Using underwater gliders to observe boundary currents

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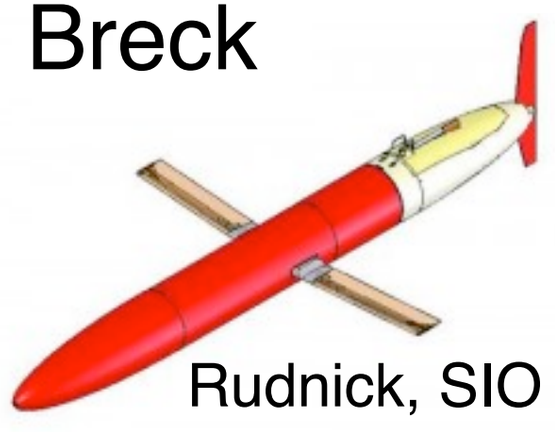

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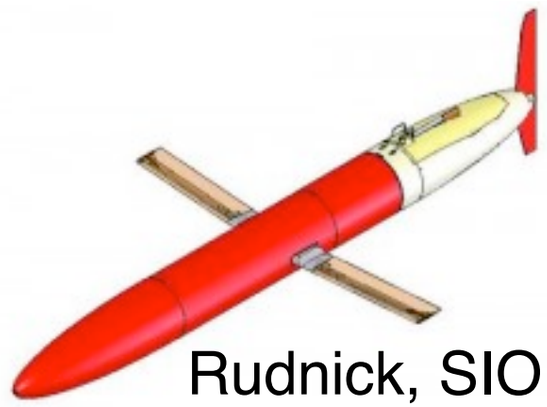
Support

- NOAA
- ONR
- NSF
- Moore Foundation
- BP
- CICESE (Mexico)
- State of California



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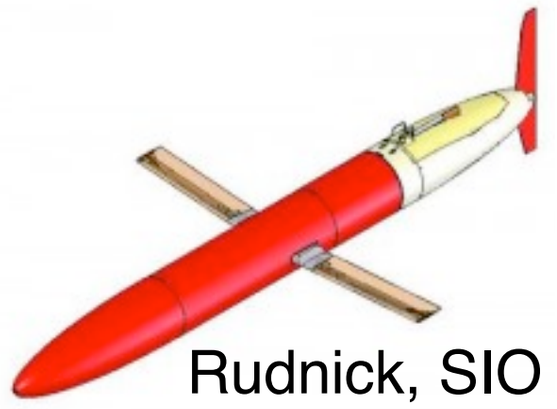
Outline

- Spray underwater glider
  - Representative of a class of gliders including Seaglider, Slocum
- Recent glider observations in boundary currents
  - California Current
  - Gulf of Mexico Loop Current
  - Mindanao Current
- Suggestions on a path forward



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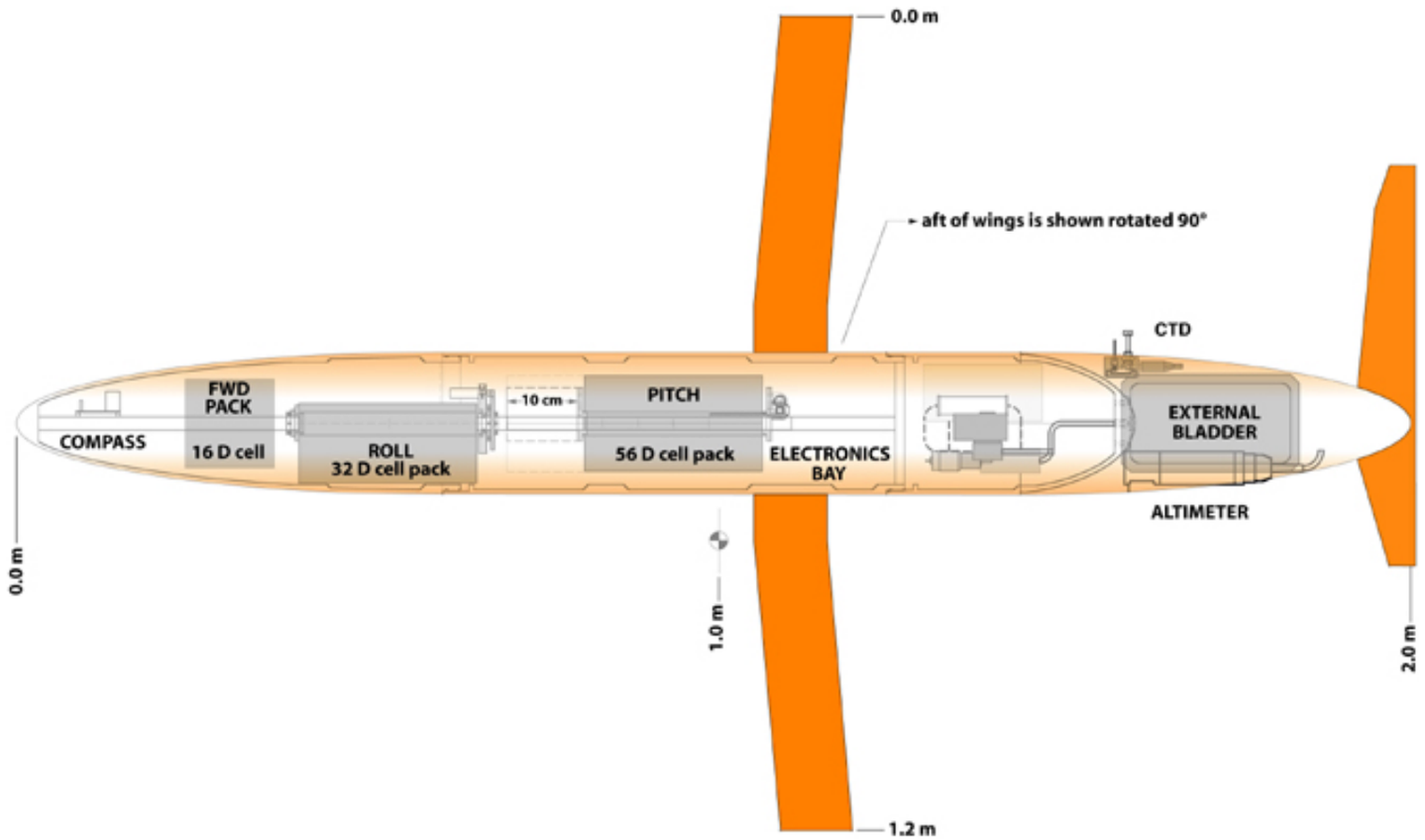
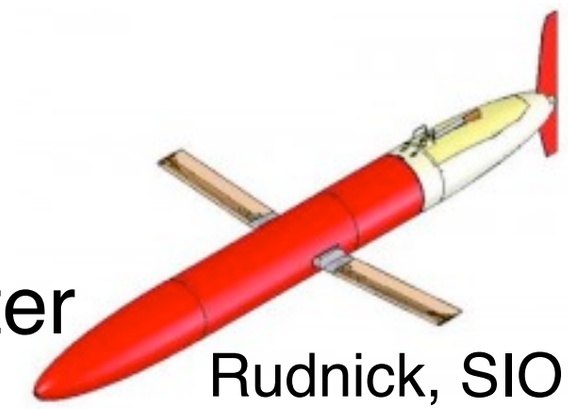
Spray underwater glider



- Weight: 50 kg, Length: 2 m, wingspan: 1 m
- Profiles by changing buoyancy
- Steers by changing center of mass
- 2-way Iridium communication
- GPS navigation
- Pressure, temperature, salinity, velocity, chlorophyll fluorescence, acoustic backscatter



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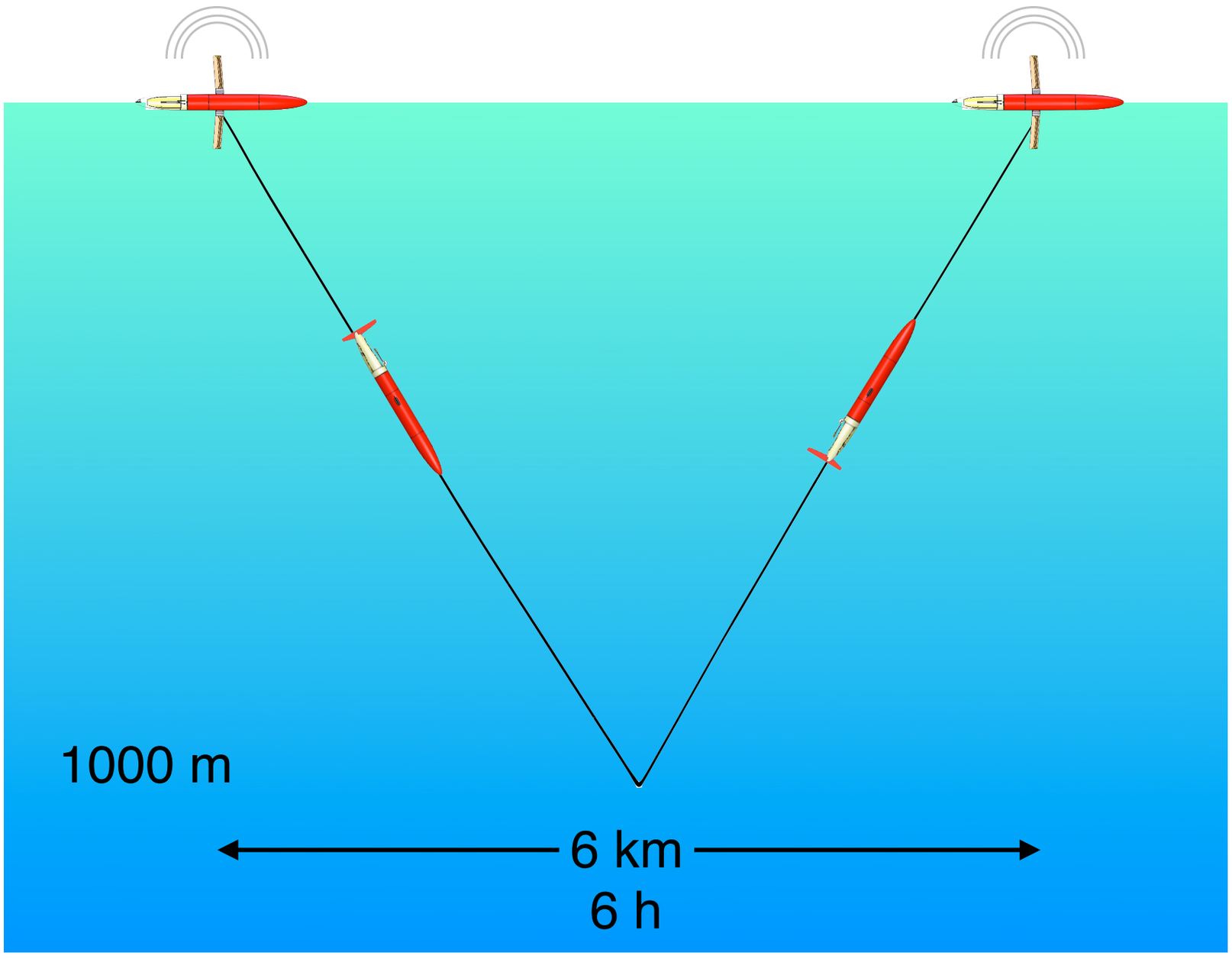
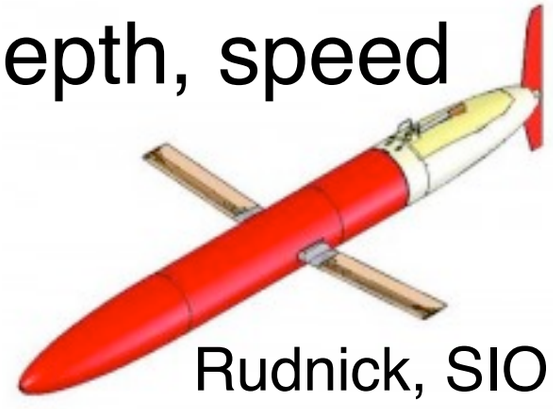
Spray operations



