

Ocean warming

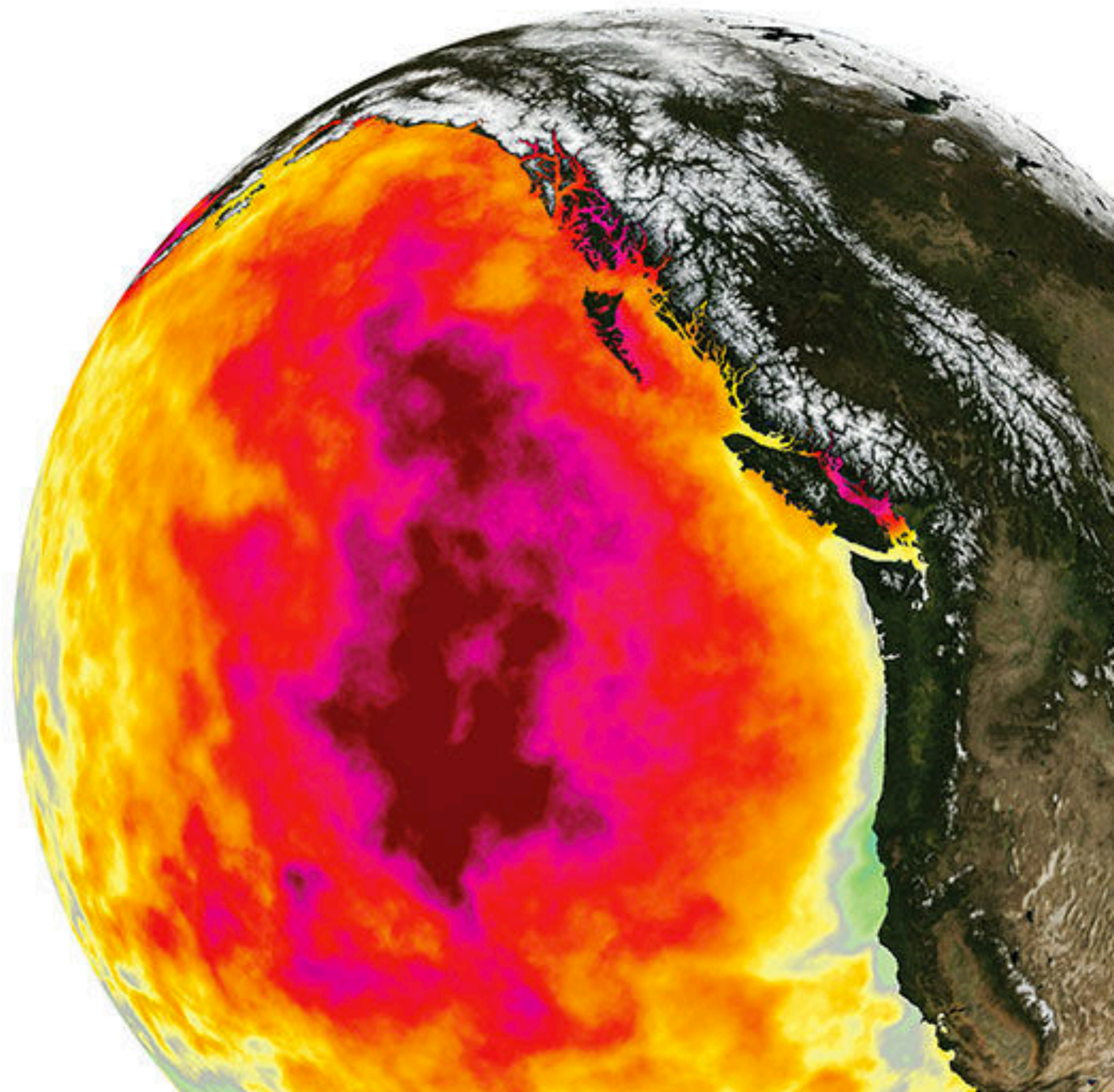
2014

*Extreme marine heatwave
("the Blob") in Gulf of Alaska*

2015

2016

2017

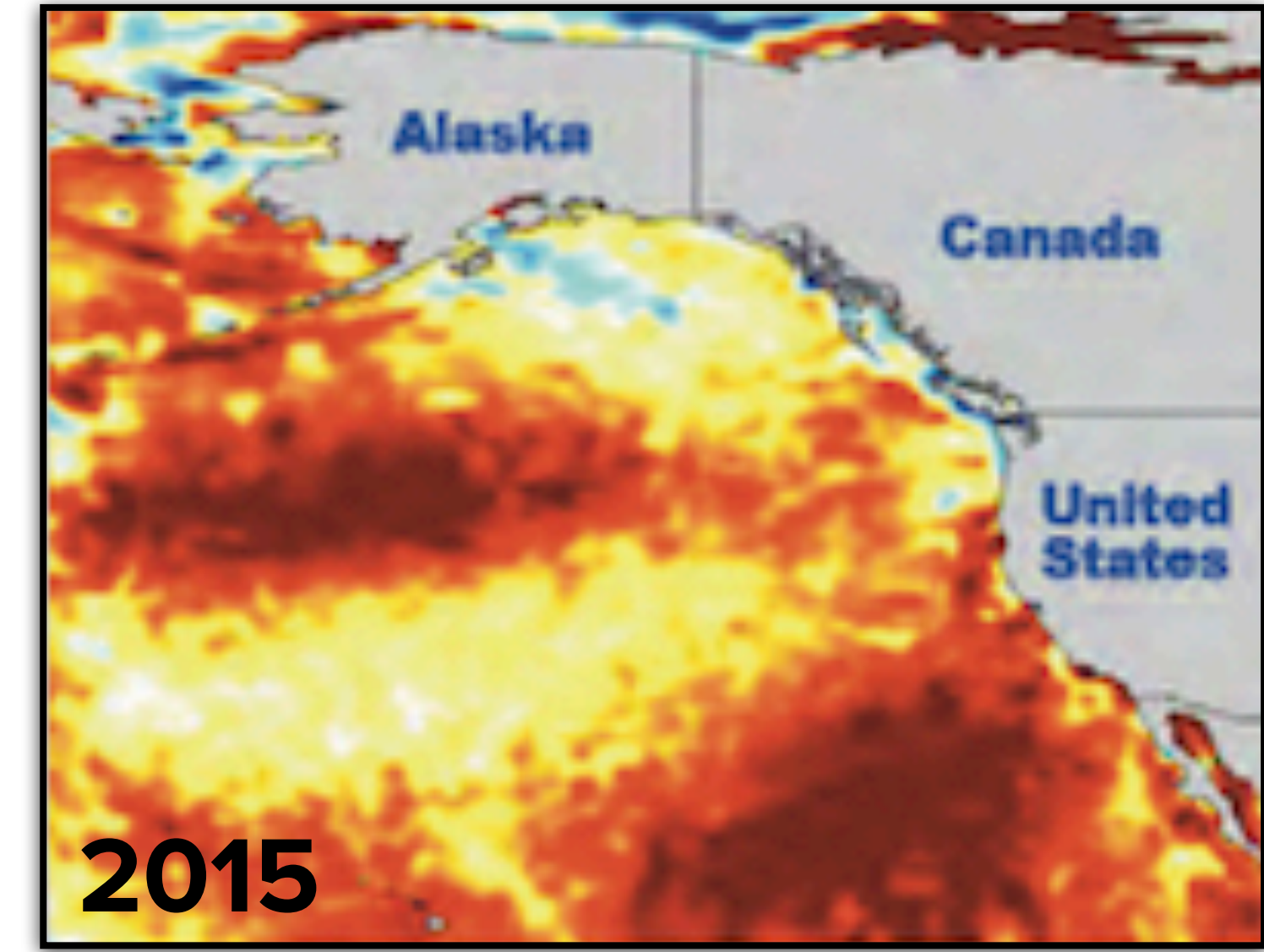
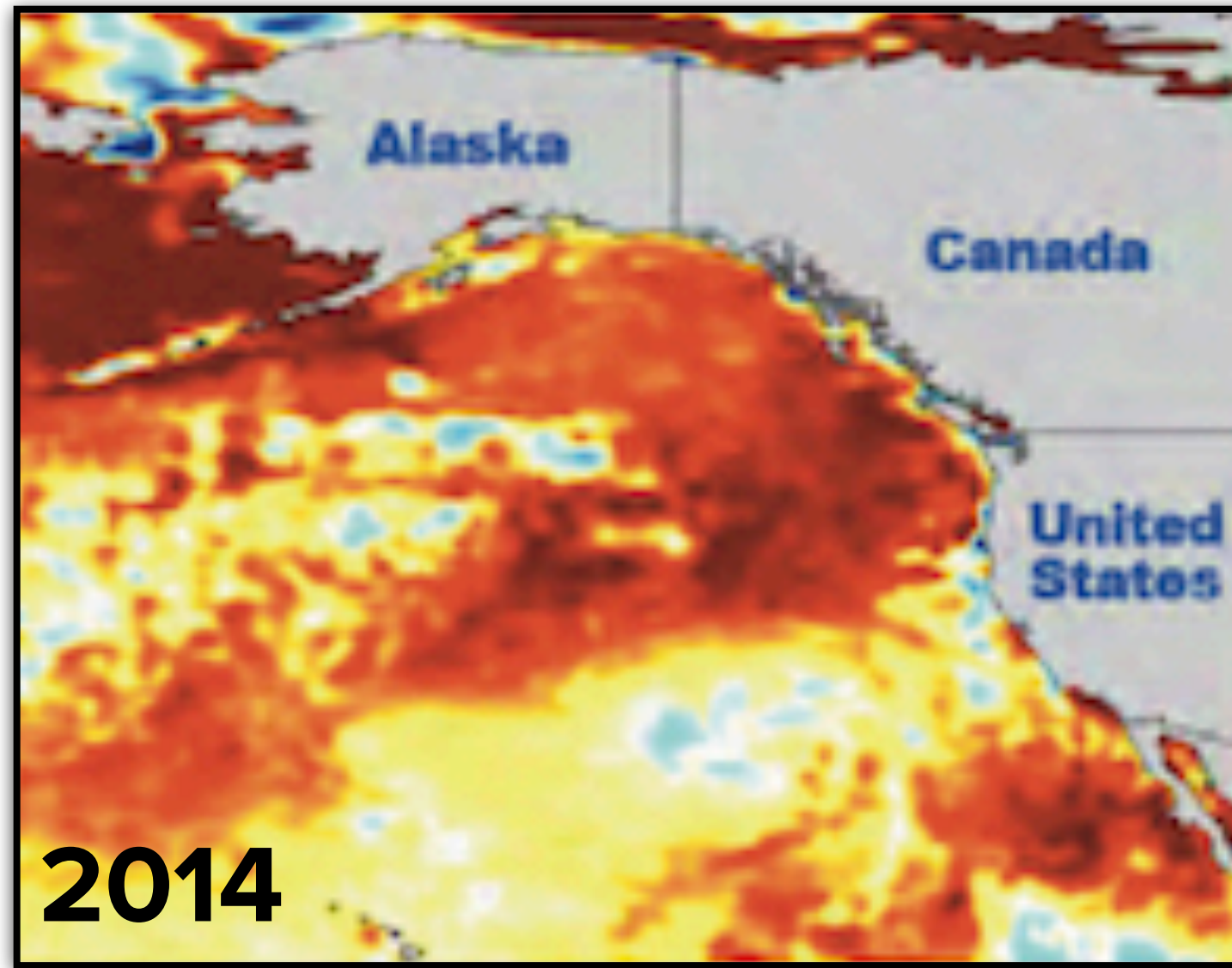


Ocean warming

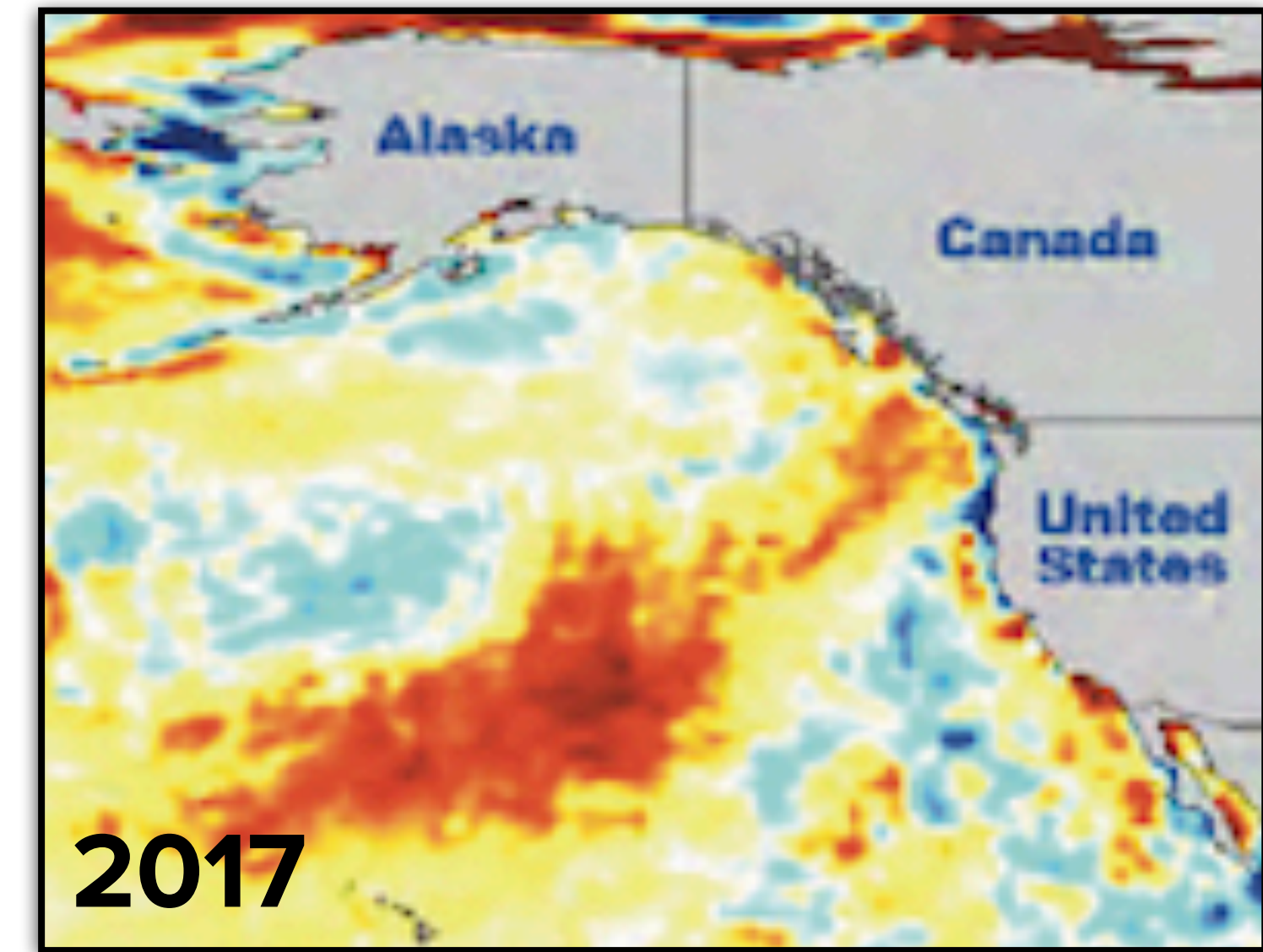
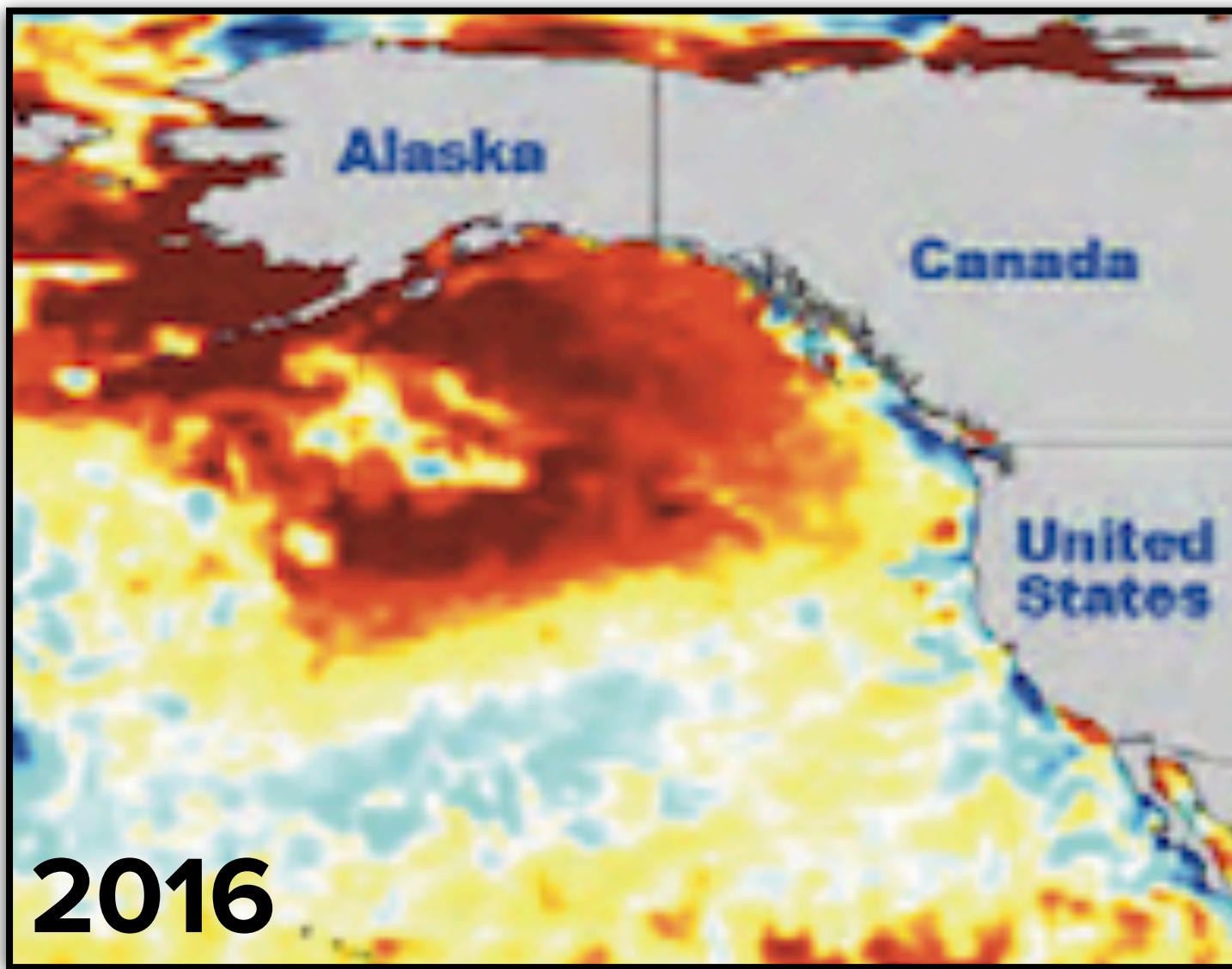
2014

