ADCP Measurements in the Discovery Islands, British Columbia, Canada

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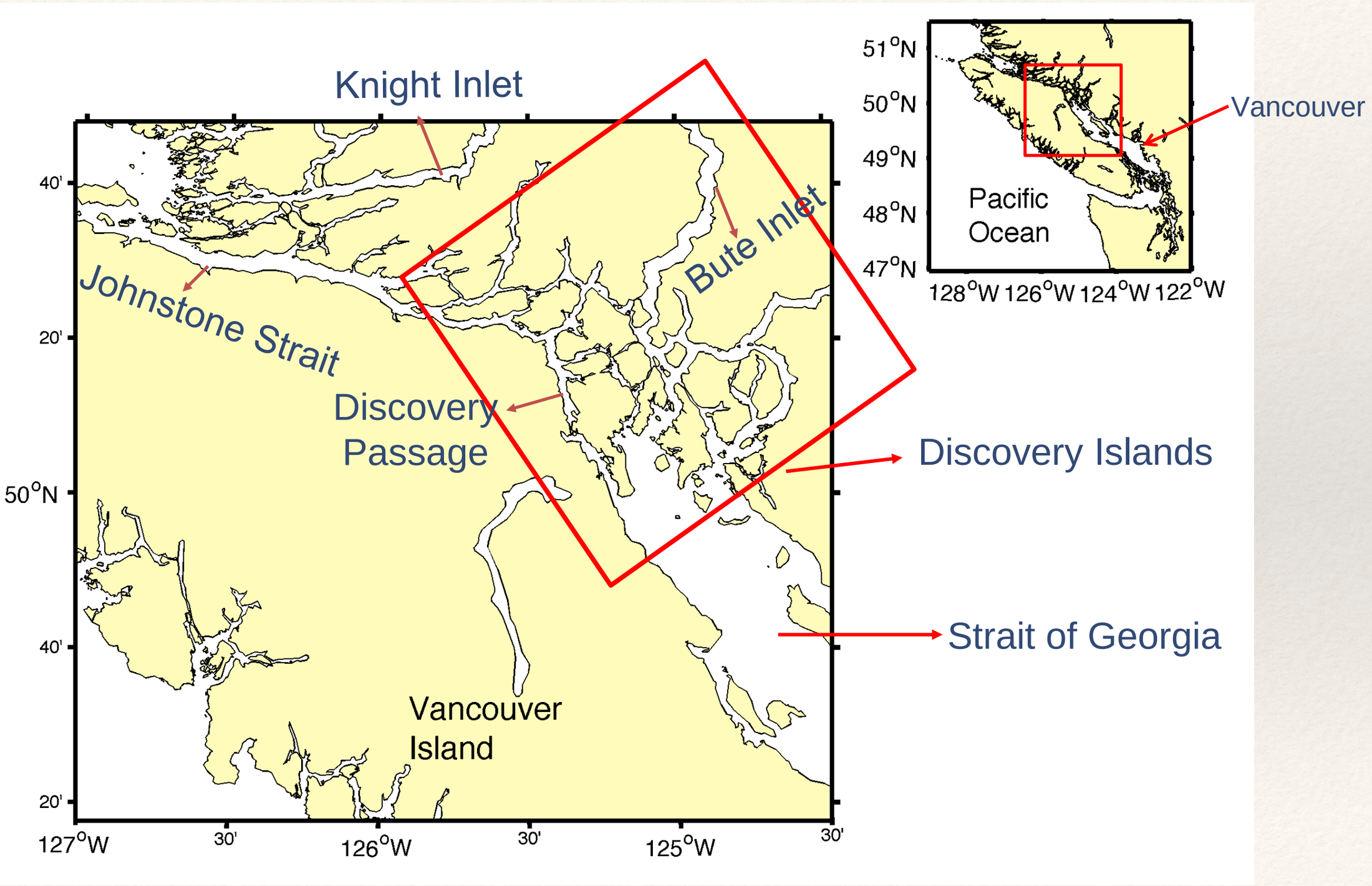
Discovery Islands



OUTLINE

1. Project motivation
2. ADCP deployments
3. Sub-tidal circulation preliminary results
4. Summary & continuing work

Project Motivation

Important region shared by migrating wild salmon and farmed finfish.

Environmental, economic and cultural imperative to understand wild and farmed fish interactions and to manage the aquaculture industry.

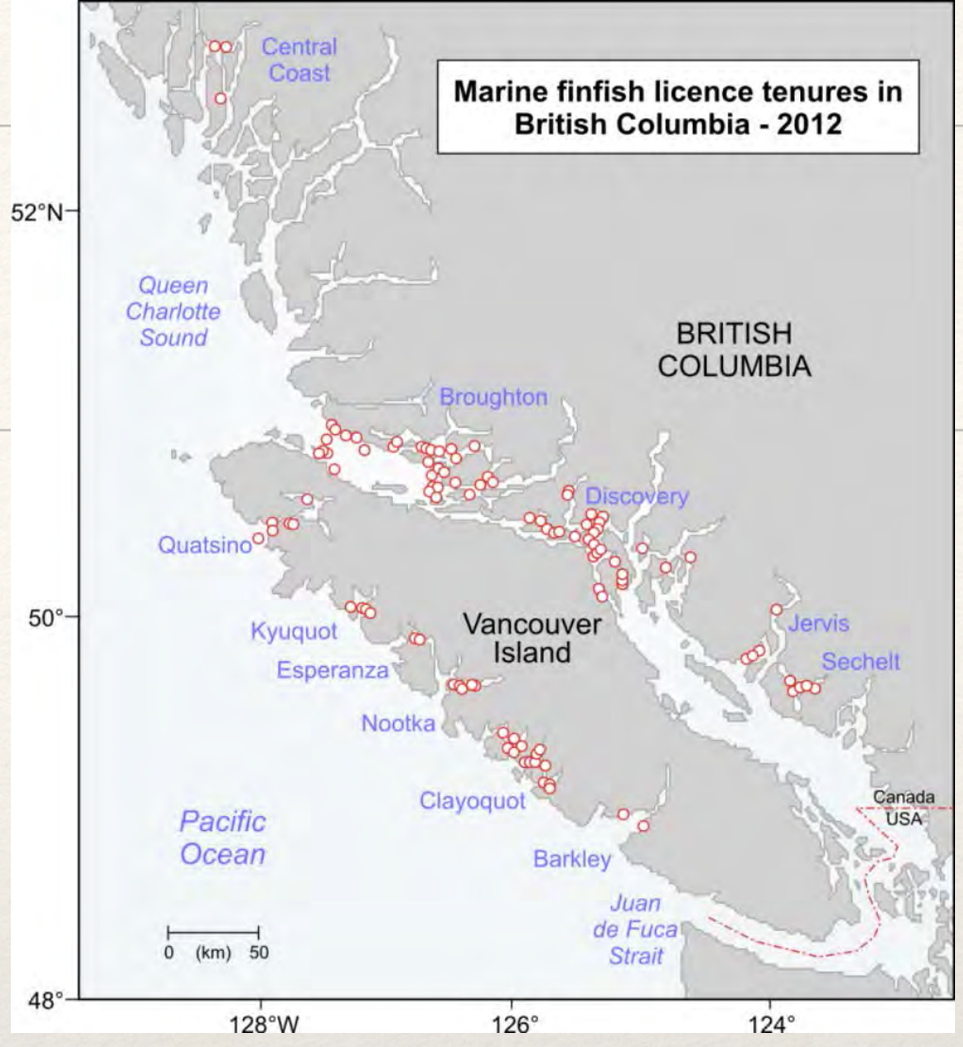
Open net-pen farms with free exchange of pathogens/disease with surrounding waters

Several disease outbreaks have occurred in the Discovery Islands in 2001-03:

- *26 farm sites infected*
- *12 million fish died or were culled*
- *$10Ms in lost revenues*

Develop a model to study pathogen transmission among farms & to wild salmon.

Observations required to force and evaluate the model.



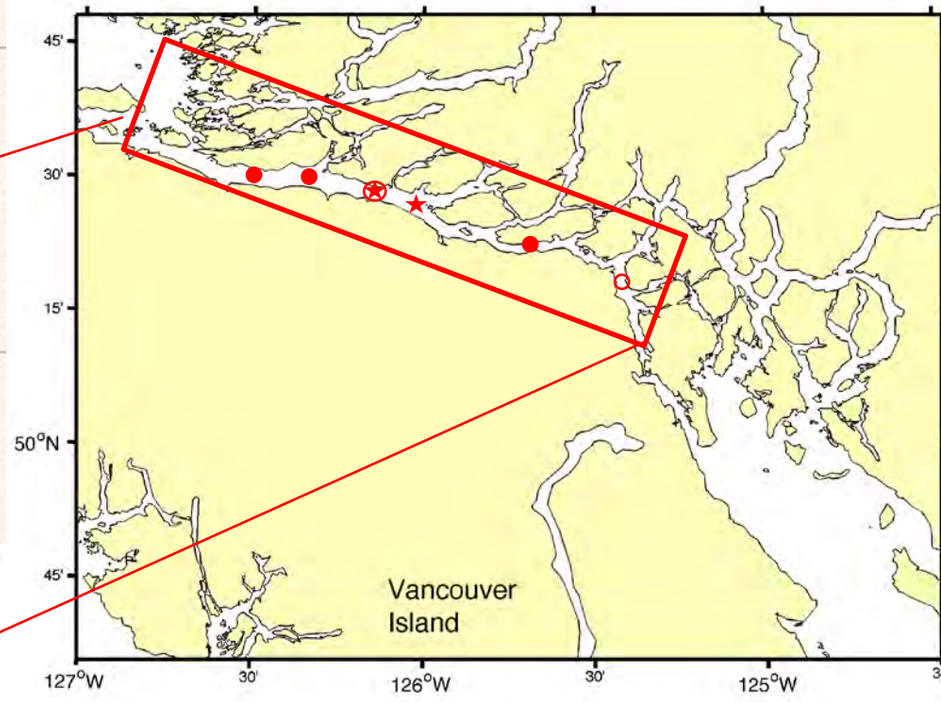
Observational challenge:

Very strong tidal currents: few direct current observations until recently

Maximum values from Canadian Tide and Current Tables Canadian Hydrographic Service, FOC

