

DISCOVER THE OCEAN. UNDERSTAND THE PLANET.

USING MULTIPLE PLATFORMS TO ASSESS A POTENTIAL LINK BETWEEN THE NORTH PACIFIC WARM ANOMALY (THE 'BLOB') AND ANOMALOUS CONDITIONS IN THE SALISH SEA DURING 2015

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PICES Annual Meeting
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OCEAN
NETWORKS
CANADA

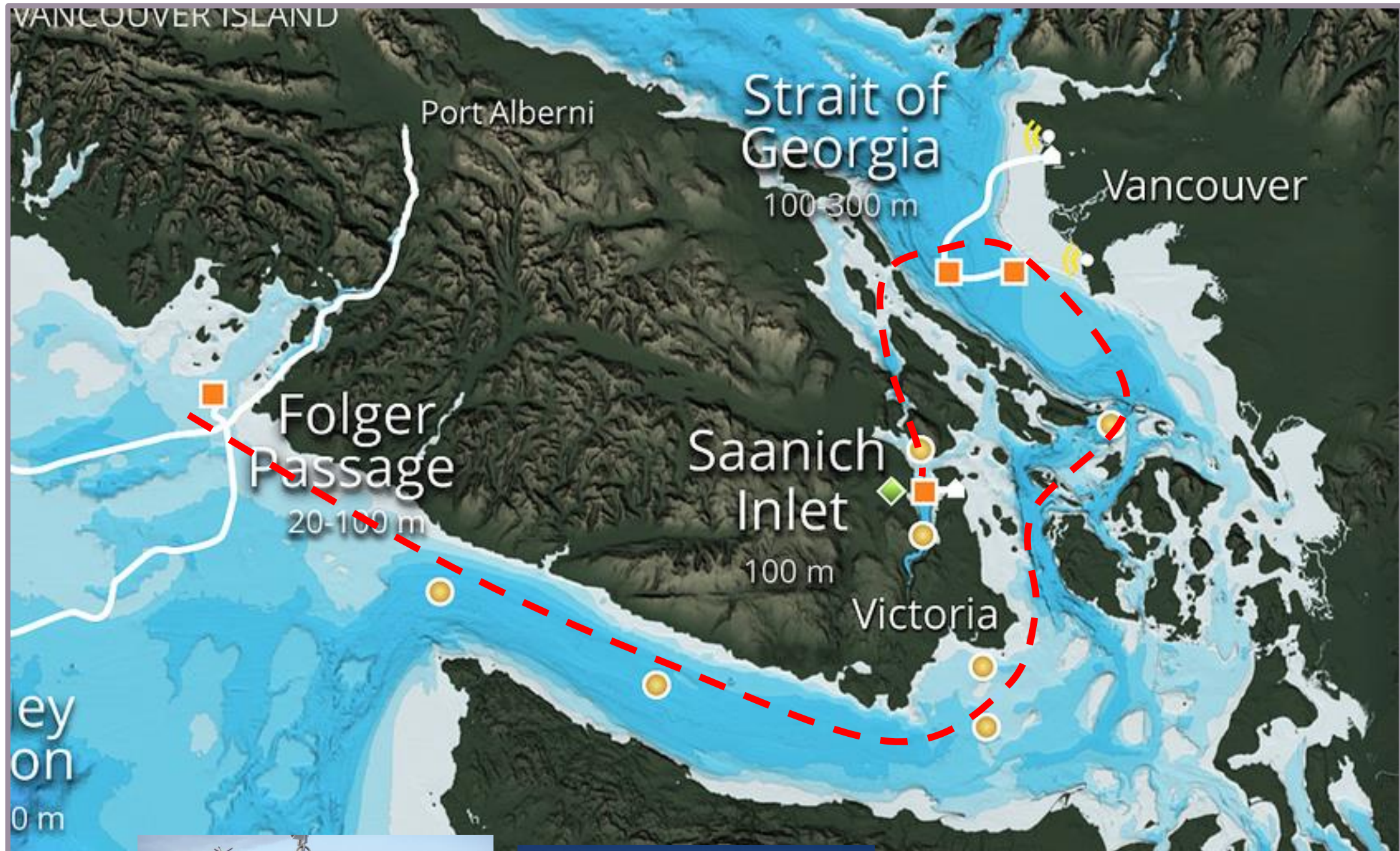


Fisheries and Oceans
Canada

Pêches et Océans
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Canada

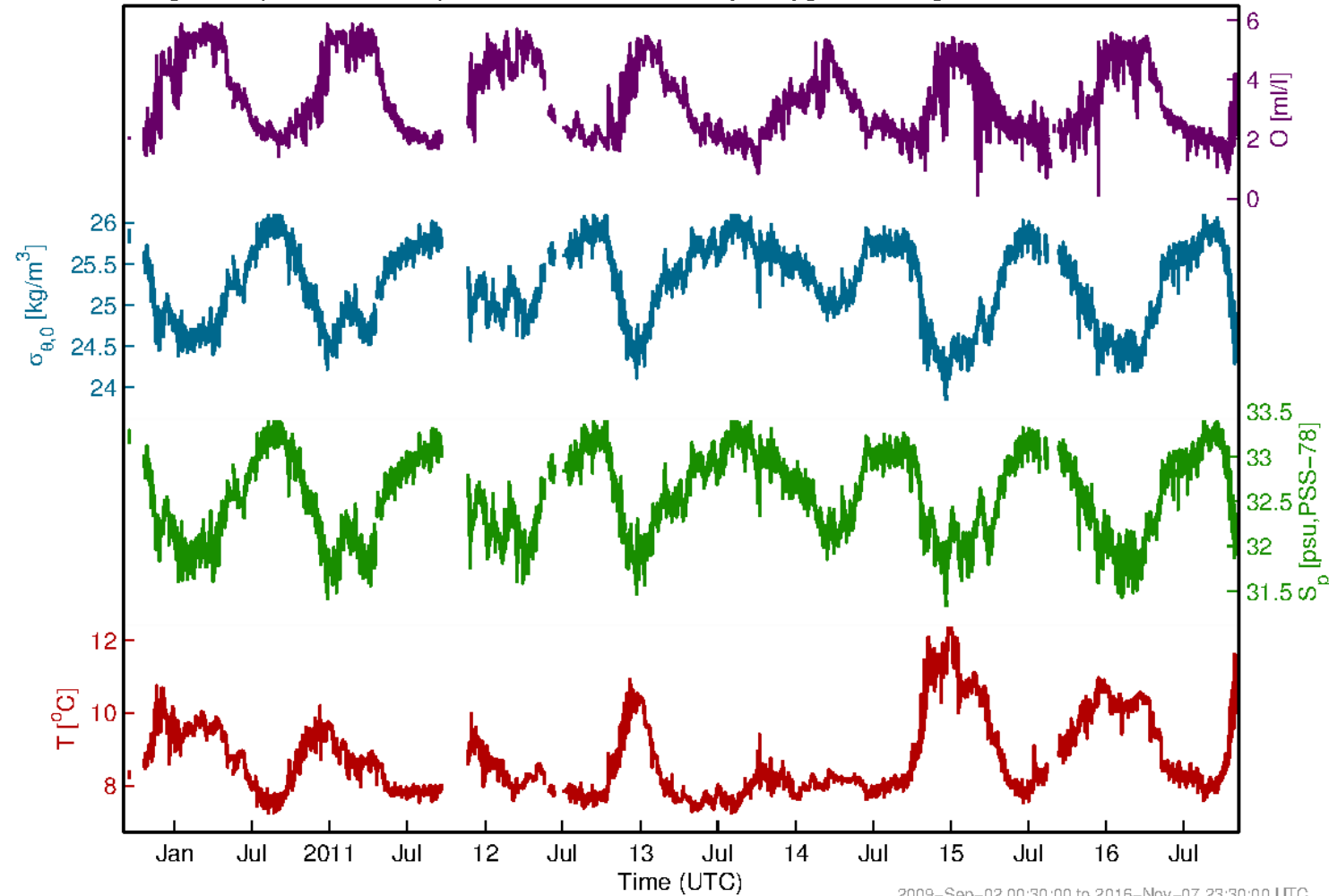
MULTI-PLATFORM COASTAL TIME-SERIES'



WARM WATER ANOMALY ARRIVES INSHORE

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Folger Deep at 97m: Temperature, Practical Salinity, Oxygen and Sigma-Theta



