

Anomalous warming and its impacts in the NE Pacific from a Canadian perspective

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Objectives

“Canada’s experience” with the unusual ocean conditions in 2014-2015:

- warm “Blob”
- ‘toxic’ phytoplankton bloom
- unusual zooplankton
- warm water fish species
- implications for seabirds and commercial fish

To some extent a summary of earlier presentations

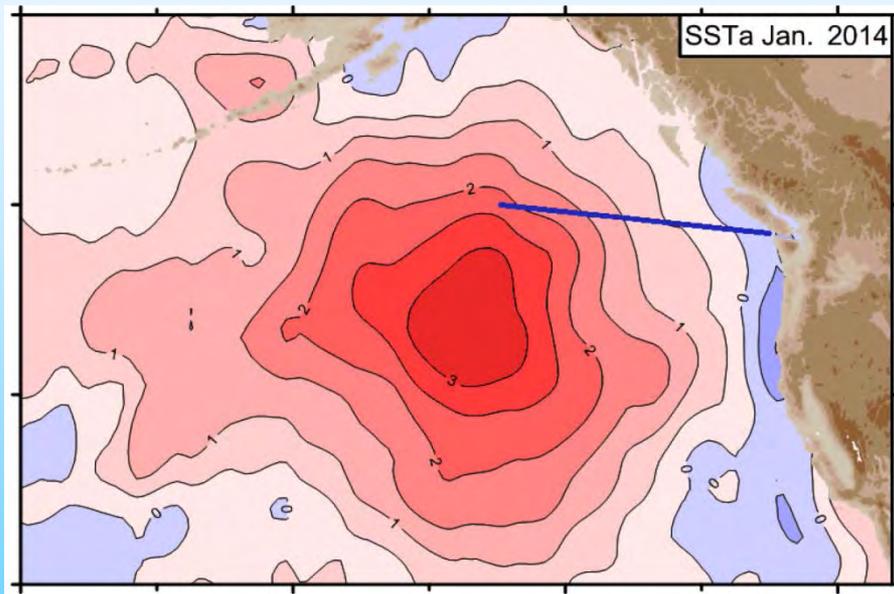


The “Blob” moves to the coast of North America

Reynold’s data

January 2014

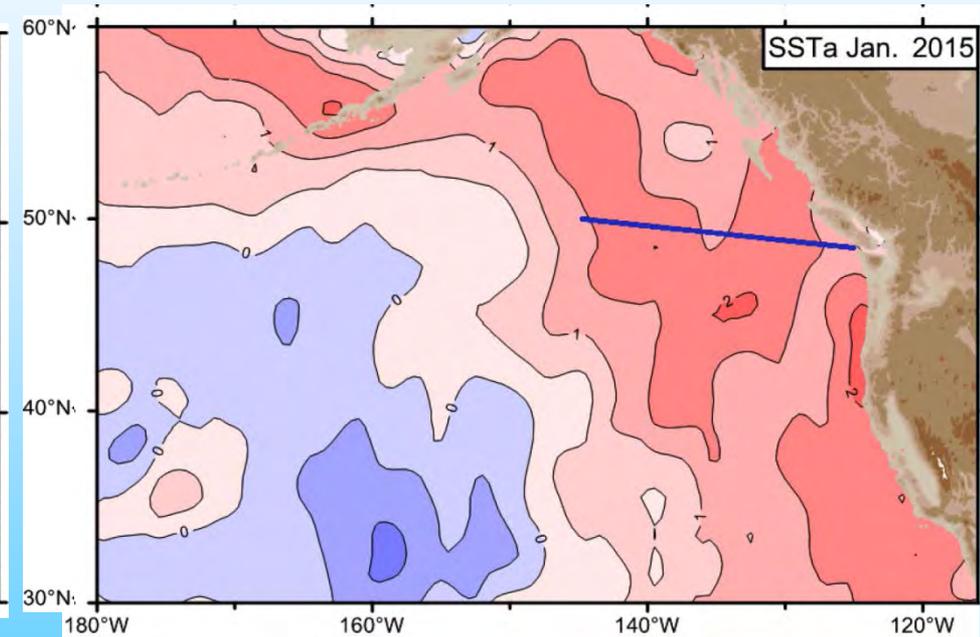
Difference from normal temperatures



Very intense warm water
(red: up to 3 °C above normal) in NE
Pacific, but cool (blue) along BC coast

January 2015

Difference from normal temperatures



NE Pacific has cooled (blue), but
warm water (red) moved to BC coast

The “Blob” in summer, 2015

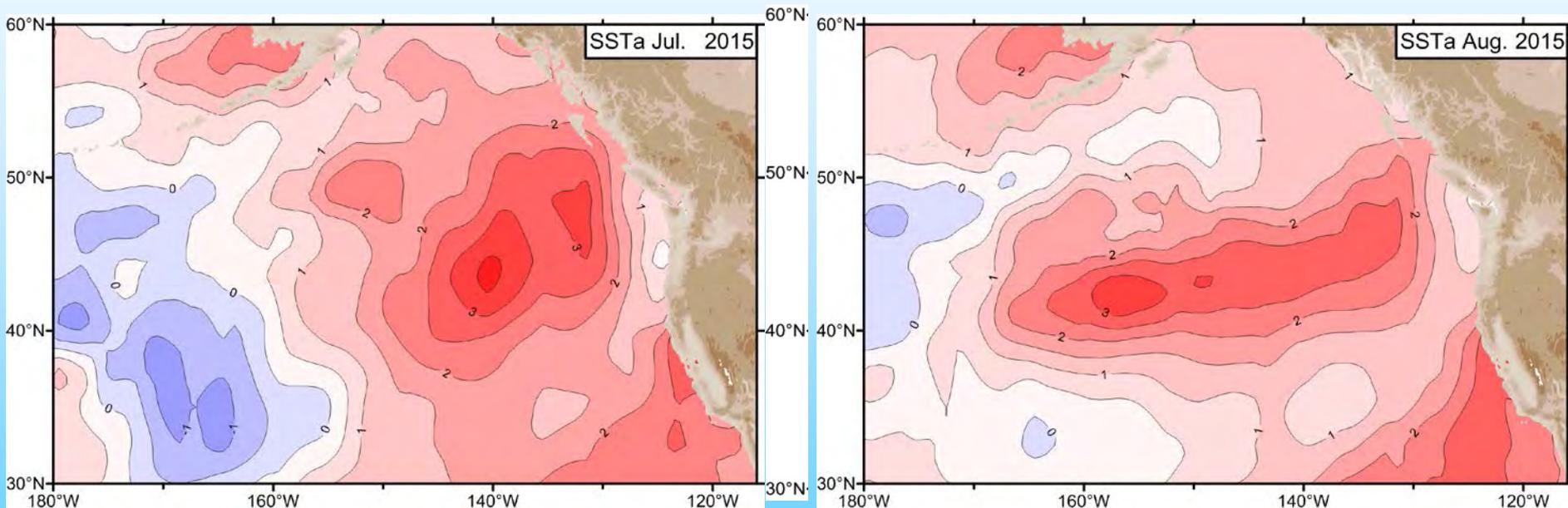
Reynold's data

July 2015

Difference from normal temperatures

August 2015

Difference from normal temperatures

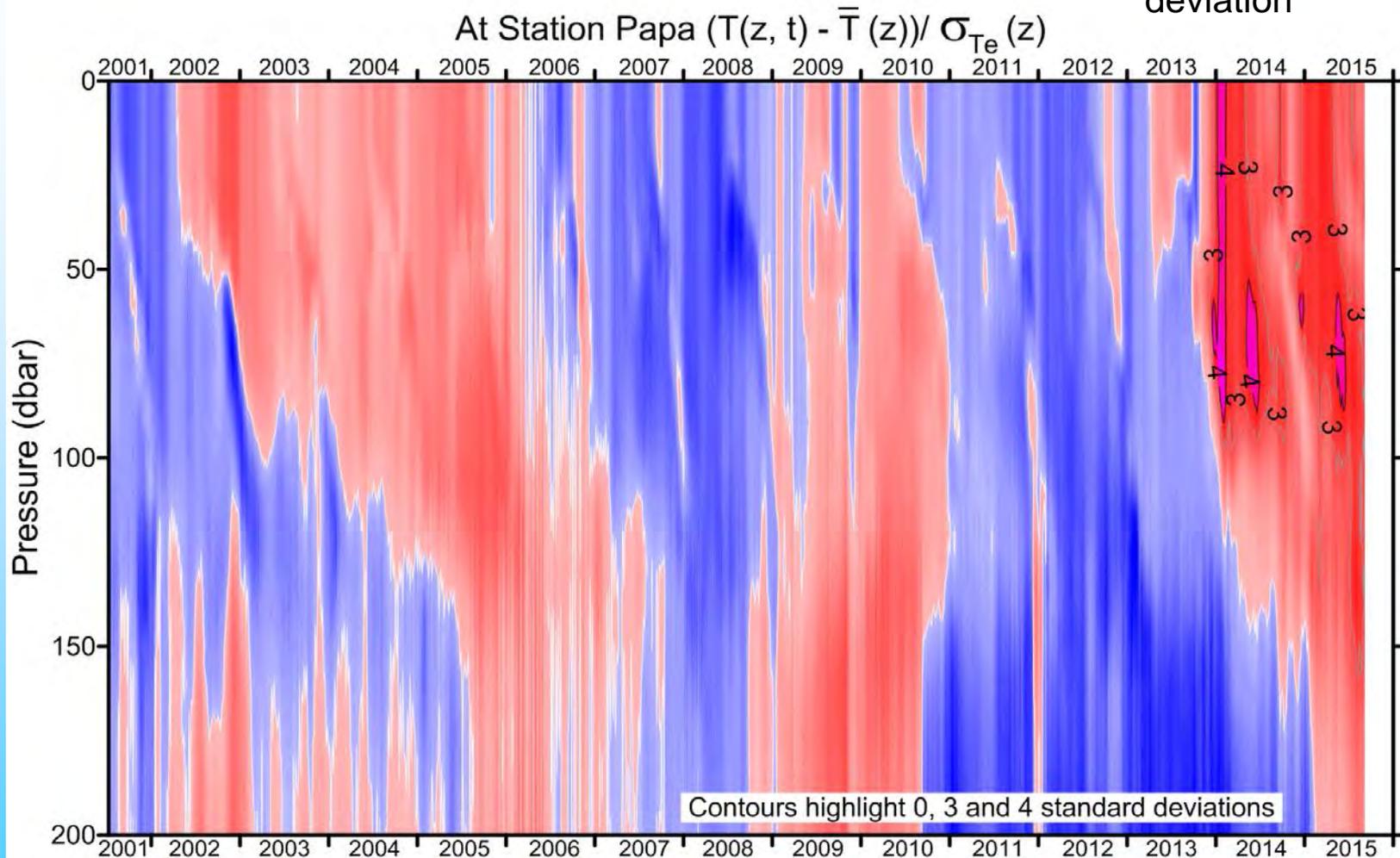


The “Blob” is still evident at the surface in the NE Pacific, but less intense than previous months



