

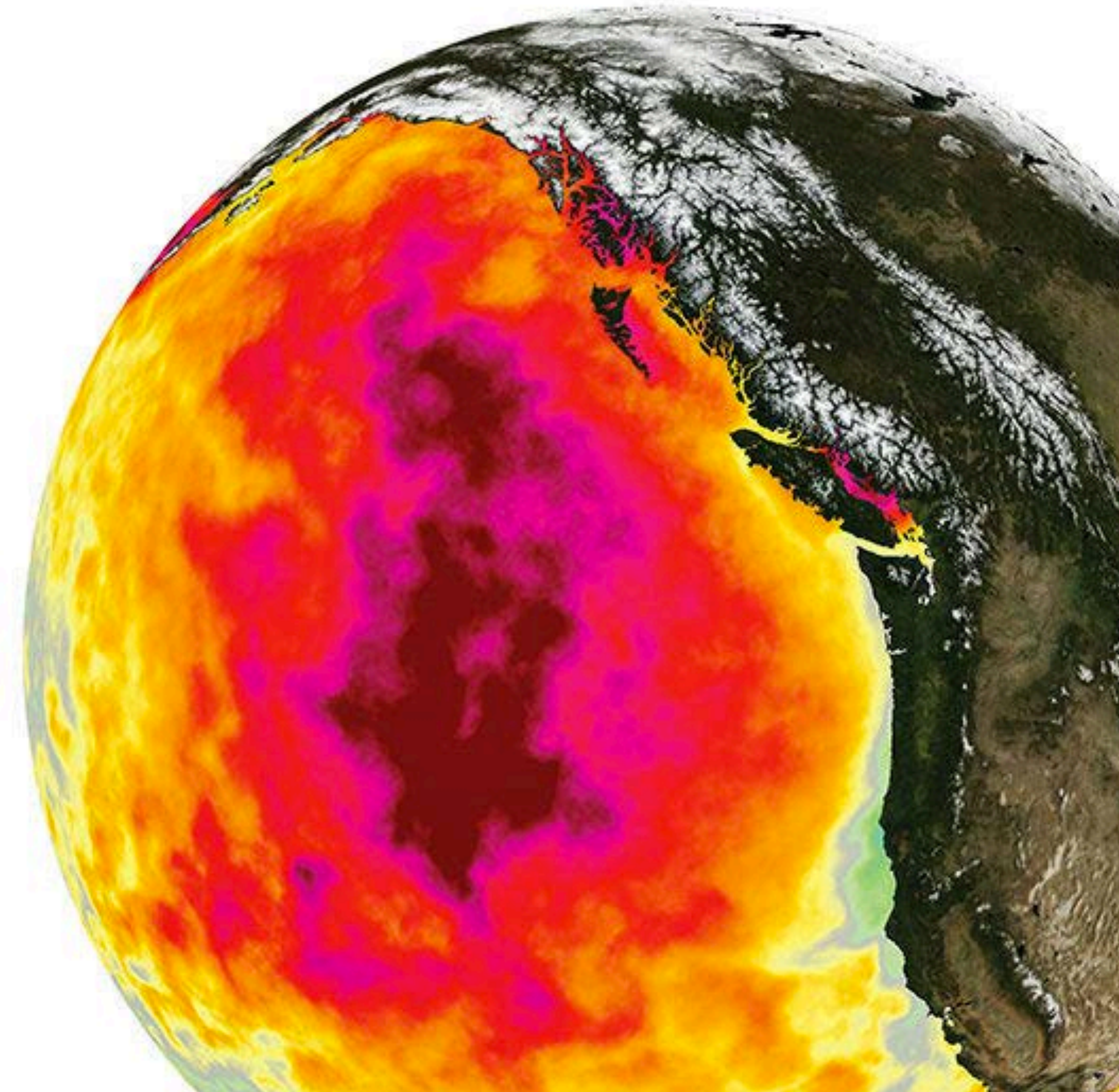
Forecasting Marine Heatwaves over the Global Ocean

Mike Jacox

NOAA Southwest Fisheries Science Center
NOAA Physical Sciences Laboratory

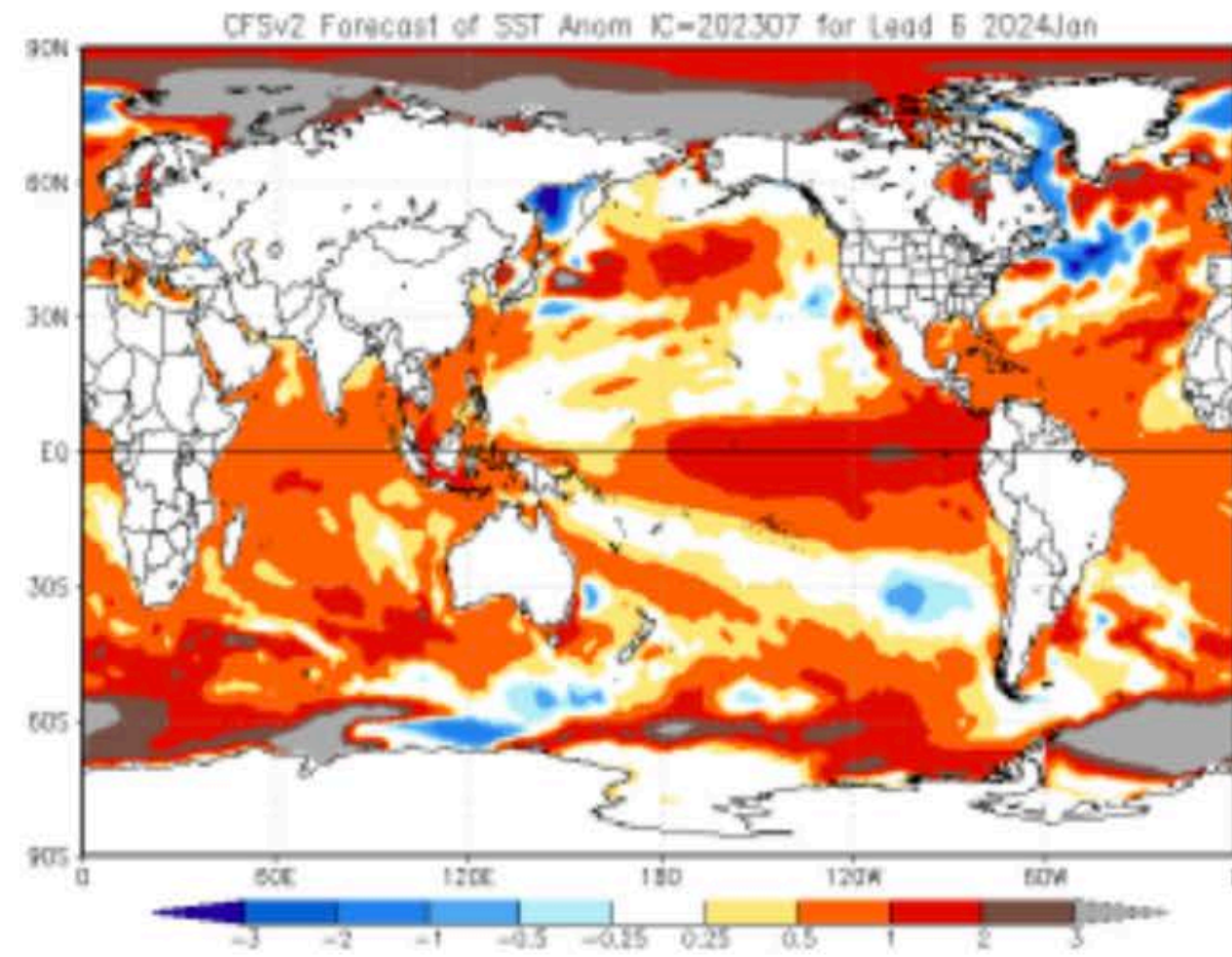
With lots of help from

Mike Alexander, Dillon Amaya, Emily Becker, Steven Bograd,
Steph Brodie, Elliott Hazen, Mer Pozo Buil, Desiree Tommasi,
Heather Welch

