



The Environment - Ocean Patterns

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

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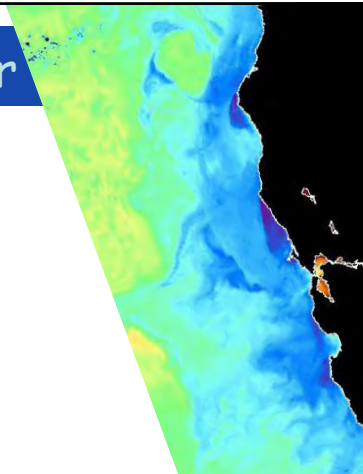
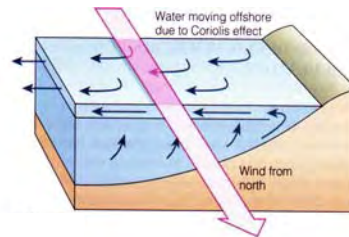
Patterns of dispersal and pelagic habitat ...
Area characterized by upwelling & mediterranean climate.

- ⊗ 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.**



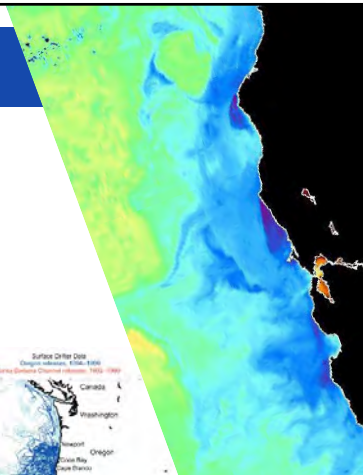
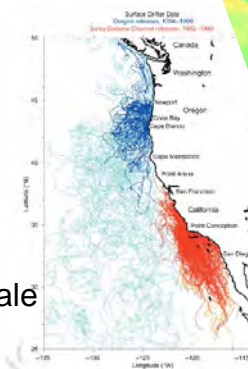
The Upwelling Center

- 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

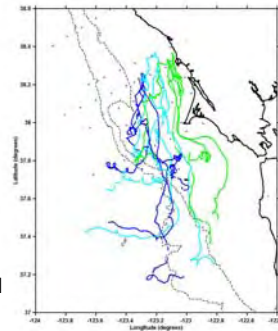
- Drakes Bay is primary retention zone (“upwelling shadow”) ... but, note shallow thermocline, influence of bay outflow, and nearshore upwelling.
- Also, water may be retained in Bodega-Tomaes system.
- “Detention” along north shore of Point Reyes.
- Small-scale nearshore areas.
- Retention in offshore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



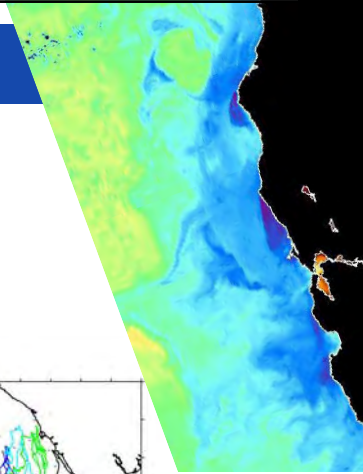


Upwelling Plume

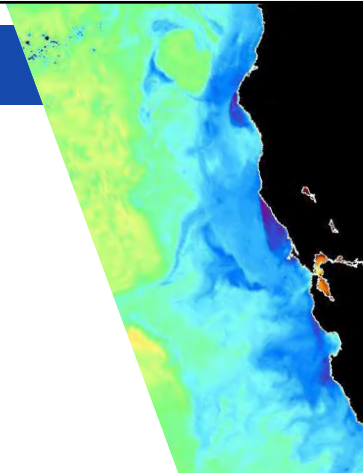
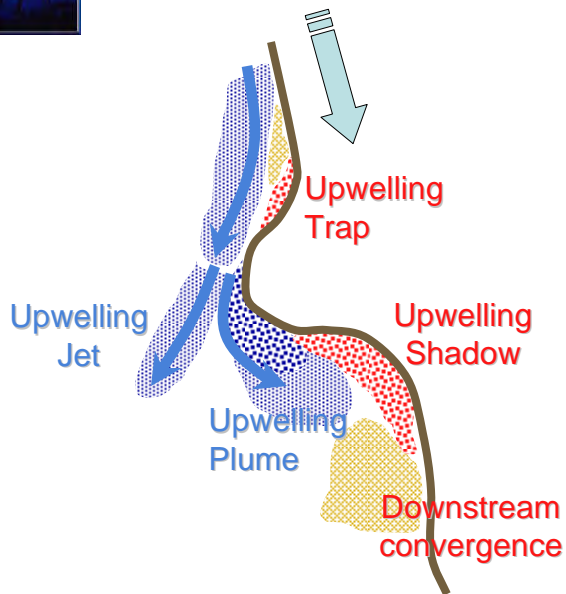
- Upwelling plume - a plume of cold, nutrient-rich water - streams south from Pt Arena.
- Plume is deflected by Pt Reyes, exporting material offshore.



