55.51N	70°51.37W	MOC 25 launch
02 Oct 88	02	37°55.72N	70°51.09W	MOC 25 bottom
02 Oct 88	03:43	37°56.07N	70°50.69W	MOC 25 surface
02 Oct 88	04:52	3 > 55.27N	70°49.36W	Grazing chamber 3
02 Oct 88	08:02	37°54.48N	70°56.36W	53μm plankton NH tow I
02 Oct 88	08:20	37°54.23N	70°50.86W	Plankton NH tow II
02 Oct 88	08:41	37°53.77N	70°50.58W	Plankton NH tow III
02 Oct 88	10:04	37°53.52N	70°54.97W	CTD 36
02 Oct 88	11:35	37°53.51N	70°55.02W	CTD 37
02 Oct 88	15:00	37°53.5 N	70°55.0 W	Light cast
02 Oct 88	16:41	37°53.66N	70°53.97W	CAM 07 launch
02 Oct 88	17:00	37°54.8 N	70°52.9 W	CAM 07 down
02 Oct 88	17:22	37°56.32N	70°51.68W	CAM 07 surface film off
02 Oct 88	17:5	37°57.03N	70°50.88W	MOC 26 start

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
04 Oct 88	22:57	37°51.66N	68°51.71W	MOC 29 at depth
04 Oct 88	23:48	37°48.22N	68°51.02W	MOC 29 at surface
05 Oct 88	00:53	37°50.12N	68°50.97W	CAM 09 down
05 Oct 88	02:13	37°43.69N	68°45.70W	CTD 40(A)

Leg 2

11 Oct 88	22:25	37°59.7 N	71°00.8 W	XBT 75
12 Oct 88	00:20:40	37°45.99N	70°46.66W	XBT 76
12 Oct 88	01:04:08	37°41.52N	70°45.44W	Abort CTD # 41 Changed CTD
12 Oct 88	01:30	37°42.26N	70°43.51W	CTD 42
12 Oct 88	02:10:10	37°43.08N	70°40.83W	MOC 30
12 Oct 88	02:48:28	37°44.59N	70°39.29W	MOC 30 start up
12 Oct 88	03:04	37°45.22N	70°38.72W	XBT 77
12 Oct 88	03:17:15	37°45.73N	70°38.33W	MOC 30 surface
12 Oct 88	04:43:52	37°37.69N	70°31.41W	CTD 43
12 Oct 88	05:12:45	37°38.59N	70°29.60W	MOC 31 surface
12 Oct 88	05:49:37	37°39.45N	70°28.3 W	MOC 31A at on
12 Oct 88	07:14:43	37°42.38N	70°26.31W	MOC 31A at depth
12 Oct 88	09:11:00	37°47.02N	70°23.85W	MOC 31A end
12 Oct 88	12:10:00	37°32.06N	70°24.01W	CTD 44
12 Oct 88	12:51:00	37°32.18N	70°22.64W	MOC 32 surface
12 Oct 88	13:35:50	37°31.60N	70°19.8	MOC 32 bottom
12 Oct 88	15:09:00	37°30.74N	70°14.24W	MOC 32 surface
12 Oct 88	15:34:00	37°30.8 N	70°13.2 W	light cast #1
12 Oct 88	17:43	37°44.99N	69°59.99W	CTD 45
12 Oct 88	18:38	37°47.46N	69°56.82W	MOC 33 surface
12 Oct 88	19:32	37°49.19N	69°56 10W	MOC 33 bottom
12 Oct 88	21:23	37°53.83N	69°54.05W	MOC 33 end
12 Oct 88	22:40	37°54.8 N	70°00.8 W	XBT 78
13 Oct 88	00:23	37°55.8 N	70°06.58W	CTD 46
13 Oct 88	00:50	37°56.4 N	70°06.2 W	MOC 34 in water
13 Oct 88	01:33	37°57.37N	70°05.83W	MOC 34 bottom
13 Oct 88	02:31	~37°59.47N	70°07.01W	MOC 34 at surface
13 Oct 88	04:22	38°06.29N	70°00.19W	CTD 47
13 Oct 88	05:31	38°07.63N	70°02.74W	MOC 35 in water
13 Oct 88	07:18	38°09.23N	70°06.43W	MOC 35 at 1000
13 Oct 88	08:42	38°10.2 N	70°09.62W	MOC 35 end
13 Oct 88	10:57	38°05.8 N	69°47.7 W	XBT 79
13 Oct 88	11:45	38°04.23N	69°39.50W	CDT 48
13 Oct 88	13:38	37°57.4 N	69°34.17W	XBT 80
13 Oct 88	14:05	37°55.16N	69°31.68W	CTD 49
13 Oct 88	15:15	37°56.73N	69°26.77W	Light cast #2
13 Oct 88	16:29:46	37°59.49N	69°25.51W	MOC 36
13 Oct 88	17:37:56	37°57.74N	69°22.12W	MOC 36 bottom
13 Oct 88	19:18:47	37°55.49N	69°17.46W	MOC 36 surface end
13 Oct 88	20:35:55	37°48.70N	69°15.38W	XBT 81
13 Oct 88	21:09	37°45.07N	69°64.61W	CTD 50
13 Oct 88	22:21:29	37°46.64N	69°13.64W	MOC 37
13 Oct 88	23:28:04	37°48.73N	69°12.24W	MOC 37 at 1000 m
14 Oct 88	01:03:40	37°51.38N	69°09.23W	MOC 37 surface

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
14 Oct 88	01:51:07	37°57.13N	69°07.48W	XBT 82
14 Oct 88	02:33	37°57.20N	69°10.03W	CTD 51
14 Oct 88	03:09	38°00.94N	69°04.39W	MOC 38 in water
14 Oct 88	03:51	38°02.23N	69°03.6 W	MOC 38 at depth
14 Oct 88	06:38	38°09.85N	69°6.79 W	CTD 52
14 Oct 88	07:18	38°10.33N	69°06.80W	MOC 39 in water
14 Oct 88	08:18	38°11.77N	69°08.2 W	MOC 39 at 1000 m
14 Oct 88	09:55:00	38°14.58N	69°10.12W	MOC 39 end surface
14 Oct 88	10:59:35	38°19.08N	69°04.09W	XBT 83
14 Oct 88	13:48	38°15.04N	68°50.09W	CTD 53
14 Oct 88	15:11	38°11.8 N	68°43.3 W	XBT 84
14 Oct 88	16:07	38°05.1 N	68°31.83W	Light cast #3
14 Oct 88	17:53	38°05.36N	68°26.91W	MOC 40 surface
14 Oct 88	18:49	38°07.37N	68°27.14W	MOC 40 bottom
14 Oct 88	16:50	38°04.64N	68°29.43W	CTD 54
14 Oct 88	20:32	38°10.73N	68°27.14W	MOC 40 end
14 Oct 88	22:08	38°00.90N	68°33.28W	XBT 85
14 Oct 88	22:49	37°58.00N	68°35.58W	CTD 55
14 Oct 88	23:23	37°57.6 N	68°33.56W	MOC 41 in water
15 Oct 88	00:25	37°55.73N	68°29.9 W	MOC 41 at depth
15 Oct 88	~02:00	37°53.84N	68°29.00W	MOC 41 at surface
15 Oct 88	03:04	37°52.19N	68°35.18W	XBT 86
15 Oct 88	03:48	37°51.3 N	68°42.4 W	CTD 56
15 Oct 88	04:40	37°50.14N	68°38.59W	MOC 42 in water

Note: MOC 42 stopped right after entering water. All records were deleted from computer file. The real MOC 42 information follows.

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
15 Oct 88	07:59	37°49.97N	68°39.35W	MOC 42 in water. This is second deployment of 42. First deployment aborted.
15 Oct 88	09:10	37°48.29N	68°38.69W	MOC 42 bottom
15 Oct 88	10:41:2	37°46.00N	68°39.96W	MOC 42 finished
15 Oct 88	11:52	37°40.65N	68°43.39W	CTD 57
15 Oct 88	15:25:31	37°36.94N	68°37.90W	MOC 43 start
15 Oct 88	15:40	MOC 43 scrubbed bat flooded		
15 Oct 88	16:45	37°36.81N	68°40.11W	CTD 58
15 Oct 88	18:52	37°39.9 N	68°29.0 W	XBT 87
15 Oct 88	19:32:28	37°43.9 N	68°18.34W	XBT 88
15 Oct 88	20:17:2	37°47.22N	68°08.19W	XBT 89
15 Oct 88	21:25	37°51.74N	67°56.93W	XBT 90
15 Oct 88	22:15:44	37°55.77N	67°46.37W	XBT 91
15 Oct 88	22:58	37°56.80N	67°37.60W	XBT 92
15 Oct 88	23:29	37°56.99N	67°31.19W	XBT 93
15 Oct 88	23:57	37°56.98N	67°25.67W	XBT 94
16 Oct 88	01:06	38°00.53N	67°33.36W	XBT 95
16 Oct 88	02:22	38°04.92N	67°44.94W	CTD 59
16 Oct 88	03:16	38°05.12N	67°43.85W	MOC 43 in water second try
16 Oct 88	04:04	38°04.44N	67°41.75W	at depth
16 Oct 88	05:51	38°03.09N	67°36.94W	MOC 43 at surface
16 Oct 88	07:15	37°55.47N	67°43.01W	XBT 96
16 Oct 88	08:19	37°48.69N	67°49.00W	CTD 60
16 Oct 88	09:16	37°47.76N	67°47.88W	MOC 44 start
16 Oct 88	09:34	37°46.84N	67°47.93W	MOC 44 bottom (320 m)
16 Oct 88	10:23:17	37°44:78N	67°47.65W	MOC 44 end