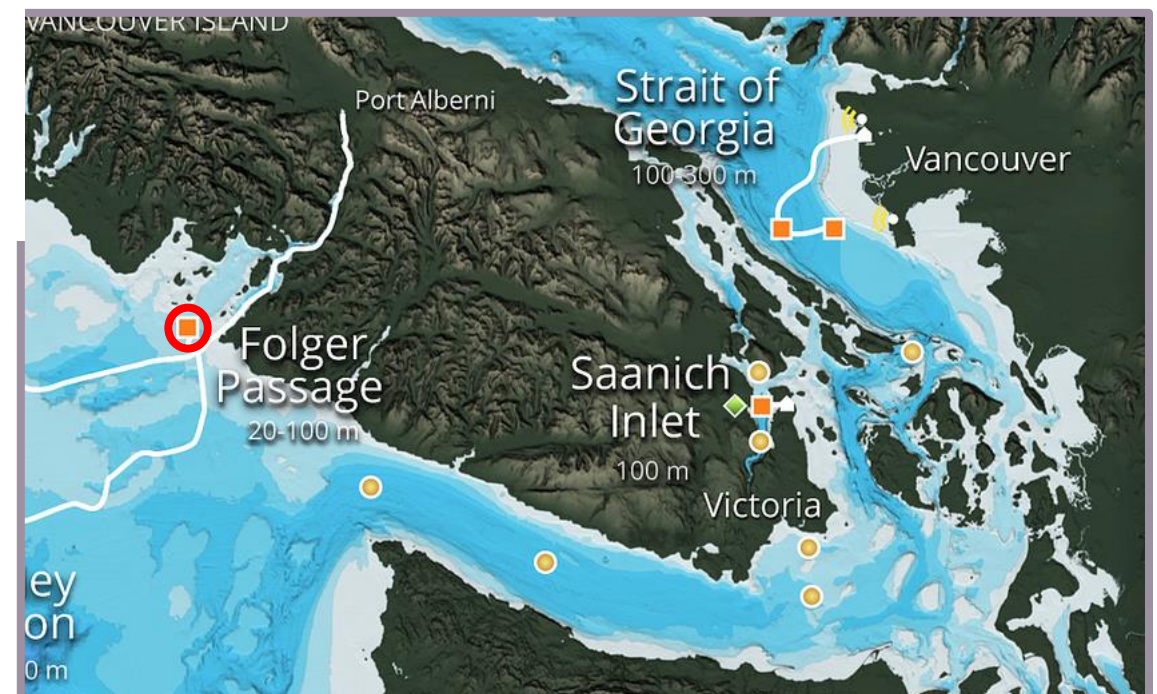
2009-Sep-02 00:30:00 to 2016-Nov-07 23:30:00 UTC
Plot generated on 2016-Nov-08 01:54:40 PST

Folger Deep:

- 6+ year time series
- 97m deployment on the shelf
- Upwelling/Downwelling periodicity

Core variables:

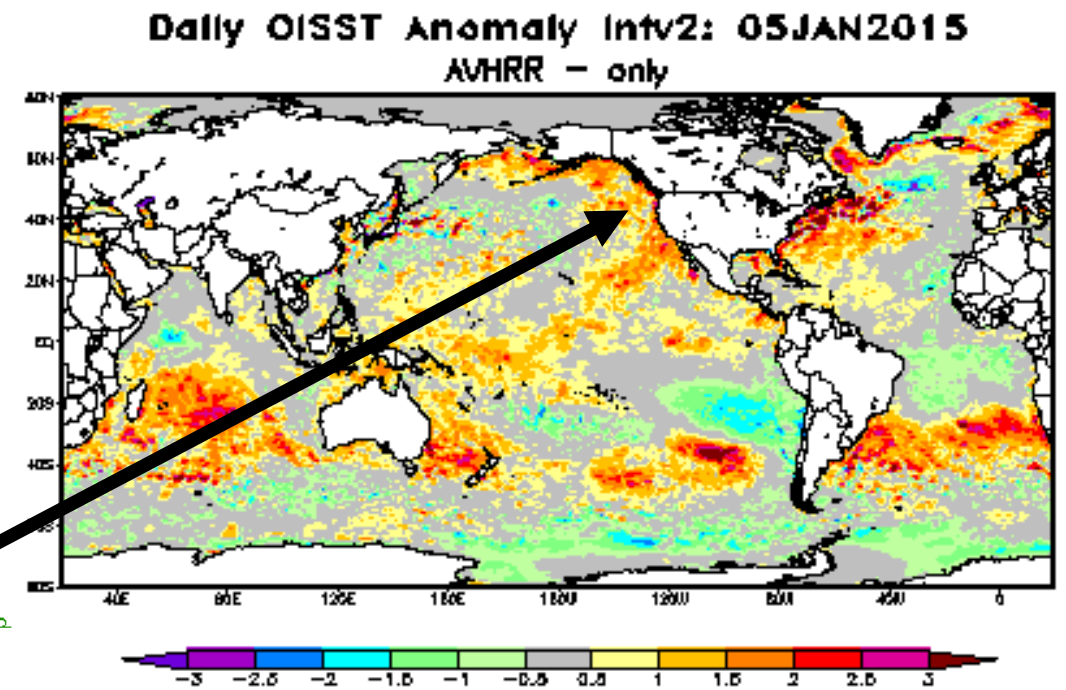
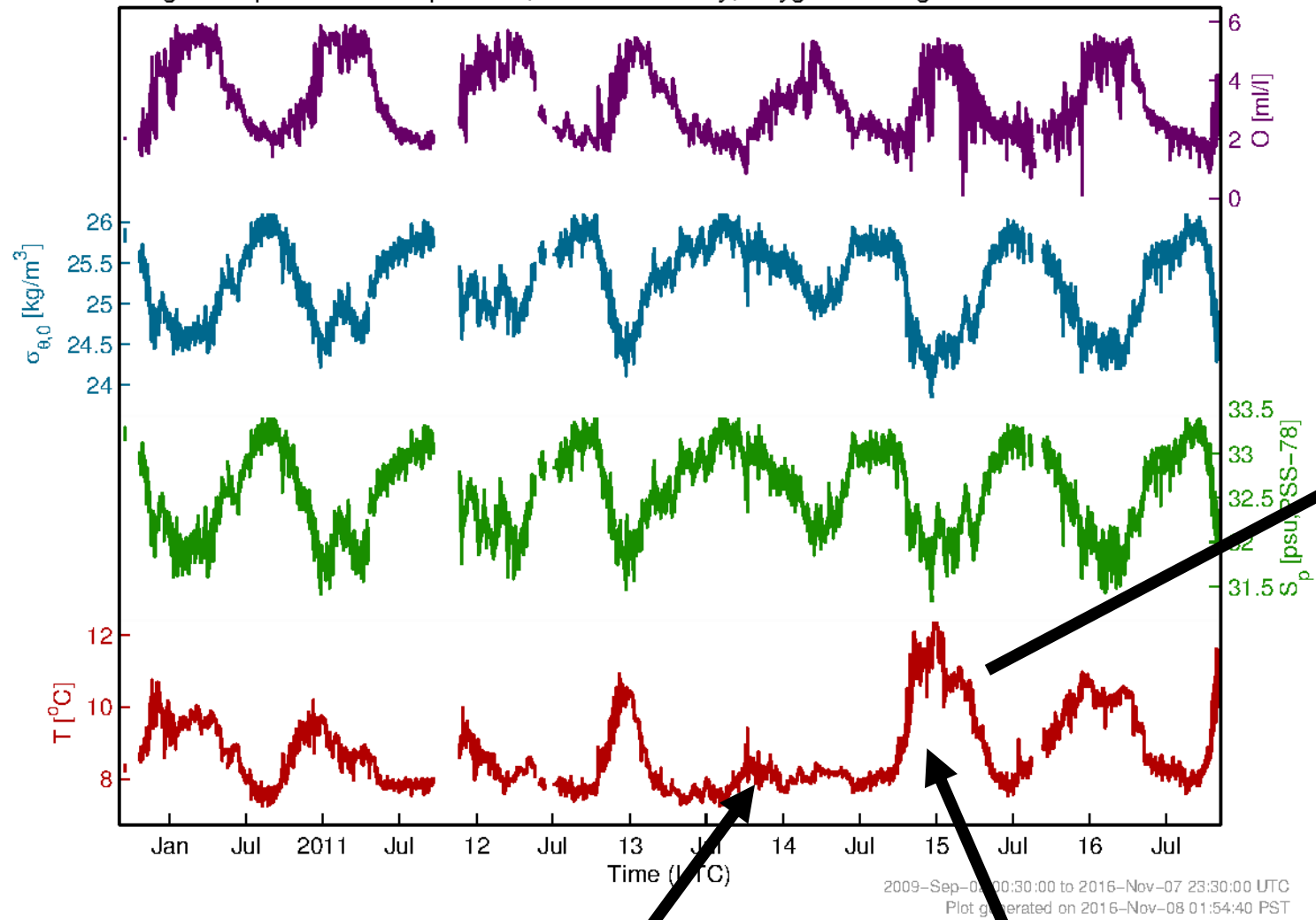
- **Dissolved oxygen**
- **Density**
- **Salinity**
- **Temperature**