- Cycle 0-1000 m, 6 km, 6 h
- Horizontal velocity: 0.25 m/s
- Vertical velocity: 0.1 m/s
- Typical duration: 3-5 months
- Endurance depends on sensor suite, stratification, dive depth, speed



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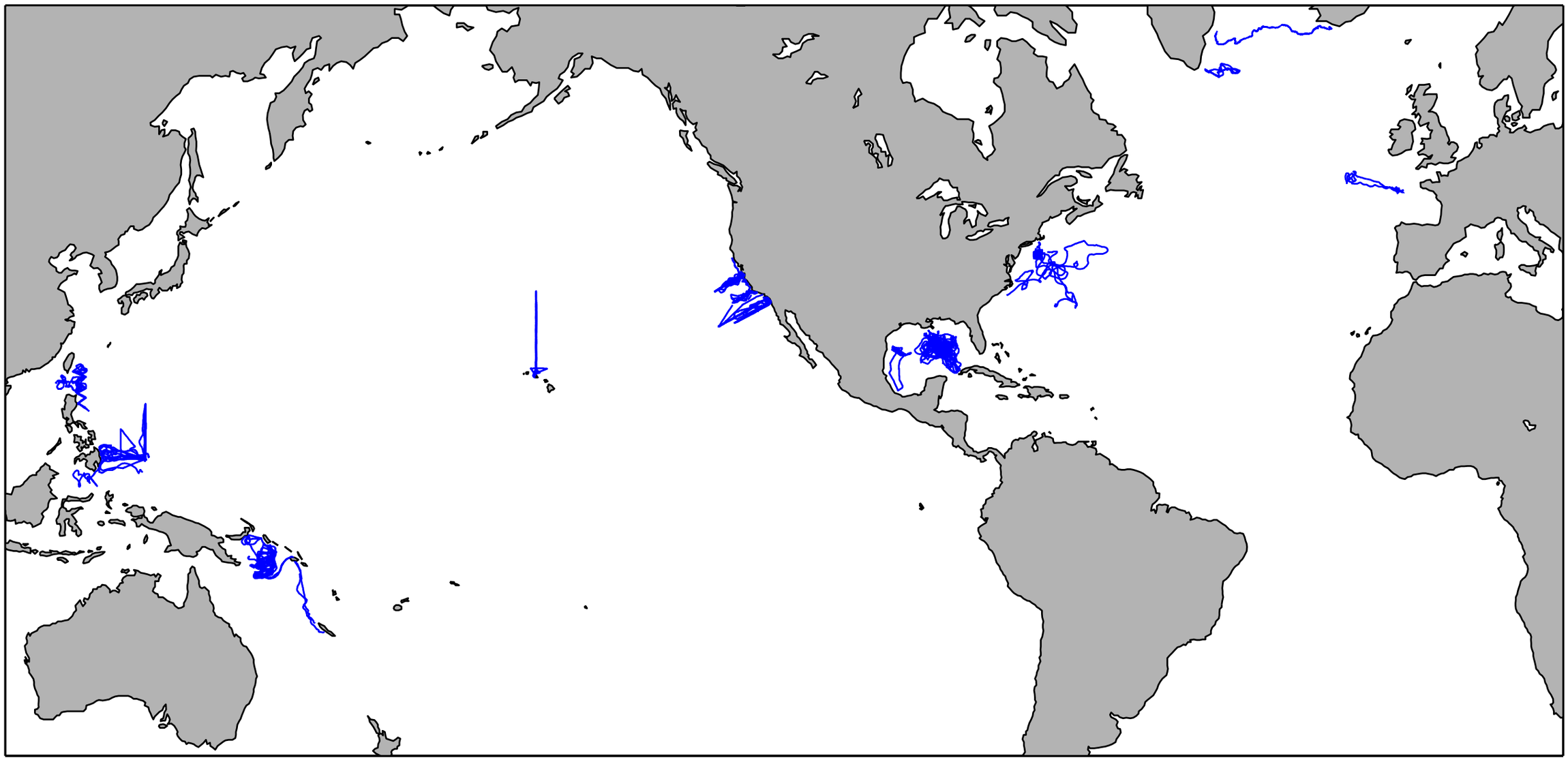
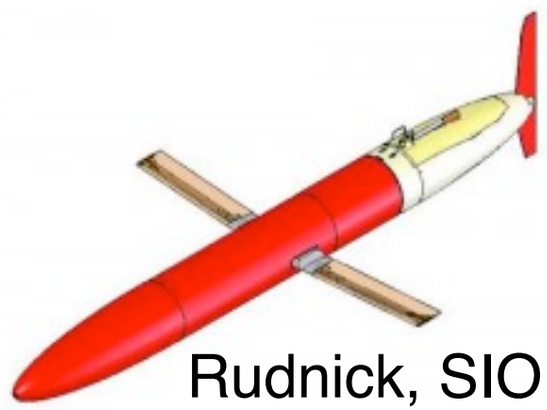
Spray glider observations around the world



- Over 332,000 km (> 8× earth's circumference)
- Over 16,000 days (> 43 years)
- Over 118,000 dives



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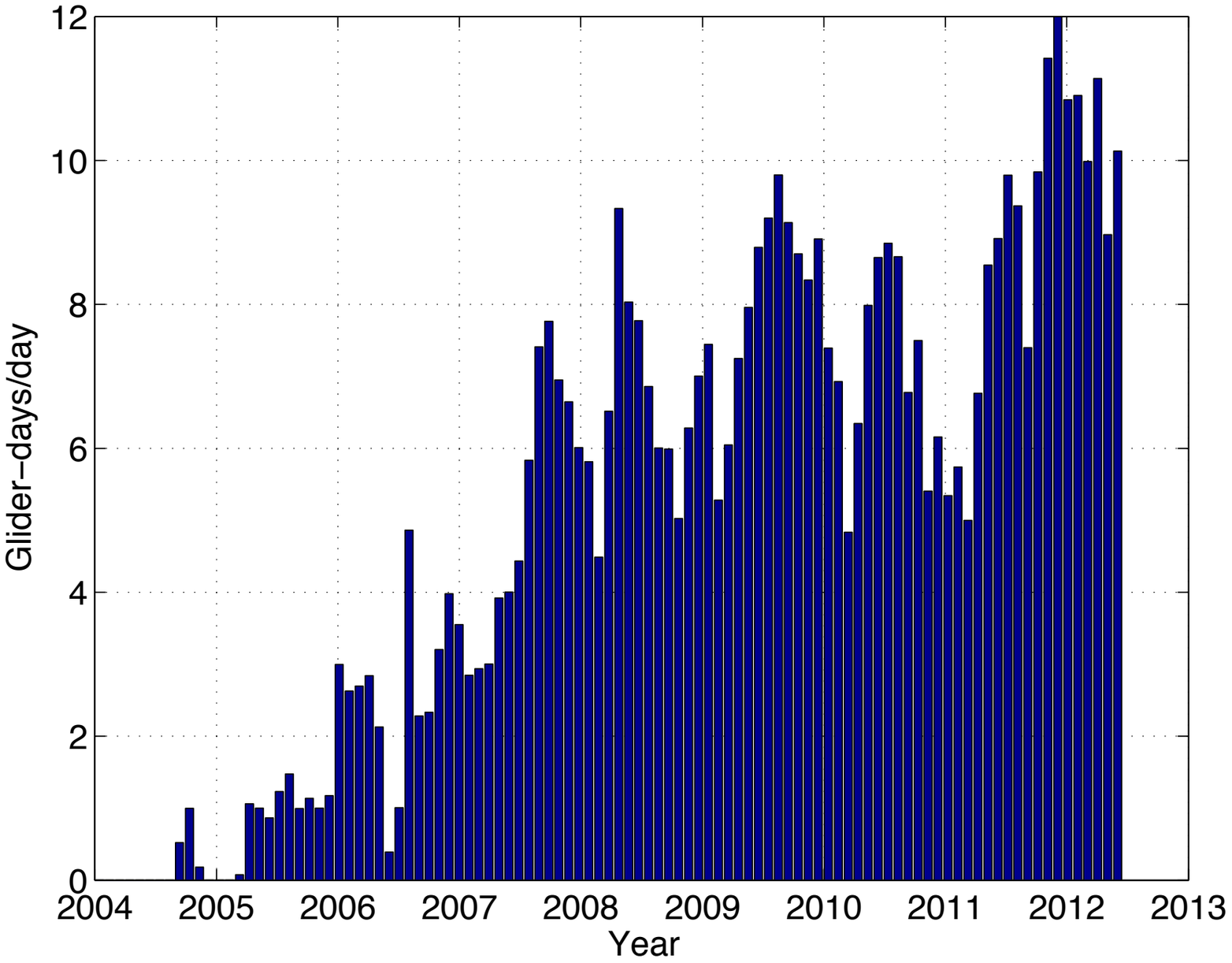
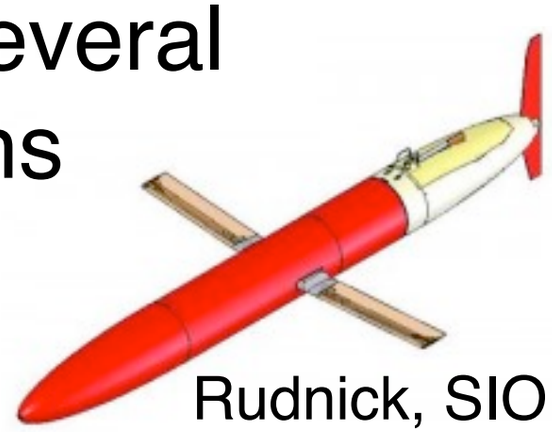
A growing enterprise



- Glider-days/day in 30-day averages
- Improving ability to sustain glider observations
- Averaging 10 gliders in the water over the last several months



