

ELCIRC Applications to British Columbia Waters

Mike Foreman
Institute of Ocean Sciences

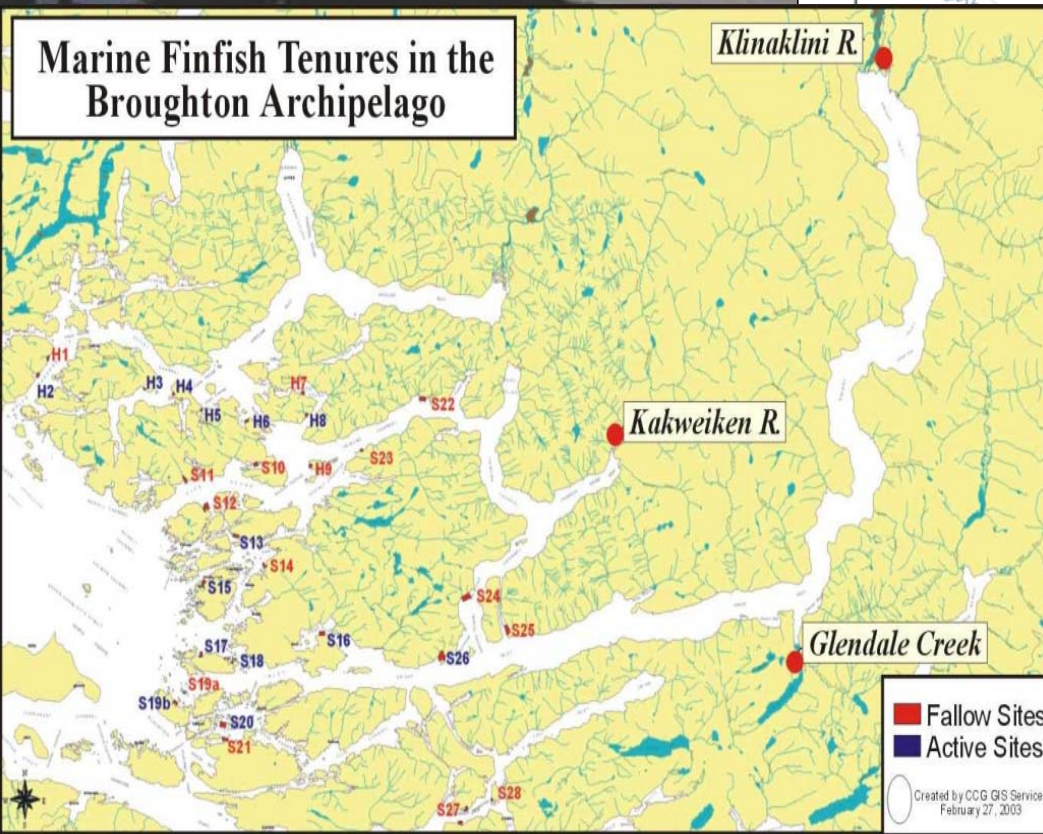
Outline:

- **Three ELCIRC applications:**
 - ④ **Fish farms in the Broughton Archipelago**
 - ④ **Harmful algal blooms & the Juan de Fuca Eddy**
 - ④ **Temperature swings in outflow from Quesnel Lake**
- **Background**
- **Preliminary results**
- **ELCIRC issues & future work**

1. Broughton Archipelago



Marine Finfish Tenures in the Broughton Archipelago



Objective:

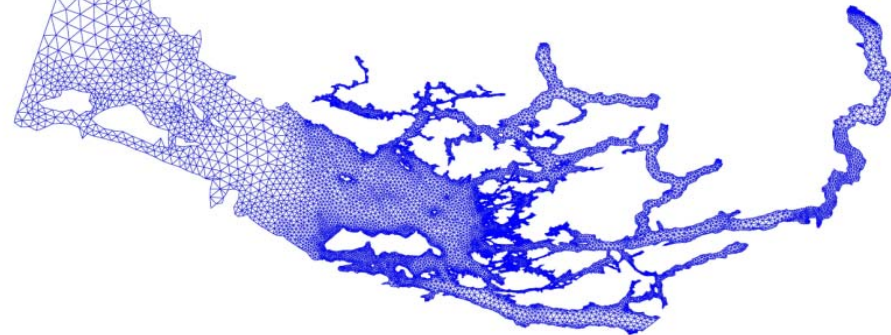
Simulate circulation and transport near salmon farms:

-issues of waste deposition, spreading of viruses, sea lice, etc...

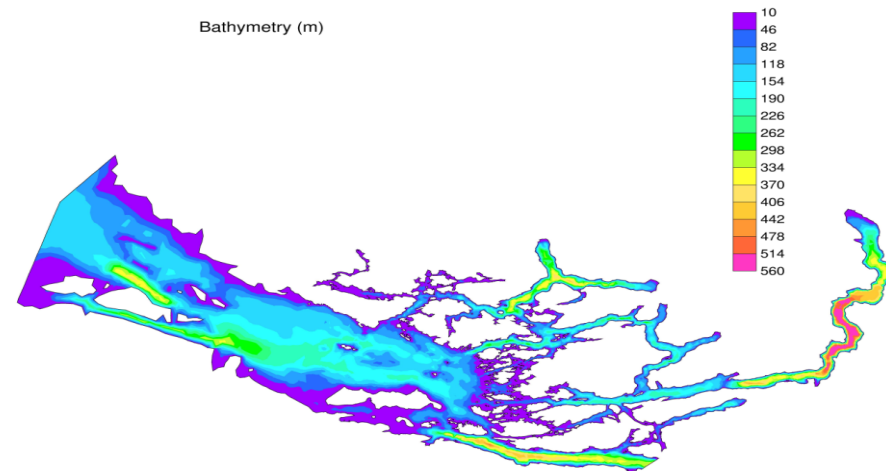
Model Grids & Forcing

- tides, buoyancy (river runoff, deep water intrusions, surface heating), and wind
- estuarine flow boundary conditions are tricky; need to nest within larger Vancouver Island grid
- initial TS from climatology (sparse for Broughton)

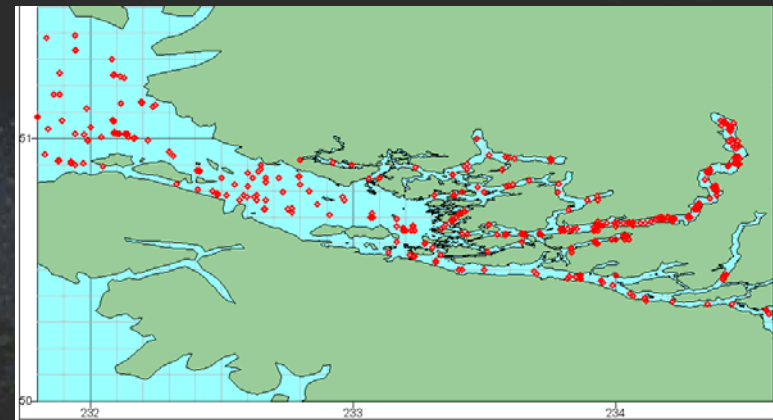
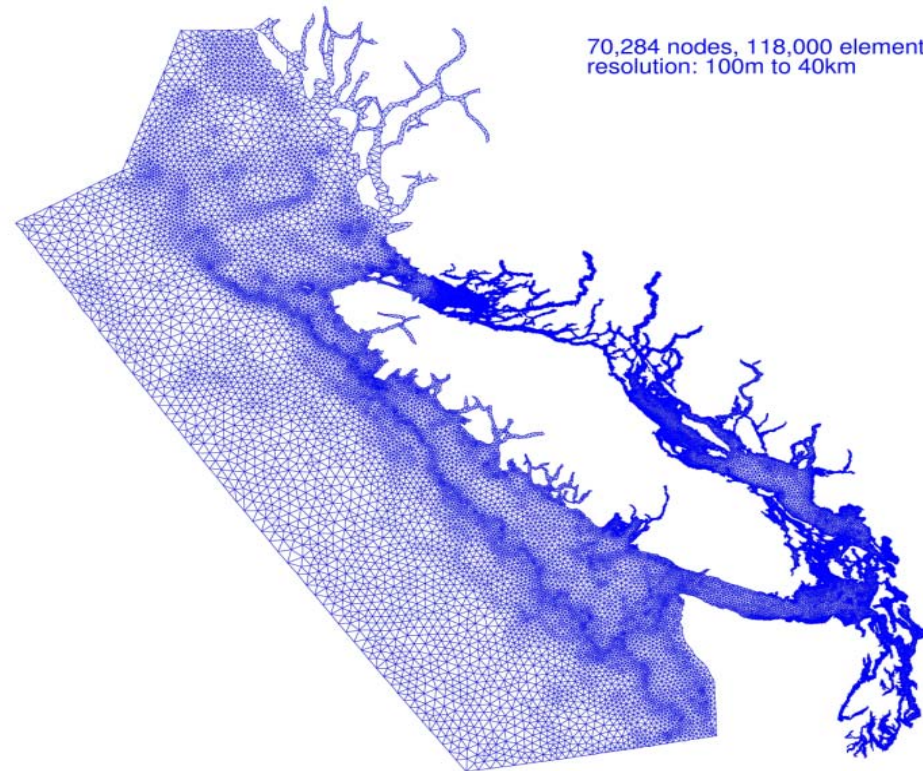
18174 nodes, 29961 triangles
resolution: 4.5km to 40m



Bathymetry (m)

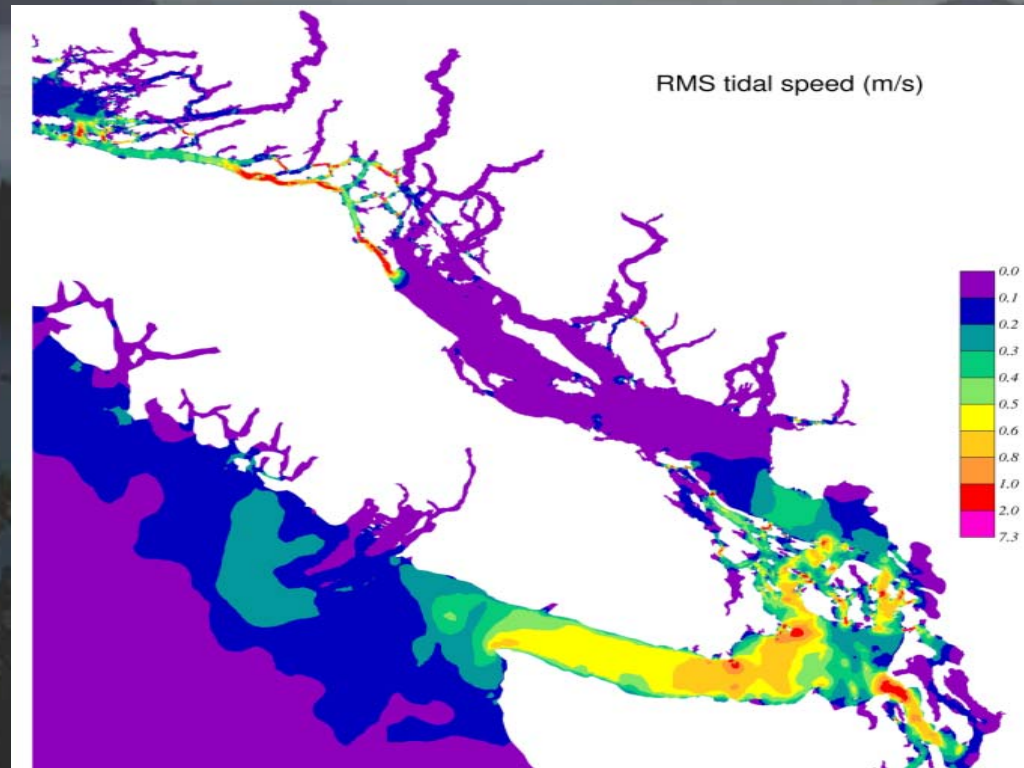
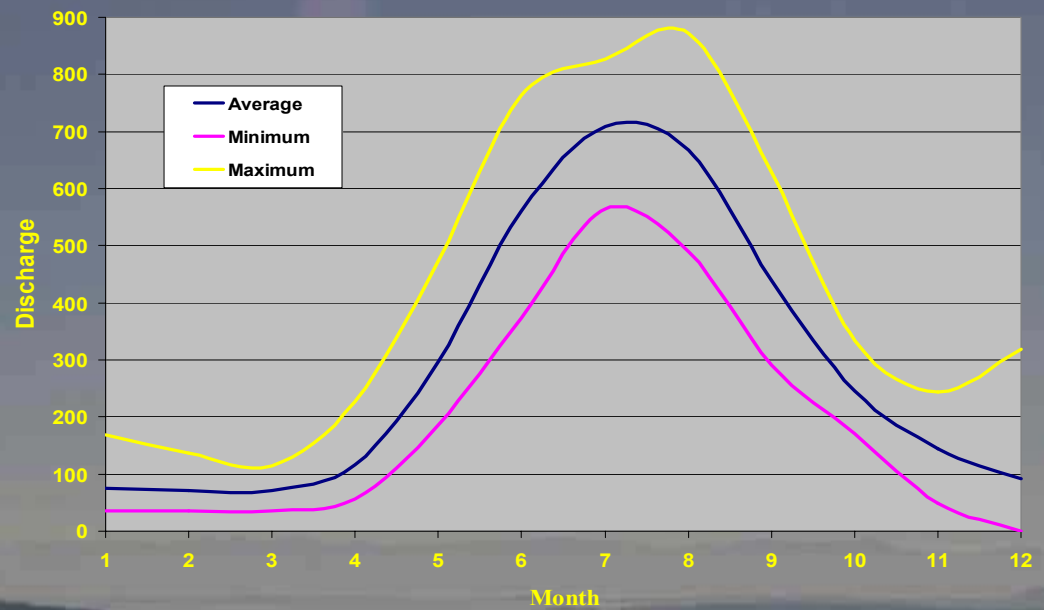


