Queen Charlotte Strait Finite Volume Community Ocean Model Development

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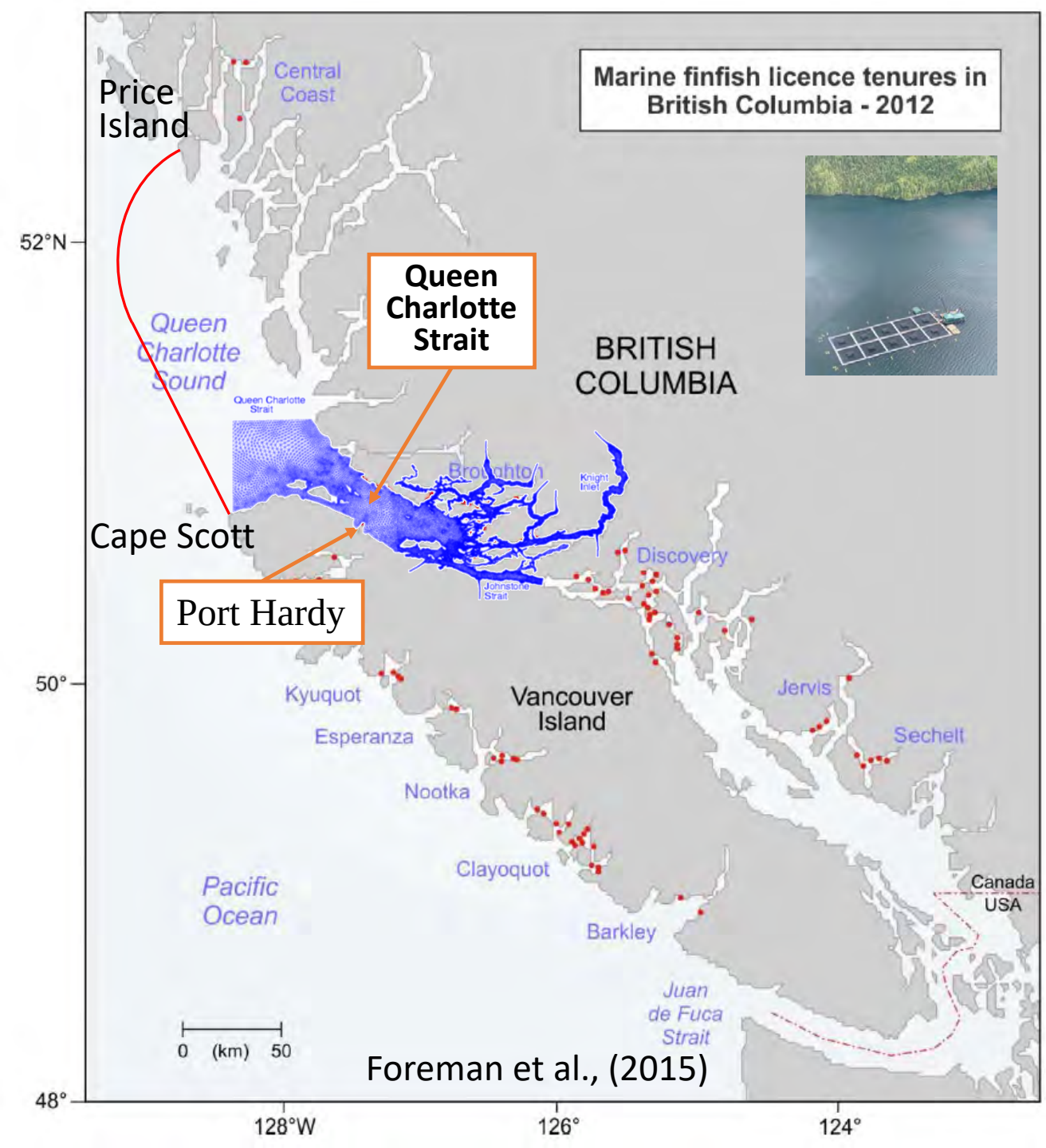
The objective is to provide a high-resolution hydrodynamic model of the region to assist in finfish farm siting and assess particle/pathogen dispersal from the farms to the environment as well as farm-to-farm interactions.

OUTLINE

- Motivation for Queen Charlotte Strait (QCS) Coastal Model
- QCS Finite Volume Community Ocean Model (FVCOM) Development
- Model Results from Preliminary Test Runs
- Summary and Future Work