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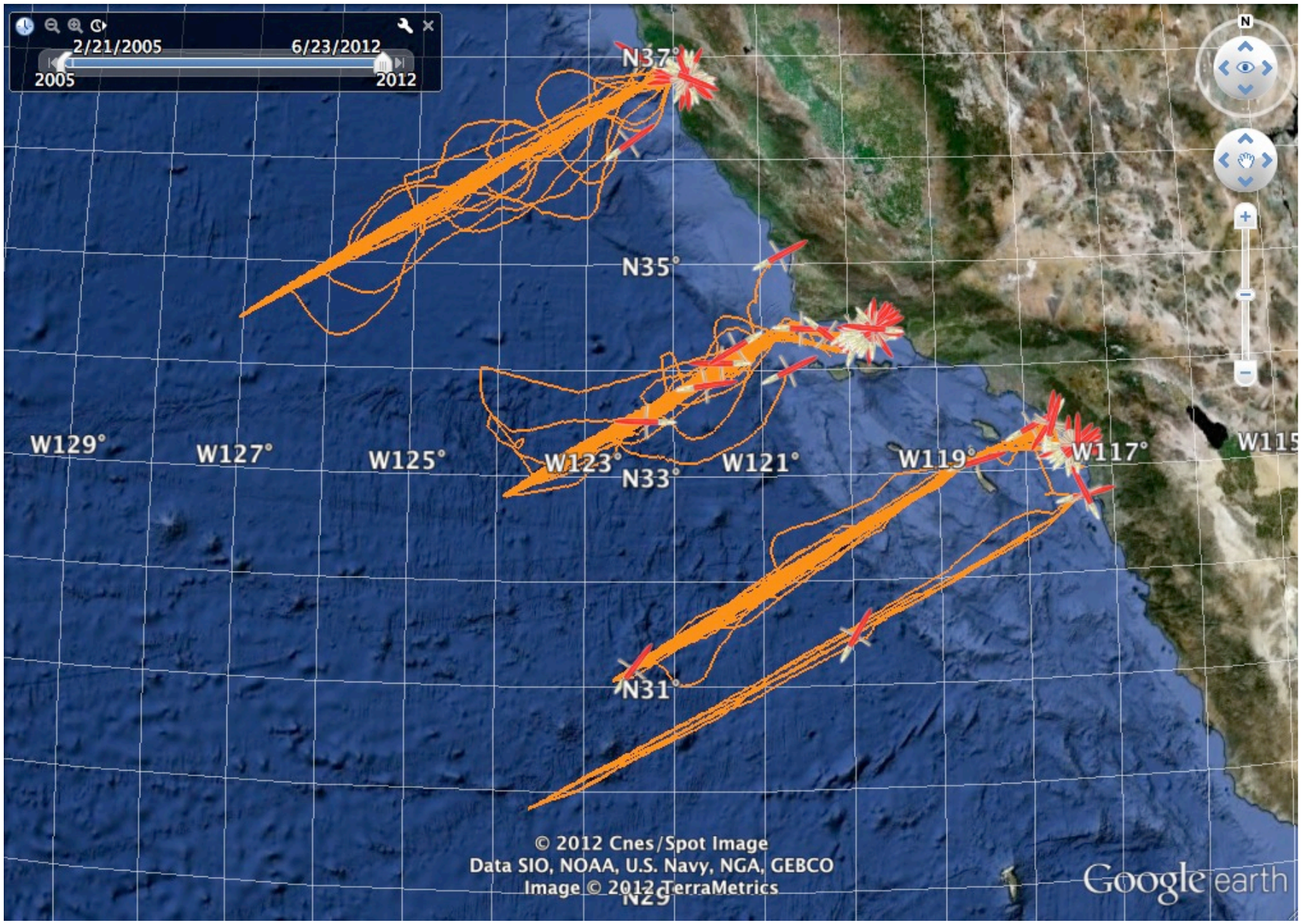
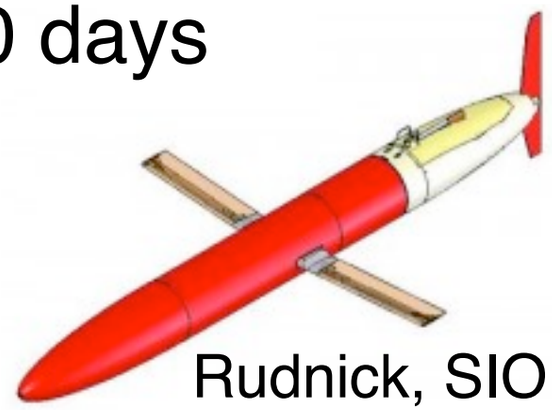
California Current



- Spray underwater gliders are part of a system to observe regional effects of climate variability.
- Sections repeated every 3 weeks
- 123,000 km over ground
- 134,000 km through water
- 5920 days

Southern California Coastal Ocean Observing System (SCCOOS)



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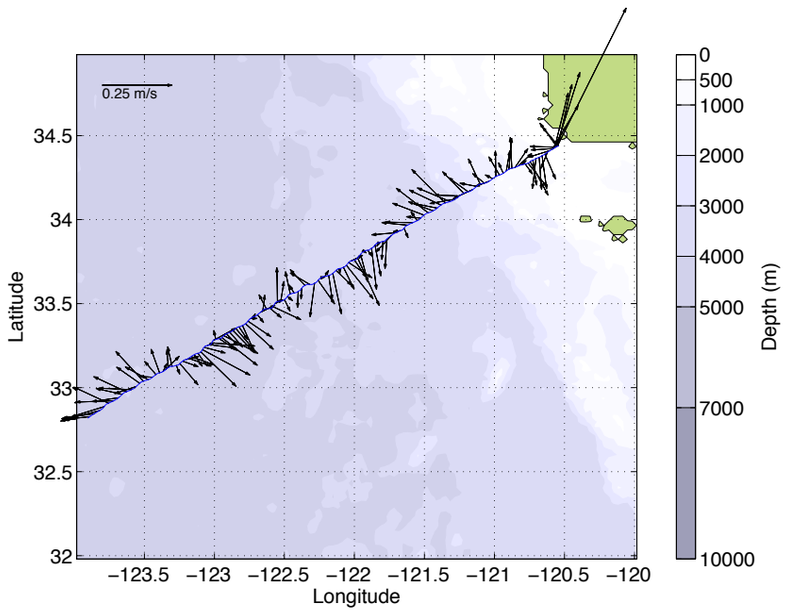
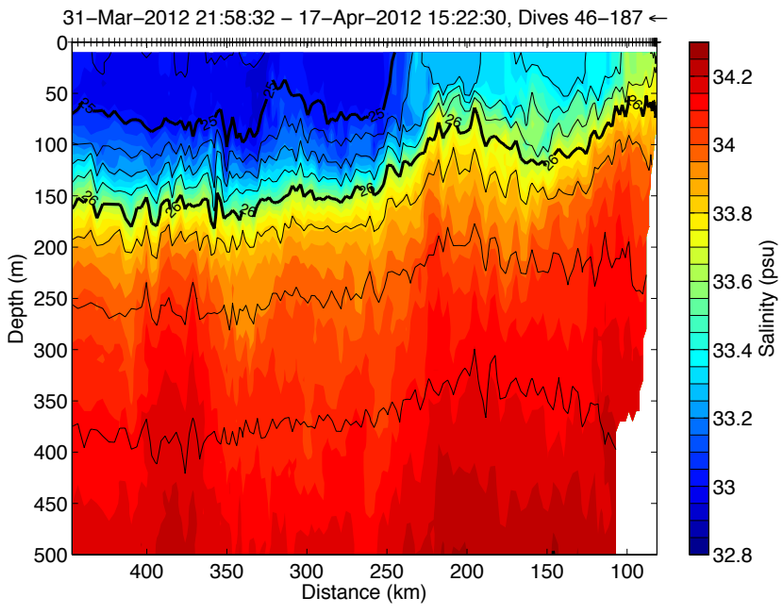
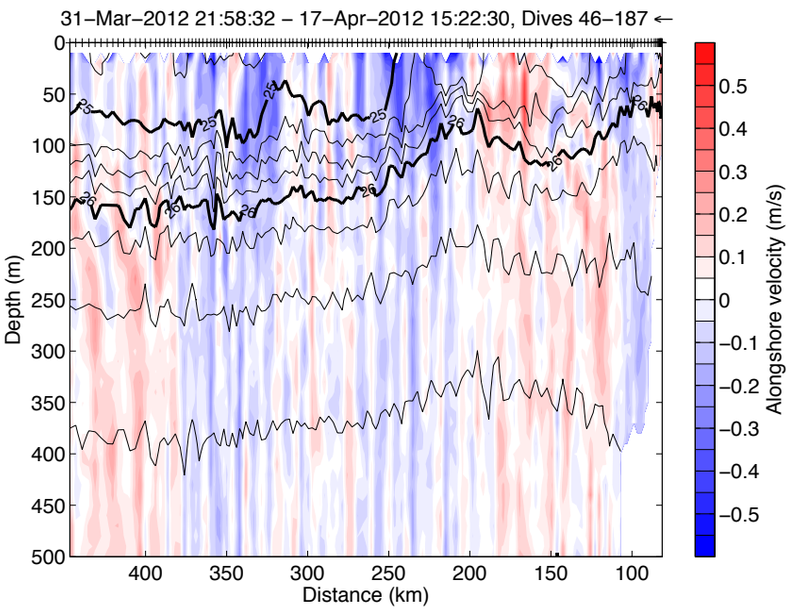
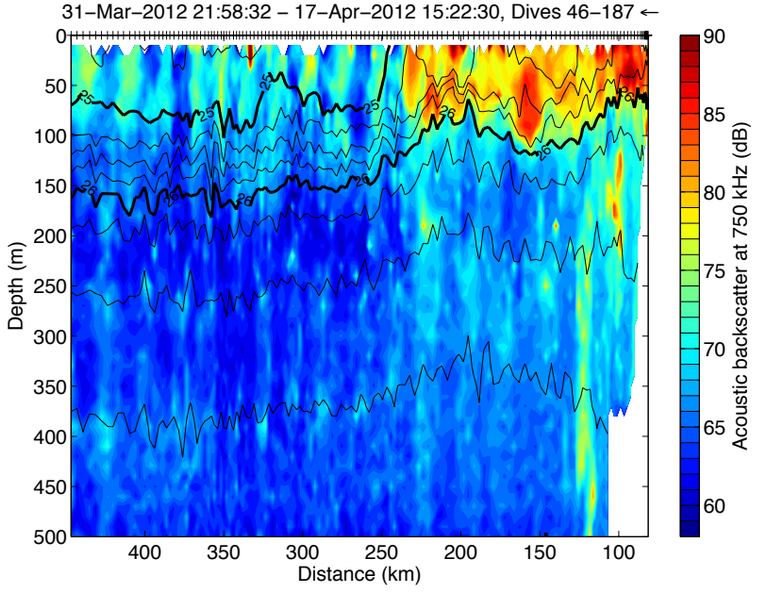
Sections on CalCOFI line 80

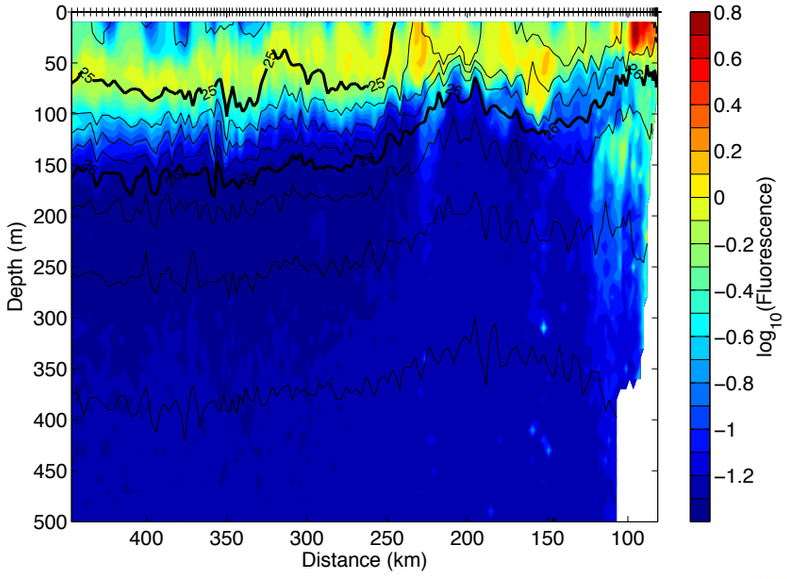


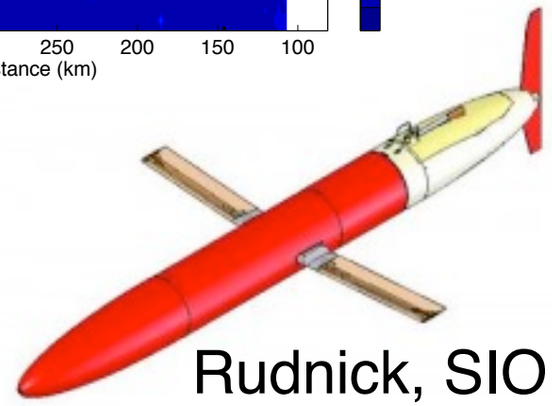




- 31 Mar - 17 Apr, 2012
- Depth-average velocity
- Salinity
- Along-shore velocity
- Acoustic backscatter
- Chlorophyll fluorescence