WARM WATER ANOMALY ARRIVES INSHORE

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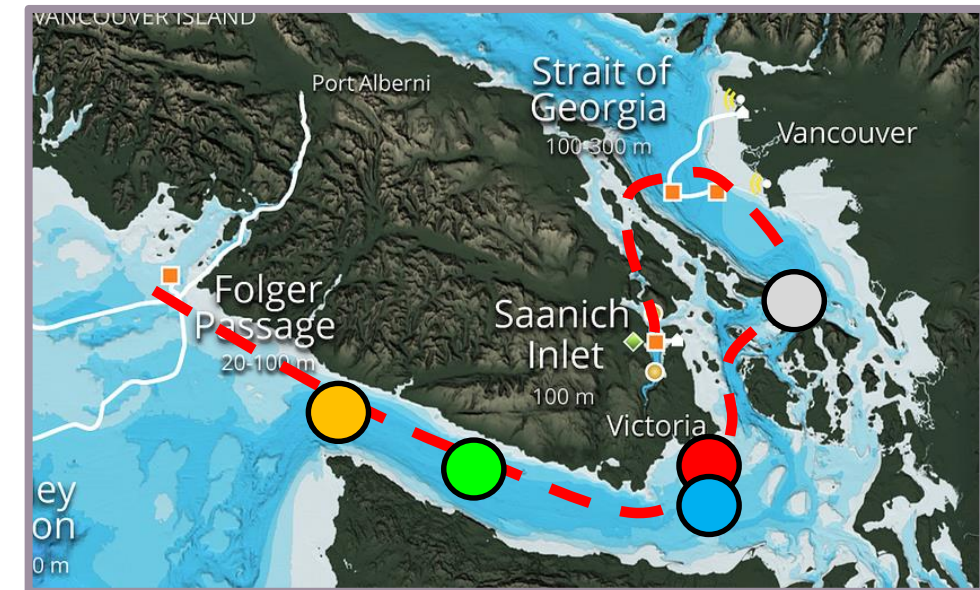
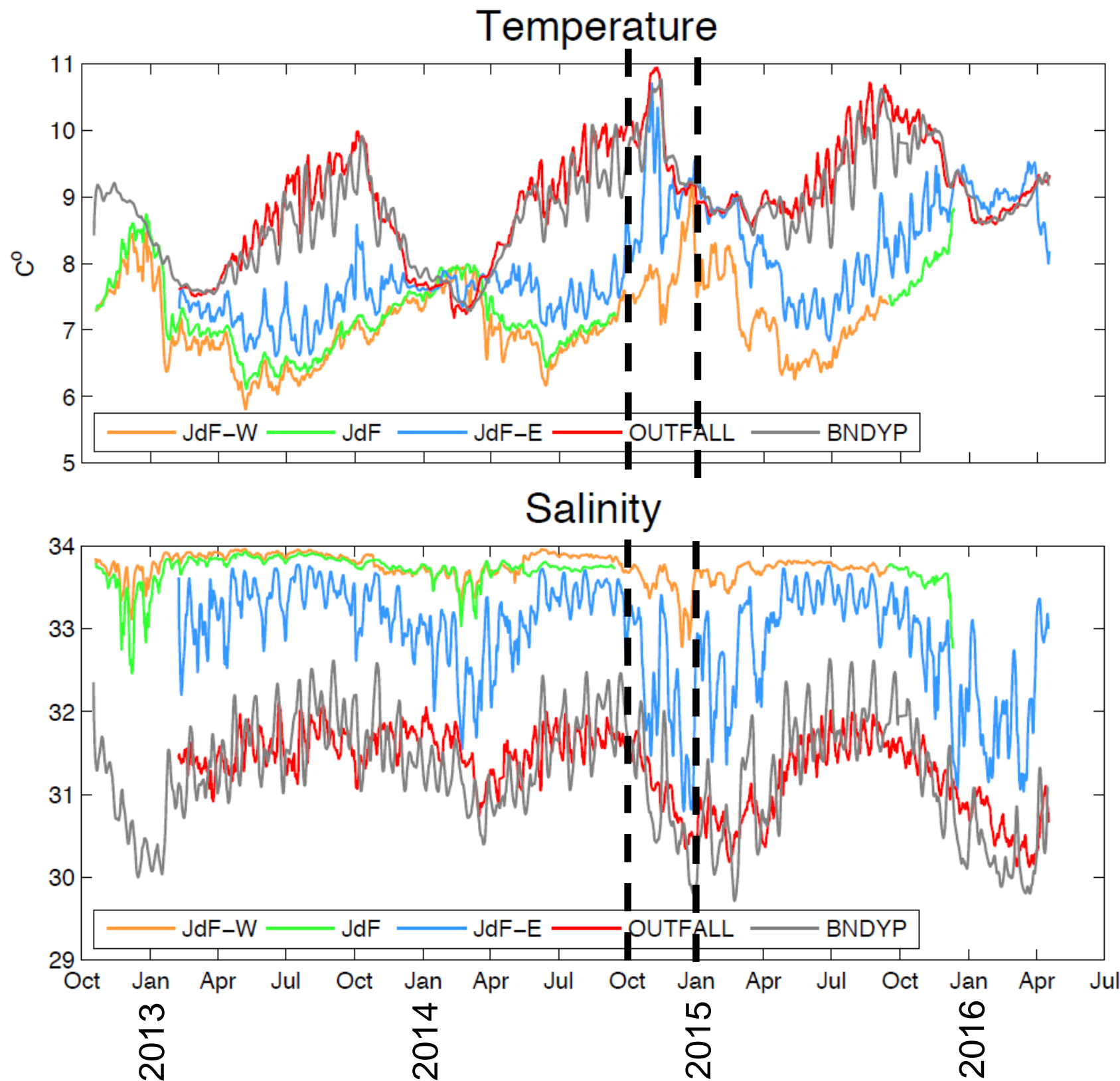
Folger Deep at 97m: Temperature, Practical Salinity, Oxygen and Sigma-Theta



Weak 2013/2014
downwelling evident
on shelf at 97 m

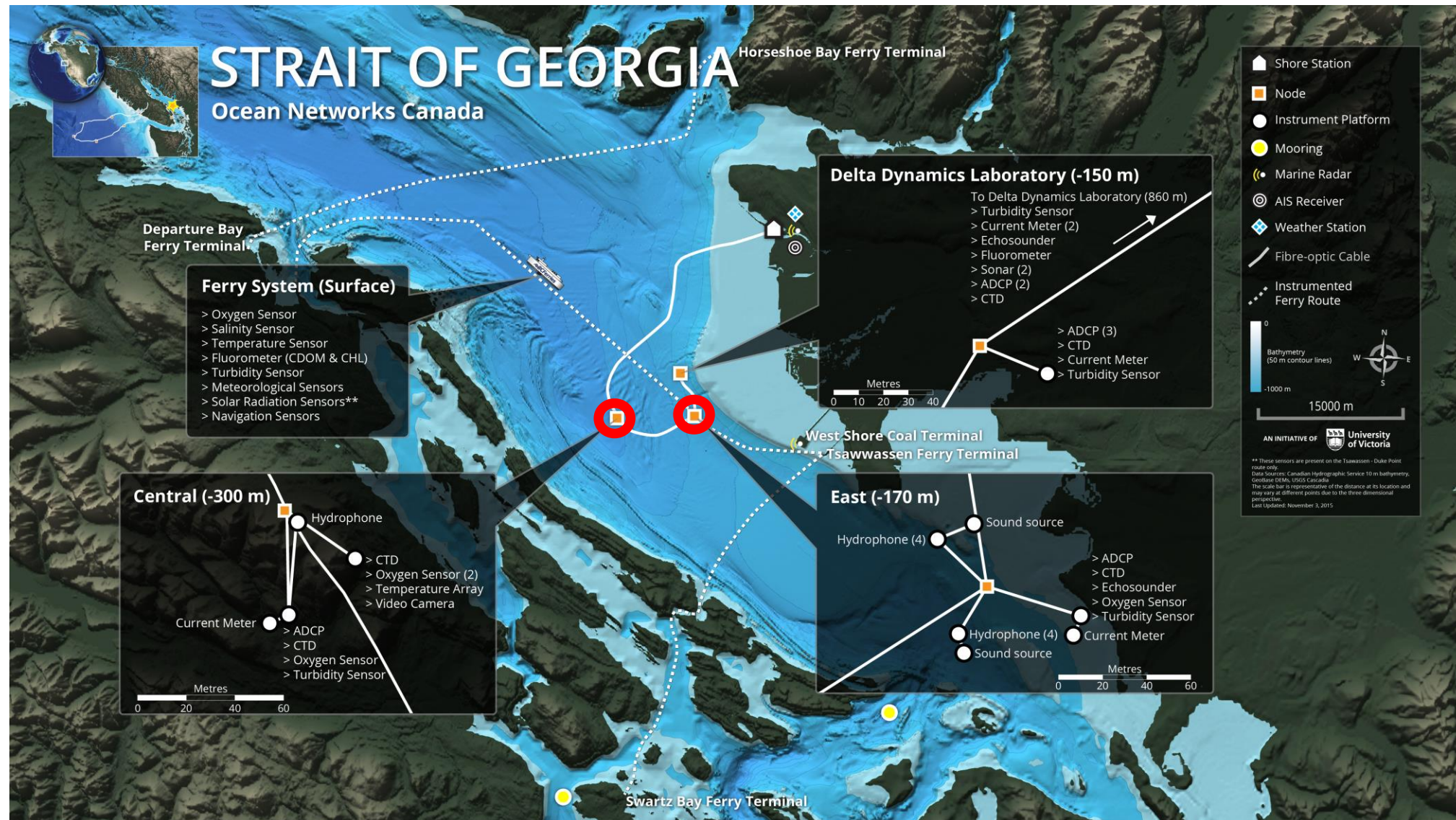
'Normal' downwelling in 2014/2015
...but very warm (+1.7 C):
"Blob" moves inshore

JUAN DE FUCA: DEEP-WATER PROPERTIES



- Very warm/fresh water apparent at Victoria and Boundary pass Oct. '14
- Not evident at deep mouth of Juan de Fuca mooring (buoyancy issue?)
- Limited winter cooling 2015-2016
- Deep water destined for the Strait of Georgia << dense than is typical

