Internal waves, tides, eddies and wind-driven currents across the inner shelf

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& Inner Shelf collaborators

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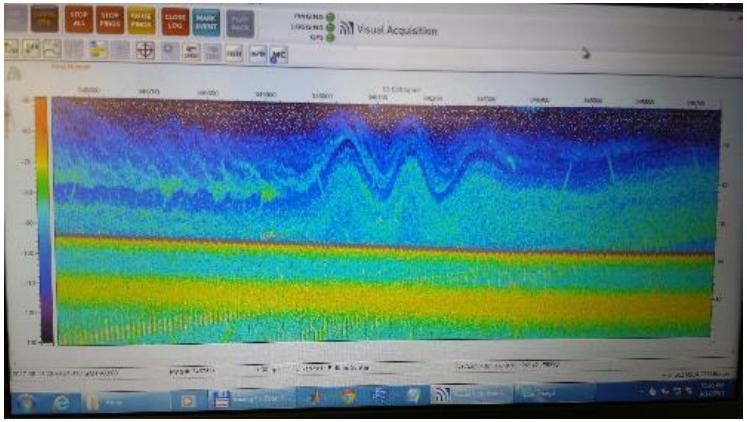
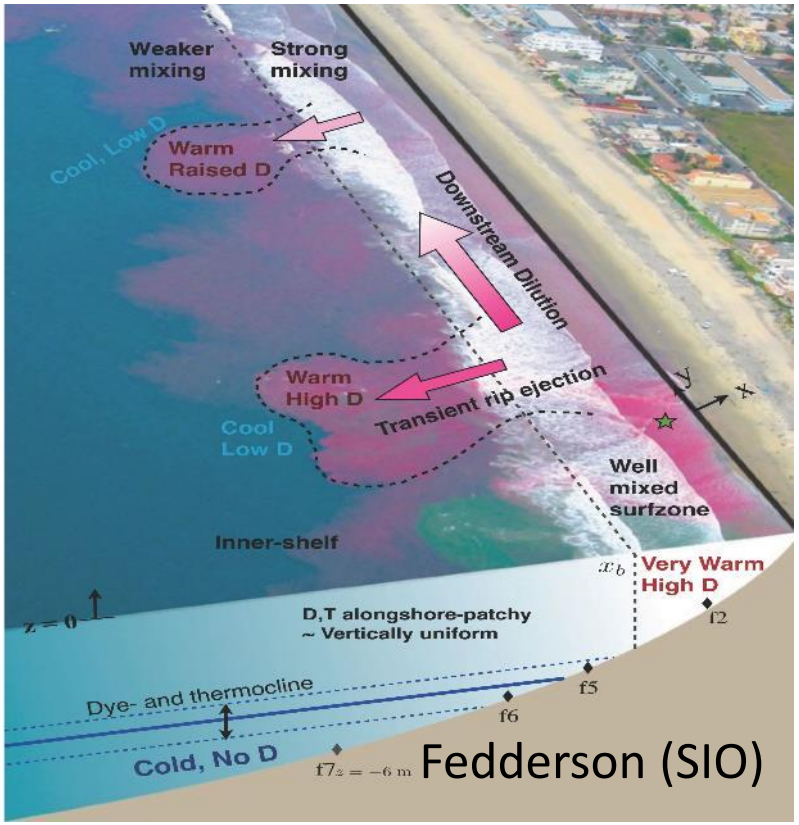
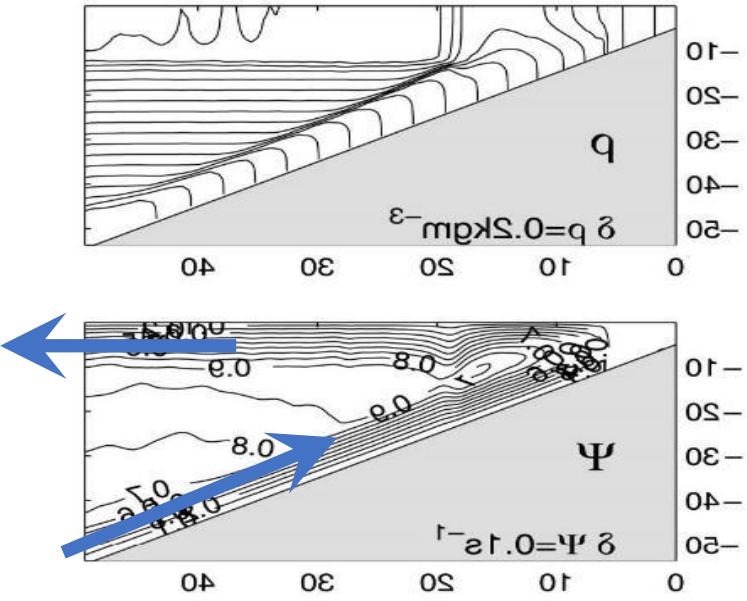
Inner Shelf: Opening the Black Box Connecting the Coastal Ocean and the Surf Zone

