# ELCIRC Applications to British Columbia Waters

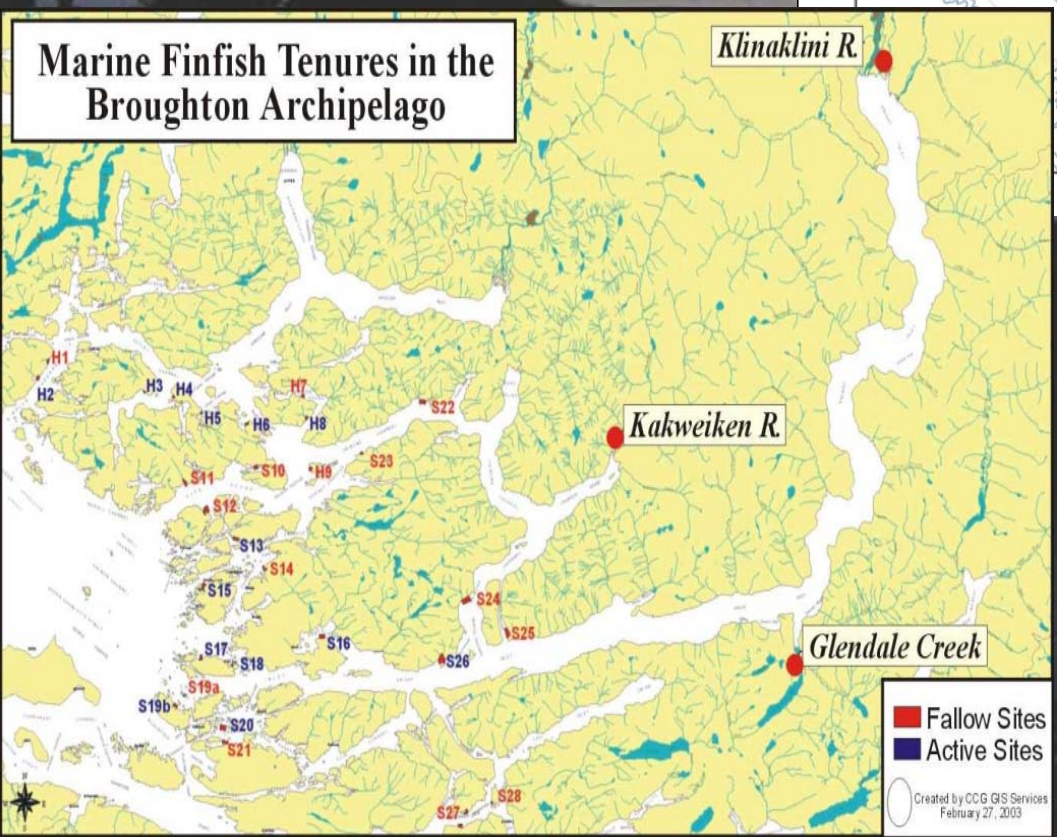
**Mike Foreman**
**Institute of Ocean Sciences**

## Outline:

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

IOS

# 1. Broughton Archipelago

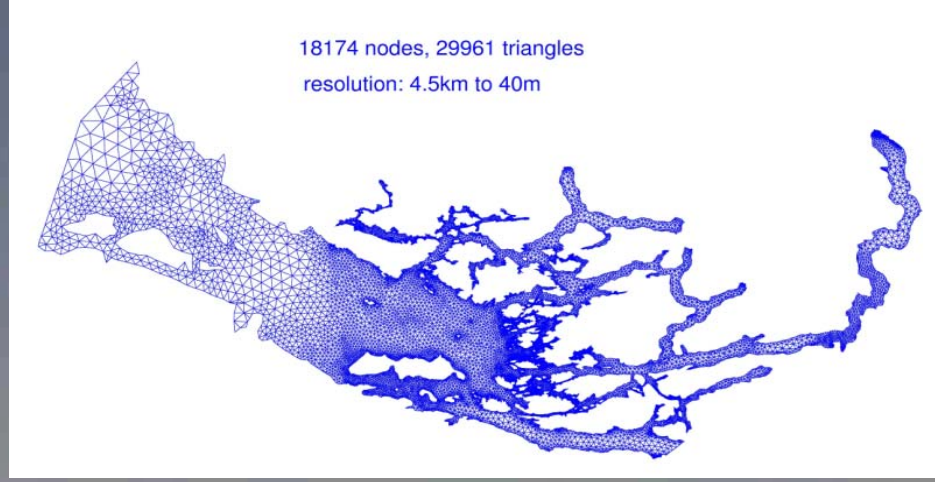

## Objective:

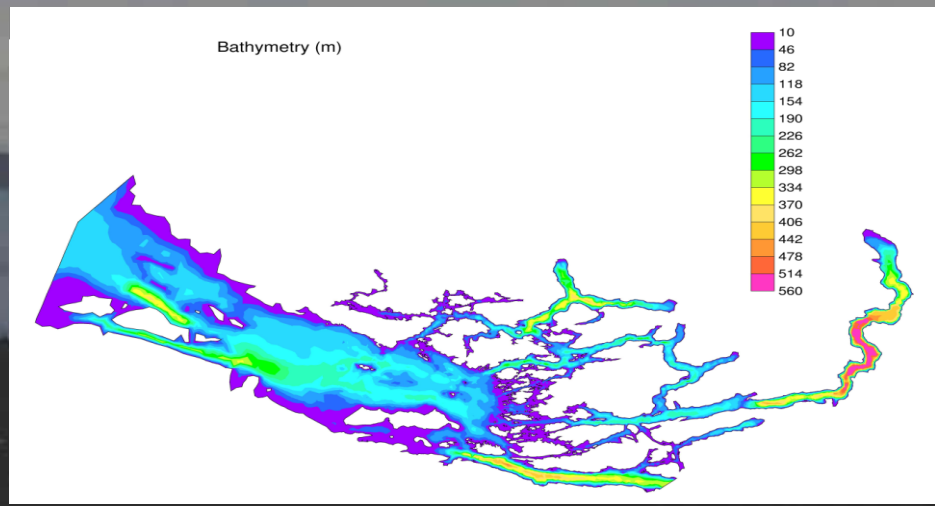
**Simulate circulation and transport near salmon farms:**

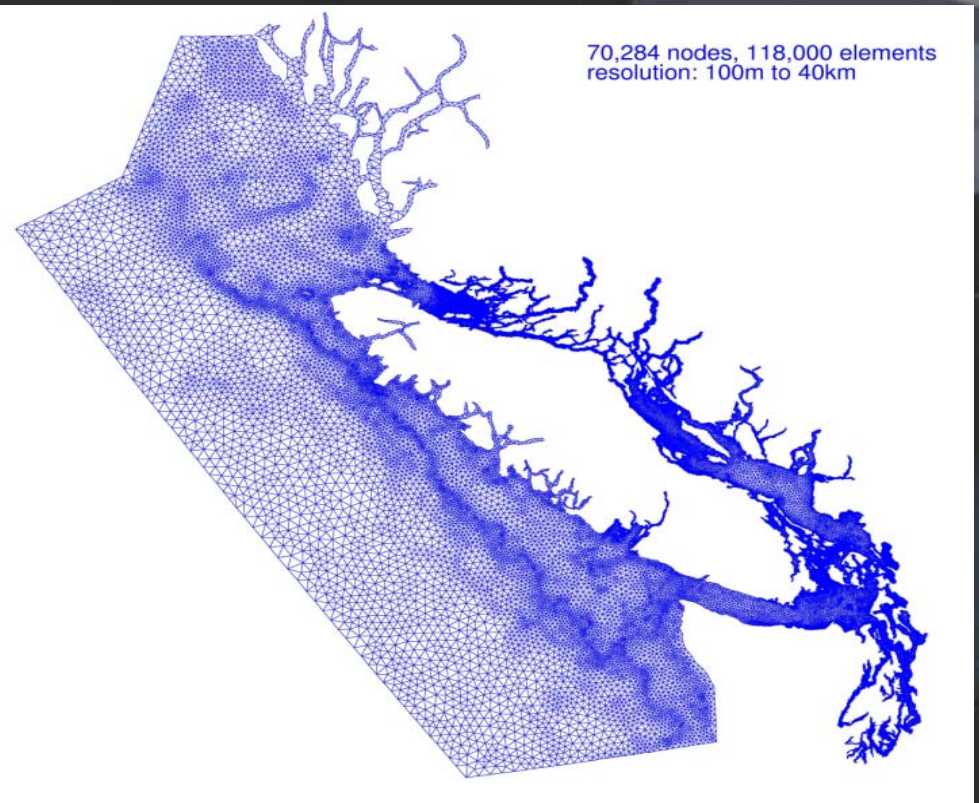
**-issues of waste deposition, spreading of viruses, sea lice, etc…**

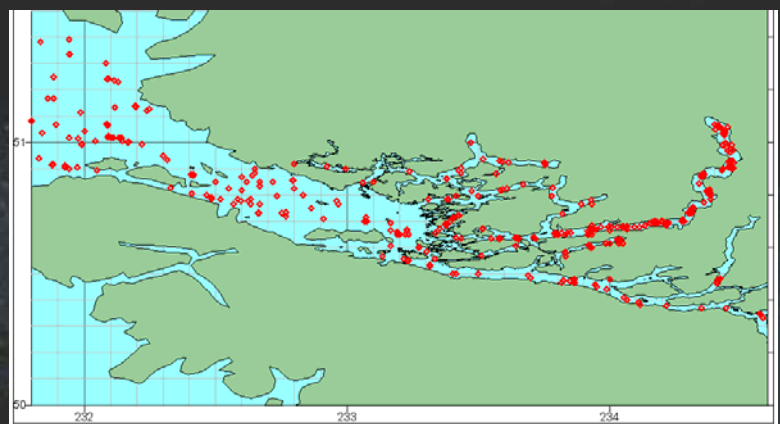
# Model Grids & Forcing

- 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)