Previous work

Mean surface flows westward in Johnstone Strait



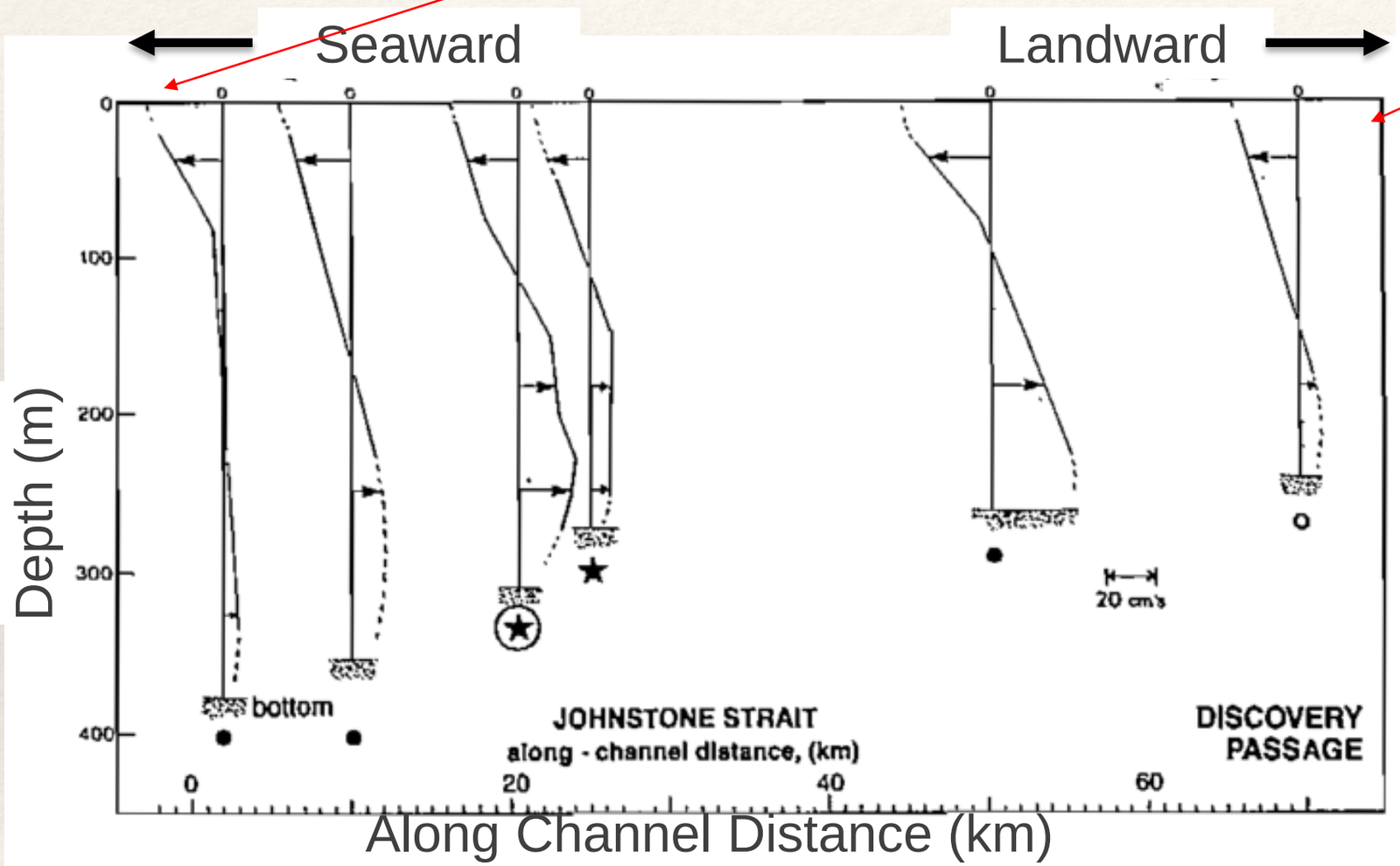
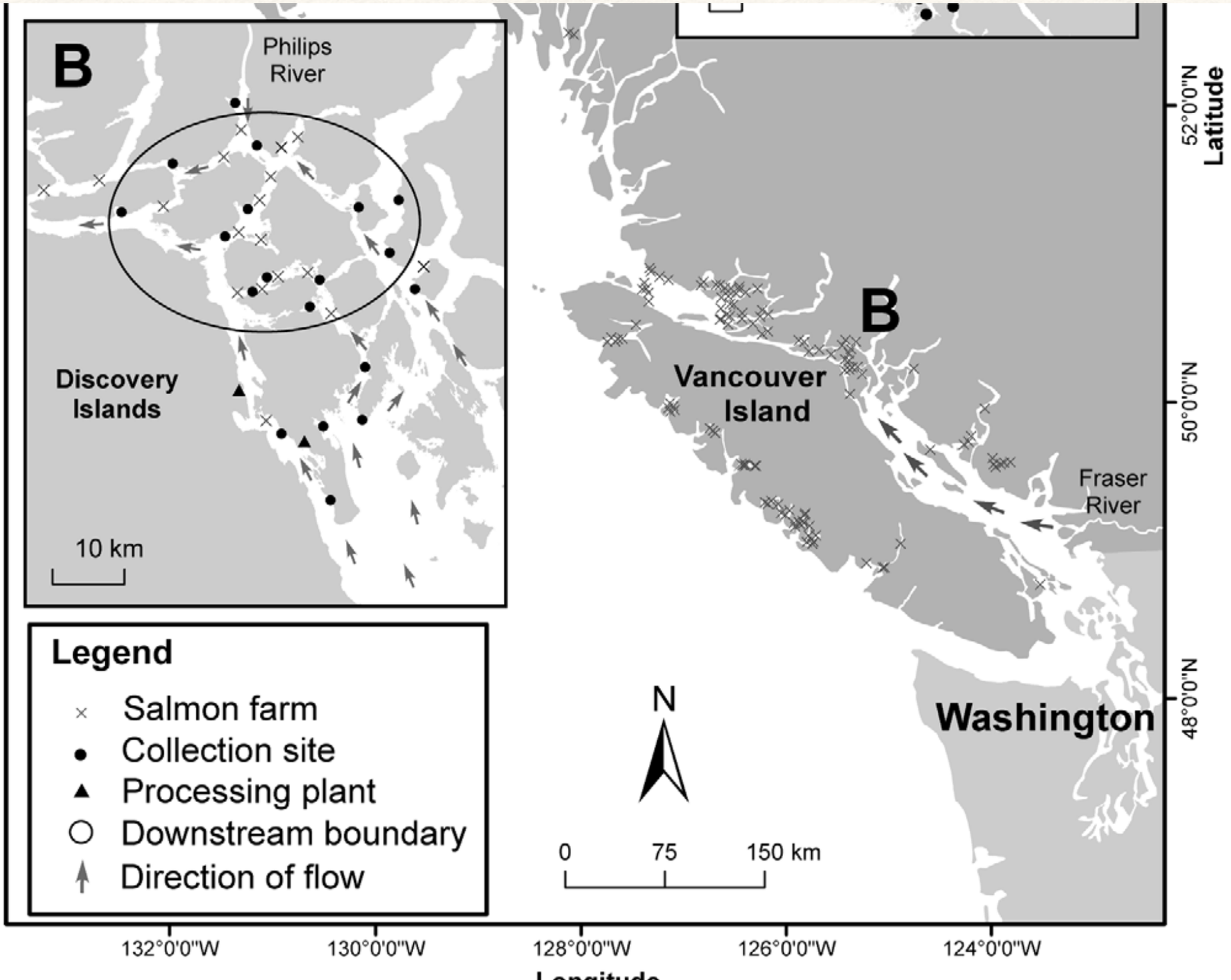


FIG. 12.10. mean flow profiles at various locations in Johnstone Strait and Discovery Passage. Symbols correspond to Fig. 12.2. Resultant currents are westward in upper layer, eastward in lower layer. Speeds obtained by measuring horizontally from vertical axis and comparing to scale.

- *Westward surface estuarine flow*
- *Eastward bottom return flow*
- *Freshwater from Strait of Georgia & Discovery Islands sources*
- *Thomson (JPO,1981)*

Commonly-held wisdom ?

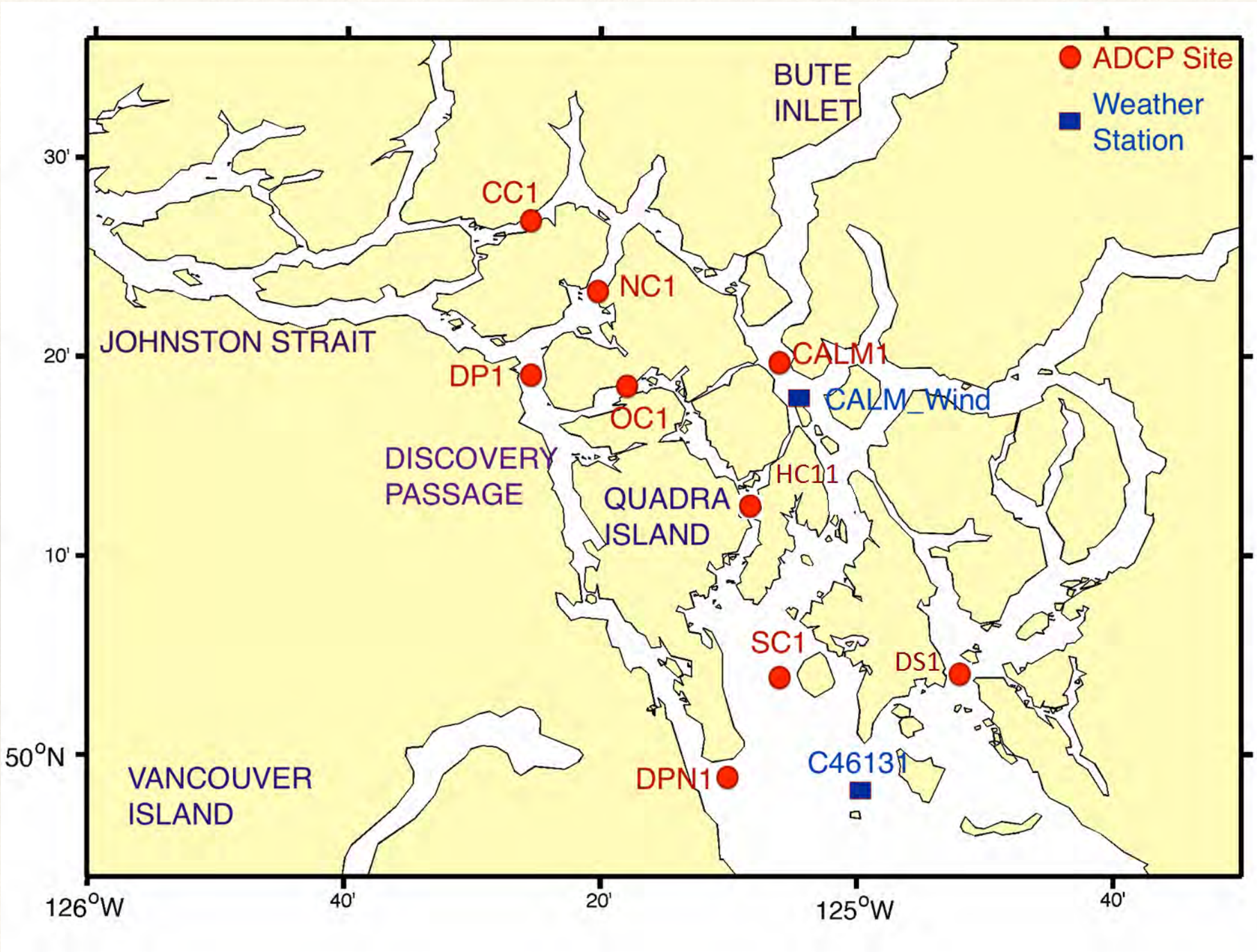


Fraser River freshwater discharge (annual average ~3000 m³/s) drives northward surface estuarine flows through all channels in Discovery Islands