Nonlinear internal waves and bores



rip currents and eddies





wind-driven cross-shelf circulation

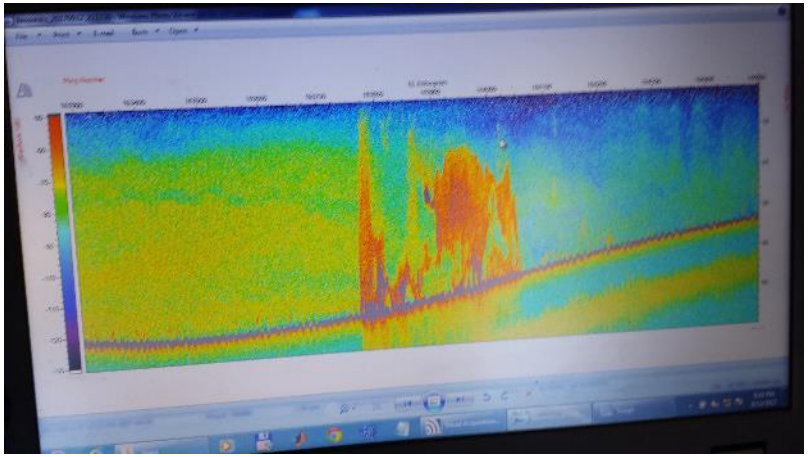
Internal wave convergence lines & influence on biology

