# Survey of Deepwater Currents in the Northwestern Gulf of Mexico


## Evans Waddell



MMS Sol. #: 1435-01-03-RP-71562



**Science Applications International Corporation**
**Raleigh, North Carolina**

# Study Objectives

A. To collect current data to increase our deepwater database and knowledge of the deep circulation in the NW GOM.

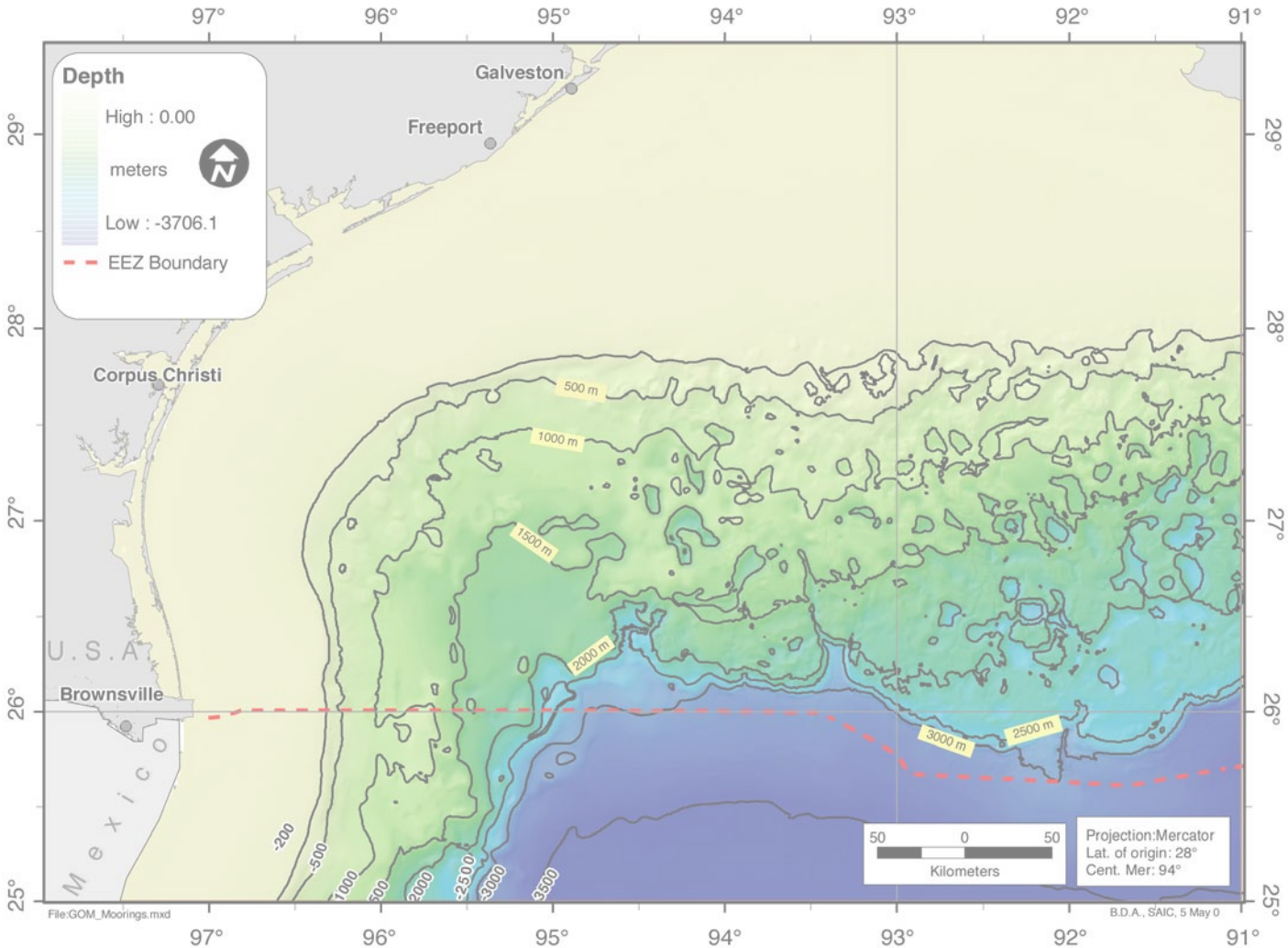
B. To gather information to estimate oceanographic parameters needed to make experimental designs of full-scale physical oceanography studies in deepwater.

C. To provide information for use in oil spill analyses including the emerging deep spill analysis and other ongoing studies, to help evaluate exploration plans, and contribute to the preparation of NEPA documents.

# Primary Data Sources

- Remote Sensing
- Eulerian/Moorings (13 full depth)
- PIES (10 units)

# Map of Study Area




SAIC
From Science to Solutions™

# Team Composition

- Science Team
  - Dr. Peter Hamilton (SAIC)
  - Dr. Robert Leben (University of Colorado)
  - Dr. Kathy Donohue (University of Rhode Island)
  - Dr. Randy Watts (University of Rhode Island)
- Program Team
  - Dr. Evans Waddell (SAIC)
  - Mr. James Singer (SAIC)
  - Mr. Paul Blankinship (SAIC)

# Science Review Group

- Dr. John Bane (University of North Carolina)
- Dr. Wilton Sturges (Florida State University/ FBN Oceanography)
- Mr. David Driver (BP)
- Dr. William Schmitz

# Initial Process Focus

- Eddy-Slope Interactions
- Deep Circulation Patterns
- High Frequency Currents

# Eddy-Slope Interactions

# Eddy-Slope Interactions: Potential Hypotheses

**H1:** Off-shelf advection of PV generates companion cyclones to LC eddies adjacent to the slope.

**H2:** Shelf-slope exchange occurs preferentially in NW corner.

**H3:** Eddy spin-down over topography is a slow process.

**H4:** Eddy energy and vorticity fluxes are transferred to the mean flow.

**H5:** LC eddies colliding with the western slope usually translate northwards into the NW corner.

**H6:** Older anticyclones adjacent to the slope can be invigorated by merging with newer LC eddies.

# Deep Currents

# Deep Currents: Potential Hypotheses

**H7**: TRW energy is refracted to the south and does not penetrate onto the upper slope.

**H8:** TRW's can be generated by the collision of LC eddies with the western slope.

**H9:** LC eddies have companion deep eddy circulations.

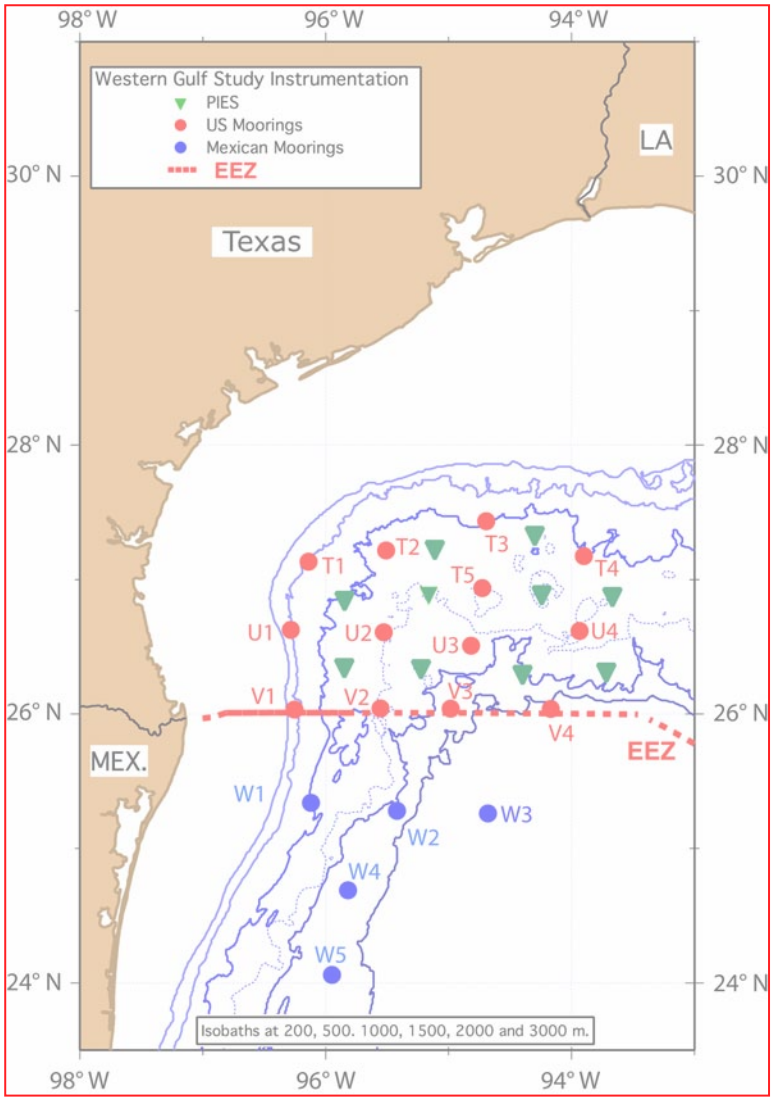
# High-Frequency
# &
# Short Duration Currents