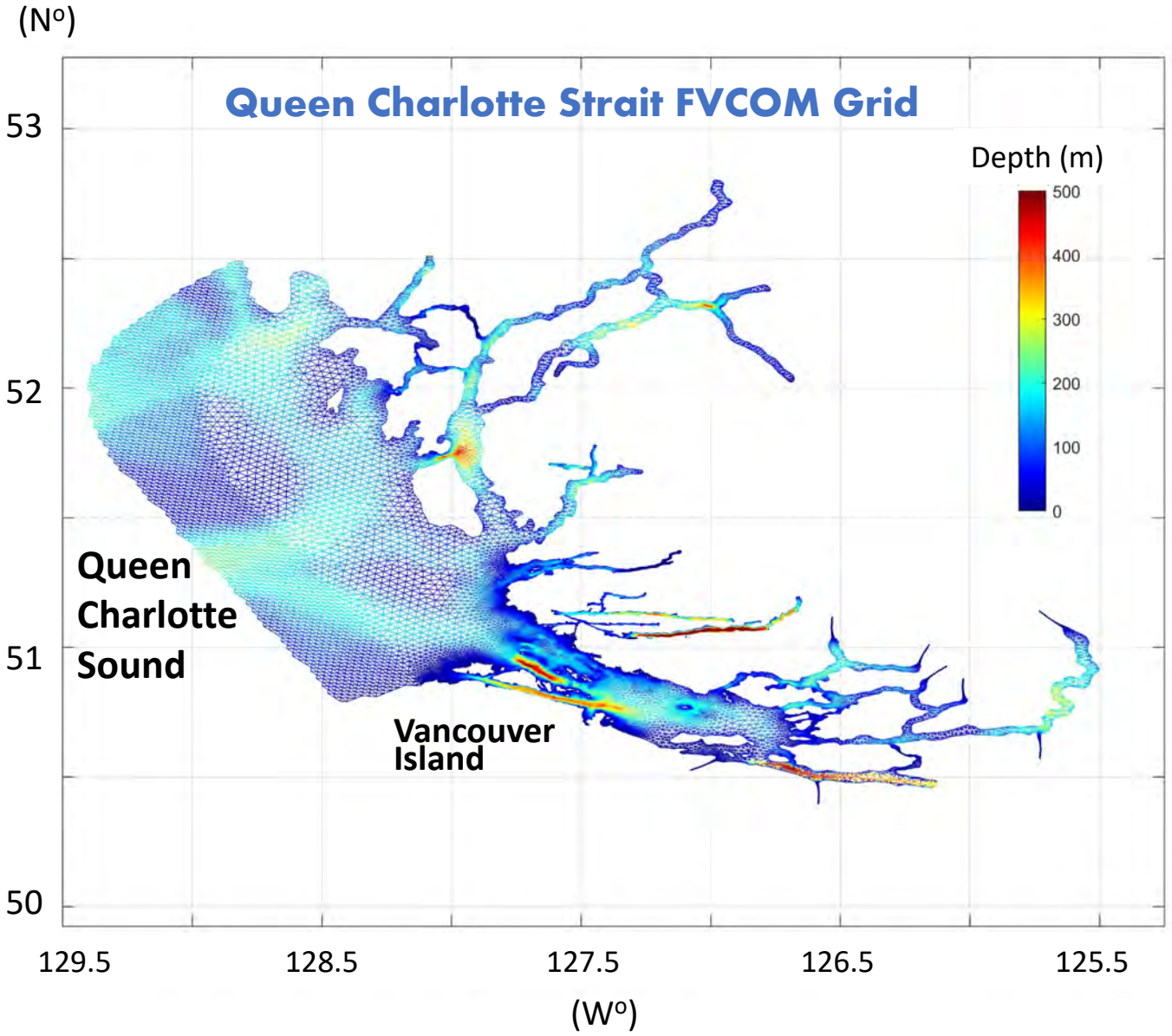
- **Starting Point**

DFO Broughton Archipelago FVCOM Model

(e.g. Foreman et al., 2009 & 2015)

- **Extended further north (Proposed)**
- **Focus of resolution changed to Queen Charlotte Strait (QCS)**
- **Coupling with a large-scale operational ocean circulation model**
- **Using surface winds and heat flux predictions from Environment and Climate Change Canada (ECCC)**

QCS FVCOM Model Development



- **Bathymetry**

British Columbia 3" Bathymetric Digital Elevation Model (National Geophysical Data Center, NGDC)

- **Coastlines**

Canadian Hydrographic Service (CHS) High Water Mark Lines (https://catalogue.data.gov.bc.ca/dataset/chs-high-water-mark-lines)

- **Grid Numbers**

122,243 nodes and 218,619 elements

- **Vertical Layers**

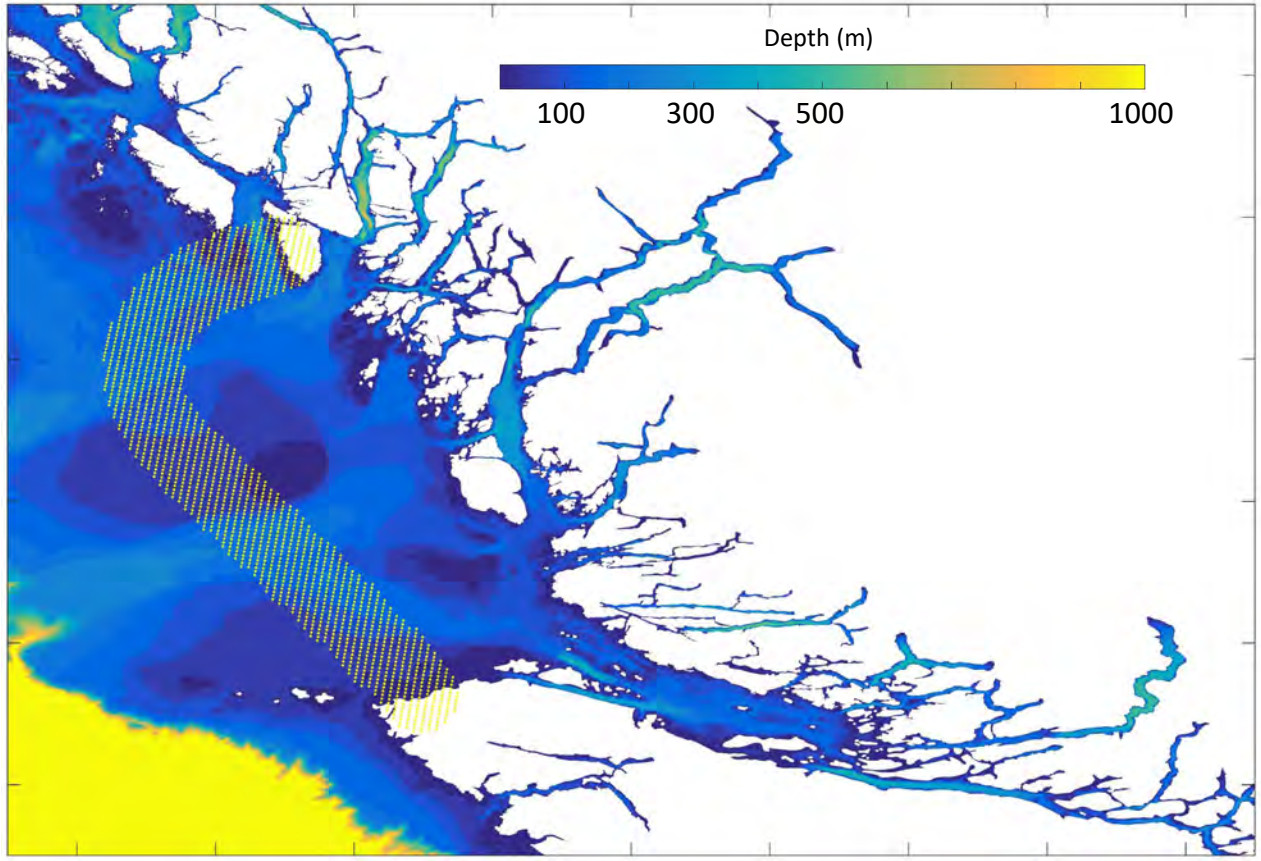
σ-coordinate system with 10 even levels (temporarily)

