Characterizing marine heatwaves in British Columbia waters

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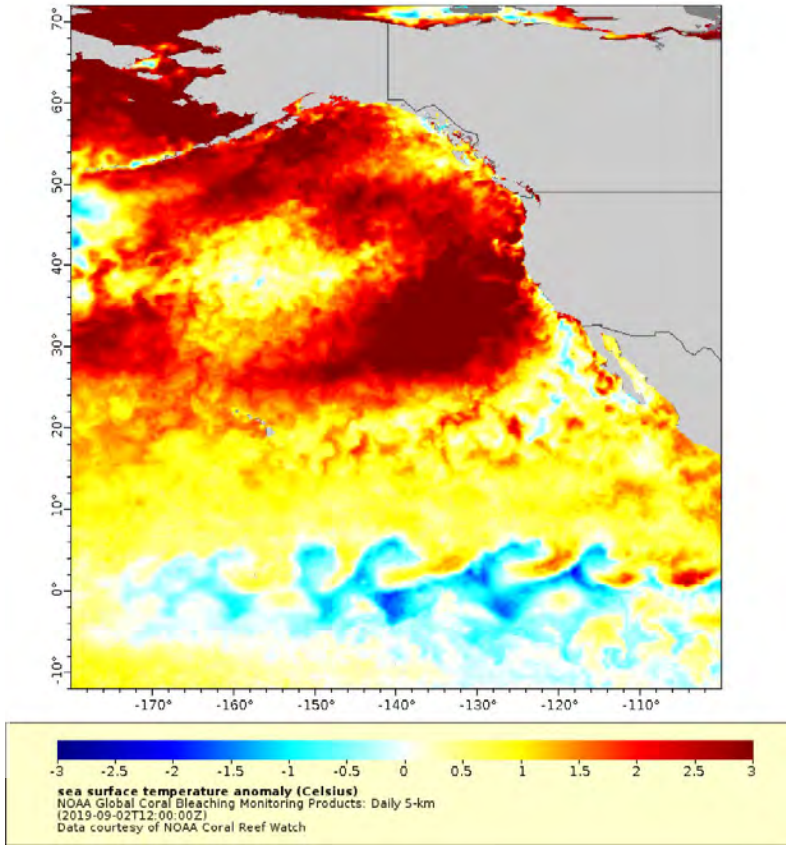
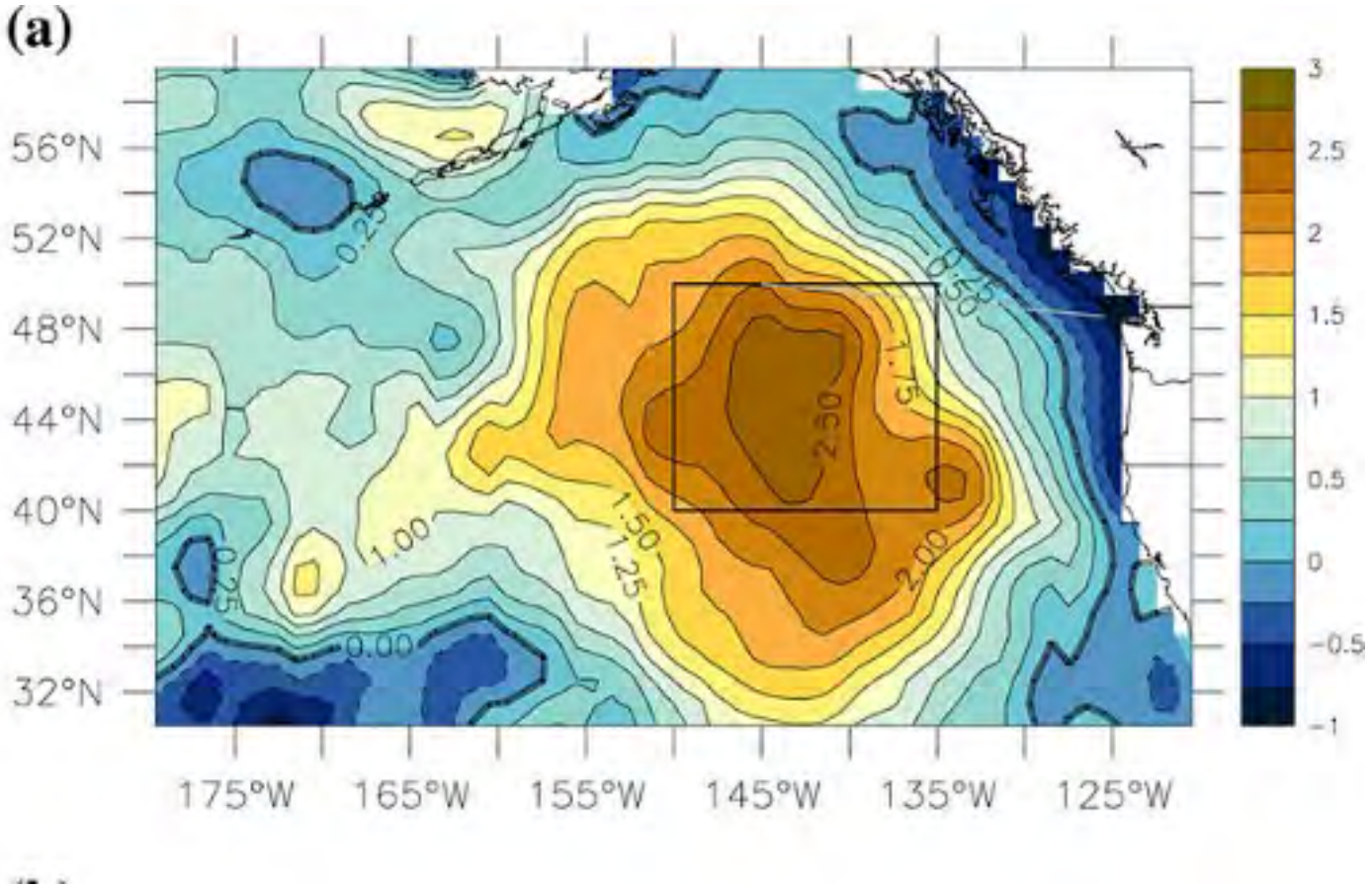
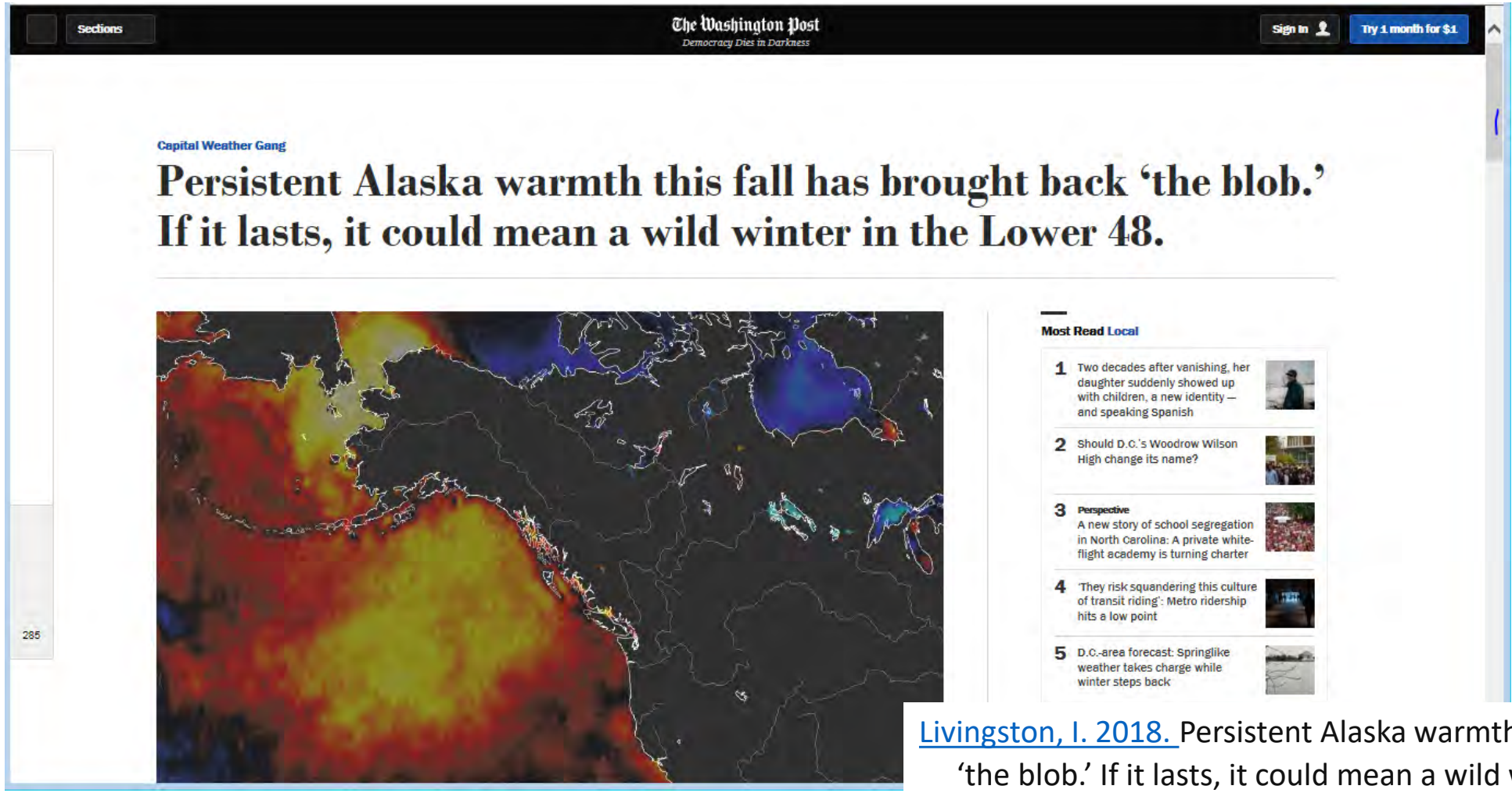


The classic NE Pacific Marine Heat Wave: The Blob

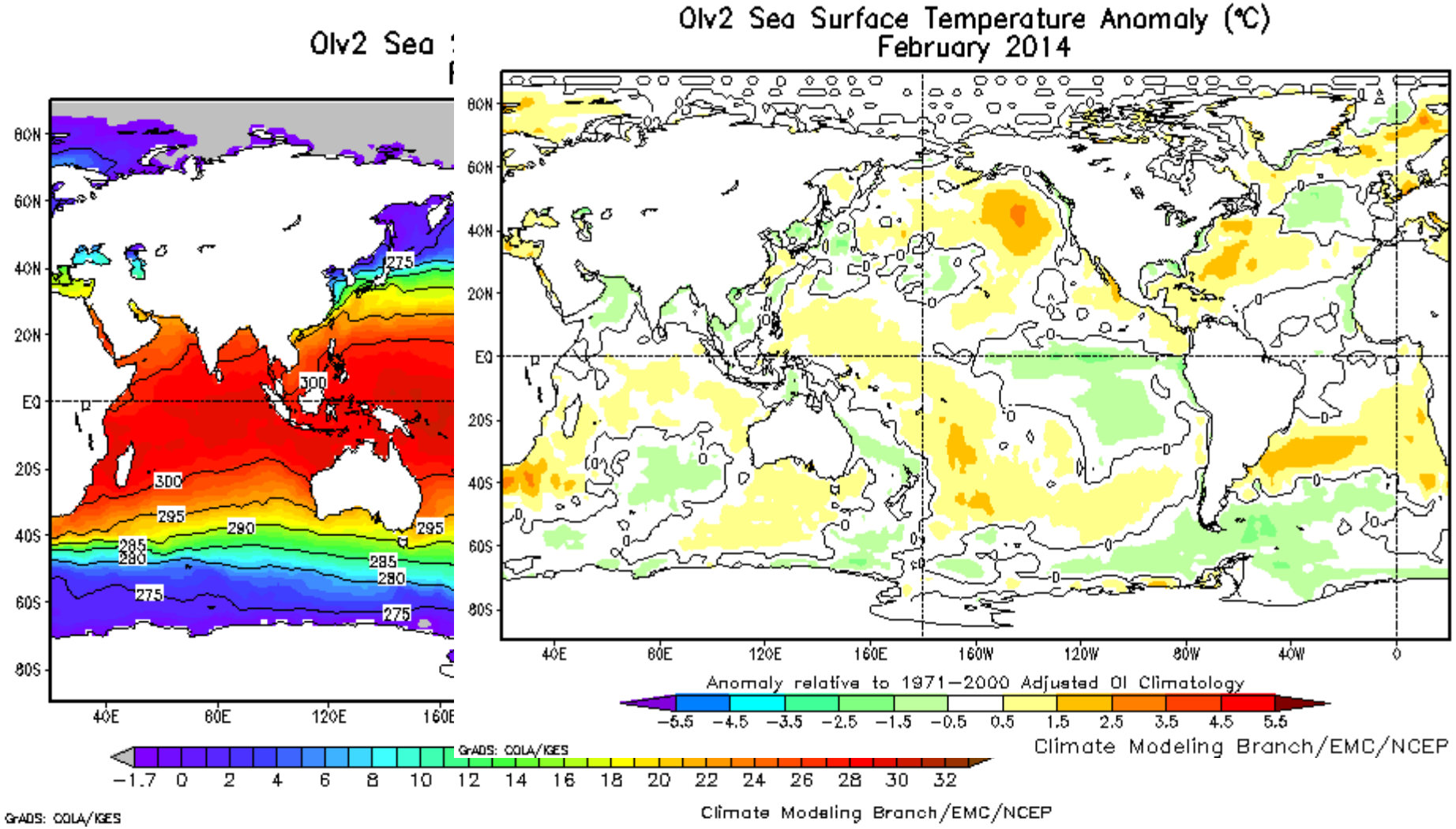
Sea Surface Temperature in Feb 2014

Bond, N.A., Cronin, M.F., Freeland, H. and Mantua, N., 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. *Geophysical Research Letters*.