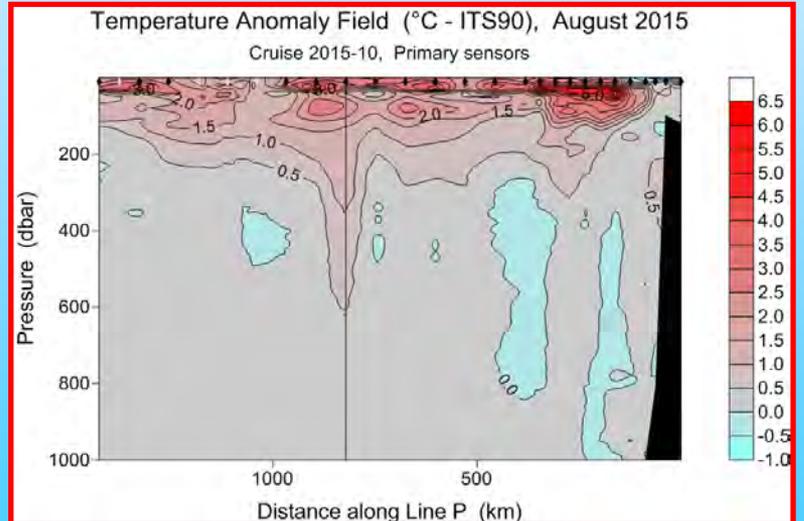
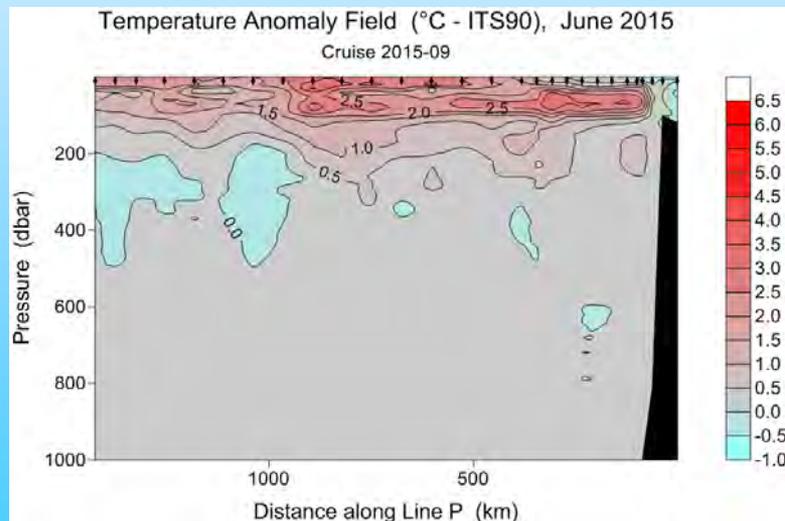
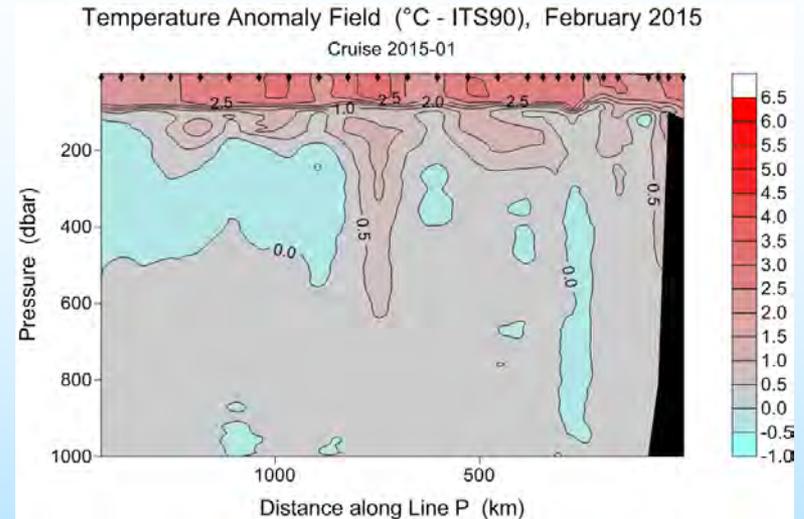
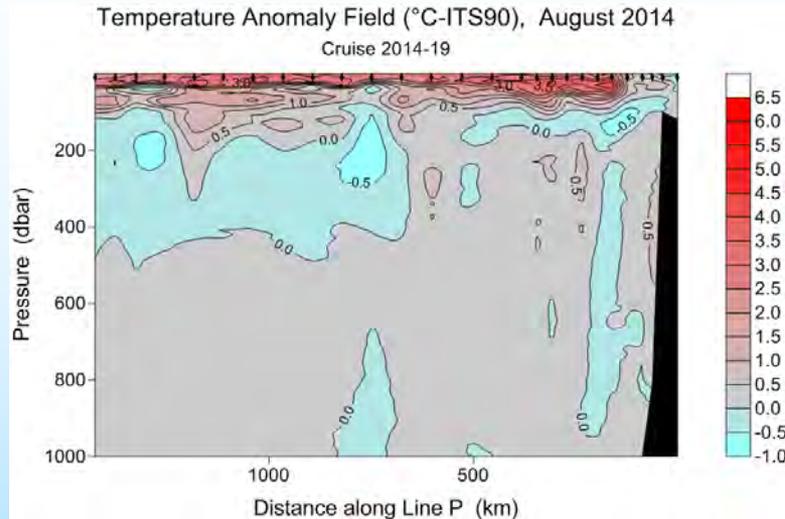
Station P upper layer temperature time series – constructed from Argo data

Temperature anomaly
normalised by standard
deviation



The “Blob” is more intense as a subsurface feature

In situ survey results indicate very warm water still present in NE Pacific, but more evident below surface depths