Drifters deployed off Bodega Head (Largier et al)

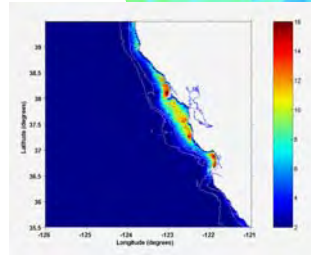
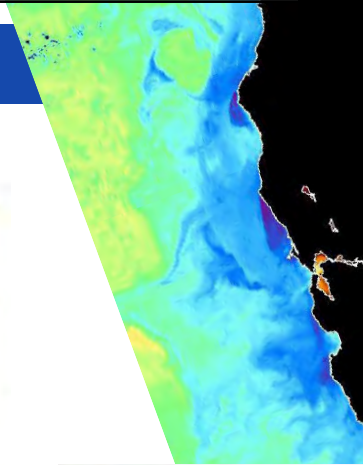
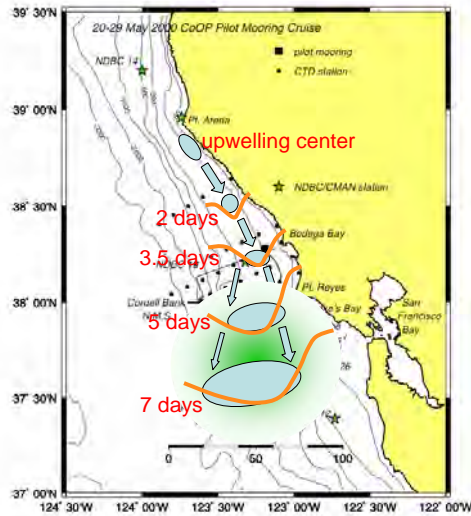


Upwelling at Capes



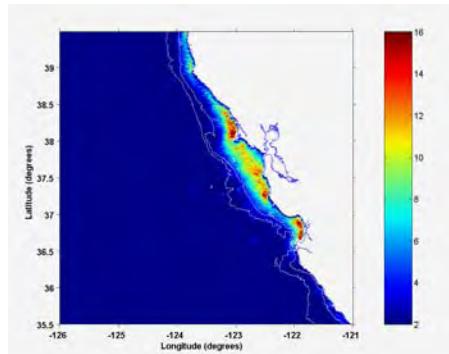


Phytoplankton



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.

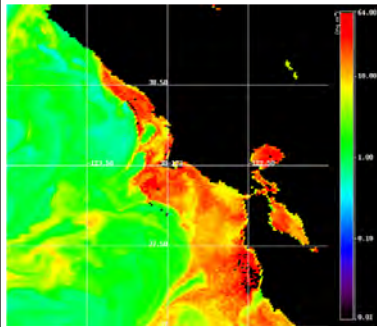


Average chlorophyll concentration from SeaWiFS (courtesy Andrea Vander Woude)



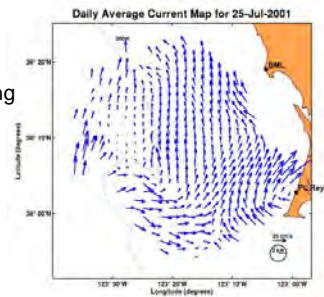
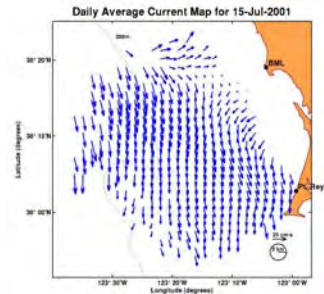
Phytoplankton & Relaxation