# High-Frequency Currents: Potential Hypotheses

**H10:** Inertial currents are generated and trapped by slope eddies as well as storms.

**H11:** Rare mid-water jets can occur during eddy interactions with the slope.

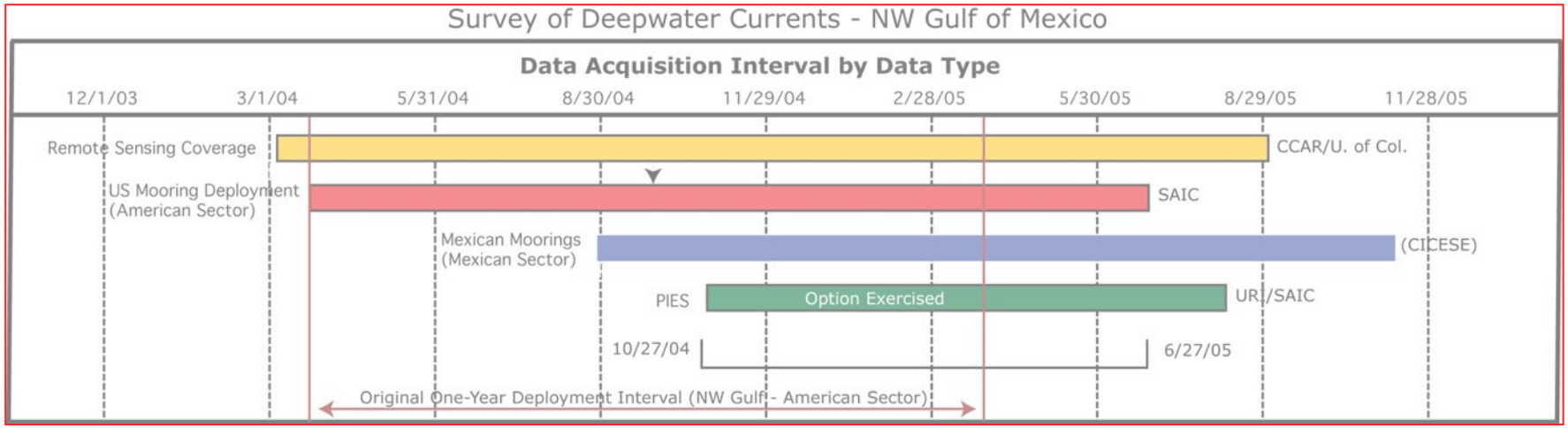
# Western Gulf Mooring & PIES Locations




- North of EEZ, 13 full-depth moorings. T, U,V going from North to South
- 10 PIES (option)
- South of EEZ, five full-depth moorings (CICESE)

SAIC
From Science to Solutions™

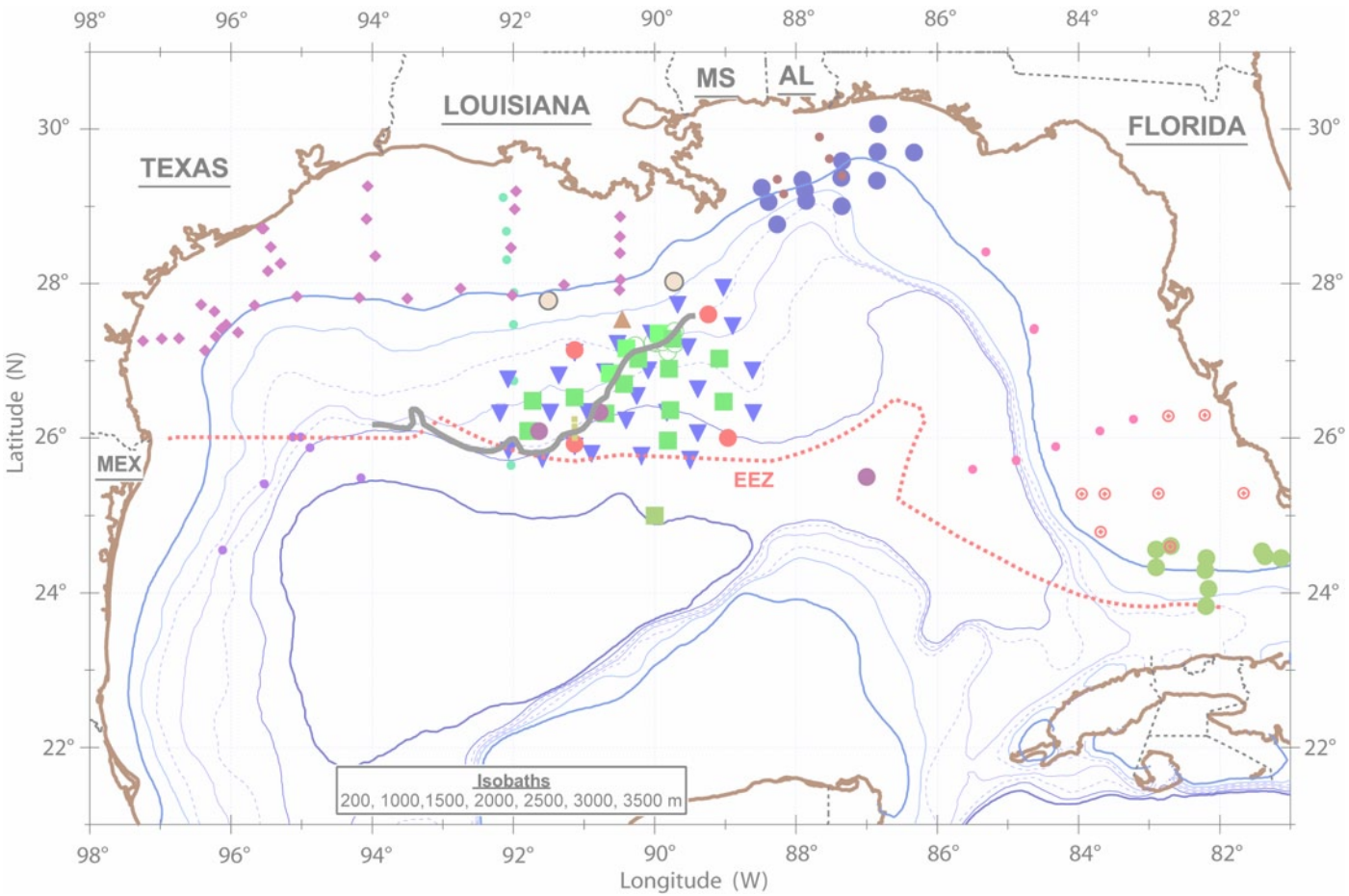
# NW Gulf Deepwater Currents




- Initial expected measurement interval shown.
- Implement PIES Option – extended field obs.
- Delay in CICESE deployment – extended field obs.
- Comprehensive (complete) data set ≈ 8+ months in duration.