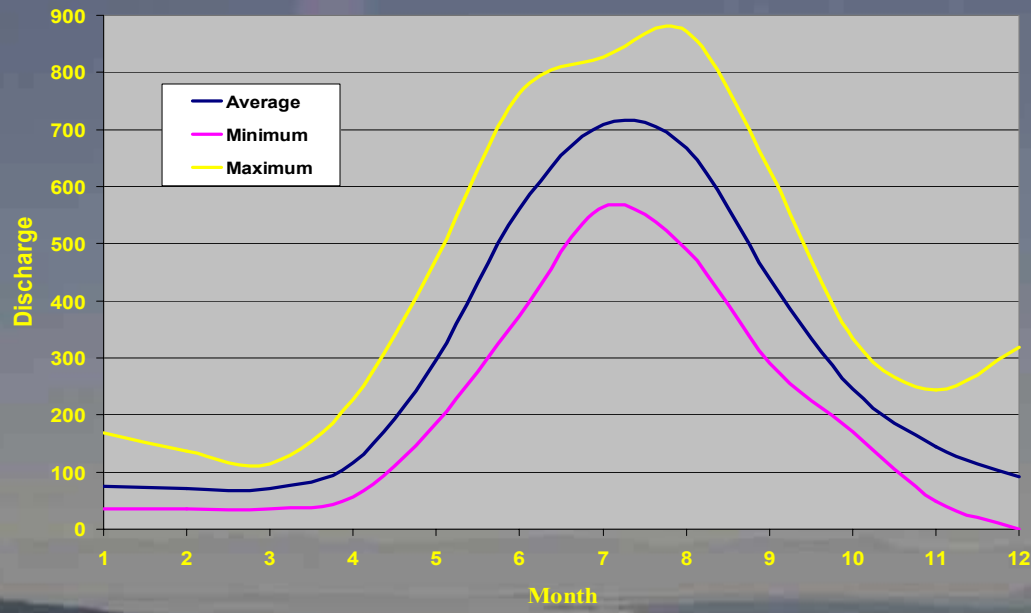



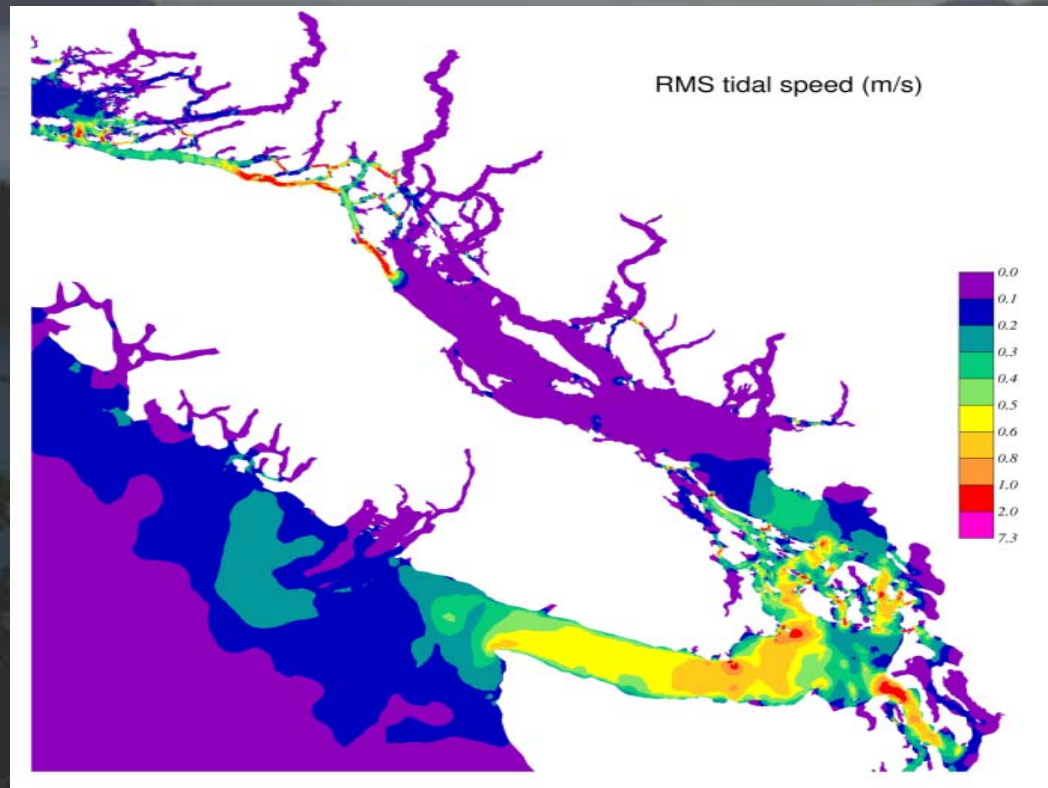



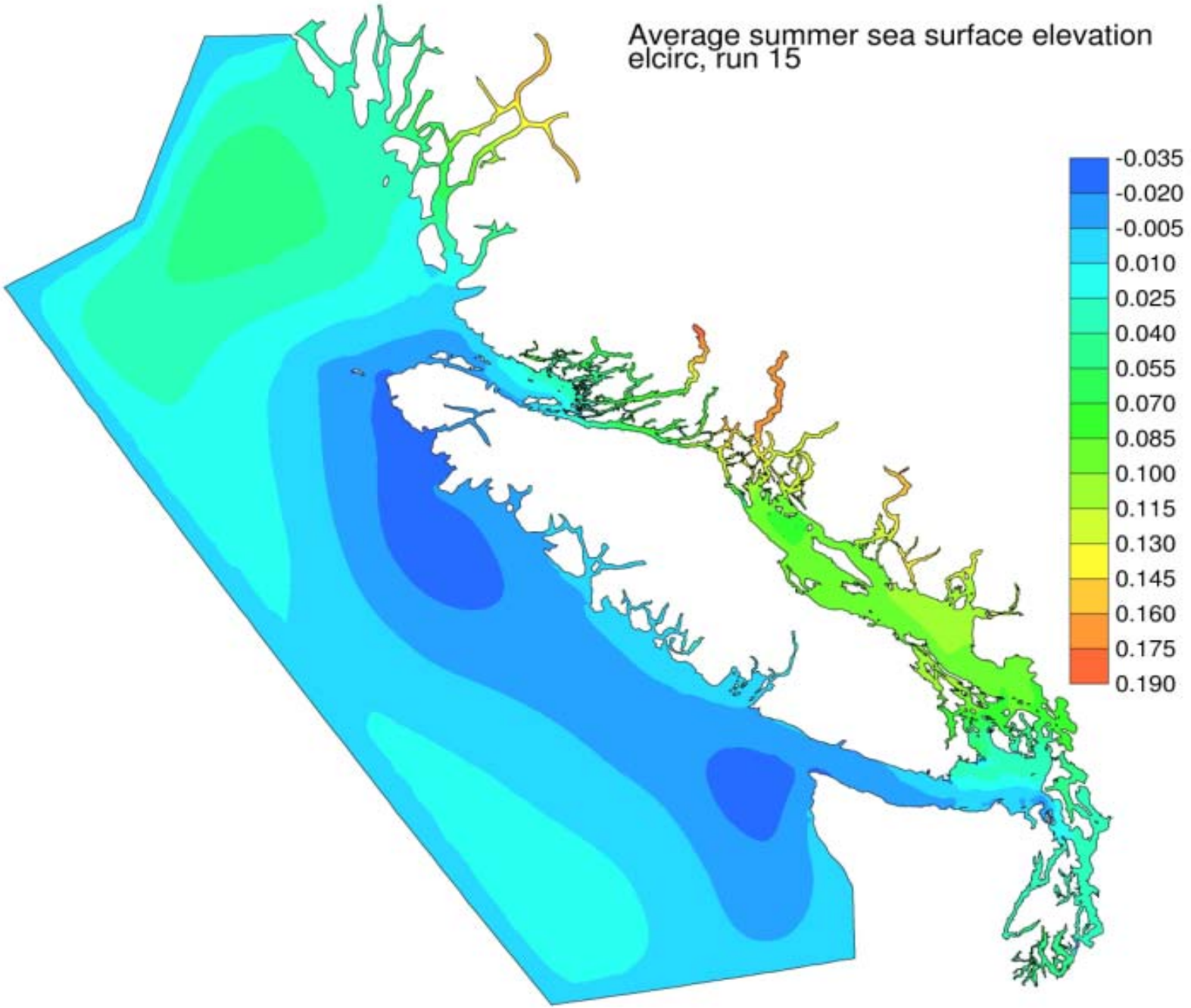



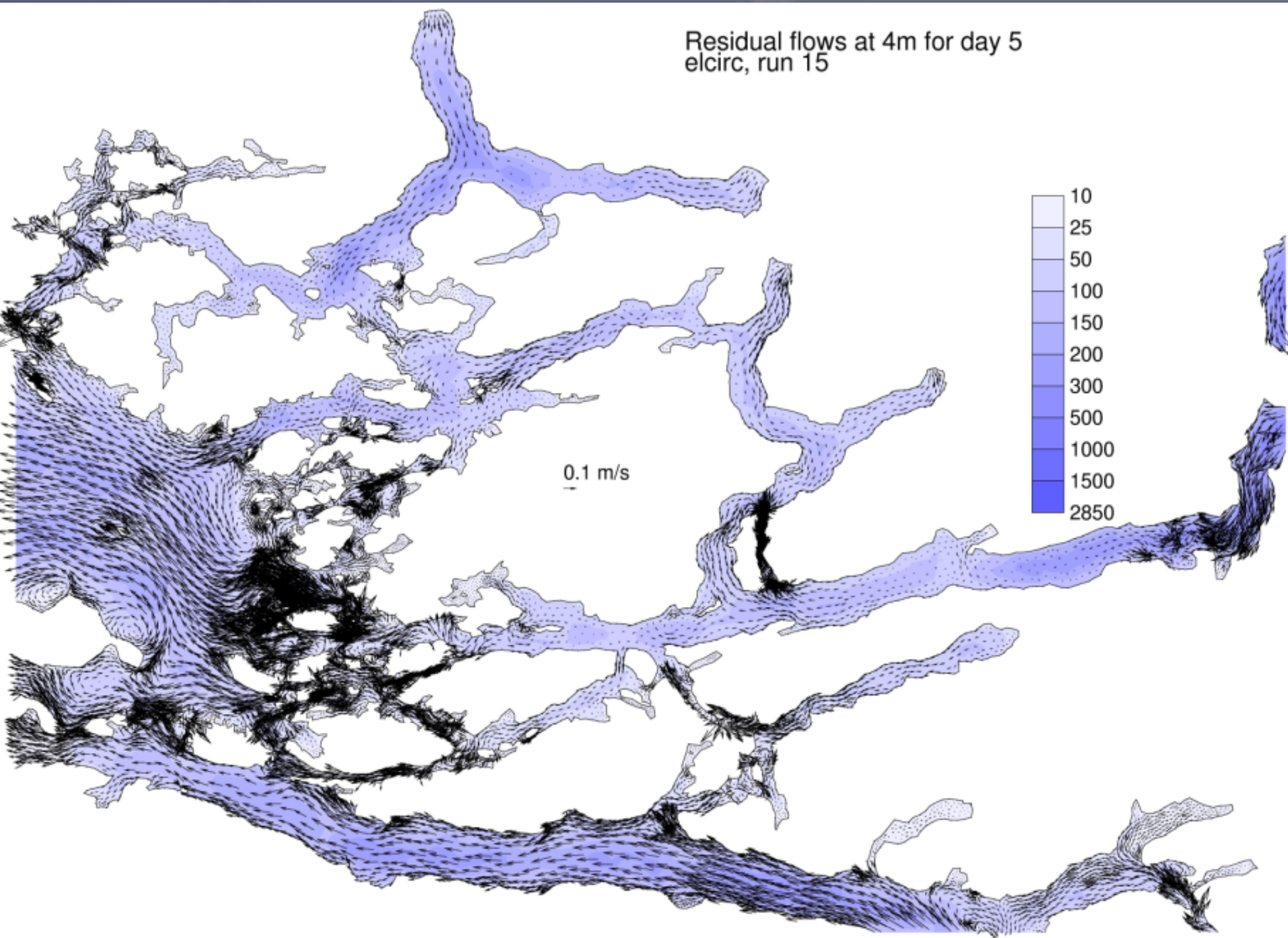
# Run Details

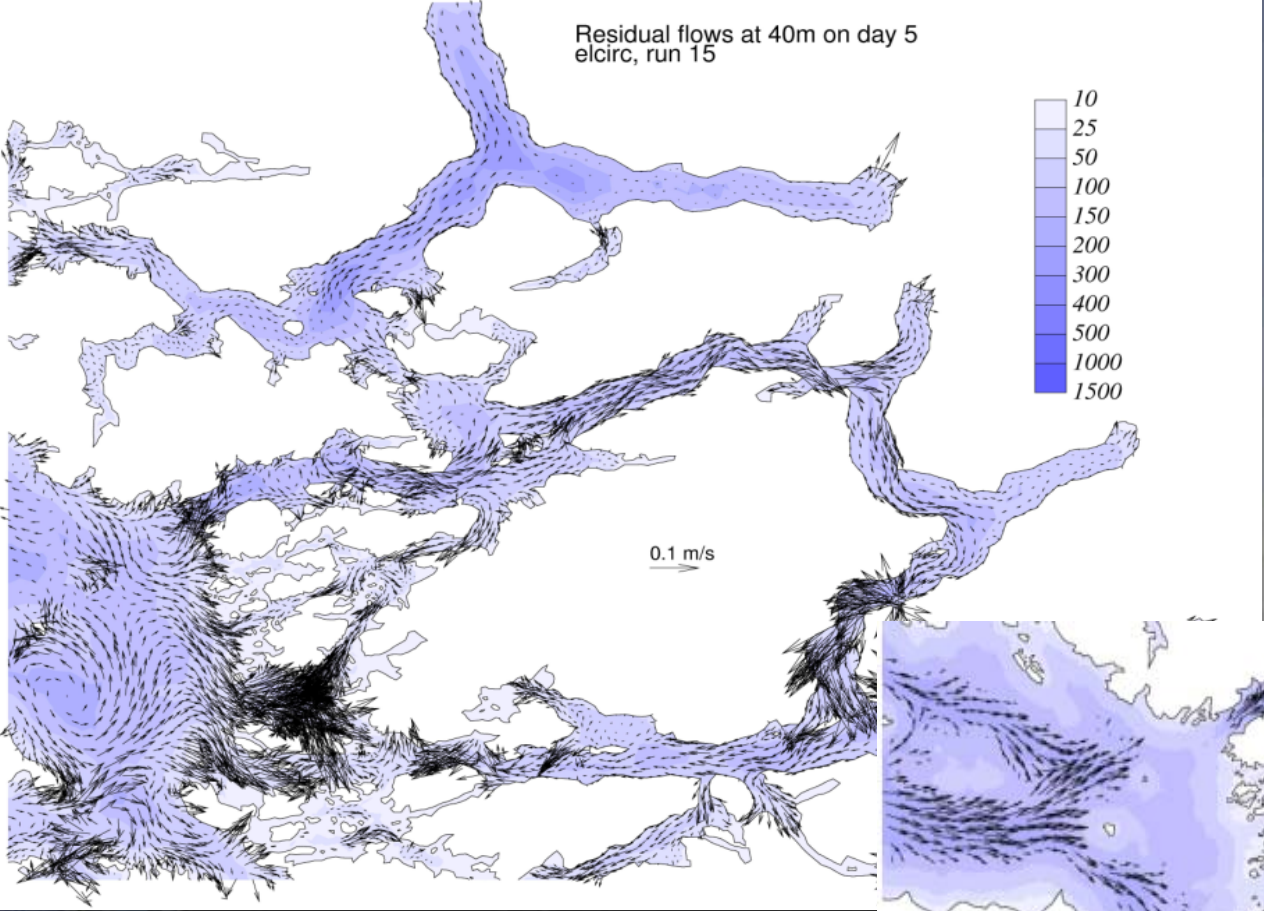
- For Broughton grid, only Klinaklini River gauged: 1977-present
  - Other discharges estimated by relative size of watersheds
- For larger grid, need to include Fraser, Homathko, & lesser rivers
- Δt=5min, 33 vertical levels