Extreme marine heatwave
("the Blob") in Gulf of Alaska

*Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record*

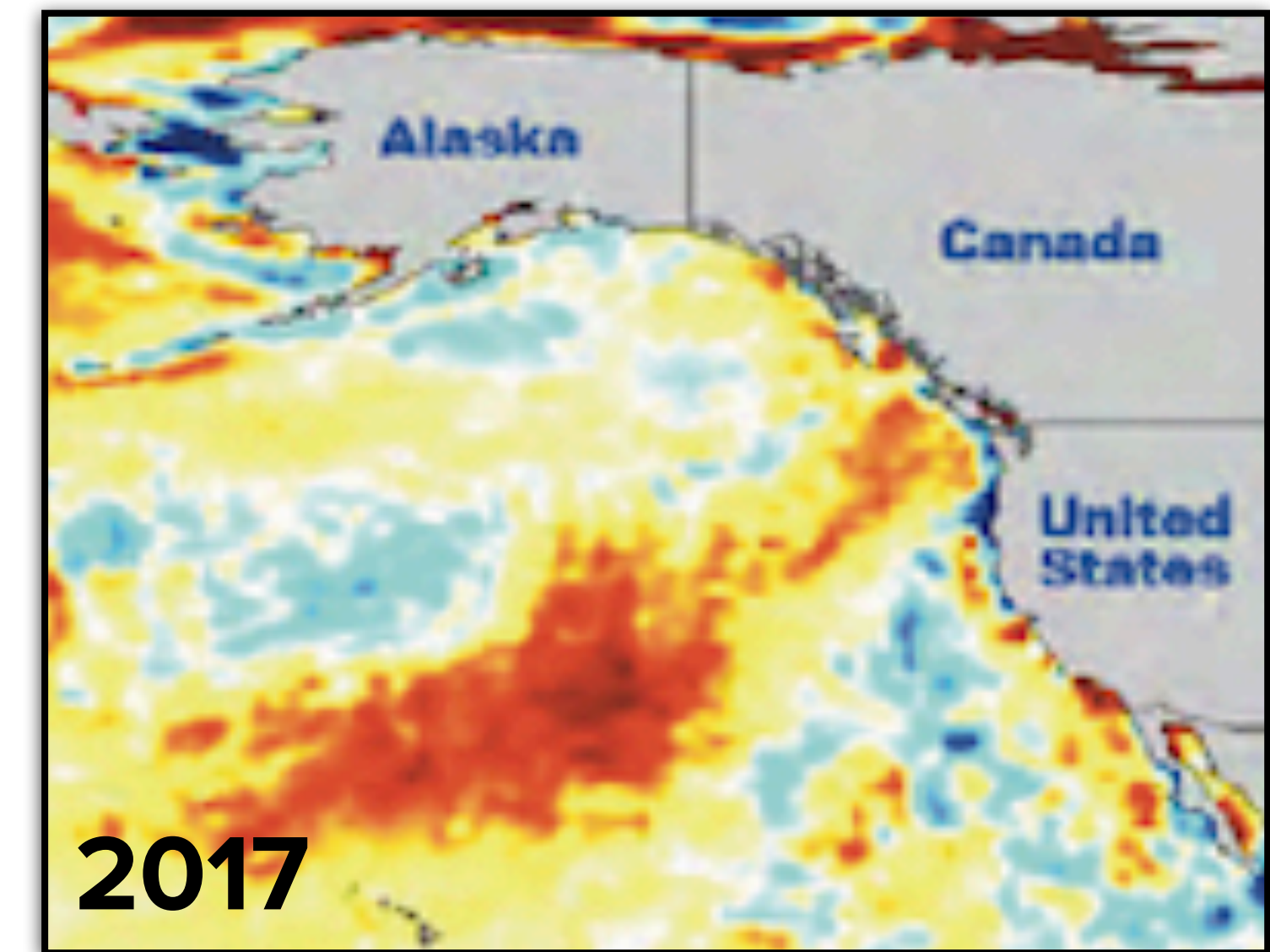
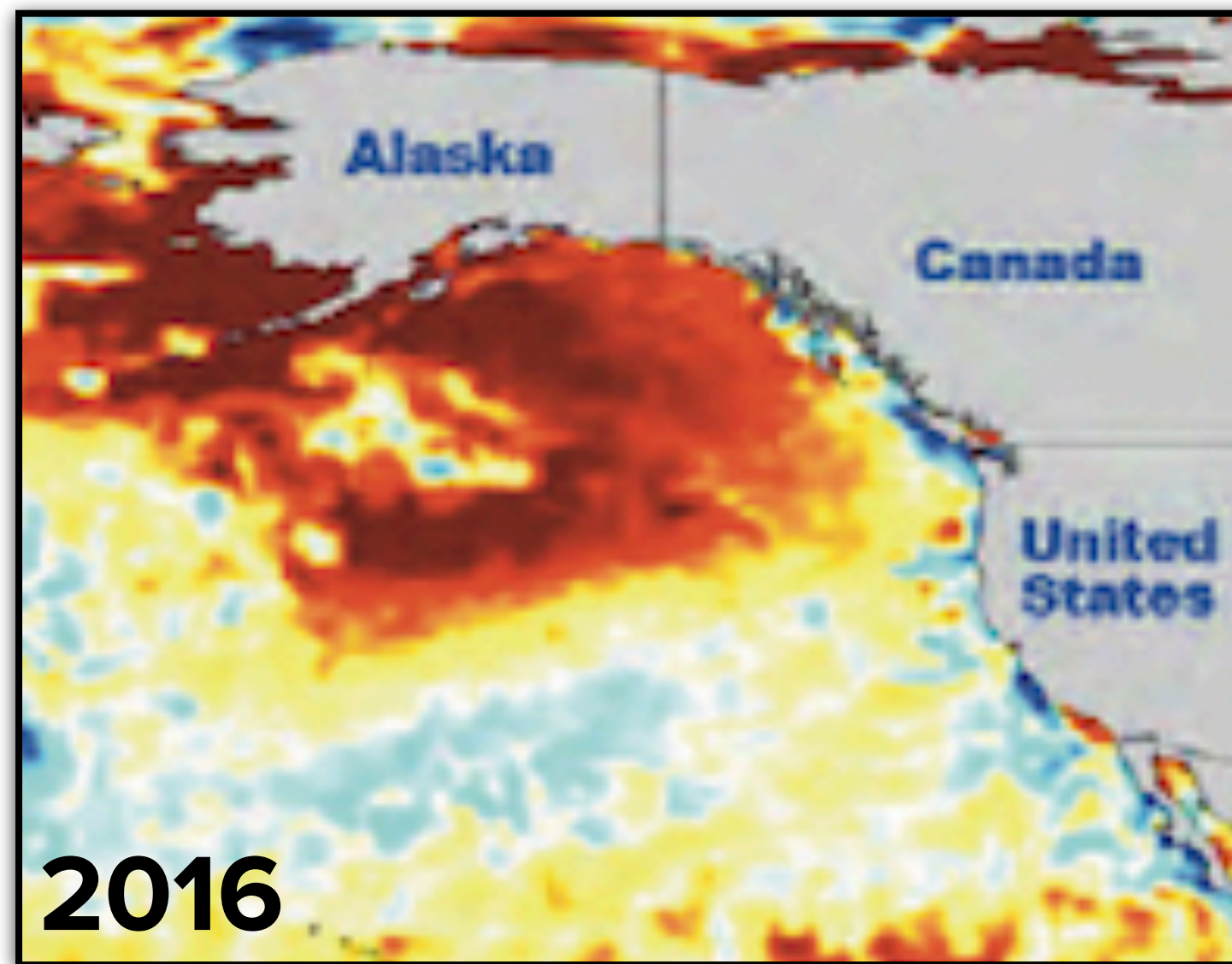
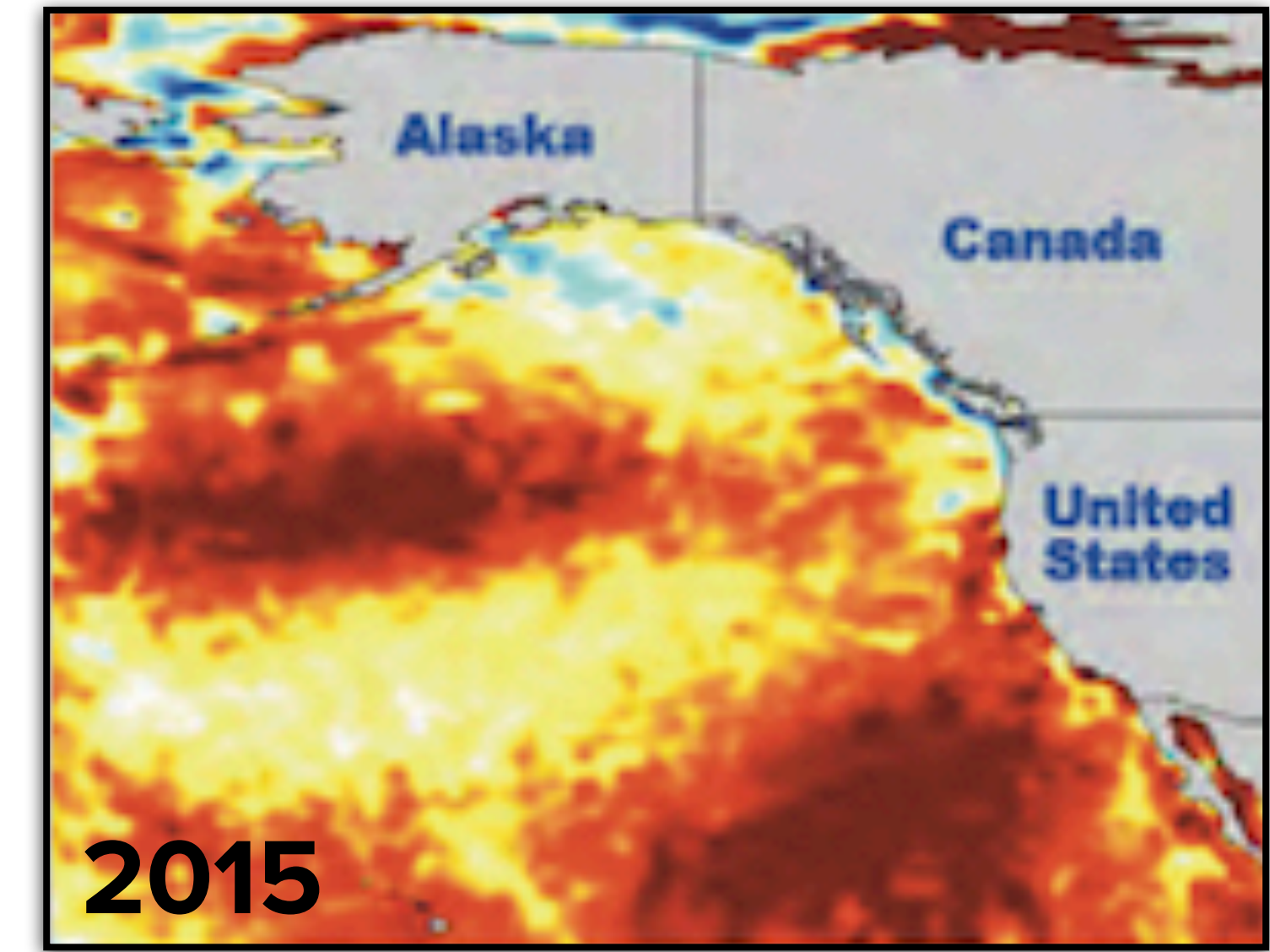
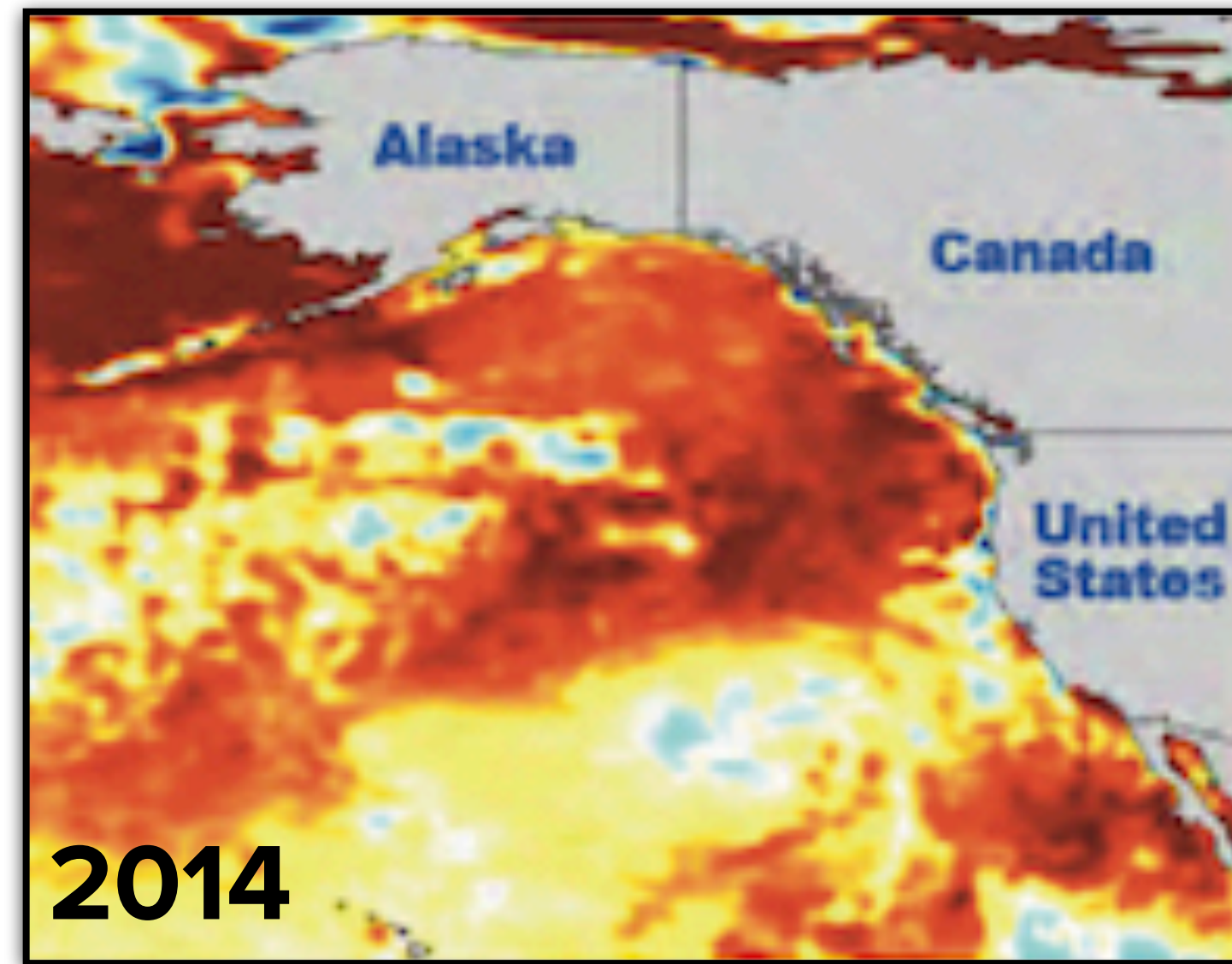
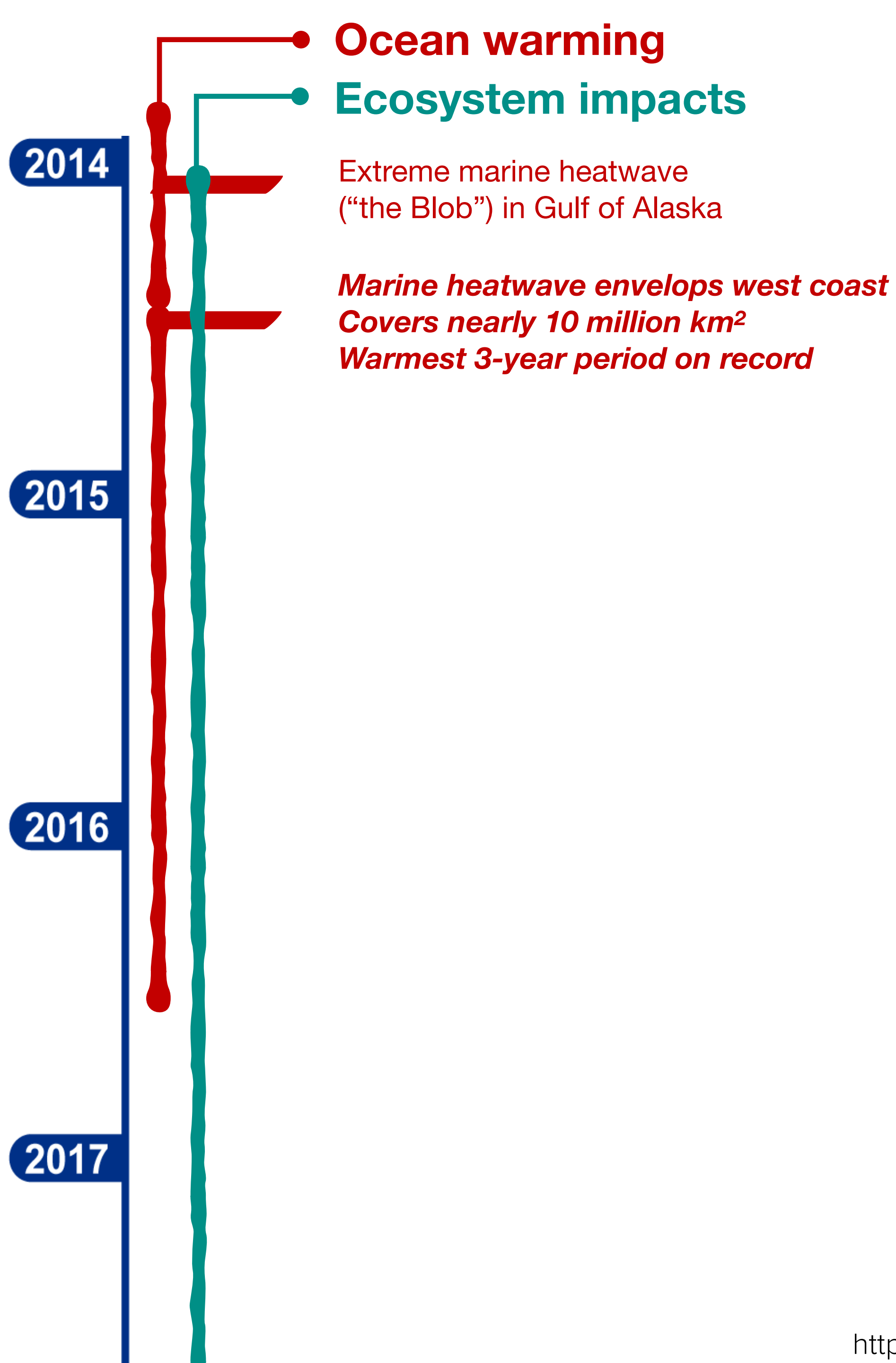


2015



2016

2017



Ocean warming

Ecosystem impacts

2014

Extreme marine heatwave
("the Blob") in Gulf of Alaska

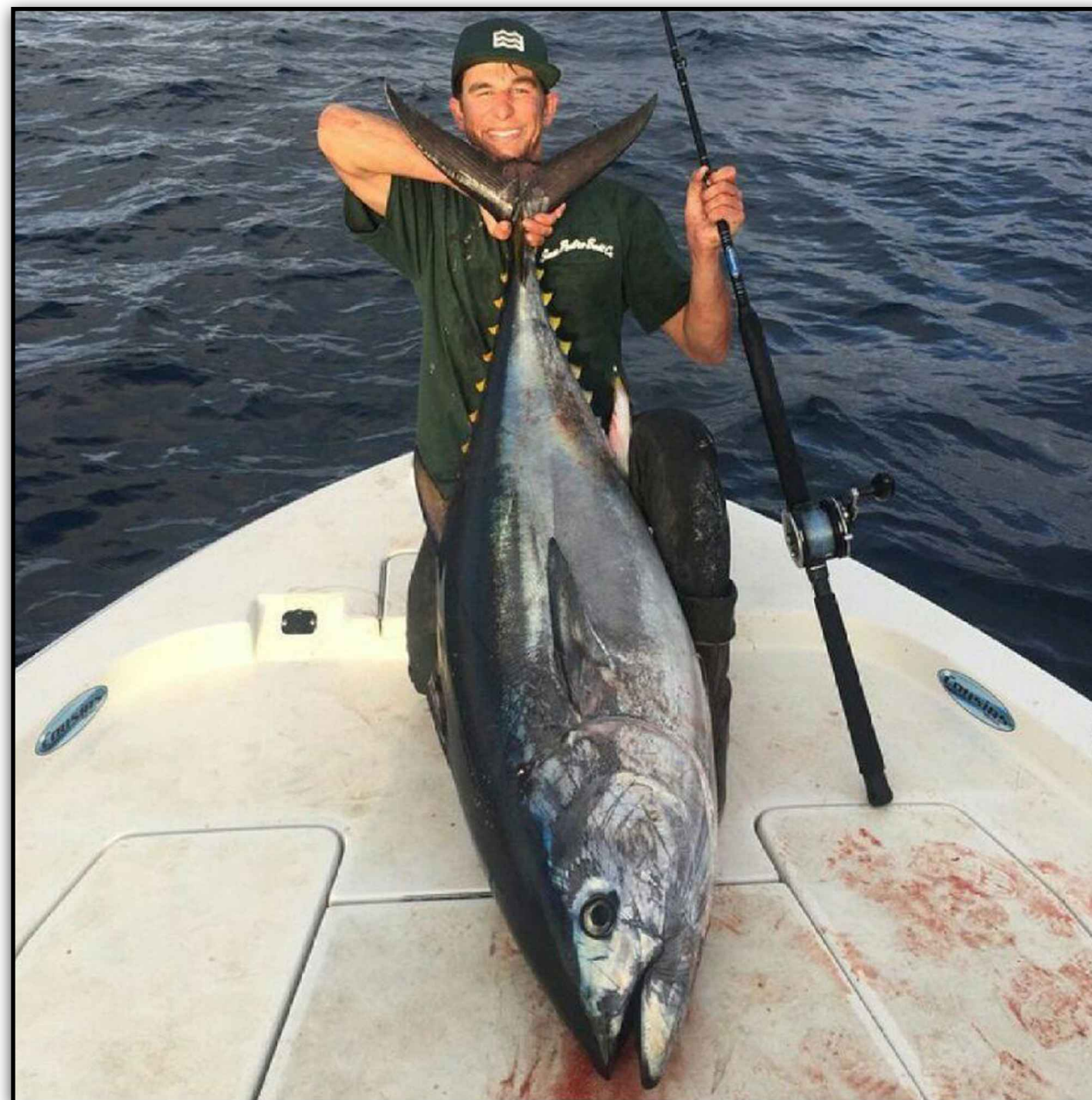
Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record

