

# Naval Research Laboratory

Stennis Space Center, MS 39529-5004

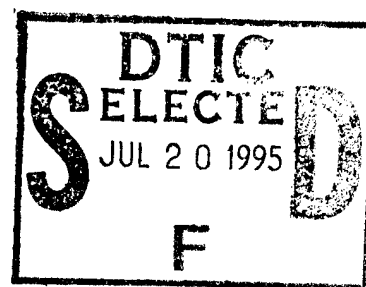


NRL/MR/7322--95-7594

## Coastal Scene Description: Interim Status Report

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*Ocean Dynamics and Prediction Branch  
Oceanography Division*



June 16, 1995

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The Coastal Scene Description Project, an exploratory development (6.2) effort, integrates data assimilation/fusion, Expert Systems, visualization techniques and feature models to create an accurate three-dimensional estimation of coastal environments. This interim status report documents FY94 accomplishments and current progress on the FY95 wrap-up. It references team contributions, interagency collaborations, capability demonstrations, feature models, data integration/visualization techniques, presentations and publications. The next milestone is a mission-driven proof-of-concept demonstration on a single platform in a specific testbed area. The demonstration results and FY95 wrap-up are forthcoming in a FY95 wrap-up report.

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this report are deliberate missing per authors,

Portia J.Harris and George W. Heburn, who wrote  
the report.

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# Coastal Scene Description: Interim Status Report

## Introduction

The major objective of the Coastal Scene Description (CSD) project is to increase effectiveness and performance across all warfare scenarios using a common tactical display to characterize and visualize the state of the environment. The approach to this objective integrates emerging technologies to create very high resolution visualizations that provide useful environmental information to tactical decision makers. These emerging technologies include data assimilation/fusion, Geographical Information System techniques, Expert Systems, and visualization schemes that resolve data integration conflicts and reasoning under uncertainty issues. A brief description of each task and the responsible laboratory follows.

- 1) Data Analysis, Feature Models, and Data Fusion  
Harvard University/Division of Applied Sciences  
(HU/DAS)  
Rutgers University/Institute of Marine and Coastal  
Sciences  
(RU/IMCS)

Acquire, assimilate, fuse, and assess mission area datum and utilize feature models to analyze the impact of environmental (atmospheric, meteorologic, oceanographic) processes on tactical decisions

- 2) Ocean Expert System  
Johns Hopkins University/Applied Physics Laboratory  
(JHU/APL)

Investigate Expert Systems reasoning schemes to formulate data representation and data interpretation methods for tactical decision knowledge bases

- 3) Shore-zone Resolution System  
Naval Research Laboratory/Stennis Space Center  
Marine Geosciences Division  
(NRL/SSC/MGD)

Identify methods to integrate multi-source/multi-type datum and resolve data variabilities to provide high fidelity atmospheric, meteorologic, oceanographic, and digital mapping, charting and geodetic data

- 4) Tactical Environmental Information System (TEIS)  
Applied Physics Laboratory/University of Washington  
(APL/UW)

Explore database management schema and visualization tools to display high fidelity informative visualizations

- 5) Project Management, System Integration, and Proof-of-Concept Demonstration  
Naval Research Laboratory/Stennis Space Center  
Oceanography Division  
(NRL/SSC/OD)

Provide overall project direction and focus to integrate project tasks on a single platform at NRL/SSC that simulates warfare scenarios using very high resolution environmental data

Appendix A gives the project overview and details of the approach, objective, deliverable(s), FY 94/95 Funding Profile, FY 94 Accomplishments, and FY 95 Plans for each task.

## **FY 94 Focus and Accomplishments**

In its initial phase, this project had four stand alone tasks. In FY 94, the project focus was to integrate all tasks to demonstrate an on-scene description for a specific mission and testbed area. The mission selections were Amphibious Warfare, Mine Countermeasures, and Special Warfare in the Straits of Sicily, Yellow Sea, Sea of Japan and other Navy interest areas.

Since there is limited high resolution environmental data in these areas, the proof-of-concept demonstration is a laboratory simulation of an Amphibious Warfare Scenario in the Middle Atlantic Bight (MAB). The MAB was selected because of its process rich/data rich features, and analogy to Navy interest areas, such as the Adriatic Sea, Sea of Japan, Yellow Sea, Persian Gulf, and Gulf of Oman. Its colocations with Navy/Marine Corps training and doctrine commands provides a mechanism to leverage other funded programs, and acquire data and system performance metrics from ongoing field exercises. Collaborations with representatives from the Defense Mapping Agency, Littoral Warfare Training Center (LWTC)/Camp LeJuene, Synthetic Theater of War (STOW) 1997, and Naval Oceanographic Office are ongoing through MiniWorkshops, site visits, system demonstrations, presentations, and publications. Agendas, attendance lists, and reference documents are attached in Appendix A through Appendix F.

The FY 94 Accomplishments were Amphibious Warfare (AMW) Critical Factor Analysis, Data Integration, Visualization Scheme Development, and a Concept Development and Demonstration Testbed Area Document.

## FY 95 Plans and Current Progress

The proof-of-concept demonstration is a data-driven milestone because the requirements for very high resolution data characterization and visualization in coastal areas. High resolution data is sparse and often times non-existent in coastal areas. Field measurements are ongoing and valid data sets are now accessible on an as needed basis. In many cases, developers, modelers, and scientists must rely on interpolation schemes, mixed resolution smoothing, or limited area coverage data sets to conduct research, development, test and evaluation. In order to meet the project objective, New Jersey Coast observations of 4 AUG 94 are used to characterize and visualize the impact of fog and upwelling predictions on Amphibious Assault.

The observations are AVHRR data from NOAA platforms 11 and 12 (every four hours) and continuous current and wind measurements from 12m depth current meters and wind sensors located 10m above the Rutgers Marine Field Station tower. The geographical area coordinates are 39:14:21N, 74:24:32W.

The current progress is based on several developmental tasks that are at or near completion.

- 1) Testbed Area Selection
- 2) High Resolution Data Source Identification
- 3) Warfare Area and Platform Host Designation
- 4) Data Management & Importation Testing

- 5) SceneObject Library Development
- 6) Upwelling/Fog Processes
- 7) Regional Atmospheric Modeling System Tests
- 8) MAB Multiscale Feature Model For Shelf, Slope and Gulf Stream and Meander Region
- 9) Multiscale Resolution Nowcasts
- 10) Two-Way Nesting: Embedded Grid To Largest Grid
- 11) SHORES Version 1 Development Using ARC/INFO & MOSAIC
- 12) Import/Export Data Exchange Functions
- 13) MOSAIC Documentation & Demonstration Development
- 14) Error Analysis Deconfliction Tool Data Checking Ops
- 15) Multi-Level Data Integration

## Future Directions

In FY 96 the project focus is very high resolution 4D currents, tides, and waves in coastal environments. Data assimilation/fusion, modeling & simulation, and system performance metrics are in review and will be adapted to very high resolution environmental applications that represent coupled interactions and generate surface nowcasts and forecasts. The two specific projects are **Coastal Simulation and Coastal Ocean Currents** with a data coupling to **Coastal Ocean Sensing and Data Fusion**.

Collaboration with the Littoral Environment Optics, NOMP, TOSL/  
TOWAN, and other funded programs leverages useful data and technology to evaluate and improve Navy system performance.

# **A P P E N D I X   A**

## **PROJECT DESCRIPTION**

### **CSD OVERVIEW**

### **CSD FUNCTIONAL DIAGRAM**

### **FUNDING PROFILE**

### **CSD FY 94 ACCOMPLISHMENTS & FY 95 PLANS**

#### **TASK DESCRIPTIONS**

**(Graphics, Objective, Approach, Deliverable)**

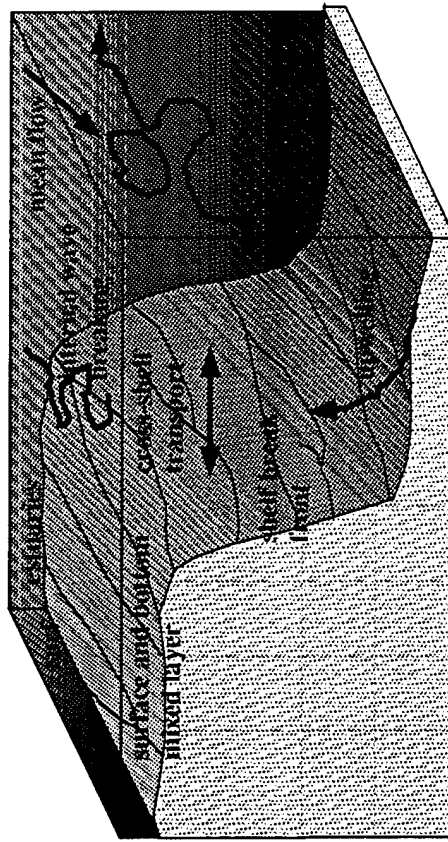
**(Funding, FY 94 Accomplishments, FY 95 Plans)**

- 1) Data Analysis, Feature Models, & Data Fusion  
Harvard University/Division of Applied Sciences**
- 2) Data Analysis, Feature Models, & Data Fusion  
Rutgers University/Institute For Coastal & Marine  
Sciences**
- 3) Ocean Expert System  
Johns Hopkins University/Applied Physics Laboratory**
- 4) Shorezone Resolution System  
Naval Research Laboratory/Marine Geosciences Division**
- 5) Tactical Environmental Information System  
Applied Physics Laboratory/University of Washington**



# Coastal Scene Description Overview

NRL Code 7320



## Objective

- Using all sources of information, measurements (in-situ and remote), climatology, and models (feature and numerical), create accurate "gridded" quantitative 3D estimation of the environment in the coastal area.
- Create "useful", informative visualizations of the state of the environment for tactical decision makers.
- Demonstrate coastal scene descriptions for Amphibious, MCM, and SpecOps scenarios.

## Approach

- Acquire environmental datum from remote imagery, water measurements, climatology, models, infrared, and optical sources to analyze, assimilate, fuse, and execute using littoral area feature models.
- Identify a proof-of-concept testbed area for simulations and demonstrations.
- Utilize Expert Systems Technology and database management schema to interpret and represent environmental datum for on-scene visualizations.
- Integrate feature model results and visualizations to provide high fidelity environmental information for coastal scene descriptions and on-scene data transfer.

- Conduct Proof-of-Concept Demonstrations
  - FY95 Amphibious
  - FY96 MCM
  - FY97 SpecOps

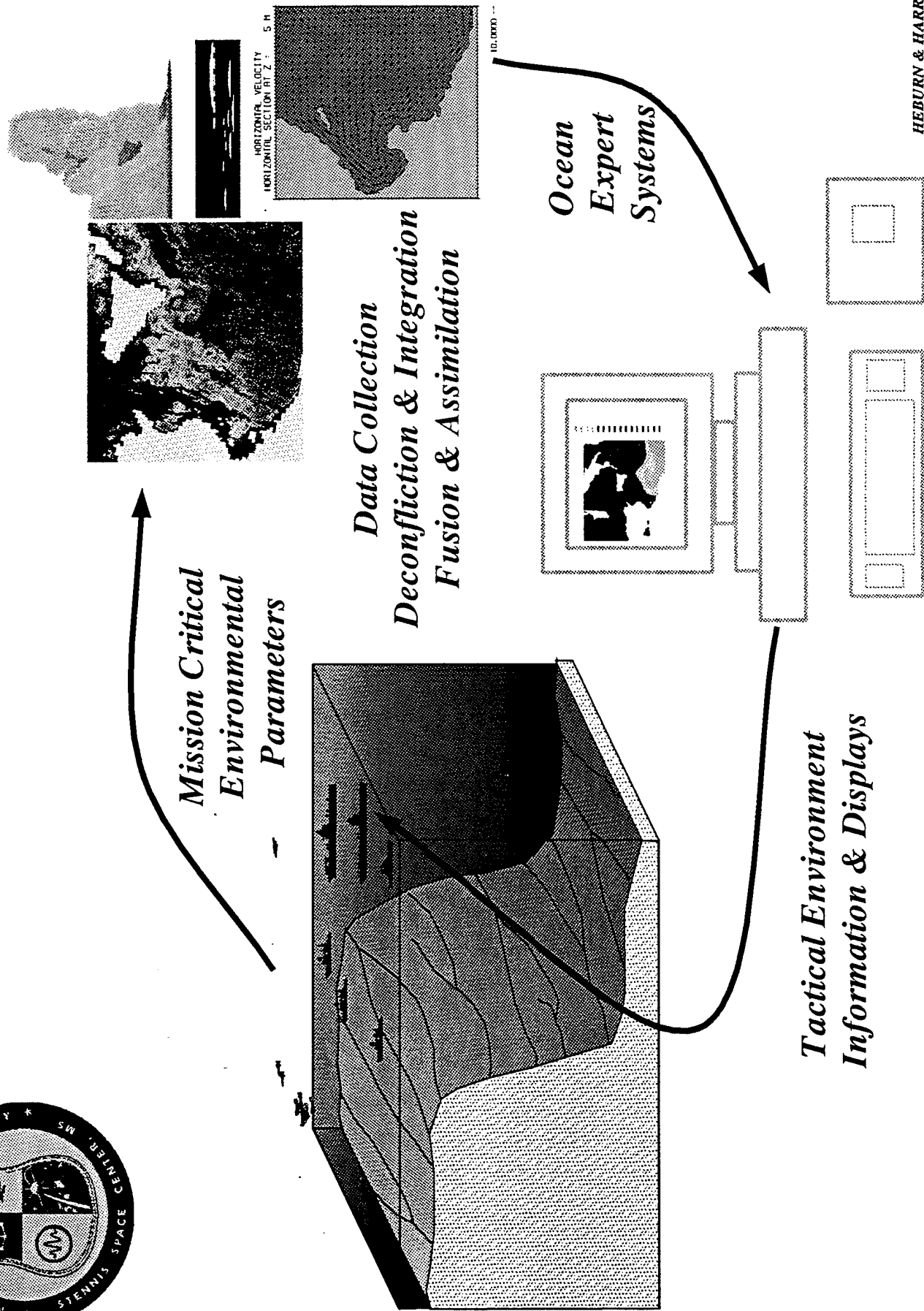
## Final Product

- On-Scene Coastal Scene Description Capability
- On-Scene High Resolution Visualizations
- Increased Tactical Decision Aid Environmental Support

HEBURN & HARRIS, 1994



# Coastal Scene Description Functional Diagram



# Funding Profile (\$K)

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| • Years | Base | Other | Total |
|---------|------|-------|-------|
| • FY94  | 950  | 630   | 1580  |
| • FY95  | 950  | 610   | 1560  |

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# **Coastal Scene Description FY 94 Accomplishments**

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- **Completed Comparative Mission Area Assessments for the Middle Atlantic Bight (MAB), Yellow Sea, and Sea of Japan**
- **Examined MAB Oceanographic and Meteorological Processes and First Generation and Advanced Scientific Visualization Tools**
- **Implemented New Data Analysis Methods and On-Scene Data Interpolation Techniques**
- **Completed Critical Factors Analysis for Amphibious Warfare Scenario**
- **Organized, Integrated, and Registered Littoral Warfare Training Center and MAB Data Resources**

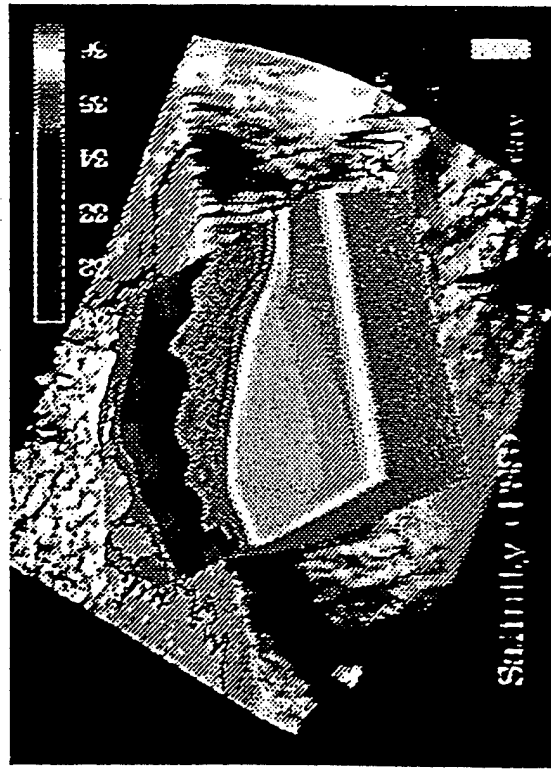
# **Coastal Scene Description FY 95 Plans**

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- **Integrate subtasks on single platform at NRL/SSC**
- **Demonstrate Proof-of-Concept for Amphibious Warfare Scenario**
- **Document Proof-of-Concept Results**
- **Host Project Review Meeting**

# COASTAL SCENE DESCRIPTION

## Data Analysis, Feature Models and Data Fusion



### Objective

The fusion of datastreams, climatology, feature and statistical models to generate accurate nowcasts of the coastal multiscale environment.

### Approach

Apply methodology to combine feature models, *in situ* and remote observations to initialize and assimilate in the dynamical models. Establish sensitivity and robustness of the method in each application.

### Deliverables

Nowcasts in selected areas of the MAB and Sicily Straits regions for the use of CSD participants.

**COASTAL SCENE DESCRIPTION**  
**Data Analysis, Feature Models and Data Fusion**

**FY 94 Funding**  
\$ 105,000

**FY 95 Proposed Funding**  
\$ 110,000

**Accomplishments**

Implementation of multiscale feature models for the shelf-break and Gulf Stream System.  
Fusion of multiscale feature models and MARMAP datasets.

**Plans**

Rapid Assessment Cruise in the Sicily Straits.  
Generation of nowcasts for the MAB and Straits of Sicily regions.

# Coastal Scene Description

## Data Analysis, Feature Model and Data Fusion

Mid Atlantic Bight      South Atlantic Bight



### Objective

Analysis and fusion of oceanographic data and models for 3-D coastal scene description in the Middle and South Atlantic Bights.

### Approach

- \*Collect relevant oceanographic and meteorological data.
- \*Acquire or construct accurate coastline/bathymetry database.
- \*Compile datasets in a Geographic Information System (GIS).
- \*Summarize events and trends of interest to CSD participants.
- \*Distribute required datasets to other CSD participants.

### Deliverables

- \*MAB and SAB oceanographic/meteorological datasets.
- \*Accurate coastlines and bathymetry.
- \*Geographic Information System.
- \*Event summaries.

# Coastal Scene Description

## Data Analysis, Feature Model and Data Fusion

FY 94 Funding

\$0

FY 95 Proposed Funding

\$90,000

Accomplishments

New Start

### Plans

\*Acquire relevant oceanographic and meteorological data from:

- Rutgers Marine Remote Sensing Lab, New Brunswick, NJ
- Rutgers Longterm Ecosystem Observatory, Tuckerton, NJ
- CERC Field Research Facility, Duck, NC
- LWTC, Camp Lejeune, NC
- NOAA Buoys, C-MAN and Tidal Stations.

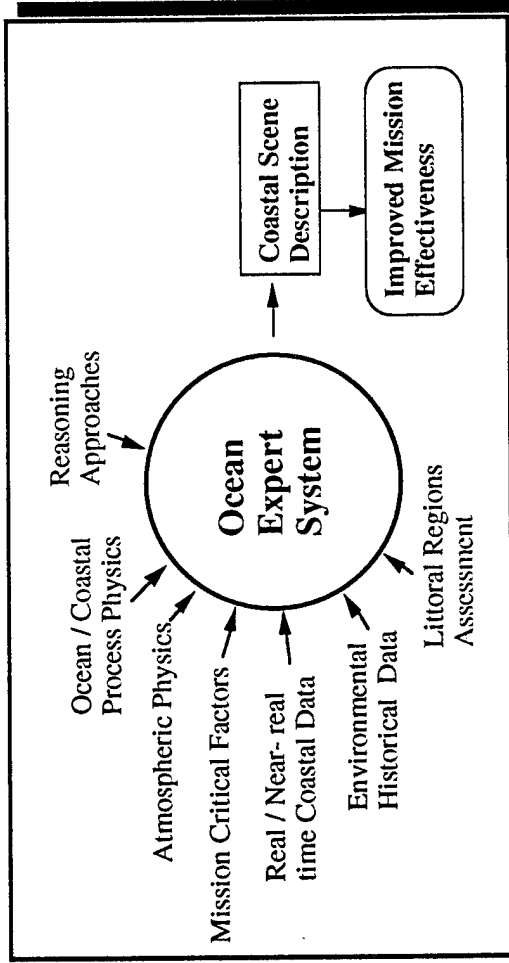
\*Concentrate on data collection starting in 1993, due to availability of satellite imagery.

\*Construct GIS with MAB and SAB subregions.

\*Use GIS to develop summary descriptions of important events and trends.



# Coastal Scene Description Ocean Expert System



## Objectives

- Provide mission dependent description of coastal environmental "scene" to enhance tactical decisions and mission effectiveness
- Provide the technology to support and implement the coastal scene description

## Deliverables

- Periodic computer-based demonstrations showing increasing functionality in individual components and integrated system
  - FY94: Reasoning Tools, Envir. Data Bases, Display
  - FY95: Amphibious Assault Process Physics (Upwelling, Fog)
  - FY96: Mine Countermeasures
- Reports providing periodic assessments on importance of coastal processes in key foreign littoral regions
- Quarterly and Annual Status Reports, Technical Papers

## Approach

- Use mission to focus attention on coastal environmental critical factors
- Represent dominant oceanic and atmospheric processes which determine the critical environmental parameters
- Use expert system tools to unite process physics with real-time measurements and historical databases
- Focus on tactical decision maker who will use coastal scene description to enhance mission planning and execution

# *Coastal Scene Description*

## Ocean Expert System



### FY94 Funding

\$336 K

### FY95 Funding

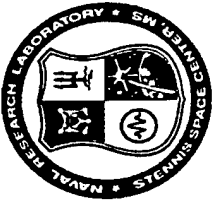
\$280 K

### Accomplishments

- Completed critical factors analysis for amphibious assault
- Compared and assessed coastal process reasoning approaches
- Provided a comparative assesment of important oceanographic and meteorological processes in foreign littoral regions
  - Coordinated white paper selecting Mid Atlantic Bight/Littoral Warfare Training Complex (MAB/LWTC) as focus area for coastal scene description coordination
- Provided in-situ data analysis from navy platform on patrol to examine detection and display of frontal crossings
- Acquired and installed environmental data bases

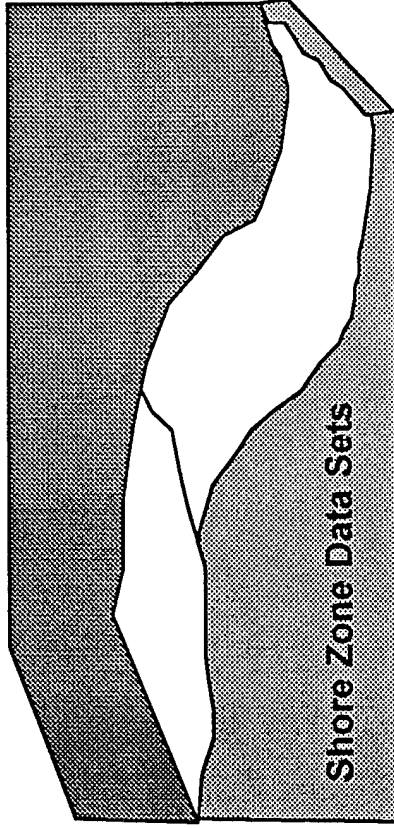
### Plans

- Focus on amphibious assault and description of coastal upwelling and fog to provide "proof of concept" demonstration
- Develop OES tools and data bases necessary for optimal scene rendering
- Assess importance of analogous processes in foreign littoral regions
- Provide in situ data assesment for TOMS coastal data in Gulf of Mexico as sample of handling real-time measurements from Navy platform



# Coastal Scene Description Shore-zone data REsolution System

SeamlessTopo/Ocean/Atmos.  
Data Integration



## *Objective*

Provide dMCG data integration support to CSD

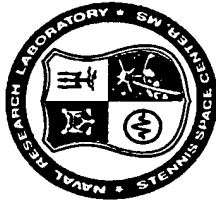
- 1) Interactive spatial data fusion/integration
- 2) Error/Conflict Analysis Tools
- 3) Software Tools for supervised/un-supervised data deconfliction
- 4) Enhanced data exchange utilities using HDF
- 5) Provide multi-thematic deconflicted data to MAB Testbed

## *Deliverables*

- Enhanced SHORES User Interface
- MAB Testbed Data Sets
- Error/Conflict Analysis Utilities
- Deconfliction Tools
- User Documentation

## *Approach*

- Utilize Public Domain and COTS GIS
- Provide on-line data analysis using GeoBASE and MUSE
- Distribute data as HDF Vsets
- Continue examination of industry standards and current research



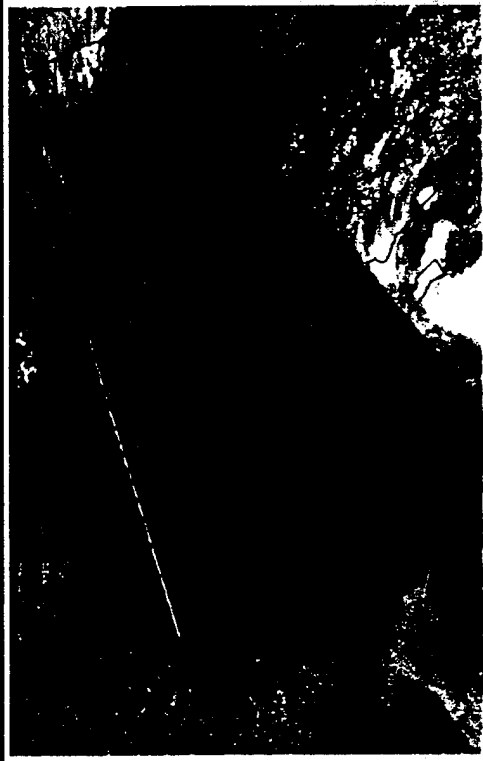
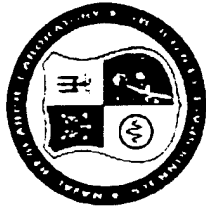
# Coastal Scene Description Shore-zone data REsolution System

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><i><b>FY94 Funding</b></i><br/><i><b>\$150,000</b></i></p> <p><i><b>Accomplishments</b></i></p> <ul style="list-style-type: none"> <li>• Provided dMC&amp;G liaison to CSD</li> <li>• Attended program meetings</li> <li>• Identified/Collected/Imported dMC&amp;G data into ARC/INFO</li> <li>• Implemented HDF import/export functions for ARC data</li> <li>• Delivered HDF Structured data to CSD participants</li> <li>• Began Developing SHORES error/conflict analysis tools</li> </ul> | <p><i><b>FY95</b></i><br/><i><b>Proposed Funding</b></i><br/><i><b>\$215,000</b></i></p> <p><i><b>Plans</b></i></p> <ul style="list-style-type: none"> <li>• Enhance Data Exchange Process</li> <li>• Modify/enhance error/conflict analysis &amp; deconfliction tools</li> <li>• Implement additional HDF viewing capabilities</li> <li>• Gather/distribute additional dMC&amp;G data for MAB Testbed</li> <li>• Provide data integration support for oceanographic/atmospheric data with dMC&amp;G data</li> </ul> |
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# Coastal Scene Description

## Tactical Environmental Information System



### Objective

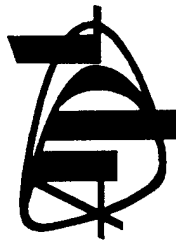
Provide working test bed for new technologies that support data assimilation, data fusion and visualizations for improved description of the coastal environment.

### Approach

- New object-oriented data management schema
- Implementation of foundation classes for use by CSD
- Application and integration of scientific visualizations to database schema
- Support Proof-of-concept demonstrations

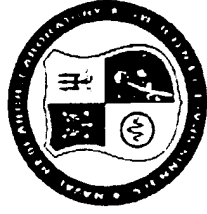
### Deliverables and Transitions

- Deliver documented, supported, software libraries for building CSD applications and visualizations
- Deliver object-oriented data management software for supporting persistence
- Provide TEIS software libraries for use in SPP-ADM program and ultimately SIMAS II fleet usage
- Provide data visualizations for NAVO DMARS program



# Coastal Scene Description

## Tactical Environmental Information System



### FY 94 Funding

Expected 400K  
Received 336K

### FY95 Proposed Funding

Proposed 400K

### Accomplishments

- Designed object-oriented persistent data management software and completed evaluation of commercial databases
- Added over 60 new data classes to TEIS libraries and redesigned them to support multiple distributed views
- Developed new software prototypes to testbed TEIS libraries and new visualizations
- Developed distributed processing prototype

### Plans 95

- Document and deliver TEIS libraries supporting multiple distributed views to CSD partners and others
- Refine and extend object-oriented data management software
- Extend distributed processing prototype and define a CSD network interface
- Implement data analysis tools
- Assess software requirements for LWTC/STOW 97 and CSD collaborations

# **A P P E N D I X   B**

## **Tactical Oceanography Simulation Laboratory Coastal Scene Description Technical Working Group Meeting**

**22 MAR 95**

**AGENDA**

**ATTENDEES**

**MEETING NOTES**

**Tactical Oceanography Simulation Laboratory/  
Coastal Scene Description (TOSL/CSD)  
Technical Working Group Meeting  
Naval Research Laboratory  
Stennis Space Center, MS 39529  
22 March 1995  
Agenda**

- 0830 Welcome
- 0845 CSD Overview
- 0915 Ocean Expert System
- 0930 Tactical Environmental Information System
- 0945 Shorezone Resolution System
- 1000 Data Analysis, Feature Models, Data Fusion  
Harvard University  
Rutgers University
- 1030 Break
- 1040 TOSL Overview
- 1100 TOSL Demonstration
- 1130 Working Lunch
- 1230 TOSL/CSD Integration Requirements  
Network Access  
Hardware/Software Support  
System Configuration (Memory, Storage, Data Transfer,  
Hardcopy Output)  
Moasic, World Wide Web, HDF Format

**Upcoming Events**

**Preliminary AMW Demo Dry Run 18 - 21 APR**

**CSD Review & AMW Demonstration 24 MAY 95**

Tactical Oceanography Simulation Laboratory/  
Coastal Scene Description (TOSL/CSD)  
Technical Working Group Meeting  
Naval Research Laboratory  
Stennis Space Center, MS 39529  
22 March 1995

Attendees

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## **TOSL/CSD Meeting Notes**

### **22 March 1995**

CSD team members and Ms. Susan Starke, TOSL representative, met to discuss using the TOSL platform for the CSD Wrap-Up Demonstration. Dr. George Heburn gave the project overview and each task leader gave a brief description of their needs for the demonstration. Ms. Starke gave a TOSL demo that included an overview of its current capabilities using several data analysis and visualization tools. She discussed models, data, and the benefits of TOSL/CSD efforts to generate useful simulation tools.

CSD team members will have access to TOSL Tools and TOWAN Data to ingest CSD tools and data. After much discussion of declining budgets, the body was advised to seek other sources for FY 96 funding. The FY 95 Wrap-Up Project will transition current tools to NRL/SSC, provide documentation, and demonstrate individual task with some integration with other tasks. The demonstration is tentatively scheduled for an internal project review in June.

**A P P E N D I X   C**  
**MINIWORKSHOP (APL/UW)**  
**14 FEB 95**

**AGENDA**

**ATTENDEES**

**HANDOUTS**

- 1) A Rapid Assessment Cruise in the Straits of Sicily**
- 2) Middle Atlantic Bight Data Sets**
- 3) Middle Atlantic Bight Summer Trends**
- 4) Amphibious Assault Scene Description Status**
- 5) The Regional Atmospheric Modeling System**
- 6) Meeting Goals**
- 7) The SceneObject Framework Design**
- 8) SHORES: SHOr-zone Data RESolution**
- 9) Tactical Oceanography Simulation Laboratory**

**Coastal Scene Description MiniWorkshop  
Applied Physics Laboratory  
University of Washington  
14 February 1995  
Agenda**

**FY95 Project Direction/Budget & Funding**  
George Heburn/Naval Research Laboratory/Stennis Space Center

**Status Reports**

**Data Assimilation, Feature Models, Data Fusion**

**Rapid Assessment Cruise**  
Carlos Lozano/Harvard University

**Middle Atlantic Bight Data Sets**  
Laurel Henderson/Rutgers University

**Middle Atlantic Bight Summer Trends**  
Mike Crowley/Rutgers University

**Ocean Expert System/Amphibious Assault Scene Description Status**  
Steve Mack/Johns Hopkins University/Applied Physics Laboratory

**Regional Atmospheric Modeling System**  
Charles Schemm/Johns Hopkins University/Applied Physics Laboratory

**Tactical Environmental Information System**  
Bob Miyamoto/Applied Physics Laboratory/University of Washington

**Shorezone Resolution System**  
John Breckenridge/Naval Research Laboratory/Stennis Space Center

**Amphibious Warfare Demonstration**  
Portia Harris/Naval Research Laboratory/Stennis Space Center

**15 MAR**                      **Coastal Scene Description/Tactical Oceanography**  
                                 **Simulation Laboratory Technical Work Group**

**17 APR - 21 APR Preliminary Amphibious Warfare Demo Dry Run**

**This week is a MiniWorkweek for all participants to install, test  
evaluate and determine where we are in terms of the 24 MAY Coastal  
Scene Description Review and Amphibious Warfare Demonstration**

**\*\*\*\*\* 24 MAY CSD Review & Amphibious Warfare Demonstration \*\*\*\*\***

14 copies each

Coastal Scene Description MiniWorkshop  
Applied Physics Laboratory  
University of Washington  
14 February 1995

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# COASTAL SCENE DESCRIPTION

A Rapid Assessment Cruise  
in the Straits of Sicily.

MAB: Nested domains.

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APL/UW February 14 1995

REAL TIME NOWCASTING AND FORECASTING

R/V Alliance NOV94 Cruise

11-22 November 1994

A.R. Robinson <sup>1</sup>, H.G. Arango <sup>1</sup>, W.G. Leslie <sup>1</sup>

C.J. Lozano <sup>1</sup>, P.J. Haley <sup>1</sup>, A. Gangopadhyay <sup>1</sup>, N.Q. Sloan <sup>1</sup>

A. Warn-Varnas <sup>2,3</sup>, P.-M. Poulain <sup>2</sup>, A. Miller <sup>2</sup>,

G. Baldasserini-Battistelli <sup>2</sup>, M. Zahorodny <sup>2</sup>, P. Zanasca <sup>2</sup>

HARVARD UNIVERSITY <sup>(1)</sup>

Division of Applied Sciences

Department of Earth and Planetary Sciences

Cambridge, Massachusetts

SACLANT Undersea Research Centre <sup>(2)</sup>

La Spezia, Italia

Present affiliation: NRL Stennis <sup>(3)</sup>

## AIS94 — Scientific Objectives

- Rapid Assessment of multiscale structures

Mesoscale Features over Large-Scale Region [MS-LR]

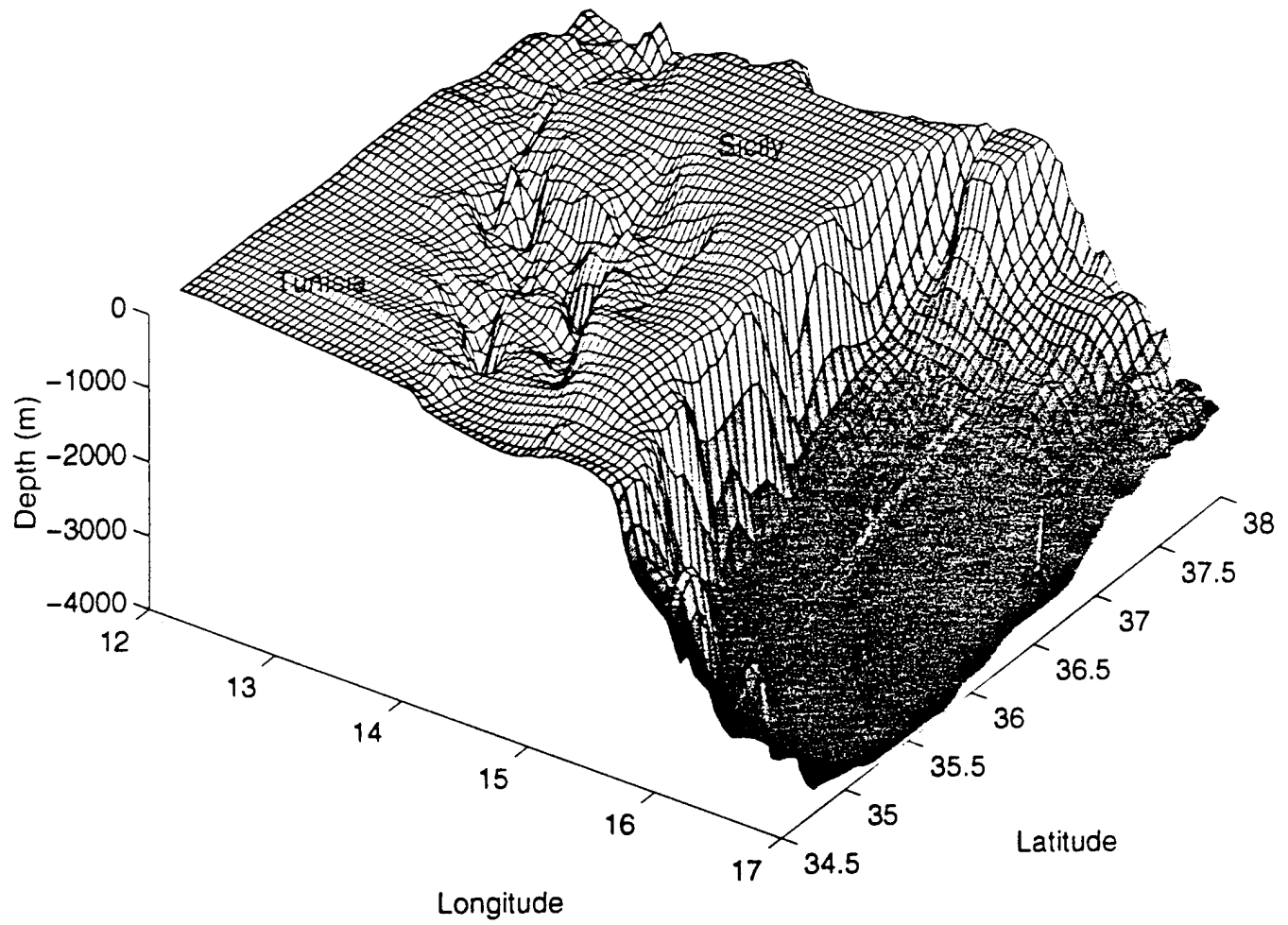
Sub-mesoscale Features over Mesoscale Region [MS-MR]

- To exercise H O P S in a complicated region: deep / shelf-break / shelf ocean with tall and steep topography
- To demonstrate the real-time nowcasting and short-term forecasting operations by:

Assimilation of Direct Data Streams in a regional Multi-scale Nested primitive equation model set up with Climatology, Feature models and wind-forcing.

- To study the dynamics of the Atlantic Ionian Stream, its filamented and frontal features and its transition from a flow over the shelf to a flow over deep water

# Straits of Sicily–Western Ionian



## AIS94 CRUISE Approach

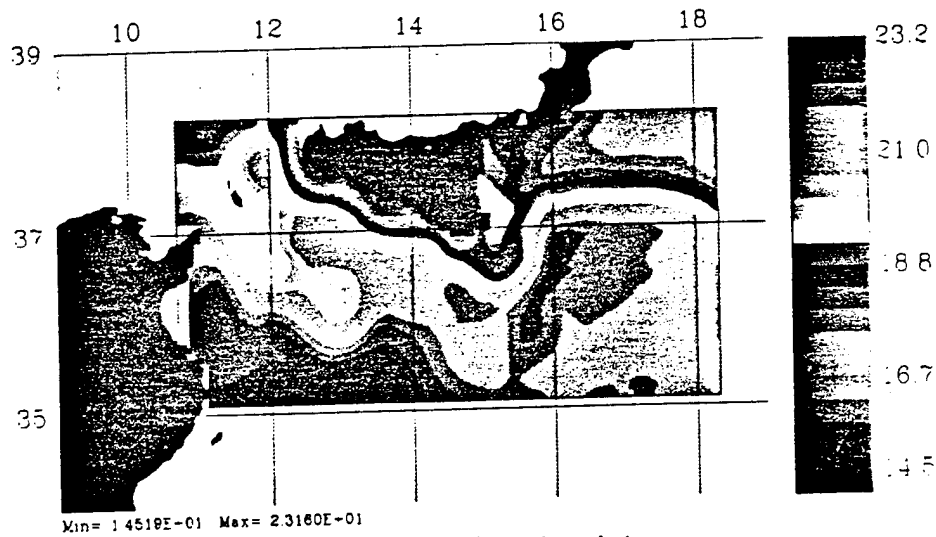
- Survey of Mesoscale in Large Region
- Large Domain Initialized via

Climatology and Feature Models

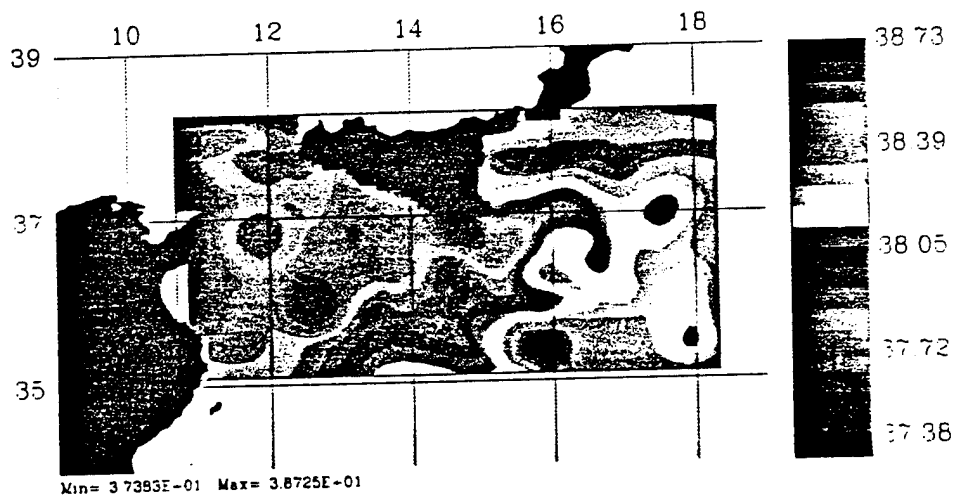
- Assimilation In Nested Domains – Multiscales
- **NOWCASTS and SHORT-TERM FORECASTS**

obtained by assimilation of

Direct Data Streams (*In Situ*, Remotely Sensed), and  
Model Simulations



Temperature (deg C) at Level 1



Salinity (PSS) at Level 1

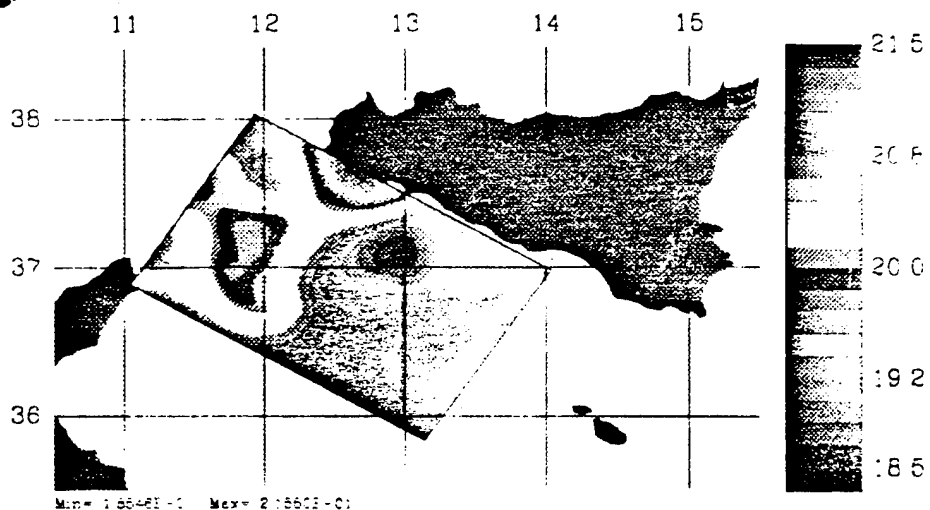


# HARVARD / SACLANT

AIS94 R/V Alliance Nowcast/Forecast Simulation (RGNF2C)

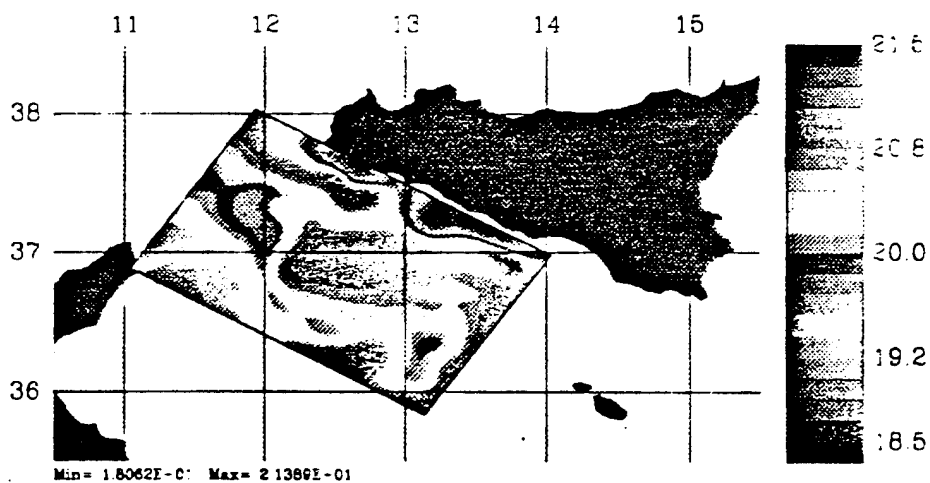
Climatology plus Tracks 1-3; Assimilation Tracks 4-6

Temperature at Level: 1



Min= 1.854E-01 Max= 2.1550E-01

Nowcast: 13 Nov 1994



Min= 1.8062E-01 Max= 2.1389E-01

4.00 Day Forecast: 17 Nov 1994

HGA  
ARL

Nov 16, 1994

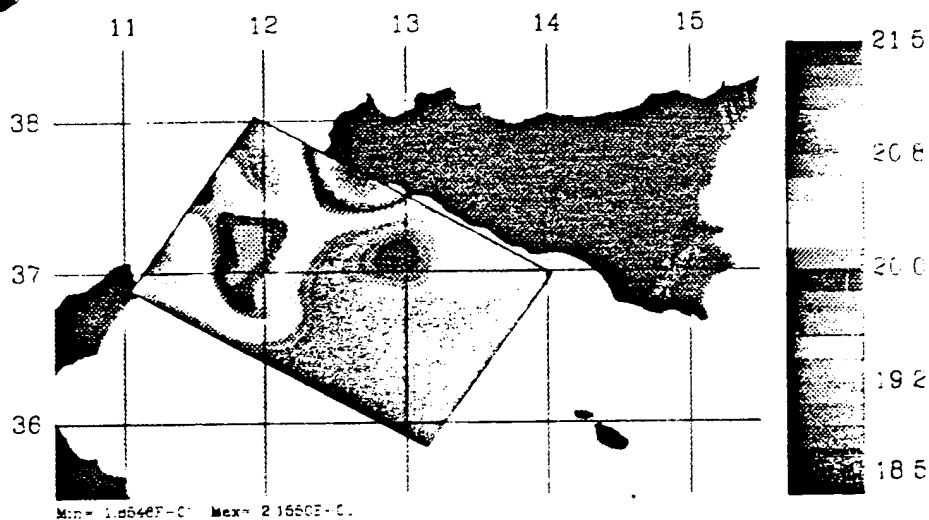


# HARVARD / SACLANT

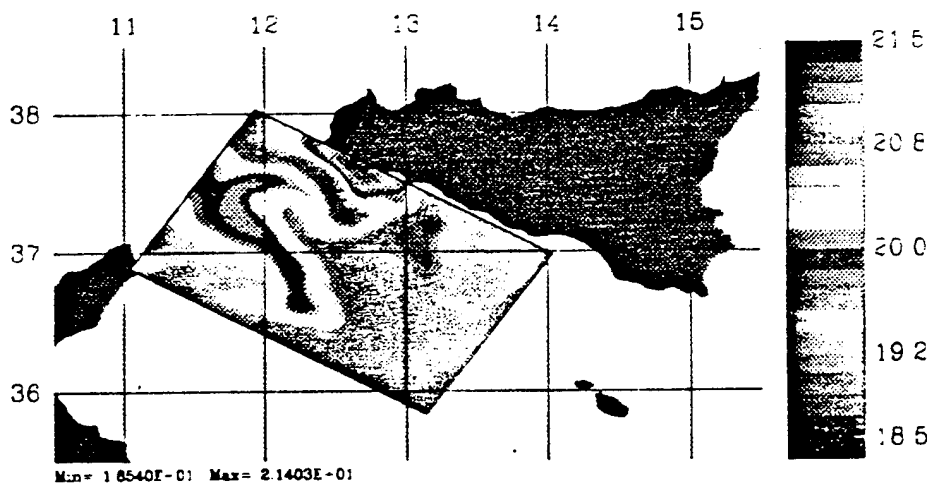
AIS94 R/V Alliance Nowcast/Forecast Simulation (RONFIC)

Climatology plus Tracks 1-3

Temperature at Level 1



Nowcast 13 Nov 1994



4.00 Day Forecast : 17 Nov 1994

HGA  
ARR

Nov 18, 1994

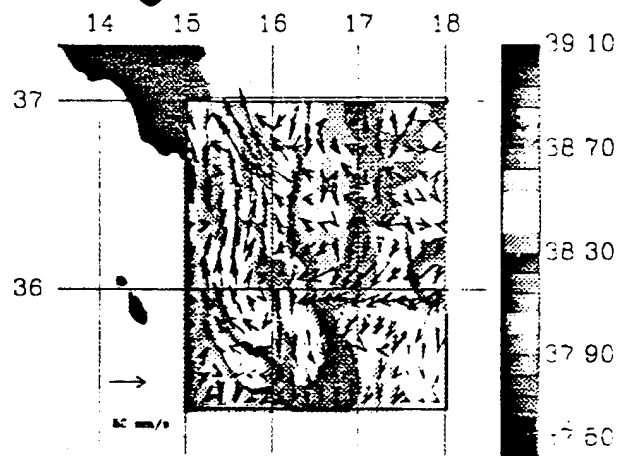


# HARVARD / SACLANT

ALS94 R/V Alliance Nowcast/Forecast Simulation (RONF5C)

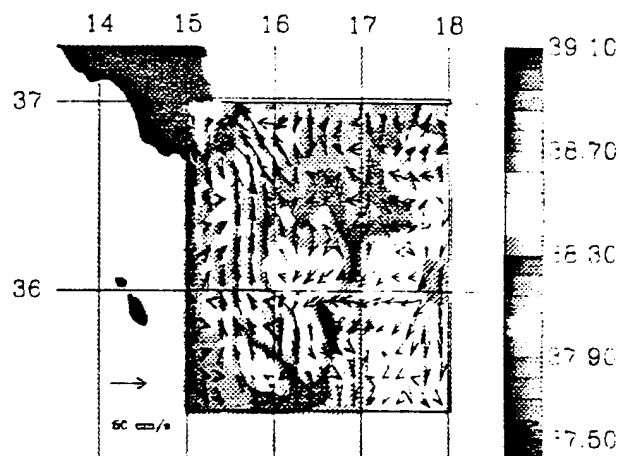
Climatology plus Tracks 11-18; Assimilation Tracks 19-22

250 Day Forecast - 19 Nov 1994



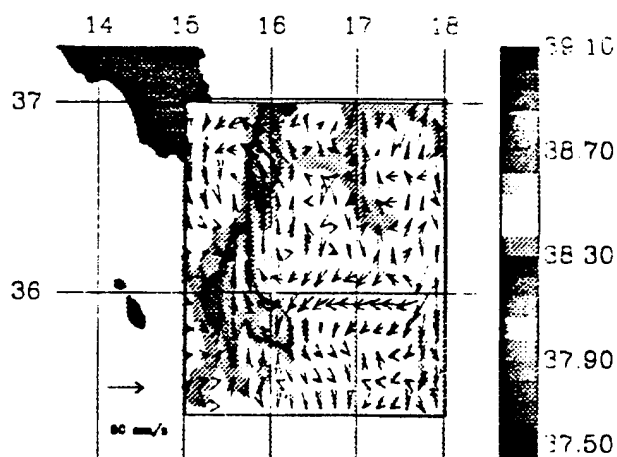
Min= 1.8163E-00 Max= 6.0612E-01

Salinity (PSS) at 15 m



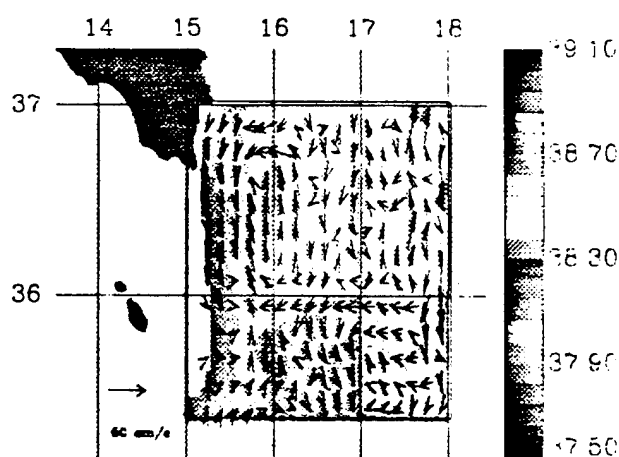
Min= 1.1970E-00 Max= 3.9900E-01

Salinity (PSS) at 75 m



Min= 1.1248E-00 Max= 3.7494E-01

Salinity (PSS) at 125 m



Min= 1.1410E-00 Max= 3.8034E-01

Salinity (PSS) at 225 m

21 44  
H-8

- Phenomenology:

Atlantic Ionian Stream, Jets, Filaments, Eddies

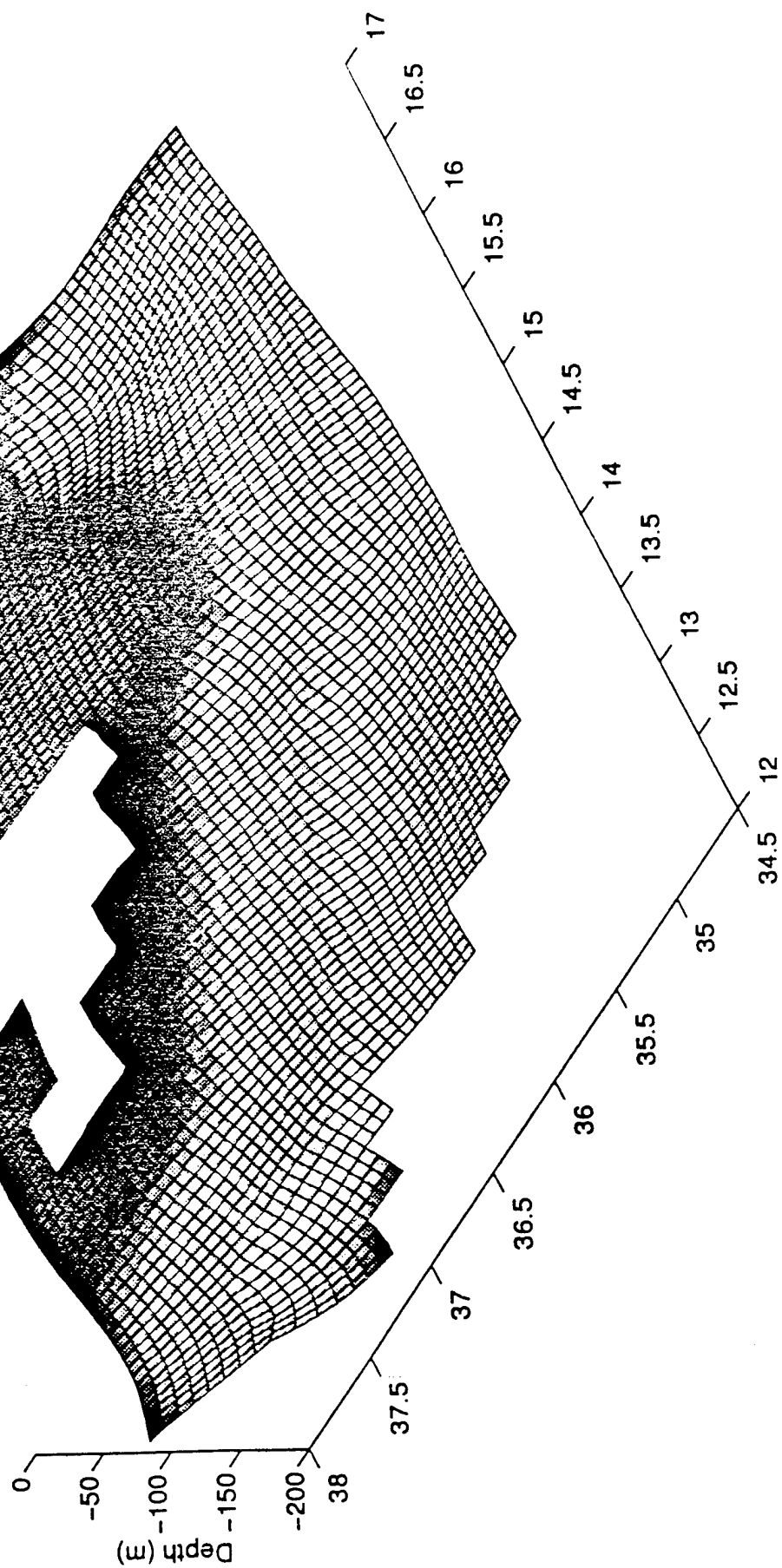
Deep Levantine Intermediate Water Flow

Wind-driven Coastal Sicilian Current and Upwelling

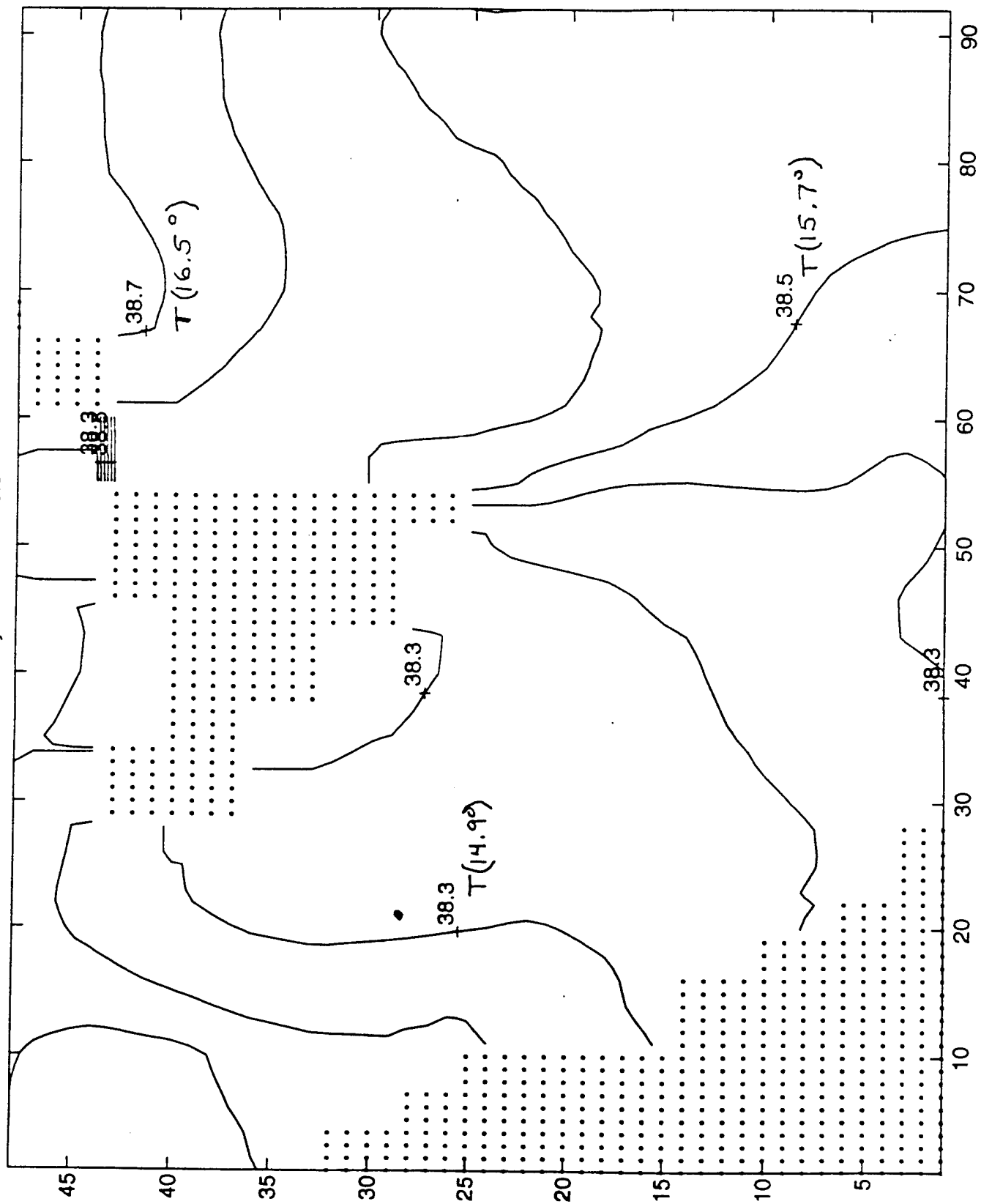
Atmospheric Forcings – Winds, Heat Flux, Buoyancy

Mixing of multiple water masses

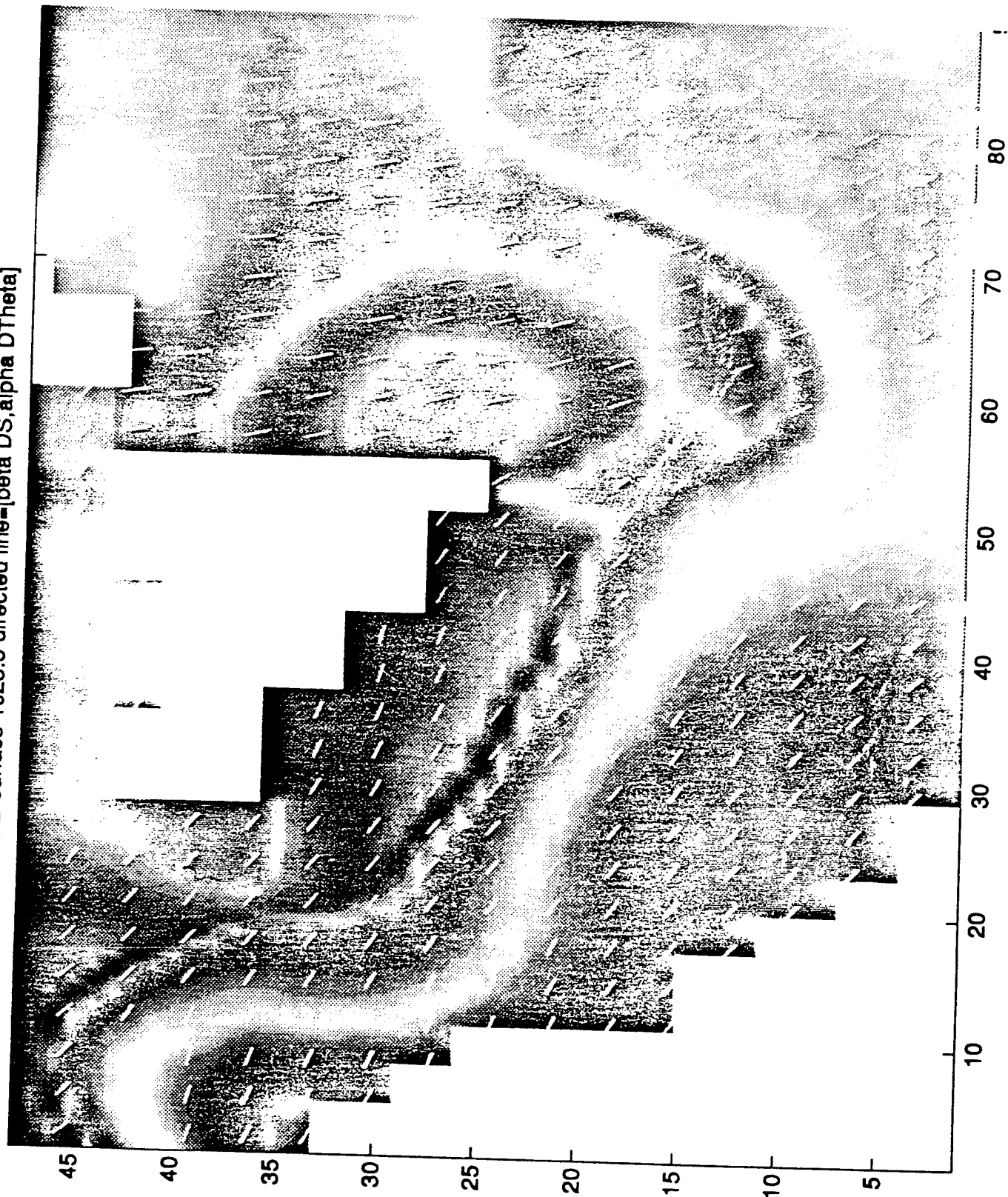
Surface Flux Transformations



Salinity at PD = 1028.5



PD surface 1028.5 directed line--[beta DS,alpha DTheta]



## Future Plans

- Tri-modal Real-time Investigation

Preliminary Expedition [AIS-94]

Explore and Identify phenomena [Cruise planned in Oct-Nov, 1995].