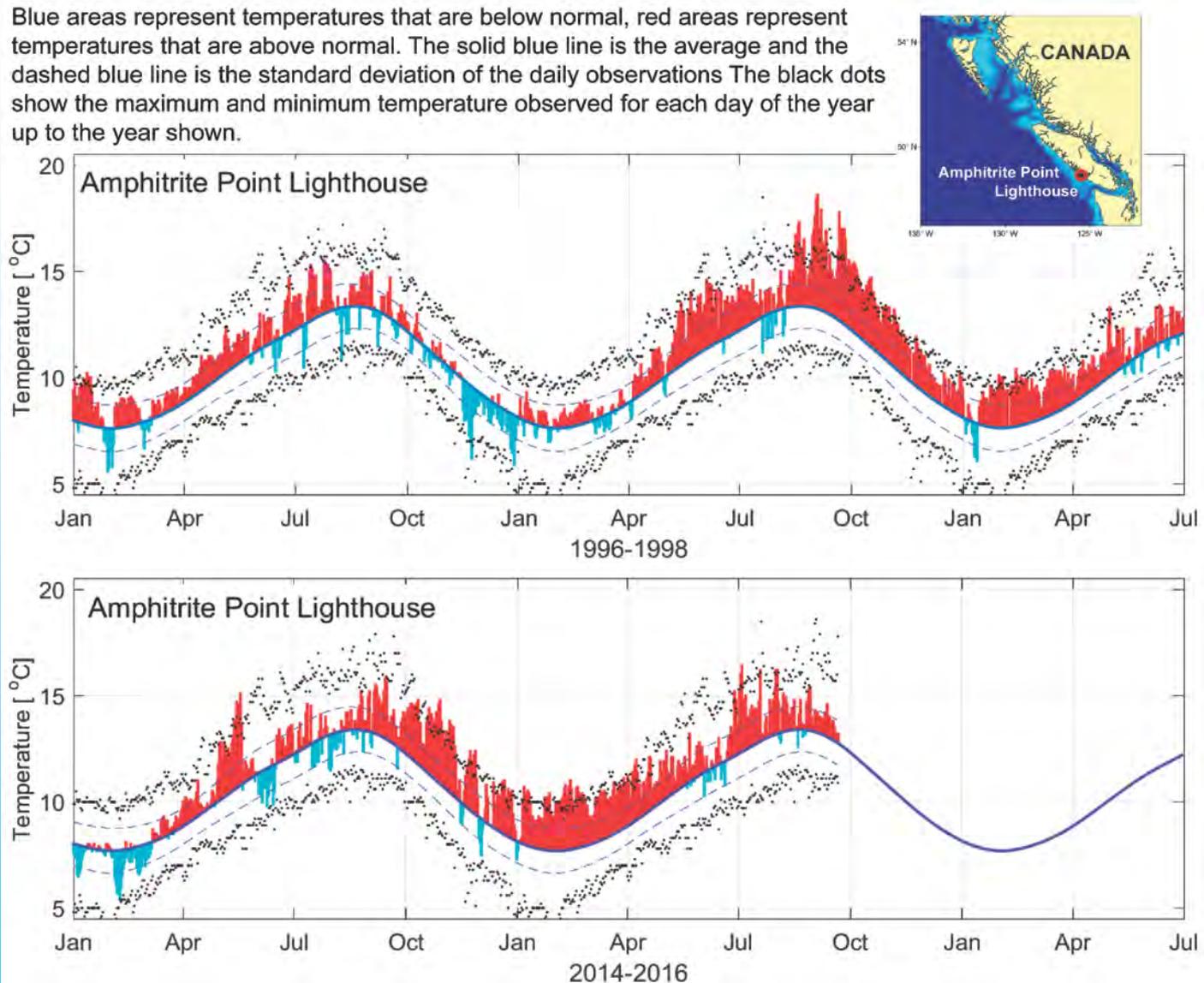
Marie
Robert,
IOS

Temperature anomalies along Line P with respect to the 1956 – 1991 averages



Coastal BC: very high SSTs October 2014 to present

ENSO,
1996 -
1998

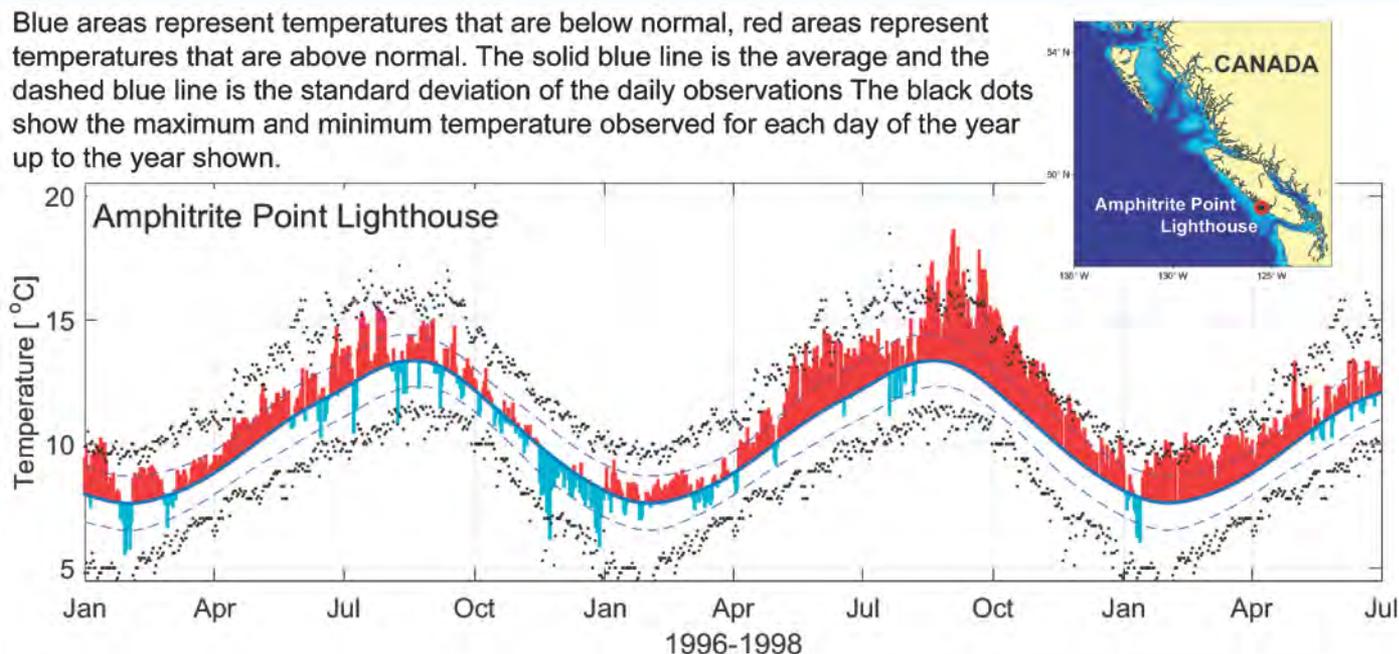


The
“Blob”,
2014 -
2016

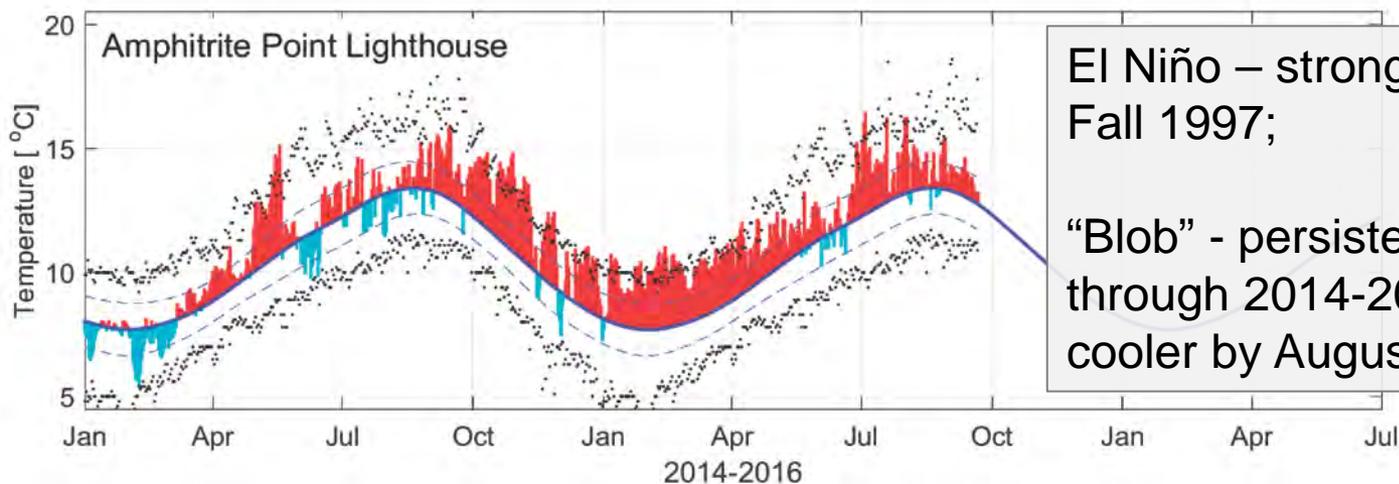


Coastal BC: very high SSTs October 2014 to present

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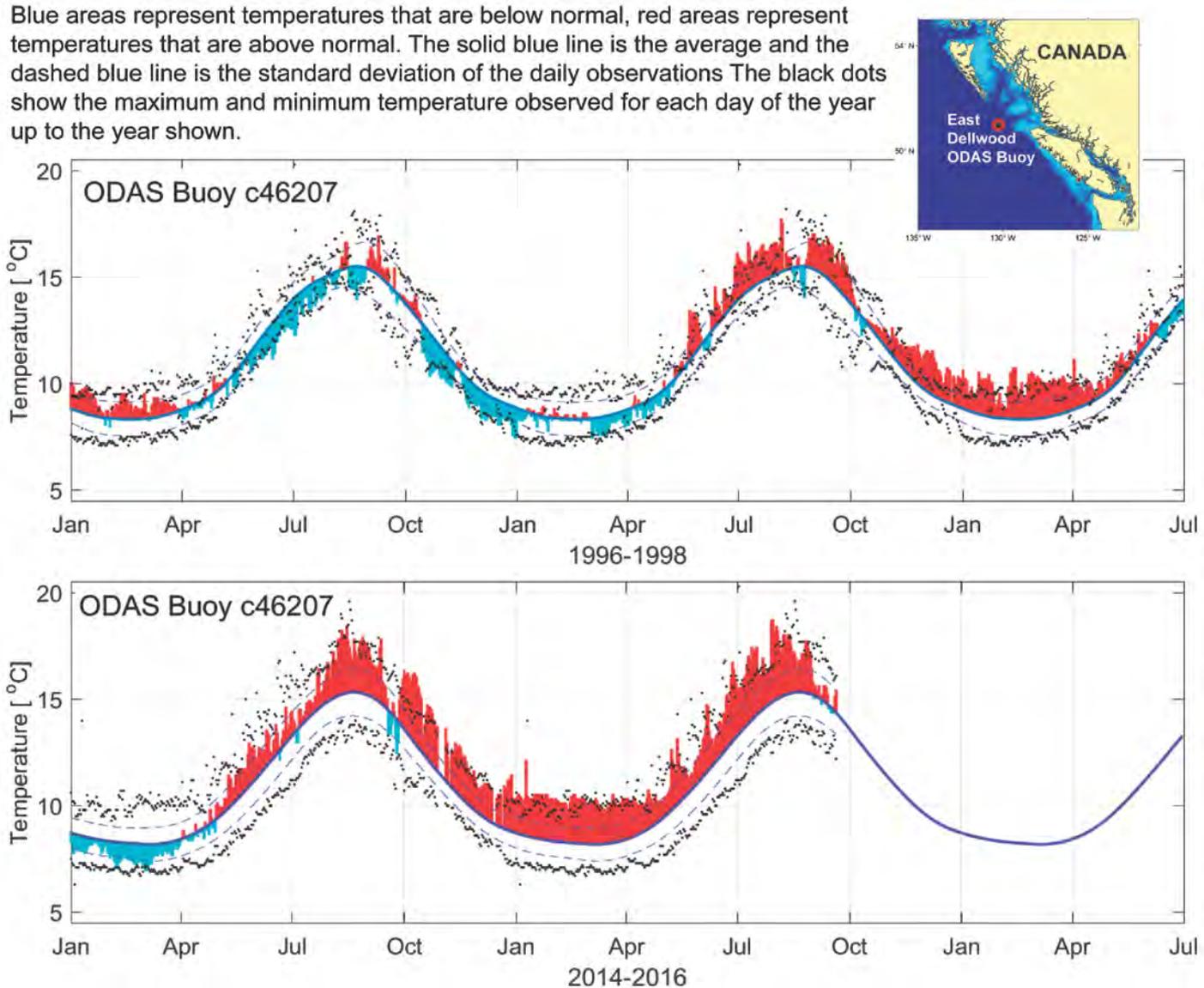
El Niño – strongest in
Fall 1997;