Price et. al, (PloS ONE, 2011

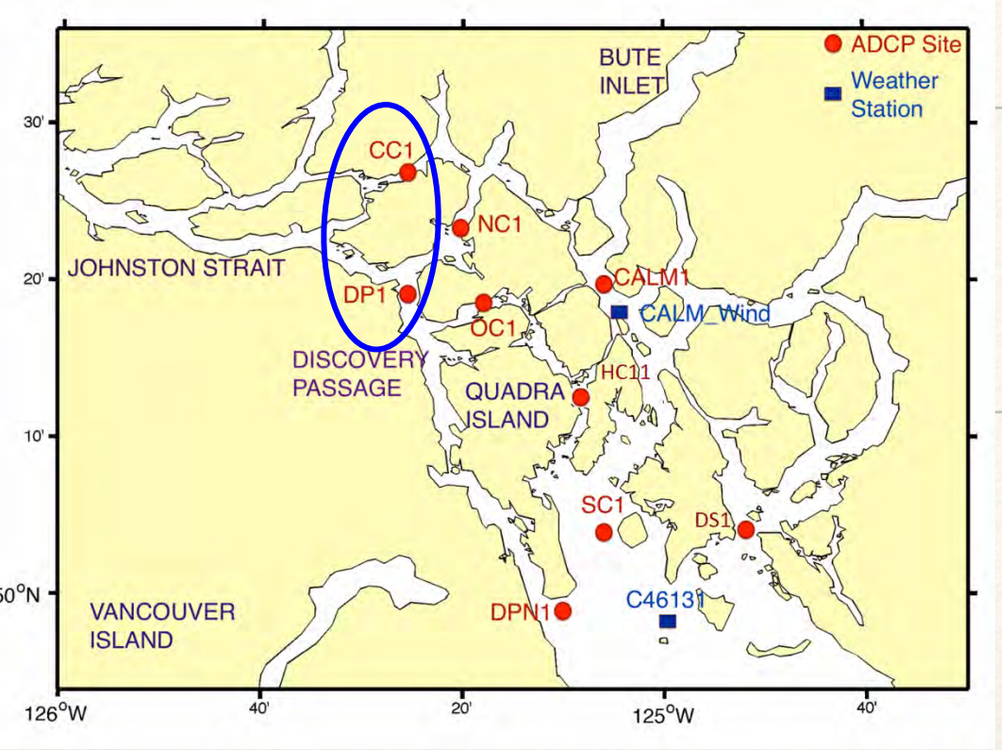
2010-15 ADCP & Select Wind Station Locations

- 2-3 simultaneous ADCP deployments since 2010
- Typically for 1-2 years then moved
- 1-3 upward looking instruments with different frequencies
- Typically 1 ADCP on bottom & another at 40-50m depth

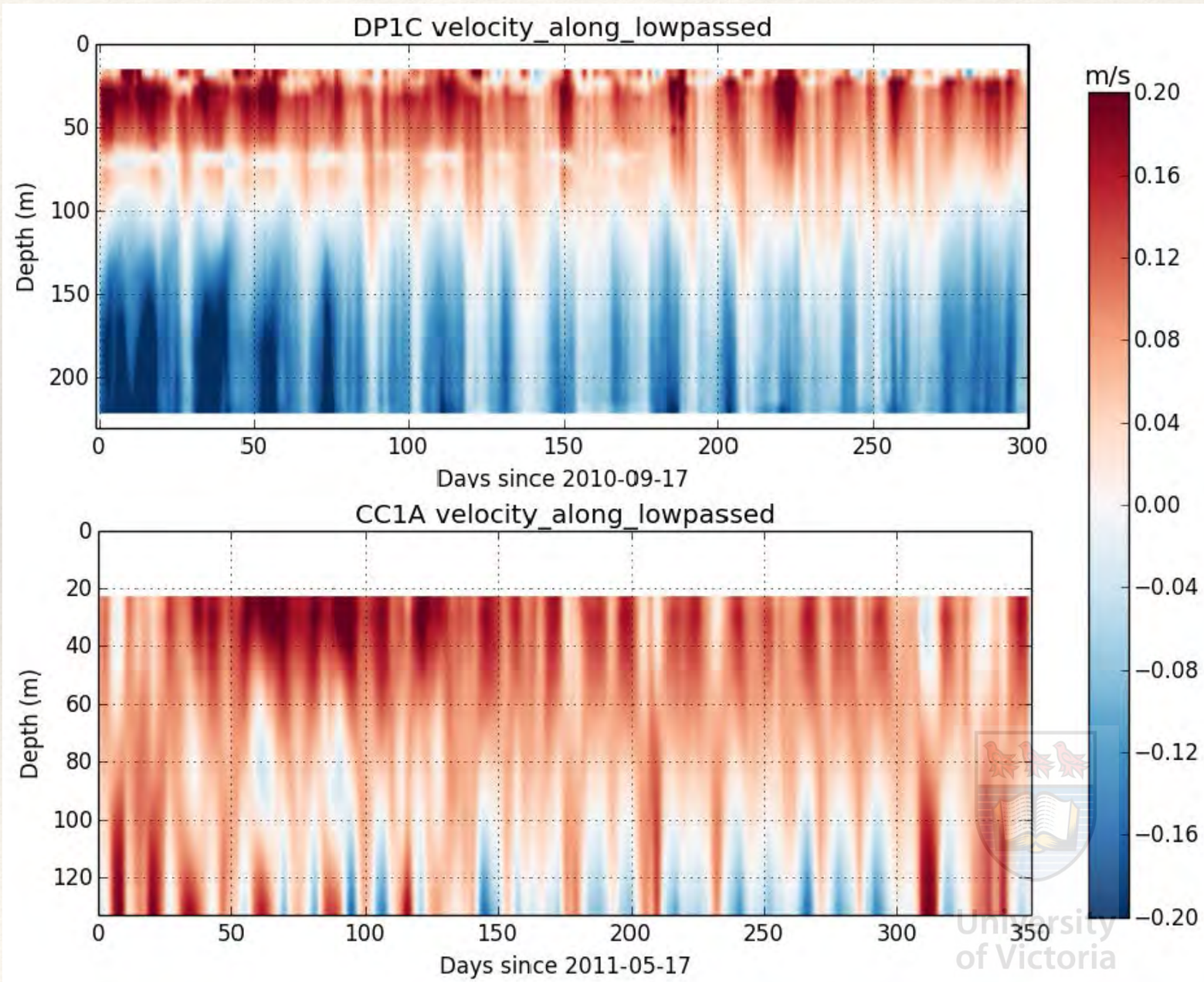


Network of temporary wind stations provided atmospheric forcing data

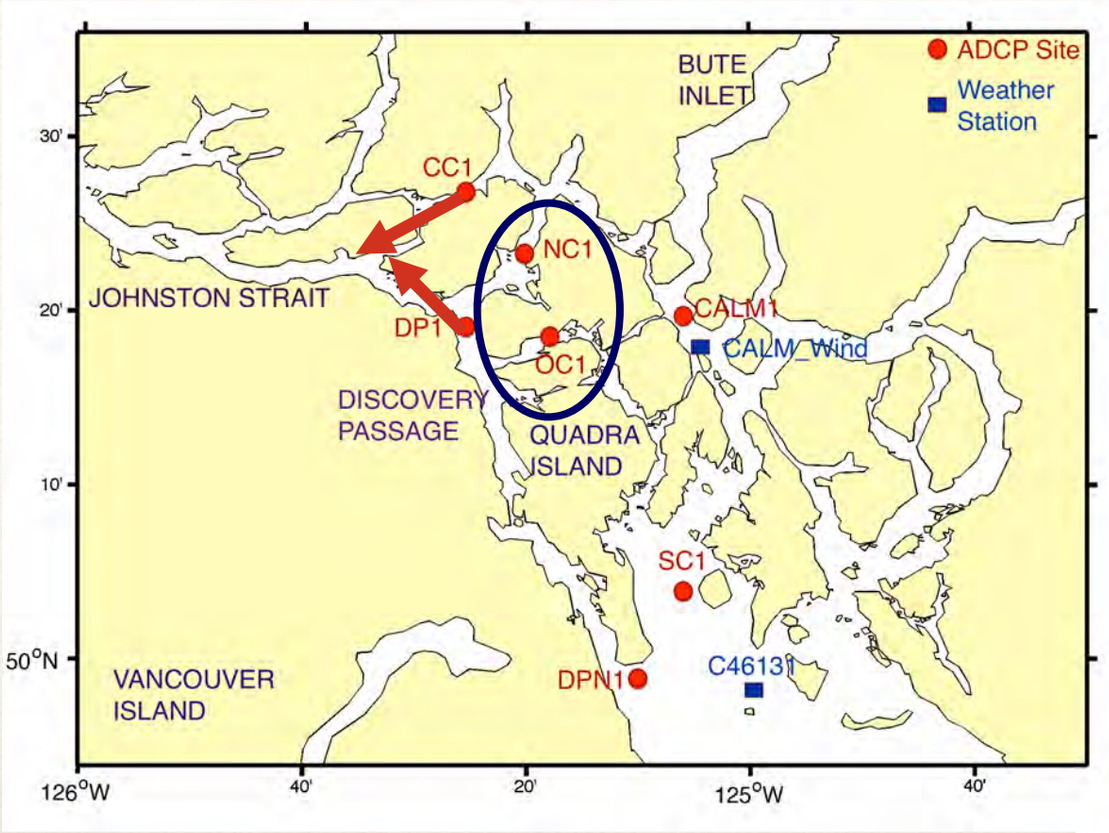
DP1 and CC1 along-channel sub-tidal flows



- Low-pass filtered to remove tides
- DP1C positive is northward
- CC1A positive is westward
- both agree with conventional wisdom
- Note spring-neap modulation of 2-layer thicknesses