Livingston, I. 2018. Persistent Alaska warmth this fall has brought back 'the blob.' If it lasts, it could mean a wild winter in the Lower 48. Washington Post, October 18, 2018. https://www.washingtonpost.com/weather/2018/10/18/persistent-alaska-warmth-this-fall-has-brought-back-blob-if-it-lasts-it-could-mean-wild-winter-lower/


Olv2 Sea
80N
60N
40N
20N
EQ
20S
40S
60S
80S
40E
80E
120E
160E
275
300
295
290
285
280
GrADS: COLA/IGES
−1.7 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
GrADS: COLA/IGES
Olv2 Sea Surface Temperature Anomaly (°C)
February 2014
80N
60N
40N
20N
EQ
20S
40S
60S
80S
40E
80E
120E
160E
160W
120W
80W
40W
0
Anomaly relative to 1971−2000 Adjusted OI Climatology
−5.5 −4.5 −3.5 −2.5 −1.5 −0.5 0.5 1.5 2.5 3.5 4.5 5.5
Climate Modeling Branch/EMC/NCEP
Climate Modeling Branch/EMC/NCEP

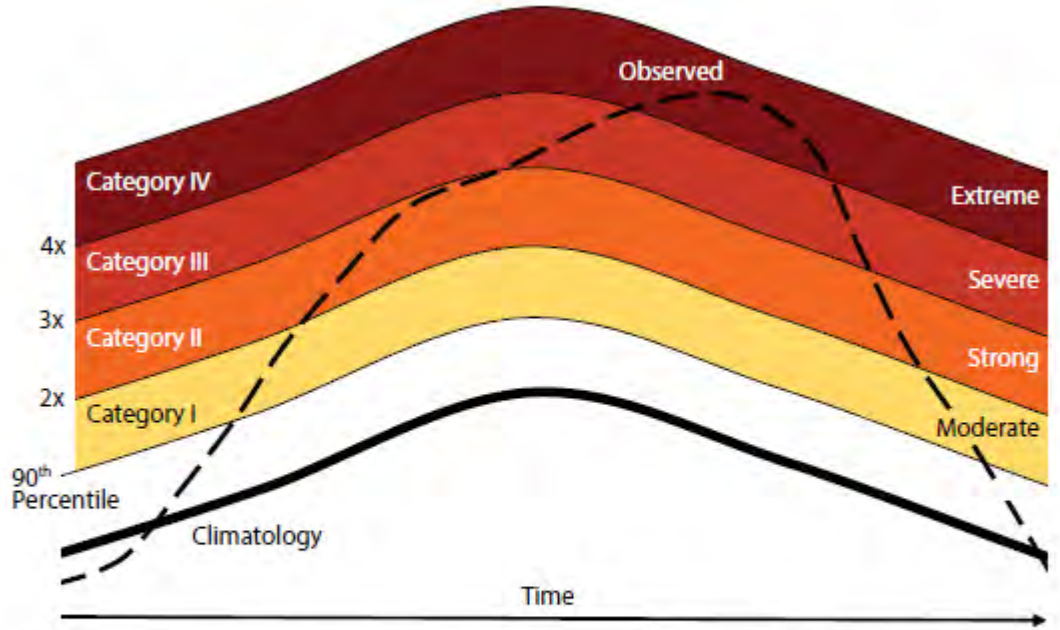


FIGURE 2. Categorization schematic for marine heatwaves (MHWs) showing the observed temperature time series (dashed line), the long-term regional climatology (bold line), and the 90th percentile climatology (thin line). Multiples of the 90th percentile difference (2× twice, 3× three times, etc.) from the mean climatology value define each of the categories I–IV, with corresponding descriptors from moderate to extreme. This example peaked as a Category IV (extreme) MHW.

Hobday, A.J., E.C.J. Oliver, A. Sen Gupta, J.A. Benthuysen, M.T. Burrows, M.G. Donat, N.J. Holbrook, P.J. Moore, M.S. Thomsen, T. Wernberg, and D.A. Smale. 2018. Categorizing and naming marine heatwaves. *Oceanography* 31(2):162–173, https://doi.org/10.5670/oceanog.2018.205.

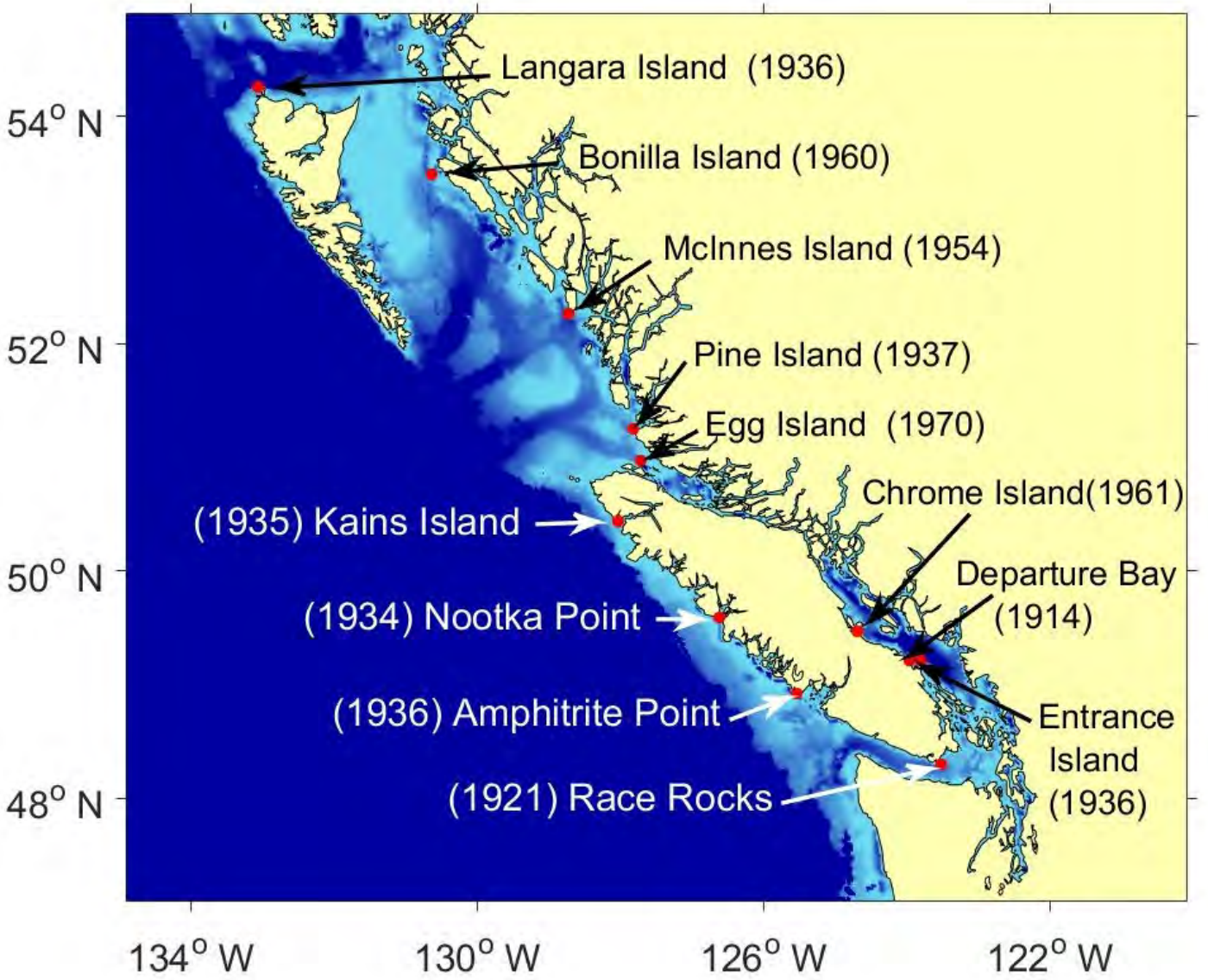
Questions

- Do the marine heat wave statistics at coastal lighthouses reflect those seen on the shelf? This would allow for analysis of records extending back 80-100 years.
- What can we say about the origins of the 2018-19 Marine Wave in northern BC?

Weather buoy locations

54°N
48°N
145°W
140°W
135°W
130°W
125°W
Central Dixon
West Dixon
North Nomad
N. Hecate
West Moresby
S. Hecate
South Moresby
West Sea Otter
Middle Nomad
East Dellwood
South Brooks
La Perouse
South Nomad
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500