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



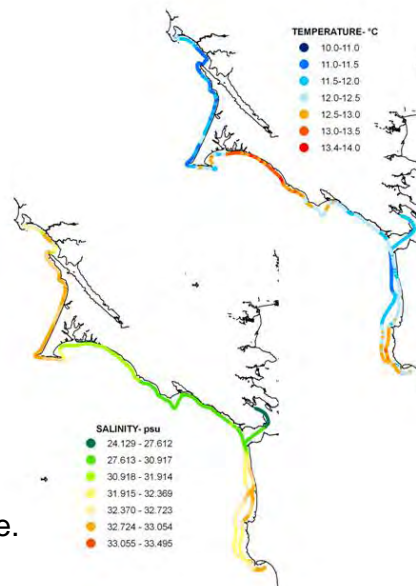
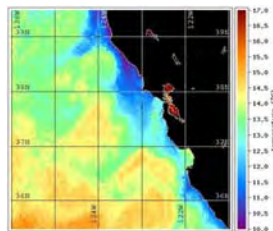
HF radar maps of surface current during upwelling and relaxation.

SeaWiFS image of chlorophyll concentration.



San Francisco Bay Outflow

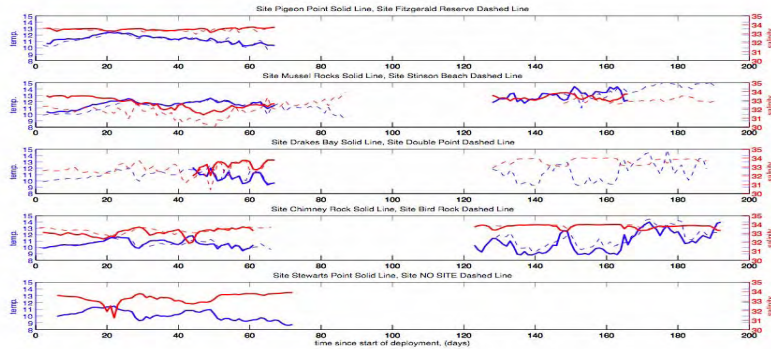
- Moves south during upwelling - minimal contact with shore.
- Found attached to shore up to Bolinas (frontal feature) & low-salinity surface water up to Pt Reyes.
- Moves north during weak or southerly winds & after strong freshwater flow - contact with shore. Not washed out of Drakes Bay during upwelling.





San Francisco Bay Outflow

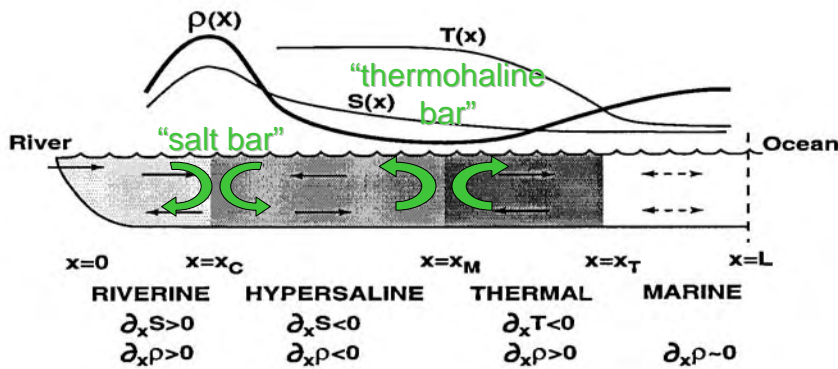
- Moves south during upwelling - minimal contact with shore.
- Moves north during weak/south winds & after strong freshwater flow - maximum contact with shore & min dilution ... positive and negative impacts.