Marine species shift north to cooler waters

2015

2016

2017

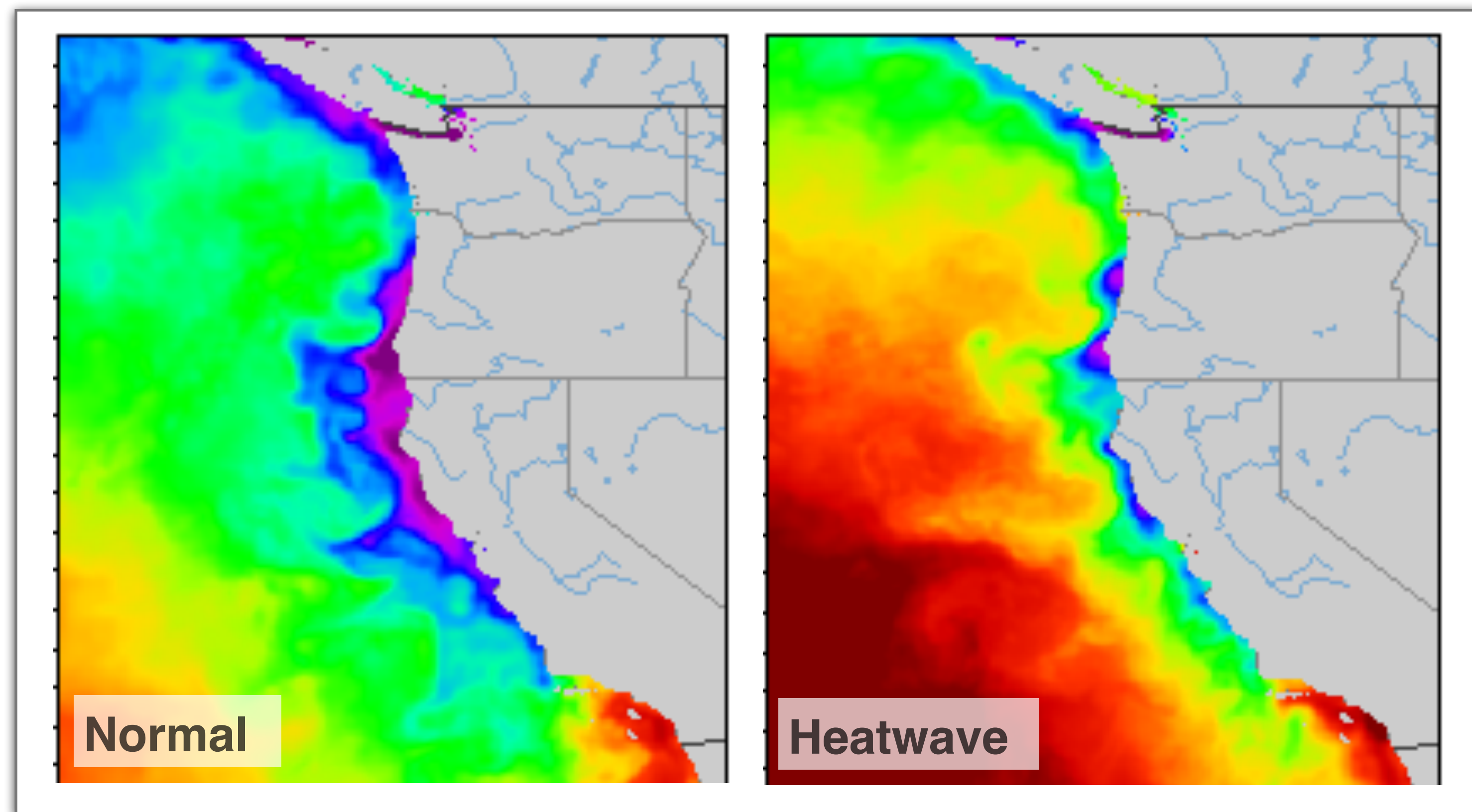
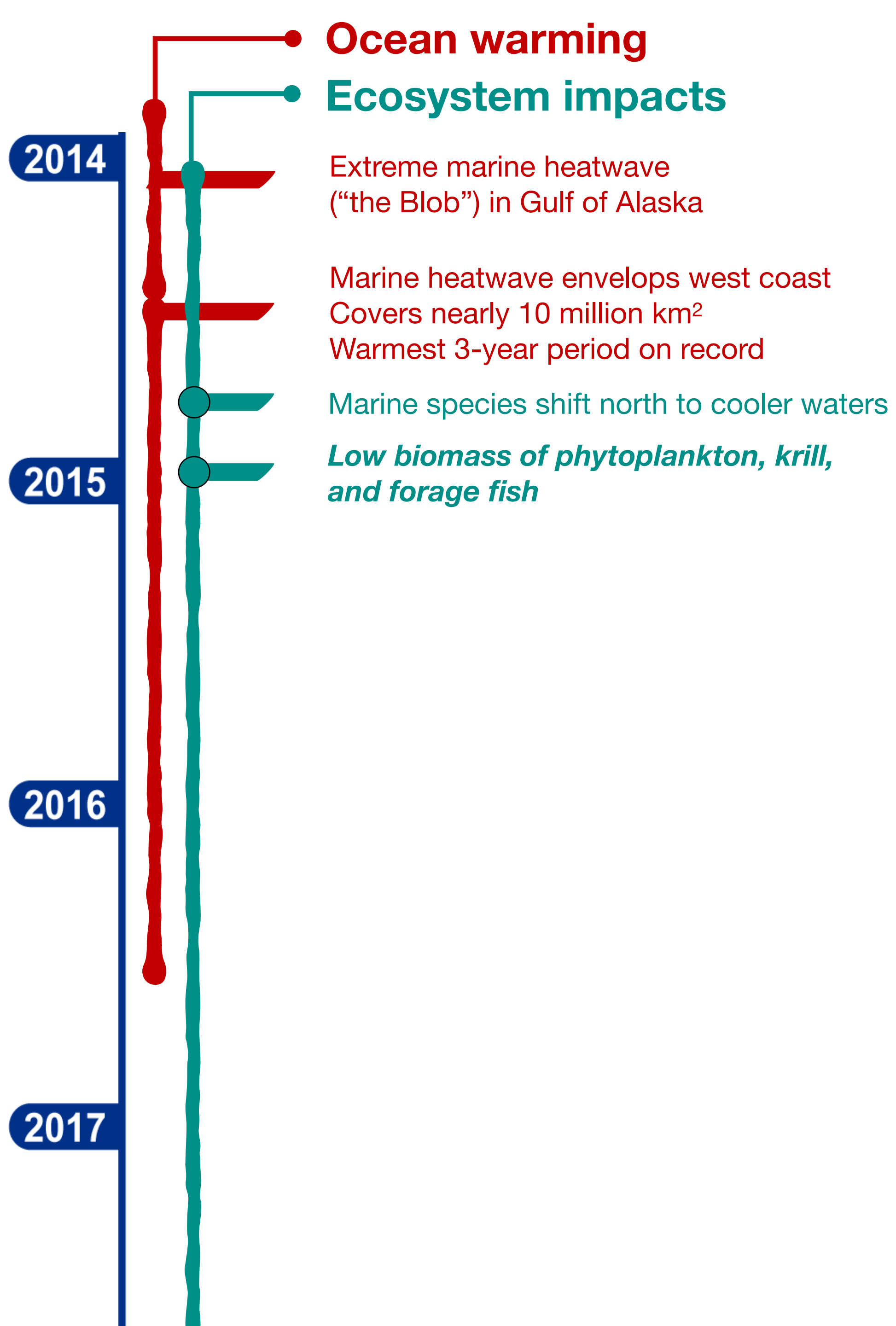


Ocean heat waves dramatically shift habitats

by NOAA Fisheries 14 Aug 2020 19:00 UTC



The range of smooth hammerhead sharks shifted north as much 2,800 kilometers, more than 1,700 miles, during a major marine heatwave that affected the northeast Pacific Ocean from 2013 into 2015. The heatwave was known as 'The Blob.' © Richard Herrmann / NOAA Fisheries



2014
2015
2016
2017

Ocean warming
Ecosystem impacts

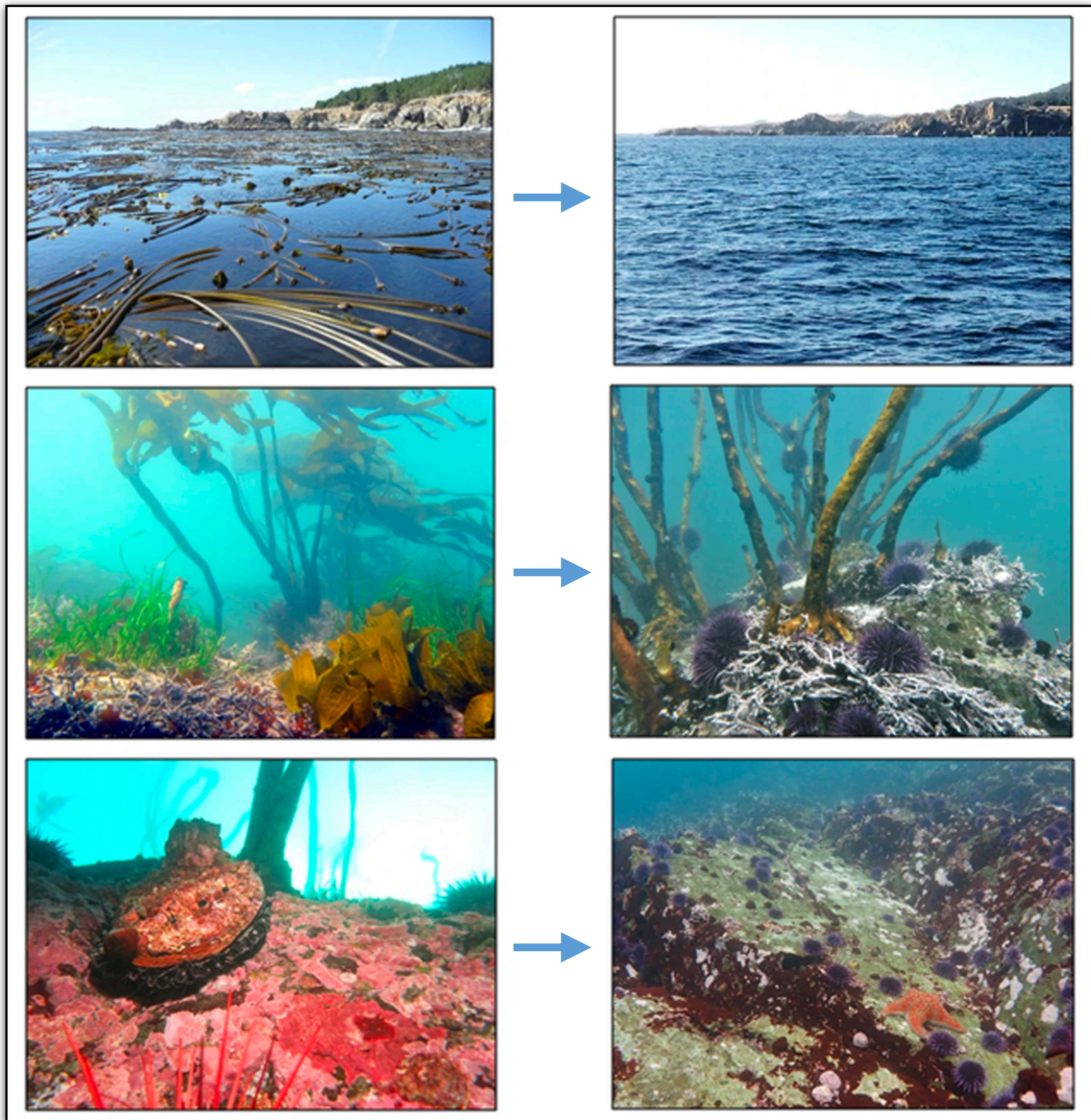
Extreme marine heatwave
("the Blob") in Gulf of Alaska

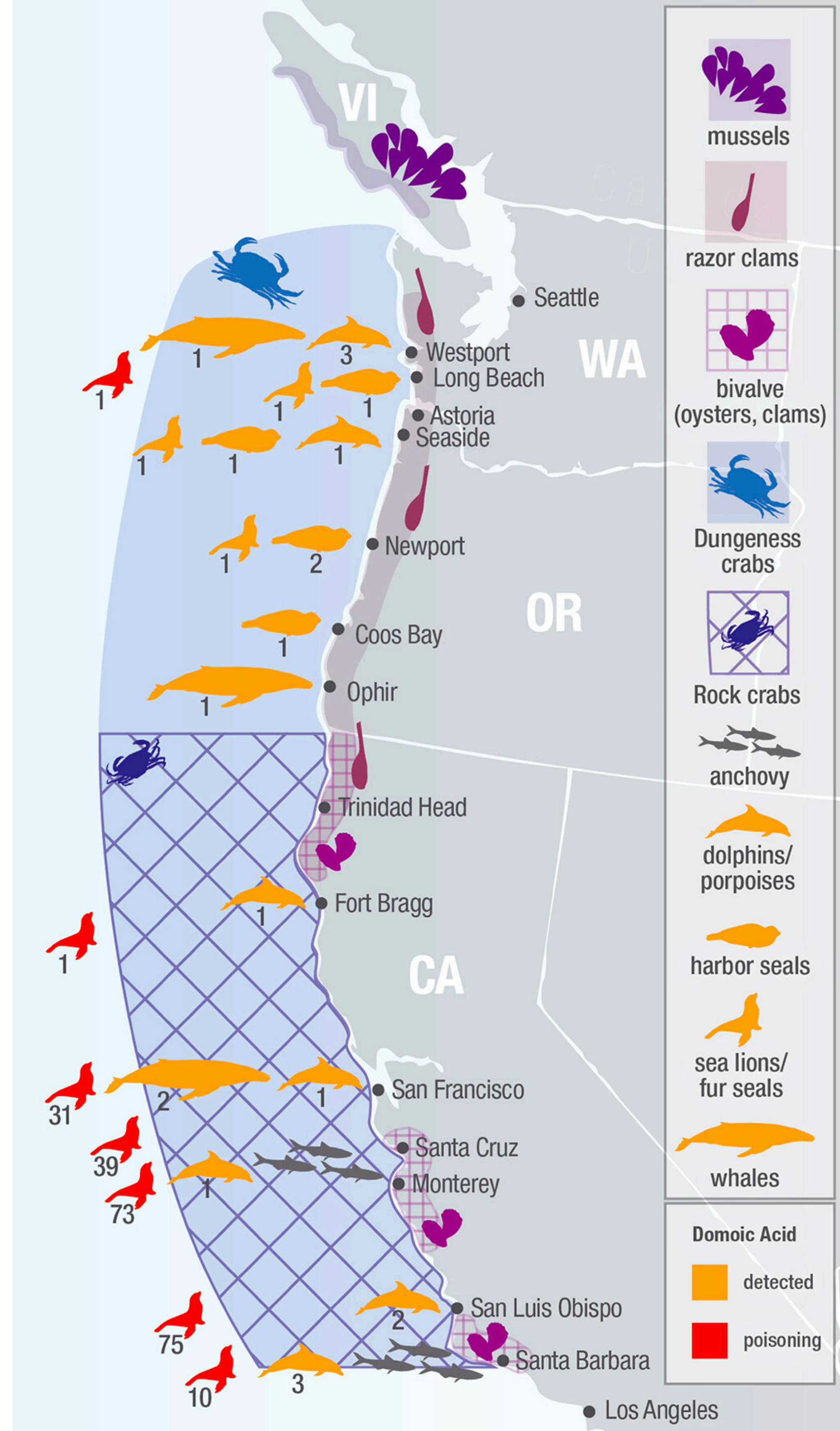
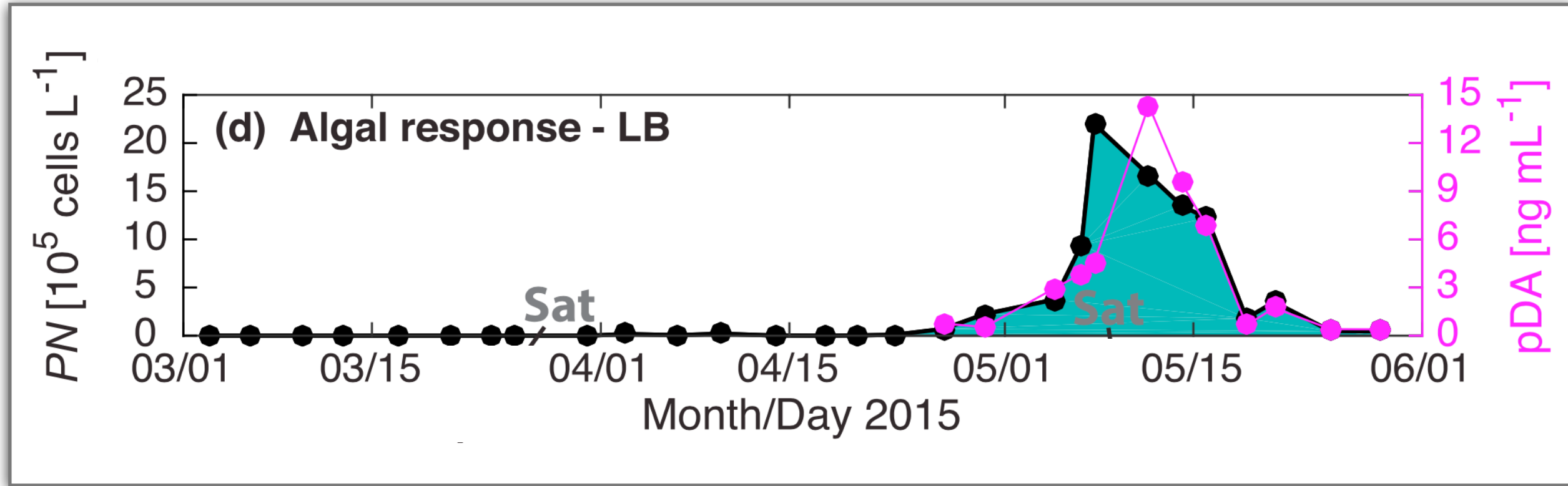
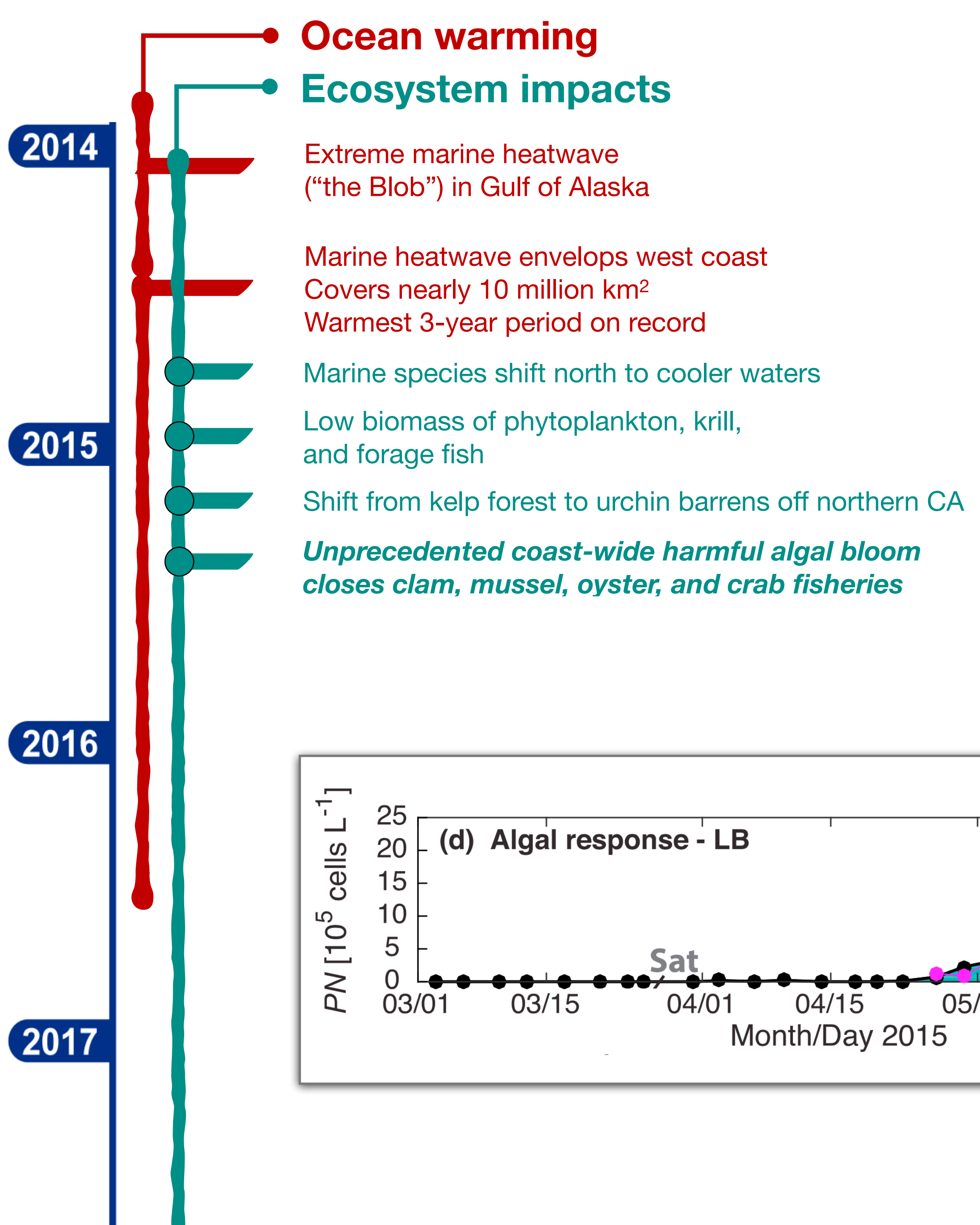
Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record