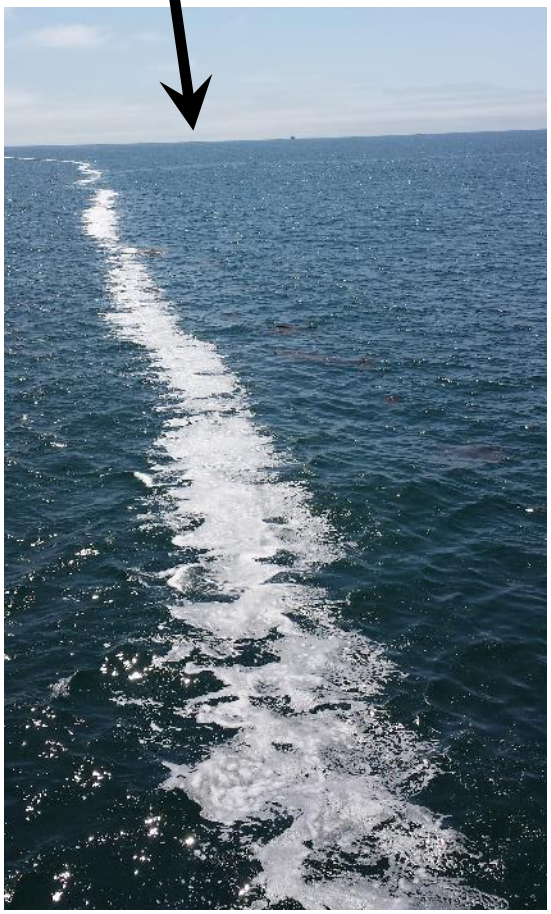
"bait balls" in echosounder

murres lined up offshore

feeding dolphins

foam line





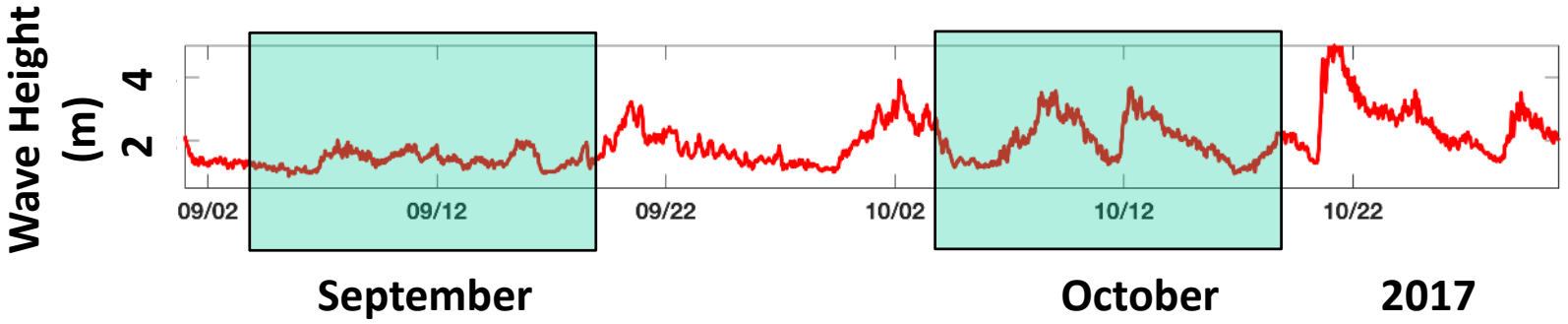
OBJECTIVES: INNER SHELF (5-50 m)

- measure & understand processes that contribute to exchange
  1. shoreward transport of material by **nonlinear internal waves and bores**
  2. **cross-shelf eddy flux from current instabilities**

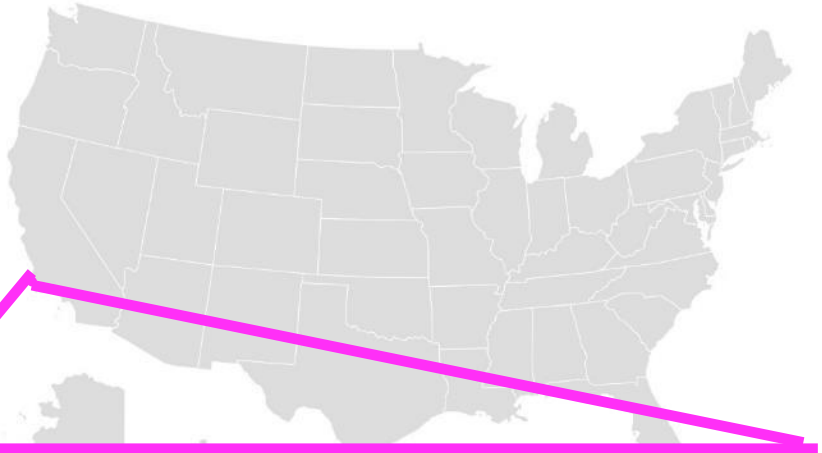
- Use in-water data to interpret and understand **remotely-sensed data** (X-band radar, aircraft, satellite)

- produce an inner-shelf data set that will be used to verify and advance **numerical ocean circulation models**

field worked: calm conditions in September; increasing waves in October



Inner Shelf Experiment
September – October 2017
north of Point Conception, California