70,284 nodes, 118,000 elements
resolution: 100m to 40km

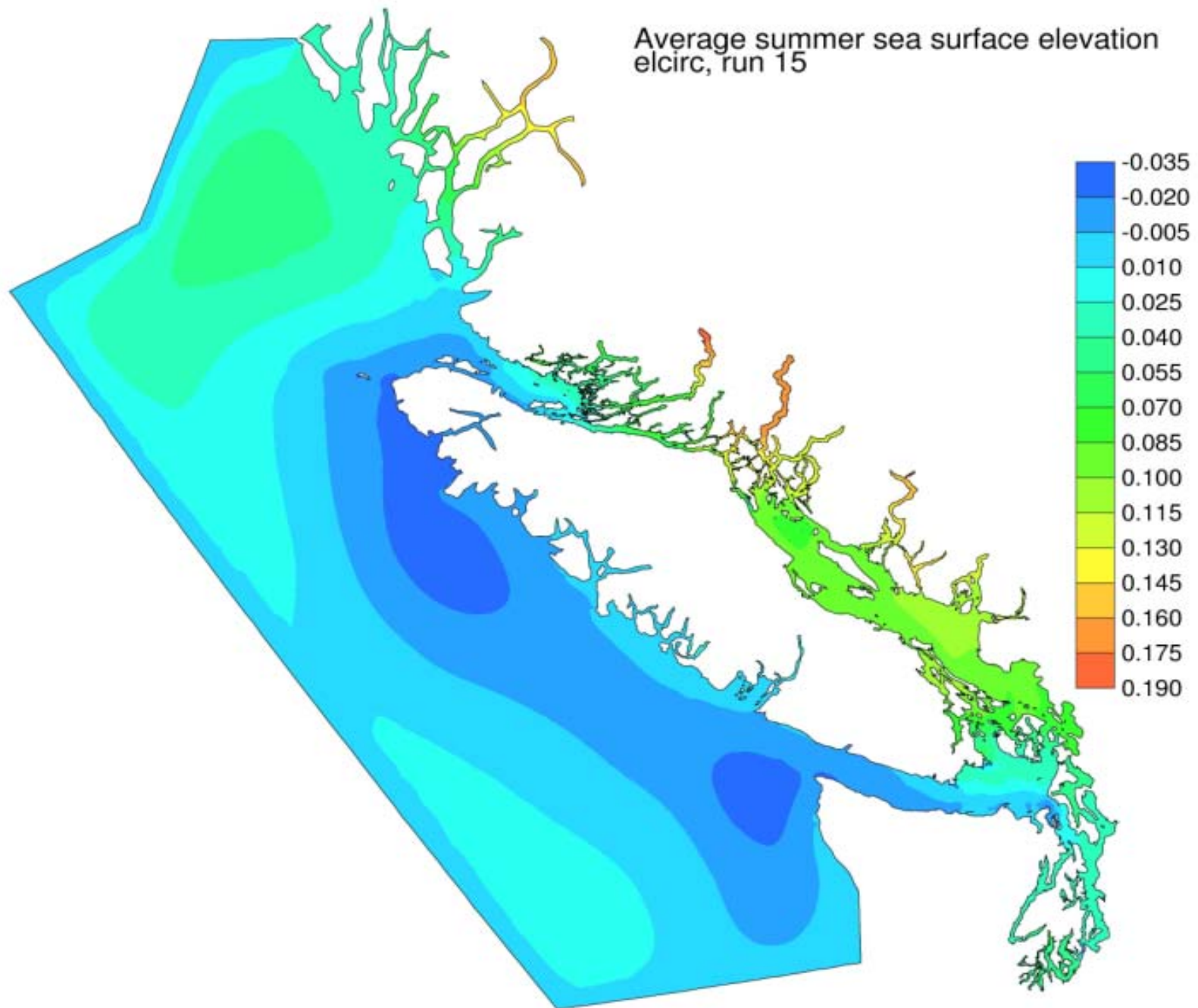


Run Details

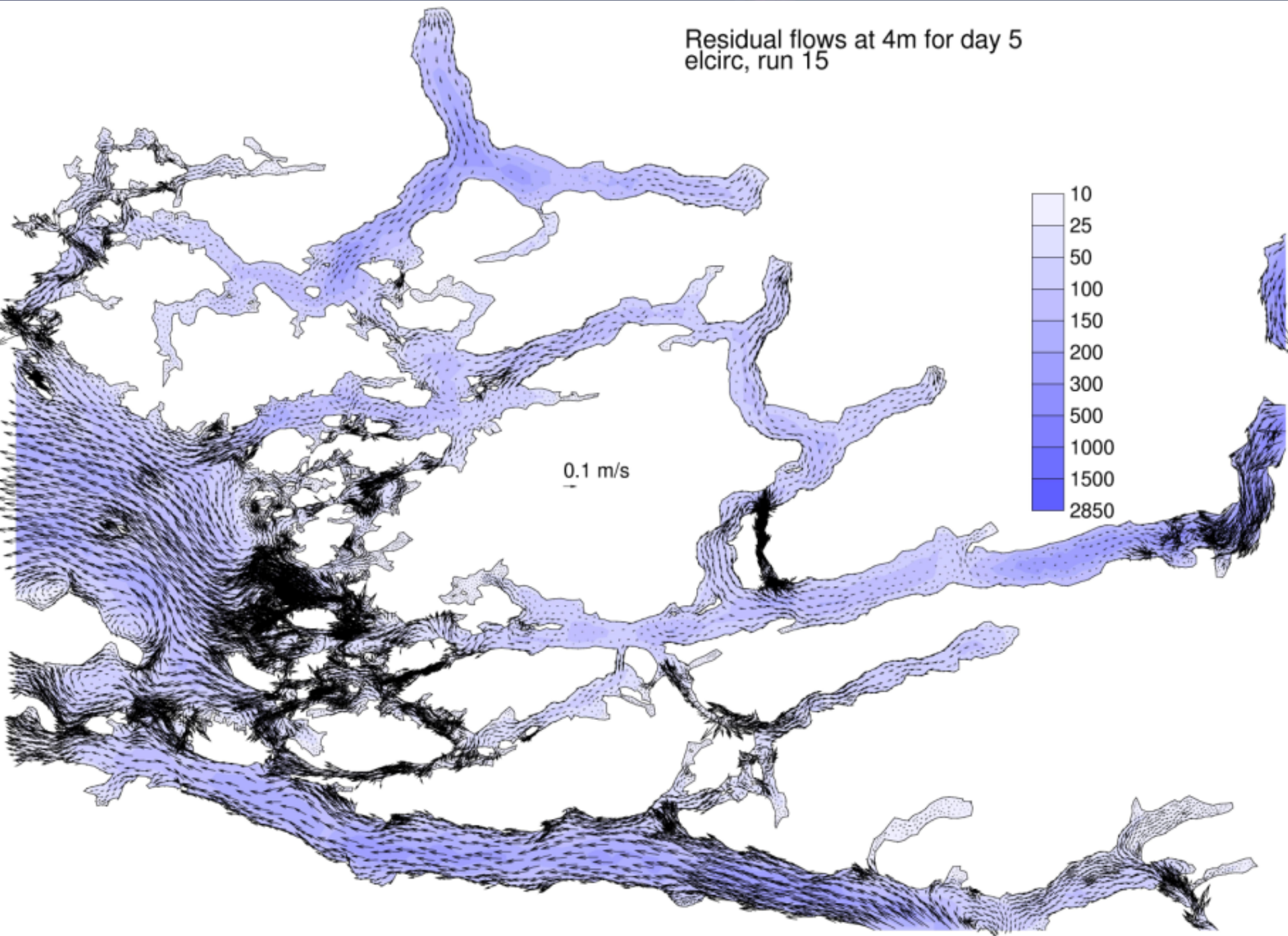
- For Broughton grid, only Klinaklini River gauged: 1977-present
 - ⌚ Other discharges estimated by relative size of watersheds
- For larger grid, need to include Fraser, Homathko, & lesser rivers
- $\Delta t = 5\text{min}$, 33 vertical levels
- KL/KC turbulence
- 2 or 4 tidal constituents



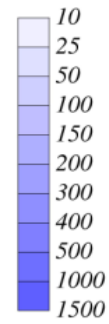
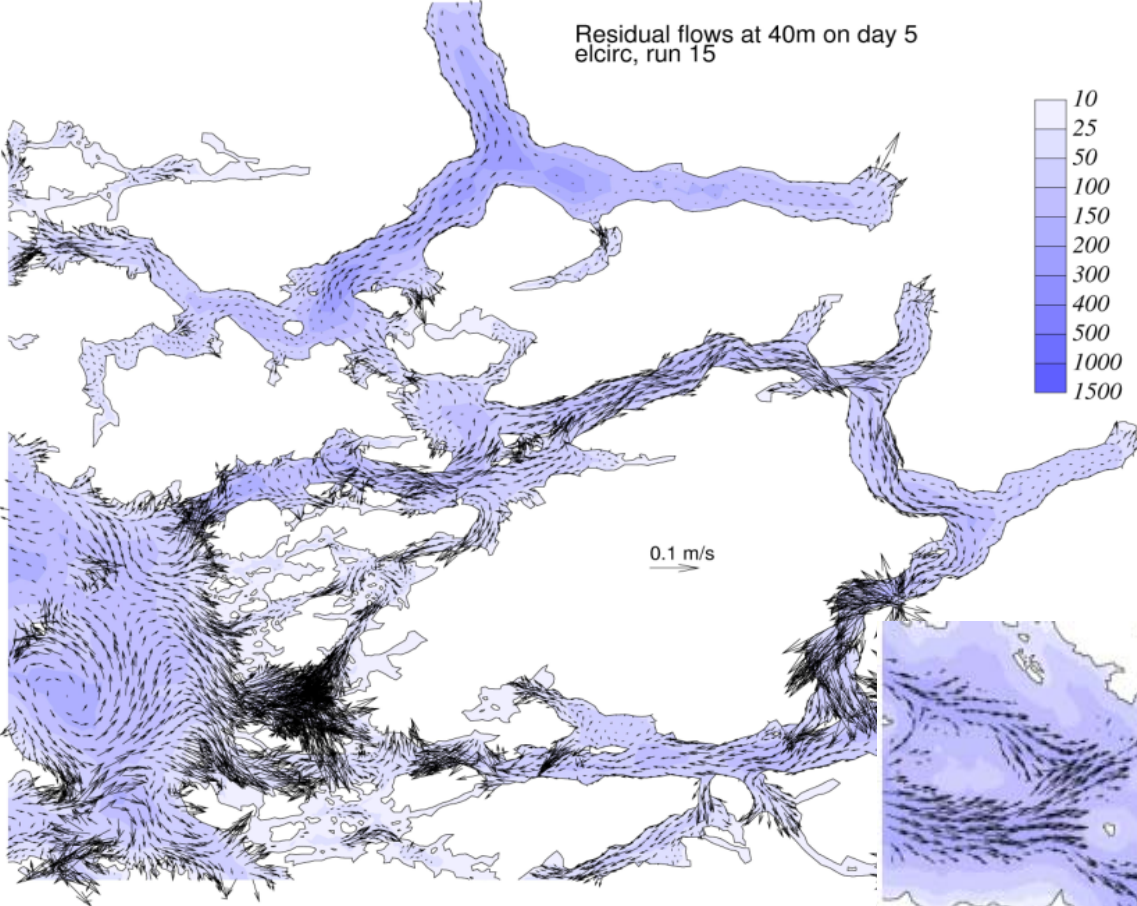
Average summer sea surface elevation
elcirc, run 15



