Modeling and Observational Studies of the Juan de Fuca Eddy

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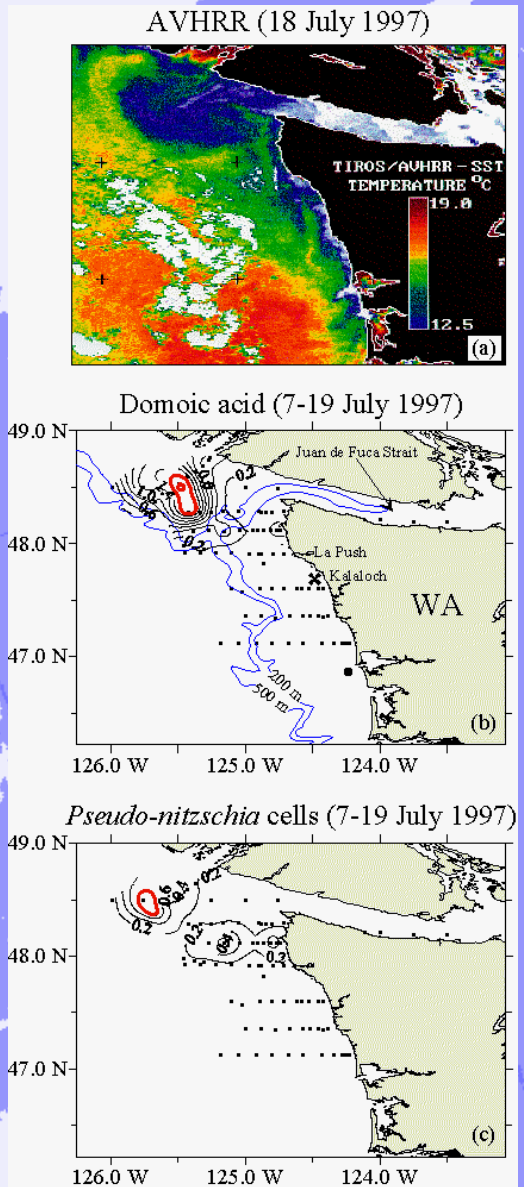
Project Background & Objectives



- **Juan de Fuca Eddy is a summer upwelling feature off the entrance of Juan de Fuca Strait**
  - **may be the initiation site for toxic *Pseudo-nitzschia* that cause harmful algal blooms impacting clams & crabs along the Washington coast**
  - **Tully (1942), Freeland & Denman (1982), Denman & Freeland (1985), Weaver & Hsieh (1987), Freeland & McIntosh (1989)**
  - **Freeland & Denman (1982) showed eddy was comprised of upwelled California Undercurrent water**
    - **Speculated on eddy force balance but not generation mechanism**

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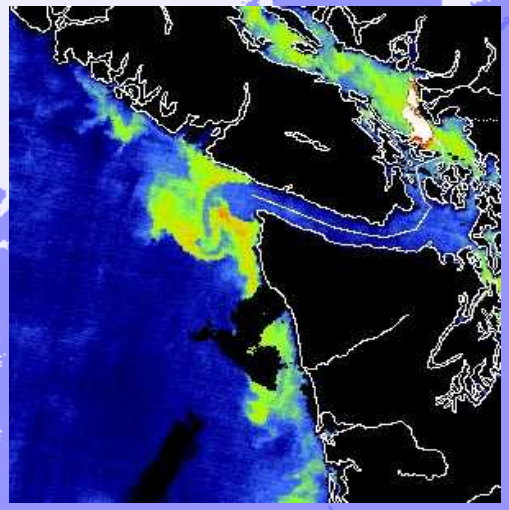
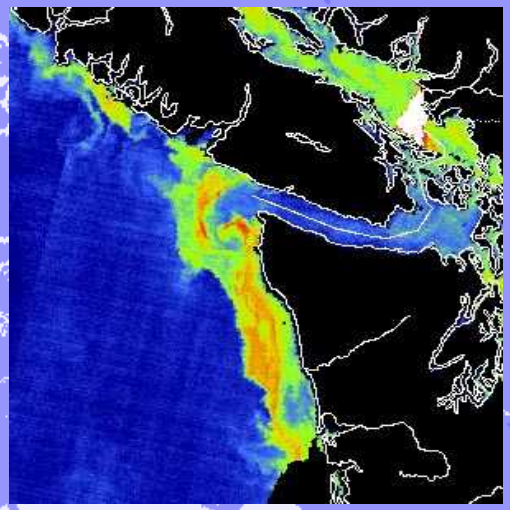


