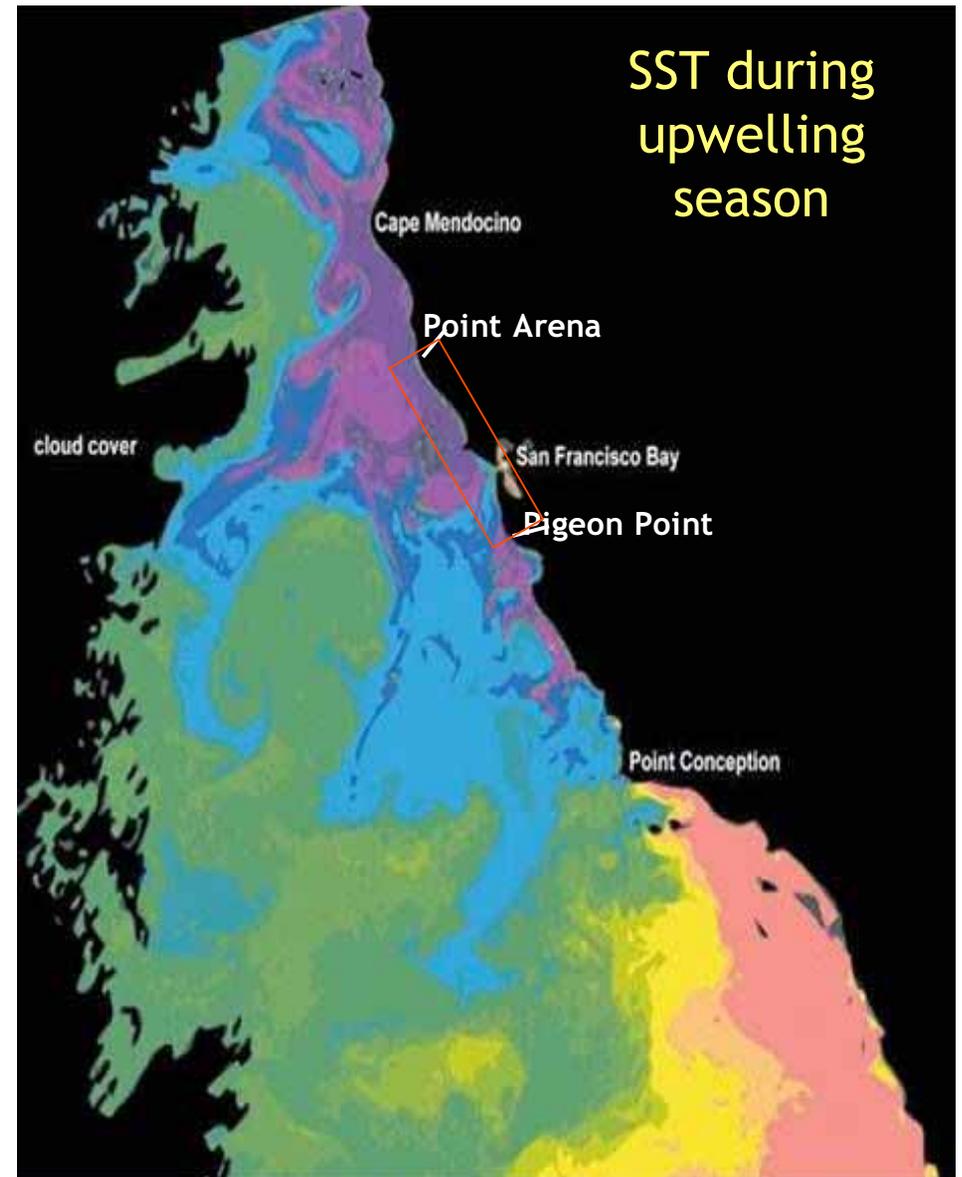




The Environment - Ocean Patterns

*If we knew
the hue of
the blue ...*

John Largier
MLPA Science Advisory Team
Bodega Marine Laboratory (UCD)
jlargier@ucdavis.edu





The Environment - Ocean Patterns

Patterns of dispersal and pelagic habitat ...
Area characterized by upwelling & mediterranean climate.

- ⊗ The ***Upwelling*** Story ...
 - ... upwelling center at Point Arena;
 - ... retention areas;
 - ... time & space scales of phytoplankton blooms.

- ⊗ The ***Bay Outflow*** Story ...

- ⊗ The ***Estuary*** Story ...
 - ... outflow;
 - ... inflow.

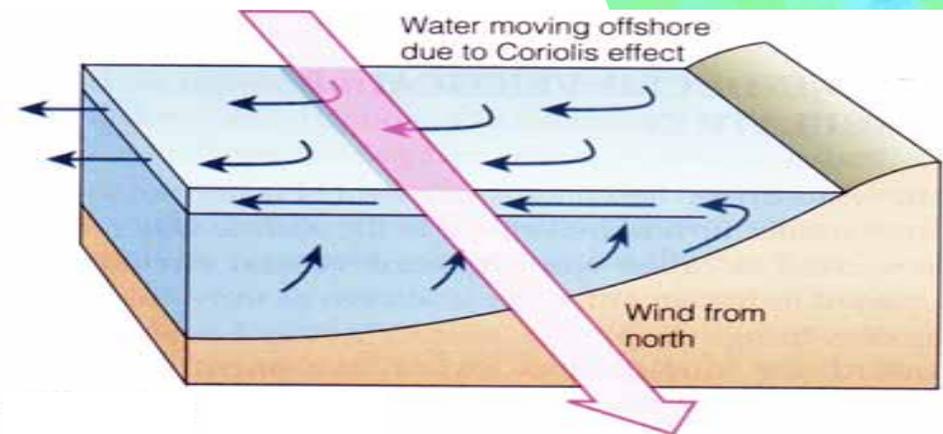
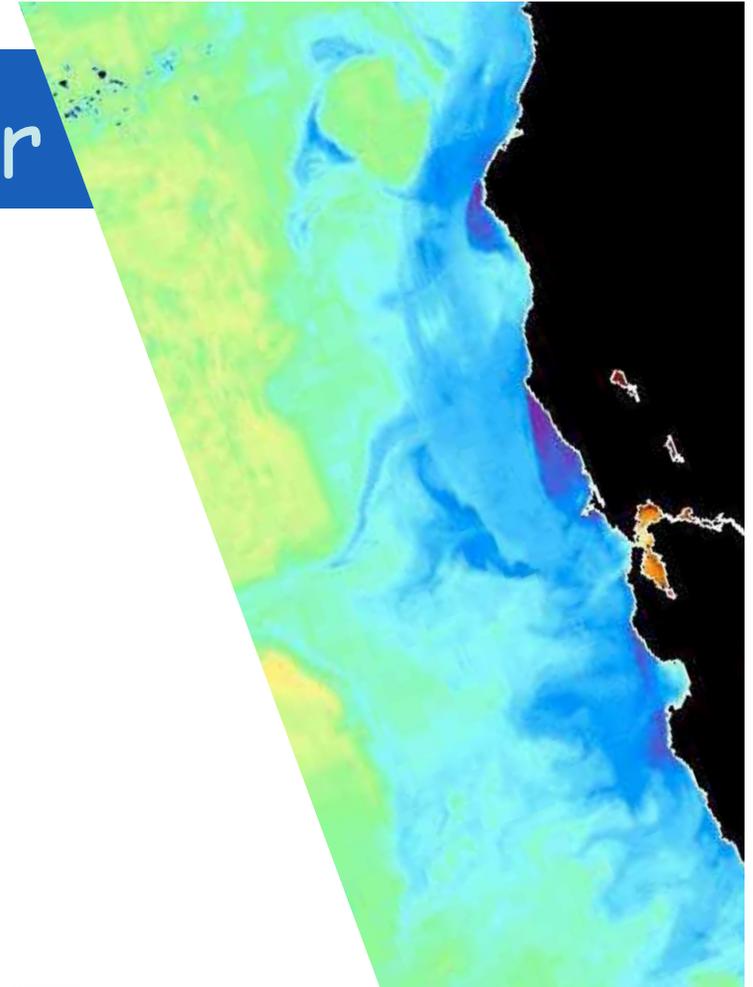
- ⊗ ***The Wave Exposure Story.***