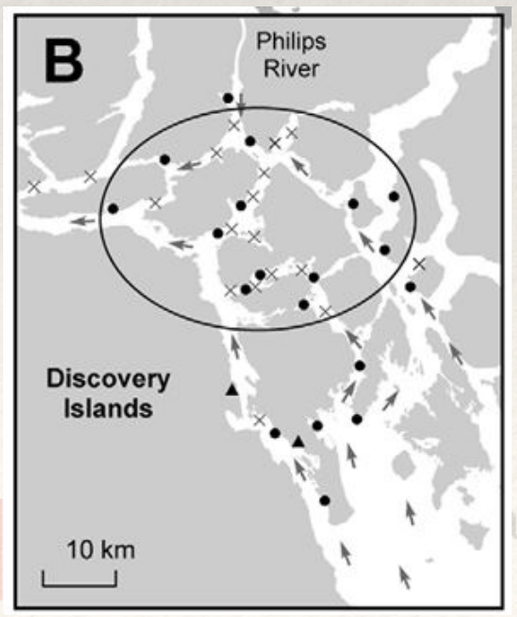


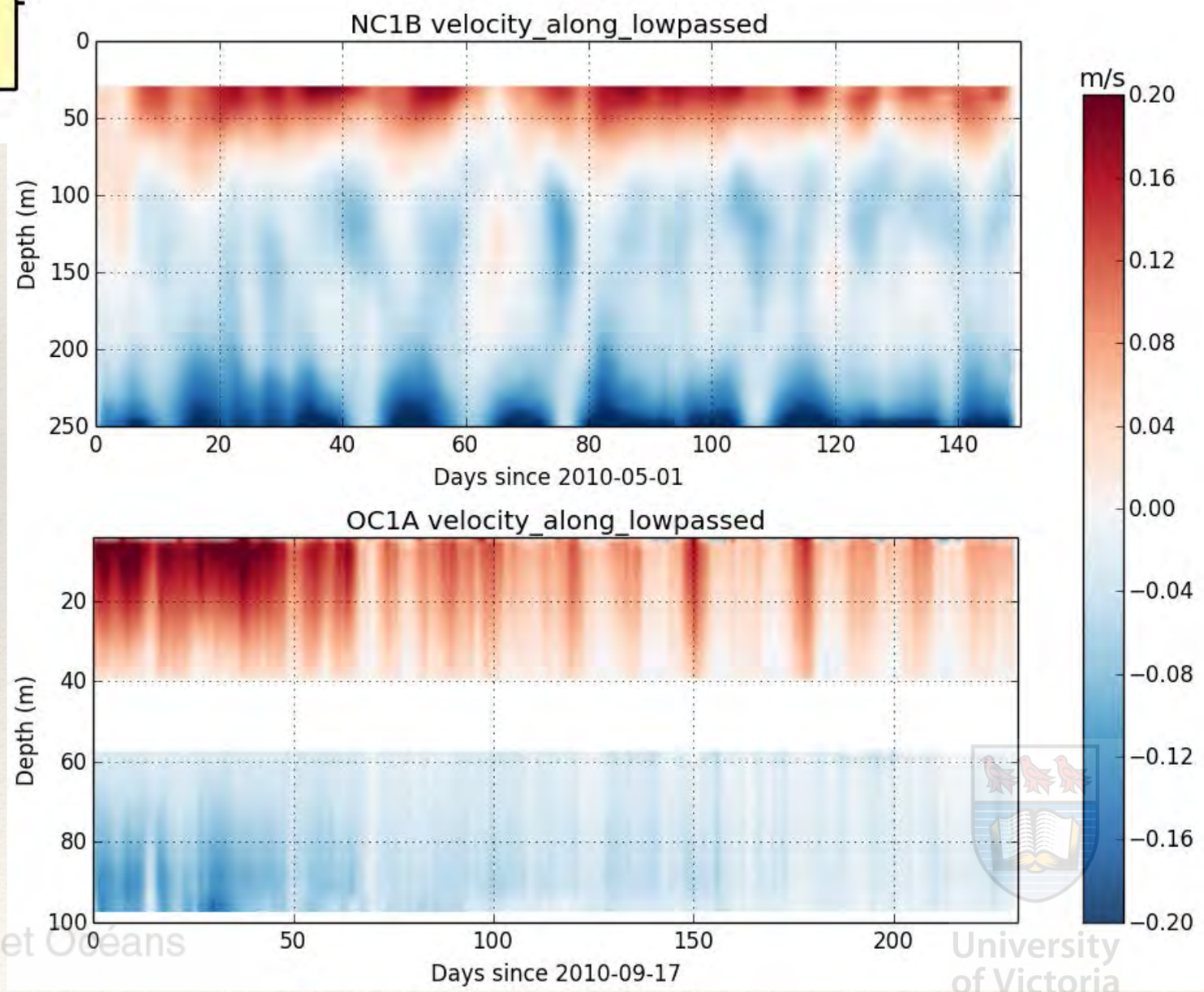
NC1 and OC1 along-channel sub-tidal flows



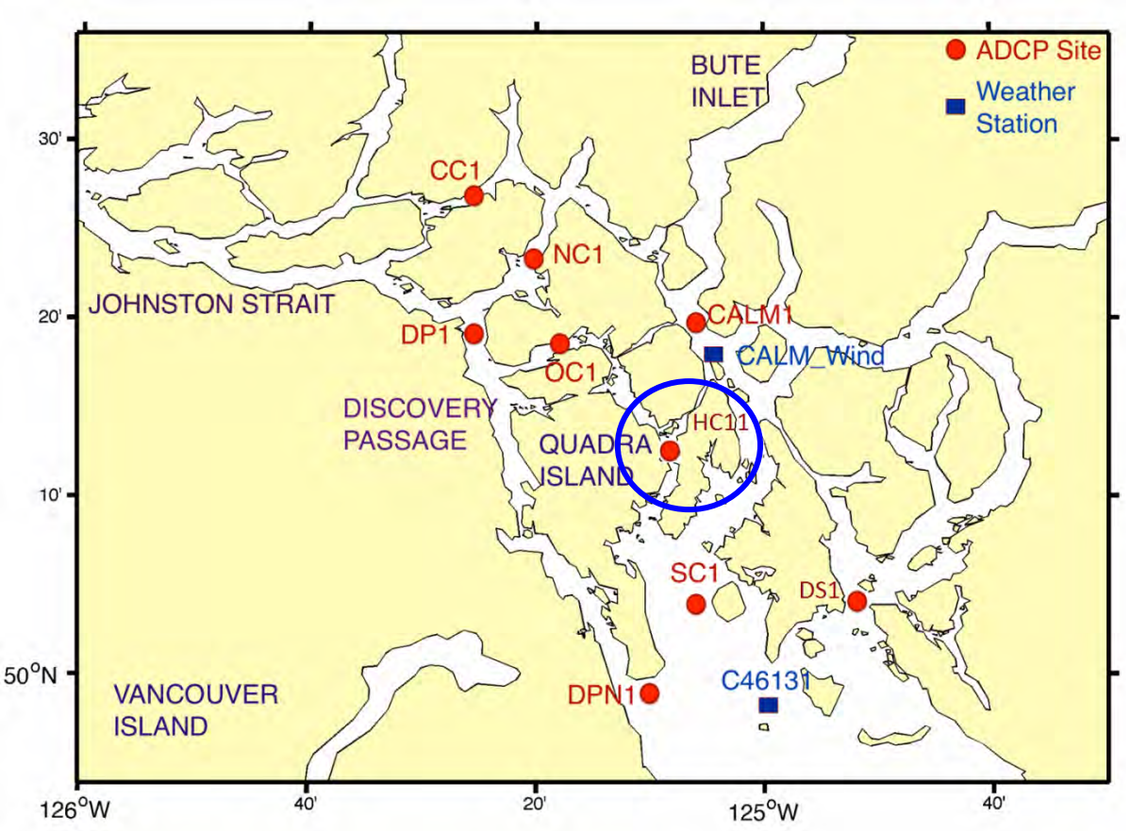
Surface flows are southwestward

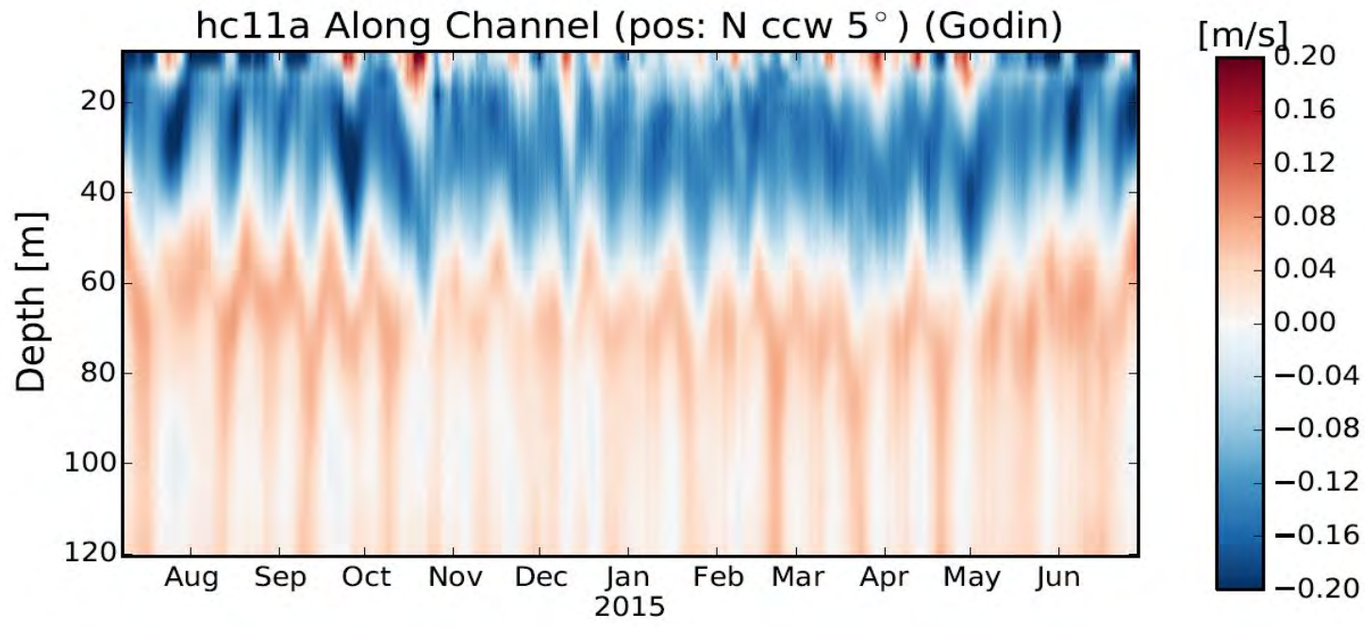
- Not inconsistent with conventional wisdom