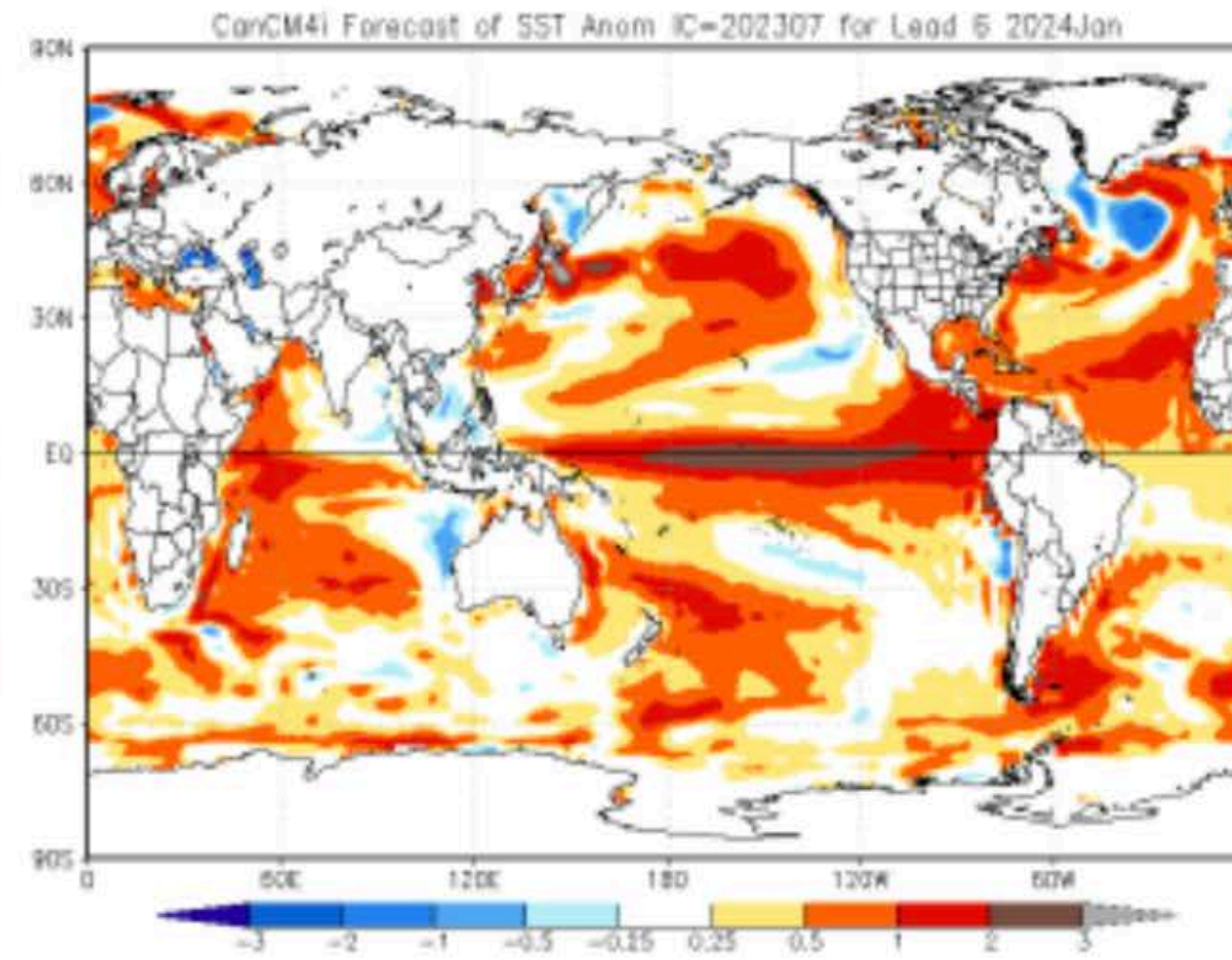


Leveraging forecasts in the North American Multimodel Ensemble...