- ⊗ The Story of ***Temporal Variability.***



The Upwelling Center

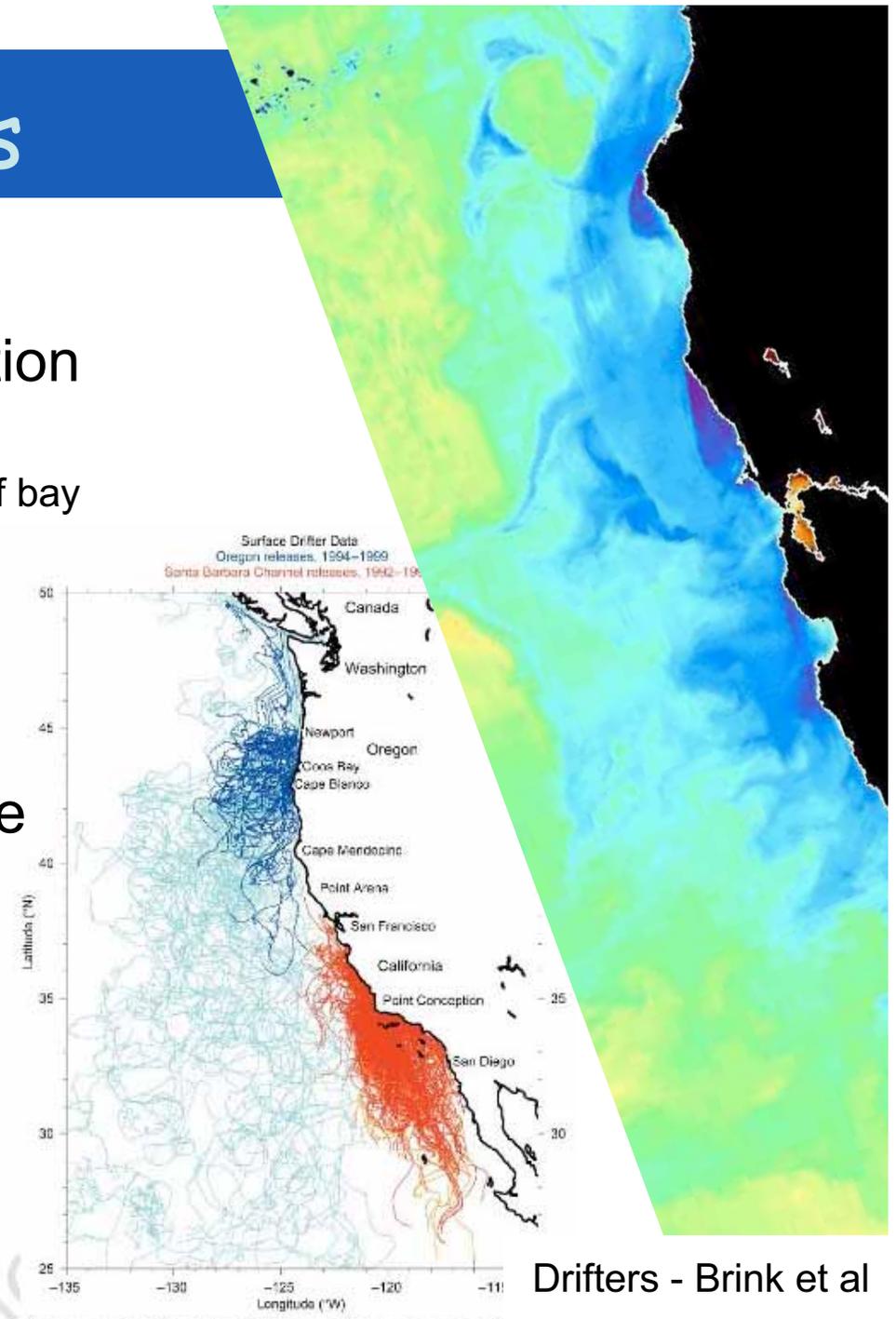
- Point Arena is a strong and persistent upwelling center.
- Area of active upwelling expands and contracts.
- Cold water streams south to Point Reyes, Cordell Bank, Farallones Islands and Gulf of the Farallones.
- Cold upwelled water is loaded with nutrients.





Retention Areas

- Drakes Bay is primary retention zone (“upwelling shadow”) ... but, note shallow thermocline, influence of bay outflow, and nearshore upwelling.
- Also, water may be retained in Bodega-Tomaes system.
- “Detention” along north shore of Point Reyes.
- Nearshore boundary layer including small coves and indentations.
- Retention in offshore mesoscale eddies.