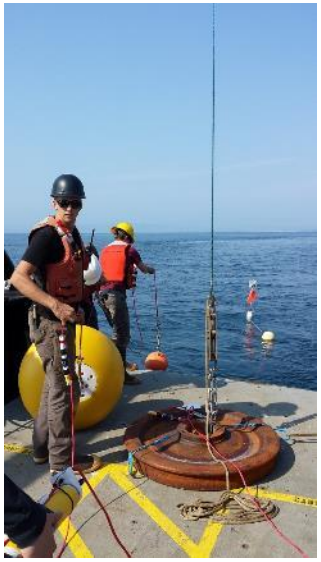


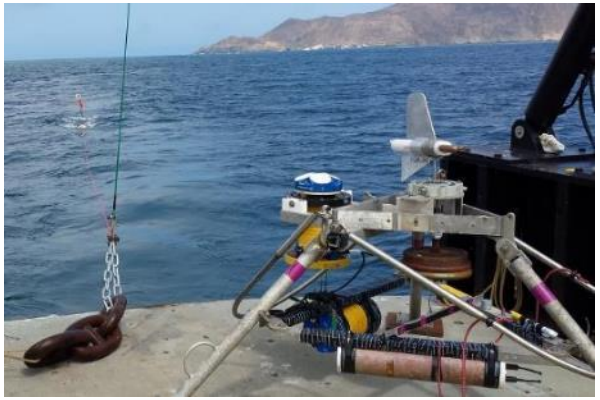
straight coastline

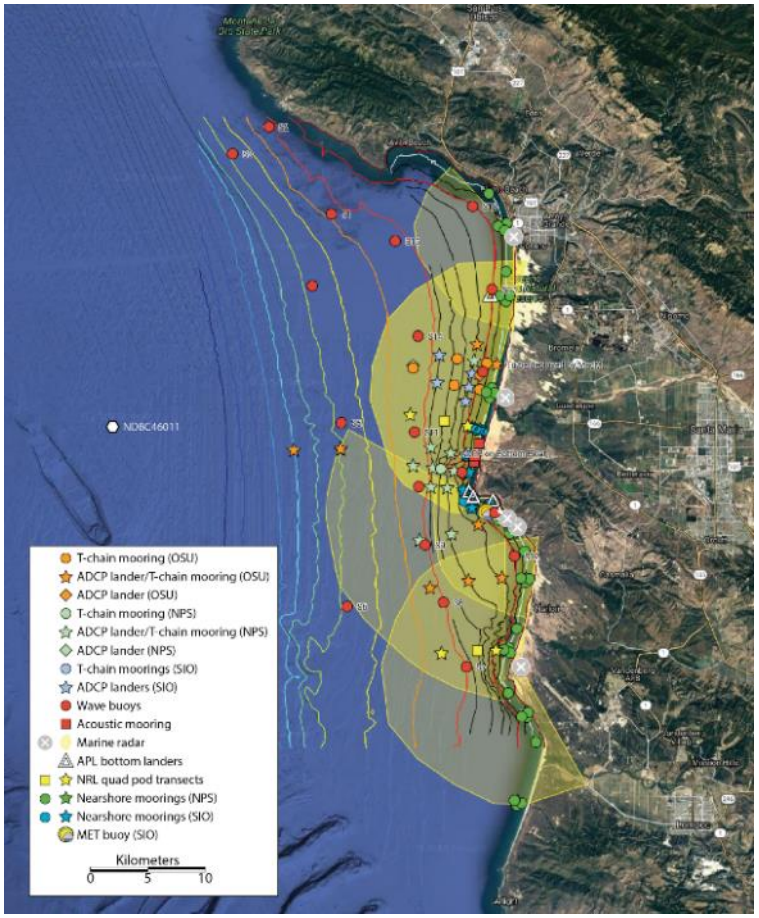
rocky headland

Deploy a high-spatial resolution moored array – in collaboration with ISDRI colleagues – from the mid-shelf to the edge of the surfzone

OSU: 8 bottom landers w/ADCPs; 11 temperature string moorings with pressure, GusTs, & chipods (total of 80 moorings on shelf; another 80 in surfzone)