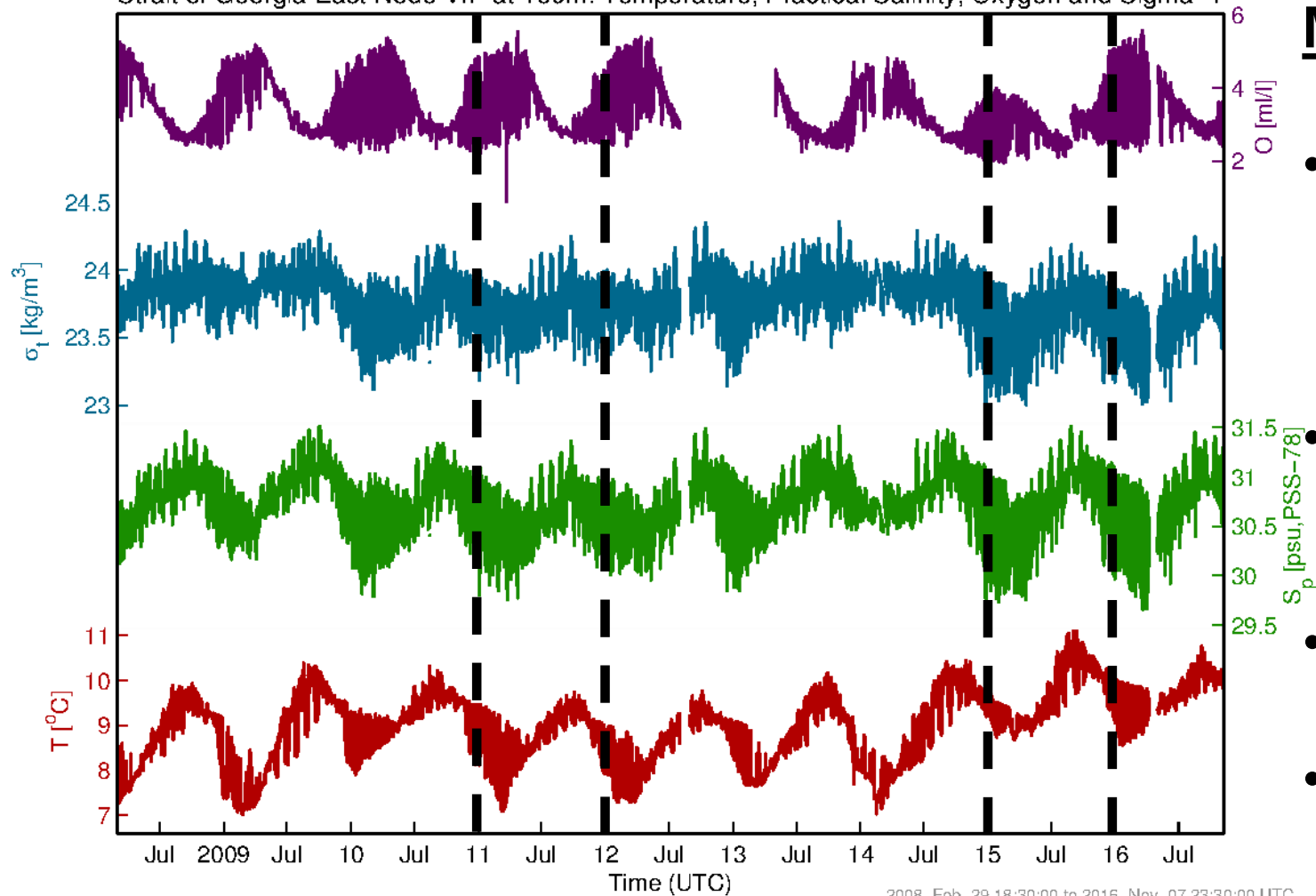
STRAIT OF GEORGIA: DEEP-WATER PROPERTIES



STRAIT OF GEORGIA: EAST NODE [170M]

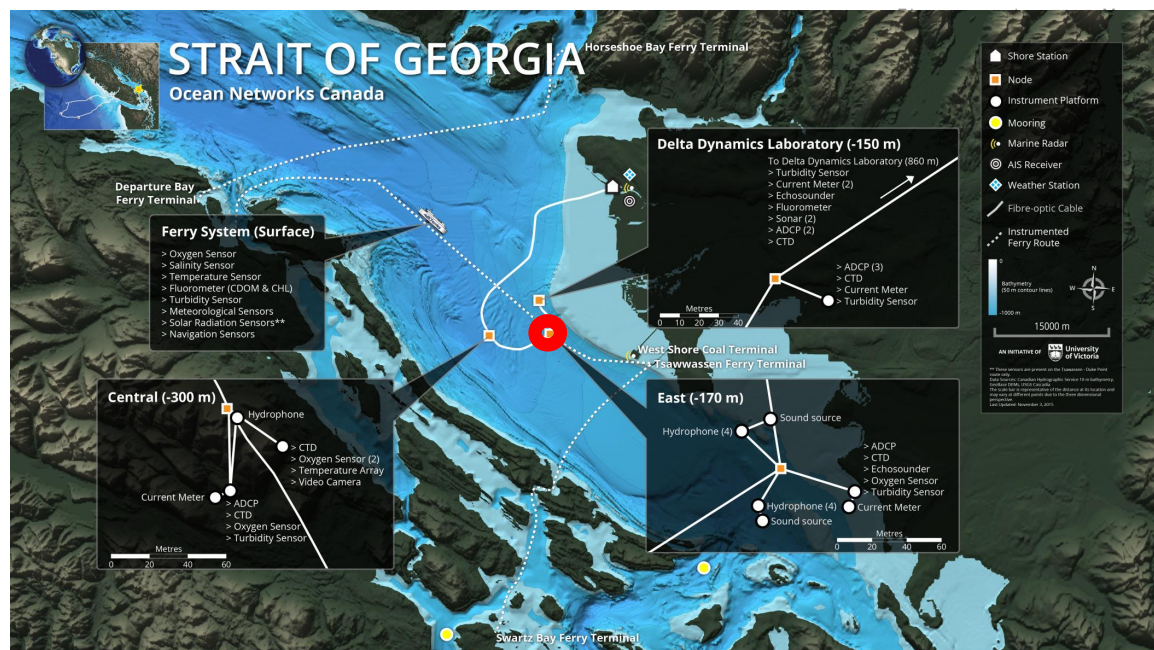
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Strait of Georgia East Node VIP at 169m: Temperature, Practical Salinity, Oxygen and Sigma-T



Mid-depth perspective (8 years):

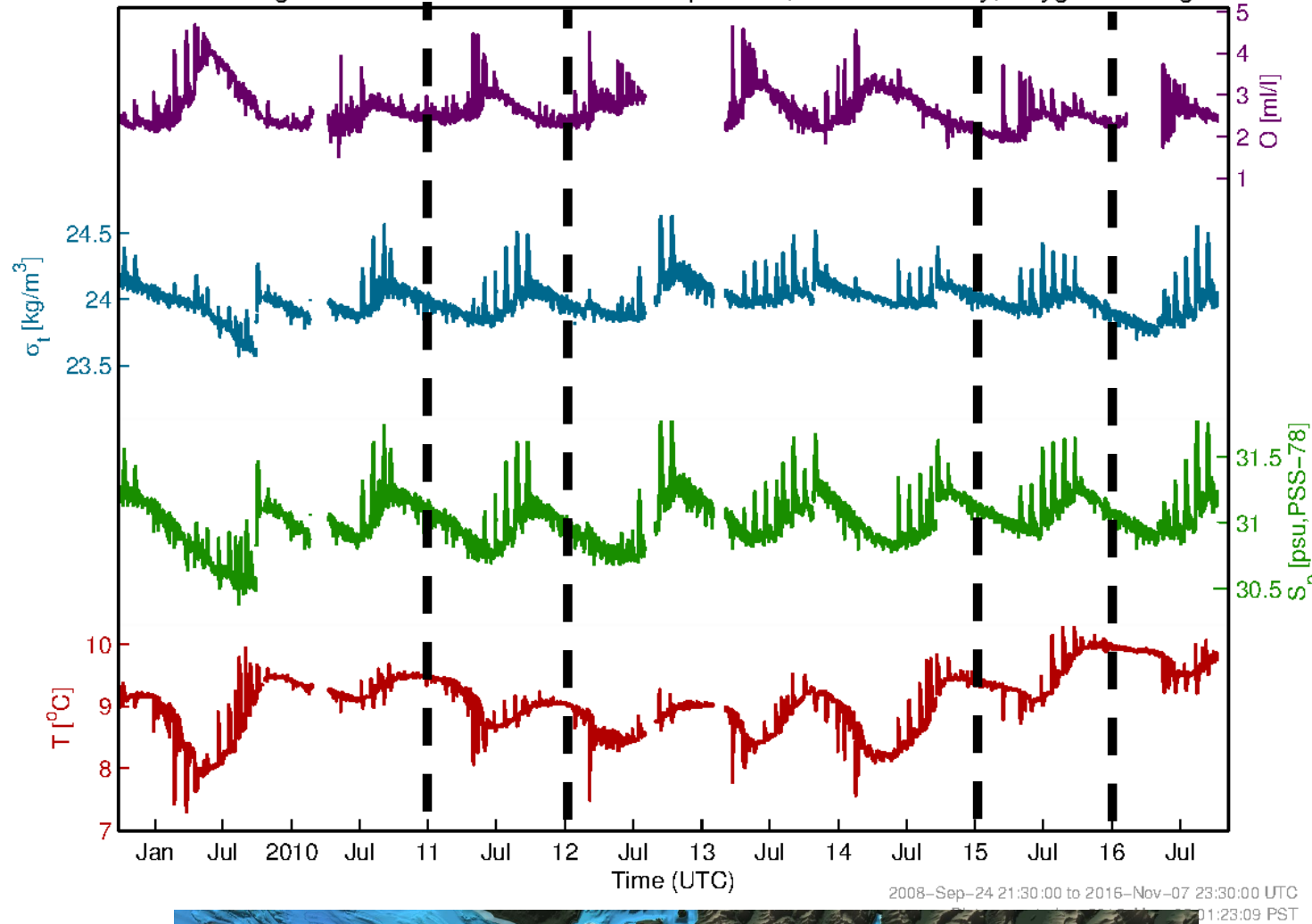
- Summer = warming/salinity increase (arriving from JdF– deep water renewal events)
- Winter = cooling/freshening (arriving with flood tides – top down flux)
- 2015 temporal pattern is not unusual
- Winter = very fresh with *marginal* cooling
- 2015 Winter oxygen maxima = lowest values for time series
- Recent summer warming is the warmest for this time series