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
16 Oct 88	11:55	37°39.77N	67°48.88W	CTD 61
16 Oct 88	13:29:02	37°38.82N	67°48.21W	MOC 45 start
16 Oct 88	14:09	37°37.10N	67°48.35W	MOC 45 bottom
16 Oct 88	15:24	37°34.20N	67°48.57W	MOC 45 fini
16 Oct 88	17:15	37°28.96N	67°54.23W	CTD 62
16 Oct 88	19:02:00	37°31.53N	67°55.96W	XBT 97
16 Oct 88	19:59	37°38.66N	67°59.28W	XBT 98
16 Oct 88	20:57	37°45.70N	68°03.11W	XBT 99
16 Oct 88	22:05	37°48.48N	68°04.03W	CTD 63
16 Oct 88	22:52	37°47.54N	68°02.17W	MOC 46 in water
16 Oct 88	23:31	37°46.43N	68°01.02W	MOC 46 at depth
17 Oct 88	00:43	37°44.53N	67°58.98W	MOC 46 at surface
17 Oct 88	01:26	37°44.21N	68°00.47W	XBT 100
17 Oct 88	01:59	37°43.42N	68°04.23W	XBT 101
17 Oct 88	02:46	37°42.07N	68°11.05W	XBT 102
17 Oct 88	03:31	37°40.80N	68°17.35W	XBT 103
17 Oct 88	04:30	37°39.5 N	68°25.09W	XBT 104
17 Oct 88	05:27	37°37.78N	68°32.22W	XBT 105
17 Oct 88	07:19	37°35.5 N	68°45.3 W	XBT 106
17 Oct 88	08:35	37°35.76N	68°45.51W	Lang drift
17 Oct 88	08:49	37°35.81N	68°44.29W	CTD 64
17 Oct 88	10.42	37°36.18N	68°36.28W	in situ line
17 Oct 88	12:50	37°36.54N	68°28.23W	CTD 65
17 Oct 88	16:08	37°36.68N	68°15.40W	CTD 66
17 Oct 88	19:31	37°37.10N	68°02.90W	Ring net #1
17 Oct 88	19:40	37°36.63N	68°02.70W	CTD 67
17 Oct 88	22:43	37°36.94N	67°53.80W	Buoy recorder
17 Oct 88	23:09	37°37.22N	67°51.27W	Ring net #2
17 Oct 88	23:18	37°37.4 N	67°50.8 W	XBT 107
18 Oct 88	04:04	37°37.97N	68°27.56W	XBT 108
18 Oct 88	11:36	37°39.5 N	69°16.12W	XBT 109
18 Oct 88	12:32	37°39.22N	69°22.61W	XBT 110
18 Oct 88	13:27	SAIL LORAN inputs back after lightning strike		
18 Oct 88	14:06	37°38.48N	69°33.33W	XBT 111
18 Oct 88	15:33	37°38.1 N	69°42.9 W	XBT 112
18 Oct 88	16:46	37°37.54N	69°50.77W	Light last
18 Oct 88	17:18	37°37.24N	69°47.80W	Note

Lightning strike, ≈ 08:00, 10/18/88 - knocks out: 1) ADCP repaired (≈ 15:25) (SAIL, input); 2) LORAN - repaired (13:27); 3) Windspeed, direction; 4) A.T.S.

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
18 Oct 88	17:25	37°37.21N	69°47.26W	CTD 68
18 Oct 88	19:34	37°36.52N	69°57.12W	XBT 113
18 Oct 88	19:41	37°36.31N	69°56.8 W	Ring net #3
18 Oct 88	22:15	37°35.67N	70°12.17W	XBT 114
18 Oct 88	22:15	37°35.67N	70°12.17W	C/C 300°T
18 Oct 88	23:18	37°39.60N	70°17.72W	XBT 115
19 Oct 88	0:15:12	37°43.50N	70°22.17W	XBT 116
19 Oct 88	0:47:56	37°45.80N	70°24.69W	XBT 117
19 Oct 88	01:34	37°45.91N	70°22.91W	Ring net #4
19 Oct 88	01:53:20	37°45.78N	70°21.76W	MOC 47
19 Oct 88	02:37	37°46.72N	70°18.70W	MOC 47 at 1000 m
19 Oct 88	04:05	37°48.41N	70°15.07W	MOC 47 end
19 Oct 88	04:14	37°48.40N	70°14.85W	XBT 118
19 Oct 88	05:09	37°42.06N	70°12.84W	XBT 119
19 Oct 88	05:40	37°40.88N	70°11.07W	Prod. Buoy #2

GMT DATE	GMT TIME	POSITION		ACTIVITY (SEQ. NO.)
19 Oct 88	08:35	37°39.84N	69°54.11W	CTD 70
19 Oct 88	01:02	37°46.43N	70°25.25W	CTD 69
19 Oct 88	10:35:0	37°38.85N	69°42.23W	Prod buoy launch Bigelow
19 Oct 88	13:01	37°38.27N	69°28.55W	CTD 71
19 Oct 88	16:02	37°38.56N	69°10.86W	CTD 72
19 Oct 88	22:34	37°39.65N	68°34.78W	Boru buoys recovered
19 Oct 88	22:45	37°39.67N	68°34.4 W	Ring net #5
19 Oct 88	22:55	37°39.78N	68°33.42W	CTD 73
19 Oct 88	23:29	37°40.17N	68°31.66W	MOC 48 start in water
19 Oct 88	23:39	37°40.32N	68°31.04W	MOC 48 at 250 m
20 Oct 88	00:12	37°41.07N	68°29.21W	MOC 48 at end surface
20 Oct 88	00:20	37°41.34N	68°28.99W	C/C 310°T
20 Oct 88	01:00:20	37°44.77N	68°31.01W	XBT 120
20 Oct 88	01:35	37°45.78N	68°29.84W	MOC 49 in water
20 Oct 88	01:05	37°45.25N	68°31.26W	CTD 74
20 Oct 88	01:50	37°46.23N	68°29.43W	MOC 49 at 250 m
20 Oct 88	02:29	37°47.22N	68°28.14W	MOC 49 at surface
20 Oct 88	02:45	37°47.40N	68°27.52W	Ring net #6
20 Oct 88	04:00:00	37°51.07N	68°29.16W	XBT 121
20 Oct 88	05:02:30	37°56.87N	68°35.81W	XBT 122
20 Oct 88	06:01	38°02.03N	68°43.16W	XBT 123
21 Oct 88	08:01	37°55.1 N	72°51.5 W	XBT 124
21 Oct 88	08:33	37°51.01N	72°57.42W	CTD 75
21 Oct 88	09:24	37°50.35N	72°58.86W	Langdon drift #3
21 Oct 88	10:14	37°50.07N	72°59.41W	Bigelow in situ
21 Oct 88	12:52	37°48.60N	73°00.61W	CTD 76
21 Oct 88	13:28	37°47.97N	73°02.29W	MOC 50
21 Oct 88	13:40	37°47.97N	73°01.87W	MOC 50 at depth
21 Oct 88	14:23	37°47.66N	73°00.67W	MOC 50 at surface
21 Oct 88	16:20	37°46.76N	73°03.89W	CTD 77
21 Oct 88	17:47	37°46.26N	73°05.57W	MOC 51 in water
21 Oct 88	18:03	37°46.31N	73°04.92W	MOC 51 at depth
21 Oct 88	18:48	37°46.44N	73°03.29W	MOC 51 at surface
21 Oct 88	19:16	37°47.37N	73° 5.74W	CTD 78
21 Oct 88	19:53	37°46.72N	73°05.69W	MOC 52 in water
21 Oct 88	20:06	37°46.41N	73°05.35W	MOC 52 at 250 m
21 Oct 88	20:44	37°46.13N	73°04.03W	MOC 52

Participating Personnel in the R/V Cape Hatteras, Biosynop Cruise
September 21 - October 21, 1988

Science Party Leg I

Dr. Peter Ortner, Chief Scientist, RSMAS, AOML
Dr. Jeffrey N. Napp, RSMAS
Mr. David Nieman, RSMAS
Dr. Sharon L. Smith, Brookhaven
Dr. Cabbel Davis, WHOI
Dr. Steve Lohrenz, USM
Ms. Linda Stathoplis, URI
Dr. Craig Taylor, WHOI
Mr. Tim Boynton, Duke
Dr. Guillermo Podesta, NASA/NRC

Science Party Leg II

Dr. Donald Olson, Chief Scientist, RSMAS
Dr. Cabbel Davis WHOI
Dr. Carin Ashjiam, URI
Dr. Charles Yentsch, Bigelow
Dr. John Cullen, Bigelow
Mr. Mike Cucci, Bigelow
Mr. Dave Phinney, Bigelow
Mr. MacIntyre, Bigelow
Mr. Jack Laird, Bigelow
Dr. Sharon L. Smith, Brookhaven
Dr. Chris Langdon, Lamont
Mr. Tim Boynton

CRUISE REPORT: CI8903 BIOSYNOP II

March 30-April 28, 1989

Overview

The second cruise set to synoptically survey the biophysical interactions in a Gulf Stream meander (**BIOSYNOP II**) involved three vessels: R/V Endeavor (URI, physical/phytoplankton biomass), USNS Bartlett (NORDA, bioacoustics, phytoplankton), and R/V Columbus Iselin (UM, zooplankton and phytoplankton). This report covers the operations of the latter ship. Efforts on board can be split into three areas: phytoplankton biomass and productivity (Yentsch and coworkers), zooplankton (Ortner/Davis/Napp/Holliday/Pieper/Flagg) and logistics and physical data support (Olson/Flagg). In addition, there was a piggy-back effort to sample dimethylsulfide in the atmosphere and surface waters (Matrai/Cooper) and neuston tows to collect fish larvae (Clarke). The primary effort was funded by the Office of Naval Research with additional funding for technical development (satellite realtime data and acoustic Doppler processing) from NSF facilities. The sulfur work is supported separately through NASA. Fish larval work was funded through NOAA. Iselin activities involved a cruise from Miami to Miami with two intermediate port stops in Rhode Island (URI).