Verify and Validate the regional operational model

- Will provide materials and methodology for coastal scene description, consistent with available data, models and historical knowledge of synoptic structures.

## MAB: Nested Domains

- Large Domain: 7.5km grid size

Mesoscale Features over Large-Scale Region [MS-LR]

- Shelf and Slope Domain: 2km grid size

Sub-mesoscale Features over Mesoscale Region [SMS-MR]

- Shelf Domain: 1/2km grid size

Support High resolution data over Sub-Mesoscale Region  
[HR-SMR]

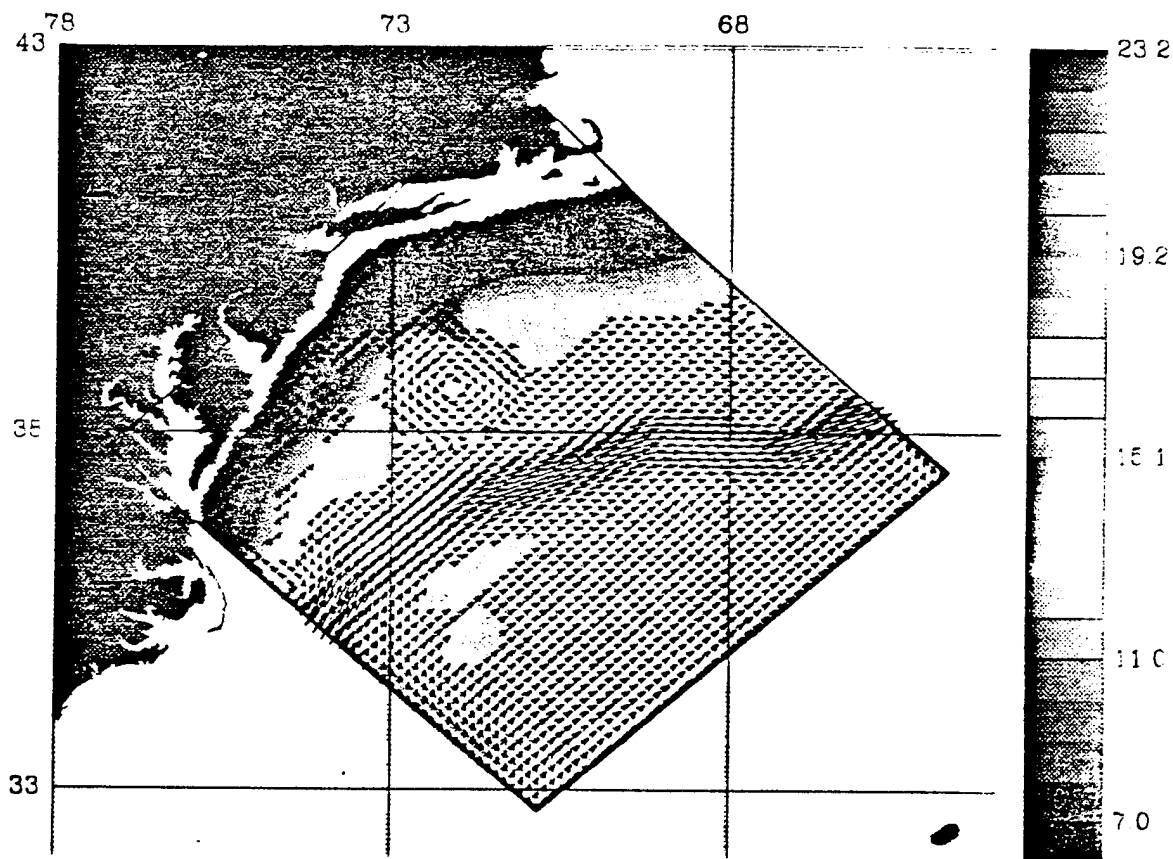


# Harvard Primitive Equation Model

Feature Model Initialization + Surface Forcing

Gulf Stream, Ring and Shelfbreak Front

5.00 Day Forecast : 11 May 1987



Min = 3.5647E+00 Max = 1.1849E+02

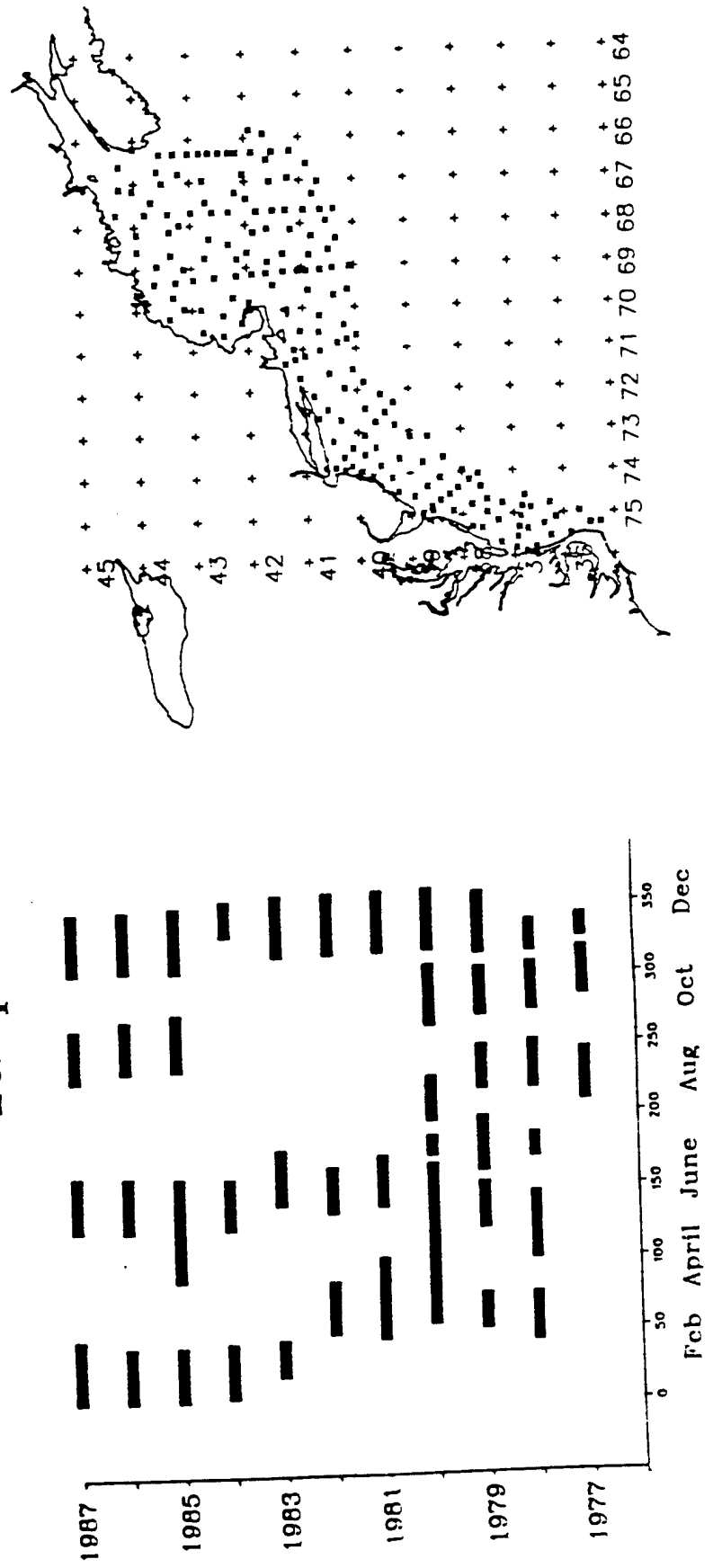
Temperature (deg C) at 1 m

# US National Marine Fisheries Service MARMAP Data

6970 Profiles Collected on 51 Mid-Atlantic Bight Surveys

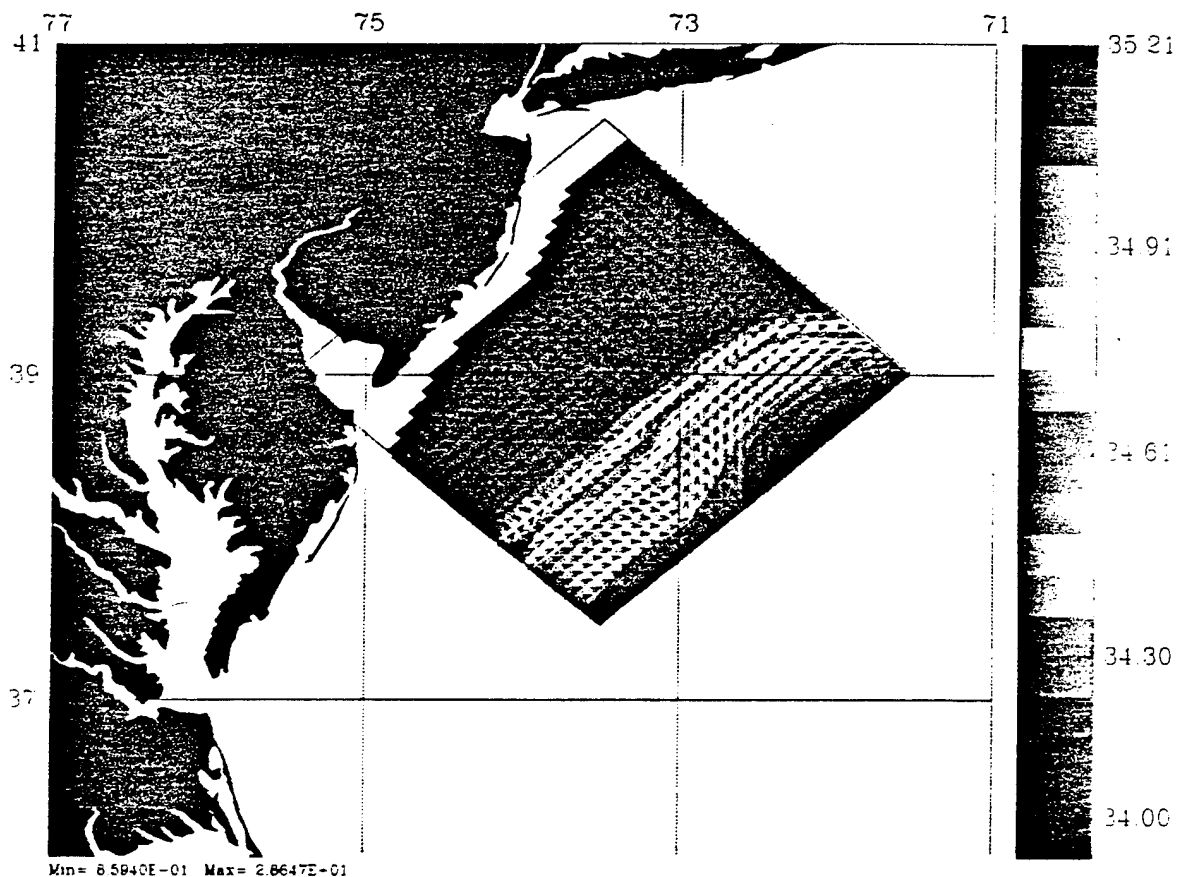
25 Surveys are Hydrographic (P,T,S) Only  
26 Surveys include Chlorophyll, Nitrate, Phosphate and Silicate  
Many Surveys also include Zooplankton

## Temporal and Spatial Coverage





New Jersey Coast to Slope  
Nowcast : 6 May 1987



Salinity (PSS) at 1 m



- One way nesting: large domain provides initial and boundary conditions to smaller domain(s).
- Two way nesting: large domain provides boundary conditions, smaller domain(s) updates through averaging forcings in the large domain.
- Applications of nesting in CSD:

1way: Pass remote information to small domains. e.g. Coastal Trapped Waves.

2way: Provide a consistent propagation of information across domains at reasonable computational cost.

# MAB Data Sets

available at

Institute of Marine & Coastal Sciences,  
Rutgers University

Scott Glenn  
Laurel Henderson  
Mike Crowley

# Coastal Scene Description

## Data Analysis, Feature Model and Data Fusion

Mid Atlantic Bight      South Atlantic Bight



### Objective

Analysis and fusion of oceanographic data and models for 3-D coastal scene description in the Middle and South Atlantic Bights.

### Approach

- \*Collect relevant oceanographic and meteorological data.
- \*Acquire or construct accurate coastline/bathymetry database.
- \*Compile datasets in a Geographic Information System (GIS).
- \*Summarize events and trends of interest to CSD participants.
- \*Distribute required datasets to other CSD participants.

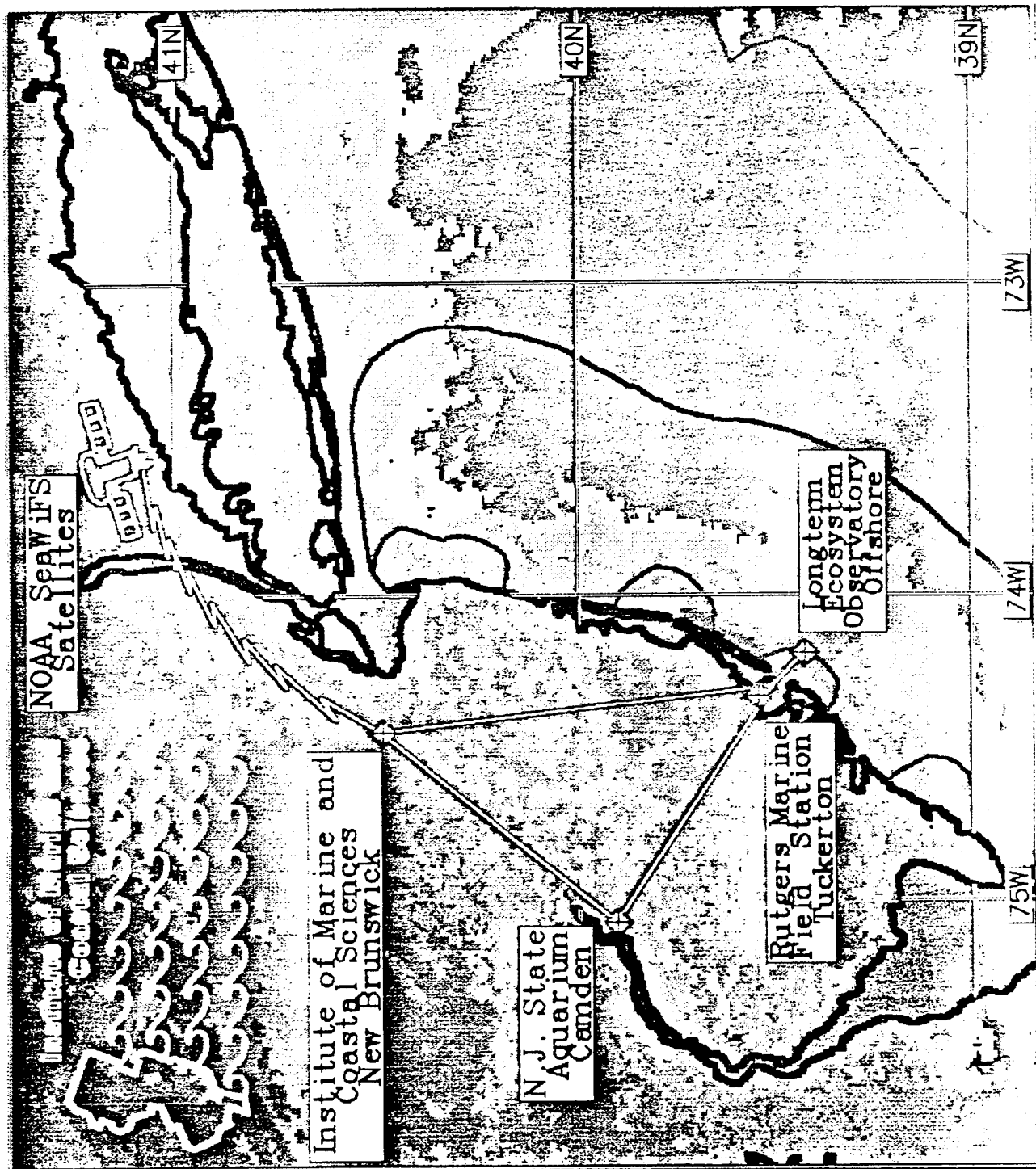
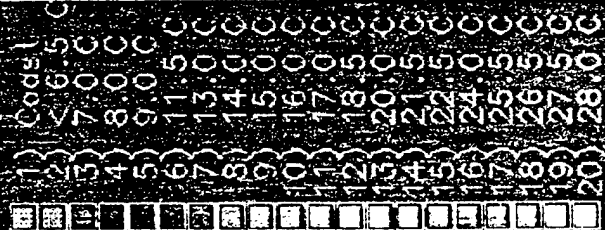
### Deliverables

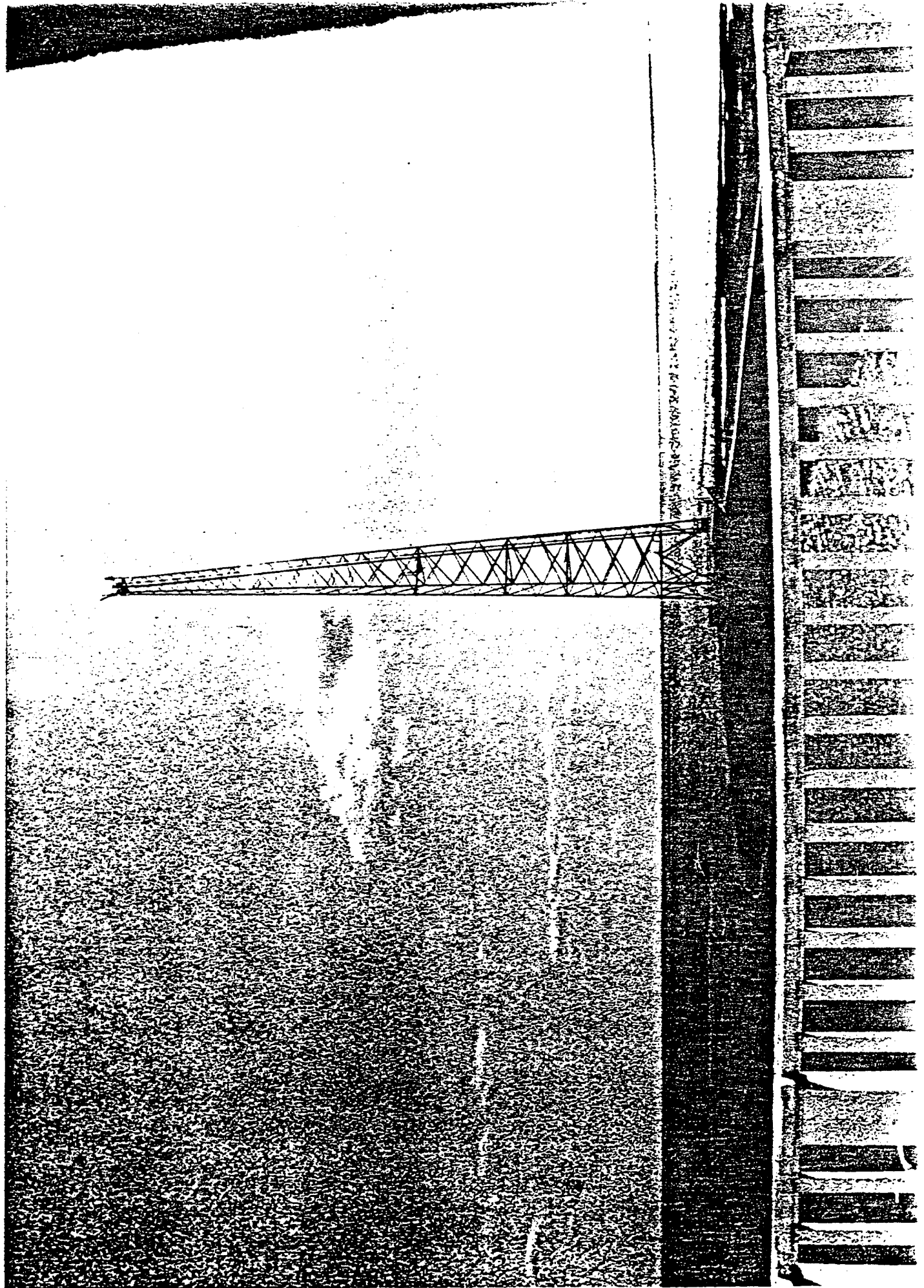
- \*MAB and SAB oceanographic/meteorological datasets.
- \*Accurate coastlines and bathymetry.
- \*Geographic Information System.
- \*Event summaries.

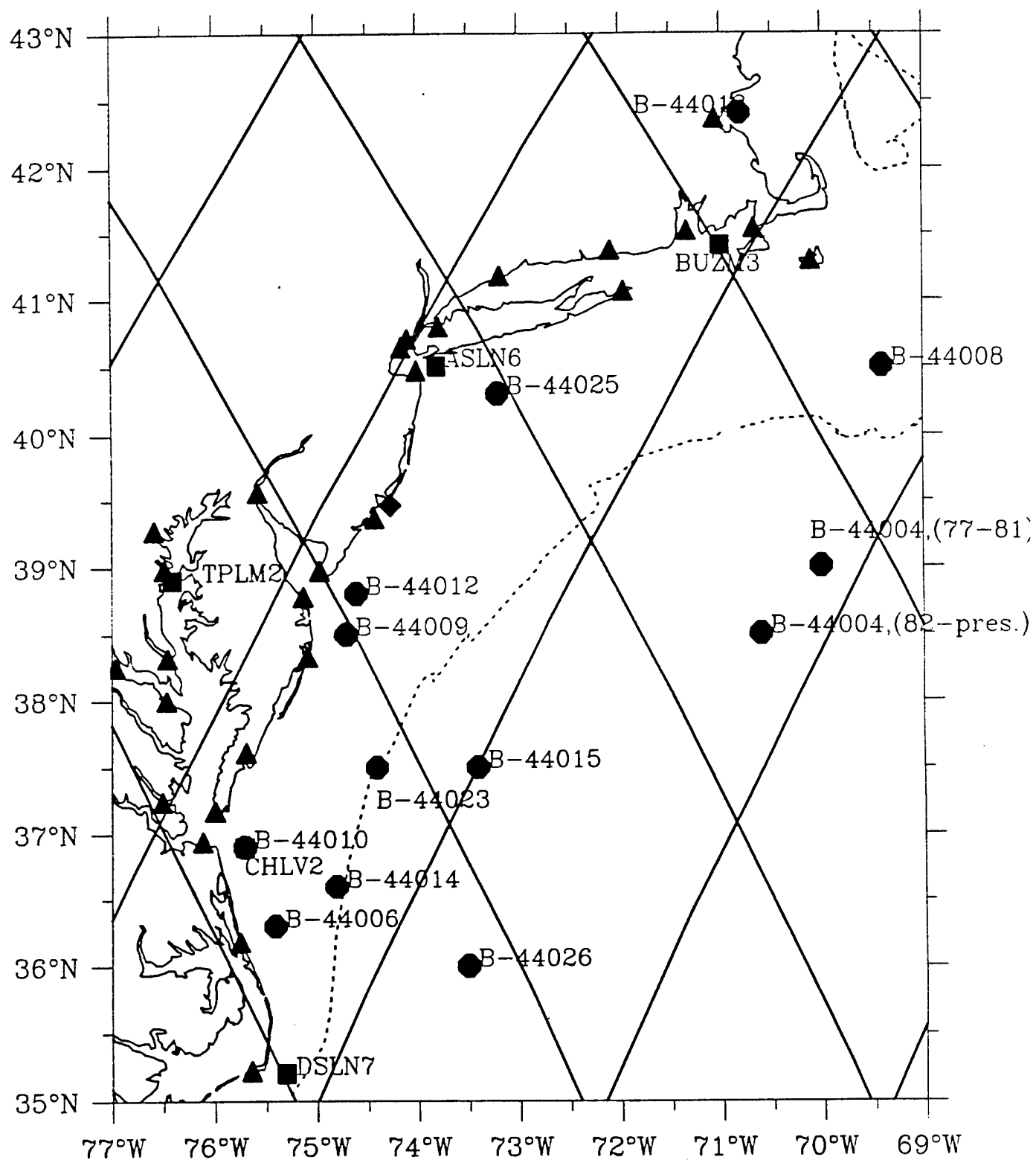
June 26  
1994

10:41  
GMT

Sea  
Surface  
Temp



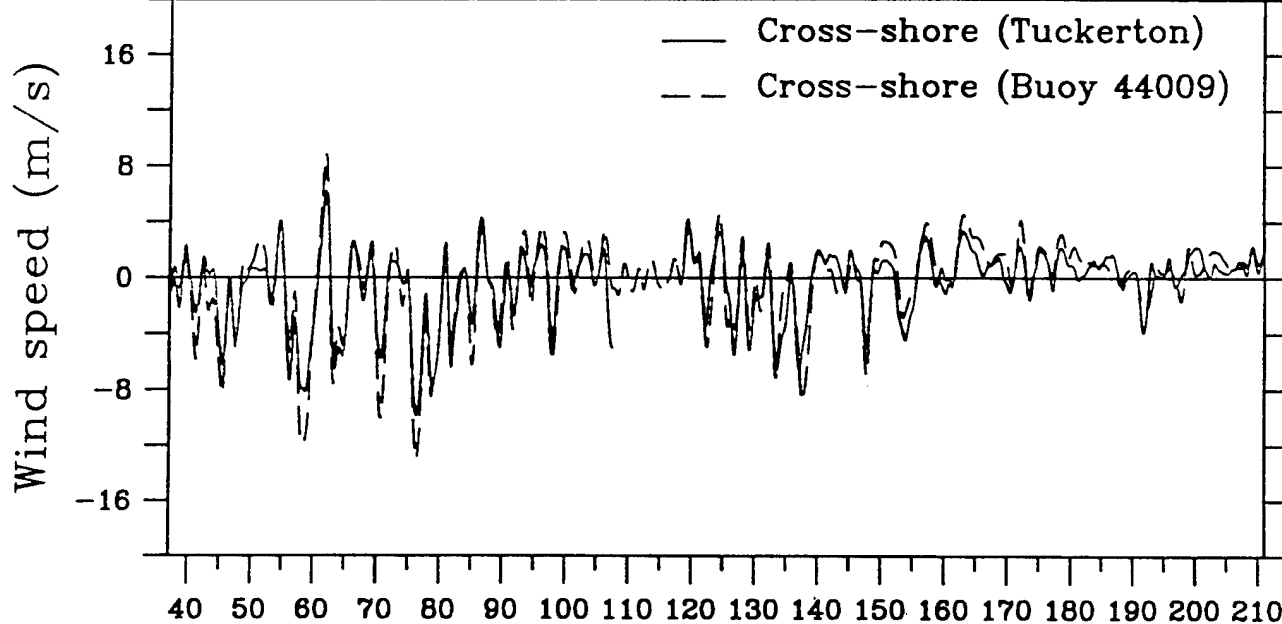
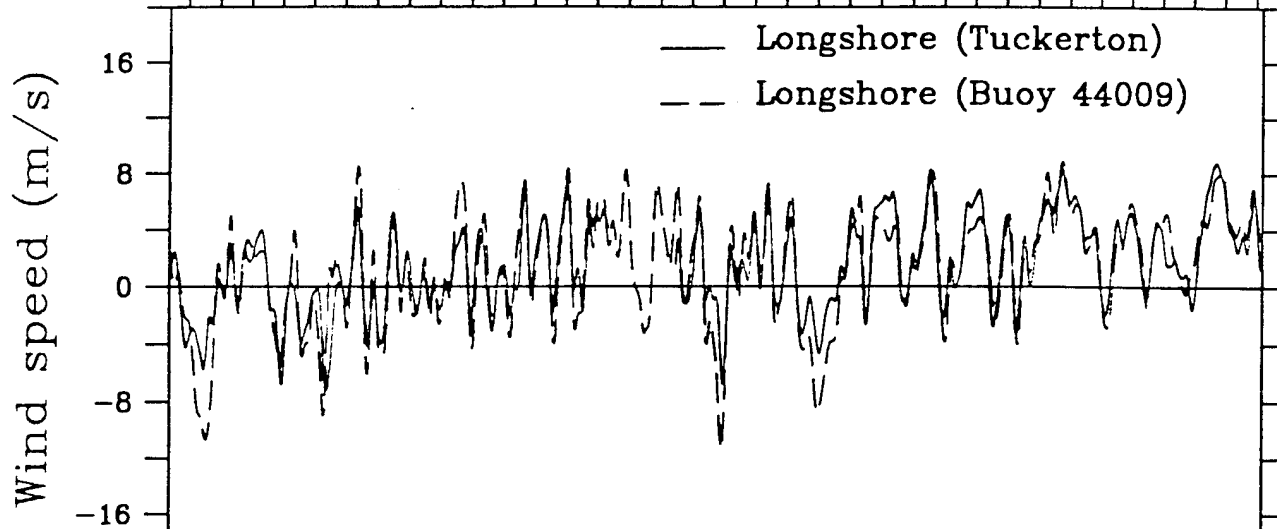




NOAA Buoys, C-MAN & Tide Stations. TOPEX Ground Tracks.

Year Day (1994)

40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210



Year Day (1994)

Buoy 44009 vs Tuckerton Wind Sensor

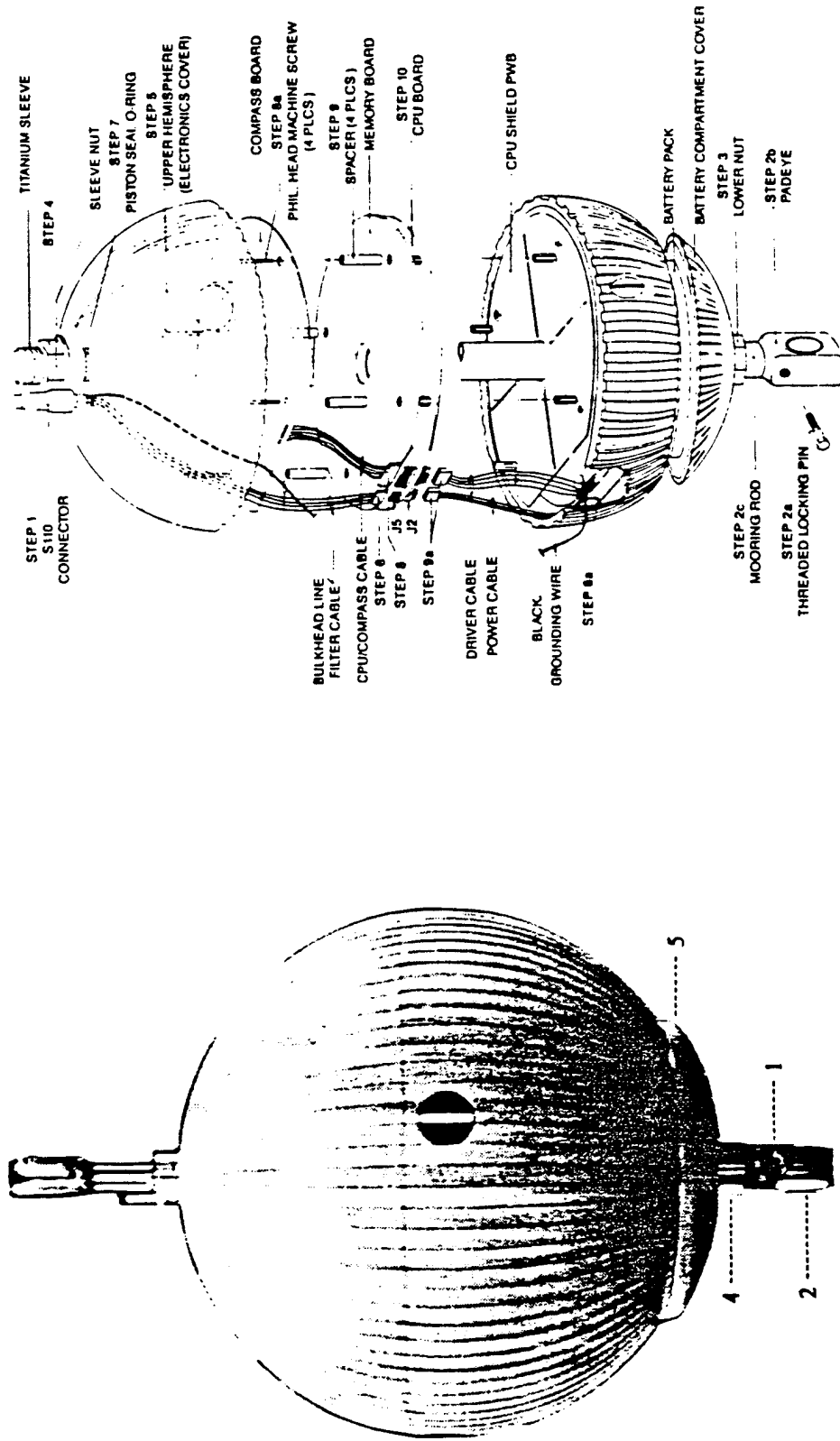
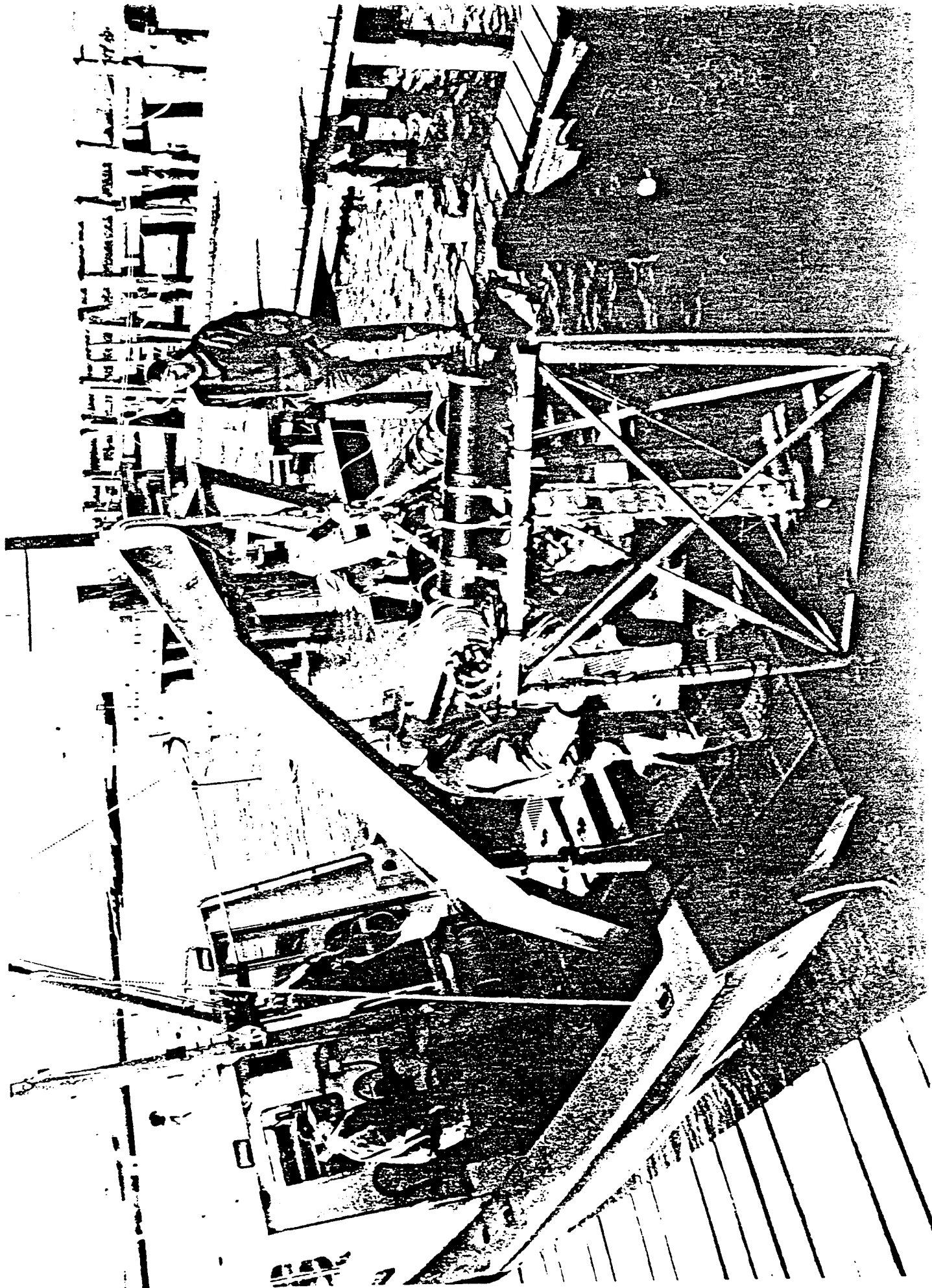
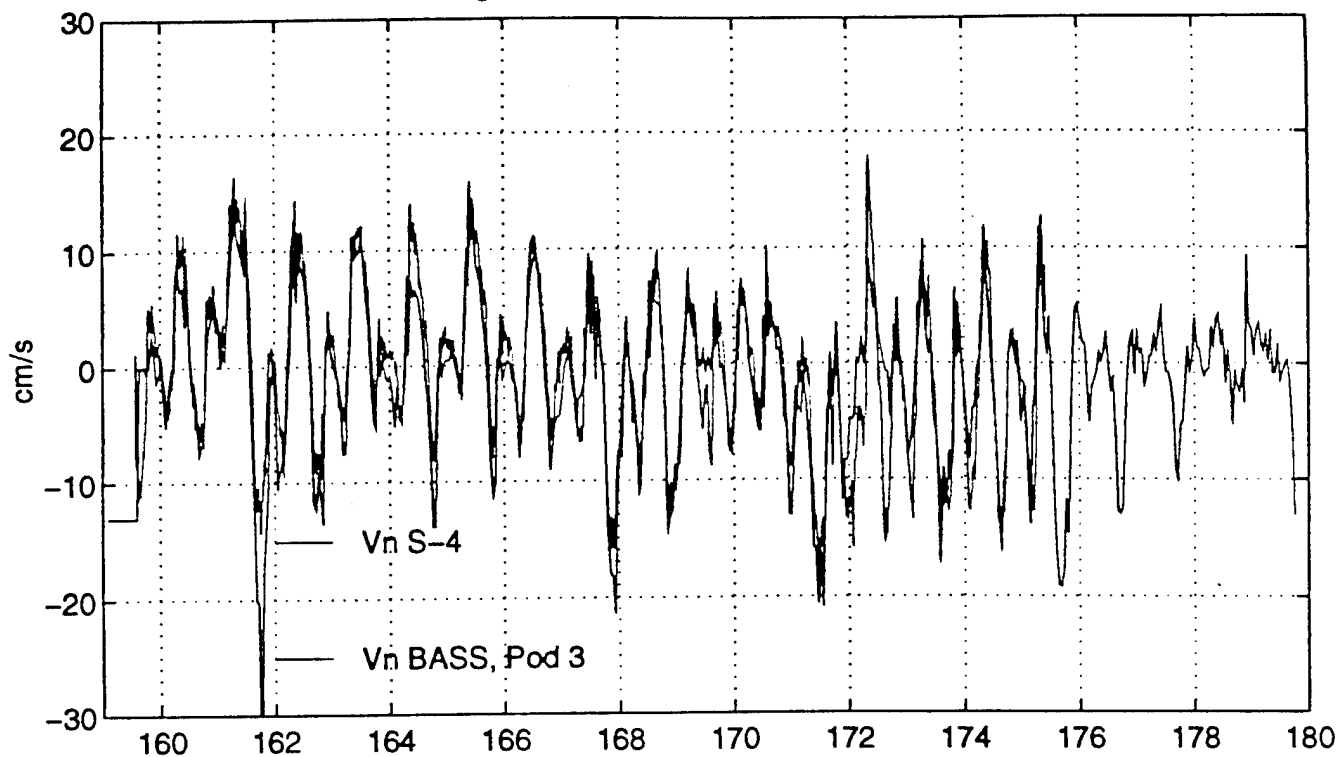
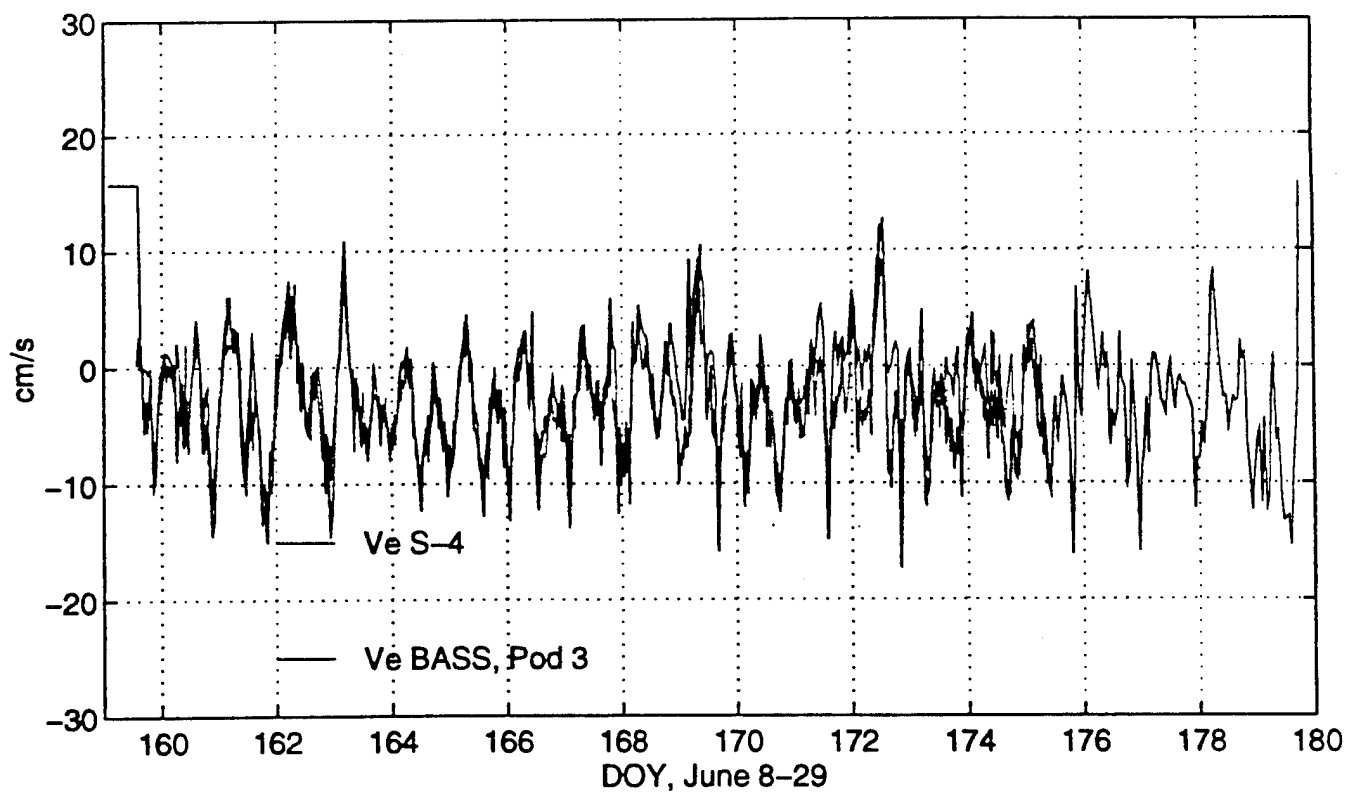


Figure 20: Photo and schematic of InterOcean Systems, Inc. S4 Current Meter.





POD 3



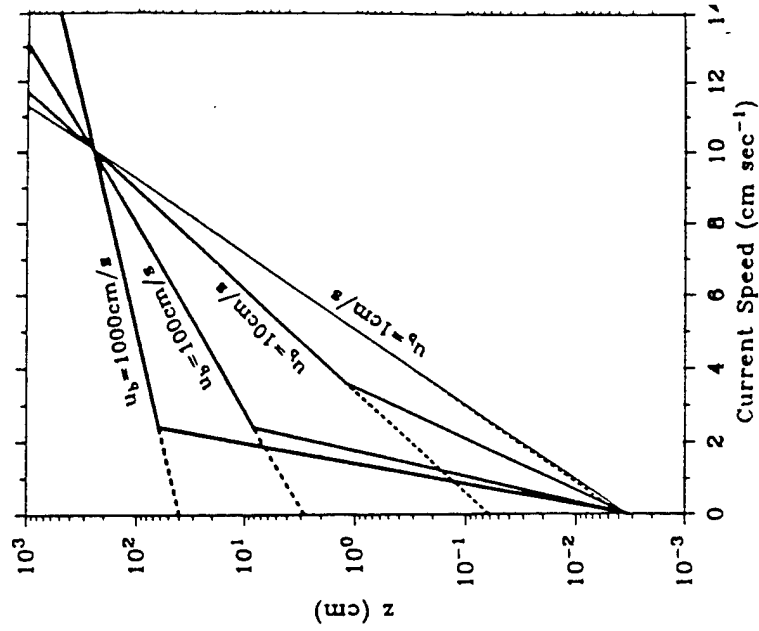
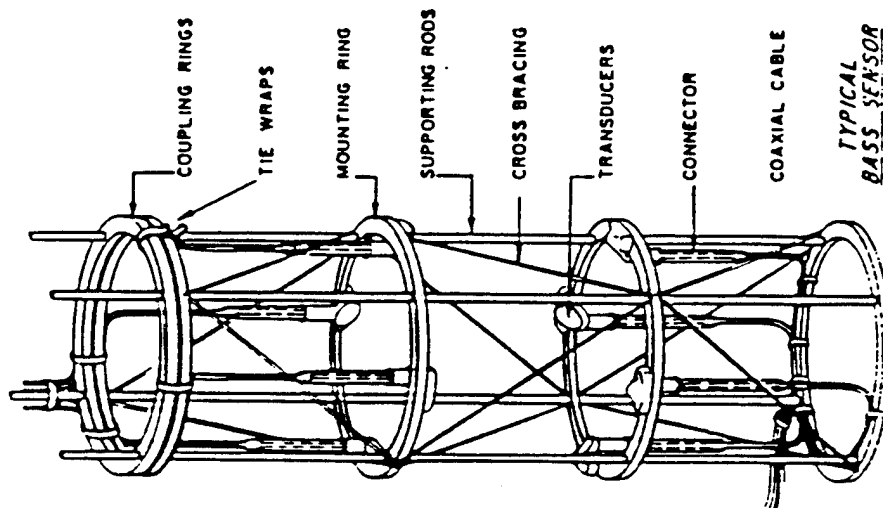
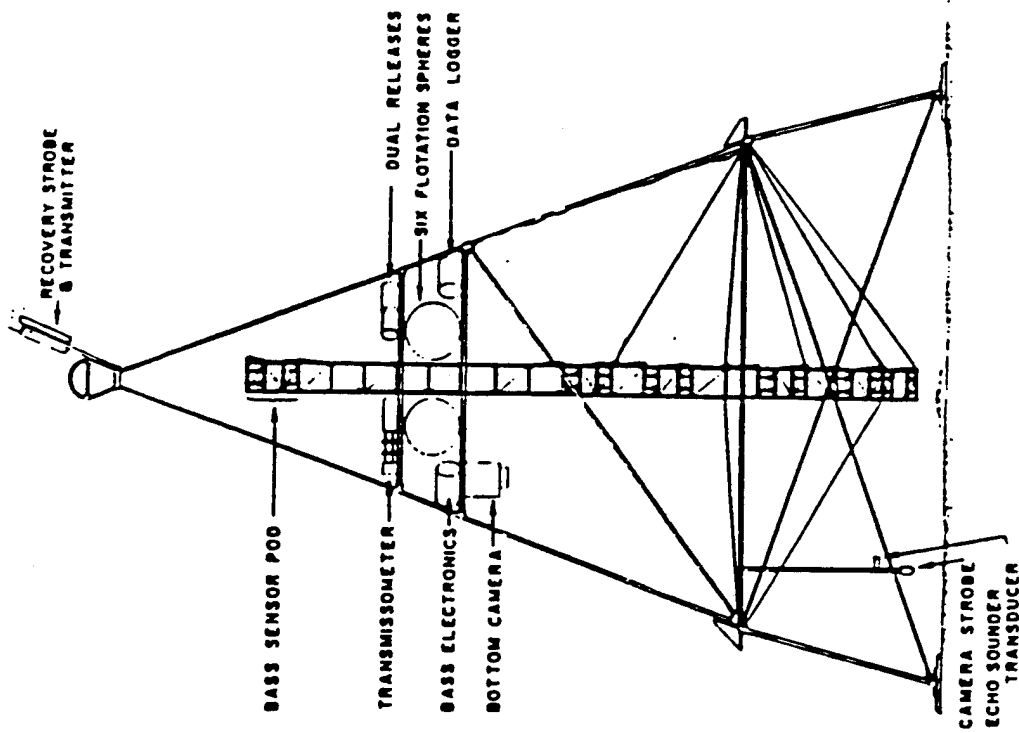
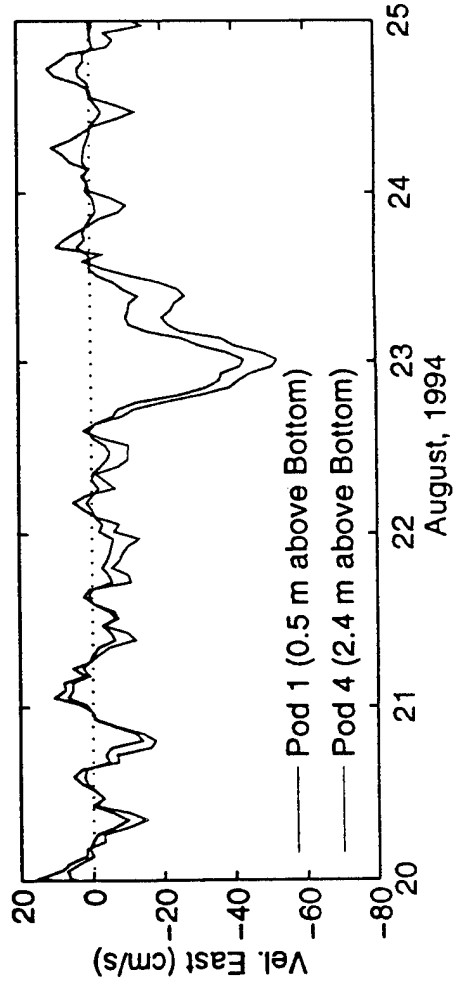
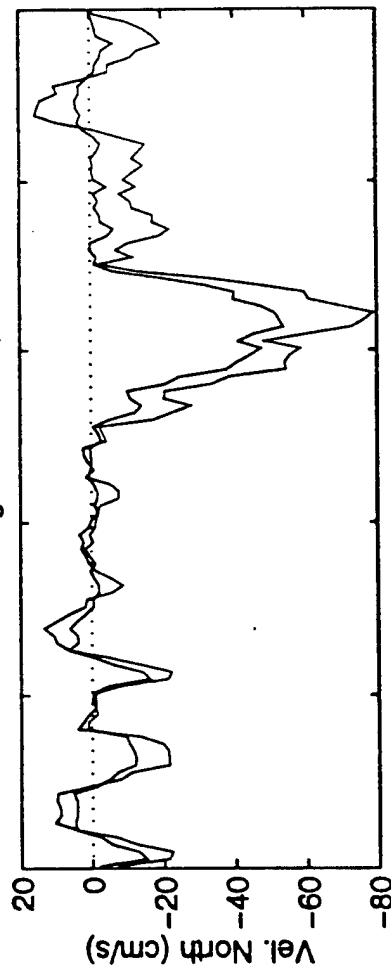
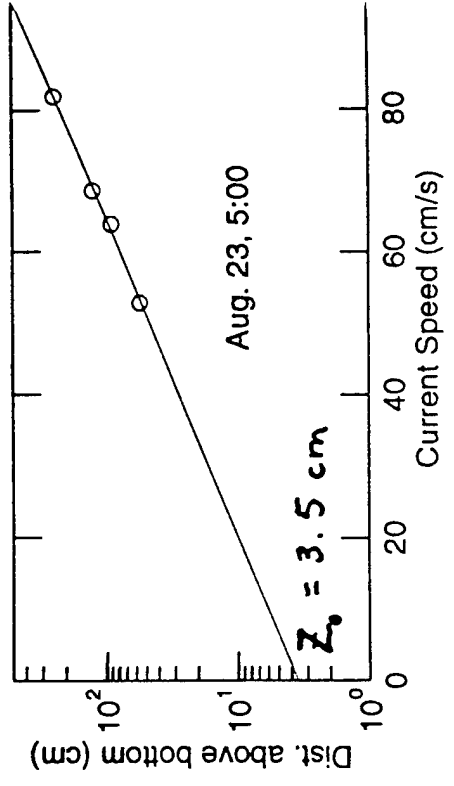
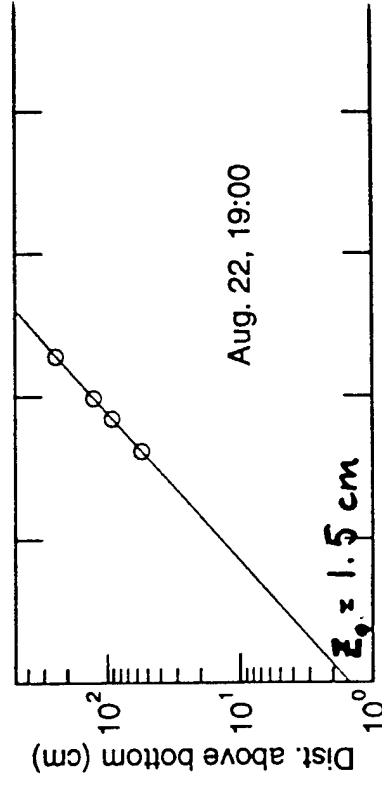


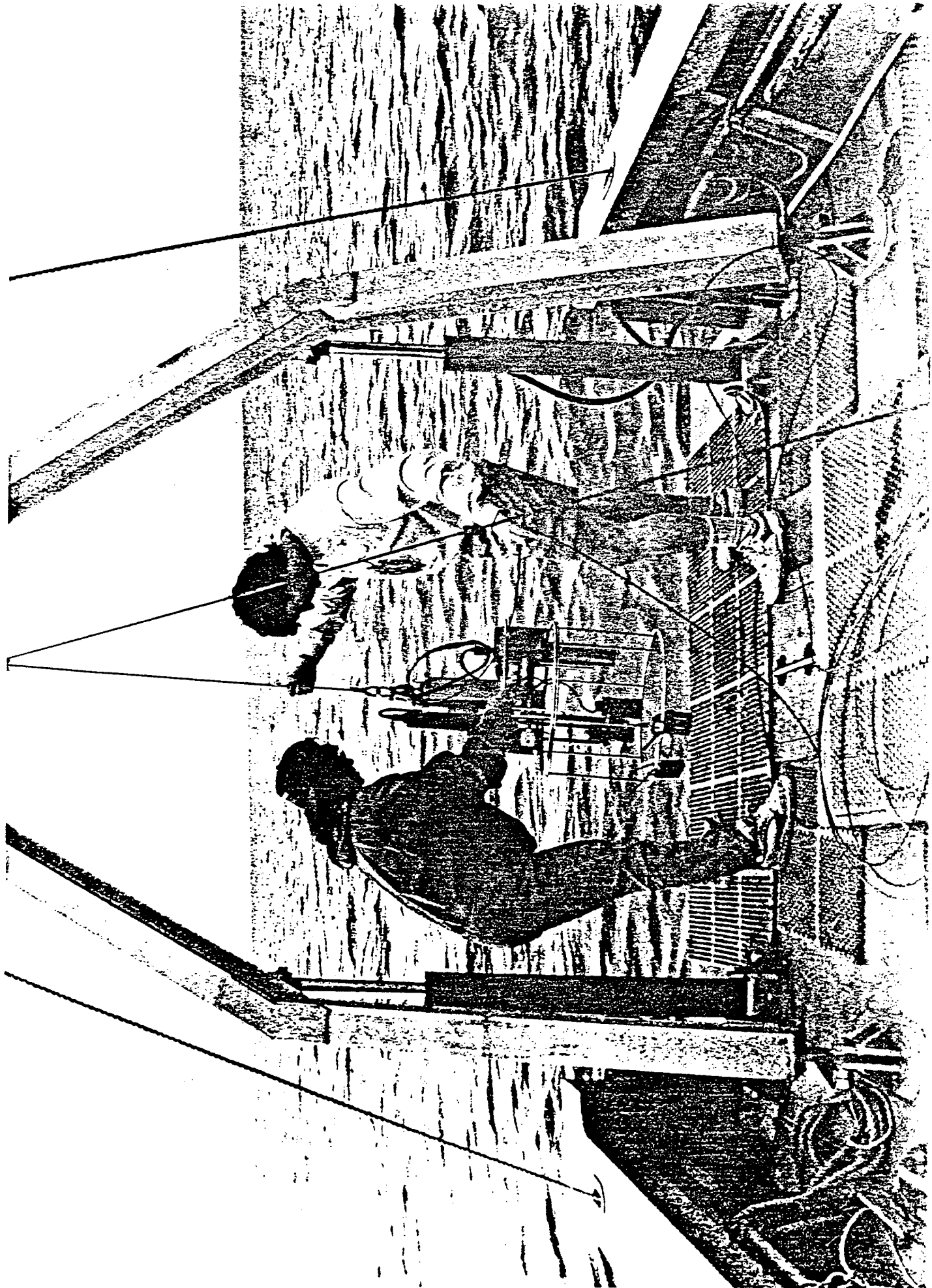
Figure 21: Typical BASS Sensor and BASS Sensor Array

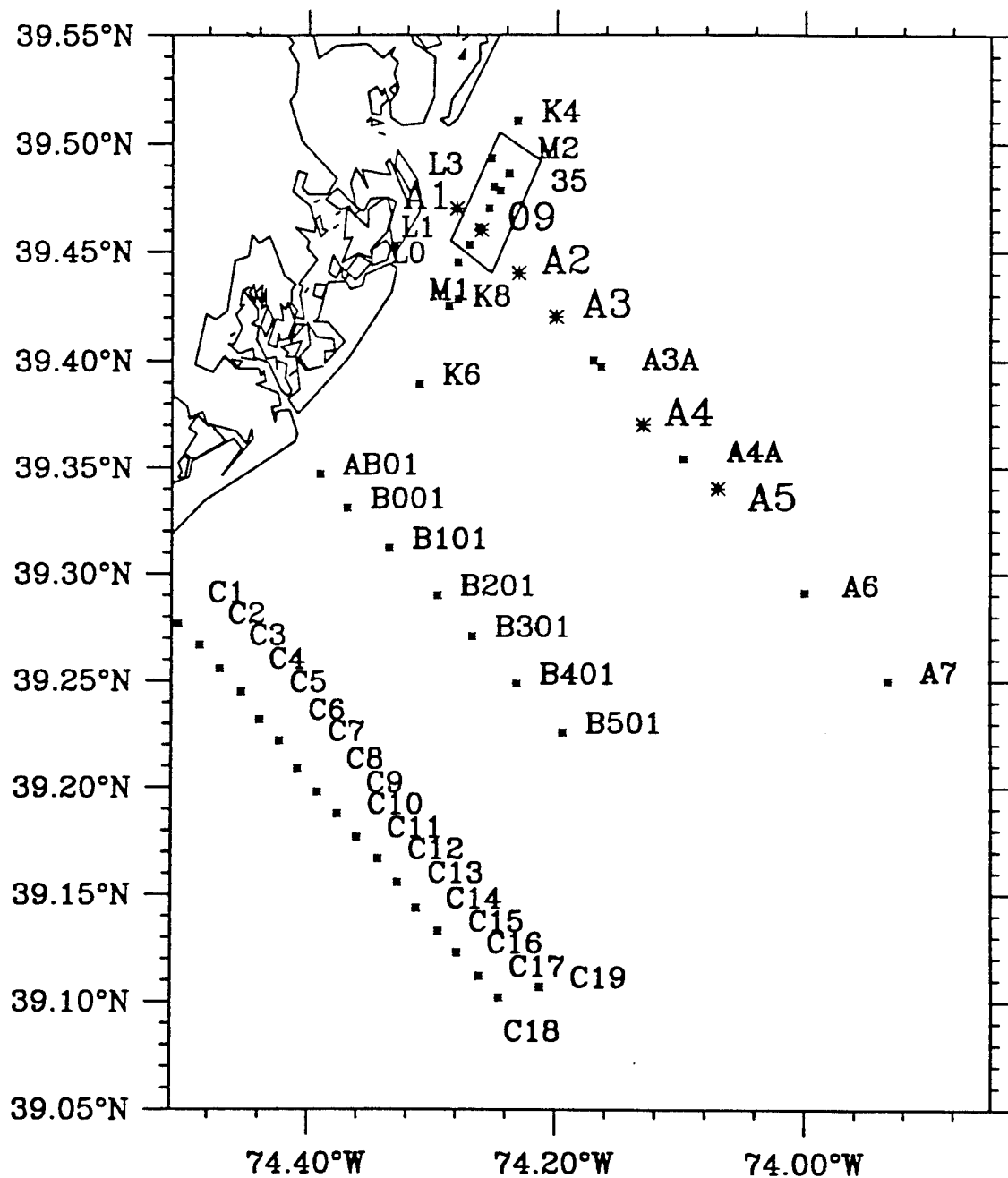
BASS Average Velocities, Pods 1 & 4



BASS Velocity Profiles, Pods 1-4

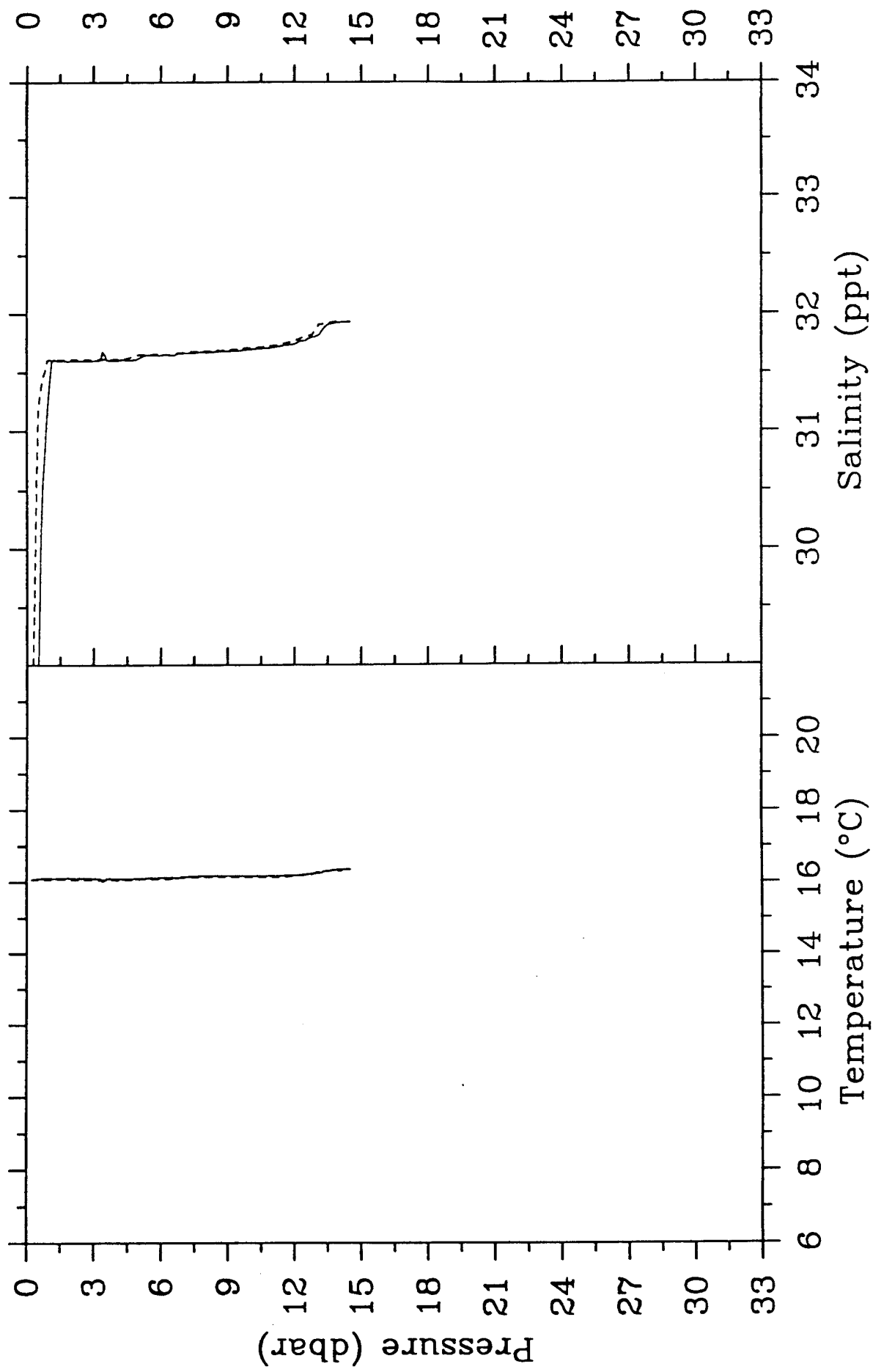






Locations of LEO-15 CTD Surveys: 1994

# LEO-15 CTD Surveys: October 25, 1994



1993 Year (month)

1994 Year (month)

1

3

5

7

9

11

1

3

5

7

9

11

0

2

4

6

8

10

Depth(m)