STRAIT OF GEORGIA: CENTRAL NODE (300M)

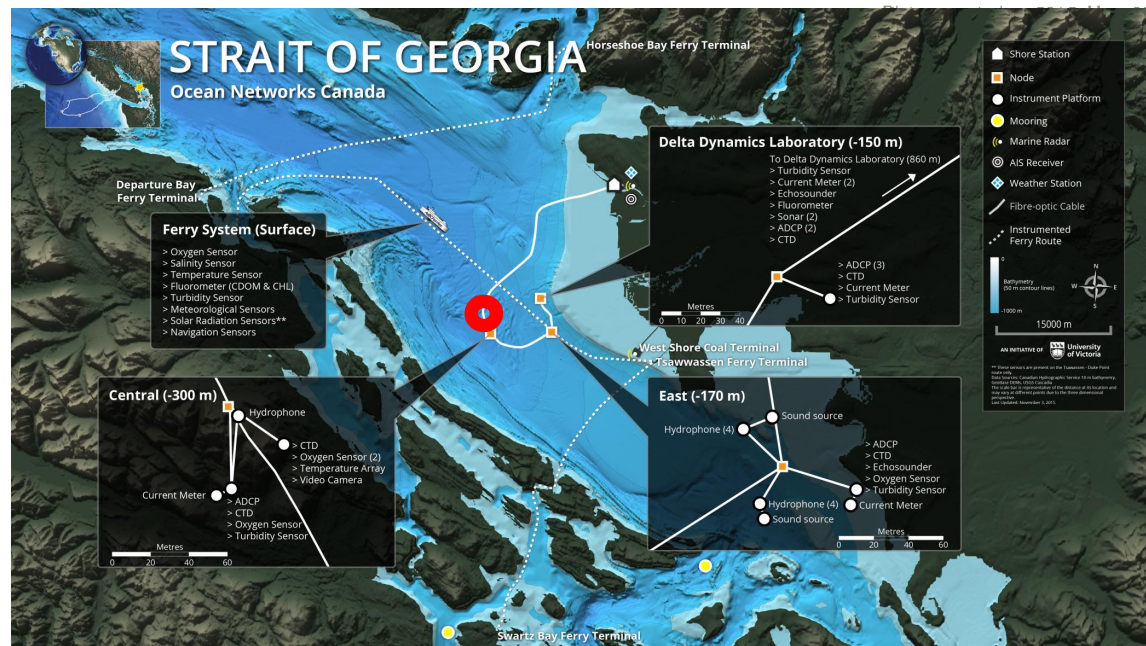
OCEAN NETWORKS CANADA VENUS

Strait of Georgia Central Node VIP at 301m: Temperature, Practical Salinity, Oxygen and Sigma-T



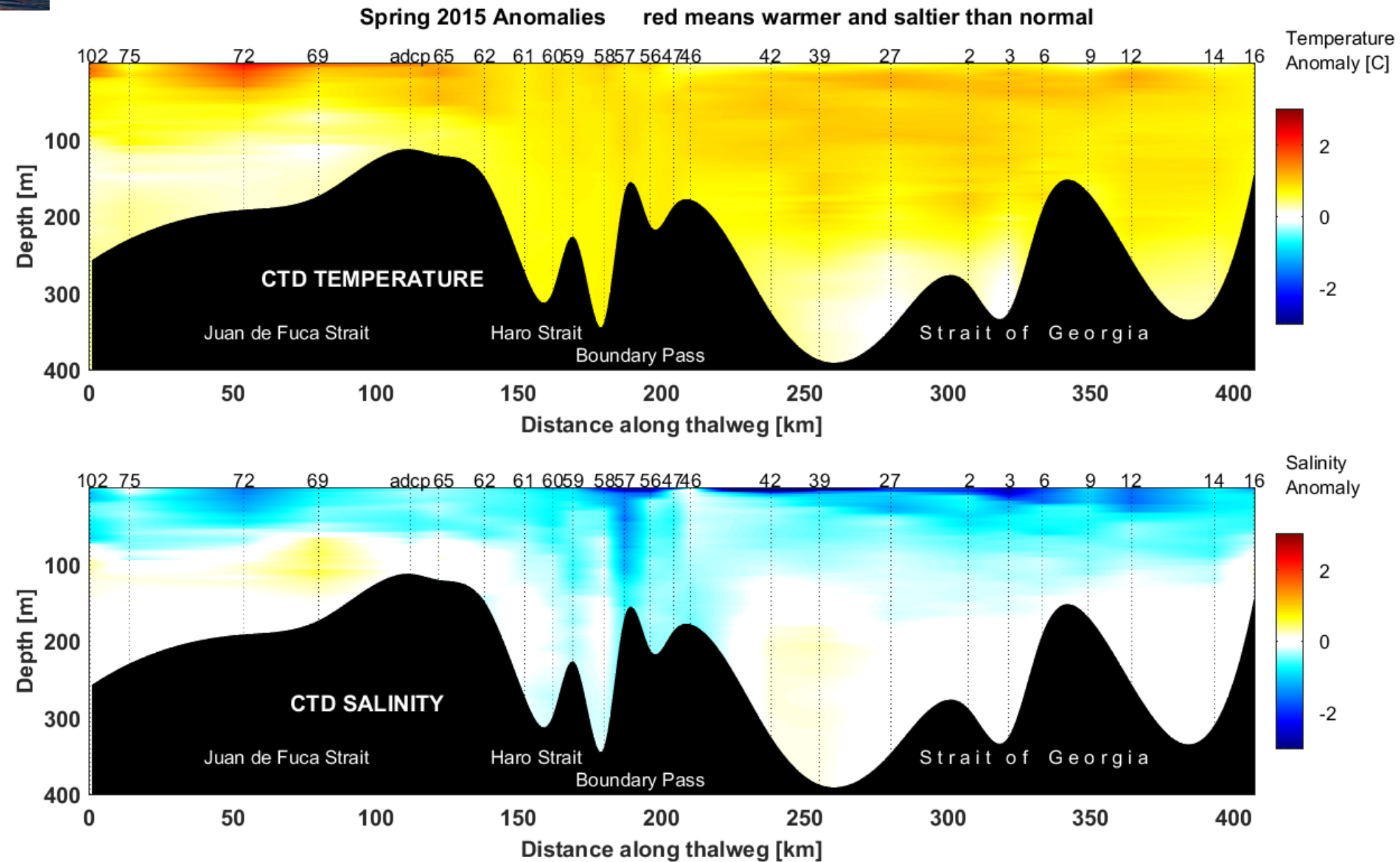
Deep-basin perspective (7 years):

- Summer = warming/salinity increase (deep water renewal events)
- Winter = cooling/freshening (arriving with flood tides – top down flux)
- 2015 temporal pattern is not unusual
- Winter = *marginal* seasonal cooling
- Recent winter oxygen maxima = lowest values for time series
- Recent summer warming is the warmest for this time series