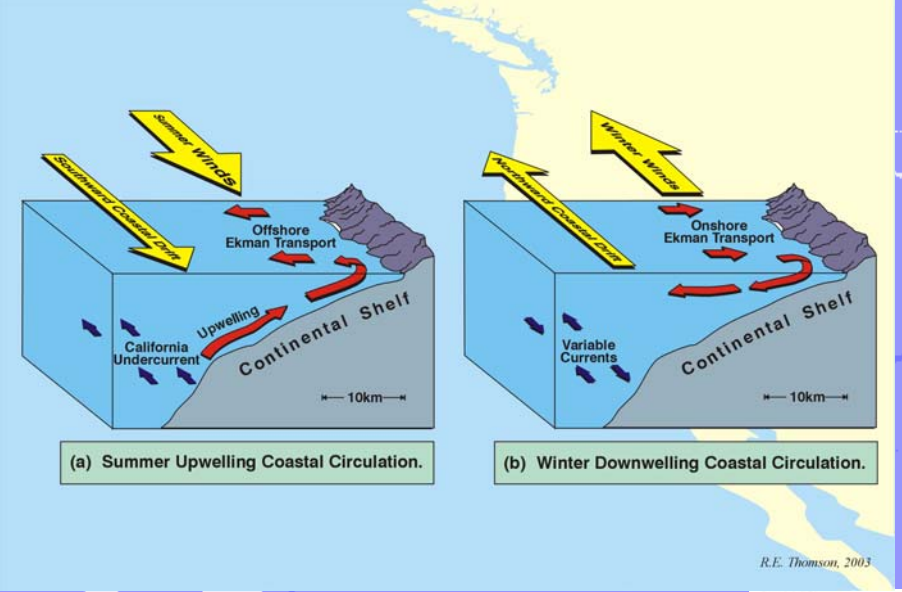


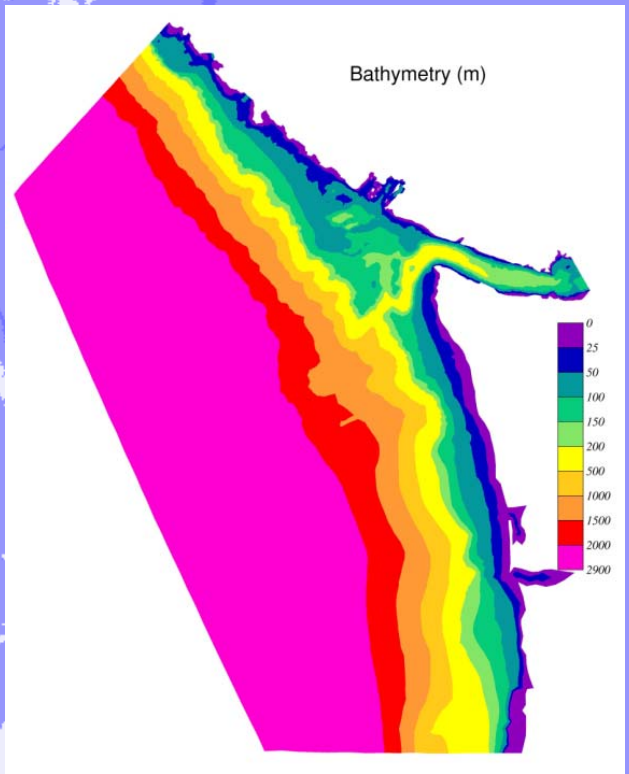
- **ECOHAB PNW:**
  - multi-disciplinary project to study ecology & oceanography of these HABs
  - Five cruises since June 2003
  - Biological & chemical studies
  - Physical & biological modeling

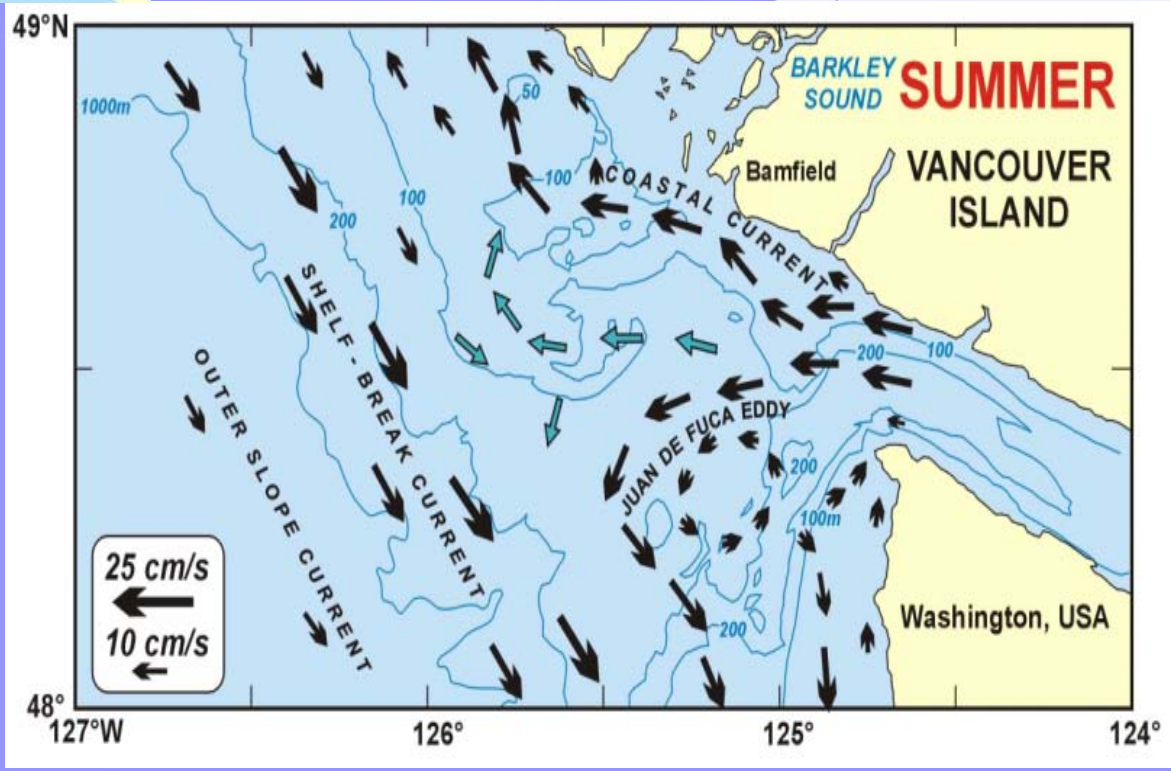
- **Today's focus:**
  - Physical observations
  - Model process studies on the eddy generation