Data collected on the Iselin included 174 expendable bathythermograph (XBT) drops, 30 CTD's, 18 MOCNESS tows, 13 zooplankton camera deployments, 12 zooplankton grazing experiments and various auxiliary measurements. Five-liter Niskins on the CTD casts were sampled for chlorophyll, particle assays using beam attenuation and flow cytometry, oxygen, salts, and nutrients. Casts done at mid-photo period (approximately local noon) were accompanied by light casts using a multi-wave length photometer. Productivity work included photosynthetron incubations from bottle samples and two in situ drift incubations in the two end-member water masses, the Slope and Sargasso. Continuous underway chlorophyll and beam transmission were also collected throughout the cruise. Most CTD casts were also accompanied by a dual-net nauplii vertical tow from the CTD wire (upper 100 m). To augment the MOCNESS samples in rough weather seven 1-meter net hauls were also done. Neuston tows of 15 minute duration accompanied most stations for a total of 30 hauls. Zooplankton grazing rates were measured in a series of deck incubations (Napp). The grazing experiments used swimming zooplanktors from vertical net hauls placed in water collected with 30-liter Niskin casts. The latter made use of tritiated methylamine as a tracer in a three compartment model of the system. On the first leg a 21 beam acoustic zooplankton imaging system was deployed (MAPS: Holliday and Pieper). Additional bioacoustic sampling included a single frequency (1.2 MHz) forward-looking system on the camera and use of a modified set of software to record returns from the RDI acoustic Doppler system (Flagg/Smith). Physical measurements included the various profiles from the XBT's, CTD, MOCNESS and camera and continuous underway Doppler profiling. In support of the mapping, activities near realtime satellite imagery was obtained through Miami at approximately two day intervals.

Eliminating sailing time to and from the operations area, there were twenty two days for operations in the chosen meander. The meander was a well developed system with the crest of the meander at approximately 69.5° W at the start of the operation and a trough at 67.5° W as shown in Figs. 1-3. Figures 1 and 2 also show the cruise tracks for each leg of the cruise along with Doppler current vectors. The depth of the 12° C isotherm is shown in Fig. 3 in plane view a) and in a 3-D visualization b).

Following a set of test stations in the Gulf Stream south of Cape Hatteras, a mesoscale survey of the meander with MOCNESS and CTD was started (2-4-89). On the third transect of this survey, the weather started to deteriorate. By the 4th of April operations were reduced to XBT and Doppler surveying only. These conditions continued through the fifth and sixth while the ship completed a XBT/Doppler survey through the meander. A partially successful station in the Slope Water was occupied on the 7th with a MAPS (acoustic zooplankton profiler) cast and CTD. The plankton camera, however, failed to work. By late on the 7th, the weather was again deteriorating. The decision was made to get sea room between the ship and the explosive storm climatological track by steaming southeastward into the Sargasso Sea. The morning of April 8th saw gale force winds (60kts sustained with gust into the 70's). Deck gear and rigging for trawling work were damaged by seas forcing an early stop in Narragansett.

To summarize, the first leg was severely compromised by weather. A full physical survey of the meander was accomplished, and continuous biological (surface chlorophyll and ADCP sound scattering measurements) collected except during the heaviest seas. Operation of heavy equipment over the side of the ship (CTD, MOCNESS, MAPS) was, however, greatly curtailed due to sea state. Damages to equipment in the heavy pounding taken during the gale is probably at least partially responsible for difficulties encountered on the second leg.

The second leg left Rhode Island on 11 April and conducted an XBT transect across the Slope Water. Upon reaching the operations area, the hydraulics for the uptake spools on the trawl and conducting winch failed. After an attempt to repair the hydraulics at sea, the ship headed back into Rhode Island. There it was met by Ron Huchinson and Jack Crawford with spare connections for rigging the spare pump. In total, this problem cost two and a half days with transit. A nonfunctional sea water system pump was also replaced during the port stop.

After transit back to the crest of the target meander, a "drift-through" fine scale survey in the stream core was begun. Here approximately two days were lost due to malfunctions in the camera system. The final drift through proceeded with a total of thirteen camera tows and CTD's. A suite of grazing experiments were also carried out during the drift. Two attempts to actually follow a drifter through the meander were unsuccessful due to loss of the drifters. The first was lost while on station in heavy seas, and the second either due to marker light failure or collision with the ship. In the future the simple radar transponder system or an ARGOS unit should be used for this type of operation despite the incremental cost which made them impossible in BIOSYNOP.

The fine scale survey was followed by two in situ productivity stations in the Slope Water and then the start of a final mesoscale survey. In concern for time, this survey was done against the current, i.e. from east to west. Five cross sections of this survey covering approximately two-thirds of the meander were completed before the ship was forced to leave the area by time constraints. The final station involving an in situ productivity drift and some camera tows was occupied in the Sargasso Sea in route to Miami.

Specific Issues

Hydraulics: The winch systems on board the ship depend extensively on several hydraulic systems which are not fully redundant. The difficulty in repairing the "40-horse" system for the take-up spools was the result of an unfortunate error in procuring the backup system without making sure the required fittings were on board. Beyond the source of the problem the marine department was responsive and got the ship back to sea in reasonable time. The lack of full backup for the main pumps which work off a power takeoff from the engines is more worrisome. The whole issue of backup hydraulics should be reviewed.

Power: There were some problems with the performance of the protected power supplies. This may have been the result of the pounding taken during the gales. These systems should be checked.

Plumbing: The installation of plumbing in at least some of the staterooms is substandard. The failure of the wall fastenings for sinks caused a minor injury early in the cruise and resulted in the loss of one sink. The standard home fixture which is held on by gravity is not appropriate for marine use. All of the sinks on the Iselin should be provided with a mechanism to hold them down into the bulkhead fittings.

Compass heading on SAIL: The heading information provided through the SAIL system was very noisy and had a fairly sizable cosine error superimposed. For successful Doppler operation this should be fixed.

Gear handling and set up: The block provided for MOCNESS work and the reach of the A-frame made it difficult to launch and recover the net system due to the small amount of clearance between the block and the deck. The scientific party should check for block clearances before the ship leaves for a cruise to insure that their equipment is compatible with the provided gear.

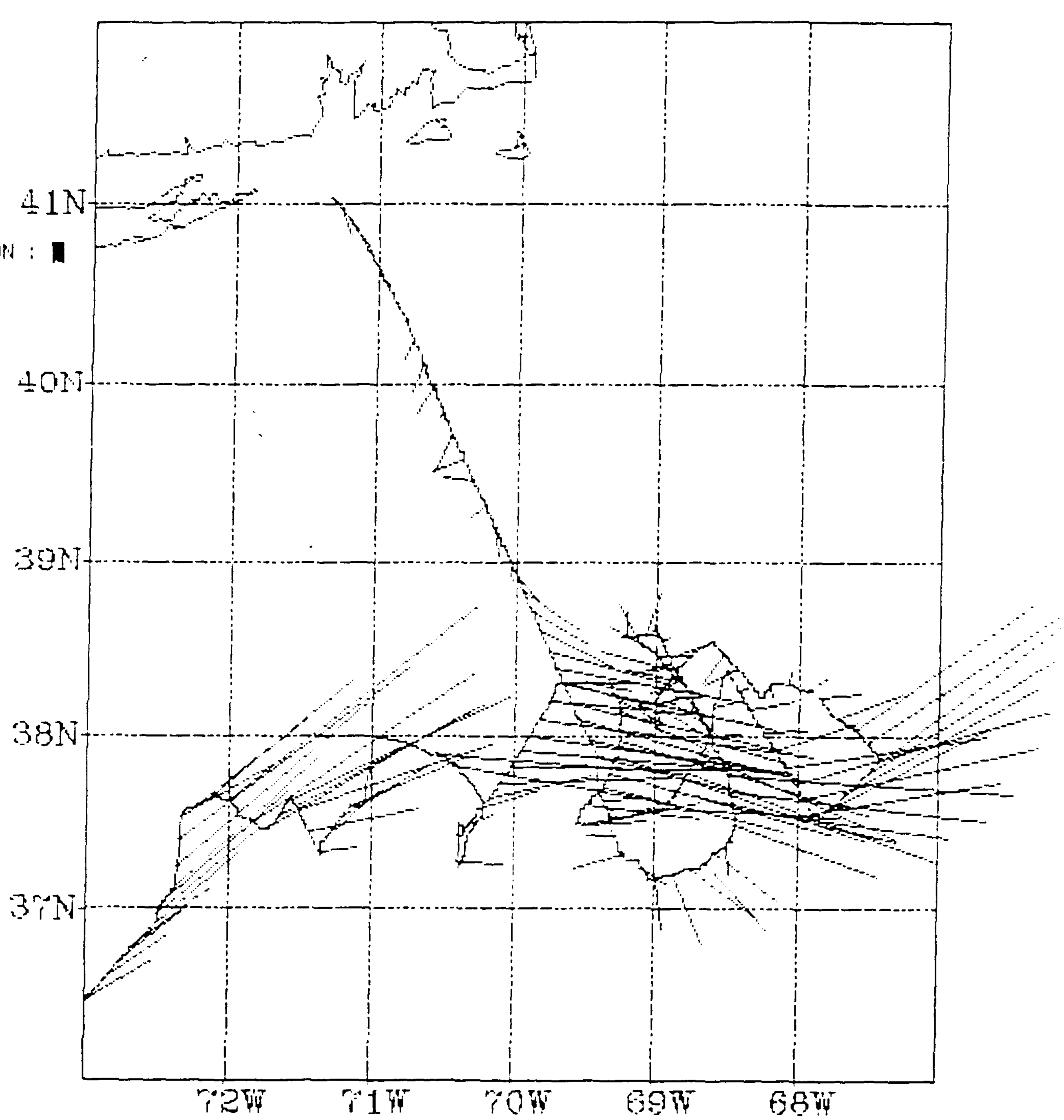
Sea water system: The bow mounted clean sea water system was unusable for much of the cruise because of bubble problems. Although it is desirable to have a forward mounted system, its siting should be such that it can provide a steady flow at moderate sea state. It is not clear what a solution to this problem would entail. Perhaps, a redesign of the forward mounting or a small forward sea chest is required.