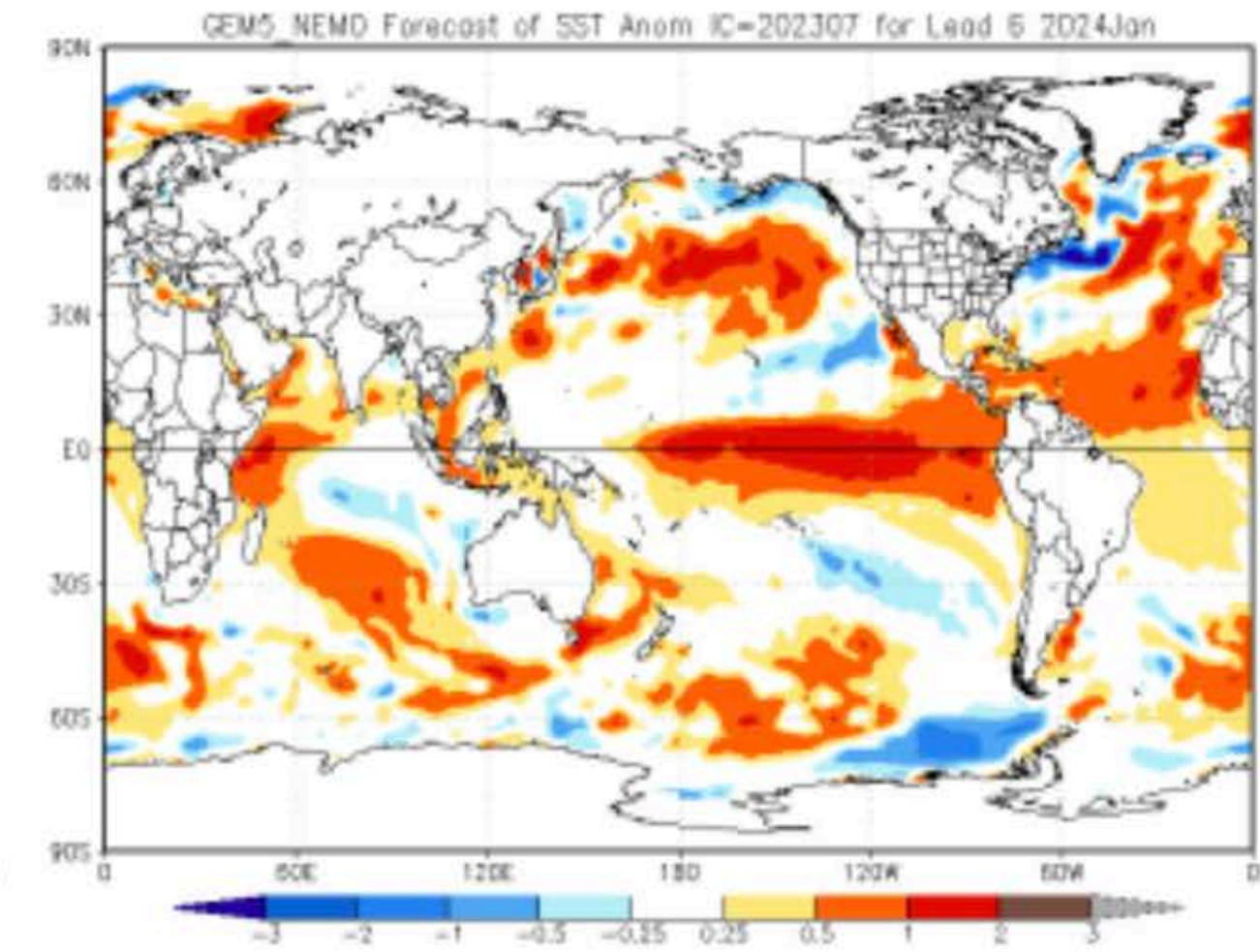
NCEP_CFSv2



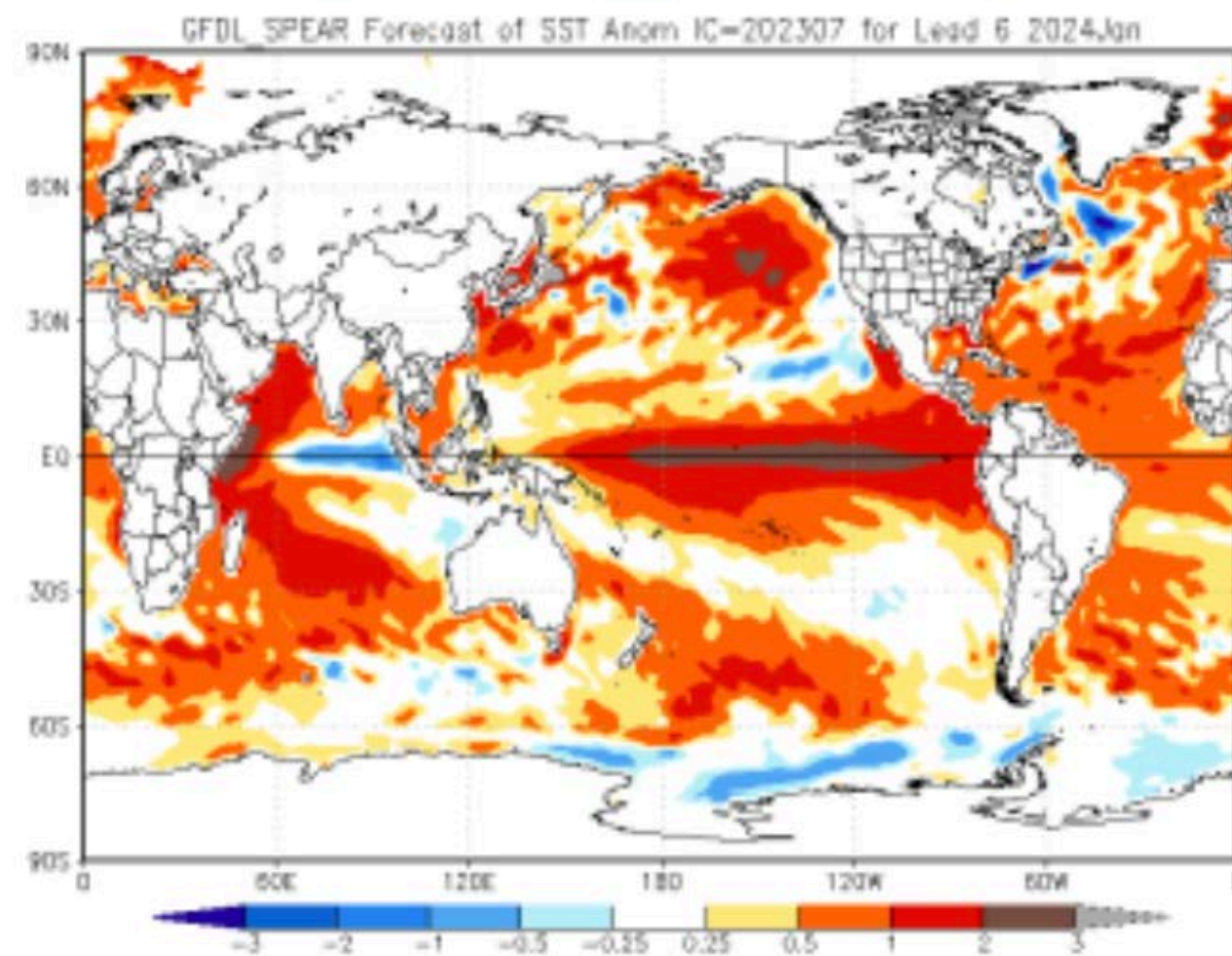
CanCM4i



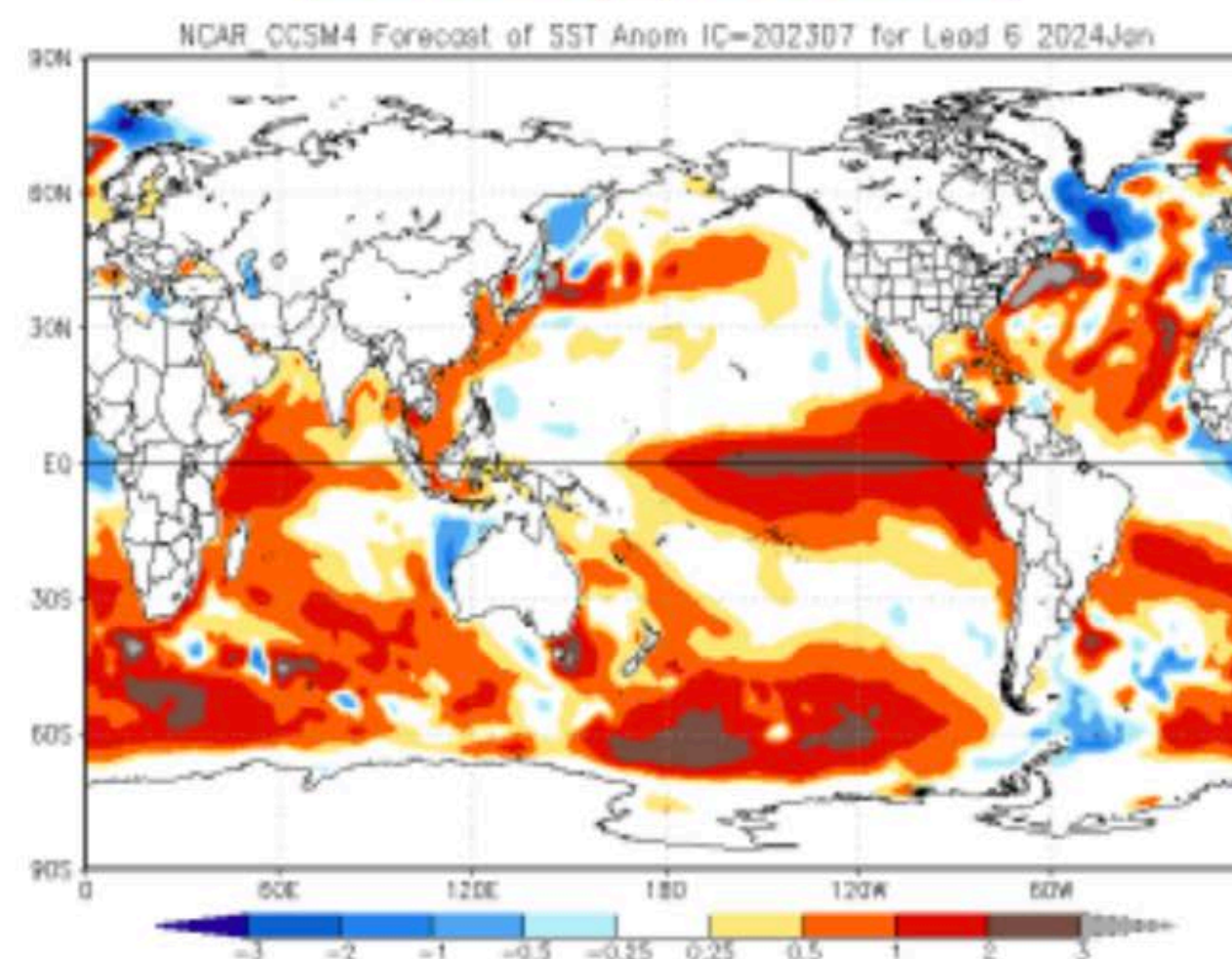
GEM5_NEMO



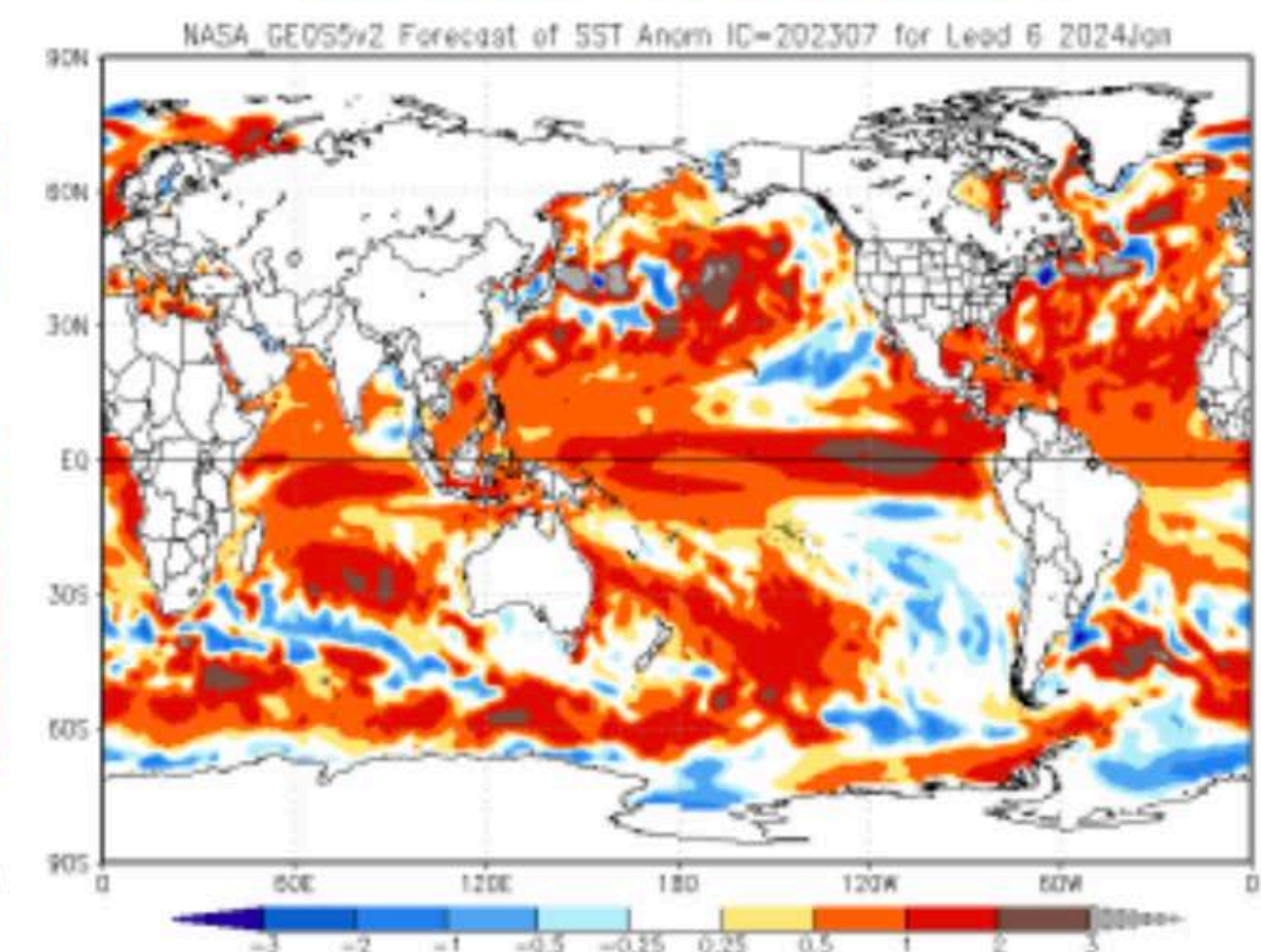
GFDL_SPEAR



NCAR_CCSM4