- **Horizontal Resolution**

50 m at the Port Hardy region

2000 m at the open ocean

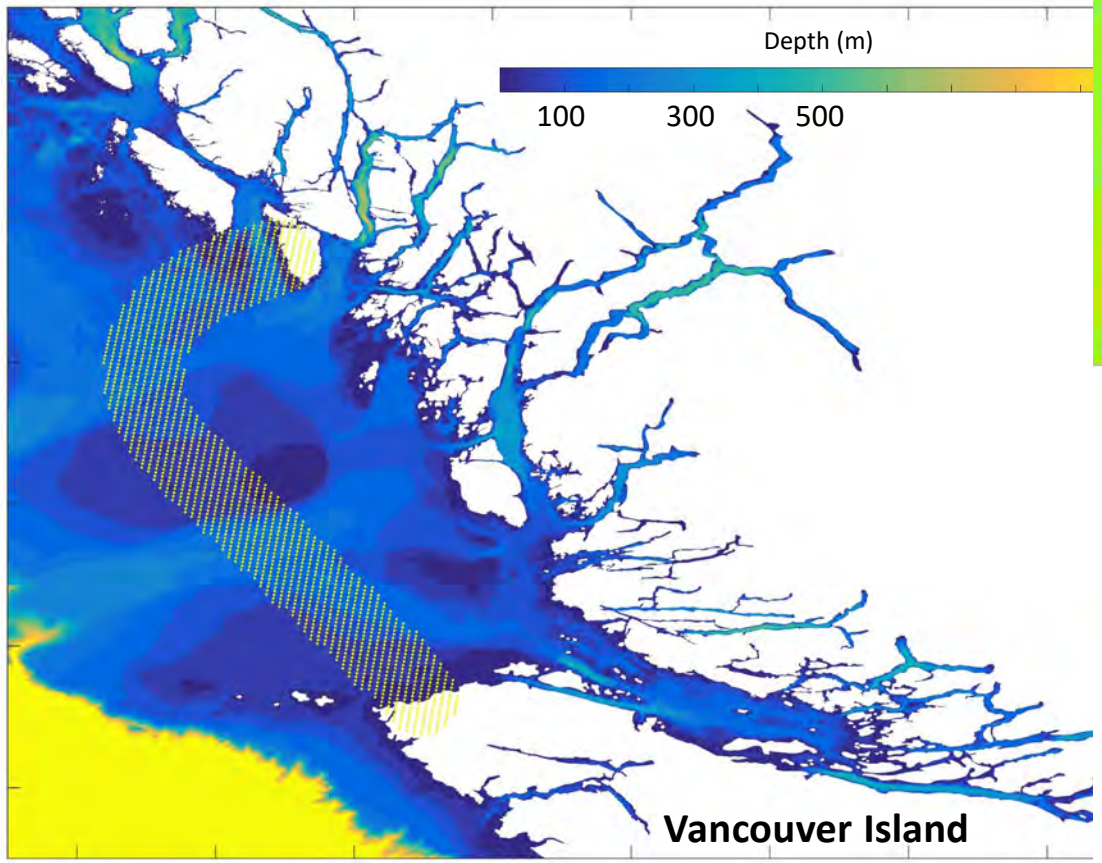
Open Boundary Coupling Zone

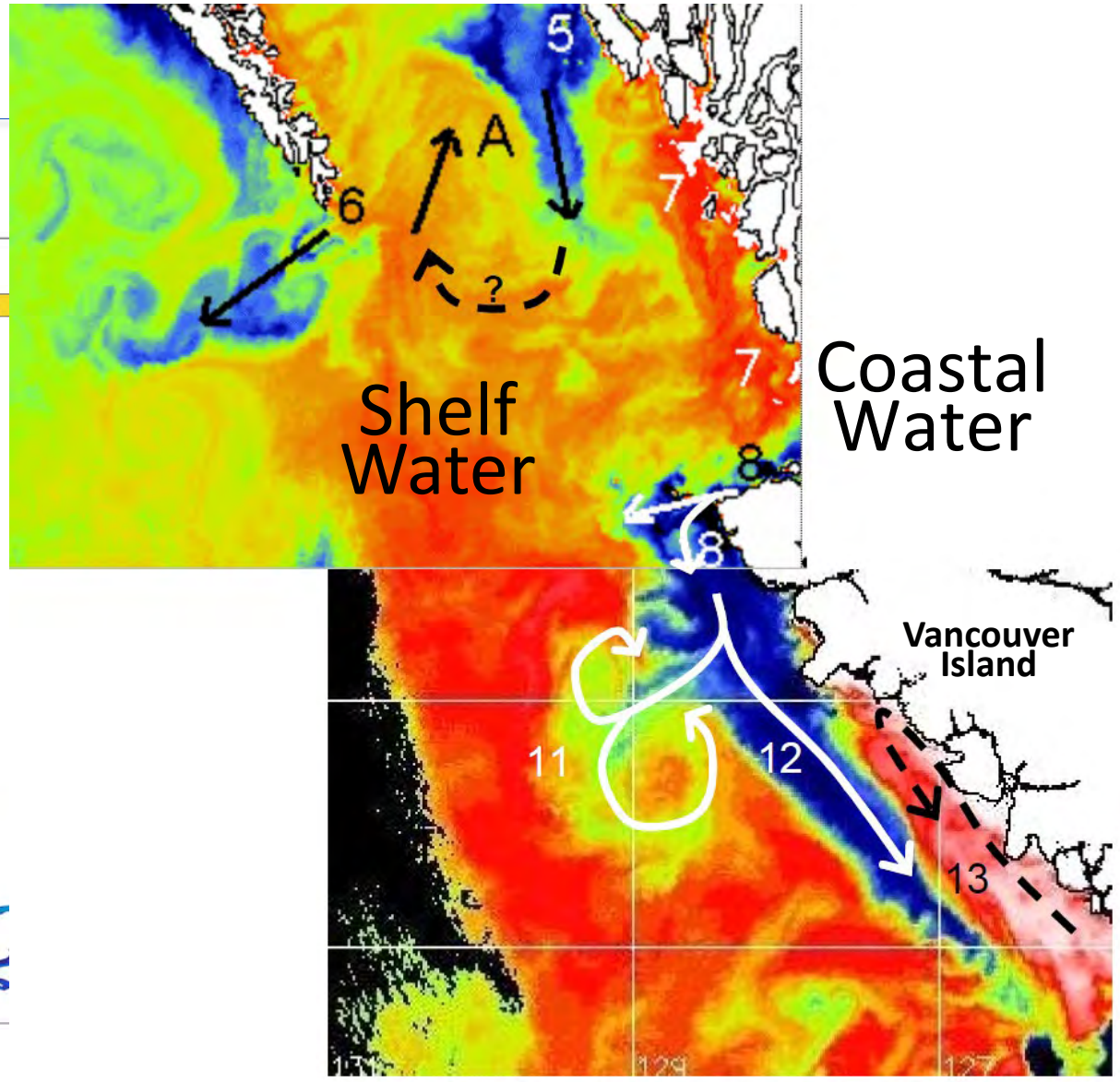


Hyperbolic tangent (tanh) weight function of distance with a relaxing time (τ)

- At the open ocean boundary (Queen Charlotte Sound), the model is one-way nested within the operational largescale Coastal Ice Ocean Prediction System for the West coast (CIOPS-W) via a 15-grid-wide overlapping zone.
- CIOPS-W is developed by the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS).
- The ocean model is based on Nucleus for European Modeling of the Ocean (NEMO) with 1/36^{o} horizontal resolution (~2.0 to 2.5km) and 75 z-level in the vertical (Δz = 1m at surface to 400m at 5000 m).