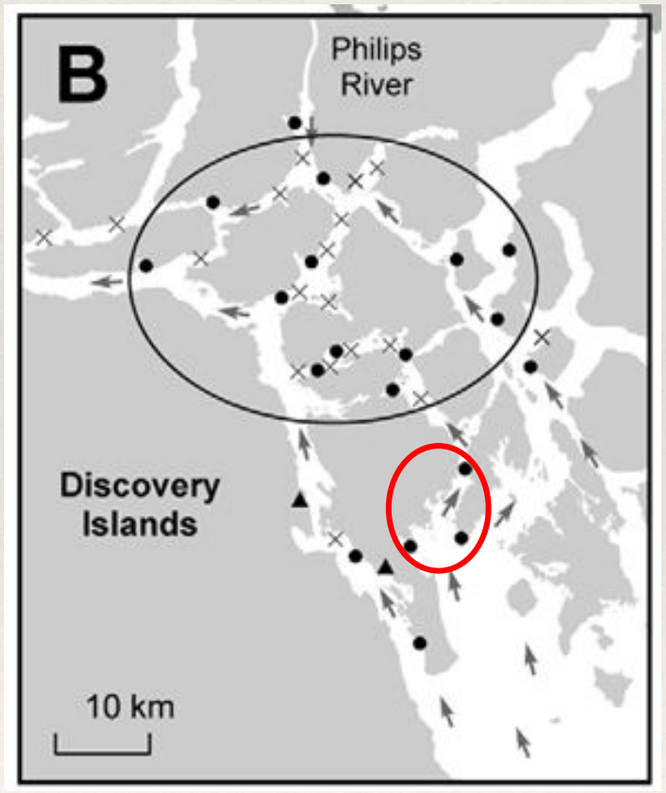


HC11 along-channel flows

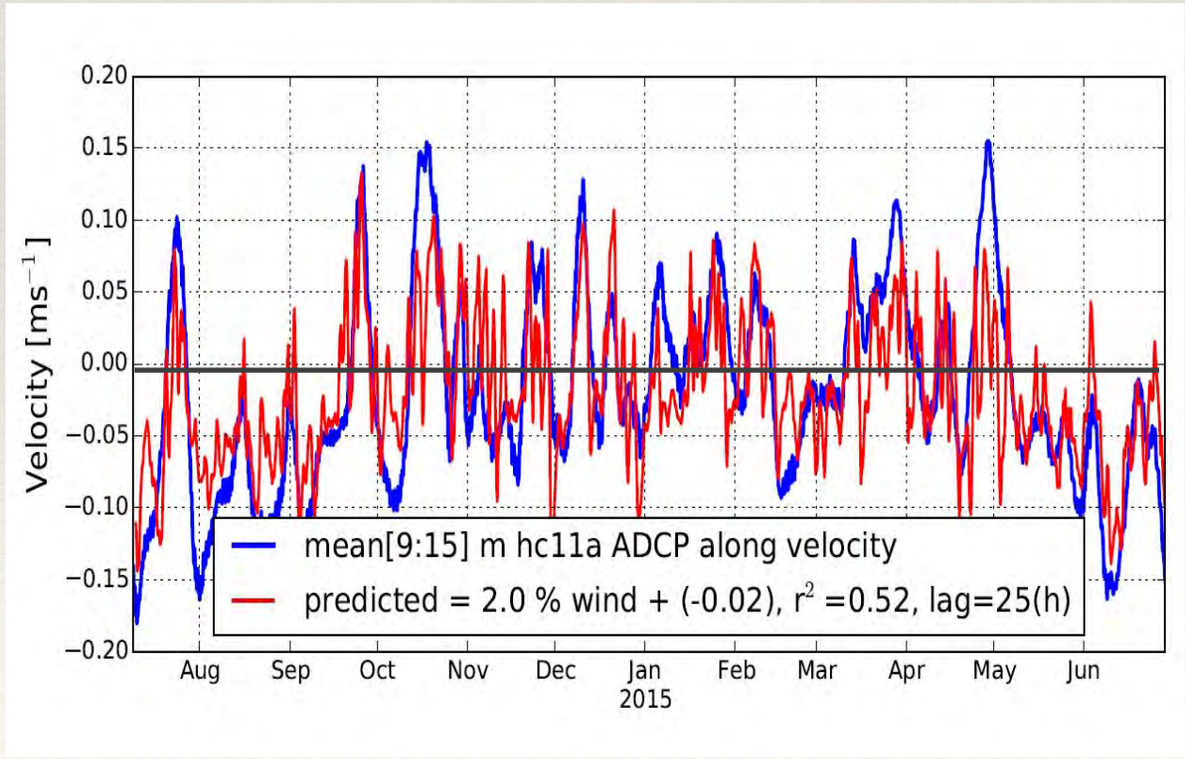




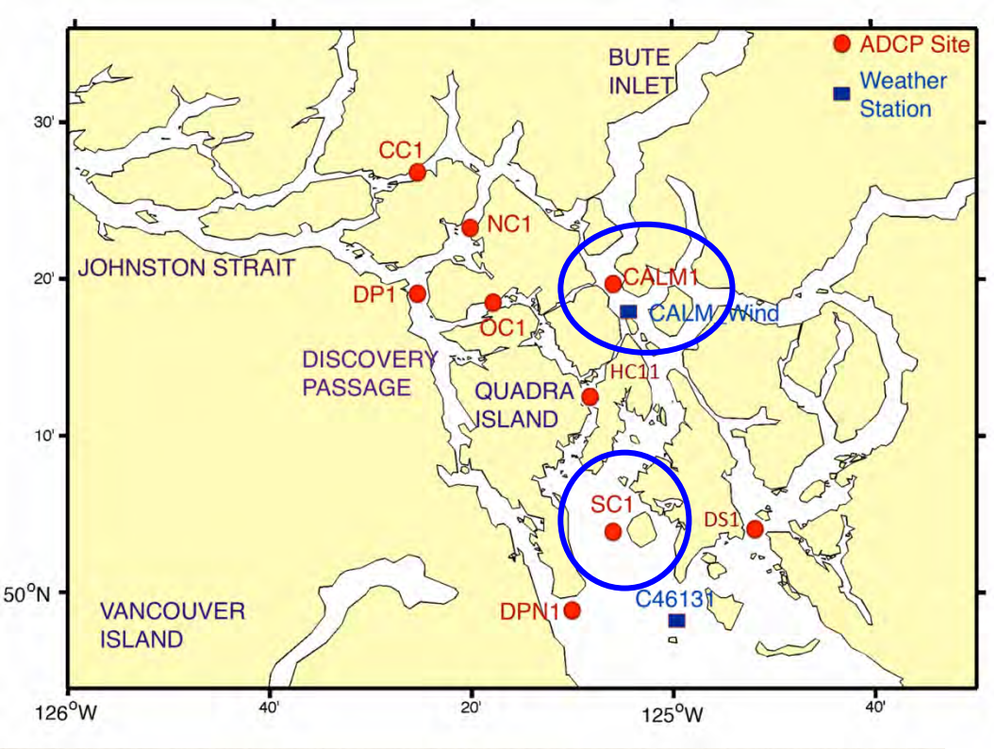
Positive is 5° ccw from north
NB. Spring-neap modulation of layer thicknesses



Wind explains some of northward surface flows but upper layer basically southward – opposite to Price et al. !

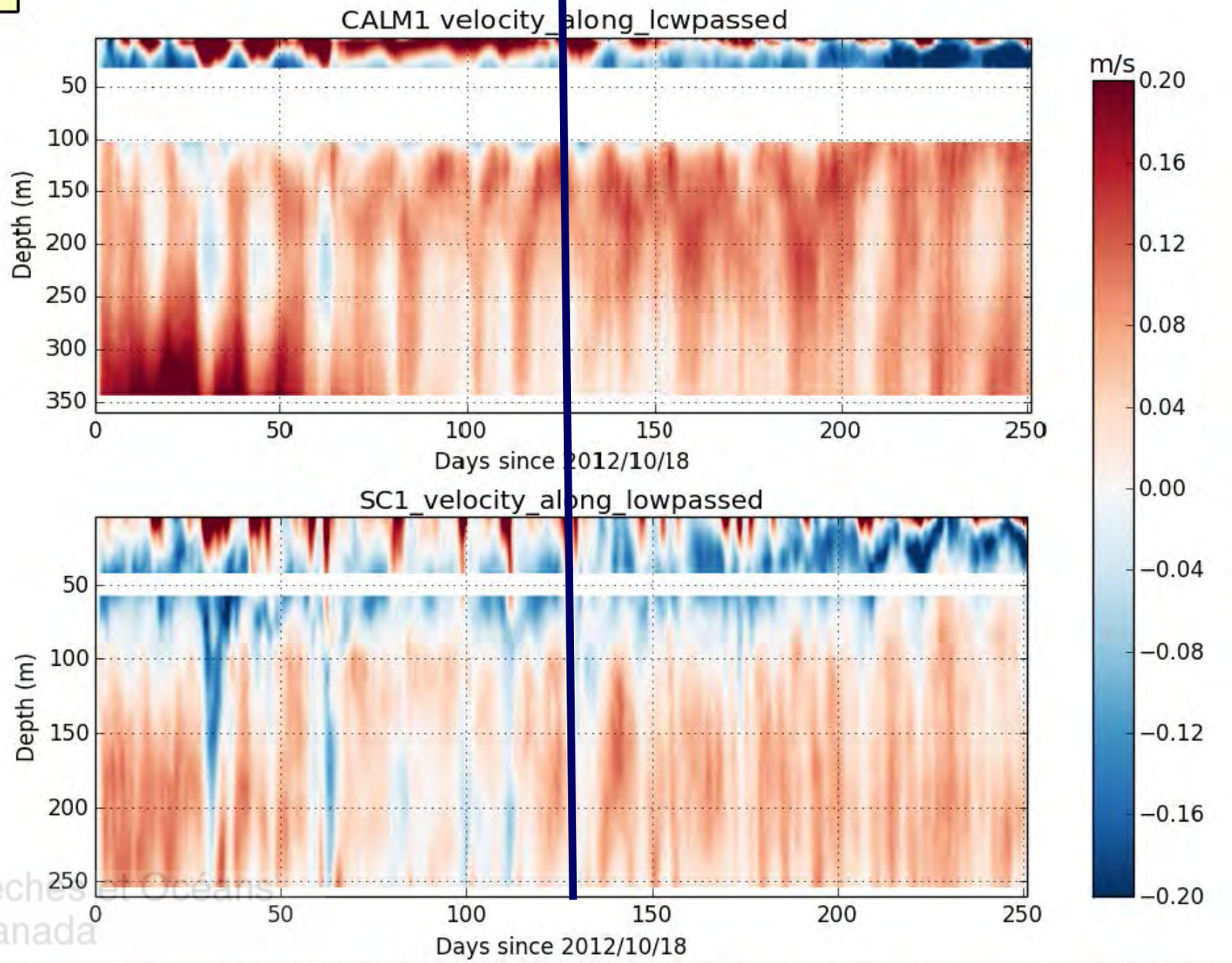


CALM1 and SC1 along-channel sub-tidal flows



- *Wind + estuarine flows: 3-layers*
- *Weaker estuarine in winter; stronger in spring*
- *Surface estuarine is southward (negative) – reverse of conventional wisdom*
- *Spring-neap modulation of estuarine layer thicknesses here too*

March



So what is going on?