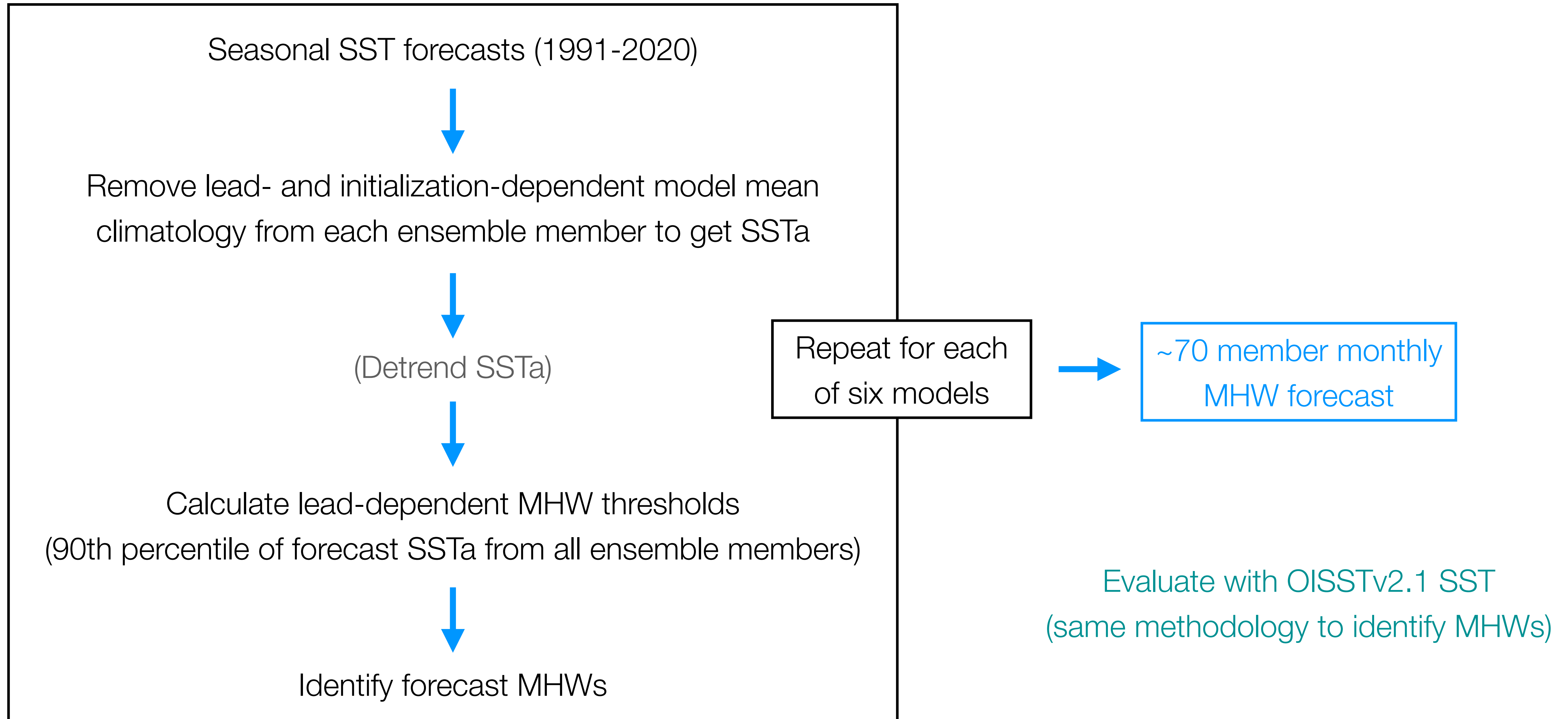


NASA_GEOS5v2



<https://www.cpc.ncep.noaa.gov/products/NMME/>

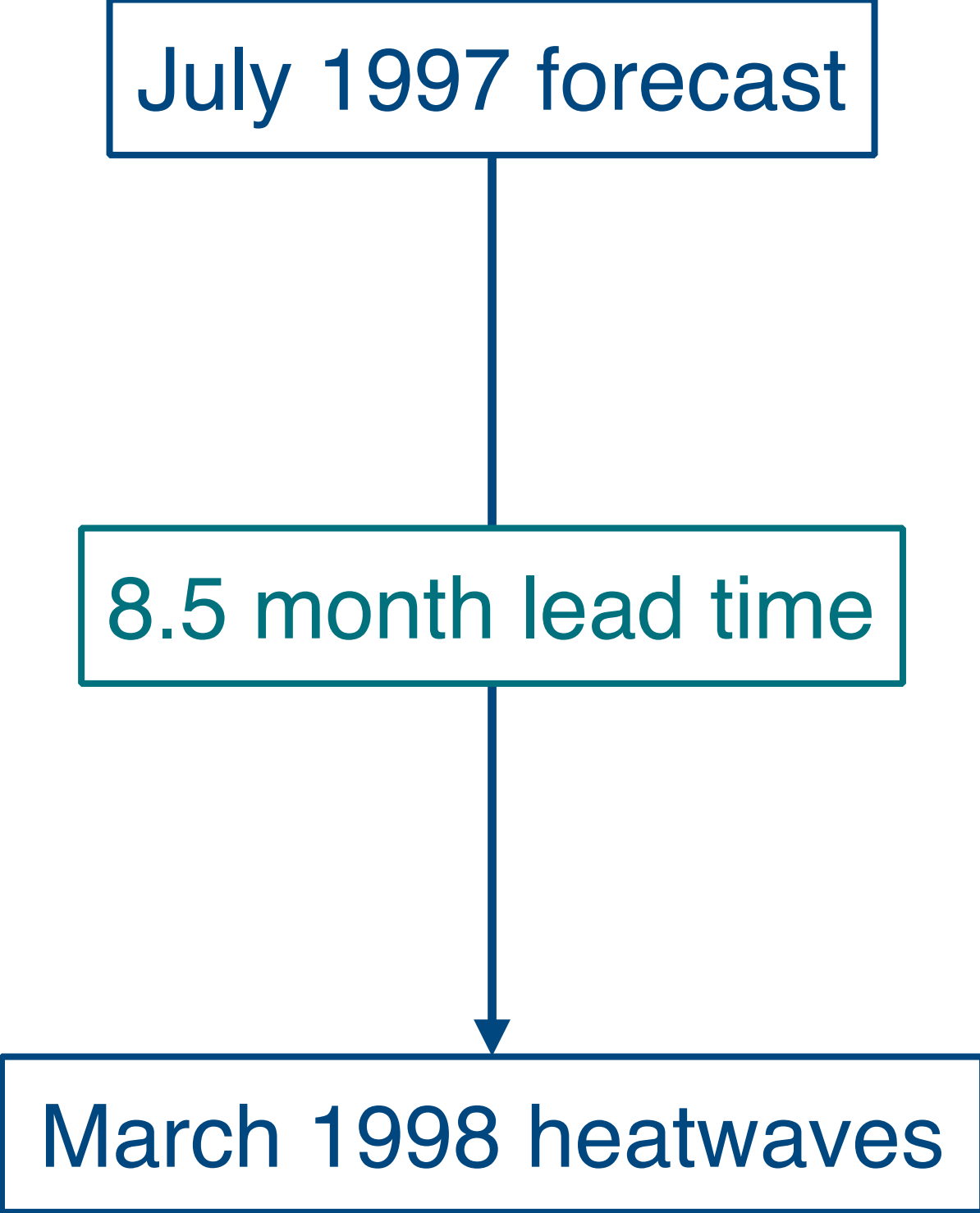
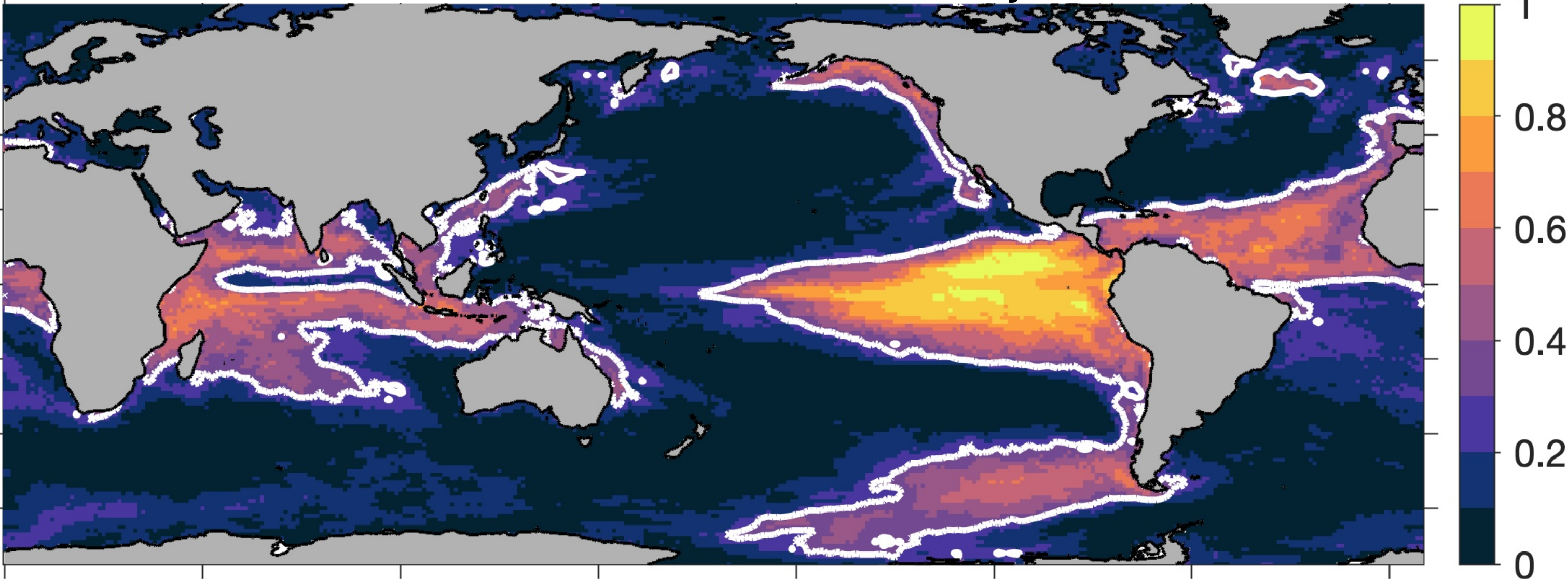
...to create seasonal marine heatwave forecasts



Jacox et al. (2022)