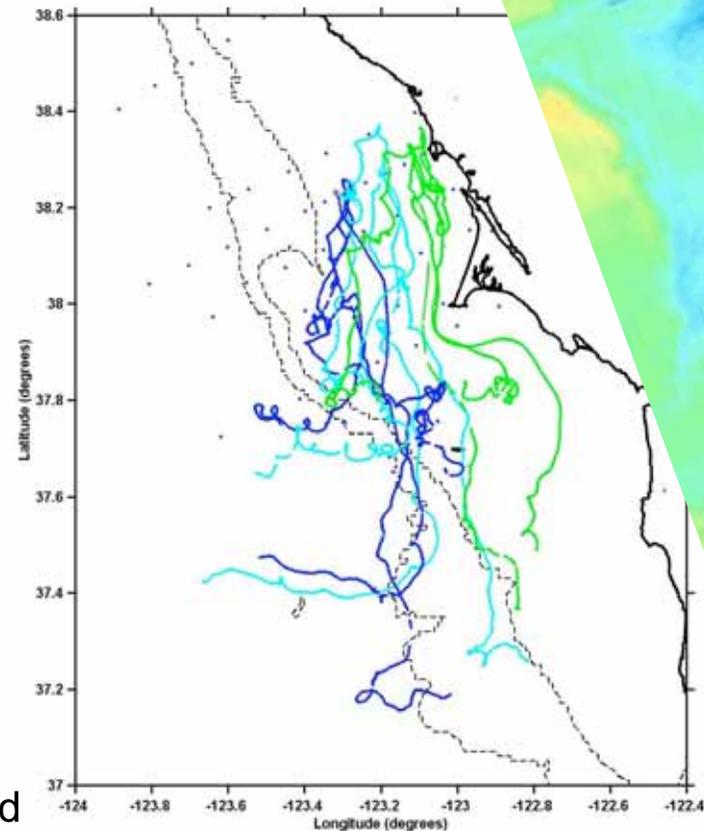


Drifters - Brink et al

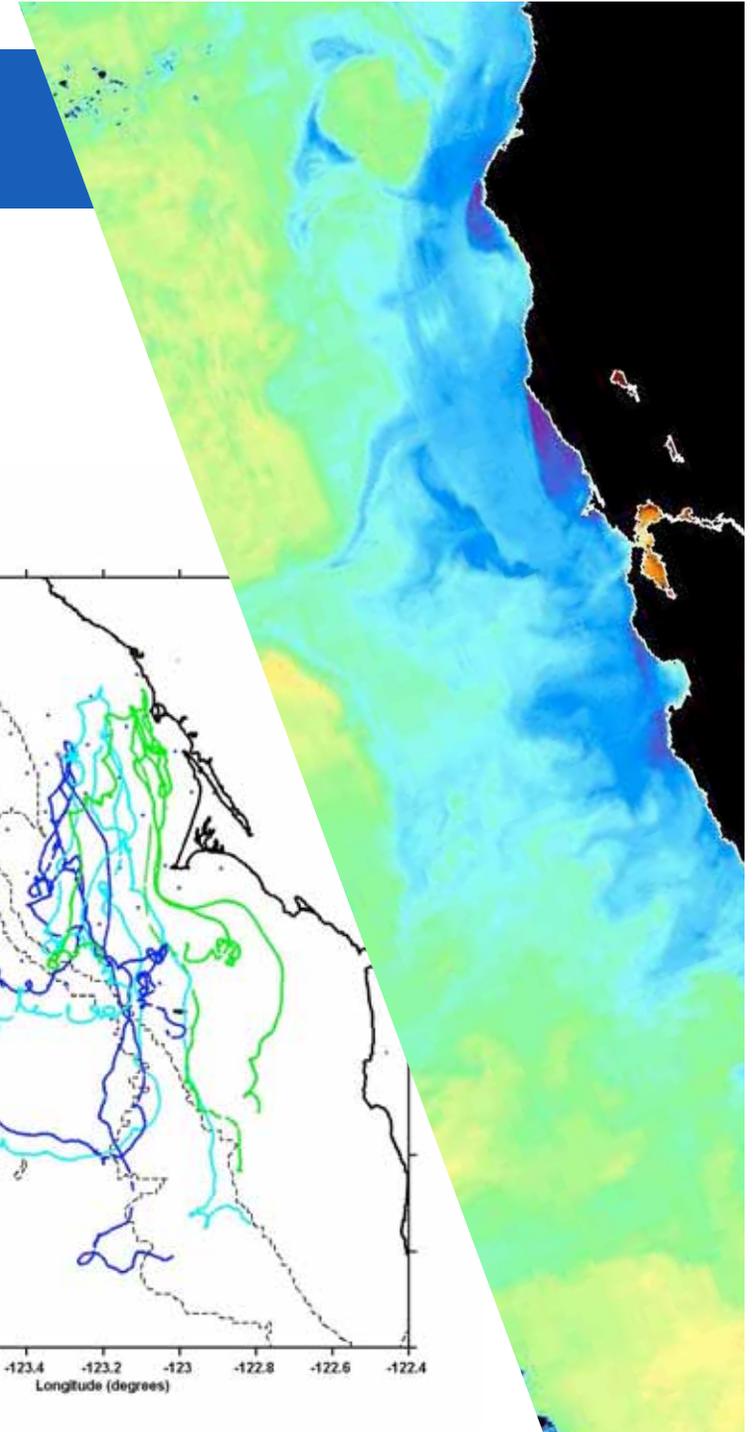


Upwelling Plume

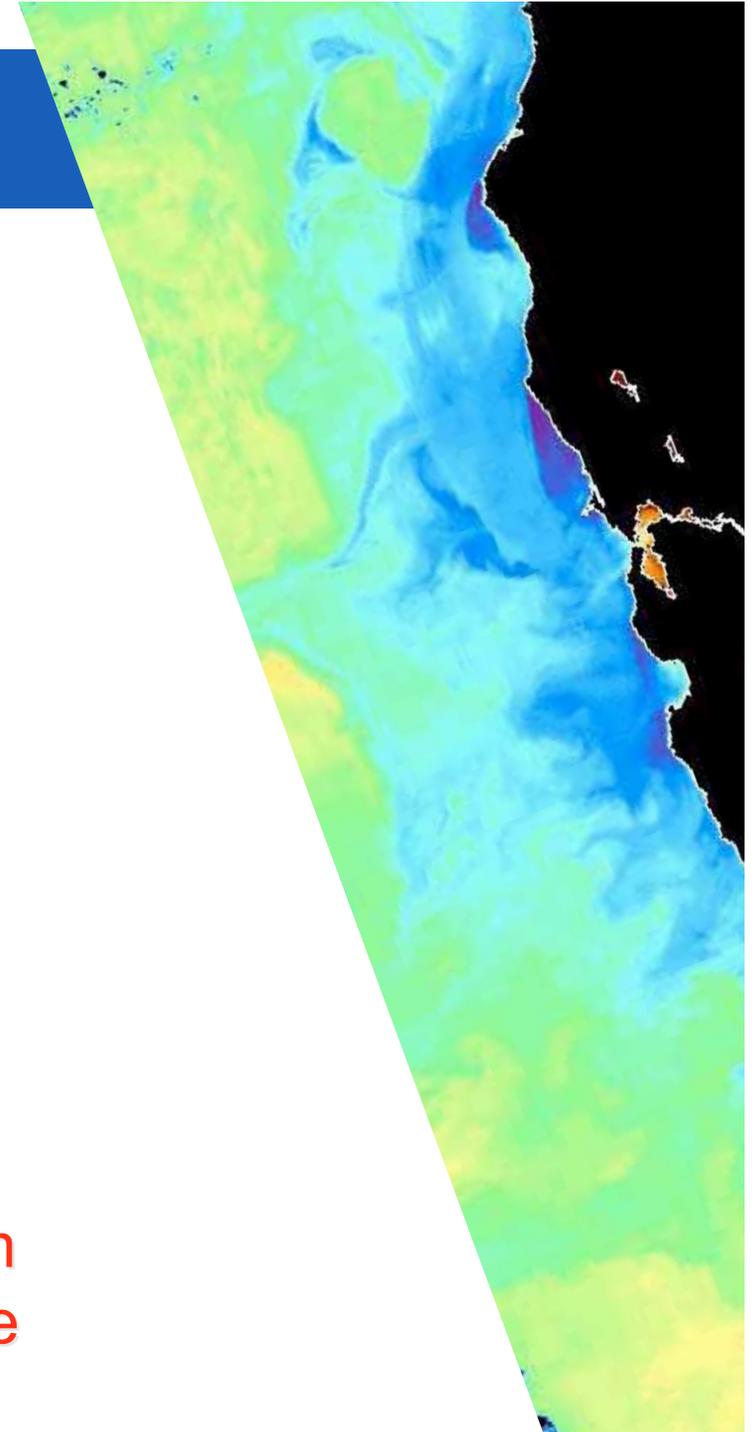
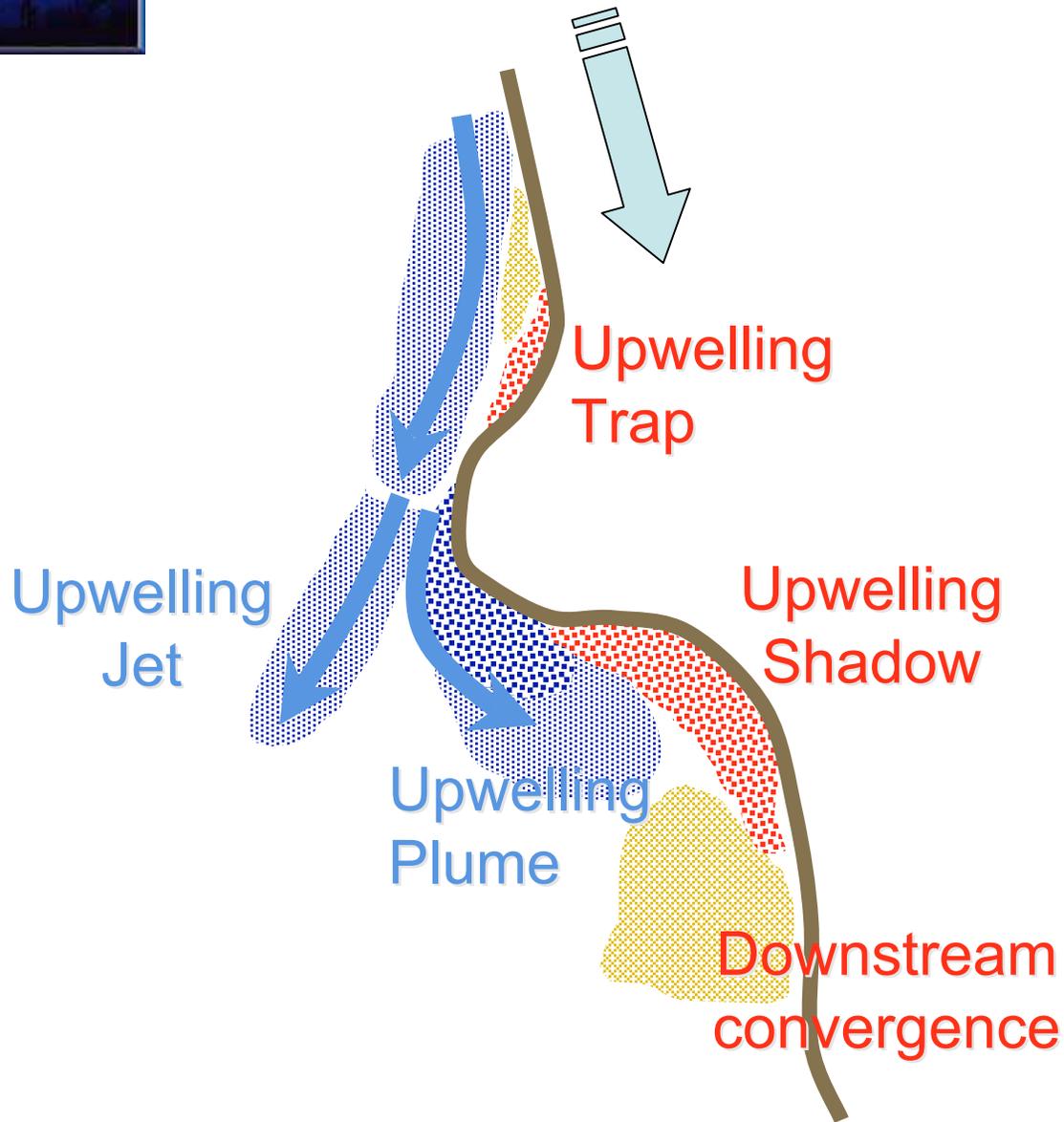
- Upwelling plume - a plume of cold, nutrient-rich water - streams south from Pt Arena.
- Plume is deflected by Pt Reyes, exporting material offshore.