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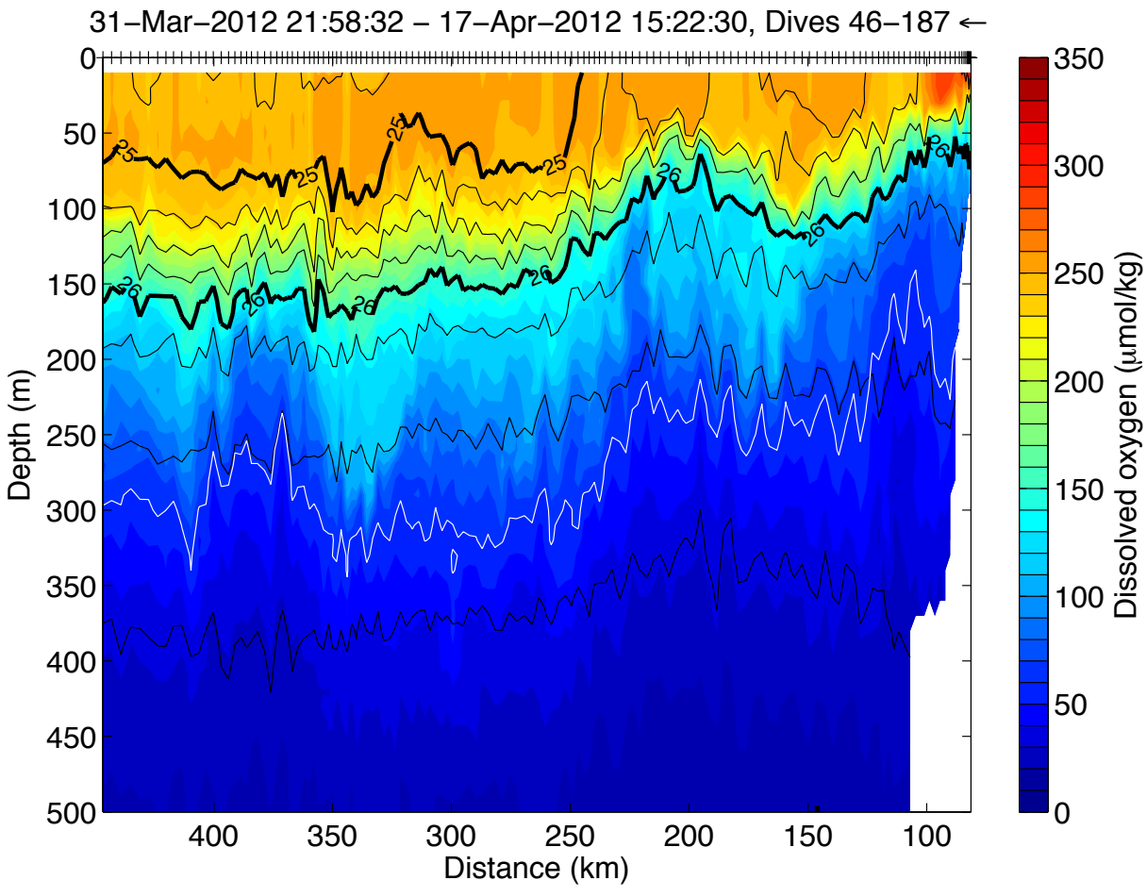
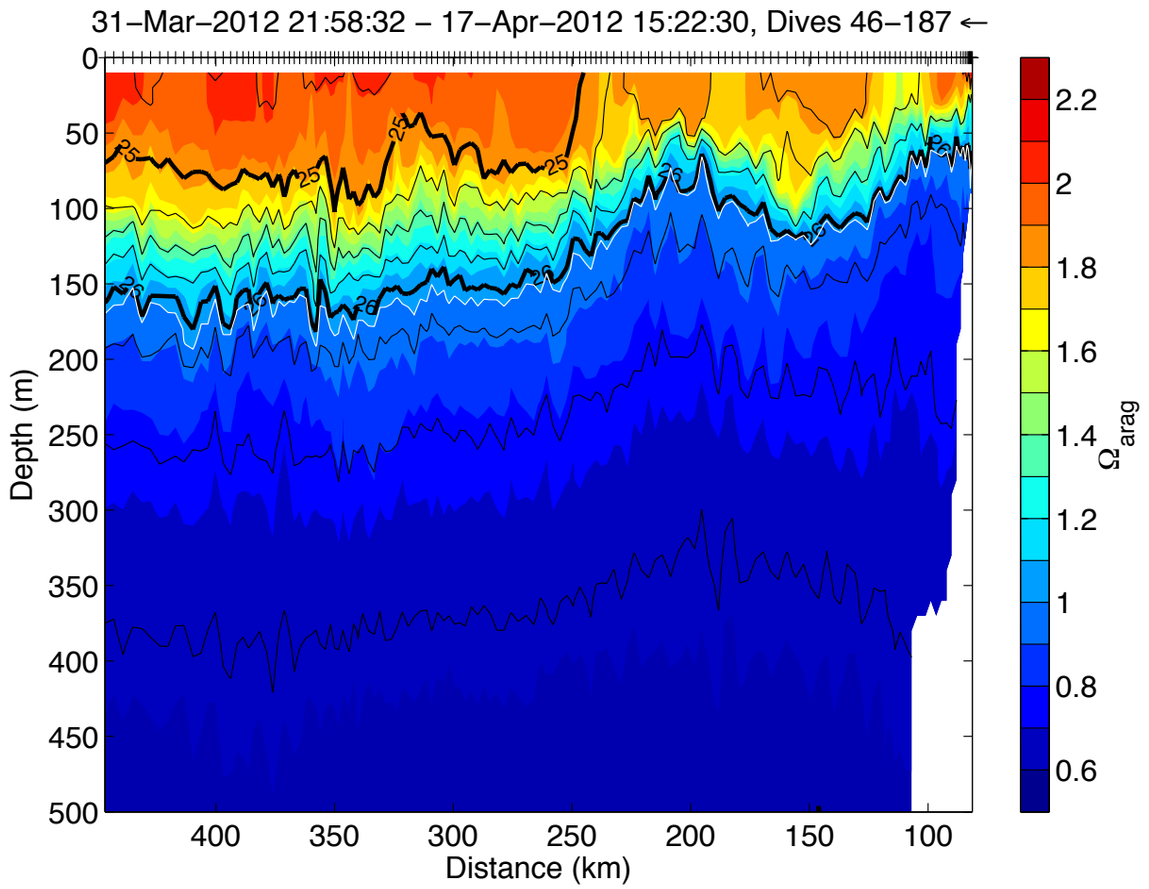
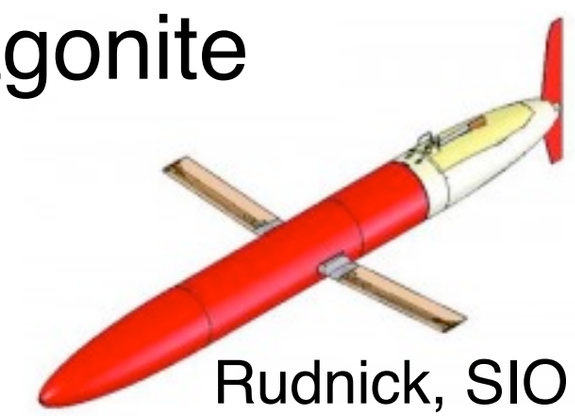
Dissolved oxygen and carbonate system





- Beginning measurements of dissolved oxygen
- Using a proxy relationship to derive aragonite saturation (Alin et al. 2012)



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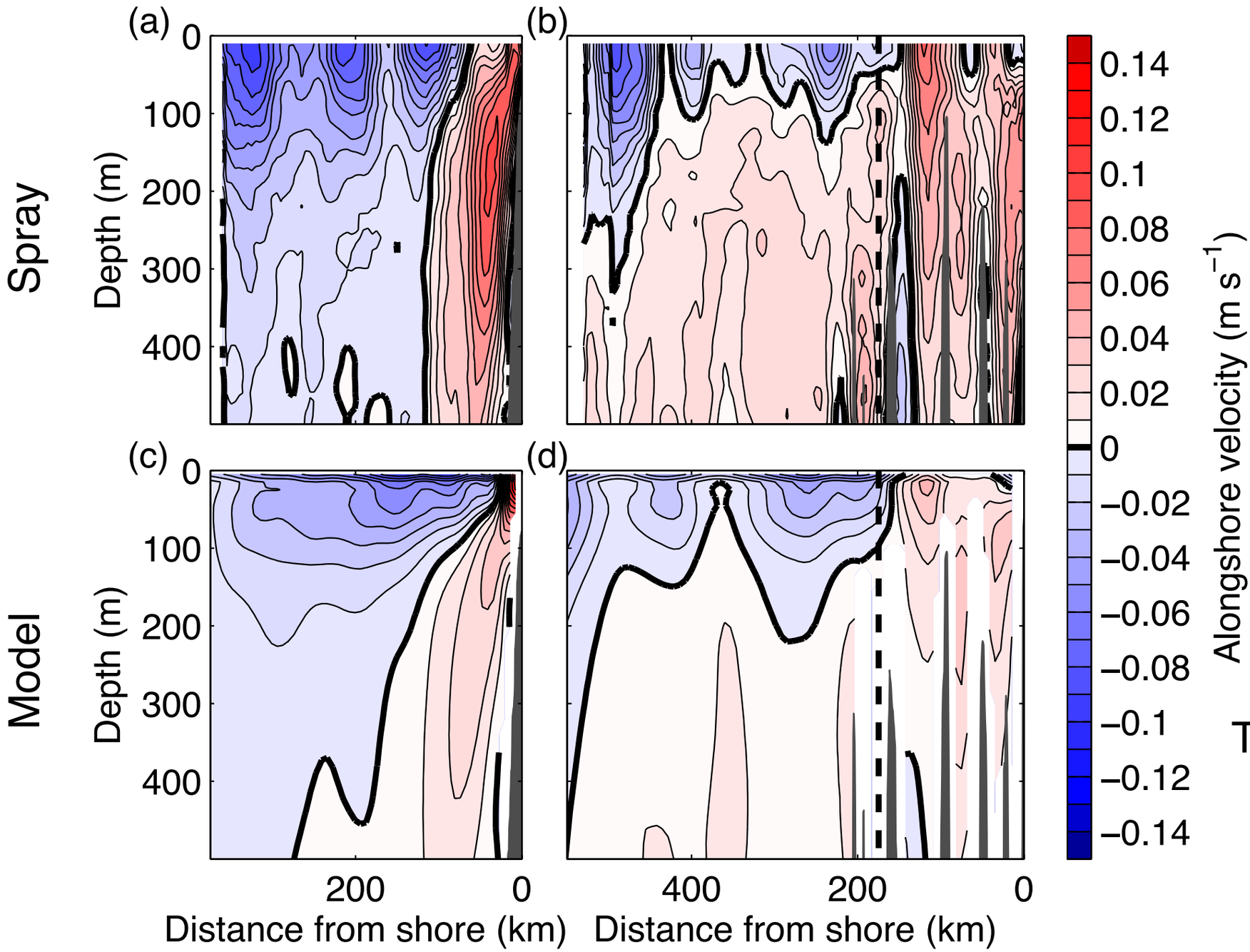
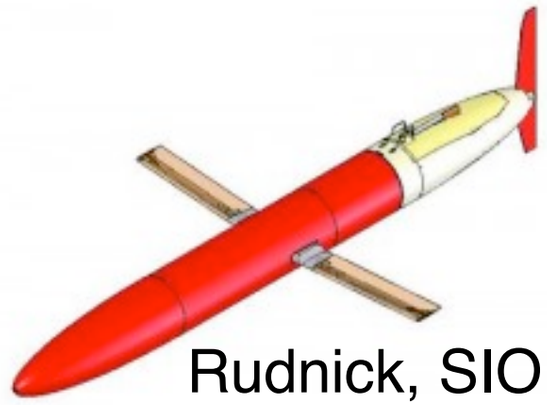
Mean alongshore velocity