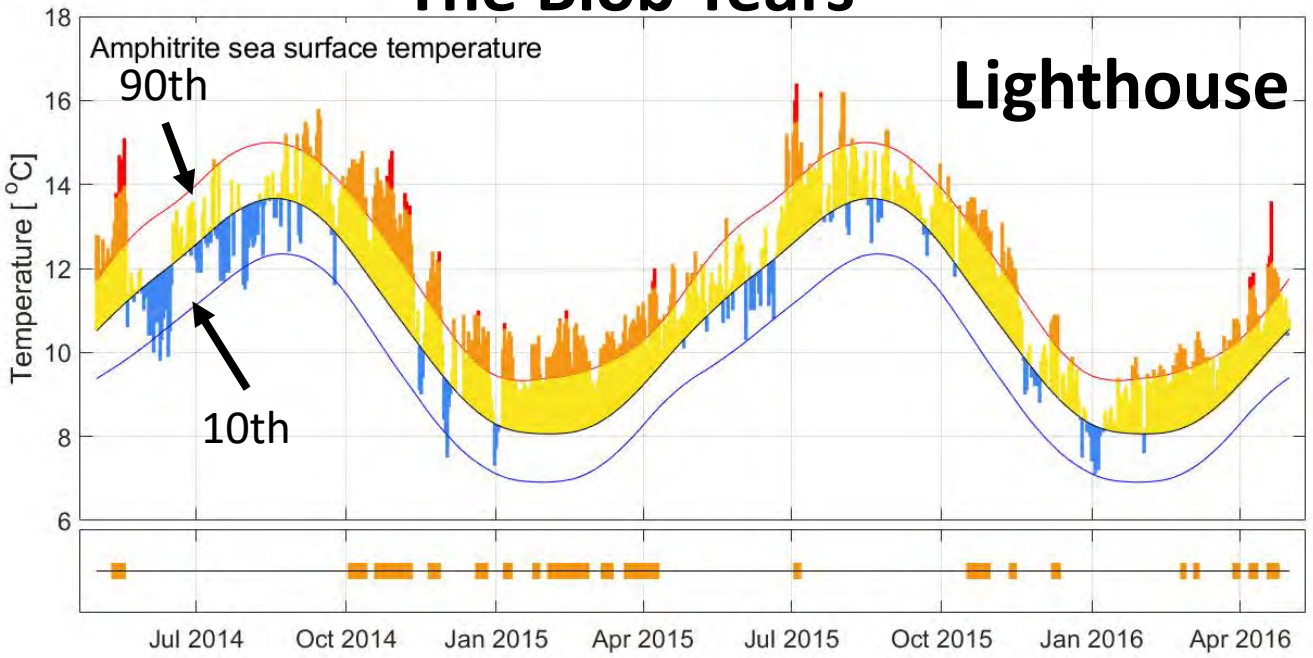
BC Shore Station Monitoring Program

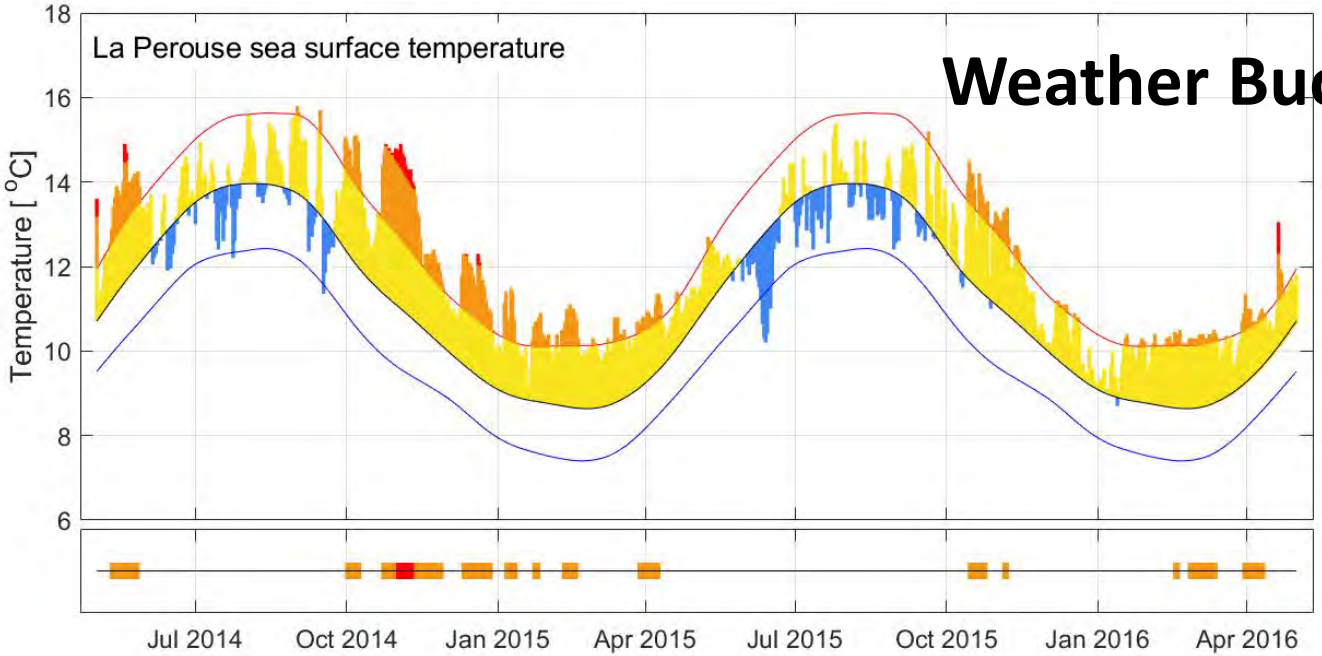


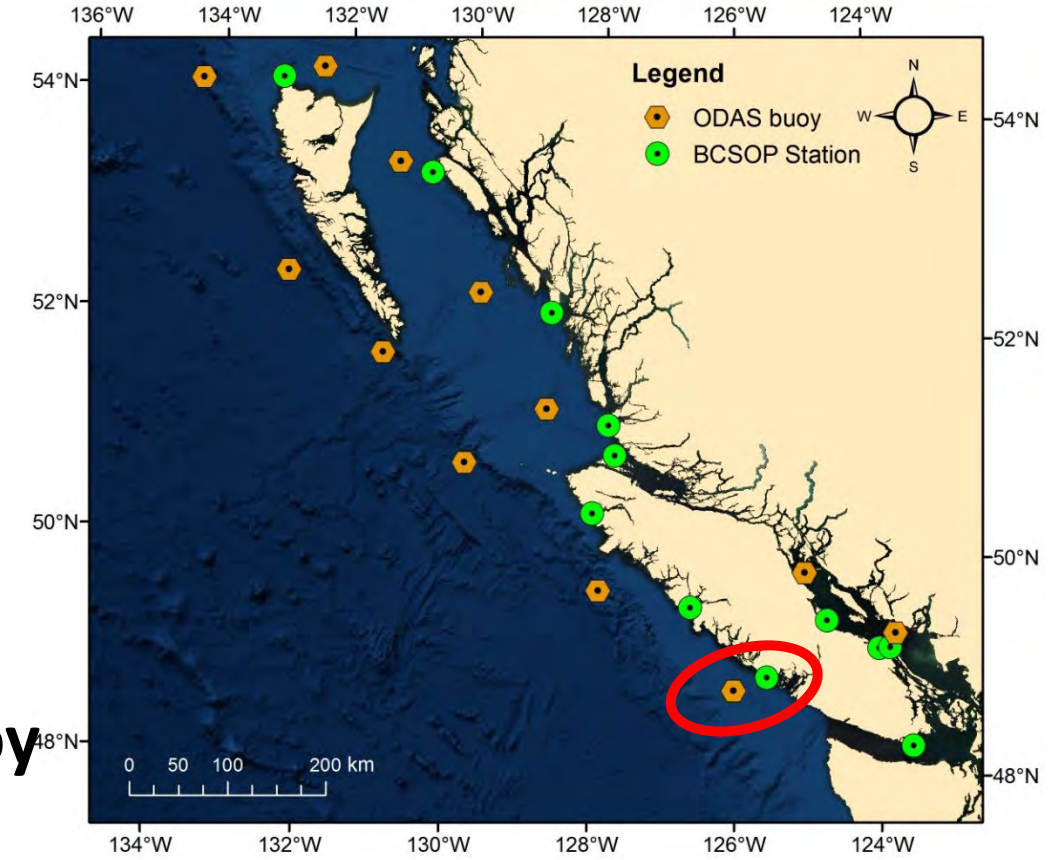
Data

- Compute daily SST from a network of weather buoys that has existed since about 1990.
- Using daily measurements from the lighthouses
- Compute mean annual cycle and 90th percentile for the reference period 1990-2019 or record length if we don't have 30 years.
- With 30 years of data, there will be almost 1100 days with SST in excess of the 90th percentile.
- Marine Heatwaves are those events lasting for 5 or more days.
-

The Blob Years

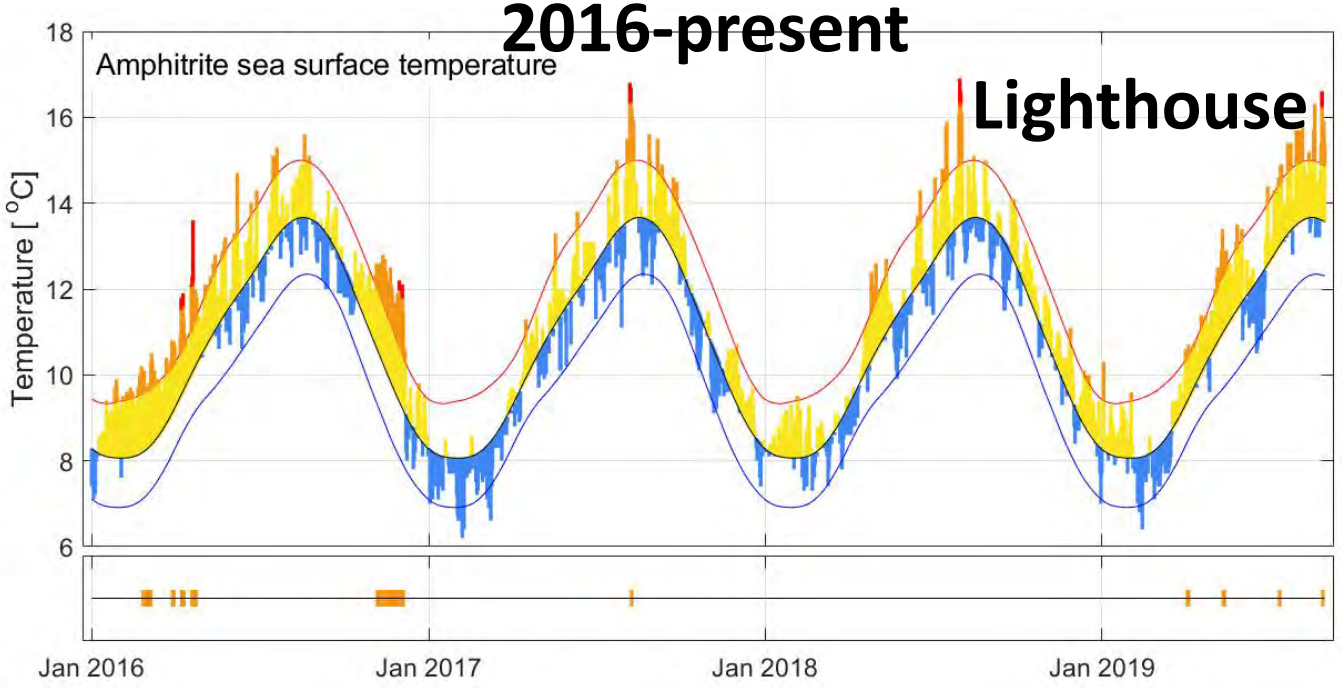


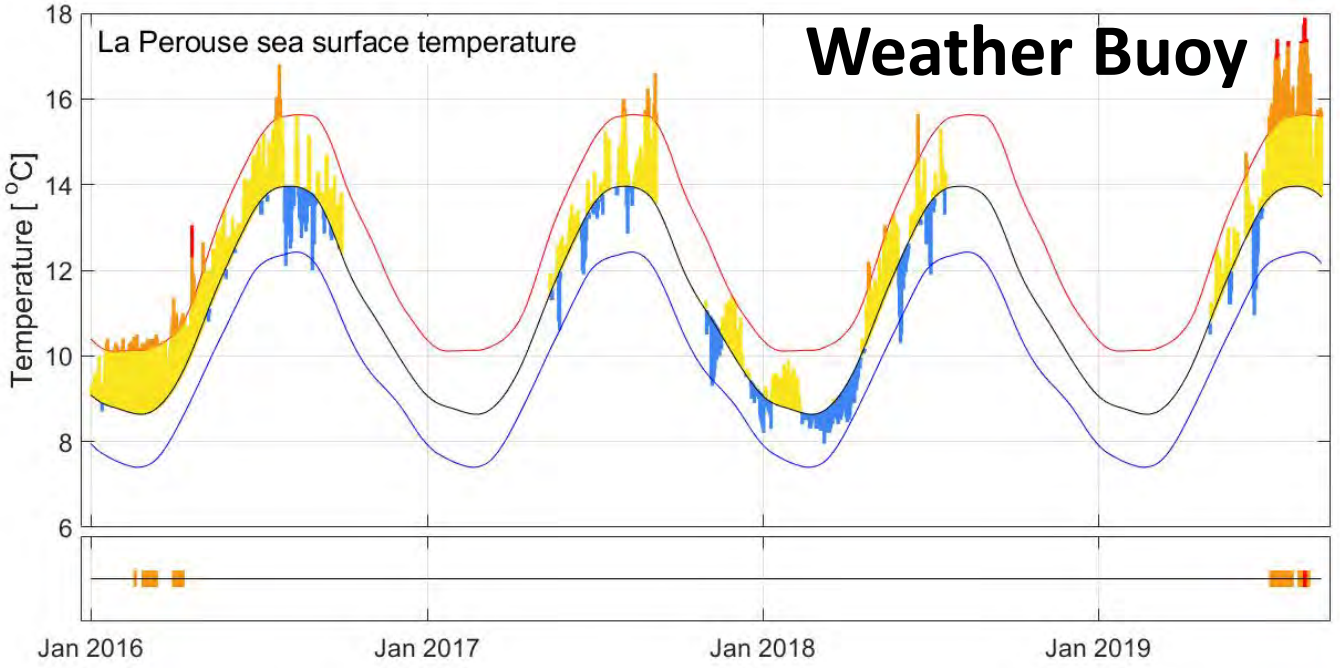


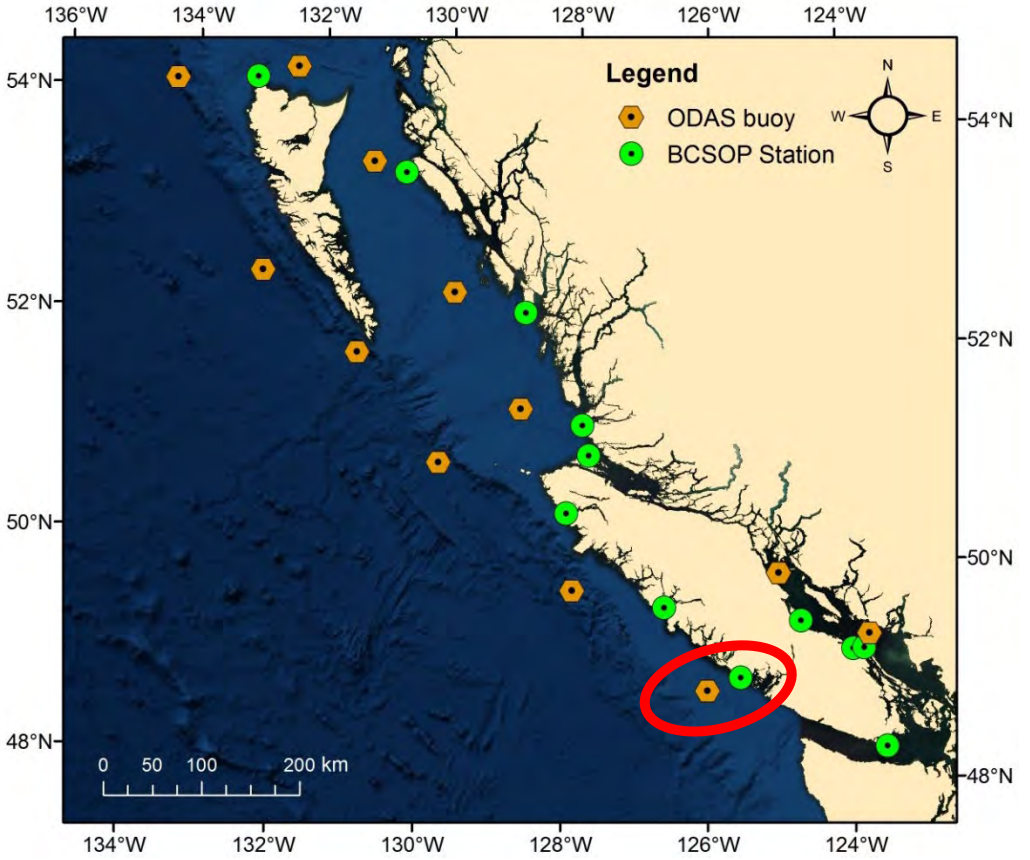


Station	Number of days		*i max*	*i cum*
	Cat 1	Cat 2	°C	°C days
Amphitrite Light	205	0	3.95	63
La Perouse Buoy	186	12	3.90	106