XBT system: The XBT system provided worked for most of the cruise with a minimal amount of data loss due to disk problems and difficulties with the Mark 9 Sippican deck unit. It would be much more efficient, however, to replace this system with a new system. Either the NOAA system with an IBM or a direct connection to the VAXs.

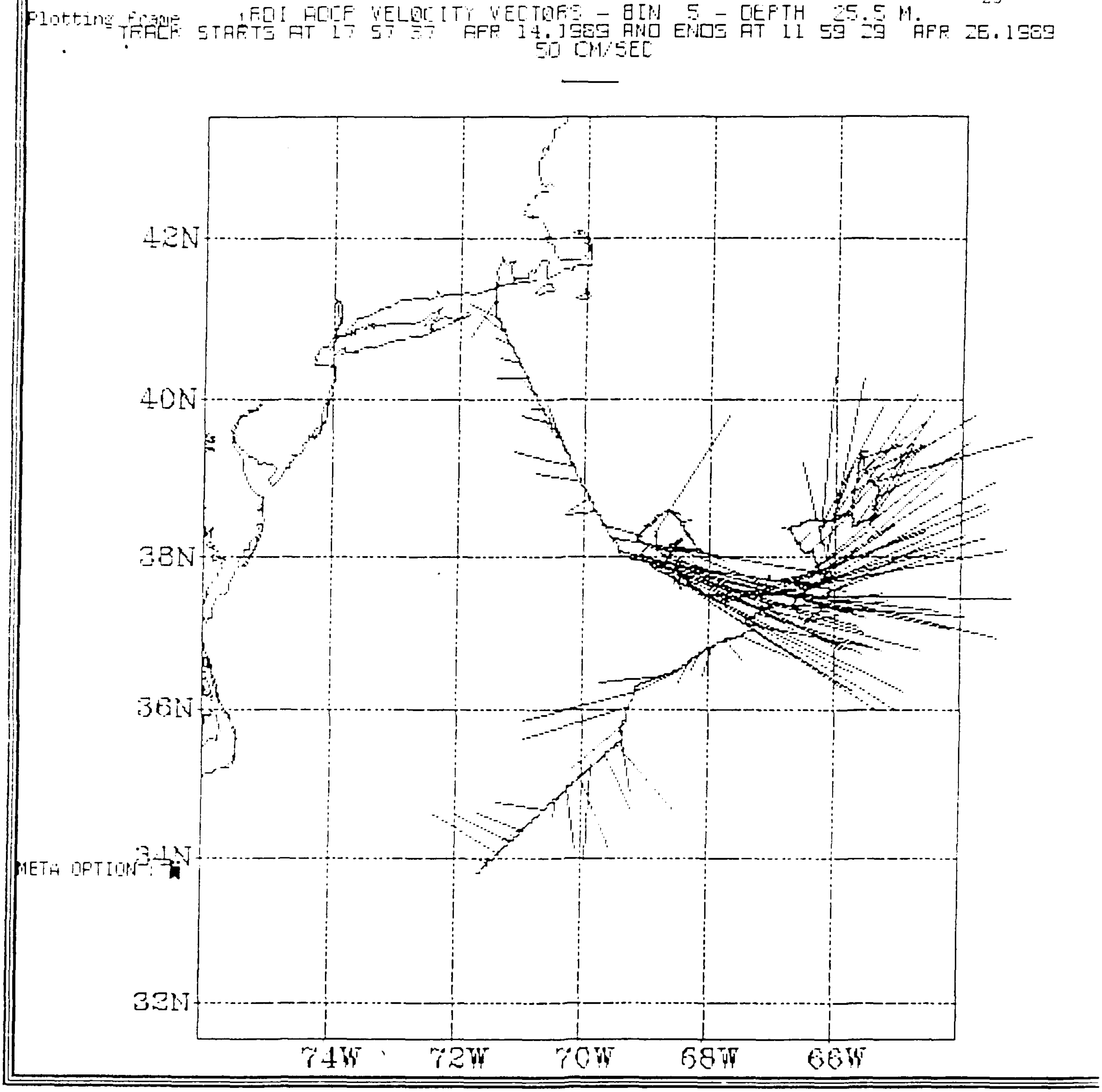
Summary

The captain and crew should be complimented on a superb performance in less than ideal conditions. Overall the ship worked well, with most of the loss in science on the cruise being a weather problem which would have occured on any vessel in the fleet. Even with the lost time, the cruise was a success. The meander survey was complete although the number of net tows was far less than planned due to weather.

Plotting frame 1EDI ADCP VELOCITY VECTORS - BIN 5 - DEPTH 25.5 M.
TRACK STARTS AT 10 41 10 APR 02.1989 AND ENDS AT 19 08 01 APR 09.1989
50 CM/SEC



Leg 1


Plotting Frame
NADI ADCP VELOCITY VECTORS - BIN 5 - DEPTH 25.5 M.
TRACK STARTS AT 17 57 37 APR 14,1989 AND ENDS AT 11 59 29 APR 26,1989
50 CM/SEC
42N
40N
38N
36N
34N
32N
74W
72W
70W
68W
66W
META OPTION : 1

BIOSYNOP CRZ
R/V Iselin CI8903
March 30, 1989 to April 28, 1989
Event Log

Date	Time	Event	Position: Latitude	Position: Longitude
Leg I				
2 Apr. 1989		JD 92		
	13:51	CTD #2	36°55.32'N	72°29.95'W
	14:10	bottom of cast		
	15:24	MOC #1	36°55.'N	72°28'W
	16:30	MOC #1 bottom	37°20.'N?	72°27.70'W
	16:30	[illegible]9 Neuston #1	37°00.98'N	72°27.47'W
	18:29	MOC #1 surface	37°05.59'N	72°23.78'W
	18:35	XBT #1 (T-7)	[illegible]05.70'N	72°23.66'W
	19:49	XBT #2 (T-7)	37°19.64'N	72°20.45'W
	21:10	CTD #4	37°33.0'N	72°19.4'W
	No CTD #3 due to software error			
	22:02	CTD #4	~37°34.78'N	72°16.57'W (22:11Z loc)
	22:35	MOC #2 surface	37°35.07'N	72°15.31W
	22:43	Neuston #2	37°35.08'N	72°15.76'W
3 Apr. 1989	0:03:49	MOC #2 bottom		
	1:18:10	MOC #2 surface	37°39.05'N	72°06.74'W
	-	Target for CTD 5/ MOC #3	37°2.'N	71°46.46'W
	01:41	XBT #3 (T6)	37°39.26'N	72°05.86'W
	02:46	XBT #4 (T7)	37°32.94'N	71°55.68'W
	03:38	CTD #5	37°28.2'N	71°44.9'W
	03:53	Naup. Net bottom	37°28.36'N	71°44.22'W

Date	Time	Event	Position Latitude	Position Longitude
Leg I				
3 Apr. 1989	04:48	MOC surface	37°29.93'N	71°41.00'W
	06:11	MOC #3 bottom	37°33.90'N	71°37.79'W
	06:20	Neuston #3	37°34.32'N	71°37.44'W
	07:35	MOC #3 surface	37°37.83'N	71°35.08'W
		XBT #5 (T7)		
	09:03	XBT #6 (T7)	37°28.42'N	71°27.21'W
	10:00	CTD #6	37°18.9'N	71°20.7'W
	10:14	Nauplii net	37°18.97'N	71°20.63'W
	11:15	MOC #4 surface	37°19.88'N	71°20.42'W
3 Apr. 1989	12:14	MOC #4 bottom	37°20.96'N	71°21.42'W
	13:16	MOC #4 surface		
	14:32	XBT #7	37°29.94'N	71°14.58'W
	15:31	CTD #7	37°35.8'N	71°08.67'W
	16:47	MOC #5 surface	37°35.83'N	71°05.08'W
	17:50	MOC #5 bottom		
	19:03	MOC #5 surface		
	(16:47, 17:50, 19:03 logged ex post facto from data sheets)			
	21:18	XBT #8	37°48.6'N	71°00.96'W
4 Apr. 1989		JD94		
	14:40	Noticed that ship heading SAIL input was broken and gyro input to ROI was wrong — was reading 28° when "true" reading should be ~210. R. Findley fixed gyro input to RDZ.		
	16:33	XBT #9	37°15.6'N	70°22.4'W
	19:04	CTD #8	37°29.3'N	70°3.0'W
	22:52	XBT #10	37°29.8'N	70°19.2'W
5 Apr. 1989				
	00:02	XBT #11	37°28.2'N	70°11.7'W