- *Considerable freshwater discharge from BC mainland rivers into northern Strait of Georgia but much is not gauged*
- *Morrison et al. (AO, 2011) estimated for 21 watersheds, 1970-2009*
- *Is this discharge sufficient to overcome Fraser's influence ?*

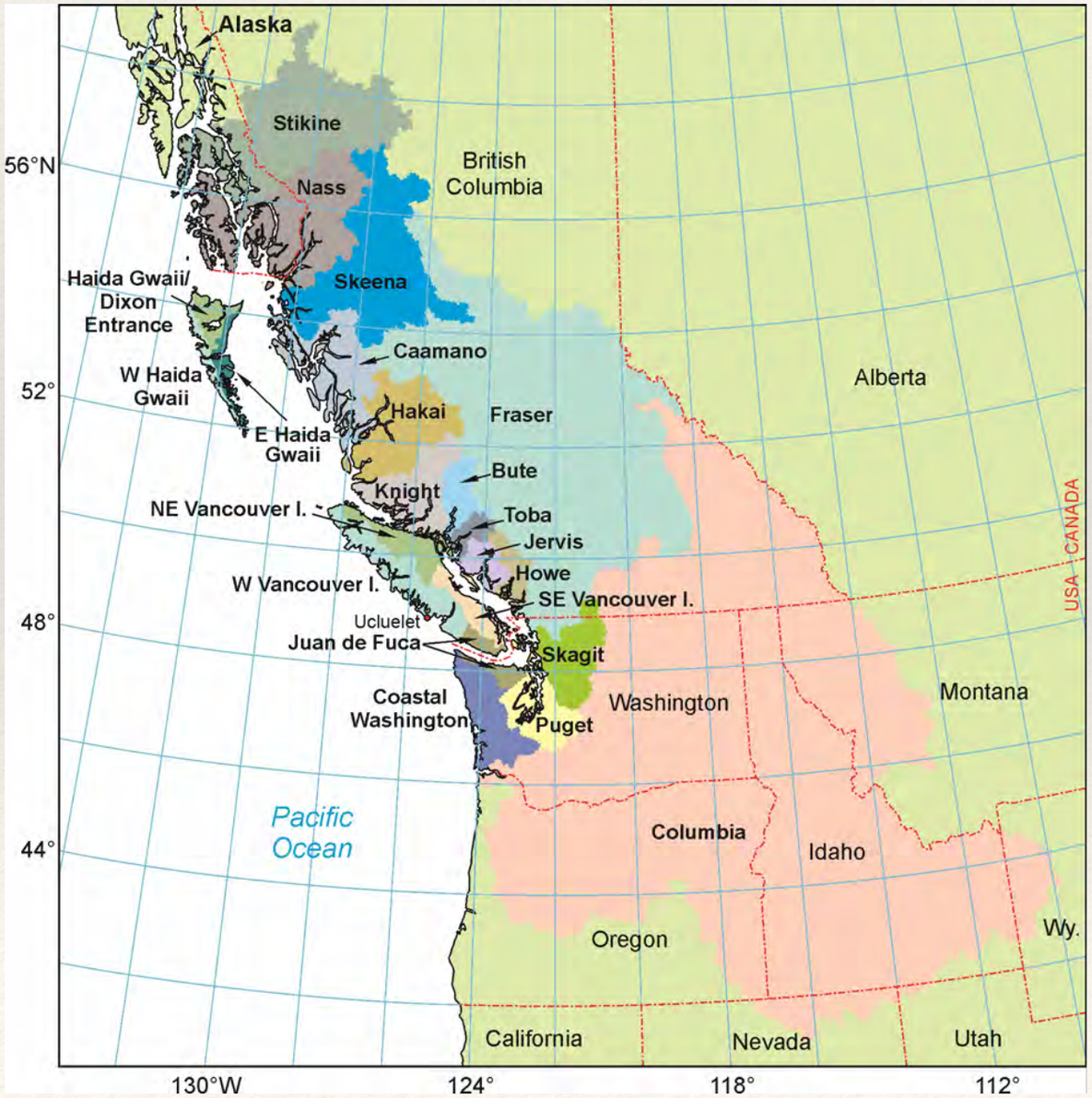


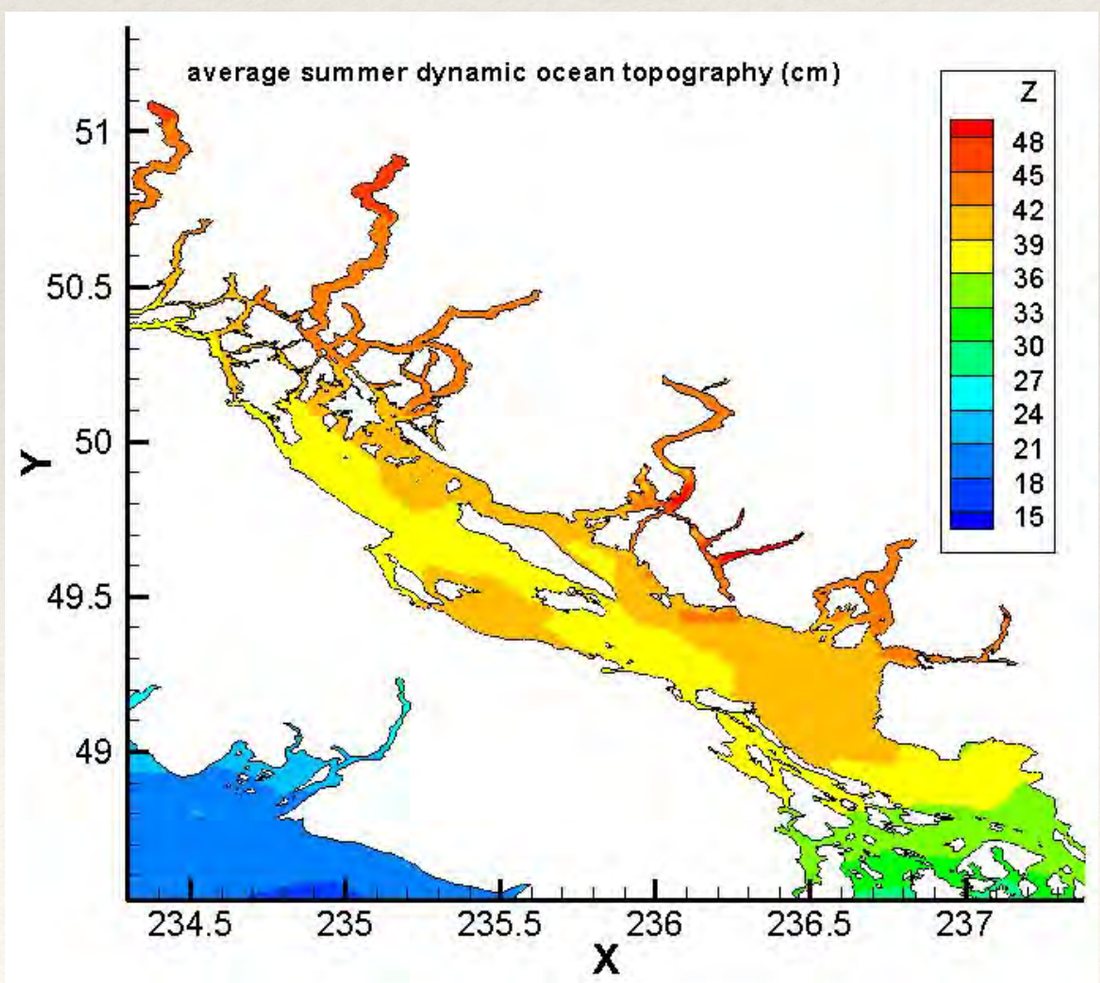
TABLE 3. Average Water Year Model runoff estimates by watershed in cubic kilometres

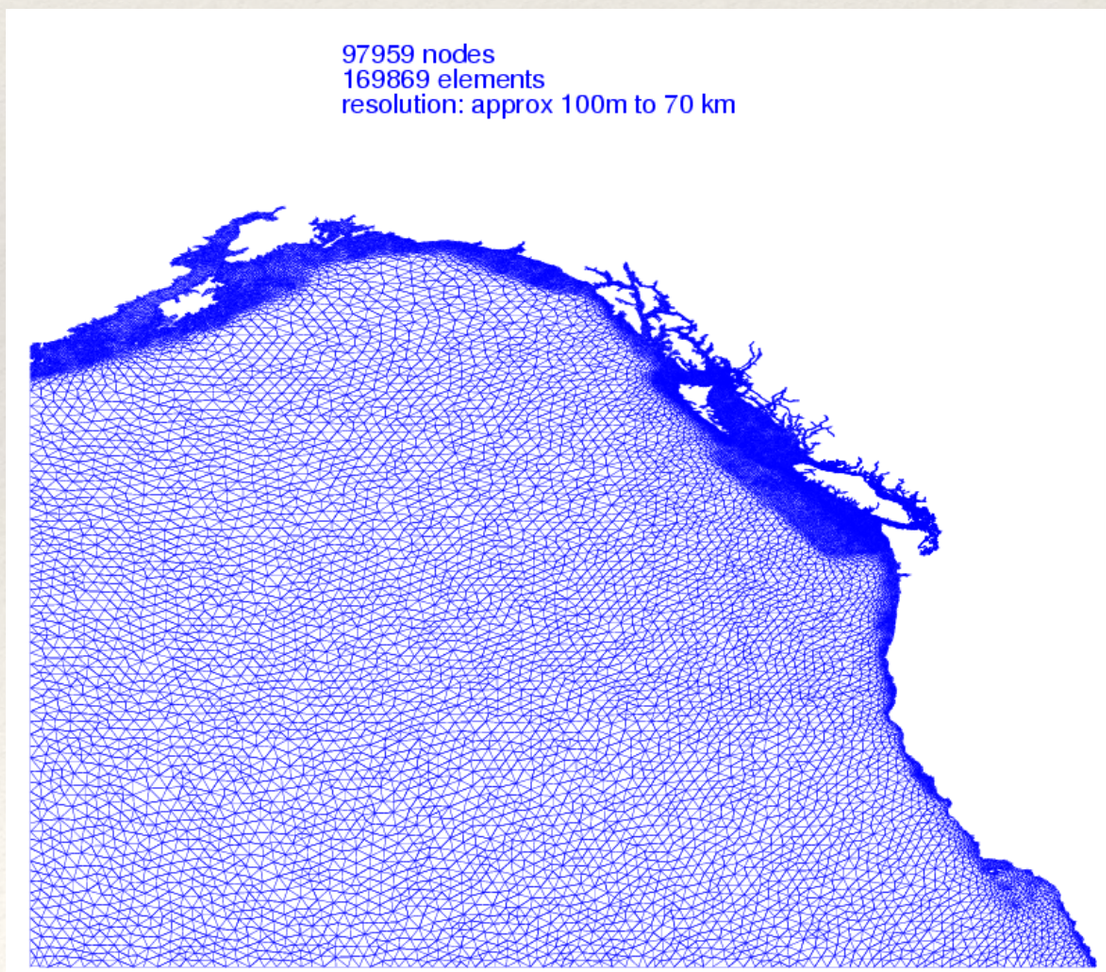
Watershed	Area	Annual	Jan.	Feb.	Mar.	Apr.
Bute	9740	17.4	0.6	0.5	0.5	0.6
Caamano	30,858	78.2	5.4	3.9	3.9	5.0
North East Vancouver Is	9709	20.1	2.5	1.6	1.6	1.7
South East Vancouver Is	6510	10.4	1.6	1.3	1.2	1.0
Fraser	235,396	111.9	4.7	3.9	4.4	6.6
Hakai	32,516	47.5	2.6	1.9	1.8	2.3
Howe	6234	18.1	0.8	0.8	0.8	1.2
Juan de Fuca	5356	12.9	2.2	1.6	1.5	1.1
Jervis	5785	9.4	0.9	0.7	0.8	0.7
Knight	19,437	36.8	1.7	0.9	1.3	1.8
Nass	55,242	100.7	6.0	5.1	4.9	6.7
Puget	17,080	15.9	1.8	1.5	1.4	1.3
Haida Gwaii Dixon	4551	9.3	1.2	0.9	0.8	0.7
East Haida Gwaii	4248	16.9	2.1	1.6	1.6	1.4
West Haida Gwaii	3245	12.4	1.5	1.1	1.2	1.0
Skagit	15,467	29.6	3.1	2.4	2.3	2.4
Skeena	56,272	49.3	1.4	1.1	1.1	2.3
Stikine	75,670	95.2	6.1	5.4	4.8	4.5
Toba	3892	8.5	0.4	0.4	0.4	0.7
Washington Coast	15,882	33.3	5.2	3.8	3.5	2.5
West Vancouver Is.	16,932	52.6	6.3	5.0	4.4	4.2
Columbia	685,292	211.4	20.3	18.1	19.3	26.8
	1,315,314	997.8	78.3	63.7	63.7	76.4