Open Boundary Coupling Zone





NOAA satellite image of SST. The lower portion was collected 23 July 1994 at about midnight PDT, the upper portion was collected 24 July 1994 at about 0600 PDT; cold water (~10°C) is represented by blue and warm (~16°C) by red. Numbers refer to features identified on the SST images. (Crawford et al., 2007)

MODEL TEST RUNS

The model has been run stably with tidal forcing, surface winds and heat flux, river discharges , and T/S activated

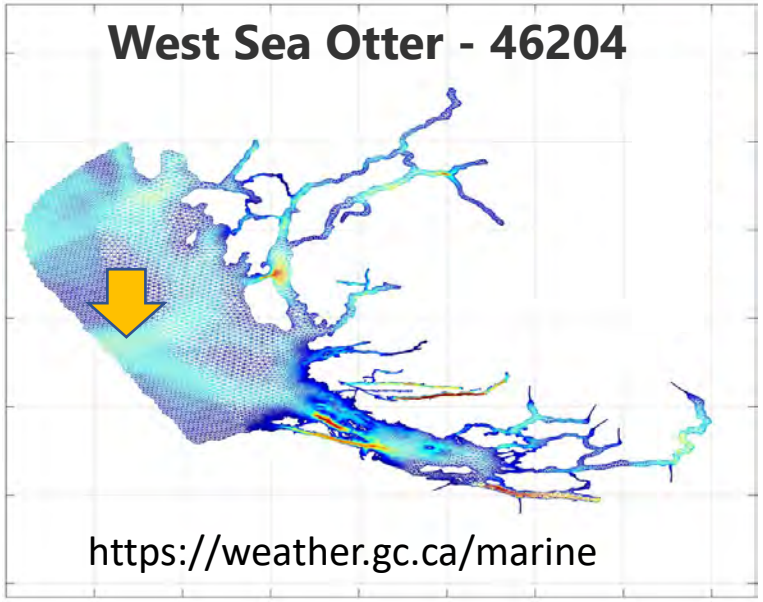
- 6 tidal constituents (K1, O1, P1, M2, N2, S2) determined from a combination of tide gauge records and the Northeast Pacific model of Foreman et al. (1993 & 2000)
- High-Resolution Deterministic Prediction System (HRDPS) from Environment and Climate Change Canada (ECCC) provides surface winds and heat flux related parameters with a 2.5 km spatial resolution
- Freshwater discharges from 5 major rivers based on National Water Data Archive (HYDAT)

Initial T/S: CIOPS-W, May 10th, 2016
Duration: May 10th to 30th, 2016
(Including the spin-up period)

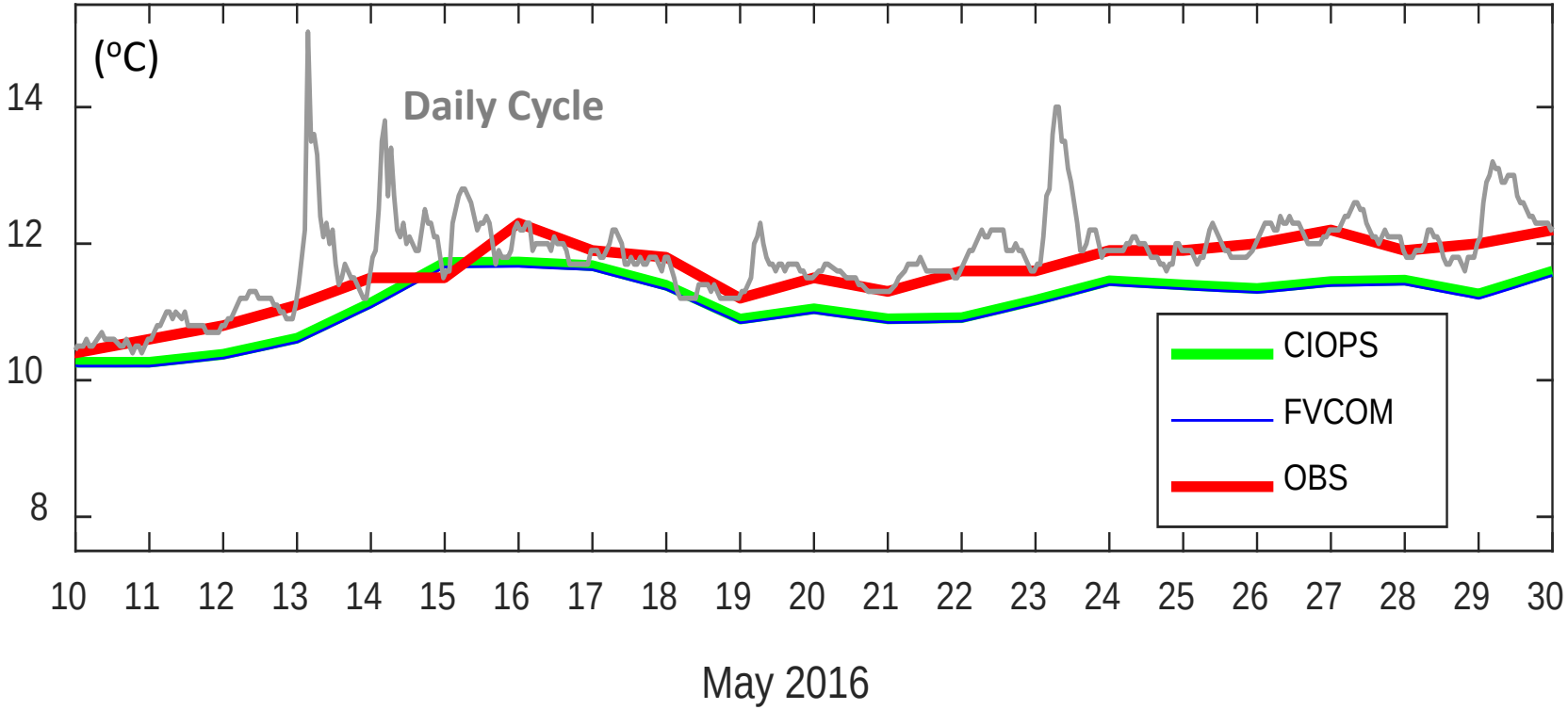
Coupling Zone	Test Run 1	Test Run 2
Surface Elevation	CIOPS-W hourly	
T and S	**CIOPS-W daily (saved at 00:00 UTC)**	
Currents	CIOPS-W daily (saved at 00:00 UTC)	
Relaxing Timescale	3 min	24 hr
Status	Done	Done

MODEL RESULTS FROM TEST RUNS

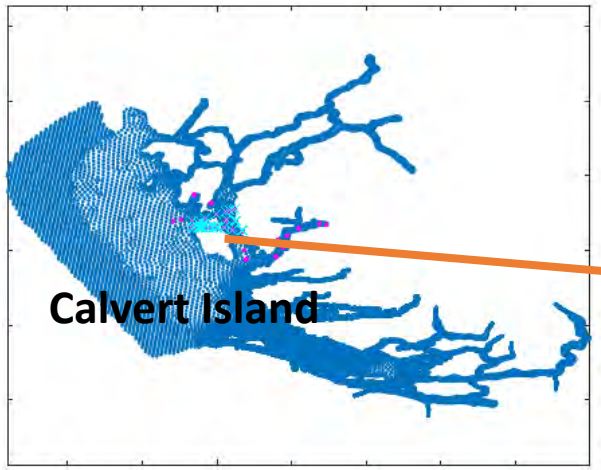
SST
(Test Run 1)