Drifters deployed off Bodega Head

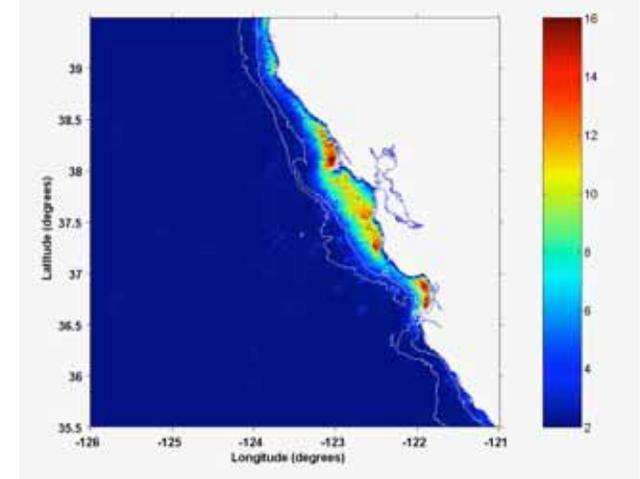
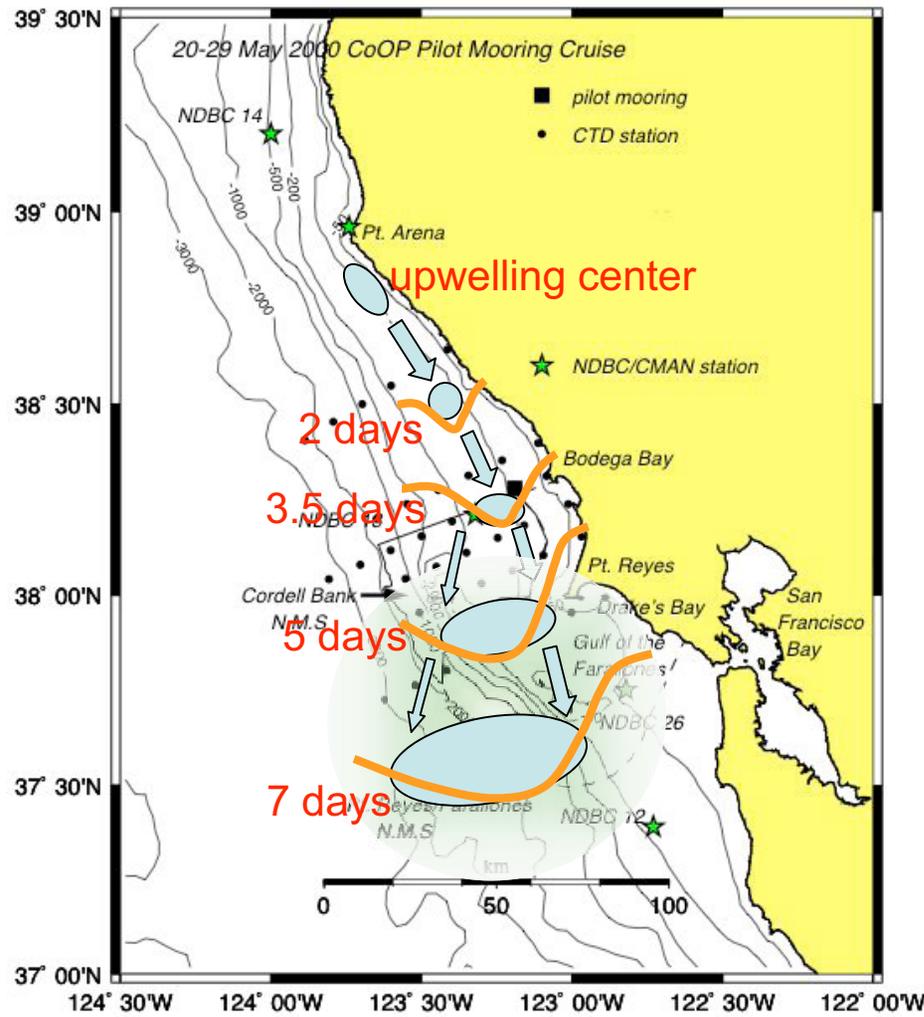
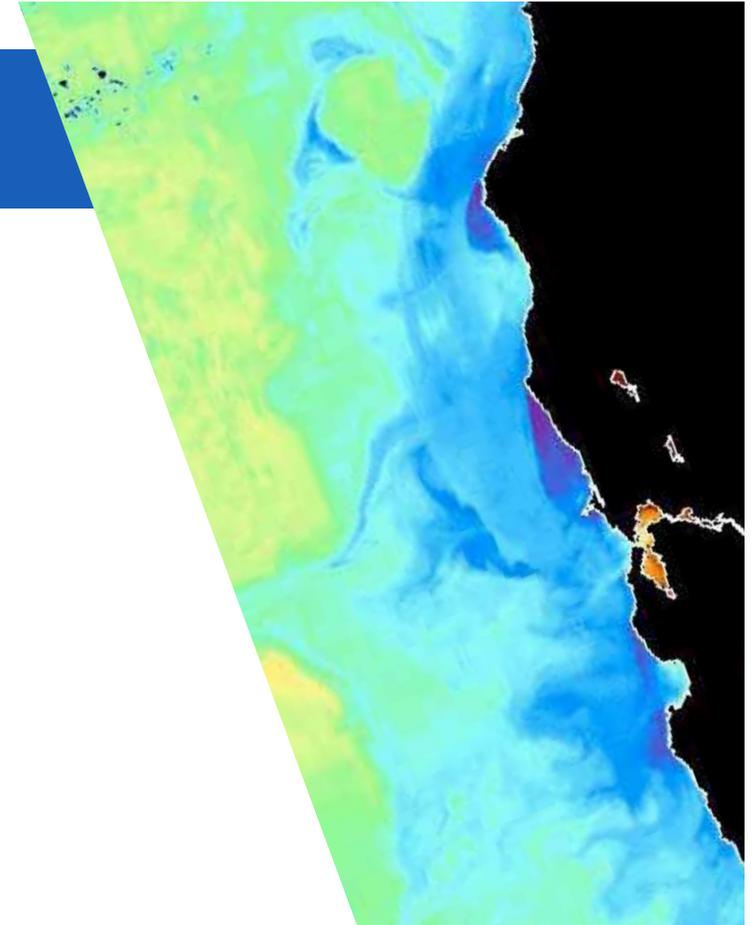


Upwelling at Capes





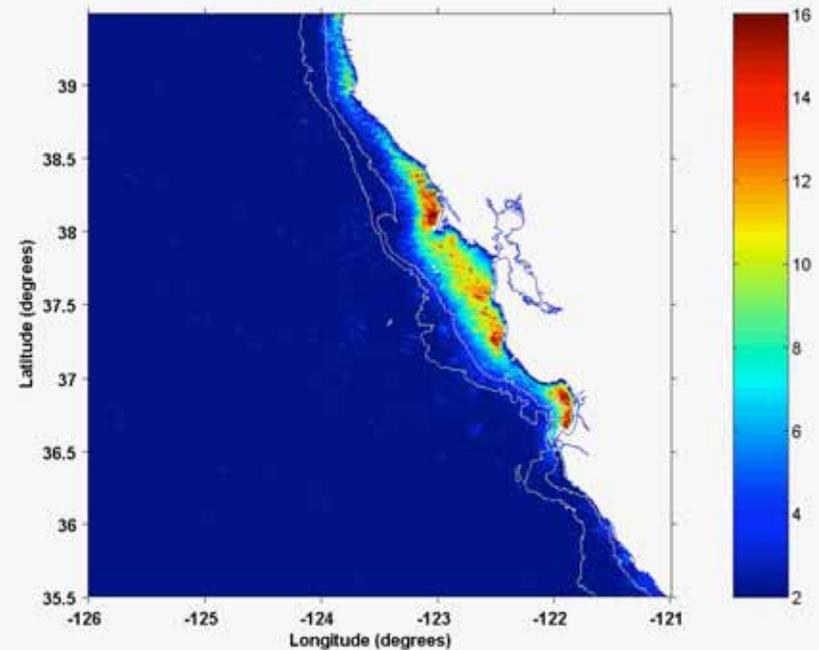
Phytoplankton





Phytoplankton Response

- Phytoplankton response time is several days.
- This is seen as a plume of chlorophyll, attaining maximum concentrations 50-100km downstream of upwelling center.
- Cordell Bank, Pt Reyes, Farallones Islands and Gulf of the Farallones are supported by Pt Arena upwelling.