- KL/KC turbulence
- 2 or 4 tidal constituents

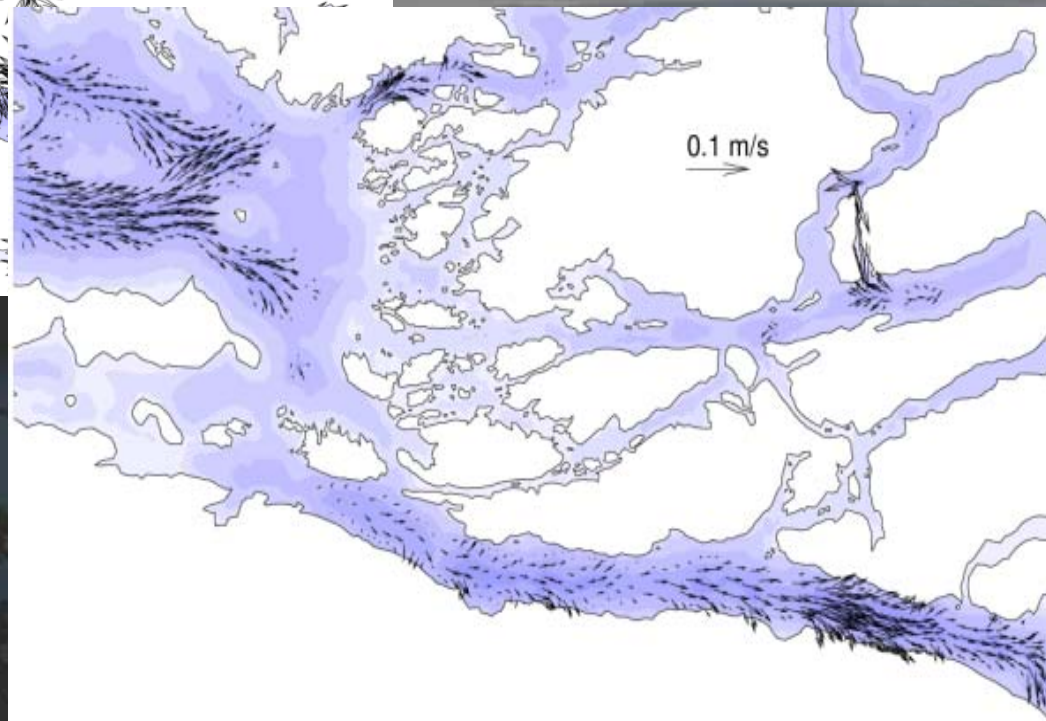


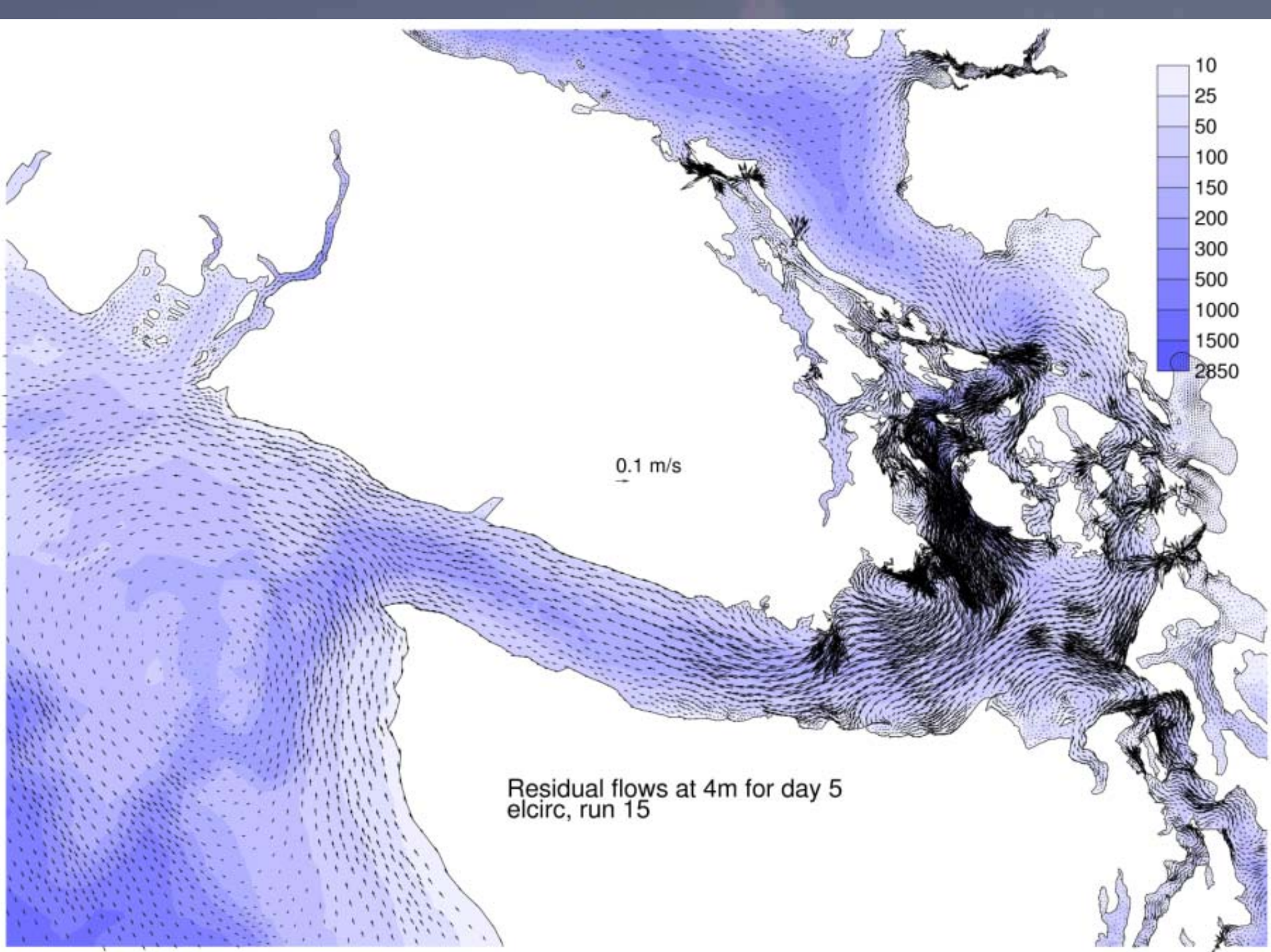

Average summer sea surface elevation
elcirc, run 15
-0.035
-0.020
-0.005
0.010
0.025
0.040
0.055
0.070
0.085
0.100
0.115
0.130
0.145
0.160
0.175
0.190

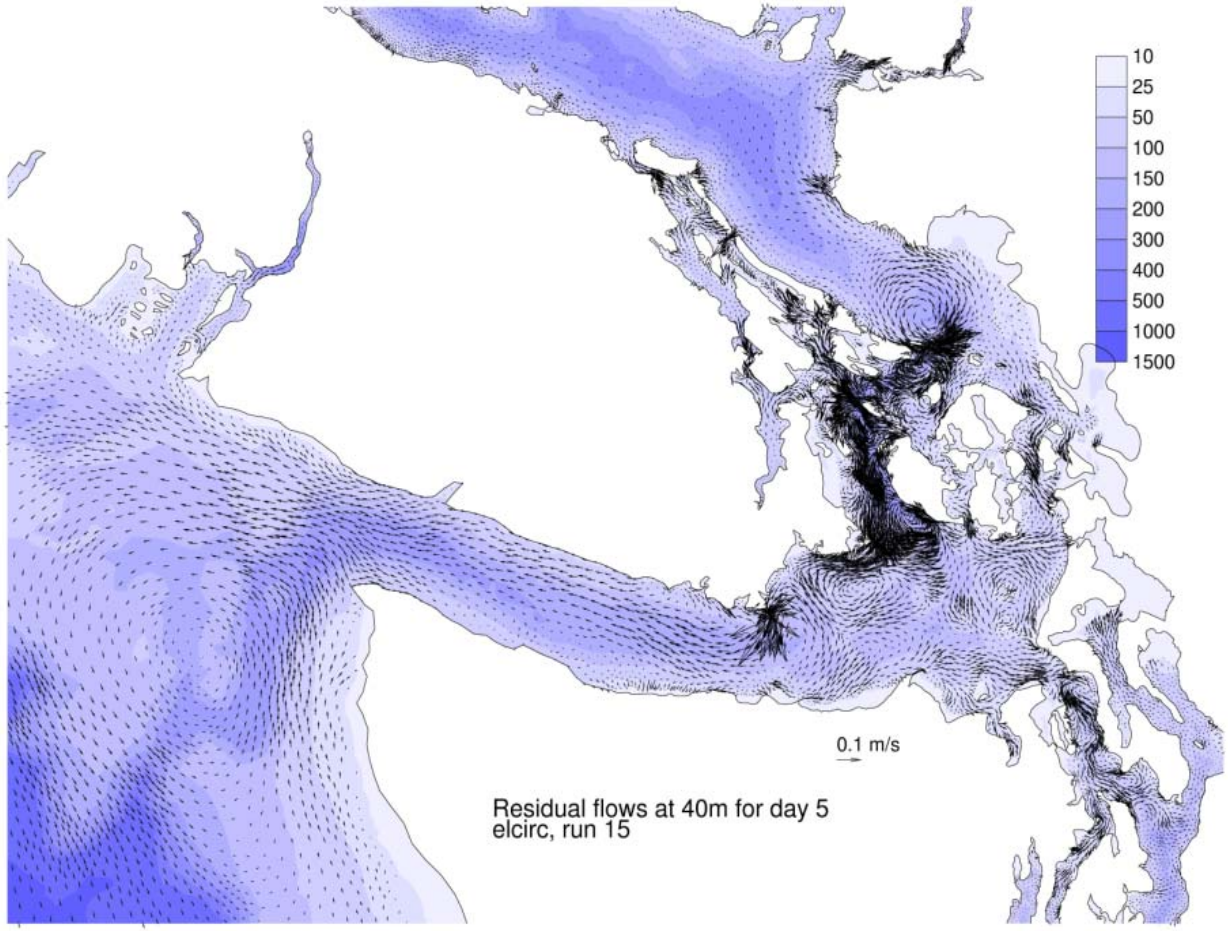

Residual flows at 4m for day 5
elcirc, run 15
10
25
50
100
150
200
300
500
1000
1500
2850
0.1 m/s