0

2

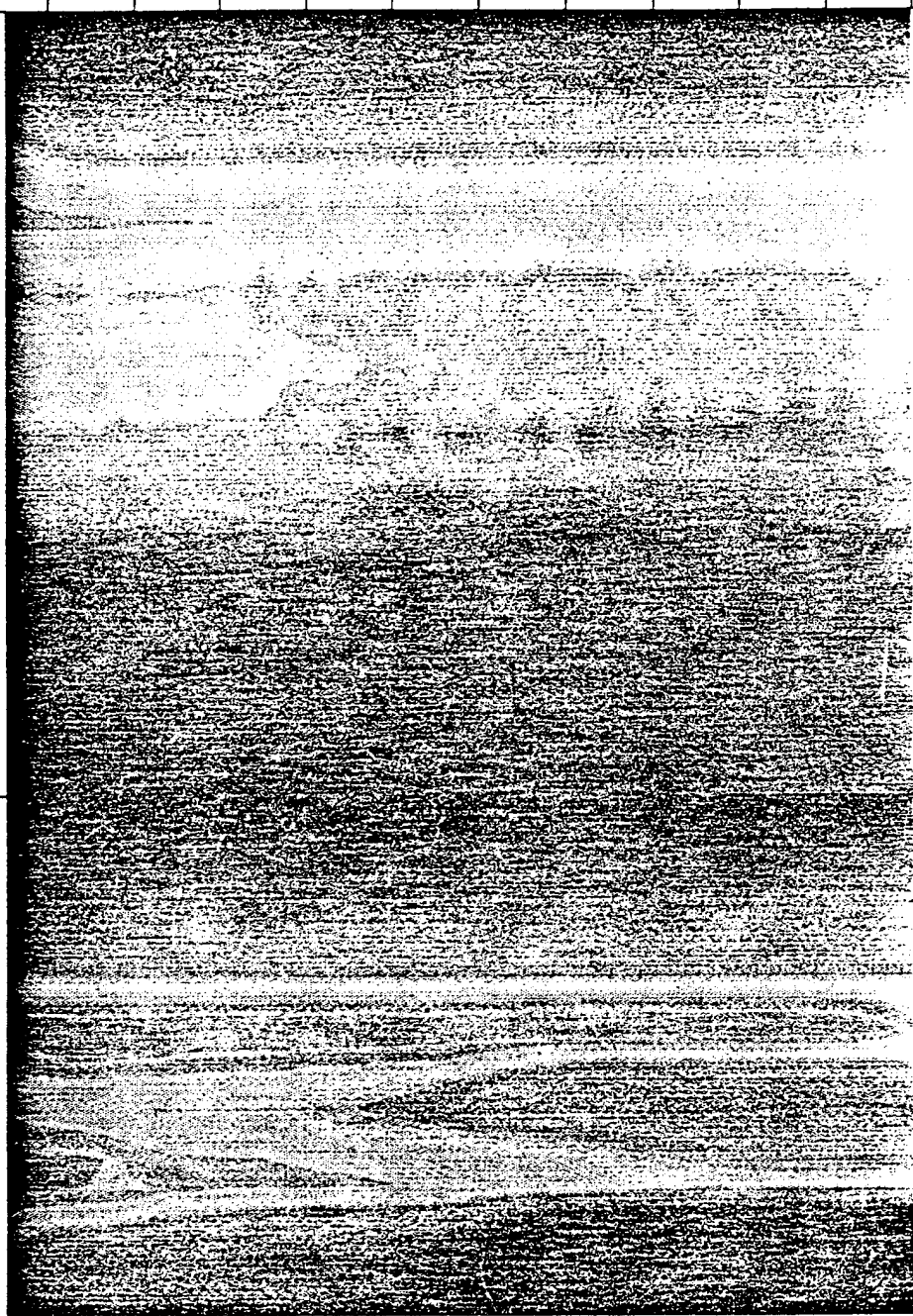
4

6

8

10

Depth(m)



1

3

5

7

9

11

1

3

5

7

9

11

Depth(m)

0

2

4

6

8

10

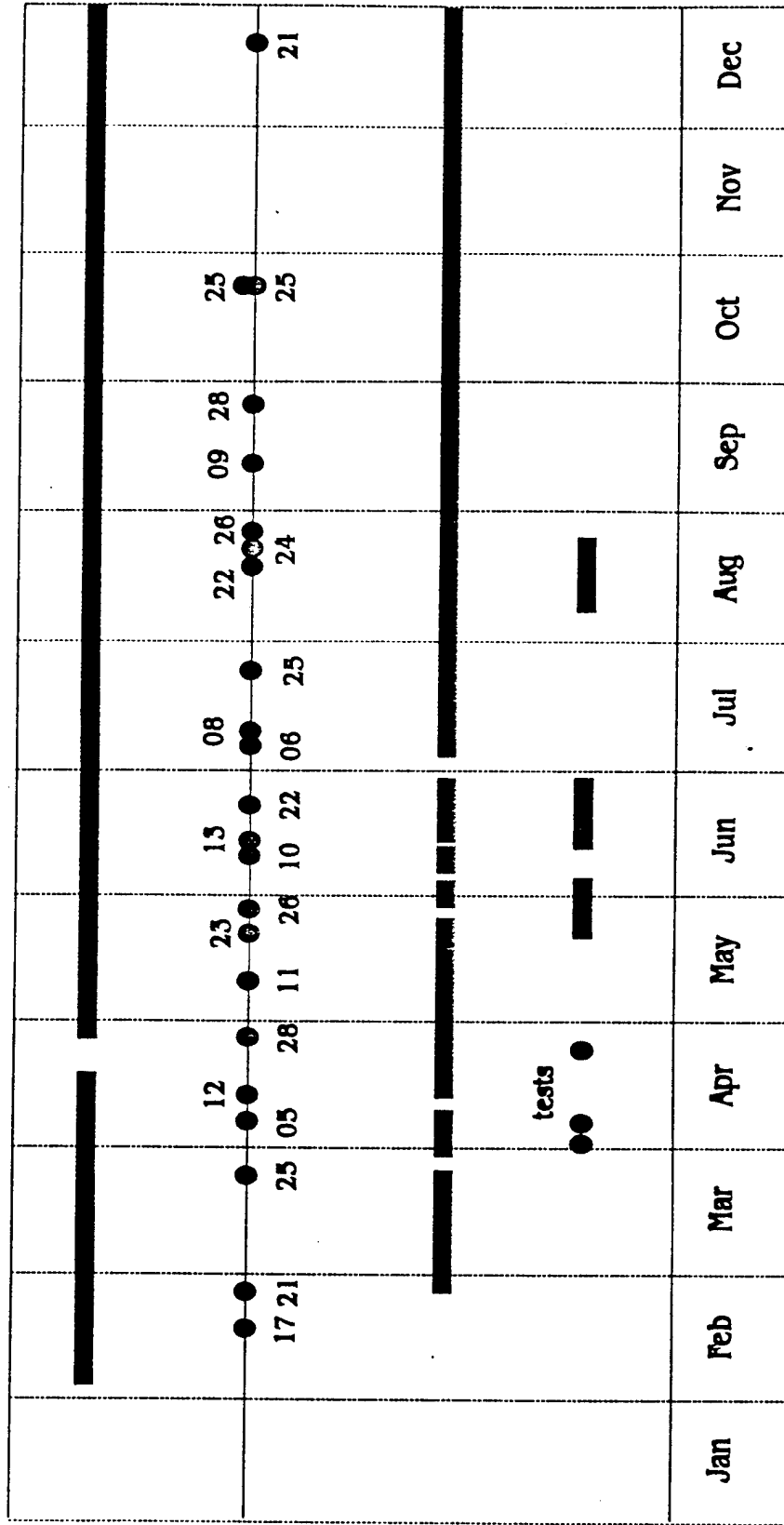
Depth(m)

1993 Year (month)

1994 Year (month)

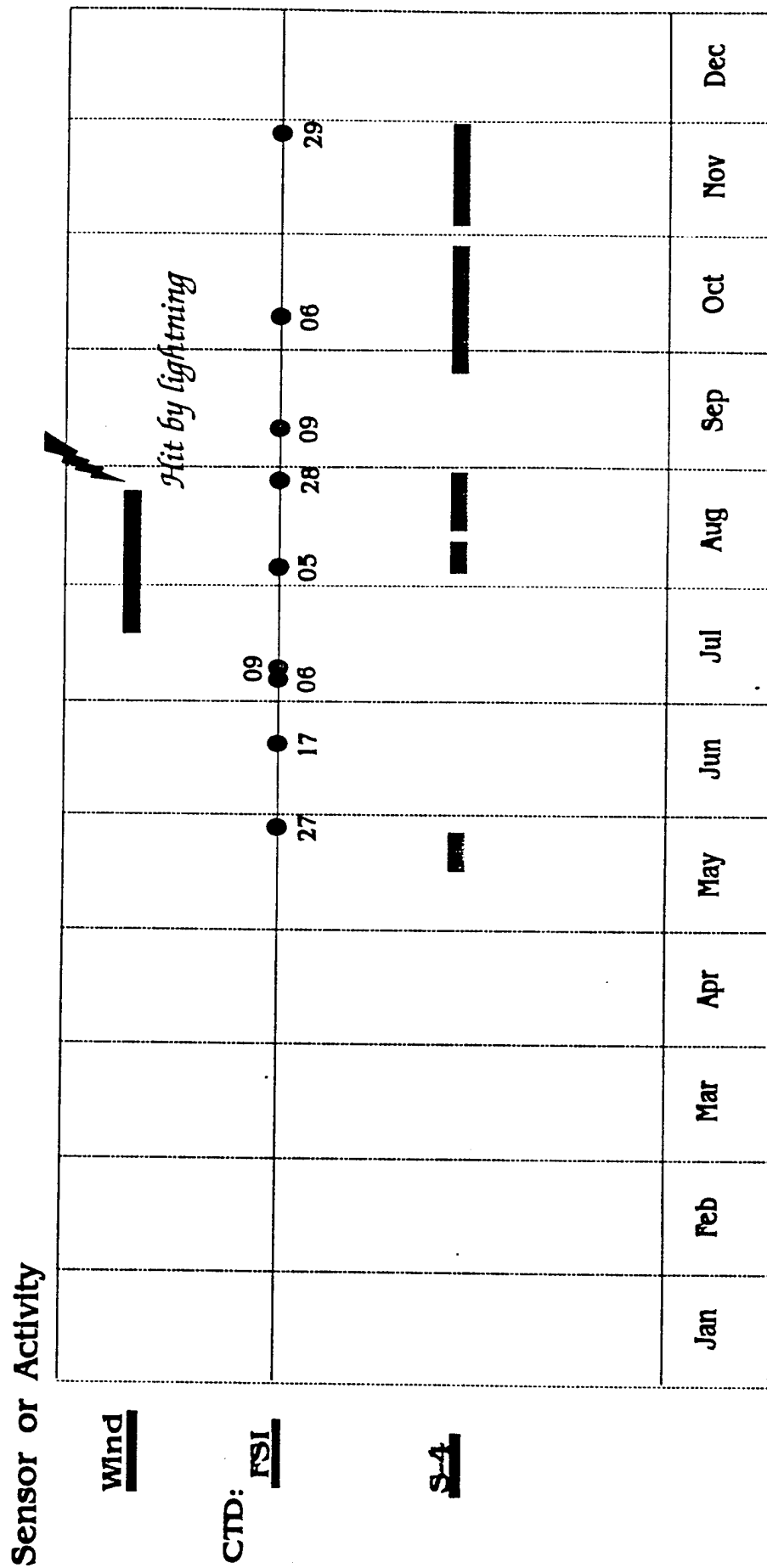
# Operational Periods for Sensors and Measurements at the LEO-15 Site

Sensor or Activity



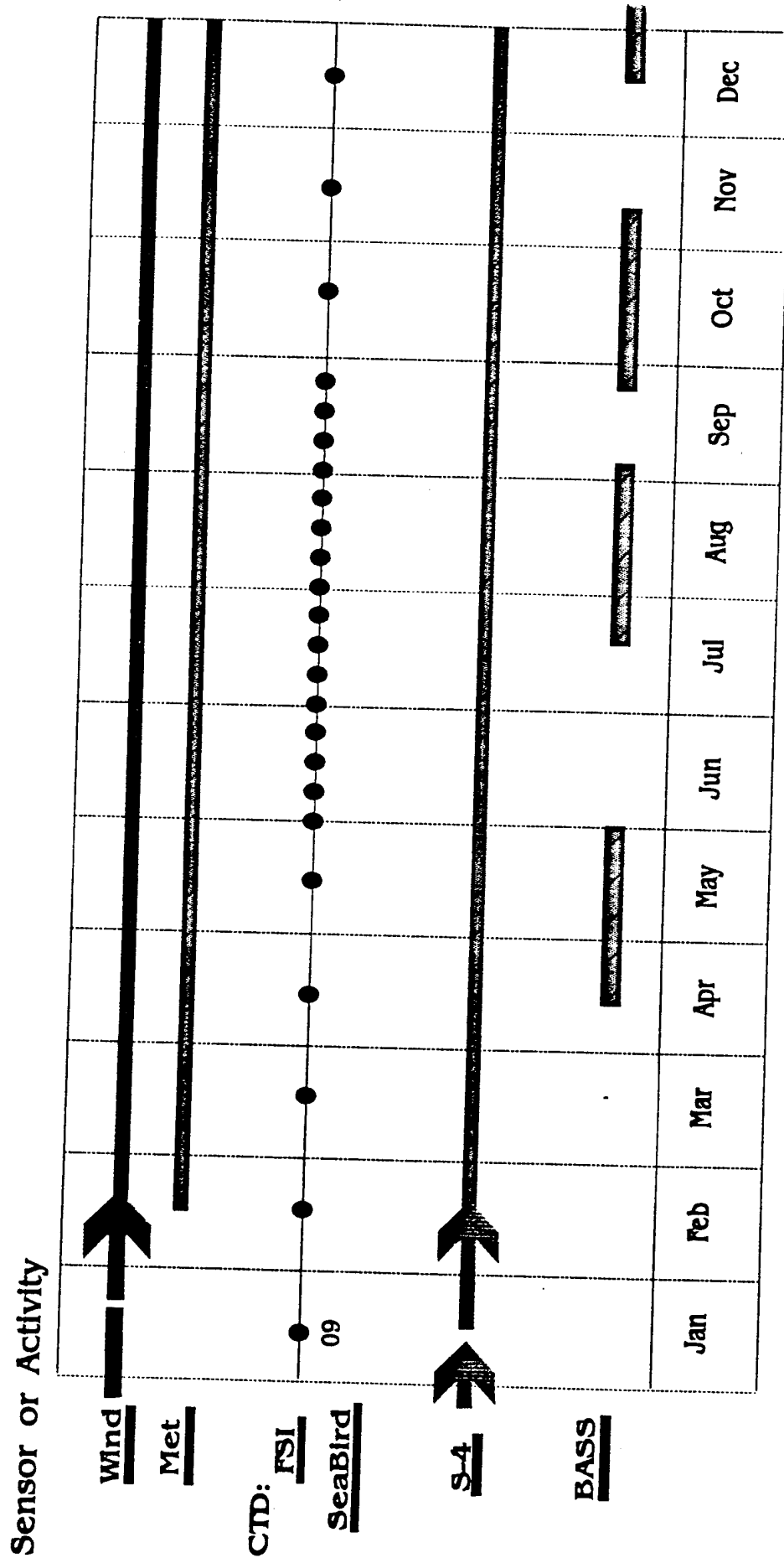
1994

# Operational Periods for Sensors and Measurements at the LEO-15 Site

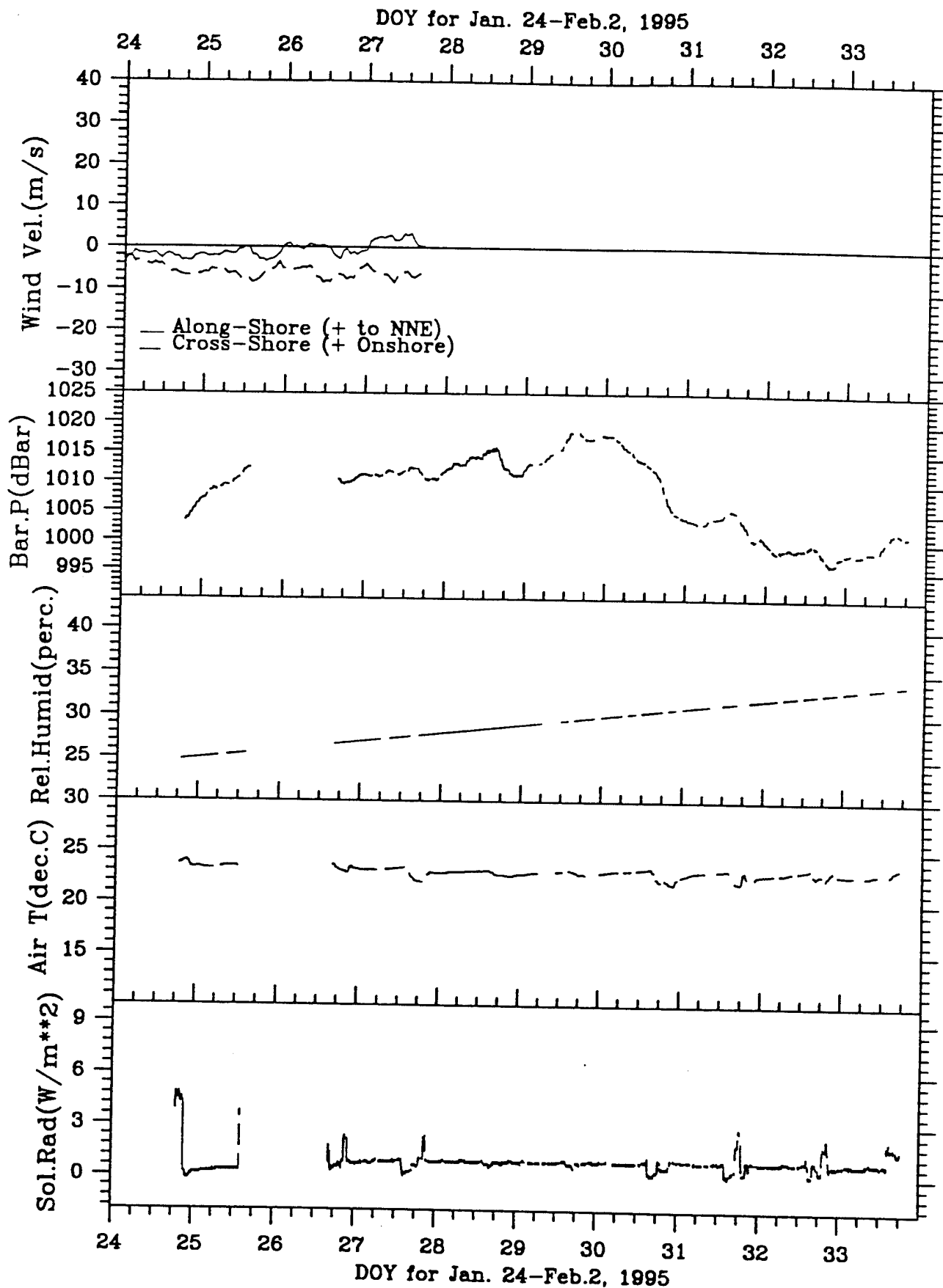


1993

# Operational Periods for Sensors and Measurements at the LEO-15 Site



1995

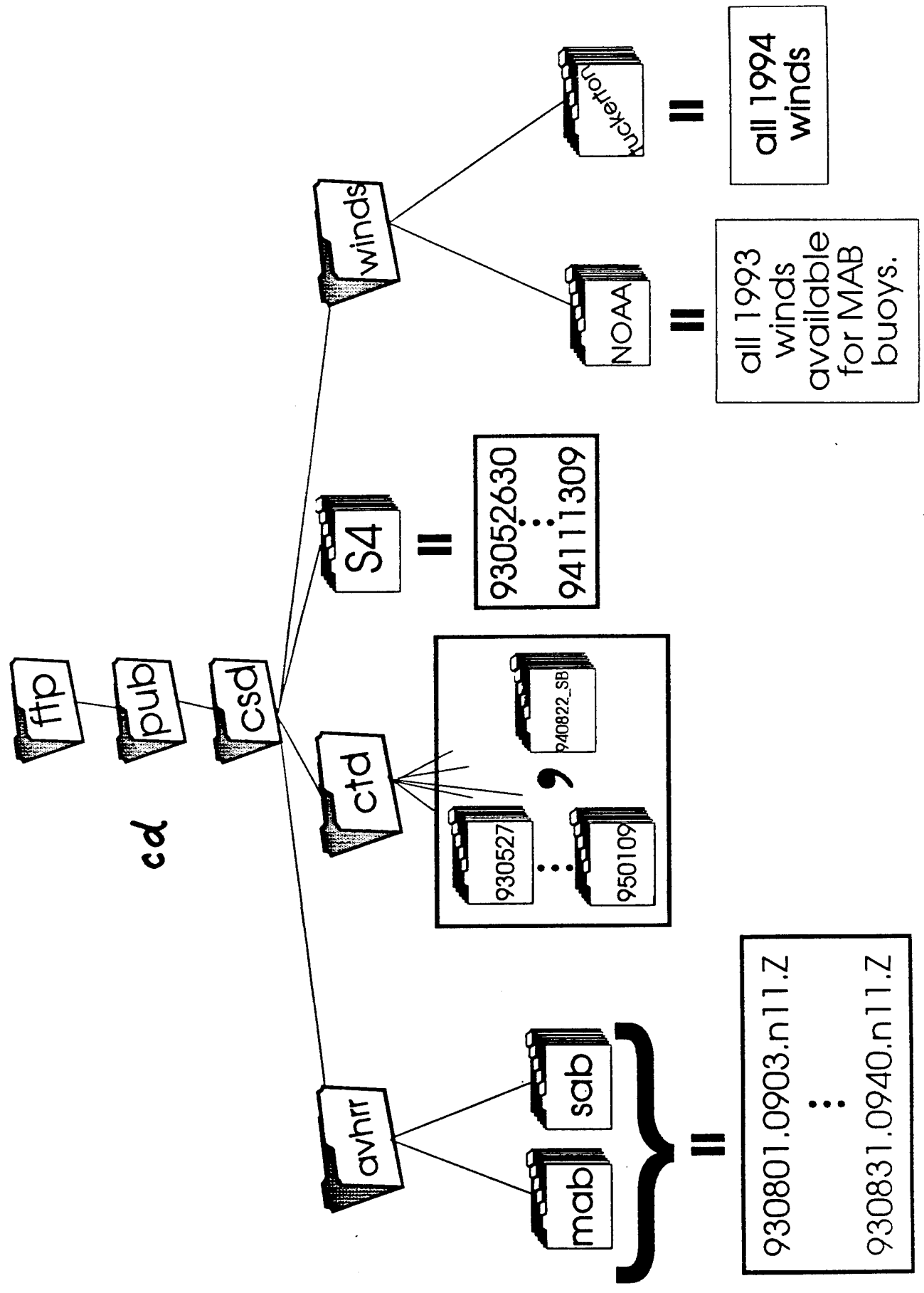


Met Data: Jan.-Feb. lab tests, 1995

## Wind Speed

[illegible]

anonymous ftp in arctic.rugers.edu



# README

This directory contains data from the S-4 Current Meter.

Each file contains 9 columns of data:

|           |                                                            |
|-----------|------------------------------------------------------------|
| Dec.D0Y   | Decimal Day-of-Year (what some people call Julian Day)     |
| U(cm/s)   | Hourly averaged velocity parallel* to the NJ coast (+ NNW) |
| V(cm/s)   | " " perpendicular* to the NJ coast (+ onshore)             |
| Depth(m)  | Water depth (meters).                                      |
| Temp(deg) | Temperature (degrees Celsius).                             |
| Sal(psu)  | Salinity (psu).                                            |
| Hs(m)     | Significant wave height.                                   |
| Tp(s)     | Peak period of the waves.                                  |
| OBS(FTU)  | Optical back-scatter.                                      |

\* The coastline of New Jersey near LEO-15 is oriented  
20 deg. E. of true North.

Inside every file, time is given as day-of-year (1 to 365), but the names of the files follow the convention YYMMDDst.dat. For example, file pub/csd/leo15/93080409.dat starts on August 4, 1993, and was at Station 09.

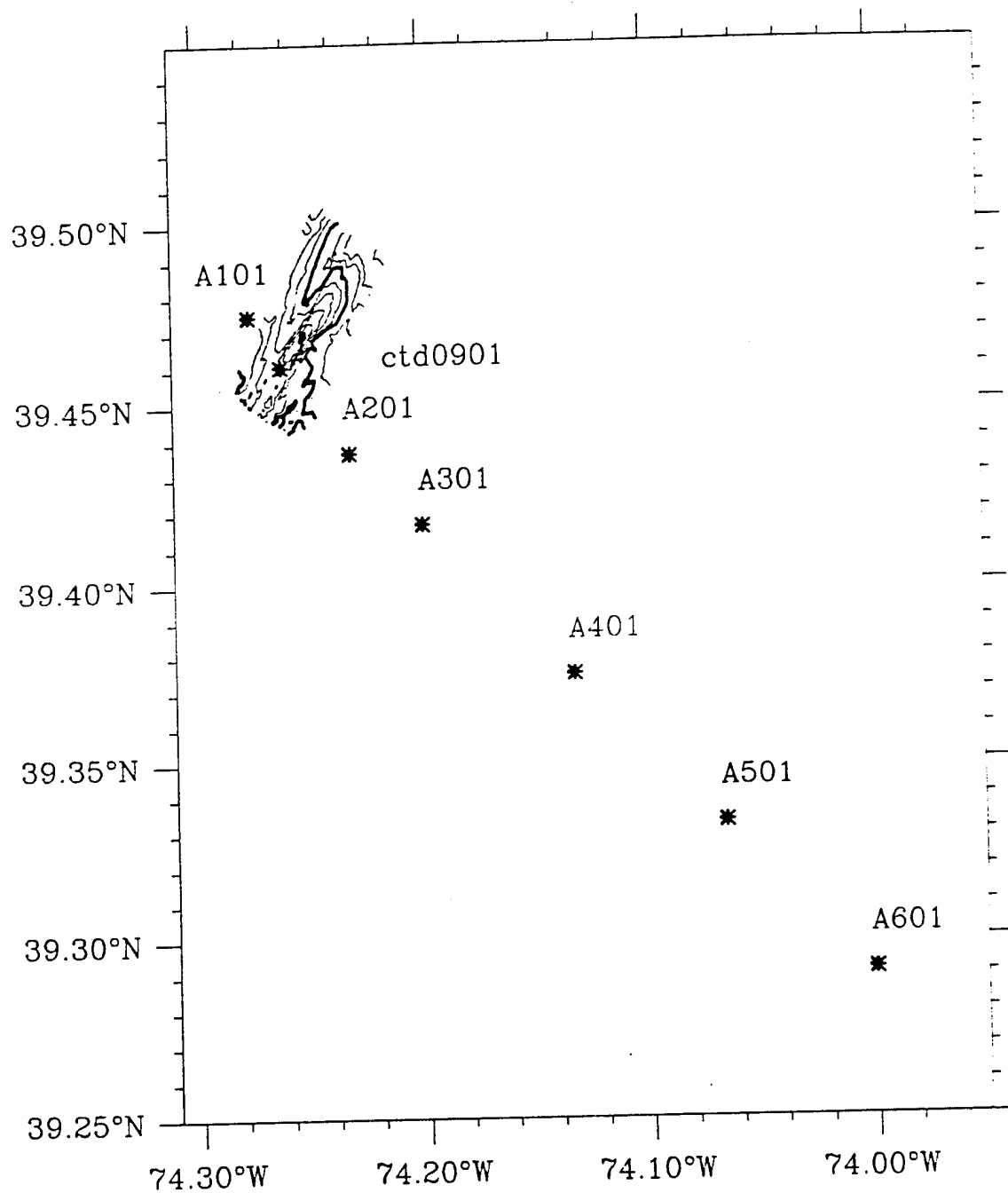
The first line of data is 216.7500, showing that data collection began on DOY 216 (August 4) at .75 hours = 18:00Z.

| Station | Latitude(N)<br>Deg. Min. | Longitude(W)<br>Deg. Min. |
|---------|--------------------------|---------------------------|
| 09      | 39 27.70                 | 74 15.73                  |
| 30      | 39 28.81                 | 74 13.22                  |
| 20      | 39 26.36                 | 74 14.54                  |

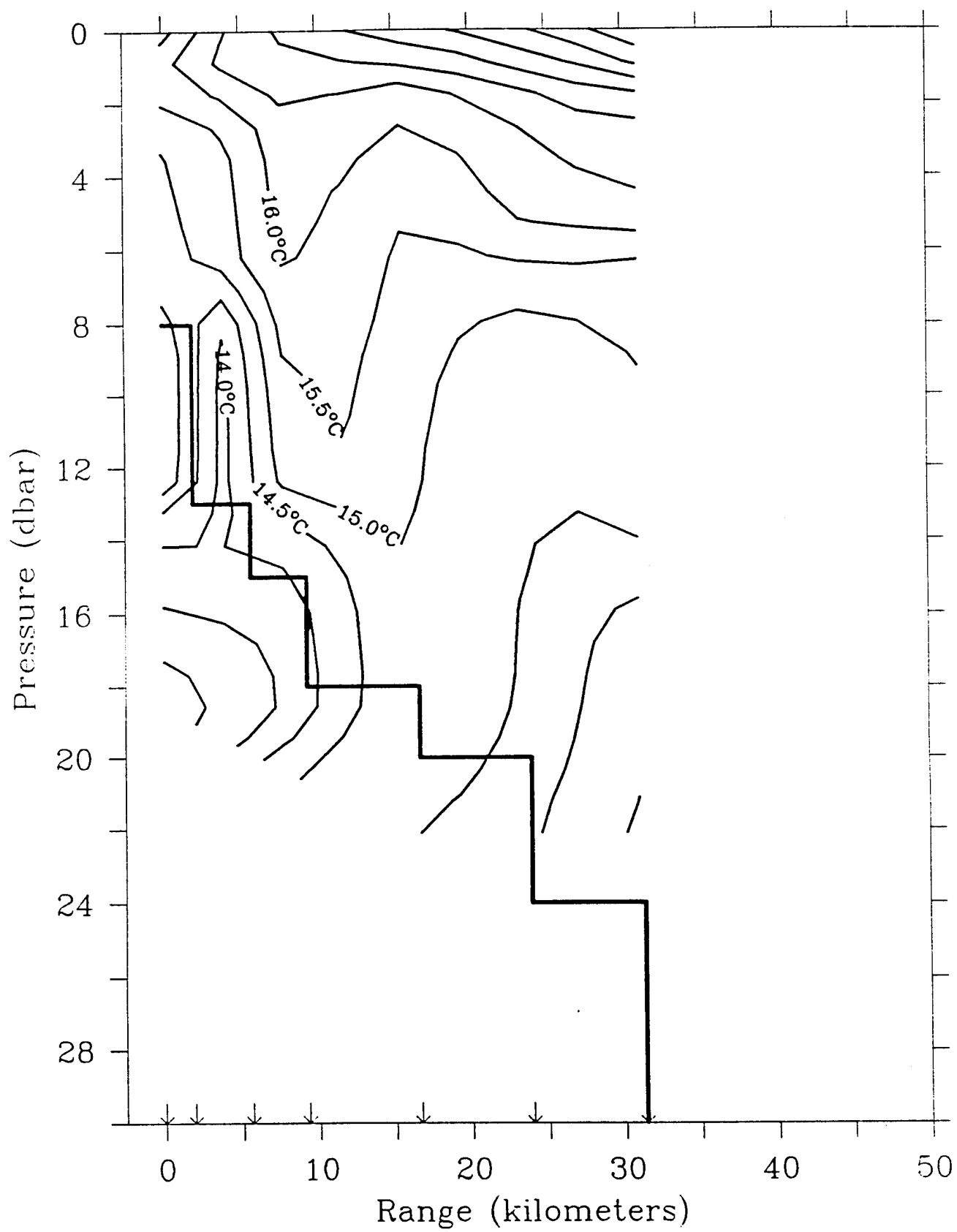
# README

Contents of directory ftp/pub/csd/ctd/940824:

|              |                                                           |
|--------------|-----------------------------------------------------------|
| README       | this file.                                                |
| position.dat | list of CTD locations for this survey.                    |
| pd0901.avg   | Down-cast data for each CTD. Data has had pitching motion |
| pda101.avg   | of ship filtered out.                                     |
| pda201.avg   |                                                           |
| pda301.avg   |                                                           |
| pda401.avg   |                                                           |
| pda501.avg   |                                                           |
| pda601.avg   |                                                           |
| Tsection.ps  | postscript file of contoured temperature data.            |
| map.ps       | postscript file of location map.                          |



LEO-15 CTD Survey: August 24, 1994



August 24, 1994: Temperature

## position.dat

| CTD  | N. LAT<br>(DEC MIN) | W. LON<br>(DEC MIN) | DEPTH<br>(Meters) | DATE        |
|------|---------------------|---------------------|-------------------|-------------|
| A101 | 39 28.51            | 74 16.56            | 8.0               | 24-AUG-1994 |
| 0901 | 39 27.68            | 74 15.75            | 13.0              | 24-AUG-1994 |
| A201 | 39 26.23            | 74 13.95            | 15.0              | 24-AUG-1994 |
| A301 | 39 24.99            | 74 11.97            | 18.0              | 24-AUG-1994 |
| A401 | 39 22.47            | 74 7.99             | 20.0              | 24-AUG-1994 |
| A501 | 39 20.01            | 74 3.99             | 24.0              | 24-AUG-1994 |
| A601 | 39 17.46            | 74 0.00             | 31.0              | 24-AUG-1994 |

# pd0901 avg

| fcount | pressure | temp    | conductiv. | salin.  | O2_c   | O2_t    | transmis. | fluorom. |
|--------|----------|---------|------------|---------|--------|---------|-----------|----------|
| 1      | 0.4000   | 16.0249 | 38.9126    | 31.3334 | 2.0546 | 19.4631 | 1.1554    | 1.6921   |
| 2      | 0.5000   | 15.9540 | 38.9126    | 31.3916 | 2.0546 | 19.4631 | 1.2401    | 1.7058   |
| 3      | 0.6000   | 15.8335 | 38.9126    | 31.4831 | 2.0546 | 19.4631 | 1.3670    | 1.7263   |
| 4      | 0.7000   | 15.8067 | 38.9126    | 31.4904 | 2.0546 | 19.4631 | 6.7647    | 1.7065   |
| 5      | 0.8000   | 15.7741 | 38.9126    | 31.5041 | 2.0546 | 19.4631 | 31.5939   | 1.6153   |
| 6      | 0.9000   | 15.7459 | 38.9126    | 31.5220 | 2.0546 | 19.4631 | 44.7588   | 1.4710   |
| 7      | 1.0000   | 15.7393 | 38.9126    | 31.4983 | 2.0546 | 19.4631 | 45.0660   | 1.3701   |
| 8      | 1.1000   | 15.7401 | 38.9126    | 31.4786 | 2.0546 | 19.4631 | 45.2260   | 1.3434   |
| 9      | 1.2000   | 15.7318 | 38.9126    | 31.5087 | 2.0546 | 19.4631 | 45.3021   | 1.3823   |
| 10     | 1.3000   | 15.7227 | 38.9126    | 31.5274 | 2.0546 | 19.4631 | 45.4861   | 1.4006   |
| 11     | 1.4000   | 15.7191 | 38.9126    | 31.5328 | 2.0546 | 19.4631 | 45.6095   | 1.4035   |
| 12     | 1.5000   | 15.7226 | 38.9126    | 31.5468 | 2.0546 | 19.4631 | 45.7964   | 1.4075   |

• • • •

To access data sets online at the Institute of Marine and  
Coastal Sciences, Rutgers University, New Brunswick, New Jersey:

```
ftp arctic.rutgers.edu          (or, ftp 128.6.141.21)
login: anonymous
password: use your e-mail address as the password
```

```
cd /pub/csd
```

```
cd to your desired directory.
```

```
say: bin
      prompt
      mget *
```

If you have any problems, email  
laurel@ahab.rutgers.edu  
crowley@atlantic.rutgers.edu  
styles@arctic.rutgers.edu  
or  
glenn@caribbean.rutgers.edu

The following is a listing of all of the sub-directories and  
a representative listing of the files available. File names  
are often in the format YYMMDDSt, where YY = year, MM = month,  
DD = day, and St = Station.

```
total 5
```

```
-rw-r--r-- 193 Feb 13 11:59 README
drwxrwxr-x 512 Jul 20 1994 avhrr
drwxrwxr-x 1024 Feb  2 12:15 ctd
drwxrwxr-x 512 Jan 31 15:40 s4
drwxrwxr-x 512 Feb 10 12:16 winds
```

```
avhrr/mab:
```

```
total 7196
```

```
-rw-rw-r-- 245581 Jul  7 1994 930801.0903.n11.Z
-rw-rw-r-- 193128 Jul  7 1994 930801.2028.n11.Z
-rw-rw-r-- 217525 Jul  7 1994 930802.0851.n11.Z
-rw-rw-r-- 198489 Jul  7 1994 930802.2016.n11.Z
-rw-rw-r-- 217779 Jul  7 1994 930805.2334.n12.Z
-rw-rw-r-- 200489 Jul  7 1994 930809.1228.n12.Z
-rw-rw-r-- 203975 Jul  7 1994 930809.2031.n11.Z
-rw-rw-r-- 235841 Jul  7 1994 930809.2348.n12.Z
-rw-rw-r-- 225759 Jul  7 1994 930810.0854.n11.Z
-rw-rw-r-- 199207 Jul  7 1994 930813.0024.n12.Z
-rw-rw-r-- 219199 Jul  7 1994 930814.0946.n11.Z
-rw-rw-r-- 215153 Jul  7 1994 930815.0934.n11.Z
-rw-rw-r-- 276012 Jul  7 1994 930818.2355.n12.Z
-rw-rw-r-- 231415 Jul  7 1994 930819.0845.n11.Z
-rw-rw-r-- 275382 Jul  7 1994 930819.2333.n12.Z
-rw-rw-r-- 190274 Jul  7 1994 930823.2101.n11.Z
-rw-rw-r-- 252961 Jul  7 1994 930823.2347.n12.Z
-rw-rw-r-- 234035 Jul  7 1994 930824.0925.n11.Z
-rw-rw-r-- 209589 Jul  7 1994 930825.2037.n11.Z
-rw-rw-r-- 194325 Jul  7 1994 930826.0900.n11.Z
-rw-rw-r-- 187283 Jul  7 1994 930826.1303.n12.Z
-rw-rw-r-- 212347 Jul  7 1994 930826.2025.n11.Z
-rw-rw-r-- 164685 Jul  7 1994 930827.0023.n12.Z
-rw-rw-r-- 193721 Jul  7 1994 930827.1241.n12.Z
-rw-rw-r-- 207075 Jul  7 1994 930827.2012.n11.Z
-rw-rw-r-- 189541 Jul  7 1994 930828.0002.n12.Z
-rw-rw-r-- 173239 Jul  7 1994 930828.1016.n11.Z
-rw-rw-r-- 167917 Jul  7 1994 930828.1220.n12.Z
-rw-rw-r-- 152099 Jul  7 1994 930828.2000.n11.Z
```

```

-rw-rwxr-- 182070 Jul 7 1994 930830.0952.n11.Z
-rw-rwxr-- 142523 Jul 7 1994 930830.1317.n12.Z
-rw-rwxr-- 147153 Jul 7 1994 930830.1936.n11.Z
-rw-rwxr-- 167551 Jul 7 1994 930831.0037.n12.Z
-rw-rwxr-- 234767 Jul 7 1994 930831.0940.n11.Z
-rw-rwxr-- 762 Jul 7 1994 README
-rw-rwxr-- 2111 Jul 7 1994 temps

```

author/sab:  
total 8084

```

-rw-rwxr-- 196872 Jul 7 1994 930801.0906.n11.s.Z
-rw-rwxr-- 137117 Jul 7 1994 930801.1343.n12.s.Z
-rw-rwxr-- 151550 Jul 7 1994 930801.2026.n11.s.Z
-rw-rwxr-- 178133 Jul 7 1994 930803.1300.n12.s.Z
-rw-rwxr-- 172325 Jul 7 1994 930804.0015.n12.s.Z
-rw-rwxr-- 179689 Jul 7 1994 930804.1010.n11.s.Z
-rw-rwxr-- 142412 Jul 7 1994 930804.1238.n12.s.Z
-rw-rwxr-- 168535 Jul 7 1994 930805.2118.n11.s.Z
-rw-rwxr-- 197241 Jul 7 1994 930806.0946.n11.s.Z
-rw-rwxr-- 163157 Jul 7 1994 930806.2105.n11.s.Z
-rw-rwxr-- 172422 Jul 7 1994 930807.0051.n12.s.Z
-rw-rwxr-- 173980 Jul 7 1994 930807.0933.n11.s.Z
-rw-rwxr-- 159163 Jul 7 1994 930807.1314.n12.s.Z
-rw-rwxr-- 142381 Jul 7 1994 930807.2053.n11.s.Z
-rw-rwxr-- 161712 Jul 7 1994 930808.0029.n12.s.Z
-rw-rwxr-- 146640 Jul 7 1994 930808.0921.n11.s.Z
-rw-rwxr-- 181694 Jul 7 1994 930812.0043.n12.s.Z
-rw-rwxr-- 182444 Jul 7 1994 930812.1013.n11.s.Z
-rw-rwxr-- 181756 Jul 7 1994 930812.1306.n12.s.Z
-rw-rwxr-- 182349 Jul 7 1994 930813.1001.n11.s.Z
-rw-rwxr-- 194124 Jul 7 1994 930814.0949.n11.s.Z
-rw-rwxr-- 212248 Jul 7 1994 930816.0924.n11.s.Z
-rw-rwxr-- 167688 Jul 7 1994 930816.2044.n11.s.Z
-rw-rwxr-- 181736 Jul 7 1994 930817.0036.n12.s.Z
-rw-rwxr-- 178980 Jul 7 1994 930817.0912.n11.s.Z
-rw-rwxr-- 159664 Jul 7 1994 930817.2032.n11.s.Z
-rw-rwxr-- 173839 Jul 7 1994 930818.0014.n12.s.Z
-rw-rwxr-- 166589 Jul 7 1994 930818.0900.n11.s.Z
-rw-rwxr-- 140591 Jul 7 1994 930819.1028.n11.s.Z
-rw-rwxr-- 192081 Jul 7 1994 930820.1016.n11.s.Z
-rw-rwxr-- 219136 Jul 7 1994 930824.0927.n11.s.Z
-rw-rwxr-- 128697 Jul 7 1994 930825.2035.n11.s.Z
-rw-rwxr-- 170570 Jul 7 1994 930826.0903.n11.s.Z
-rw-rwxr-- 181472 Jul 7 1994 930827.0021.n12.s.Z
-rw-rwxr-- 175003 Jul 7 1994 930827.2359.n12.s.Z
-rw-rwxr-- 119371 Jul 7 1994 930828.2338.n12.s.Z
-rw-rwxr-- 172173 Jul 7 1994 930829.1007.n11.s.Z
-rw-rwxr-- 134606 Jul 7 1994 930829.2127.n11.s.Z
-rw-rwxr-- 143462 Jul 7 1994 930830.0057.n12.s.Z
-rw-rwxr-- 212571 Jul 7 1994 930830.0955.n11.s.Z
-rw-rwxr-- 157235 Jul 7 1994 930830.2114.n11.s.Z
-rw-rwxr-- 172253 Jul 7 1994 930831.0035.n12.s.Z
-rw-rwxr-- 198515 Jul 7 1994 930831.0942.n11.s.Z
-rw-rwxr-- 185035 Jul 7 1994 930831.1258.n12.s.Z
-rw-rwxr-- 191169 Jul 7 1994 930831.2102.n11.s.Z
-rw-rwxr-- 956 Jul 8 1994 README
-rw-rwxr-- 2111 Jul 7 1994 temps

```

ctd:

total 30

```

drwxrwxr-x 512 Jan 5 11:11 930527
drwxr-xr-x 512 Feb 1 17:22 930617
drwxrwxr-x 512 Jan 5 11:27 930706
drwxrwxr-x 512 Jan 5 11:32 930709
drwxrwxr-x 512 Jan 5 10:45 930805
drwxrwxr-x 512 Jan 5 09:53 930828

```

```

drwxrwxr-x 512 Jan 5 09:53 930909
drwxrwxr-x 512 Jan 5 09:53 931006
drwxrwxr-x 512 Jan 5 09:53 931129
drwxrwxr-x 512 Jan 5 11:57 940217
drwxrwxr-x 512 Jan 5 12:02 940405
drwxrwxr-x 512 Jan 5 13:04 940428
drwxrwxr-x 512 Jan 5 13:14 940511
drwxrwxr-x 512 Jan 5 13:33 940523
drwxrwxr-x 512 Jan 5 13:39 940526
drwxrwxr-x 512 Jan 5 13:54 940610
drwxrwxr-x 512 Jan 5 14:01 940613
drwxrwxr-x 512 Jan 5 15:38 940622_SB
drwxrwxr-x 512 Jan 5 14:34 940706
drwxrwxr-x 1024 Jan 5 15:46 940708_SB
drwxrwxr-x 512 Jan 5 15:57 940725_SB
drwxrwxr-x 512 Jan 5 16:01 940822_SB
drwxrwxr-x 512 Feb 10 11:01 940824
drwxrwxr-x 512 Jan 6 11:43 940826_SB_At1C
drwxrwxr-x 512 Jan 5 16:18 940909_SB
drwxrwxr-x 512 Jan 5 16:27 940928_SB
drwxrwxr-x 512 Jan 5 16:34 941025_SB
drwxrwxr-x 512 Jan 5 16:38 941221_SB
drwxr-xr-x 512 Feb 2 12:25 950109
drwxrwxr-x 512 Jan 6 10:31 EXTRAsta09

```

ctd/930527:

total 7

```

-rwxrwxr-x 223 Jan 5 11:27 README
-rw-rwxr-- 1973 Jan 5 11:09 pd0901.avg.z
-rw-rwxr-- 3008 Jan 5 11:10 pd3001.avg.z
-rw-rwxr-- 161 Jan 5 11:08 position.dat

```

ctd/940622\_SB:

total 114

```

-rw-rwxr-- 576 Jan 5 15:31 0903d.avg.z
-rw-rwxr-- 577 Jan 5 15:38 README
-rw-rwxr-- 20384 Jan 5 15:26 TsecAB.ps.z
-rw-rwxr-- 11865 Jan 5 15:17 Tsection.ps.z
-rw-rwxr-- 692 Jan 5 15:31 a101d.avg.z
-rw-rwxr-- 1875 Jan 5 15:31 a201d.avg.z
-rw-rwxr-- 2437 Jan 5 15:31 a301d.avg.z
-rw-rwxr-- 2301 Jan 5 15:31 a401d.avg.z
-rw-rwxr-- 858 Jan 5 15:31 ab01d.avg.z
-rw-rwxr-- 1993 Jan 5 15:31 b001d.avg.z
-rw-rwxr-- 1755 Jan 5 15:32 b101d.avg.z
-rw-rwxr-- 2245 Jan 5 15:32 b201d.avg.z
-rw-rwxr-- 2134 Jan 5 15:32 b301d.avg.z
-rw-rwxr-- 2713 Jan 5 15:32 b401d.avg.z
-rw-rwxr-- 3410 Jan 5 15:32 b501d.avg.z
-rw-rwxr-- 52893 Jan 5 15:16 map.ps.z
-rw-rwxr-- 601 Jan 5 15:27 position.dat

```

ctd/EXTRAsta09:

(CTD cruises that consisted of 1 cast, only)

total 10

```

-rw-rwxr-- 2351 Jan 6 10:30 940221.avg.z
-rw-rwxr-- 2163 Jan 6 10:30 940325.avg.z
-rw-rwxr-- 2266 Jan 6 10:30 940412.avg.z
-rw-rwxr-- 235 Jan 6 10:27 README

```

s4:

total 980

DOY Range

|            |        |     |    |       |              |             |
|------------|--------|-----|----|-------|--------------|-------------|
| -rw-r--r-- | 21411  | Jan | 9  | 18:51 | 93052630.dat | 135.-146.   |
| -rw-r--r-- | 12642  | Jan | 9  | 16:37 | 93080409.dat | 216.-224.   |
| -rw-r--r-- | 32708  | Jan | 9  | 17:48 | 93081209.dat | 225.-242.   |
| -rw-r--r-- | 66441  | Jan | 9  | 18:17 | 93092009.dat | 263.-273    |
| -rw-r--r-- | 51926  | Jan | 9  | 18:35 | 93110309.dat | 307.-334.   |
| -rw-r--r-- | 54928  | Jan | 10 | 15:57 | 94022109.dat | 52.- 81.    |
| -rw-r--r-- | 19357  | Jan | 10 | 16:17 | 94032509.dat | 84.- 97.    |
| -rw-r--r-- | 70470  | Jan | 11 | 14:24 | 94041109.dat | 101.-139.   |
| -rw-r--r-- | 105309 | Jan | 11 | 15:48 | 94051809.dat | 139.-154.   |
| -rw-r--r-- | 11378  | Jan | 11 | 16:04 | 94060209.dat | 153.-159.   |
| -rw-r--r-- | 120398 | Jan | 11 | 18:21 | 94060709.dat | 159.-176.   |
| -rw-r--r-- | 75842  | Jan | 11 | 17:51 | 94062709.dat | 182.-222.   |
| -rw-r--r-- | 87850  | Jan | 12 | 11:53 | 94080909.dat | 222.-268.   |
| -rw-r--r-- | 70075  | Jan | 12 | 13:30 | 94100209.dat | 276.-313.   |
| -rw-r--r-- | 60595  | Jan | 12 | 13:38 | 94110320.dat | 308.-340.   |
| -rw-r--r-- | 102623 | Jan | 30 | 17:16 | 94111309.dat | 318.-365.   |
| -rwxrwxr-x | 1105   | Jan | 12 | 13:53 | README       | (-> 1-7-95) |

winds:

total 2

|            |     |     |    |       |           |
|------------|-----|-----|----|-------|-----------|
| drwxr-xr-x | 512 | Feb | 10 | 12:16 | NOAA      |
| drwxr-xr-x | 512 | Jan | 31 | 17:18 | tuckerton |

winds/NOAA:

total 490

|            |       |     |    |       |                |
|------------|-------|-----|----|-------|----------------|
| -rwxrwxr-x | 43967 | Jul | 21 | 1994  | 44008fil.dat.Z |
| -rwxrwxr-x | 36071 | Jul | 21 | 1994  | 44009fil.dat.Z |
| -rwxrwxr-x | 60383 | Jul | 21 | 1994  | 44013fil.dat.Z |
| -rwxrwxr-x | 55925 | Jul | 21 | 1994  | 44014fil.dat.Z |
| -rwxrwxr-x | 62261 | Jul | 21 | 1994  | 44025fil.dat.Z |
| -rwxrwxr-x | 60899 | Jul | 21 | 1994  | alsn6fil.dat.Z |
| -rwxrwxr-x | 60963 | Jul | 21 | 1994  | buzm3fil.dat.Z |
| -rwxrwxr-x | 60959 | Jul | 21 | 1994  | chlv2fil.dat.Z |
| -rwxrwxr-x | 55273 | Jul | 21 | 1994  | dsln7fil.dat.Z |
| -rwxrwxr-x | 1887  | Feb | 10 | 12:18 | readme.doc     |

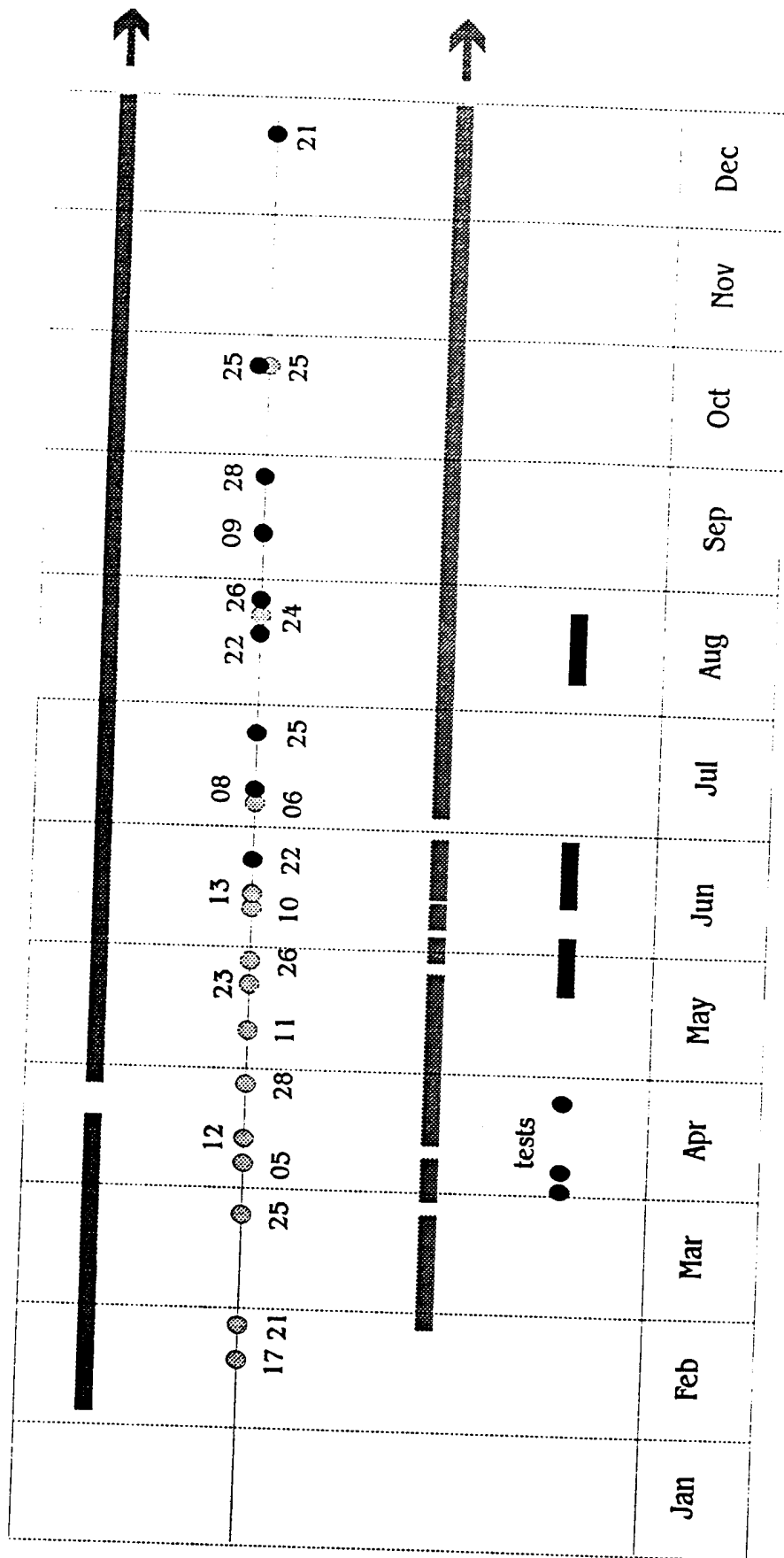
winds/tuckerton:

total 91

|            |       |     |    |       |             |
|------------|-------|-----|----|-------|-------------|
| -rw-r--r-- | 685   | Jan | 31 | 17:20 | README      |
| -rw-r--r-- | 92110 | Jan | 31 | 16:38 | all94.dat.z |

# Operational Periods for Sensors and Measurements at the LEO-15 Site

Sensor or Activity



1994

# Coastal Scene Description

## Data Analysis, Feature Model and Data Fusion

FY 94 Funding

\$0

FY 95 Proposed Funding

\$90,000

Accomplishments

New Start

### Plans

\*Acquire relevant oceanographic and meteorological data from:

- Rutgers Marine Remote Sensing Lab. New Brunswick, NJ
- Rutgers Longterm Ecosystem Observatory. Tuckerton, NJ
- CERC Field Research Facility. Duck, NC
- LWTC, Camp Lejeune, NC
- NOAA Buoys, C-MAN and Tidal Stations.

\*Concentrate on data collection starting in 1993. due to availability of satellite imagery.

\*Construct GIS with MAB and SAB subregions.

\*Use GIS to develop summary descriptions of important events and trends.

LIST OF WIND DATA AVAILABLE FOR 1993 FROM THE REMOTE SENSING  
LAB AT THE INSTITUTE OF MARINE AND COASTAL SCIENCES,  
RUTGERS UNIVERSITY\*

**NOAA buoys:**

| Station I.D. | Location       | Dates Available | Lat / Long    |
|--------------|----------------|-----------------|---------------|
| 44008        | Nantucket      | April 15-Dec 31 | 40.5N / 69.4W |
| 44009        | Delaware Bay   | June 18-Oct 31  | 38.5N / 74.7W |
| 44013        | Boston         | Complete Record | 42.4N / 70.7W |
| 44014        | Virginia Beach | Complete Record | 36.6N / 74.8W |
| 44025        | Long Island    | Complete Record | 40.3N / 73.2W |

**C-MAN Stations:**

| Station I.D. | Location         | Dates Available | Lat / Long    |
|--------------|------------------|-----------------|---------------|
| ALSN6        | Ambrose Light    | Complete Record | 40.5N / 73.8W |
| BUZM3        | Buzzards Bay     | Complete Record | 41.4N / 71.0W |
| CHLV2        | Chesapeake Light | Complete Record | 36.9N / 75.7W |
| DSL7         | Diamond Shls Lt. | Complete Record | 35.2N / 75.3W |

**Rutger's Marine Field Station at Tuckerton:**

A meteorological tower equipped with a wind sensor that measures hourly winds is located at the Tuckerton Field Station. Data collection and archiving is managed by staff employed by the Institute of Marine and Coastal Sciences, Rutgers University.

\* Wind measurements include speed and direction in various units, i.e., the NOAA buoy and C-MAN stations record in knots and the Tuckerton wind sensor in m/s. The direction compass is in standard meteorological format (0° indicates winds out of the north and proceeds in a clockwise fashion around to 360°). All clocks are synchronized to Greenwich Mean Time.