Date	Time	Event	Position Latitude	Longitude
Leg I				
5 Apr. 1989	00:58	XBT #12	37°43.14'N	70°07.02'W
	02:05	XBT #13	37°49.32'N	70°01.76'W
	03:07	XBT #14	37°55.90'N	69°56.67'W
	04:06	XBT #15	38°01.92'N	69°52.70'W
	05:04	XBT #16	38°07.83'N	69°48.07'W
	06:05	XBT #17	38°14.30'N	69°44.27'W
	07:05	XBT #18	38°18.85'N	69°39.06'W
	08:03	XBT #19	38°19.06'N	69°30.24'W
	09:03	XBT #20	38°19.25'N	69°21.66'W
	09:32	CTD #9 No Nauplii net	38°18.93'N	69°20.24'W
	10:42	MOC #6 surface	38°18.07'N	69°19.15'W
	11:58	MOC #6 bottom	38°15.80'N	69°19.24'W
	16:00	XBT #21	38°05.4'N	69°14.97'W
	17:03	XBT #22	37°54.7'N	69°17.5'W
	17:56	XBT #23	37°47.17'N	69°18.5'W
	19:00	XBT #24	37°40.06'N	69°24.73'W
	20:02	XBT #25	37°32.57'N	69°32.07'W
	21:00	XBT #26	37°30.76'N	69°23.45'W
		It wasn't stored not enough space in disk only plots and table		
	21:13	XBT #27 stored disk N°2	37°29.55'N	69°19.21'W
	22:08	XBT #28	37°33.67'N	69°05.38'W
	23:00	XBT #29	37°38.55'N	68°52.57'W
6 Apr. 1989				
	00:21	XBT #30	37°48.75'N	68°44.53'W
	01:03	XBT #31	37°58.88'N	68°32.22'W
	02:14	XBT #32 bad probe	38°12.43'N	68°34.79'W

Date	Time	Event	Position Latitude	Position Longitude
Leg I				
6 Apr. 1989	02:23	XBT #33	38°14.13'N	68°34.17'W
	03:06	XBT #34	38°22.03'N	68°31.47'W
	04:02	XBT #35	38°15.57'N	68°26.02'W
	05:01	XBT #36	38° 6.72'N	68°19.02'W
	06:01	XBT #37	37°57.19'N	68°10.55'W
	07:11	XBT #38	37°47.11'N	68°02.21'W
	08:05	XBT #39	37°39.67'N	67°56.43'W
	09:02	XBT #40	37°32.75'N	67°51.62'W
	10:18	XBT #41	37°38.41'N	67°41.85'W
	11:00	XBT #42	37°43.52'N	67°32.78'W
	11:53	XBT #43	37°51.3'N	67°25.5'W
	12:55	XBT #44	37°58.37'N	67°30.79'W
	13:57	XBT #45	38°05.2'N	67°39.8'W
	14:54	XBT #46	38°11.54'N	67°49.05'W
	16:58	XBT #47	38°19.03'N	68°12.27'W
	20:02	XBT #48	38°27.15'N	68°30.46'W
7 Apr. 1989				
	17:11	Neuston #4	38°35.15'N	69°00.08'W
	17:42	Louie #3 failed camera #1	38°35.86'N	68°59.72'W
	21:34	Neuston #5	38°36.4'N	69°02.35'W
	21:56	Out		
	22:10	CTD #10 On checking Rosette before cast positions 3 and 4 trip together	38°37.0'N	69°01.9'W
8 Apr. 1989	00:04	XBT #49 T-6 surface 16.4°C	38°29.03'N	68°55.72'W
		XBT #50 a dud (T-6)		
	01:32	XBT #51 (T-6)	38°15.02'N	68°46.61'W