Marine species shift north to cooler waters

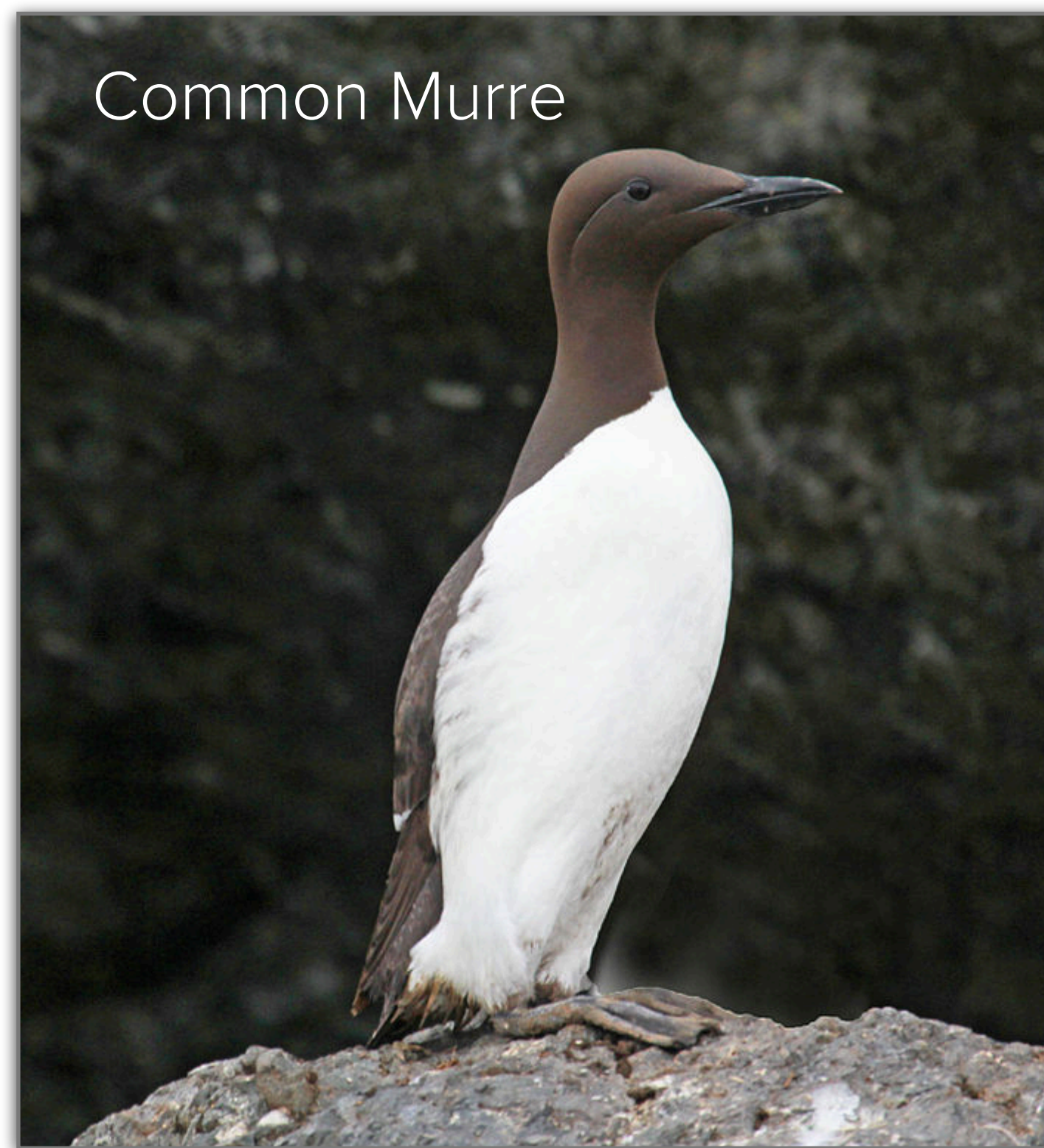
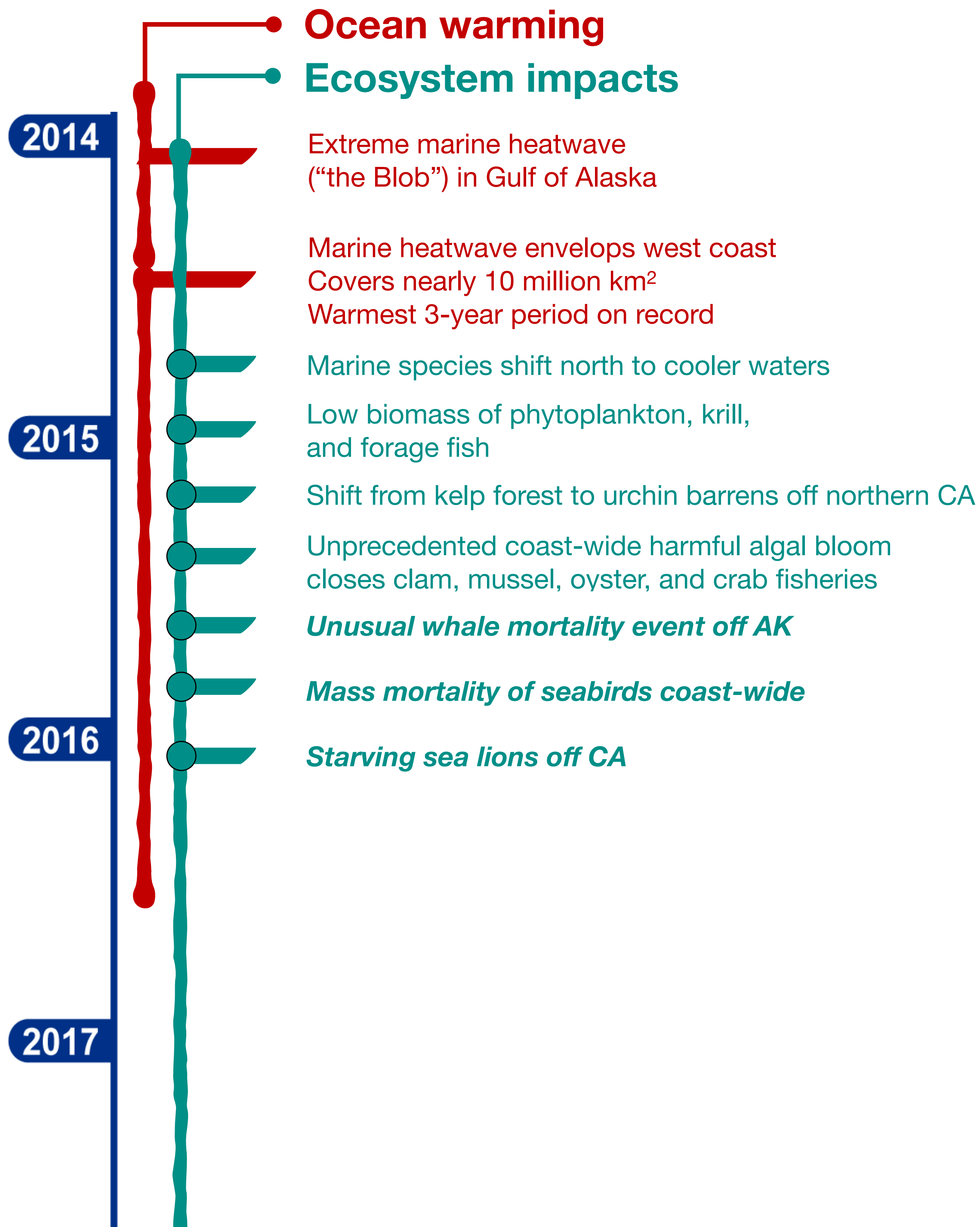
Low biomass of phytoplankton, krill,
and forage fish

Shift from kelp forest to urchin barrens off northern CA

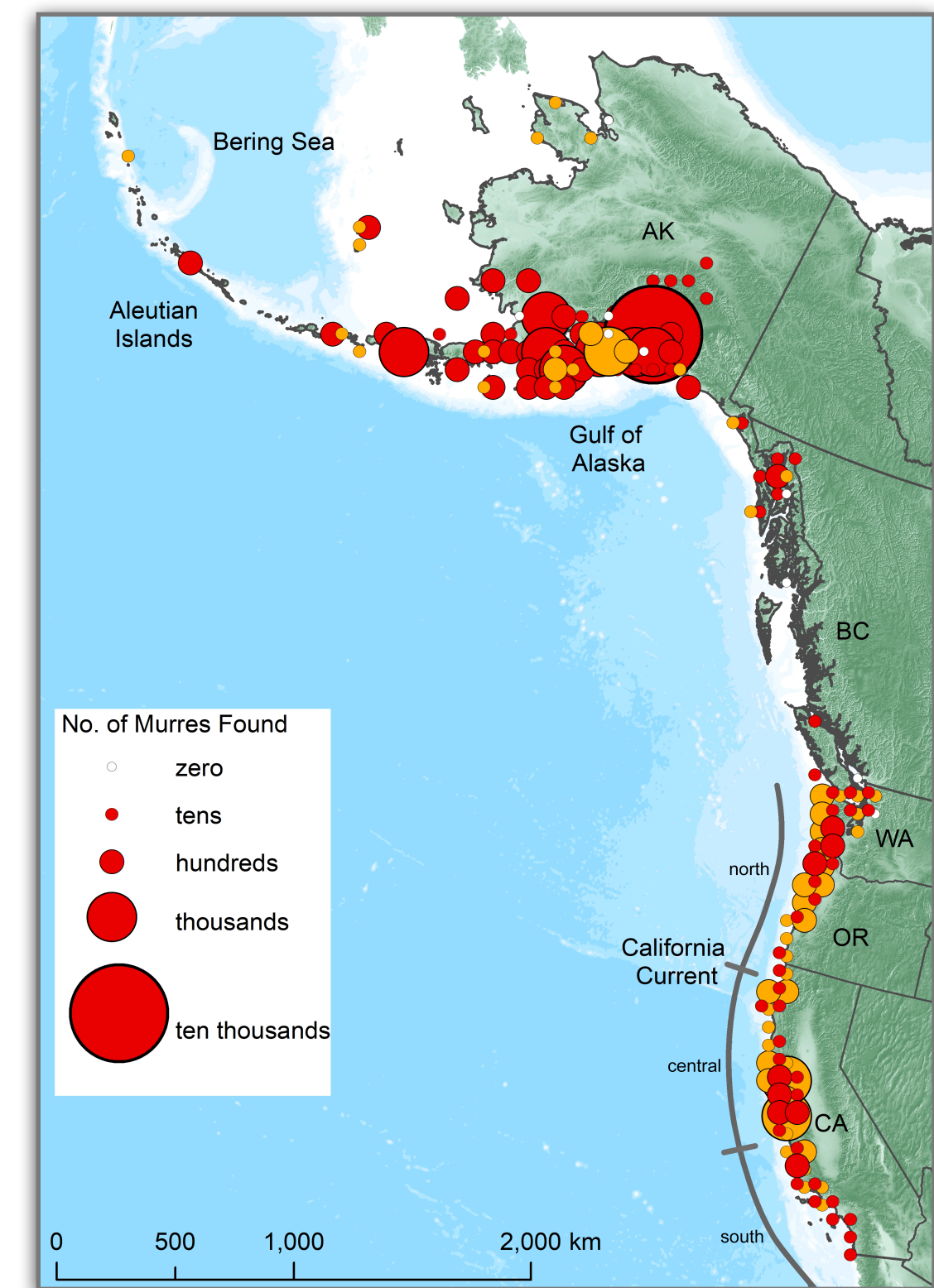




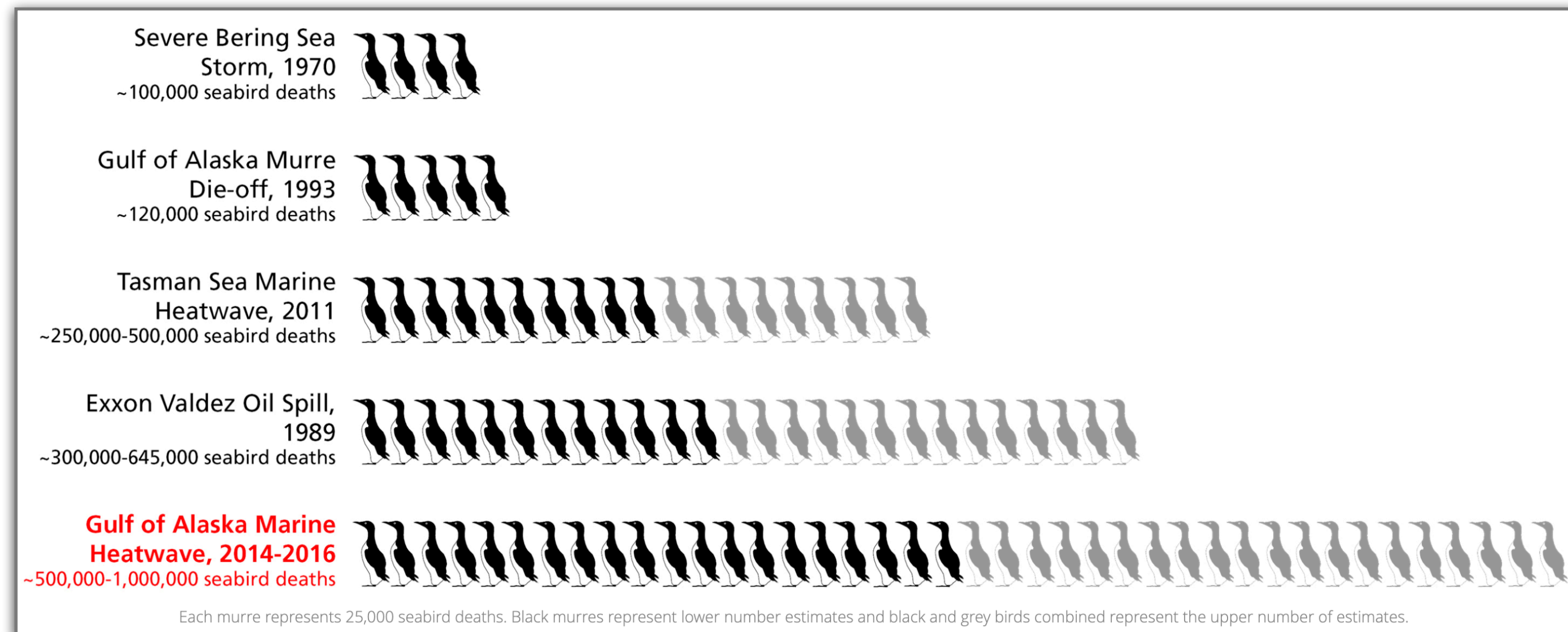
McCabe et al. (2016)



carolinabirds.org



Piatt et al. (2020)



Ocean warming

Ecosystem impacts

2014

Extreme marine heatwave
("the Blob") in Gulf of Alaska

Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record

Marine species shift north to cooler waters

2015

Low biomass of phytoplankton, krill,
and forage fish

Shift from kelp forest to urchin barrens off northern CA

Unprecedented coast-wide harmful algal bloom
closes clam, mussel, oyster, and crab fisheries

Unusual whale mortality event off AK

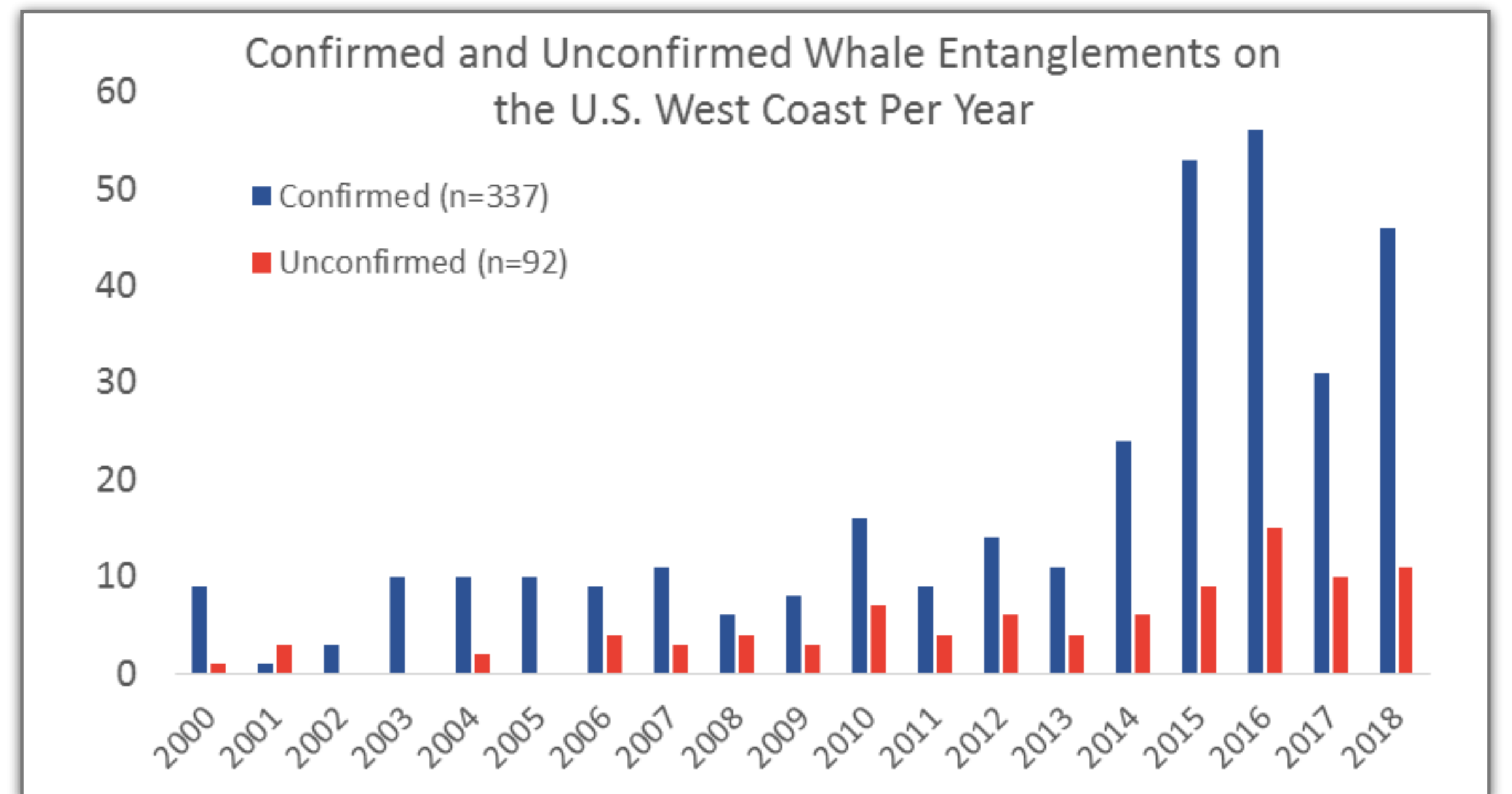
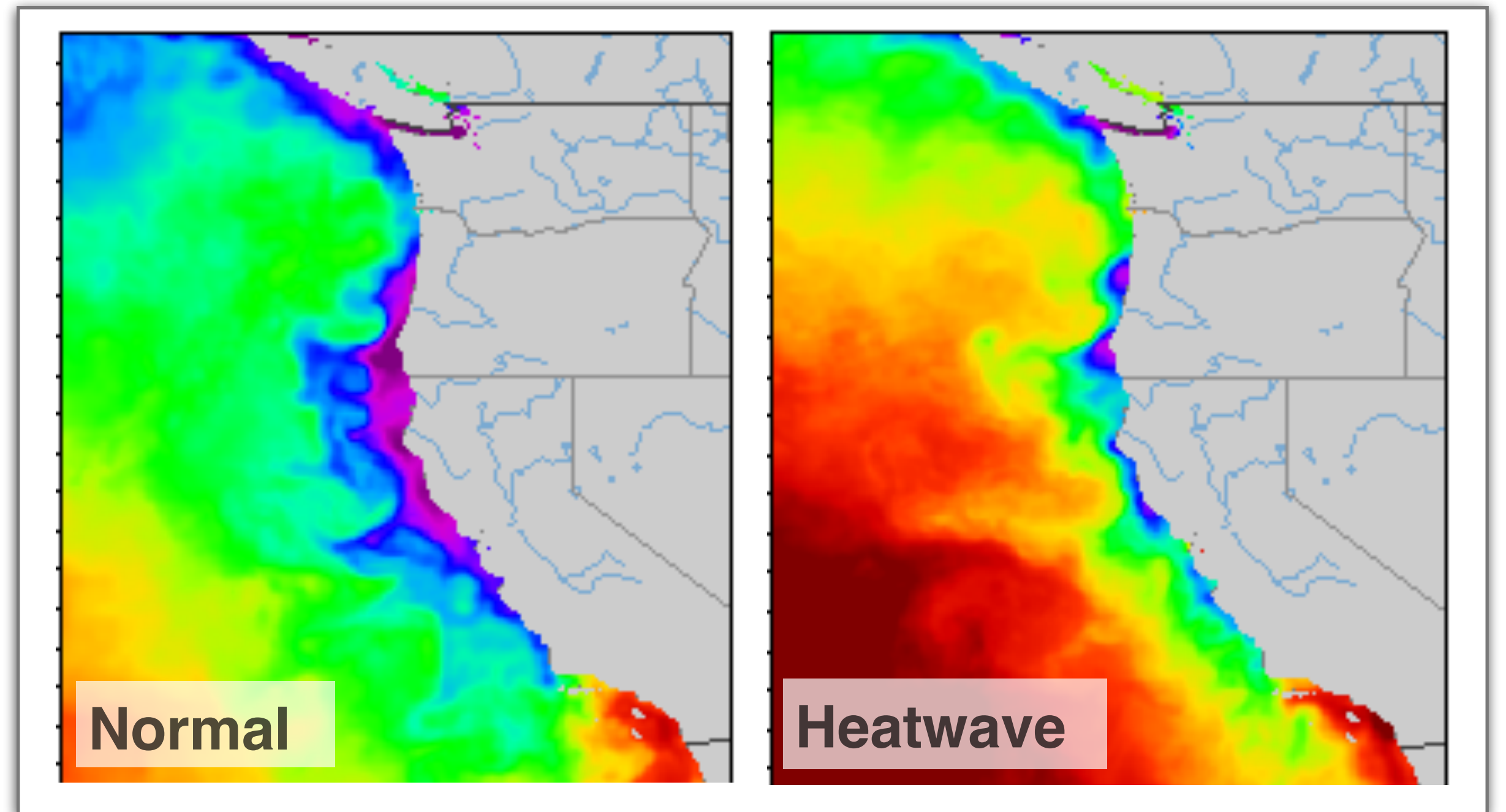
Mass mortality of seabirds coast-wide

2016

Starving sea lions off CA

**Record whale entanglements, exacerbated
by disrupted crab fishery timing in CA**

2017



See Santora et al. (2020)

Ocean warming

Ecosystem impacts

2014

Extreme marine heatwave
("the Blob") in Gulf of Alaska

Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record

Marine species shift north to cooler waters

2015

Low biomass of phytoplankton, krill,
and forage fish

Shift from kelp forest to urchin barrens off northern CA

Unprecedented coast-wide harmful algal bloom
closes clam, mussel, oyster, and crab fisheries