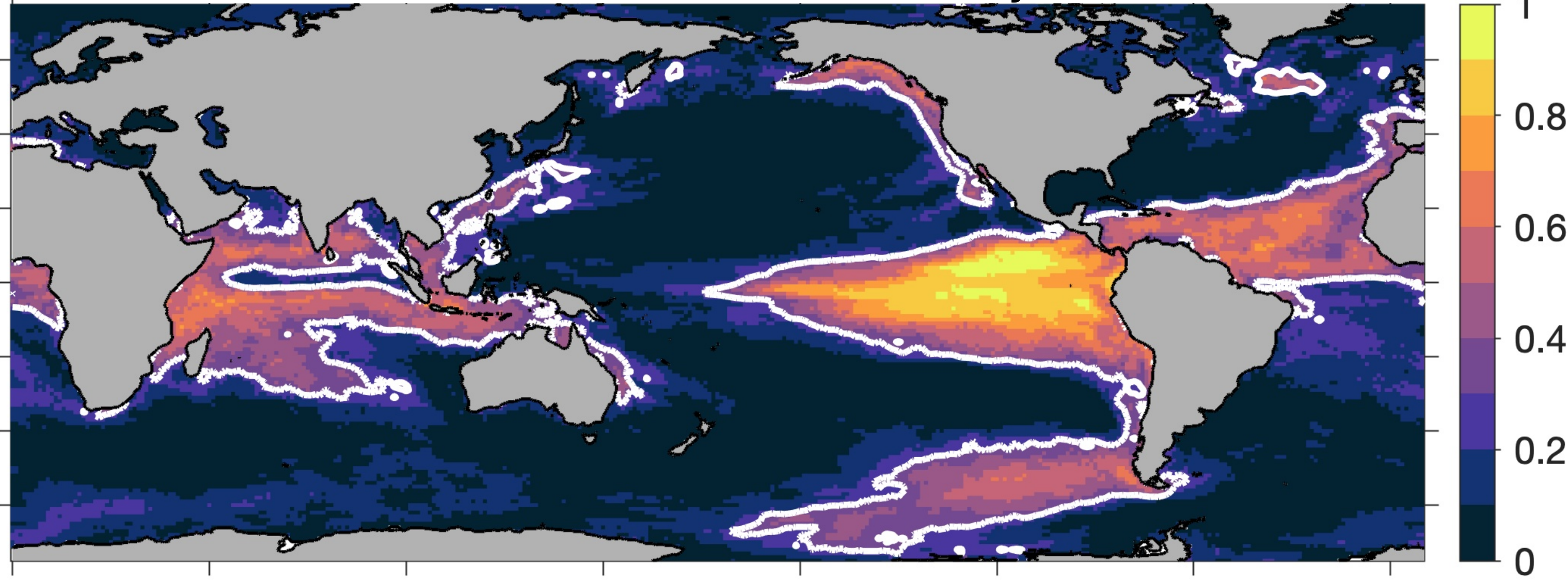
Example forecasts

Forecast Heatwave Probability

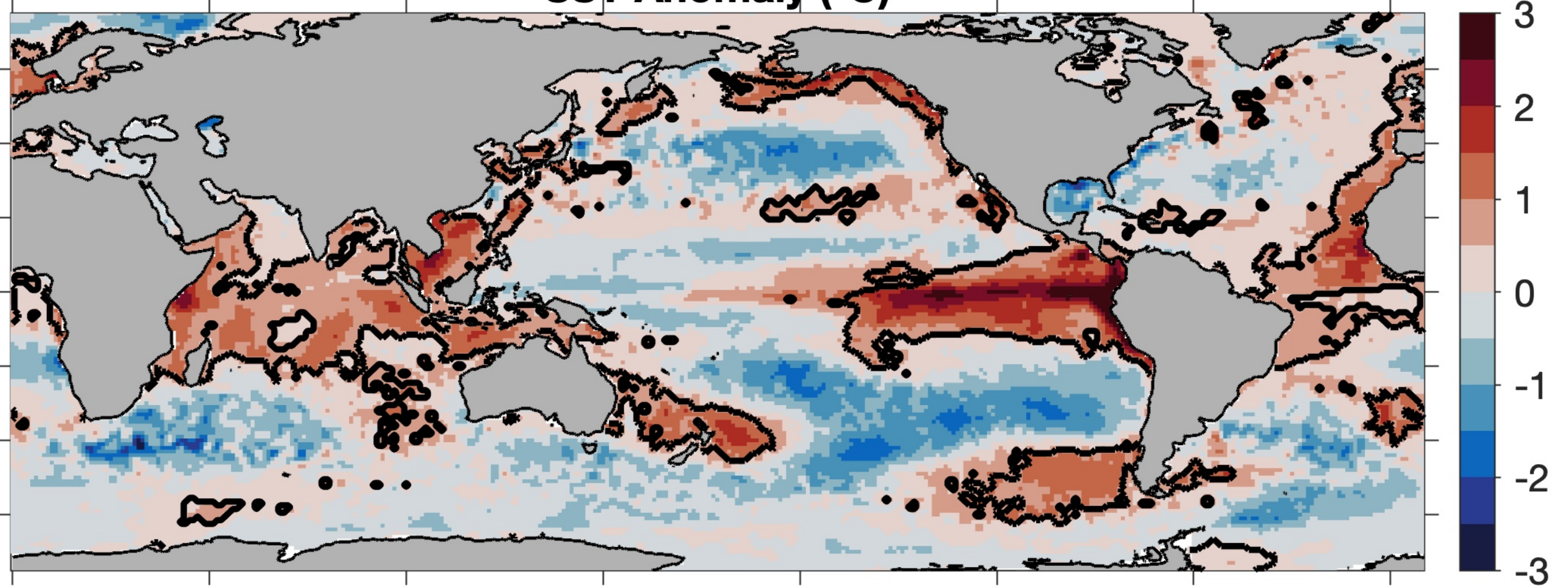


Example forecasts

Forecast Heatwave Probability



SST Anomaly (°C)



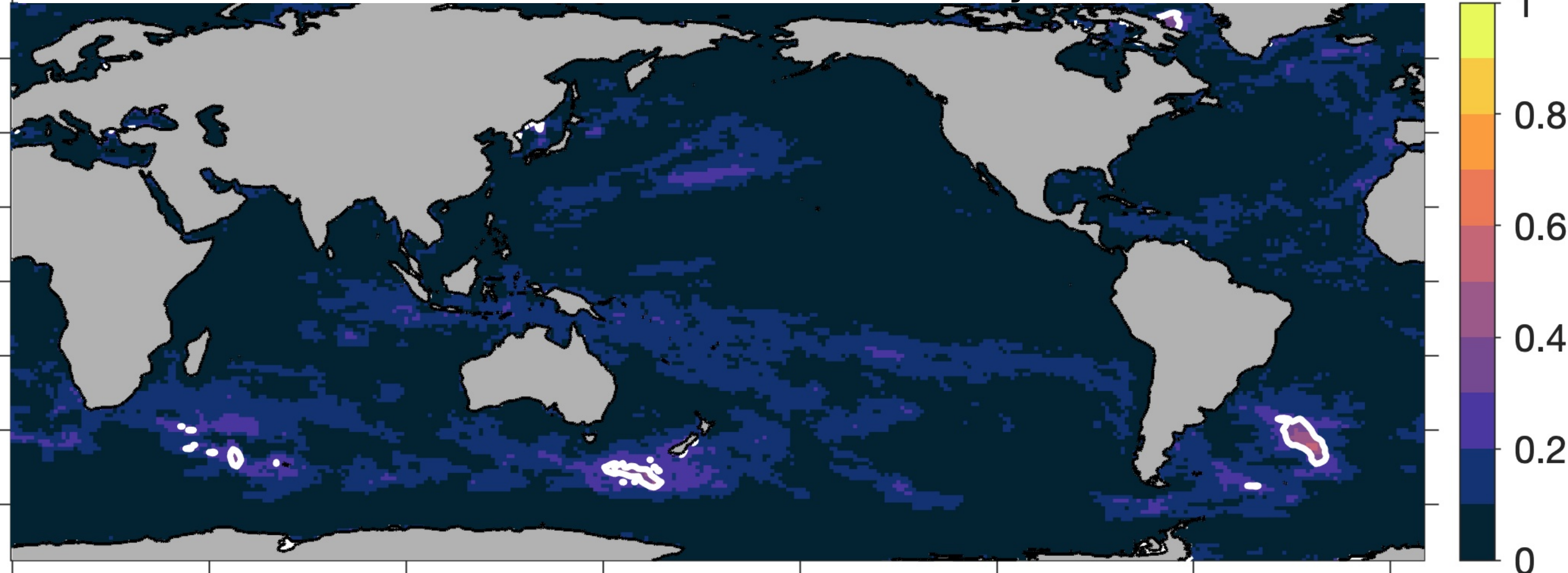
July 1997 forecast

8.5 month lead time

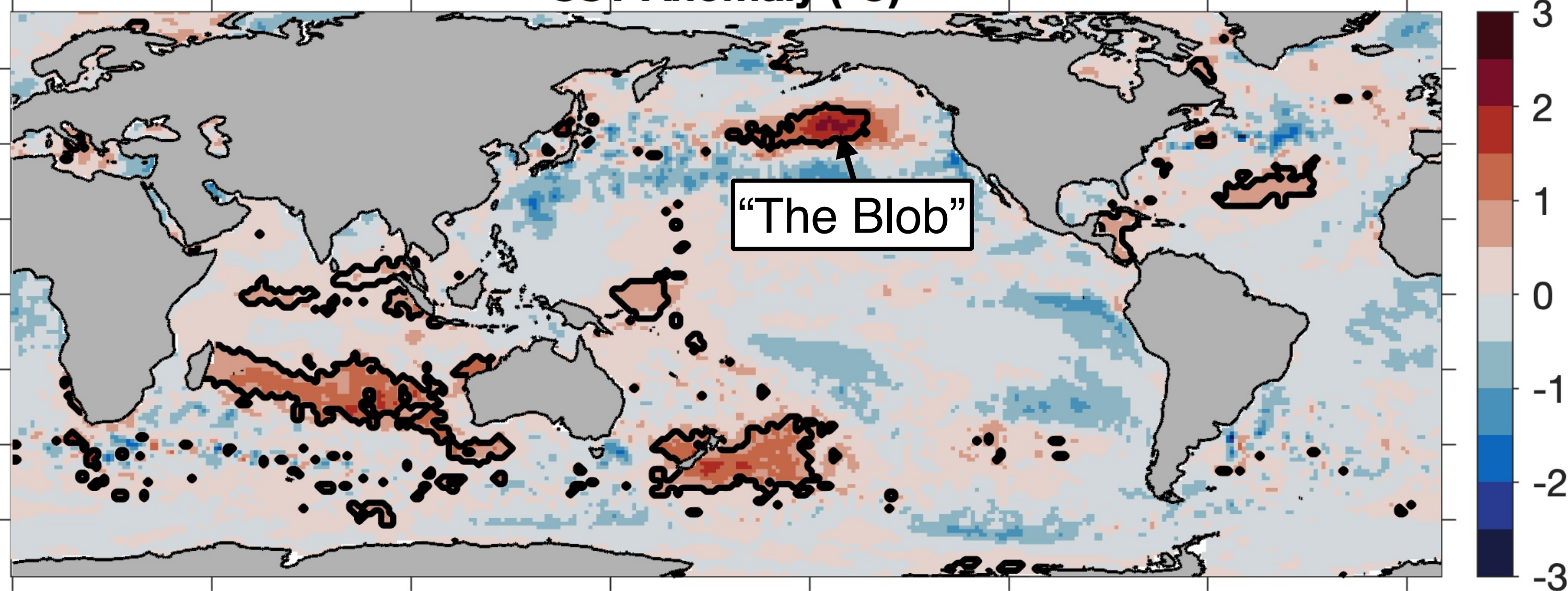
March 1998 heatwaves

Example forecasts

Forecast Heatwave Probability



SST Anomaly (°C)