Date	Time	Event	Position Latitude	Position Longitude
Leg I				
8 Apr. 1989	02:39	XBT #52 (T-6)	38°5.77'N	68°40.75'W
	03:36	XBT #53 (T-6)	38°00.12'N	68°36.90'W
	04:38	XBT #54 (T-6)	37°56.10'N	68°35.13'W
	05:33	XBT #55 (T-6)	37°52.02'N	68°32.63'W
	06:37	XBT #56 (T-7)	37°47.02'N	68°29.29'W
		wind's cranking		
	20:58	XBT #57	37°16.9'N	69°5.7'W
	22:04	XBT #58 (T-7)	37°20.58'N	69°14.31'W
	23:00	XBT #59 (T-7)	37°29.4'W	69°21.4'W
	23:59	XBT #60 (T-7)	37°38.04'N	69°22.01'W
9 Apr. 1989	01:04	XBT #61 (T-7)	37°49.15'N	69°24.29'W
	02:06	XBT #62 (T-7)	37°58.93'N	69°28.15'W
	03:02	XBT #63 (T-7)	38°08.02'N	69°33.46'W
	04:01	XBT #64 (T-7)	38°16.40'N	69°38.45'W
	05:02	XBT #65 (T-7)	38°25.41'N	69°43.39'W
	06:04	XBT #66 (T-6)	38°35.20'N	69°48.96'W
Leg II				
12 Apr. 1989				
	02:15	XBT #67 (T-6)	40°03.'N	70°22.'W
	03:35	XBT #68 (T-6)	39°49.9'N	70°08.8'W
	04:38	XBT #69 (T-6)	39°39.2'N	69°57.3'W
	05:34	XBT #70 (T-6)	39°29.4'N	69°47.3'W
	06:34	XBT #71 (T-6)	39°19.45'N	69°38.1'W
	07:36	XBT #72 (T-6)	39°09.2'N	69°28.2'W
	08:35	XBT #73 (T-6)	38°59.8'N	69°18.8'W
	09:30	XBT #74 (T-7)	38°51.16'N	69°09.71'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
12 Apr. 1989	10:30	XBT #75 (T-7)	38°41.9'N	69°00.4'W
	11:30	XBT #76 (T-7)	38°41.9'N	69°00.4'W
	12:30	XBT #77 (T-7)	38°23.00'N	68°42.00'W
	13:26	XBT #78 (T-7)	38°11.5'N	68°36.6'W
	14:52	XBT #79 (T-7)	38°00.5'N	68°29.7'W
	15:55	XBT #80 (T-7)	38°04.4'N	68°37.2'W
	17:43	CTD #11	38°08.9'N	68°39.0'W
		hydrowinch died - cast aborted - back to Narrgansett		
15 Apr. 1989		En route from Narragansett		
	11:10	XBT #81 (T-6)	40°07.0'N	70°48.8'W
	02:06	XBT #82 (T-6)	39°55.99'N	70°41.9'W
	03:04	XBT #83 (T-6)	39°46.0'N	70°34.0'W
	04:05	XBT #84 (T-6)	39°35.0'N	70°26.9'W
	05:01	XBT #85 (T-6)	39°25.4'N	70°20.3'W
	06:03	XBT #86 (T-7)	39°14.8'N	70°13.4'W
	07:03	XBT #87 (T-7)	39°03.8'N	70°07.4'W
	08:03	XBT #88 (T-7)	38°53.1'N	70°00.4'W
	09:01	XBT #89 (T-7)	38°42.7'N	69°53.1'W
	09:59	XBT #90 (T-7)	38°31.9'N	69°46.13'W
	10:58	XBT #91 (T-7)	38°21.85'N	69°38.90'W
	11:53	XBT #92 (T-7)	38°12.73'N	69°31.45'W
	12:26	XBT #93	38°07.3'N	69°32.9'W
	13:00	XBT #94	38°00.8'N	69°26.1'W
	13:08	Drifter #1 (green X)	37°59.7'N	69°23.4'W
	14:00	added a chain	37°59.7'N	69°20.21'W
	14:29	Drifter J-G 210°T port ~500 m	37°59.66'N	69°18.0'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
		camera fails (time not logged)		
15 Apr. 1989	16:32	CTD #12	37°58.1'N	69°08.4'W
	20:00	Grazing cast #1 (30 l bottles and net haul) Camera fails (unlogged)	37°57.7'N	69°07.2'W
16 Apr. 1989		Hove to gale winds		
17 Apr. 1989				
	14:40	XBT #95	38°35.4'N	68°42.2'W
	14:50	Meter-tow #1	38°35.2'N	68°42.5'W
	15:37	CTD #13	38°37.1'N	68°43.8'W
	16:38	Seiche disk	38°33.8'N	68°45.9'N
	16:44	Grazing cast #2	38°33.3'N	68°45.6'W
	17:03	Neuston #6	38°33.17'N	68°45.8'W
	17:28	Steaming 220°T (XBT 1/2 hr; Sta. 1 hr.)		
	18:00	XBT #96	38°27.7'N	68°51.1'W
	18:28	On station	38°24.40'N	68°56.4'W
	18:34	Meter-tow #2	38°24.35'N	68°56.51'W
	19:15	CTD #14	38°23.9'N	68°57.6'W
	19:26	Nauplii net at 200 m		
	20:23	Neuston #7 ending time - 20:37	38°23.25'N	68°59.14'W
	20:40	Steam to another station (XBT 1/2 hr)		
	21:09	XBT #97	38°19.83'N	69°03.67'W
	21:49	On station	38°13.88'N	69°08.66'W
	21:59	Meter-tow #3	38°13.49'N	69°08.09'W
	22:30	CTD #15	38°12.66'N	69°06.93'W
		Nauplii net ~200 m 22:43		
	23:30	Neuston #8	38°10.96'N	69°03.73'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
18 Apr. 1989				
	01:01	Cam #03	38°10.35'N	69°01.42'W
	01:30		38°05.61'N	69.02.28'W
	01:30	XBT #98	38°05.61'N	69°02.28'W
	02:17	Meter net #4	38°00.69'N	69°04.79'W
	02:50	CTD #16 Nauplii net at 200 m 03:03	37°58.889'N	69°02.94'W
	03:53	Grazing cast #3	37°55.3'N	68°57.4'W
	04:34	Cam #04	37°54.1'N	68°56.4'W
	04:45	Neuston net #9	37°53.1'N	68°54.7'W
	05:23	XBT #99	37°51.2'N	68°52.9'W
		(Latitude on file wrong)		
	05:57	Neuston #10	37°53.3'N	68°49.9'W
	05:57	XBT #100	37°53.42'N	68°49.26'W
	06:44	Cam #05 Aborted	37°51.5'N	68°46.5'W
	07:38	Drifter #2(yellow RGF/Red flag)/with light	37°49.33'N	68°43.27'W
	08:17	Bearing on drifter 263°- not on radar		
	09:00	Drifter light failed	37°46.9'N	68°37.2'W
	12:26	XBT #101	37°36.2'N	68°24.9'W
	14:33	XBT #102	37°46.6'N	68°25.8'W
	14:48	Cam #06	37°45.8'N	68°26.0'W
	15:42	Neuston #11	36°42.7'N	68°23.5'W
	16:11	CTD #17	37°41.12'N	68°21.80'W
	16:25	Nauplii net (200 m)		
		?light cast		
	19:21	End grazing cast #4	37°31.6'N	68°04.7'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
18 Apr. 1989	19:29	XBT #103	37°31.39'N	68°04.37'W
	19:40	Cam #07	37°30.93'N	68°03.80'W
	20:35	XBT #104	37°30.6'N	68°00.8'W
	20:36	Neuston #12	37°30.4'N	68°00.5'W
	21:25	XBT #105	37°28.7'N	67°58.5'W
	21:55	XBT #106	37°30.24'N	67°54.96'W
	22:57	Cam #08	37°30.28'N	67°49.16'W
	23:27	XBT #107	37°29.3'N	67°47.8'W
19 Apr. 1989				
	00:01	XBT #108		
	00:26	Graze #05	37°27.0'N	67°44.5'W
	01:38	XBT #109	37°32.04'N	67°41.6'W
	02:13	XBT #110	37°37.13'N	67°42.21'W
	02:51	XBT #111	37°33.9'N	67°32.8'W
	03:20	XBT #112	37°30.6'N	67°25.3'W
	03:48	XBT #113	37°27.3'N	67°18.1'W
	04:18	XBT #114	37°31.19'N	67°15.4'W
	05:17	XBT #115	37°31.96'N	67°10.02'W
	06:05	Cam #09	37°31.8'N	67°05.'W
	07:10	Neuston #13	37°31.8'N	66°59.1'W
	08:34	XBT 116	37°31.67'N	66°53.31'W
	09:06	Cam #10	37°34.7'N	66°51.3'W
	10:04	XBT #117	37°34.89'N	66°8.51'W
	10:16	Neuston	37°35.33'N	66°47.98'W
	11:20	XBT #118	37°42.11'N	66°45.76'W
	11:54	XBT #119	37°40.27'N	66°39.32'W
	12:20	XBT #120	37°36.90'N	66°34.17'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
19 Apr. 1989	12:51	XBT #121	37°32.91'N	66°29.48'W
	13:21	XBT #122	37°37.83'N	66°26.47'W
	13:50	XBT #123	37°43.20'N	66°23.99'W
	14:07	XBT #124	37°45.1'N	66°23.2'W
		failure in system link - no data stored - data digitalized by hand from trace		
	14:07	Cam #11	37°45.1'N	66°23.2'W
	15:00	Meter net #5	37°47.57'N	66°21.77'W
	15:29	CTD #18	37°47.44'N	66°20.73'W
		Nauplii net at 200 m		
	16:41	Neuston #15 no position		
	17:17	Light cast #3	37°47.4'N	66°15.5'W
	18:04	Grazing #06	37°47.5'N	66°13.4'W
	19:3:20	Cam #12	37°47.7'N	66°11.1'W
	19:30	XBT #125	37°47.78'N	66°10.48'W
	20:28	XBT #126	37°53.03'N	66°07.00'W
	21:00	XBT #127	37°58.99'N	66°07.27'W
	21:29	XBT #128 (T6)	38°04.55'N	66°09.37'W
	22:01	XBT #130 (T7)	38°10.84'N	66°12.0'W
	22:29	XBT #130 (T7)	38°16.56'N	66°14.44'W
	23:00	XBT #131 (T6)	38°22.88'N	66°16.70'W
	23:30	XBT #132 (T6)	38°26.32'N	66°10.43'W
20 Apr. 1989	Day 110			
	00:01	XBT #133	38°29.91'N	66°03.03'W
	00:34	XBT #134	38°33.7'N	65°55.0'W
	01:02	XBT #135	38°34.8'N	65°47.9'N
	02:04	XBT #136 (T-7)	38°37.66'N	65°44.71'W
	03:15	Cam #13	38°37.5'N	65°44.9'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
20 Apr. 1989	03:39	XBT #137	38°38.9'N	65°45.0'W
	04:21	Graze #7	38°40.87'N	65°44.87'W
	04:37	Neuston #16	38°41.72'N	65°44.86'W
	05:32	XBT #138	38°49.99'N	65°43.07'W
	06:02	XBT #139	38°56.22'N	65°41.42'W
	06:32	XBT #140	39°02.1'N	65°39.8'W
	07:00	XBT #141	39°07.2'N	65°38.6'W
	07:32	XBT #142	39°13.6'N	65°36.86'W
	08:02	XBT #143	39°18.87'N	65°35.59'W
	08:51	CTD #19	39°21.4'N	65°35.7'W
		Deploy productivity array		
	13:00	XBT #144 (T-6)	39°22.04'N	65°35.44'W
	14:59	XBT #145 (T-6)	39°21.63'N	65°34.88'W
	15:00	Cam #14	39°21.7'N	65°34.8'N
	16:00	Light cast #4	39°21.68'N	65°34.00'N
	17:36	CTD #20	39°21.64'N	65°33.53'N
	17:49	Nauplii net at 200 m		
	19:00	Grazing #8		
	19:38	Camera #15	39°21.8'N	65°32.3'N
	20:48	Neuston net #17	39°22.18'N	65°33.0'W
	23:00	Record buoy ~39°21	~65°30	
21 Apr. 1989				
	00:00	Graze #9	39°21.45'N	65°30.75'W
	00:01	XBT #146	39°21.5'N	65°31.9'W
	01:25	MOC #07	39°21.22'N	65°32.98'W
	04:29	XBT #147	39°05.32'N	65°31.40'W
	06:50	MOC #08	38°55.84'N	65°22.75'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
21 Apr. 1989	06:55	XBT #148	38°55.84'N	65°22.67'W
	09:15	XBT #149	38°47.18'N	65°21.36'W
	10:28	CTD #21 with Nauplii at 200 m	38°37.0'N	65°22.7'W
	11:59	Neuston #18	38°39.28'N	65°22.84'W
	13:04	MOC #09 surface	38°39.6'N	65°24.0'W
	14:03	MOC #09 bottom	38°39.0'N	65°23.57'N
	14:06	XBT #150	38°38.86'N	65°23.53'W
	16:30	XBT #151	38°31.44'N	65°24.59'W
	17:22	Light cast	38°24.78'N	65°27.95'W
	18:04	CTD #22	38°25.59'N	65°26.61'W
	18:10	Nauplii net at 200 m		
	19:05	Meter net #5	38°28.3'N	65°24.8'W
	19:47	Neuston net #19	38°30.32'N	65°23.13'W
	20:45	Neuston net #20	38°32.37'N	65°21.62'W
	22:22	XBT #152	38°27.76'N	65°34.10'W
	23:44	CTD #23 cast 1 rossette test	38°23.87'N	65°45.09'W
22 Apr. 1989				
	00:08	CTD #23 cast 2	38°25.36'N	65°44.22'W
	01:14	MOC #10	38°29'N	65°42.8'W
	02:13	MOC #10 bottom	38°30.2'N	65°43.8'W
	02:18	XBT #153	38°30.3'N	65°43.9'W
	03:47	MOC #10 surface	38°32.2'N	65°45.3'W
	04:12	Neuston #21	38°33.25'N	65°44.55'W
	05:29	DMS #2	38°31.88N	65°57.32'W
	07:00	MOC #11 start	38°28.3'N	66°12.0'W
	07:54	MOC #11 bottom	38°28.7'N	66°14.'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
22 Apr. 1989	07:56	XBT #154	38°28.'N	66°14.'W
	09:25	MOC #11 surface end	38°29.19'N	66°17.74'W
	09:42	Neuston #22	38°29.24'N	66°18.2'W
	09:58	DMS #3	38°30.47'N	66°18.6'N
	10:51	XBT #155	38°27.40'N	66°28.72'W
	11:40	DMS #4	38°26.0'N	66°39.5'W
	11:47	MOC #12 start	38°24.81'N	66°38.90'W
	12:50	XBT #156	38°23.73'N	66°40.67'W
	13:18	DMS #5	38°24.56'N	66°42.28'W
	14:12	MOC #12 surface end	38°21.9'N	66°45.6'W
	14:29	CTD #24	38°21.74'N	66°44.07'W
	14:37	Nauplii net	38°21.86'N	66°44.2'W
	15:10	DMS #6	38°22.0'N	66°44.4'W
	15:30	Light cast	38°22.3'N	66°44.4'W
	16:08	Neuston #23	38°22.37'N	66°44.7'W
	17:32	XBT #157	38°11.0'N	66°35.39'W
	18:27	XBT #158	38°03.94'N	66°29.43'W
	19:01	MOC #13 Abort CTD good on down	38°04.'N	66°27.5'W
	19:14	DMS #7	38°04.'N	66°28.7'W
	21:55	DMS #8	38°05.39'N	66°20.94'W
	21:55	Neuston #24	38°05.39'N	66°20.94'W
	22:14	Meter net at up 1330 MWO	38°05.39'N	66°21.20'W
	23:00	DMS #9	38°06.30'N	66°22.98'W
23 Apr. 1989	00:00	DMS #10		
	00:12	XBT #159	37°54.16'N	66°17.39'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
23 Apr. 1989	01:26	DMS #11	37°42.20'N	66°18.29'W
	01:41	CTD #25	37°42.9'N	66°12.7'W
		stripped bolt on Nauplii - no net		
	01:41	DMS #12		
	02:29	Grazing #10	37°44.17'N	66°11.15'W
	03:04	DMS #13	37°45.50'N	66°08.64'W
	03:21	MOC #14	37°46.13'N	66°09.26'W
	04:46	MOC #14 end surface	37°46.'N	66°04.'W
	05:04	DMS #15	37°47.5'N	66°04.7'W
	05:15	XBT #160	37°46.4'N	66°03.5'W
	06:01	DMS #16	37°40.5'N	66°05.2'W
	07:08	DMS #17	37°31.0'N	66°05.9'W
	08:08	DMS #18	37°22.6'N	66°09.2'W
	08:50	MOC #15 out at	37°22.17'N	66°08.55'W
	09:57	MOC #15 bottom		
	10:20	XBT #161	37°21.82'N	66°08.97'W
	11:00	DMS #19	37°22.0'N	66°08.6'W
	11:25	Neuston #25	37°22.37'N	66°08.9'W
	12:10	DMS #20	37°20.41'N	66°14.1'W
	12:49	XBT #162	37°16.07'N	66°19.34'W
	13:12	DMS #21	37°14.1'N	66°23.5'W
	13:58	XBT #163	37°09.34'N	66°30.48'W
		Data loss on EDC Z >200 m rest from plot		
	14:44	XBT #164	37°16.68'N	66°35.41'W
	17:16	XBT #165	37°26.50'N	66°36.22'W
	17:53	CTD #26 cast 1	37°28.97'N	66°38.55'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
23 Apr. 1989	18:02	Nauplii net at 200 m at 300 m workstation died. It had to be rebooted. Try upcast = case 2, didn't work. Brought CTD to surface try cast 3 data acquisition status didn't work.		
	18:59	CTD #26 cast 4	37°30.33'N	66°35.49'W
	18:46	DMS #26	37°30.7'N	66°37.9'W
	19:58	MOC #16	37°31.86'N	66°32.49'W start
	21:23	XBT #166	37°35.64'N	66°27.03'W
	22:55	MOC #16 surface	37°39.64'N	66°25.10'W
	22:57	Neuston #26	37°39.72'N	66°25.03'W
24 Apr. 1989				
	01:10	XBT #167	37°41.21'N	66°43.79'W
	02:33	Neuston #27	37°42.14'N	66°59.87'W
	03:21	MOC #17 surface	37°42.02'N	67°00.55'W
	04:18	MOC #17 bottom (1000 m)		
	04:26	XBT #168	37°44.65'N	67°01.27'W
	05:28	MOC #17 surface		
	07:40	XBT #169	37°30.8'N	67°12.5'W
	08:50	Grazing net	37°25.59'N	67°07.49'W
	09:14	MOC #18 surface	37°75.27'N	67°05.85'W
	10:23	MOC #18 bottom	37°23.4'N	67°02.52'W
	10:23	XBT #170	37°23.4'N	67°02.52'W
	11:54	MOC #18 end	37°21.3'N	66°58.6'W
	11:58	Neuston #28	37°21.26'N	66°58.50'W
	13:45	XBT #171	37°16.75'N	67°12.10'W
	15:10	CTD #27	37°09.82'N	67°24.78'W
	15:20	Nauplii net at 200 m		
	17:08	Graze #12	37°06.81'N	67°21.28'W