2016-present

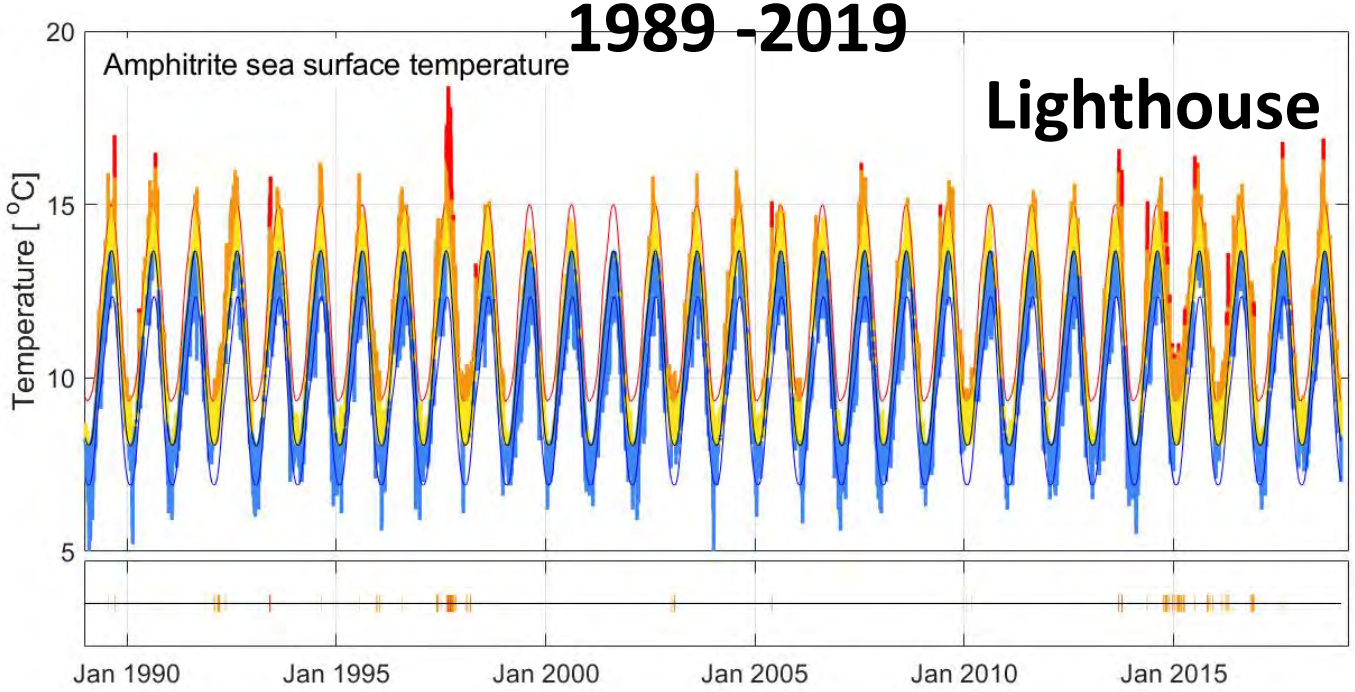


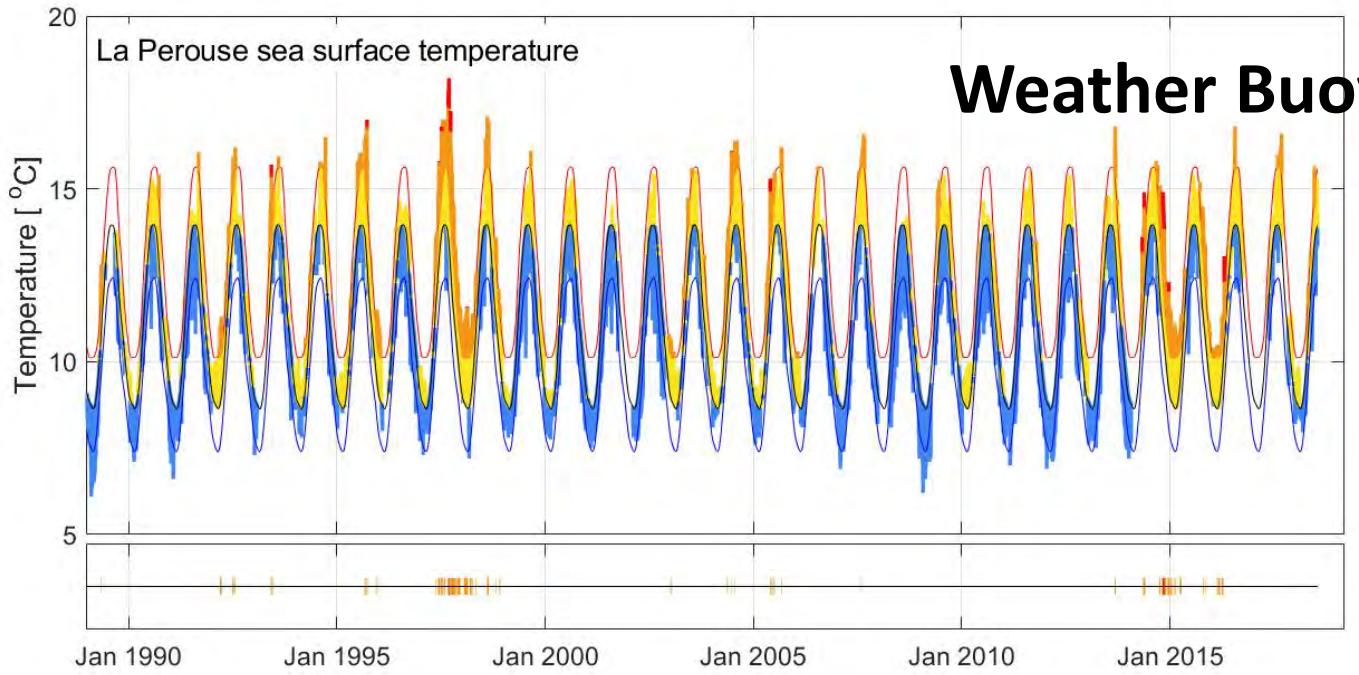


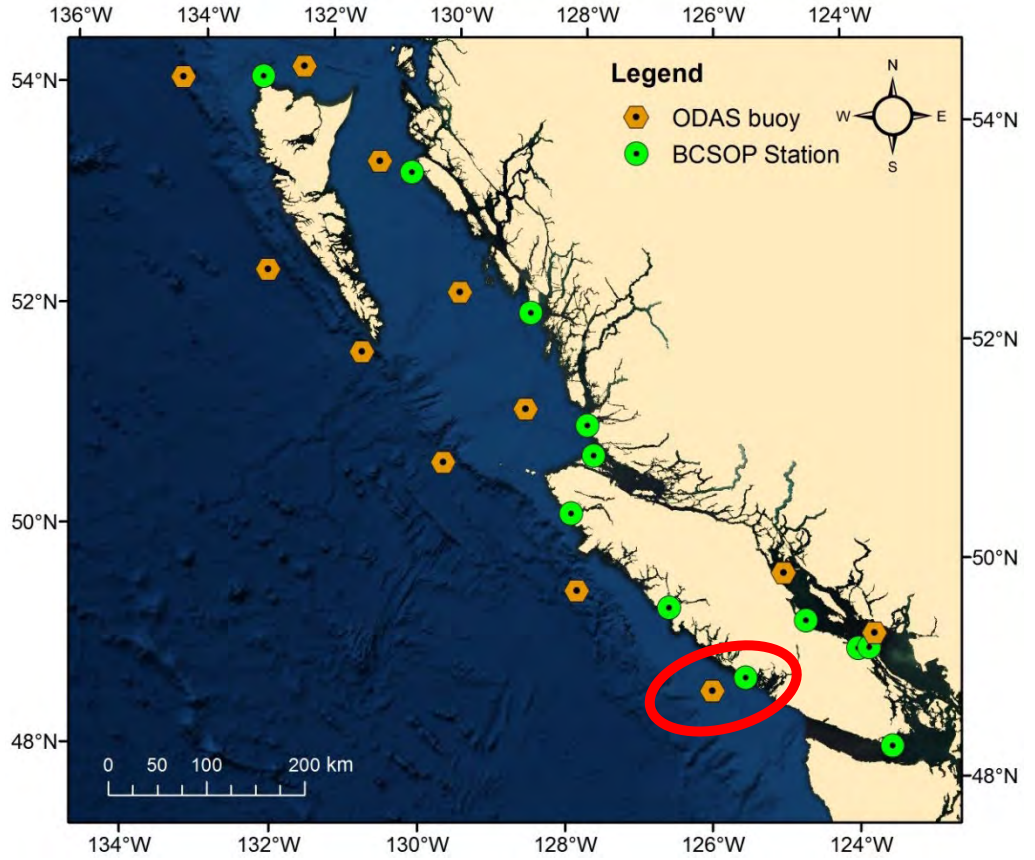


Station	Number of days		*i max*	*i cum*
	Cat 1	Cat 2	°C	°C days
Amphitrite Light	94	0	3.54	64
La Perouse Buoy	81	5	3.95	68