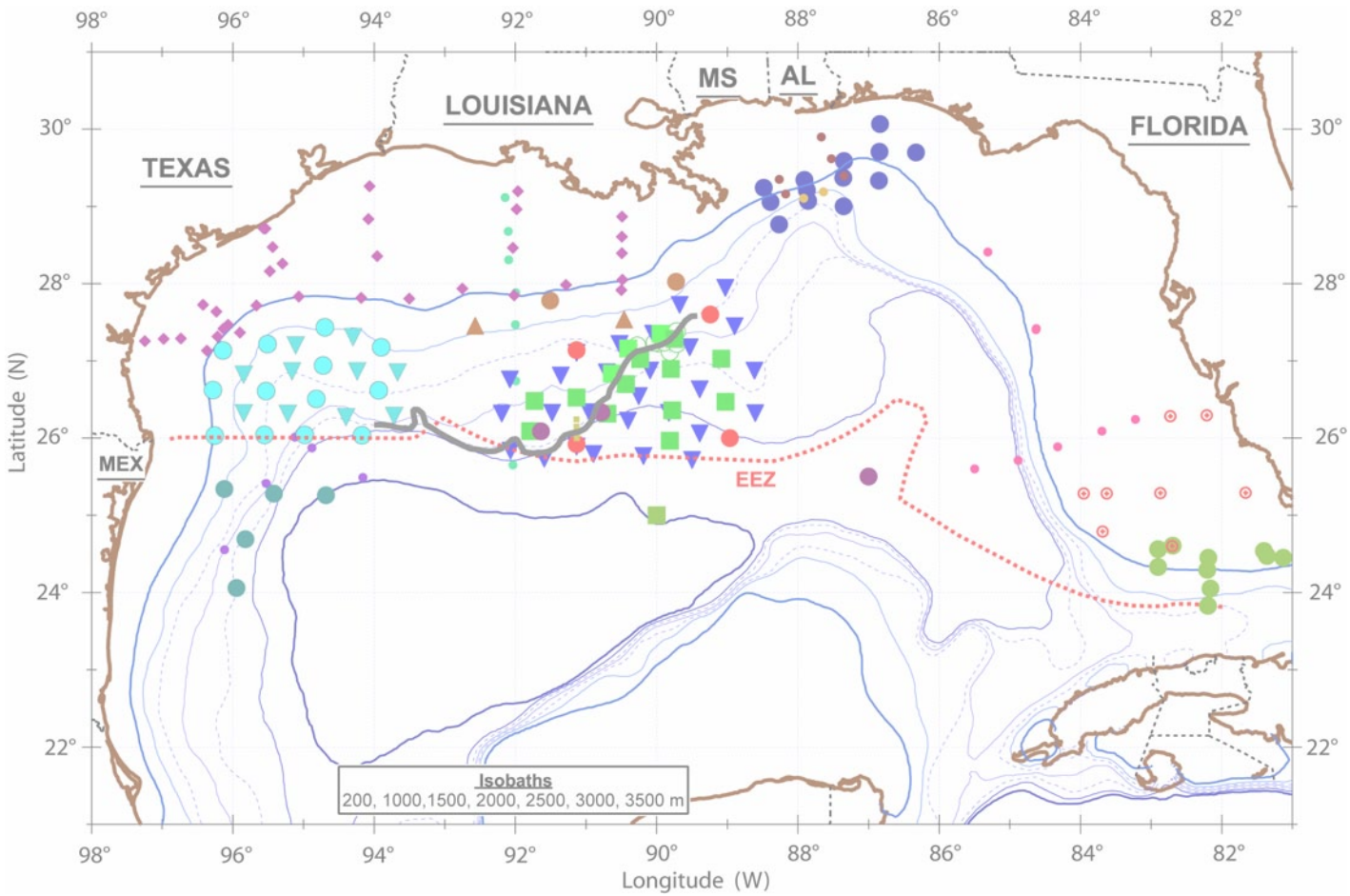
SAIC
From Science to Solutions™

# MMS Studies Prior to 2003




- General distribution of MMS observations prior to NW and NE Gulf Studies.

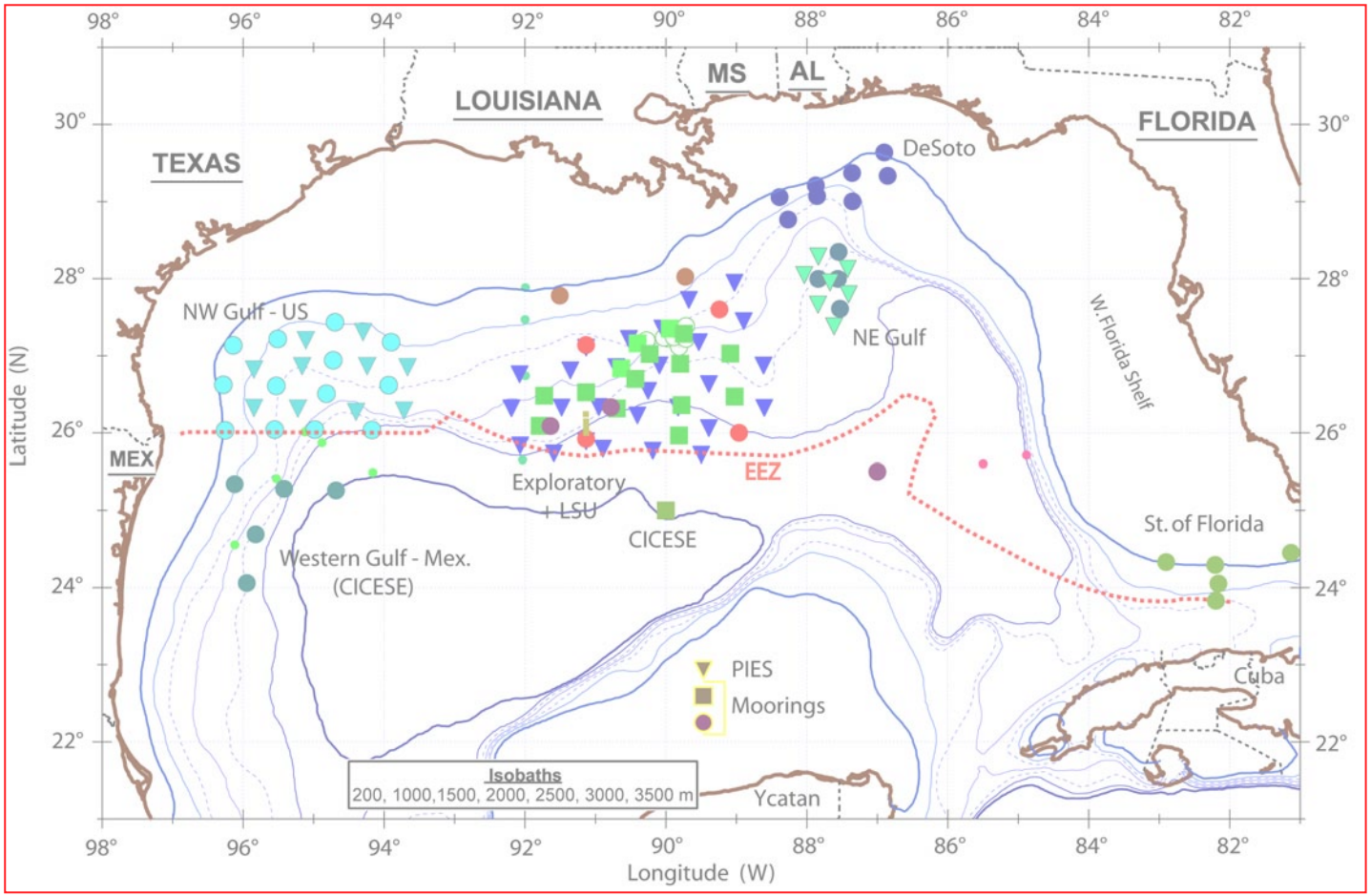
# Observations Prior to NE Study




- Distribution of observations prior to NE Gulf Study

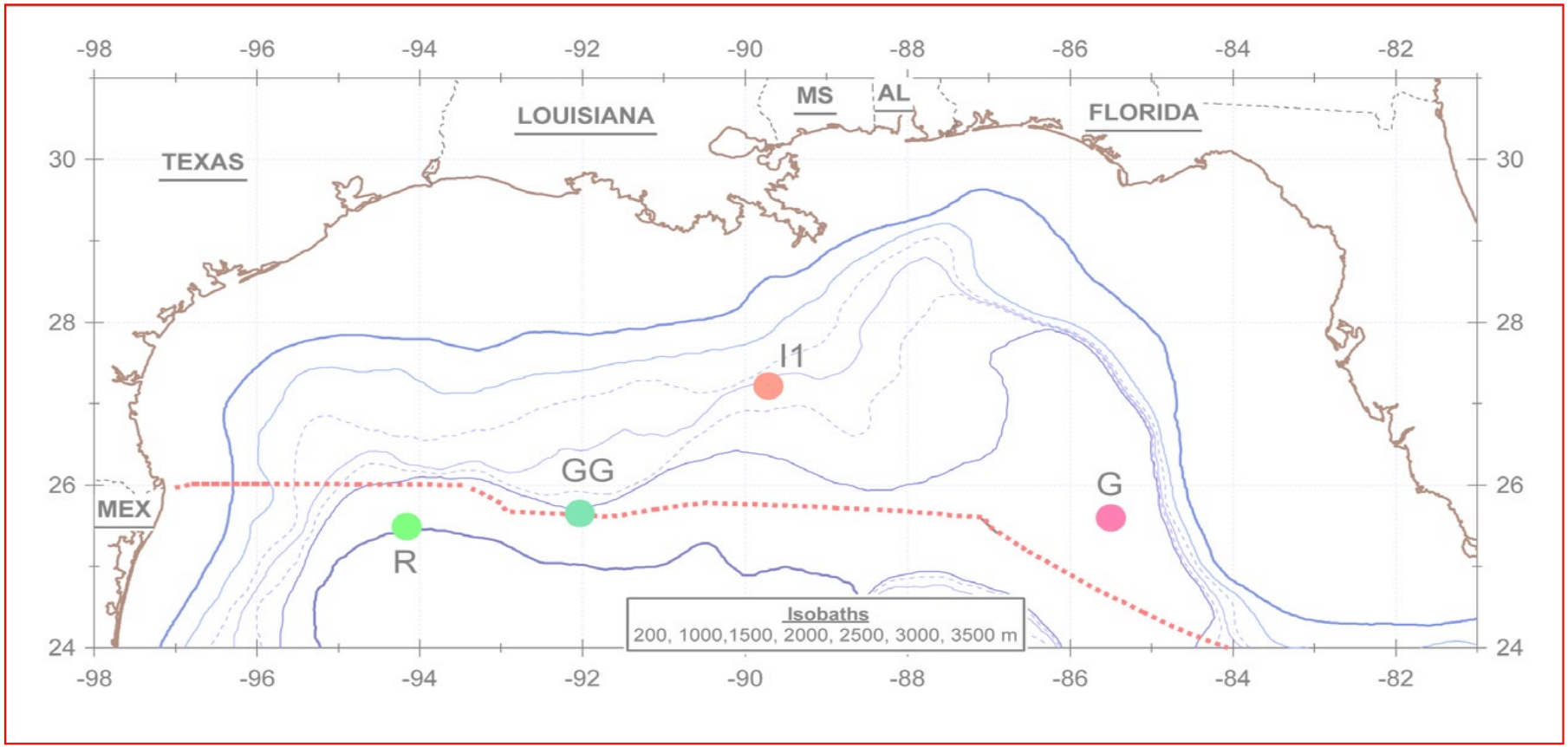
# Available Deep Observations

MMS-funded and cooperative moorings and PIES in water depths greater than 200 m.