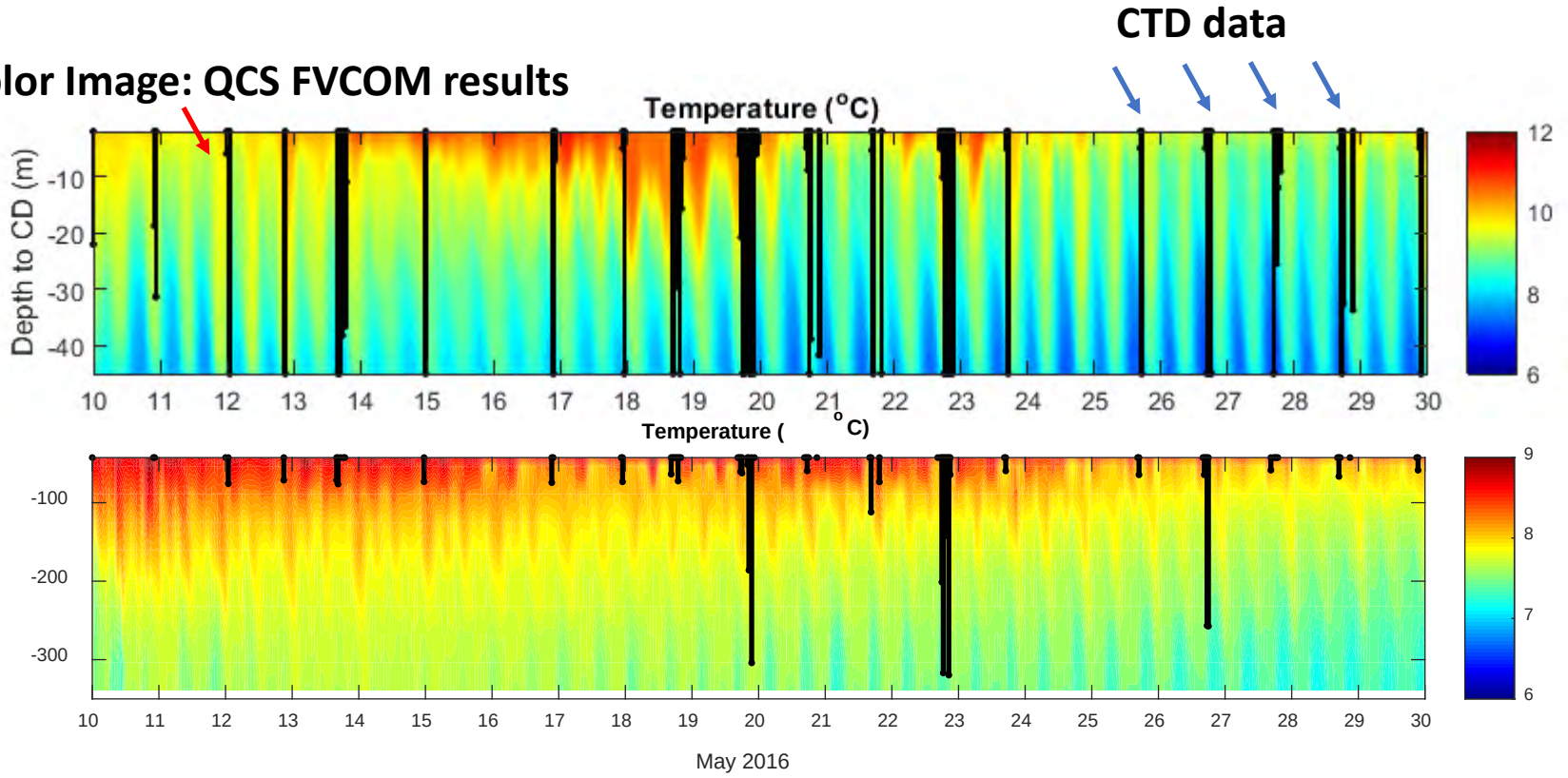


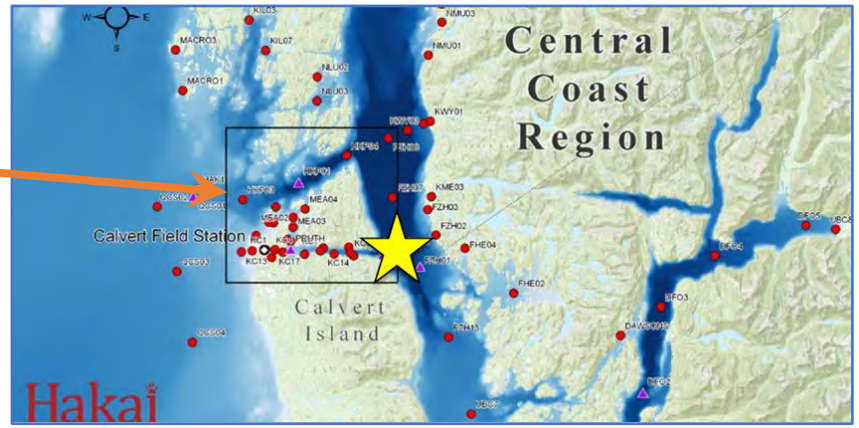
Buoy position: 51.23N 128.46W



Water Temperature at Calvert Island (Test Run 1)