“Blob” - persistent
through 2014-2015,
cooler by August 2015



BC shelfbreak: very high SSTs October 2014 to present

ENSO,
1996 -
1998

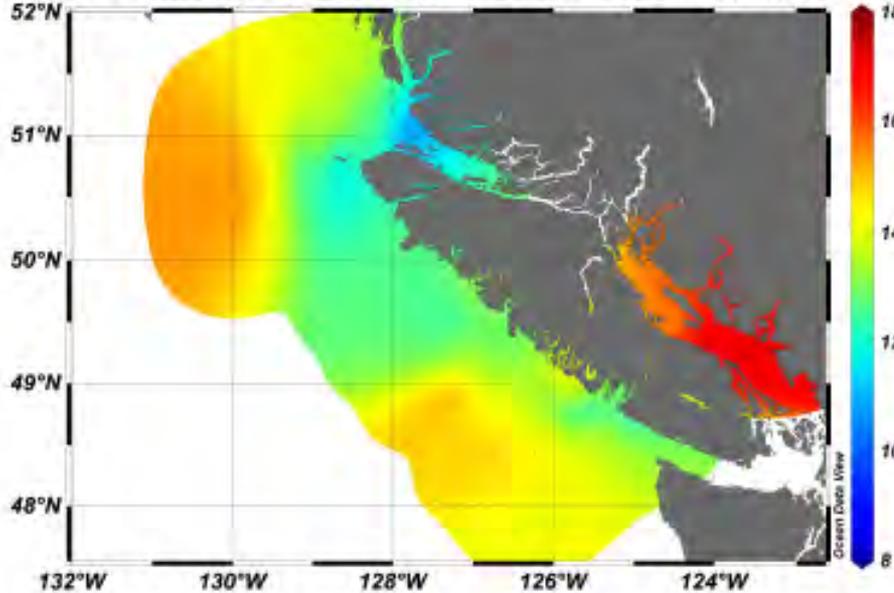


The
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2016



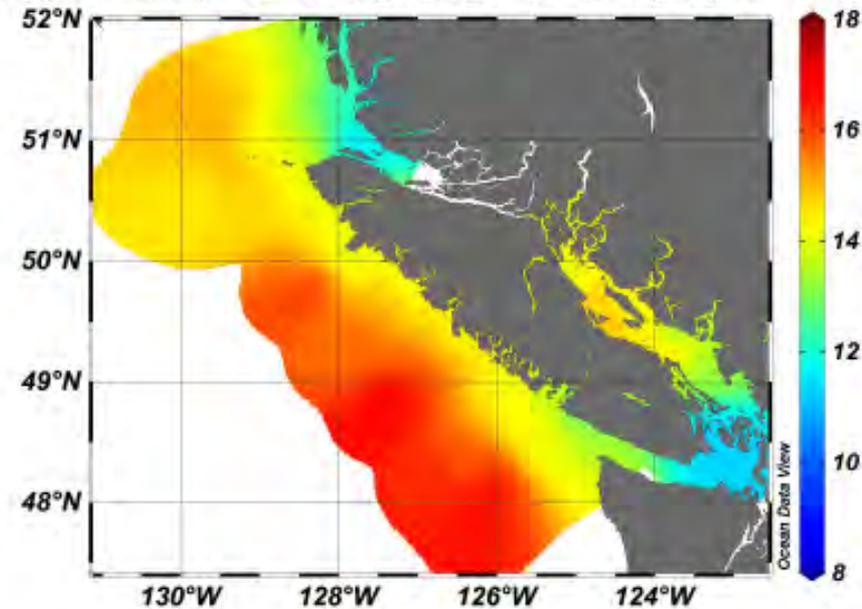
Comparison of SST around Vancouver Island, September 2014, 2015

Temperature:Primary [deg C (ITS90)] @ Pressure [decibar]=first



2014

Temperature [ITS-90, deg C] @ Pressure [db]=5



2015



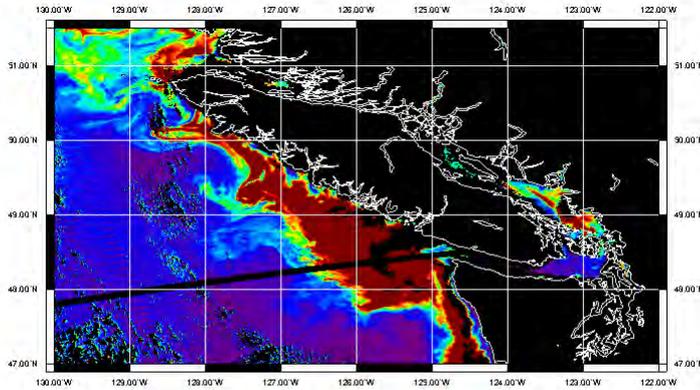
Exceptional phytoplankton bloom occurred along North American coast from May-Sept 2015

MODIS NFLH satellite images

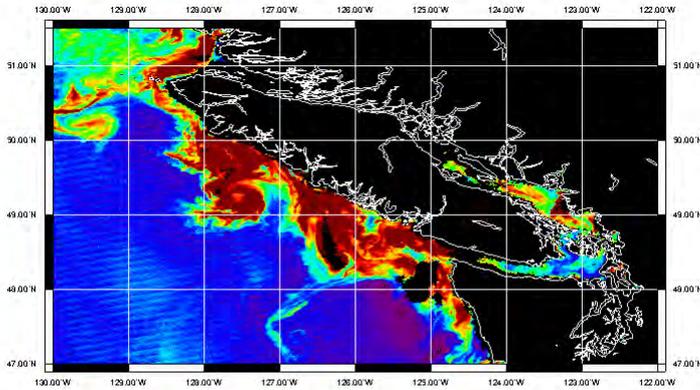
Unusual in terms of:

- spatial extent of bloom (California to Alaska)
- duration of bloom (May to Sept)
- presence of toxic phytoplankton species (domoic acid producers)

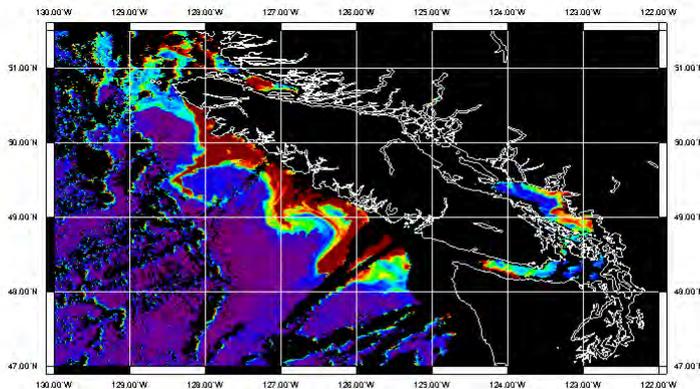
9 June
2015



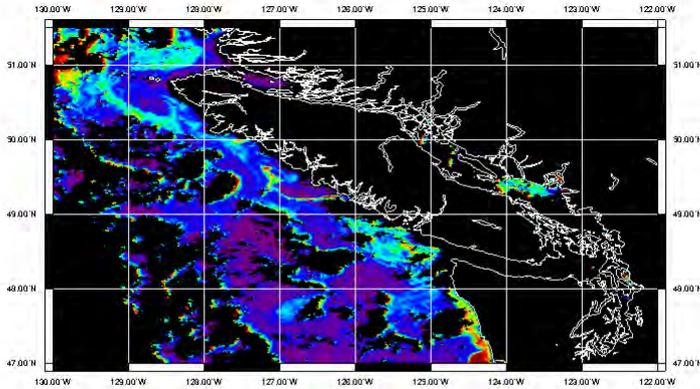
4 July
2015



6 Aug
2015



3 Sept
2015



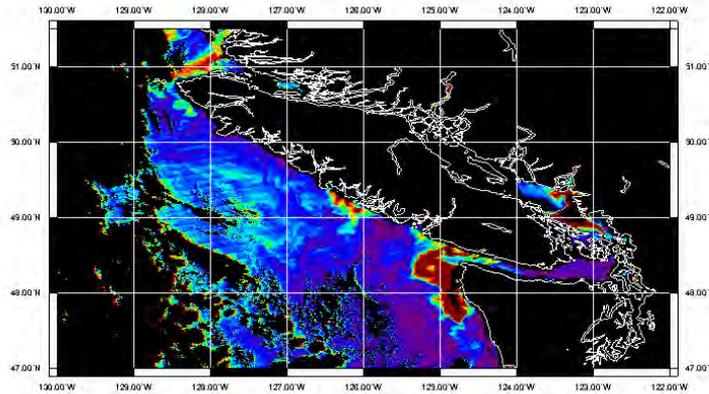
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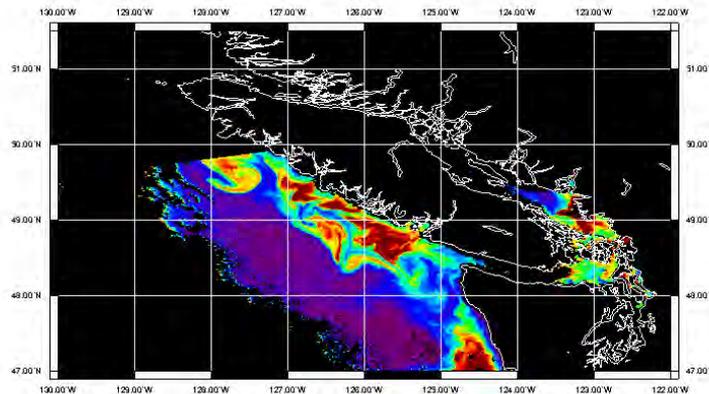
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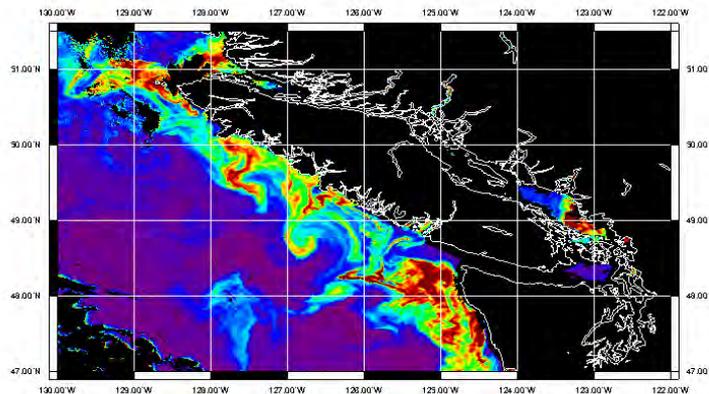
30 May
2014