MERIS satellite images courtesy of Jim Gower & Steph King

Regional Summer Circulation Features



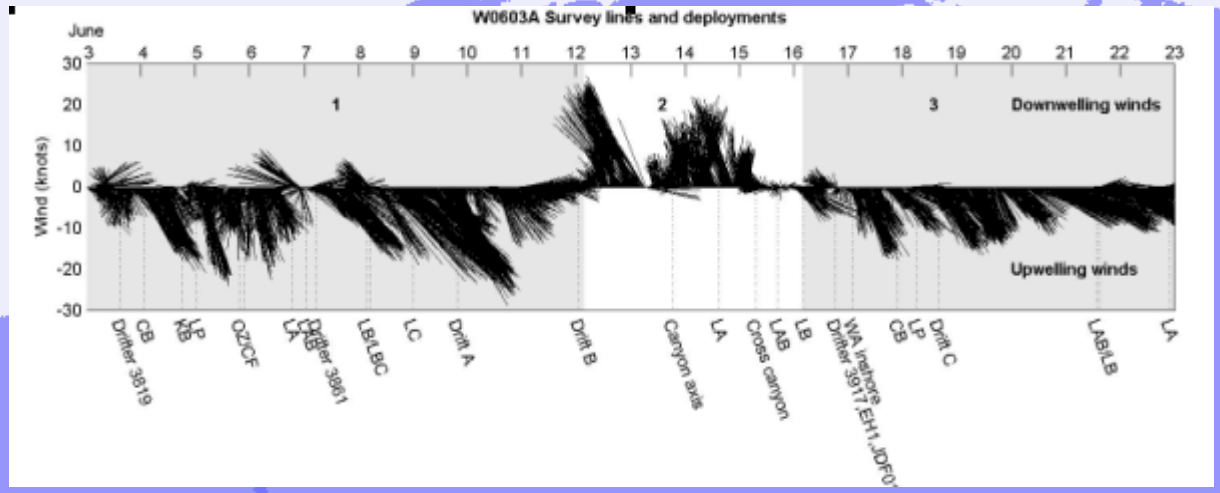




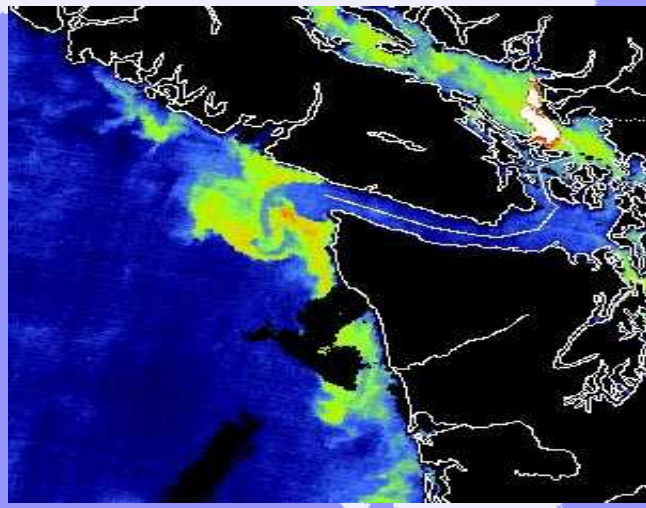
Schematics courtesy of Rick Thomson

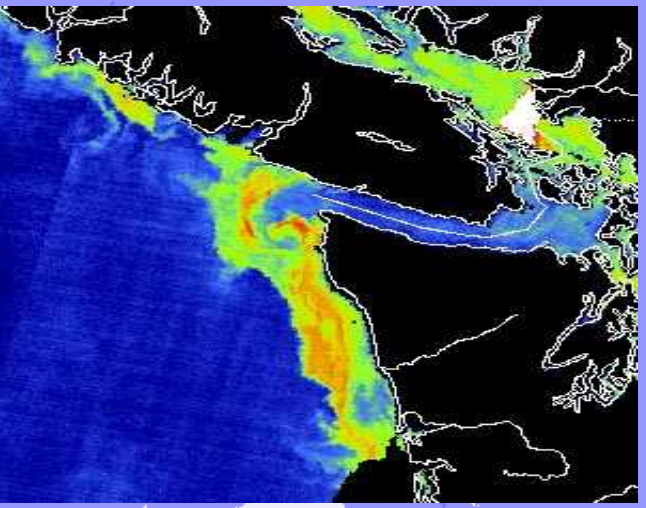
June 2003 Fluorescence (chlorophyll) from MERIS