Todd et al., 2011

Line 80 Line 90

- Undercurrent apparent in cores of poleward flow
- California current is broad equatorward flow offshore near surface
- Remarkable agreement between data and model



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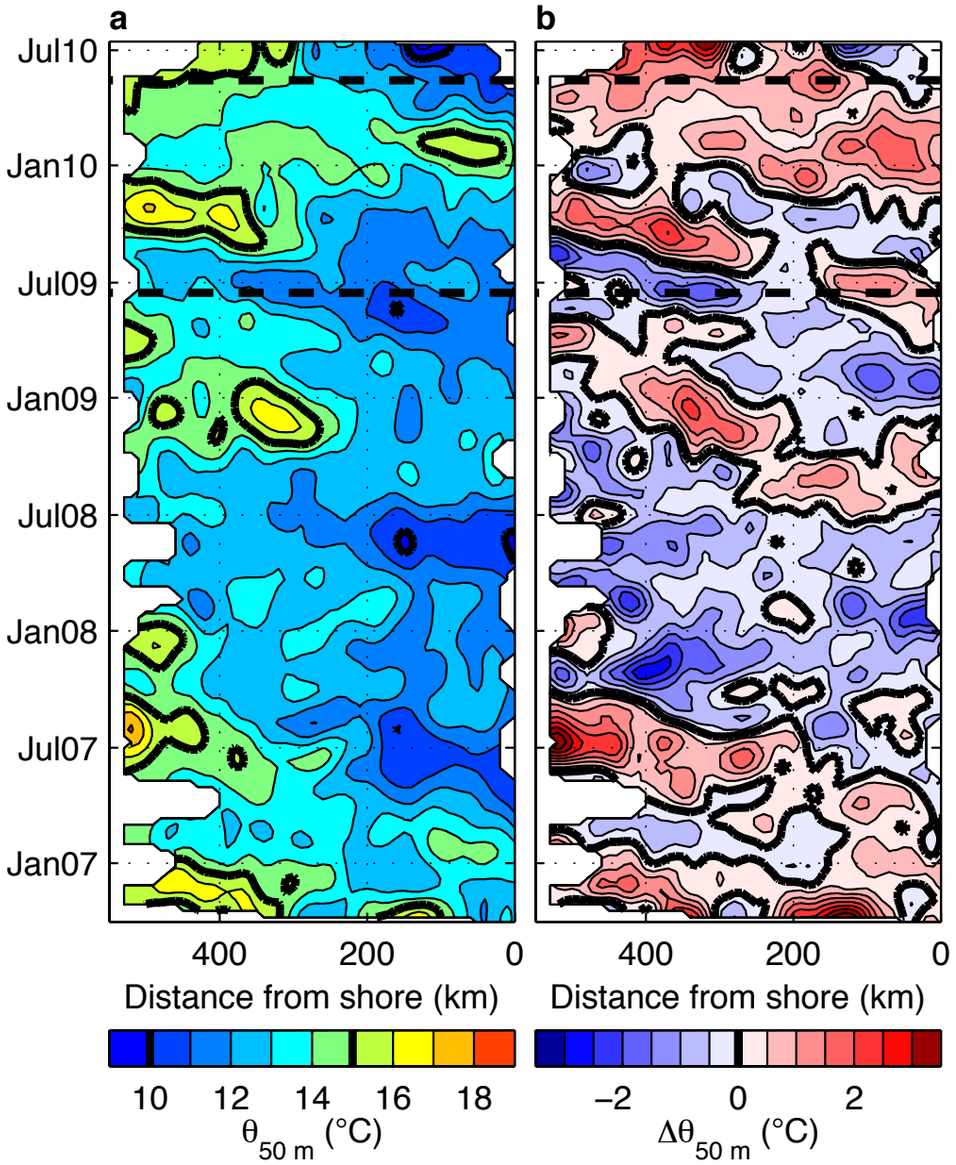
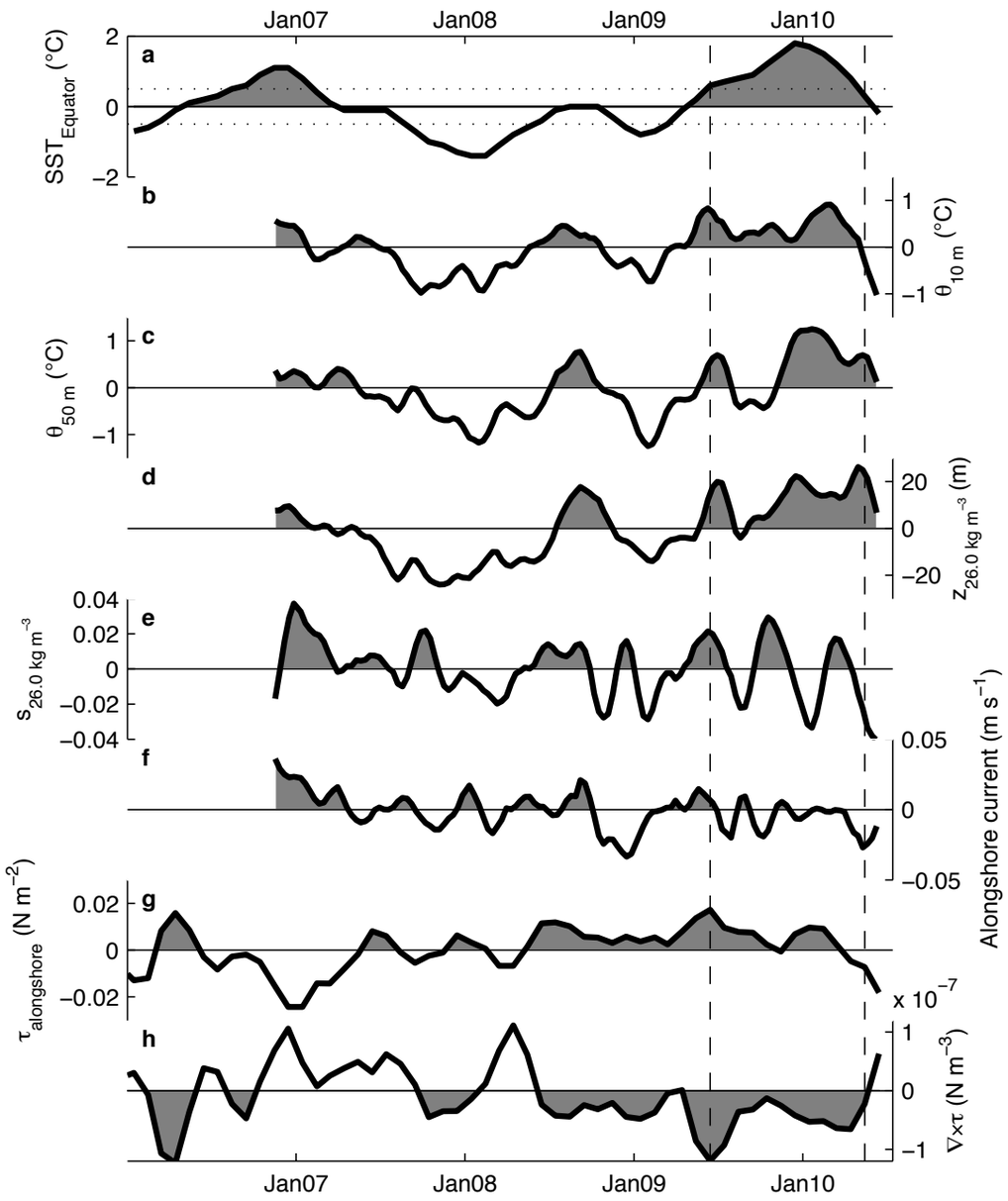
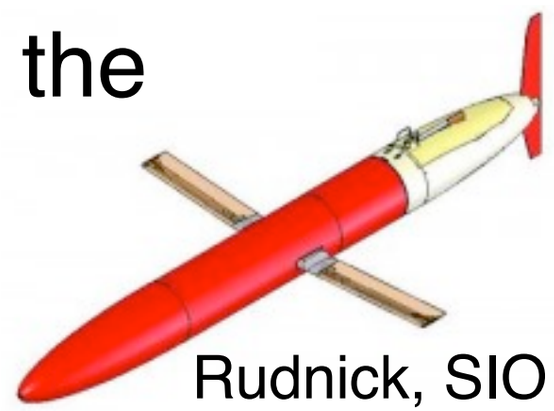
Local effects of El Niño





- El Niño seen in California waters and at the equator at nearly the same time.