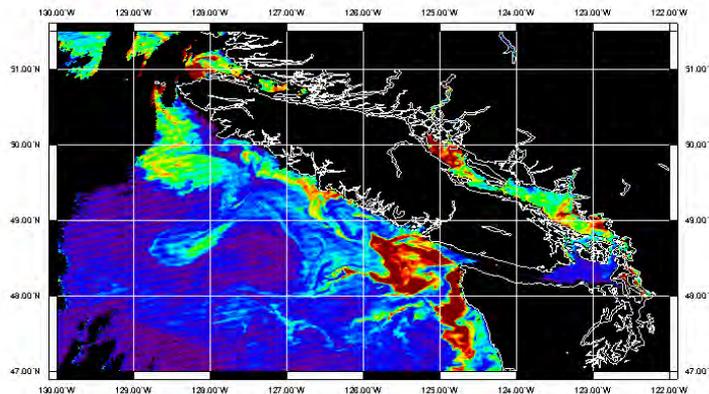
8 July
2014



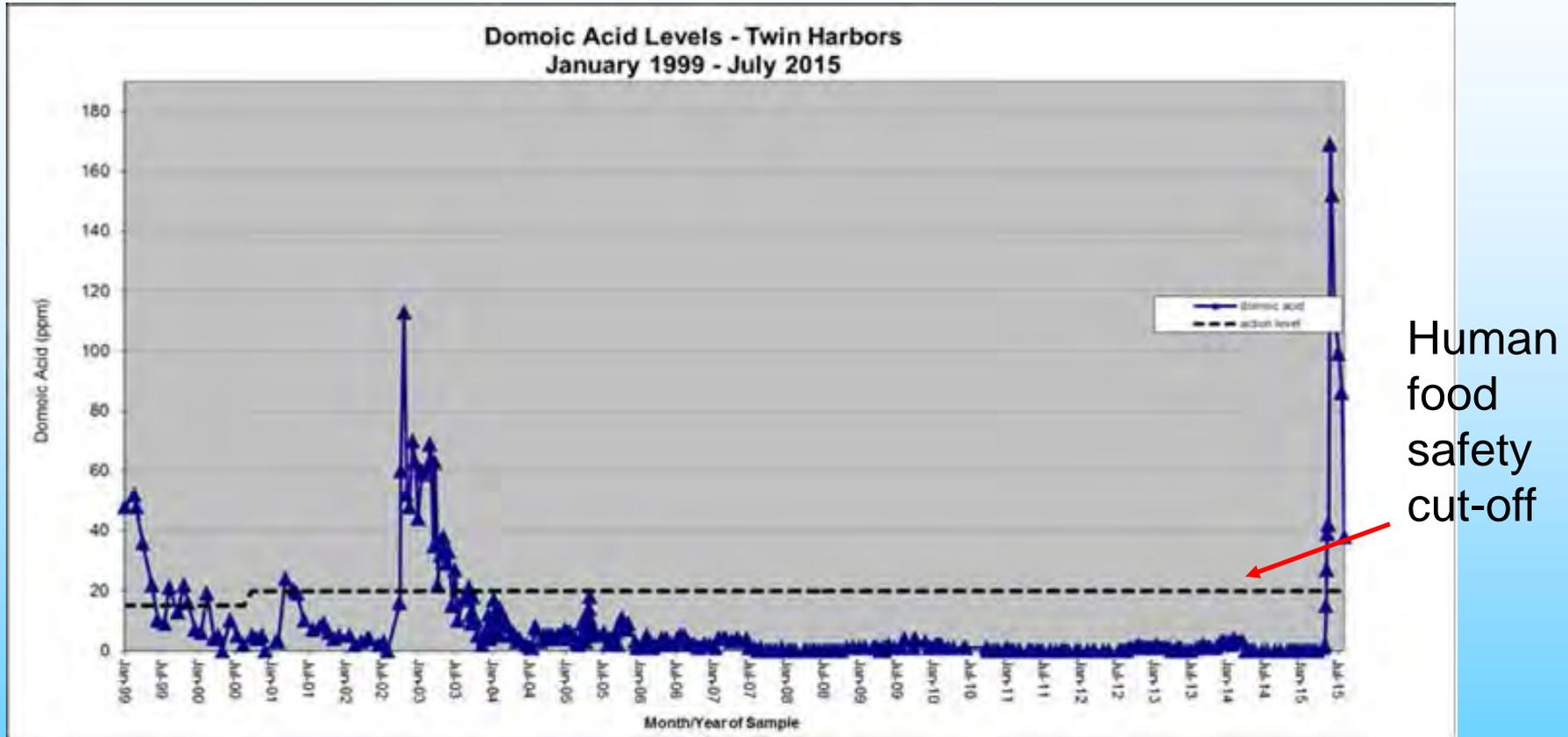
31 July
2014



5 Sept
2014



Exceptional phytoplankton bloom occurred along North American coast from May-Sept 2015



Domoic Acid concentrations, as measured in razor clams at Twin Harbors, central Washington State (January 1999 to July 2015)



Exceptional phytoplankton bloom occurred along North American coast from May-Sept 2015



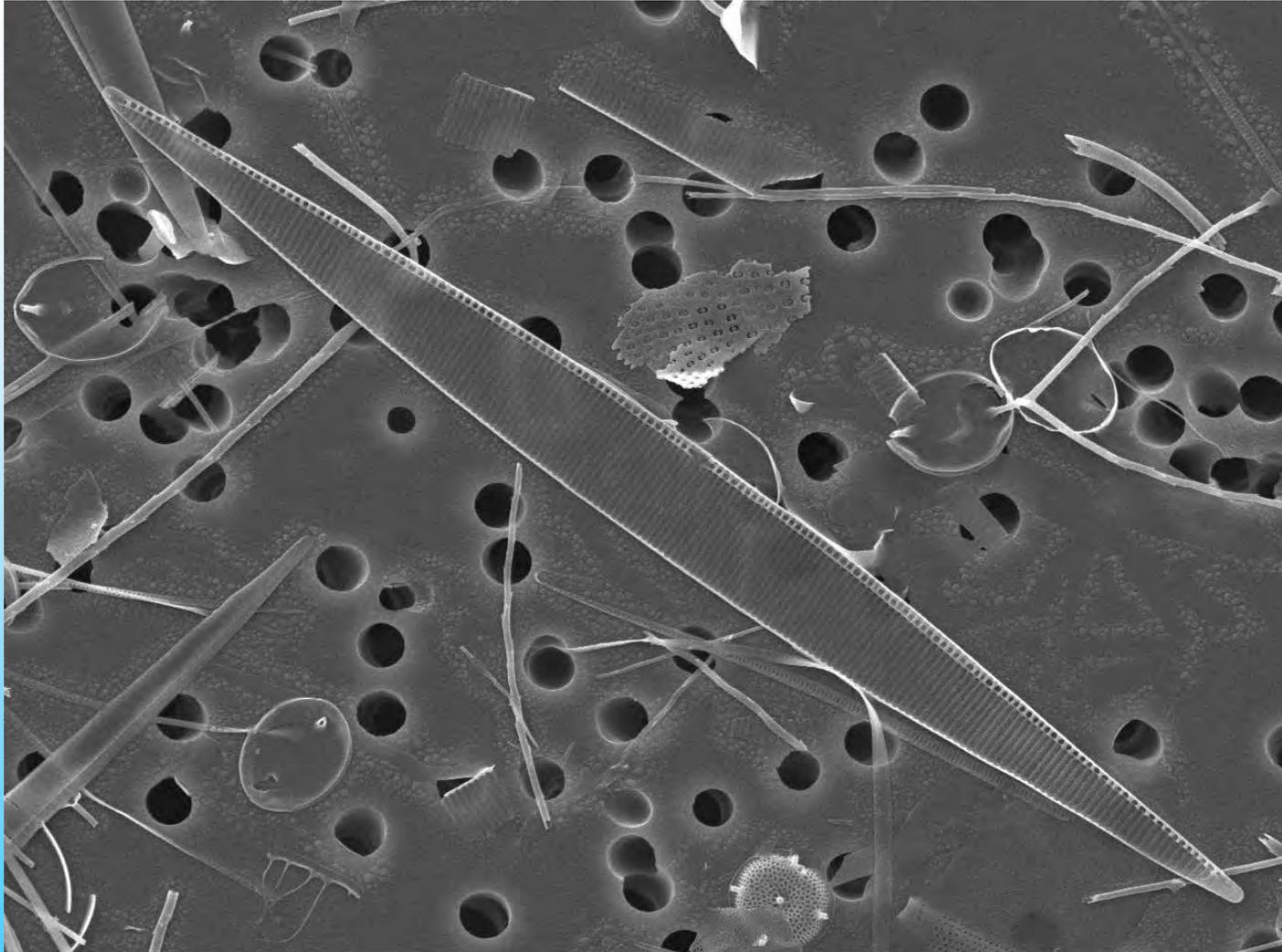
Domoic Acid
central Was



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Exceptional phytoplankton bloom occurred along North American coast from May-Sept 2015



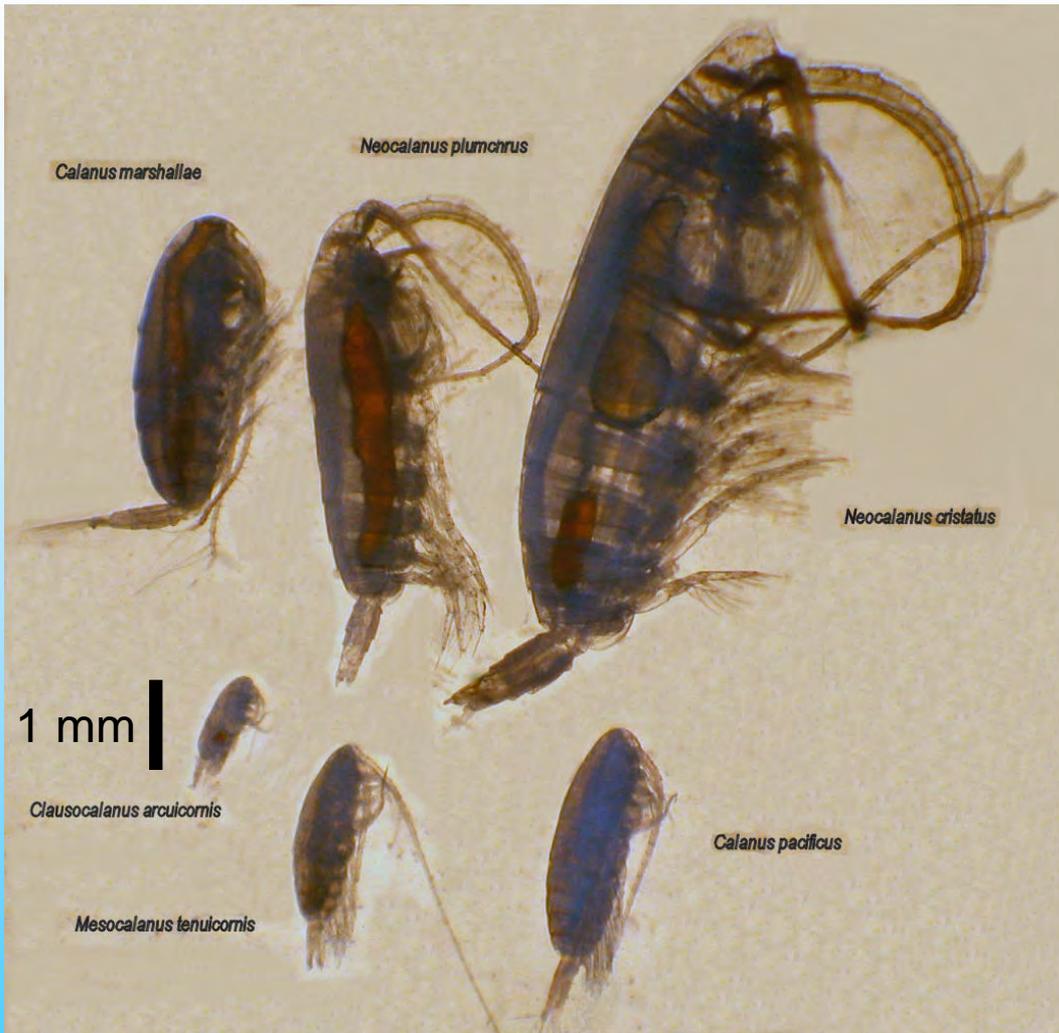
Pseudo-nitzschia fraudulenta

In early July 2015 at the shelf break, *Pseudo-nitzschia fraudulenta* comprised 32% of all diatoms, and 19% of all microplankton sampled