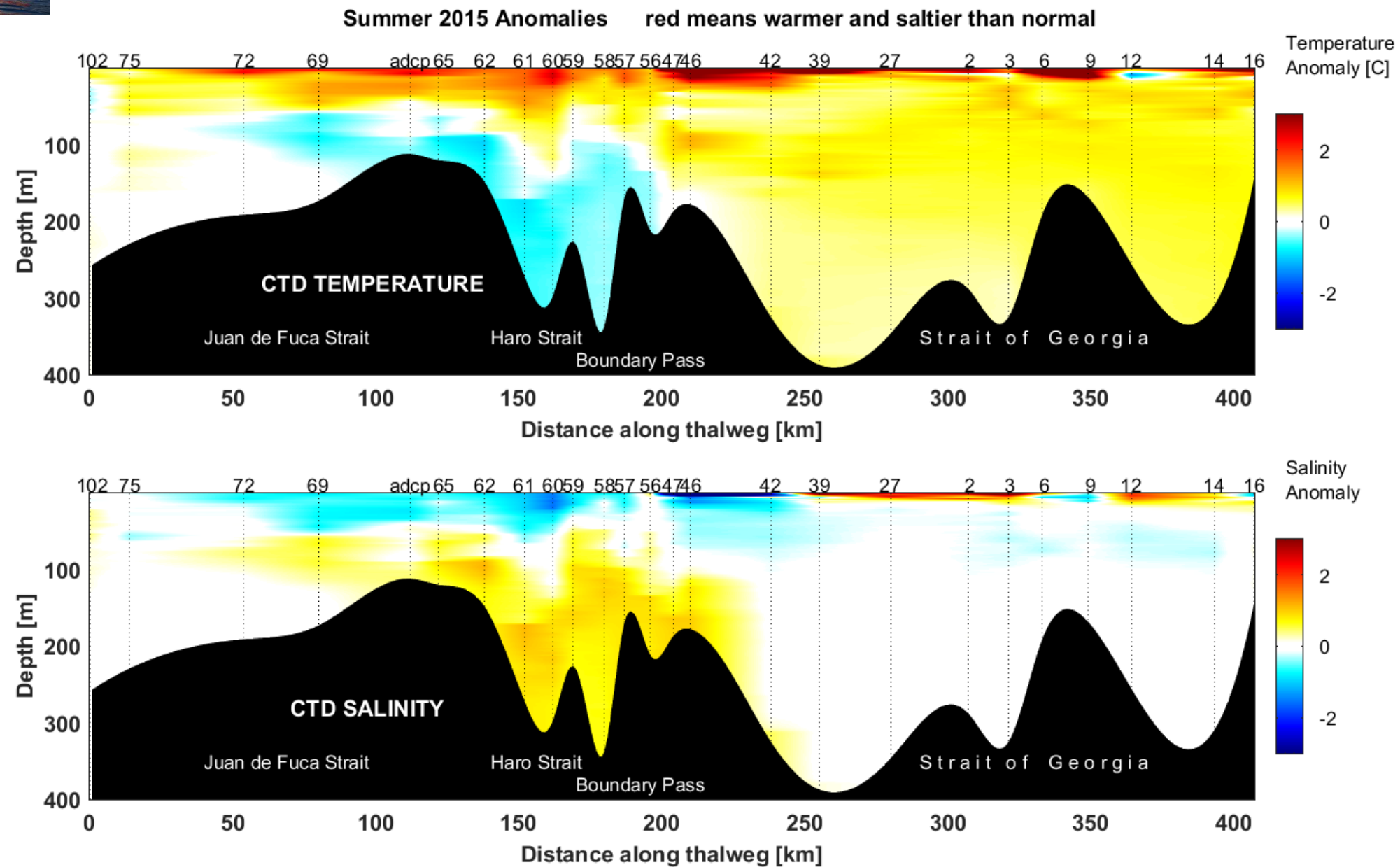
SALISH SEA: SPRING SURVEY (2015)



- Early April 2015
- Anomalously warm and fresh surface water exiting the Strait of Georgia
- Anomalously warm water entering the deep Strait of Georgia Basin



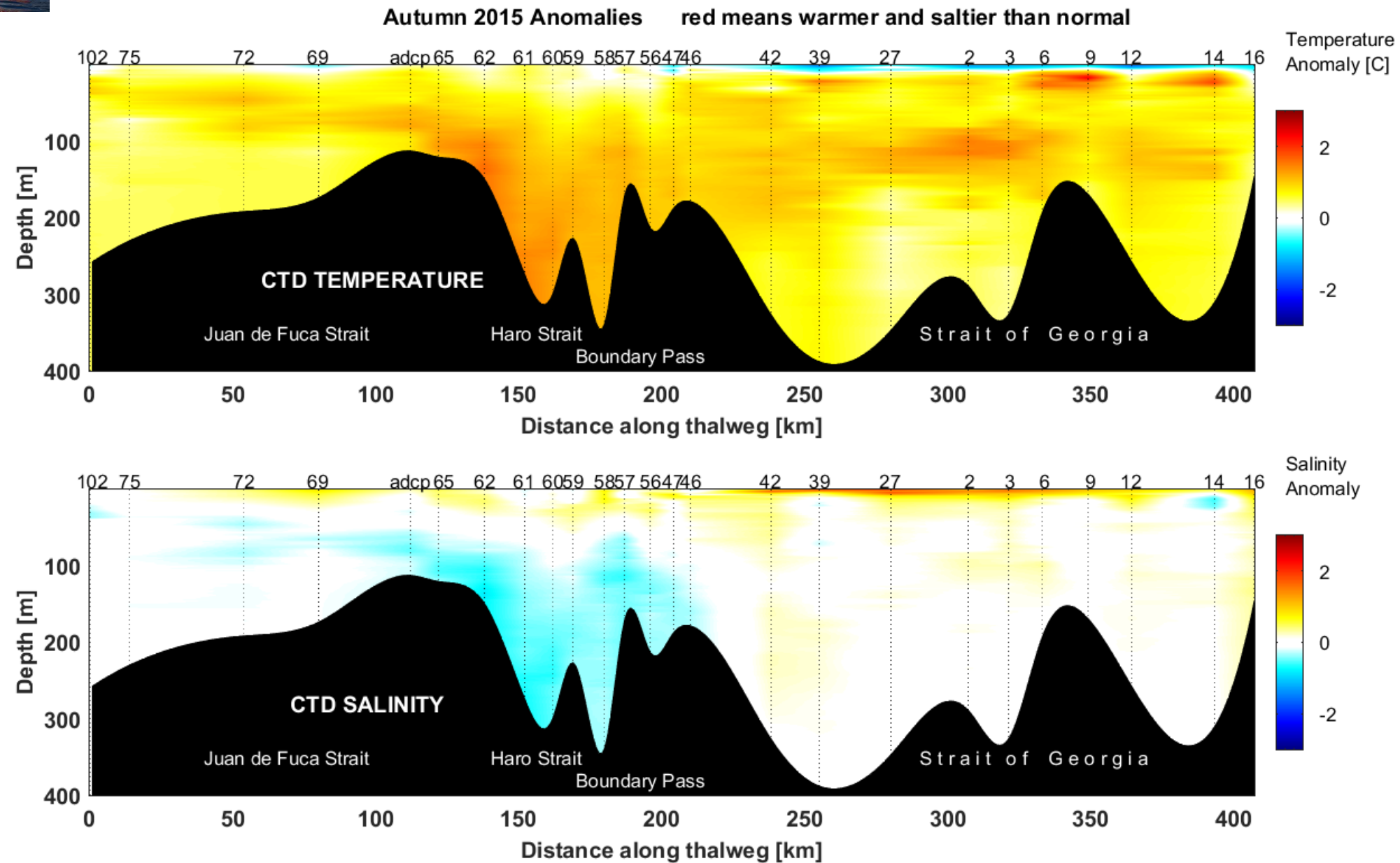
SALISH SEA: SUMMER SURVEY (2015)



- Late June 2015
- Anomalously warm and fresh surface water exiting the Strait of Georgia
- Anomalously cold and salty water in Haro Strait (entrance to Strait of Georgia)



SALISH SEA: FALL SURVEY (2015)



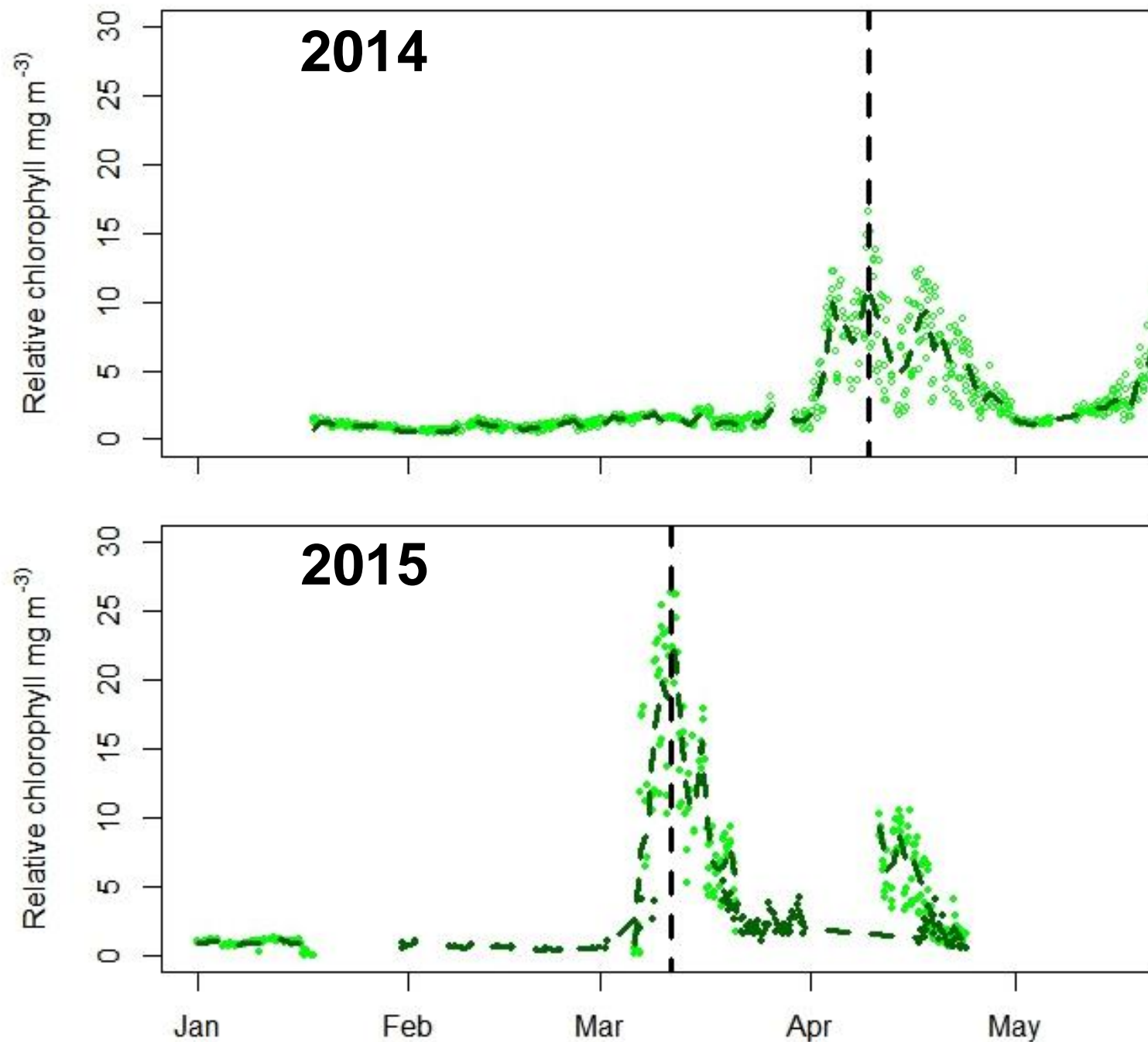
- September-October 2015
- Anomalously warm and fresh water entering the deep Strait of Georgia Basin
- Translates to limited winter cooling/ventilation of deep Strait of Georgia basin