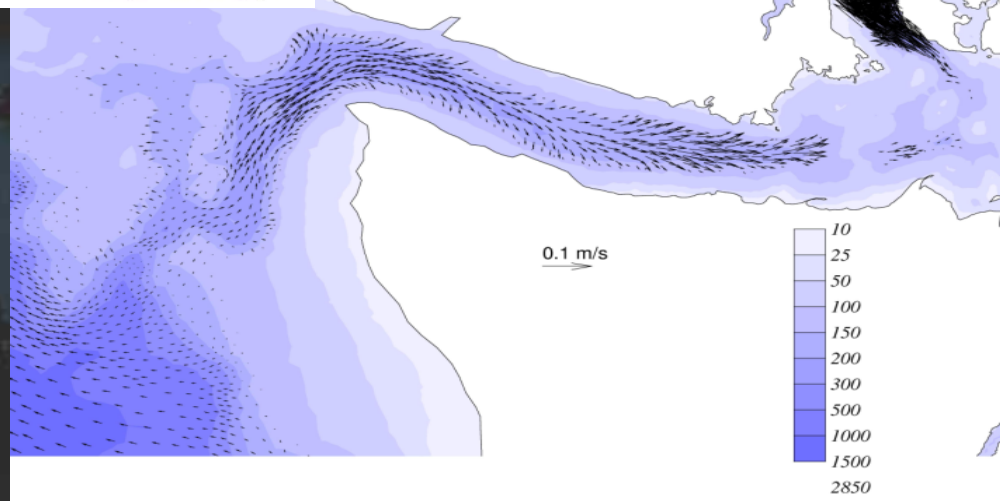


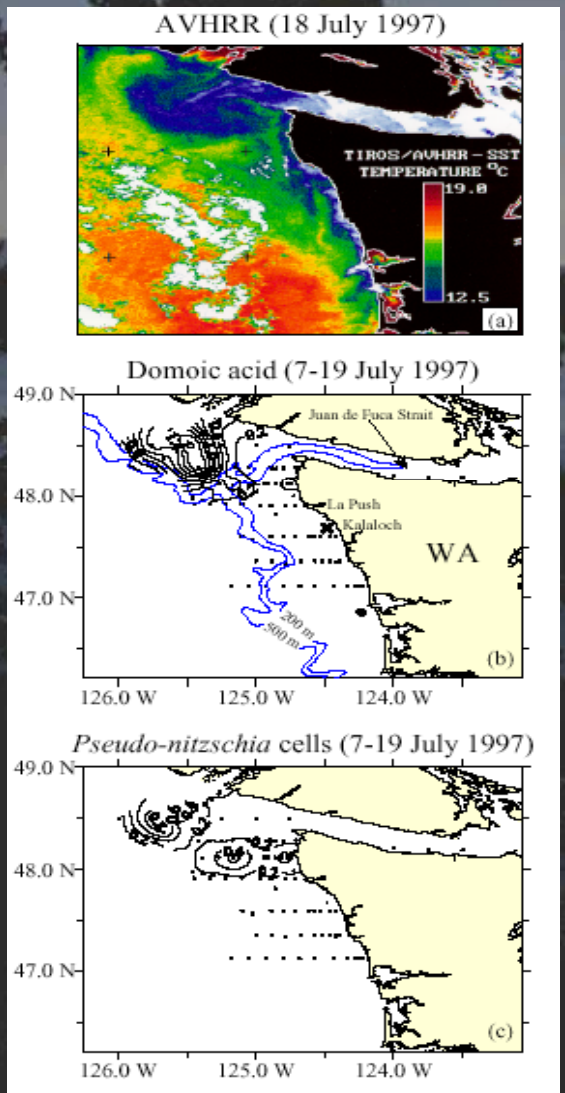

day 5 residual flows at 160m
elcirc, run 15


10
25
50
100
150
200
300
500
1000
1500
2850
0.1 m/s
Residual flows at 4m for day 5
elcirc, run 15


10
25
50
100
150
200
300
400
500
1000
1500
0.1 m/s
Residual flows at 40m for day 5
elcirc, run 15


day 5 residual flows at 160m
elcirc, run 15
0.1 m/s
10
25
50
100
150
200
300
500
1000
1500
2850

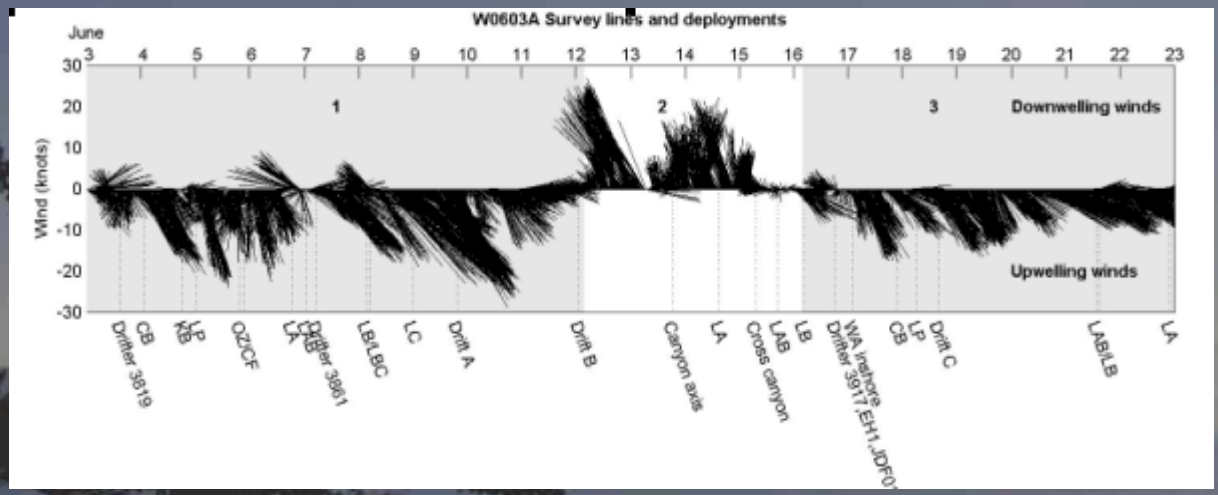
# 2. Harmful Algal Blooms off the Washington coast



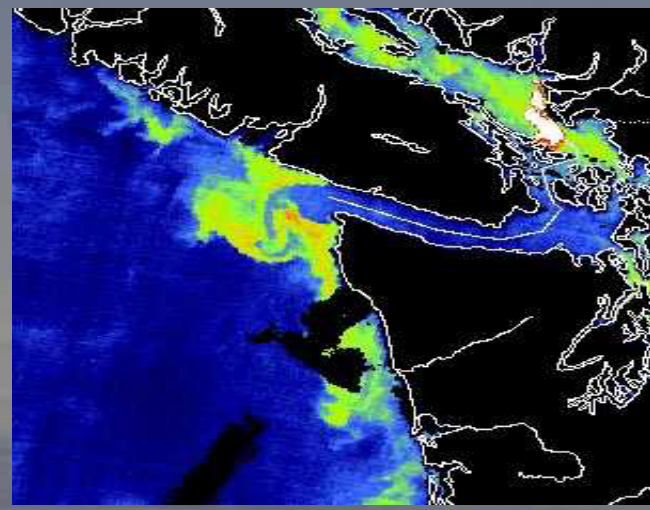

- Juan de Fuca Eddy is a summer upwelling feature off the entrance of Juan de Fuca Strait
  - Tully (1942), Freeland & Denman (1982) & others
  - may be the initiation site for toxic pseudo-nitzschia that cause harmful algal blooms impacting clams & crabs along the Washington coast
- ECOHAB PNW: multi-disciplinary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

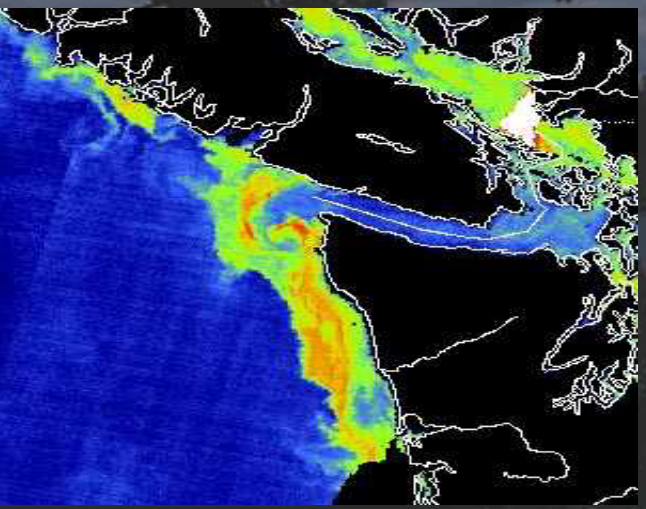
# June 2003 Fluorescence (chlorophyll) from MERIS