James Ehrman
Digital Microscopy Facility
Mount Allison University
Sackville, NB



Changes in water temperature are reflected in changes in zooplankton species composition

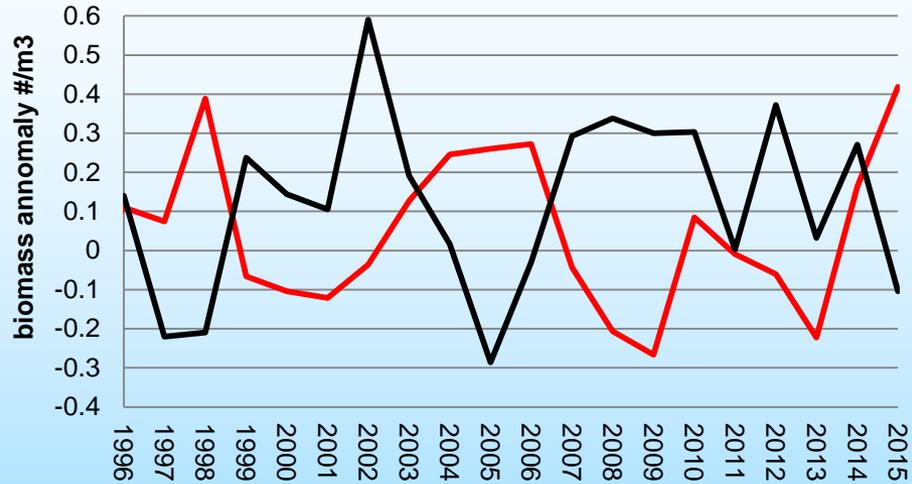


- northern-type zooplankton occurred along Vancouver Island in 1st half of 2014 when water was cool (large nutritious species, good for fish)
- but, southern-type zooplankton in 2nd half of 2014 and in 2015 when water was warm (small poor quality species)



Changes in water temperature are reflected in changes in zooplankton species composition – Copepod biomass anomaly

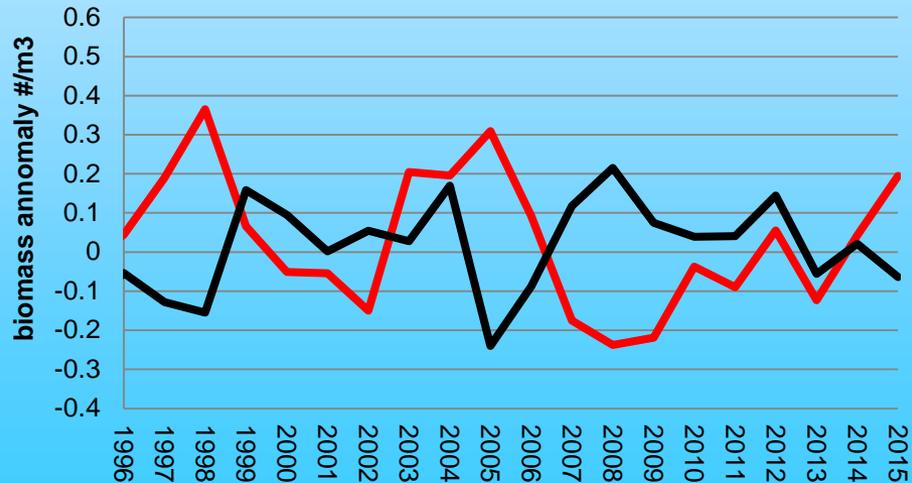
copepods SVI offshore — southern — northern



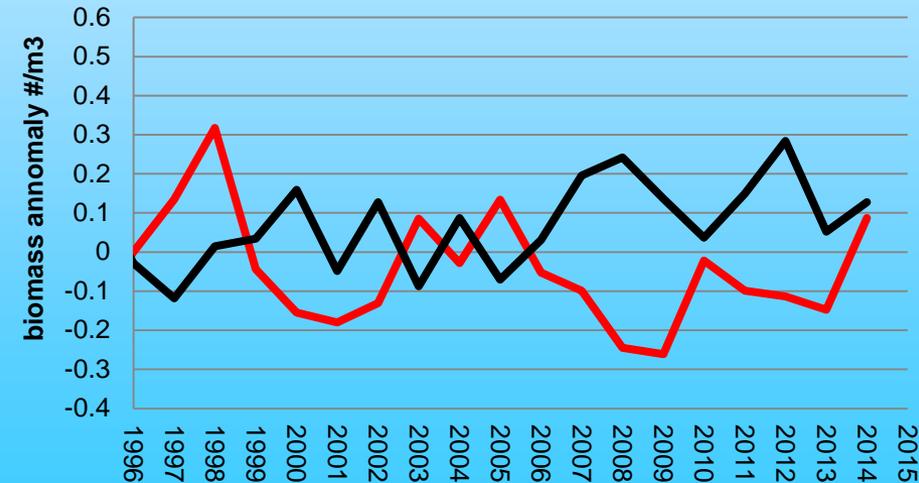
copepods NVI offshore — southern — northern



copepods SVI shelf — southern — northern

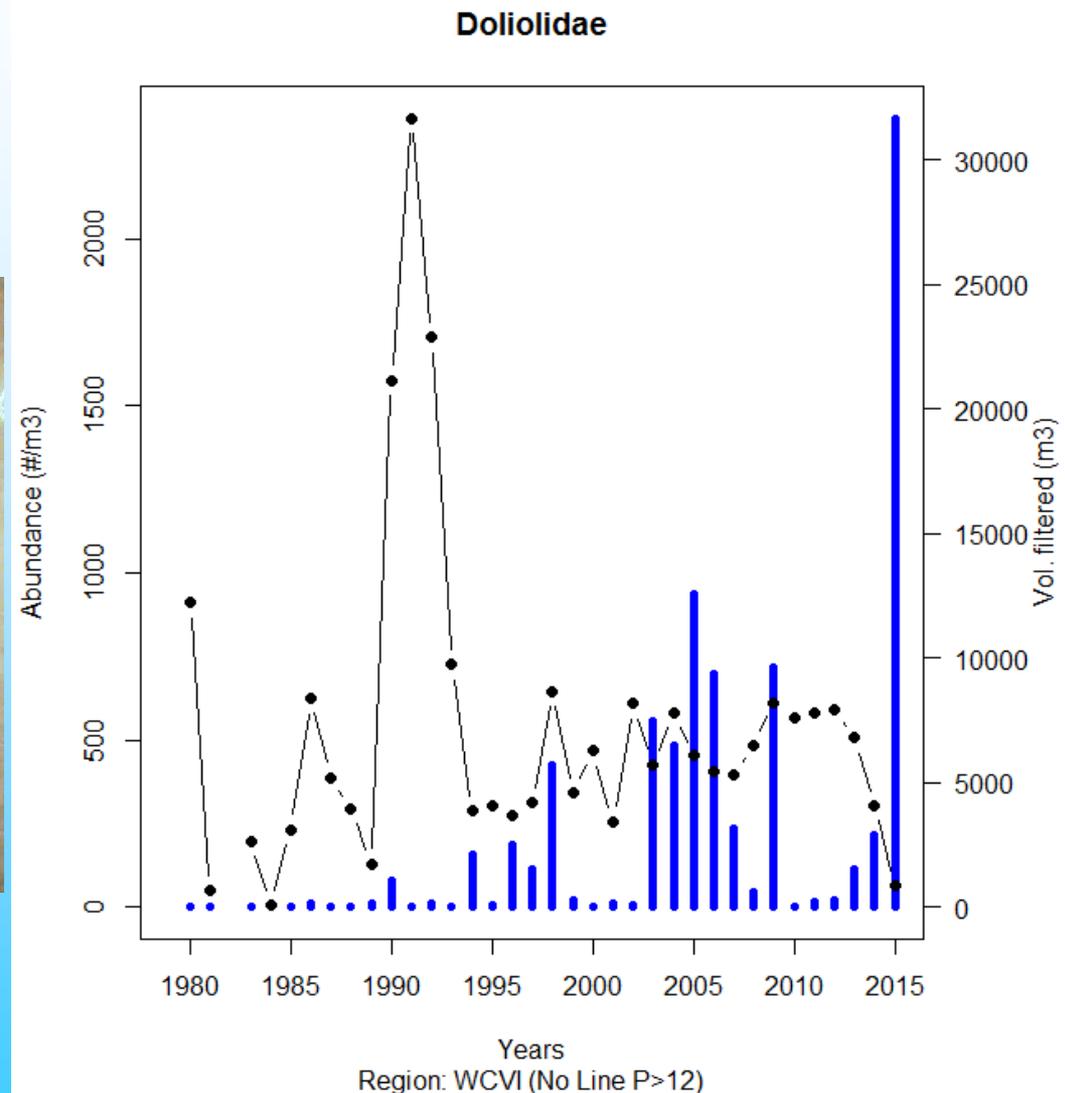
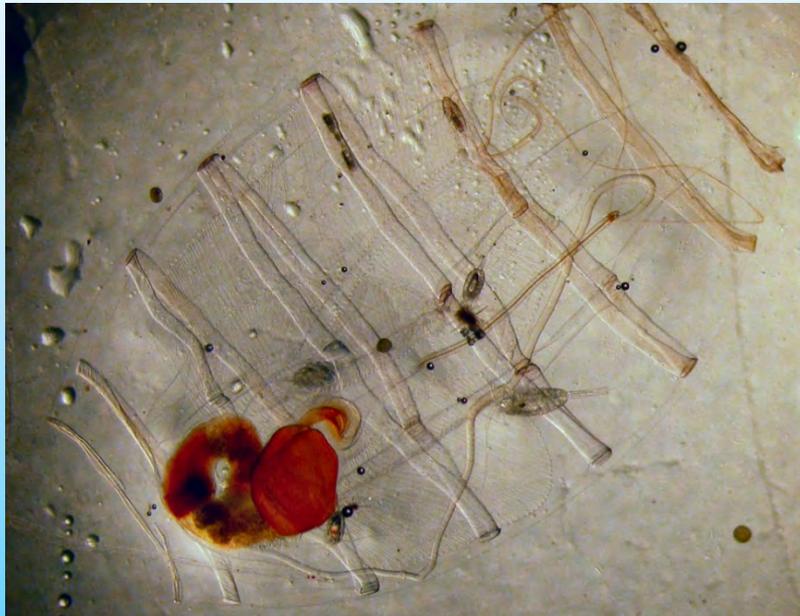