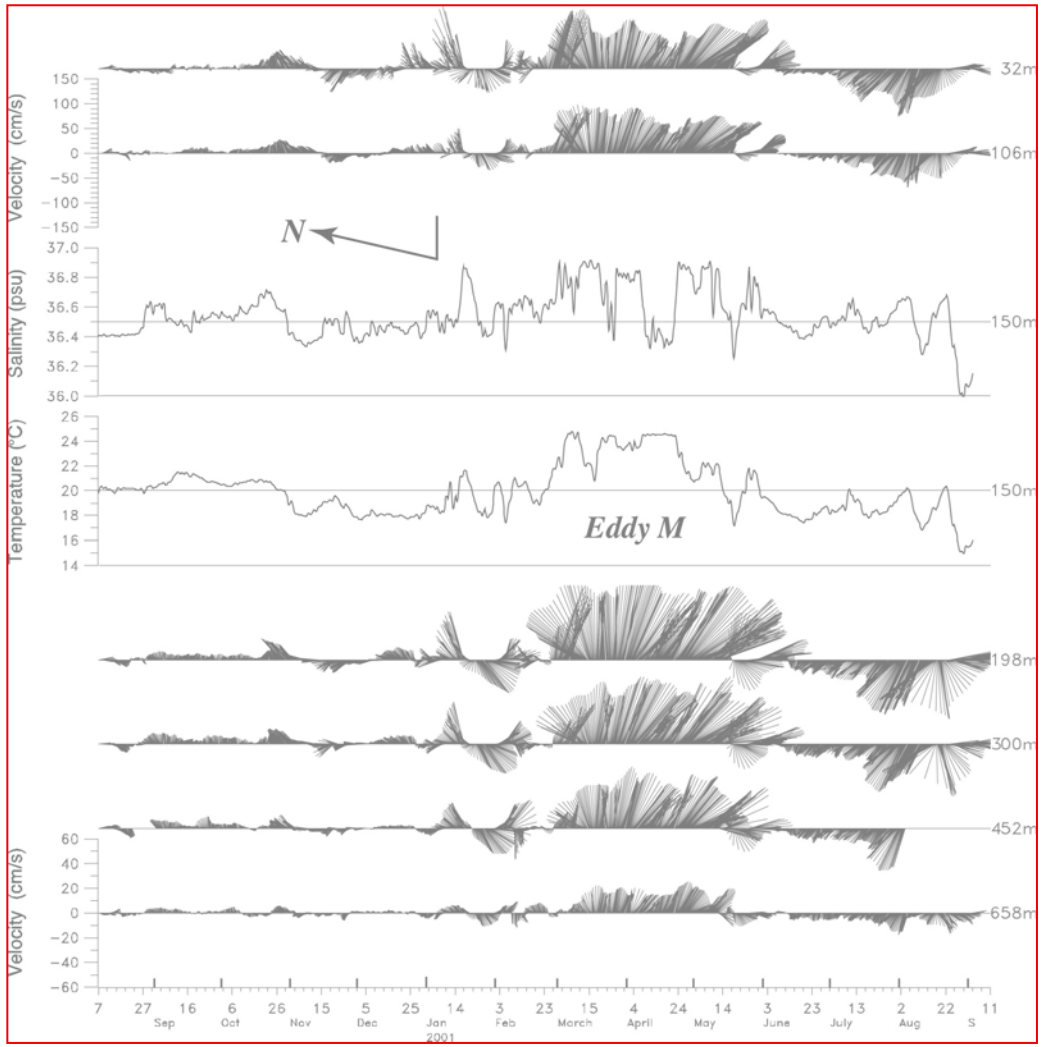

Small circles show location of moored observations take in the 1980s.

# Archival Deep Moorings



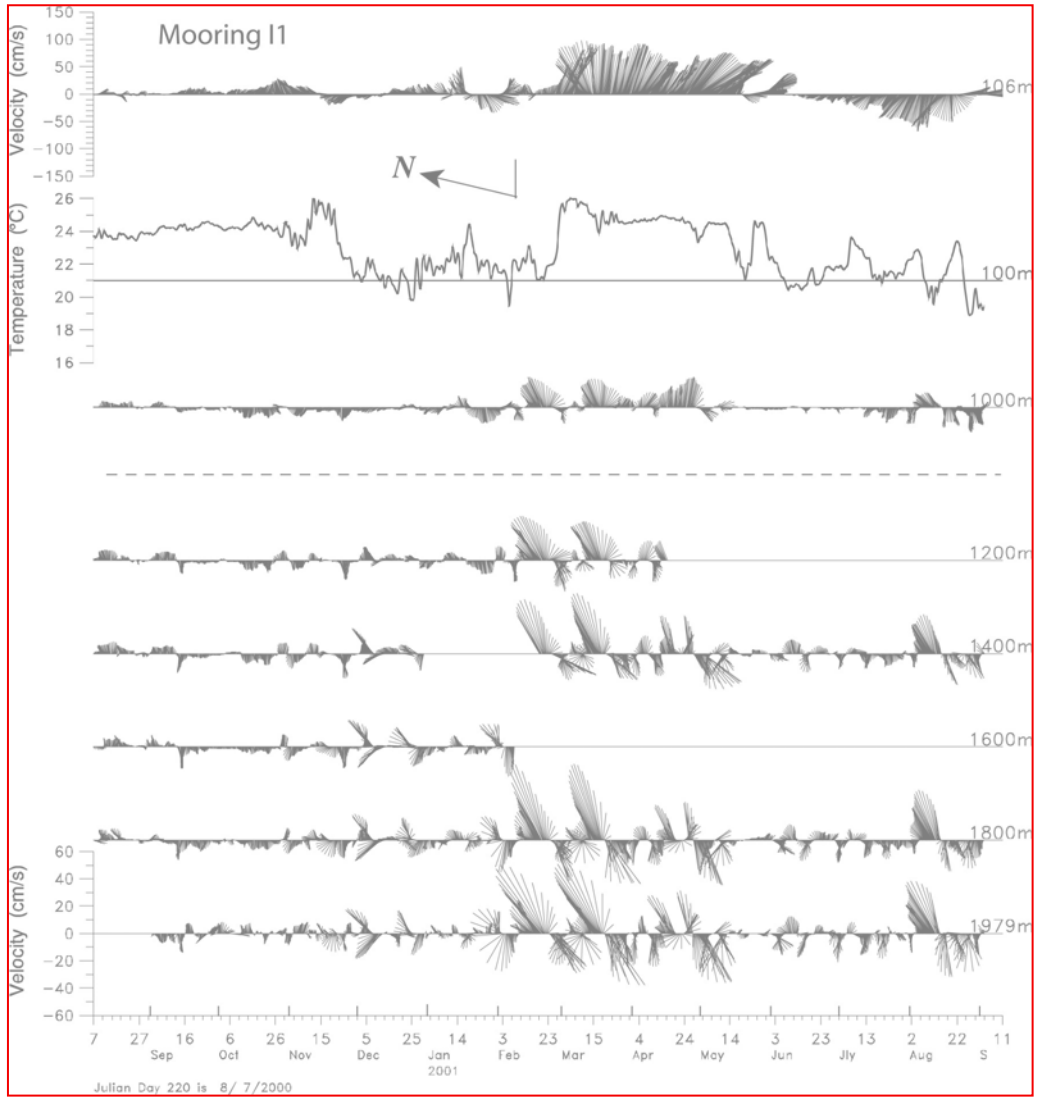
# Low-Frequency, Upper-Layer Currents

- Strong, vertically sheared currents associated with passage of a vigorous Loop Current Eddy (LCE) measured at Mooring I1.