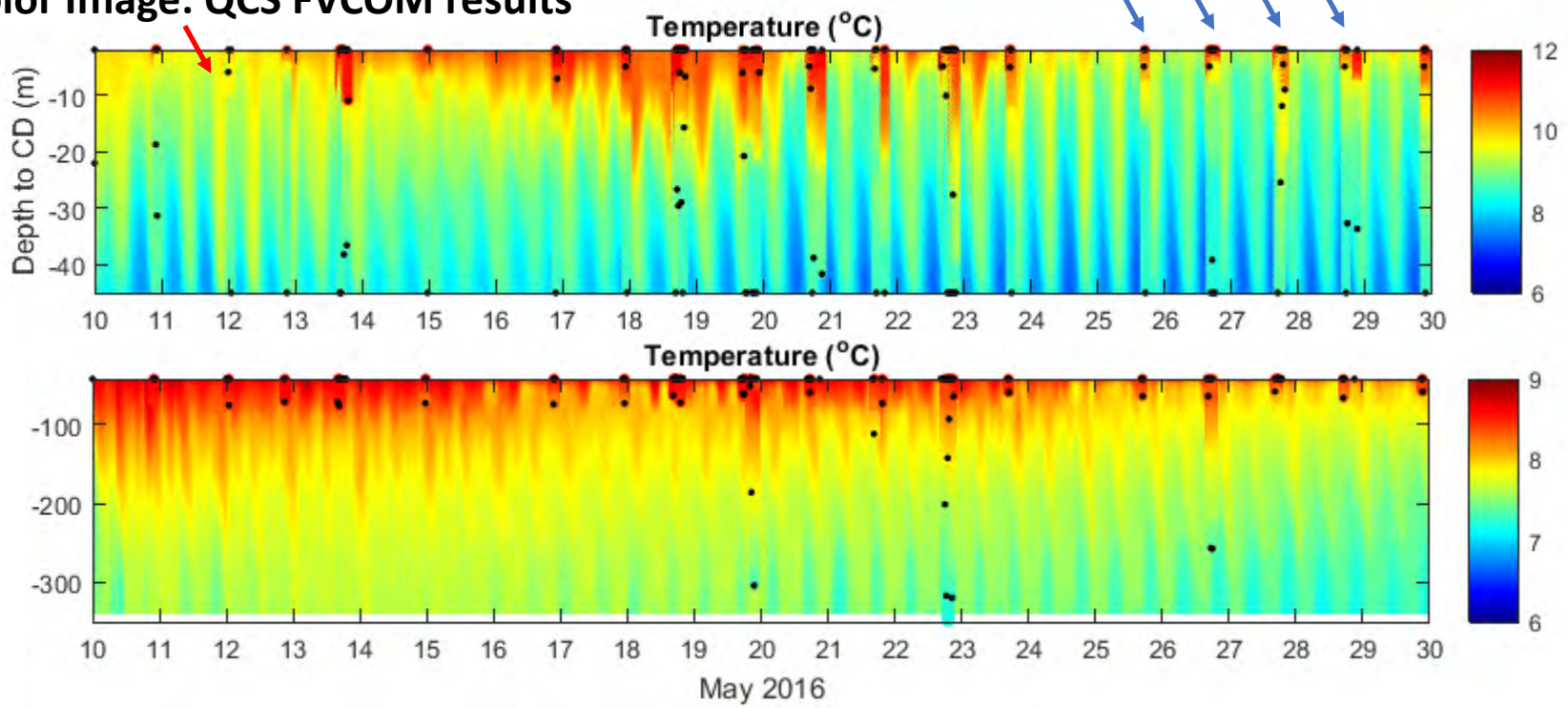


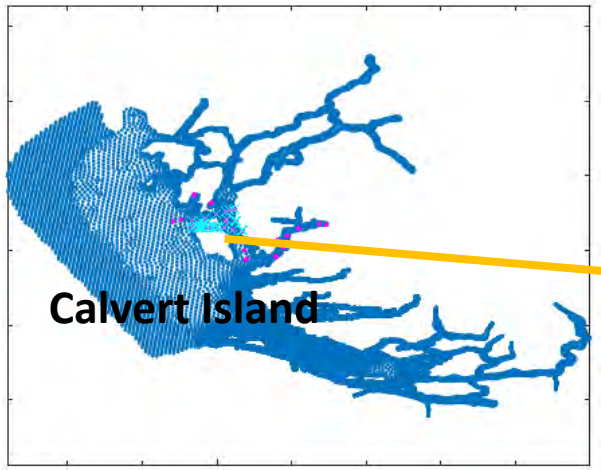
Data Source: Jennifer Jackson

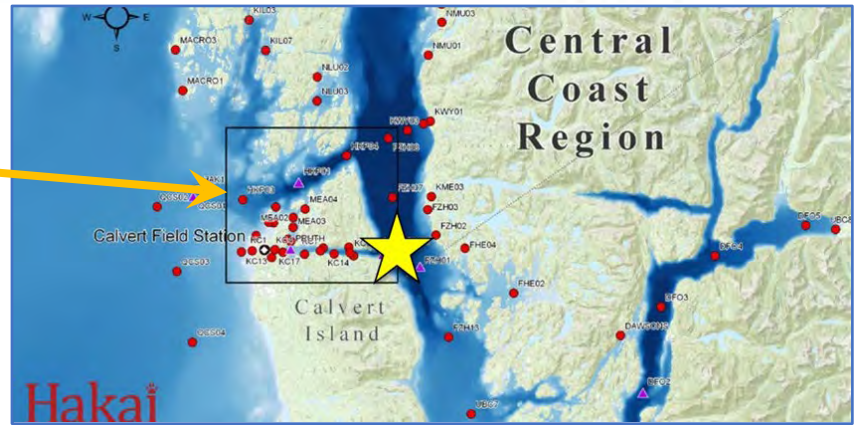
Water Temperature at Calvert Island (Test Run 1)