ship winds

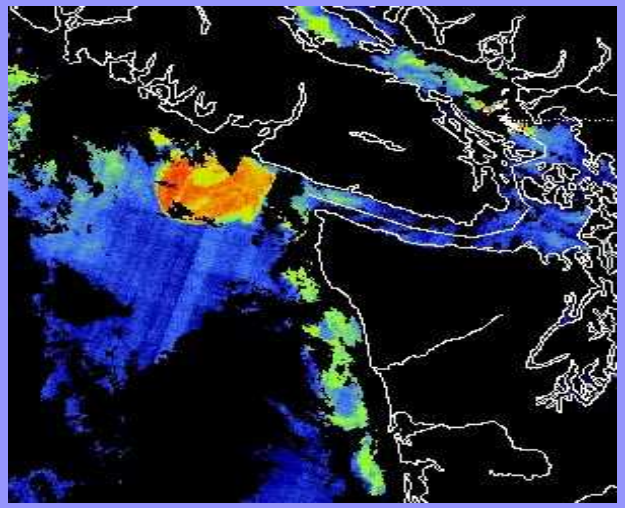


June 3

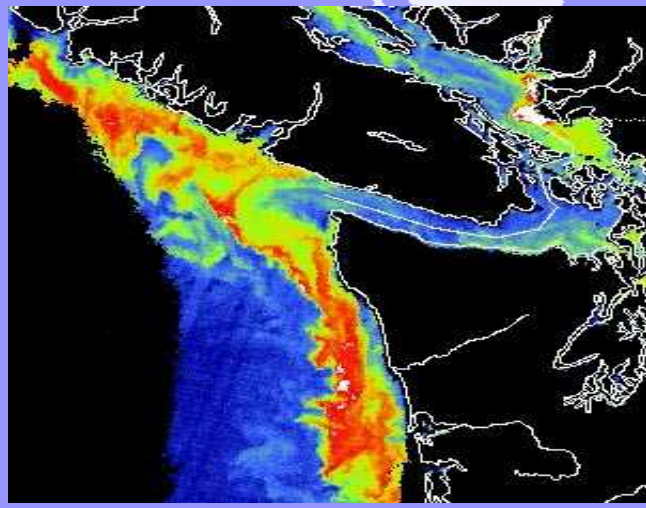




June 6



June 15

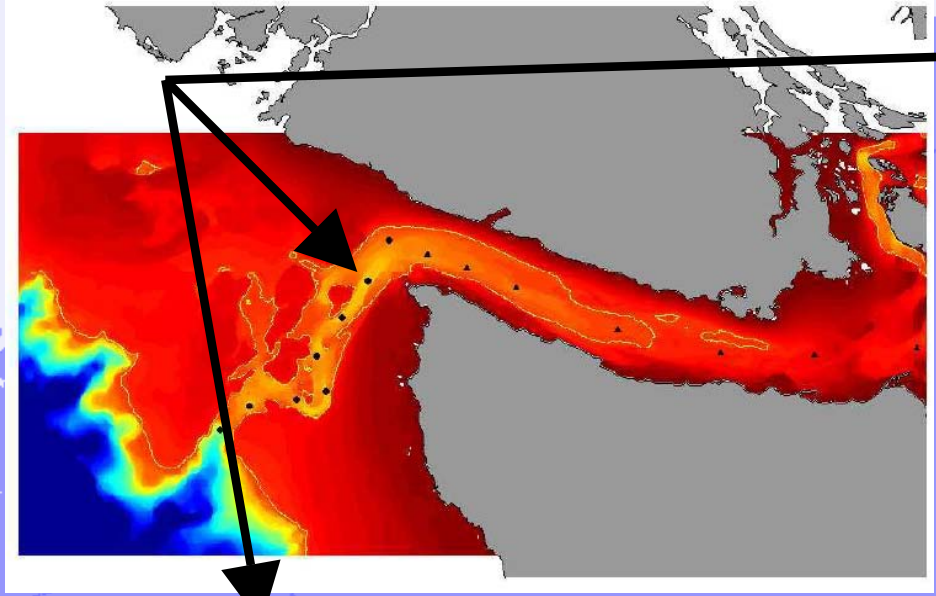


June 28

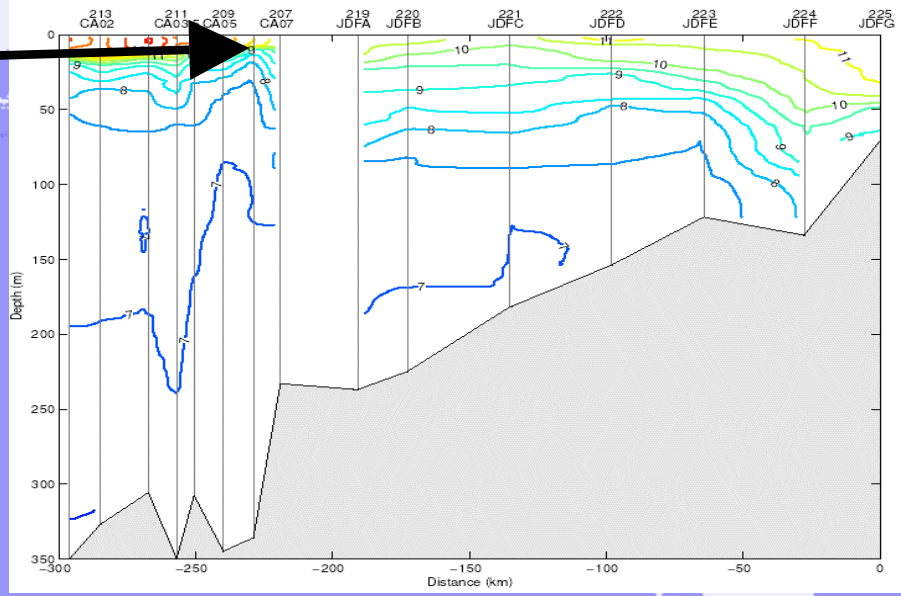
Satellite images courtesy of Jim Gower & Steph King