# Currents Through the Vertical

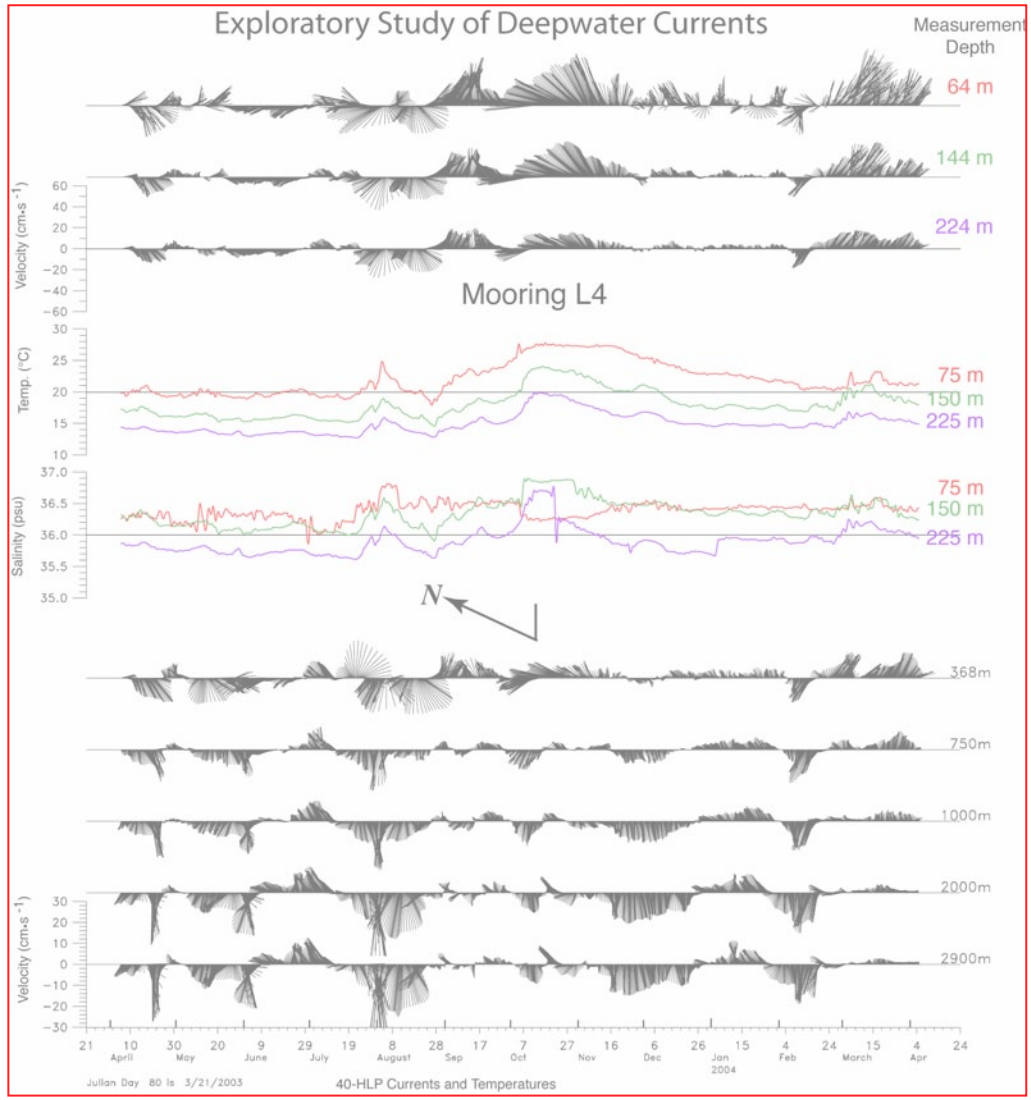
- Strong vertical similarity of velocity at depths > 1000 m.
- Upper and lower layers have different processes and patterns.
- Bottom intensification.




SAIC
From Science to Solutions™

# Currents Through the Vertical-Central Gulf

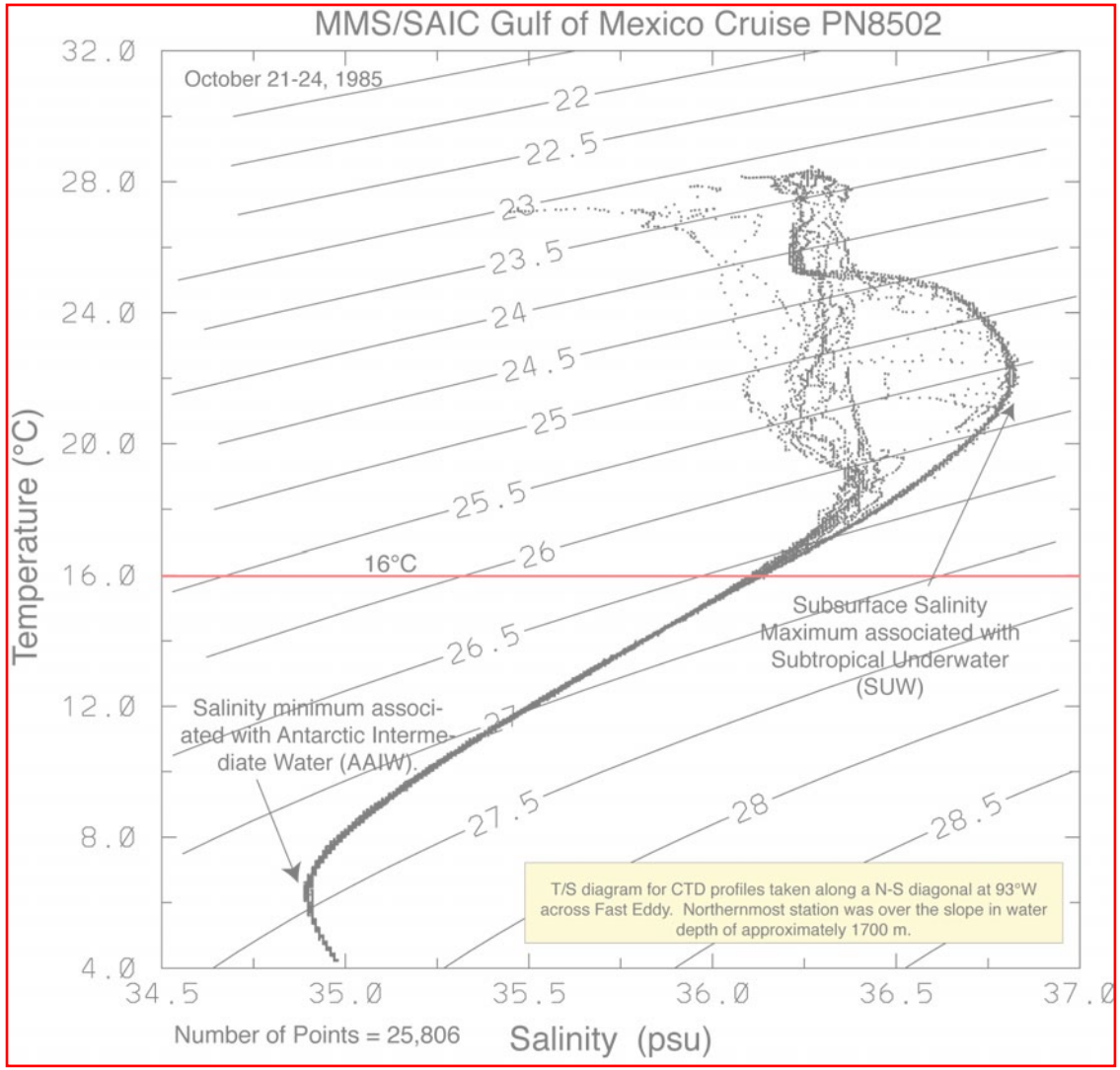
- Currents measured during exploratory
- Passage of LCE in upper layer
- Upper layer and lower layer currents different
- Vertically coherent within layers




SAIC
From Science to Solutions™

# Temperature/Salinity in the Upper Layer

- Temperature/salinity diagram for observations taken in Fast Eddy at approximately 93° W. Subsurface salinity maximum is still intact.



# Vertical Instrument Placement

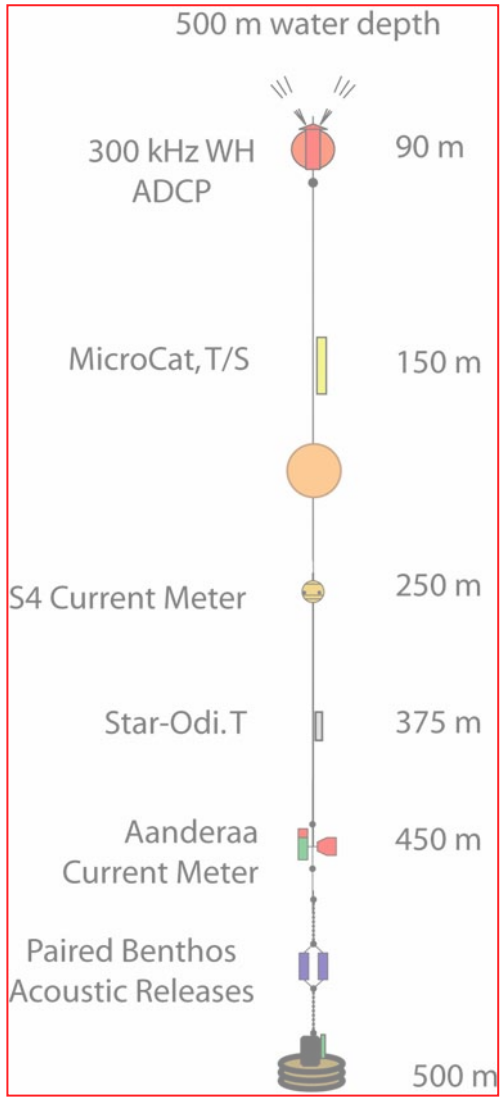
- Vertical Sensor Placement
  - Currents: Above 1000 m, currents measured at $\Delta z \leq 250$ m, at and below 1000 m, currents measured at ≈ 500 m spacing. Depending on water depth, the lowest current meter always approximately 50 m or 100 m above the local bottom.
  - Temperature/Salinity - All moorings have recording temperature sensors at ≈100, 150, 250, 375 and 500 m. All current meters/profilers also provide temperature observations. Salinity is measured with a MicroCat or SeaCat at 150 m in an effort to define the presence of the subsurface salinity maximum.