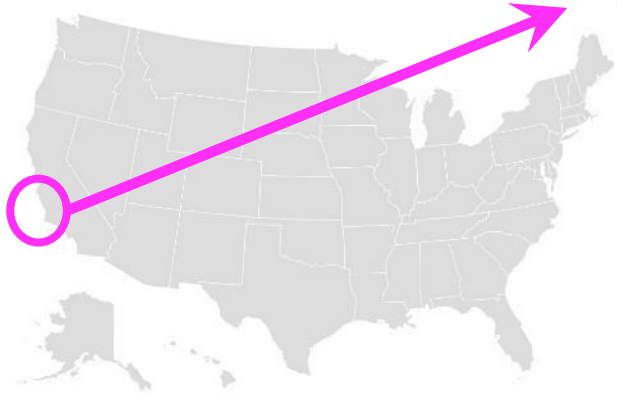
Internal Tide Generation

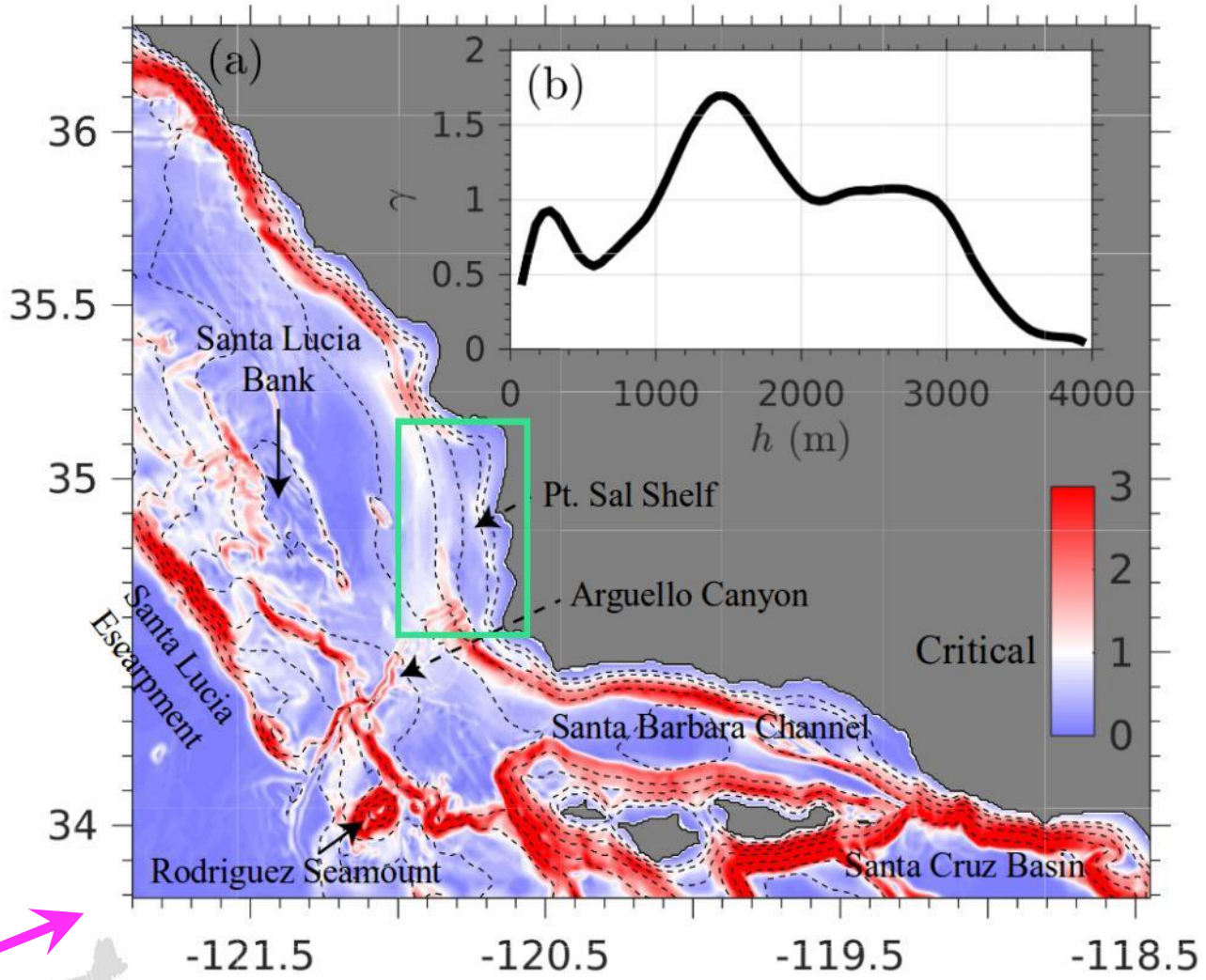
$$\gamma = |\nabla \mathbf{h}| \left(\frac{\omega^2 - f^2}{N_b^2 - \omega^2} \right)^{-0.5}$$