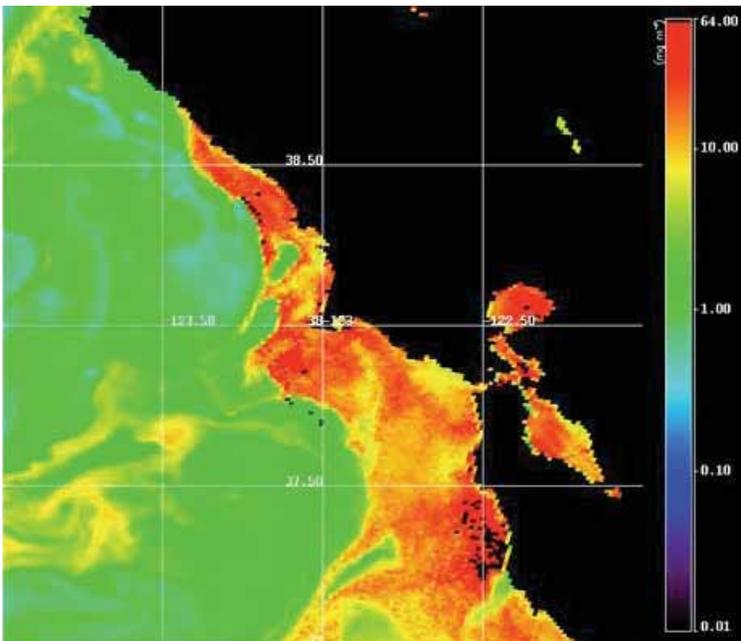


Average chlorophyll concentration from SeaWiFS
(courtesy Andrea Vander Woude)



Phytoplankton & Relaxation

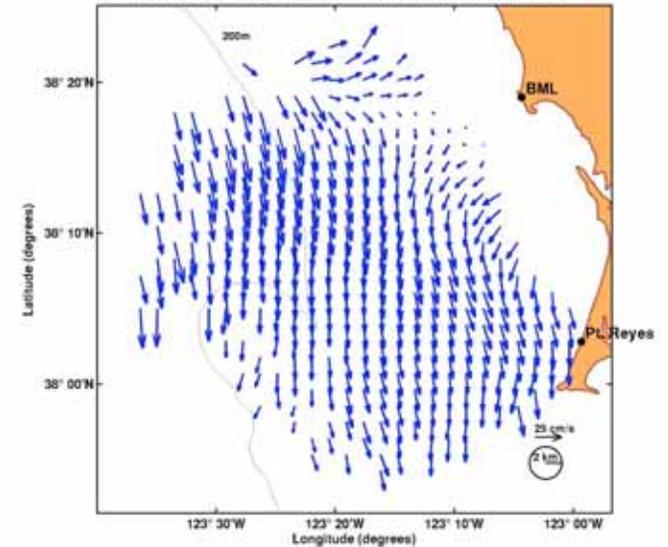
- Relaxation of the wind leads to phytoplankton blooms - shallow stratified surface layer.



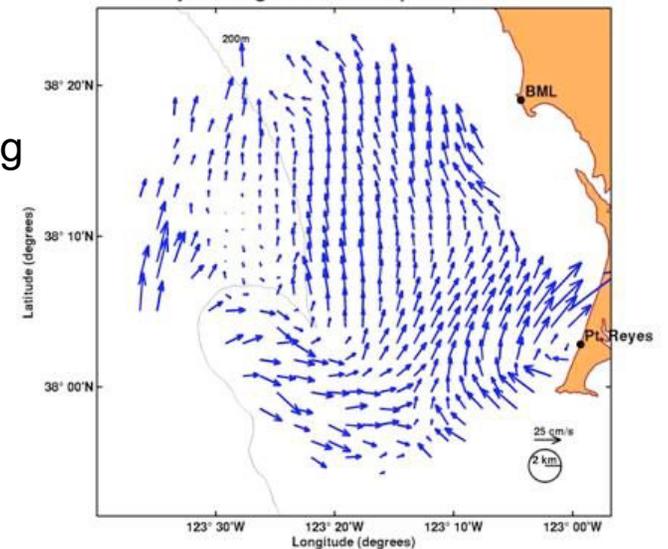
HF radar maps of surface current during upwelling and relaxation.

SeaWiFS image of chlorophyll concentration.