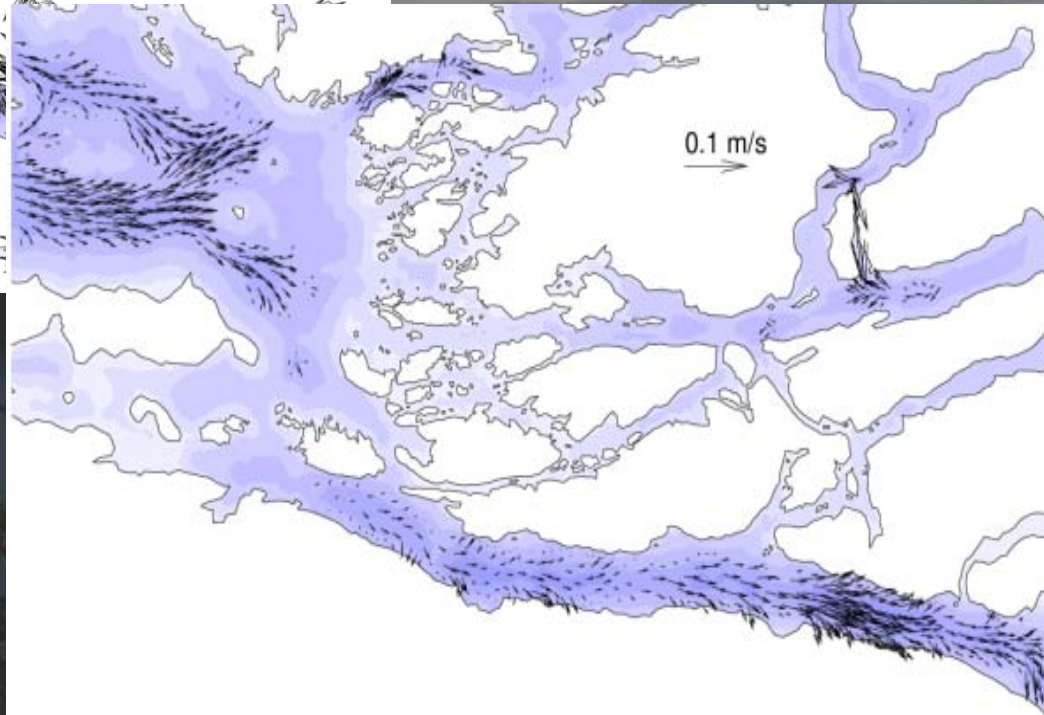
Residual flows at 4m for day 5
elcirc, run 15