Date	Time	Event	Position Latitude	Position Longitude
Leg II				
24 Apr. 1989	17:44	MOC #18	37°06.05'N	67°20.22'W
	19:43	XBT 172	37°04.11'N	67°15.54'W
25 Apr. 1989				
	08:17	XBT #173	35°52.0'N	69°17.8'W
	08:33	CTD #28 PP in situ #2	35°51.9'N	69°18.5'W
	14:03	CTD #29	35°46.38'N	69°23.73'W
	14:57	MOC TST #1	35°45.52'N	69°23.79'W
	15:31	CTD #30	35°44.97'N	69°23.99'W
	17:42	Neuston #29	35°43.01'N	69°23.65'W
	22:20	Graze #13	35°38.13'N	69°20.83'W
	23:05	XBT #174 error on disk EOF - data not stored.	35°37.58'N	69°20.29'W
	23:07	Neuston #30	35°37.48'N	69°20.34'W

Participating Personnel on R/V Iselin
Leg I March 30, 1989 - April 11, 1989
Leg II April 12 - 28, 1989

BioSYNOP II, Cruise No: CI8903
P.I. Donald B. Olson

	Name	Title	Affiliation	Code*	Leg
1.	Donald B. Olson	Chief Scientist	UM/RSMAS/MPO	S, 1	I, II
2.	Geoffrey Samuels	Remote Sensing	UM/RSMAS/MPO	T, 1	I, II
3.	Cristina Forbes	Remote Sensing	UM/RSMAS/MPO	GS, 1	I, II
4.	Richard Findley	Technician	UM/RSMAS/OTECH	T, 1	I
5.	Manuel Aparicio	Technician	UM/RSMAS/OTECH	T, 1	I, II
6.	Walter Maxwell	Technician	UM/RSMAS/OTECH	T, 1	I, II
7.	Jeffrey Napp	Bioacoustics	UM/RSMAS/BLR	S, 1	I, II
8.	Elizabeth Clarke	Bioacoustics	UM/RSMAS/BLR	S, 2	I, II
9.	Patricia Matrai	Phytoplankton	UM/RSMAS/MAC	S, 1,3	II
10.	David Cooper	Atmos. sulfur gas measurements	UM/RSMAS/MAC	S, 3	II
11.	Peter Ortner	Zooplankton	NOAA/OAR/ERL/AOML	S, 1	I, II
12.	Shailer R. Cummings	Zooplankton	NOAA/ERL/AOML/ Ocean Chemistry	T, 1	I, II
13.	Richard Pieper	Bioacoustics	USC	S, 1	I
14.	John Dawson	Bioacoustics	USC	T, 1	I
15.	Charles Yentsch	Phytoplankton	Bigelow Laboratory	S, 1	II
16.	David Phinney	Phytoplankton	Bigelow Laboratory	T, 1	I, II
17.	Terry Cucci	Phytoplankton	Bigelow Laboratory	T, 1	II
18.	John Laird	Phytoplankton	Bigelow Laboratory	T, 1	I
19.	Cabell Davis	Zooplankton	WHOI	S, 1	I, II
20.	Peter V. Lane	Bioacoustics	Brookhaven	T, 1	II
21.	Charles Flagg	Bioacoustics	Brookhaven	S, 1	I
22.	George Sedberry		Mar. Resources	S, 1	I
23.	Kevin Davis		Mar. Resources	S, 1	I
24.	Charles Barans		Mar. Resources	S, 1	II
25.	Dale Vance Holliday	Bioacoustics	Tracor, Inc.	S, 1	I
26.	Ben William Jones	Bioacoustics	Tracor, Inc.	T, 1	I

*S = Scientist
GS = Graduate Student
T = Technician
1 = ONR grant
2 = SEFCAR grant
3 = NASA grant

The SYNOPtician

"All the News and Data That's Fit to Print"

May 1990 Volume One Number 3

In this Issue:

Can Localized Clusters of Velocity Data Be Useful For Data Assimilation?