To access data sets online at the Institute of Marine and  
Coastal Sciences, Rutgers University, New Brunswick, New Jersey:

```
ftp arctic.rutgers.edu          (or, ftp 128.6.141.21)
login: anonymous
password: use your e-mail address as the password
```

```
cd /pub/csd
```

```
cd to your desired directory.
```

```
say: bin
      prompt
      mget *
```

If you have any problems, email  
laurel@ahab.rutgers.edu  
crowley@atlantic.rutgers.edu  
styles@arctic.rutgers.edu  
or  
glenn@caribbean.rutgers.edu

The following is a listing of all of the sub-directories and  
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DD = day, and St = Station.

```
total 5
```

```
-rw-r--r-- 193 Feb 13 11:59 README
drwxrwxr-x 512 Jul 20 1994 avhrr
drwxrwxr-x 1024 Feb  2 12:15 ctd
drwxrwxr-x 512 Jan 31 15:40 s4
drwxrwxr-x 512 Feb 10 12:16 winds
```

```
avhrr/mab:
```

```
total 7196
```

```
-rw-rwxr-- 245581 Jul  7 1994 930801.0903.n11.Z
-rw-rwxr-- 193128 Jul  7 1994 930801.2028.n11.Z
-rw-rwxr-- 217525 Jul  7 1994 930802.0851.n11.Z
-rw-rwxr-- 198489 Jul  7 1994 930802.2016.n11.Z
-rw-rwxr-- 217779 Jul  7 1994 930805.2334.n12.Z
-rw-rwxr-- 200489 Jul  7 1994 930809.1228.n12.Z
-rw-rwxr-- 203975 Jul  7 1994 930809.2031.n11.Z
-rw-rwxr-- 235841 Jul  7 1994 930809.2348.n12.Z
-rw-rwxr-- 225759 Jul  7 1994 930810.0854.n11.Z
-rw-rwxr-- 199207 Jul  7 1994 930813.0024.n12.Z
-rw-rwxr-- 219199 Jul  7 1994 930814.0946.n11.Z
-rw-rwxr-- 215153 Jul  7 1994 930815.0934.n11.Z
-rw-rwxr-- 276012 Jul  7 1994 930818.2355.n12.Z
-rw-rwxr-- 231415 Jul  7 1994 930819.0845.n11.Z
-rw-rwxr-- 275382 Jul  7 1994 930819.2333.n12.Z
-rw-rwxr-- 190274 Jul  7 1994 930823.2101.n11.Z
-rw-rwxr-- 252961 Jul  7 1994 930823.2347.n12.Z
-rw-rwxr-- 234035 Jul  7 1994 930824.0925.n11.Z
-rw-rwxr-- 209589 Jul  7 1994 930825.2037.n11.Z
-rw-rwxr-- 194325 Jul  7 1994 930826.0900.n11.Z
-rw-rwxr-- 187283 Jul  7 1994 930826.1303.n12.Z
-rw-rwxr-- 212347 Jul  7 1994 930826.2025.n11.Z
-rw-rwxr-- 164685 Jul  7 1994 930827.0023.n12.Z
-rw-rwxr-- 193721 Jul  7 1994 930827.1241.n12.Z
-rw-rwxr-- 207075 Jul  7 1994 930827.2012.n11.Z
-rw-rwxr-- 189541 Jul  7 1994 930828.0002.n12.Z
-rw-rwxr-- 173239 Jul  7 1994 930828.1016.n11.Z
-rw-rwxr-- 167917 Jul  7 1994 930828.1220.n12.Z
-rw-rwxr-- 152099 Jul  7 1994 930828.2000.n11.Z
```

```

-rw-rwxr-- 182070 Jul 7 1994 930830.0952.n11.Z
-rw-rwxr-- 142523 Jul 7 1994 930830.1317.n12.Z
-rw-rwxr-- 147153 Jul 7 1994 930830.1936.n11.Z
-rw-rwxr-- 167551 Jul 7 1994 930831.0037.n12.Z
-rw-rwxr-- 234767 Jul 7 1994 930831.0940.n11.Z
-rw-rwxr-- 762 Jul 7 1994 README
-rw-rwxr-- 2111 Jul 7 1994 temps

```

avhrr/sab:  
total 8084

```

-rw-rwxr-- 196872 Jul 7 1994 930801.0906.n11.s.Z
-rw-rwxr-- 137117 Jul 7 1994 930801.1343.n12.s.Z
-rw-rwxr-- 151550 Jul 7 1994 930801.2026.n11.s.Z
-rw-rwxr-- 178133 Jul 7 1994 930803.1300.n12.s.Z
-rw-rwxr-- 172325 Jul 7 1994 930804.0015.n12.s.Z
-rw-rwxr-- 179689 Jul 7 1994 930804.1010.n11.s.Z
-rw-rwxr-- 142412 Jul 7 1994 930804.1238.n12.s.Z
-rw-rwxr-- 168535 Jul 7 1994 930805.2118.n11.s.Z
-rw-rwxr-- 197241 Jul 7 1994 930806.0946.n11.s.Z
-rw-rwxr-- 163157 Jul 7 1994 930806.2105.n11.s.Z
-rw-rwxr-- 172422 Jul 7 1994 930807.0051.n12.s.Z
-rw-rwxr-- 173980 Jul 7 1994 930807.0933.n11.s.Z
-rw-rwxr-- 158163 Jul 7 1994 930807.1314.n12.s.Z
-rw-rwxr-- 142381 Jul 7 1994 930807.2053.n11.s.Z
-rw-rwxr-- 161712 Jul 7 1994 930808.0029.n12.s.Z
-rw-rwxr-- 146640 Jul 7 1994 930808.0921.n11.s.Z
-rw-rwxr-- 181694 Jul 7 1994 930812.0043.n12.s.Z
-rw-rwxr-- 182444 Jul 7 1994 930812.1013.n11.s.Z
-rw-rwxr-- 181756 Jul 7 1994 930812.1306.n12.s.Z
-rw-rwxr-- 182349 Jul 7 1994 930813.1001.n11.s.Z
-rw-rwxr-- 194124 Jul 7 1994 930814.0949.n11.s.Z
-rw-rwxr-- 212248 Jul 7 1994 930816.0924.n11.s.Z
-rw-rwxr-- 167688 Jul 7 1994 930816.2044.n11.s.Z
-rw-rwxr-- 181736 Jul 7 1994 930817.0036.n12.s.Z
-rw-rwxr-- 178980 Jul 7 1994 930817.0912.n11.s.Z
-rw-rwxr-- 159664 Jul 7 1994 930817.2032.n11.s.Z
-rw-rwxr-- 173839 Jul 7 1994 930818.0014.n12.s.Z
-rw-rwxr-- 166589 Jul 7 1994 930818.0900.n11.s.Z
-rw-rwxr-- 140591 Jul 7 1994 930819.1028.n11.s.Z
-rw-rwxr-- 192081 Jul 7 1994 930920.1016.n11.s.Z
-rw-rwxr-- 219136 Jul 7 1994 930824.0927.n11.s.Z
-rw-rwxr-- 128697 Jul 7 1994 930825.2035.n11.s.Z
-rw-rwxr-- 170570 Jul 7 1994 930826.0903.n11.s.Z
-rw-rwxr-- 181472 Jul 7 1994 930827.0021.n12.s.Z
-rw-rwxr-- 175003 Jul 7 1994 930827.2359.n12.s.Z
-rw-rwxr-- 119371 Jul 7 1994 930828.2338.n12.s.Z
-rw-rwxr-- 172173 Jul 7 1994 930829.1007.n11.s.Z
-rw-rwxr-- 134606 Jul 7 1994 930829.2127.n11.s.Z
-rw-rwxr-- 143462 Jul 7 1994 930830.0057.n12.s.Z
-rw-rwxr-- 212571 Jul 7 1994 930830.0955.n11.s.Z
-rw-rwxr-- 157235 Jul 7 1994 930830.2114.n11.s.Z
-rw-rwxr-- 172253 Jul 7 1994 930831.0035.n12.s.Z
-rw-rwxr-- 198515 Jul 7 1994 930831.0942.n11.s.Z
-rw-rwxr-- 185035 Jul 7 1994 930831.1258.n12.s.Z
-rw-rwxr-- 191169 Jul 7 1994 930831.2102.n11.s.Z
-rw-rwxr-- 956 Jul 8 1994 README
-rw-rwxr-- 2111 Jul 7 1994 temps

```

ctd:

total 30

```

drwxrwxr-x 512 Jan 5 11:11 930527
drwxr-xr-x 512 Feb 1 17:22 930617
drwxrwxr-x 512 Jan 5 11:27 930706
drwxrwxr-x 512 Jan 5 11:32 930709
drwxrwxr-x 512 Jan 5 10:45 930805
drwxrwxr-x 512 Jan 5 09:53 930828

```

|            |      |     |    |       |                |
|------------|------|-----|----|-------|----------------|
| drwxrwxr-x | 512  | Jan | 5  | 09:53 | 930909         |
| drwxrwxr-x | 512  | Jan | 5  | 09:53 | 931006         |
| drwxrwxr-x | 512  | Jan | 5  | 09:53 | 931129         |
| drwxrwxr-x | 512  | Jan | 5  | 11:57 | 940217         |
| drwxrwxr-x | 512  | Jan | 5  | 12:02 | 940405         |
| drwxrwxr-x | 512  | Jan | 5  | 13:04 | 940428         |
| drwxrwxr-x | 512  | Jan | 5  | 13:14 | 940511         |
| drwxrwxr-x | 512  | Jan | 5  | 13:33 | 940523         |
| drwxrwxr-x | 512  | Jan | 5  | 13:39 | 940526         |
| drwxrwxr-x | 512  | Jan | 5  | 13:54 | 940610         |
| drwxrwxr-x | 512  | Jan | 5  | 14:01 | 940613         |
| drwxrwxr-x | 512  | Jan | 5  | 15:38 | 940622_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 14:34 | 940706         |
| drwxrwxr-x | 1024 | Jan | 5  | 15:46 | 940708_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 15:57 | 940725_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 16:01 | 940822_SB      |
| drwxrwxr-x | 512  | Feb | 10 | 11:01 | 940824         |
| drwxrwxr-x | 512  | Jan | 6  | 11:43 | 940826_SB_At1C |
| drwxrwxr-x | 512  | Jan | 5  | 16:18 | 940909_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 16:27 | 940928_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 16:34 | 941025_SB      |
| drwxrwxr-x | 512  | Jan | 5  | 16:38 | 941221_SB      |
| drwxr-xr-x | 512  | Feb | 2  | 12:25 | 950109         |
| drwxrwxr-x | 512  | Jan | 6  | 10:31 | EXTRAsta09     |

ctd/930527:

total 7

|            |      |     |   |       |              |
|------------|------|-----|---|-------|--------------|
| -rwxrwxr-x | 223  | Jan | 5 | 11:27 | README       |
| -rw-rwxr-- | 1973 | Jan | 5 | 11:09 | pd0901.avg.z |
| -rw-rwxr-- | 3008 | Jan | 5 | 11:10 | pd3001.avg.z |
| -rw-rwxr-- | 161  | Jan | 5 | 11:08 | position.dat |

ctd/940622\_SB:

total 114

|            |       |     |   |       |               |
|------------|-------|-----|---|-------|---------------|
| -rw-rwxr-- | 576   | Jan | 5 | 15:31 | 0903d.avg.z   |
| -rw-rwxr-- | 577   | Jan | 5 | 15:38 | README        |
| -rw-rwxr-- | 20384 | Jan | 5 | 15:26 | TsecAB.ps.z   |
| -rw-rwxr-- | 11865 | Jan | 5 | 15:17 | Tsection.ps.z |
| -rw-rwxr-- | 692   | Jan | 5 | 15:31 | a101d.avg.z   |
| -rw-rwxr-- | 1875  | Jan | 5 | 15:31 | a201d.avg.z   |
| -rw-rwxr-- | 2437  | Jan | 5 | 15:31 | a301d.avg.z   |
| -rw-rwxr-- | 2301  | Jan | 5 | 15:31 | a401d.avg.z   |
| -rw-rwxr-- | 858   | Jan | 5 | 15:31 | ab01d.avg.z   |
| -rw-rwxr-- | 1993  | Jan | 5 | 15:31 | b001d.avg.z   |
| -rw-rwxr-- | 1755  | Jan | 5 | 15:32 | b101d.avg.z   |
| -rw-rwxr-- | 2245  | Jan | 5 | 15:32 | b201d.avg.z   |
| -rw-rwxr-- | 2134  | Jan | 5 | 15:32 | b301d.avg.z   |
| -rw-rwxr-- | 2713  | Jan | 5 | 15:32 | b401d.avg.z   |
| -rw-rwxr-- | 3410  | Jan | 5 | 15:32 | b501d.avg.z   |
| -rw-rwxr-- | 52893 | Jan | 5 | 15:16 | map.ps.z      |
| -rw-rwxr-- | 601   | Jan | 5 | 15:27 | position.dat  |

ctd/EXTRAsta09:

(CTD cruises that consisted of 1 cast, only)

total 10

|            |      |     |   |       |              |
|------------|------|-----|---|-------|--------------|
| -rw-rwxr-- | 2351 | Jan | 6 | 10:30 | 940221.avg.z |
| -rw-rwxr-- | 2163 | Jan | 6 | 10:30 | 940325.avg.z |
| -rw-rwxr-- | 2266 | Jan | 6 | 10:30 | 940412.avg.z |
| -rw-rwxr-- | 235  | Jan | 6 | 10:27 | README       |

```

s4:
total 980
-rw-r--r-- 21411 Jan  9 18:51 93052630.dat      135.-146.
-rw-r--r-- 12642 Jan  9 16:37 93080409.dat      216.-224.
-rw-r--r-- 32708 Jan  9 17:48 93081209.dat      225.-242.
-rw-r--r-- 66441 Jan  9 18:17 93092009.dat      263.-273
-rw-r--r-- 51826 Jan  9 18:35 93110309.dat      307.-334.
-rw-r--r-- 54828 Jan 10 15:57 94022109.dat       52.- 81.
-rw-r--r-- 19357 Jan 10 16:17 94032509.dat       84.- 97.
-rw-r--r-- 70470 Jan 11 14:24 94041109.dat      101.-139.
-rw-r--r--105309 Jan 11 15:48 94051809.dat      139.-154.
-rw-r--r-- 11378 Jan 11 16:04 94060209.dat      153.-159.
-rw-r--r--120398 Jan 11 18:21 94060709.dat      159.-176.
-rw-r--r-- 75842 Jan 11 17:51 94062709.dat      182.-222.
-rw-r--r-- 87850 Jan 12 11:53 94080909.dat      222.-268.
-rw-r--r-- 70075 Jan 12 13:30 94100209.dat      276.-313.
-rw-r--r-- 60595 Jan 12 13:38 94110320.dat      308.-340.
-rw-r--r--102623 Jan 30 17:16 94111309.dat      318.-365. (-> 1-7-95)
-rwxrwxr-x  1105 Jan 12 13:53 README

```

```

winds:
total 2
drwxr-xr-x    512 Feb 10 12:16 NOAA
drwxr-xr-x    512 Jan 31 17:18 tuckerton

```

```

winds/NOAA:
total 490
-rwxrwxr-x 43967 Jul 21 1994 44008fil.dat.Z
-rwxrwxr-x 36071 Jul 21 1994 44009fil.dat.Z
-rwxrwxr-x 60383 Jul 21 1994 44013fil.dat.Z
-rwxrwxr-x 55925 Jul 21 1994 44014fil.dat.Z
-rwxrwxr-x 62261 Jul 21 1994 44025fil.dat.Z
-rwxrwxr-x 60899 Jul 21 1994 alsn6fil.dat.Z
-rwxrwxr-x 60963 Jul 21 1994 buzm3fil.dat.Z
-rwxrwxr-x 60959 Jul 21 1994 chlv2fil.dat.Z
-rwxrwxr-x 55273 Jul 21 1994 dsln7fil.dat.Z
-rwxrwxr-x 1887 Feb 10 12:18 readme.doc

```

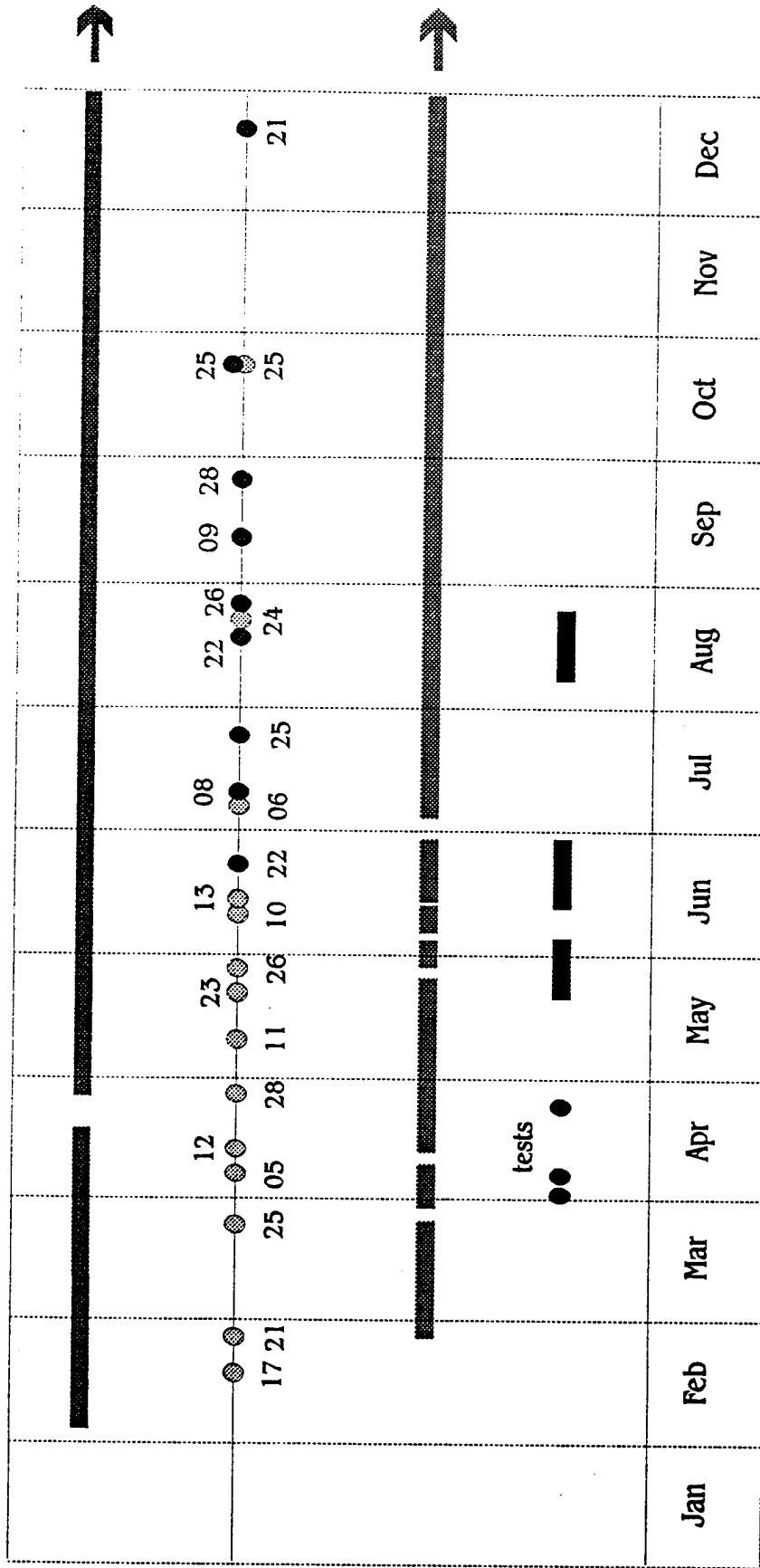
```

winds/tuckerton:
total 91
-rw-r--r-- 685 Jan 31 17:20 README
-rw-r--r-- 92110 Jan 31 16:38 all194.dat.z

```

# Operational Periods for Sensors and Measurements at the LEO-15 Site

Sensor or Activity



# MAB Summer Trends

observed at

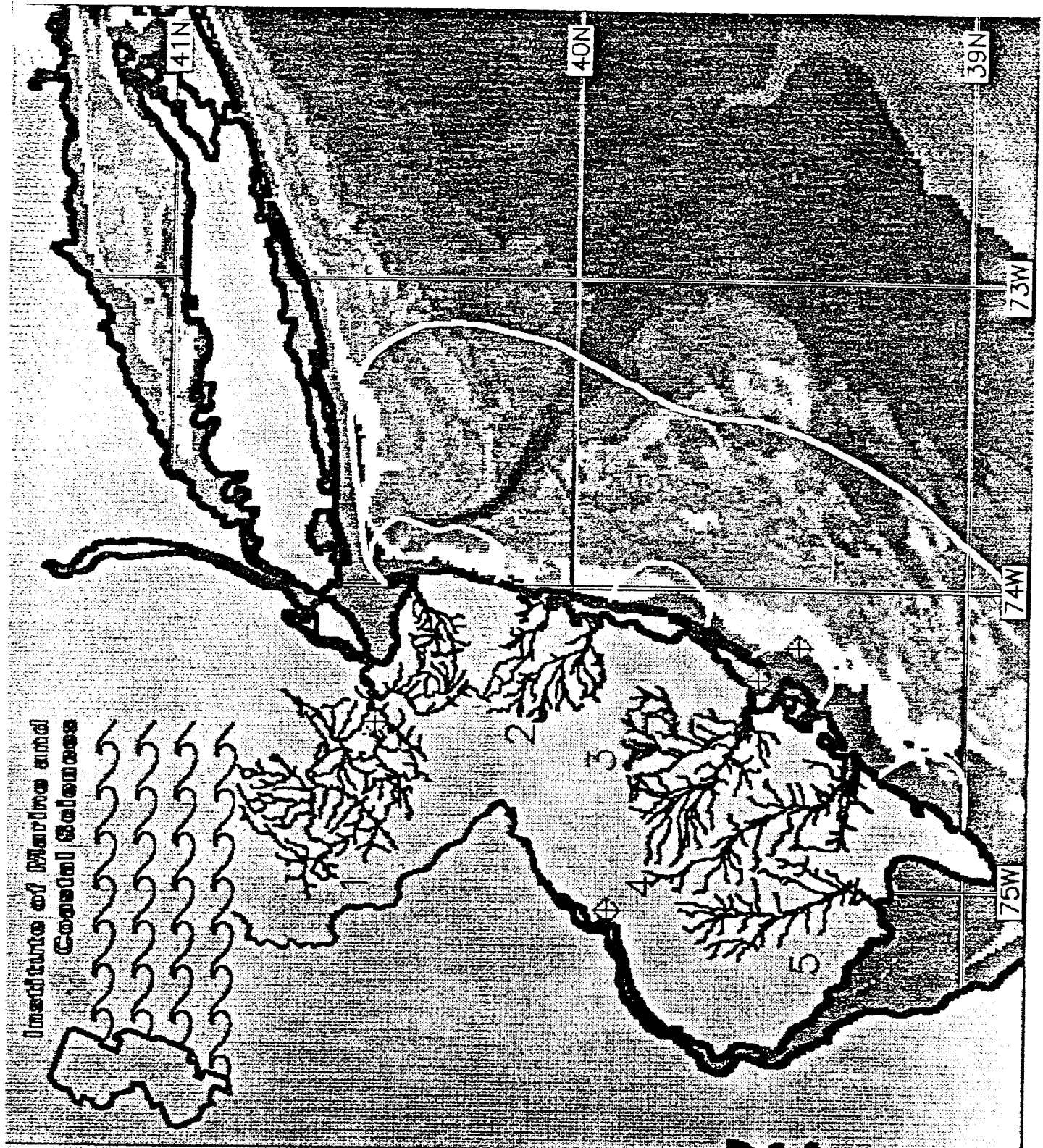
Institute of Marine & Coastal Sciences,  
Rutgers University

Scott Glenn  
Mike Crowley  
Laurel Henderson

|                                                                                     |    |   |        |   |  |  |  |
|-------------------------------------------------------------------------------------|----|---|--------|---|--|--|--|
|     | 1  | ) | Clouds |   |  |  |  |
|    | 2  | ) | <1.0   | C |  |  |  |
|    | 3  | ) | 2.5    | C |  |  |  |
|    | 4  | ) | 5.0    | C |  |  |  |
|    | 5  | ) | 7.5    | C |  |  |  |
|    | 6  | ) | 10.0   | C |  |  |  |
|    | 7  | ) | 12.0   | C |  |  |  |
|    | 8  | ) | 14.0   | C |  |  |  |
|    | 9  | ) | 15.0   | C |  |  |  |
|    | 10 | ) | 17.0   | C |  |  |  |
|   | 11 | ) | 19.0   | C |  |  |  |
|  | 12 | ) | 21.0   | C |  |  |  |
|  | 13 | ) | 22.5   | C |  |  |  |
|  | 14 | ) | 24.0   | C |  |  |  |
|  | 15 | ) | 25.0   | C |  |  |  |
|  | 16 | ) | 26.0   | C |  |  |  |
|  | 17 | ) | 27.5   | C |  |  |  |
|  | 18 | ) | 30.0   | C |  |  |  |
|  | 19 | ) | 33.0   | C |  |  |  |
|  | 20 | ) | 35.0   | C |  |  |  |

# Bathymetry

|    |        |
|----|--------|
| 1  | LAND   |
| 2  | 12 m   |
| 3  | 15 m   |
| 4  | 20 m   |
| 5  | 25 m   |
| 6  | 30 m   |
| 7  | 35 m   |
| 8  | 40 m   |
| 9  | 45 m   |
| 10 | 50 m   |
| 11 | 60 m   |
| 12 | 70 m   |
| 13 | 80 m   |
| 14 | 90 m   |
| 15 | 100 m  |
| 16 | 150 m  |
| 17 | 200 m  |
| 18 | 500 m  |
| 19 | 1000 m |
| 20 | 2500 m |



Institute of Marine and Coastal Sciences

# IMCS Bathymetry of the LEO-15 Area

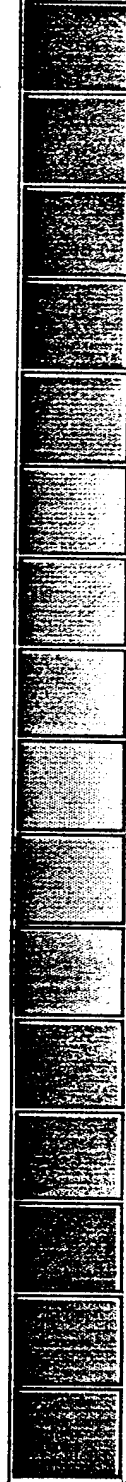
miles

0 2

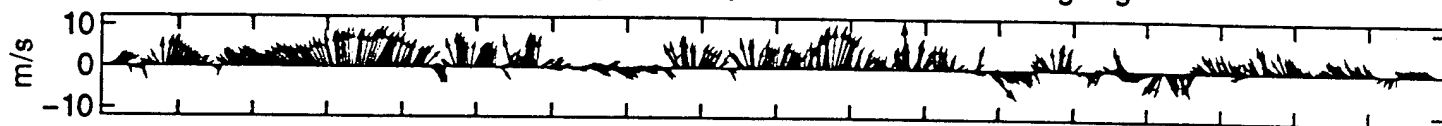
Research  
Area

Depths in feet

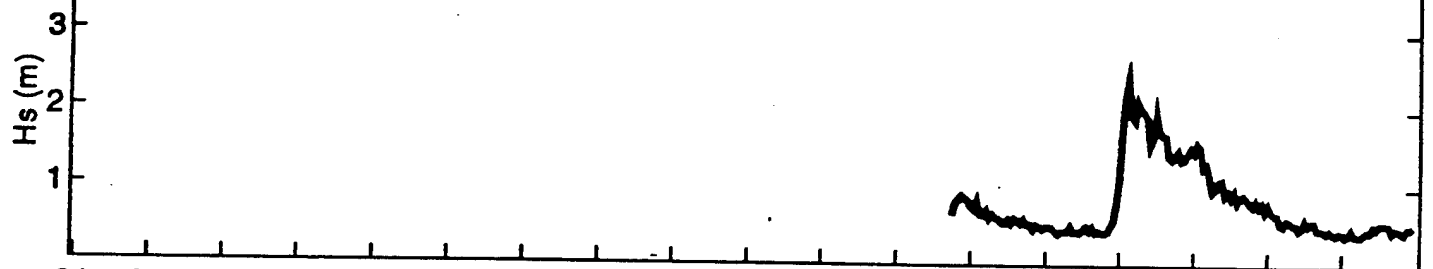
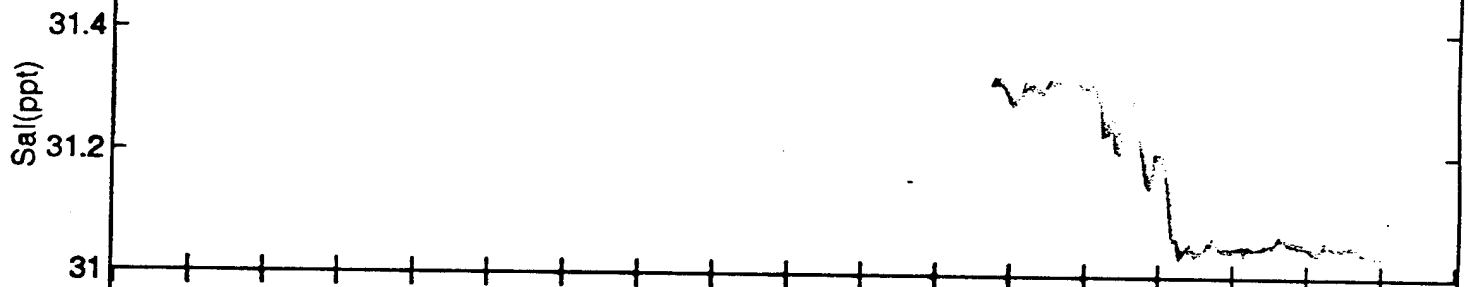
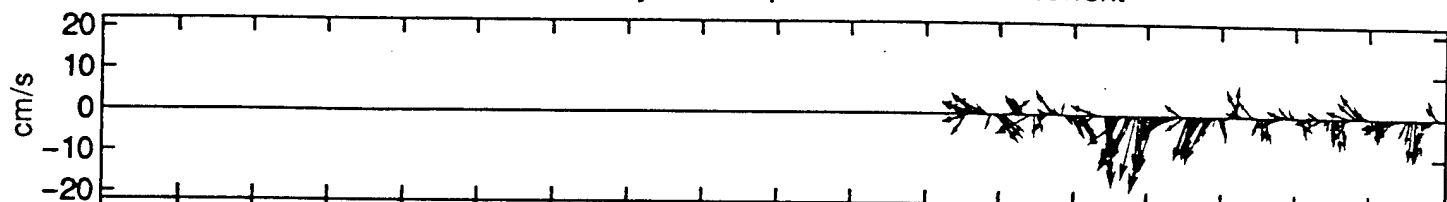
Land 5 10 15 20 25 30 35 40 45 50 55 60 65 70



Wind Velocity; arrows point in direction wind is going



Current Velocity; arrows point in direction of current



24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10  
July 24-Aug. 10, 1993

July 25, 1993  
12:51 GMT

41 N

40 N

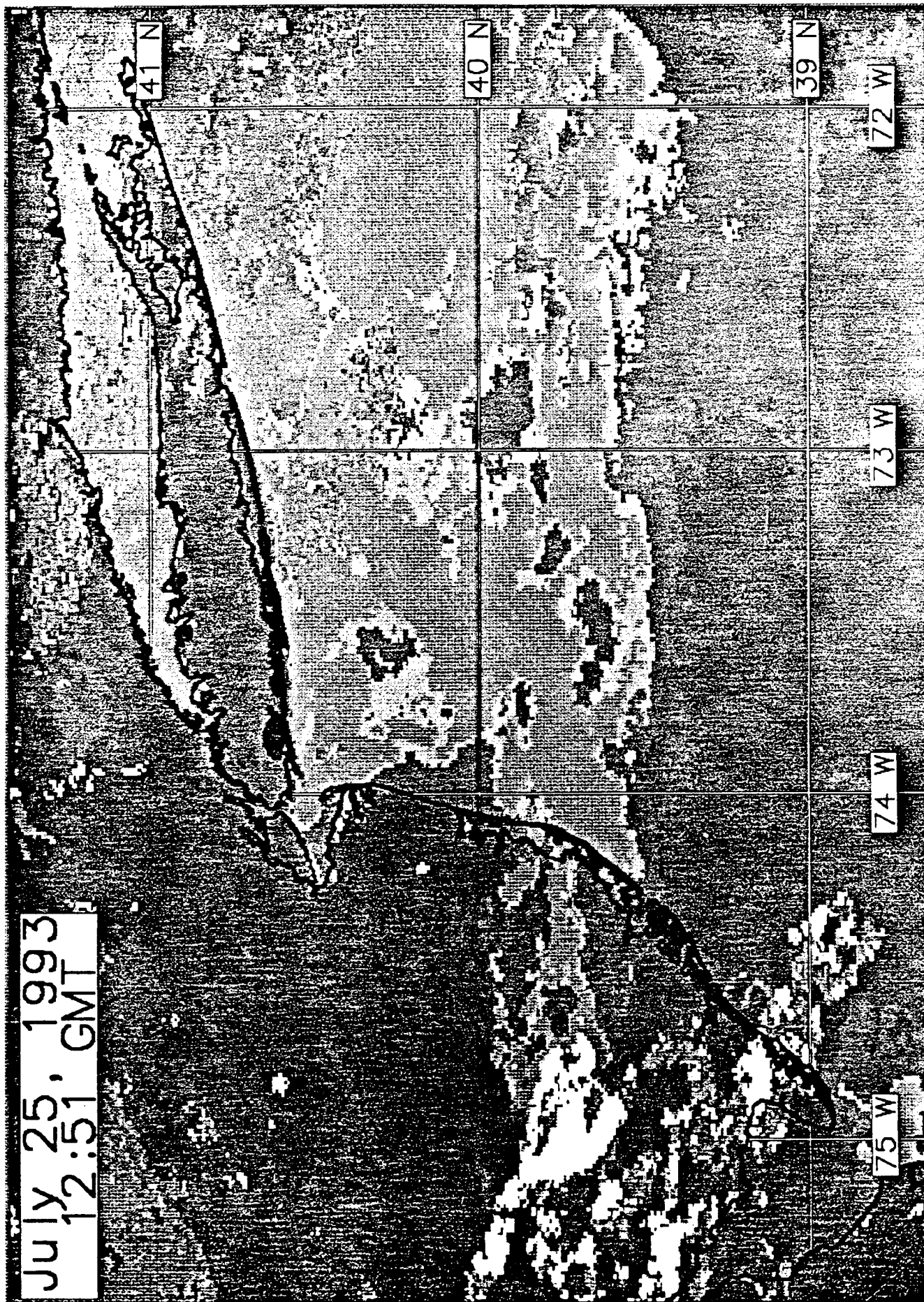
39 N

72 W

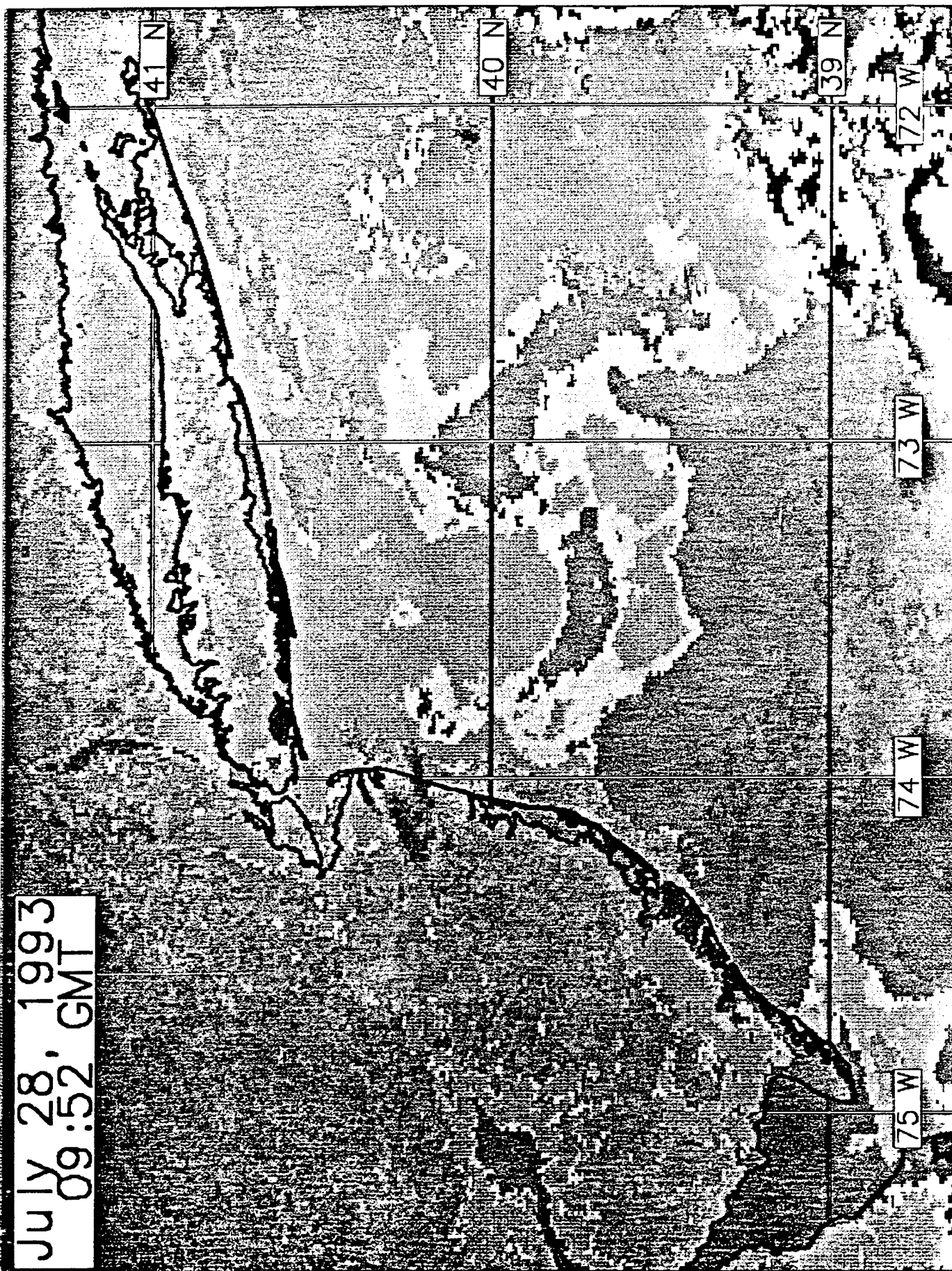
73 W

74 W

75 W



July 28, 1993  
09:52 GMT



Aug 02, 1993  
20:16 GMT

41 N

40 N

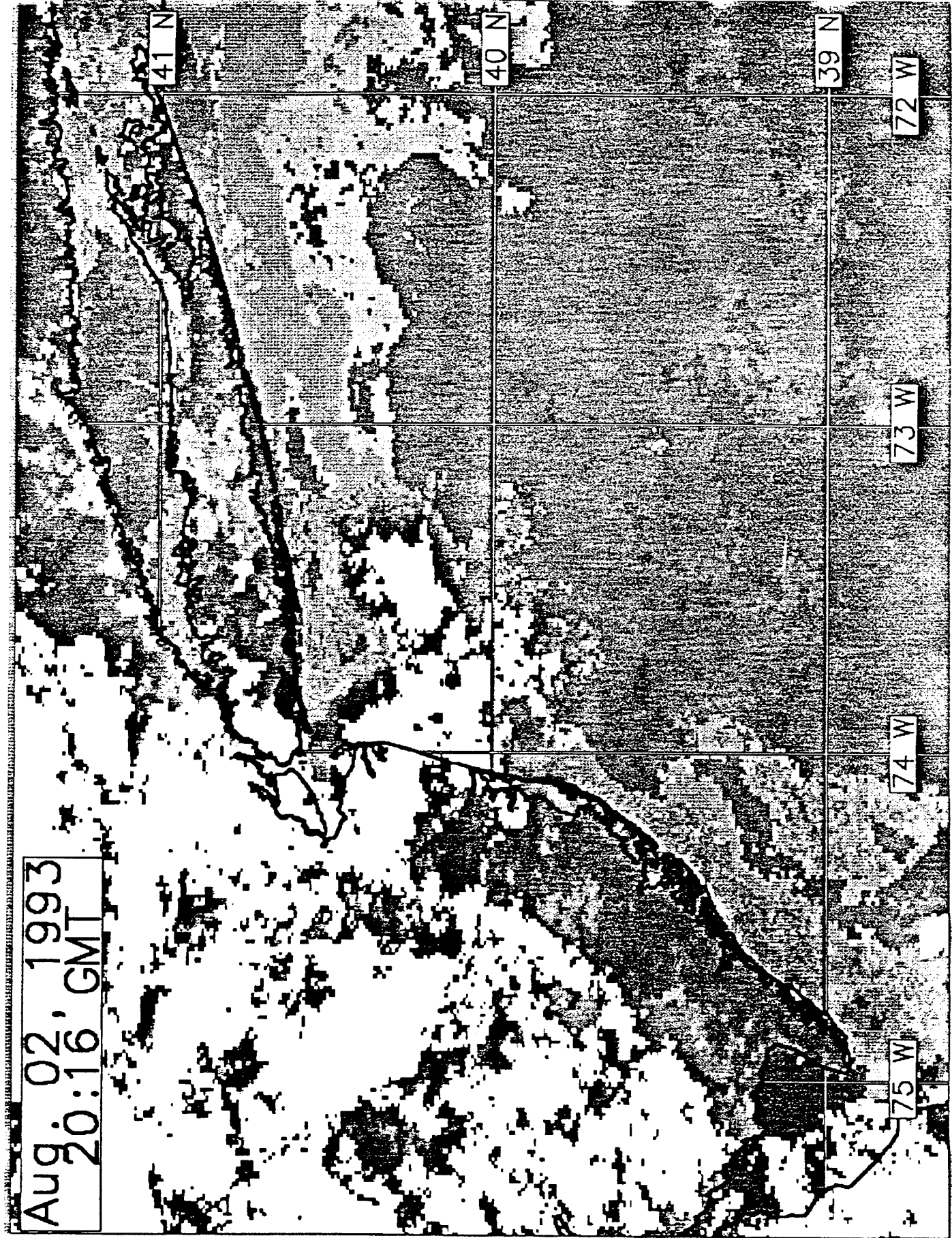
39 N

72 W

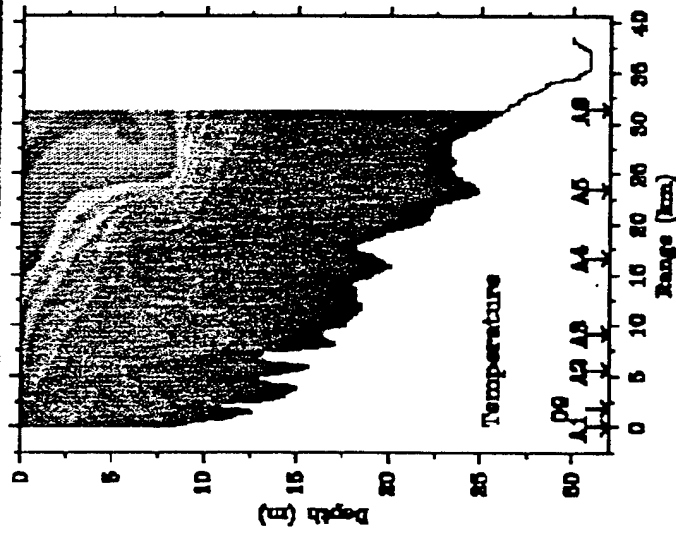
73 W

74 W

75 W



August 5, 1993  
23:34 GMT



WS 9.9 m/s  
WD 194 deg  
CS 12 cm/s  
CD 98 deg  
T 12.6 C  
S 31.6 ppt  
Hs 0.6 m  
Tp 7.9 sec  
OBS 5.8 ftu

SSW 4  
SSW 6  
S 4  
SW 4

75 W

74 W

39 N

40 N

Aug. 09, 1993  
20:31 GMT

41 N

40 N

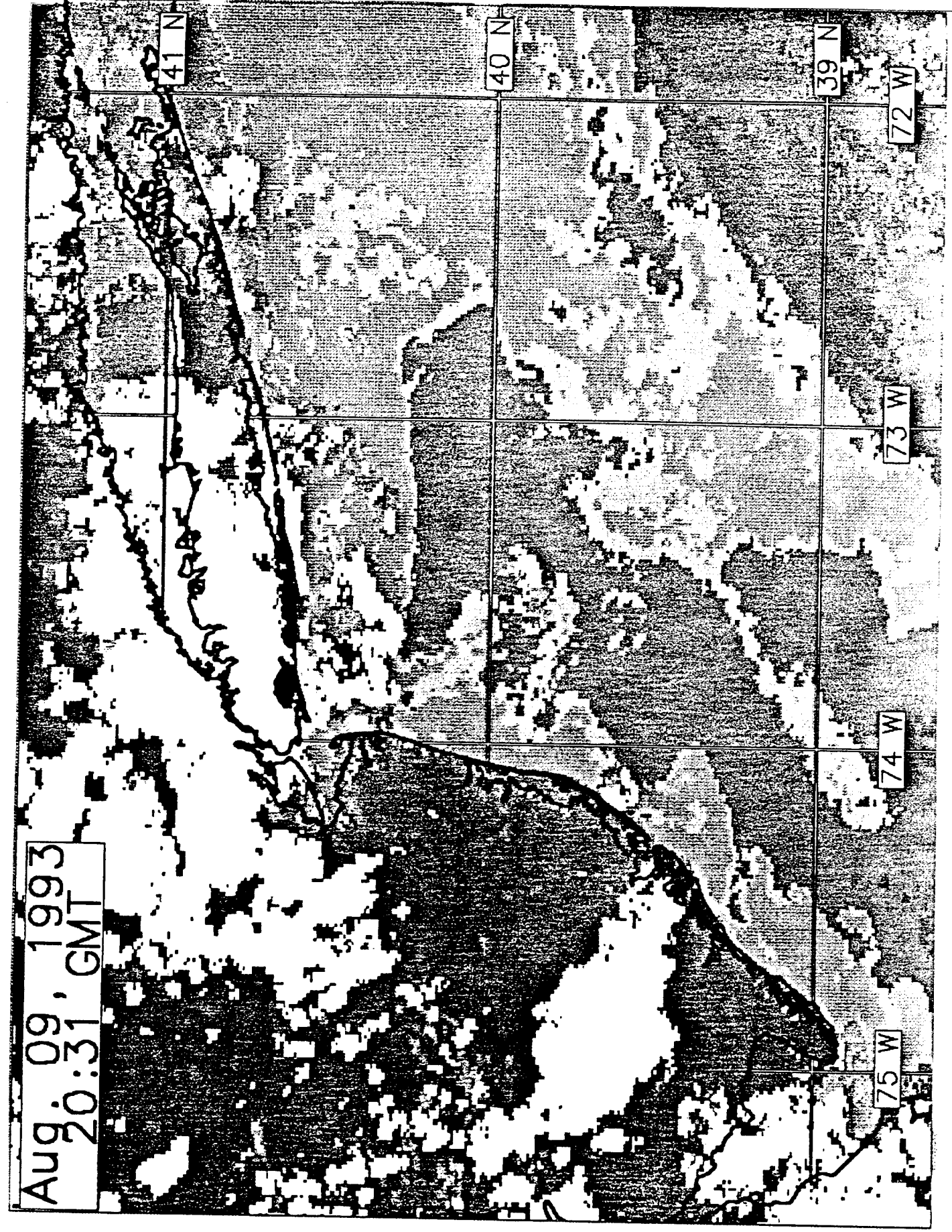
39 N

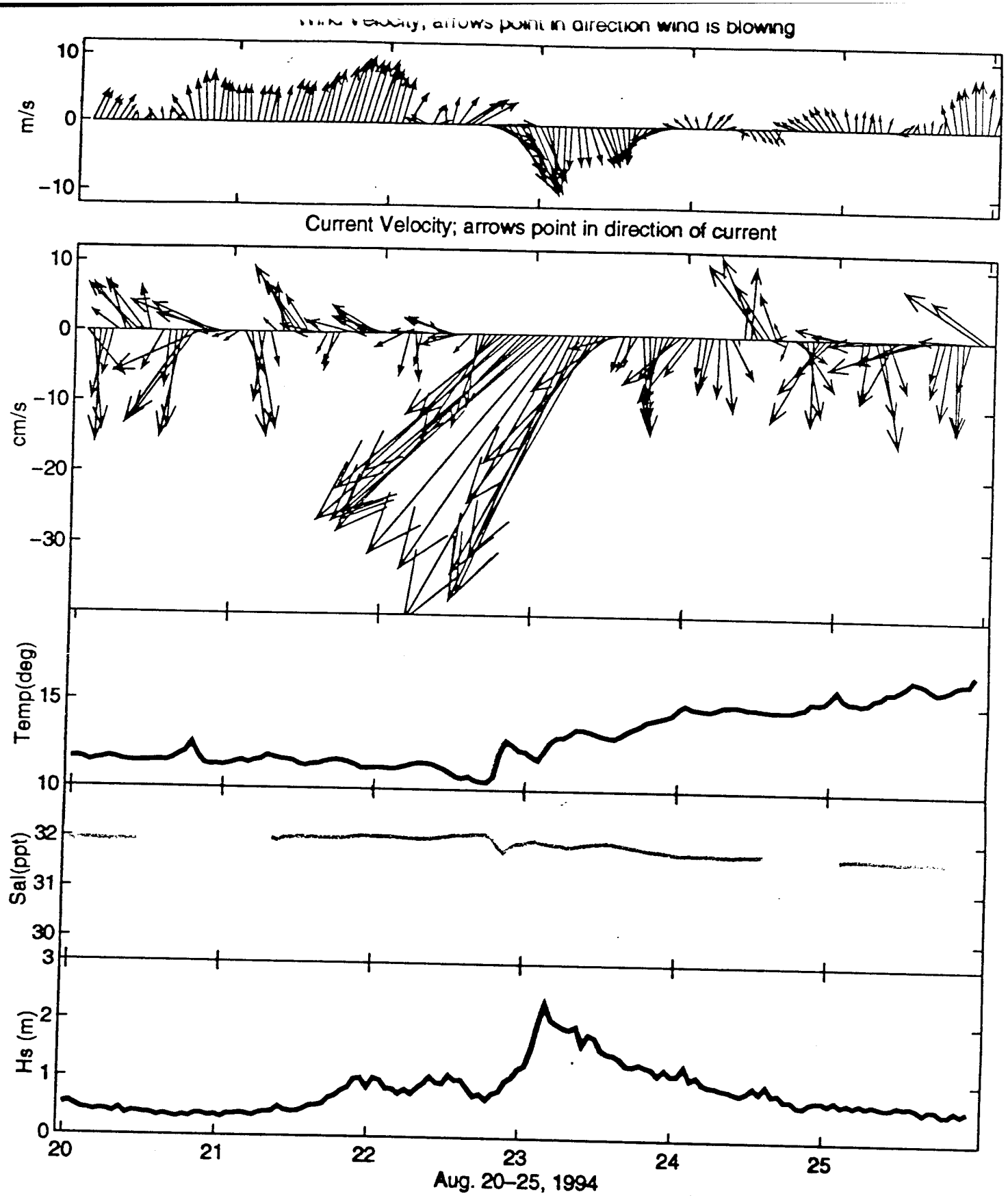
72 W

73 W

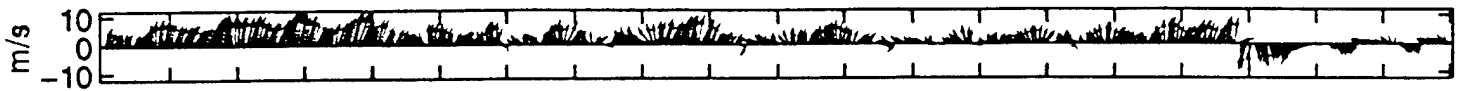
74 W

75 W

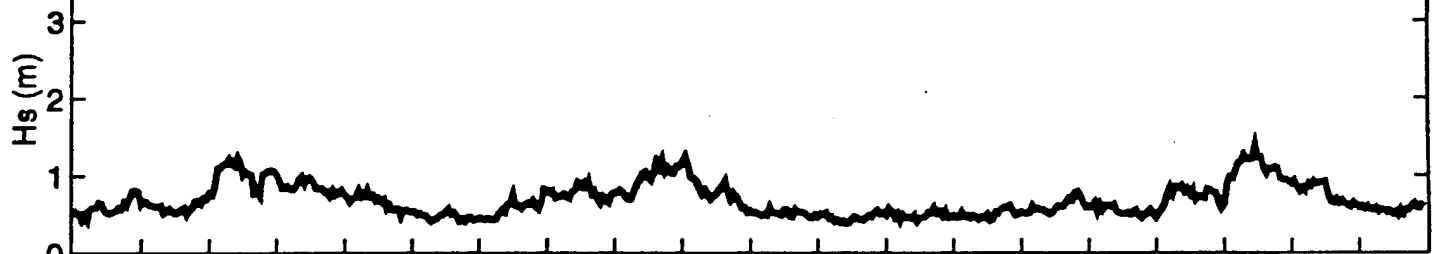
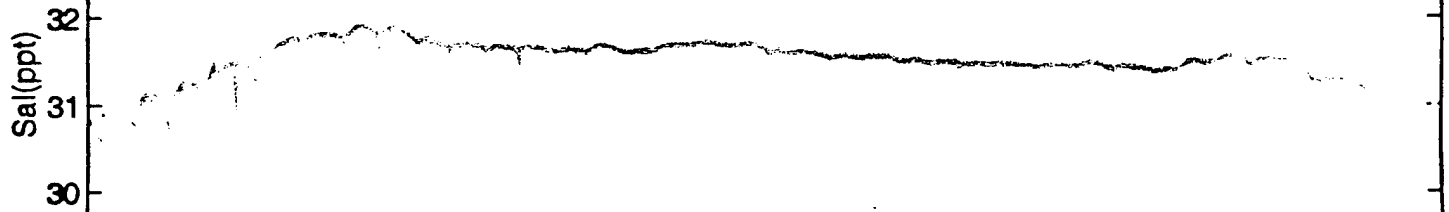
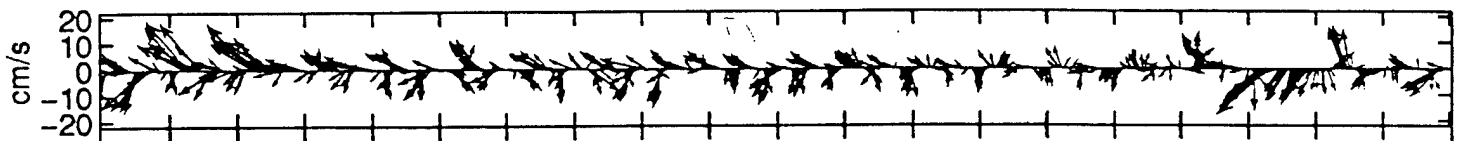




Wind Velocity; arrows point in direction wind is going



Current Velocity; arrows point in direction of current



July 20-Aug. 8, 1994

July 21, 1994  
13:09 GMT

41 N

40 N

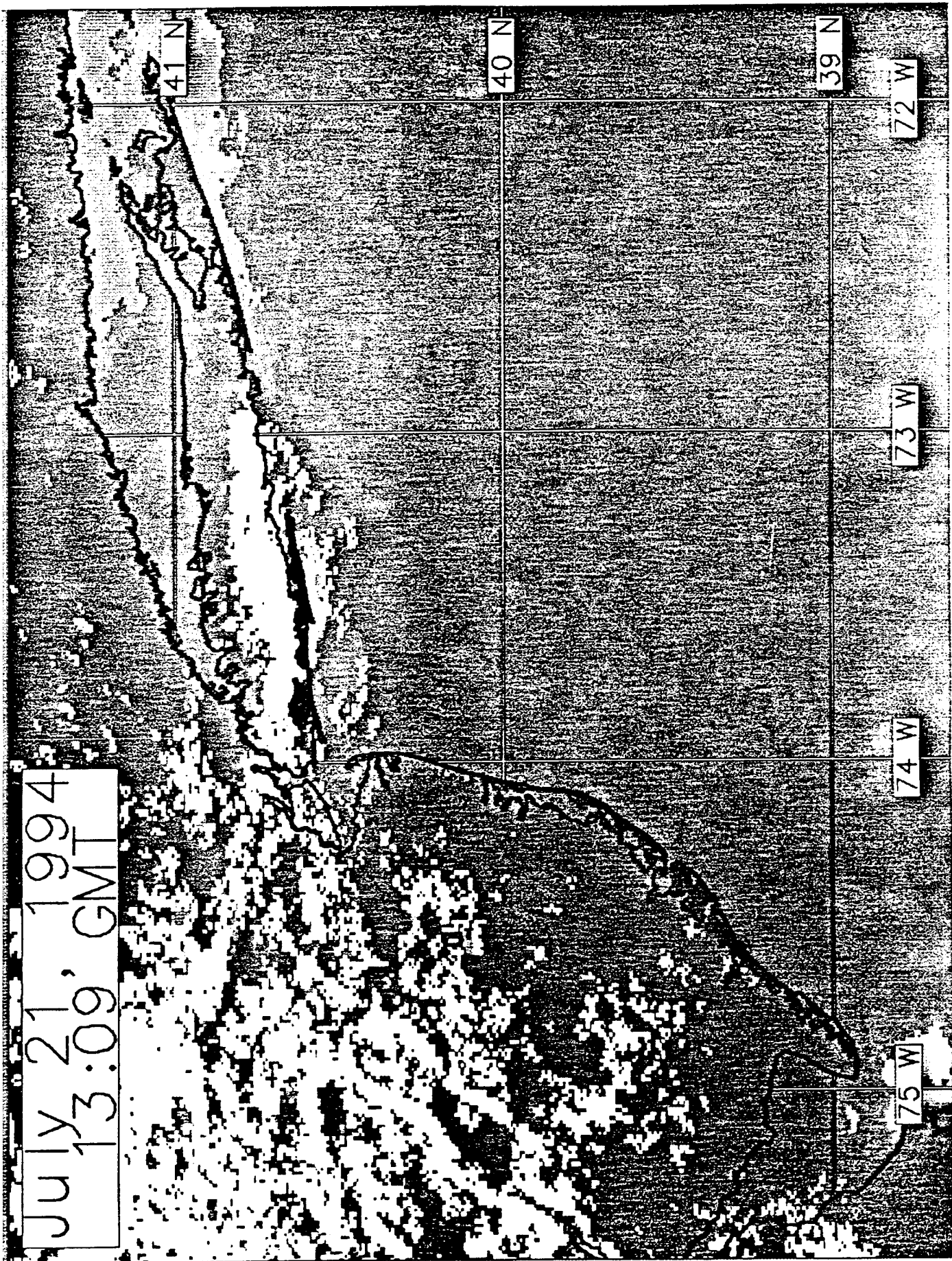
39 N

72 W

73 W

74 W

75 W



July 23, 1994  
00:08 GMT

41 N

40 N

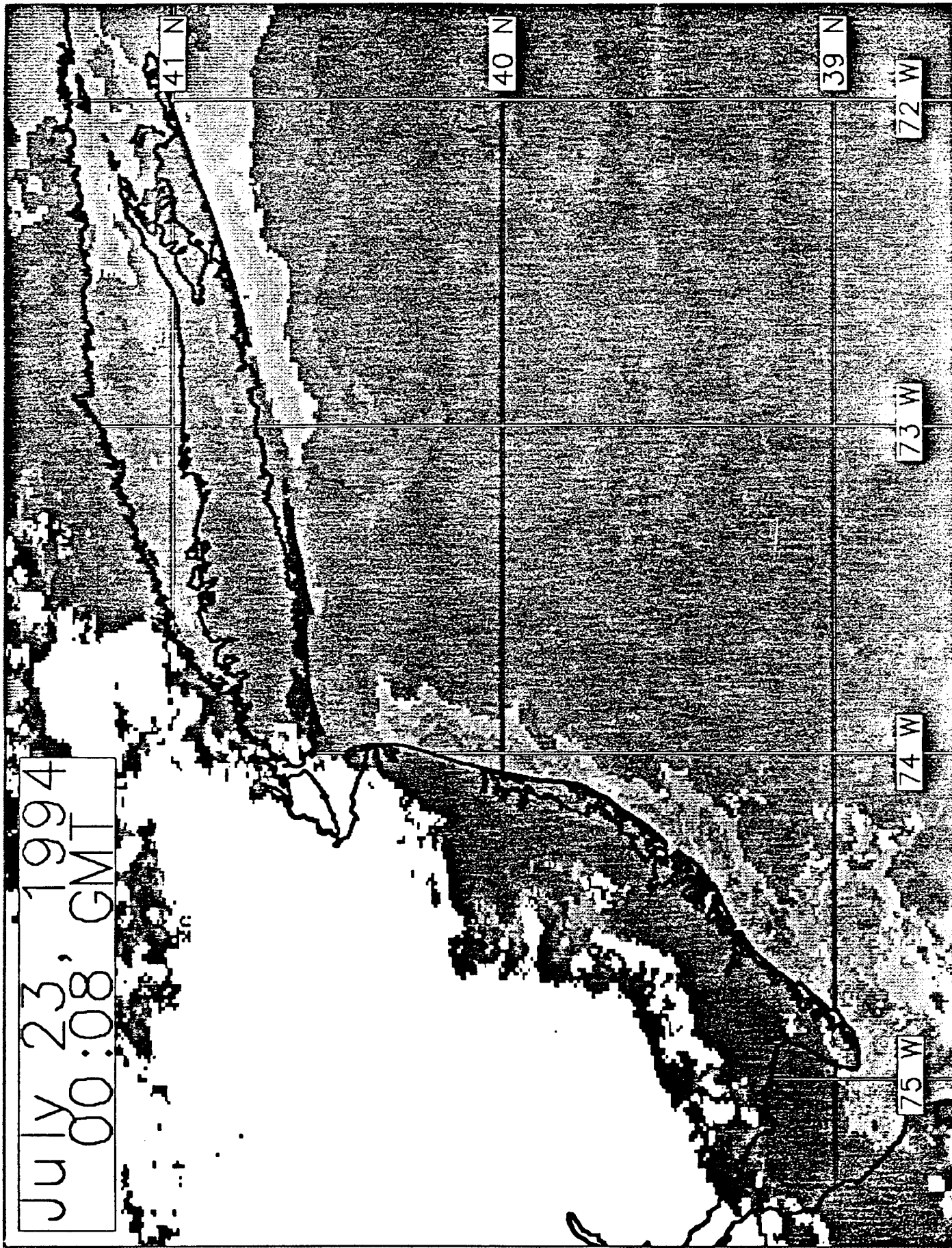
39 N

72 W

73 W

74 W

75 W



July 25, 1994  
09:46 GMT

41 N

40 N

39 N

72 W

73 W

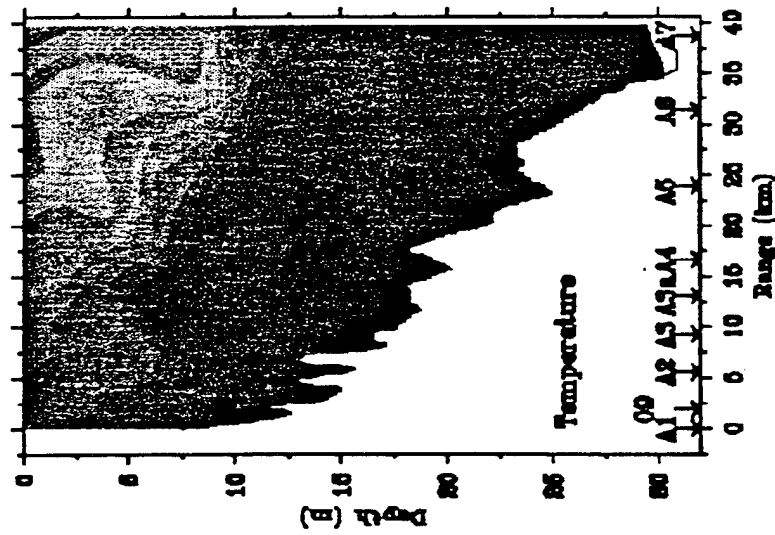
74 W

75 W



Instructions of Marine and  
Coastal Engineers

July 25, 1994  
09:46 GMT



WS 3.7 m/s  
WD 188 deg.  
CS 21.1 cm/s  
CD 85 deg.  
T 11.0 C  
S 31.7 ppt  
Hs 0.5 m  
Tp 6.5 sec  
OBS no data