Todd et al., 2011



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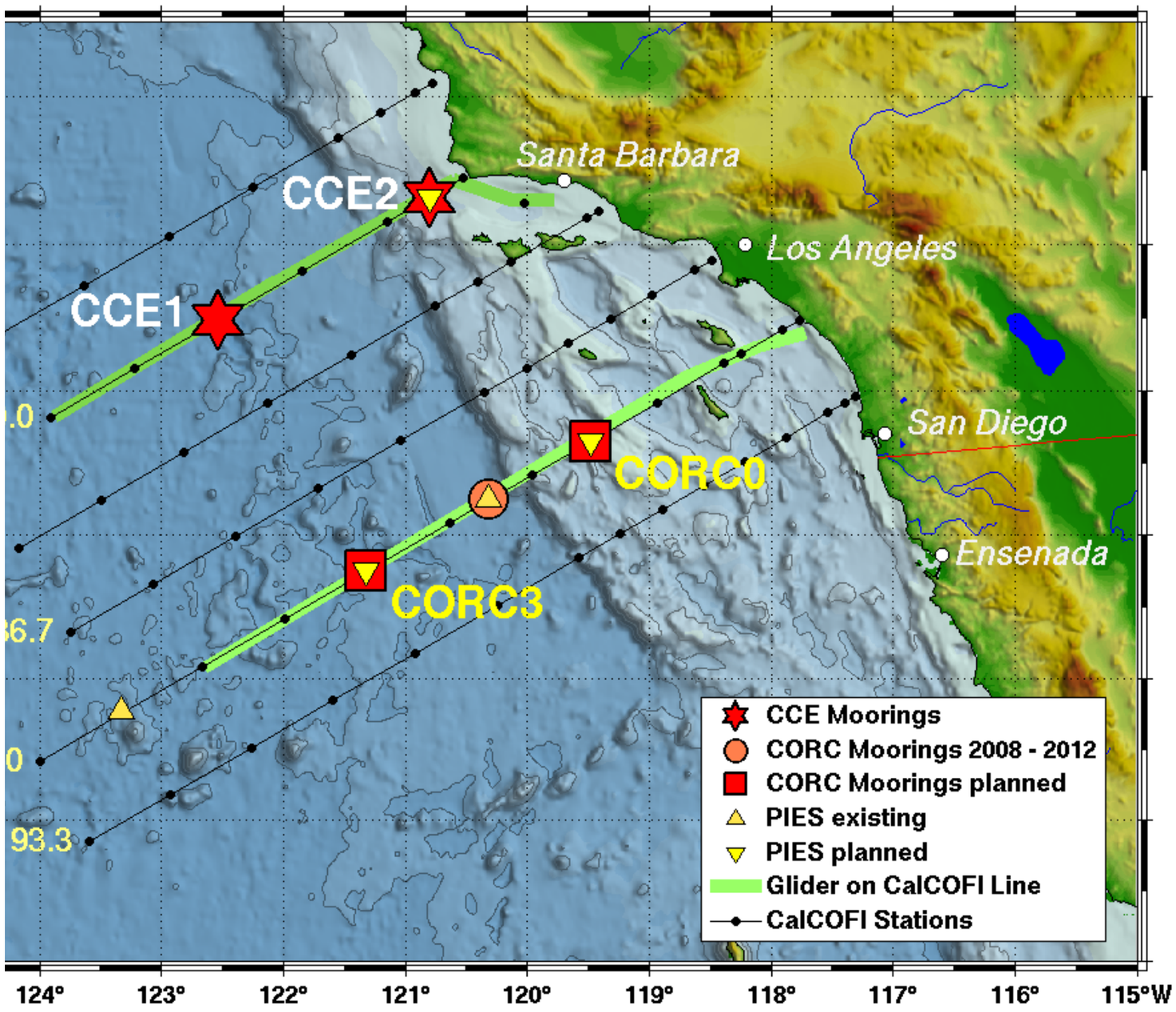
Gliders, moorings, and PIES as an integrated system



- Gliders used for acoustic transfer of data from subsurface moorings and PIES
- The combination of observing platforms improves sampling in space and time

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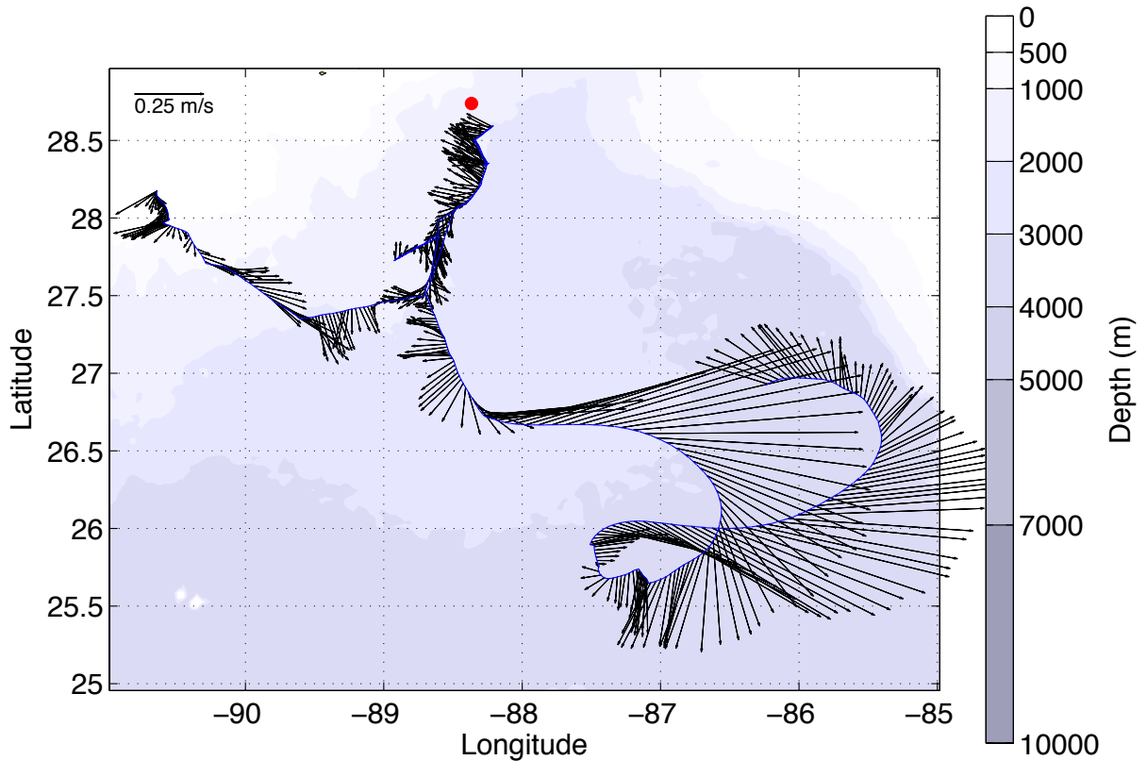
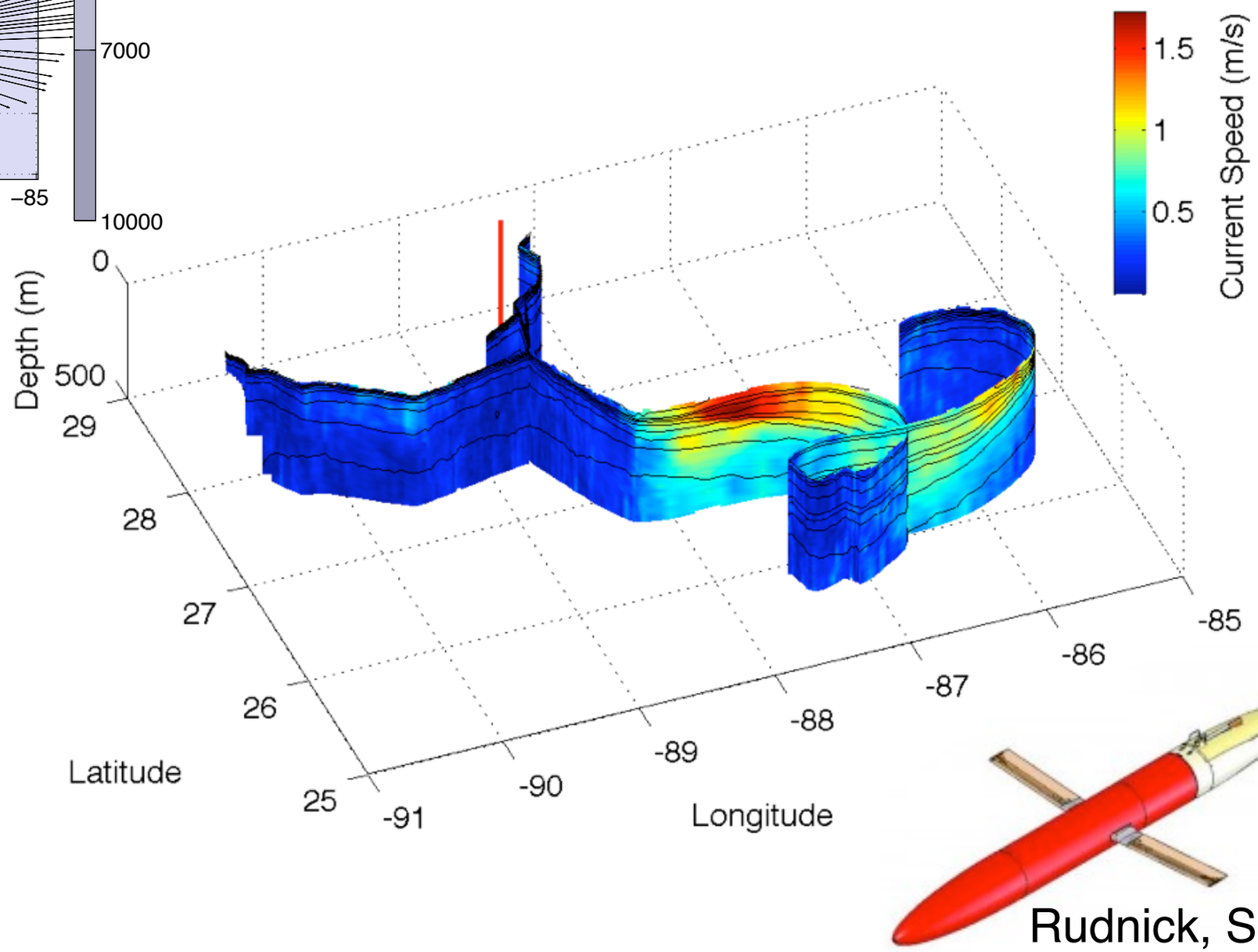
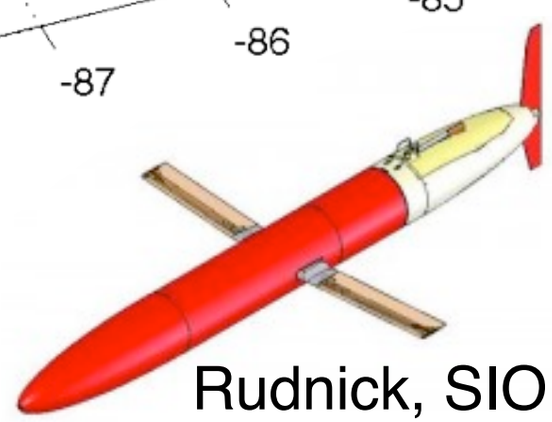
Gulf of Mexico