CTD data

Color Image: QCS FVCOM results

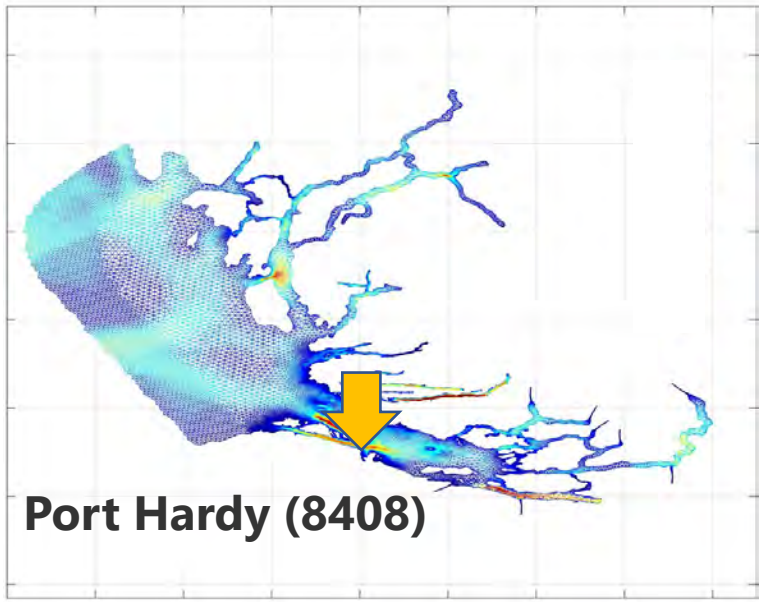






Data Source: Jennifer Jackson

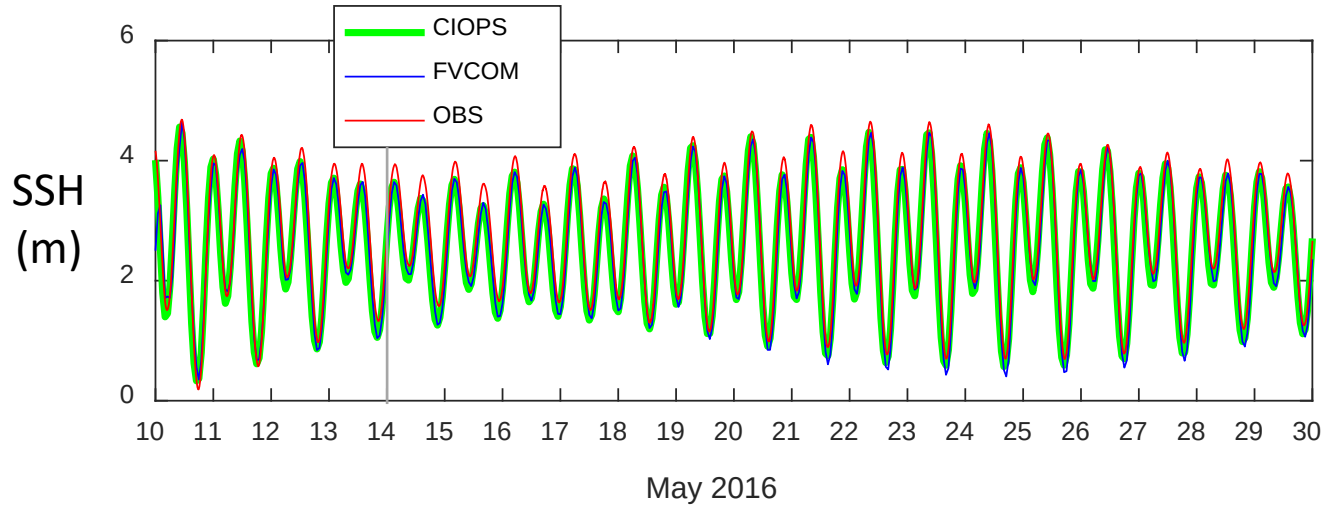
MODEL RESULTS FROM TEST RUNS



https://www.waterlevels.gc.ca/

- *Amplitude ratio = modeled/observed*
- *Phase difference = modeled – observed*
- *May 14-30, 2016*

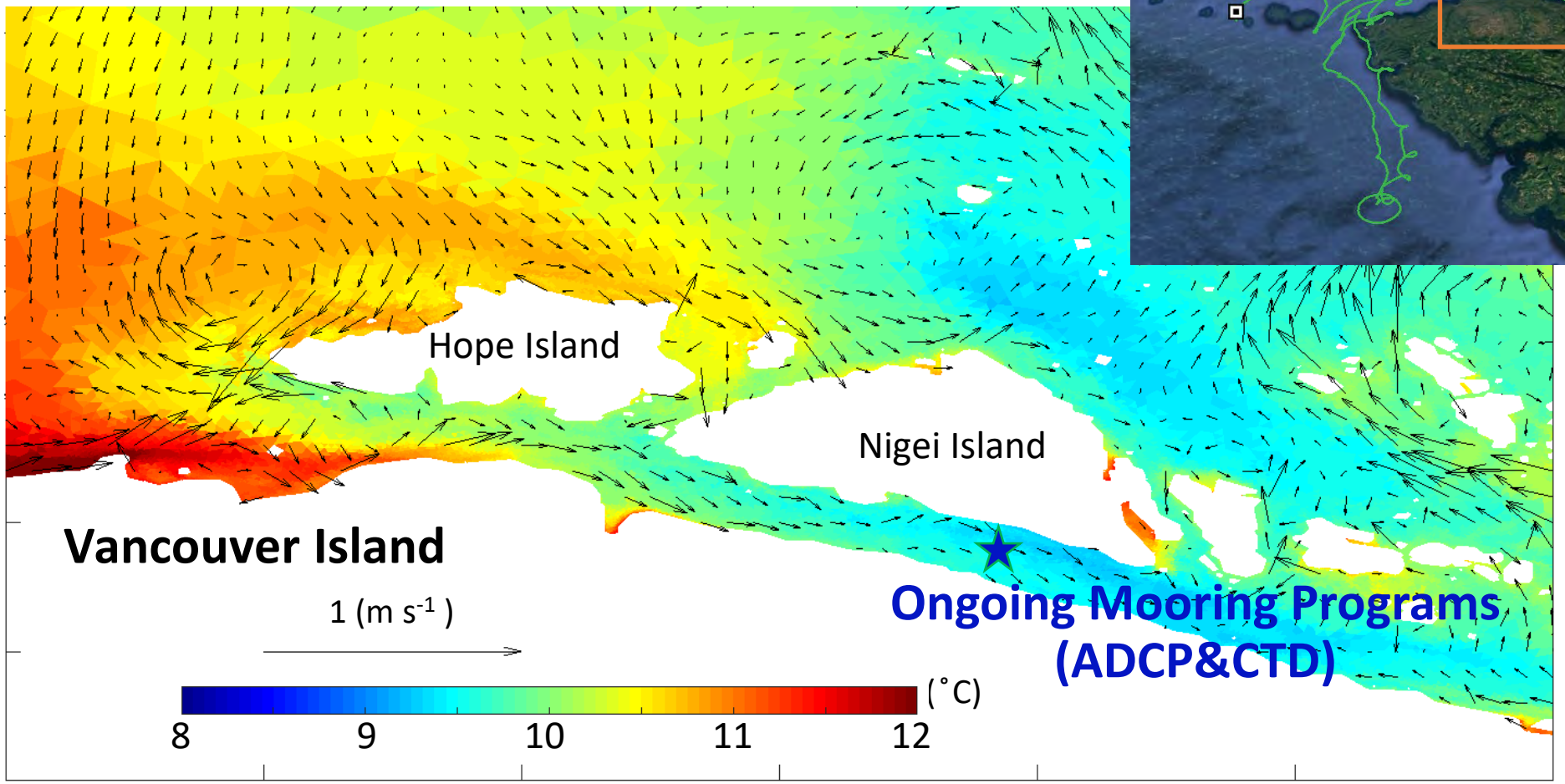
Tidal Levels (Test Run 1)



Tidal Constituent	Amp ratio to OBS		Phase diff(°) to OBS	
	CIOPS-W	FVCOM	CIOPS-W	FVCOM
K1	1.12	0.99	-4.9	1.1
O1	1.03	0.97	0.2	7.3
P1	1.12	0.99	-4.9	1.1
K2	0.99	1.02	-12.4	2.3
M2	1.00	1.02	-11.6	1.6
S2	0.99	1.02	-12.4	2.3