SSW 3  
SSW 7  
SSW 9  
SSW 8  
S 5

40 N

39 N

74 W

75 W

Aug 08, 1994  
21:40 GMT

41 N

40 N

39 N

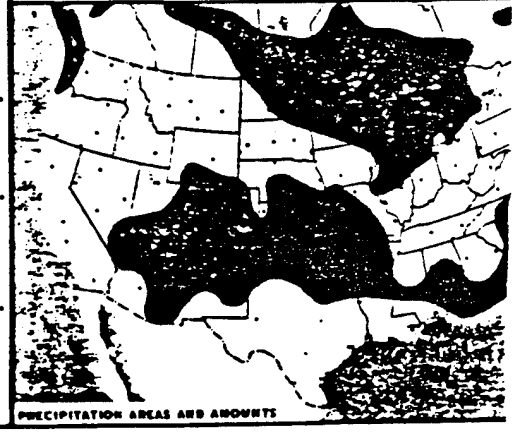
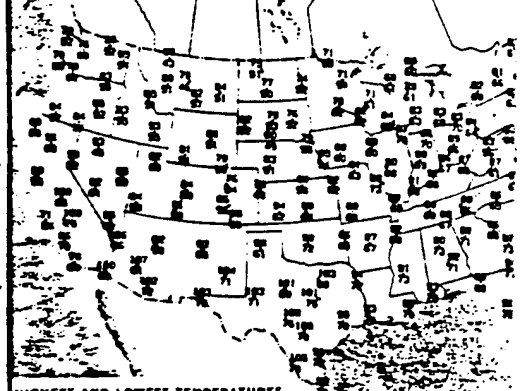
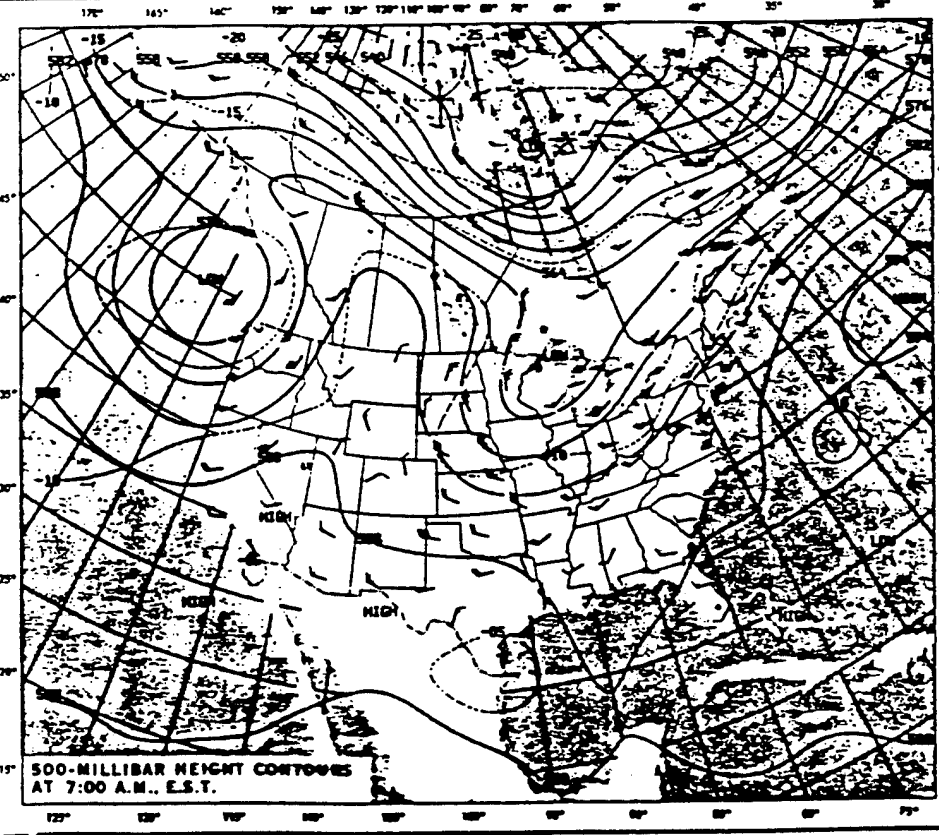
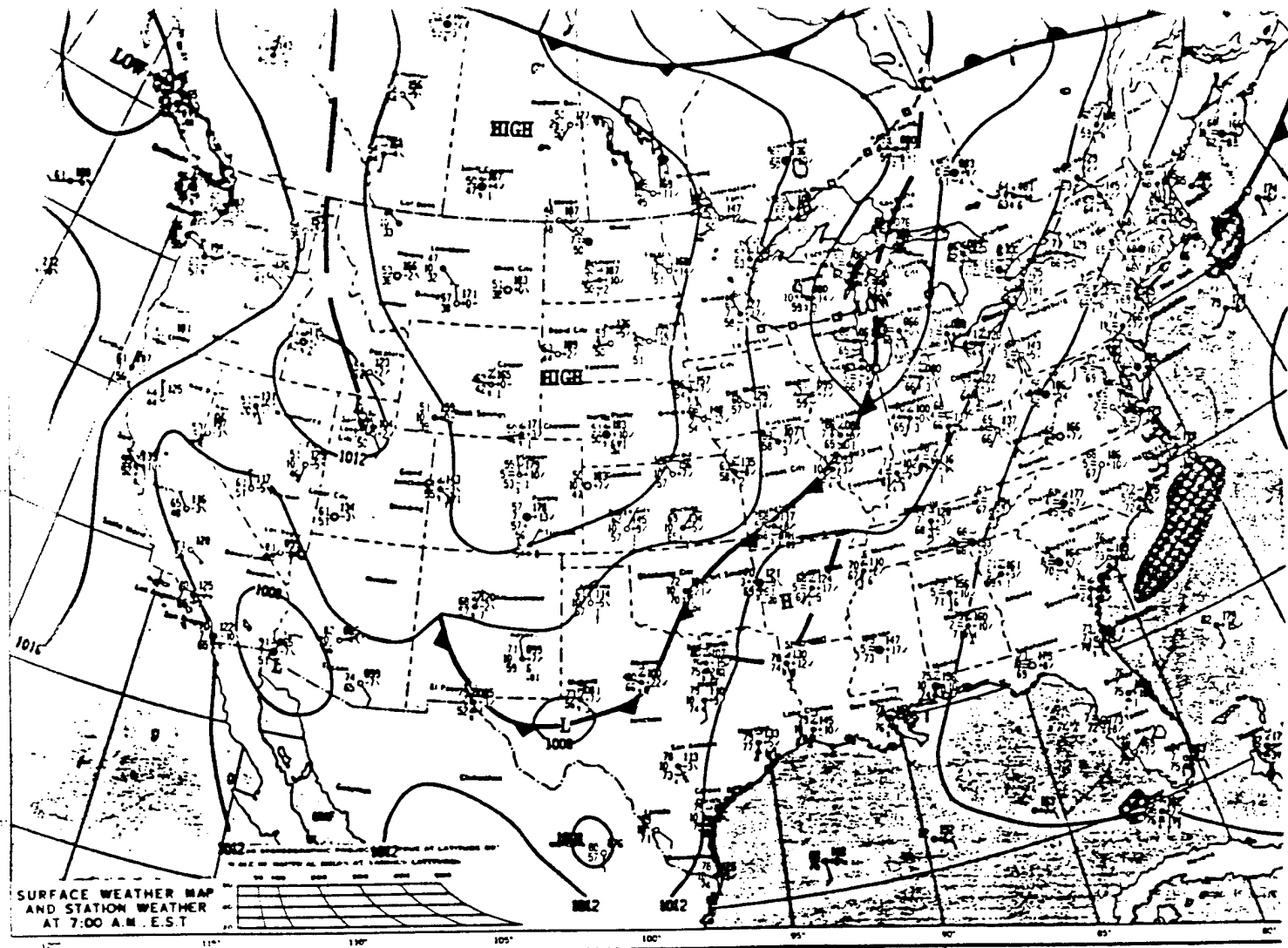
72 W

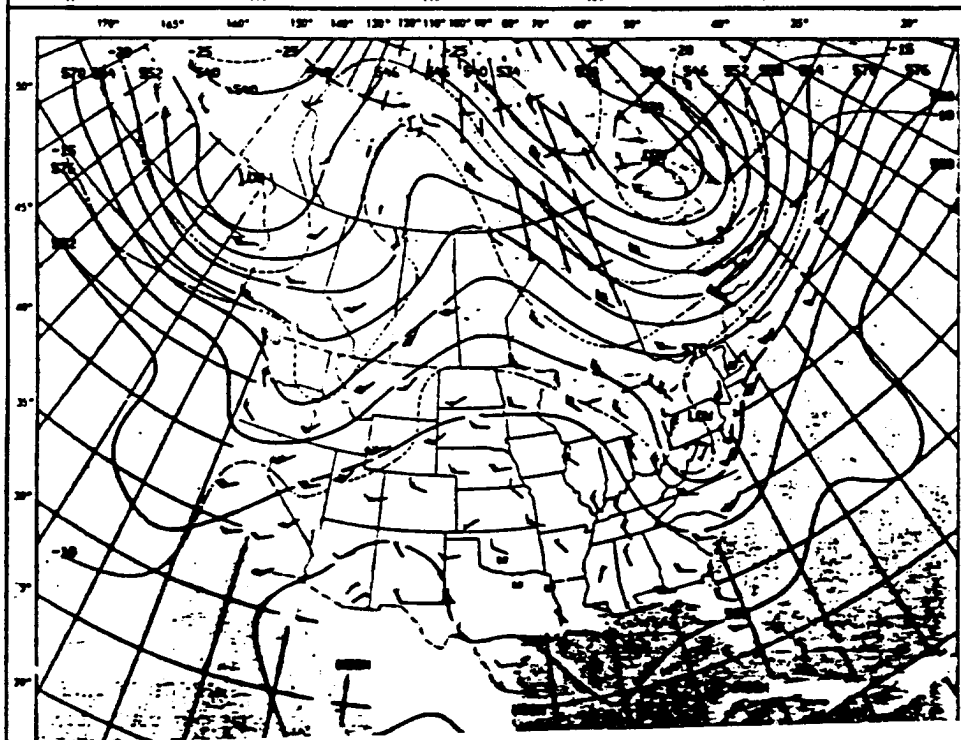
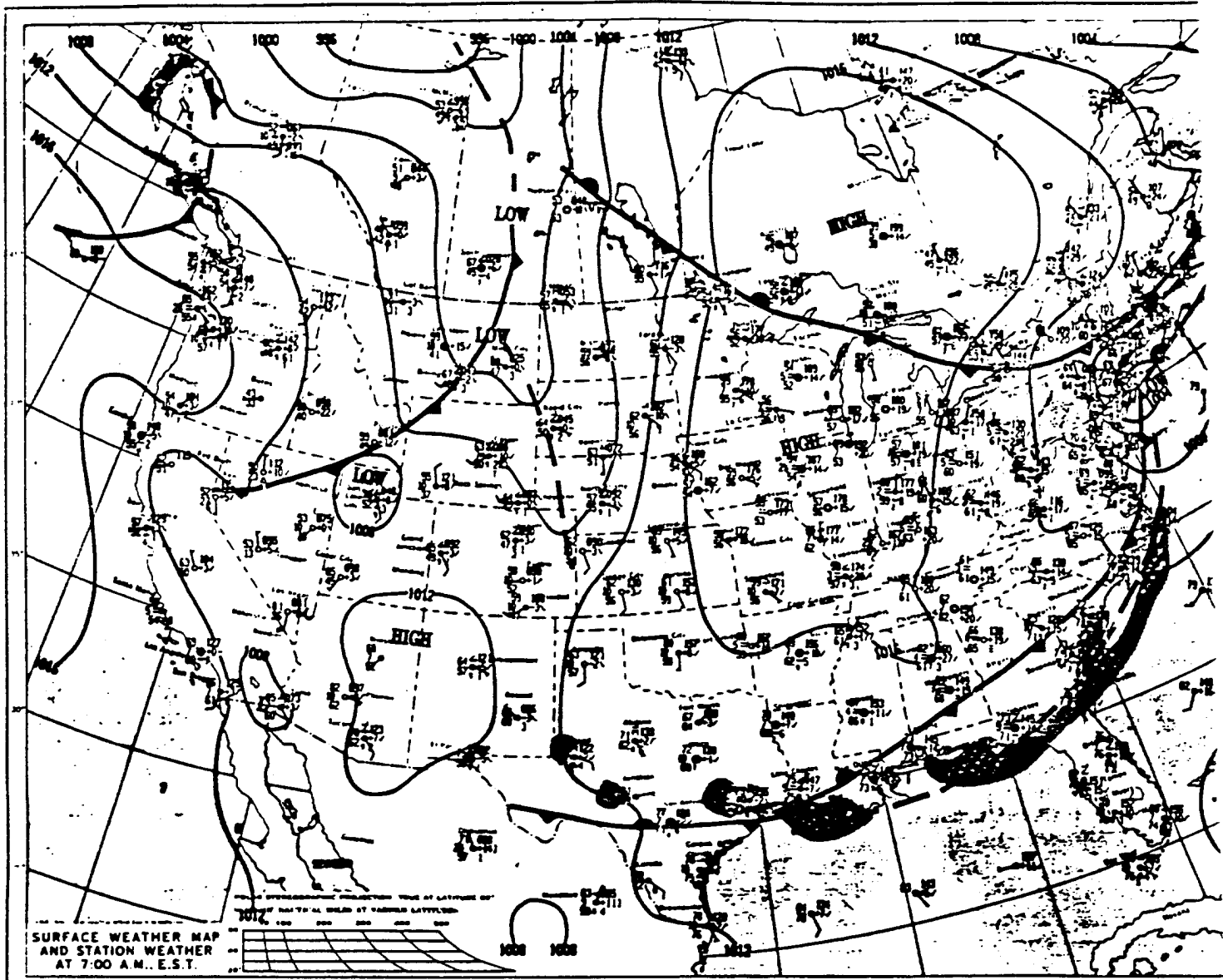
73 W

74 W

75 W

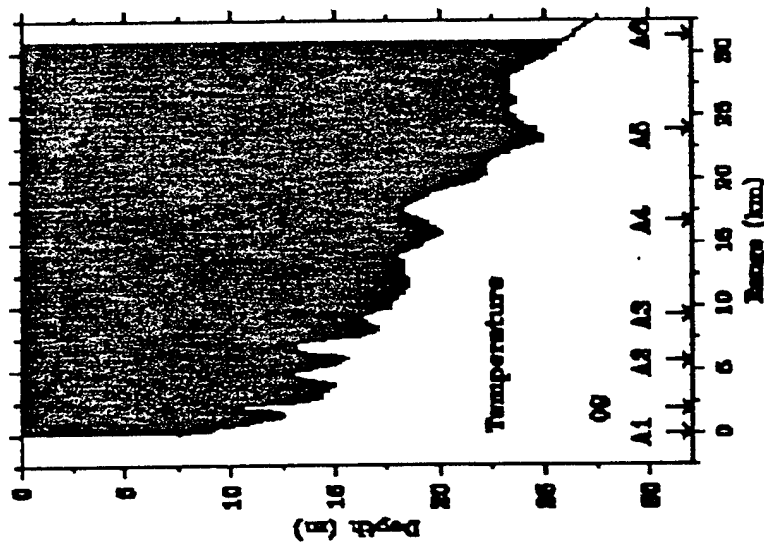






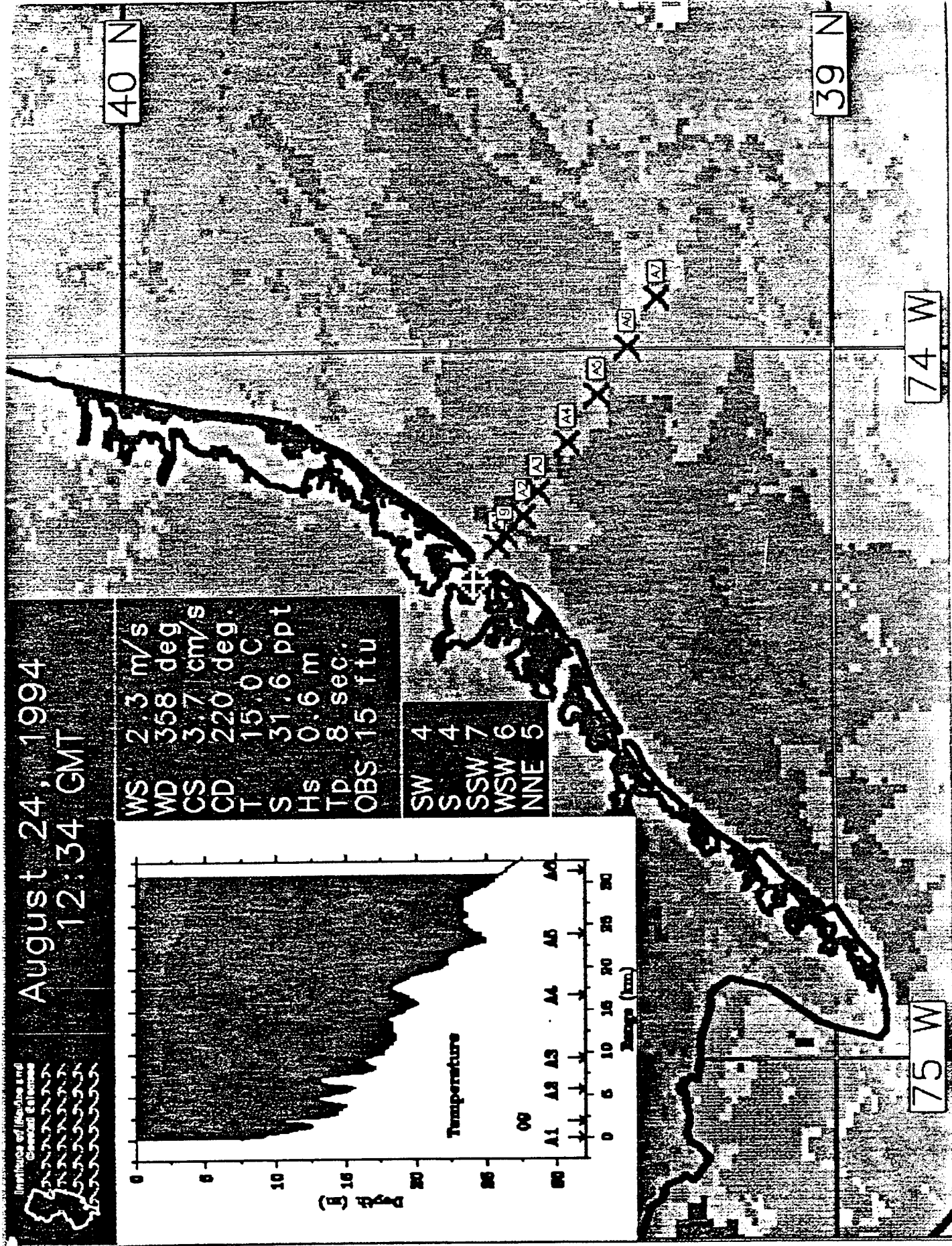


August 24, 1994  
12:34 GMT



WS 2.3 m/s  
WD 358 deg  
CS 3.7 cm/s  
CD 220 deg  
T 15.0 C  
S 31.6 ppt  
Hs 0.6 m  
Tp 8 sec  
OBS 15 ftu

SW 4  
S 4  
SSW 7  
WSW 6  
NNE 5





*Coastal Scene Description*  
**Ocean Expert System**

**Amphibious Assault Scene Description Status**

**Stephen A. Mack  
Lien T. Duong  
David J. Scheerer**

**CSD Mini-Workshop  
APL/UW  
Seattle, Washington**

**14 February, 1995**



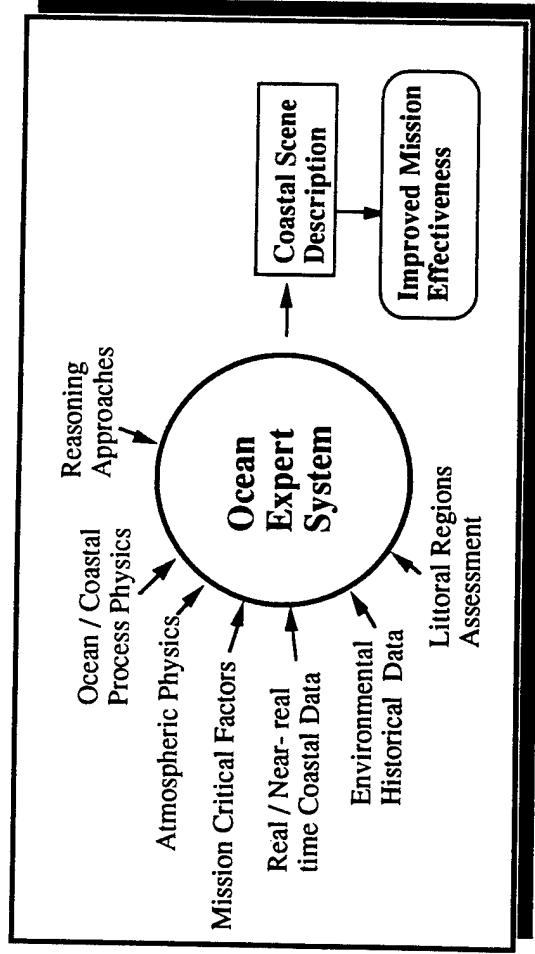
# Topics

## **OES UPDATE:**

- OES Project Objectives / Approach
- Amphibious Assault Scenario
- Important Coastal Processes: Upwelling; Fog; Sea Breeze; Surf ....
- Ocean Expert System Strawman Description
- Use of HyperText Markup Language (HTML)
- Narrative and Qualitative Description
- Upwelling / Fog: Sample World Regions

**STATUS OF REGIONAL ATMOSPHERIC MODELING SYSTEM  
(RAMS) - C.E. Schemm and L.P. Manzi**

# Coastal Scene Description Ocean Expert System



## Objectives

- Provide mission dependent description of coastal environmental "scene" to enhance tactical decisions and mission effectiveness
- Provide the technology to support and implement the coastal scene description

## Deliverables

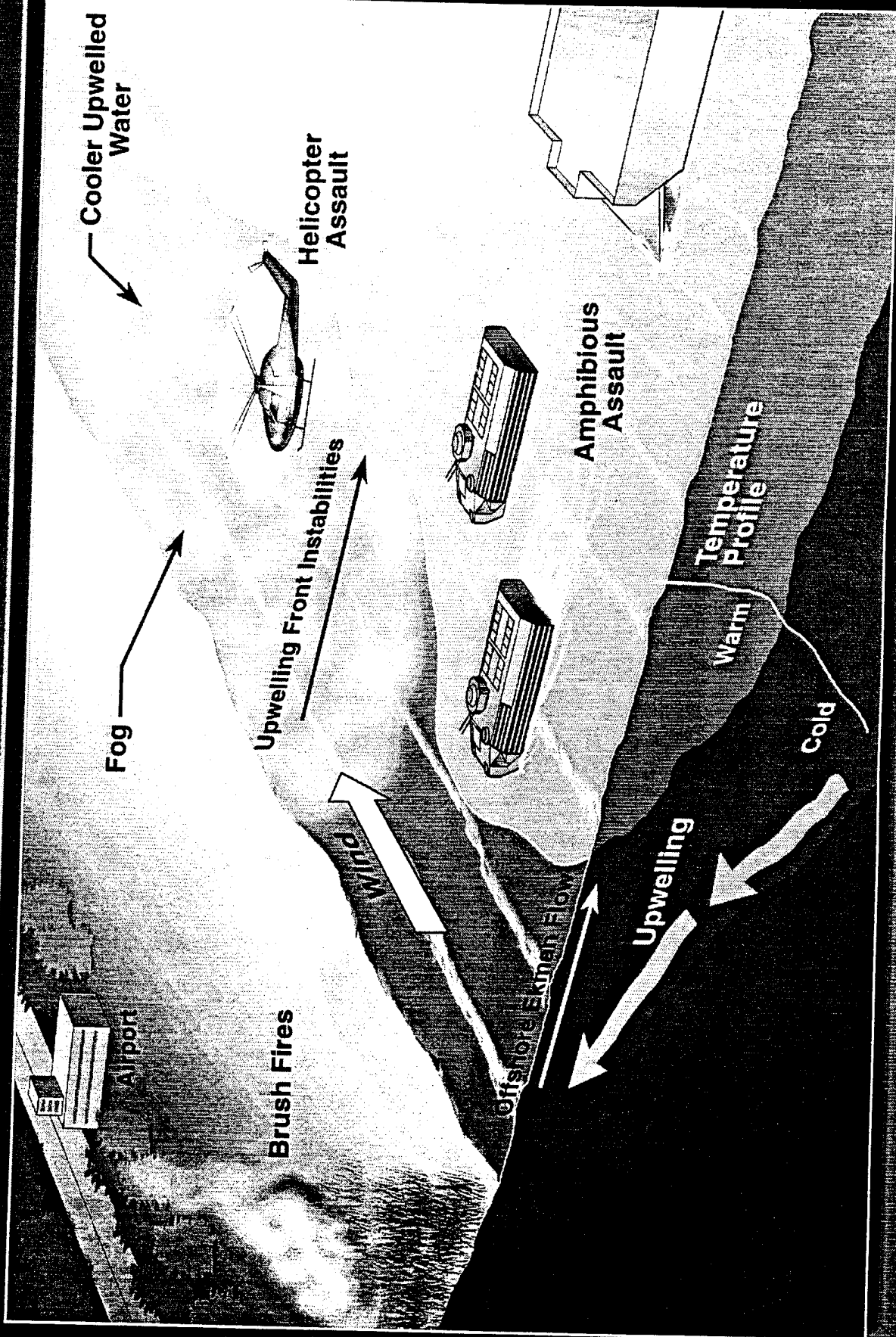
- Periodic computer-based demonstrations showing increasing functionality in individual components and integrated system
  - FY94: Reasoning Tools, Envir. Data Bases, Display
  - FY95: Amphibious Assault Process Physics (Upwelling, Fog)
  - FY96: Mine Countermeasures
- Reports providing periodic assessments on importance of coastal processes in key foreign littoral regions
- Quarterly and Annual Status Reports, Technical Papers

## Approach

- Use mission to focus attention on coastal environmental critical factors
- Represent dominant oceanic and atmospheric processes which determine the critical environmental parameters
- Use expert system tools to unite process physics with real-time measurements and historical databases
- Focus on tactical decision maker who will use coastal scene description to enhance mission planning and execution

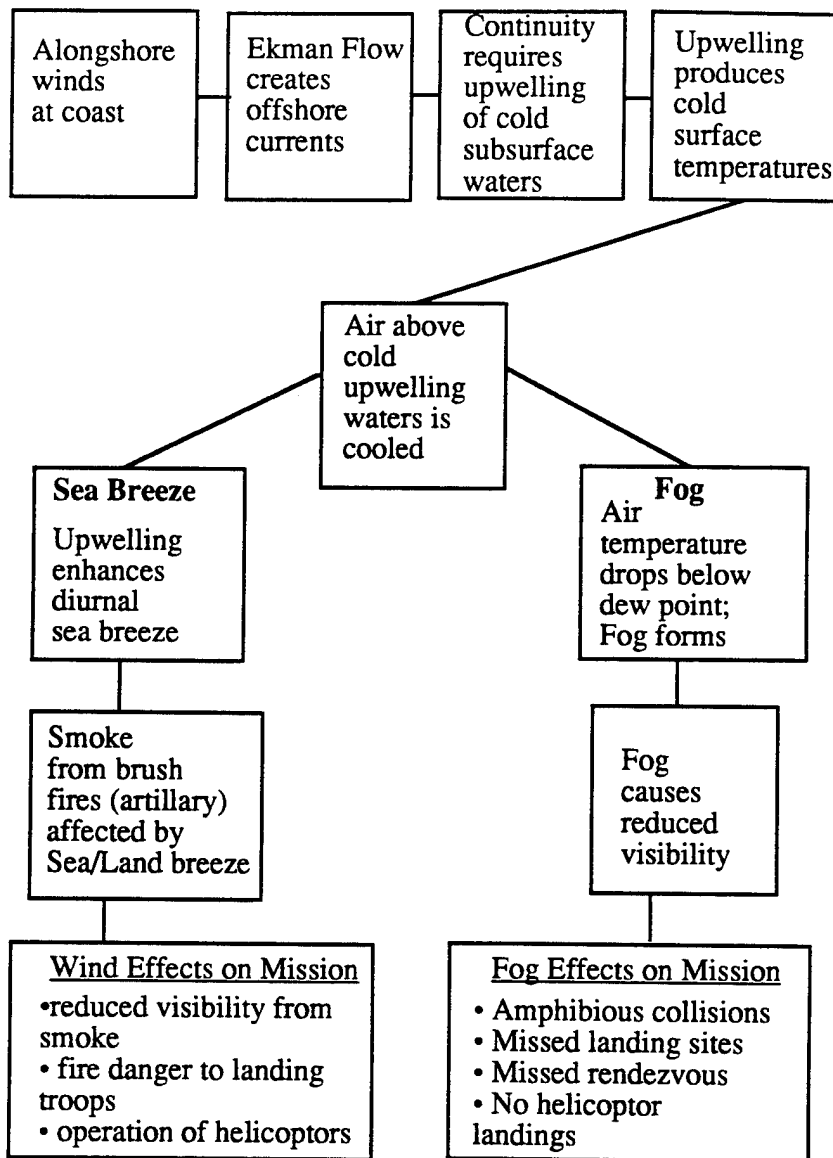


# Coastal Scene Description Amphibious Assault Upwelling/Fog



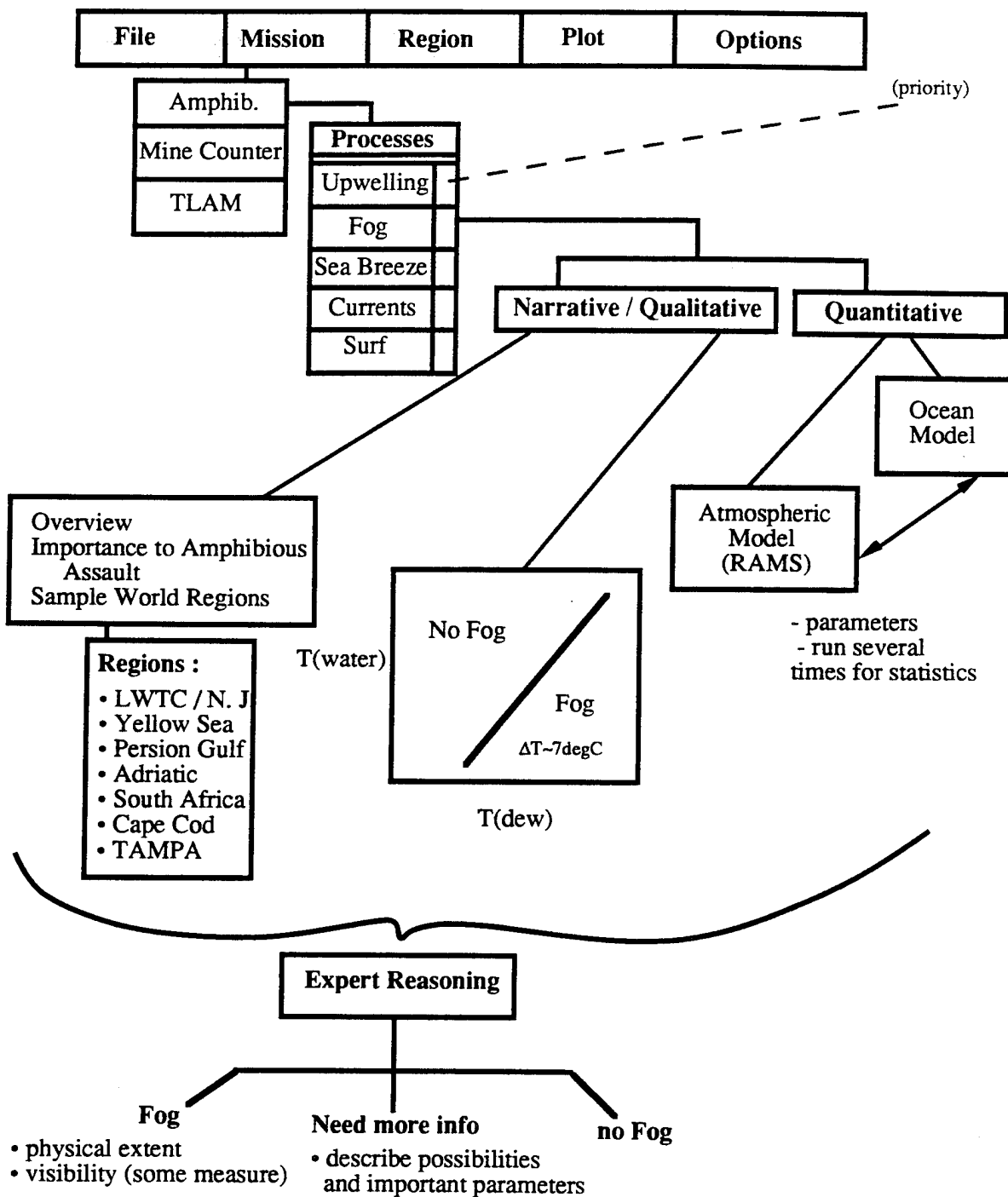


**Relationship of Atmospheric and Oceanographic  
Processes to  
Amphibious Assault Mission;  
Coastal Upwelling / Fog / Sea Breeze**



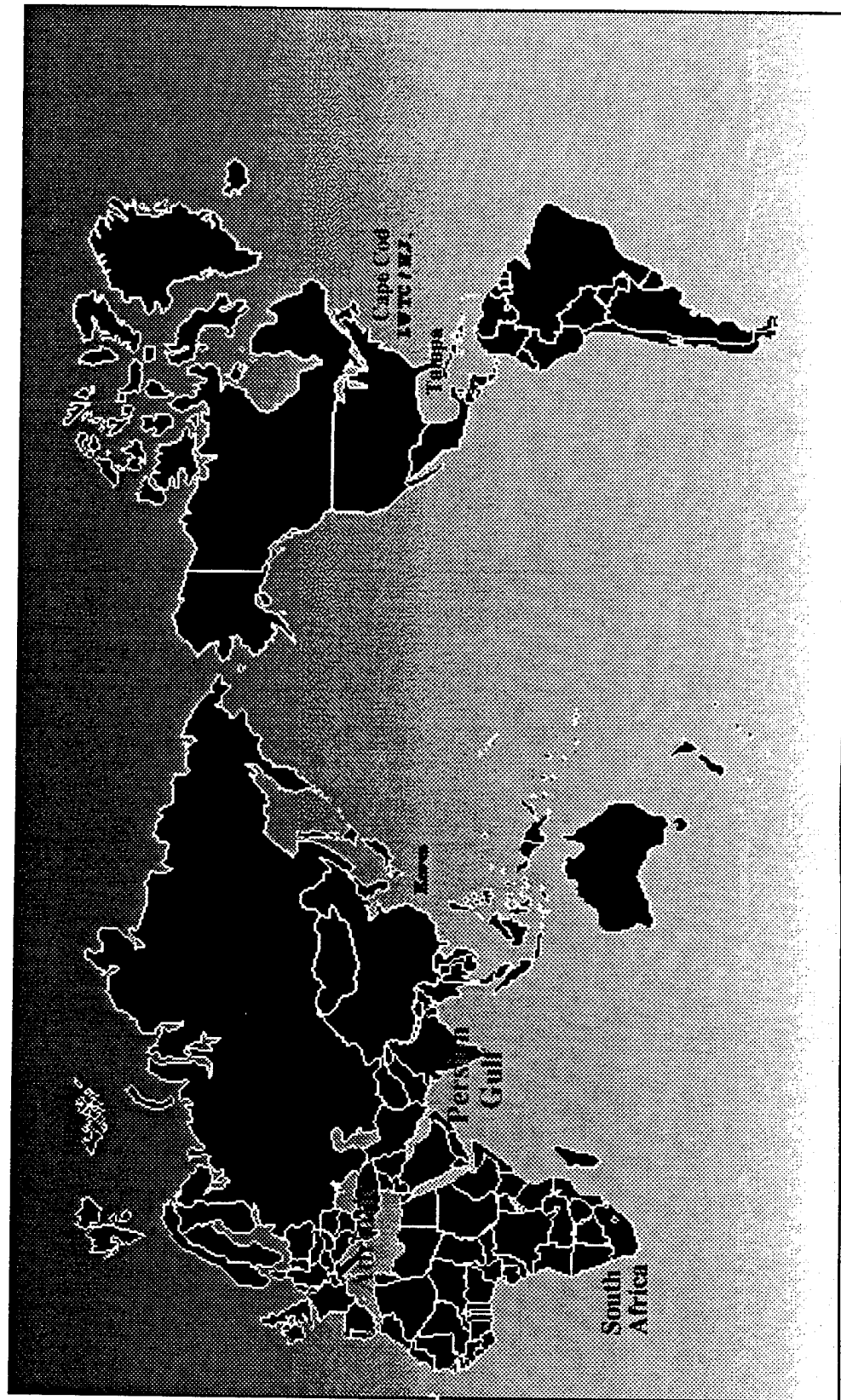


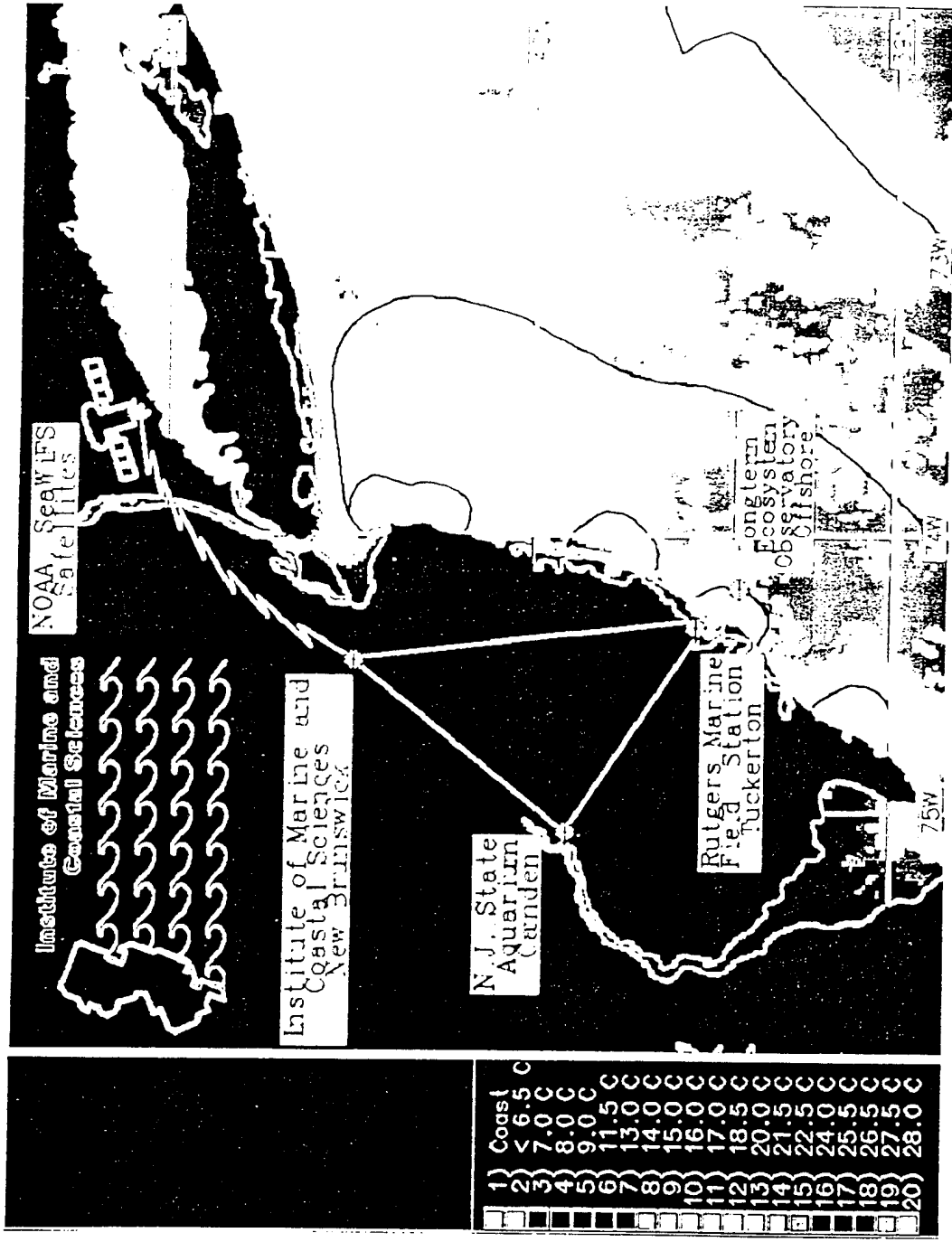
# Coastal Scene Description Ocean Expert System





*Coastal Scene Description*  
Ocean Expert System  
World Map Menu (Upwelling / Fog)

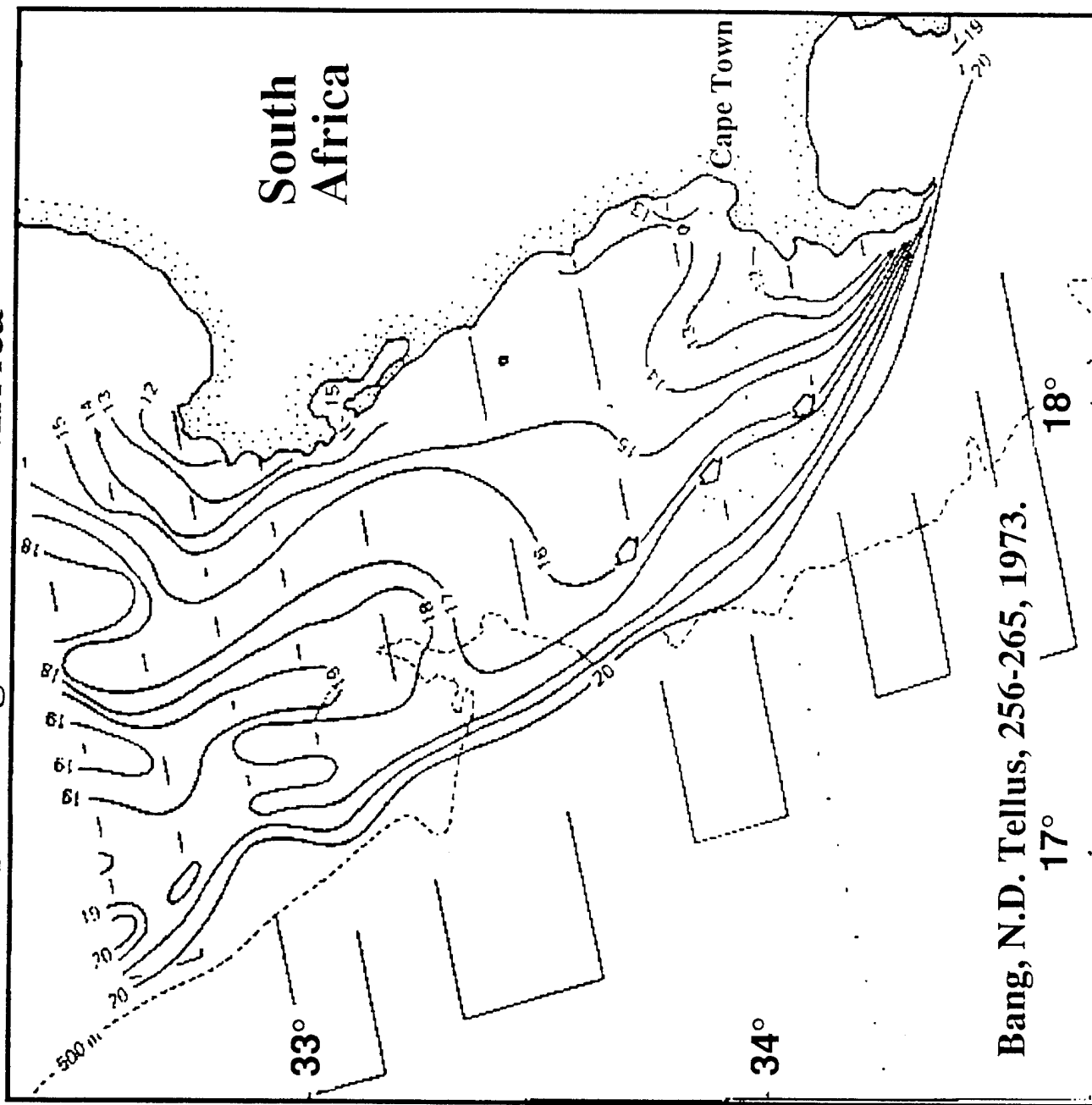




from :S.M. Glenn



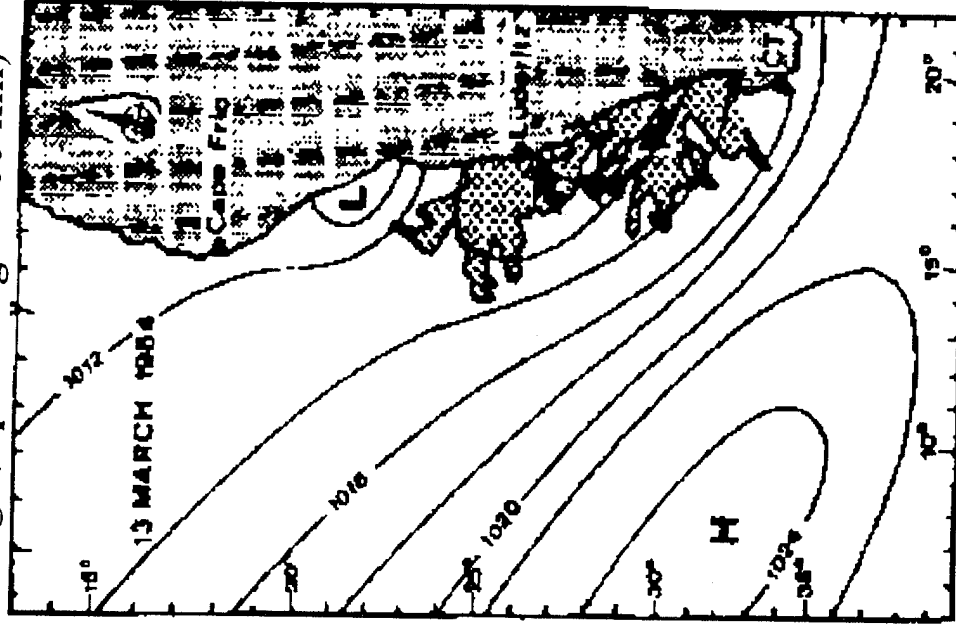
## Upwelling off South Africa



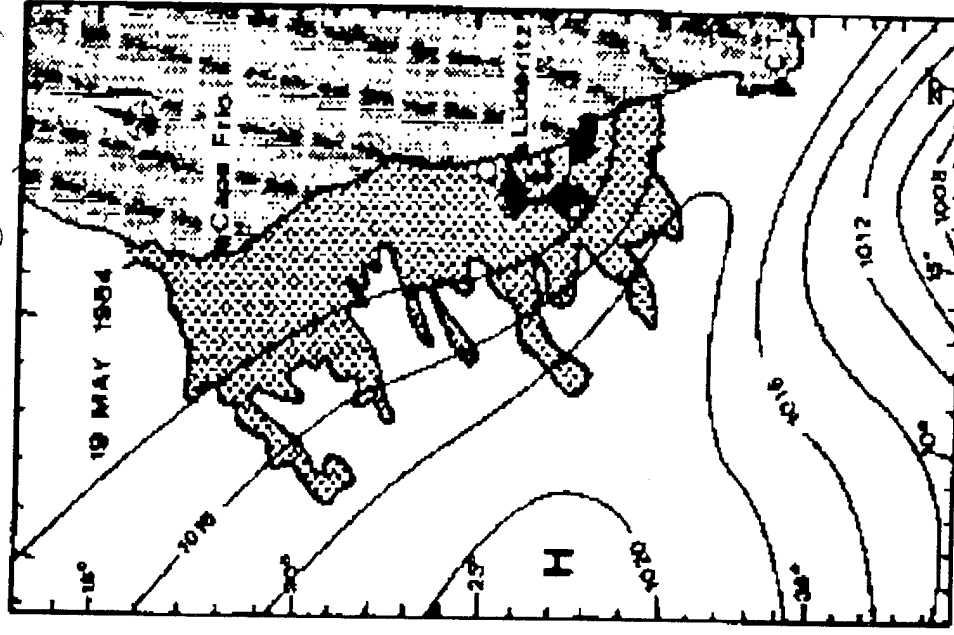


## Upwelling & Fog (West Coast of S. Africa)

Fog (Upwelling < 200 km)



No Fog (Upwelling > 200km)

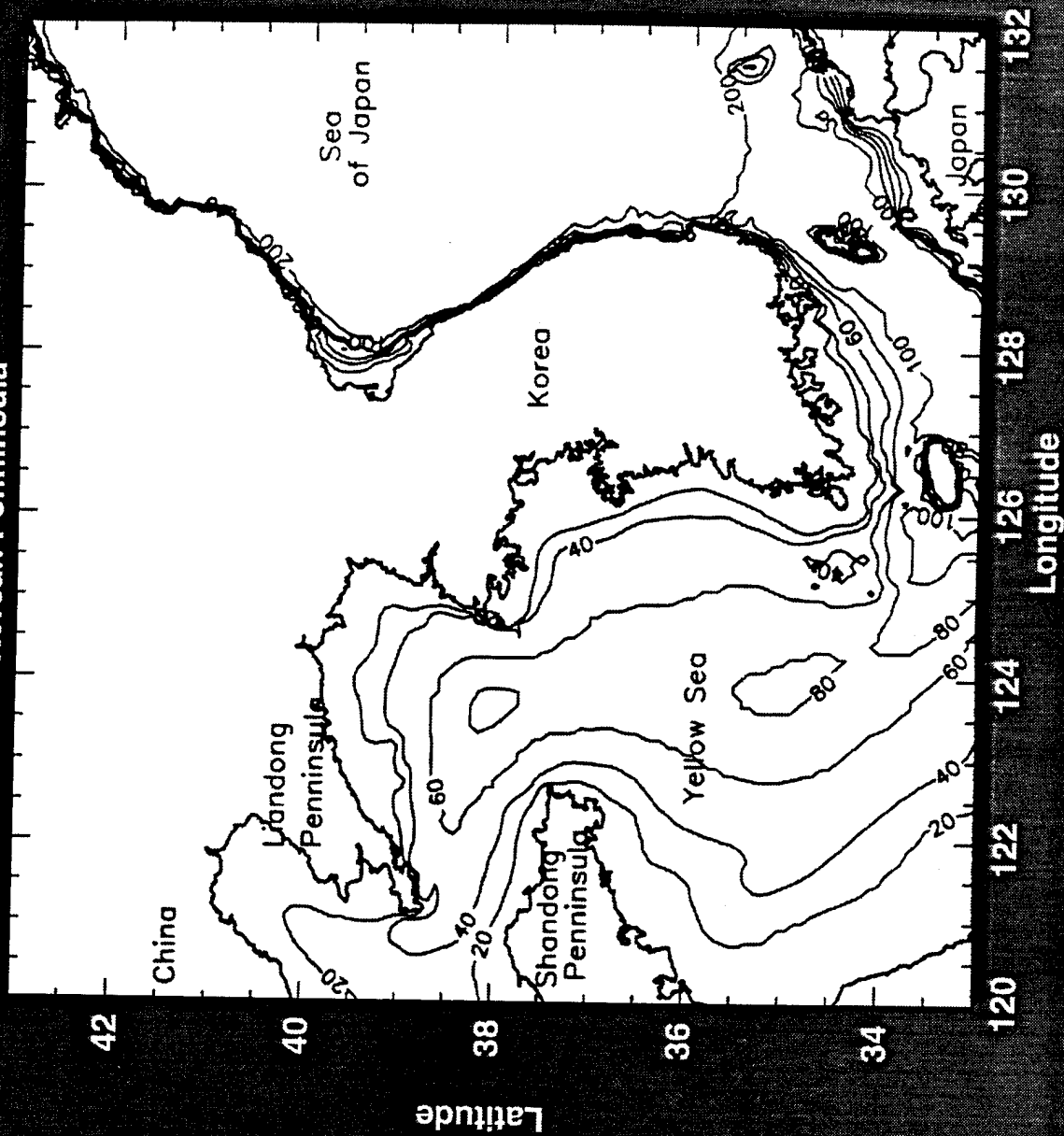


Oliver, J., and P.L. Stockton, "The Influence of Upwelling Extent Upon Fog Incidence at Luderitz, Southern Africa," International J. of Climatology, 9, 69-75.



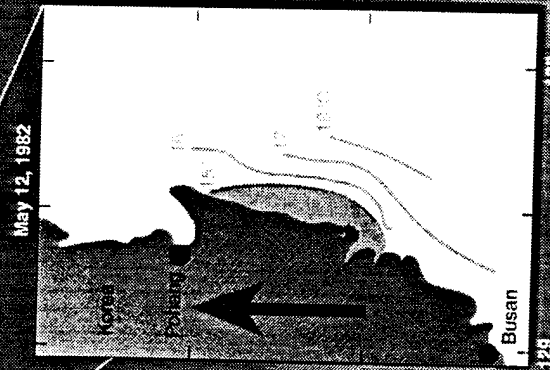
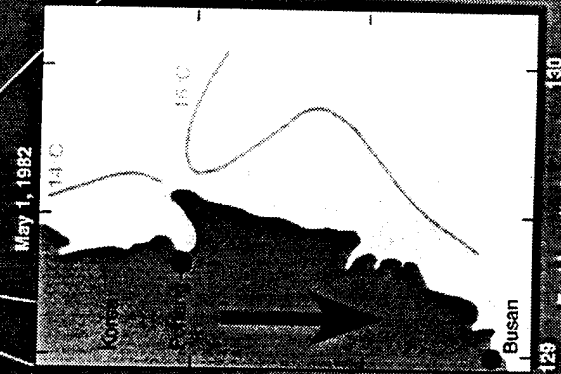
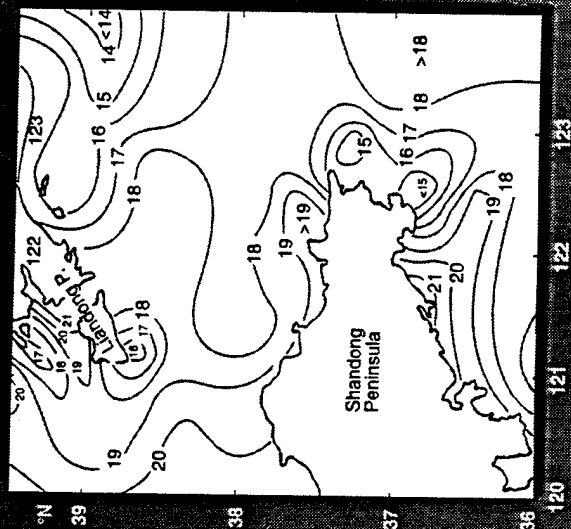
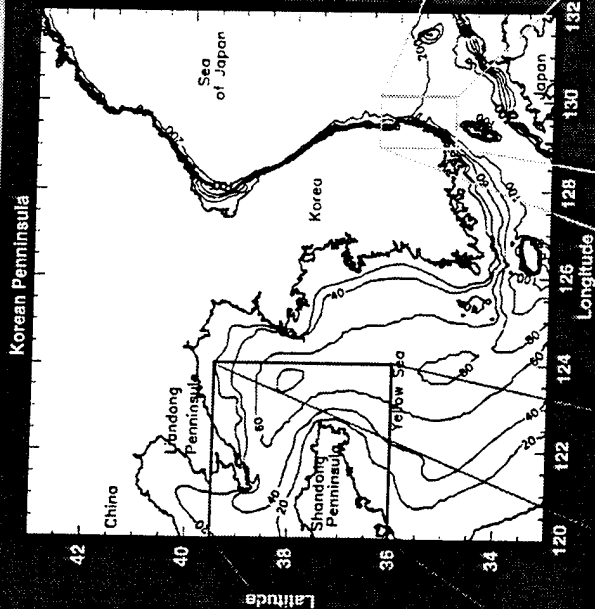
# Korea: Upwelling/Fog

## Korean Peninsula





# Korea: Upwelling/Fog



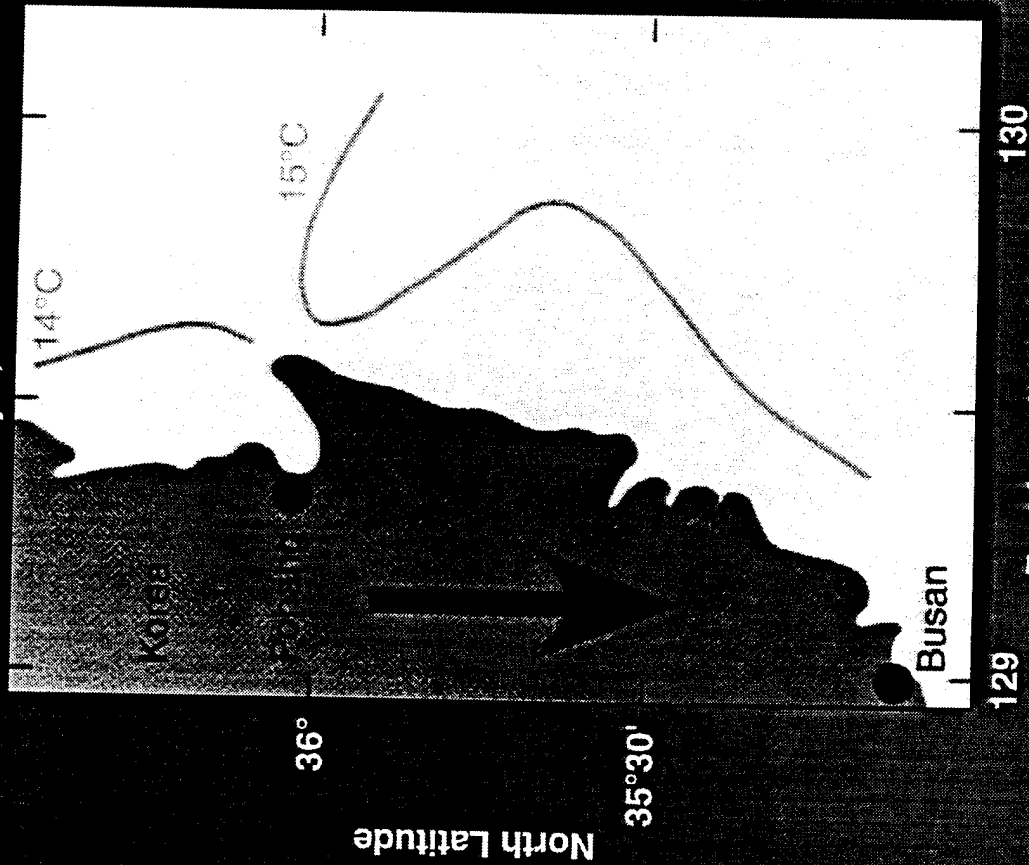
(From Guo and Zia, 1984, p. 123)

Adapted from Bryn and Baum, 1984

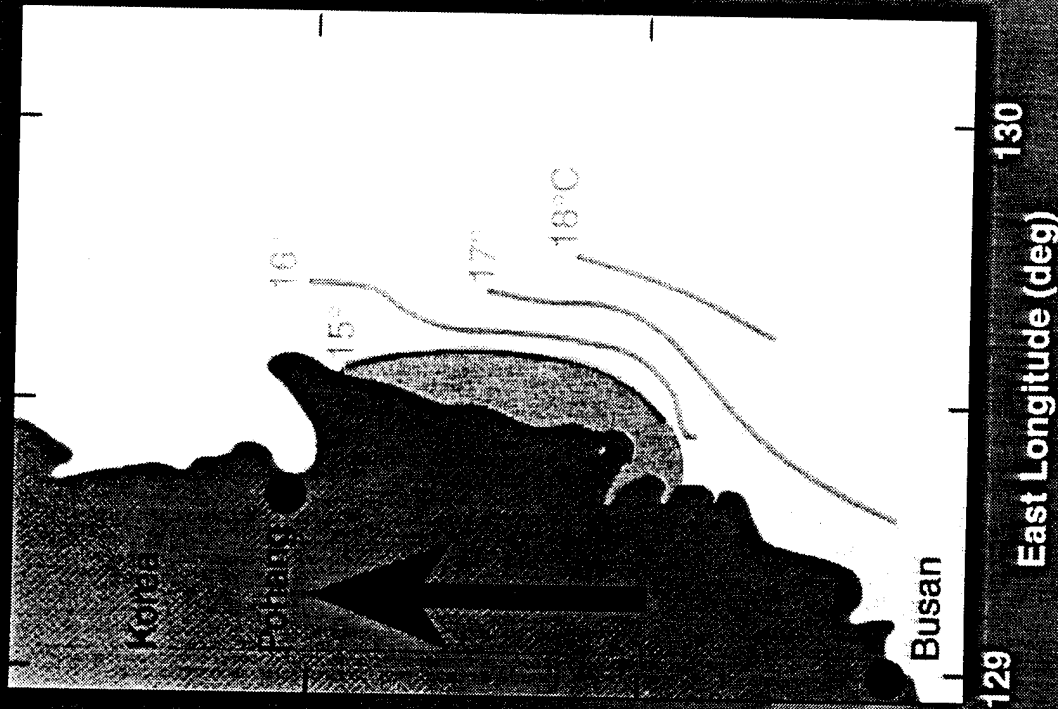


# Upwelling Off South Korea

May 1, 1982



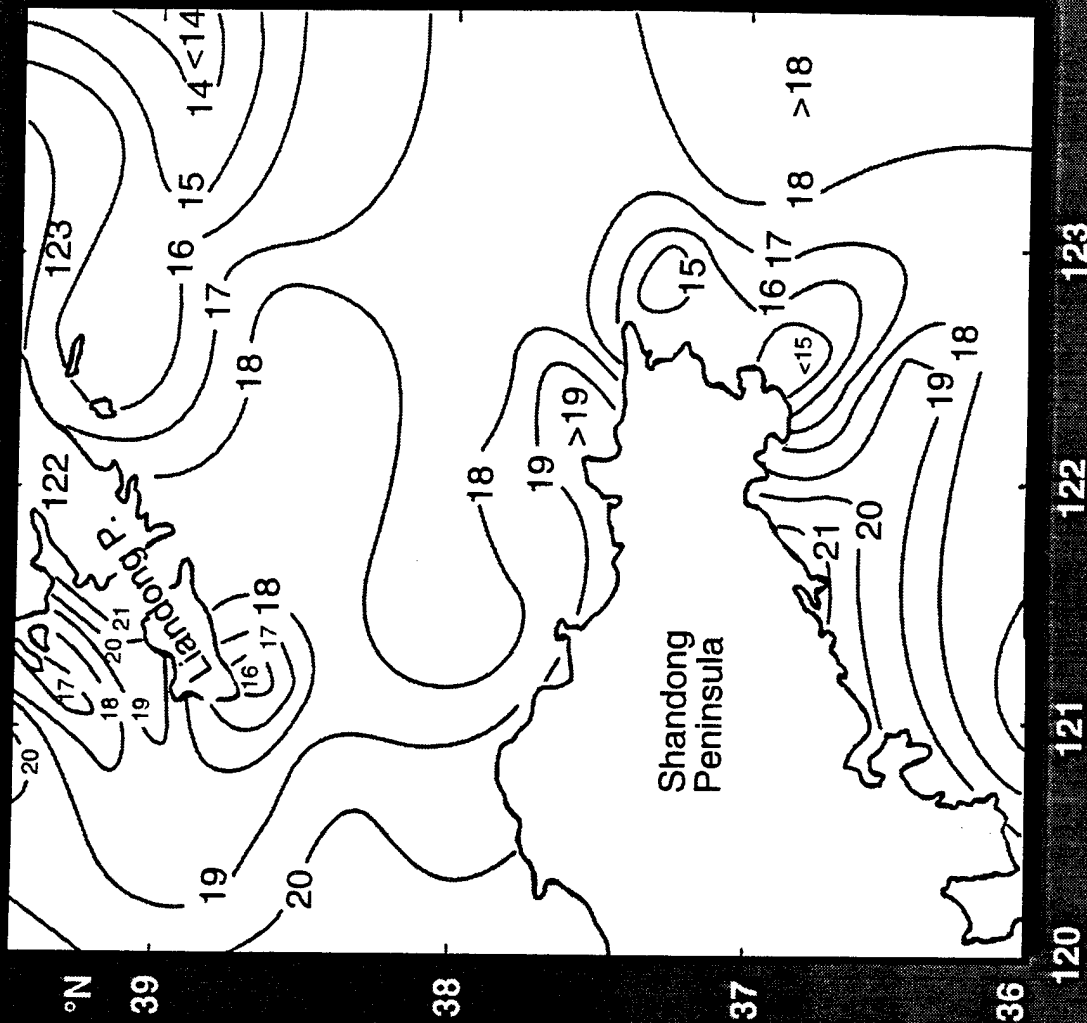
May 12, 1982



(Adapted from Byun and Seung, 1984)