BIOLOGICAL RESPONSE: ONC-BC FERRIES



- BC Ferries vessels instrumentation includes: Temperature, Salinity and Dissolved Oxygen, Chlorophyll fluorescence
- Fine resolution: every 10 seconds
- Useful for tracking the start of the spring phytoplankton bloom

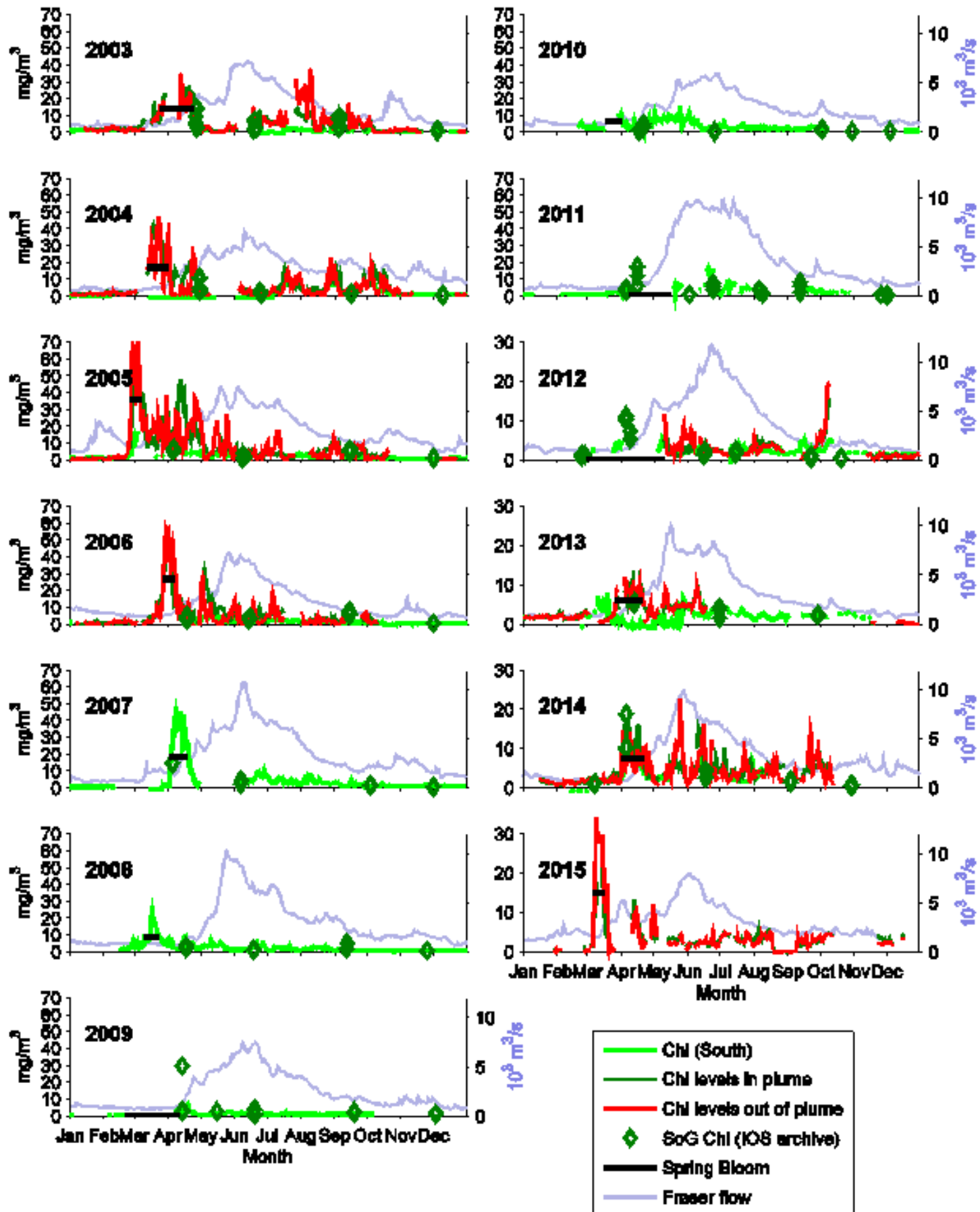
SPRING PHYTOPLANKTON BLOOM: 2014 & 2015



Bloom timing:

- Long-term mean date = March 25
- 2014 peak biomass = April 9
- Relatively “late”
- 2015 peak biomass = March 11
- Relatively “early” (29 days earlier than 2014)
- 2nd earliest bloom since 2001
- Earliest bloom = 2005 (late-Feb)

SPRING PHYTOPLANKTON BLOOMS: 2003-2015



Surface Chl fluor. time-series:

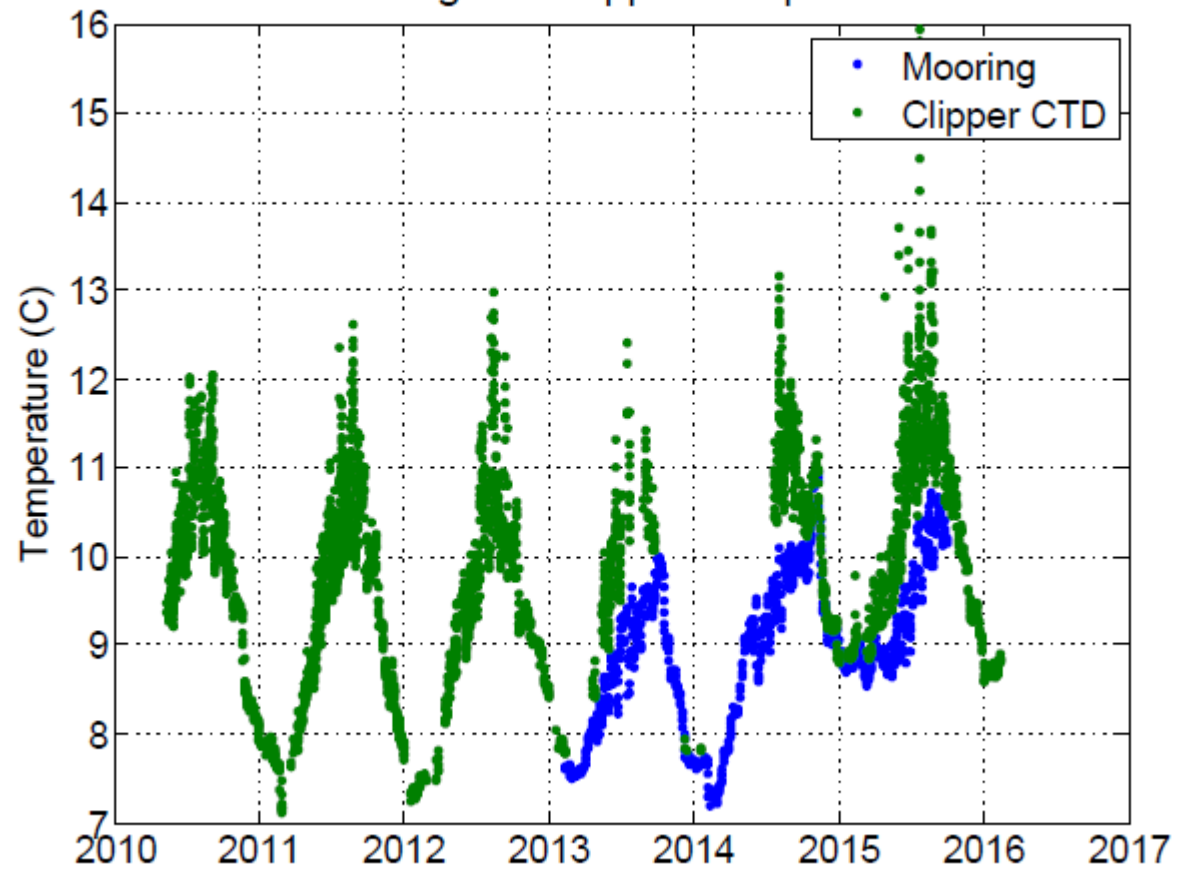
- 2003 (2001) – present
- **South** and **Central (out-plume)** routes
- 2015: Relatively high Fraser R. discharge in late winter – warm & calm conditions
- 2015 = early bloom; similar to late winter conditions in 2005
- 2015 bloom = short duration & moderate biomass production

(Fig. courtesy Rich Pawlowicz, UBC)