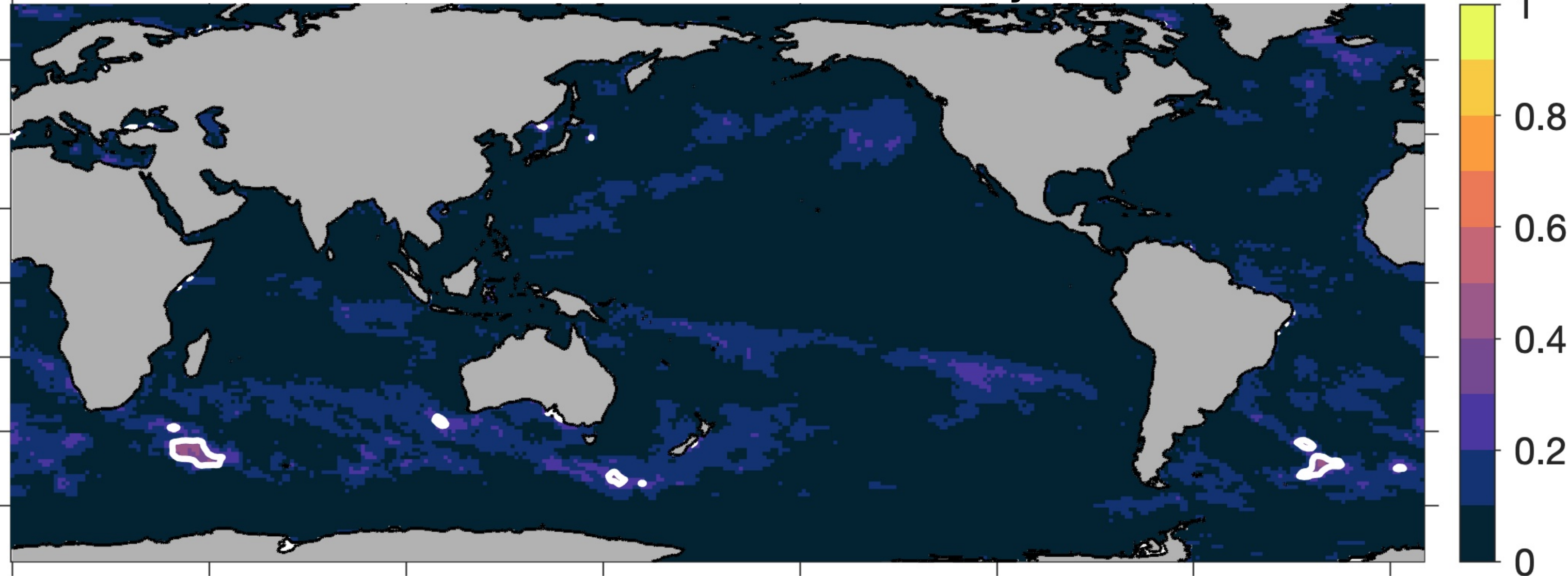
March 2013 forecast

8.5 month lead time

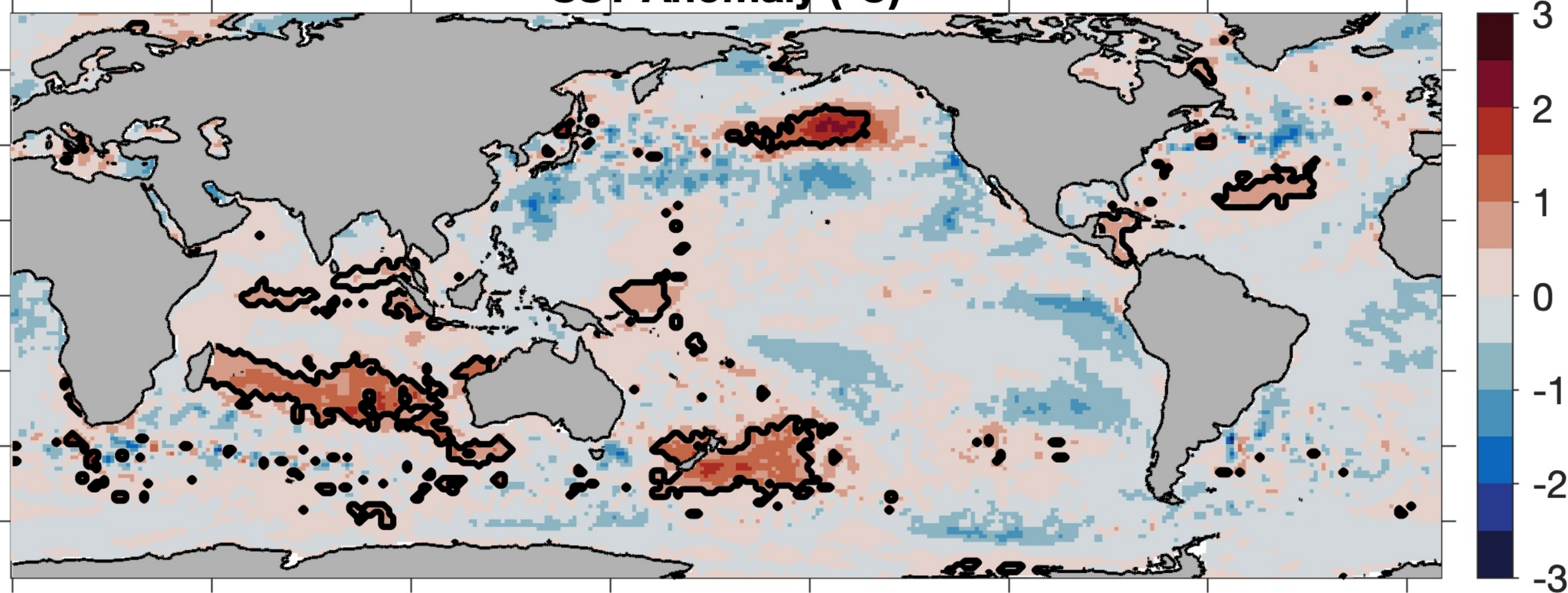
November 2013 heatwaves

Example forecasts

Forecast Heatwave Probability



SST Anomaly (°C)