Fraser annual discharge approx 3 times more but …

Mean Dynamic Ocean Topography (DOT)

- Foreman et al. (GRL, 2008) northeast Pacific model
- Forcing = average seasonal i) NCEP winds & ii) 3D temperature and salinity fields (from all available CTD data)
- Diagnostic model (FUNDY5) calculation, analogous to dynamic height but with more physics
- Shows higher elevations along northeastern Strait of Georgia & up inlets
  - surface water flows downhill so from Bute, Toba into northern Strait of Georgia, consistent with ADCP measurements





Continuing Modeling Work

- Use ADCP currents to continue evaluating FVCOM model for Discovery Islands region
  - http://fvcom.smast.umassd.edu/fvcom/
- Horizontal & vertical grids:
  - 35609 nodes, 65473 triangles
  - Resolution from 1.7km to 90m
  - 12 rivers
  - 20 unequally-spaced sigma coordinates in vertical
- Prognostic model shows similar DOT values but also includes tidal residual elevations (top panel)
  - Tricky to separate these from buoyancy & wind contributions
- Foreman et al. (AO, 2012)

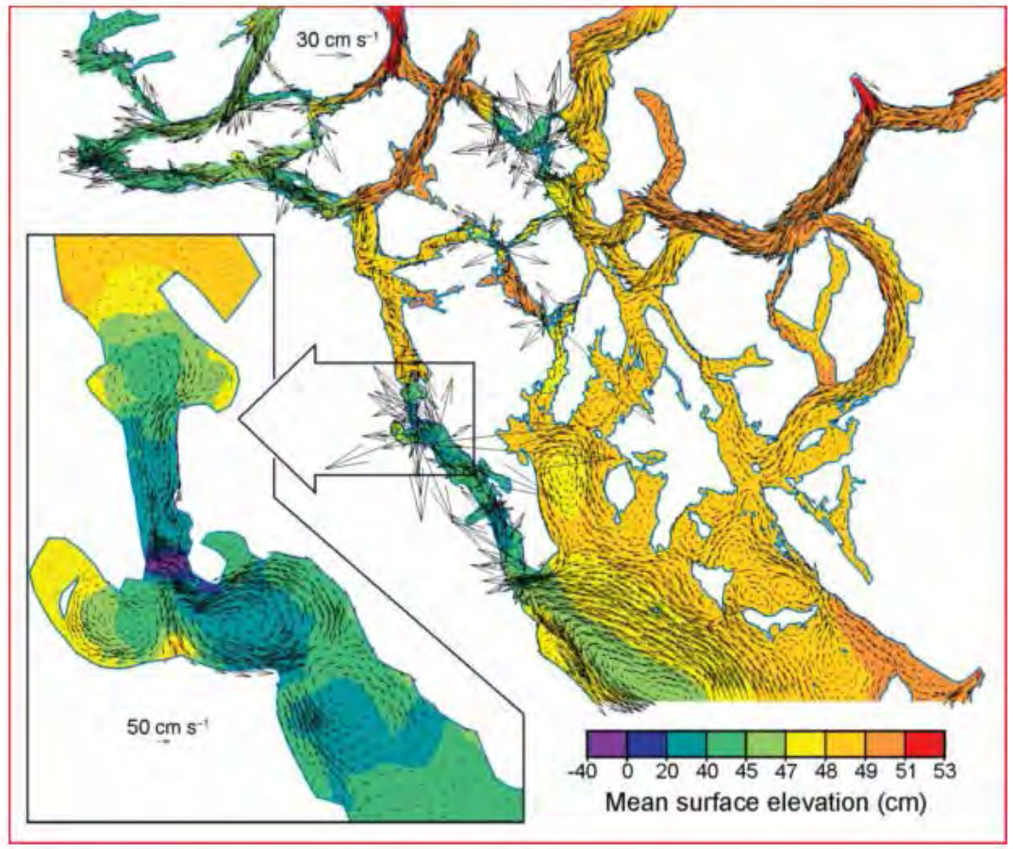
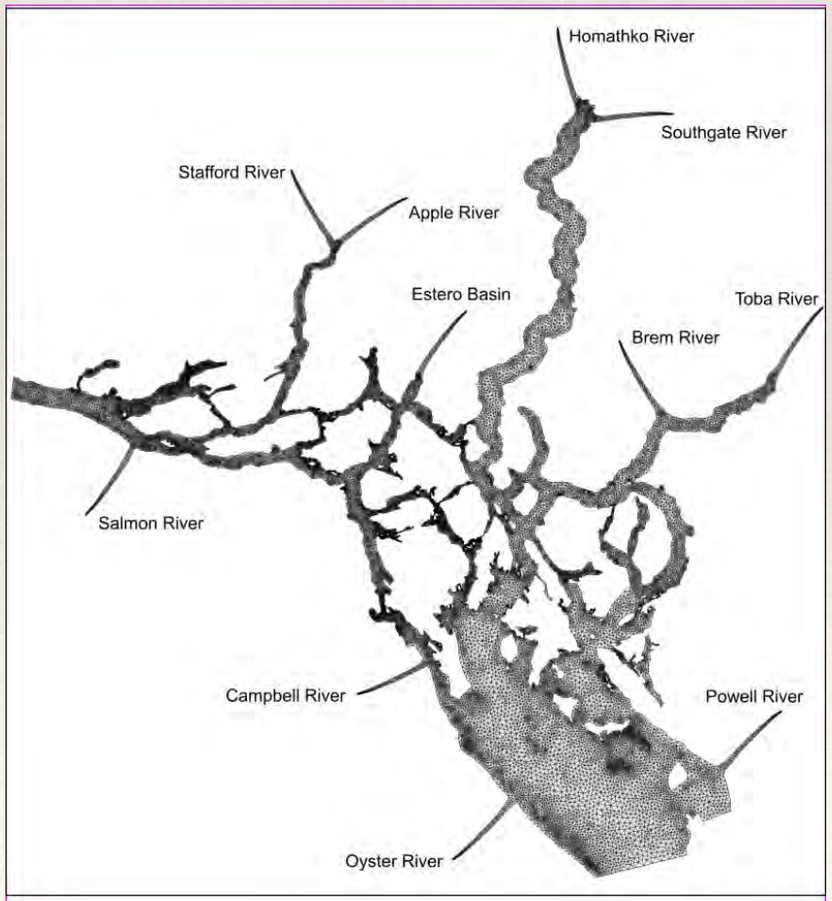
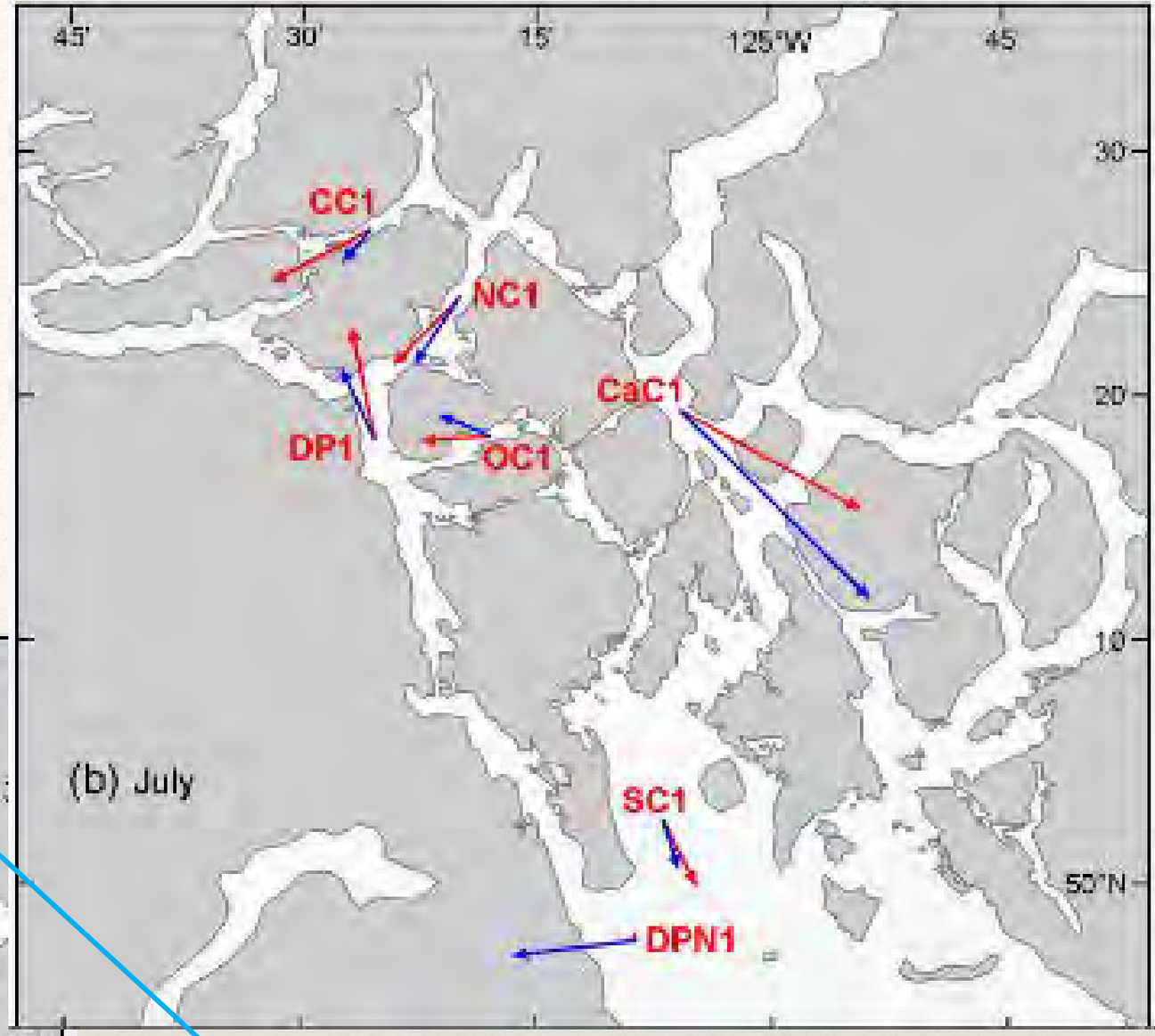
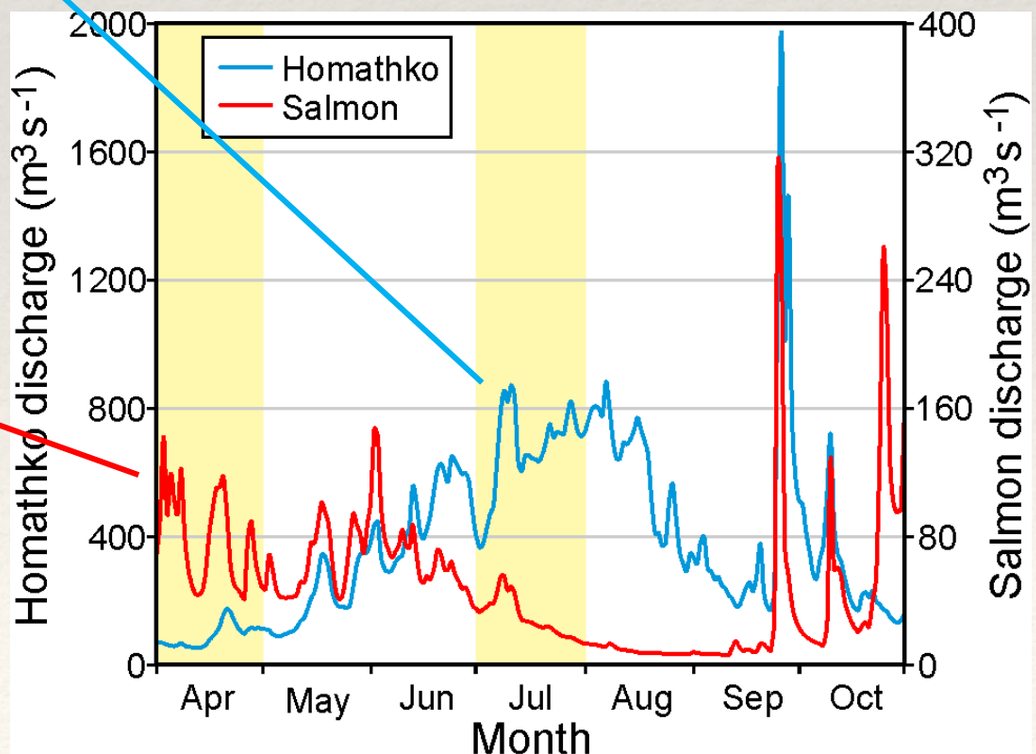