Daily Average Current Map for 15-Jul-2001

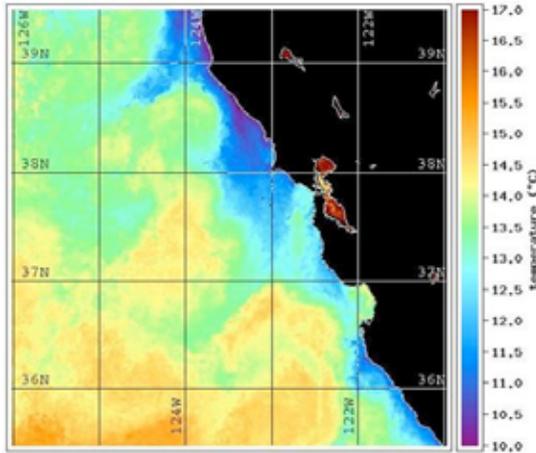


Daily Average Current Map for 25-Jul-2001

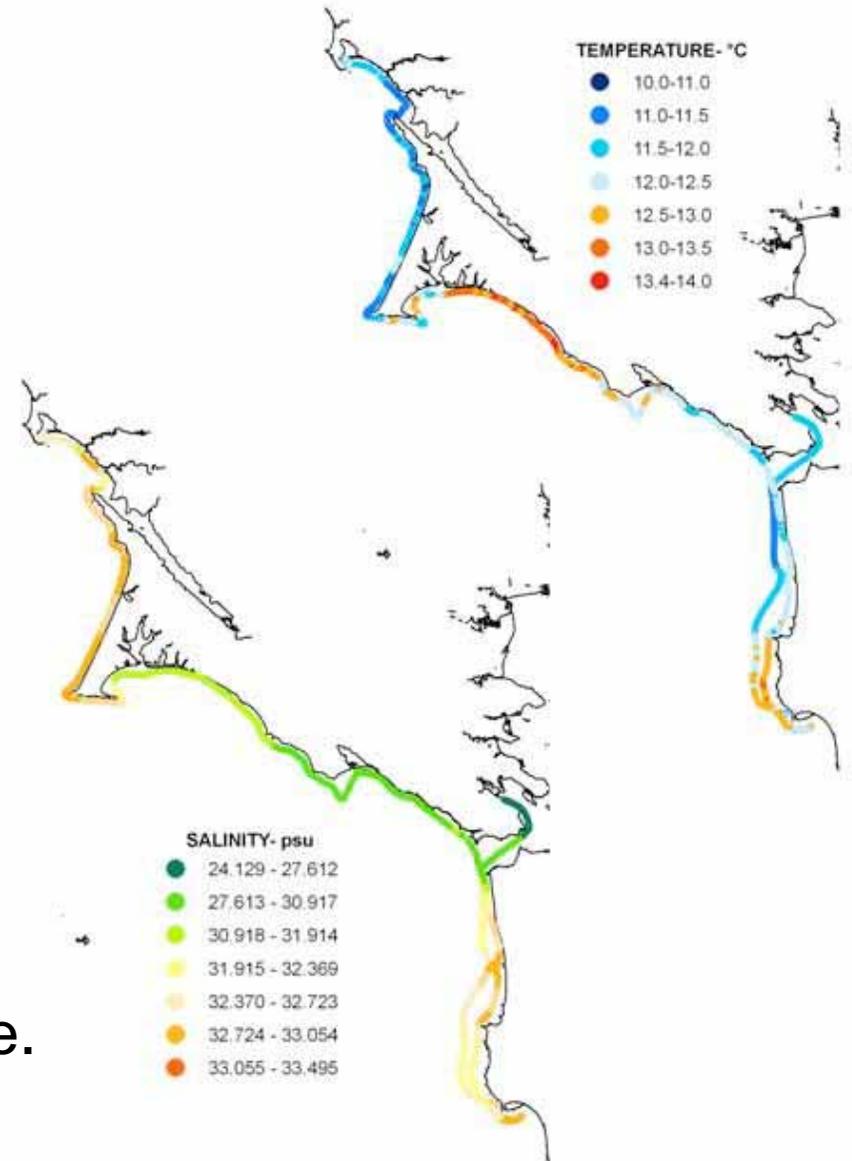




San Francisco Bay Outflow



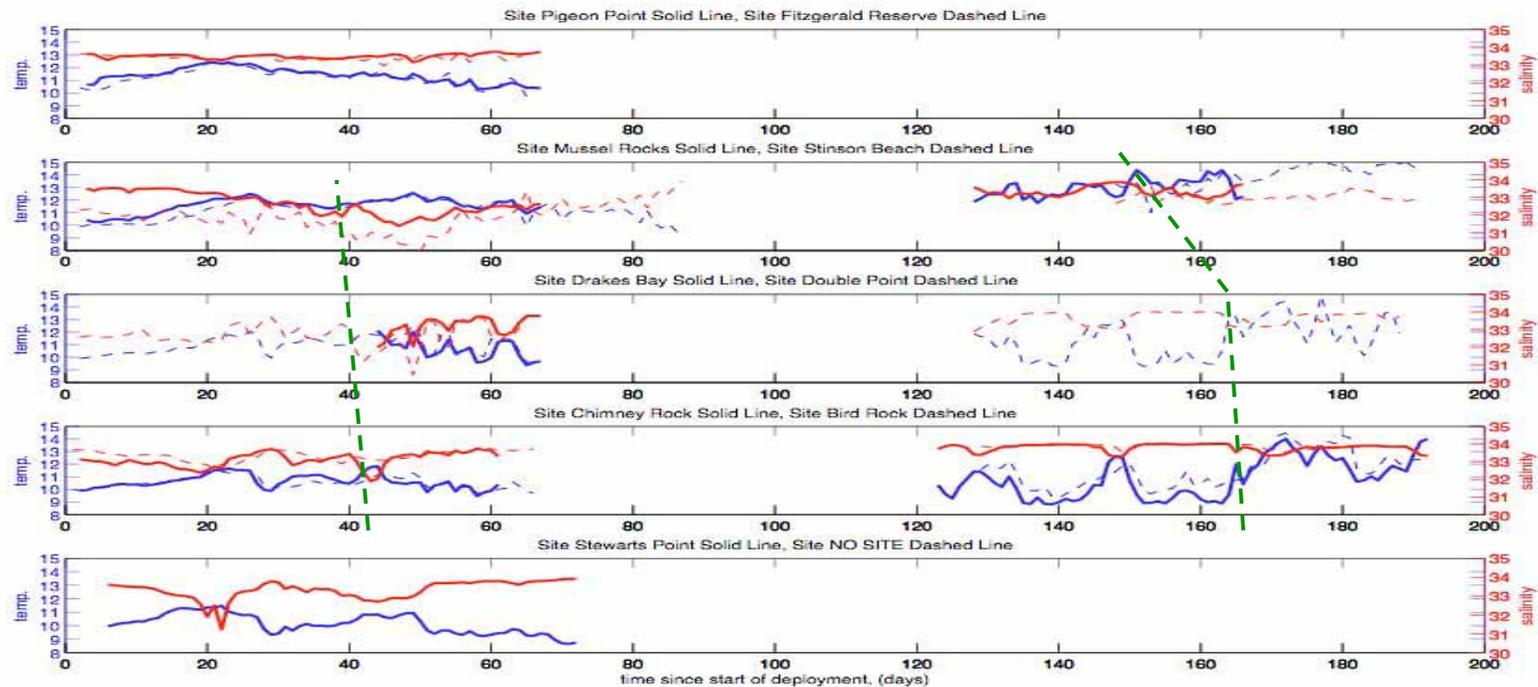
- Moves south during upwelling - minimal contact with shore.
- Found attached to shore up to Bolinas (frontal feature) & low-salinity surface water up to Pt Reyes.
- Moves north during weak or southerly winds & after strong freshwater flow - contact with shore. Not washed out of Drakes Bay during upwelling.





San Francisco Bay Outflow

- Moves south during upwelling - minimal contact with shore.
- Moves north during weak/south winds & after strong freshwater flow - maximum contact with shore & min dilution ... positive and negative impacts.





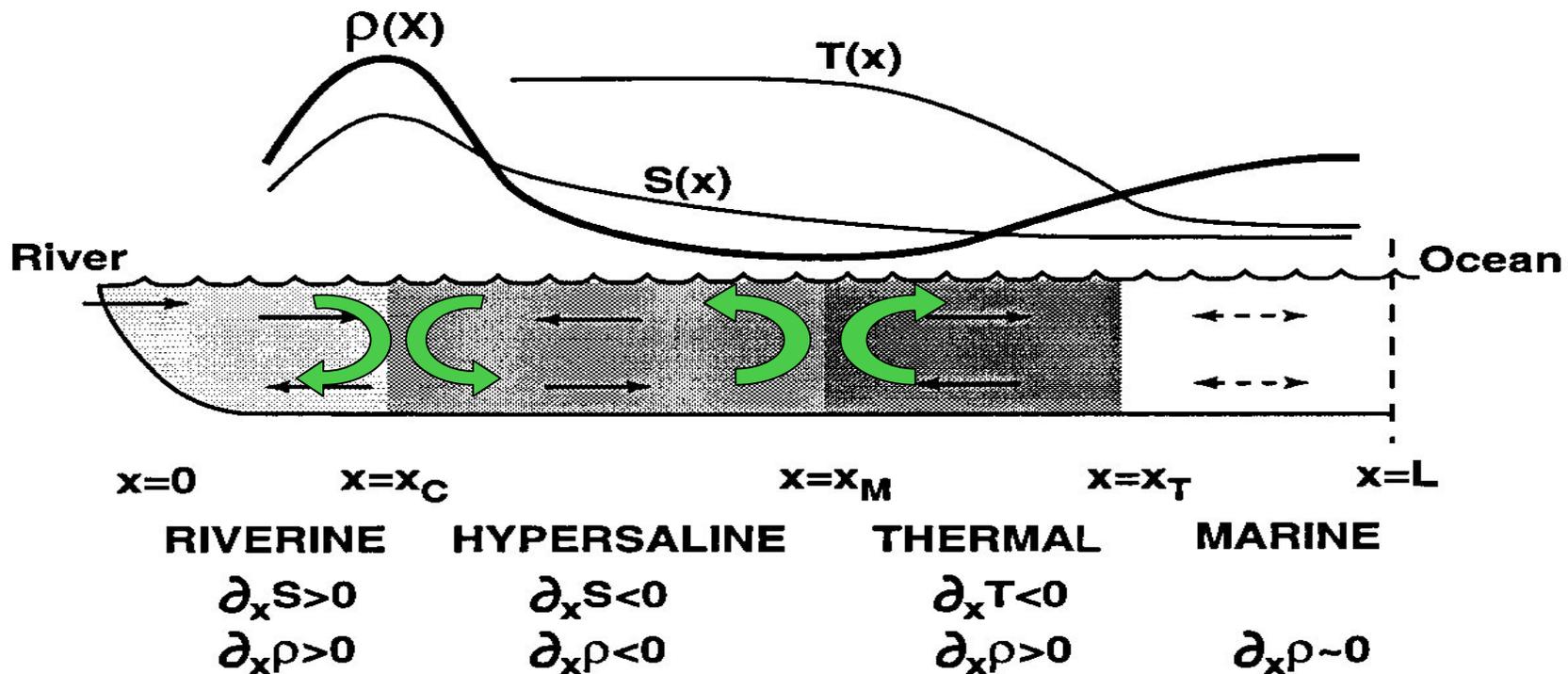
San Francisco Bay Outflow



Estuaries



- **Low-inflow estuaries**, like Tomales Bay and Bodega Harbor.
- Long residence, clear longitudinal zonation - protection of “backwaters”