Paola Malanotte-Rizzoli and Roberta E. Young
MIT

The forthcoming availability of global synoptic datasets provided by satellite, among which altimetry will be the most important, has prompted the oceanographic modeling community to initiate a new body of research already well developed in meteorology and known under the general name of data assimilation. The most general definition which may be given of the concept of data assimilation is that it constitutes a blending of a numerical model simulation of the ocean circulation with one or more datasets describing one or more dynamical fields in the region of interest. However, even though unprecedented, these synoptic-satellite datasets will still be available only at the sea surface, not for the ocean interior. Thus, ocean models will have to play a much more important role than their meteorological counterpart since fairly complete observations of the four dimensional ocean structure (space and time) will still be lacking for the foreseeable future.

For what satellite altimetry is concerned, numerous studies have already been carried out to assess the effectiveness of the data assimilation process in dynamically transferring the altimeter information (sea surface height) into the deep oceanic layers, thus reconstructing the (unknown) deep circulation. Some of these studies have also focussed upon the degradation of this effectiveness with the decrease in

Continued on Page 2

BIOSYNOP: Biophysical Studies of Gulf Stream Meanders

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This note presents a description of a collaborative study of the biological features associated with the Gulf Stream front and their response to physical processes associated with meandering of the western boundary current. The effort was proposed as an interdisciplinary program to augment the physical oceanographic SYNOP program currently funded by ONR and NSF. One of the arguments for such a program was the context supplied by the extensive SYNOP effort for the biological measurements and models.

While physically the Gulf Stream can be defined as a swift current jet with strong cross stream temperature changes, the stream also has strong biological characteristics. Just as it forms the boundary between the subtropical gyre and the cool, fresh Slope Water, it is also a transition region between the oligotrophic Sargasso Sea environment and the highly productive boreal zone. Therefore the transition in physical characteristics (c.f. Watts, 1983; Halkin and Rossby, 1985; Bower et al., 1985) is associated with a transition in the biogeographic sense as well. Changes in thermohaline stratification and nutrient profiles lead to enhanced primary productivity relative to central gyre conditions found to the south (Cox et al., 1982; Brown et al., 1985). The attendant changes in physical and biological factors lead to large changes in both the zooplankton and nekton biomass and in the speciation within representative

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the space resolution of the data. Specifically, when the surface pressure is provided at the data assimilation process is reduced considerably (intermittent assimilation). On the other hand, a coarsening of the space resolution of the surface data immediately worsens the assimilation process and the model eventually becomes incapable of reconstructing the deep circulation (Malanotte-Rizzoli et al., 1989; Holland and Malanotte-Rizzoli, 1989).

Thus the question immediately arising is: can more traditional oceanographic data, with coarse space resolution and localized in limited areas, be effective at all when assimilated into an ocean circulation model? Consider for instance the SYNOP experiment and the clusters of current meter moorings constituting the Eastern and Western arrays. Can the velocity data with high time sampling frequency provided by these arrays be capable to force a Gulf Stream system numerical model to reconstruct the observed Gulf Stream behavior in any region of the SYNOP domain? To begin to address this question we have run an idealized assimilation experiment of velocity data with a Spectral Primitive Equation Model (S.P.E.M.) originally developed by D. Haidvogel and implemented by us to inflow/outflow boundary conditions respectively at the western and eastern boundaries. The model configuration is of a zonal channel, with dimensions of 1875 km (east-west) by 1400 km (north-south) by 5000 m (depth) over a flat bottom. The horizontal resolution is of 14 km and 5 collocation points (levels) are allowed in the vertical. The eastern and western SYNOP arrays, shown in Fig. 1a for the SYNOP region, are idealized in the model domain as two identical clusters of 13 moorings, with each pair of adjacent moorings ~100 km apart. Velocity data are provided at every time step (continuous time assimilation), at each of the 5 vertical levels (corresponding to 5 current meters equally spaced in depth at each mooring). At each data point, the velocity information is "spread" around it through a Gaussian correlation function with a correlation distance of ~50 km. The "nudging" technique introduced by Holland and Malanotte-Rizzoli (1989) is used for data assimilation. The twin experiment approach is used; it consists of three steps. Run first a baseline experiment for a fixed time interval, 60 days in our experiment. This is the "true" ocean from which the time series of velocity data is extracted at the array locations shown in Fig. 1b. Second, select a different initial condition and let the model run for the same time interval of 60 days. The model evolution is quite different from the first run and this second run constitutes the "false" ocean. Third, run the data assimilation experiment in which the model is started from the initial condition of the "false" ocean but the evolution is forced by the assimilation of the velocity data extracted from the "true" ocean at the two arrays of Fig. 1b. If the assimilation process is successful, the "true" ocean features will be reconstructed in the assimilation experiment.

Fig. 2a,b,c,d show the results of such an experiment at initial time and day 20-46-56 respectively of the assimilation. They show the density field (temperature) at the surface. The top panel shows the "true" ocean from which the velocity data are extracted; the bottom panel shows the "false" ocean, i.e. how the Gulf Stream Jet would have evolved starting from a different initial condition in the unconstrained model; the middle panel shows the assimilation results, i.e., the jet evolution starting from the "false" initial condition but with the constraints provided by the velocity data at the two arrays of Fig. 1b (notice that most of the model domain is still unconstrained in the assimilation experiment).

At initial time (Fig. 2a) the false ocean and the assimilation calculation are obviously identical and very different from the true ocean. At day 20 (Fig. 2b) the jet evolution in the middle panel is still much more similar to the false ocean (bottom panel) than to the true one (top panel). At day 46 (Fig. 2c) the effect of the data assimilation is begun to be felt by the model with a partial reconstruction of the big northward meander between the two arrays. Finally, at day 56 (Fig. 2d) the assimilation process has been very successful in reconstructing the northward elongated meander on the verge of breaking off and eddy shedding. The assimilation evolution of the middle panel of Fig. 2d is now remarkably similar to the "true" ocean of the top panel and quite different from the "false", unconstrained ocean of the bottom panel. The rms-error (not shown) between the assimilation run and the true ocean has decreased considerably over the 56 days of the experiment, especially in the region between the two arrays.

These initial assimilation results are quite exciting and promising. Even though carried out in an idealized model configuration and with model-simulated data, they show very clearly that localized clusters of velocity data such as those measured in the SYNOP eastern and western arrays can be quite successful in forcing a numerical circulation model to reconstruct the "true" behavior of the Gulf Stream Jet, at least surely for the region comprised between the arrays. The optimistic perspective is that the assimilation of the "real" SYNOP velocity data into a more realistic model configuration, with realistic topography and Gulf Stream Jet initialization, will be equally successful in reconstructing the realistic evolution of the Gulf Stream in the SYNOP region.

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groups such as the copepods (Grice and Hart, 1962; Backus et al., 1977; Wiebe et al., 1985; Wishner and Allison, 1986).

While the large scale nature of the biogeographic transition across the Gulf Stream is fairly well known as is the nature of the evolution of biological communities within the mesoscale eddies or rings formed by the meandering of the current (The Ring Group, 1981; Wiebe et al., 1985), the knowledge of the ecotone (Brandt and Wadley, 1981) within the Stream itself is poor. Much of the previous work has consisted of cross stream transects of species distributions or extensive work in the adjacent water masses. In particular, little is known about the downstream evolution of Gulf Stream plankton communities, or the role played in these changes by the Stream's meandering process with its attendant frontogenesis and cross-stream mixing.

The BIOSYNOP effort has specifically addressed this latter issue and the underlying biological and physical dynamics responsible for changes along the stream edge. The major objectives of BIOSYNOP are to study:

1) Frontal enhancement of phytoplankton biomass and productivity associated with upwelling in meander crests and mixing.

2) Responses of zooplankton and micronekton to the distribution of phytoplankton biomass and physical processes in the Gulf Stream front.

3) Fine and mesoscale abundance and biomass distributions across the Gulf Stream front.

The relevant time and space scales to be considered involve a wide range of values. For the physical processes these range from the relatively brief temporal events associated with vertical mixing to the upwelling of fluid parcels as they traverse the meander crest (Fig. 1). Relevant biological time scales include those of phytoplankton physiological adaptations (seconds to hours) to the longer-term changes in macrozooplankton and nekton standing stock and distribution (days to weeks to months). The physical processes of interest include nutrient enrichment via lateral and vertical mixing coupled to the three-dimensional fluid flows (up- and downwelling); these processes also have a direct influence on sedimentation and active swimming behavior (Okubo, 1978; Olson and Backus, 1985; Yenstch and Phinney, 1985). The interaction between the flow field and stratification are also being examined, particularly as it relates to patchiness within the frontal region.

The field program consisted of two multi-ship cruise efforts, one in October 1988 and another in April 1989, to survey a meander. The R/V Endeavor carried out a combination of Lagrangian float mapping of the thermocline flow field and CTD cross sections of one half of a meander. The second ship (R/V Cape Hatteras in fall and R/V Columbus Iselin in spring) completed synoptic mapping of a meander with a combination of CTD, XBT and MOCNESS as well as fine scale surveys in selected regions in the Gulf Stream front. In the spring a third ship, USNS Bartlett completed underway pigment and acoustic sampling along a meander. A summary of the biological ships track during the two efforts along with ADCP near surface velocities is shown in Fig. 2. Preliminary zooplankton biomass distributions from the fall 1988 cruise are given in Fig. 3.

A table of the bioSYNOP participants and their interests is included elsewhere in the newsletter.

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