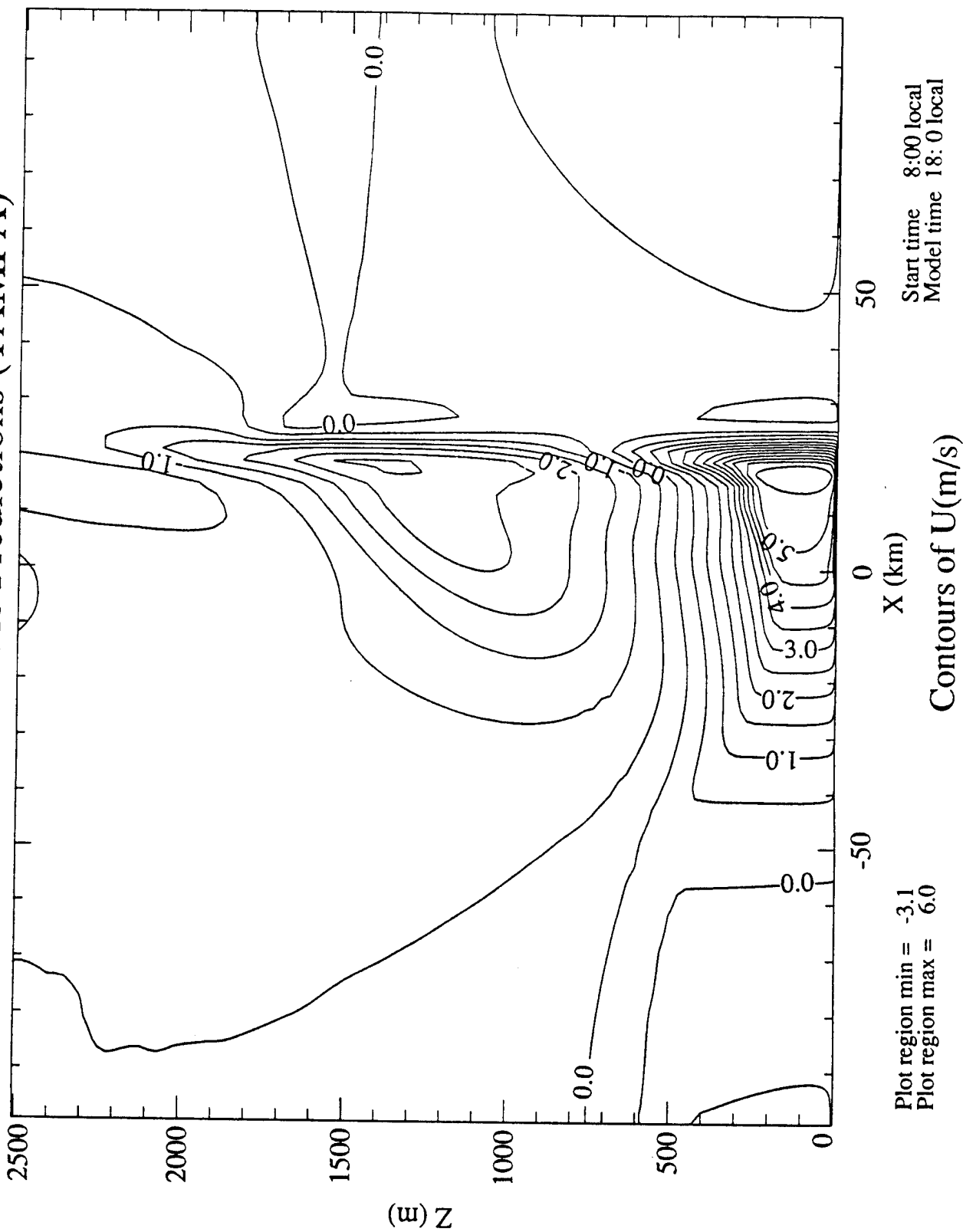


# Upwelling in Yellow Sea



( From Guo and Zia, 1984, p. 124)

# RAMS Sea Breeze Predictions (TAMPA)





# Summary

- **Work in progress for user friendly description of mission critical ocean and atmospheric environmental conditions for Amphibious Assault**
- **Scene description should include:**
  - **Narrative / Qualitative Description (Mission Relevant)**
  - **Quantitative Predictions from Ocean and Atmospheric Models**
  - **Expert Reasoning to handle scene description when detailed modeling not available due to lack of model or necessary input parameters**
- **OES scene description currently accesses sample embedded information / data on host computer but can access remote data via internet or Def. Sim. Internet - (e.g. Rutgers AVHRR images, or CTD data)**
- **HyperText Markup Language valuable for hardware independent display of local or remote data. Should be host computer independent.**
- **Will refine contents of OES and incorporate RAMS predictions.**
- **Install and integrate on SGI hardware at NRL/Stennis**

# THE REGIONAL ATMOSPHERIC MODELING SYSTEM (RAMS)

by

C. E. Schemm  
L. P. Manzi

## COASTAL SCENE DESCRIPTION MINI-WORKSHOP

Applied Physics Laboratory  
University of Washington  
Seattle, Washington

14 February 1995



## OBJECTIVES

- Provide Capability to Predict Atmospheric Conditions Important to the Formation of Fog in the Marine Boundary Layer & Adjacent Coastal Areas
  - » fully integrated in OES
  - or
  - » off-line with scenarios run to provide needed information
- Provide Capability to Predict Meteorological Variables (e.g., Surface Winds, Heat and Moisture Fluxes) Needed to Drive Regional Ocean Models

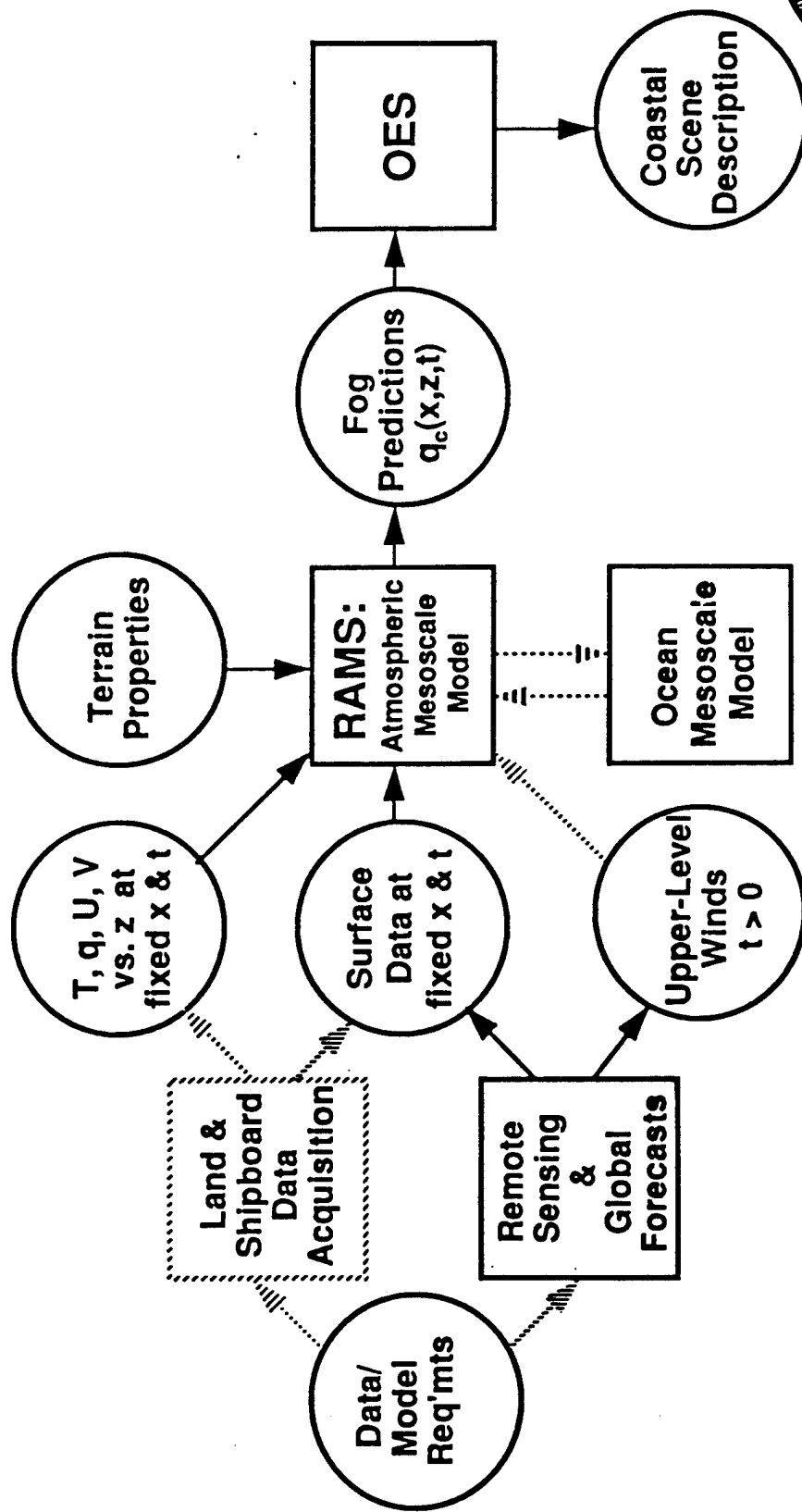


## APPROACH

- USE COLORADO STATE UNIVERSITY REGIONAL ATMOSPHERIC MODELING SYSTEM (RAMS)
- CARRY OUT SERIES OF CHECKOUT/VALIDATION RUNS
  - 2- and 3-D versions of RAMS
  - Investigate mesoscale phenomena of interest
    - » land/sea breeze cycle
    - » mountain/valley winds
    - » cloud & fog formation
  - compare with data & with analytical model solutions
  - test sensitivity to gridpoint resolution, initialization, boundary conditions, etc.
- FOCUS ON INITIAL DEMONSTRATION
  - Mid-Atlantic Bight



## Possible Operational Model Scenario



## OUTLINE

- DESCRIPTION OF RAMS
- SAMPLE CALCULATIONS
  - Sea Breeze, Flat Terrain (Tampa, FL)
  - Mountain/Valley Winds (Bell-Shaped Mountain)
  - Cloud Generation
- PLANNED FUTURE ACTIVITIES

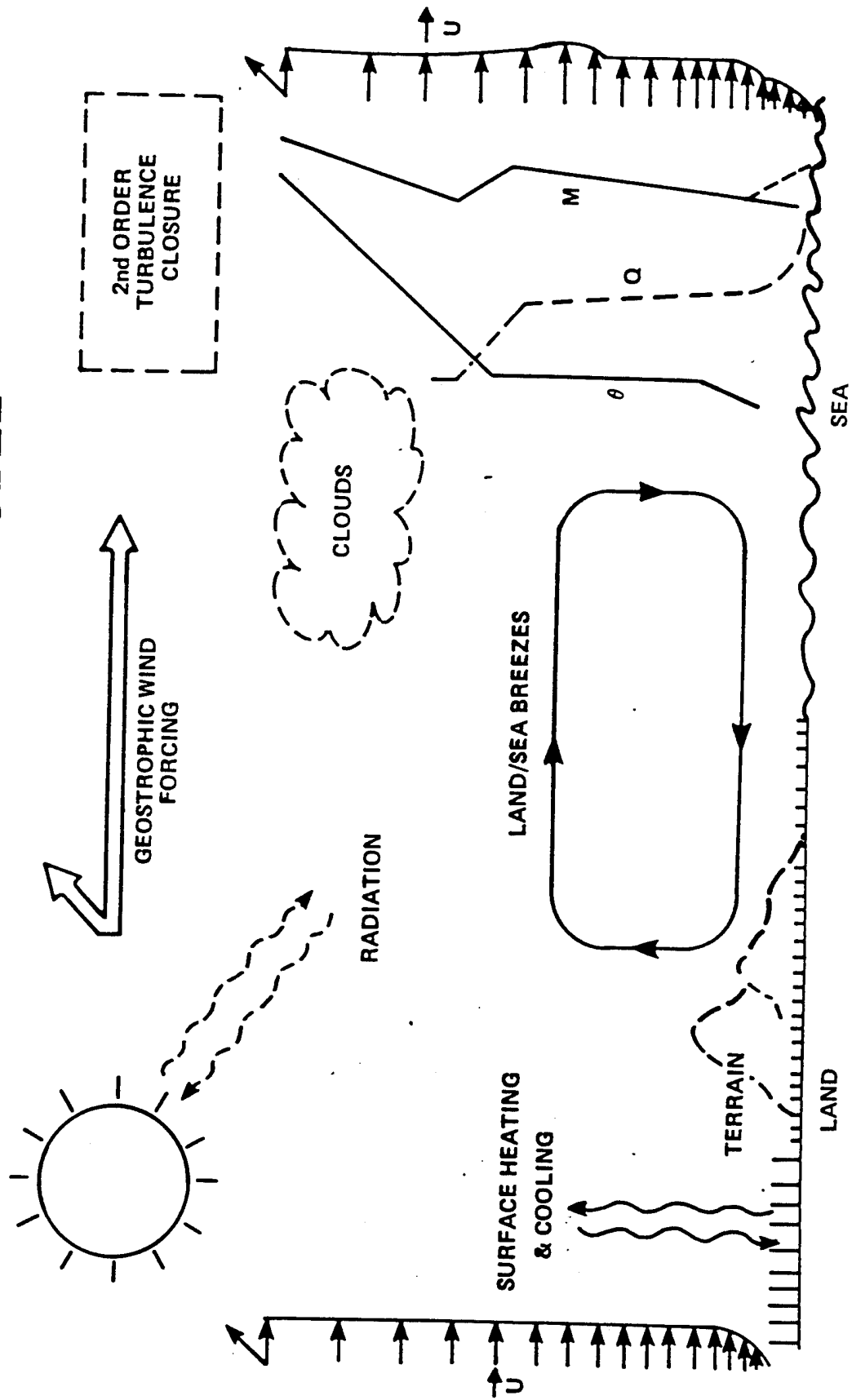


## THE COLORADO STATE UNIVERSITY REGIONAL ATMOSPHERIC MODELING SYSTEM

- Offspring of Two R&D Models in Existence since the 1970s
  - CSU Mesoscale Model (R. Pielke)
  - CSU Cumulus Model (W. Cotton)
- Maintained by and Licensed through ASter, Inc.
  - division of Mission Research Corp.
  - C. Tremback, R. Walko
- Acquired by JHU/APL in 1994 for Application to Radar Propagation Studies
  - replacement for an in-house code developed in 1980s
- Features not Generally Available in Mesoscale Models
  - sigma-z coordinates with variable vertical resolution
  - nested grid in horizontal allows high resolution locally
  - non-hydrostatic option
  - cloud microphysics (4 levels of complexity)
  - option to initialize from NMC global analyses



# 2-D MESOSCALE MODEL



## APL PLANETARY BOUNDARY LAYER MODEL

### PHYSICS

- 3D Reynolds Averaged Eqns. - Boussinesq and Hydrostatic Appxs.
- Differential Equations for U, V,  $\Theta$  and Q (Specific Humidity)
  - vertical velocity and pressure obtained algebraically
- 2D + Time Version Neglects Cross-Track Derivatives
- Assumption of Horizontal Homogeneity  $\Rightarrow$  1D + Time Version

$$\frac{\partial U}{\partial t} = +f(V - V_g) - \frac{\partial}{\partial z} \langle u'w' \rangle \quad \frac{\partial V}{\partial t} = -f(U - U_g) - \frac{\partial}{\partial z} \langle v'w' \rangle$$

$$\frac{\partial \theta_v}{\partial t} = -\frac{\partial}{\partial z} \langle w'\theta_v' \rangle + S_\theta \quad \frac{\partial Q}{\partial t} = -\frac{\partial}{\partial z} \langle w'q' \rangle$$

- Eddy Viscosity or 2nd-Order Turbulence Closure Schemes

### NUMERICS

- Staggered Grid with Logarithmically Stretched Vertical Coordinate
  - $\Delta z \approx 10$  to 50 m
- Leapfrog Time Differencing
  - diffusive terms treated implicitly (75% weighting to forward time step)



Table 1. *Model Characteristics and Options*

| Category                   | Available options                                                                                                                                                                                           | References and additional remarks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Basic equations            | <ul style="list-style-type: none"> <li>• Nonhydrostatic; compressible</li> <li>• Hydrostatic; anelastic or incompressible</li> </ul>                                                                        | Tripoli and Cotton (1980).<br>Tremback et al. (1985).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Dimensionality             | <ul style="list-style-type: none"> <li>• 1D</li> <li>• 2D</li> <li>• 3D</li> </ul>                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Vertical coordinates       | <ul style="list-style-type: none"> <li>• Cartesian</li> <li>• Terrain-following <math>\sigma_z</math></li> </ul>                                                                                            | Clark (1977); Tripoli and Cotton (1982).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Horizontal coordinates     | <ul style="list-style-type: none"> <li>• Cartesian</li> <li>• Stereographic tangent plane</li> </ul>                                                                                                        | Projection tangent point can be located anywhere on sphere.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Grid stagger and structure | <ul style="list-style-type: none"> <li>• Arakawa C grid, single grid (fixed)</li> <li>• Arakawa C grid, multiple nested grids (fixed)</li> <li>• Arakawa C grid, multiple nested grids (movable)</li> </ul> | No limit on number of grids; no limit on number of nesting levels; grids can be added, removed during simulation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Time differencing          | <ul style="list-style-type: none"> <li>• Leapfrog; time split; 2nd or 4th order spatial accuracy</li> <li>• Forward; 2nd or 6th order spatial accuracy</li> </ul>                                           | Leapfrog on long timestep, forward-backward on small timestep; flux conservative form (Tripoli and Cotton, 1982).<br>Forward-backward time-split; flux conservative form (Tremback et al., 1987).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Turbulence closure         | <ul style="list-style-type: none"> <li>• Smagorinsky deformation K</li> <li>• O'Brien K/Blackadar K</li> <li>• Deardorff level 2.5 K</li> </ul>                                                             | <i>Ri</i> dependence (Tripoli, 1986).<br>O'Brien first-order K for unstable conditions; Blackadar Local K for stable conditions (McNider and Pielke, 1981).<br>Eddy viscosity is a function of prognostic TKE (Deardorff, 1980).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Stable precipitation       | <ul style="list-style-type: none"> <li>• No condensation</li> <li>• Condensation</li> </ul>                                                                                                                 | Grid points fully saturated or unsaturated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Cumulus parameterization   | <ul style="list-style-type: none"> <li>• None</li> <li>• Modified Kuo</li> </ul>                                                                                                                            | Tremback (1990).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Explicit microphysics      | <ul style="list-style-type: none"> <li>• None</li> <li>• Warm microphysics</li> <li>• Ice microphysics – specified nucleation</li> <li>• Ice microphysics – predicted nucleation</li> </ul>                 | Warm rain conversion and accretion of cloud water ( $r_c$ ) to raindrops ( $r_r$ ); evaporation and sedimentation (Tripoli and Cotton, 1980).<br>Warm microphysics plus nucleation of ice crystals ( $r_i$ ), conversion nucleation and accretion of graupel ( $r_g$ ), growth of ice crystals ( $r_i$ ), evaporation, melting and sedimentation (Cotton et al., 1982).<br>Warm microphysics plus above plus nucleation and sink of crystal concentration ( $N_i$ ), conversion and growth of aggregates ( $r_a$ ), melting, evaporation and sedimentation. The nucleation model includes: sorption; deposition; contact nucleation by Brownian collision plus thermophoresis plus diffusiophoresis; and secondary ice crystal production by rime-splinter mechanism (Cotton et al., 1986; Meyers et al., 1991). |
| Radiation                  | <ul style="list-style-type: none"> <li>• No radiation</li> <li>• Shortwave I</li> </ul>                                                                                                                     | Molecular scattering, absorption of clear air (Yamamoto, 1962), ozone absorption (Lacis and Hansen, 1974) and reflectance, transmittance and absorptance of a cloud layer (Stephens, 1978), clear-cloudy mixed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

Table 1. (Continued)

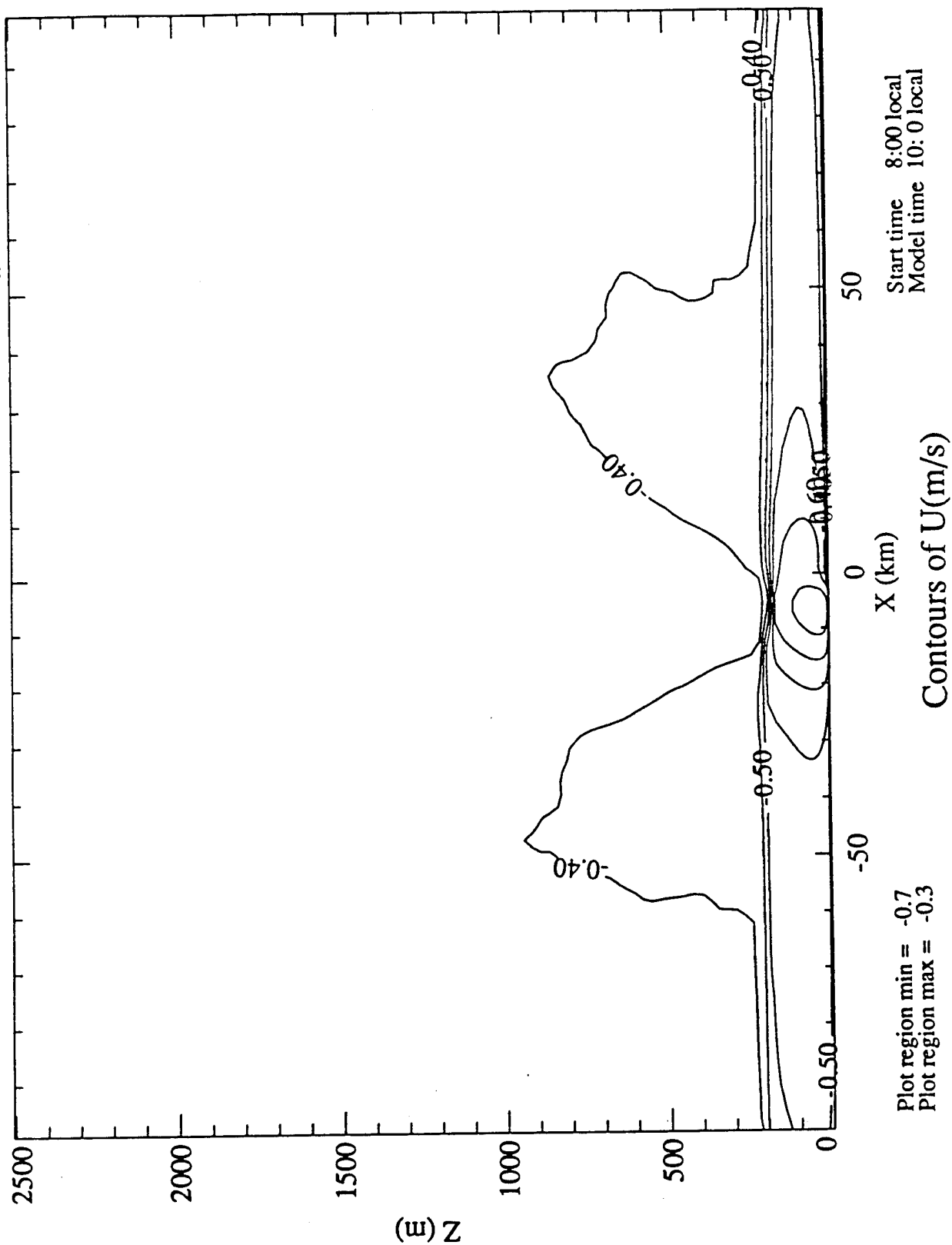
| Category                | Available options                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | References and additional remarks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | <ul style="list-style-type: none"> <li>• Shortwave II</li> <li>• Longwave I</li> <li>• Longwave II</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                | <p>layer approach (Stephens, 1977). See Chen and Cotton (1983, 1987).</p> <p>Effects of forward Rayleigh scattering (Atwater and Brown, 1974), absorption by water vapor (McDonald, 1960), and terrain slope (Kondrat'yev, 1969). See Mahrer and Pielke (1977).</p> <p>Emissivity of a clear atmosphere (Rodgers, 1967), emissivity of cloud layer (Stephens, 1978), and emissivity of "clear and cloudy" mixed layer (Herman and Goody, 1976). See Chen and Cotton (1983, 1987).</p> <p>Emissivities of water vapor (Jacobs et al., 1974) and carbon dioxide (Kondrat'yev, 1969) and the computationally efficient technique of Sasamori (1972). See Mahrer and Pielke (1977).</p> |
| Surface layer           | <ul style="list-style-type: none"> <li>• Louis (1979)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                             | Surface roughness specified over land, predicted over water.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Lower boundary          | <ul style="list-style-type: none"> <li>• Specified air-surface temperature and moisture differences</li> <li>• Diagnosed surface temperature and moisture fluxes based on a prognostic soil model</li> <li>• Vegetation parameterization</li> </ul>                                                                                                                                                                                                                                                          | <p>Tremback and Kessler (1985); McCumber and Pielke (1981).</p> <p>McCumber and Pielke (1981); Avissar and Mahrer (1988); Lee (1992).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Upper boundary          | <ul style="list-style-type: none"> <li>• Rigid lid</li> <li>• Prognostic surface pressure</li> <li>• Material surface</li> <li>• Gravity-wave radiation condition</li> <li>• Optional Rayleigh friction layer</li> </ul>                                                                                                                                                                                                                                                                                     | <p>Nonhydrostatic model only.</p> <p>Hydrostatic model only.</p> <p>Hydrostatic model only (Mahrer and Pielke, 1977).</p> <p>Klemp and Durran (1983).</p> <p>With any of the above conditions (Clark, 1977; Cram, 1990).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Lateral boundaries      | <ul style="list-style-type: none"> <li>• Radiative boundary condition I</li> <li>• Radiative boundary condition II</li> <li>• Radiative boundary condition III</li> <li>• Radiative boundary condition and MCR</li> <li>• Large-scale sponge boundary conditions</li> <li>• Large-scale nudging boundary conditions</li> <li>• Horizontally homogeneous (HHI)</li> <li>• HHI plus variations to force cloud initiation</li> <li>• Variable initialization I</li> <li>• Variable initialization II</li> </ul> | <p>Orlanski (1976).</p> <p>Klemp and Wilhelmson (1978a, b).</p> <p>Klemp and Lilly (1978).</p> <p>Fixed conditions at Mesoscale Compensation Region (MCR) boundary (Tripoli and Cotton, 1982).</p> <p>Synoptic-scale boundary forcing (Perkey and Kreitzberg, 1976).</p> <p>Synoptic-scale boundary forcing (Davies, 1983).</p> <p>NMC and ECMWF data interpolated directly to model grid.</p> <p>Isentropic analysis of NMC or ECMWF data and/or upper air soundings and interpolated to model grid (Tremback, 1990).</p>                                                                                                                                                          |
| Transport and diffusion | <ul style="list-style-type: none"> <li>• Lagrangian particle dispersion module</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                    | Handles point, line, area or volume sources (McNider, 1981; McNider et al., 1988; Uliasz, 1993).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

## SEA-BREEZE CALCULATION: TAMPA, FL

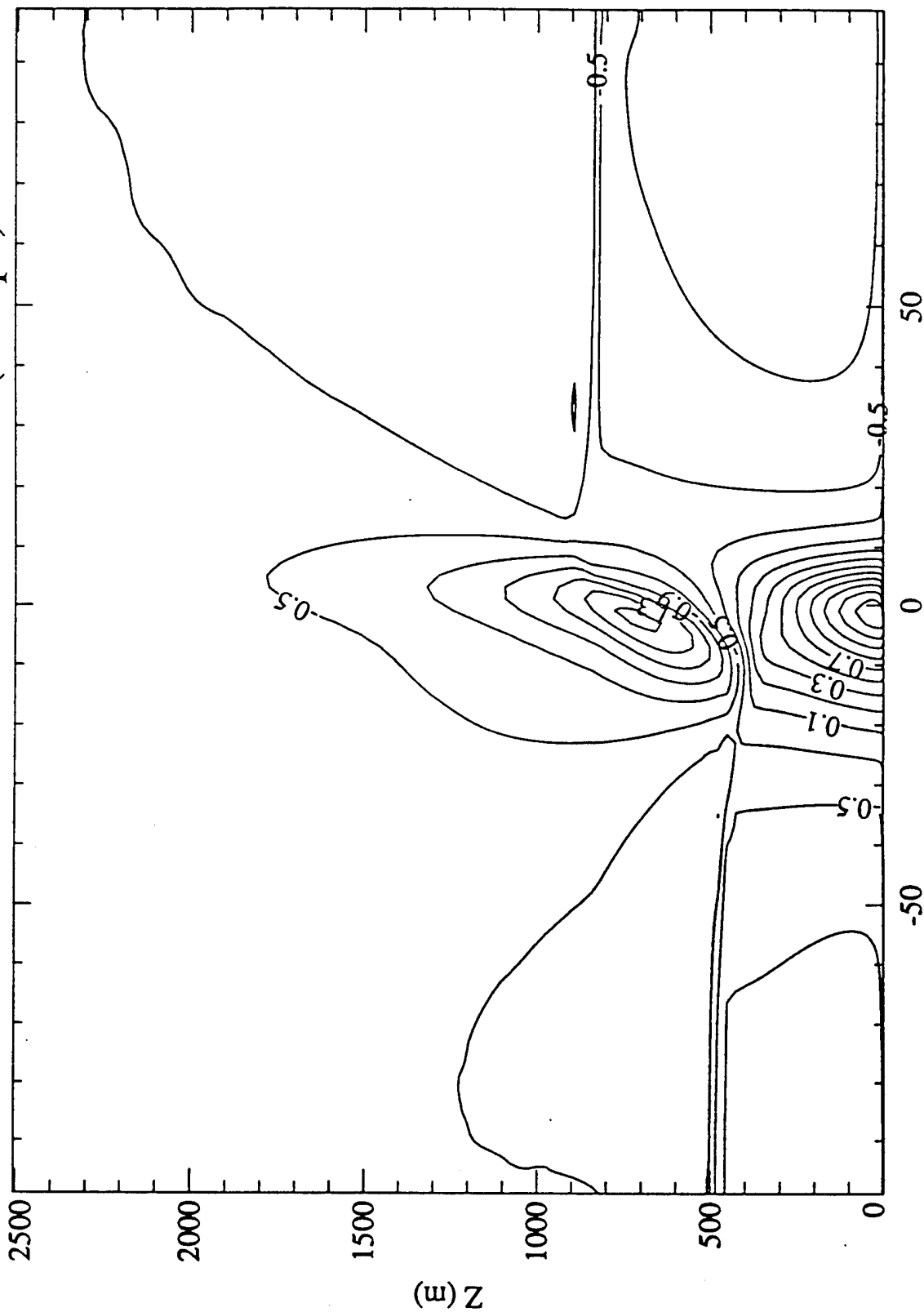
- 2-D Version of RAMS
  - oriented perpendicular to coastline
  - 200 km horizontal domain with  $\Delta x = 2$  km
  - 4 km vertical extent; stretched grid with max  $\Delta z = 26$  m
- Options
  - non-hydrostatic
  - flat terrain
  - no clouds
- Initialization
  - single rawinsonde at 0800LT, 13 July 1993
- Surface Forcing
  - sea-surface temperature fixed at 29 degC (climatology)
  - heat & moisture fluxes over land calculated
- Model Run for 12 Hours
- Predicted Observed Reversal in Surface Winds



# RAMS Sea Breeze Predictions (Tampa)



# RAMS Sea Breeze Predictions (Tampa)

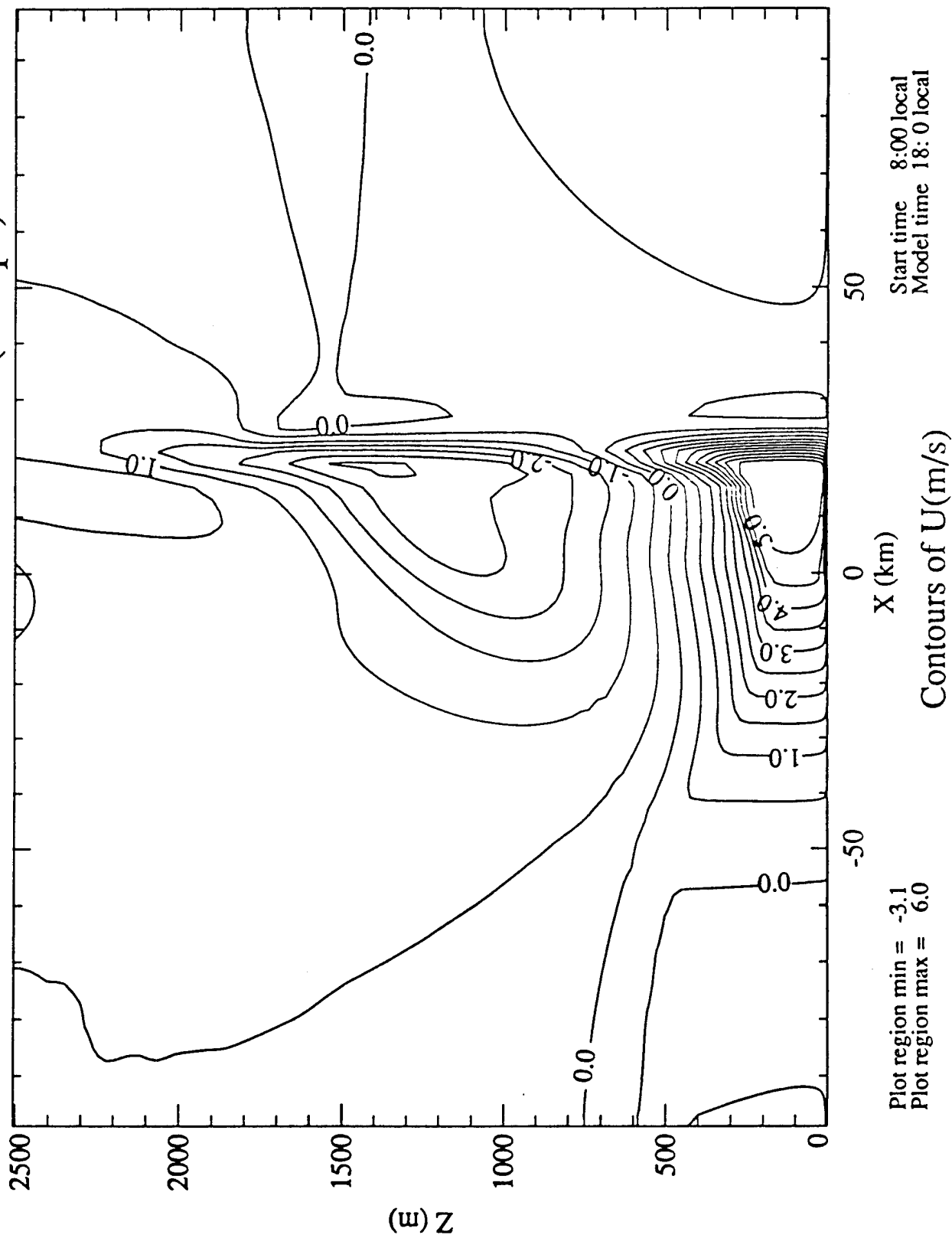


Start time 8:00 local  
Model time 14:00 local

Contours of U(m/s)

Plot region min = -1.6  
Plot region max = 1.7

# RAMS Sea Breeze Predictions (Tampa)

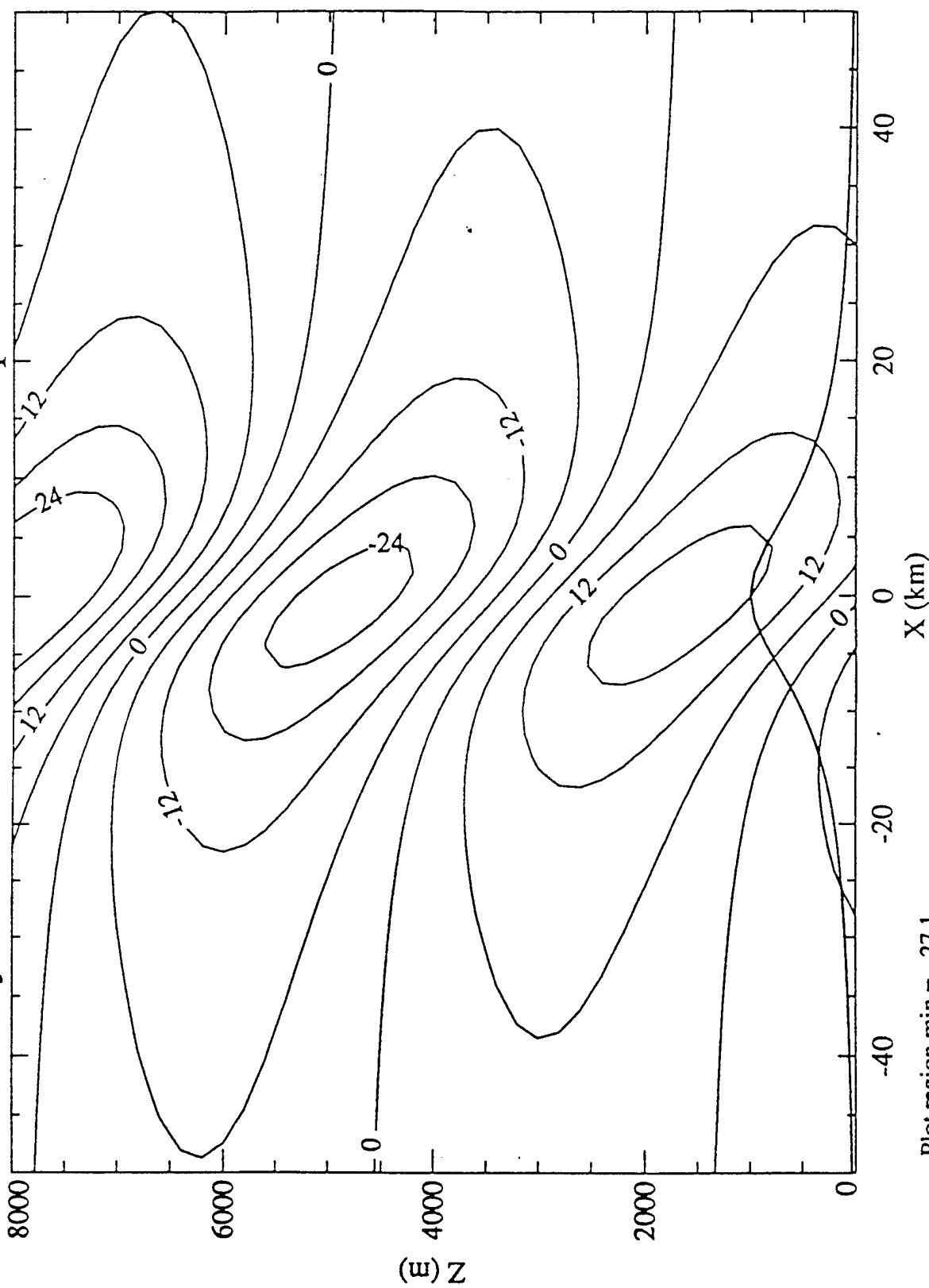


## VARIABLE-TERRAIN CALCULATION

- Flow over Idealized Mountain
  - bell-shaped with  $z_g(x) = ha^2/(x^2 + a^2)$
  - $h = 10$  m;  $a = 10$  km
- Analytical Solution for Small Perturbations
  - Durran & Klemp, MWR, 1983
- RAMS Model Parameters
  - $180 \times 16$  km with  $\Delta x = 2$  km &  $\Delta z = 200$  m
  - 8 km absorbing layer at top
- Initial Conditions
  - isothermal:  $T = 250K$
  - no moisture
  - $U = 20$  m/sec (uniform)
- Model Integrated to Steady State



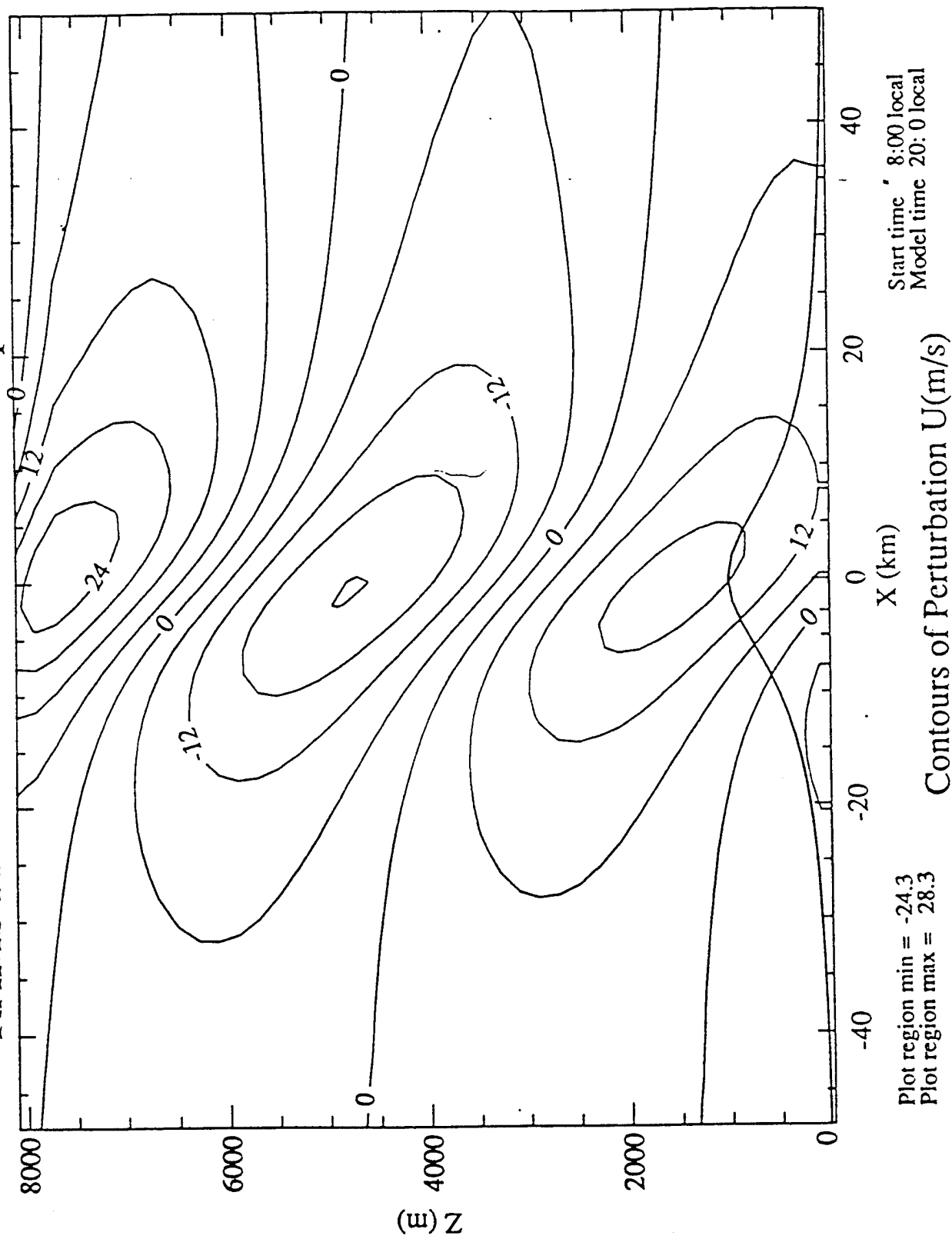
# Analytic Solution: Flow over Bell-shaped Mountain



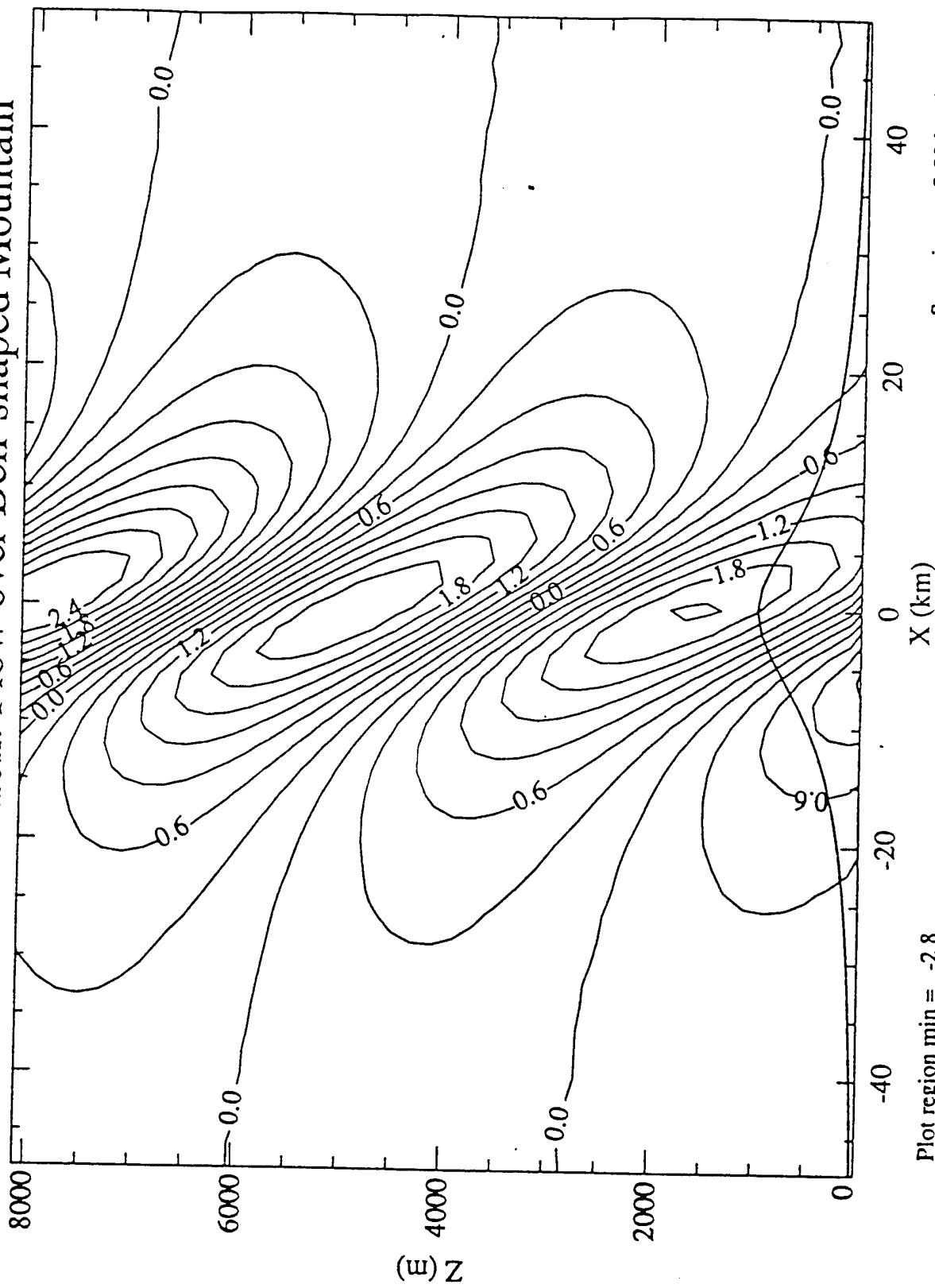
Plot region min = -27.1  
Plot region max = 33.8

Contours of Perturbation  $U$ (m/s)

# RAMS Prediction: Flow over Bell-shaped Mountain



# RAMS Prediction: Flow over Bell-shaped Mountain

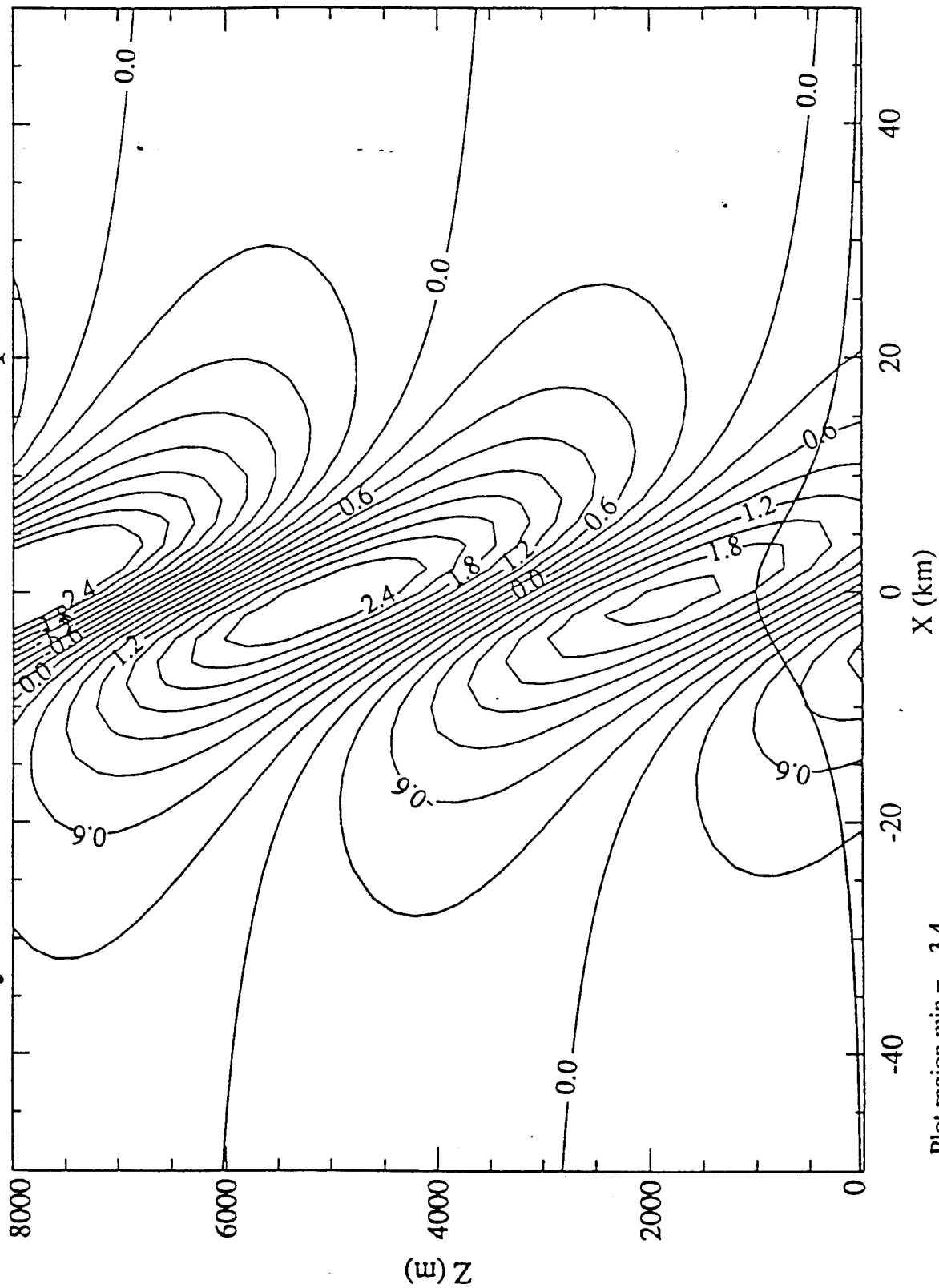


Plot region min = -2.8  
Plot region max = 2.4

Start time 8:00 local  
Model time 20:0 local

Contours of Perturbation  $W$ (m/s)

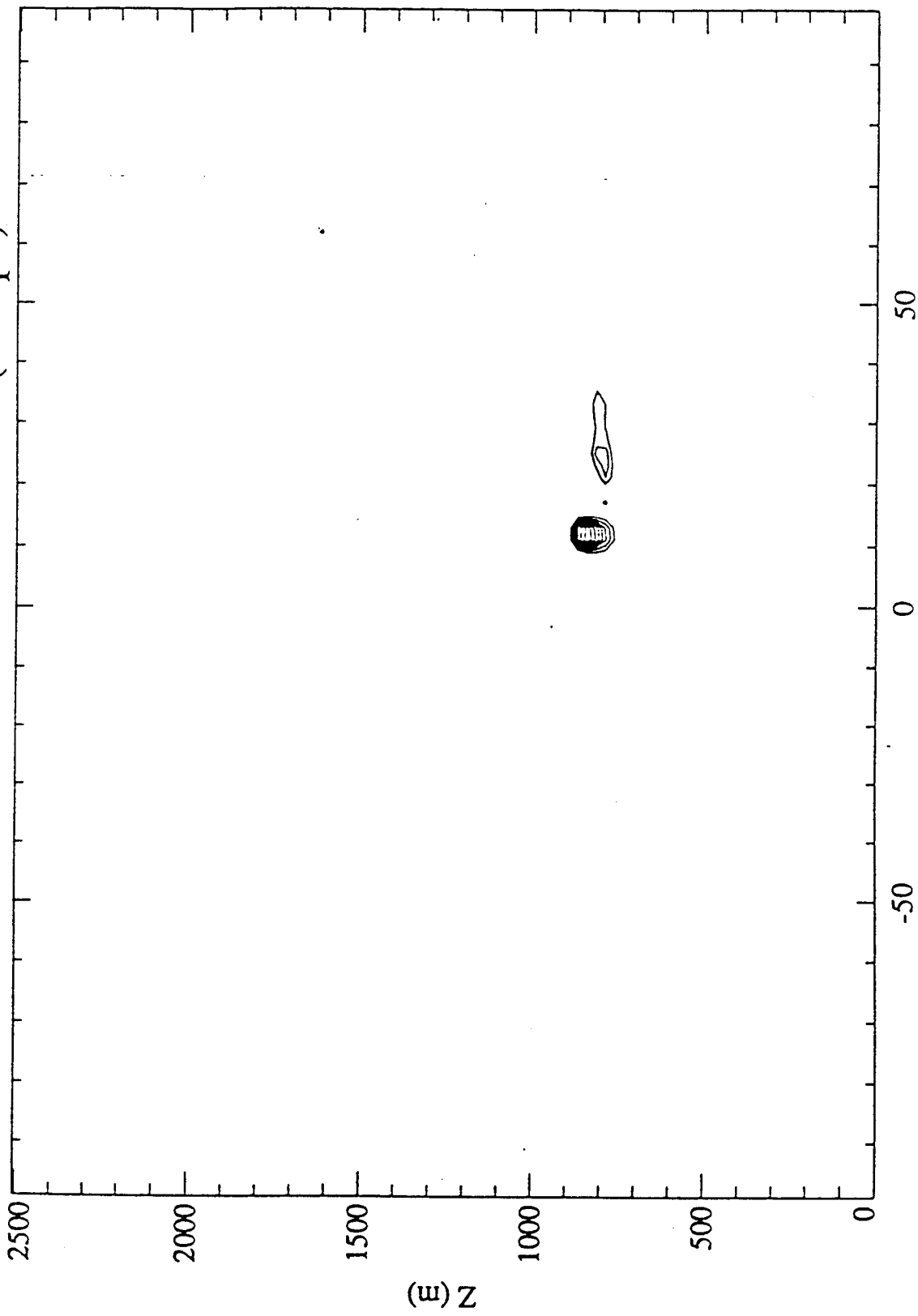
# Analytic Solution: Flow over Bell-shaped Mountain



Plot region min = -3.4  
Plot region max = 2.8

Contours of Perturbation  $W$ (m/s)

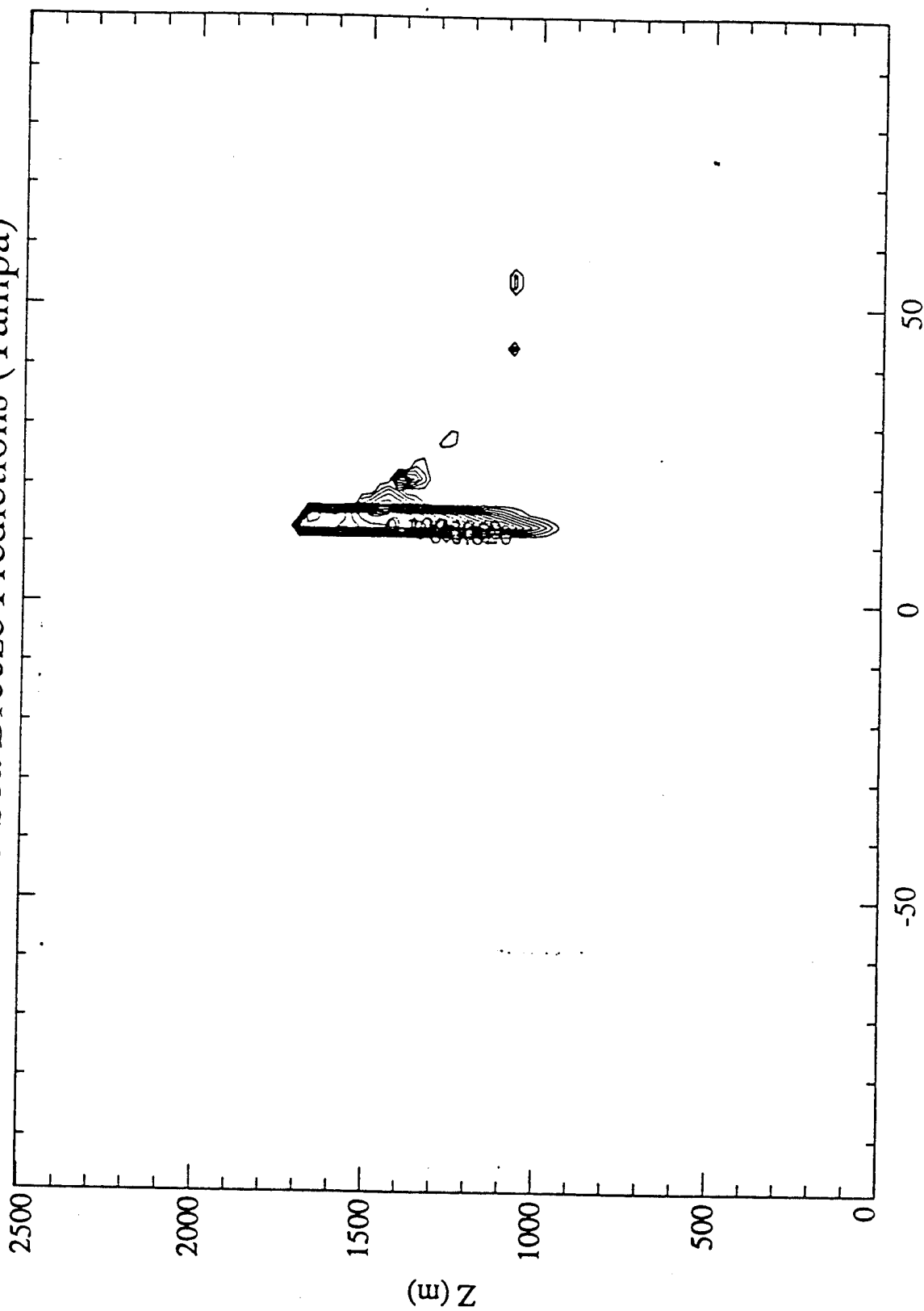
# RAMS Sea Breeze Predictions (Tampa)



Contours of Cloud Water (g/kg)

Start time 8:00 local  
Model time 14:00 local

# RAMS Sea Breeze Predictions (Tampa)



Plot region min = 0.0  
Plot region max = 0.2

Contours of Cloud Water (g/kg)

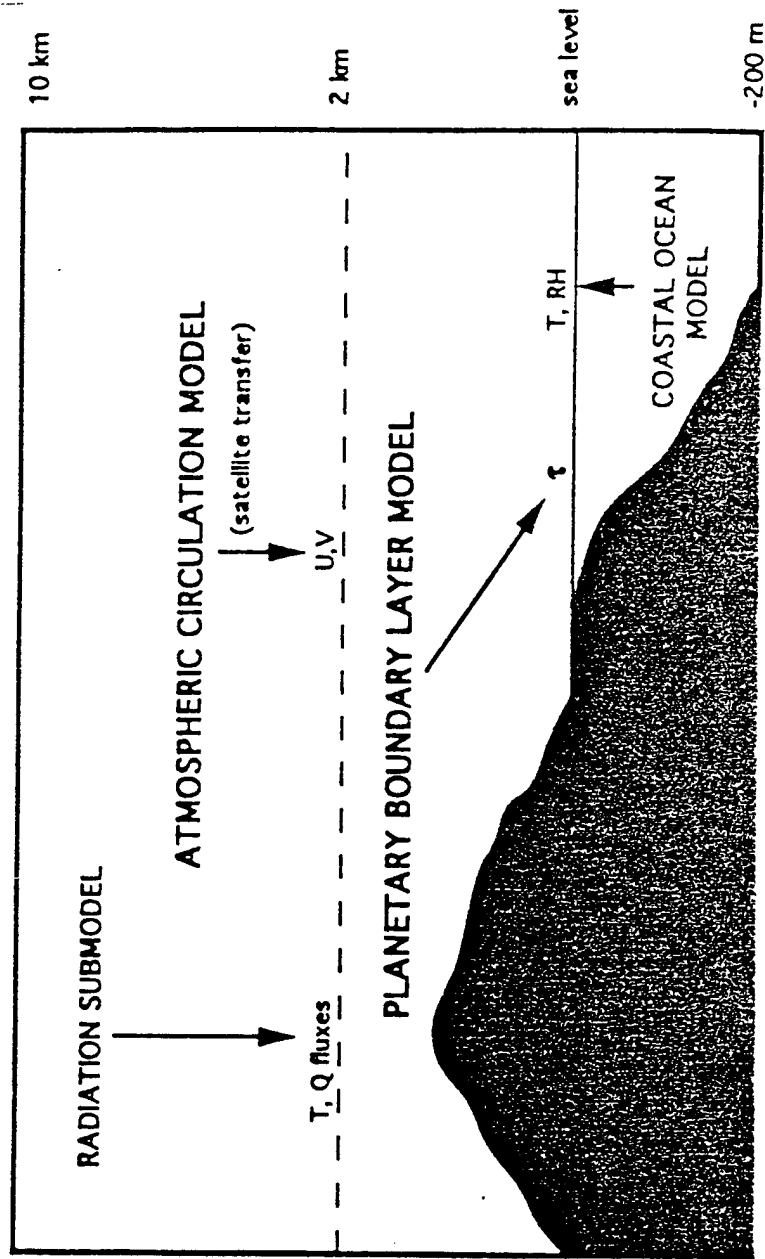
Start time 8:00 local  
Model time 16:00 local

## SUMMARY

- Preliminary Model Testing Underway
- Results to Date Encouraging
- Issues Remaining to be Addressed
  - Ability to predict fog
    - » need for cloud microphysics
  - Required model configuration
    - » spatial resolution
    - » adequacy of 2-D predictions
  - Availability of data for demonstration
    - » initialization: vertical profile(s) of U, V, T & RH
    - » boundary conditions (time-dependent):
      - surface temperature
      - upper-level winds



# REQUIRED MODEL INTERFACES





## Goals of this meeting

**Assess shared goal**

**Identify what we have**

**Identify what we need: software/hardware**

**Assess how to get what we need**

**A. What are the demands of the mission?**

**B. What do we mean by integration?**

1. Software packages - which ones integrate?
2. Identify integration difficulty

**C. What is our agreed upon definition of the ultimate goal for the Coastal Scene Description?**



## **Goals of this meeting**

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- B. What do we mean by integration?**
  - 1. Software packages - which ones integrate?
  - 2. Identify integration difficulty
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**What is our ultimate shared goal?**

**A. Provide Enviromental Coastal Scene Descriptions that are shareable (over the network) by real and simulated entities**

1. Historical data - database
2. Real instruments
3. Virtual instruments

**B. Underlying Network Architecture**

DIS (?)