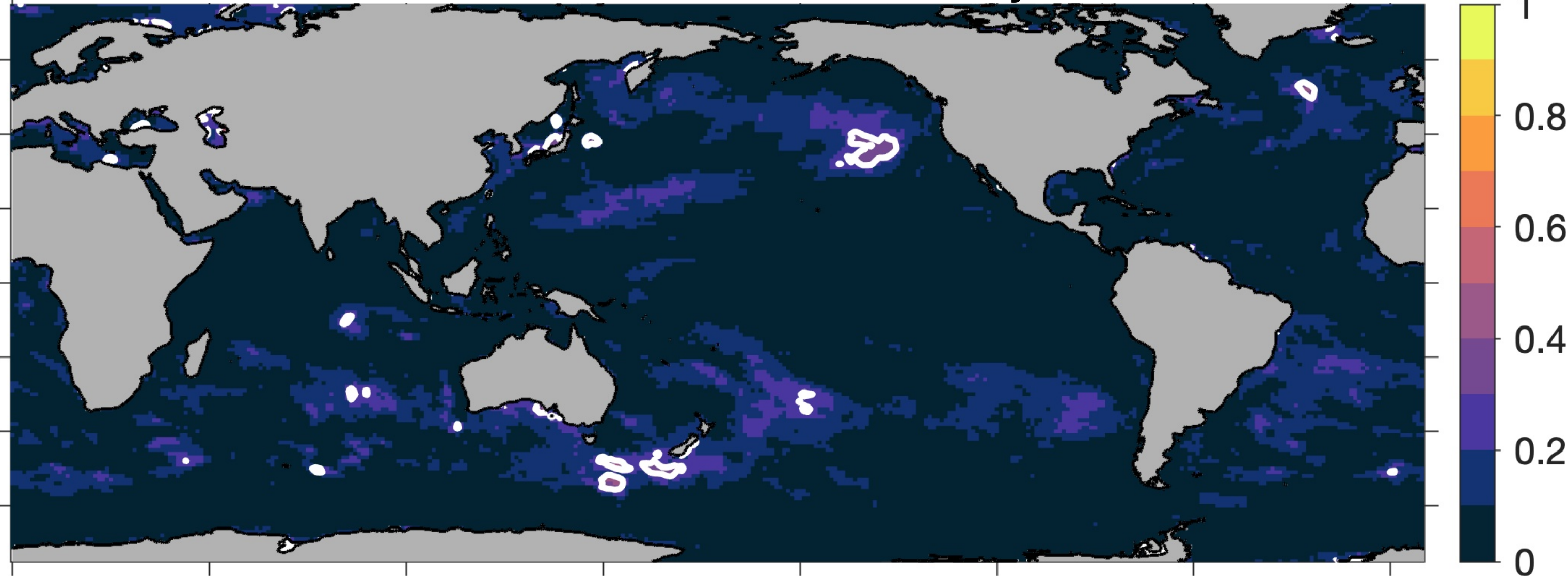
July 2013 forecast

4.5 month lead time

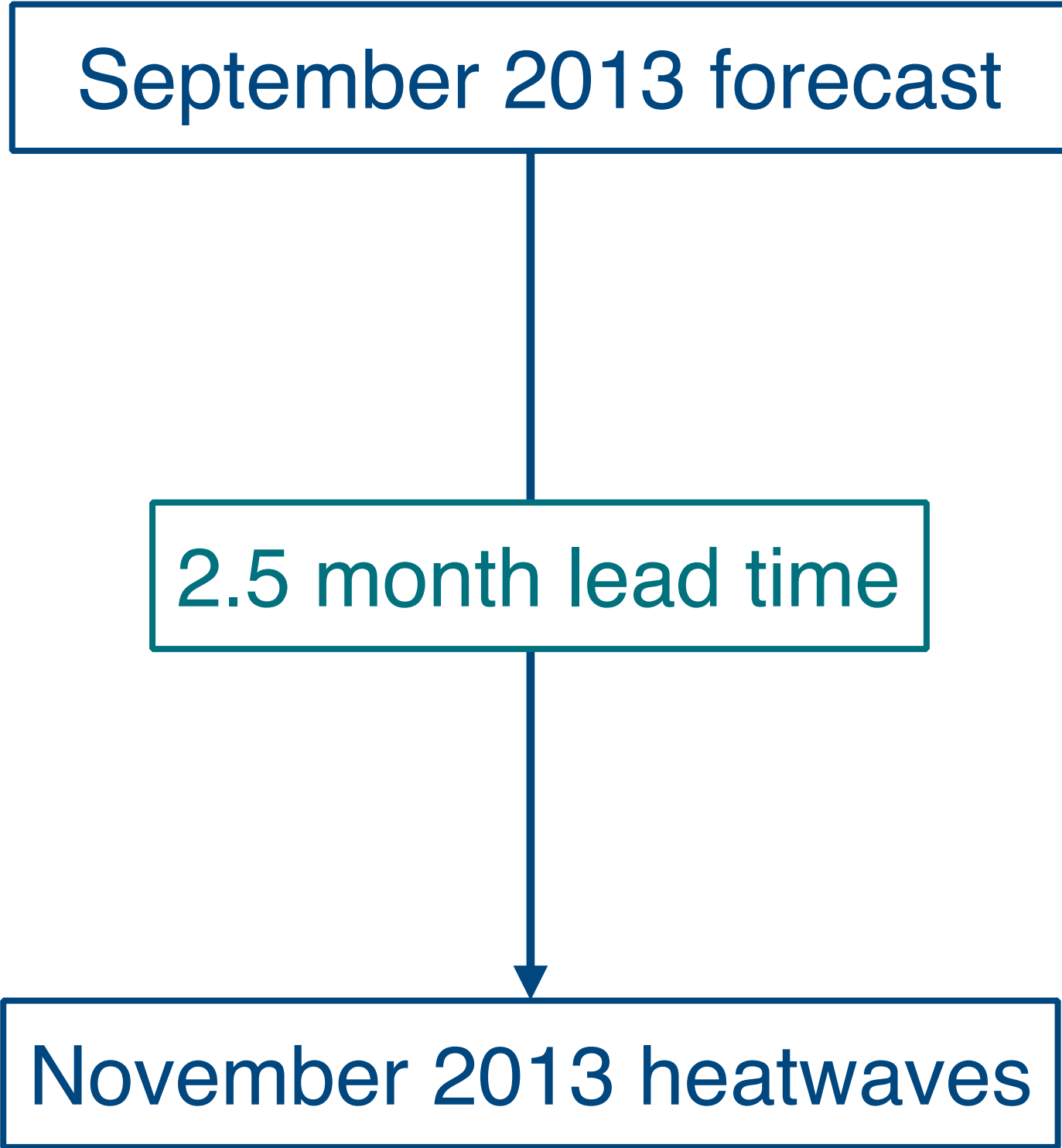
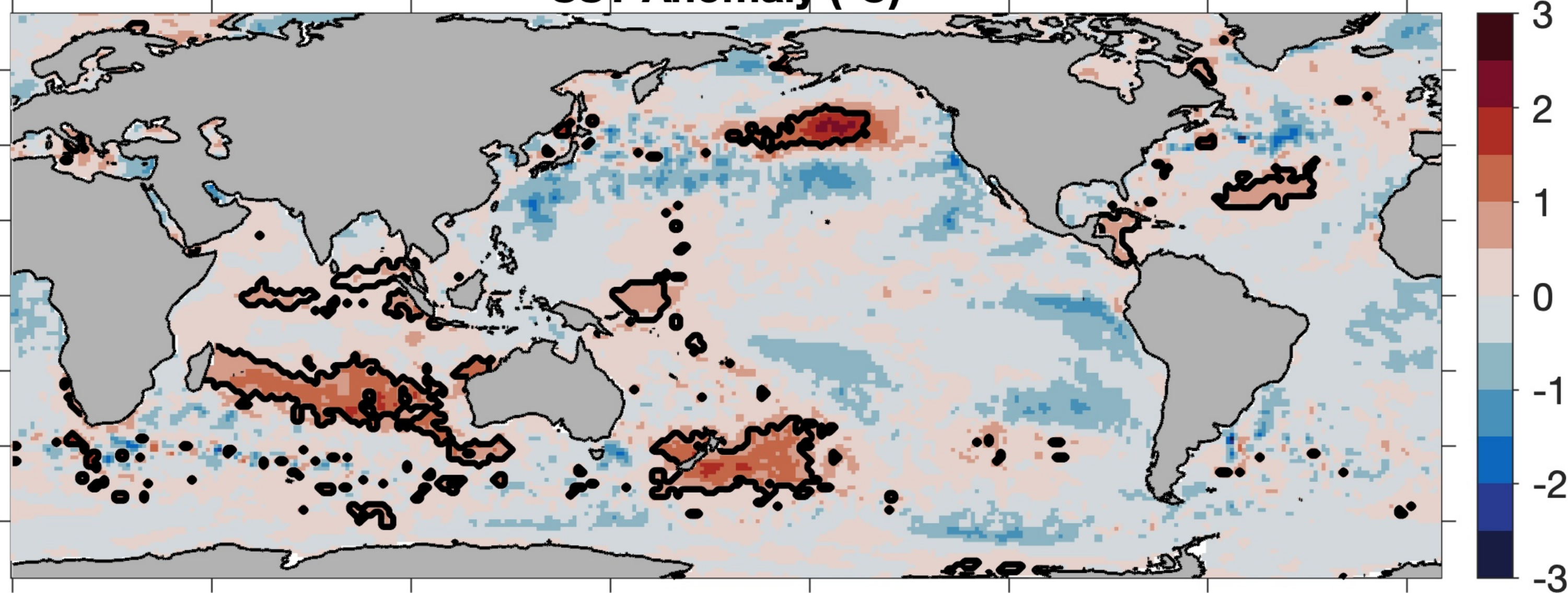
November 2013 heatwaves

Example forecasts

Forecast Heatwave Probability

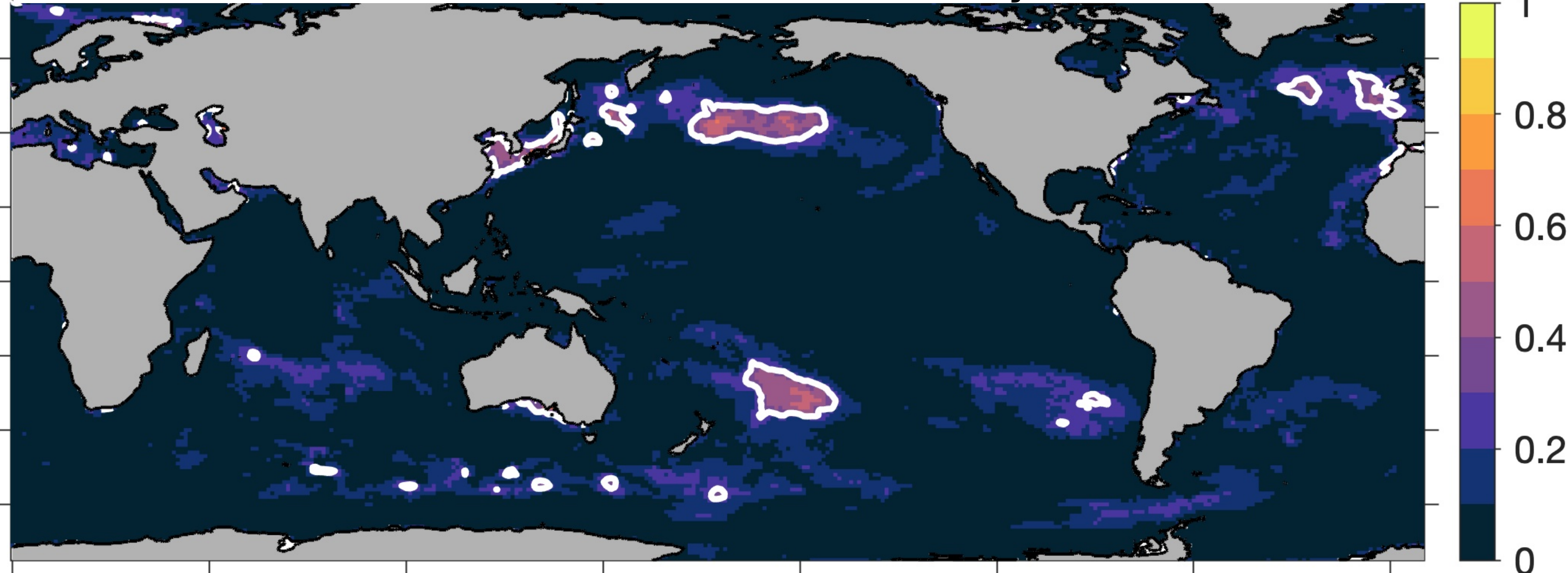


SST Anomaly (°C)