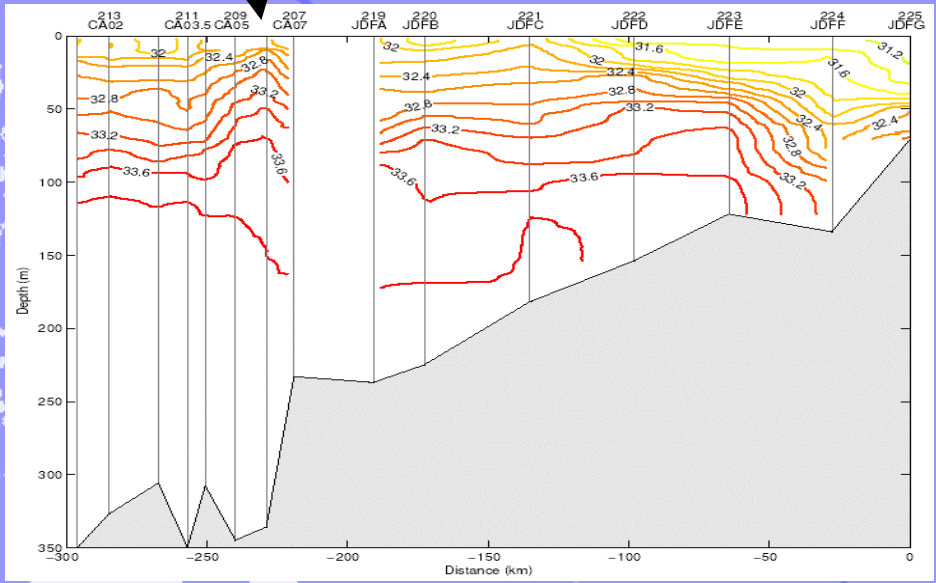
September 2003 Along-Canyon Survey

stations

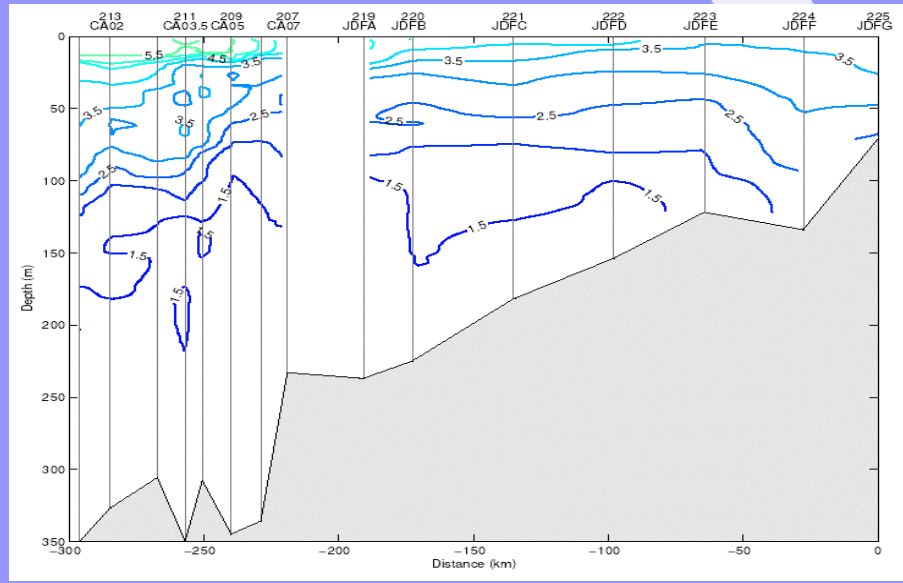


temperature



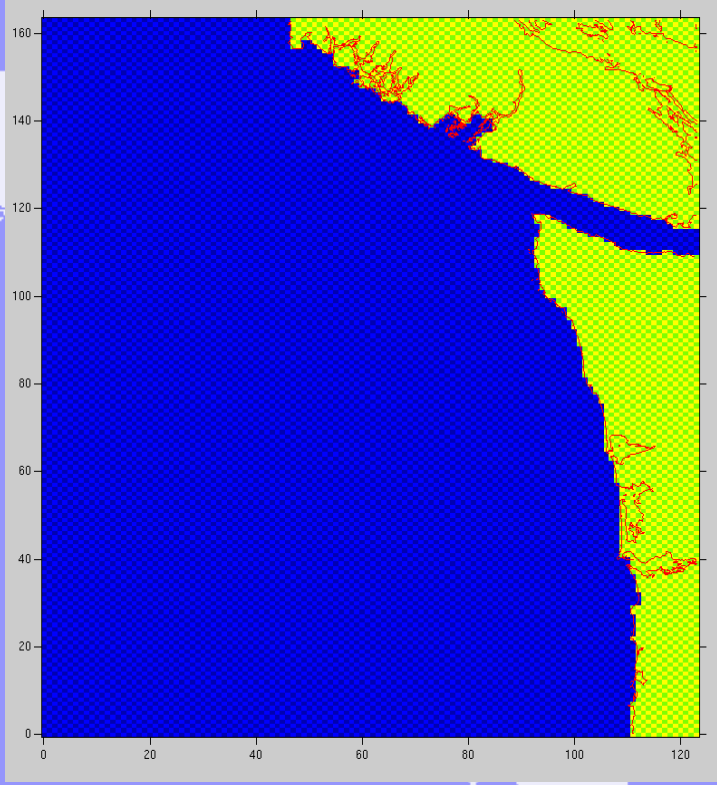


salinity

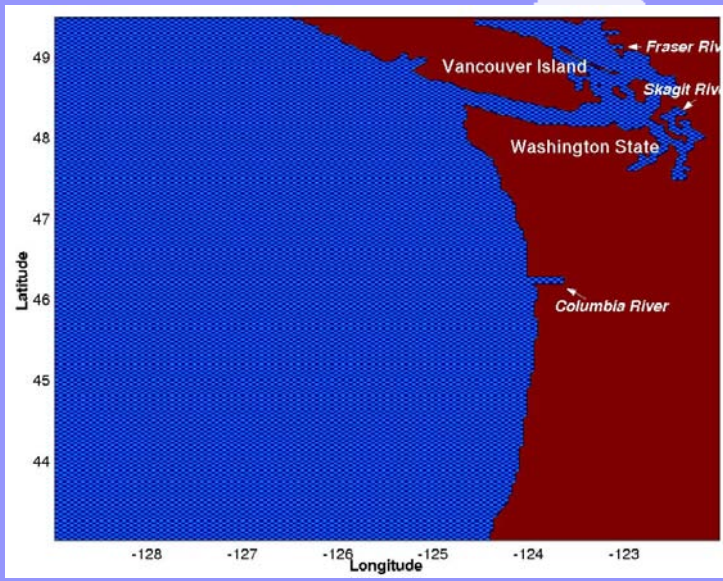


oxygen

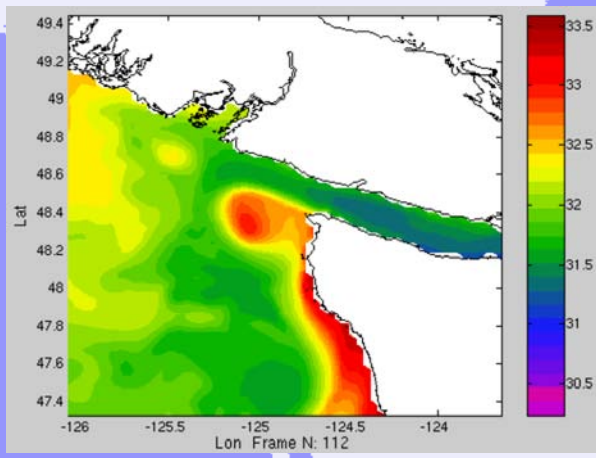
Regional Ocean Modeling System (ROMS)



- Two grids:
  - 1. only to eastern JdF
  - 2. first grid + Puget, southern Georgia, Fraser & Skagit River discharges
- 3km resolution
- 30 S-surfaces in vertical
- 3rd order upwind advection
- Marchesiello et al. (2001) radiation/nudging boundary conditions
- KPP mixing
- MPI & OpenMP versions