Unusual whale mortality event off AK

Mass mortality of seabirds coast-wide

2016

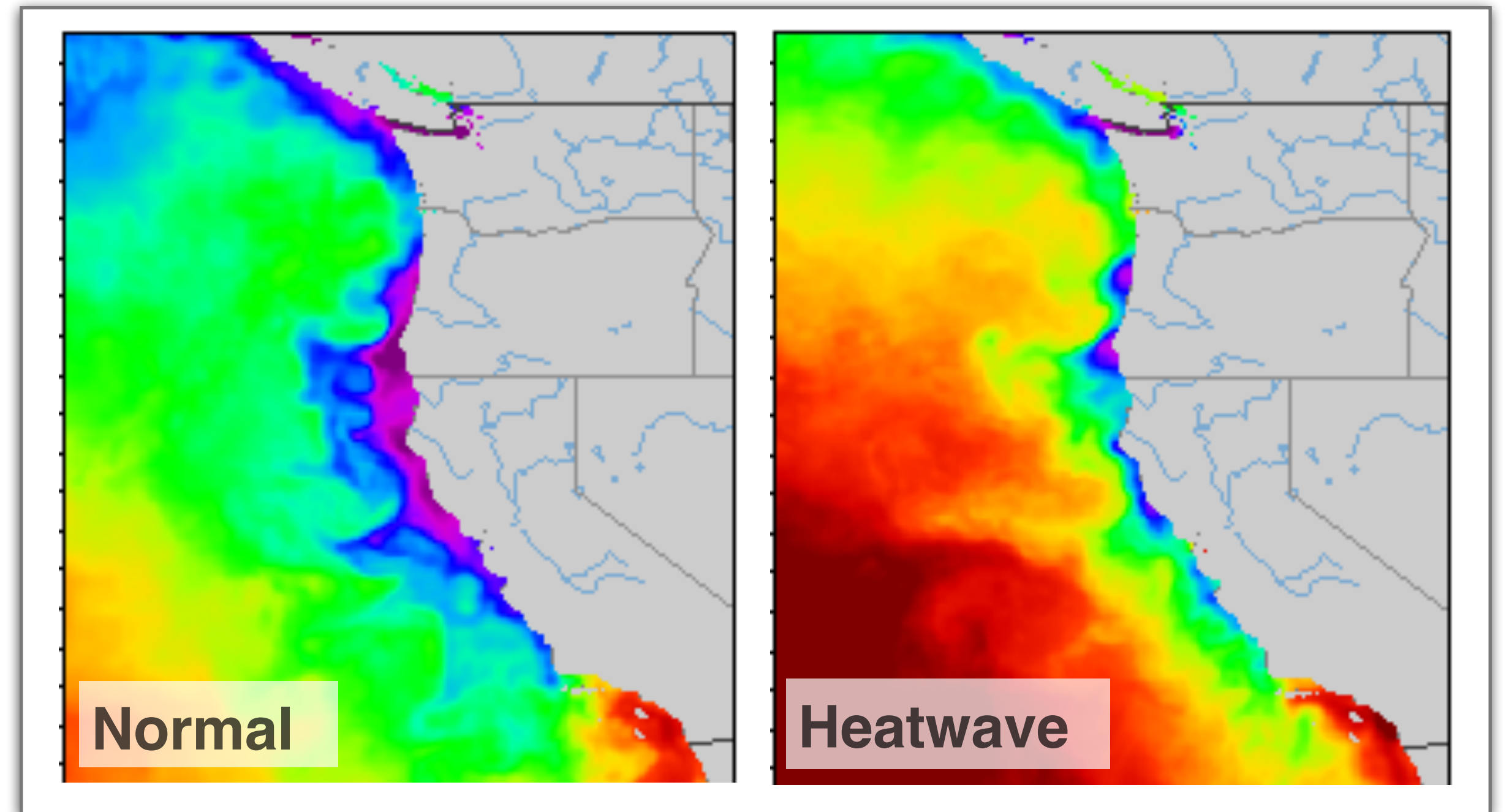
Starving sea lions off CA

Record whale entanglements, exacerbated by
disrupted crab fishery timing in CA

*Reduced salmon survival leads to
low returns in coastal states*

2017

Pacific cod declines in Gulf of Alaska



Fishery Disasters				
	AK	WA	OR	CA
Salmon				
Crab				
Cod				
Sardine				

Ocean warming

Ecosystem impacts

2014

Extreme marine heatwave
("the Blob") in Gulf of Alaska

Marine heatwave envelops west coast
Covers nearly 10 million km²
Warmest 3-year period on record

2015

Marine species shift north to cooler waters

Low biomass of phytoplankton, krill,
and forage fish

Shift from kelp forest to urchin barrens off northern CA

Unprecedented coast-wide harmful algal bloom
closes clam, mussel, oyster, and crab fisheries

Unusual whale mortality event off AK

Mass mortality of seabirds coast-wide

2016

Starving sea lions off CA

Record whale entanglements, exacerbated by
disrupted crab fishery timing in CA

Reduced salmon survival leads to
low returns in coastal states

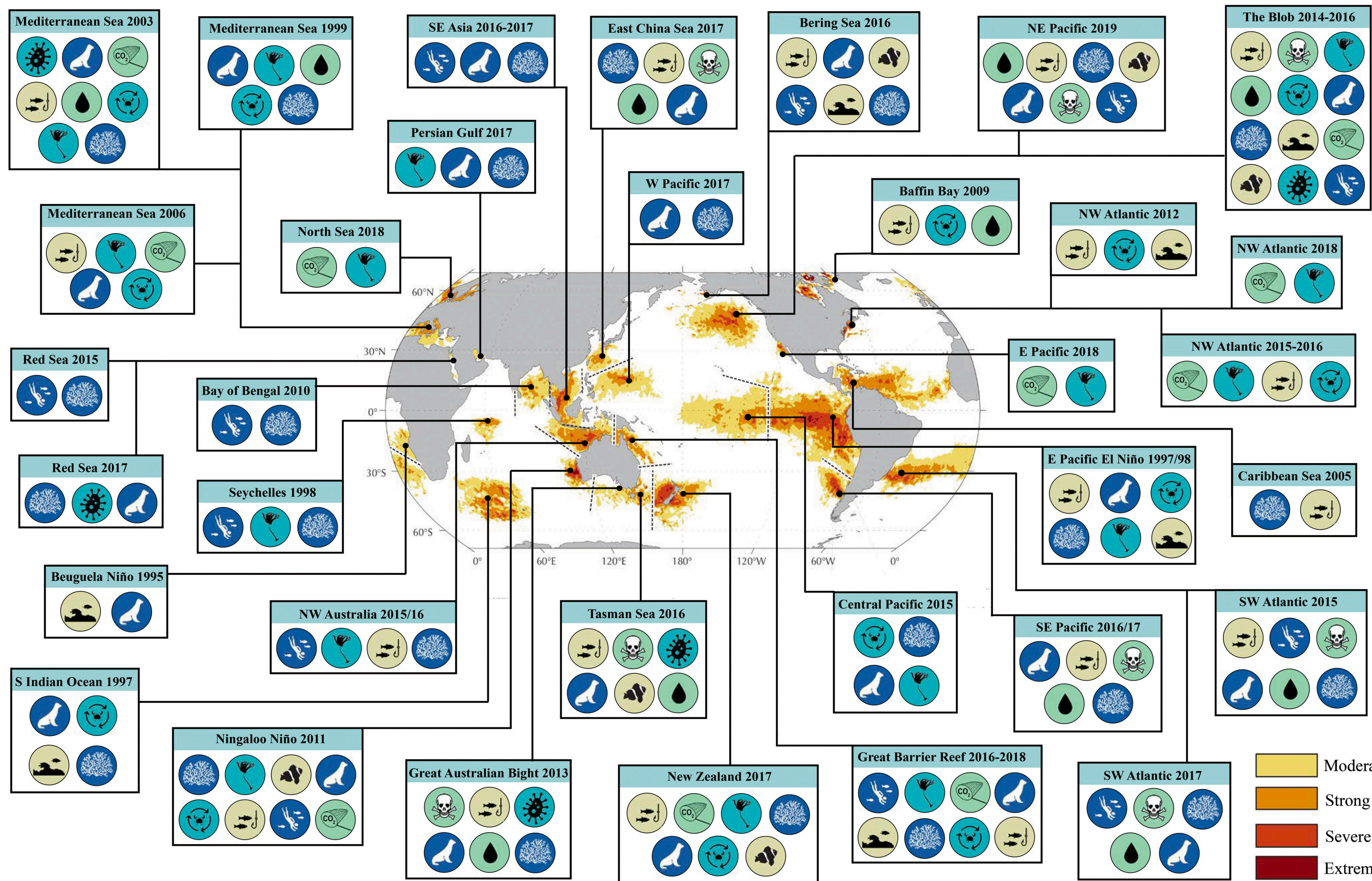
2017

Pacific cod declines in Gulf of Alaska

Anchovy population boom off OR & CA

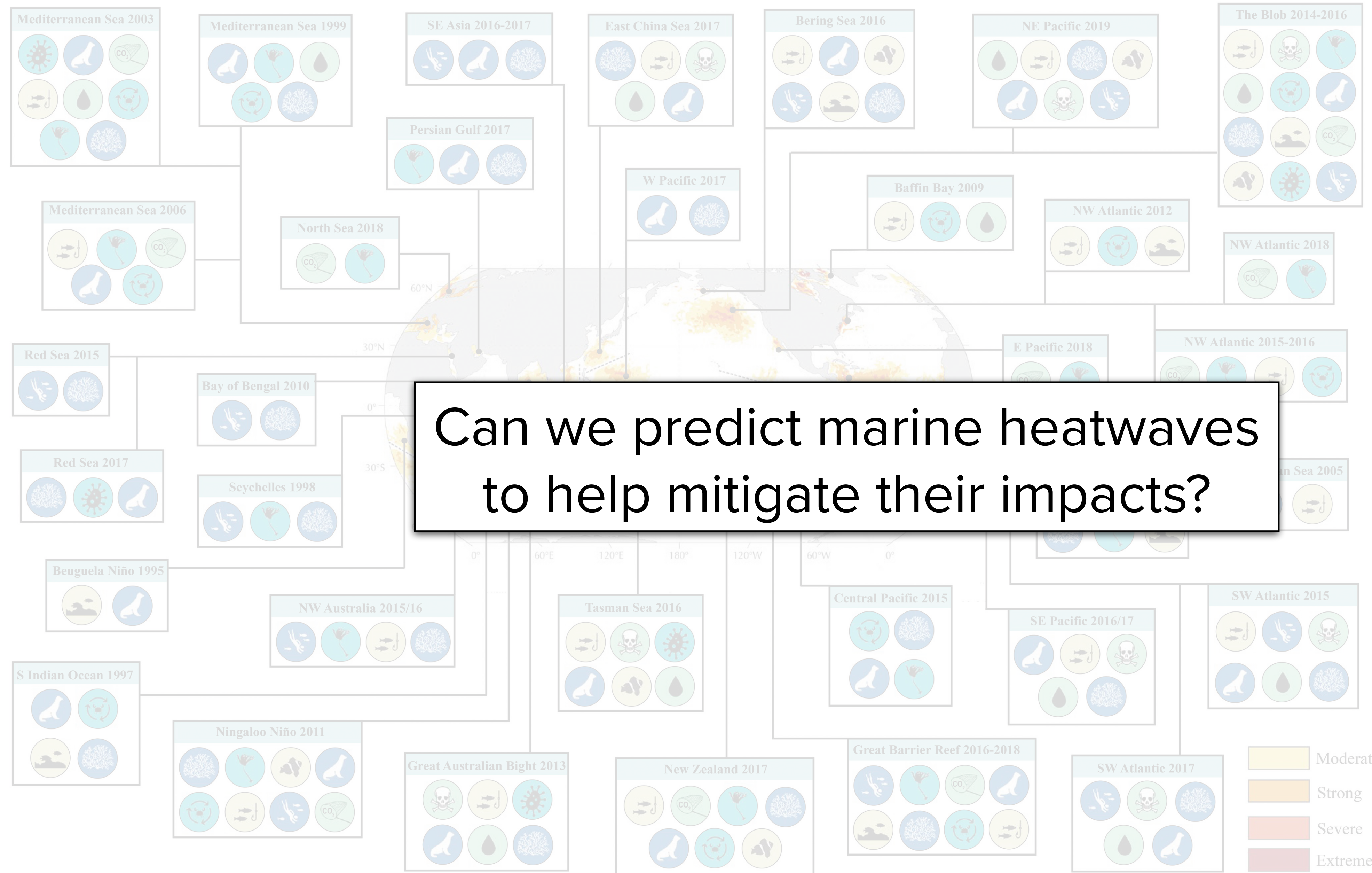


<https://www.cnn.com/2014/07/10/us/la-jolla-anchovies>



Legend for Impact Types:

- Aquaculture / fisheries impacts
- Range shift
- Tropicalization of species
- Harmful Algal Blooms
- Water quality impact
- Carbon capture impact
- Restructuring of ecosystems
- Life history impact
- Disease
- Tourism and recreation
- Mass mortalities
- Spiritual / aesthetic appreciation



Can we predict marine heatwaves to help mitigate their impacts?

This legend lists various impacts of marine heatwaves, each associated with a circular icon:

- Aquaculture / fisheries impacts (Icon: Fish and hook)
- Range shift (Icon: Fish and arrow)
- Tropicalization of species (Icon: Fish and globe)
- Harmful Algal Blooms (Icon: Skull and crossbones)
- Water quality impact (Icon: Water drop)
- Carbon capture impact (Icon: CO2)
- Restructuring of ecosystems (Icon: Fish and circular arrows)
- Life history impact (Icon: Fish and circular arrows)
- Disease (Icon: Sun with rays)
- Tourism and recreation (Icon: Hand and fish)
- Mass mortalities (Icon: Dog)
- Spiritual / aesthetic appreciation (Icon: Fish)

Latest Forecast Report (New!)

How to use this forecast tool?

Initial year

Initial month

Remove long-term temperature trends?

2023

x

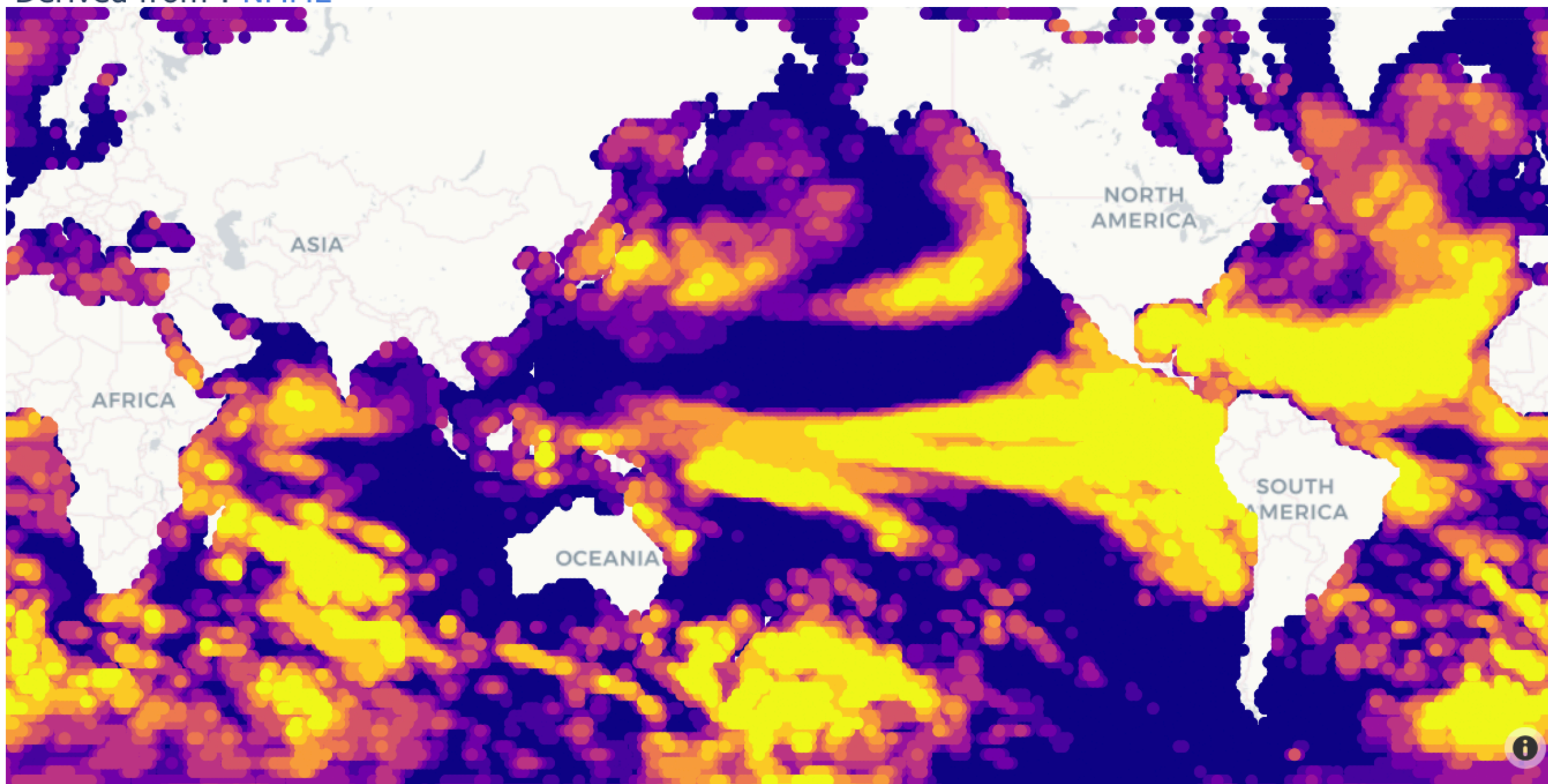
Aug

x

No Yes

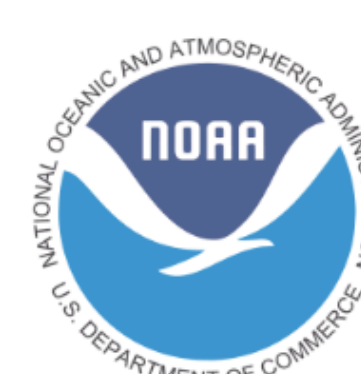
Marine Heatwave (MHW) Forecast [Jacox et al., 2022]

Derived from : NMME



MHW probability

- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%



Current forecast for this month (August 2023)

Lead time = 0.5 months (08/2023)



Marine heatwave forecasts issued monthly by NOAA

Built on output from climate models in the North American Multi-model Ensemble

Uses an ensemble of >70 forecasts from six global climate models

Predictions up to one year ahead

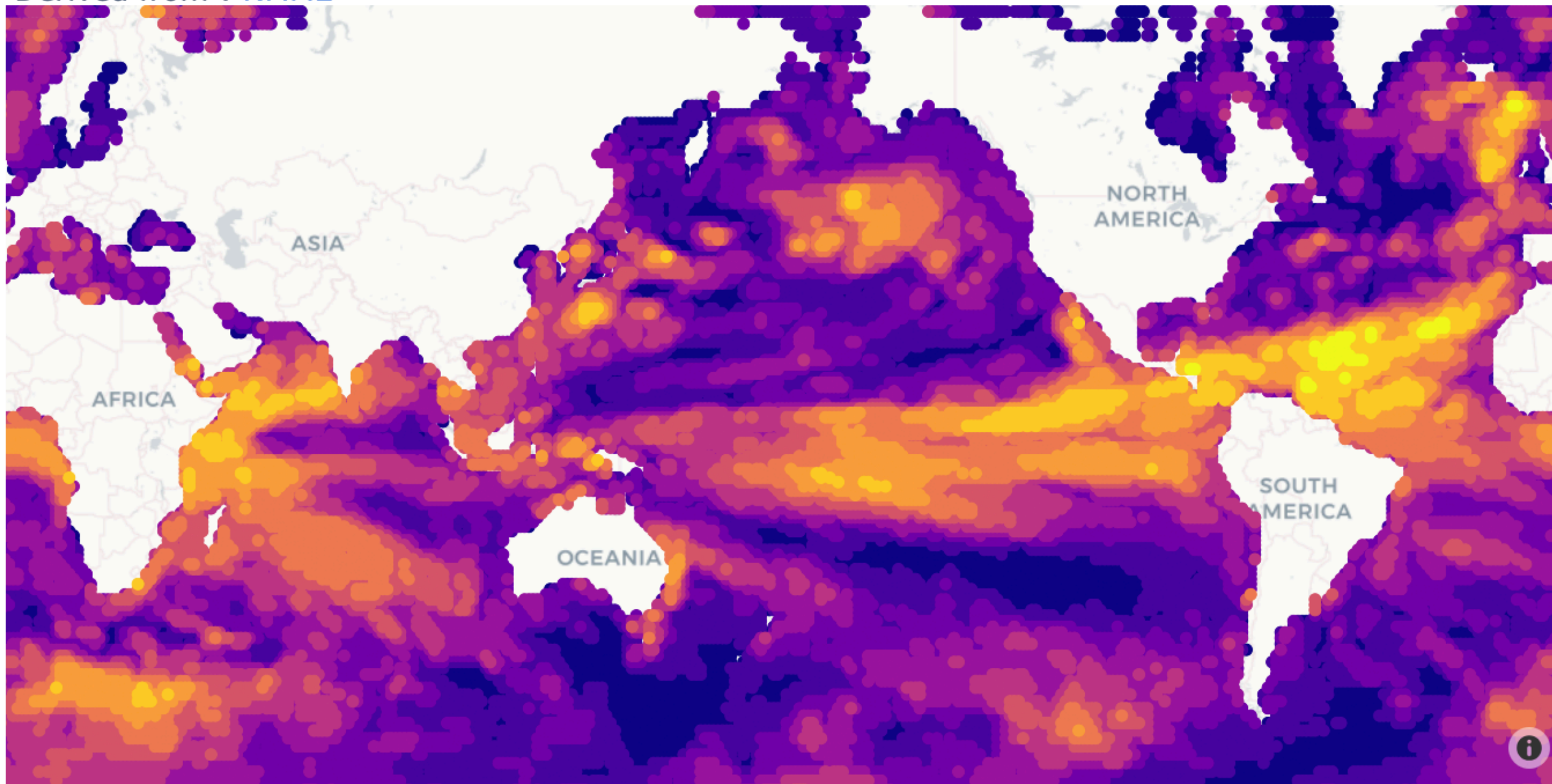
Current and past forecasts online

Latest Forecast Report (New!)

How to use this forecast tool?