Residual flows at 40m on day 5
elcirt, run 15

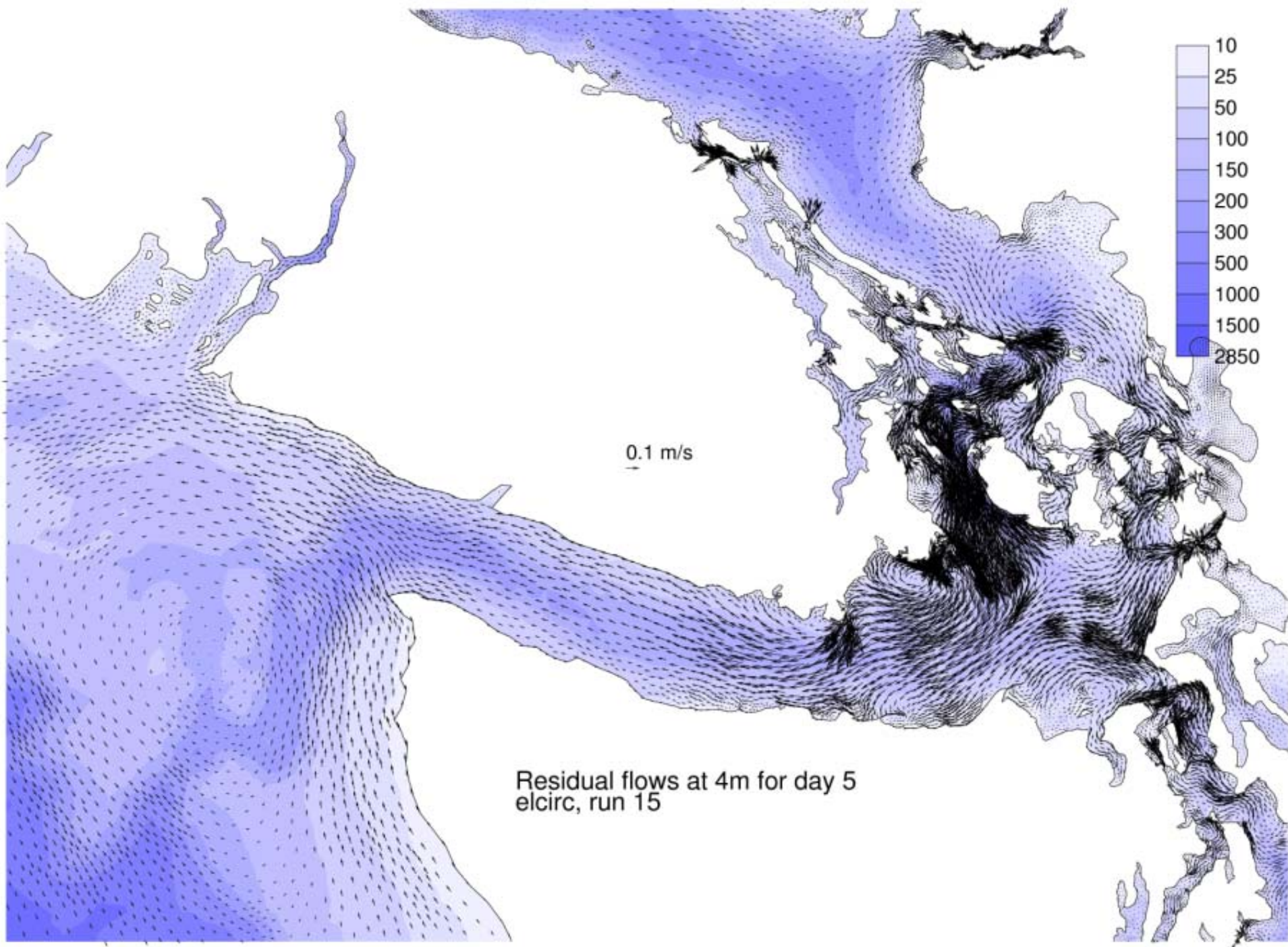


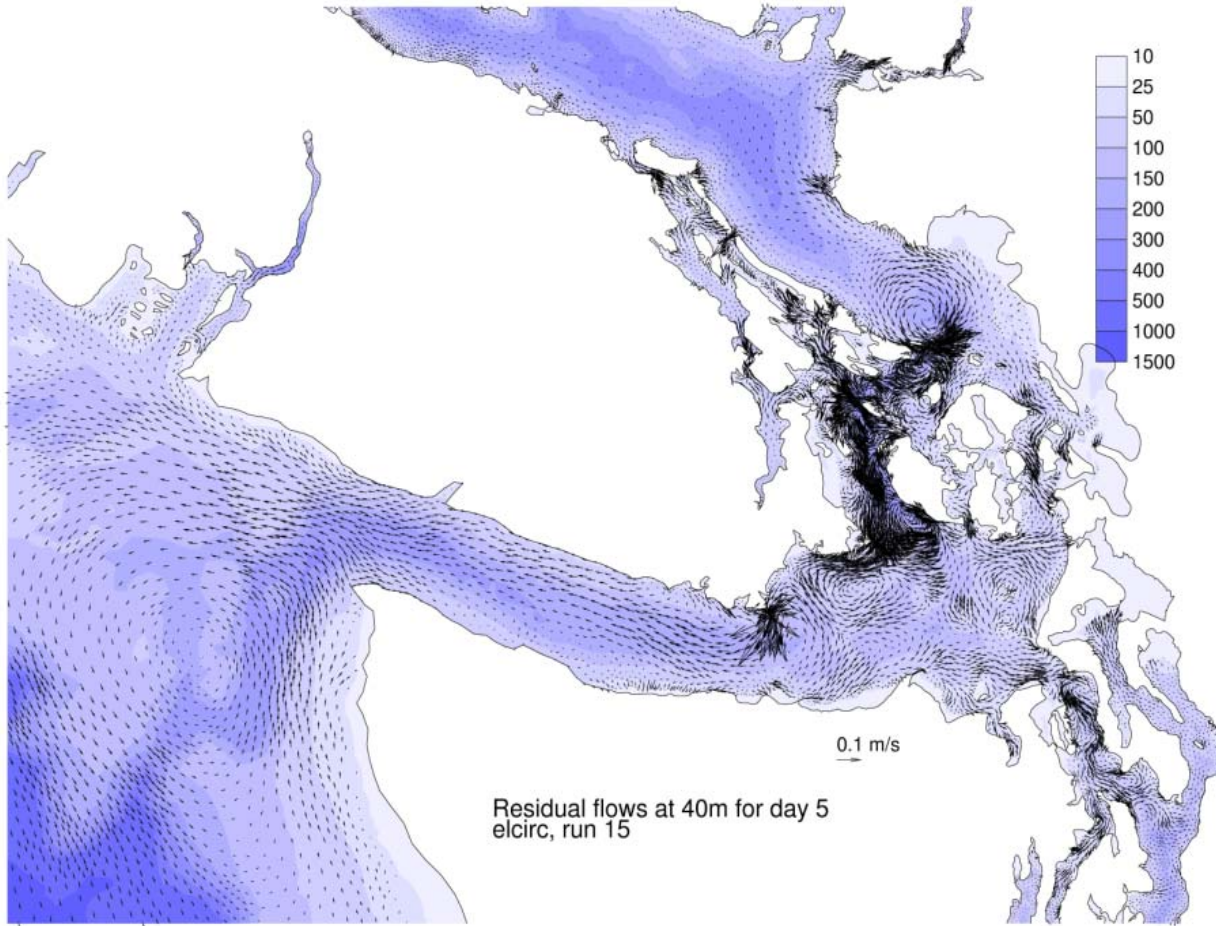
0.1 m/s



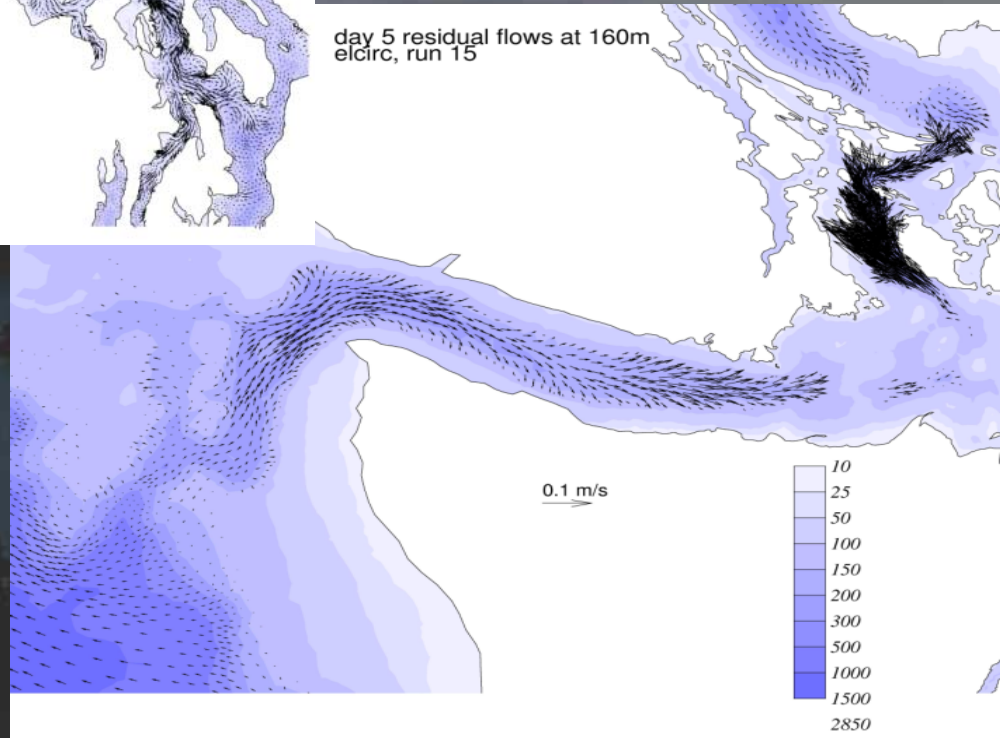
0.1 m/s

day 5 residual flows at 160m
elcirt, run 15



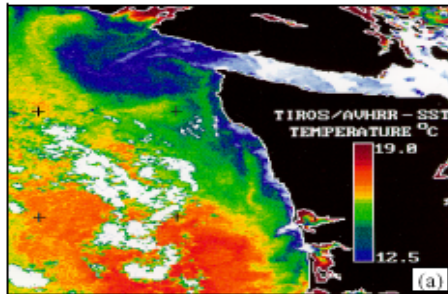


day 5 residual flows at 160m
elcirc, run 15

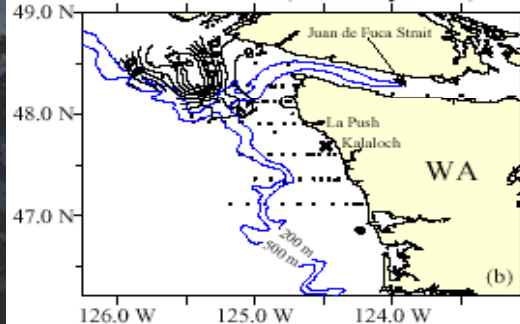


2. Harmful Algal Blooms off the Washington coast

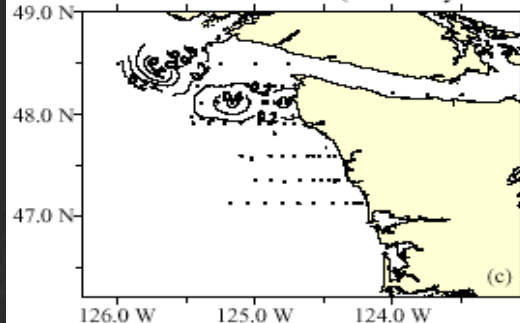
AVHRR (18 July 1997)



Domoic acid (7-19 July 1997)



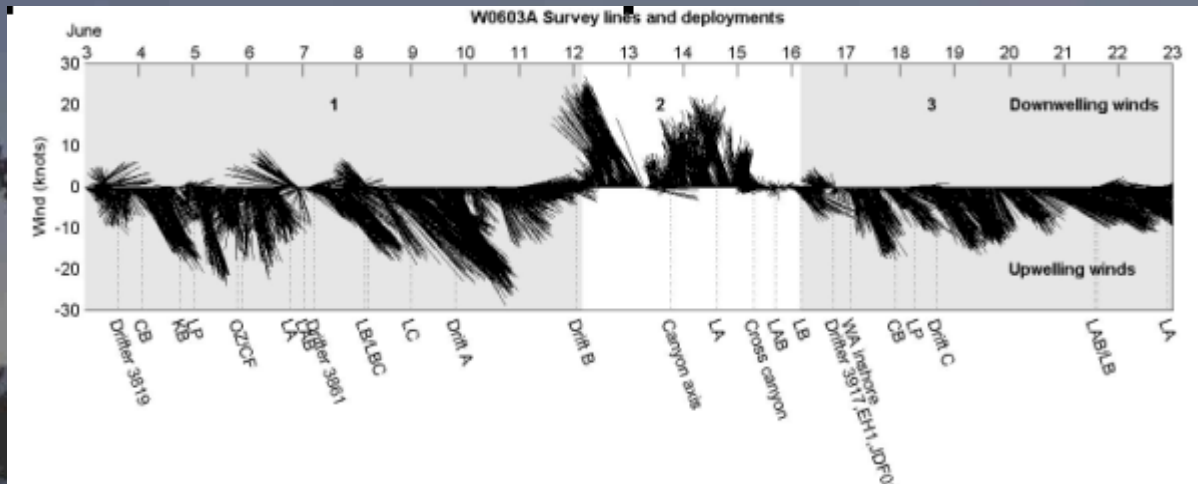
Pseudo-nitzschia cells (7-19 July 1997)



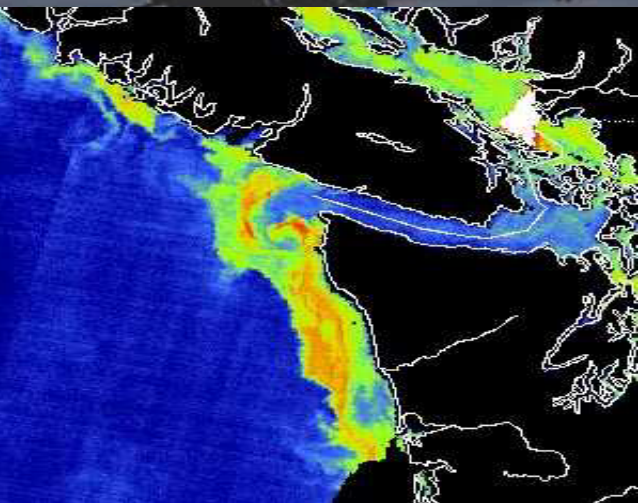
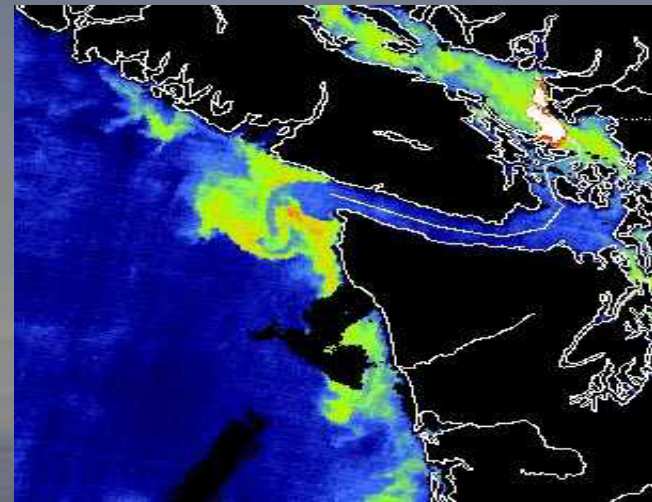
- Juan de Fuca Eddy is a summer upwelling feature off the entrance of Juan de Fuca Strait
 - ⌚ Tully (1942), Freeland & Denman (1982) & others
 - ⌚ may be the initiation site for toxic pseudo-nitzschia that cause harmful algal blooms impacting clams & crabs along the Washington coast
- ECOHAB PNW: multi-disciplinary project to study ecology & oceanography of these HABs
 - ⌚ June & September 2003 cruises
 - ⌚ ELCIRC to hindcast June 2003 circulation

June 2003 Fluorescence (chlorophyll) from MERIS

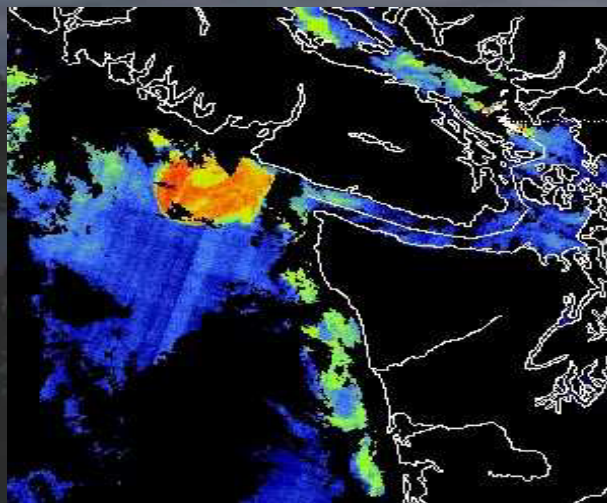
ship winds



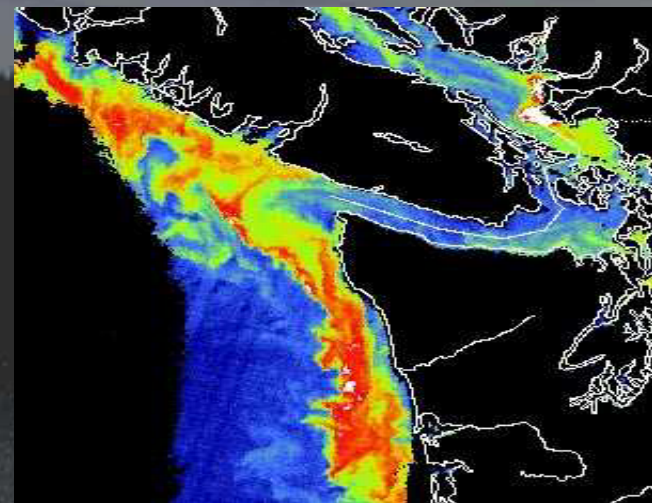
June 3



June 6



June 15

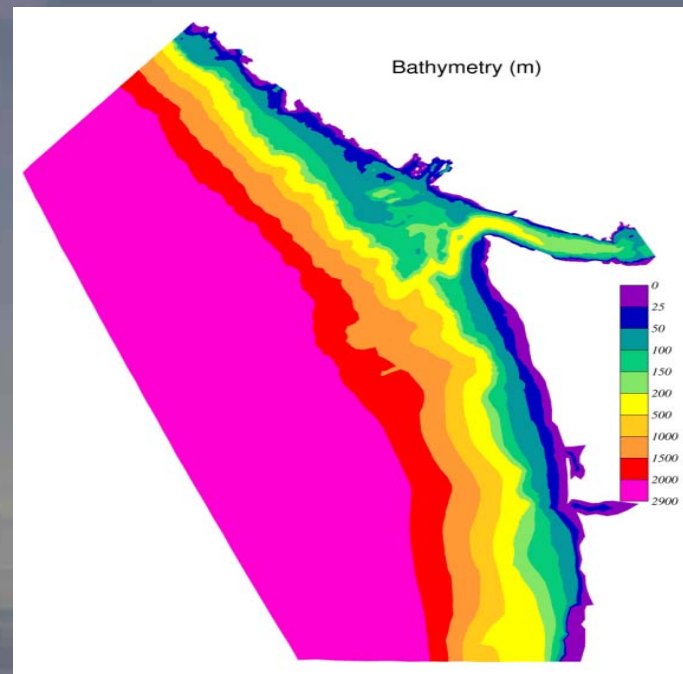
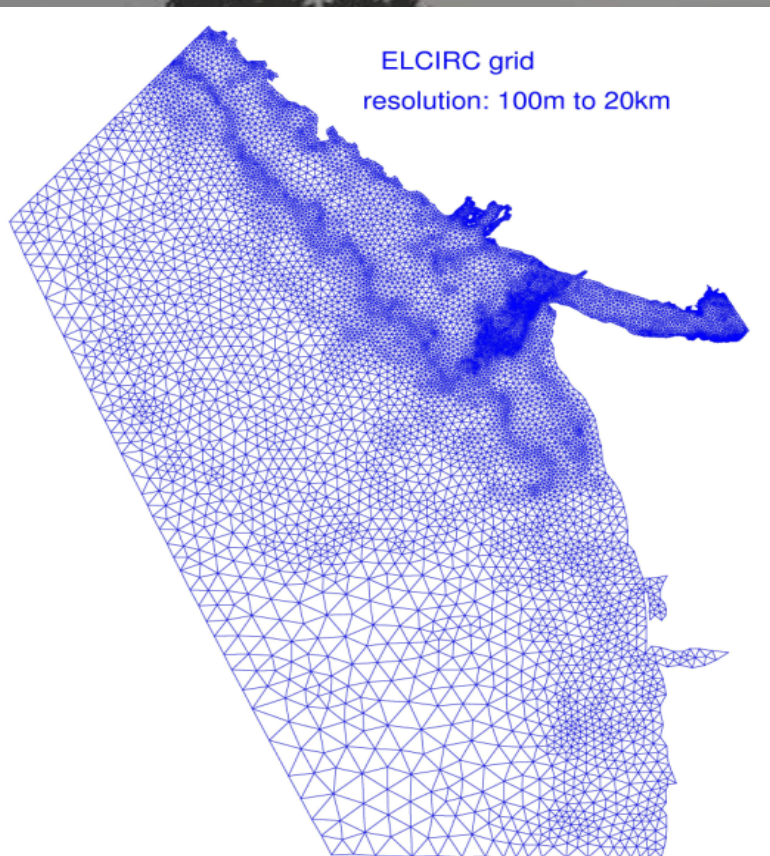