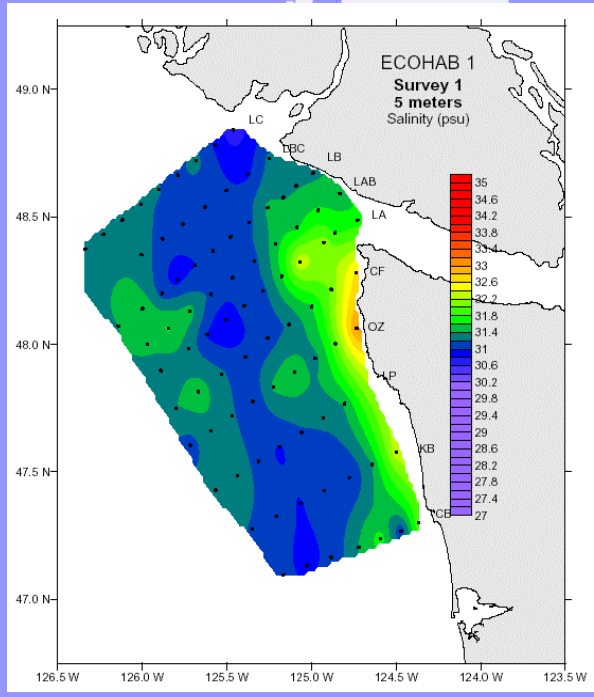


Eddy Generation Process Studies



☆ **Average summer circulation**

- 1st grid
- No tides
- Average summer winds
- Initial TS from climatology
- Estuarine flow thru boundary conditions in Juan de Fuca
- Run for 30 days