$\gamma < 1$ transmission

$\gamma = 1$ generation

$\gamma > 1$ reflection

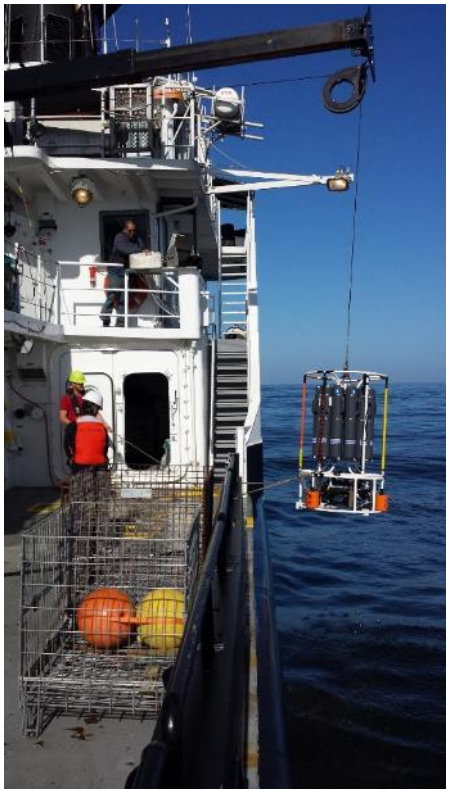


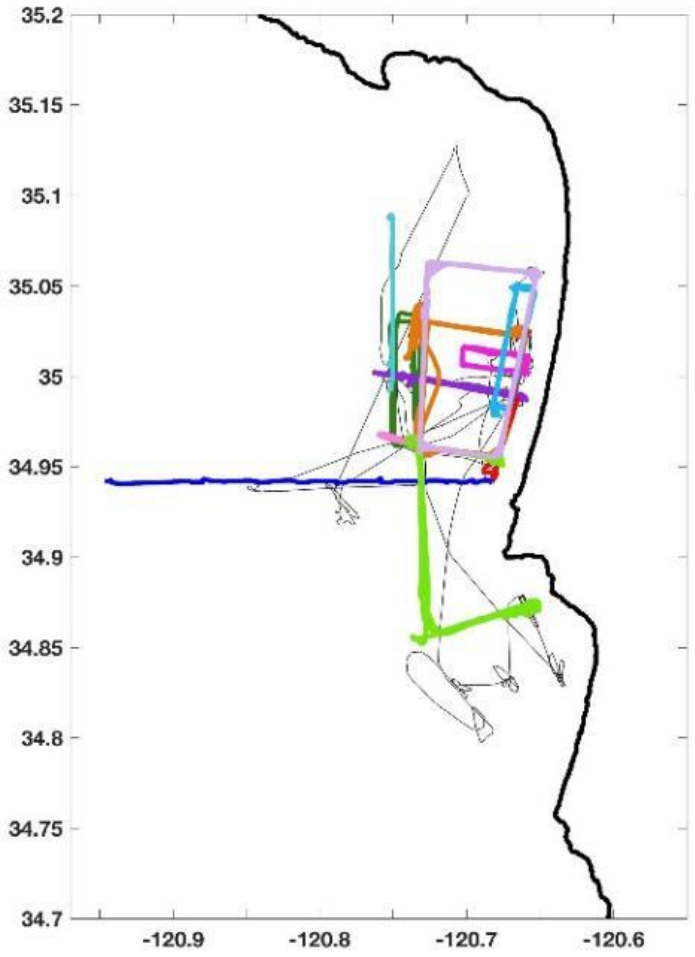


Kumar et al. 2018

Repeatedly measure the cross-shelf and vertical distribution of hydrographic and velocity fields across the mid to inner shelf and relate them to wind forcing

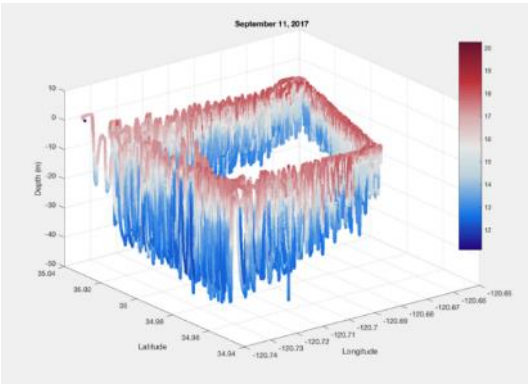
CTD, ADCPs (hull & pole), GusTs, bowchain, radiometer, radar