June 28

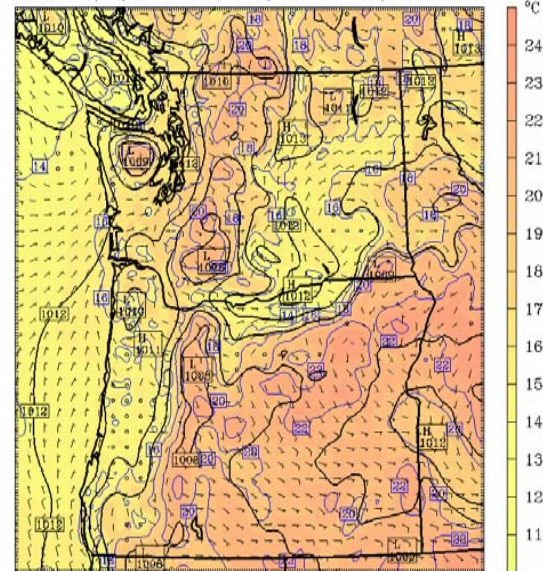
Satellite images courtesy of Jim Gower & Steph King

June 2003 Simulation

- ↻ 10.8K nodes
- ↻ 40 level surfaces
- ↻ winds from UW MM5 model (4 km)
 - ↻ no surface heat flux
- ↻ initial TS from climatology & boundary
TS nudged back to initial values
- ↻ 4 tidal constituents



UW MM5-GFS 4km Domain Init: 12 UTC Fri 03 Oct 03
Fcast: 6 h Valid: 18 UTC Fri 03 Oct 03 (11 PDT Fri 03 Oct 03)
Temperature at 925 mb (°C)
Sea Level Pressure (hPa) Wind at 10m (full barb = 10kts)

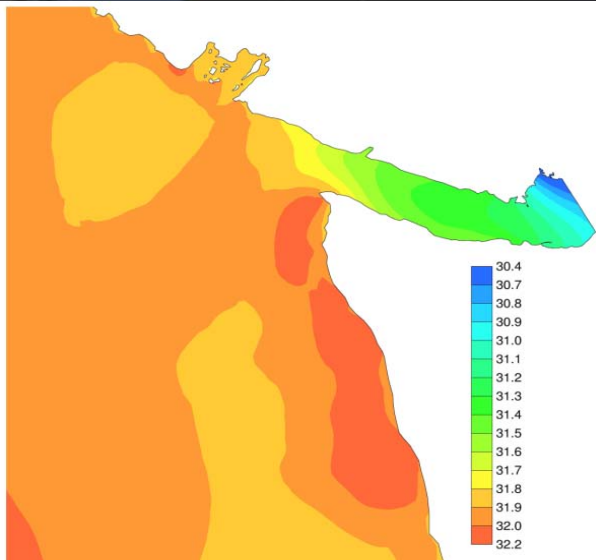
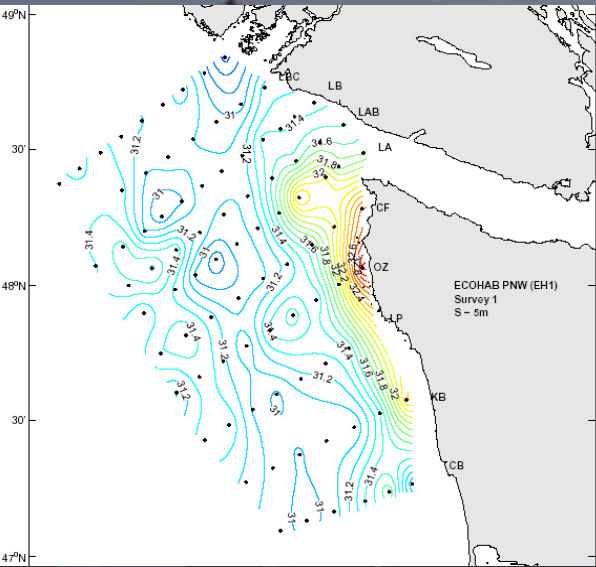


CONTOURS: UNITS=hPa LOW= 1000.6 HIGH= 1013.0 INTERVAL= 1.0000
CUTOFFS: UNITS=°C LOW= 10.000 HIGH= 24.000 INTERVAL= 2.0000
Model Info: Y3.5.3 No Cumulus MRF PBL Simple Ice 4 km, 37 levels, 1 sec

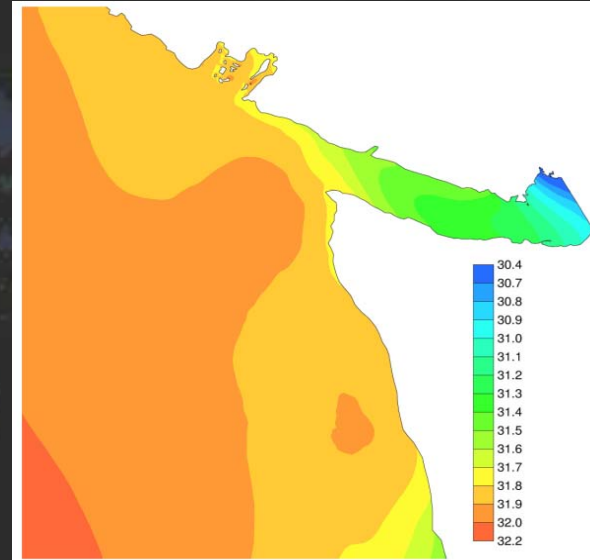
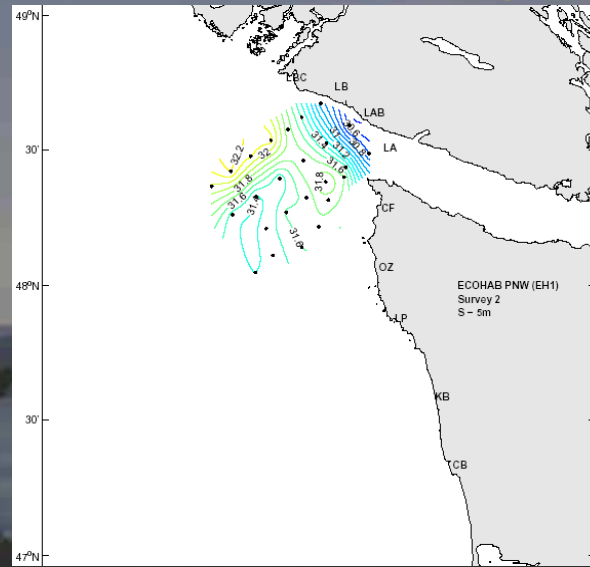
Preliminary Results

Salinity at 5m

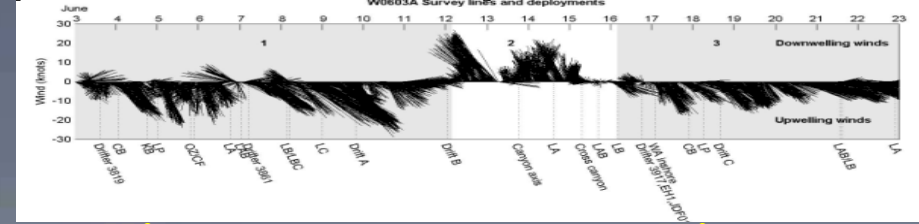
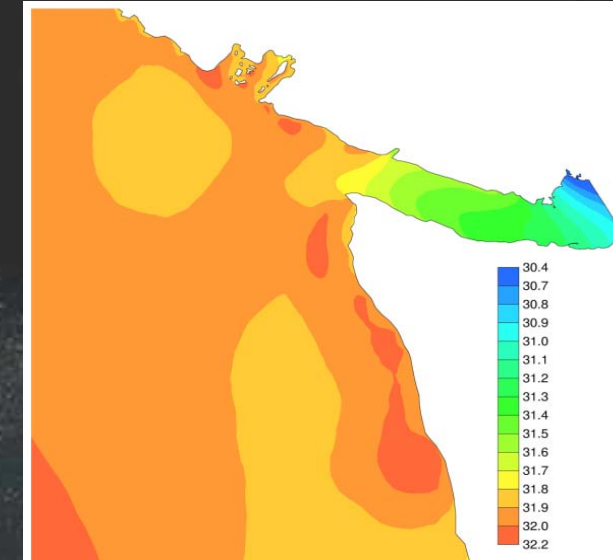
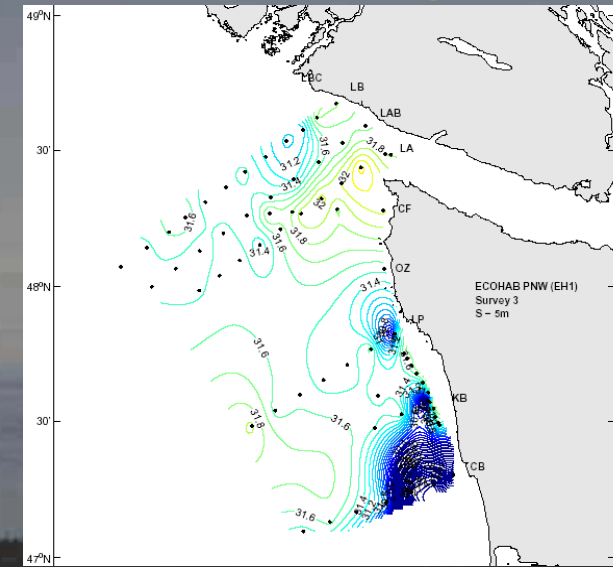
upwelling