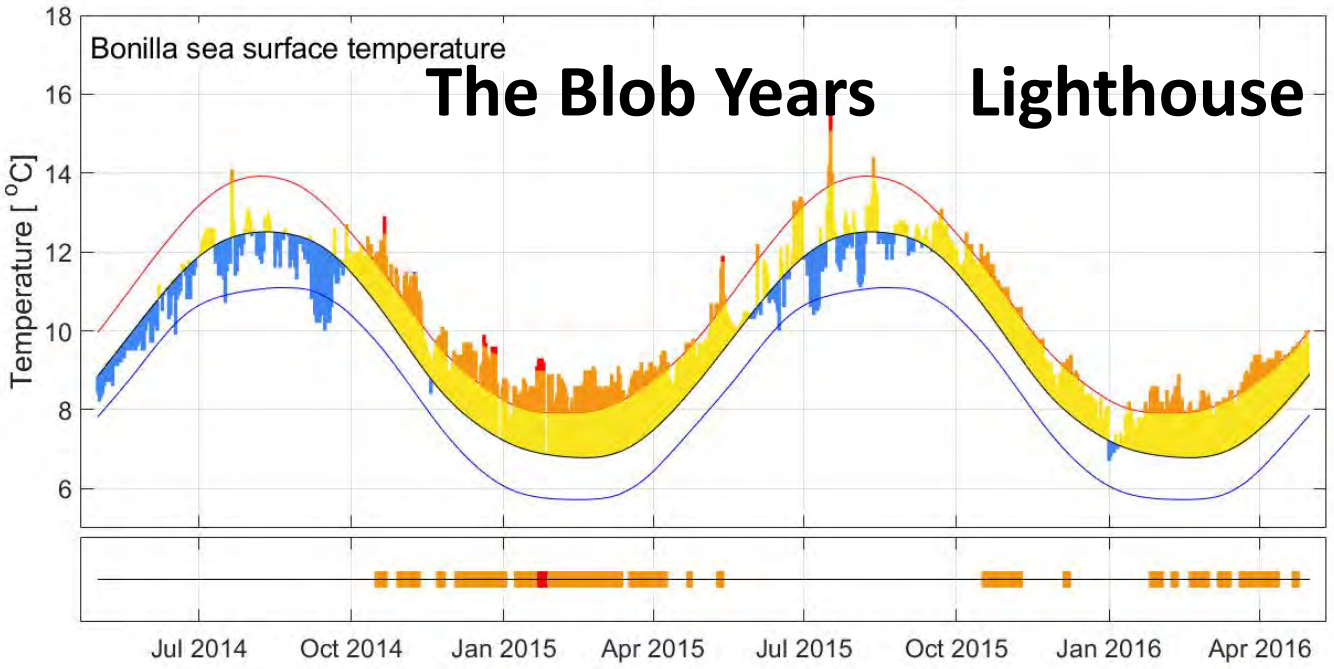
1989 -2019





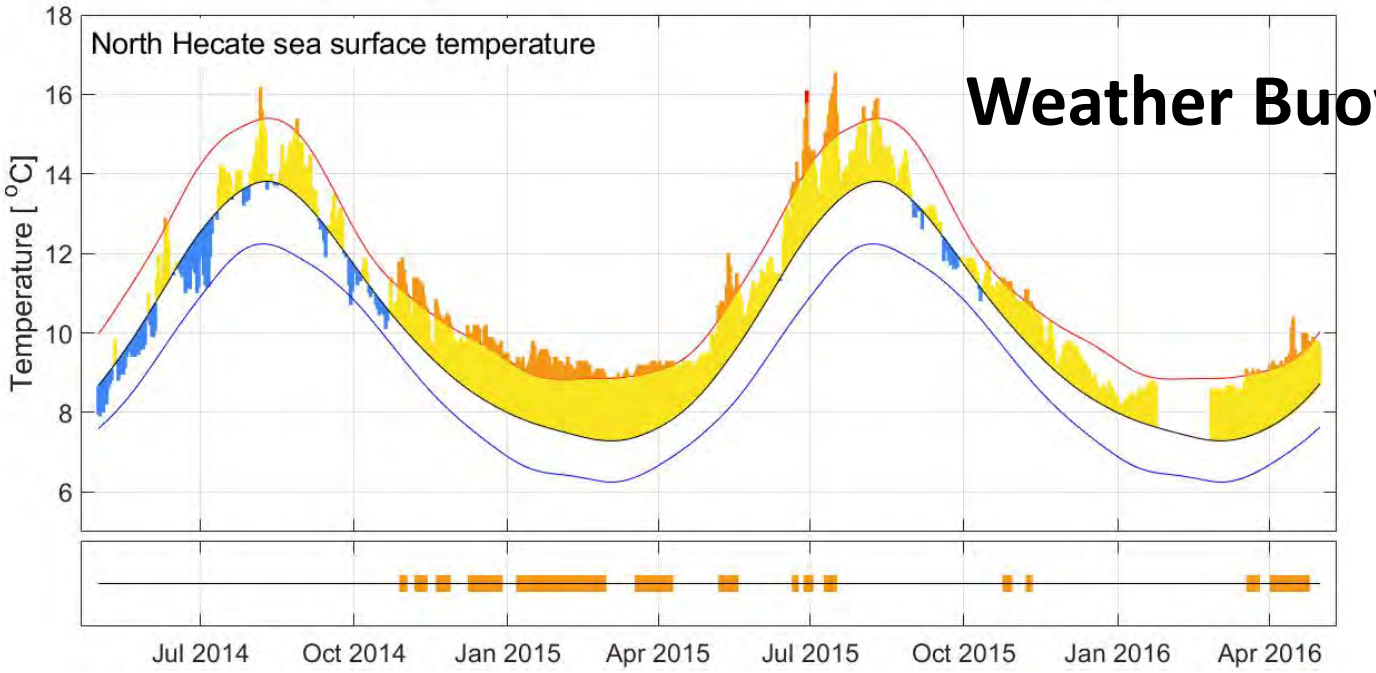


Station	Number of days		*i max*	*i cum*
	Cat 1	Cat 2	°C	°C days
Amphitrite Light	541	31	5.07	152
La Perouse Buoy	599	20	4.76	130