# Vertical Instrument Placement

- Each mooring included an ADCP to measure currents in the upper portions of the water column. In water depths > 500 m, a 75 kHz ADCP was used near the top of each mooring. On the three, 500 m moorings, 300 kHz ADCPs were used. Temperature/ salinity sensors were attached to wire extending above the ADCPs.

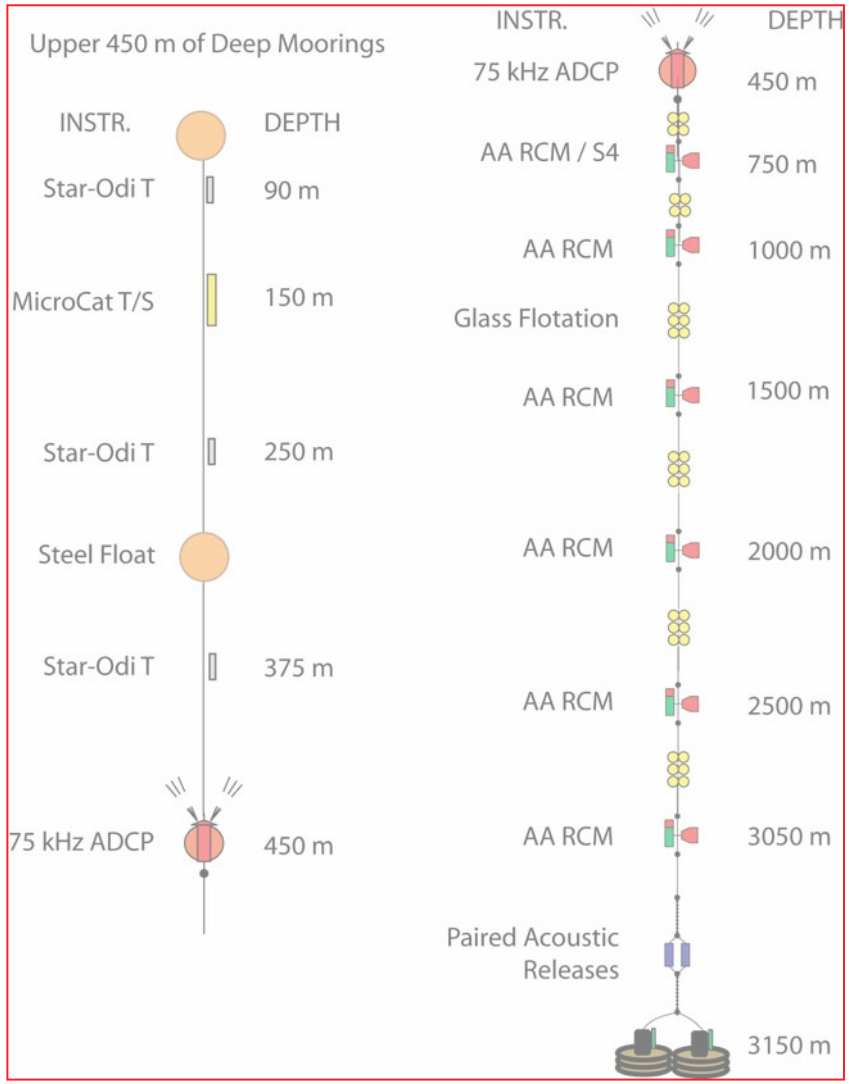
# Mooring on 500 m Isobath

- 300 kHz ADCP @ 90 m
- CMs at 250 and 450 m
- MicroCat at 150 m (T/S maximum)
- Star-odi at 375 m



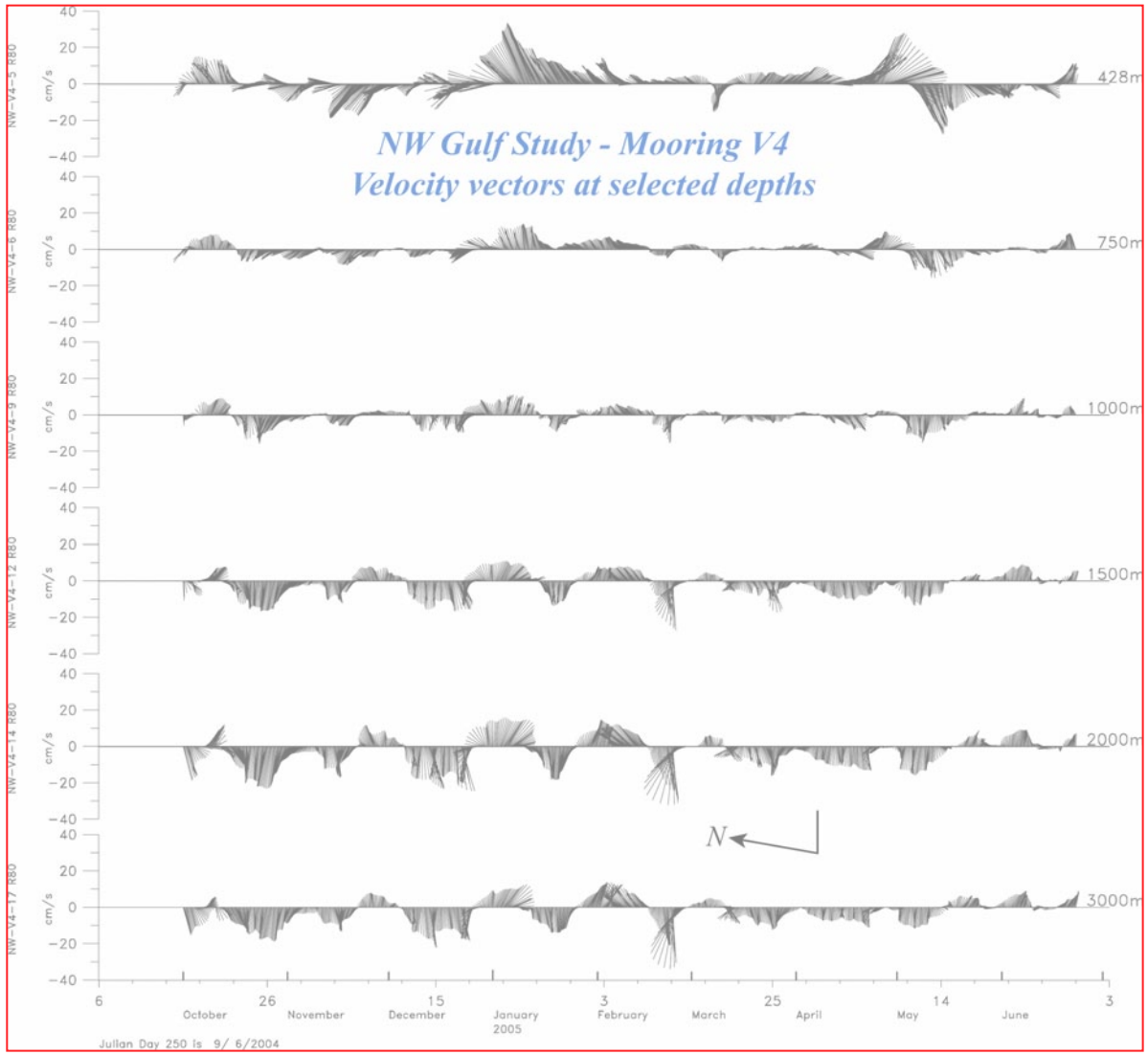
# Schematic of Deep Moorings

- 75 kHz ADCP @ 450 m
- CMs at 250 m interval to 1000 m
- CMs at 500 m intervals below 1000 m
- CM 100 m above bottom