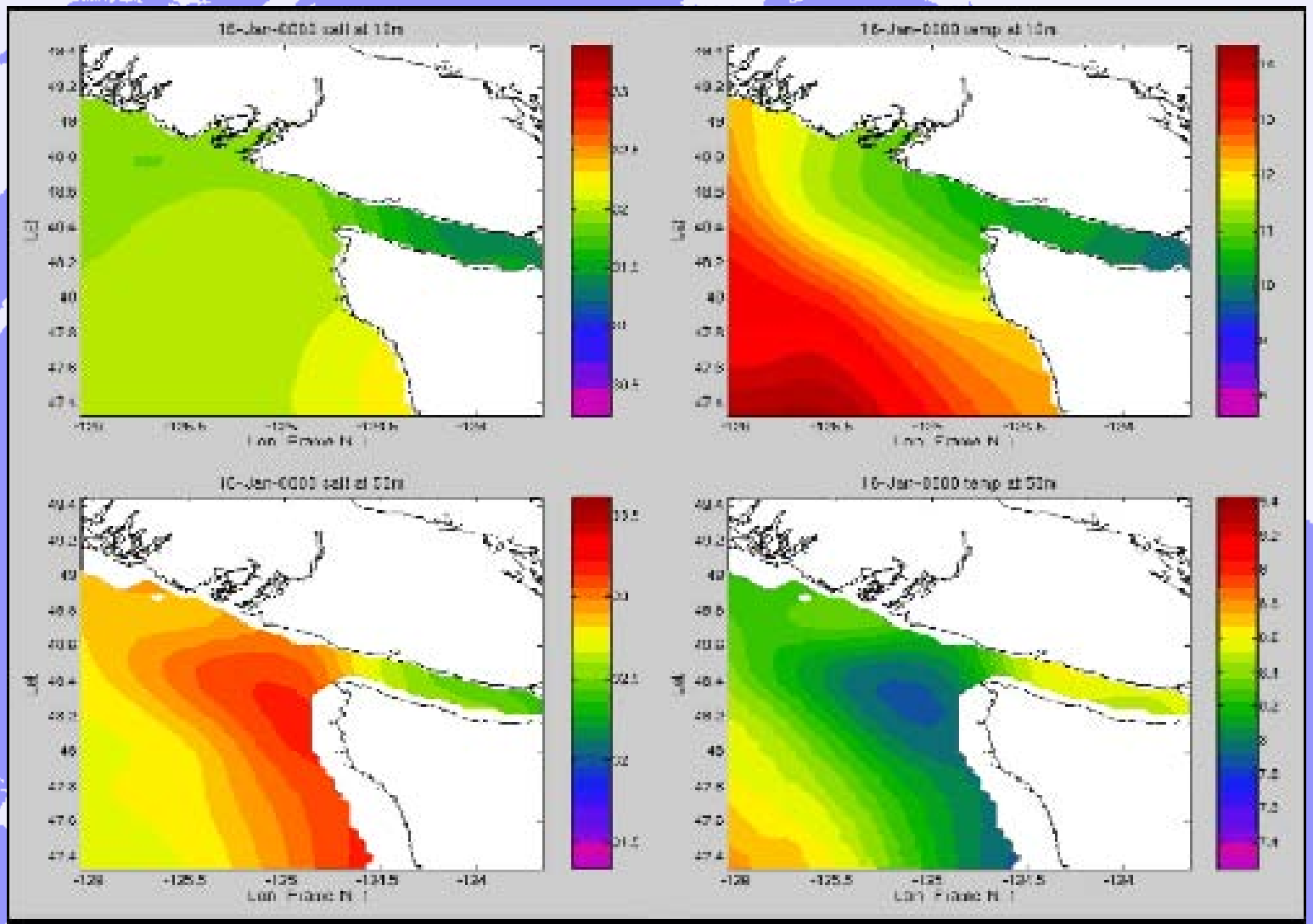
☆ Steady Summer Wind & Estuarine Flow

30 days, 6 hour frames

salinity

initial TS from climatology

temperature

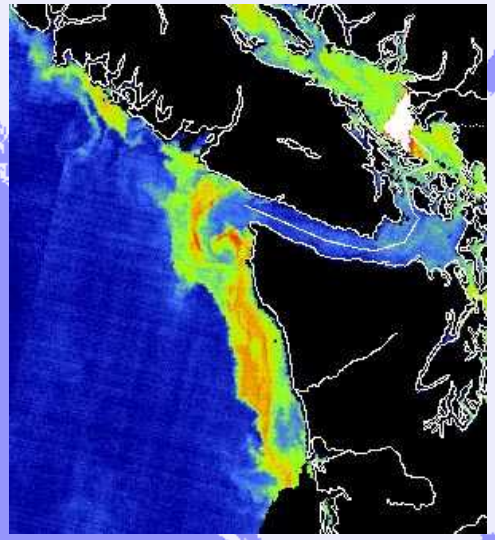


10m

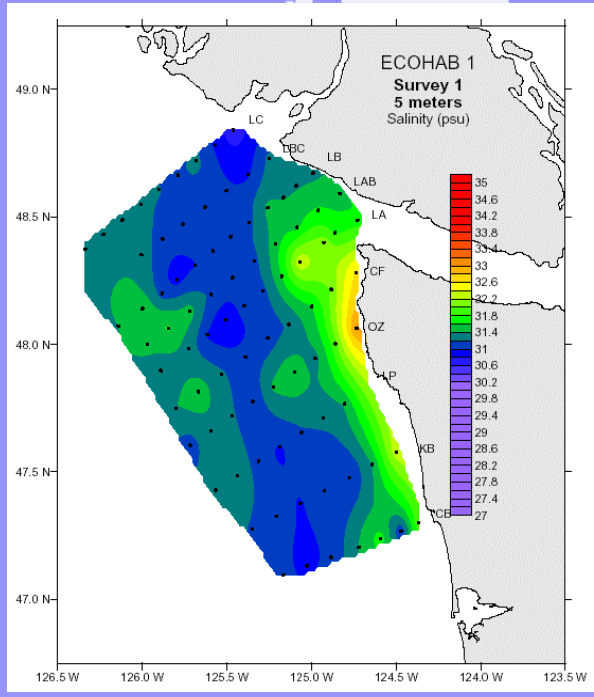
50m

jdf2_4panel-from-avis

Eddy Generation Process Studies

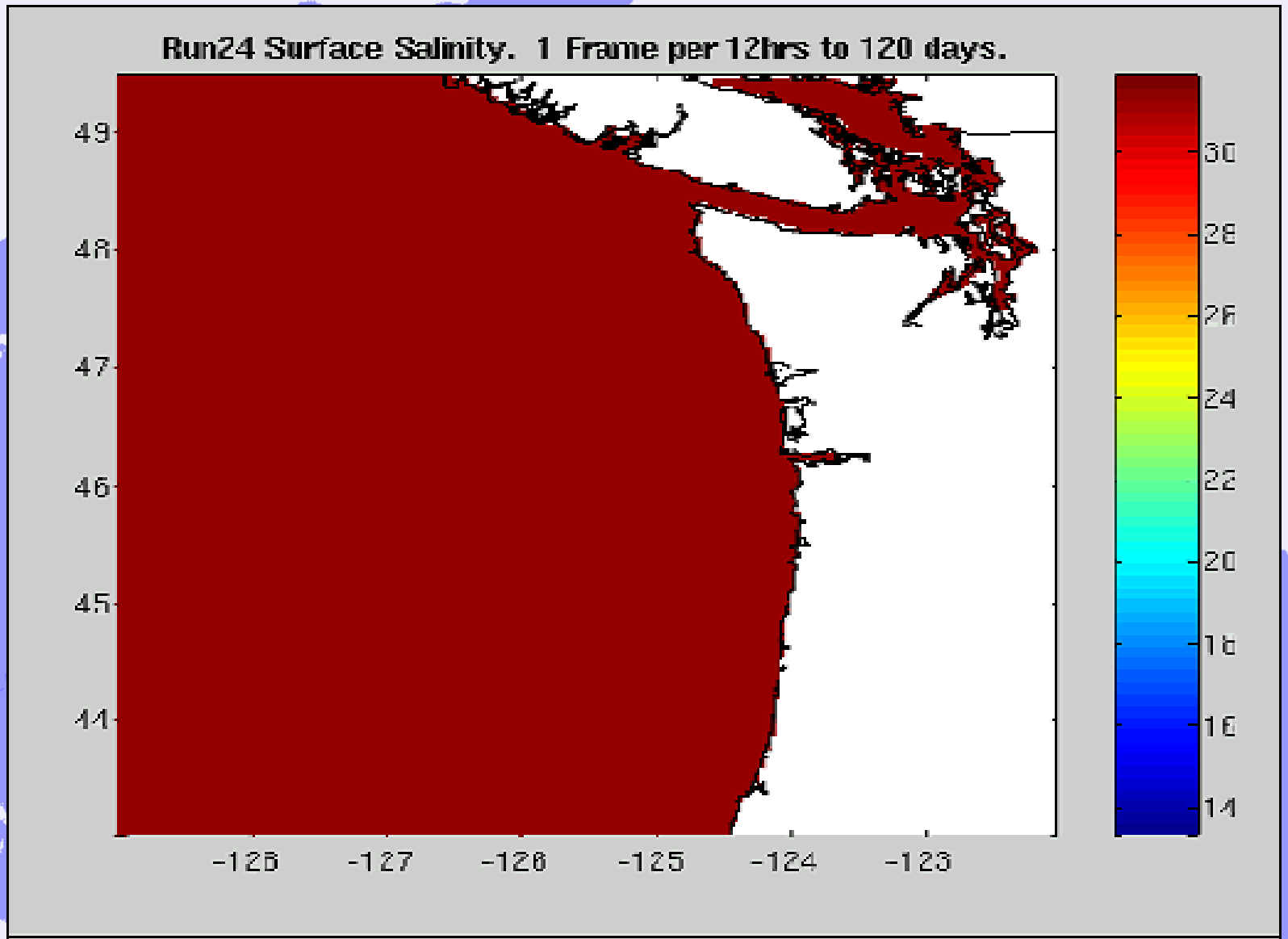


- ☆ **Average summer circulation conclusion**
  - Eddy generated from enhanced upwelling off Cape Flattery (?)
  - But we may have prejudiced results by starting with climatology
- **River discharges**
  - 2nd grid, no tides or wind
  - Fraser & Skagit discharges
  - Initial TS = same profiles everywhere
  - Run for 120 days
- **River discharges & tides**
  - 2nd grid, no wind
  - Fraser & Skagit discharges
  - Initial TS = same profiles everywhere
  - M_2, S_2, K_1, O_1 tidal forcing on all boundaries
  - Run for 90 days