## Action Items

### **A. Little Creek, Norfolk, Navy's amphibious warfare B. Terrain Data**

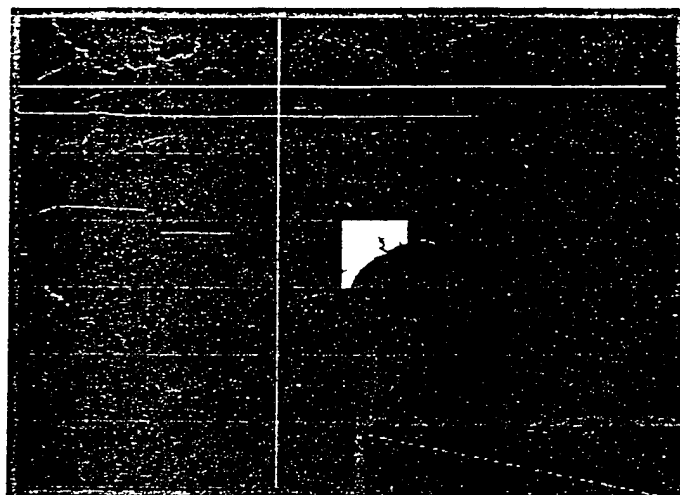
ACOM (Atlantic Command), Quantico, VA  
Major Mosely

### **C. Oceanographic Data**

Oceanographer of Navy, MC&G  
CAPT Huncada  
Mary Classon

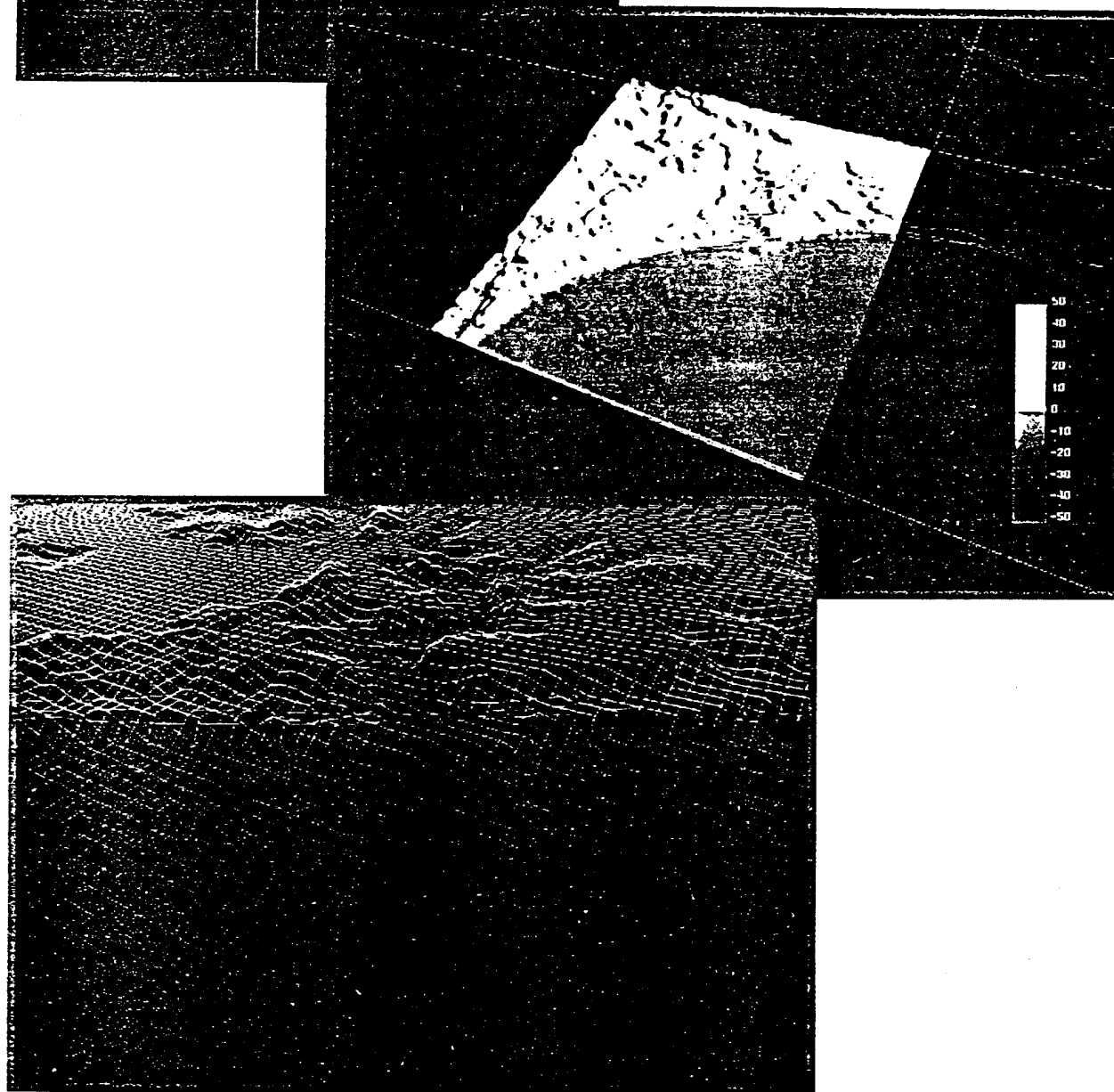
1. Generate requests
2. DMA check
3. Acquisition

# Topography for 34°-35°N 77°-78°W



Topographic data. USGS  
30 second elevations

Rivers and coastlines  
form CIA WorldMap

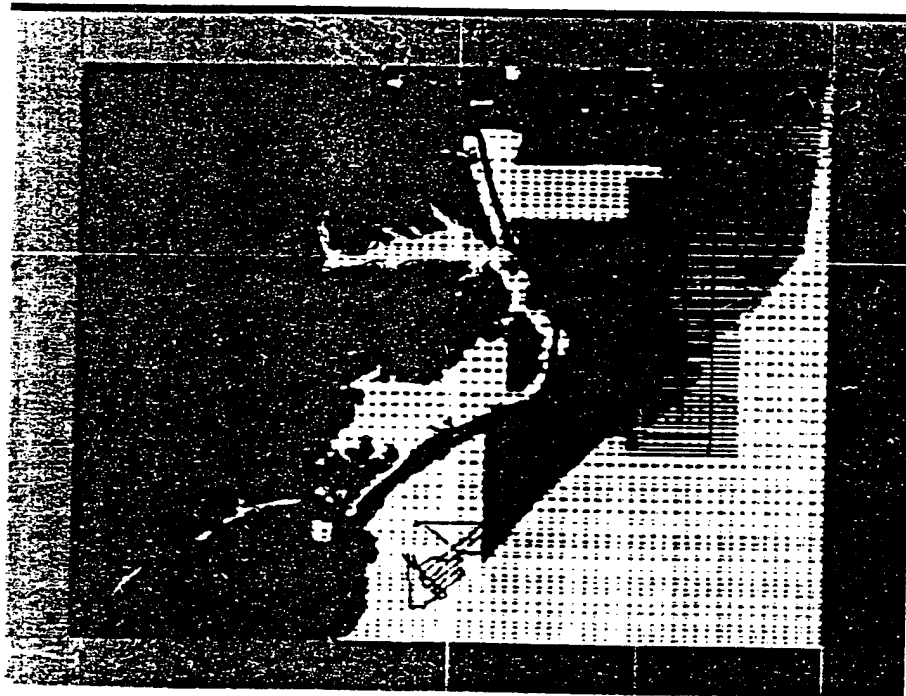


storm 6/13/94

Topography for 34-37N 74-78E  
from USGS 30 second elevations



Missing values shown in red



# The SceneObject Framework Design

Bill Hess

Applied Physics Laboratory  
University of Washington

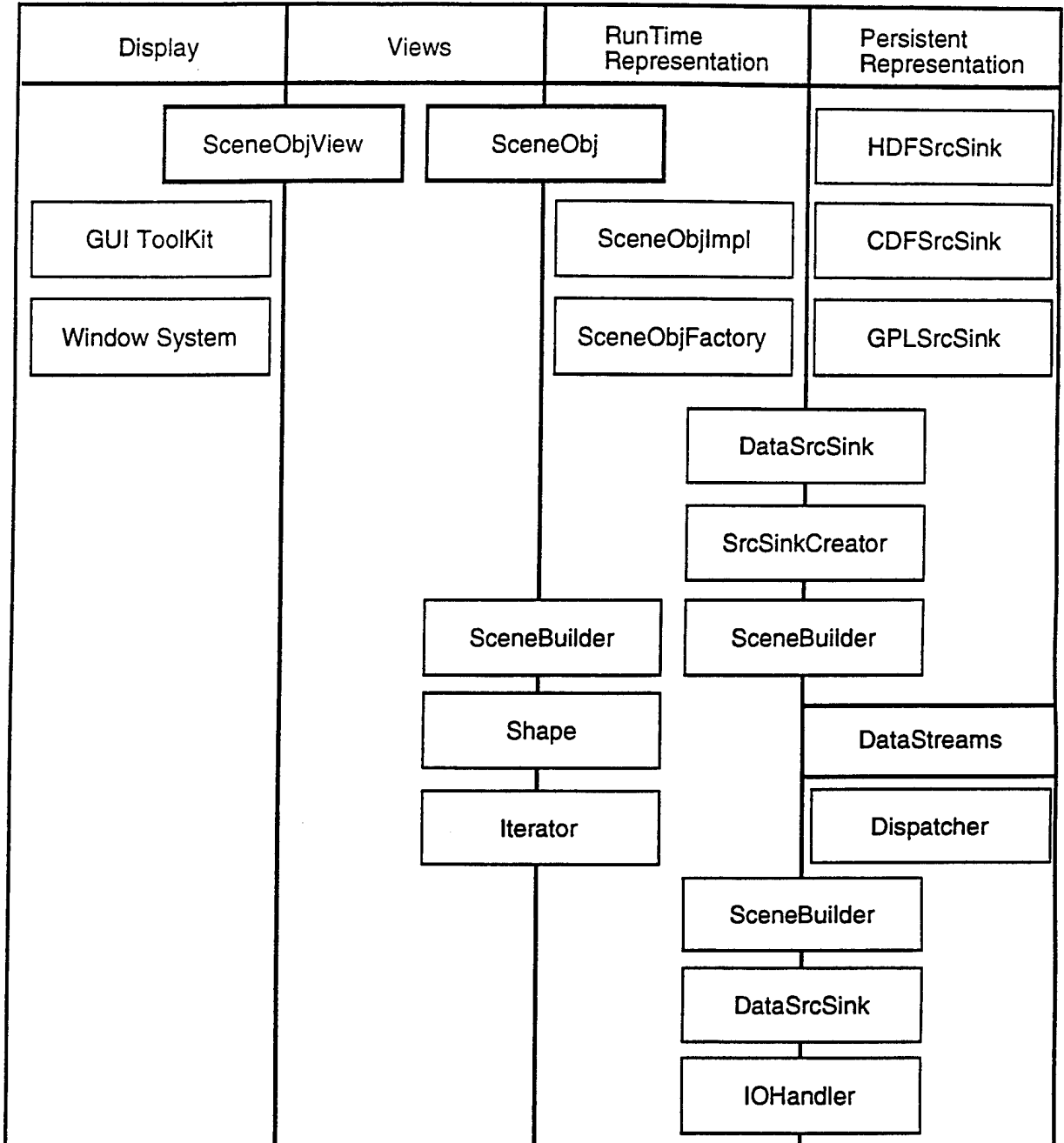
## 1 Objective

Design a system of C++ classes for the representation, manipulation, and display of spatially distributed coastal scene description data.

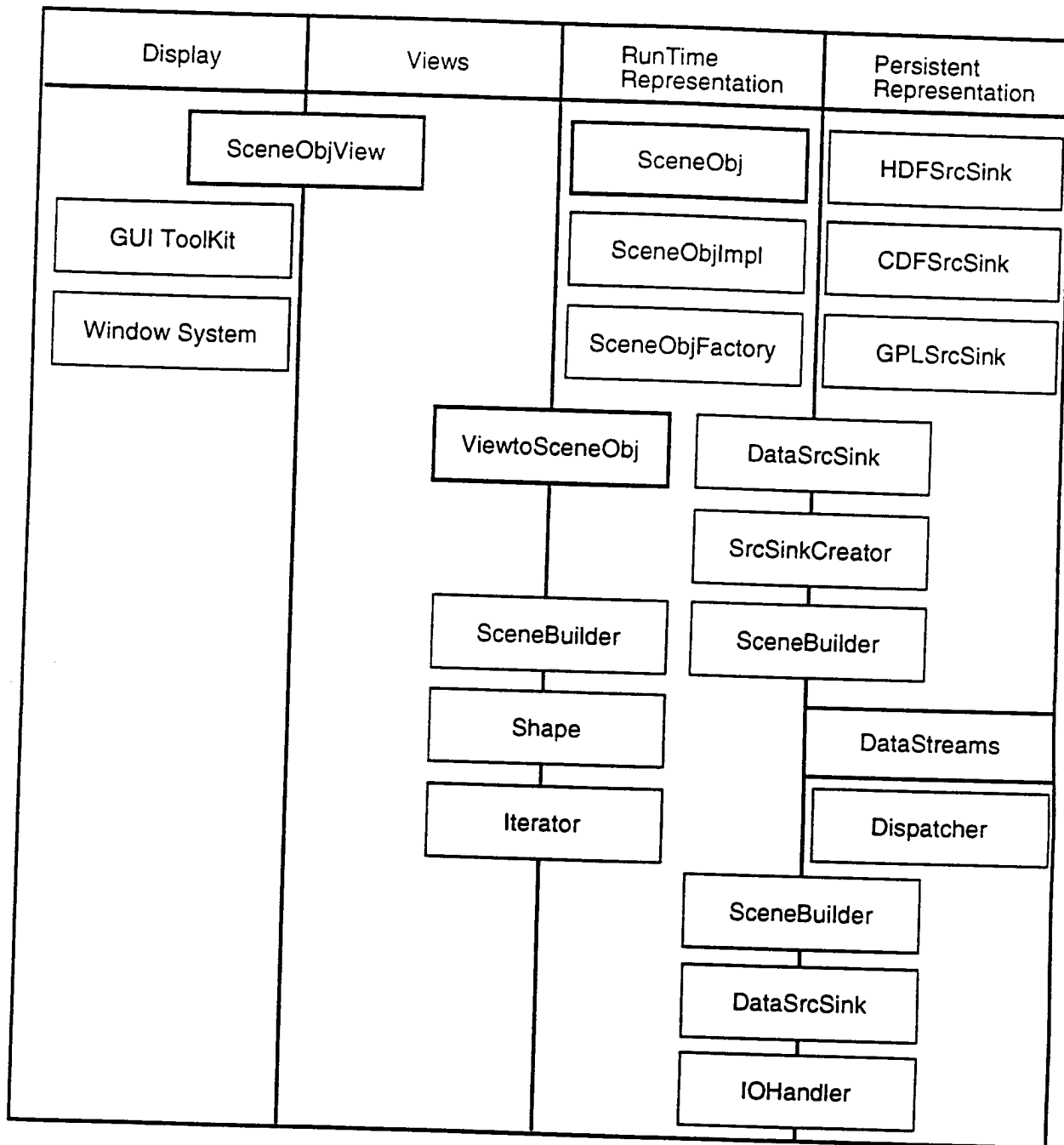
## 2 Design Principles

1. Favor composition over inheritance.
  - Avoids *class explosion*
  - Allows us to adapt the system at link and run times.
2. Hide object instantiation from application code.
  - Allows us to minimize the effect of extending the set of objects in the system.
3. Separate object interface from its implementation.
  - Allows us to change representation and algorithms without changing the application code or recompiling.
4. Hide the persistent form of the data from the application.
  - Allows us to change, add, and interchange data formats without reworking the application code.
5. Separate objects' representation from their display.
  - Allows multiple views of the data.
  - Supports views on multiple platforms.
  - Makes objects platform independent.
6. Support adaptive resolution.
  - Good performance when zooming and panning large dense data sets.
  - Matches the resolution of the data to that of the display. Avoids:
    - Aliasing from over plotting the display resolution
    - *Blocky* displays from under plotting display resolution.

### 3 Overall Architecture

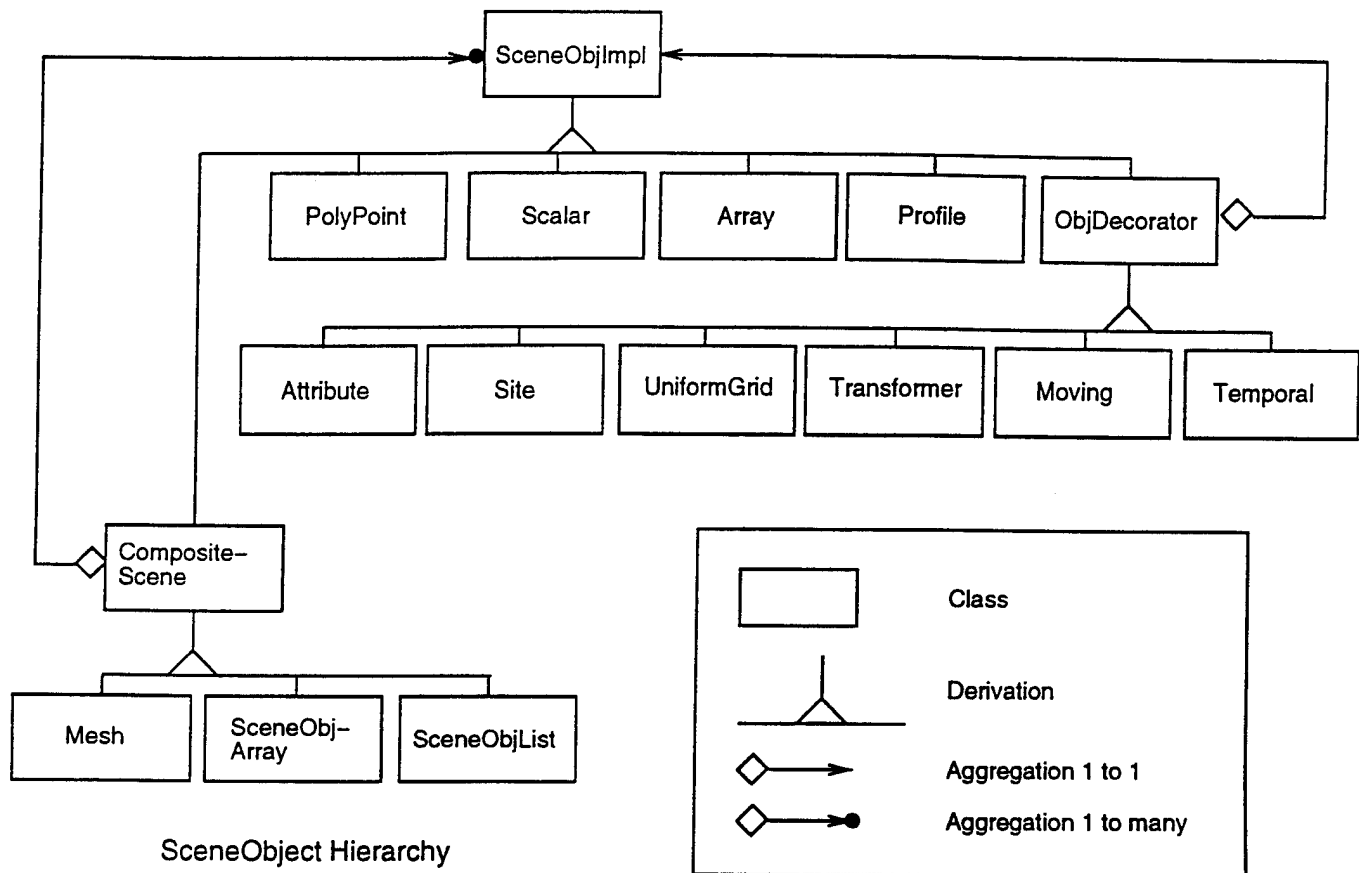


Architecture with Model View Implementation



Architecture with Mediator Implementation

## 5 SceneObjects



**SceneObj** The base class for all other scene description classes. This class provides a common interface to the classes in this hierarchy.

**PolyPoint** A polygon used for representing areas on a plane; land masses for example.

**Scalar** Represents a floating point scalar measurement at a single location; depth for example.

**Array** An N-dimensional array of floating point values ( $N \leq 8$ ).

**Profile** An depth profile or time series of measurements at a single location. The number of parameters and the number of samples is arbitrary.

## 8 SceneObj Interface

```
class SceneObjImpl : public utBody {
public:
    virtual ~SceneObjImpl();

                                // cloning and copying
    virtual SceneObj clone(int deep = 0) const = 0;
    void copy(const SceneObjImpl*, int deep);

                                // getting and setting location
    virtual void move_abs(const utPoint&);
    virtual void move_rel(const utPoint&);
    virtual void get_origin(utPoint&) const = 0;
    virtual utPoint get_origin() const = 0;
    virtual void get_bounds(utPoint& p1, utPoint& p2) const = 0;

                                // request SceneObj shape
    virtual const Shape get_shape() const = 0;

                                // containment and intersections
    virtual int contains(const utPoint&, double tol=0.0) const = 0;
    virtual int intersects(const utPoint& p1, const utPoint& p2) const = 0;

                                // setting and getting MonoSceneObj bodies.
    virtual void body(SceneObj&);
    virtual SceneObj body();

                                // composite SceneObj operations
    virtual void insert(SceneObj&);
    virtual void append(SceneObj&);
    virtual void merge(SceneObj&);
    virtual void lazy(int yesno);
    virtual int lazy() const;
    virtual void remove(SceneObj&);
    virtual void clear();
    virtual int member(const SceneObj&) const;
    virtual int nelements() const;
```

```

// accessing values
virtual void set_array(utArray<double>& v, const utSlice&);
virtual utArray<double> get_array(const utSlice&);

// iterator creation
virtual FaceItr createFaceItr();
virtual EdgeItr createEdgeItr();
virtual ArrayItr createArrayItr(const utSlice&);
virtual PointItr createPointItr();
virtual SceneObjItr createSceneObjItr();
virtual SceneObjItr create_traversal(const utString& type);

// Attributes
virtual void set_attributes(AttrCatalog*);
virtual AttrCatalog* get_attributes();

// coordinate transformations
virtual void push_transform(const utTransform&);
virtual void transfrom(const utTransform&);
virtual pop_transform();
virtual const utTransform* current_transform() const;

// loading and storing objects
virtual int load(DataSrcSink*);
virtual int save(DataSrcSink*);

// object liveliness
virtual int active();

// object identity
virtual void id(int ident);
virtual int id();
};

```

## 9 Example

### 9.1 SceneObject Registration

Here is an example of using the SceneObjFactory to build a registry of SceneObjs. Notice that some of the objects are built from composites of others:

```
static void init()
{
    SceneObjFactory* f = SceneObjFactory::instance();

    f->register_obj("SceneObjList", SceneObj(new SceneObjList));
    f->register_obj("Scalar", SceneObj(new Scalar));
    f->register_obj("NullObj", SceneObj(new NullObj));
    f->register_obj("Site", SceneObj(new Site));
    f->register_obj("Mesh", SceneObj(new Mesh));
    f->register_obj("Ident", SceneObj(new Ident));

    SceneObj scalar = f->create_obj("Scalar");
    SceneObj scalar_site = f->create_obj("Site");
    scalar_site->body(scalar);
    f->register_obj("ScalarSite", scalar_site);
}
```

## 9.2 SceneObj Creation

Now we create a composite using the registered objects. However, the code below does not need to know what kind of composite it is building, or what kind of objects it is creating. We want to add an identifier to the objects in the composite so we build attach an object identifier feature on the fly:

```
static SceneObj create_composite(int n, const utString& comp_type,
                                const utString& obj_type)
{
    SceneObjFactory* f = SceneObjFactory::instance();
    SceneObj comp = f->create_obj(comp_type);
    SceneObj proto = f->create_obj(obj_type);
    SceneObj ident = f->create_obj("Ident");

    if (comp != 0 && proto != 0 && ident != 0) {
        int i;
        utArray<double> v(1);
        comp->lazy(1);

        for (i = 0; i < n; ++i) {
            SceneObj s = ident->clone(1);

            s->body(proto->clone(1));
            s->id(i);
            v(0) = uniform();
            s->set_array(v, utSlice());
            s->move_abs(get_coord());
            comp->insert(s);
        }
        comp->lazy(0);
    }
    return comp;
}
```

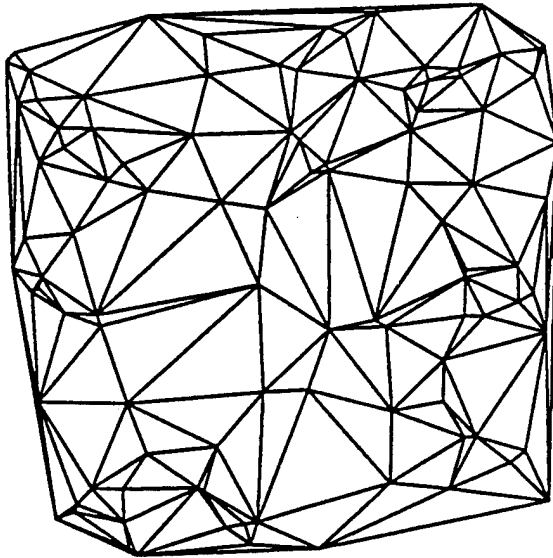
### 9.3 Iteration

Finally we want to plot out resulting structure. We are passed an iterator, but we don't really care where it comes from:

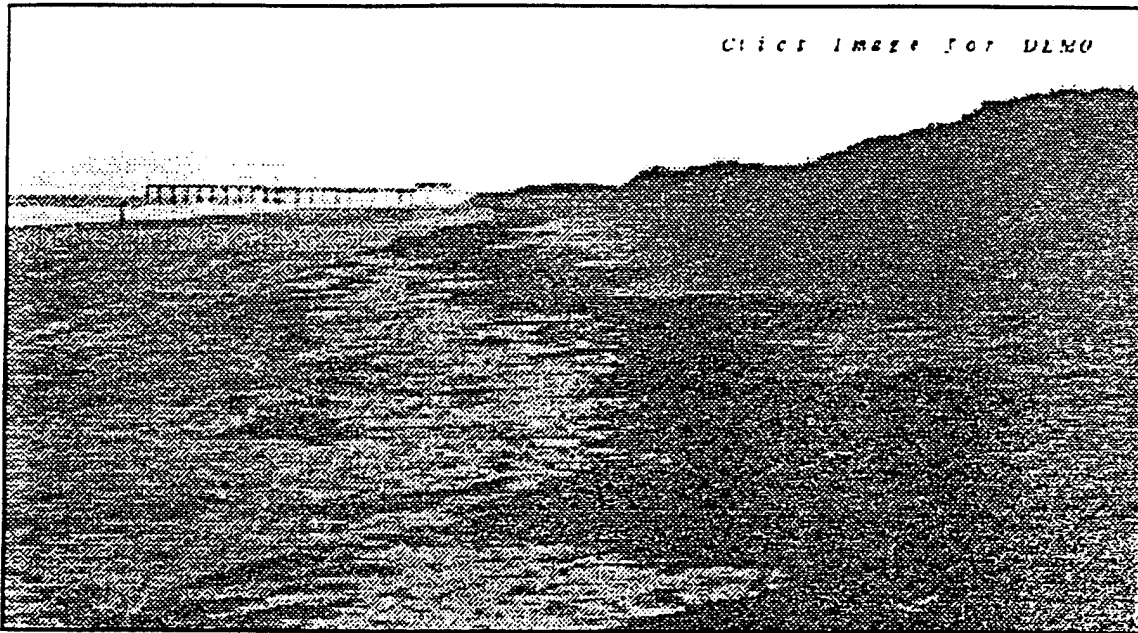
```
static void plot_faces(FaceItr& itr, Render& r)
{
    r.push_color(rdColor(0.0, 0.0, 0.0));
    for (; itr->more(); itr->next()) {
        Edge* e = itr->current();

        r.new_path();
        r.move_to(e->org()->get_origin());
        r.line_to(e->dest()->get_origin());
        r.line_to(e->onext()->dest()->get_origin());
        r.close_path();
        r.stroke();
    }
    r.pop_color();
}
```

### 9.4 Result



## SHORES : SHORe-zone data RESolution



Data Exchange

Data Integration

Error Analysis

Deconfliction

### SHORES Program Information

#### Research Overview

Click on picture above or options below.

- [General Info](#) (slide show)
- Research Documentation
  - [Research Plan](#)
  - [Research Documentation](#)
  - [Findings](#)
- [Demonstration Environment](#)

#### Software Environment

- [Data Exchange](#)  
Provides interactive selection and transfer of digital MC&G data sets for MAB/LWTC regions. Click [here for documentation](#) or data exchange button above to execute software.
- [Data Integration](#)  
Provides methods for integrating multi-source/multi-resolution MC&G data with user specified data. Click [here for documentation](#) or data integration button above to execute software.
- [Error/Conflict Analysis](#)  
Provides methods for indentifying errors and conflicts associated with data integration. Click [here for documentation](#) or error analysis button above to execute software.
- [Deconfliction Tools](#)  
Provides methods for resolving errors and conflicts. Click [here for documentation](#) or

deconfliction button above to execute software.

## References

- Data Reduction and Error Analysis for the Physical Sciences
- 



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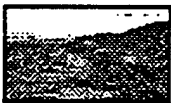
## Data Exchange



---

### Master MAB/LWTC Data Library

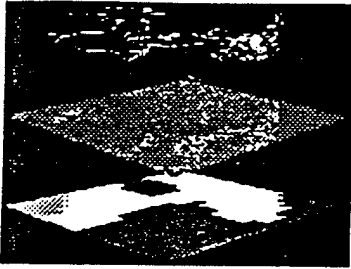
- Bathymetry
    - [5 minute World Topography.....IMAGE](#)
    - [5 minute World Relief.....IMAGE](#)
    - [30 second USGS Topography.....IMAGE](#)
    - [30 second USGS Relief.....IMAGE](#)
    - [NOAA East U.S. Bathymetry contours.....IMAGE](#)
    - [NOS 15 second point Bathymetry.....IMAGE](#)
  - Shoreline
    - [1:30000000 Browse Shoreline.....IMAGE](#)
    - [1:250000 World Vector Shoreline.....IMAGE](#)
    - [1:80000 East U.S. NOS Shoreline.....IMAGE](#)
  - Cultural
    - [East U.S. USGS Roads.....IMAGE](#)
    - [East U.S. USGS RailRoads.....IMAGE](#)
    - [East U.S. USGS Rivers.....IMAGE](#)
    - [East U.S. USGS Political Boundaries.....IMAGE](#)
  - Geophysical
    - [North America Gravity.....IMAGE](#)
  - Digital Chart of the World Data
    - [Political and Ocean Boundaries.....IMAGE](#)
    - [Hypsography and Ocean Feature Data.....IMAGE](#)
    - [Supplemental Hypsography Line Data.....IMAGE](#)
    - [Supplemental Hypsography Point Data.....IMAGE](#)
    - [Cities.....IMAGE](#)
    - [Populated Places.....IMAGE](#)
    - [Roads.....IMAGE](#)
    - [Vegetation Data.....IMAGE](#)
    - [Hypsography Data.....IMAGE](#)
- 



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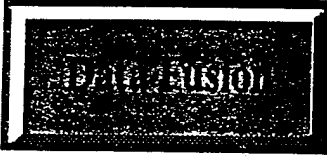


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## Data Integration Process

Input Data + Integration Process = Output Data

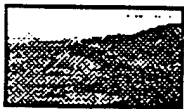
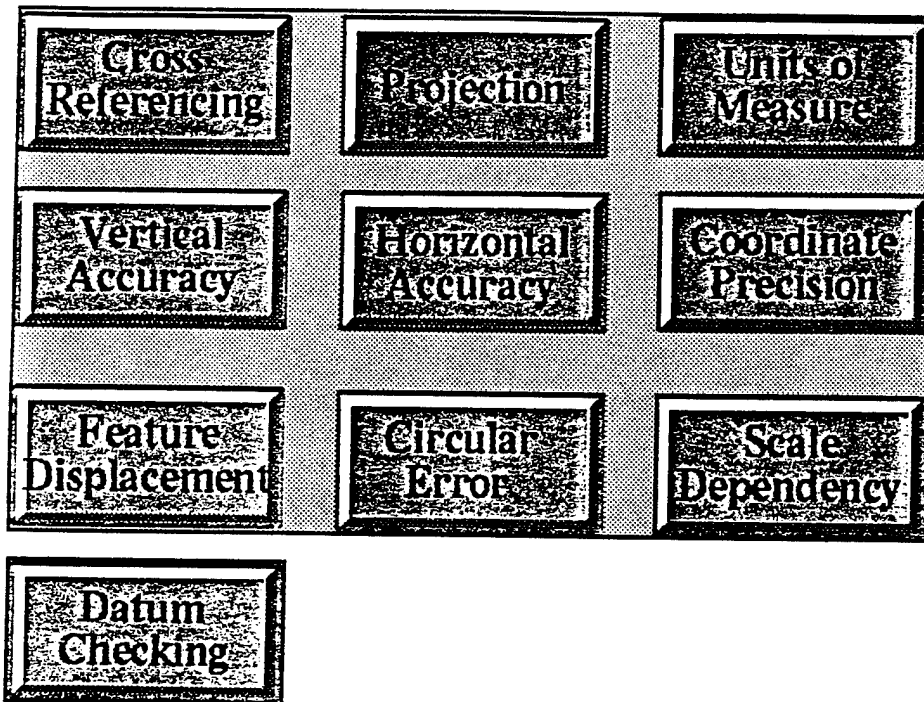


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## Error/Conflict Analysis Tools

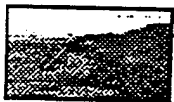
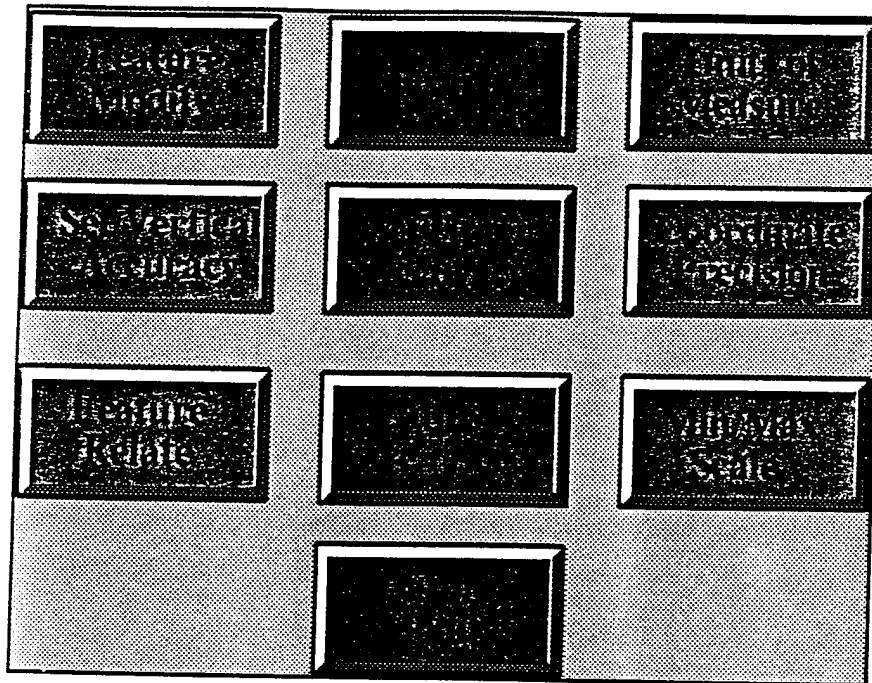


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## Deconfliction Tools



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Naval Research Laboratory

# Tactical Oceanography Simulation Laboratory (TOSL)

Stennis Space Center

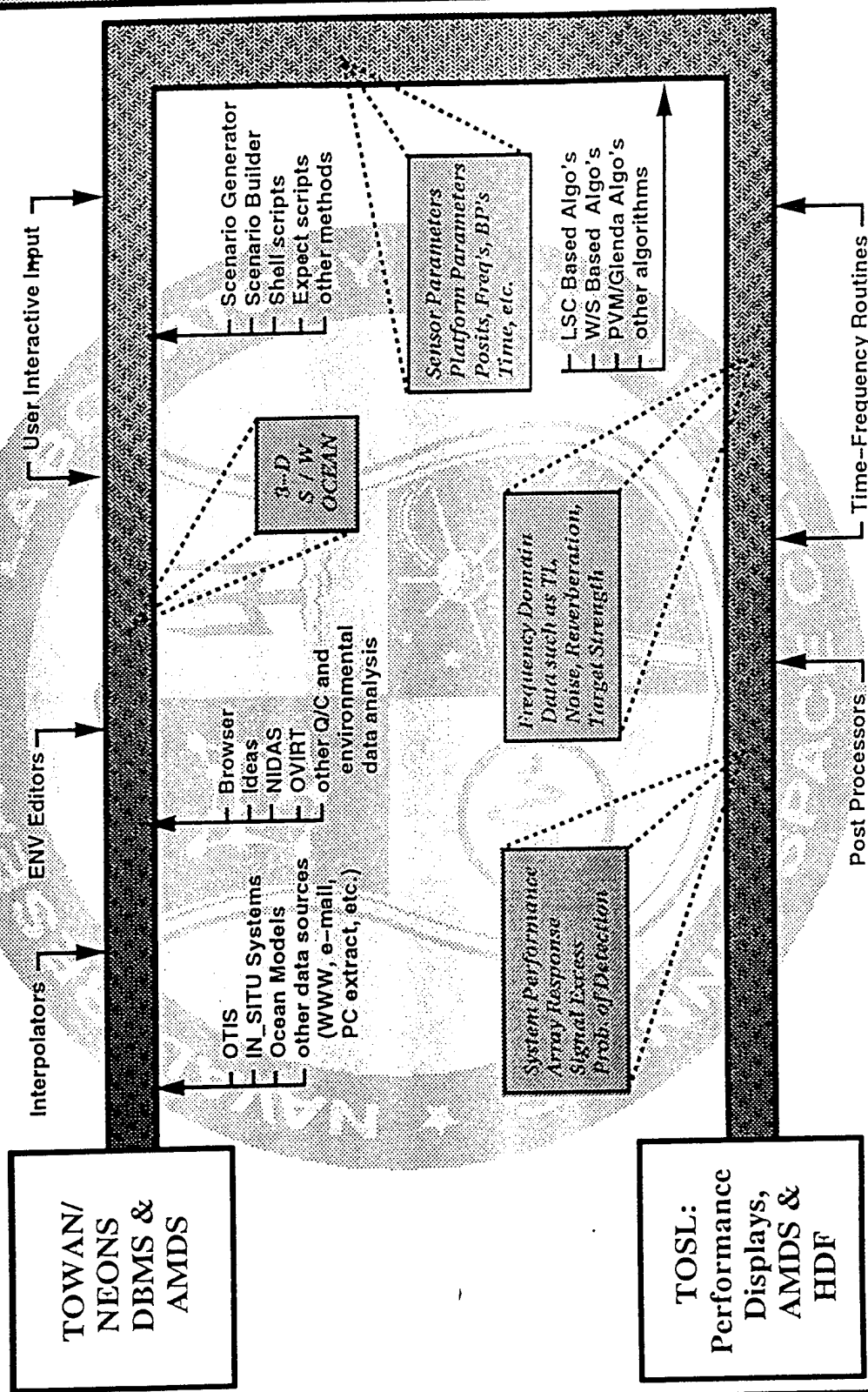
Code 7180

## OBJECTIVE

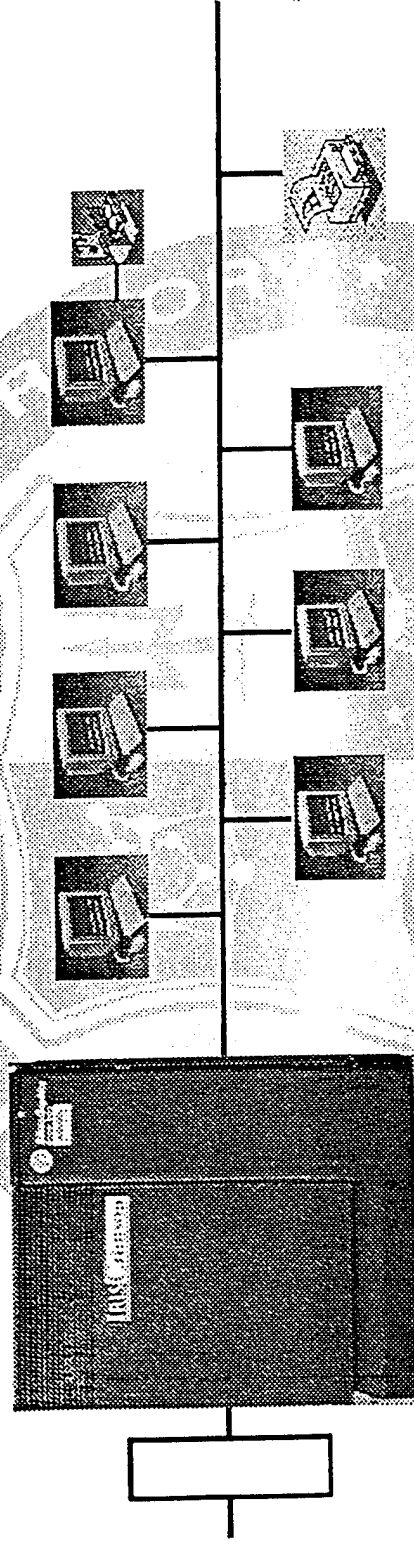
- ▶ Demonstrate the efficiency of exact computer recreations and simulations applied to sensor weapons and related environmental acoustic issues.
- ▶ Apply the laboratory capability over the 3–5 orders of magnitude that span MIW/MCM through all ranges of USW systems to include the lowest 10 Hz mine sweeping technologies.
- ▶ Support mission rehearsal, system acquisition and training in both real and realistic environments.

## APPROACH

- ▶ Develop an advanced computer graphics applications facility utilizing the acoustic simulation development algorithm(s) for computation.
- ▶ Establish network connections to super computing capability.
- ▶ Develop practical user oriented interface to LSC based simulation algorithm.
- ▶ Develop graphic displays that rapidly and accurately replicate real environmental acoustic data, model calculations and sensor/system characteristics.



# TOSL HARDWARE LAYOUT



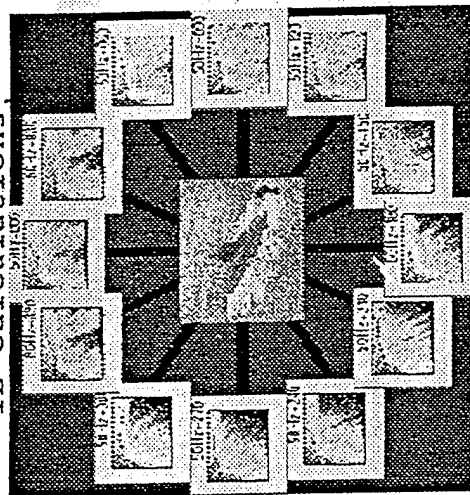
- 1 Crimson (file server)
- 6 Programmer Indigos
- 1 Common Indigo
- Cisco Router & Tek DS

# Naval Research Laboratory

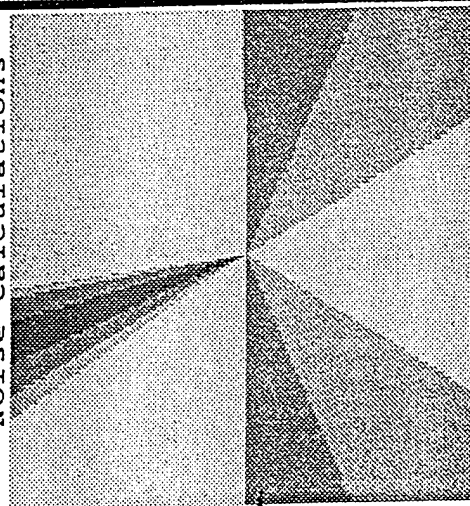
Environment



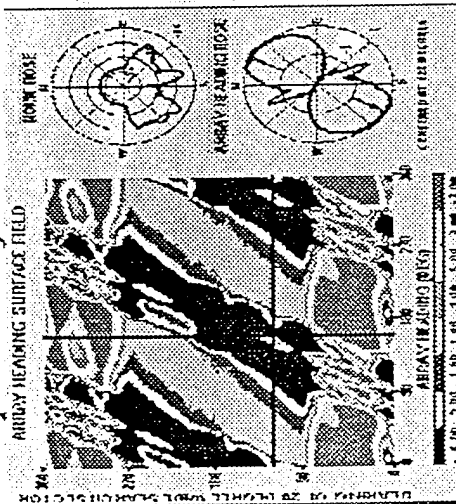
TL Calculations



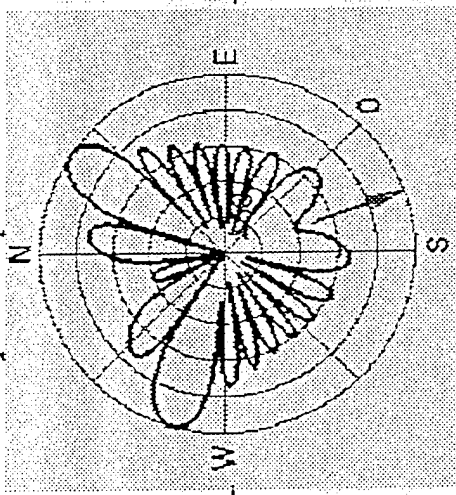
Noise Calculations



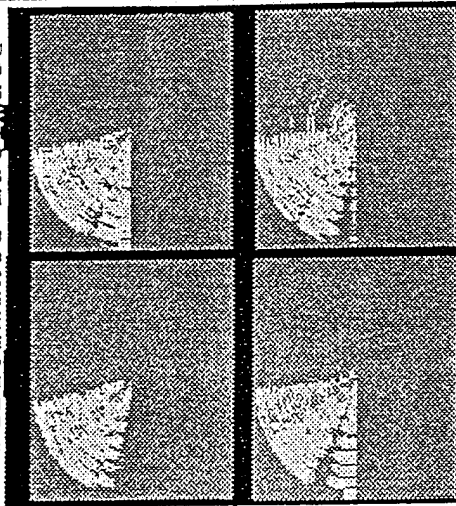
Array Heading Noise Rose



Array Beampattern



Performance Estimate



Performance Prediction Based on Fully Coupled EVA Calculations

Stennis Space Center

Code 7180

## Summary and Conclusions

- ▶ TOSL = suite of independently developed *cooperating* modules/processes to manage TACO information flow and to provide interactive 3-D graphics
- ▶ TOSL allows "niche" experts & expertise to *join* other experts (env, modelling, acoustics, GUI, graphics, ...) quickly and efficiently to explore EVA issues.
- ▶ TOSL provides *access* to the "best" available data sources, be they benchmark, experimental, modelled, Navy standard, user supplied, ...
- ▶ TOSL uses information flow and modular software to yield:

**seamless end-to-end integration  
of research products for the  
purposes of exploratory development**

# **A P P E N D I X D**

**DEMONSTRATION & MINIWORKSHOP  
NRL/SSC  
26 OCT 94**

## **HARVARD OCEAN PREDICTION SYSTEM**

### **AGENDA**

### **ATTENDEES**

### **HANDOUTS**

- 1) Harvard Ocean Prediction System Description**
- 2) A System of Integrated Algorithms For The Efficient  
Estimation of Oceanic Fields VIA the Fusion of Data  
and Dynamics**

### **CSD MINIWORKSHOP**

### **CSD NOTES**

# **Demonstration**

**HARVARD  
OCEAN PREDICTION SYSTEM**

**0900**

**Wednesday, October 26**

**NRL Conference Room  
Building 1005 Room A32**

Harvard Ocean Prediction System Demonstration  
26 October 1994

0900 Welcome

Dr. George W. Heburn  
NRL  
Ocean Prediction and Dynamics Branch

0910 Demonstration Overview

Dr. Allan R. Robinson  
Harvard University

0920 Demonstration

Harvard Ocean Prediction System

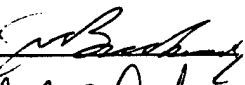
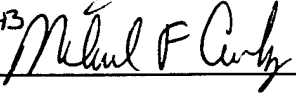
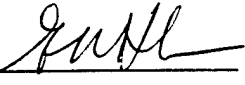
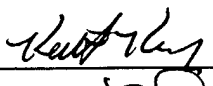
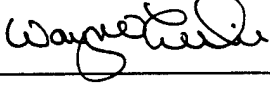
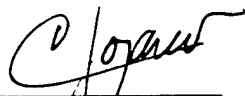
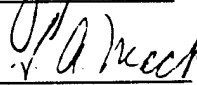
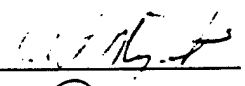
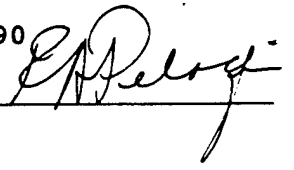
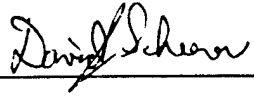
Wayne Leslie  
Harvard University

1010 Discussion

1020 Remarks

Mr. Robert Peloquin  
ONR  
Ocean, Atmosphere, and Space Department

Harvard Ocean Prediction System Demonstration  
Coastal Scene Description Mini-Workshop  
Naval Research Laboratory  
Stennis Space Center, MS 39529-5004  
26 October 1994

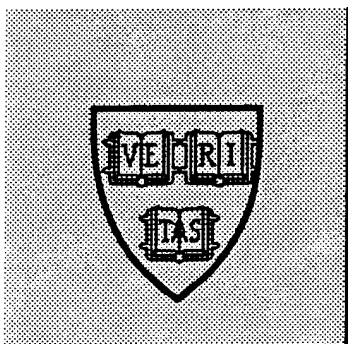
| NAME/EMAIL                                                   | ORGANIZATION | COM          | PHONE<br>DSN                       | FAX          | SIGNATURE                                                                             |
|--------------------------------------------------------------|--------------|--------------|------------------------------------|--------------|---------------------------------------------------------------------------------------|
| Arango, Hernan<br>ARANGO @ PACIFIC.HARVARD.EDU<br>MODS @ " " | HARVARD      | (617)        | 495-3457                           |              |    |
| Breckenridge, John<br>jbreck@dittohd.nrlssc.navy.mil         | NRL          | (601)        | 688-485-5224/4853                  |              |    |
| Crowley, Mike<br>crowley@caribbean.rutgers.edu<br>atlantic   | RUTGERS      | 908-932-6555 | X543                               |              |    |
| Dantzler, Lee<br>dantzhll@jhuapl.edu                         | JHU/APL      | (301)        | 953-5387/6667                      |              |                                                                                       |
| Glenn, Scott<br>glenn@caribbean.rutgers.edu                  | RUTGERS      | (908)        | 932-6555 X544/1821                 |              |                                                                                       |
| Harris, Portia<br>harris@nrlssc.navy.mil                     | NRL          | (601)        | 688-485-5787/4759                  |              |    |
| Heburn, George<br>heburn@nrlssc.navy.mil                     | NRL          | (601)        | 688-485-5448/4759                  |              |   |
| Kerr, Keith<br>keith@anchor.apl.washington.edu               | APL/UW       | (206)        | 543-1268/685-4404                  |              |  |
| Leslie, Wayne<br>leslie@pacific.harvard.edu                  | HARVARD      | (617)        | 495-4569/5192                      |              |  |
| Lozano, Carlos<br>LOZANO @ PACIFIC.HARVARD.EDU               | HARVARD      | (617)        | 495-9807                           |              |  |
| Mack, Stephen<br>steve_mack@jhuapl.edu                       | JHU/APL      | (301)        | 953-6478                           | FAX 953-4908 |  |
| Miyamoto, Robert<br>rtm@apl.washington.edu                   | APL/UW       | (206)        | 543-1303/6785                      |              |  |
| Peloquin, Robert                                             | ONR          | (703)        | 696-226-6463/3390<br>6462          |              |  |
| Robinson, Allan<br>robinson@pacific.harvard.edu              | HARVARD      | (617)        | 495-2819/5192                      |              |                                                                                       |
| Scheerer, David<br>dsj@stdc.jhuapl.edu                       | JHU/APL      | (301)        | 953- <del>6908</del> 6908<br>X8754 |              |  |



# The Harvard Ocean Prediction System

**Harvard Oceanography Group  
Division of Applied Sciences**

*Department of Earth and  
Planetary Sciences*



*System software is available upon request to:*

**Allan R. Robinson, *Principal Investigator***  
robinson@pacific.harvard.edu

**Hernan G. Arango, *Lead Scientist***  
arango@baltic.harvard.edu

## System Description

The Harvard Ocean Prediction System (HOPS) is a computer-based system designed to provide

- a) for the naval ocean forecaster accurate estimates of ocean fields in a timely and reliable manner;
- b) for the physical oceanography scientist realistic simulations of the ocean in order to study fundamental dynamical mesoscale processes;
- c) for the acoustical oceanography scientist tools to obtain reliable representations of the mesoscale sound speed variability;
- d) for the bio-geochemical oceanography scientist an integrated environment to carry out coupled physical-bio-geochemical model simulations.

HOPS is an on-going project at the Harvard University sponsored by the Office of Naval Research. The system represents the structuring of experience gained by the Harvard group in ocean forecasting and simulations since 1984. During this period the group has conducted five real-time forecasting aboard ship exercises over the world oceans; maintained a quasi-operational forecast center for the Gulf Stream and Meander System (1987-1989); researched and developed practical data assimilation schemes and physical, and bio-geochemical models.

The system is designed to accommodate different needs. The HOPS configured as a nowcast/forecast system is designed to meet shipboard operational needs requiring adaptability to diverse datastreams and dominant physics in a given region, and has the ability to be exercised fully as a stand-alone system utilizing ship gathered information only.

The HOPS, configured as a research and training tool for physical oceanography scientists, facilitates the generation of physical fields suitable for process studies, and allows efficient exploration and exploitation of new algorithms and ideas.

The configuration of HOPS for interdisciplinary research is now under development. It is intended to provide a laboratory to investigate the influence of the physical environment on the evolution of oceanic bio-geochemical mass.

In order to accommodate these diverse needs the system is *portable*, *flexible* and *efficient*. These attributes are understood as follows:

*Portable.* The system can be setup in arbitrary ocean regions where synoptic realizations with mesoscale resolution is well supported by data.

*Flexible.* The system supports the use of various data types, remote and *in situ*, and it is setup for an optimal use of its information content by the system in a timely manner. The system contains a suite of intercompatible physical models with varying physics permitting the adaptation of the system to the dynamical regime of the targeted forecasting area. The system includes tools to construct regional observational and model climatology, statistical correlations of observables and model variables, and feature models.

The *efficiency* of the system requires:

- a) *Robust and fast processing* in each system component, and reliable intercomponent communications.
- b) *User interfaces* to guide system processes, especially data and forecast products, quality control and process troubleshooting.
- c) *Visualization and display* tools to facilitate the scientific study of intermediate and final products.
- d) *Interfaces* with other systems (acoustical, biogeochemical, management models, and geophysical fluid dynamics analysis tools).

Figure 1 shows a functional schematic of HOPS. The arrows indicate the main flow of information and the boxes contain activities and process products. The HOPS flow diagram includes other intercomponent connections not shown in Figure 1 for the sake of clarity. It is to be noted that the notion of a dynamical model as the centerpiece of the system is abandoned and emphasis is given to a synergetic view where judicious improvements of a system component benefit the overall system performance. Therefore, a particular configuration is tested for sensitivity and robustness of results using Observing System Simulation Experiments (OSSE). With this viewpoint in mind, a brief description of the system components and areas of current developments follows.

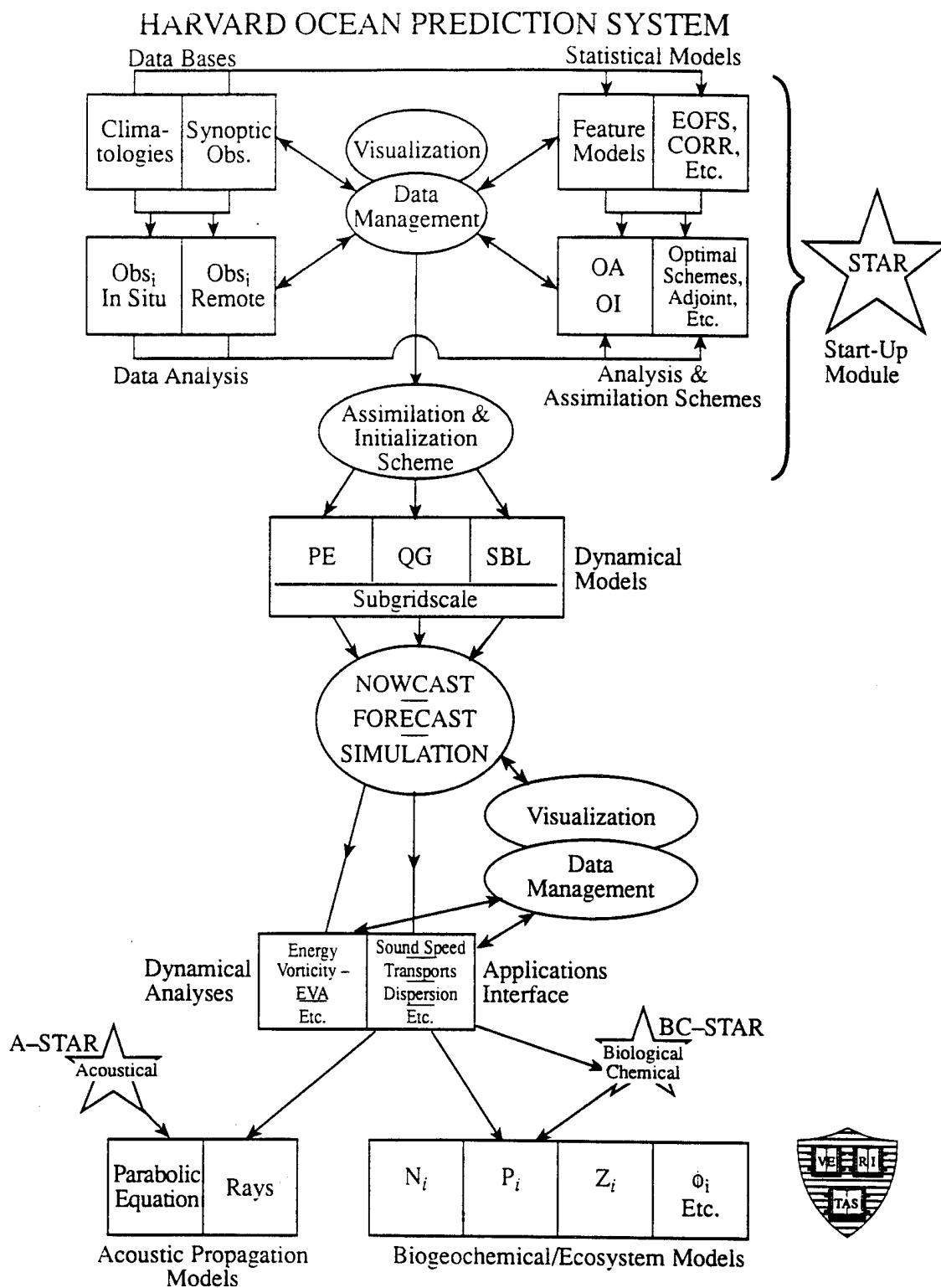
**Statistical Database.** This component embodies our previous knowledge of the region and previous system performance. This information is configured in a form suitable by use with other system components. The traditionally historical data for a region is complemented with statistical correlations between observables and model state variables, semianalytical synthesis of synoptic patterns (feature models), and empirical orthogonal functions.

In order to monitor the system skills, the statistical database must include measurements of model performance both for single forecasts and seasonal forecasts. In addition, there is a need to develop statistical indicators of the impact of observations to the system skill. This information is necessary in the development and design of cost-effective observational strategies.

**Statistical Models** in the system comprise the set of statistical based procedures to interpolate and extrapolate information to the model grid both in space and time. It is convenient to separate — as shown in Figure 1 — a set of exclusively statistically based procedures. This prepares the data for model ingestion from those mixed statistical-dynamical procedures here referred to as assimilation schemes. Optimal analysis EOF vertical extensions, cross correlations, combined optimal analysis and feature models, and water mass models are part of the statistical tools available in the system.

**Dynamical Model Set.** In the system, this is a set of dynamical models amenable to configuration with physics suitable to the region dynamics for interpolation, adjustment (nowcasting) and forecasting.

The suite of the Harvard dynamical models includes a primitive equation model for regional forecasting, a baroclinic quasigeostrophic model for open domains and semi-enclosed seas or ocean regions with or without islands. The quasigeostrophic model has in addition



a module to include surface boundary layer physics, and within this module a biological module can be attached. The quasigeostrophic model can be used for initialization with data of the primitive equation model in the slow manifold.

The dynamical model interconnectivity can be achieved in nested domains with one- and two-way interaction. The latter now under development is intended to provide an avenue to resolve multiscales.

The quasigeostrophic model and the primitive equation models include a suite of codes to track drifters and passive tracers.

**Energy Vorticity Analysis.** Ocean mesoscale is eventful; consequently, there is a need to provide the ocean forecaster with tools to recognize and monitor these events in order to improve the forecaster's skills. Energy and vorticity analysis of events are tailored to operational needs, providing a powerful addition to the ocean forecaster's tool kit.

**Data Assimilation** strategies in a forecast system provide the means for model initialization and update, melding model fields and primary data, tuning of model physical parameters, and providing error estimates.

In a traditional view the dynamical model and the data assimilation schemes act in parallel — the former providing dynamical adjustment and evolution, the latter improving estimates of model fields and updating error estimates. In this sense, the assimilation scheme provides corrections externally to the model. Techniques based upon sequential estimation (optimal interpolation) are available in the system. Sequential estimation provides a time history of fields in dynamical adjustment and error evaluation interrupted by corrections introduced by the assimilation scheme. In distinction, the adjoint method yields a *continuous* history of dynamically balanced fields, and optionally with improved model physical parameters. In either case, it is possible to design strategies for which the time evolution of fields is mostly dominated by the dynamics enabling dynamically consistent approximations to the data. These fields can then be fruitfully used in forecast and dynamical studies. The method of the adjoint for the quasigeostrophic model which has been constructed and utilized in data assimilation studies (Moore, 1991), will be integrated into the system.

The time evolution of error fields is connected with the time evolution of the moments of physical fields and the theory to estimate their evolution is not well developed yet. These error growth estimates are needed within the forecast system to facilitate forecast quality control and evaluation and to aid in the design of cost-effective observational strategies.