## ship winds

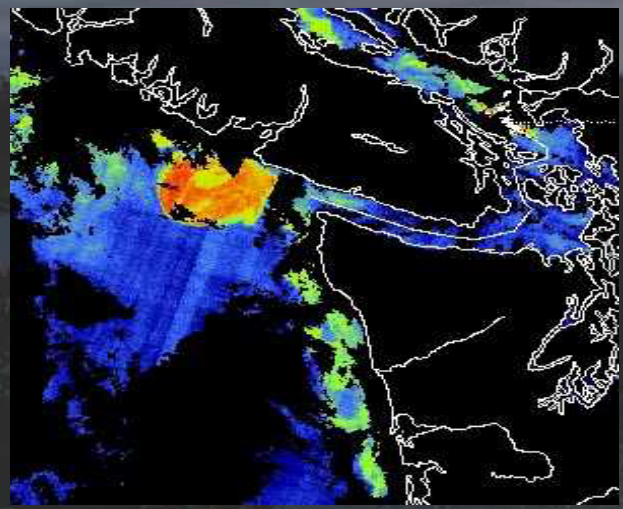



## June 3

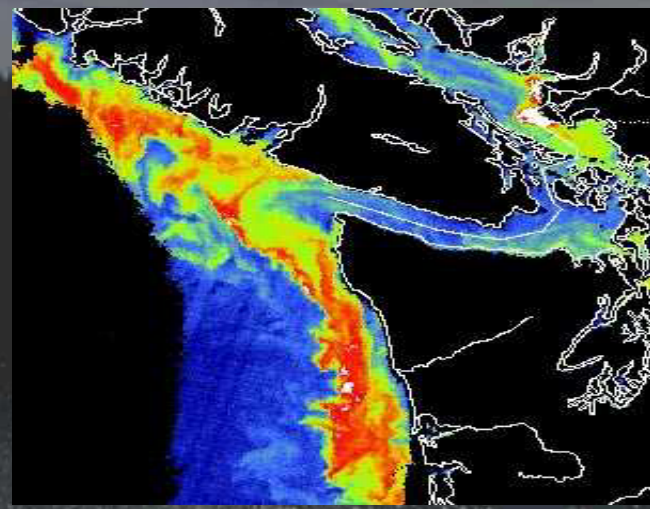




## June 6



## June 15

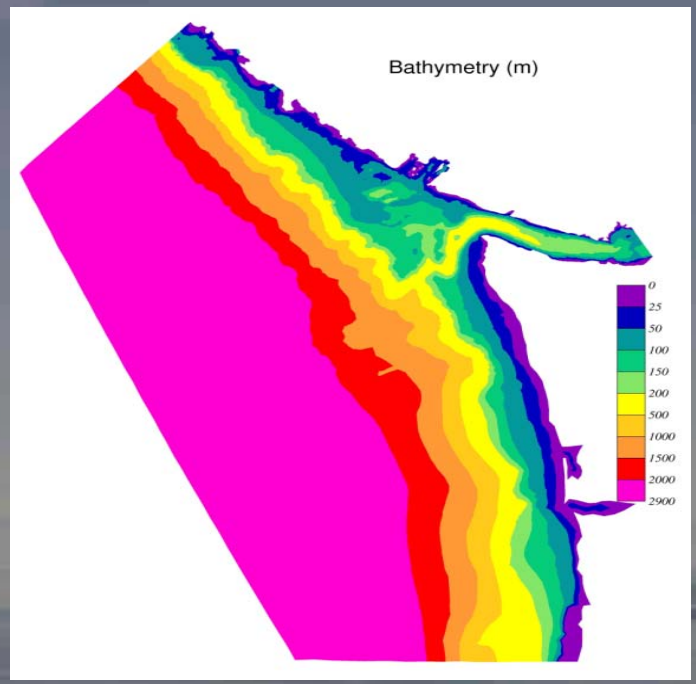


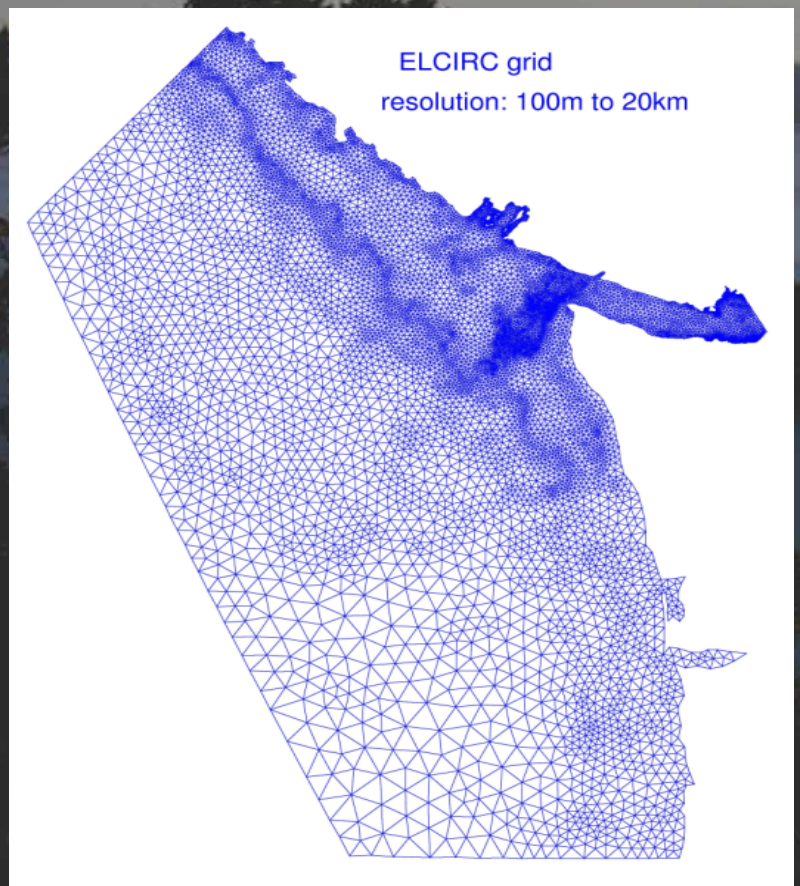
## June 28

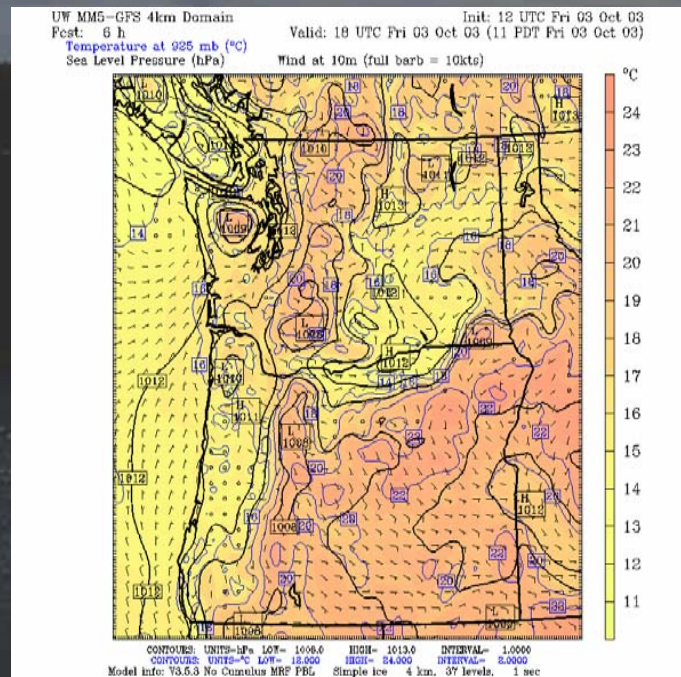
Satellite images courtesy of Jim Gower & Steph King

# June 2003 Simulation

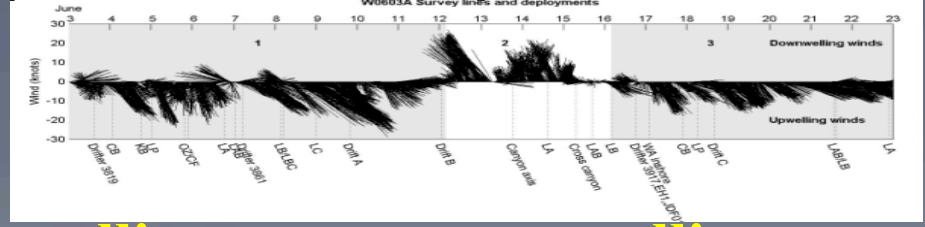
- 10.8K nodes
- 40 level surfaces
- winds from UW MM5 model (4 km)
  - no surface heat flux
- initial TS from climatology & boundary
  TS nudged back to initial values
- 4 tidal constituents