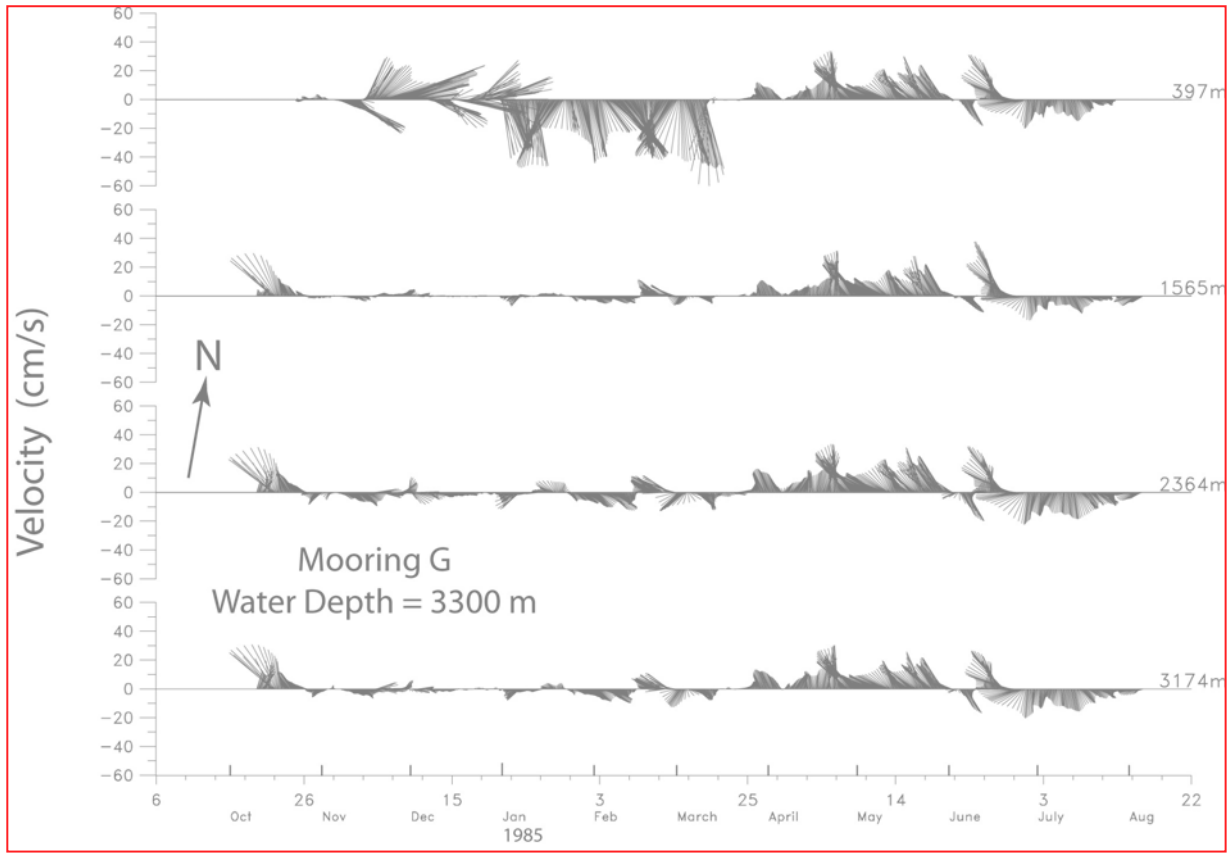
# NW Gulf – Velocity Through the Vertical

- Expected vertical coherence of velocity in the lower layer was seen in the NW Gulf Study.

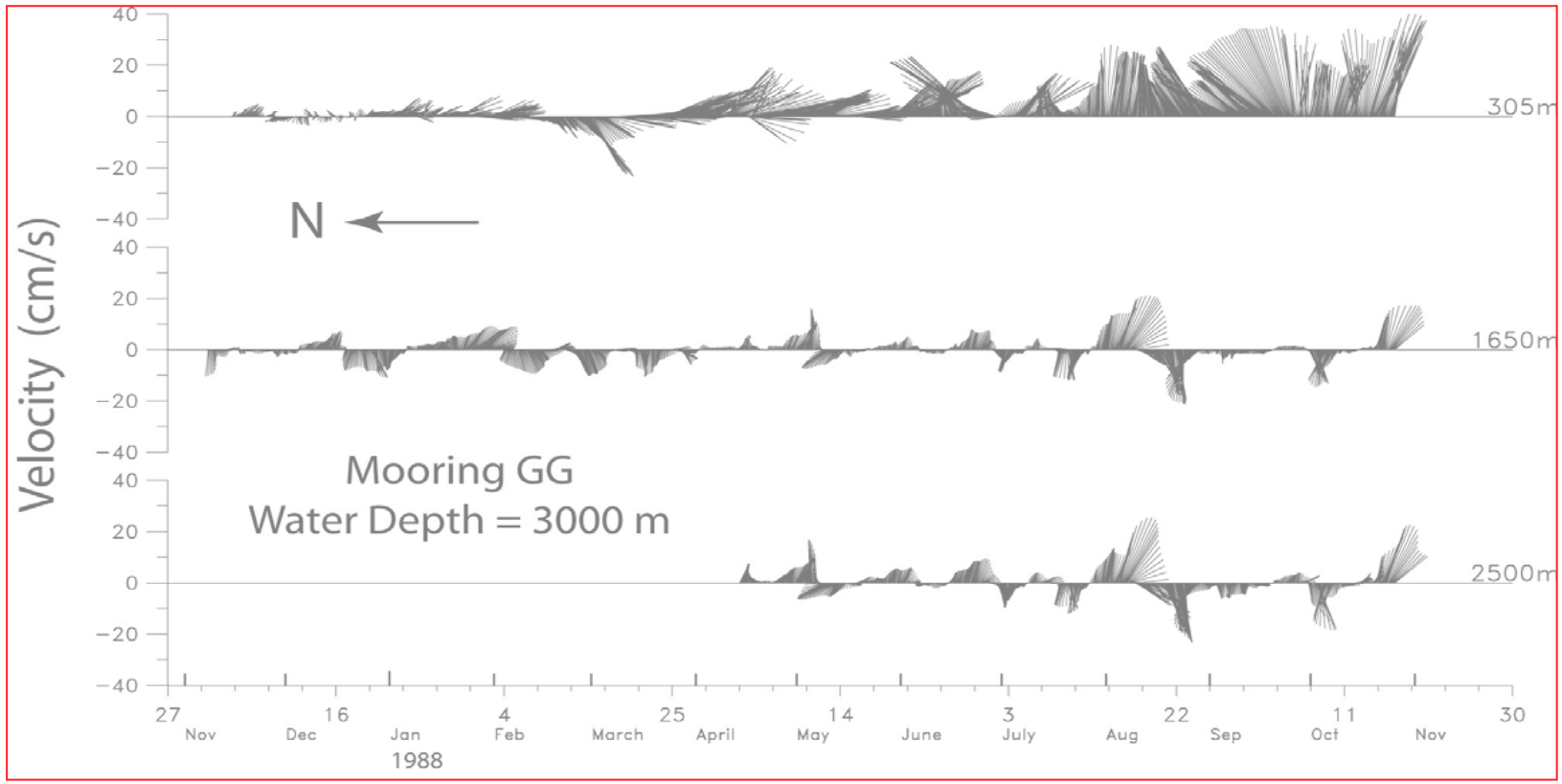


# Under the LC

- Deep currents are coherent, with more vigorous currents directed toward the north – counter to the LC.
- Surface-to-bottom coherence did occur with both N and S components.