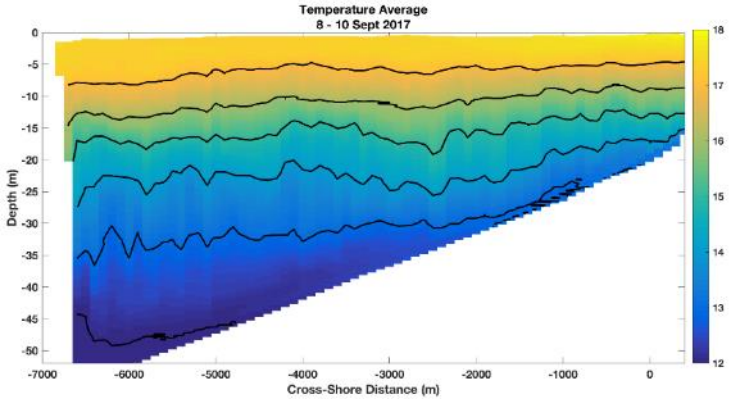


But what about the subtidal hydrography & circulation …

repeated flux box around mooring array
~10 times around box; ~2.5 tidal cycles

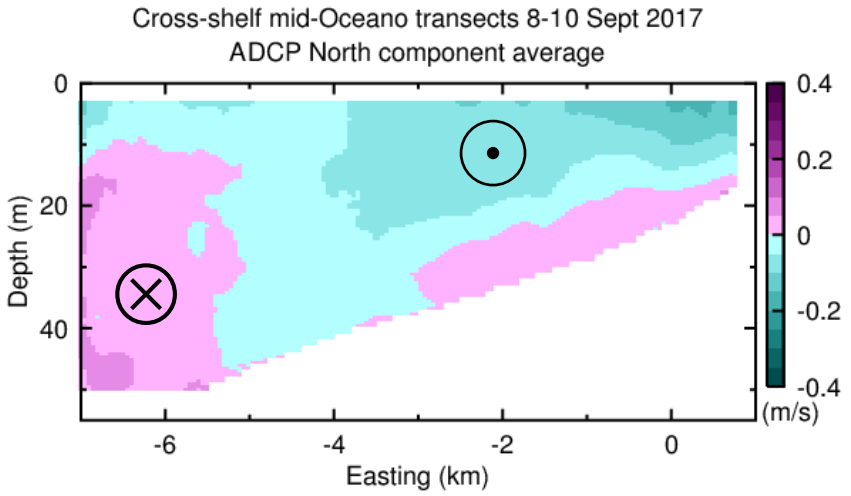


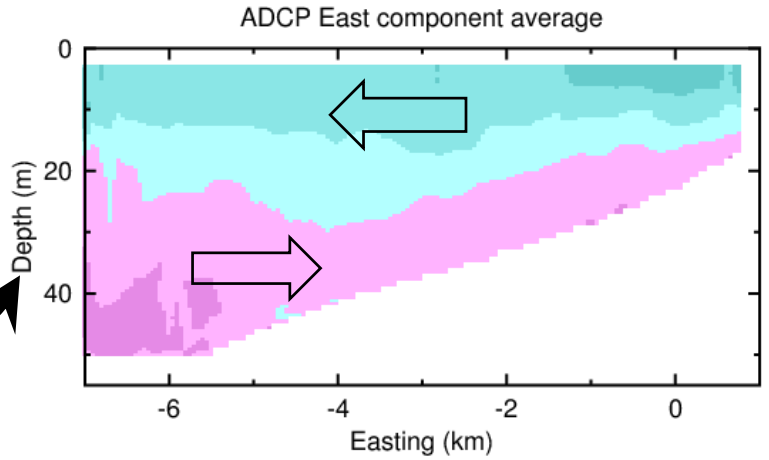
removes internal tide &
Nonlinear Internal Waves/bores



Surface-intensified, southward upwelling jet overriding weak northward flow

Classic wind-driven Ekman layer offshore, onshore return flow beneath





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Summary

- **Internal bore fronts coherent along-shore ~40 km**
  - internal waves can vary <1 km along shore
- **2 internal bores every semidiurnal period**
  - 80% of them are observable to the 15m isobath
  - 30% can be tracked to the 9m isobath
- **Changes in the wave guide** within the shoaling region and over the 2 months
  = **upwelling and wind relaxation**
- Next up: flux estimates from ship and moorings

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Collaborators: Mick Haller, Alex Simpson, Jen MacKinnon, Amy Waterhouse, John Colosi, Jim Moum, Johannes Becherer, Jamie MacMahan and many others