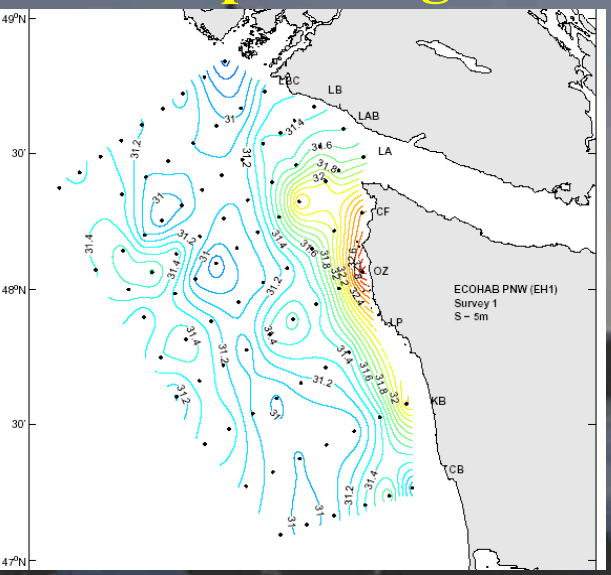



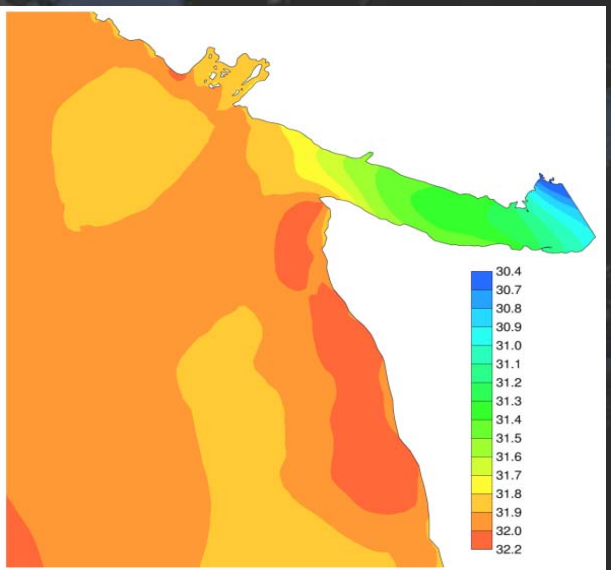



# Preliminary Results
# Salinity at 5m

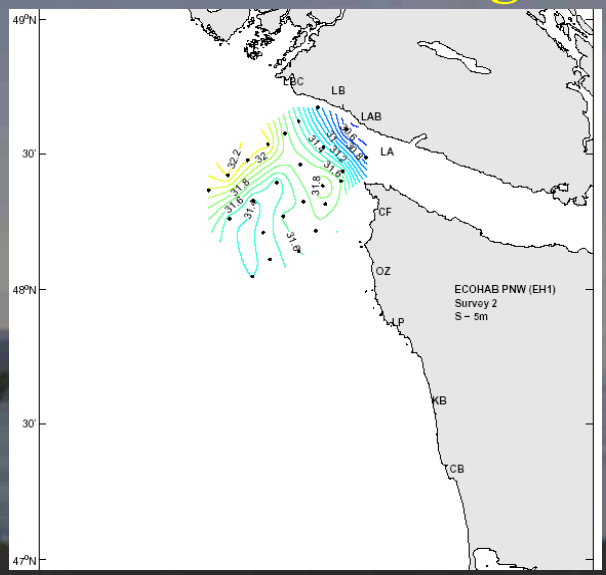


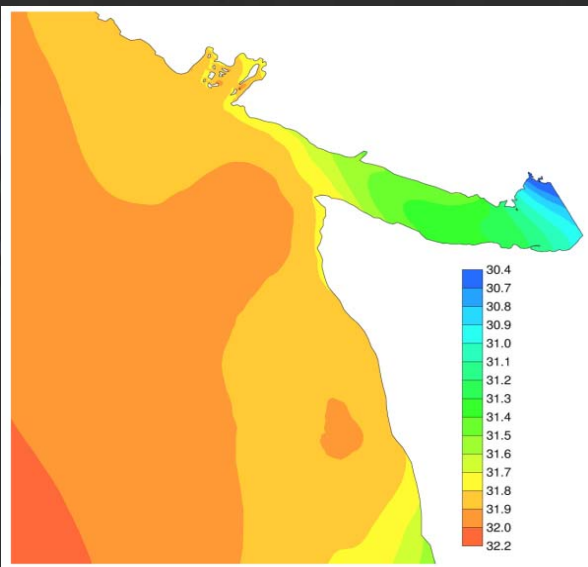

## upwelling



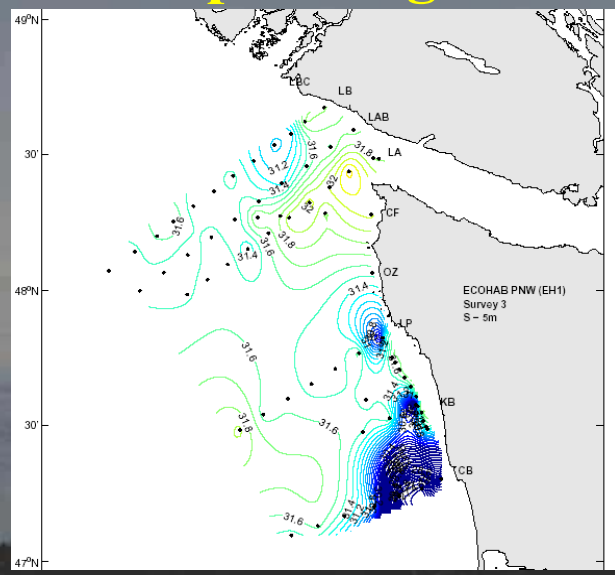



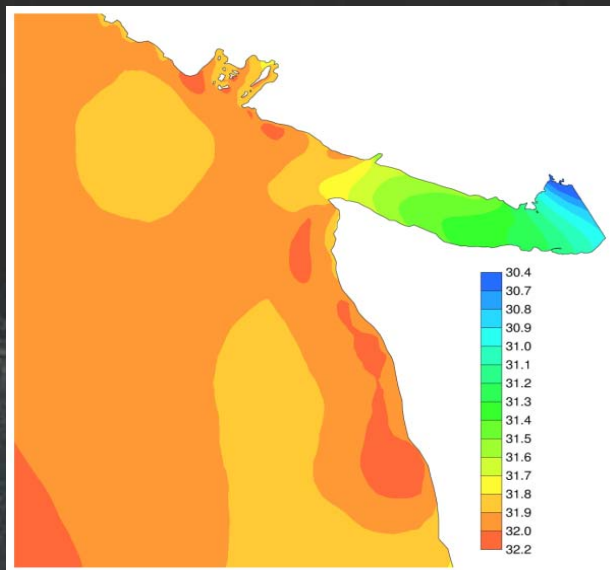

## downwelling



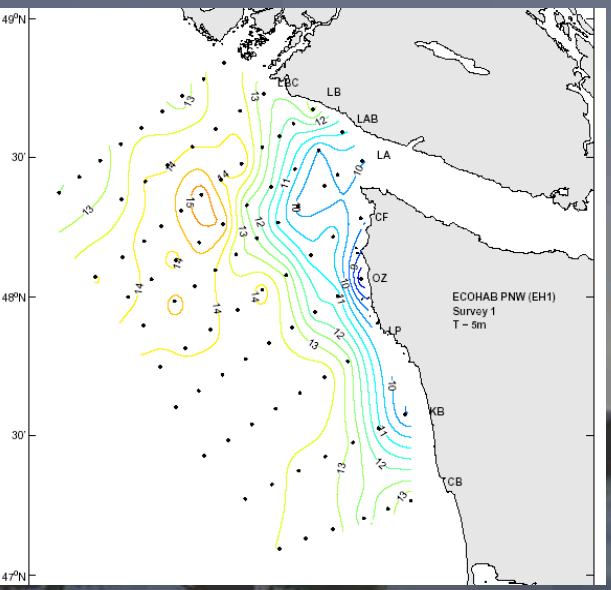

## upwelling

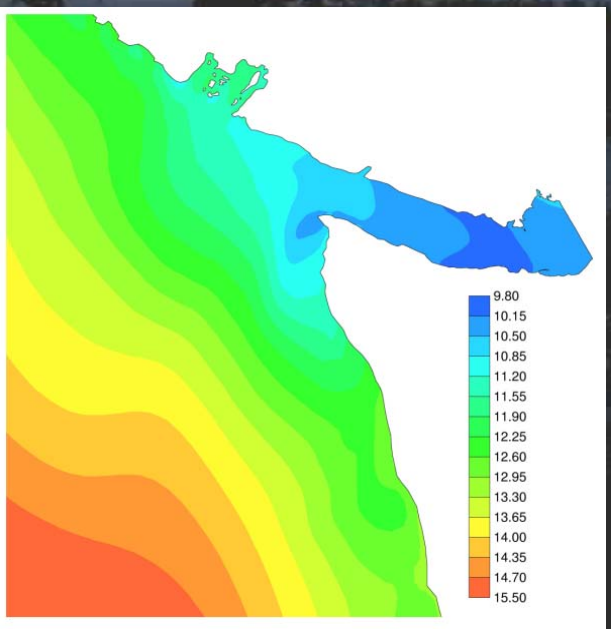


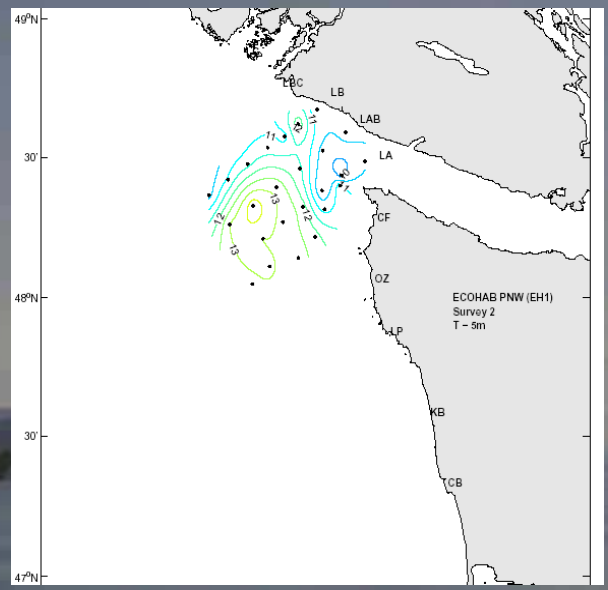
# Temperature at 5m

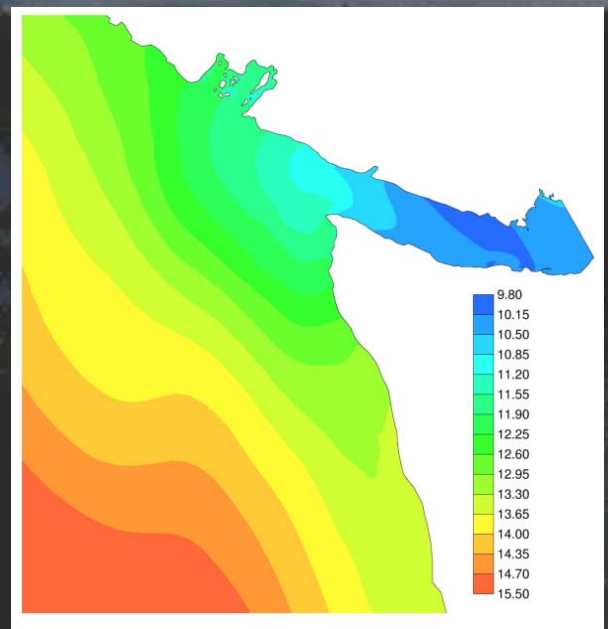
## upwelling



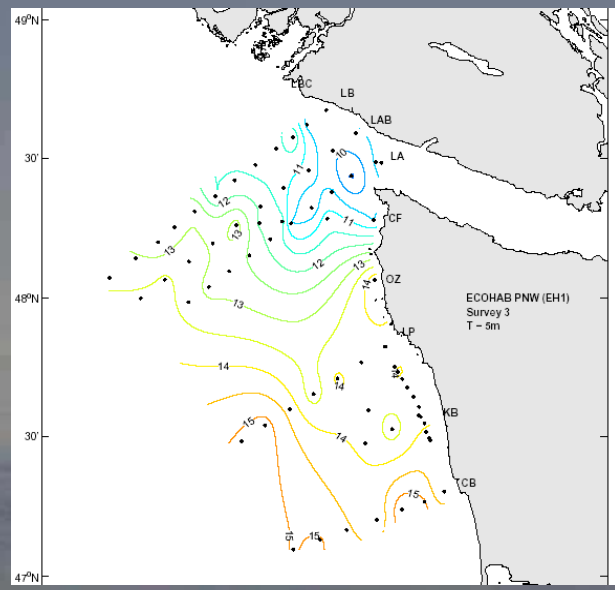



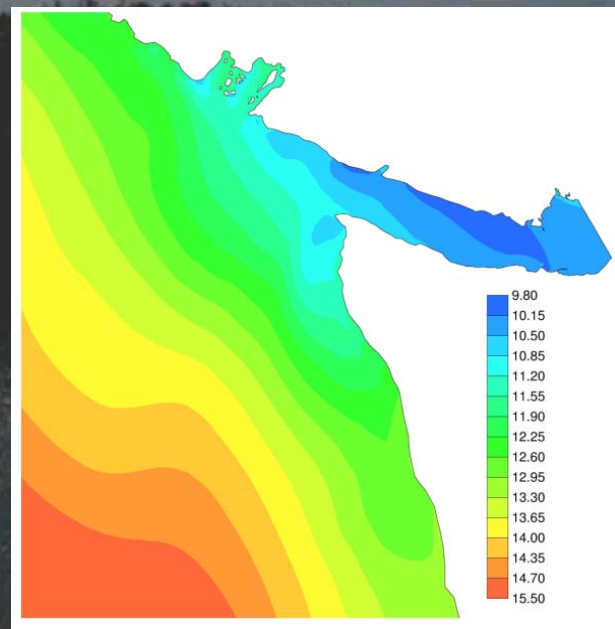

## downwelling



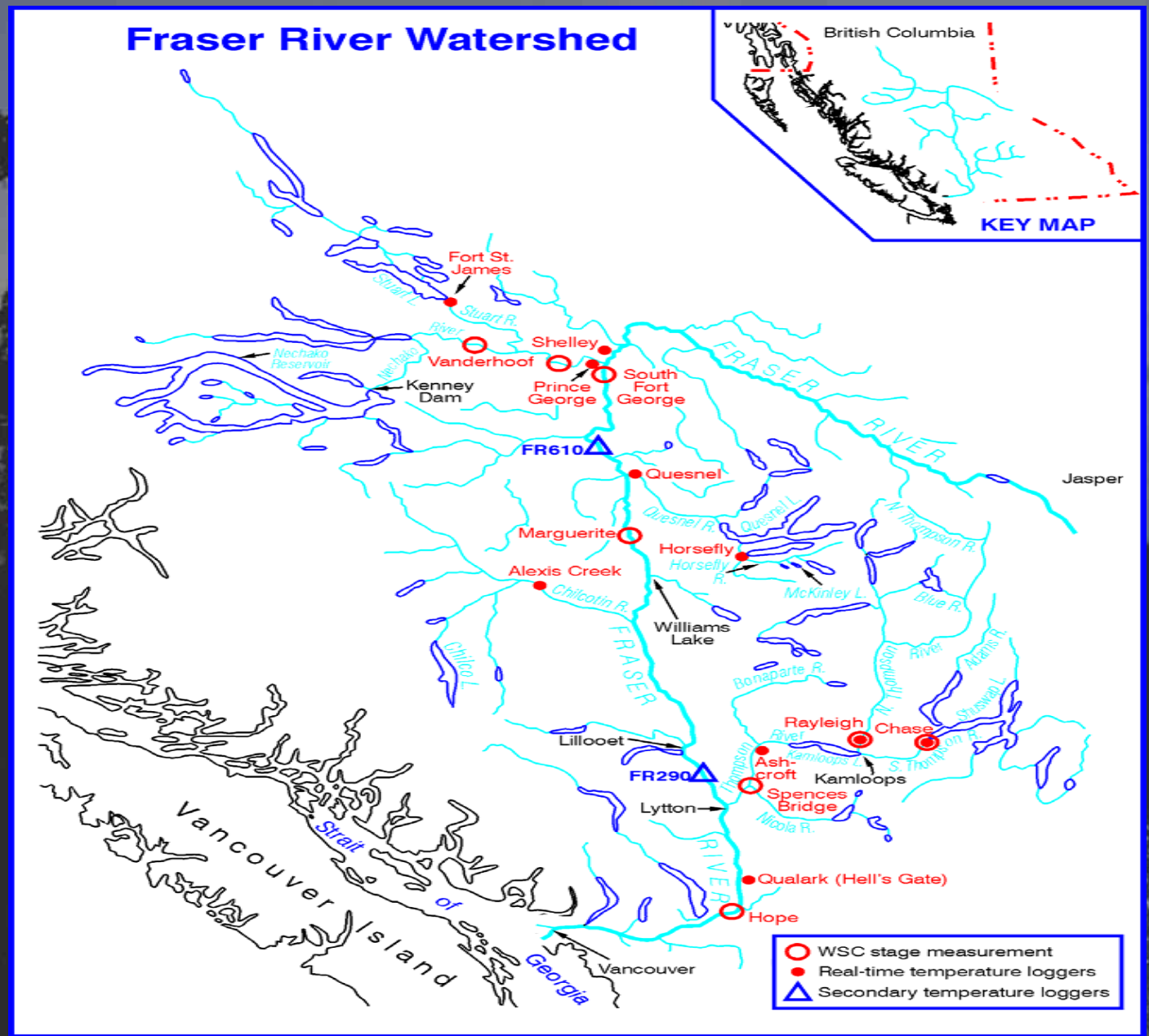




## upwelling

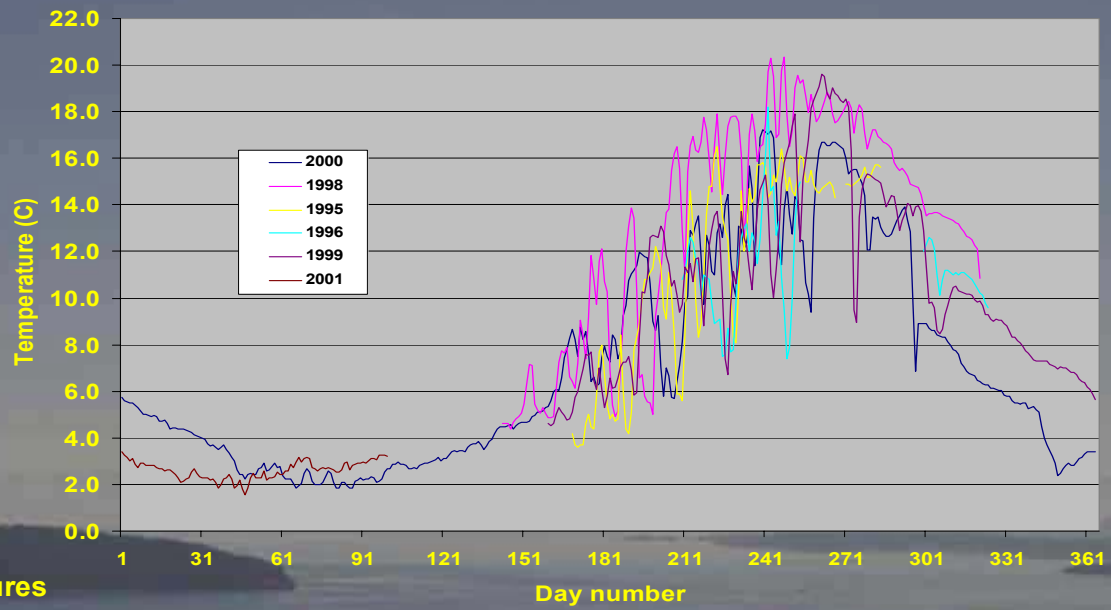


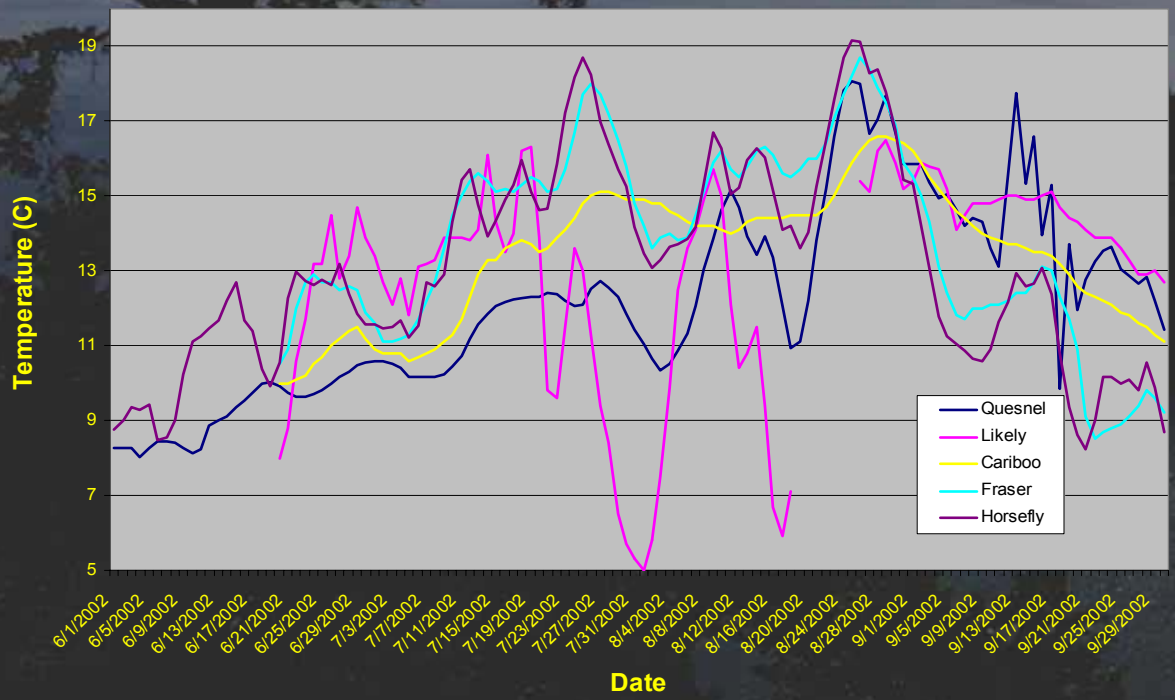