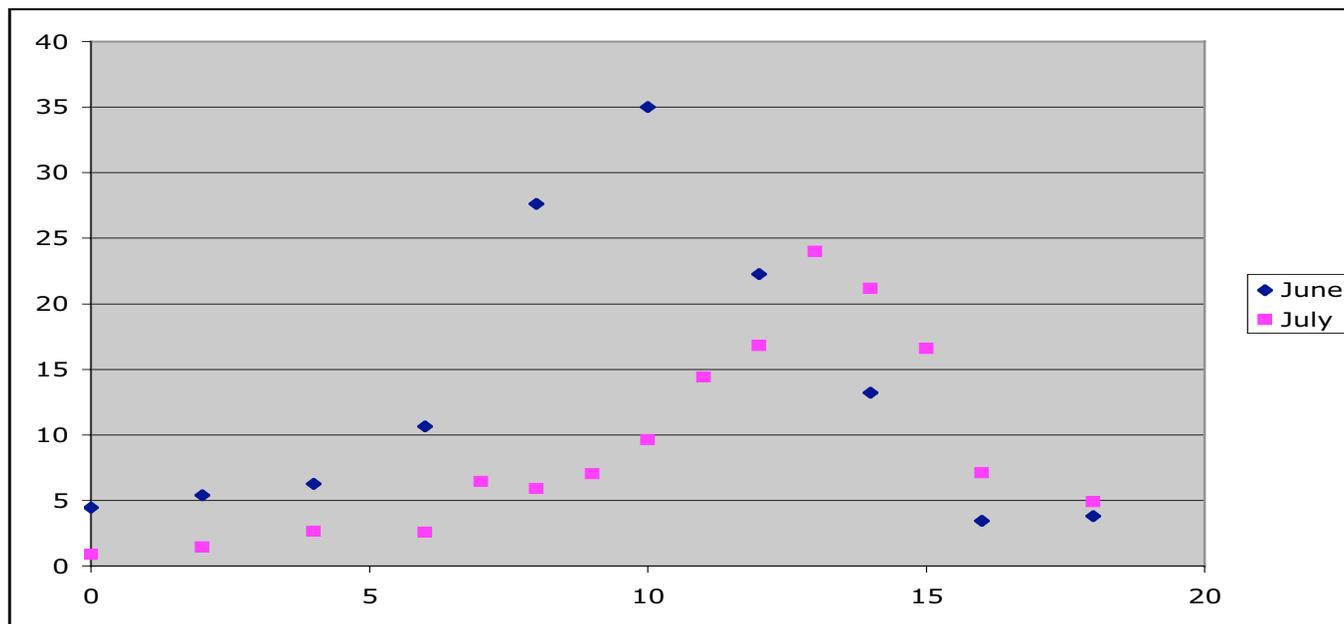




Estuaries



- **Low-inflow estuaries**, like Tomales Bay and Bodega Harbor.
- Nutrient supply from ocean - spatial pattern of phytoplankton.



Marine

Thermal

Hypersaline

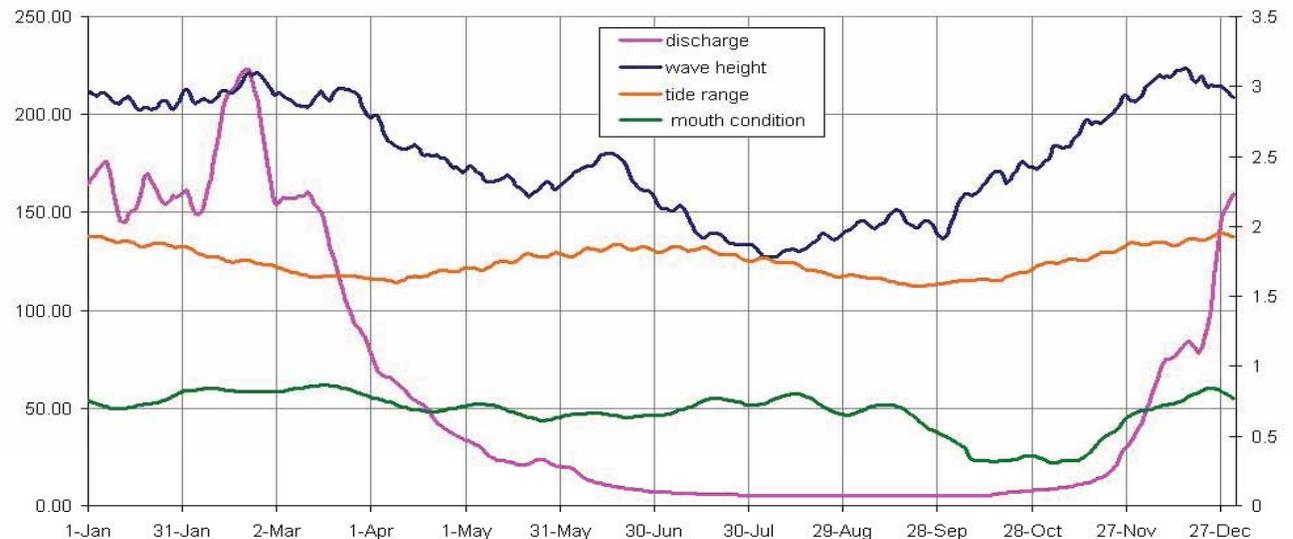
Chlorophyll fluor. data
(courtesy David Kimbro)



Estuaries



- **Bar-built estuaries**, like Russian River, Gualala, Salmon Creek.
- Highly stratified at times, leading to high T and low DO.
- Deep pools on curves vs shallow sections.
- Salinity intrusion.
- Residence time.
- Mouth closure.
- Outflow plumes (Stewarts Point 2007).