downwelling

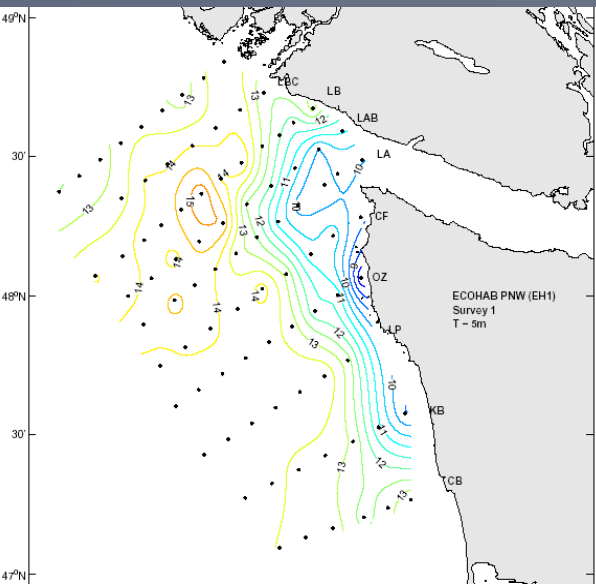


upwelling

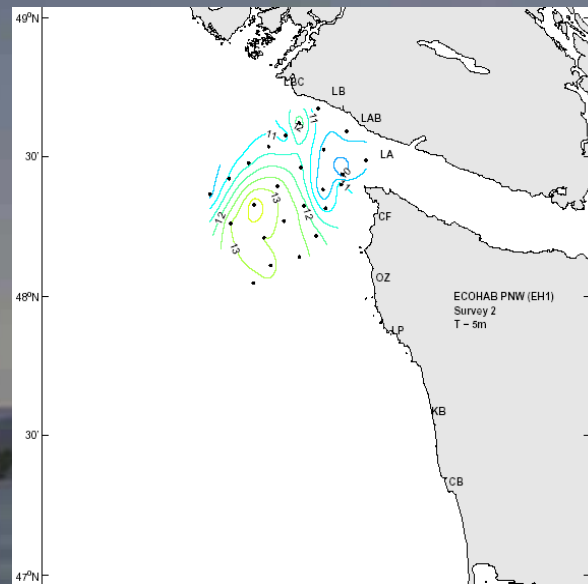


Temperature at 5m

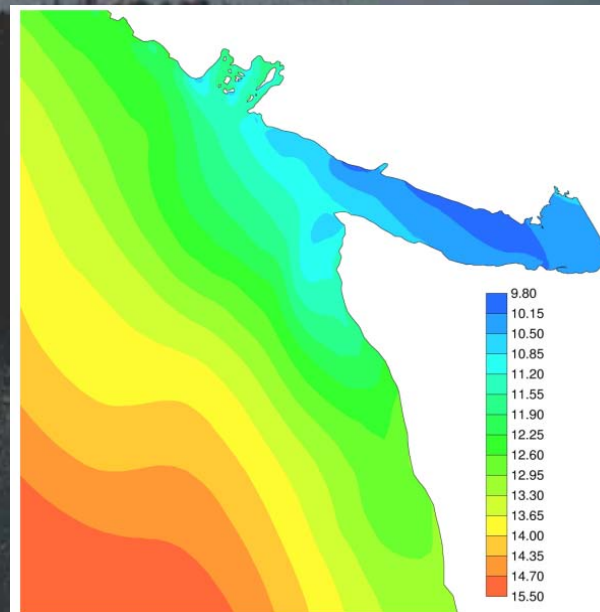
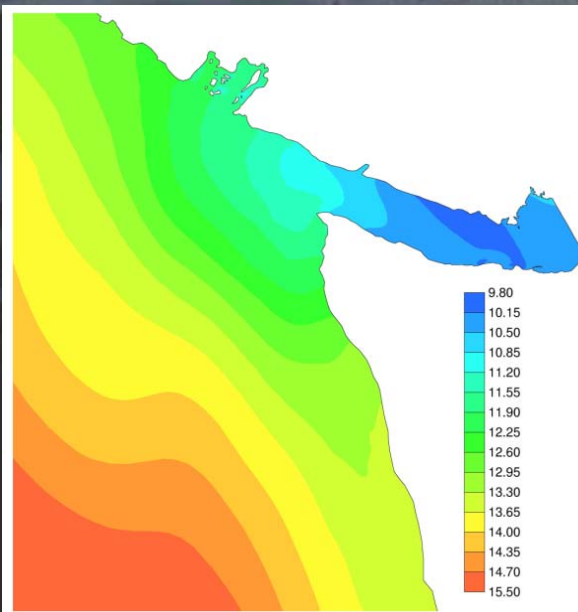
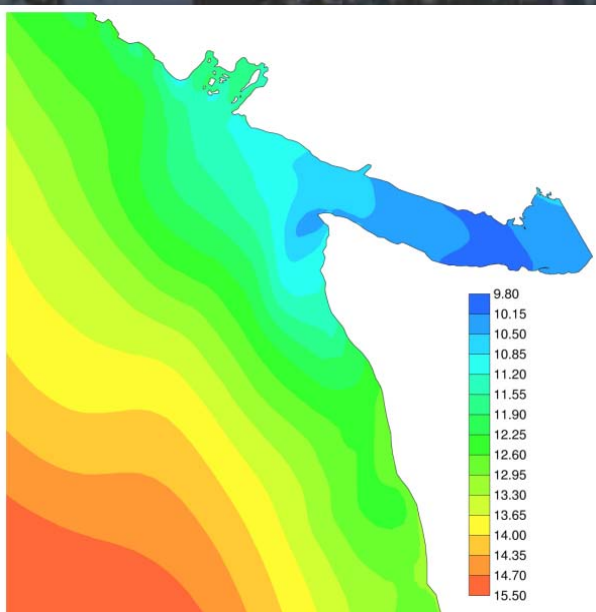
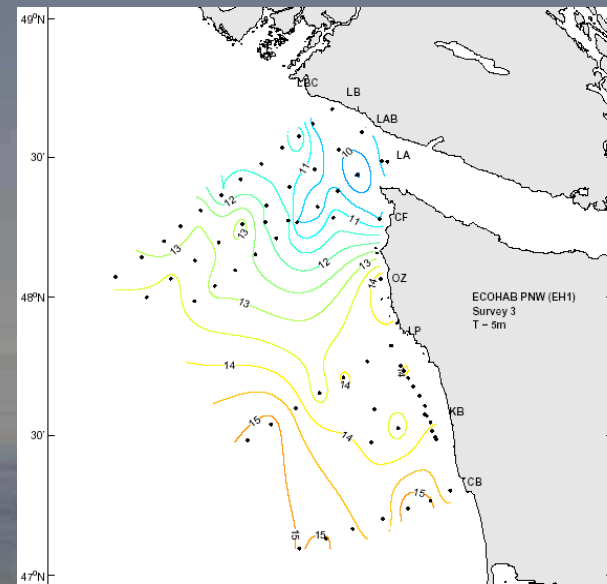
upwelling