# 3. Temperature Oscillations in Quesnel River & Lake

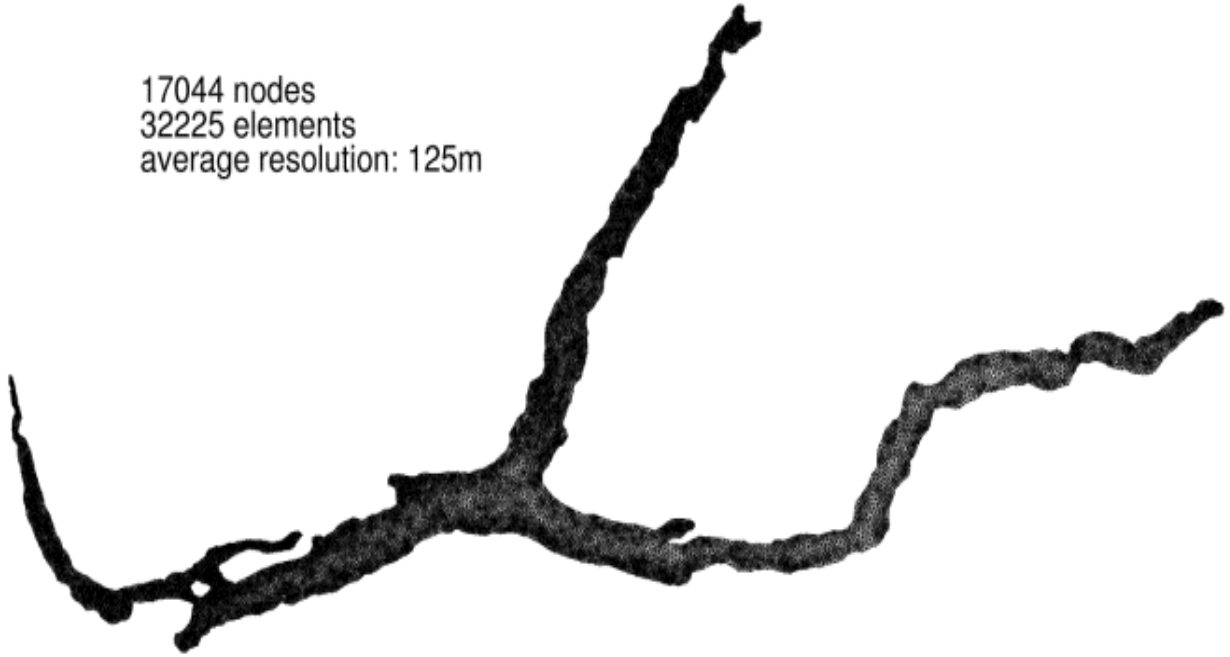


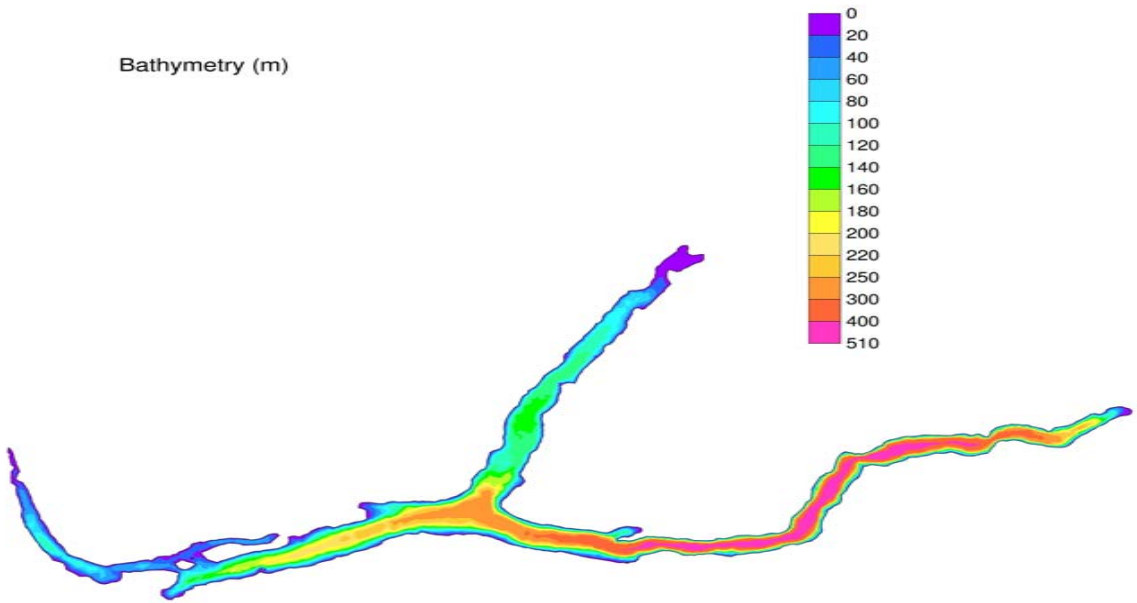
# Motivation


Mean Temperature at Likely
Temperature (C)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1
31
61
91
121
151
181
211
241
271
301
331
361
Day number
2000
1998
1995
1996
1999
2001

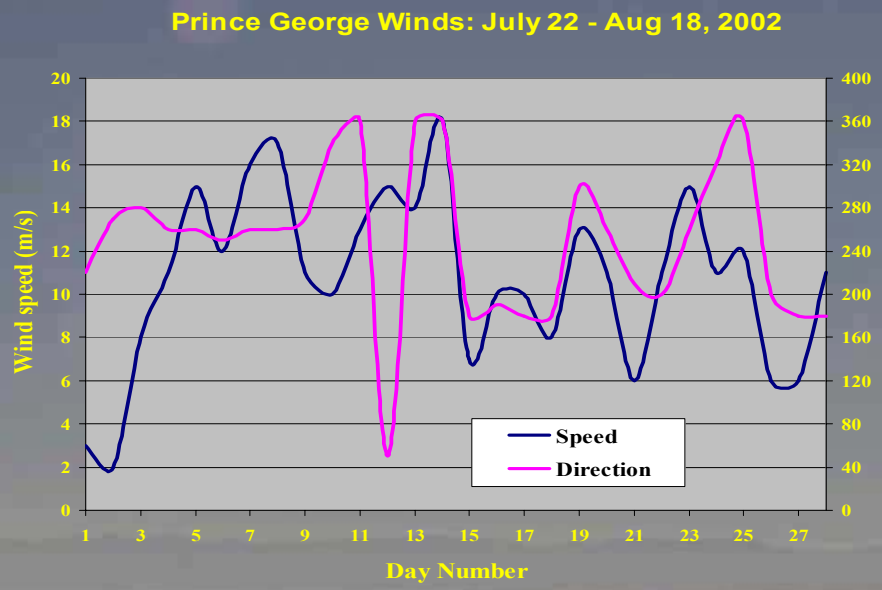

2002 Water temperatures
Temperature (C)
19
17
15
13
11
9
7
5
6/1/2002
6/5/2002
6/9/2002
6/13/2002
6/17/2002
6/21/2002
6/25/2002
6/29/2002
7/3/2002
7/7/2002
7/11/2002
7/15/2002
7/19/2002
7/23/2002
7/27/2002
7/31/2002
8/4/2002
8/8/2002
8/12/2002
8/16/2002
8/20/2002
8/24/2002
8/28/2002
9/1/2002
9/5/2002
9/9/2002
9/13/2002
9/17/2002
9/21/2002
9/25/2002
9/29/2002
Date
Quesnel
Likely
Cariboo
Fraser
Horsefly