Estuaries



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

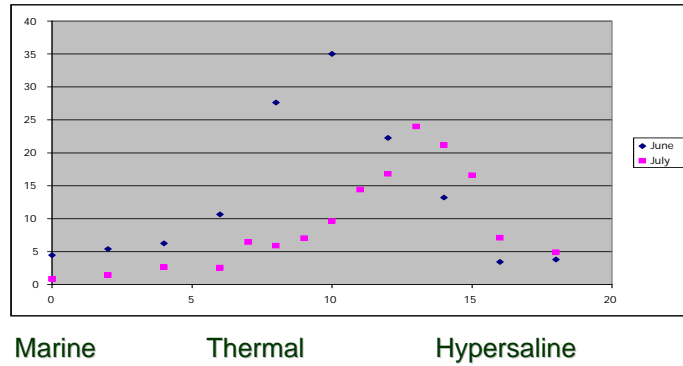




Estuaries



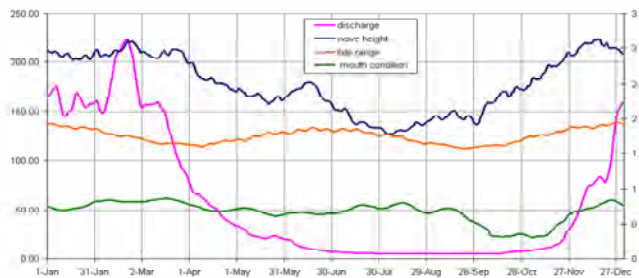
- **Low-inflow estuaries**, like Tomales Bay and Bodega Harbor.
- Nutrient supply from ocean - spatial pattern of phytoplankton.



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).

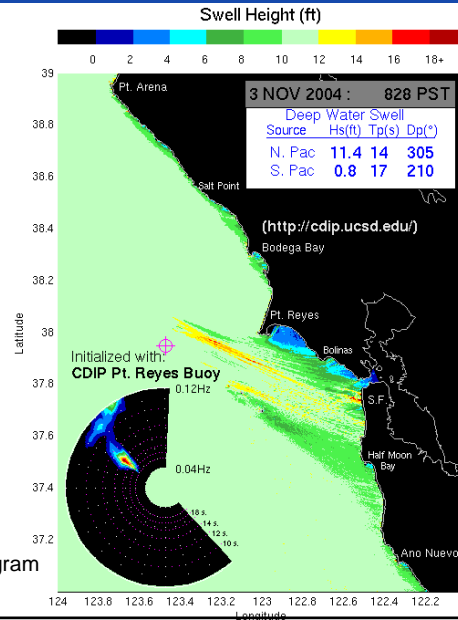




Wave Exposure

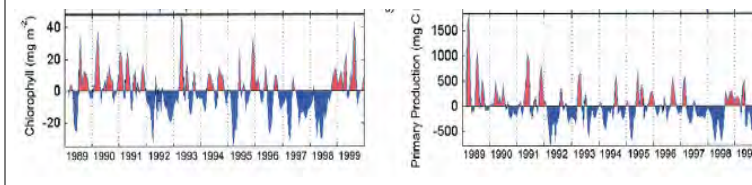
- Deep-sea “swell” refract and diffract.
- Also, “sea” from local winds.
- Alongshore transport - zone of impact associated with land runoff.

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



Temporal Variability

MBARI/Chavez data, 1989-99

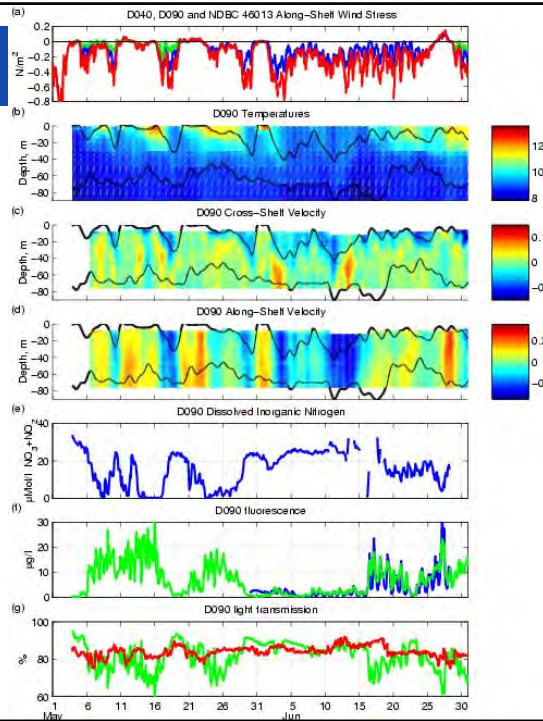


- Have described spatial patterns.
- Recognize temporal variability - diurnal, synoptic, seasonal, interannual, trend.
- **Short-term variability** characterizes the suitability of habitat - need high-resolution monitoring.
- **Long-term variability** characterizes fluctuations in a population - need 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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