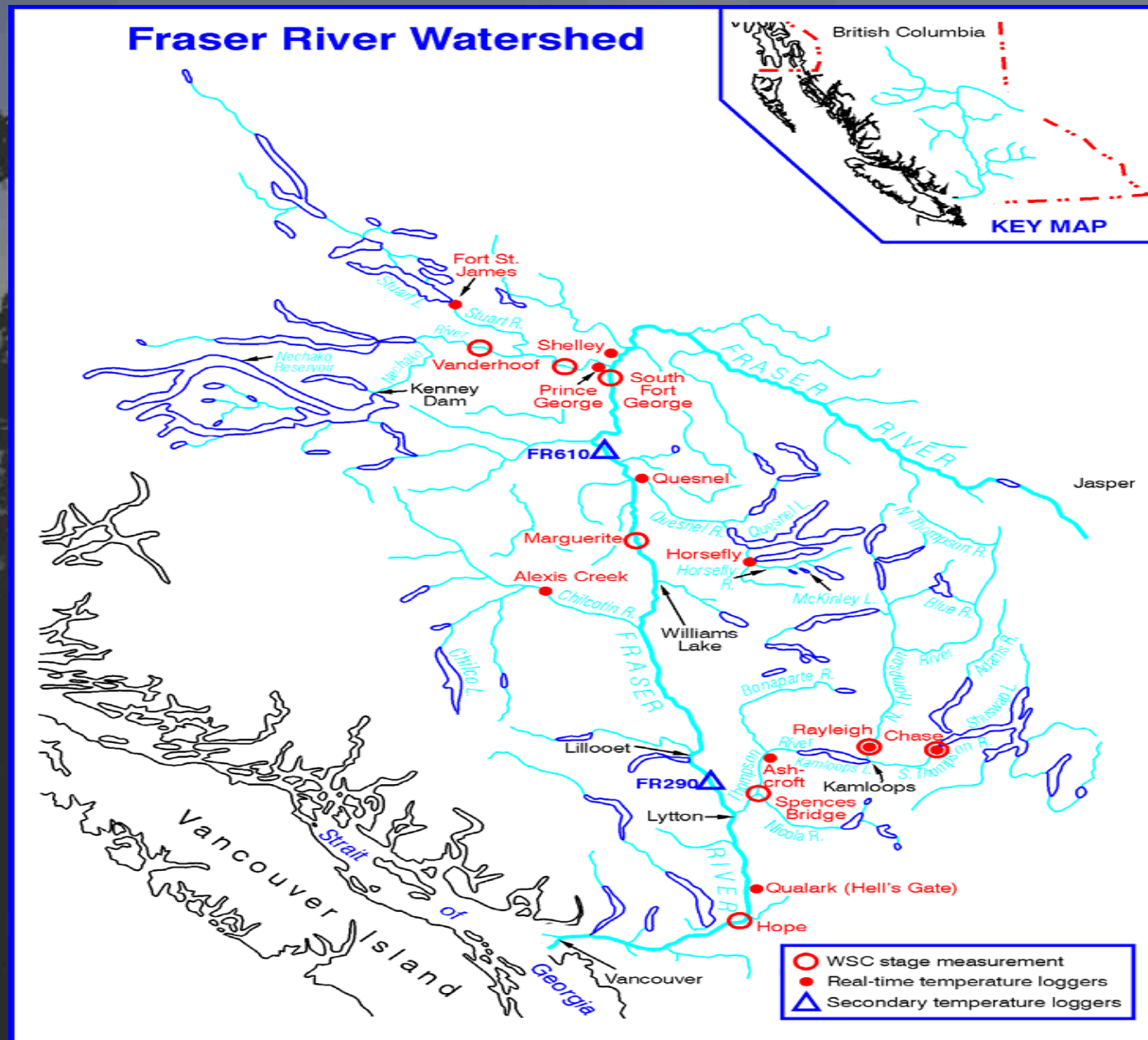


downwelling



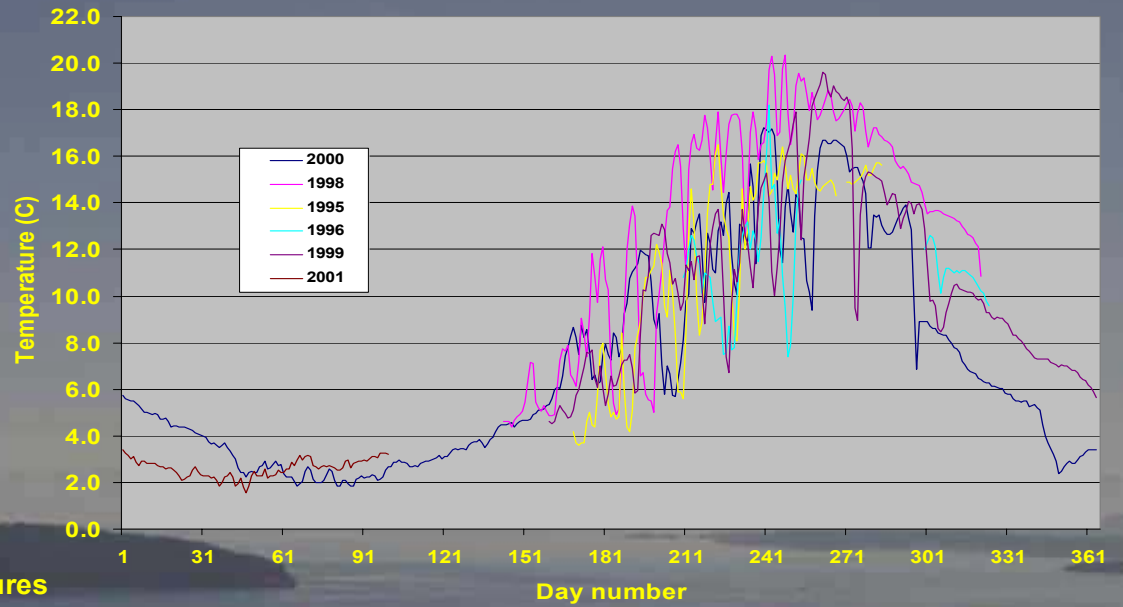
upwelling



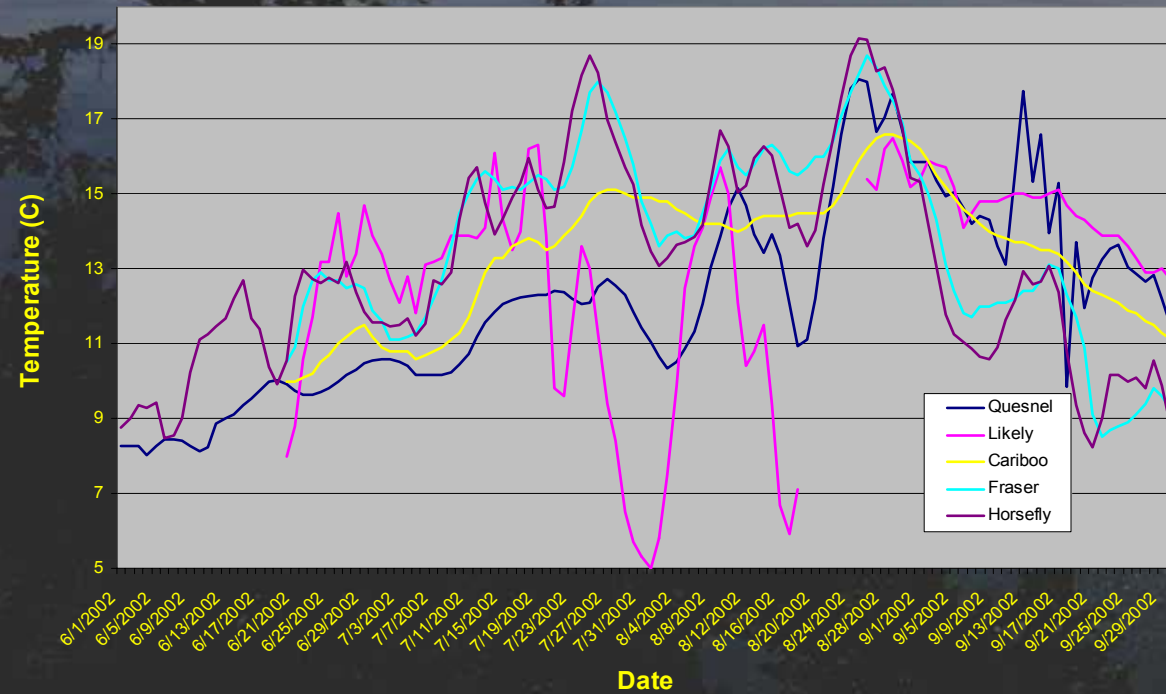


Motivation

Mean Temperature at Likely

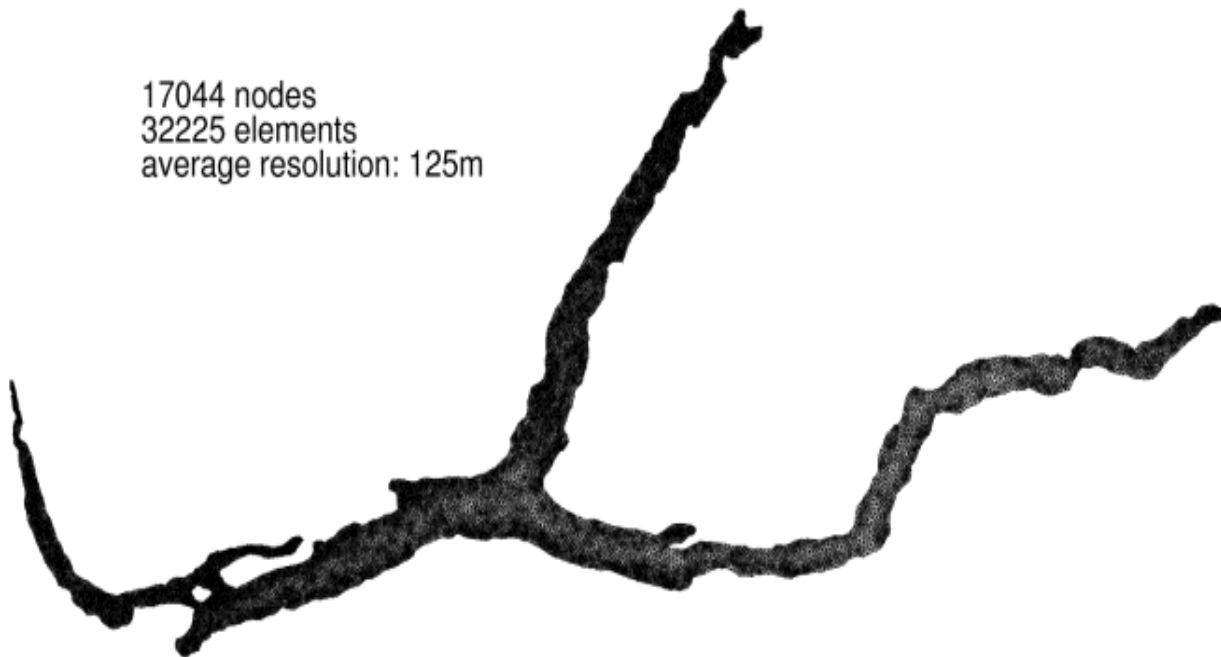


2002 Water temperatures

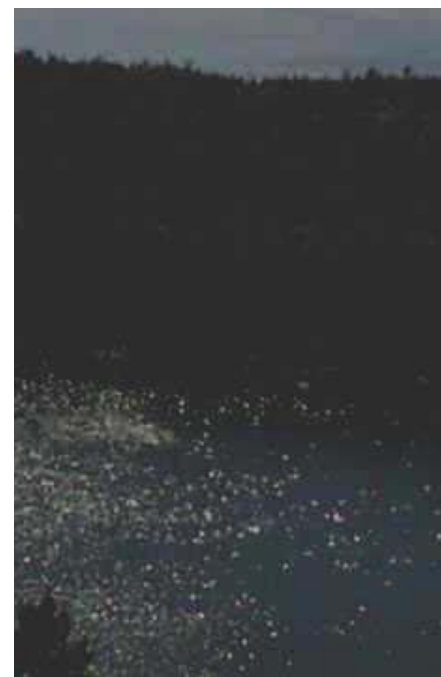
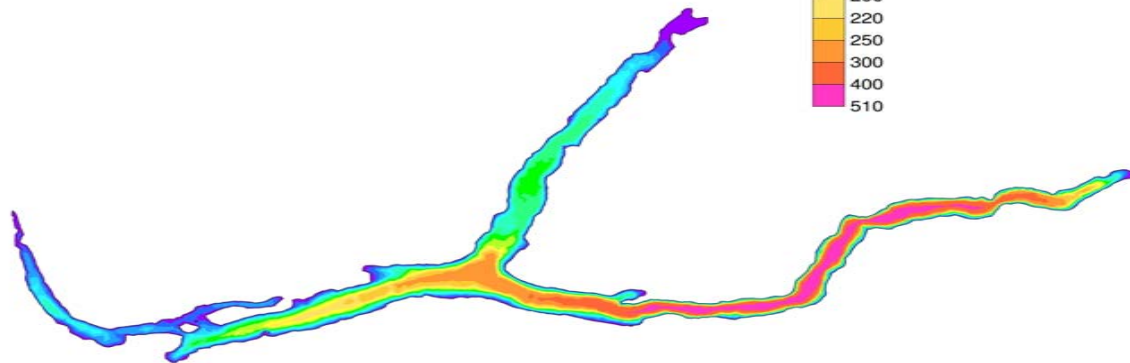
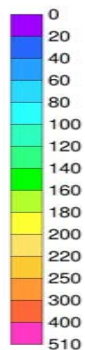


Model Grid & Bathymetry

17044 nodes
32225 elements
average resolution: 125m

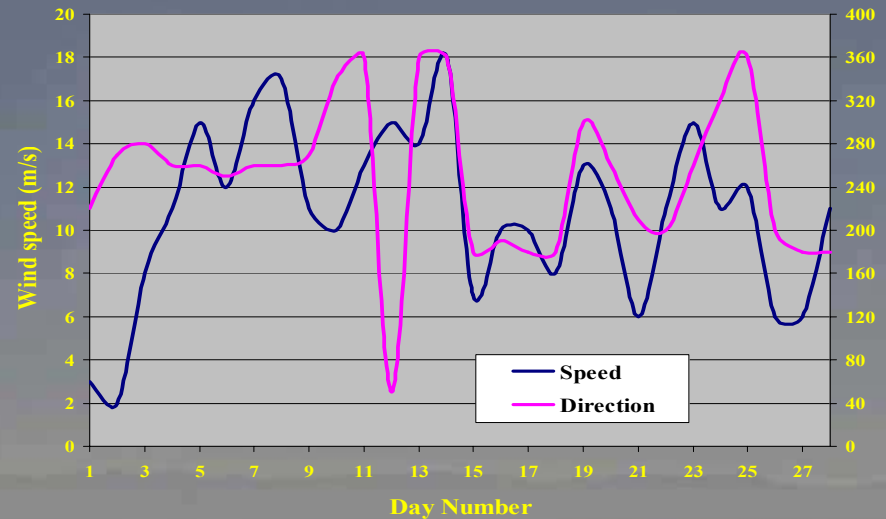


Bathymetry (m)



Preliminary Run

Prince George Winds: July 22 - Aug 18, 2002



- Initial vertical temp profile from 2003 thermistor data
- River discharges: Likely, Horsefly, Mitchell, Niagara
- Forcing = July 22 – Aug 10, 2002 Prince George winds
- Nudged surface temp back to initial values with 12hr e-folding time scale
- $\Delta t = 10 \text{ min}$
- Vertical viscosity & horizontal/vertical diffusion important
 - MY & KL/KC too diffusive: too much mixing at depth
 - Used $v_{\text{diff}} = t_{\text{diff}} = 0.000001$
 - temp fixed below 80m
 - Lagrangian time stepping also diffusive

Prince George Winds: July 22 - Aug 18, 2002

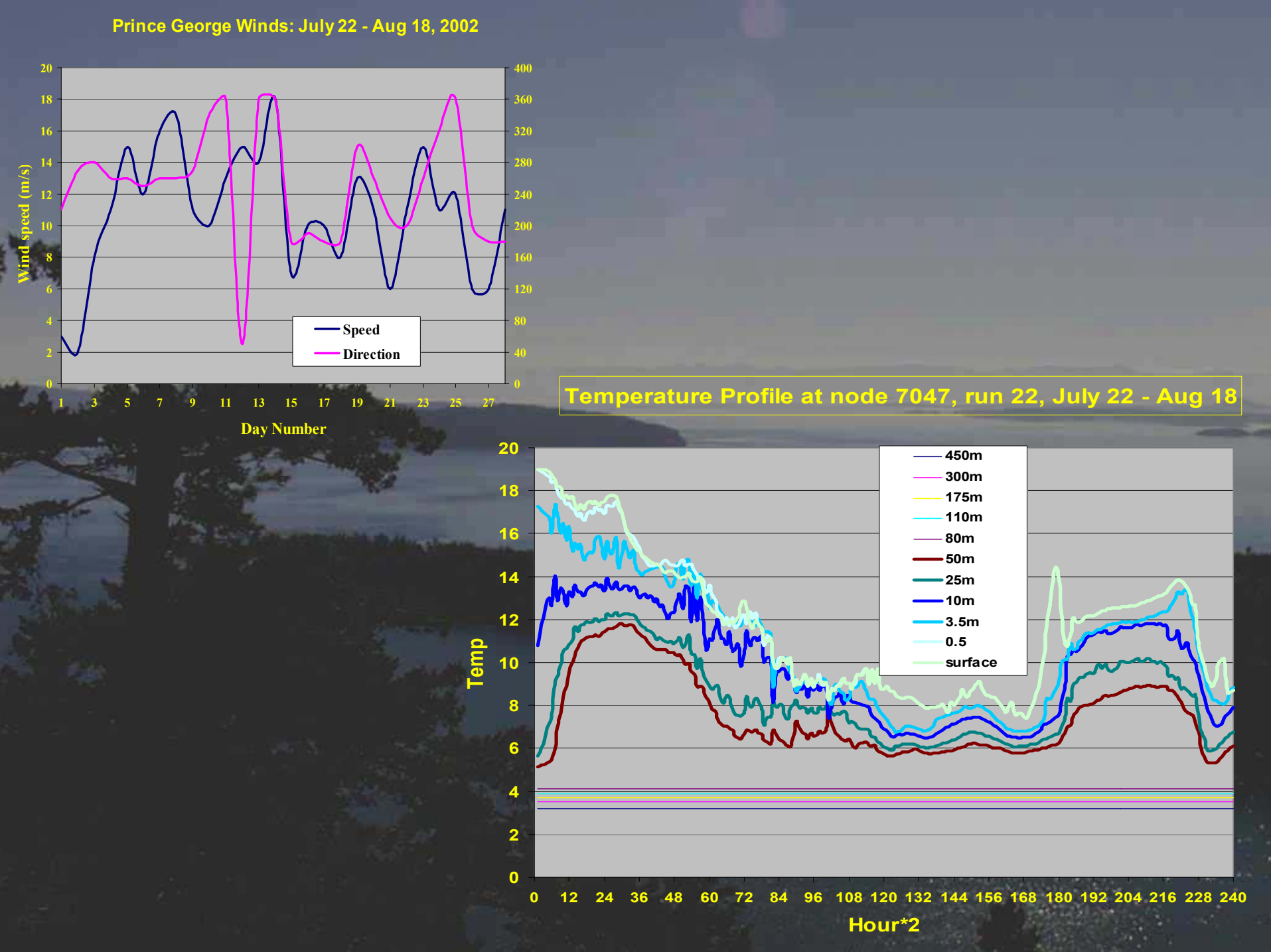
This graph displays wind speed and direction over a 28-day period. The left y-axis represents wind speed in m/s (0 to 20), and the right y-axis represents wind direction in degrees (0 to 400). The x-axis shows the day number (1 to 27). Wind speed is shown as a blue line, and wind direction is shown as a magenta line.