River Discharges

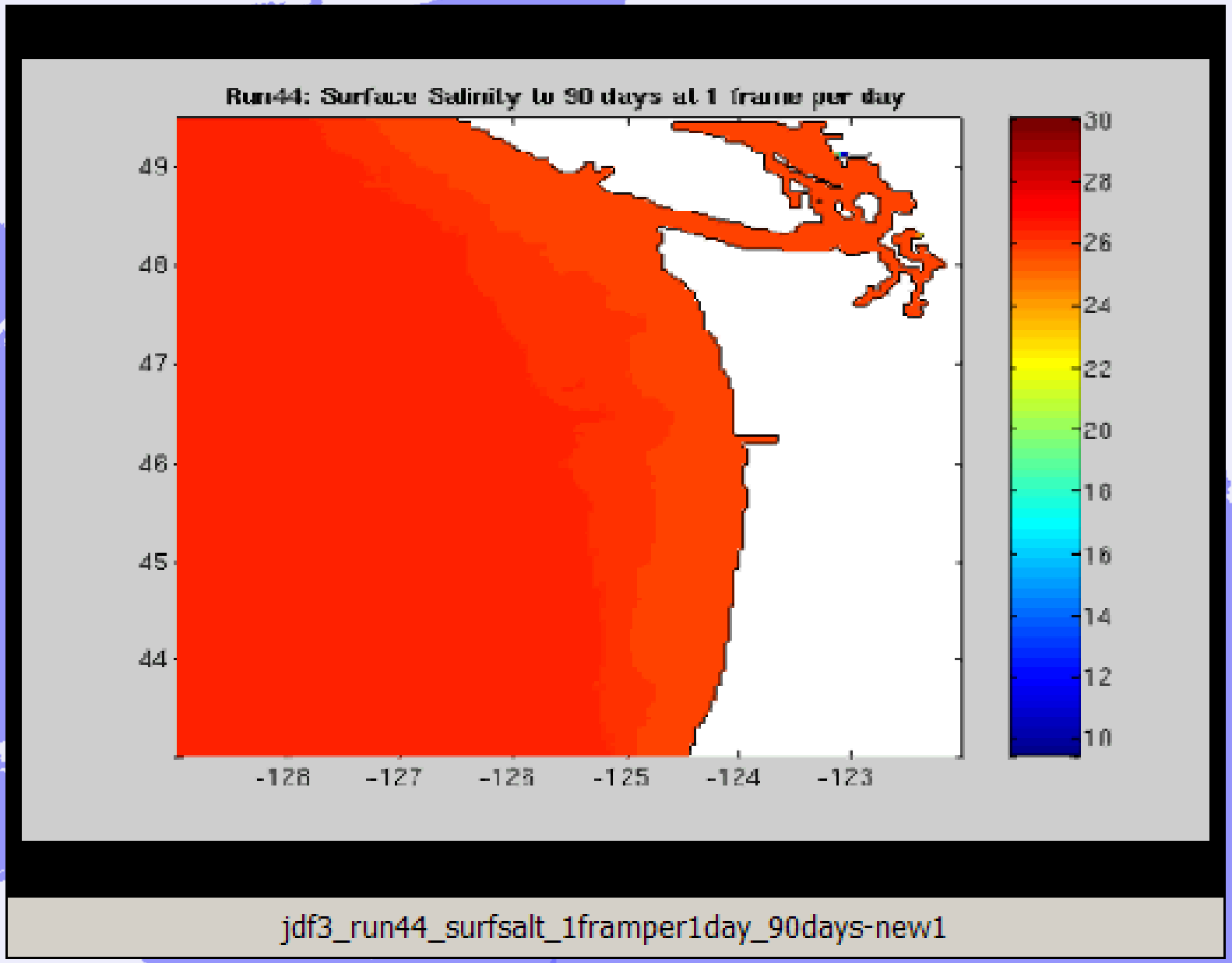
Initial conditions: same TS profiles everywhere



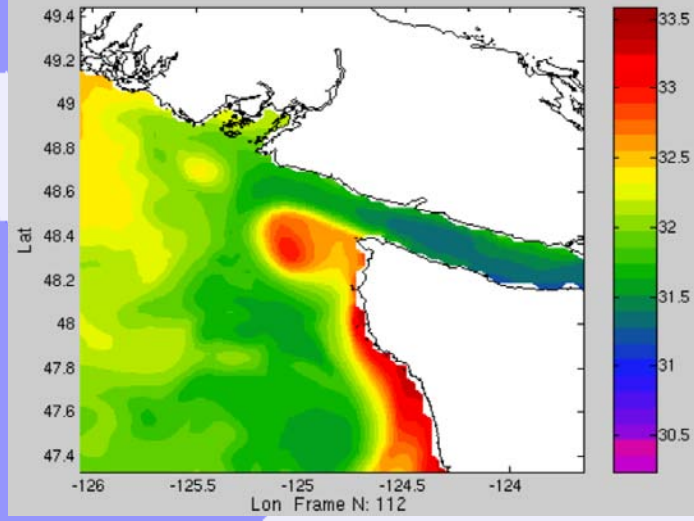
jdf3_run24_surfsalt_1frameper12hrs_120days-new2

River Discharge & Tides

Initial conditions: same TS profiles everywhere



River Discharge Summary



- River discharge sets up estuarine flow & coastal current
  - But too shallow → needs mixing
- Including tides (with 3km resolution)
  - too much mixing in Gulf & San Juan Islands
  - Prevents estuarine flow in Juan de Fuca Strait
  - But intriguing upwelling in JdF
- More analyses & simulations required
  - Finer resolution through islands
  - Different mixing ?

Conclusions

- **Observations:**
  - satellite images show that eddy collapses (surface only?) with northward winds
  - along-canyon CTD survey shows max upwelling underneath eddy
- **ROMS process studies:**
  - winds & JdF estuarine flow sufficient for eddy formation if start with climatology
  - Work still needed to generate eddy from winds & river discharge into initial TS profiles

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