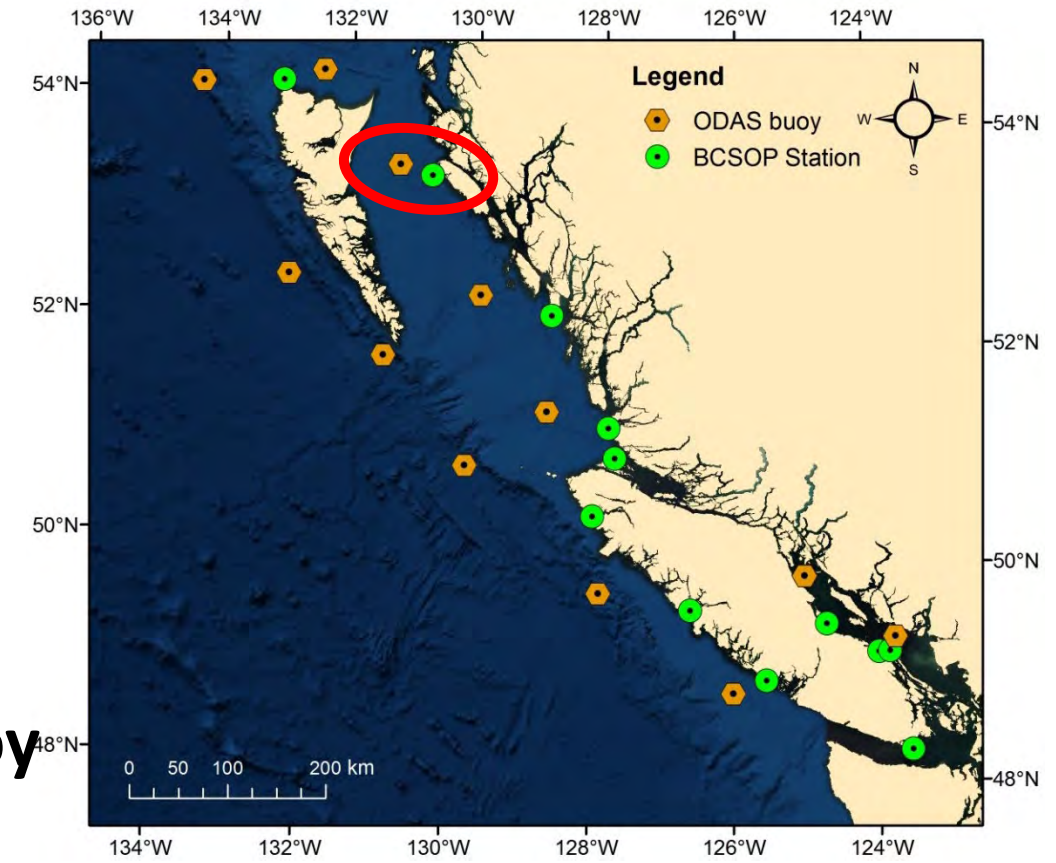


The Blob Years

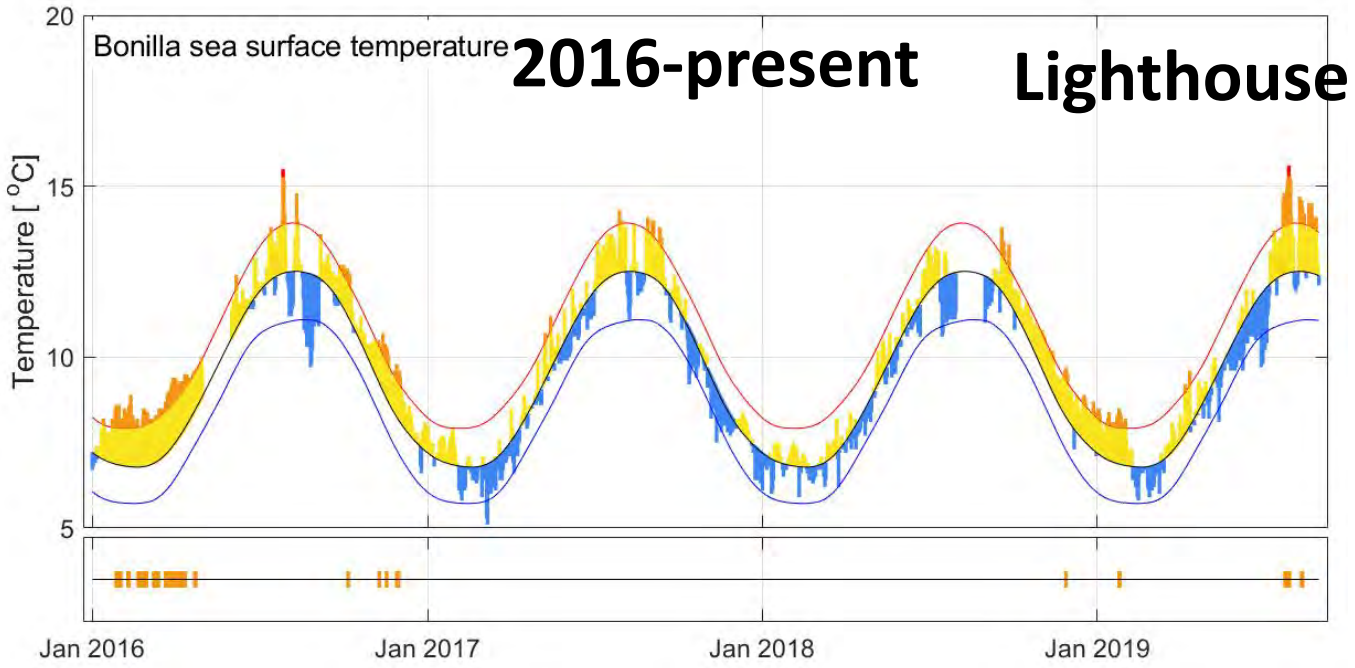
Lighthouse

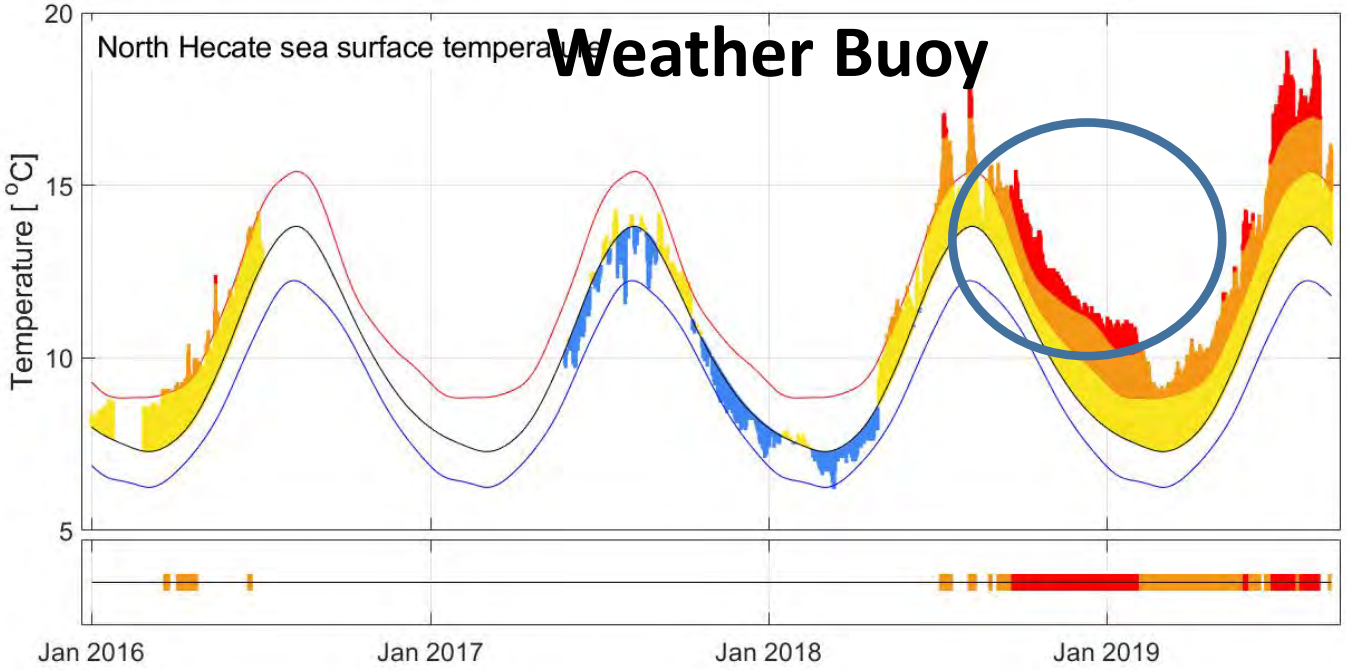


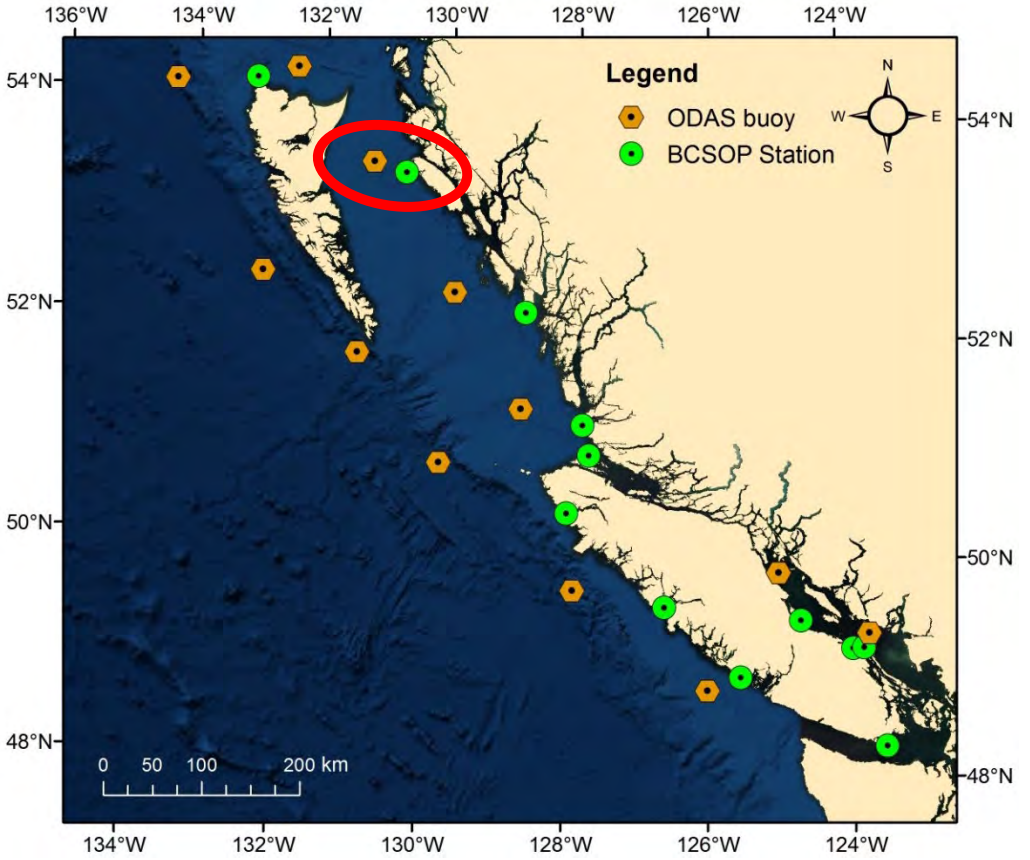
Weather Buoy



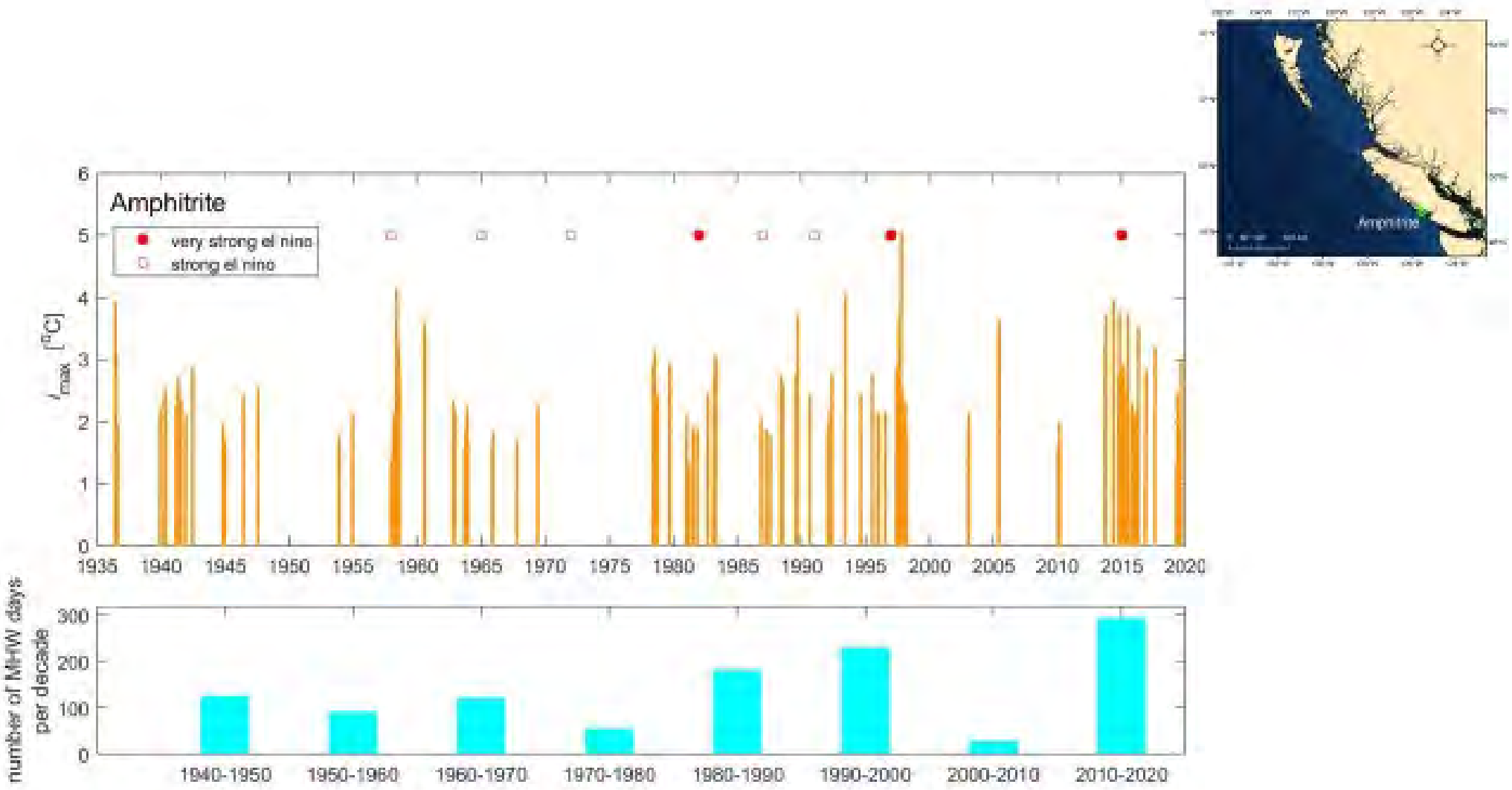
Station	Number of days		*i max*	*i cum*
	Cat 1	Cat 2	°C	°C days
Bonilla Light	271	7	2.48	120
North Hecate Buoy	206	0	3.67	94