copepods NVI shelf — southern — northern



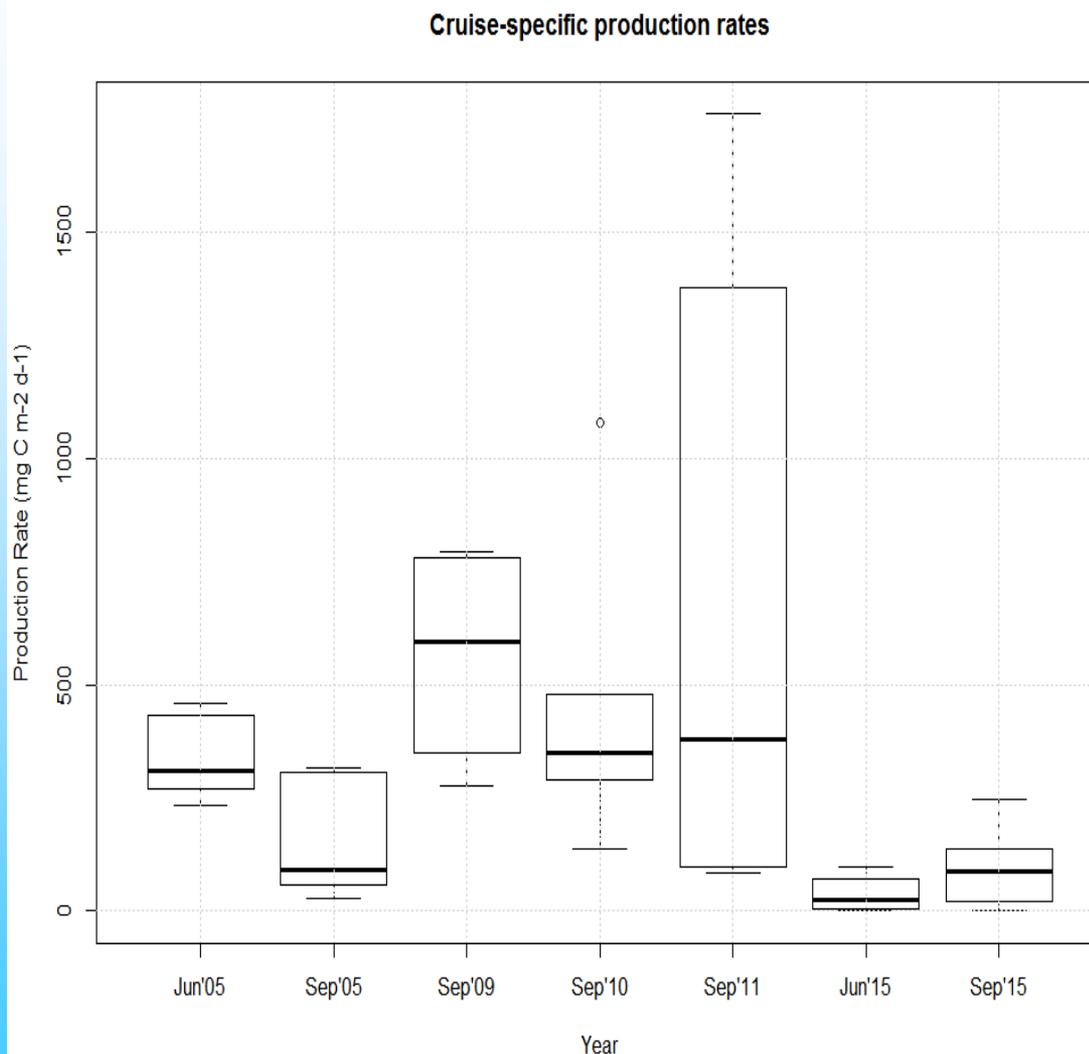
Changes in water temperature are reflected in changes in zooplankton species composition

Exceptional abundances of gelatinous zooplankton



Crustacean secondary productivity was near zero in May and Sept 2015 along west coast Vancouver Island

Crustacean production rate ($\text{mg C m}^{-2} \text{d}^{-1}$)



Chitobiase
crustacean
secondary
production
method

A. Sastri, J. Dower



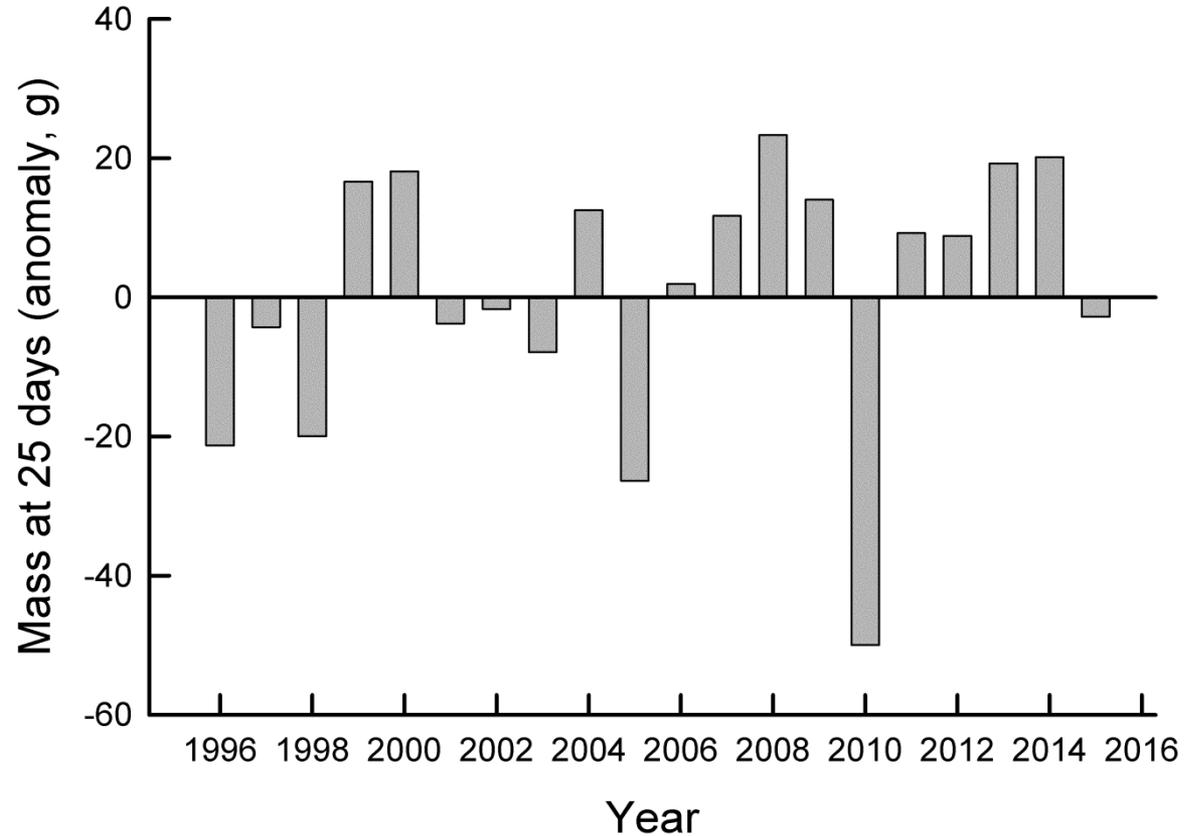
Implications for seabirds

Growth rates in Cassin's Auklets on Triangle Island in Spring

Mean 25 day mass high in 2014, normal in 2015



National Geographic Society



Implications for fish – Pacific salmon returns to BC

Returns to date suggest **ocean conditions “not bad” for Sockeye salmon** that went to sea in 2014 or earlier

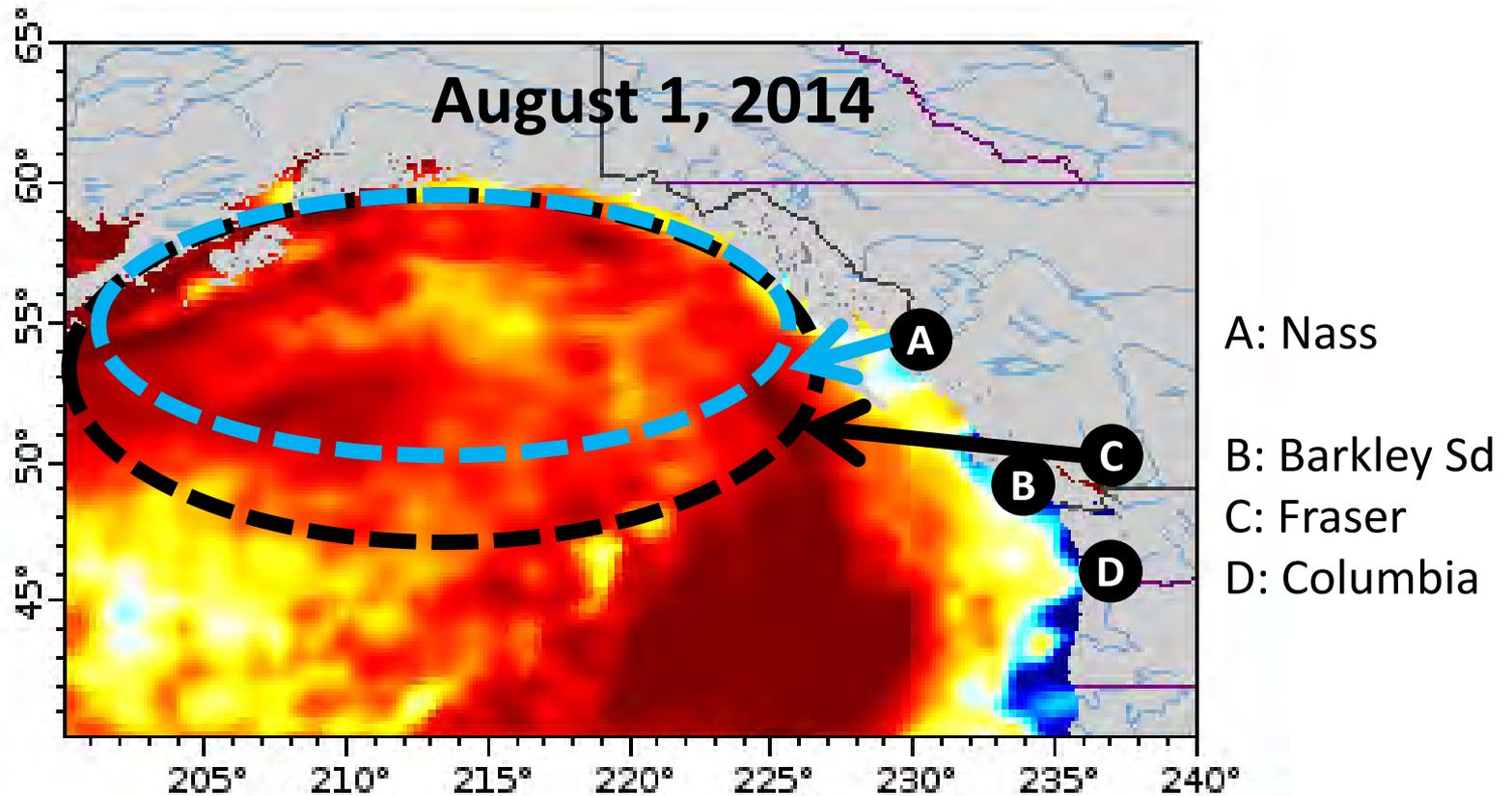
But - problem in summer 2015 was in-river conditions:

- Sockeye salmon returning to natal rivers can slow their migrations as temperatures warm, then pool in deeper waters which have lower oxygen concentrations (e.g. Somass River in Alberni Inlet on Vancouver Island);
- conditions persisting for 30-40 days reduce ability of Sockeye salmon to swim upstream

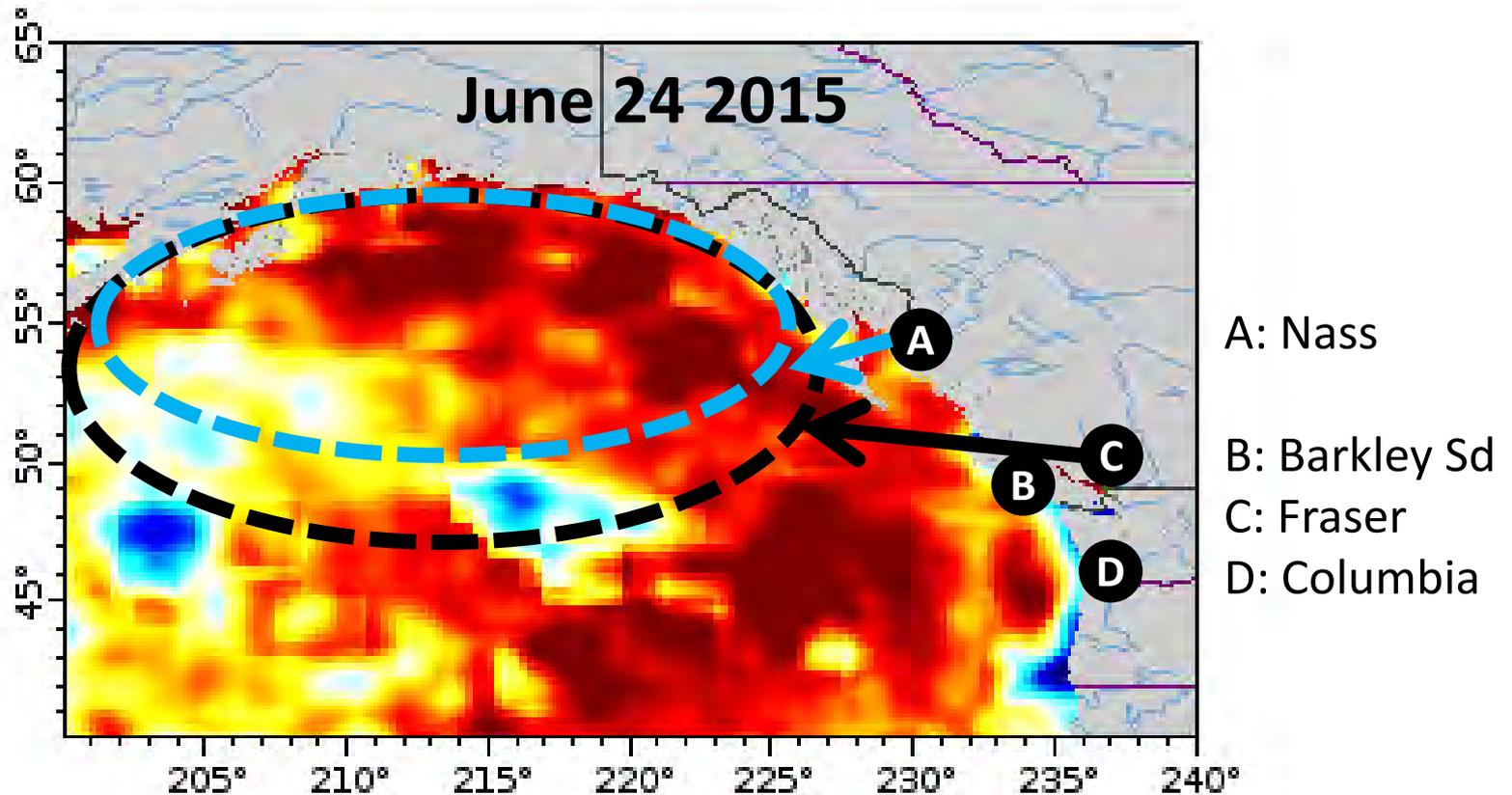
For juvenile salmon:

Warm conditions in Spring-Summer 2015 (poor food, increased predators) indicate poor survival and reduced abundances likely for salmon returning in 2016 and 2017

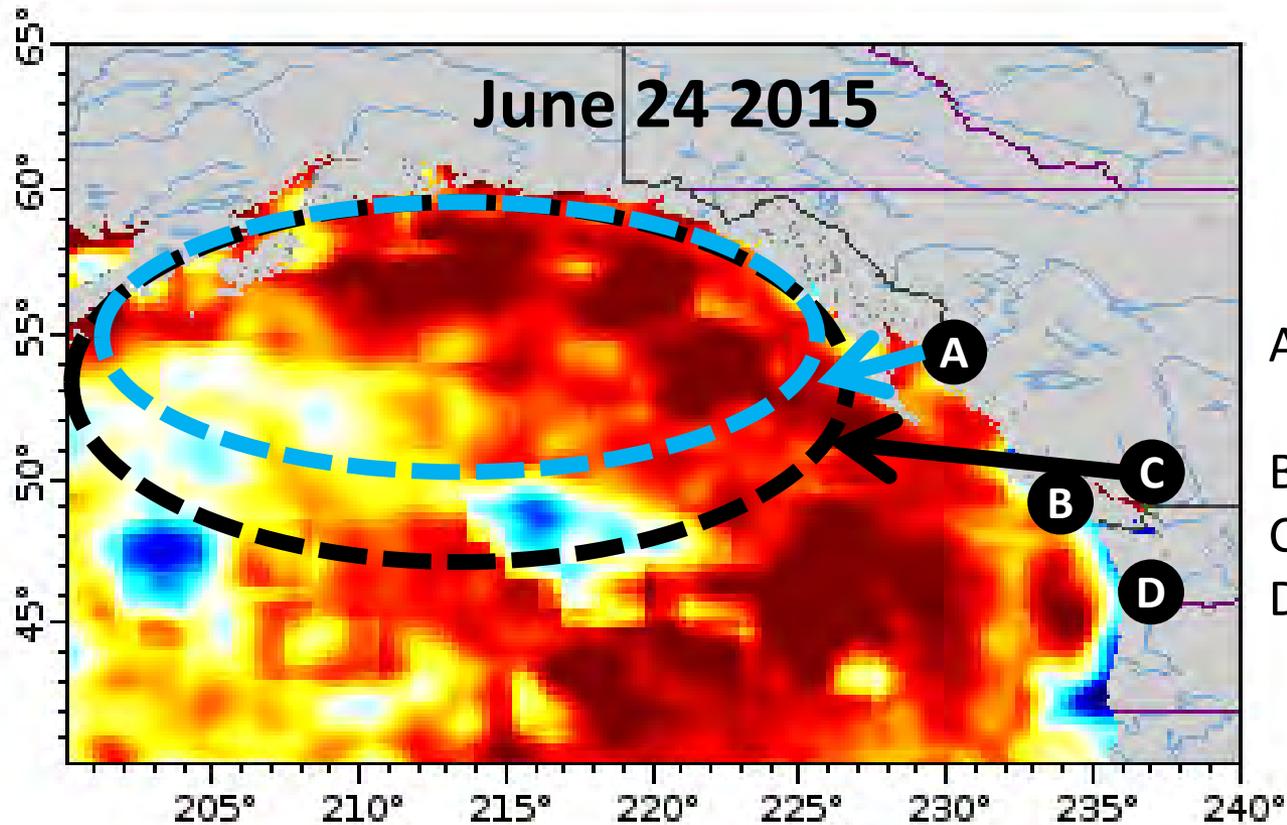
The “Blob” and sockeye salmon returns to BC rivers



The “Blob” and sockeye salmon returns to BC rivers



The “Blob” and sockeye salmon returns to BC rivers



Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
A	10	26	23	31	27	30	6	2	1	13	5	8	14	19	11	15	25	3	4	9	16	12	28	29	21	24	18	22	20	17	7
B	12	24	15	10	23	25	2	7	5	21	31	20	19	16	18	26	13	6	8	14	22	27	29	30	17	3	4	11	28	9	1
C	10	8	14	25	5	3	12	17	2	6	24	21	7	13	26	18	15	9	20	22	16	11	31	29	30	1	19	27	23	4	28
D	9	19	11	16	23	21	17	14	15	30	31	26	22	29	28	13	12	20	24	10	18	25	27	5	8	4	6	2	7	1	3

Implications for fish – Potential temperature effects on Pacific herring

- spawn deposition area
- changes in fecundity and egg size
- survival of eggs and larvae
- recruitment
- growth during first year
- amount of bird predation on herring
- Spring bloom timing and availability/timing of herring prey
- Other effects (e.g., bacteria/fungus?)



Implications for fish – Potential temperature effects on Pacific herring

- spawn deposition area
- change
- survival
- recruit
- growth
- amount
- Spring
- Other



orey



Implications for fish – warm water migrants into Canadian waters



Finescale Triggerfish, *Balistes polylepis*,
26.3 cm Standard length (Courtesy RBCM)



Pacific Pompano (butterfish)



Louvar, *Louvaris imperialis*,
72.0 cm SL (Courtesy RBCM)



Summary

- “Blob” still present in Gulf of Alaska (and is stronger at depth)
- Waiting to see how El Niño develops and interacts with The “Blob”
- Exceptional phytoplankton bloom created considerable media interest
- Unusual zooplankton species composition is the ‘untold story’ of this summer off the west coast of Vancouver Island
 - lack of crustaceans, dominance of gelatinous zooplankton
- In Summer 2015, “Blob” was strongest as an offshelf feature
- Impacts to Cassin’s auklet chick growth rates not obvious in spring 2015
- Few apparent negative consequences to Sockeye salmon returning in 2015, but potential for significant negative impacts to salmon returns over next three years
- DFO is advising the public and fisher’s organisations about these unusual events, and discussing management options