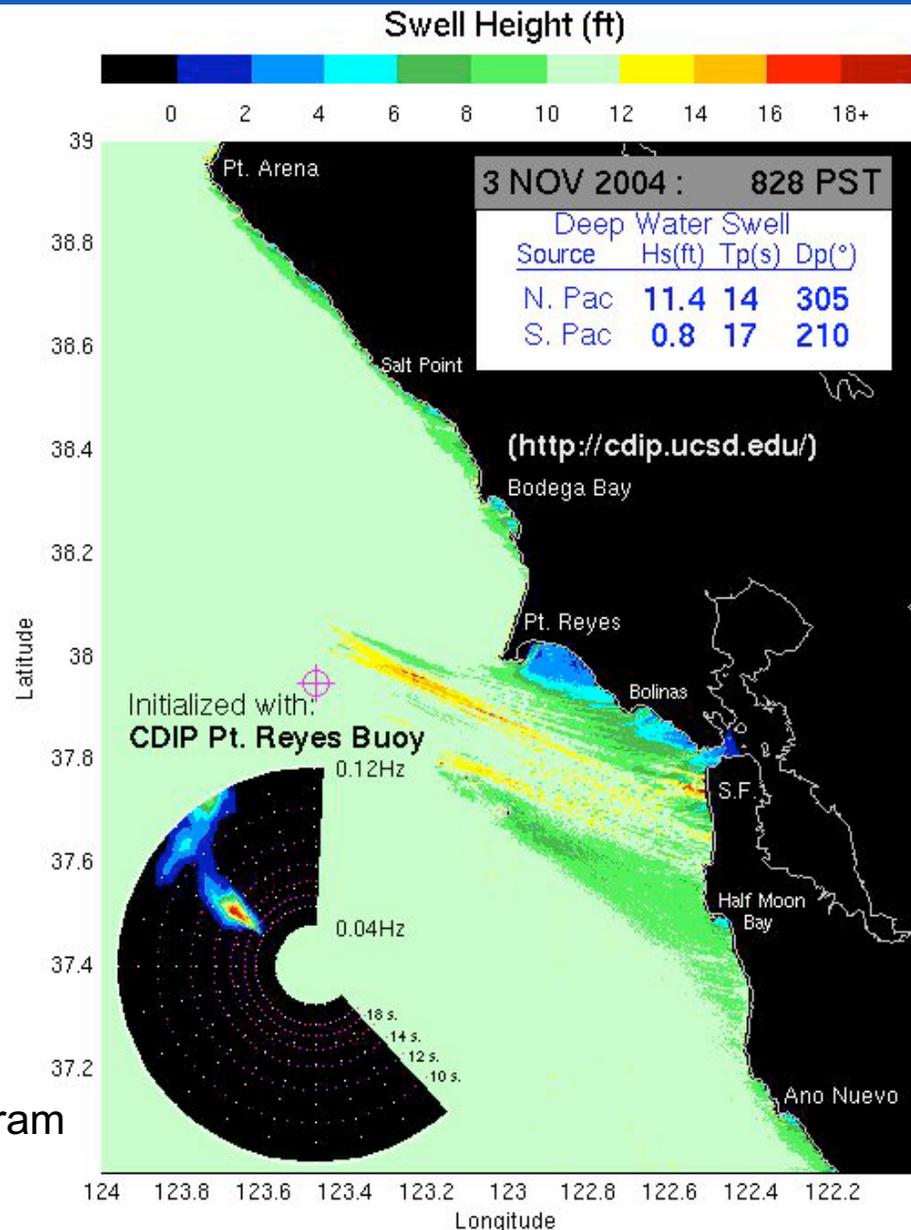




Wave Exposure

- Deep-sea “swell” refract and diffract.
- Also, “sea” from local winds.
- Alongshore transport - zone of impact associated with land runoff.

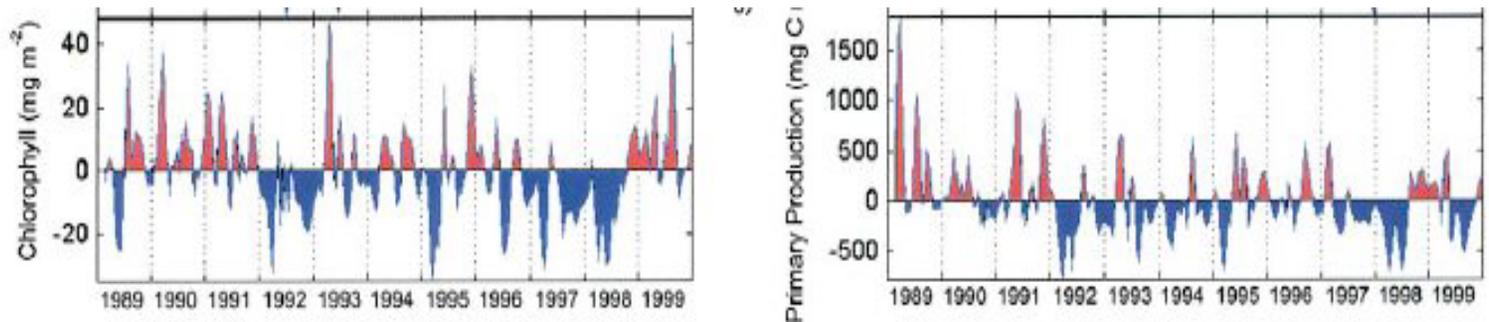
CDIP data - Coastal Data Information Program
<http://cdip.ucsd.edu>





Temporal Variability

MBARI/Chavez
data, 1989-99

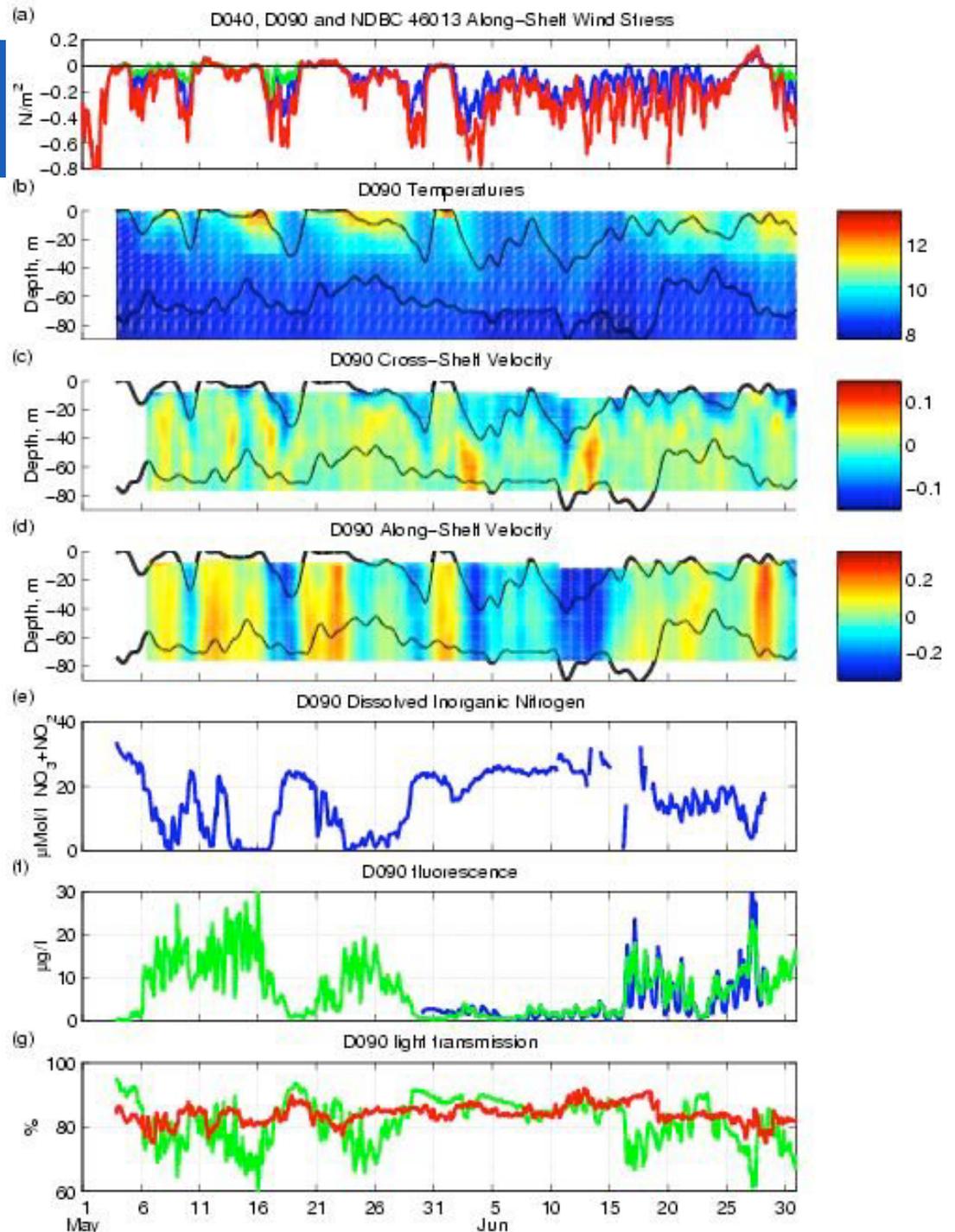


- Have described spatial patterns.
- Recognize temporal variability - diurnal, synoptic, seasonal, interannual, trend.
- **Short-term variability** characterizes the suitability of habitat - need high-resolution monitoring.
- **Long-term variability** characterizes fluctuations in a population - need long-term monitoring.
- Interaction of time scales, e.g., timing of spring transition, match-mismatch ideas (salmon smolts entering ocean).



t-variability

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The Environment - Monitoring

Gerstle Cove ASBS & Salt Point MPA
Fort Ross MPA
Sonoma Coast MPA
Bodega Marine Life Refuge and ASBS
Estero Americano CCA (also GFNMS)
Estero San Antonio CCA (also GFNMS)
Tomales Bay (NPS and GFNMS)
Bird Rock ASBS
Cordell Bank NMS
Pt Reyes National Seashore
includes Drakes Estero
Point Reyes Headlands ASBS
Duxbury Reef ASBS
Gulf of Farallones NMS
includes Bolinas Lagoon
Golden Gate National Recreation Area



Existing monitoring
& CeNCOOS proposed monitoring
for Pt Reyes area



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