# Model Grid & Bathymetry



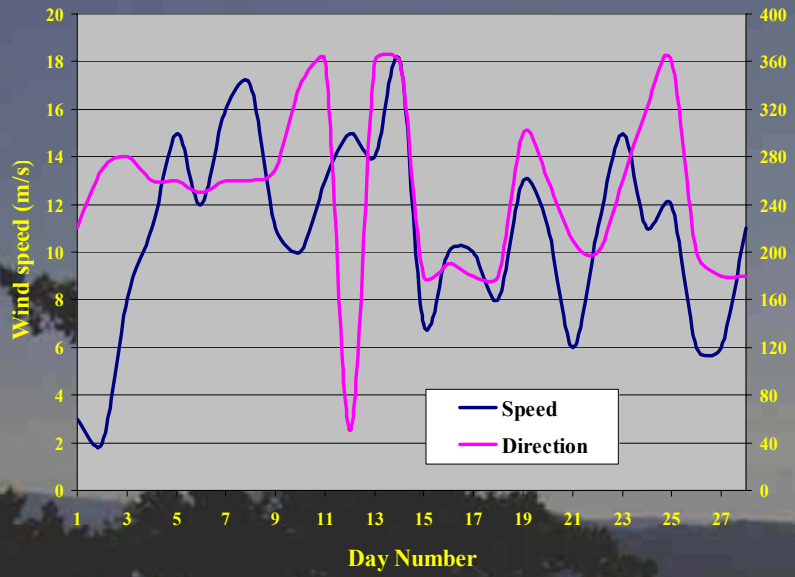




# Preliminary Run

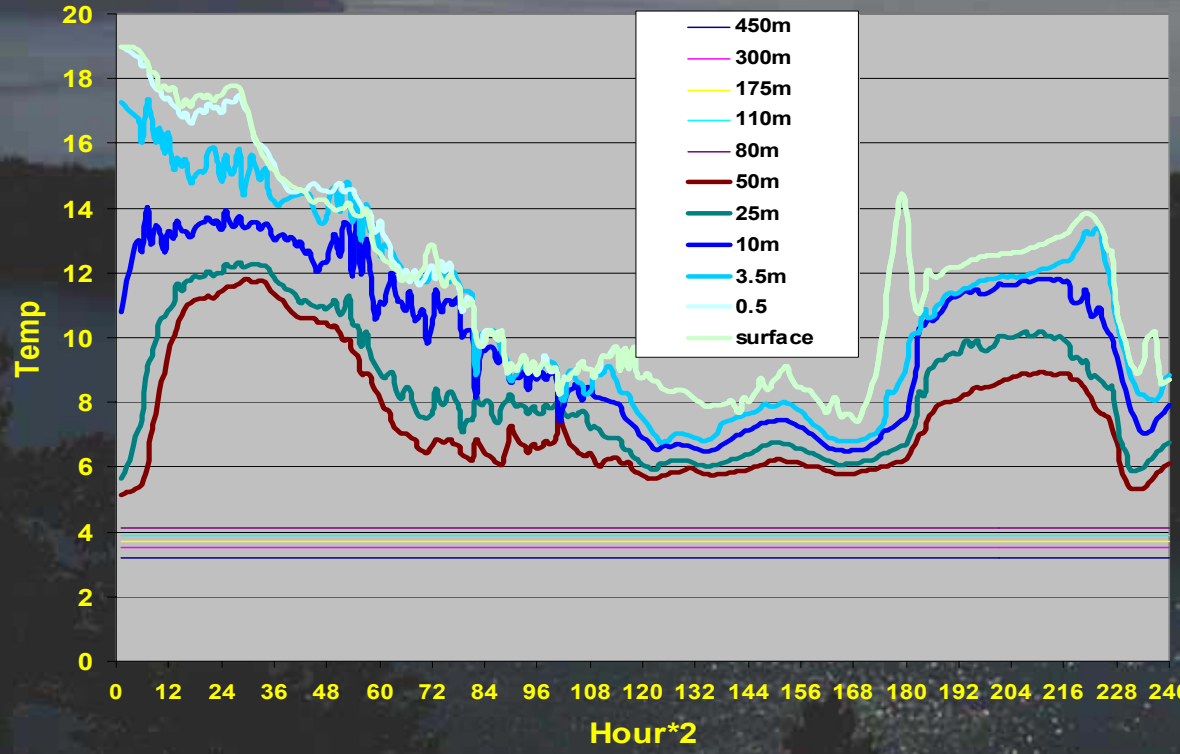



- Initial vertical temp profile from 2003 thermistor data
- River discharges: Likely, Horsefly, Mitchell, Niagara
- Forcing = July 22 – Aug 10, 2002 Prince George winds
- Nudged surface temp back to initial values with 12hr e-folding time scale
- $\Delta t$=10min
- Vertical viscosity & horizontal/vertical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

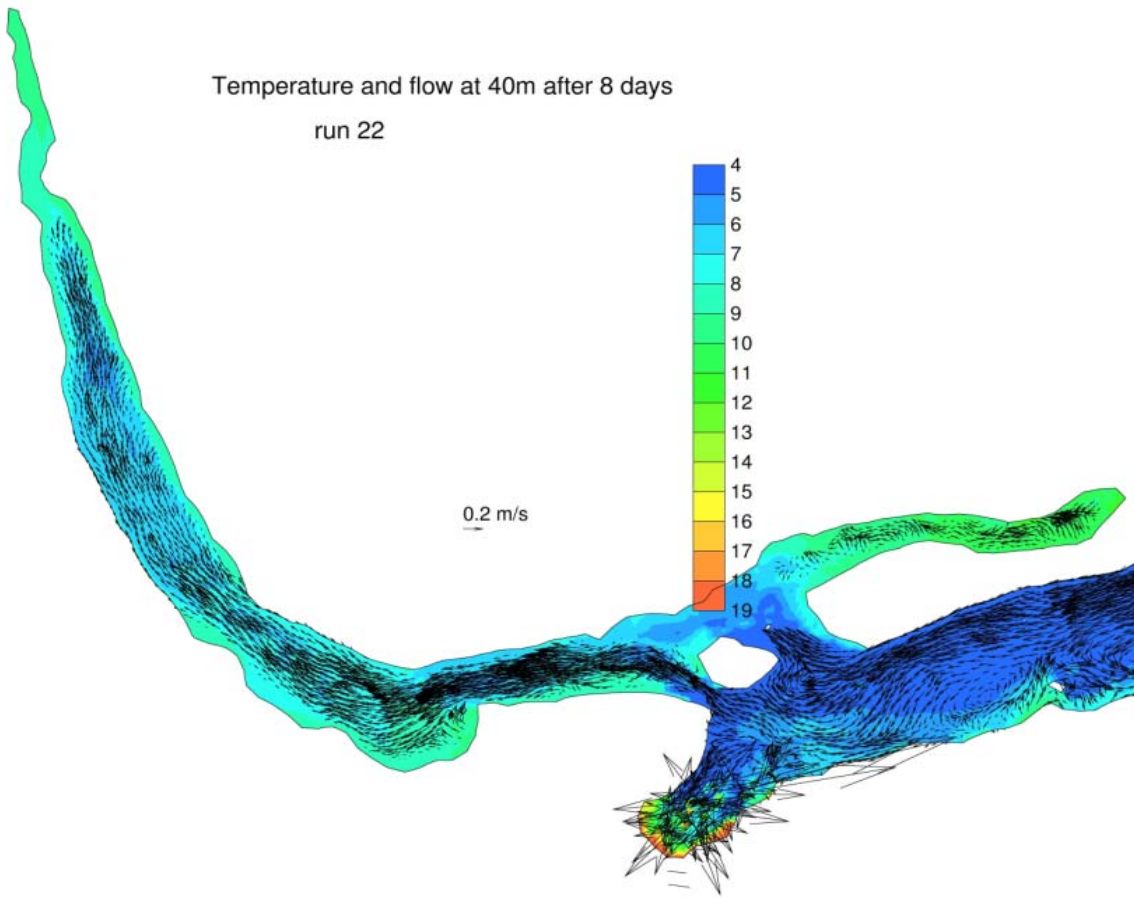
## Prince George Winds: July 22 - Aug 18, 2002

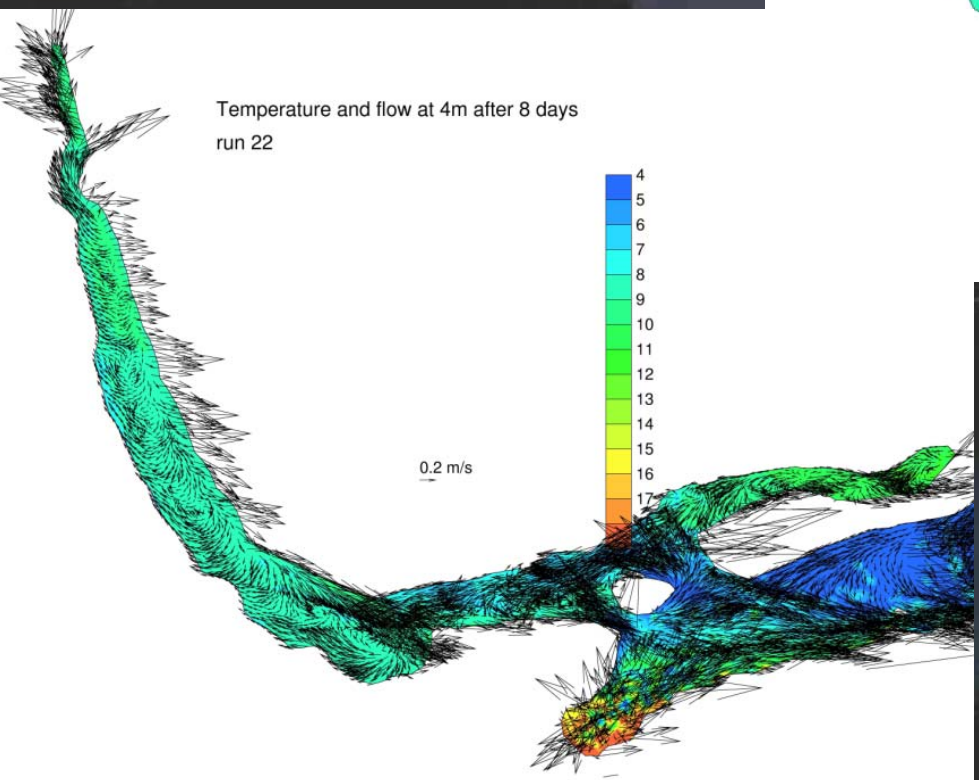



## Temperature Profile at node 7047, run 22, July 22 - Aug 18



# Results


Temperature and flow at 40m after 8 days
run 22
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0.2 m/s


Temperature and flow at 4m after 8 days
run 22
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0.2 m/s

# 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)