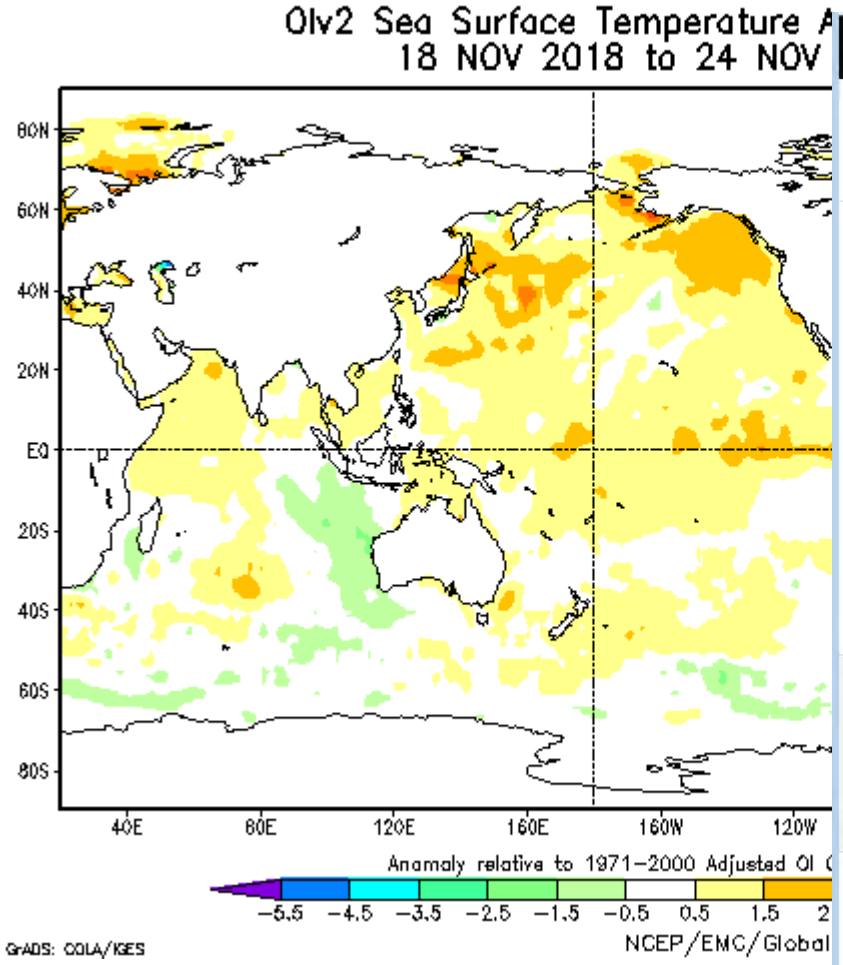


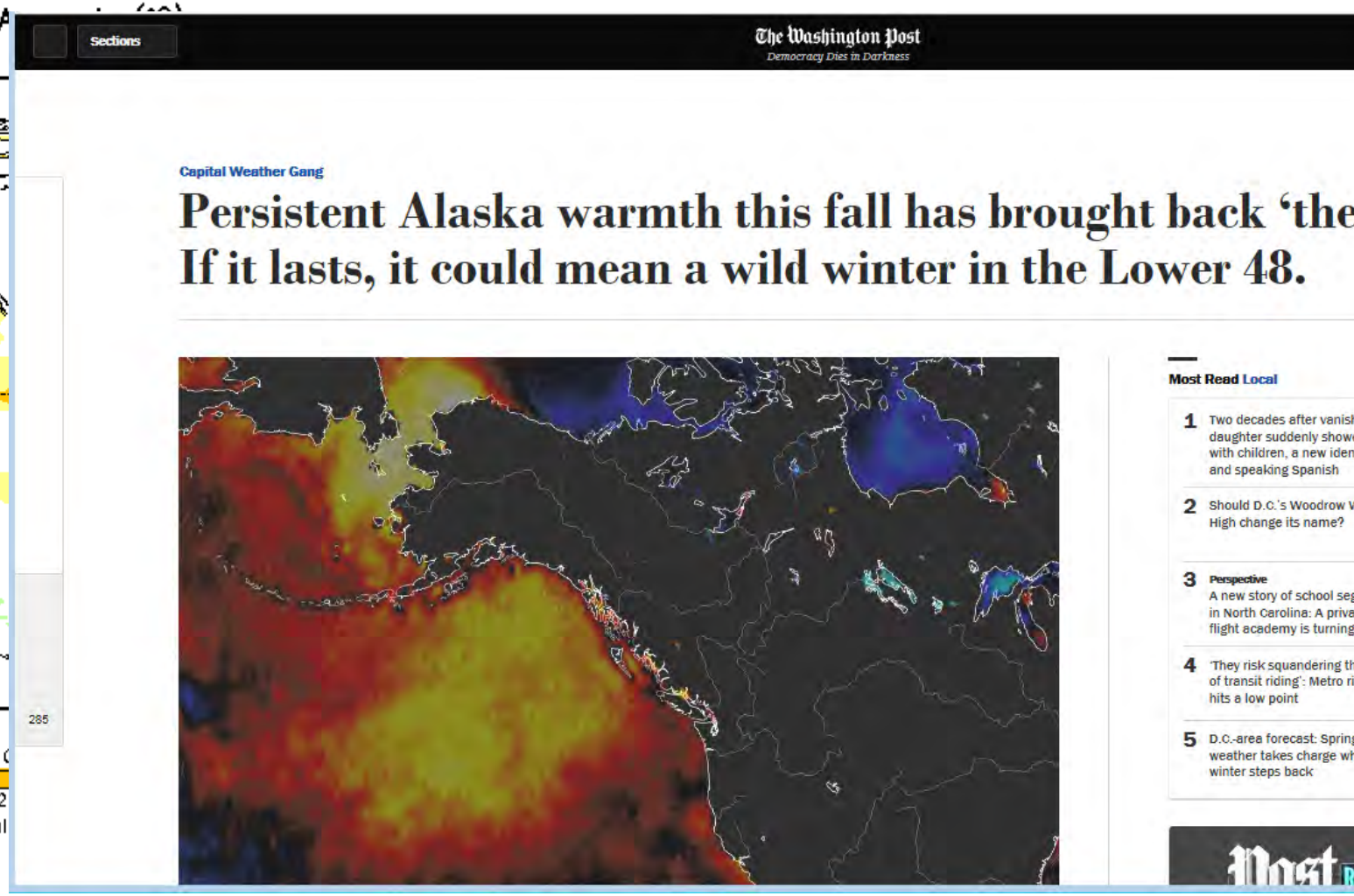


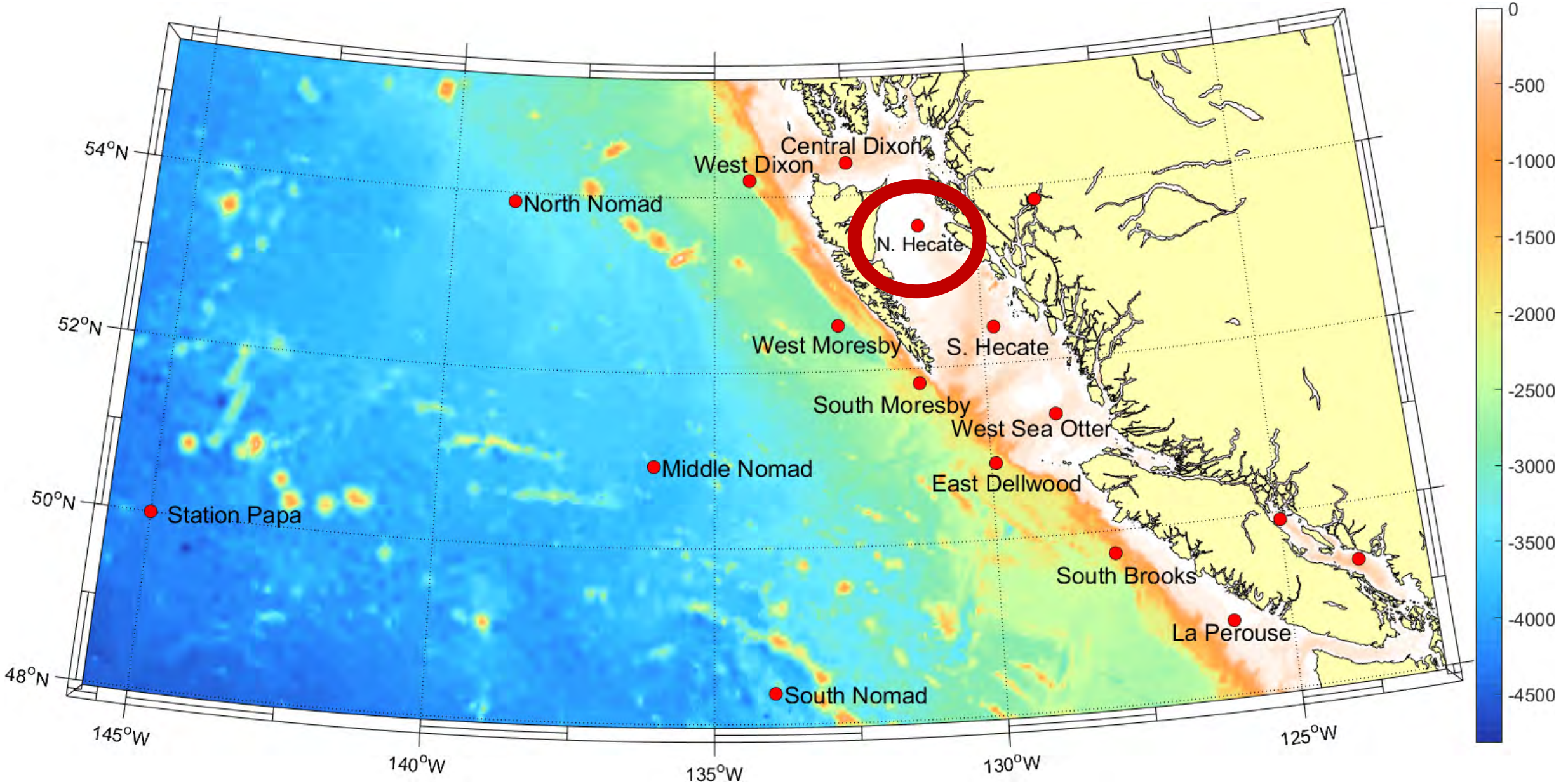
Station	Number of days		*i max*	*i cum*
	Cat 1	Cat 2	°C	°C days
Bonilla Light	120	0	3.14	42
North Hecate Buoy	428	198	5.68	733


Amphitrite
very strong el nino
strong el nino
I_{max} [°C]
0
1
2
3
4
5
6
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
number of MHW days per decade
0
100
200
300
1940-1950
1950-1960
1960-1970
1970-1980
1980-1990
1990-2000
2000-2010
2010-2020

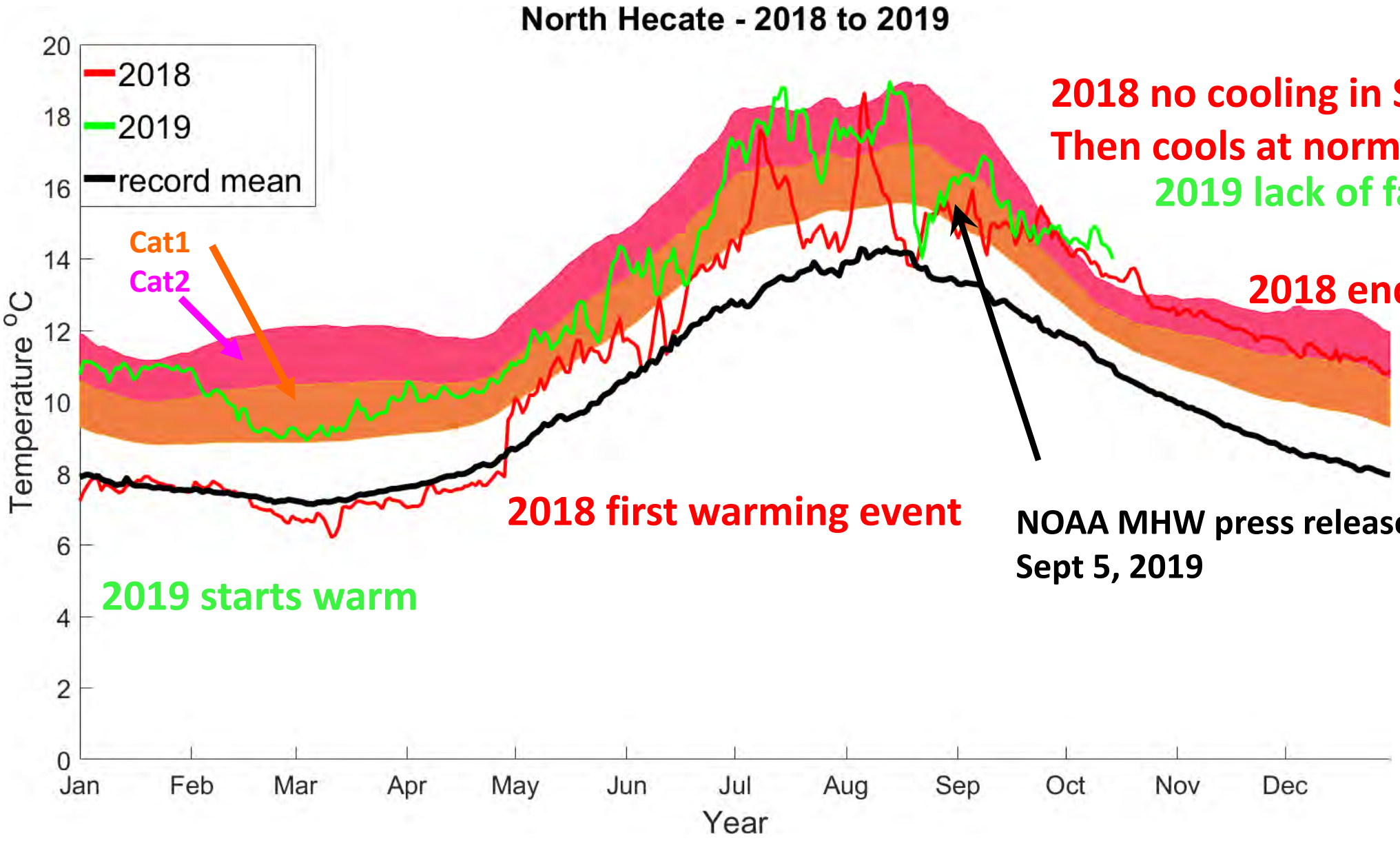
Satellite SST ANOMALY 18-24 November 2018





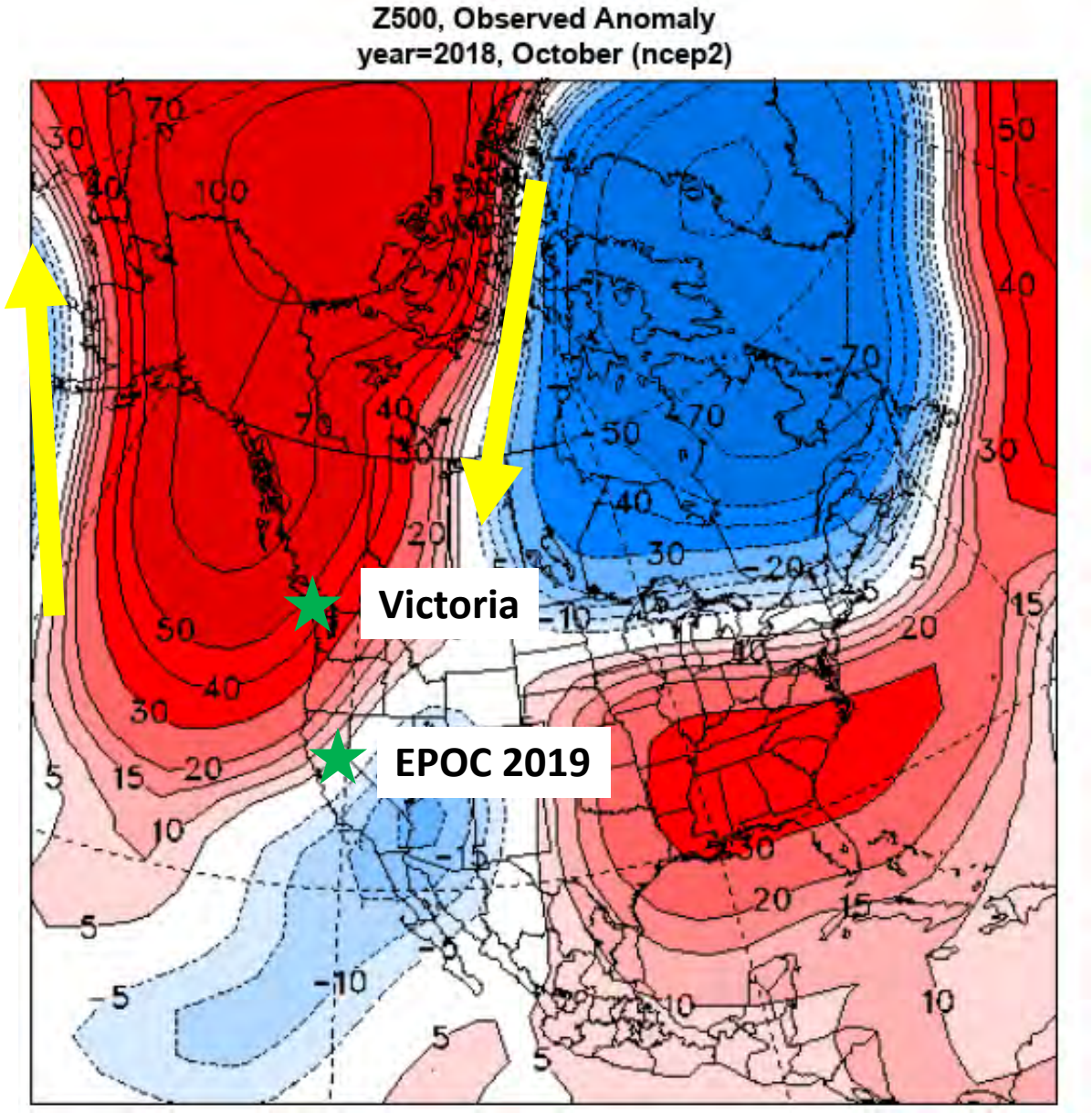

Central Dixon
West Dixon
North Nomad
N. Hecate
West Moresby
S. Hecate
South Moresby
West Sea Otter
Middle Nomad
East Dellwood
Station Papa
South Brooks
La Perouse
South Nomad
54°N
52°N
50°N
48°N
145°W
140°W
135°W
130°W
125°W
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500

North Hecate 2018-2019



500 mb height anomaly October 2018

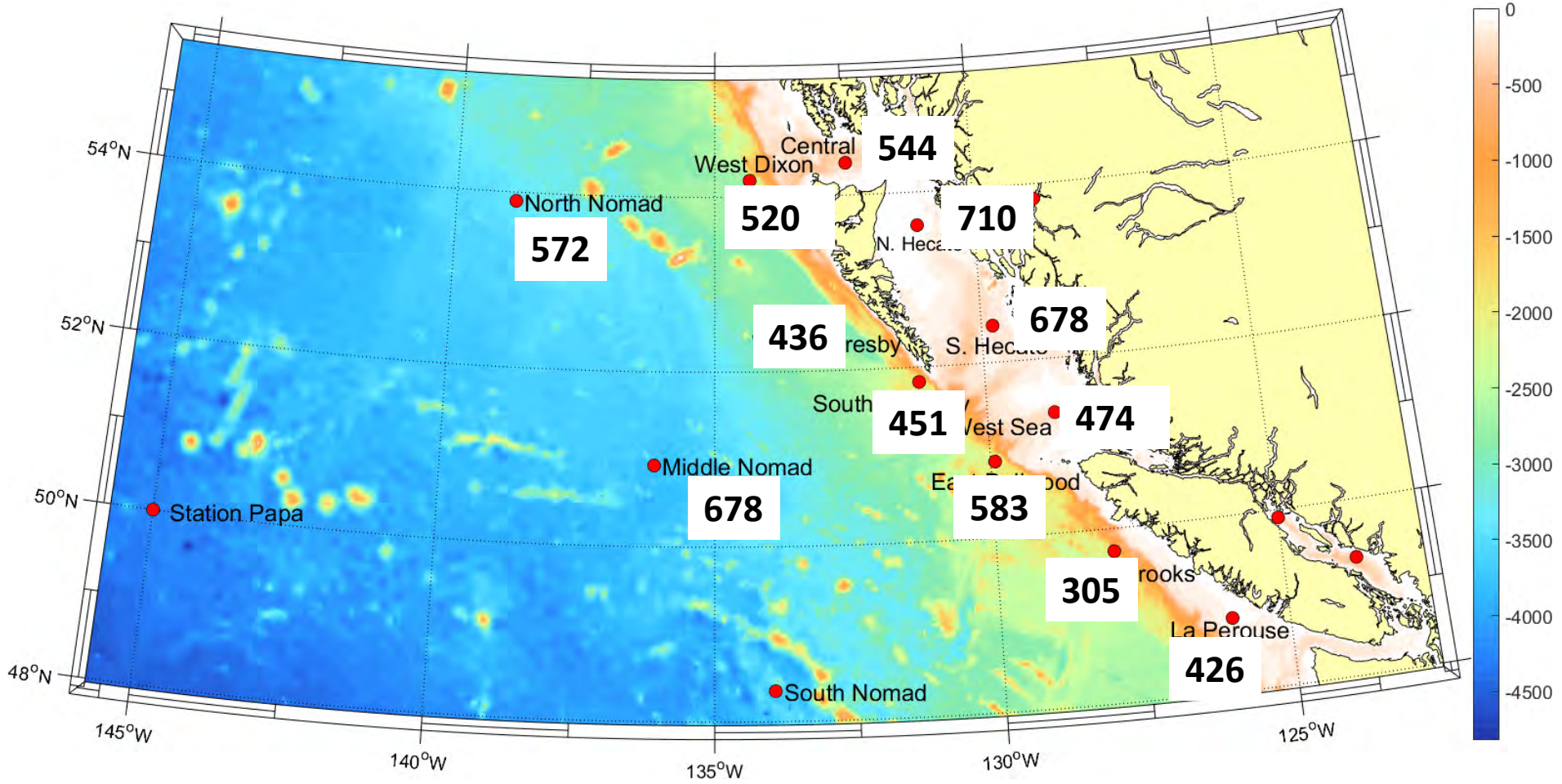
- **October 2018 - the peak of the SST anomaly along the west coast**
- **High pressure keeping weather systems from reaching the west coast.**
- **This pressure anomaly is high enough in the atmosphere to be an indicator of jet stream activity.**
- **Notice the east west dipole.**
- **This system is pushing air into the Arctic over the north Pacific and that air then comes back down across continental North America.**
- **September and November showed a similar pattern.**