As part of the interdisciplinary efforts at Harvard, interfaces for acoustical models with the primitive equation and the quasigeostrophic model have been constructed, and biogeochemical models are now attached to the quasigeostrophic-surface boundary layer model. These model components are integrated into HOPS. The acoustical models are exercised routinely in shipboard exercises.

## Software Summary and Software Attributes

In this section a succinct summary of the Harvard Ocean Prediction System (HOPS) software and its attributes is provided.

### System Components

The system modules are implemented in FORTRAN77. The source code is in compliance with the standard. The source code and ancillary files are maintained using the SCCS utility. Executables are created using the MAKE utility. In addition to the libraries associated to standard FORTRAN compilers the system uses the following libraries: NetCDF, GKS/NCAR graphics, PPLUS, IBM data explorer and PVM.

### Data Format

The designated primary data format is NetCDF supported and freely distributed by Unidata/UCAR. The migration to this data format for all the datasets is near completion.

### System Modularity

Modularity is achieved by restricting a module to accomplish a simple set of tasks with minimum inputs and outputs, and keeping, within each module, isolated input/output interfaces. This permits rapid exchange and replacement of modules.

### Software Portability

The system modules are fully supported presently in the following hardware platforms: SUN, DEC, IRIS, CRAY (YMP, C90)

Import/export of NetCDF to other commonly used data formats or database management systems is widely supported. Postprocessing tools for NetCDF files (graphics, data base management system functions, etc.) are readily available in the network.

### Software Performance and Robustness

Extensive use of the system in real time and in the laboratory shows robust results. The entire forecasting procedures were accomplished in about three hours clocktime in the Iceland-Faeroe Frontal region.

### Graphics

The system uses and supports utilities for the following graphics packages: NCAR GKS, IBM DX, PPLUS, and MATLAB.

The visualization/animation of data using IBM Visualization Data Explorer has been recently initiated. The first generation of products using this tool is under development.

### Datasets

- Bathymetry (TOPO5/NOAA)
- Coastlines (CIA)
- Climatologies: TS (Levitus, Robinson-Bauer, Hellerman-Rosenstein); Atmospheric forcing for the Mediterranean Sea (May, Gilman-Garrett); E-P (Ooort); p (Yaggear); Heat Fluxes (ECMWF, FNOC and NMC).
- NAVOCEANO XBT (91,92 Mediterranean Sea)
- NAVOCEANO Floats 92,93 Mediterranean Sea)
- CTD, XBT (NODC, all data sets).

- Winds (FNOC, ECMWF)
- Atmospheric fluxes (FNOC, ECMWF)
- Eastern Mediterranean POEM hydrography datasets (85,86,87,91,93).
- GULFCAST datasets (1987–1989)
- GEOSAT altimetry.
- TOPEX/POSEIDON datasets (all).
- MODE and POLYMODE datasets (all).
- JGFOS-91 dataset.
- CTD/XBT IFF (NAVO, SACLANT 87,88,89,91,92,93) datasets.
- MARMAP/FISHERIES datasets.
- GEOSECS dataset.
- TTO (NAS and TAS) dataset.
- SYNOP dataset.
- BIOSYNOP dataset.
- CTD OPTOMA.
- CTD/XBT AthenA.

### Statistical Models

*Multivariate Objective Analysis Package(OA).* Includes a generic and a suite of specialized OA modules.

*Single and Multiscale Feature Models* for data synthesis, model initialization and data assimilation schemes.

*Empirical Orthogonal Functions Schemes* for data reduction, vertical extension, interpolation and couplings with interdisciplinary models.

### Dynamical/Biological Model Components

*Primitive Equation Model* with terrain following coordinates including tall or steep topography, and open/closed/semi-enclosed boundaries.

*Quasigeostrophic Baroclinic Model* for open/closed/semi-enclosed regions. *Bulk Surface Boundary Layer Module* attached to the quasigeostrophic model.

*Four Compartment (Phytoplankton, Heterothrops, Nitrate, Ammonium) Biological Module* imbedded in the surface boundary layer module.

*Energy Vorticity Analysis Modules* to construct vorticity and energy balances for quasigeostrophic and primitive equation fields.

*Lagrangian Drifters Modules* imbedded in the quasigeostrophic model and the primitive equation models.

*Passive Tracers Modules* imbedded in the quasigeostrophic model and the primitive equation models.

*Ray Tracer Model* from Scripps.

*2D and 3D Parabolic Equation Acoustical Models* from NUSC.

### Data Assimilation

*Intermittent Assimilation Modules* imbedded in the quasigeostrophic and Primitive Equation Models. Presently the Intermittent Assimilation module exercises an Optimal Interpolation Algorithm.

*Adjoint Assimilation Module* imbedded in the quasigeostrophic model.

# Harvard Ocean Prediction System (HOPS)

## A SYSTEM OF INTEGRATED ALGORITHMS FOR THE EFFICIENT ESTIMATION OF OCEANIC FIELDS VIA THE FUSION OF DATA AND DYNAMICS

**Elements:** • Databases and Data Streams

- Data Analysis Schemes
- Statistical Models
- Data Assimilation Schemes
- Dynamical Models
- Dynamical Analysis Schemes
- Applications Interfaces
- Data Management Tools
- Visualization Tools
- Fields - Space, time distribution of  
oceanic variables

# Field Estimates and Products

Accurate three-dimensional fields with time evolution

## Field estimates via data assimilation

Melded data and dynamics for efficient, accurate and realistic estimates

## Nowcasts

Best present estimate with past and present data and dynamics

## Forecasts

Nowcast projected forward in time via dynamics

## Hindcasts and data driven simulations

Estimate at a given time utilizes past and future data to provide most realistic estimate possible

Physical fields ( $v, p, T, S$ ); Acoustical, biological and chemical fields

Vorticity and energy balances, primary productivity, etc.

# Domains of Application

A rapidly deployable, relocatable system

Any region of the world ocean of interest

Open, partially open or closed domains

Operational model

Arbitrary vertical coasts for shelf or deep ocean

Research/Operational Model

Any region, including across the shelf break

Domains for resolution of multi-scale processes:

Nested subdomains for local higher resolution

Operational Model

One-way nesting

Research/Operational Model

Two-way nesting

# Methods of Estimation and Modes of Application

System allows immediate extraction of a relevant configuration for a specific application

## Configuration considerations:

- Operational or research application
- Technician or scientist user
- Desired final product
- Regional dynamics
- Data resources
- Logistical considerations
  - Real-time, shipboard forecasts
  - vs. laboratory simulations

## Sample configurations:

1. Hydrography - OA - nowcast/forecast  
e.g. rapid assessment
2. Satellite altimetry - OA/EOF - nowcast/forecast  
e.g. no *in situ* data, continued updating
3. Satellite altimetry - feature model - nowcast  
e.g. no *in situ* data, rapid assessment

## Example configurations:

4. Iceland/Faeroes Front
5. JGOFS - NE Atlantic spring bloom
6. Western North Atlantic

## 1993 Iceland-Faeroes Front Experiment

- Initialization and updating with substantial resources
  - CTD's, XCTD's, XBT's
  - ARGOS tracked surface drifters
  - Feature Model
- Primitive Equation Model
- Coupled QG-SBL Models, Parabolic Equation Acoustic Propagation model
- To Demonstrate:
  - Shipboard forecasting in real-time with data assimilation
  - Model forecasting verification
  - Acoustic propagation forecasting
  - Prediction and assimilation of drifter data
  - Observational System Simulation Experiment (OSSE)
- Film Clips:
  - Domain, model set-up, observations
  - Temperature evolution
  - Lagrangian trajectories
  - Surface Boundary Layer forecasting

# 1989 JGOFS Spring Bloom Experiment

- Initialization with minimal resources
  - GEOSAT
  - AXBT's
  - Feature Model
- Coupled QG-SBL-Biological Model
- To Demonstrate:
  - Biological Dynamics
  - Physical-Biological Interactions
- Film Clips:
  - Nitrate
  - Phytoplankton
  - Zooplankton

## Western North Atlantic: GS, Slope, MAB

- Initialization and updating with minimal to substantial resources
  - OTIS
  - Multiscale Feature Model (MSFM)
  - GEOSAT, IR SST, CTD's, AXBT'S
- Primitive Equation Model
- To Demonstrate:
  - Nowcasting and forecasting with a selection of assimilation and initialization schemes
  - OTIS, Multiscale Feature Models, direct data streams
  - Dynamical model validation, calibration and verification
  - Hindcasting across shelf break of coupled shelf and deep oceans
- Film Clips:
  - OTIS initialization, GEOSAT assimilation
  - Model calibration
  - MSFM initialization
  - Mid-Atlantic Bight initialization

# System Attributes

## Flexible, portable system

- Robust software supported on various hardware platforms; workstations - supercomputers
- Uniform data representation
- Adaptable to regional physics and available data
- Efficiently set up for arbitrary ocean regions
- Exercised in several real-time shipboard operations

## Versatile, modular components

- Facilitates configuration for specific needs
- Existing modules allow choice of physics, statistics, analyses, bio-chem dynamics and acoustic propagation
- Allows replacement of modules and extension of system via different modules
- Facilitates adaptation to new applications and interfacing to other systems

## Accurate and efficient:

- Validated in GS, IFF, JGOFS, AthenA, EMed
- Verified in GS, IFF
- Timely delivery of nowcasts and forecasts at sea

# Ocean Prediction Systems

Nowcasts, forecasts, data-driven simulations for the physical-biological-acoustical ocean

Multiscales - shipboard, coastal, regional, basin, etc.

Coupled interdisciplinary models and observational network system with data assimilation for prediction and monitoring

Observational system simulation experiment (OSSE)

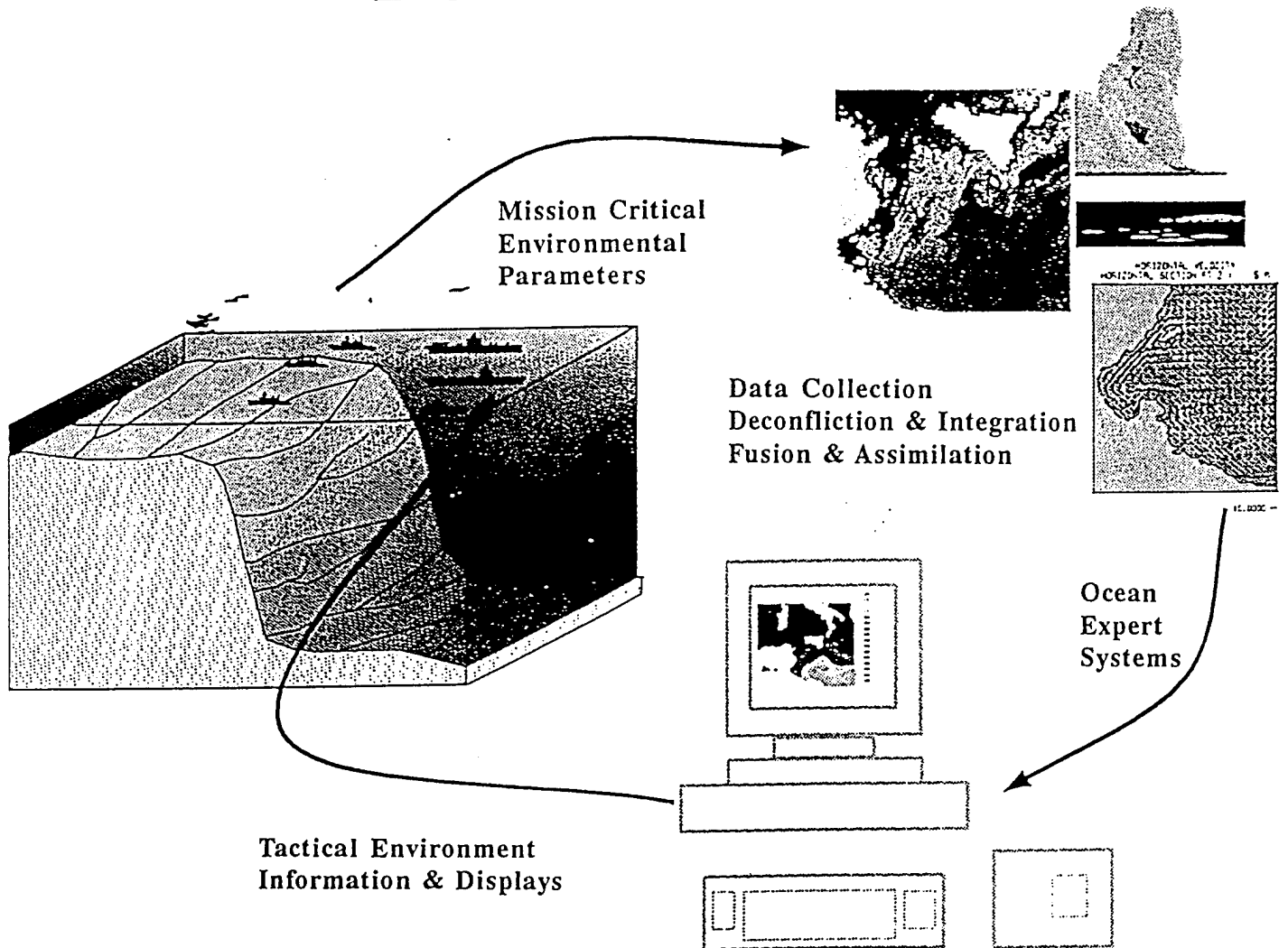
Naval and marine operations

Resource exploration, exploitation and management

EEZ management and pollution control

Biogeochemical cycle, ecosystem and climate dynamics research

# Coastal Scene Description Project Demonstrations



**Wednesday, October 26  
1030  
NRL Conference Room  
Building 1005 Room A32**

Coastal Scene Description Demonstration  
26 October 1994

1030 Welcome

Portia J. Harris  
NRL  
Ocean Prediction and Dynamics Branch

1040 Demonstration Overview

Dr. George W. Heburn  
NRL  
Ocean Prediction and Dynamics Branch

1050 Demonstrations

Ocean Expert System

David J. Scheerer  
Johns Hopkins University/Applied Physics Laboratory

Shore-zone Resolution System

John L. Breckenridge  
NRL  
Mapping, Charting and Geodesy

1130 Lunch

1230 FY 95 Focus

1300 Action Items

Upcoming Events

MABPOM  
3-4 November 94  
Rutgers University

VII. Proposed Mini-Workshop Meeting Schedule

26 October 94 NRL/SSC  
26 January 95 APL/UW  
26 April 95 Harvard University  
26 July 95 JHU/APL

## MEMO

To: CSD Team Members  
Subj: CSD MiniWorkshop Notes  
Date: 22 DEC 94

1. The October 94 MiniWorkshop convened at NRL-SSC in conjunction with the Harvard Ocean Prediction System (HOPS) and CSD Demonstrations. Enclosure 1 lists the attendees.

2. Dr. Alan Robinson and Mr. Wayne Leslie gave the HOPS Demo and Mr. Mike Crowley gave a Data Analysis, Feature Model and Data Fusion presentation.

3. The FY 95 focus is a NRL-SSC on-site capability that integrates all efforts on a single platform. The objective is to host an AMW proof-of-concept simulation demonstration in the MAB/LWTC or an analogous high Navy interest area. In order to achieve this objective, well defined hardware, software, and interface requirements must be forwarded to NRL-SSC for on-site system configuration. Timelines and major events that impact the FY 95 efforts are shown below.

|                 |                                             |
|-----------------|---------------------------------------------|
| 9 JAN - 20 JAN  | System Configuration Review                 |
| 23 JAN - 24 FEB | CSD Data/Software Acquisitions              |
| 9 JAN - 10 MAR  | Hardware/Software Procurement               |
| 10 MAR - 31 MAR | System Installation and Checkout            |
| 3 APR - 14 APR  | CSD Data/Software Rehost                    |
| 17 APR - 8 MAY  | Amphibious Warfare Simulation Development   |
| 15 MAY - 16 MAY | CSD Review/Amphibious Warfare Demonstration |

Dr. George Heburn addressed core and other budget issues.

4. Discussion of needs and issues that impact the FY 95 efforts were numerous.

### NEEDS

Common Interface Definition

OODBM Structure - DSI Conformance

Environmental Characterization

- Upwelling (Oceanographic precursor to Fog)
- Fog (Atmospheric, Amphibious driver)
- Landing Collisions (Fog, Visibility)
- Surf Conditions (Wind, Weather, Open Ocean, Waves, Longshore Currents)

### ISSUES

High probability of Fog occurrence useful to Mission Planner

How are Fog conditions handled in Op Planning

Entry against a Rip Tide

Air Space Control, Amphibious Assault Scenarios & Simulations

Distributed Info for Project Integration, Aerial Photos,

Coastal Bathymetry, SDV Position, Climatology Variations,

High Resolution Spatial and Temporal Scales Data Sources

5. System integration and data resource investigations will be on-going with specific action items reports at the next meeting. Keith Kerr will provide hardware info and Portia Harris will provide sources and make contacts for Landsat and Remote Sensing data from aircraft for Atlantic City, NJ, Tuckerton, NJ, Duck, NC, and the Onslow Bay area.

6. APL/UW will host the next meeting.

# Attendees

## NAME/EMAIL/PHONE

|                    |                                |                         |
|--------------------|--------------------------------|-------------------------|
| Arango, Hernan     | arango@pacific.harvard.edu     | (617) 495-3457          |
| Breckenridge, John | jbreck@dittohd.nrlssc.navy.mil | (601) 688-5224          |
| Crowley, Michael   | crowley@caribbean.rutgers.edu  | (908) 932-6555<br>X543  |
| Glenn, Scott       | glenn@caribbean.rutgers.edu    | (908) 932-6555<br>X544  |
| Harris, Portia     | harris@nrlssc.navy.mil         | (601) 688-5787          |
| Heburn, George     | heburn@nrlssc.navy.mil         | (601) 688-5448          |
| Kerr, Keith        | keith.apl.washington.edu       | (206) 543-1268          |
| Leslie, Wayne      | leslie@pacific.harvard.edu     | (617) 495-4569          |
| Lozano, Carlos     | lozano@pacific.harvard.edu     | (617) 495-9807          |
| Mack, Stephen      | steve_mack@jhuapl.edu          | (301) 953-6478          |
| Miyamoto, Robert   | rtm@apl.washington.edu         | (206) 543-1303          |
| Peloquin, Robert   | ONR                            | (703) 696-6462          |
| Robinson, Alan     | robinson@pacific.harvard.edu   | (617) 495-5192          |
| Scheerer, David    | djs@jhuapl.edu                 | (301) 953-6000<br>X8754 |

Enclosure (1)

# **A P P E N D I X   E**

## **SITE VISITS**

- 1) LITTORAL WARFARE TRAINING CENTER  
CAMP LeJUENE**
- 2) MARINE CORPS MODELING AND SIMULATION  
WORKING GROUP  
QUANTICO, VA**

## COASTAL SCENE DESCRIPTION MINI-WORKSHOP TRIP REPORT

Coastal Scene      Description      (CSD)      Mini-Workshop

participants met at Camp Lejeune 15-16 June 1994. Briefs, tours, specific project discussions, and Littoral Warfare Training Complex (LWTC) development issues addressed Mini-Workshop objectives to better understand and influence LWTC developments through information interchange among academic, government, and private sector researchers. The agenda and roster are in Enclosures (1) and (2) respectively.

The Command Brief emphasized the need for a facility that provides a platform to verify and validate operations using datum and models to simulate littoral environments. Land management, forestry, fish and wildlife briefs stressed the importance of natural history resources in the area. A walking tour of Upper New River Riparian Sanctuary on Paradise Point provided observations of many vegetation and riverine features. Periodic Capability Exercises demonstrate the facility's diversity and similarities to littoral environments. LWTC coastline features enable mission planners and mission analysts to generate operational scenarios that evaluate training objectives, system performance, and operational effectiveness.

The vision brief given by Jeff O'Byrne highlighted the LWTC objectives and operational training requirements shown in Enclosure (3). Middle Atlantic Region features and processes include Area Military Complexes, Urban Target Com-

plexes and beach suitable for seaborne and helo-borne assaults that are representative of combat environments and littoral operational areas.

George Heburn gave the CSD Project overview and discussed the Middle Atlantic Bight (MAB) as the specific area of interest for OES, TEIS, SHORES, and DA&F Projects. Edwin Danford, Maria Kalcic, and John Breckenridge addressed data standards and the availability of high resolution digital data. George Kerr addressed the roles of TOWAN and TOSL and need for additional datum. (See Enclosure (4))

Weather station personnel at MCAS New River gave an impressive demonstration of their worldwide forecasting capability and offered to support MAB data collection and deploy a buoy station in support of Janice Boyd's XMOOR and other CSD project efforts.

The Mini-Workshop addressed the need for alliance among mission developers, mission planners, and mission users (civilian and military components). Communications (letting the right hand know what the left hand is doing) and product integration during initial development phases is necessary to achieve a desirable measure of effectiveness and measure of performance that is second to none. Increased knowledge and understanding of oceanographic, atmospheric, and topographic variability in littoral environments can be better understood using LWTC resources to simulate/construct mock operations and achieve a high probability of REAL-time mission success.

NRLWLTC4  
14 Jun 94

WELCOME to CAMP LEJEUNE!

On behalf of Brigadier General Livingston we, Lieutenant Wetmore, Gunnery Sergeant Wochna, and Jeff O'Byrne would like to welcome you to Camp Lejeune. We will be responsible for your safety and comfort during your visit. If you have any questions or problems when we are not with you, we can be reached at 910-451-5747. In addition, Jeff can be reached at home, 910-455-3828. We will be happy to do whatever is necessary to make your visit a stressless success.

We encourage you to wear casual clothes with walking shoes. We won't do much walking, but it won't be on sidewalks. You encouraged to bring binoculars and cameras.

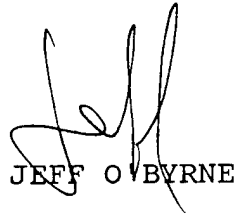
The schedule as currently established is:

| <u>Date</u> | <u>Time</u> | <u>Event</u>                                                                                     | <u>Responsible</u> | <u>Location</u>                                                          |
|-------------|-------------|--------------------------------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------|
| 14 Jun      |             | Pickup by MCB vehicle at A.J.Ellis Airport<br>for transport to Hampton Inn or Paradise Point BOQ |                    |                                                                          |
| 15 Jun      | 0700        | Breakfast                                                                                        |                    | Hampton Inn,<br>Shoney's(across the<br>street) or the<br>Officer's Club. |
|             | 0730        | Depart for Camp Lejeune                                                                          |                    | Hampton Inn                                                              |
|             | 0800        | Welcome aboard                                                                                   |                    | Officer's<br>Club(Eagle's Nest)                                          |
|             | 0815        | Command Brief                                                                                    |                    | Officer's Club                                                           |
|             | 0900        | Natural history brief<br>Peter Black<br>Carmen Lombardo                                          |                    | Officer's Club                                                           |
|             | 1130        | Lunch                                                                                            |                    | Officer's Club                                                           |
|             | 1230        | Walking tour of Paradise Pt<br>Peter Black<br>Carmen Lombardo                                    |                    | Upper New River<br>Riparian sanctuary                                    |
|             | 1430        | LWTC Vision Brief<br>Jeff O'Byrne                                                                |                    | Officer's Club                                                           |
|             | 1500        | Committee matters<br>Portia Harris                                                               |                    | Officer's Club                                                           |

Enclosure (1)

16 Jun

|      |                                                 |             |
|------|-------------------------------------------------|-------------|
| 0700 | Check out of motel                              | Hampton Inn |
|      | Put luggage in bus                              |             |
| 0715 | Depart Hampton Inn                              |             |
| 0745 | Arrive Paradise Point BOQ                       |             |
|      | Put luggage in bus.                             |             |
| 0730 | Depart for tour of Camp Lejeune littoral areas. |             |
|      | (Lunch will be in a commercial establishment    |             |
|      | somewhere along the road.)                      |             |
| 1530 | Arrive at airport, (we'll adjust to meet        |             |
|      | schedules).                                     |             |



JEFF O'BYRNE

Coastal Scene Description Mini-Workshop - Littoral Warfare Training Center  
Camp Lejeune - Jacksonville, NC - 15-16 June 1994

| NAME/EMAIL                                         | ORGANIZATION | PHONE               |
|----------------------------------------------------|--------------|---------------------|
| Boyd, Janice<br>boyd@nrlssc.navy.mil               | NRL          | (601) 688-5251      |
| Breckenridge<br>jbreck@dittohd.nrlssc.navy.mil     | NRL          | (601) 688-5224      |
| Danford, Edwin                                     | DMA          | (703) 285-9326      |
| Dantzler, Lee<br>dantzhl1@jhuapl.edu               | JHU/APL      | (301) 953-5387      |
| Glenn, Scott<br>glenn@caribbean.rutgers.edu        | RUTGERS      | (908) 932-6555 X544 |
| Harris, Portia<br>harris@nrlssc.navy.mil           | NRL          | (601) 688-5787      |
| Heburn, George<br>heburn@lexington.nrlssc.navy.mil | NRL          | (601) 688-5448      |
| Kalcic, Maria<br>kalcic@nrlssc.navy.mil            | NRL          | (601) 688-4436      |
| Kerr, George<br>kerr@nrlssc.navy.mil               | NRL          | (601) 688-4627      |
| Kerr, Keith<br>keith@anchor.apl.washington.edu     | APL/UW       | (206) 543-1268      |
| Mack, Stephen<br>steve_mack@jhuapl.edu             | JHU/APL      | (301) 953-6478      |
| Miyamoto, Robert<br>rtm@apl.washington.edu         | APL/UW       | (206) 543-1303      |
| Robinson, Allan<br>robinson@pacific.harvard.edu    | HARVARD      | (617) 495-2819      |
| Scheerer, David<br>dsj@stdc.jhuapl.edu             | JHU/APL      | (301) 953-6908      |
| Styles, Richard<br>styles@arctic.rutgers.edu       | RUTGERS      | (908) 932-6555 X543 |

Enclosure (2)

Coastal Scene Description Mini-Workshop - Littoral Warfare Training Center  
Camp Lejuene - Jacksonville, NC - 15-16 June 1994

| NAME                                                                                | ORGANIZATION | PHONE          |
|-------------------------------------------------------------------------------------|--------------|----------------|
| LtCol M. J. Swords<br>Director, Training<br>Resources Management<br>Division (TRMD) | Camp Lejuene | (910) 451-5747 |
| Jeff O'Byrne<br>TRMD                                                                | Camp Lejuene | (910) 451-5747 |
| 1st Lt Kevin Wetmore<br>Operations Division                                         | Camp Lejuene | (910) 451-5276 |
| GySgt Brian Wochna<br>TRMD                                                          | Camp Lejuene | (910) 451-5747 |
| Carmen Lombardo<br>Fish & Wildlife Division                                         | Camp Lejuene | (910) 451-2195 |
| Peter Black<br>LUMS & Forestry                                                      | Camp Lejuene | (910) 451-5063 |
| Mary Lynn Phillips<br>GIS Manager                                                   | Camp Lejuene | (910) 451-5876 |

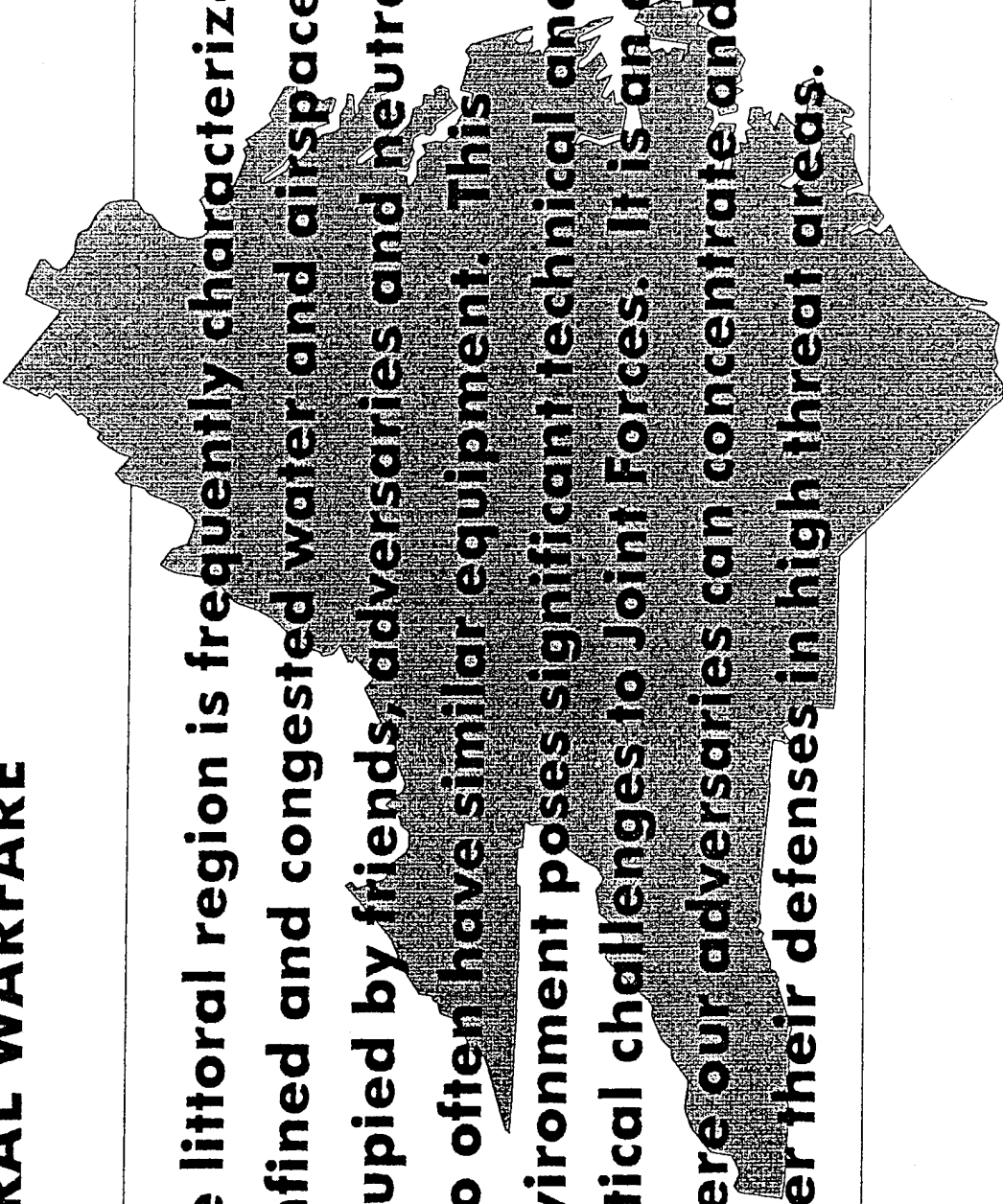
# LITTORAL

# WARFARE TRAINING COMPLEX

# LITTORAL WARFARE TRAINING COMPLEX

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## LITTORAL WARFARE



The littoral region is frequently characterized by (confined and congested water and airspace) occupied by friends, adversaries and neutrals who often have similar equipment. This environment poses significant technical and tactical challenges to Joint Forces. It is an area where our adversaries can concentrate and layer their defenses in high threat areas.

# LITTORAL WARFARE TRAINING COMPLEX

---

**"...From the Sea" Mandates:**

- **A change to link Naval Warfare to Joint Warfare.**
- **Training as a cohesive total Joint Force (Sea-Air-Land Team) with the capability to accomplish:**
  - Command, Control and Surveillance**
  - Battlespace Dominance**
  - Power Projection**
  - Force Sustainment**
- **A Littoral Warfare Training Complex meets this need and will allow us to "TRAIN AS WE WILL FIGHT."**

# LITTORAL WARFARE TRAINING COMPLEX

---

## OBJECTIVES

- Provide for Operating Force training requirements and validation of doctrine and plans.
- Allow for total C 4 I training at the operational level.
- Allow for force-on-force and multiple threat scenario generation.
- Allow for connectivity and continuity between the training commands and field applications of constructive, virtual and live simulations.
- Provide for autonomous range sector operations capability to meet day to day basic and intermediate training requirements.
- Link existing collocated infrastructures to realize a sophisticated Littoral Warfare combat environment with instrumentation.

# **LITTORAL WARFARE TRAINING COMPLEX**

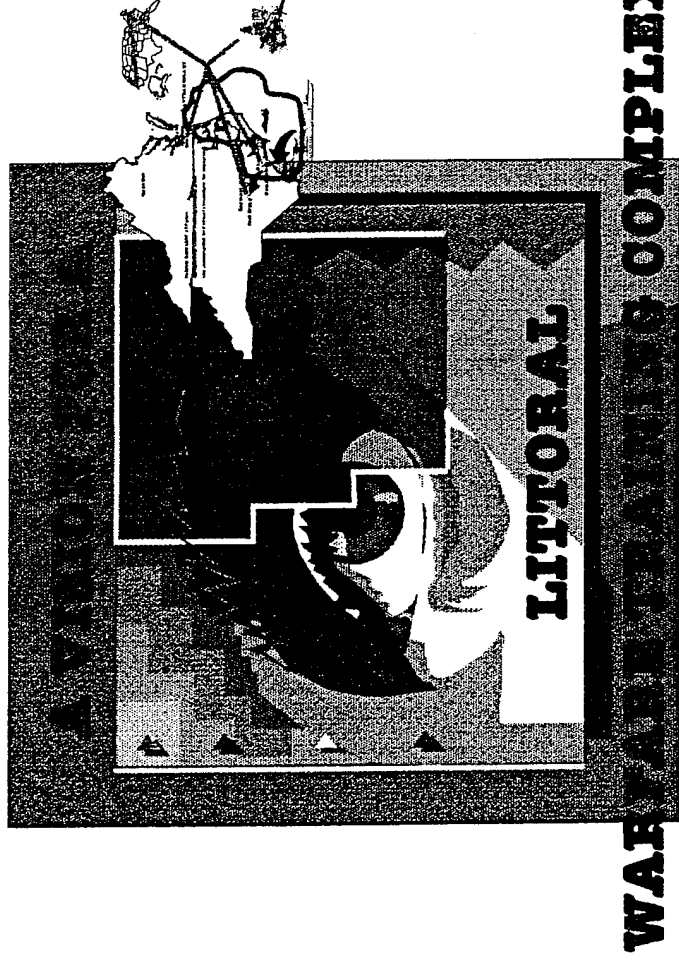
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- **What are the complex's present capabilities?**
- **What capabilities need enhancing?**

# METHODOLOGY

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**How Will We Get There?**



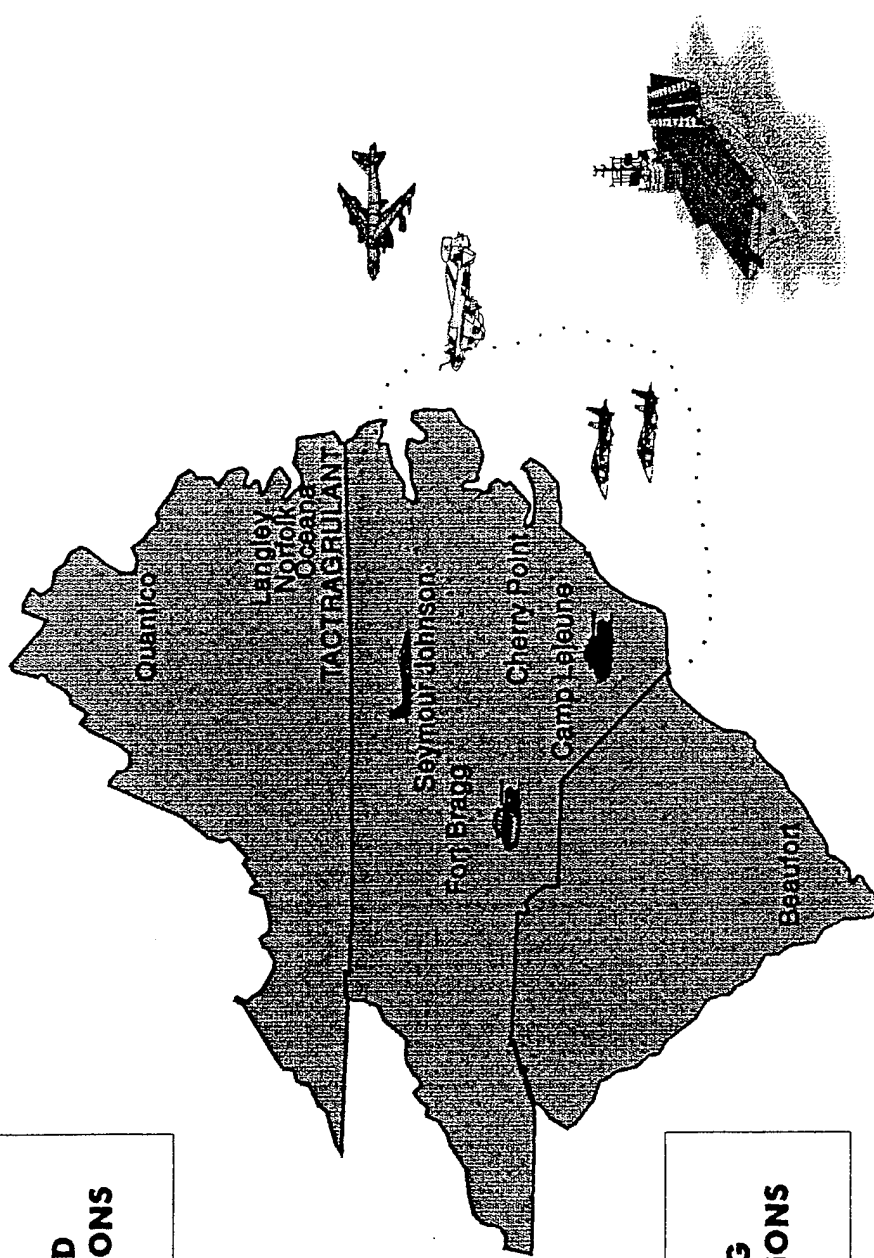
**H-1 COMMAND CENTER**

# LITTORAL WARFARE TRAINING COMPLEX

COMMAND  
ORGANIZATIONS

RANGE  
AREAS

TRAINING  
ORGANIZATIONS



# **LITTORAL WARFARE TRAINING COMPLEX**

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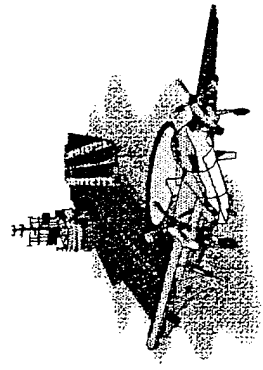
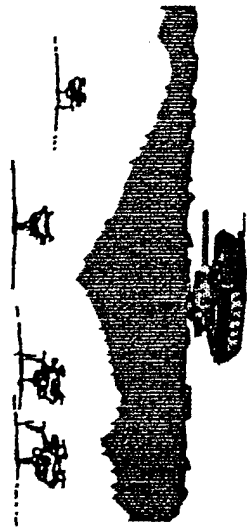
## **Operating Forces Must:**

- Train to fully integrate the Joint Sea-Air-Land team in all functional warfare areas.
- Train to conduct operations from the sea in a littoral environment, mastery of which cannot be presumed.
- Identify and train to the diversified threats and unique tactical challenges that will be encountered in the littoral environment.

# LITTORAL WARFARE TRAINING COMPLEX

## "Total" Force on Force Capability

LIVE/VIRTUAL/CONSTRUCTIVE



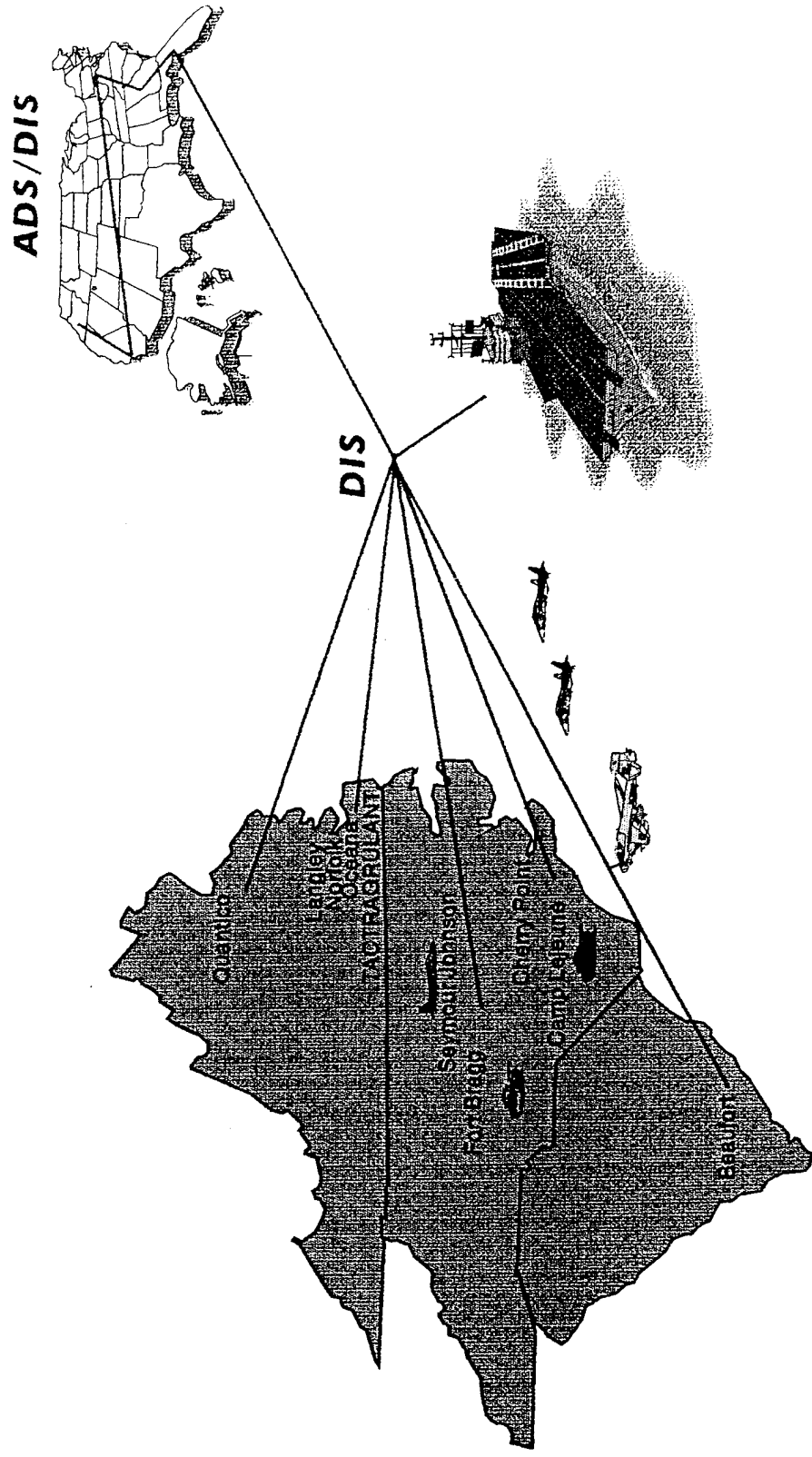
- Combined Arms
- Integrated Air Defenses/C<sub>4</sub>I
- Fixed Wing (Strike)
- Fixed Wing (Fighter/Interceptor)
- Rotary Wing
- Ground Forces  
(Military, Paramilitary, Terrorist)
- Armored Units
- Artillery Units
- Coastal Antiship Missiles/Artillery
- Riverine Units
- Special Operations Forces
- Mobile Logistics/Support Units
- Mine Warfare Units
- Signal Intelligence/Electronic Warfare Units



- Aircraft Carriers (U.S. Only)
- Surface Combatants
- Auxiliary Ships
- Amphibious Ships
- MAGTF (ACE/GCE)
- Support Craft
- Support Units
- Submarines
- Patrol Combatants
- Maritime Patrol Units
- Mine Warfare Units
- Fixed Wing (land based/sea based)
- Rotary Wing
- Special Operations Forces

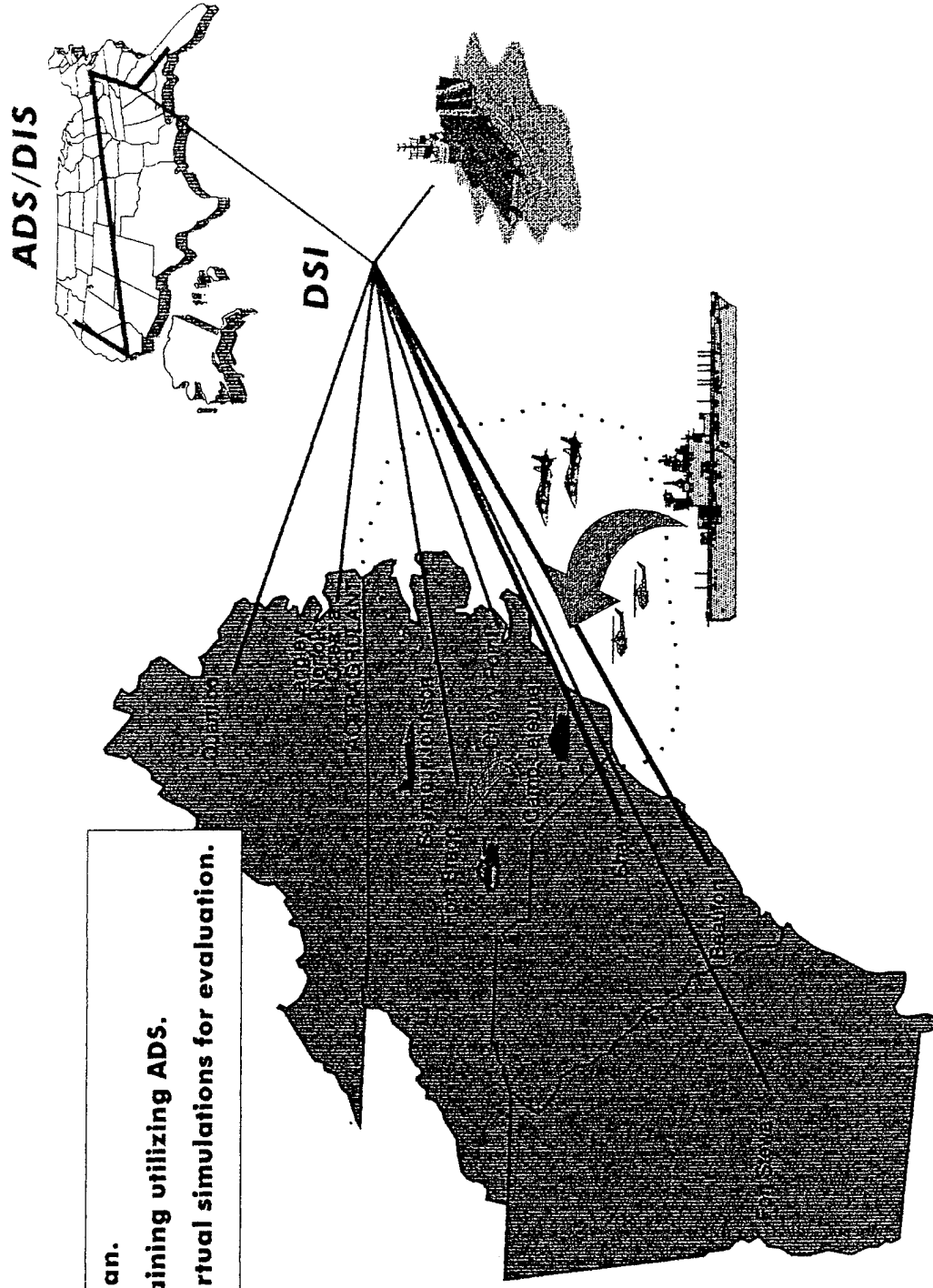
# LITTORAL WARFARE TRAINING COMPLEX

## Interconnectivity for Total Force Training



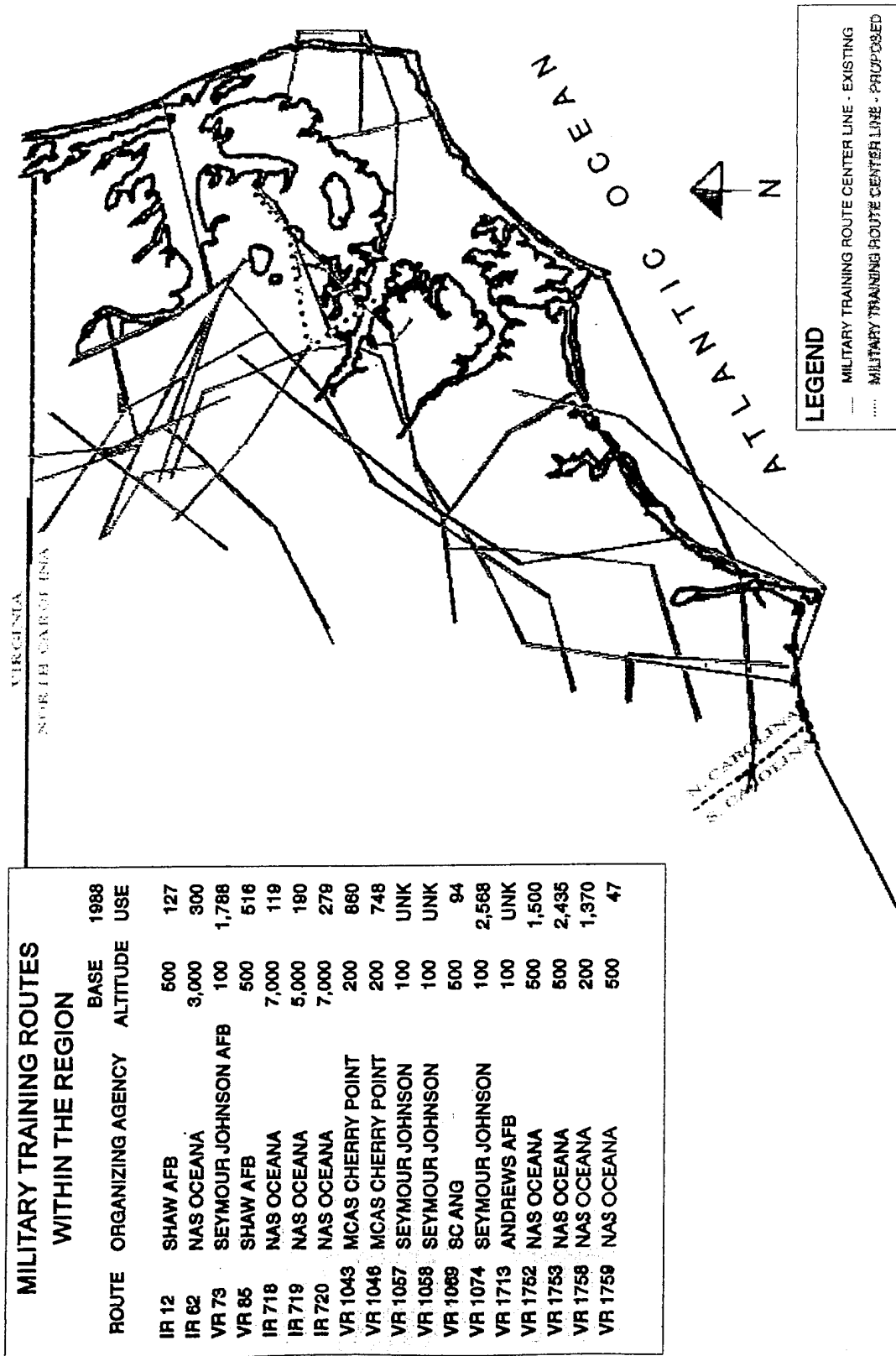
# Demonstration of Capability

**Live, constructive and virtual simulations for evaluation.**



# CONTROLLED AIR/LAND/SEA SPACE

## MILITARY LOW LEVEL (100-7000 FEET) ROUTES THAT CONNECT TO AREA



# **LITTORAL WARFARE TRAINING COMPLEX**

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**The Mid-Atlantic Region is a littoral operational area with regard to combat environment representation to include:**

- **Area Military Complexes**
- **Urban Target Complexes**
- **Beachhead Complexes**

# **LITTORAL WARFARE TRAINING COMPLEX**

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## **Summary**

- **Meets evolving requirements**
- **Major infrastructure in place**
- **Strong political support**
- **Exploits existing and emerging technology**
- **Low risk - high pay off investment**

# LITTORAL WARFARE TRAINING COMPLEX

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## Summary

- Pragmatic and parallel development of inter-range and intra-range subcomponents is crucial
- LWTC concepts will meet new joint force tactical training requirements if implemented
- LWTC investment strategy would:
  - Establish total C<sub>4</sub>I training capability
  - Be cost effective
  - Facilitate timely transition
  - Validate Doctrine/Research & Development/Procurement/OPLANS
- LWTC would complement 29 Palms/NTC/Red Flag Complex
- LWTC fully integrates naval strike/amphibious, ground, and air operations across entire spectrum

# Tactical Oceanography Program

## Coastal Scene Description Project

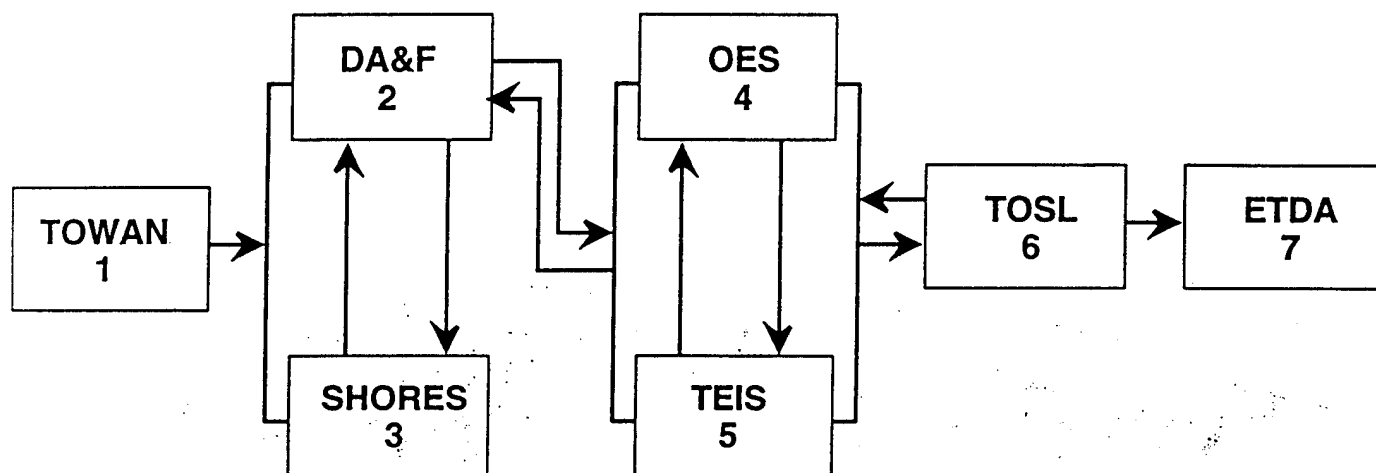


Figure 1. Tactical Oceanography Product Integration Diagram

1. Tactical Oceanography Wide Area Network
2. Data Assimilation & Fusion
3. Shallow-Water Hypsographic Oceanographic Registration and Data Evaluation System
4. Ocean Expert System
5. Tactical Environmental Information System
6. Tactical Oceanography Simulation Laboratory
7. Environmental Tactical Decision Aid

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| Subject             | Briefer                    | Tab |
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| M&S Mgmt Intro      | Col Hanover                | B   |
| STOW/LeatherNet     | LCdr Feldmann/Capt Bryant  | C   |
| LWTC                | Jeff O'Byrne               | D   |
| JMCM ACTD           | Mr. Blumenthal/Maj Wysocki | E   |
| MTWS update         | Maj Connally               | F   |
| JSIMS               | Capt Falkey                | G   |
| MAGTF II/LOG issues | Ms Sheila Finke            | H   |
| JWID-95             | Maj Terry                  | I   |
| JTCTS               | Maj O'Connor               | J   |
| Plenary Session     | Col Hanover                | K   |
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| Notes               |                            | M   |



## MCMSWG 20 Oct 94 Agenda

|             |                     |                            |
|-------------|---------------------|----------------------------|
| 0850 - 0900 | Admin Remarks       | Lt Dave Farris             |
| 0900 - 0930 | M&S Mgmt Intro      | Col Hanover                |
| 0930 - 1030 | STOW/LeatherNet     | LCDR Feldmann/Capt Bryant  |
| 1030 - 1045 | Break               |                            |
| 1045 - 1130 | LWTC                | Jeff O'Byrne               |
| 1130 - 1230 | Lunch               |                            |
| 1230 - 1300 | JMCM ACTD           | Mr. Blumenthal/Maj Wysocki |
| 1300 - 1330 | MTWS update         | Maj Connally               |
| 1330 - 1415 | JSIMS               | CAPT Falkey                |
| 1415 - 1430 | Break               |                            |
| 1430 - 1500 | MAGTF II/LOG issues | Ms. Sheila Finke           |
| 1500 - 1530 | JWID-95             | Maj Terry                  |
| 1530 - 1550 | JTCTS               | Maj O'Conner               |
| 1550 - 1630 | Plenary Session     | Col Hanover                |

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4:04 PM  
10/12/04

## ***The Commandant's Direction . . .***

***"Before we buy, build or fight . . ."***

The M&S Master Plan, together with the Investment Plan, will direct the Corps' M&S technology exploitation in all facets of the combat development/execution process.

Accordingly, ensure your interests are represented in the Plans!

MCMSMO

4:04 PM  
10/15/04

## *The Universe of M&S...* **AGENCIES**

- DoD
- DoN
- CINCS
- JCS
- HQMC
- MCAGCC
- FMF

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## The Universe of M&S . . . SYSTEMS

|                    | <u>Low Tech</u>  | <u>Medium Tech</u> | <u>High Tech</u> |
|--------------------|------------------|--------------------|------------------|
| <i>Individual</i>  | CBT              | ISMT               | TTES             |
| <i>Tactical</i>    | ??               | ??                 | Leathernet       |
| <i>Campaign</i>    | ??               | MTWS               | JSIMS/Leathernet |
| <i>Acquisition</i> | ??               | Ad Hoc             | JSIMS/Ad Hoc     |
| <i>DSS</i>         | MAGTF II/LOG AIS |                    | JSIMS/??         |

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## ***The Concept-to-Reality Process***

- **Study the Playing Field**
  - what is realistic, available, *affordable*?
- **Articulate the Need**
  - Fleet Operational or Mission Needs Statement (FONS/MNS)
- **Construct a Program Proposal**
- **Prioritize the Programs for the POM**
  - compete in the POM process – Politics!
- **Develop the Product**
  - user must participate in alpha and beta testing
- **Procure the Product**

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## ***The Role of the Working Group***

- **Get the Requirements on the Table**
  - Ensure your commanders are aware of developments
- **Assist in the Prioritization Effort**
- **Participate in the Development Process**
  - Development testing takes money and manpower

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**Proposed  
USMC Involvement  
in  
STOW-97**



**MCMSMO Brief to MCMSWG  
20 October 1994**

## Desired Level of MARFOR "Play" in STOW-97

- MEU/ARG in theater
  - Forward presence
  - CLF reports to CATF
- MEU expands to MEF (FWD)
  - COMMARFOR ashore



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- Possible scenario. . .
  - NCA deems conflict imminent
  - CJTF assigned
  - MPF movement initiated
  - CG II MEF designated as COMMARFOR
  - MEF (FWD) deploys
  - Absorbs MEU



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This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or printed text on the paper.

## Desired Level of MARFOR "Play" in STOW-97 (cont)

- Possible scenario. . . (cont)
  - OMFTS capability in theater
  - CJTF commences hostilities
  - MEF (FWD) seizes port and airfield
  - MPF offload
  - AFOE commences buildup
  - MEF established



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## USMC Participation in STOW-97: MAGTF Elements

- CE - Live
  - JTASC, MCCCCF (?)
- ACE - Virtual (ModSAF) and/or Live (instrumented)
  - JTASC (virtual), MCCCCF(?) (virtual), Cherry Pt TACTS range (live), MAWTS (live)
- CSSE - Constructive (ALSP Confederation) or Virtual (ModSAF)
  - JTASC, II MEF Wargaming Center
- GCE - Virtual (ModSAF)
  - MCAGCC ADS Demo Site



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## STOW-97 USMC Issues

- MARFORLANT/USACOM Concept of ops??
  - MARFORPAC/MCAGCC
  - 17 Nov - Brief to USACOM
- M&S infrastructure to support participation
  - MCCCCF/LWTC
  - MTWS - ALSP link
  - DSI @ CLNC and MAWTS
  - DIS/TACTS range interface @ MAWTS
  - TACTS coverage/integration into AOA chosen
- Littoral environment & amphib ops assets
  - JCOS role?



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## STOW-97 USMC Issues (cont)

- Coordination with CINCLANTFLT efforts and goals
- Workup, tech demo and FV opportunities for USMC STOW-97 involvement
  - Tier 2 exercises - FLEETEX
  - MSTP Phase 3 CPX
  - CAX



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# **A P P E N D I X F**

## **PUBLICATIONS AND PRESENTATIONS**

# **FY 94 Publications**

## **JHU/APL**

Johns Hopkins APL Technical Digest

Volume 14 Number 2(1993)

"An Expert System For Describing and Predicting the  
Coastal Ocean Environment"

Johns Hopkins APL Technical Digest

Volume 14 Number 3(1993)

"Reasoning Under Uncertainty for a Coastal Ocean  
Expert System"

Oceans 1994

"An Expert System for Describing the Coastal Ocean  
Environment"

Coastal Scene Description Concept Development and  
Demonstration Test Bed Area

STD-N-989

10 June 1994

## **APL/UW**

The Evolution of the Tactical Environmental  
Information System Classes

July 1994

## **HU/DAS**

Harvard Open Ocean Model Reports

Reports in Meteorology and Oceanography

Number 50

August 1994

Real Time Nowcasting and Forecasting Operational  
Forecasts and Simulation Experiments At Sea

# **FY 94 Publications**

## **RU/IMCS**

1994 Ocean Sciences Meeting

"Remote Sensing and In-Situ Observations of Coastal  
Upwelling/Downwelling Offshore of New Jersey"

"Continental Shelf Circulation and Sediment Transport  
During A Middle Atlantic Bight Northeaster Storm"

## **NRL/SSC/OD**

6th IEEE International Conference On  
Tools With Artificial Intelligence

New Orleans, LA  
6-9 November 1994  
NRL/PP/7320--94-0032

"Intelligent Tools For Environmental Tactical  
Decisions Aids"

# **FY 95 Publications**

## **HU/DAS**

"A Robust Optimal Interpolation Scheme For Real Data  
Assimilation in the Harvard Ocean Prediction System"  
(In Preparation)

## **NRL/SSC/MGD**

SHORES Research Plan NRL Memorandum Report  
(In Preparation)

SHORES Research Findings NRL Report  
(In Preparation)

## **NRL/SSC/OD**

"Coastal Scene Description: Interim Status Report"

NRL/MR/7322--95-7594

## **FY 95 Presentations**

### **NOV 94 - Middle Atlantic Bight Physical Oceanography & Meteorology Workshop**

Rutgers University  
New Brunswick, NJ  
3-4 November 1994

"A Summer of Upwelling Observations Offshore  
New Jersey"  
RU/IMCS

"Simulations in the Middle Atlantic Bight:  
Shelf-break Dynamics and Ring Interactions"  
HU/DAS

"Middle Atlantic Bight Significance to the  
Coastal Scene Description Project"  
NRL/SSC/OD

### **FEB 95 - Mississippi Academy of Sciences**

Marine and Atmospheric Sciences Division  
Biloxi, MS  
9-10 February 1995  
NRL/SSC/OD  
NRL/PP/7322--95-0077

"Environmental Factors That Influence  
Amphibious Assault Mission Effectiveness"