Day Number	Wind Speed (m/s)	Wind Direction (degrees)
1	3	240
3	2	280
5	15	280
7	12	280
9	17	280
11	10	360
13	18	40
15	7	200
17	10	180
19	13	320
21	6	200
23	15	320
25	12	280
27	11	200

Temperature Profile at node 7047, run 22, July 22 - Aug 18

This graph displays temperature profiles at various heights over a 240-hour period. The y-axis represents temperature in degrees Celsius (0 to 20), and the x-axis represents time in hours (0 to 240). The profiles are shown for heights of 450m, 300m, 175m, 110m, 80m, 50m, 25m, 10m, 3.5m, 0.5m, and the surface. The surface temperature is shown as a green line, and the other heights are shown as lines of various colors.

Hour*2	Surface Temp (C)
0	19
12	17
24	17
36	17
48	15
60	14
72	12
84	10
96	9
108	9
120	8
132	8
144	8
156	9
168	8
180	14
192	12
204	12
216	13
228	8
240	9



Prince George Winds: July 22 - Aug 18, 2002

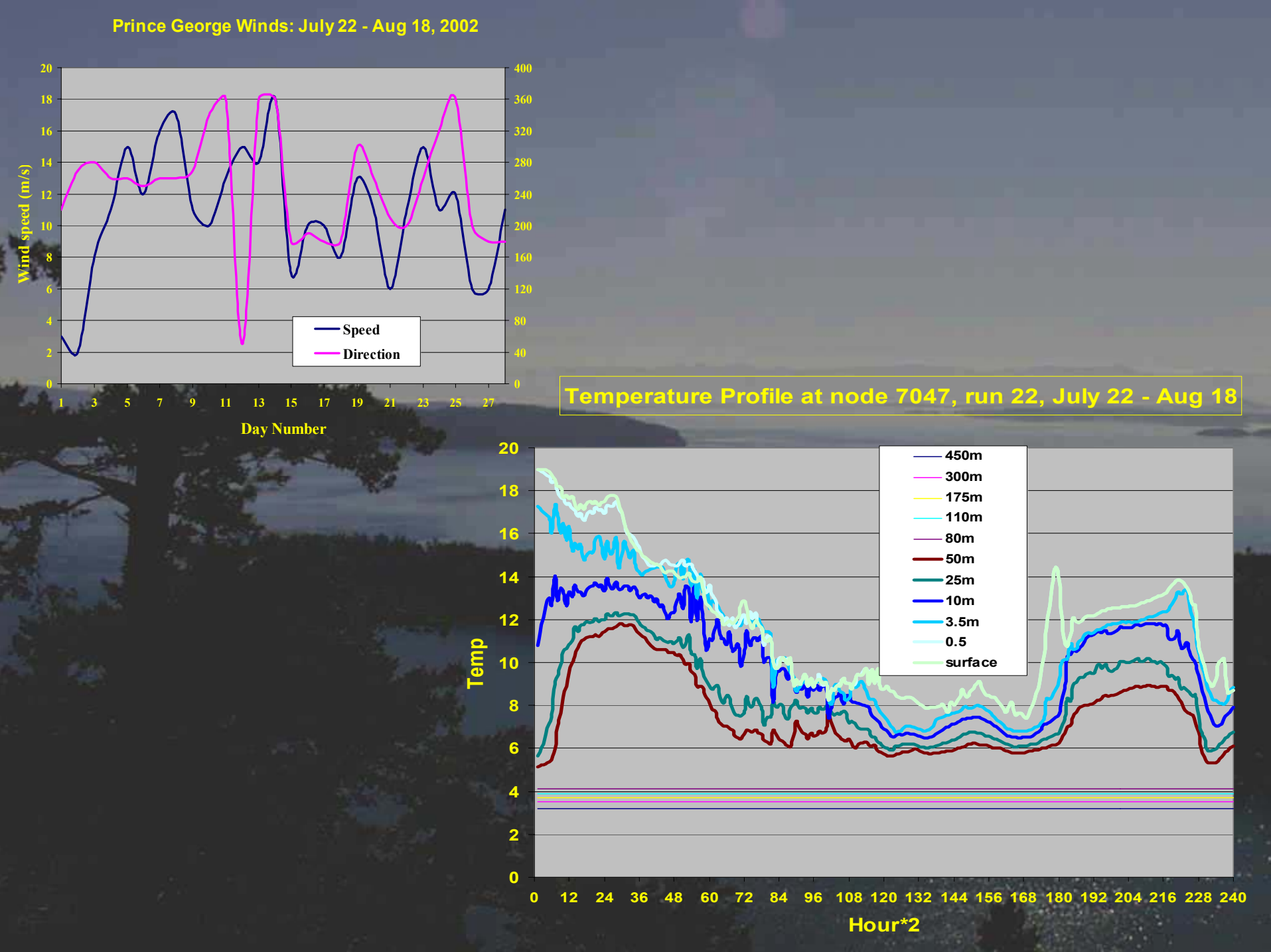
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Day Number	Wind Speed (m/s)	Wind Direction (degrees)
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7	12	280
9	17	280
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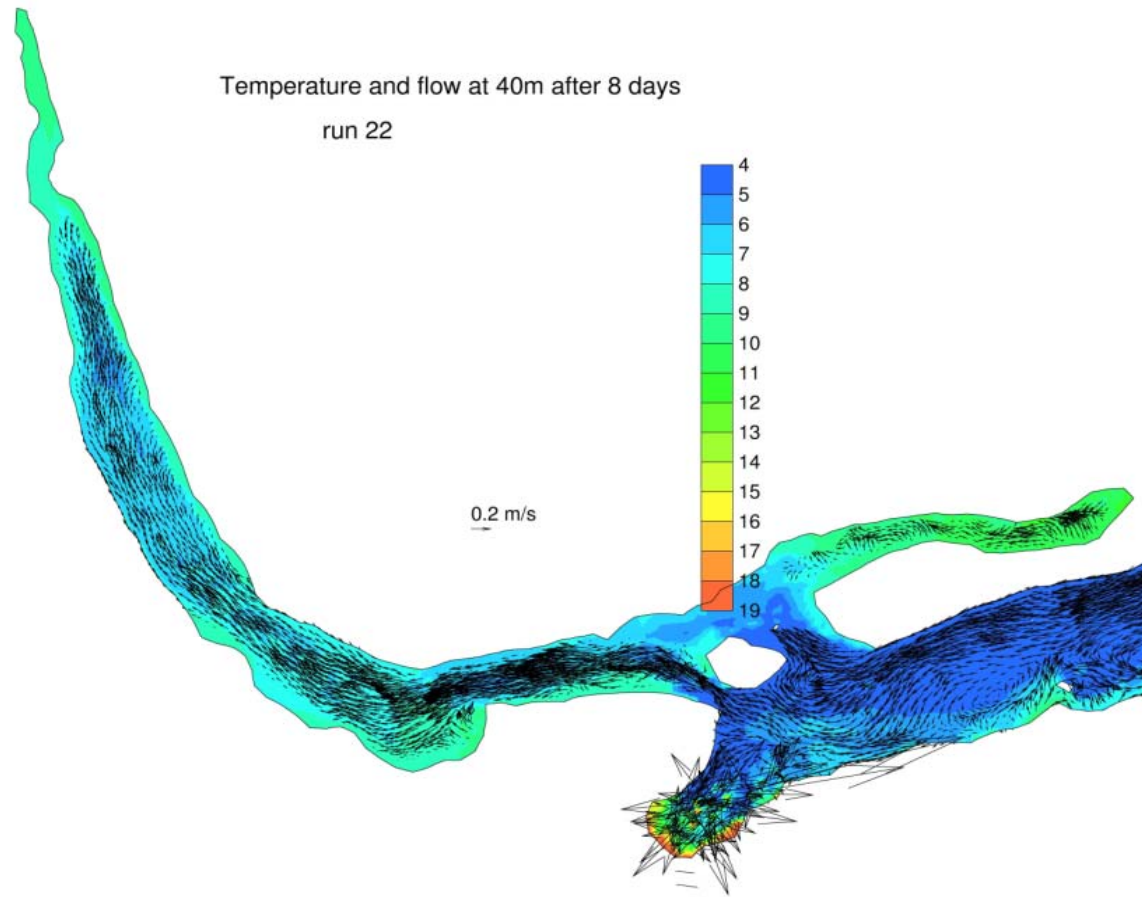
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168	8
180	14
192	12
204	12
216	12
228	12
240	8



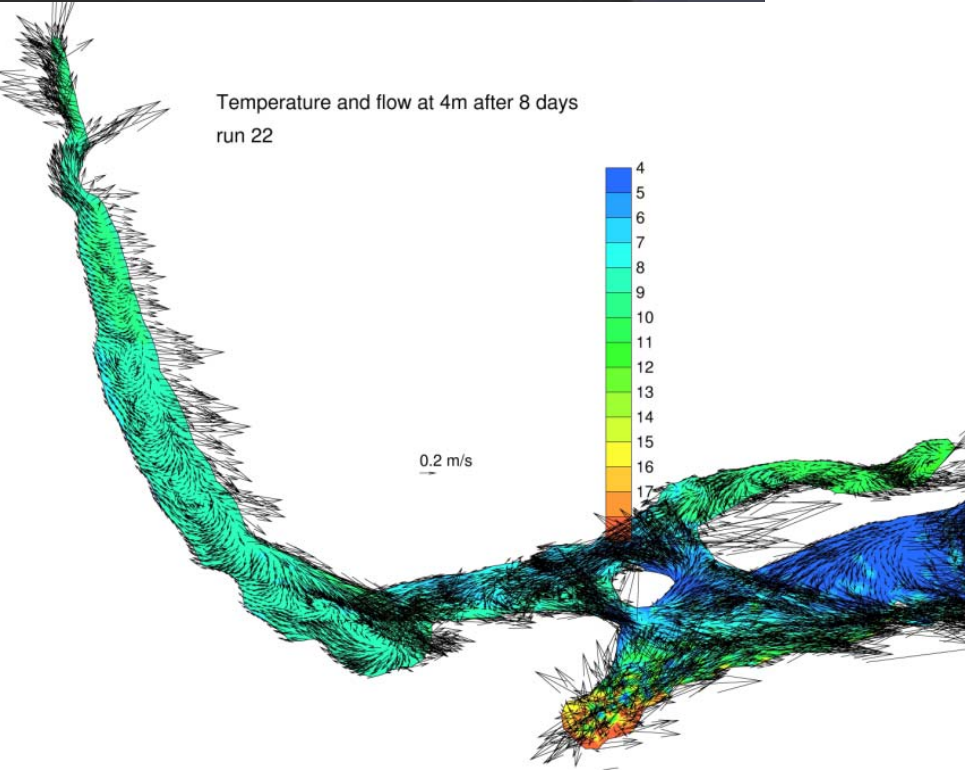
Results



Temperature and flow at 40m after 8 days
run 22



Temperature and flow at 4m after 8 days
run 22



Summary & Outstanding Issues

1) Broughton Archipelago application:

- ⬇ reasonably accurate tides & estuarine flow except in Johnstone Strait (local bcs problematic - need nesting from larger grid?)
- ⬇ Noise in some portions of grid (eg, Knight Inlet). Quads vs triangles ?

2) ECOHAB PNW simulations

- ⬇ reasonable simulation of June 2003 TS fields
- ⬇ will use for ship-mounted ACDP de-tiding
- ⬇ need to include Columbia discharge, better atmos forcing, & better JdF & upstream bcs (coastally trapped waves from Oregon/California)
- ⬇ has problems generating Juan de Fuca Eddy when don't start with climatology (ditto Haida Eddy; higher order numerics needed?)

3) Quesnel Lake upwelling

- ⬇ needs better atmospheric forcing (*sflux_subs6.f90*)
- ⬇ overly diffusive
- ⬇ may need new equation of state (UBC student)