Initial year: 2023 x Initial month: Aug x Remove long-term temperature trends? No Yes

Marine Heatwave (MHW) Forecast [Jacox et al., 2022] Derived from : NMME



- MHW probability
- 0-10%
 - 10-20%
 - 20-30%
 - 30-40%
 - 40-50%
 - 50-60%
 - 60-70%
 - 70-80%
 - 80-90%
 - 90-100%



Lead time = 6.5 months (02/2024)



Marine heatwave forecasts issued monthly by NOAA

Built on output from climate models in the North American Multi-model Ensemble

Uses an ensemble of >70 forecasts from six global climate models

Predictions up to one year ahead

Current and past forecasts online

Current forecast for 6 months from now (February 2024)

Marine Heatwave Forecast Monthly Report

Marine heatwave forecasts are experimental and intended for research purposes

[Back to the Interactive Forecasts](#)

Forecast initial time **July 2023**

Forecast period **July 2023 - June 2024**

Global Marine Heatwave Forecast Discussion

Observed and forecasted values include the effects of long-term warming. Values with the long-term warming trend removed are in brackets.

Current marine heatwave conditions:

Approximately 44% [25%] of the global ocean is currently experiencing MHWs, which ranks 1st [13th] among all months since 1991.

Widespread marine heatwaves (MHW) are currently found in the eastern equatorial Pacific, the Northeast Pacific, the Northwest Pacific and the Sea of Japan, the tropical North Atlantic, the Caribbean Sea, the Gulf of Mexico, the Northeast Atlantic from northern Africa to Norway, the Southwest Pacific near New Zealand, and the Southern Indian Ocean, and all sectors (Indian, Pacific, Atlantic) of the Southern Ocean.

Marine heatwave forecasts:

Forecasts predict that MHW coverage will increase to approximately 50% [25%] of the global oceans in September-October 2023. Below is a regionally refined focus:

- **Eastern Tropical Pacific** - MHW conditions are forecasted to persist through the end of the year (70-90% [50-80%] chance; high confidence), with the intensity of the anomalies also forecasted to grow as El Niño continues to develop.
- **North Pacific** - MHW conditions in the central North Pacific offshore are forecasted to persist through the end of the year in the central North Pacific (50-80% [40-60%] chance; low confidence) and the Northwest Pacific off Japan (50-80% [20-50%] chance; low confidence). Forecasts also show elevated risk of MHW conditions along the U.S. west coast and Gulf of Alaska in boreal spring 2024 (30-50% [20-30%] chance; medium confidence).
- **Southwest Pacific** - MHW conditions are forecasted to persist off the southeast coast of New Zealand through October 2023 (60-90% [20-40%] chance; medium confidence) with MHW likelihood falling by the end of the year.

Marine heatwave forecasts issued monthly by NOAA

Built on output from climate models in the North American Multi-model Ensemble

Uses an ensemble of >70 forecasts from six global climate models

Predictions up to one year ahead

Current and past forecasts online

How good are the forecasts?



Marine Heatwave Forecast Monthly Report

Marine heatwave forecasts are experimental and intended for research purposes

[Back to the Interactive Forecasts](#)

Forecast initial time **July 2023**

Forecast period **July 2023 - June 2024**

Global Marine Heatwave Forecast Discussion

Observed and forecasted values include the effects of long-term warming. Values with the long-term warming trend removed are in brackets.

Current marine heatwave conditions:

Approximately 44% [25%] of the global ocean is currently experiencing MHWs, which ranks 1st [13th] among all months since 1991.

Widespread marine heatwaves (MHW) are currently found in the eastern equatorial Pacific, the Northeast Pacific, the Northwest Pacific and the Sea of Japan, the tropical North Atlantic, the Caribbean Sea, the Gulf of Mexico, the Northeast Atlantic from northern Africa to Norway, the Southwest Pacific near New Zealand, and the Southern Indian Ocean, and all sectors (Indian, Pacific, Atlantic) of the Southern Ocean.

Marine heatwave forecasts:

Forecasts predict that MHW coverage will increase to approximately 50% [25%] of the global oceans in September-October 2023. Below is a regionally refined focus:

- **Eastern Tropical Pacific** - MHW conditions are forecasted to persist through the end of the year (70-90% [50-80%] chance; high confidence), with the intensity of the anomalies also forecasted to grow as El Niño continues to develop.
- **North Pacific** - MHW conditions in the central North Pacific offshore are forecasted to persist through the end of the year in the central North Pacific (50-80% [40-60%] chance; low confidence) and the Northwest Pacific off Japan (50-80% [20-50%] chance; low confidence). Forecasts also show elevated risk of MHW conditions along the U.S. west coast and Gulf of Alaska in boreal spring 2024 (30-50% [20-30%] chance; medium confidence).
- **Southwest Pacific** - MHW conditions are forecasted to persist off the southeast coast of New Zealand through October 2023 (60-90% [20-40%] chance; medium confidence) with MHW likelihood falling by the end of the year.

Marine heatwave forecasts issued monthly by NOAA

Built on output from climate models in the North American Multi-model Ensemble

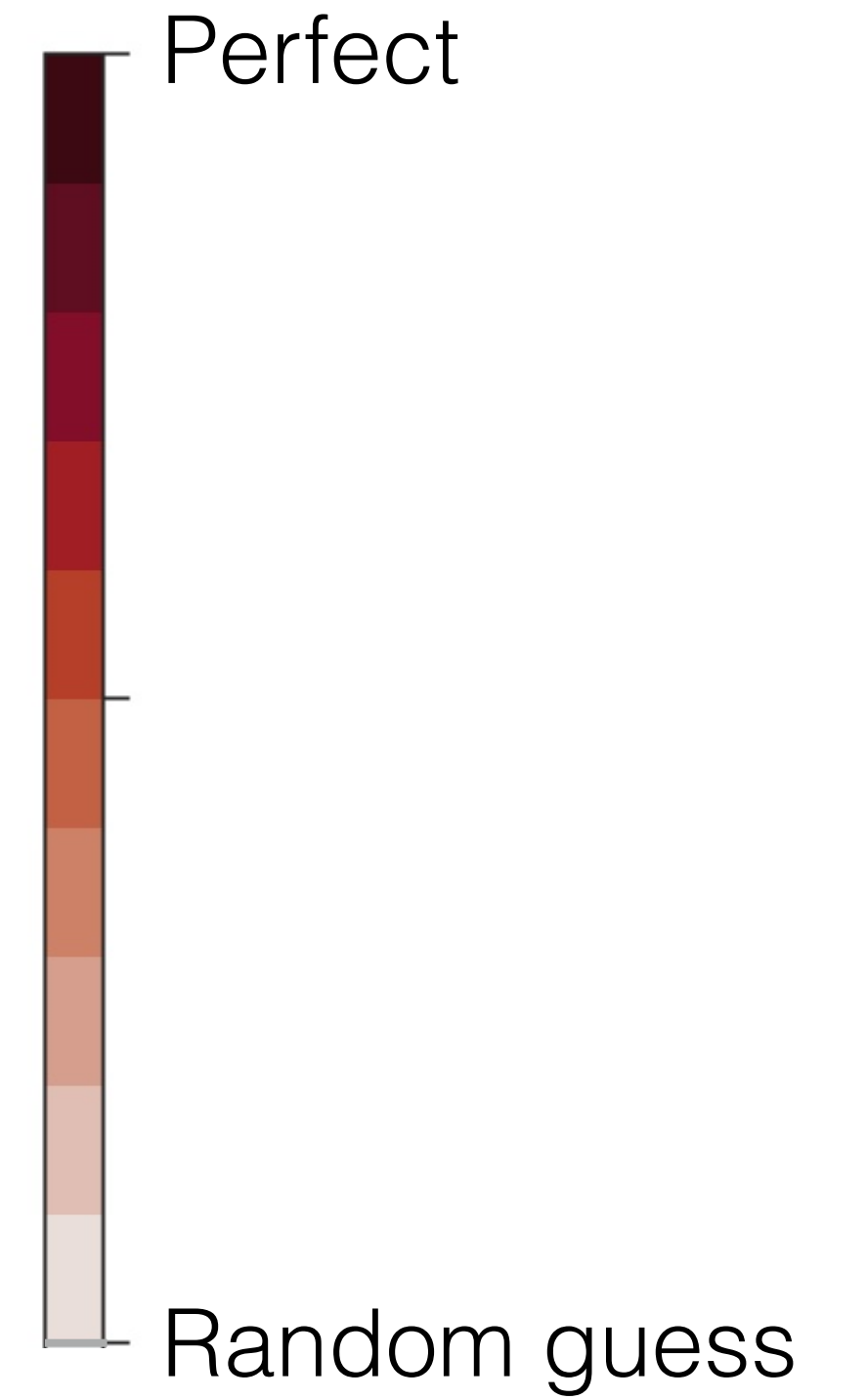
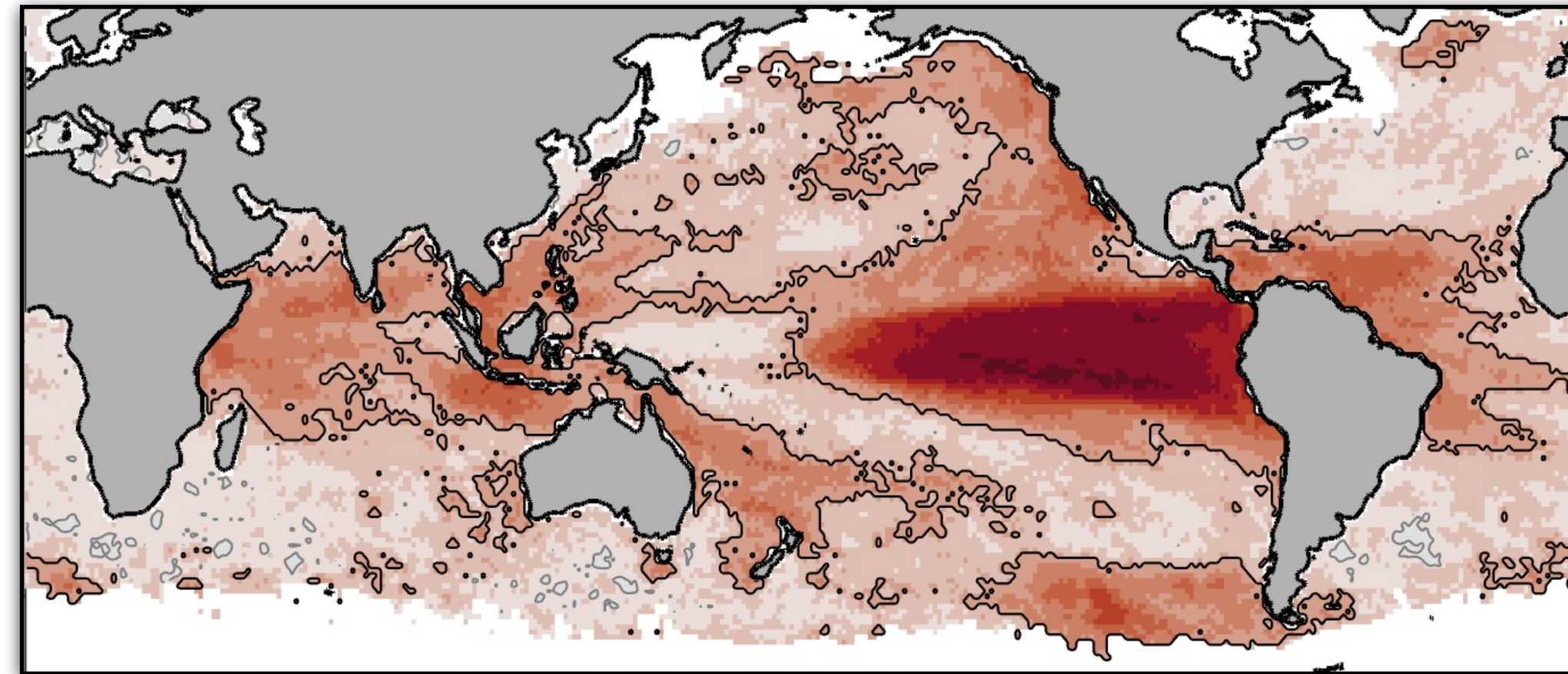
Uses an ensemble of >70 forecasts from six global climate models

Predictions up to one year ahead

Current and past forecasts online

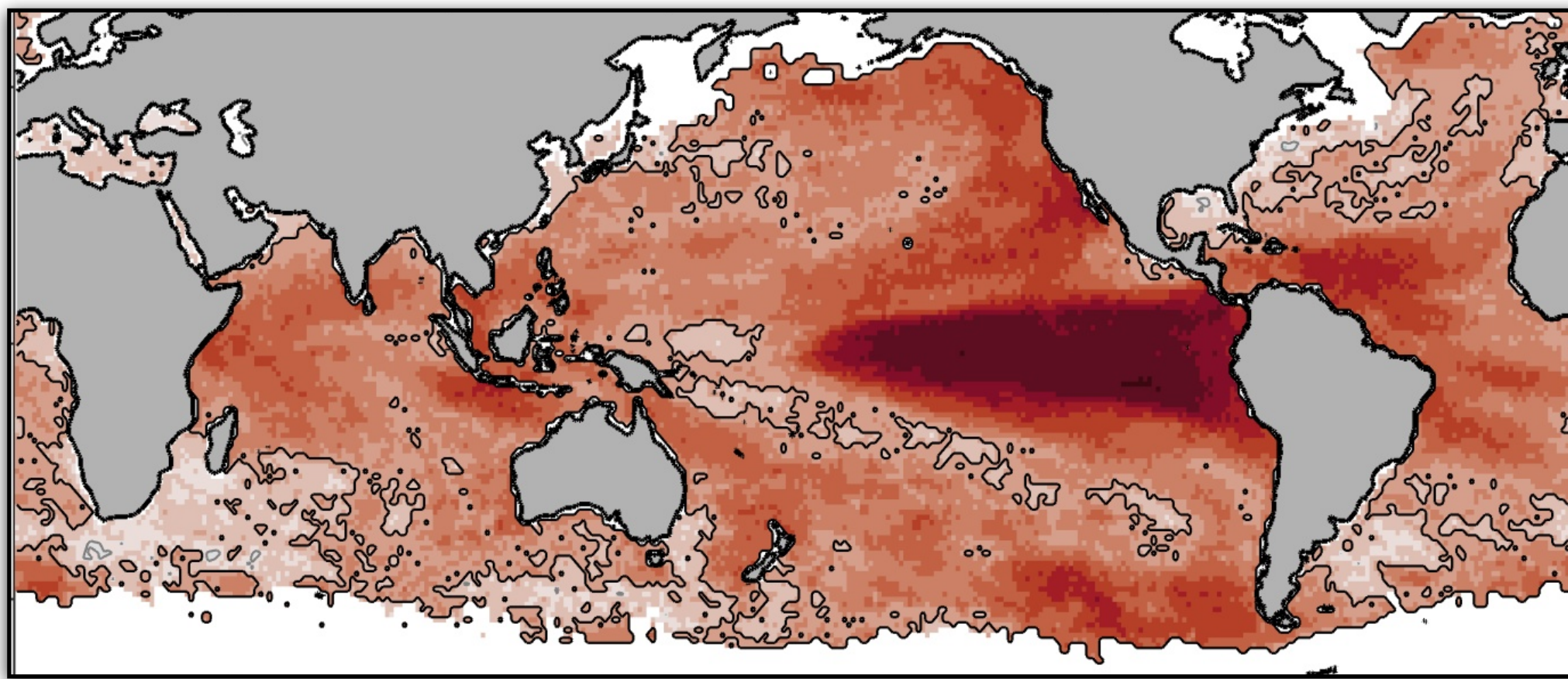
How good are the forecasts?

3 months ahead

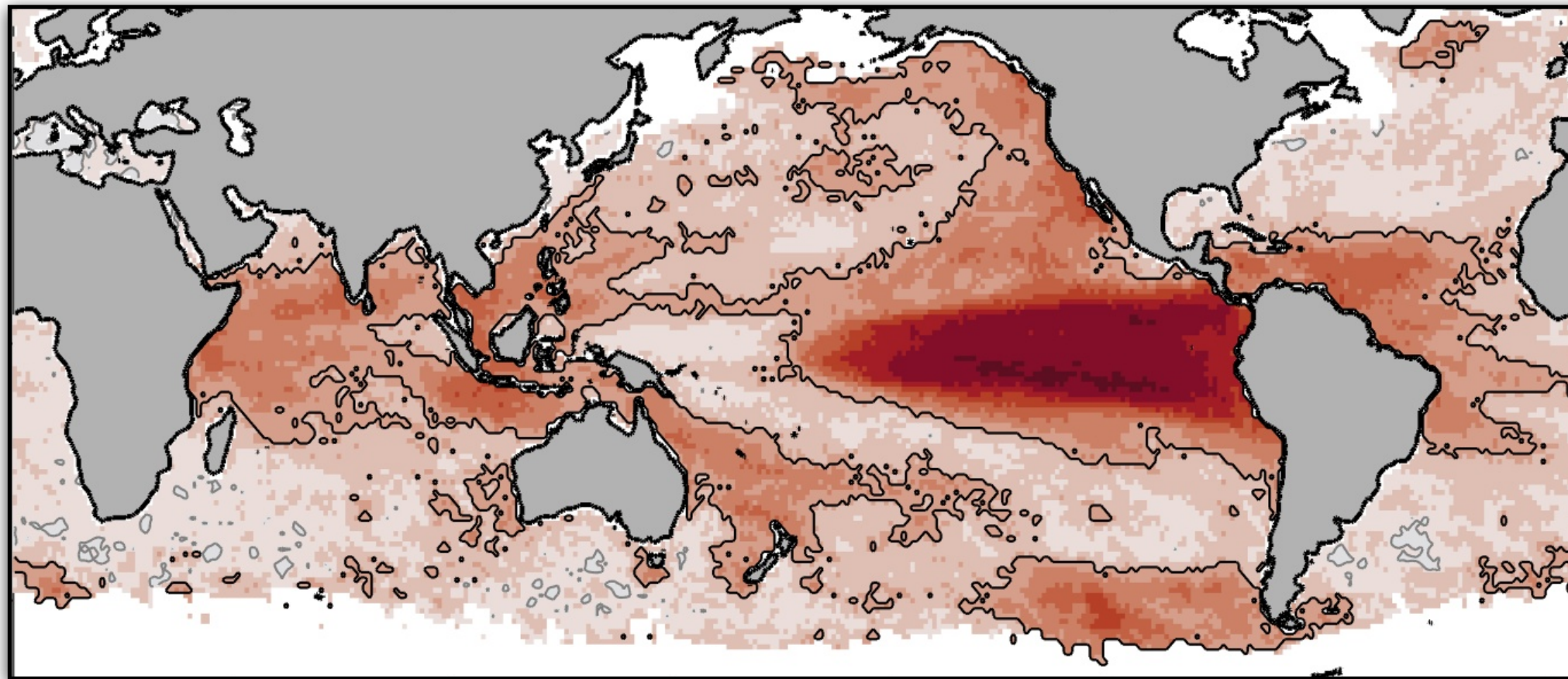


How good are the forecasts?