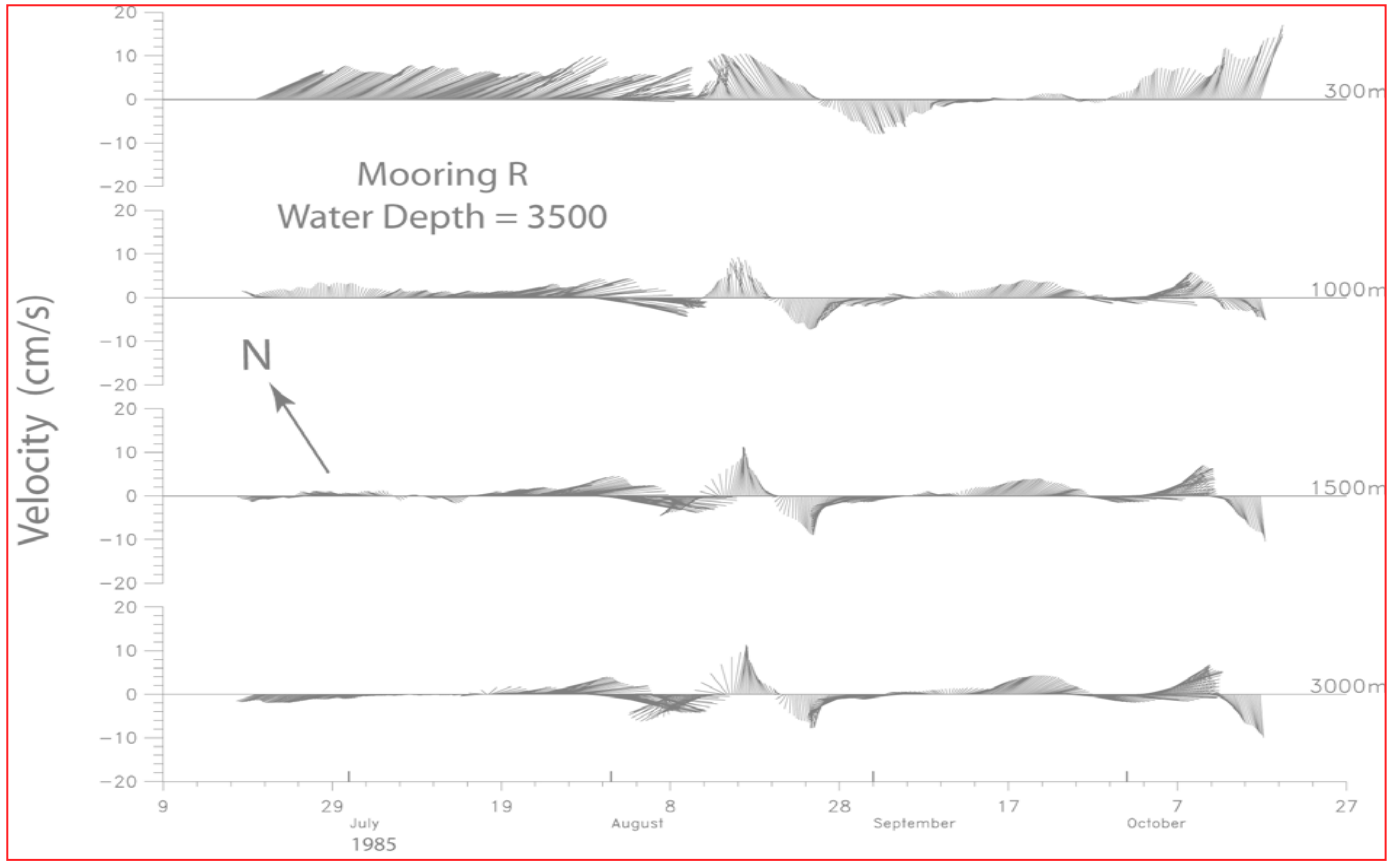
# West Central Gulf




- At least the lower half of the water column was similar with weak shear away from the bottom.

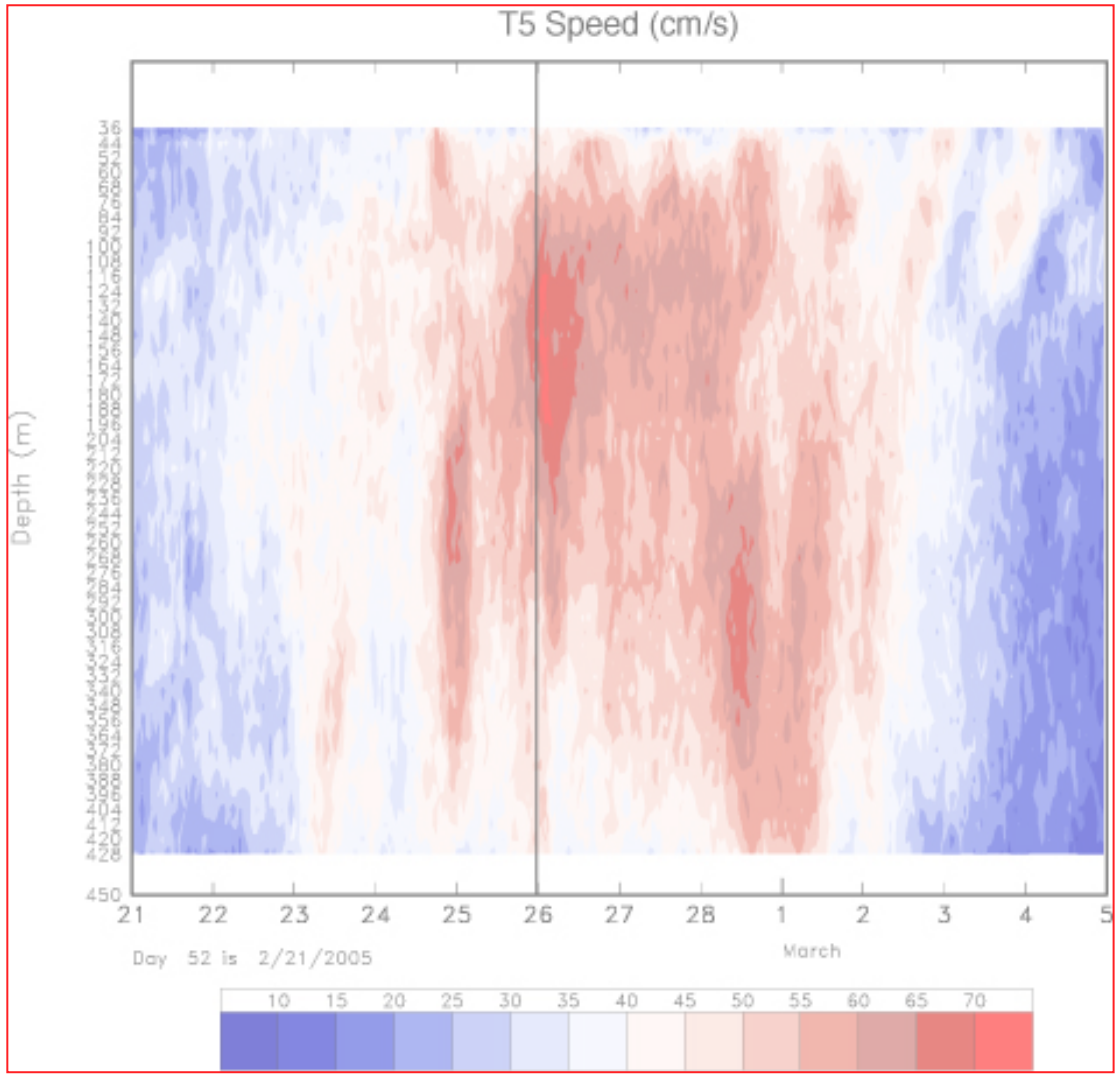
# Deep Western Gulf

- Currents over the lower 2500m were strongly coherent.



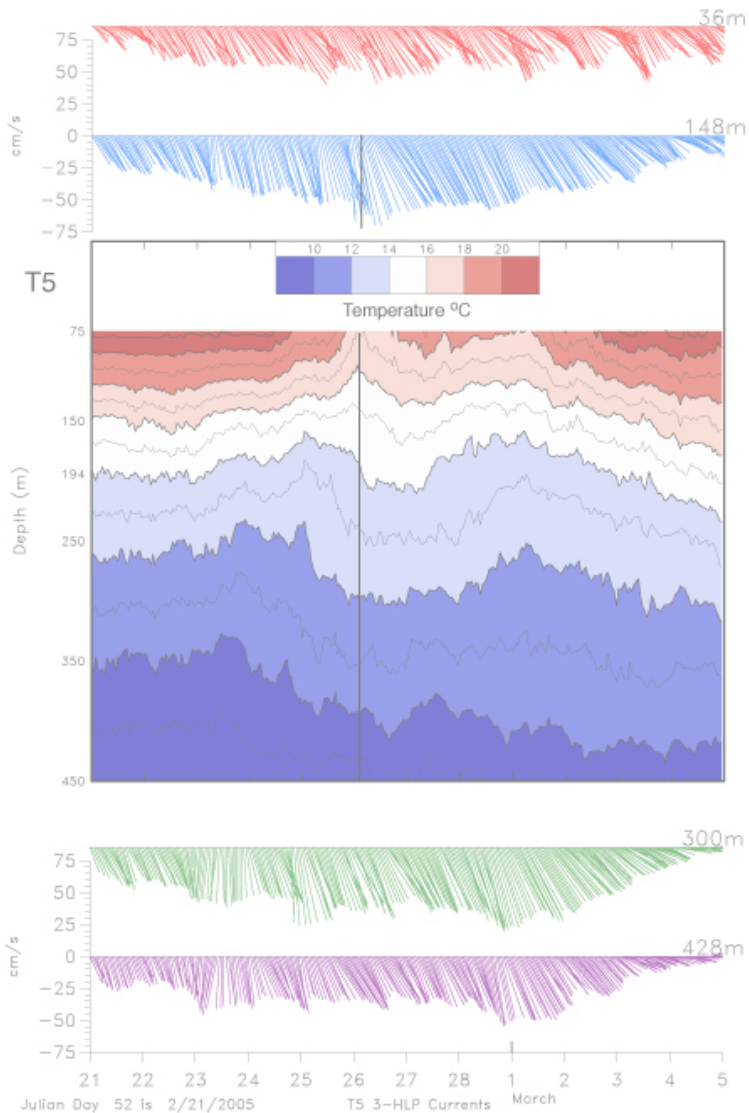
# Jet Occurrence – One of Several

- Higher current "jet" located between ≈100–200 m, duration less than a day.
- Embedded in higher speed episode.



# Jet Occurrence

- Probably in conjunction with intersecting warm and cool eddies.




SAIC
From Science to Solutions™

# Key Remaining Activities

| | |
|---|---|
| PI Report Writing | 15 Nov 06 – 15 Jan 07 |
| SAIC Rpt. Prep. | 15 Jan 07 – 15 Mar 07 |
| Submit Draft Final Rpt. | 15 March 07 |
| MMS Review of Draft | 15 March 07 – 1 May 07 |
| SAIC Prep. Proof Rpt. | 1 May 07 – 1 June 07 |
| Submit Proof Copy | 1 June 07 |
| MMS Review | 1 June 07 – 15 July 07 |
| SAIC Prep. Final | 15 July 07 – 15 August 07 |
| Submit Final Version | 15 August 07 |
| Contract Ends | 31 August 07 |