June 7 - July 26, 2010







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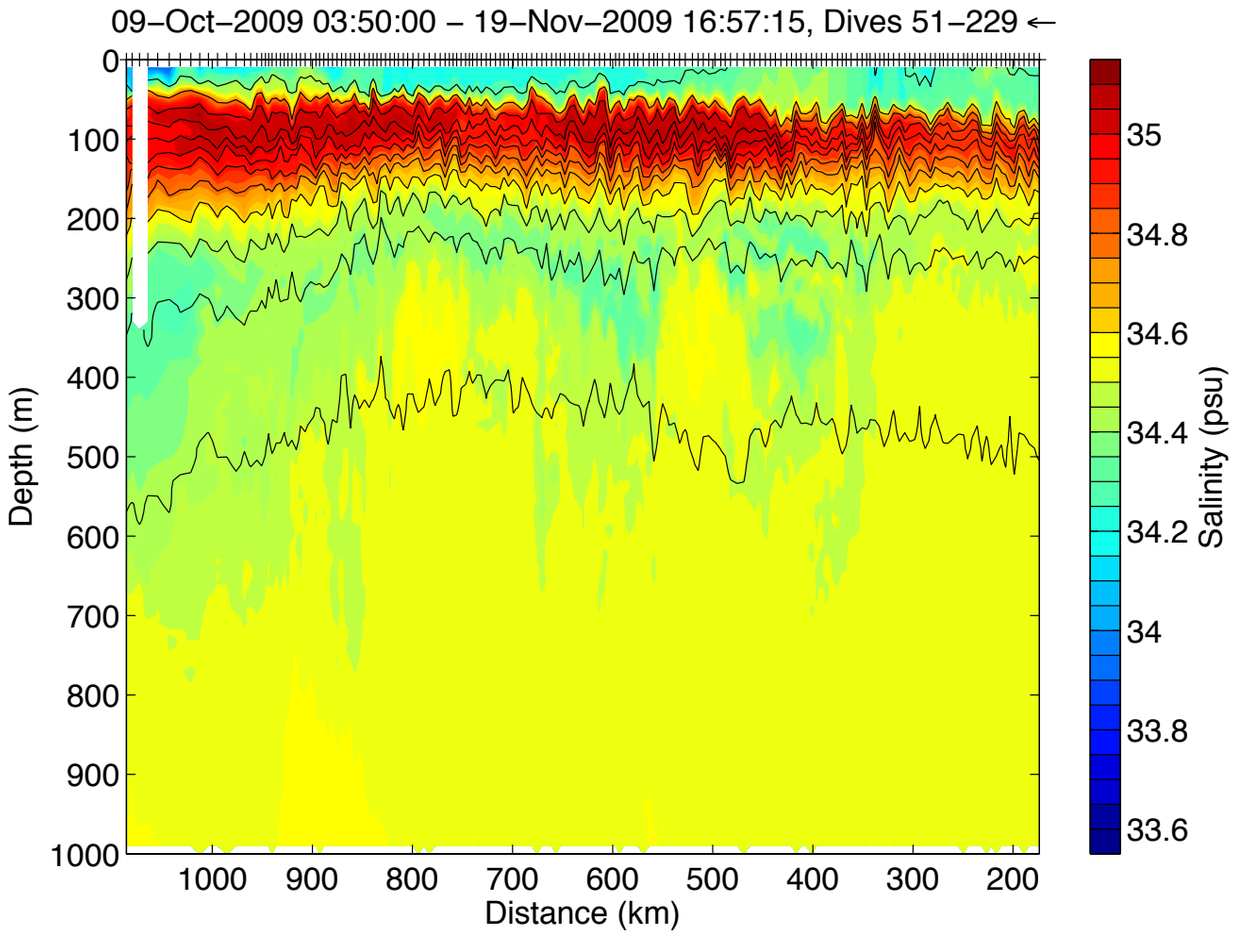
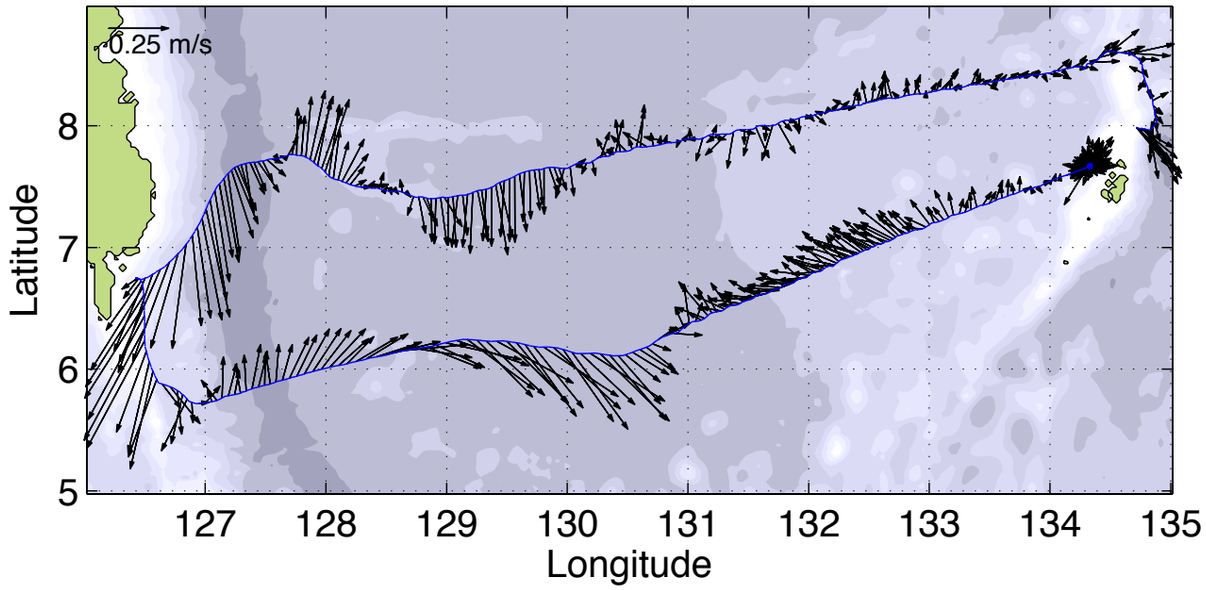
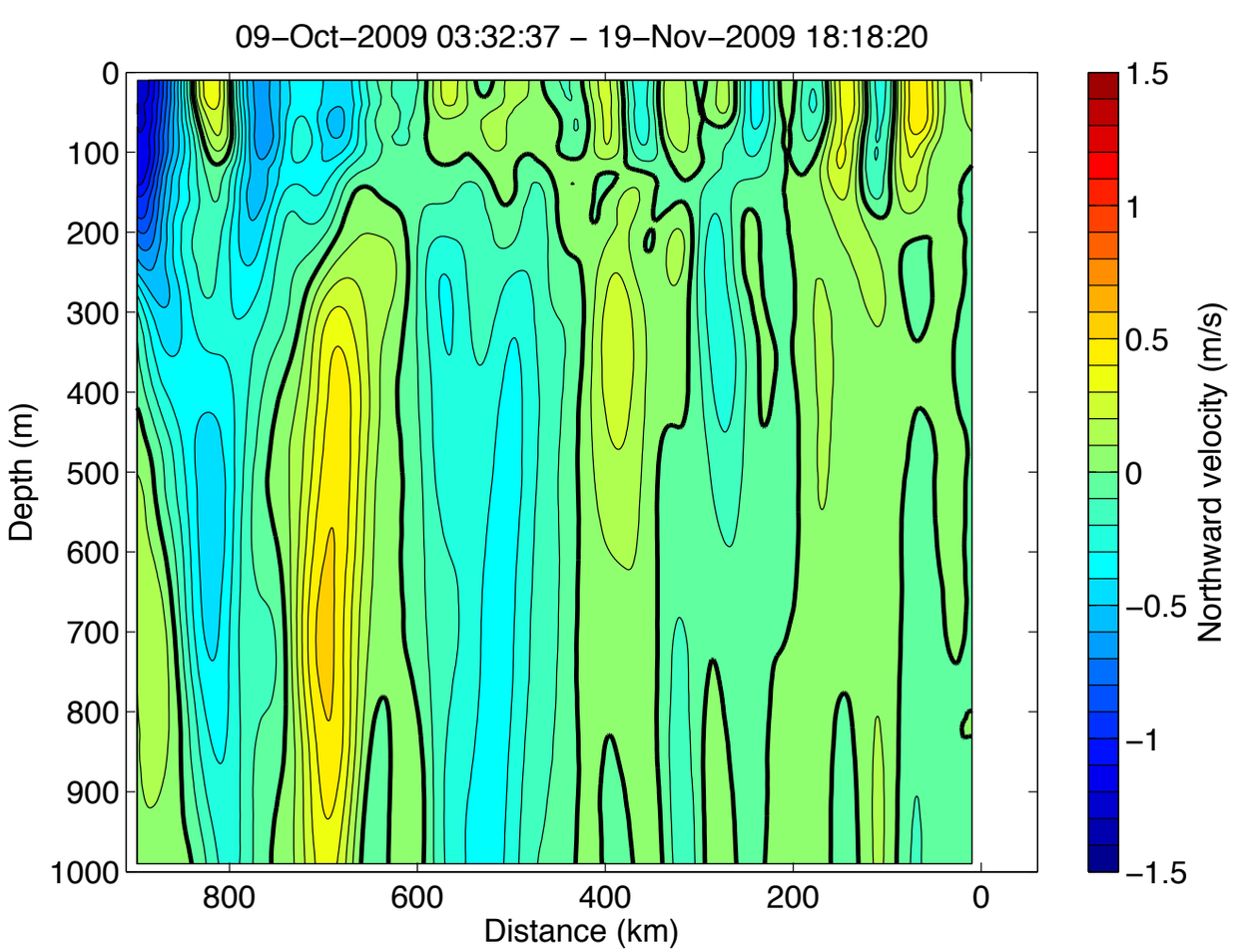
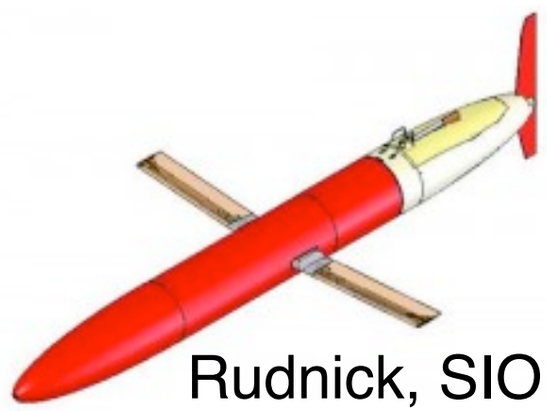


Mindanao Current





- Geostrophic velocity
- Mindanao current and undercurrent



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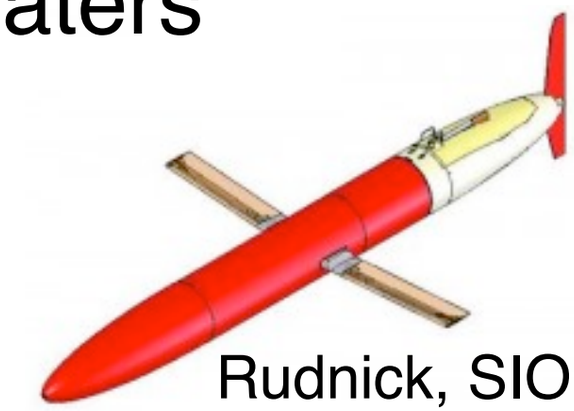
A path forward

- A national glider network focusing on US waters
  - Connect the coastal and open ocean
  - Climate variability, ecosystem, water quality
  - Planning underway
  - Workshop: August 1-3, 2012
  - Document to be completed by December
- Boundary currents in other countries' waters
  - Partnerships



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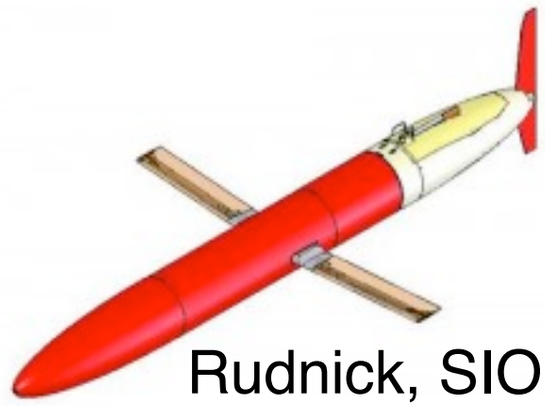
A few comments on sampling by gliders