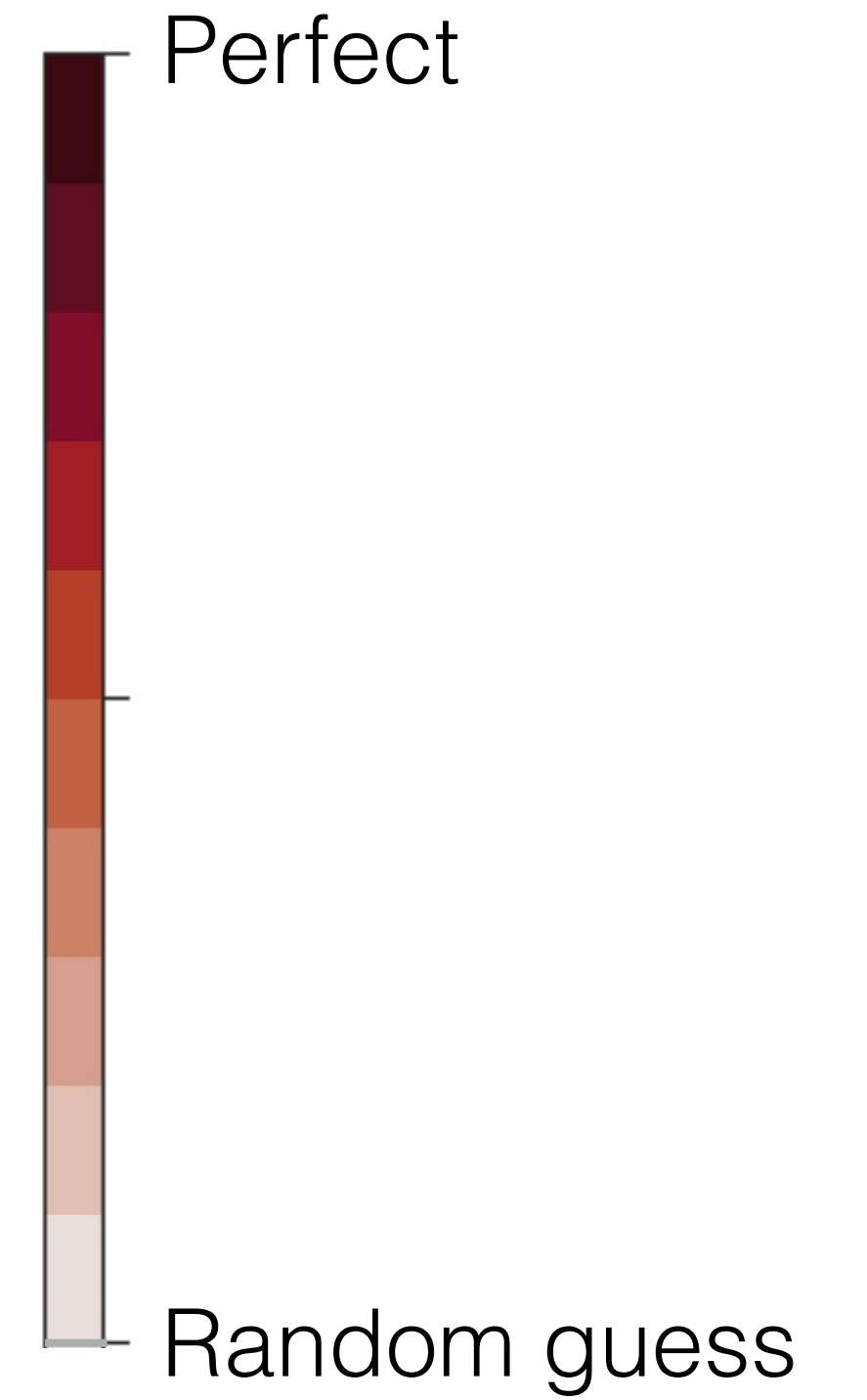
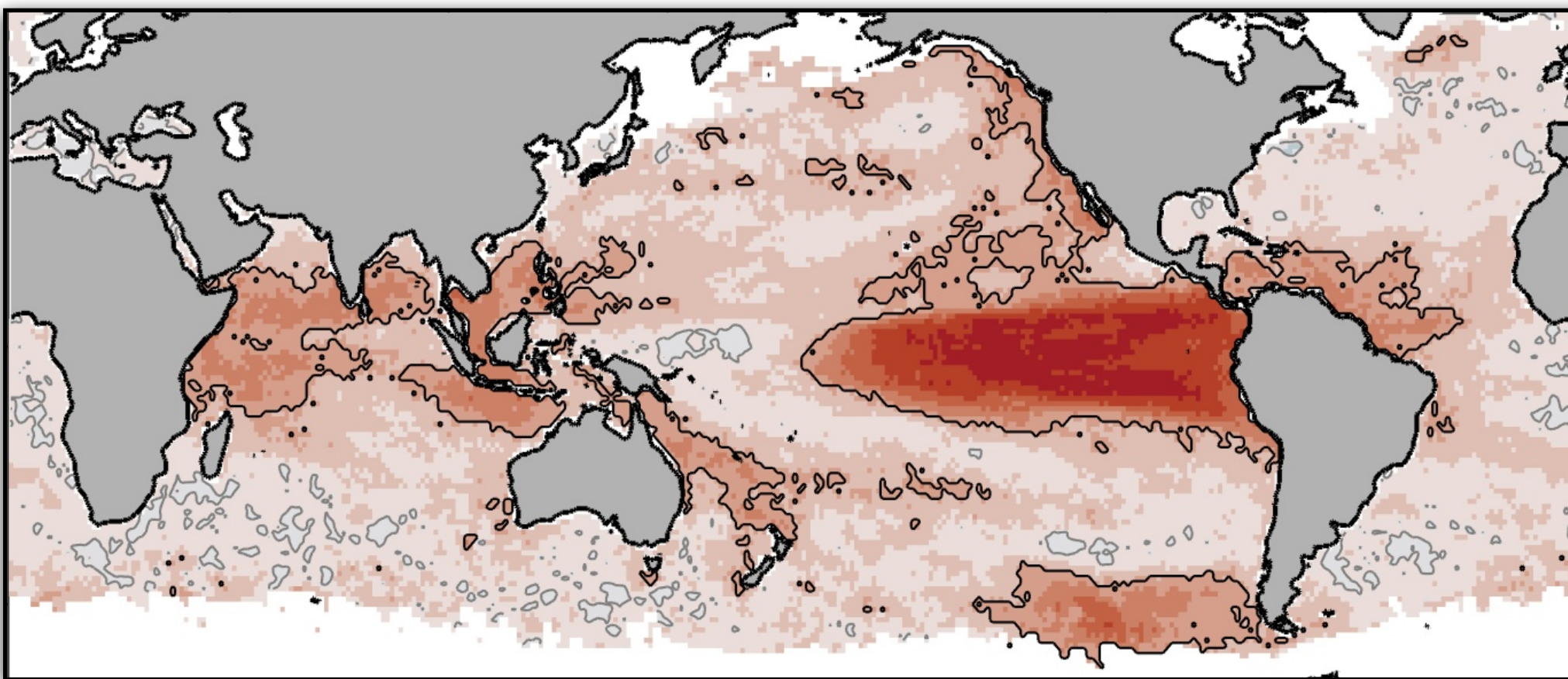
1 month ahead



3 months ahead

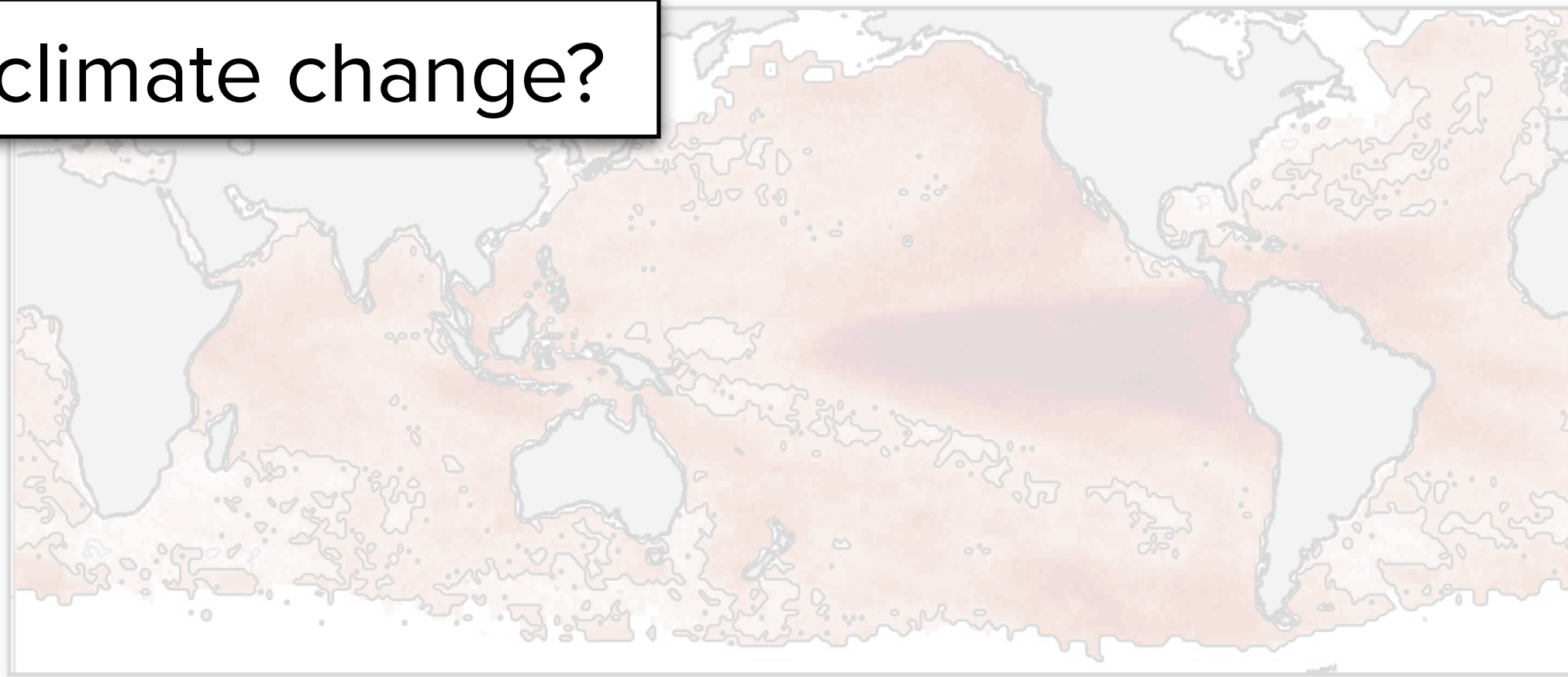


6 months ahead

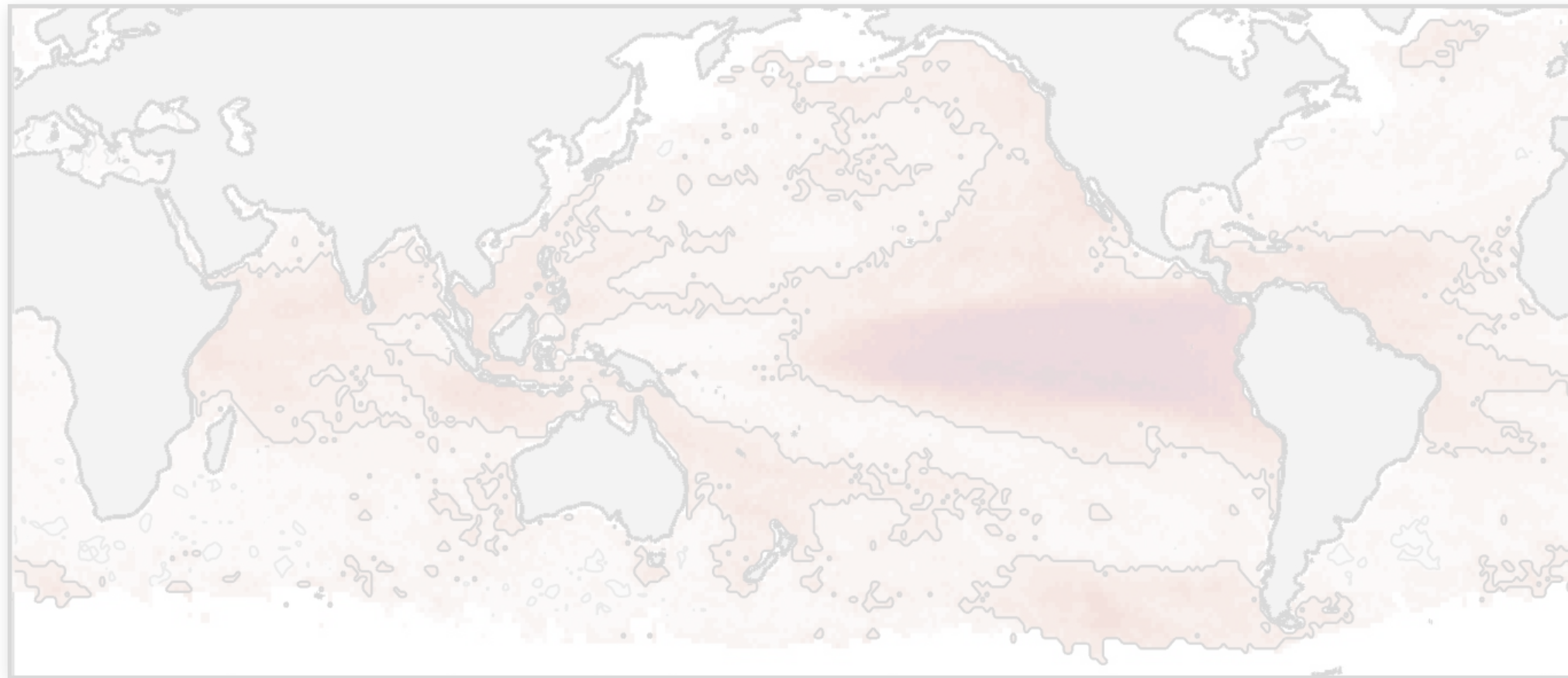


How do marine heatwaves relate to climate change?

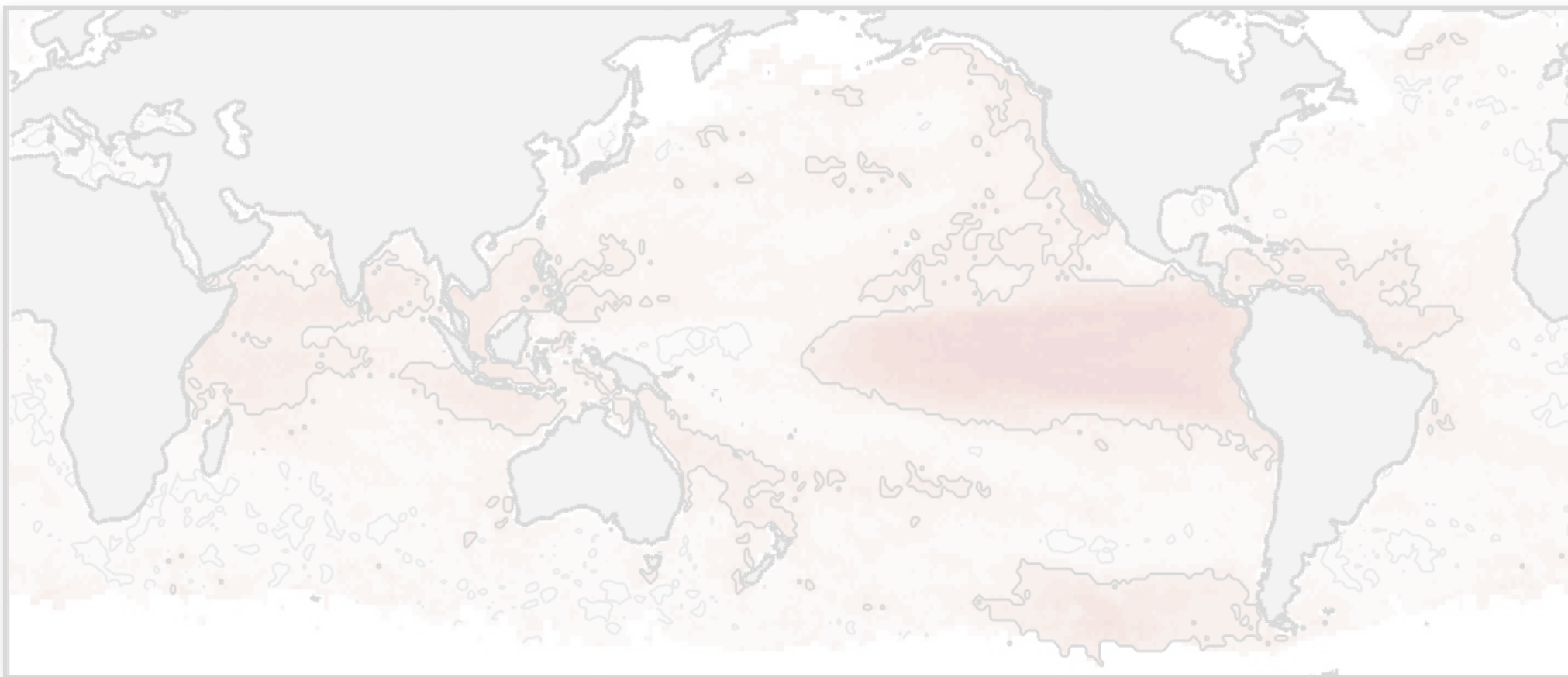
1 month ahead



3 months ahead



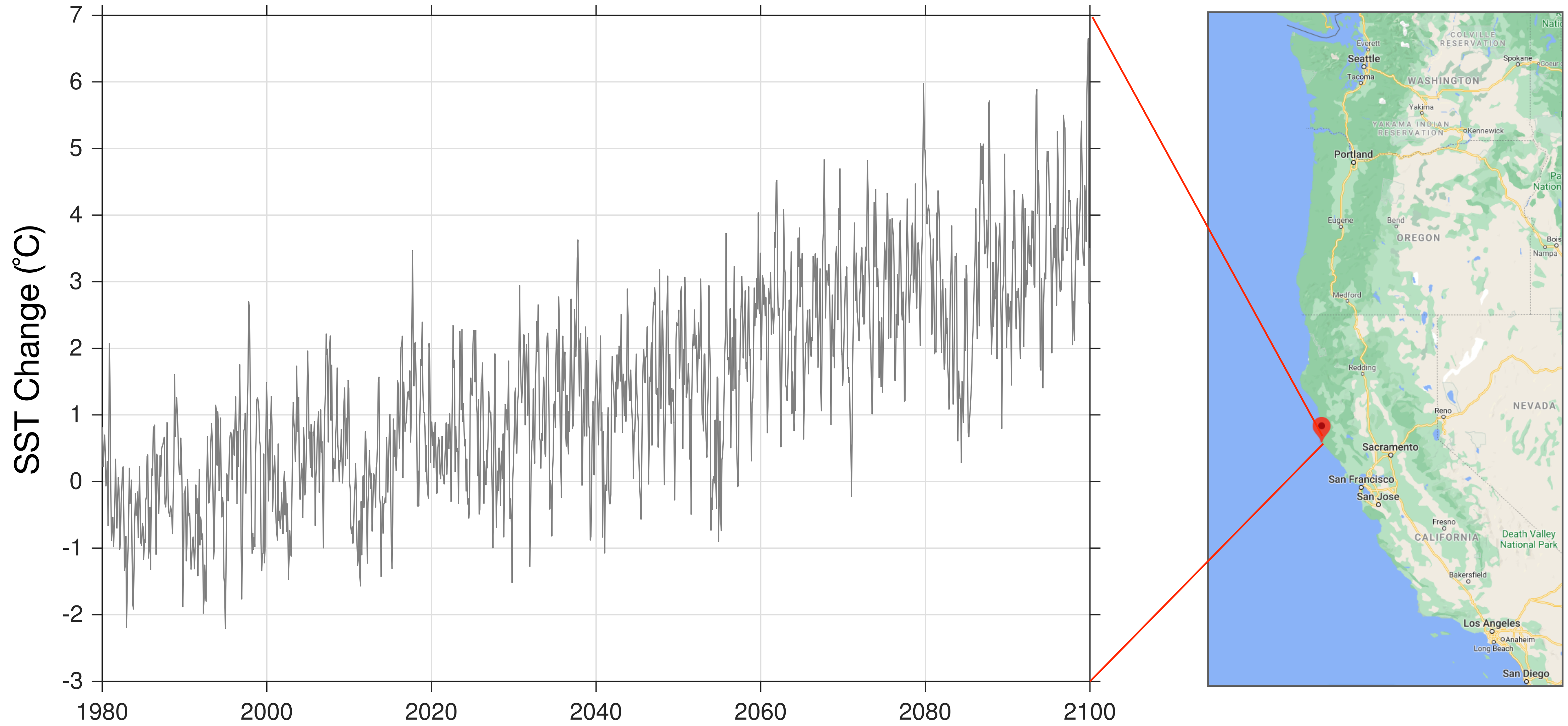
6 months ahead



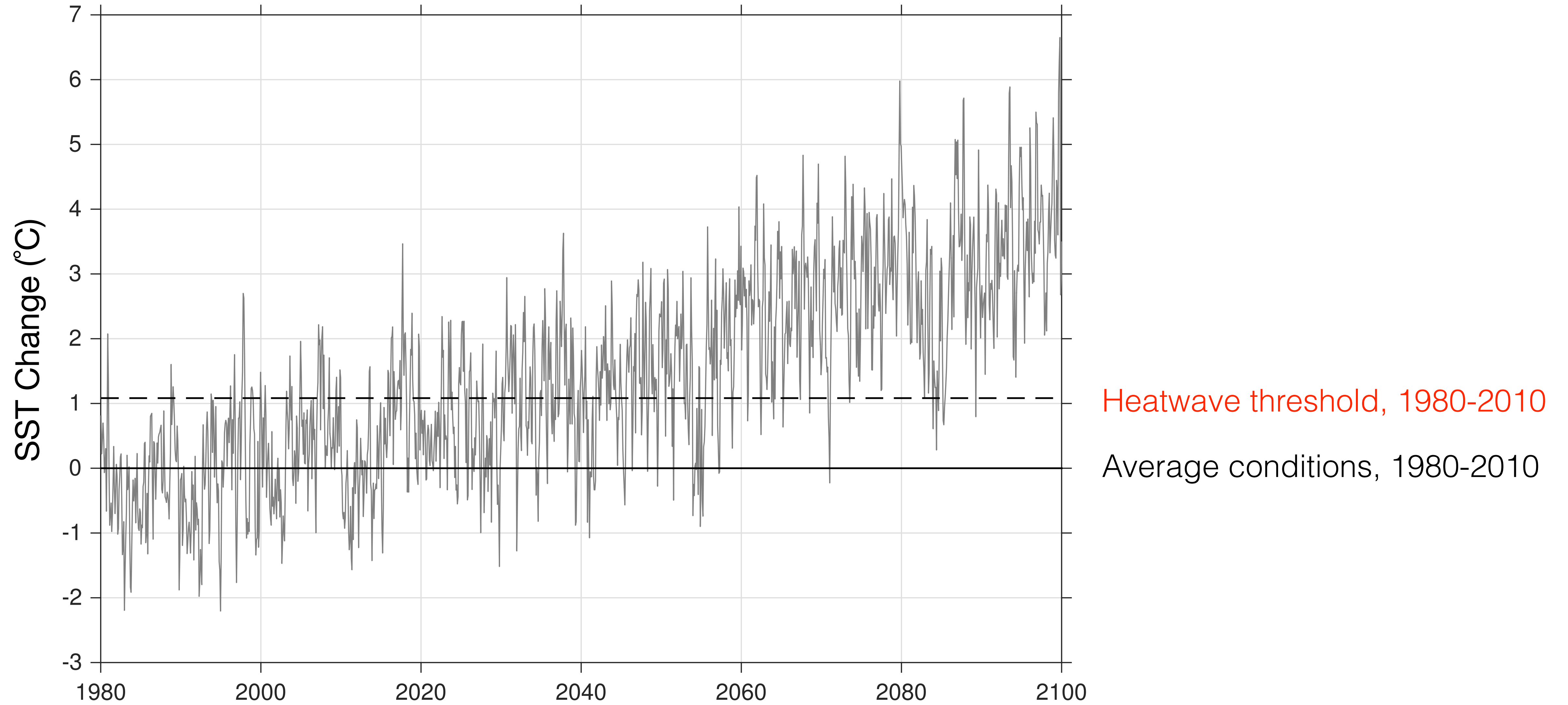
Perfect

Random guess

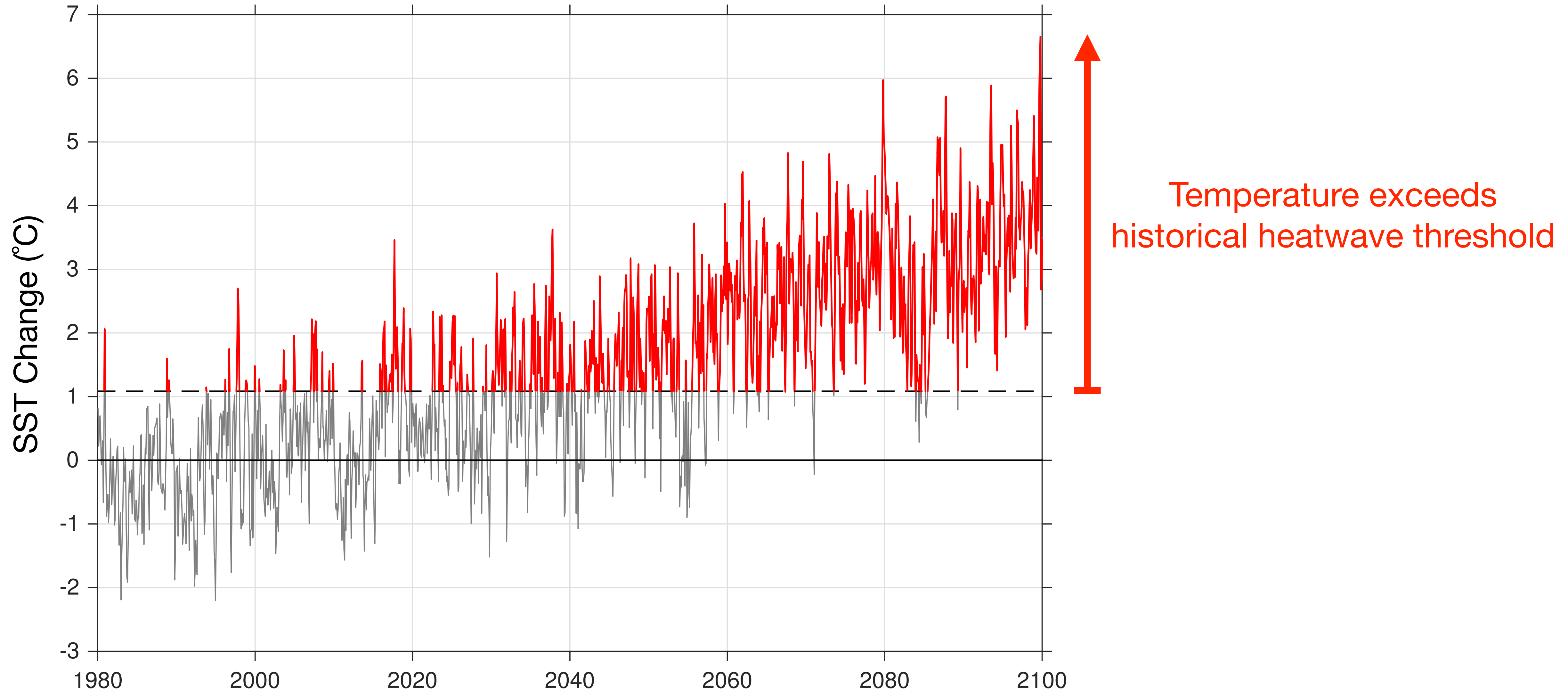
How do marine heatwaves relate to climate change?