SUMMARY

- Warm water anomaly arrived inshore October 2014
- Anomalously warm/fresh water identified in bottom waters of the eastern Juan de Fuca Strait approaching Haro Strait
- 2015-2016 seasonal patterns of deep cooling/warming largely consistent with expectations however:
 - Cooling period (winter) is less cool and dense – low(est) dissolved oxygen concentrations in 2015
 - Warming period is very warm – current bottom water temperatures in the Salish Sea are warmest for the ONC time-series
- Surface conditions have remained warmer than average since the arrival of the ‘blob’
- 2015 spring bloom started 4 weeks earlier than 2014 (warm & calm conditions – high river discharge in late winter)
- Current warm conditions in the Strait of Georgia cannot attributed entirely to ‘blob water’ but also to broader atmospheric conditions

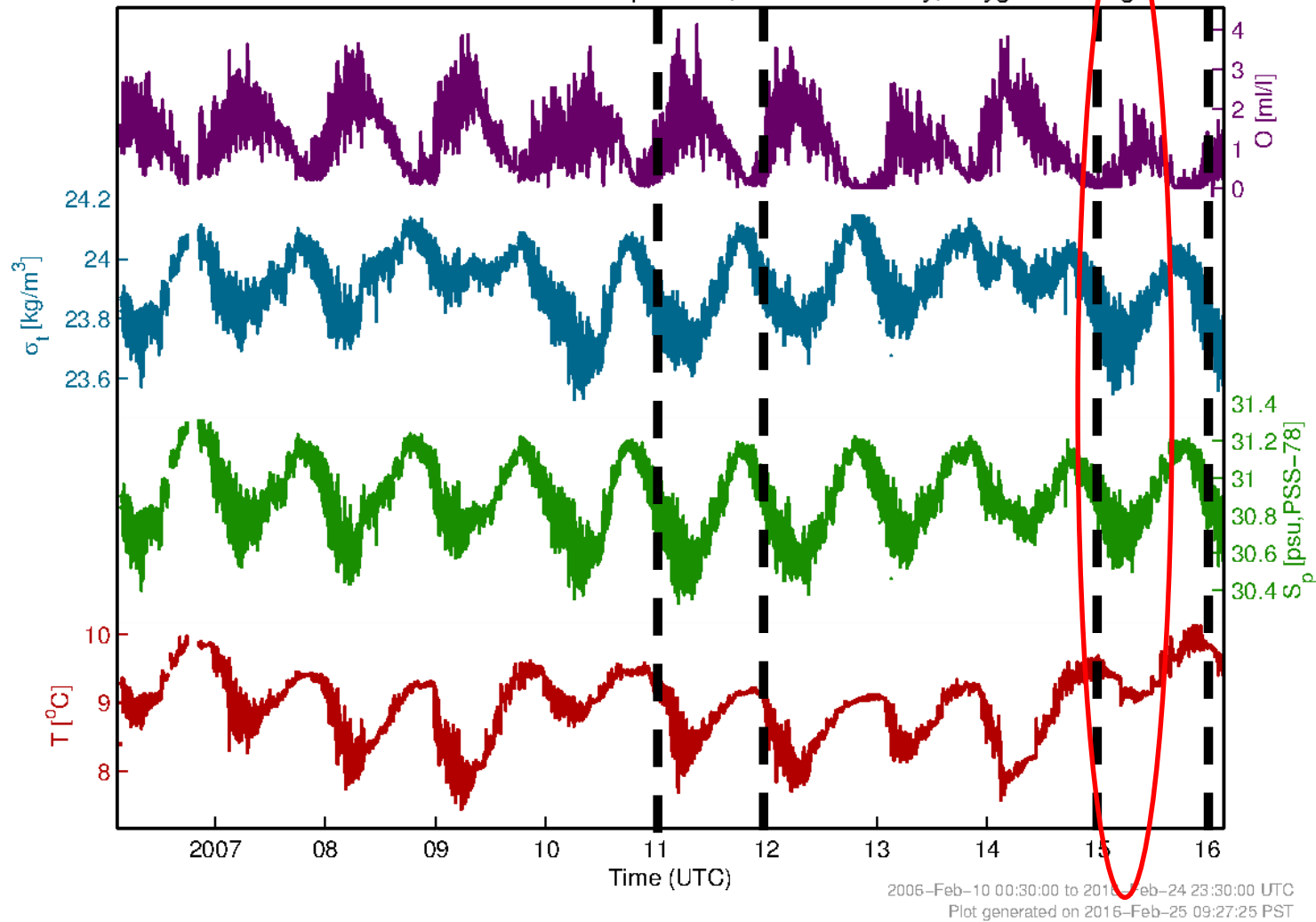
Mooring and Clipper Temperature



SAANICH INLET NODE [97 M]

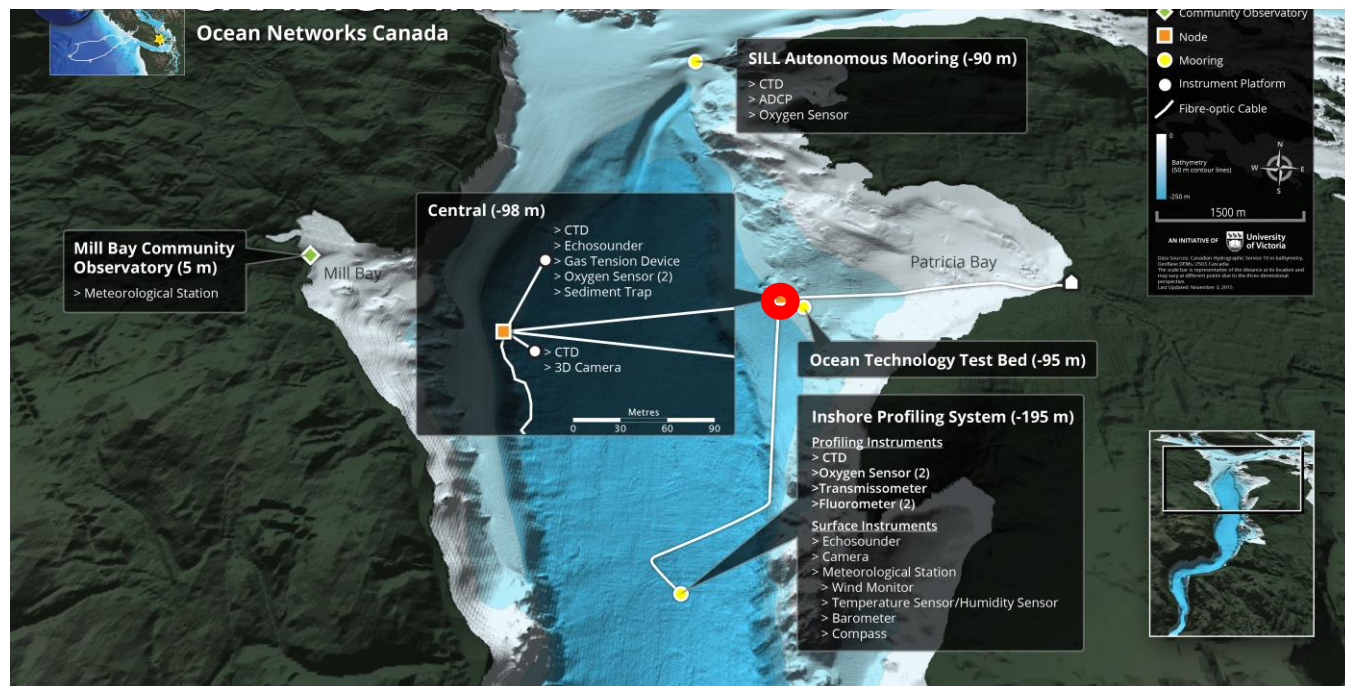
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Saanich Inlet Central Node VIP at 96m: Temperature, Practical Salinity, Oxygen and Sigma-T



Mid-basin perspective (10 years):

- 97 m – hypoxia transition zone
- Broadly similar pattern to the Strait of Georgia
- Dense (warm-salty) waters pass over the sill in summer-fall
- Lower density (high temperature) water entering Saanich Inlet in the fall 2014
- Limited cooling in the winter – warmest temperatures over the last 10 years



The NE Pacific warm anomaly (the 'warm Blob') was first identified offshore in the Gulf of Alaska in late 2013/early 2014, following limited fall/winter cooling and downwelling associated with a weak Aleutian Low. More typical downwelling conditions returned during the 2014/2015 fall-winter period and transported some of the warm surface waters onto the West coast of North America. Both the strength of seasonal downwelling and the arrival of anomalously warm waters onto the shelf of Vancouver Island were recorded by a cabled sea-floor instrument platform at Folger Passage (97 m; Ocean Networks Canada). Subsequent to the inshore arrival of the 'Blob', mid- and deep-basin conditions recorded by cabled instruments in the Strait of Georgia were indicative of limited deep-water renewal (i.e. anomalously low deep-water dissolved oxygen conditions). Limited deep-water renewal may be attributed to the inability of low-density (warm) waters entering the basin from Juan de Fuca Strait to penetrate deep into the basin. Both the Strait of Georgia and Saanich Inlet (inshore fjord) experienced little-to-no winter cooling during the 2015/2016 winter season. Here we take advantage of a number of publicly-available high-resolution time-series measurements (fixed and mobile platforms) to assess whether anomalous deep-water conditions inshore can be directly attributed to an inshore incursion of the 'blob' or if warmer than average local conditions promoted surface warming which limiting deep-water renewal into both the Strait of Georgia and Saanich Inlet.