- Gliders compared to ships
- Effect of internal waves



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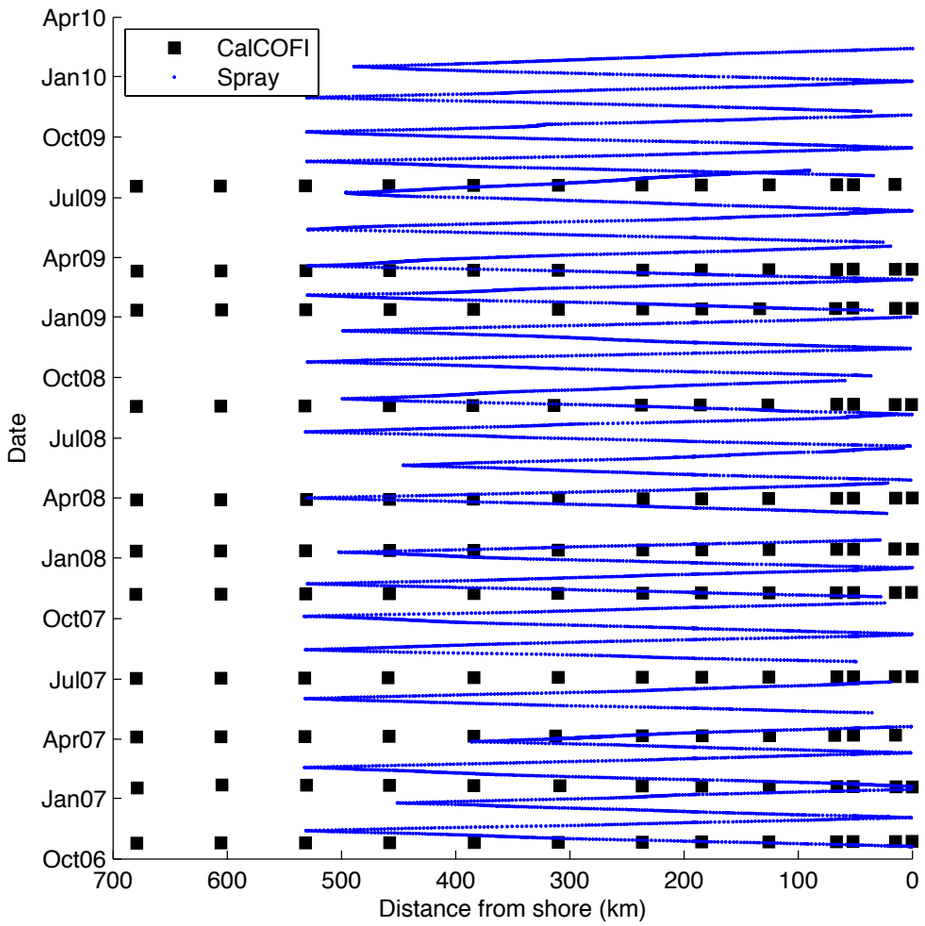
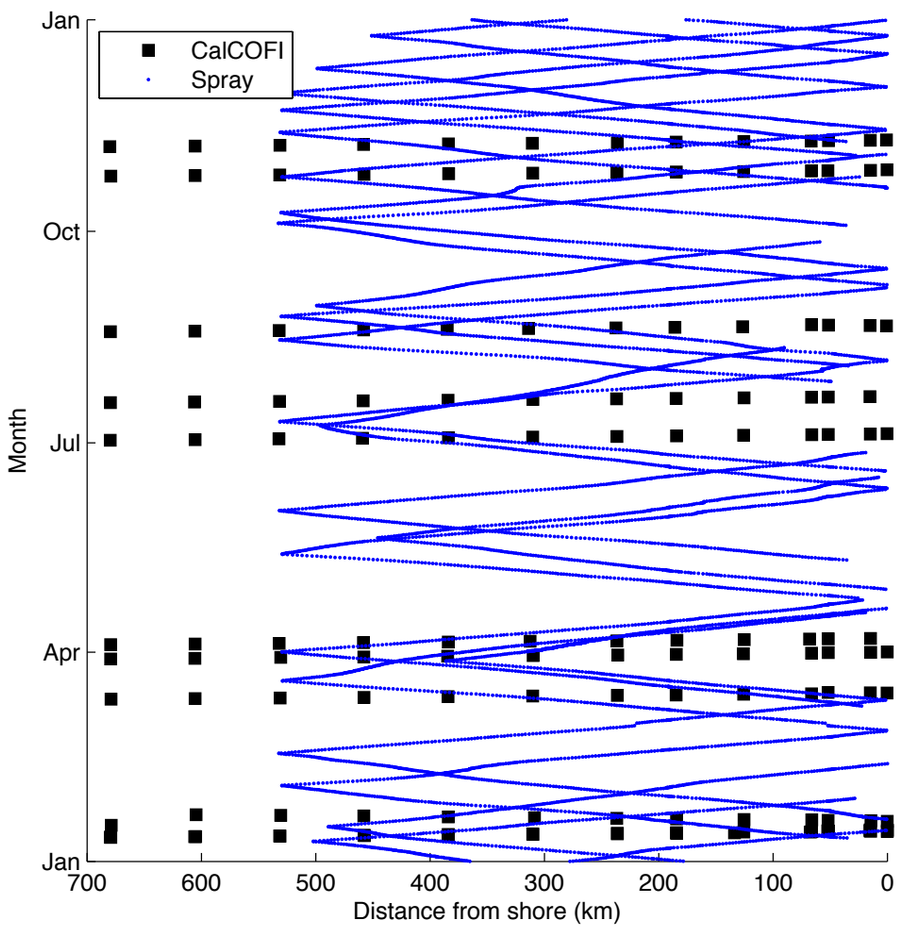
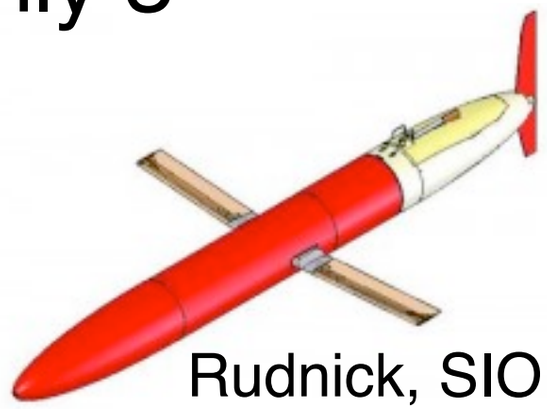
Spray sampling





- Line 90
- Roughly 50 times as many Spray profiles as ship stations in the same time period
- A virtue of Spray is continual presence.
- Annual cycle resolved in only 3 years



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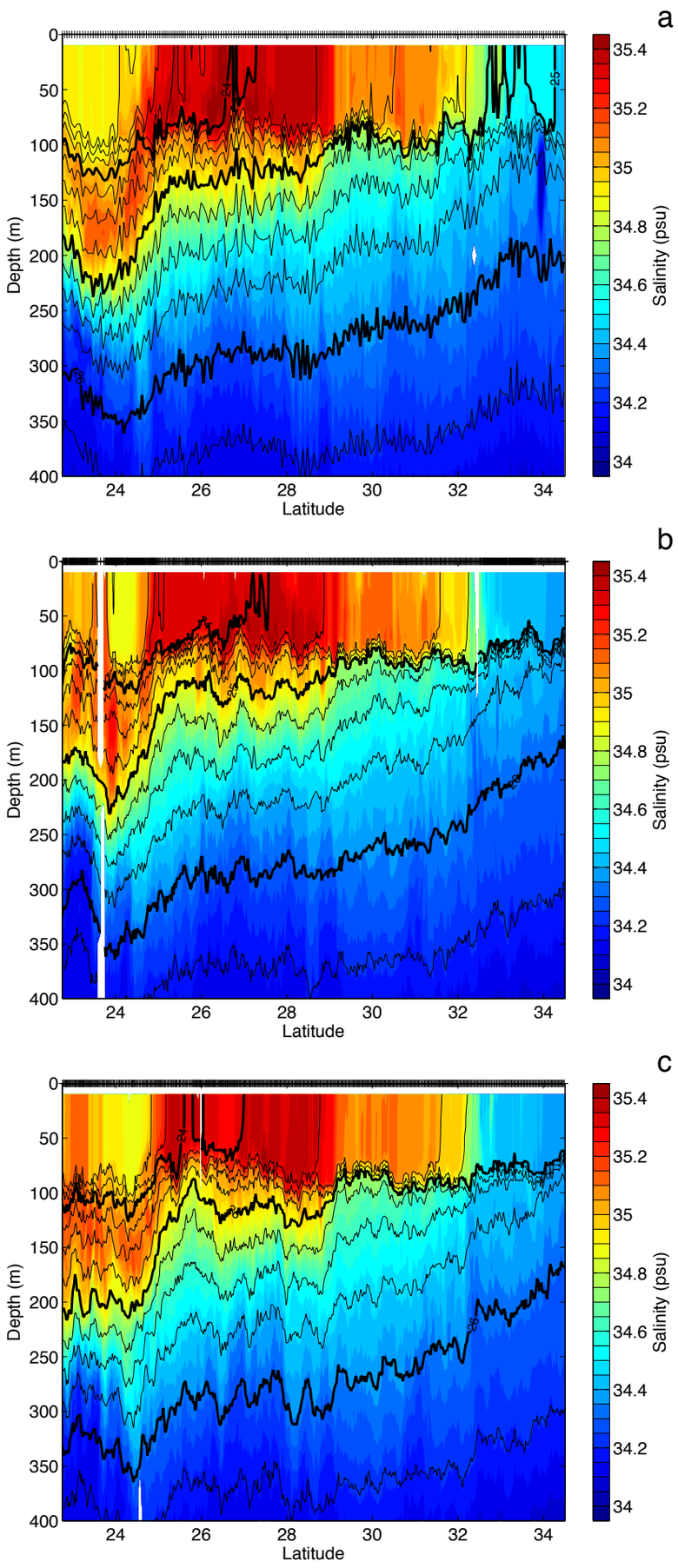
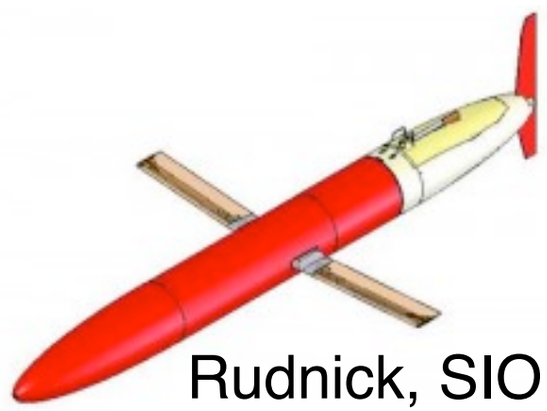


Sections measured by Spray and SeaSoar

- Section northward from Station Aloha at 22.75°N to 34.5°N, along 158°W
- Spray section took 52 days, SeaSoar took 3.8 days
- Large scale structure similar
- Variability in isopycnal depth larger in Spray data

Rudnick and Cole, 2011



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