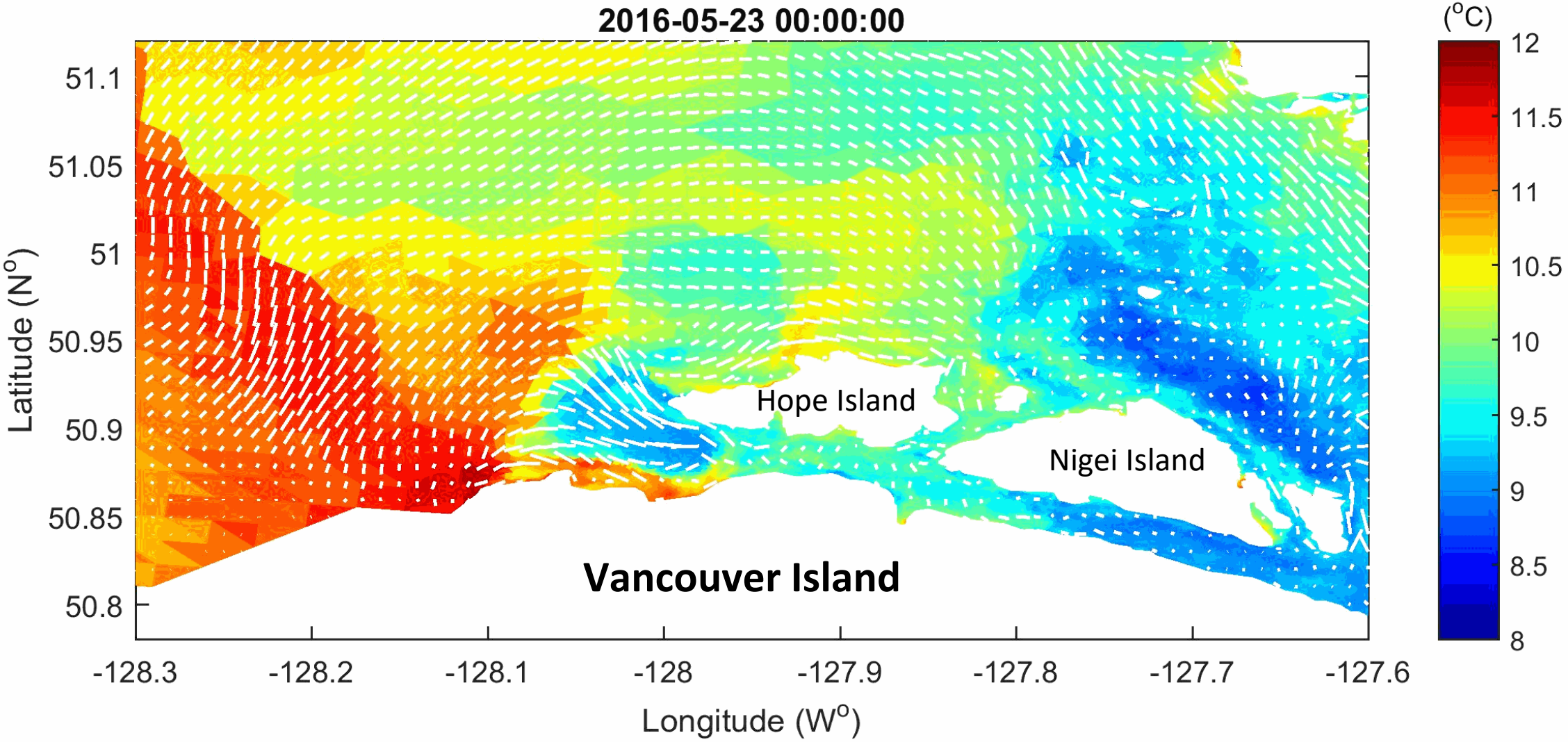
Currents in Goletas Channel (Test Run 1)

Max SST and Mean Surface Currents (May 14-30, 2016)



Drifter Trajectory Source: Glenn Cooper

Test Run 1: one-day Animation for SST and Surface Currents during Spring-Tide (May 23, 2016)



MODEL RESULTS FROM TEST RUNS

- *Amplitude ratio = modeled/observed*
- *Phase difference = modeled – observed*
- *May 14-30, 2016*

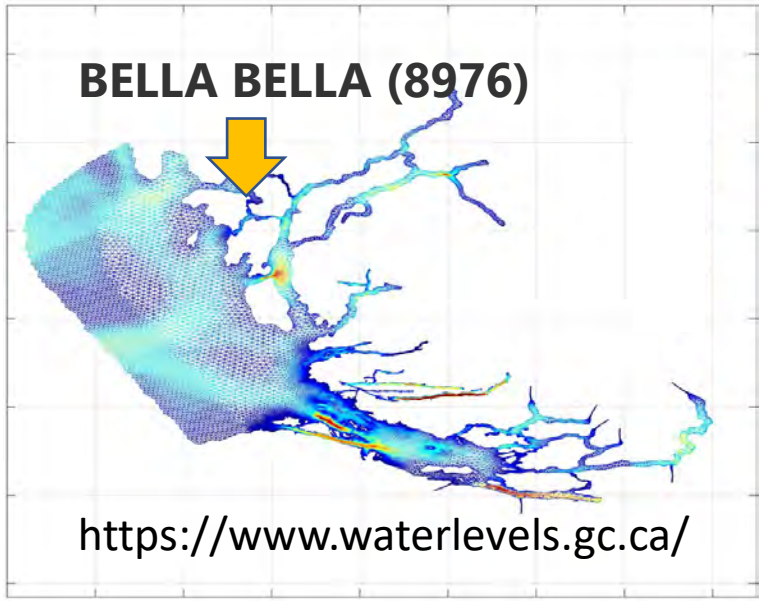
Test Run 1:

Relaxing timescale = 3 min

Test Run 2:

Relaxing timescale = 24 hr

Tidal Constituent	CIOPS-W		FVCOM Run1		FVCOM Run2	
	Amp ratio	Phase diff°	Amp ratio	Phase diff°	Amp ratio	Phase diff°
K1	0.93	11.2	0.87	16.1	0.86	9.7
O1	1.06	-4.9	0.99	-16.5	0.94	-8.1
P1	1.14	-2.8	1.06	2.1	1.06	-4.4
K2	1.04	-17.4	0.86	2.2	0.98	-12.7
M2	1.03	-11.0	0.85	5.2	0.96	-11.4
S2	1.05	-9.2	0.88	10.4	1.00	-4.5



Conclusion:

- The 3-min relaxation at the coupling zone suppresses the tides, because of using the instant daily ocean currents (U,V) from CIOPS-W
- Central Coast BC is affected more than Queen Charlotte Strait
- Semi-diurnal amplitudes are affected more than diurnal amplitudes
- This suppression could be mitigated by increasing the relaxation timescale

SUMMARY

- Queen Charlotte Strait (QCS) Coastal Model using FVCOM is under development
- Primary model results have been examined by comparison with CIOPS-W results and limited observations in the domain
- The model has demonstrated reasonable skills for water levels and temperatures in the test runs

FUTURE WORK

- Test Run 3 with hourly CIOPS-W T/S and currents
- Better resolution in the vertical
- More freshwater discharges for un-gauged rivers
- Further model validation and evaluation

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MAIN REFERENCES

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