2018-19 Story for BC

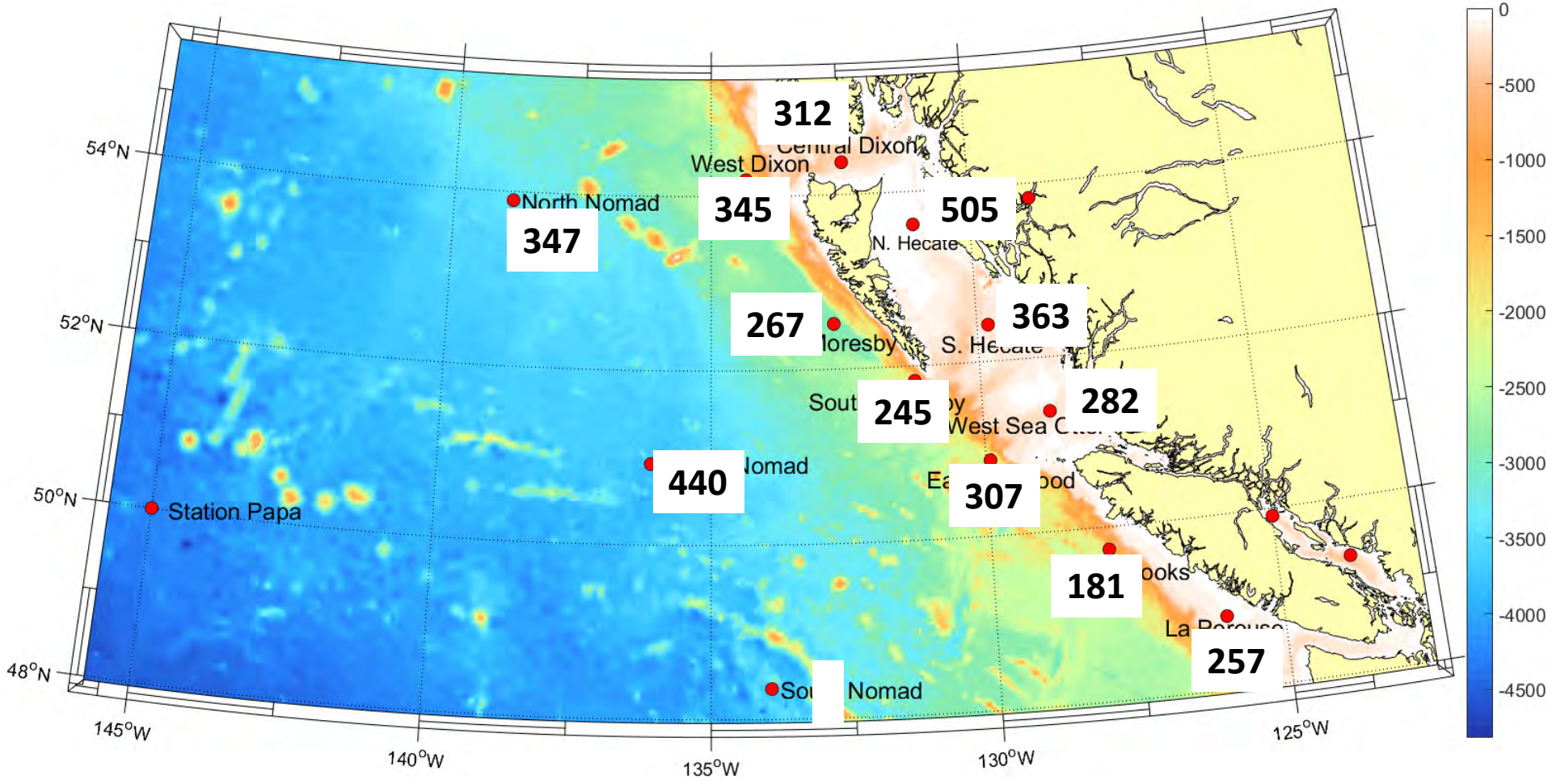
- **Lack of cooling (as opposed to warming) is an important part of the MHW story in the fall.**
- **In 2018, the lack of fall cooling was likely due to the lack of fall storms (there were none).**
- **Then when the storms resumed they cooled the ocean at the usual rate. Which means the warm anomaly remained well into the winter.**
- **Anomaly remains until there are a series of stronger than 'normal' storms. So you don't need the 500 mb height anomaly to persist all fall and winter.**
- **This is likely part of the story for the 2014-2016 Blob event as seen at the weather buoys.**

Days in excess of 90th percentile: 2010-2019



Maximum value is a bit less than 1100 days. Expected value for 10 years is about 360 days

Cat1+ Marine Heatwave days: 2010-2019



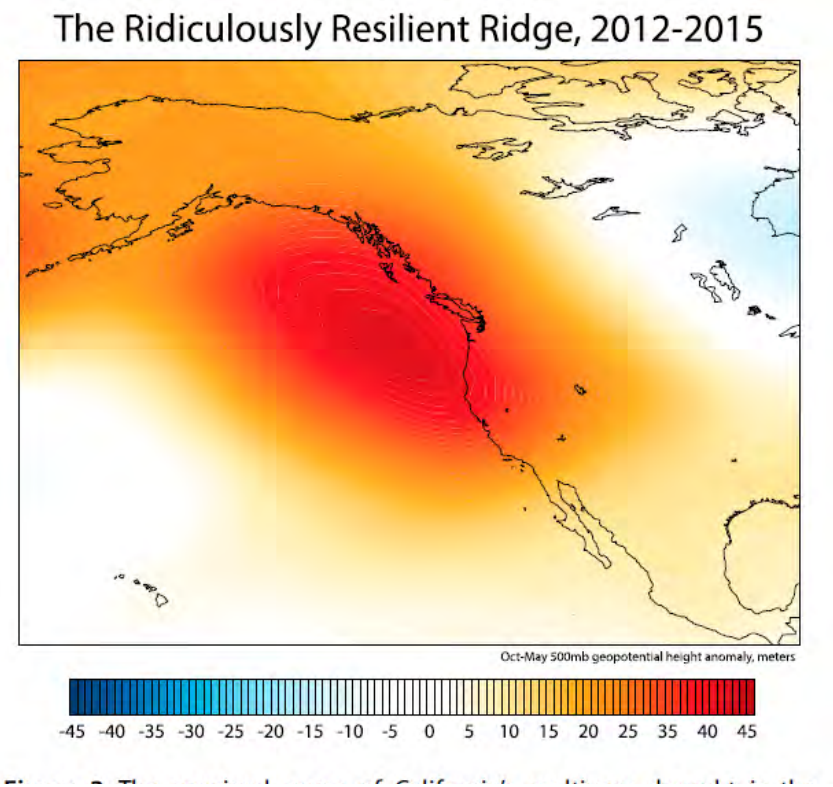
Potential links between Marine Heat Waves and Drought

The proximal cause of California's multiyear drought is the remarkable persistence of a region of mid-trophospheric high pressure known at the "Ridiculously Resilient Ridge". Swain 2015.

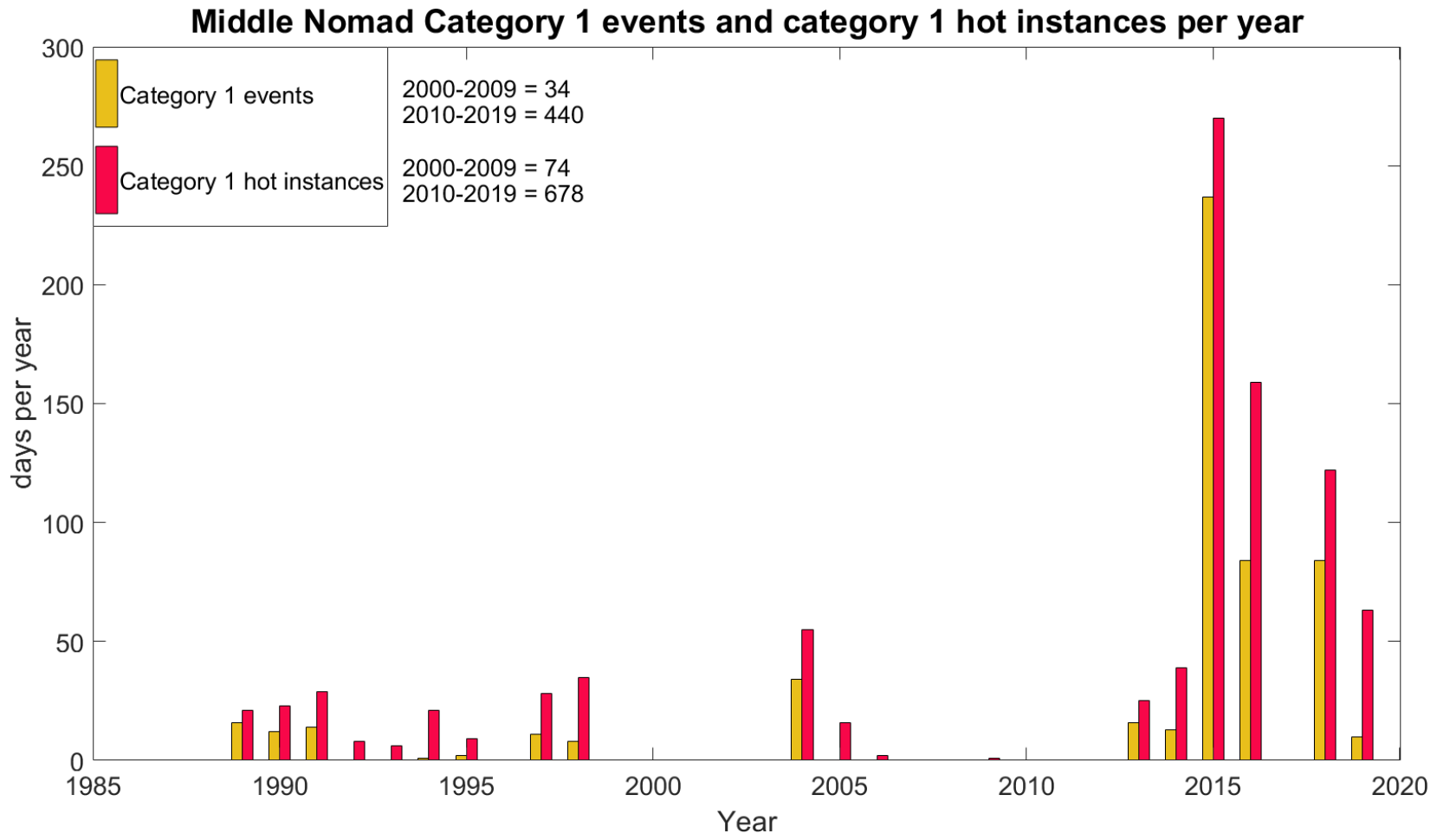
Notice the anomaly is centred at the latitude of Victoria not California.

In 2018 the ridge was centred in Alaska and we had a drought in NW BC.

Any relationship between Marine Heat Waves and drought will by mediated by how the atmospheric ridge modifies the circulation and affects the transport of moisture.



Swain, D.L., 2015. A tale of two California droughts: Lessons amidst record warmth and dryness in a region of complex physical and human geography. *Geophysical Research Letters*, *42*(22), pp.9999-10.


Middle Nomad Category 1 events and category 1 hot instances per year
Category 1 events
Category 1 hot instances
2000-2009 = 34
2010-2019 = 440
2000-2009 = 74
2010-2019 = 678
days per year
Year
0
50
100
150
200
250
300
1985
1990
1995
2000
2005
2010
2015
2020