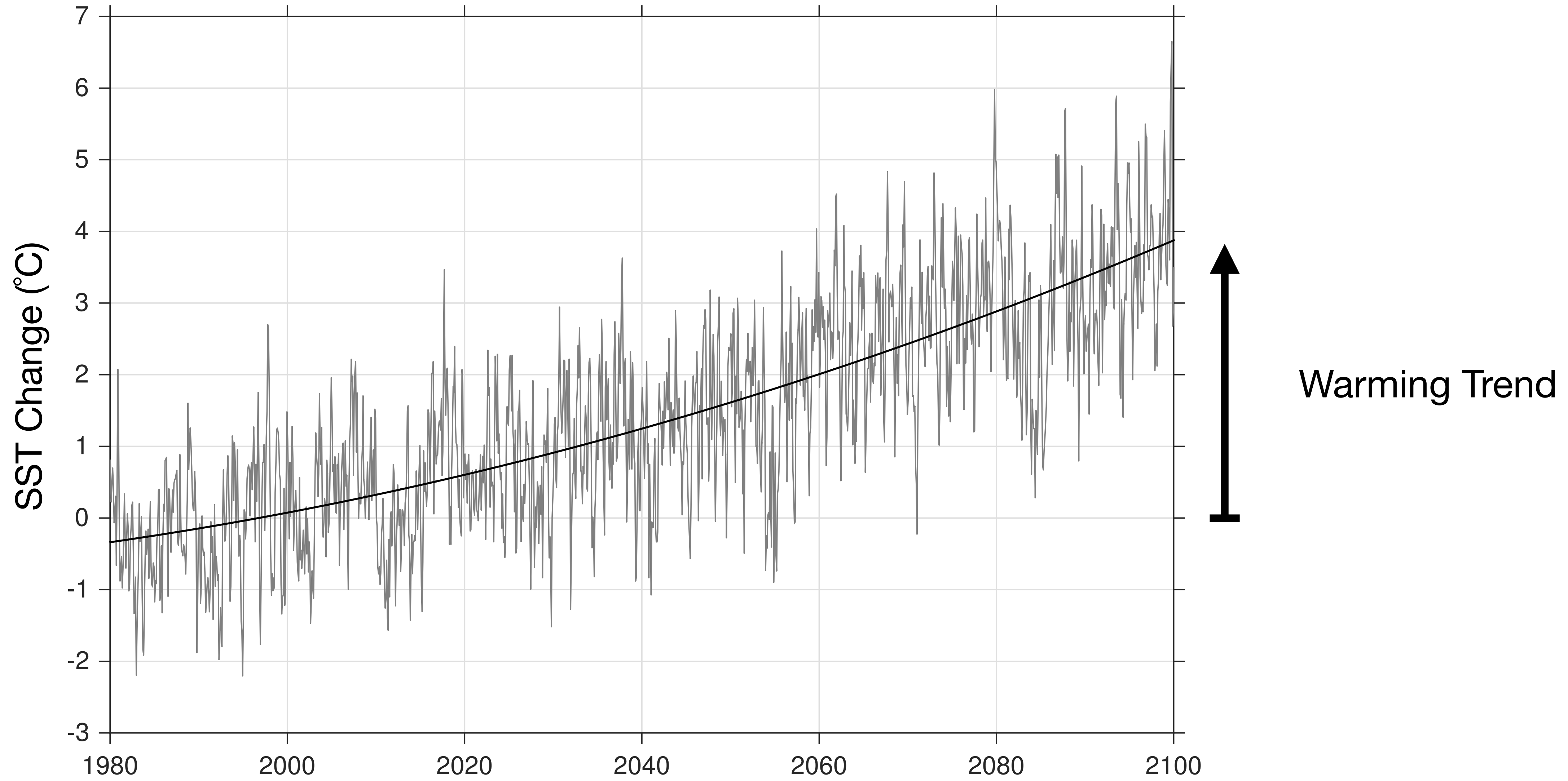
How do marine heatwaves relate to climate change?



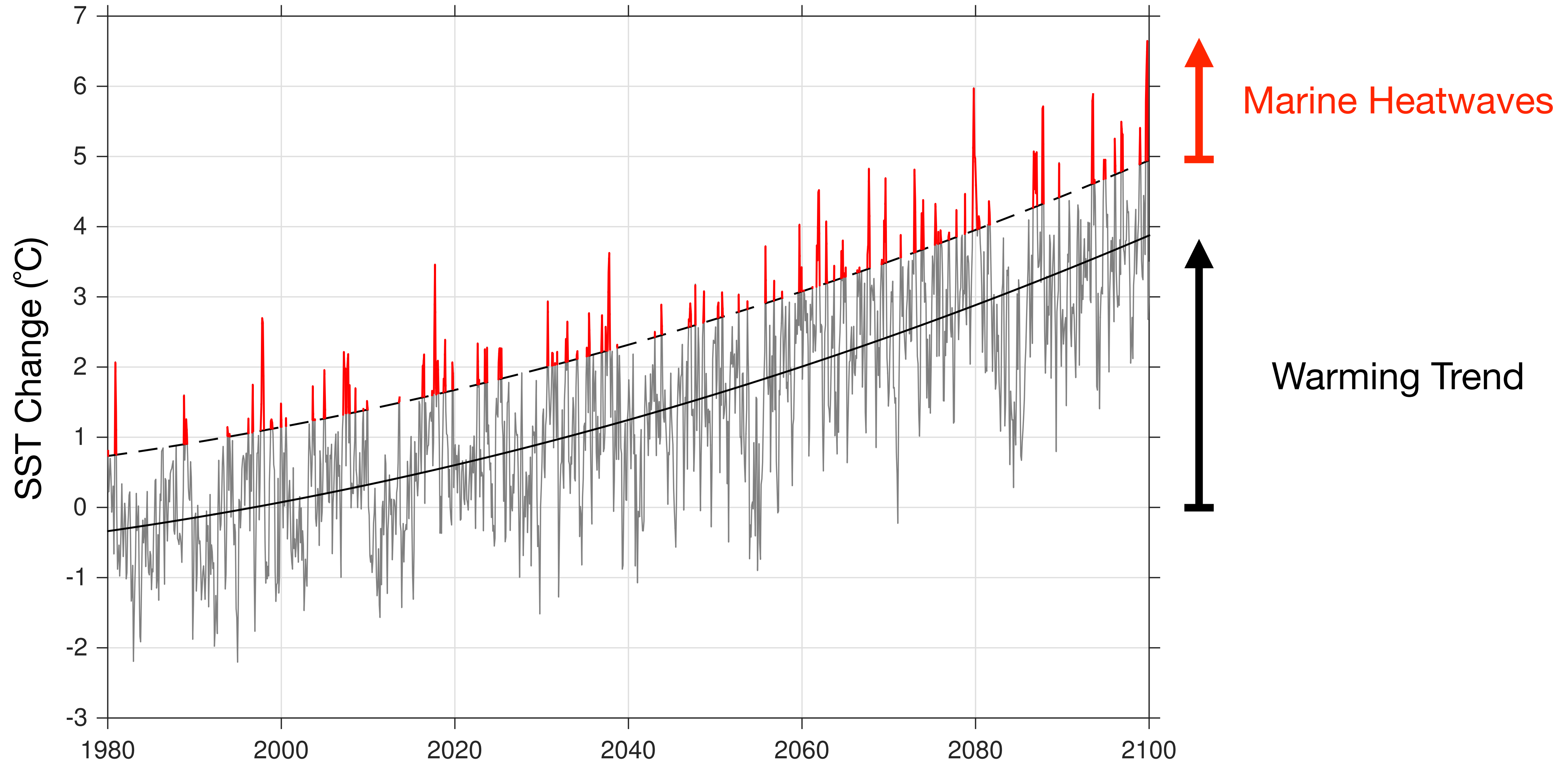
How do marine heatwaves relate to climate change?



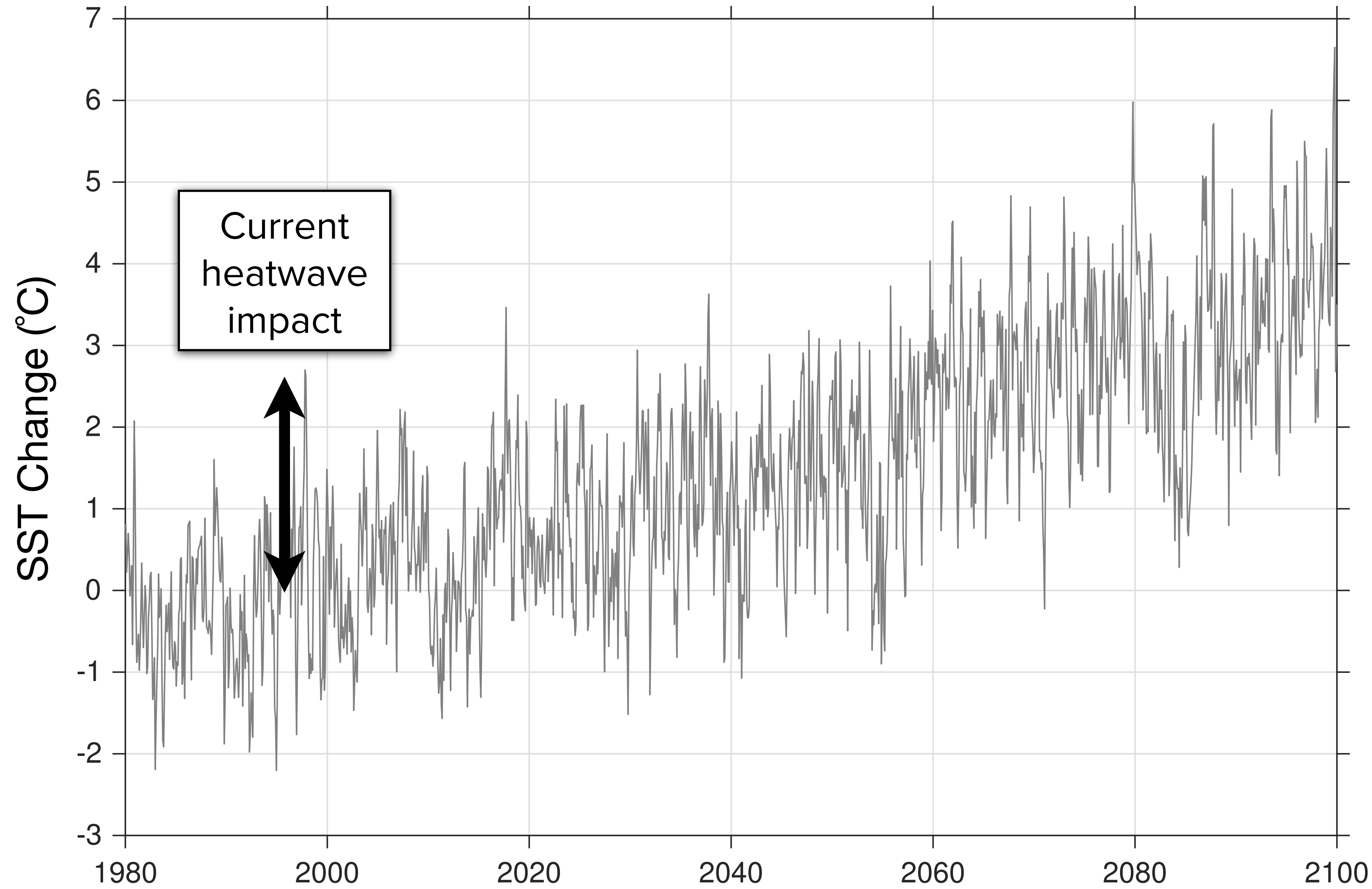
How do marine heatwaves relate to climate change?



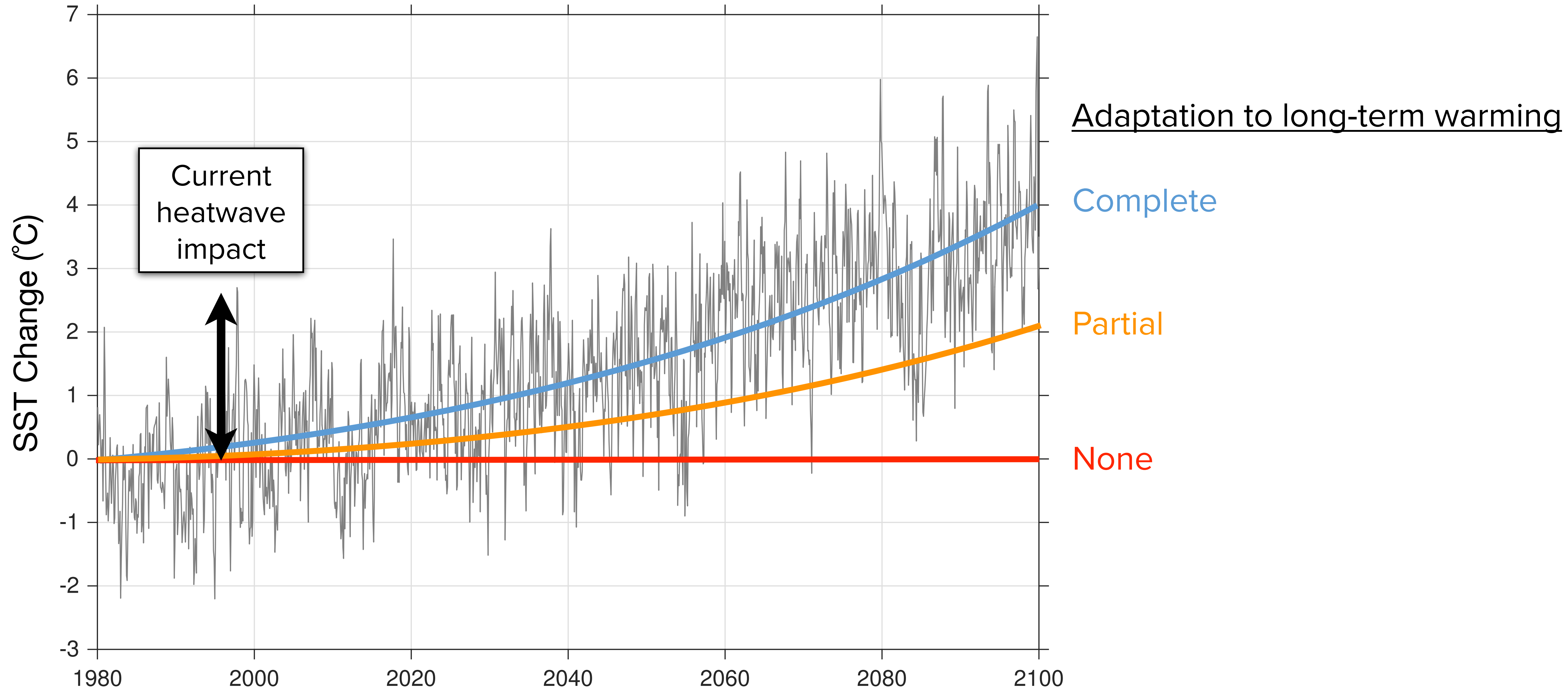
How do marine heatwaves relate to climate change?



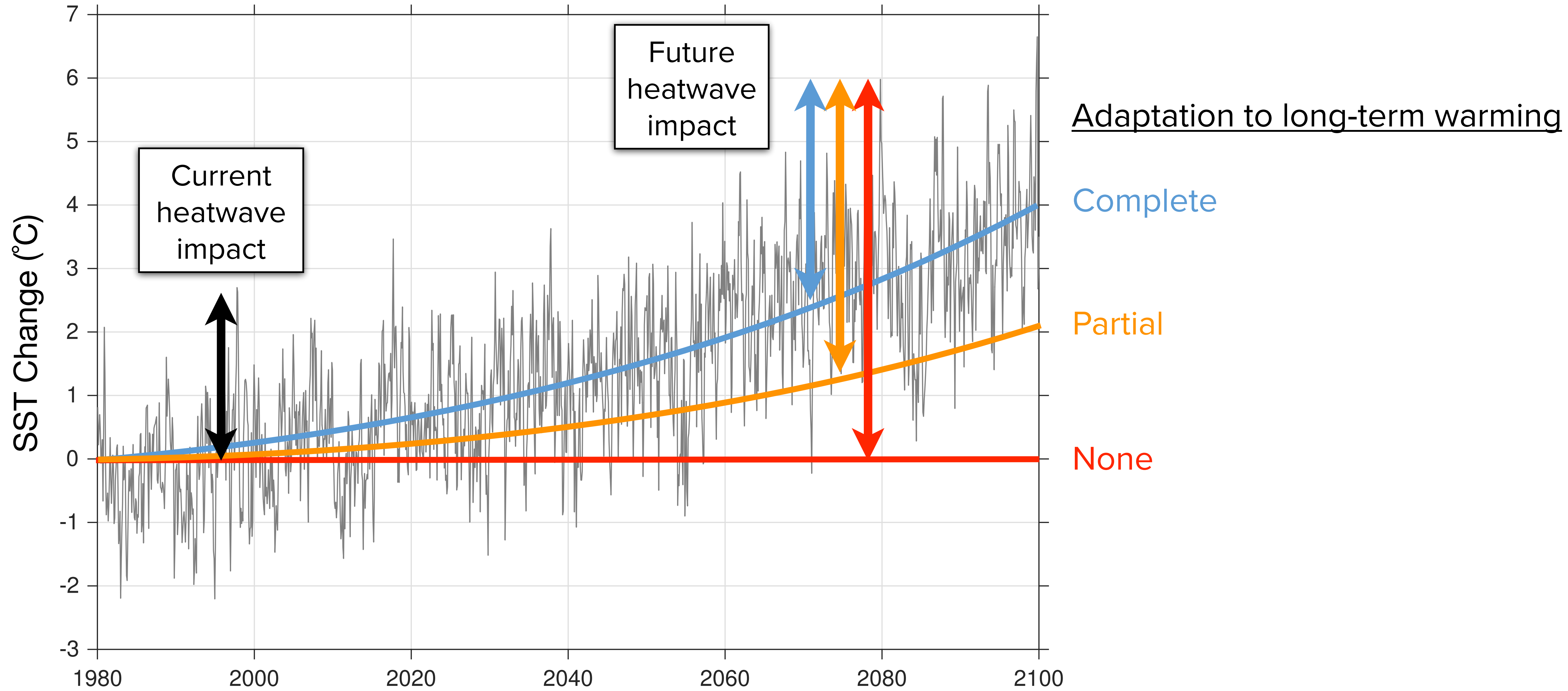
How do marine heatwaves relate to climate change?



How do marine heatwaves relate to climate change?



How do marine heatwaves relate to climate change?



Thank You!

Dillon Amaya
dillon.amaya@noaa.gov

Mike Jacox
michael.jacox@noaa.gov