Fig. 10 Mean model surface elevations and flows at 1 m depth computed by harmonic analyses for the period 4–28 April 2010. Only vectors at nodes separated by a minimum of 600 m are shown in the larger region; all vectors are shown in the Seymour Narrows insert.



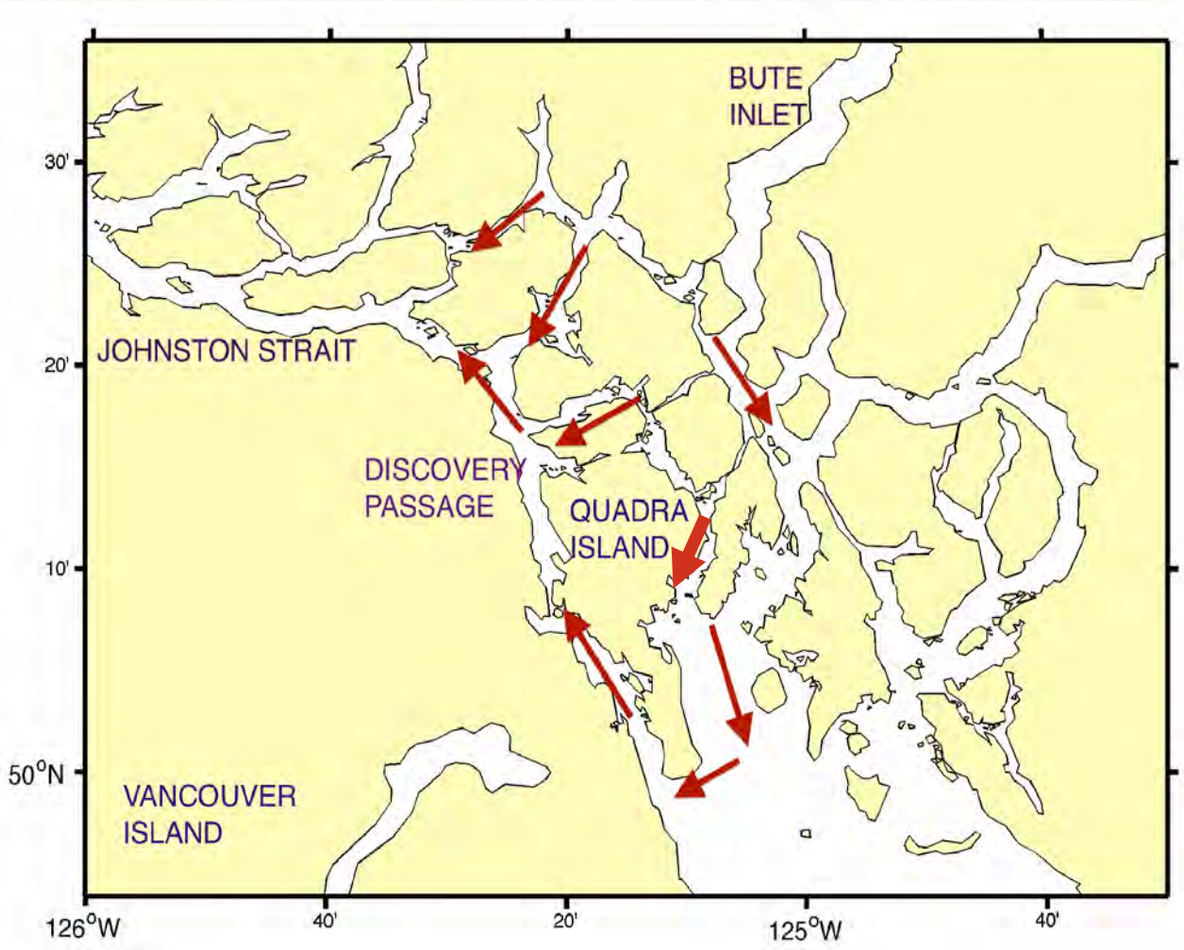
April & July 2010 Near-Surface Mean Flows: Observed vs FVCOM

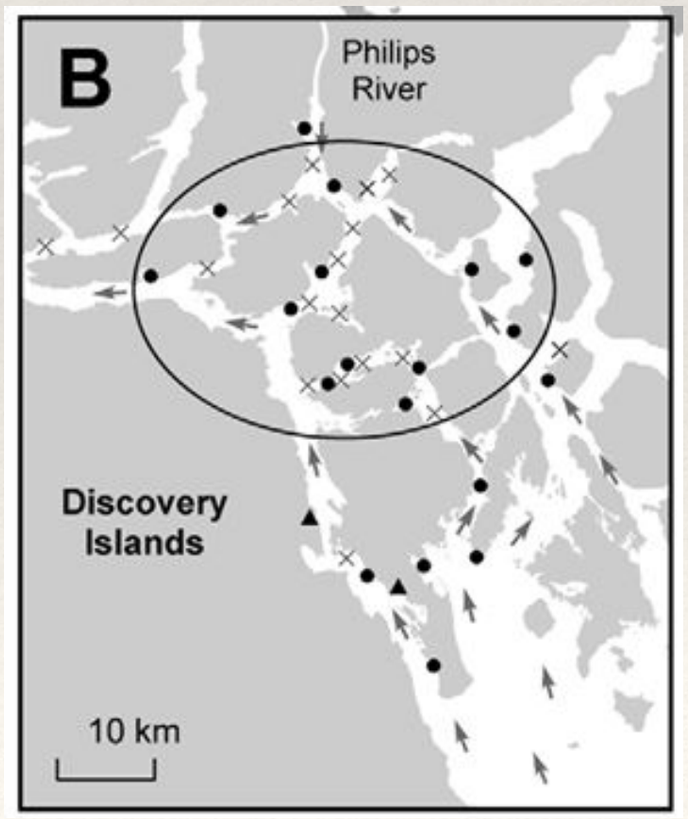




Summary

- *Mean sub-tidal flows do not go northward through all the Discovery Islands channels*
  - *southward on eastern side*
- *Freshwater discharges from mainland rivers are important*
- *ADCP flows (tidal & sub-tidal) will be used to evaluate numerical models & better understand physics*
- *Seasonal, spring-neap, & inter-annual variations need further study*
- *Winds also important and their effects will be analysed next*





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  - Darren Tuele, Tom Juhasz, David Spears, Lucius Perreault for ADCP deployment & recovery
  - Funding:
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- **Aquaculture Industry**
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marineharvest

cermaq

Grieg Seafood

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Thank you