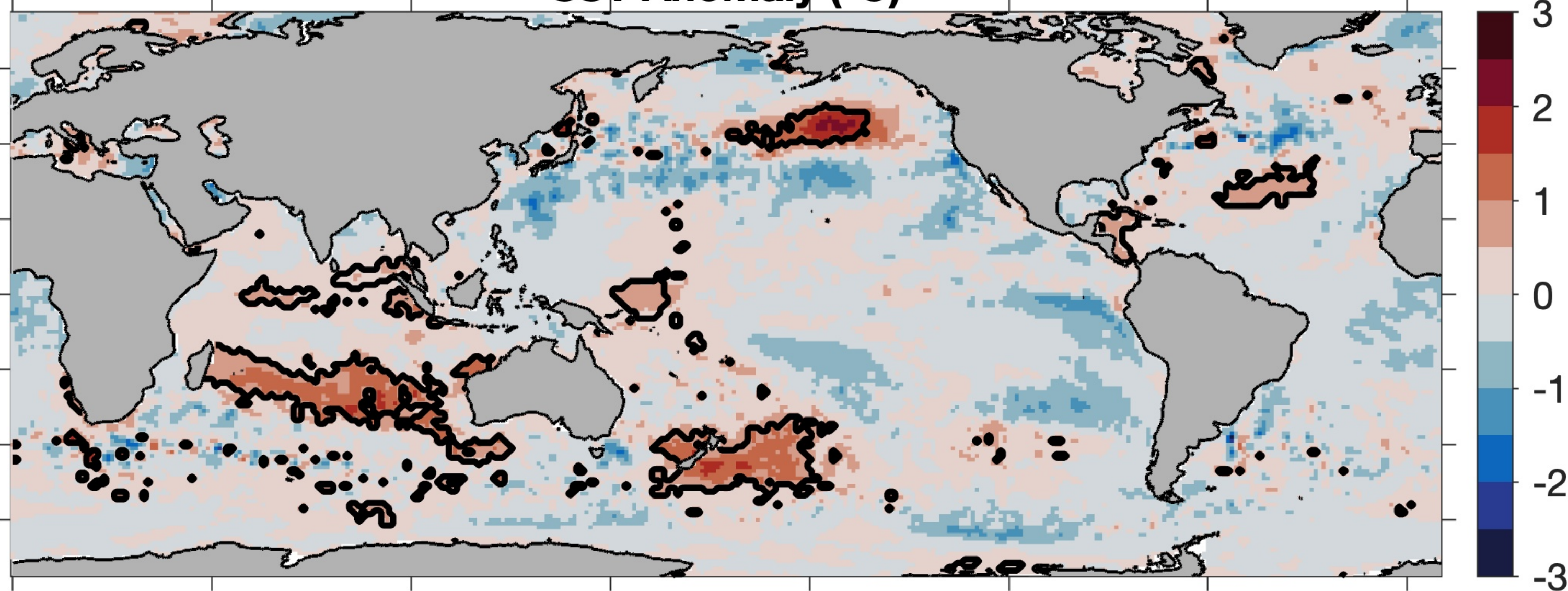


Example forecasts

Forecast Heatwave Probability



SST Anomaly (°C)

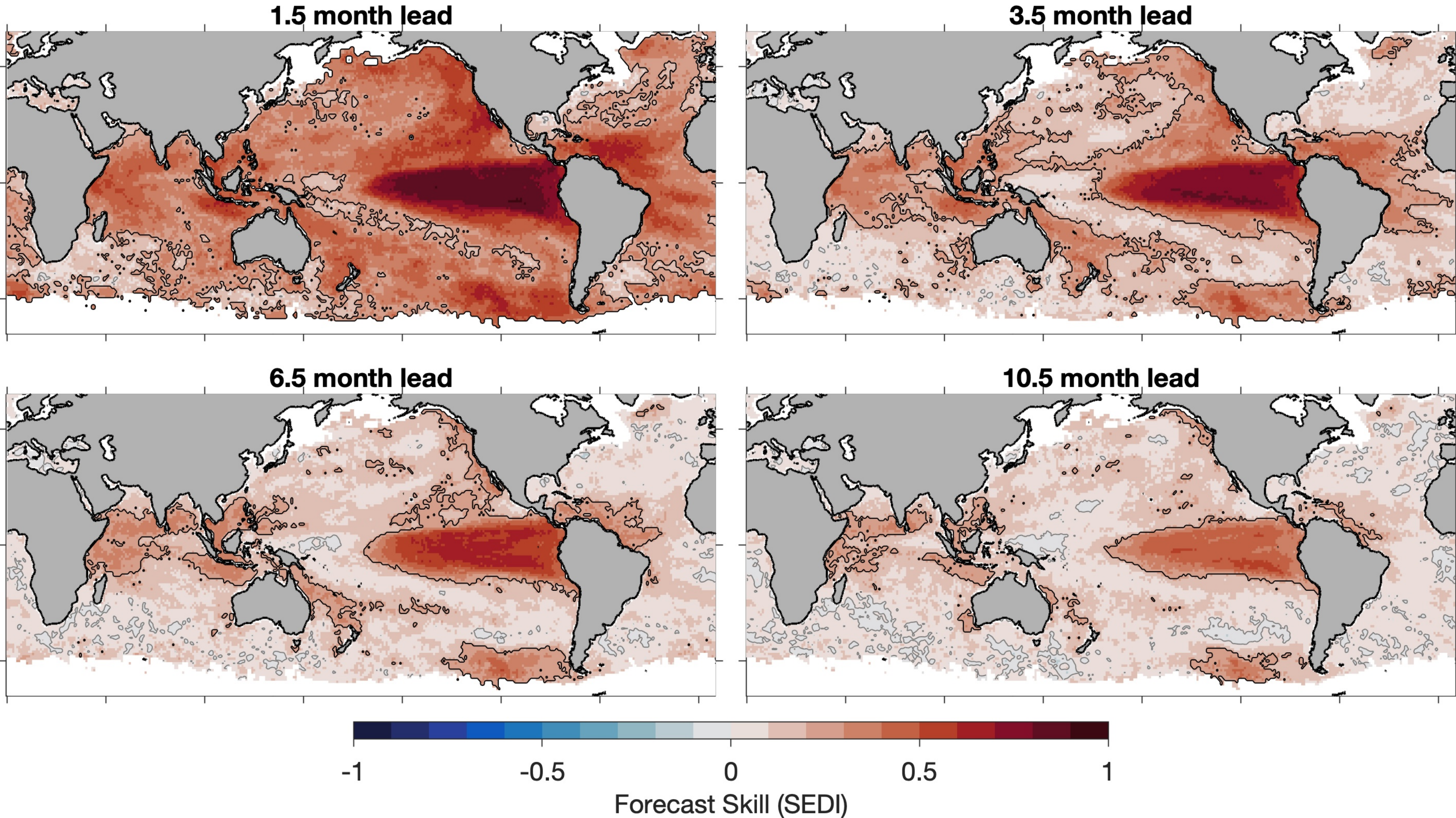


October 2013 forecast

1.5 month lead time

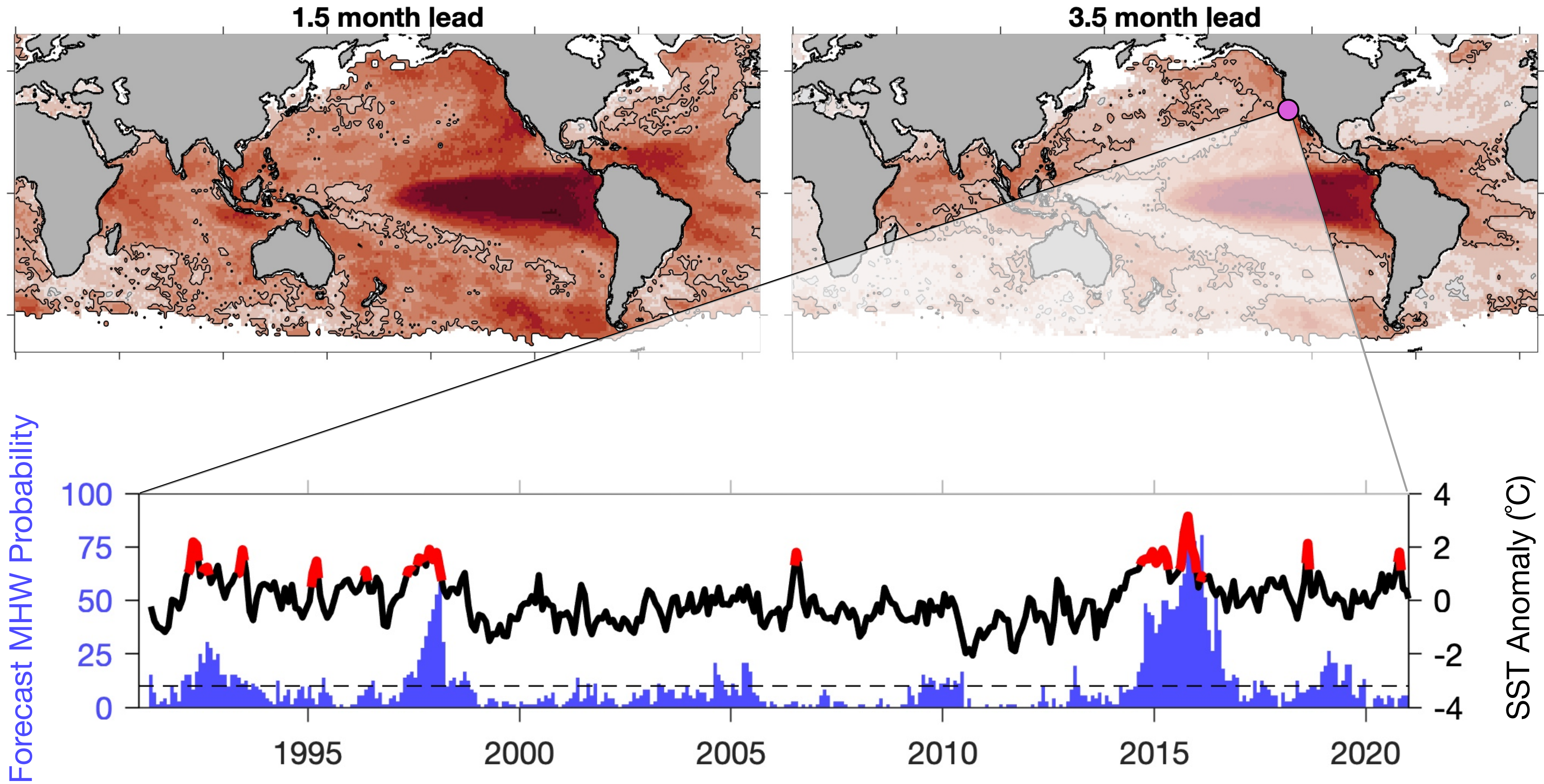
November 2013 heatwaves

Marine heatwave forecast skill



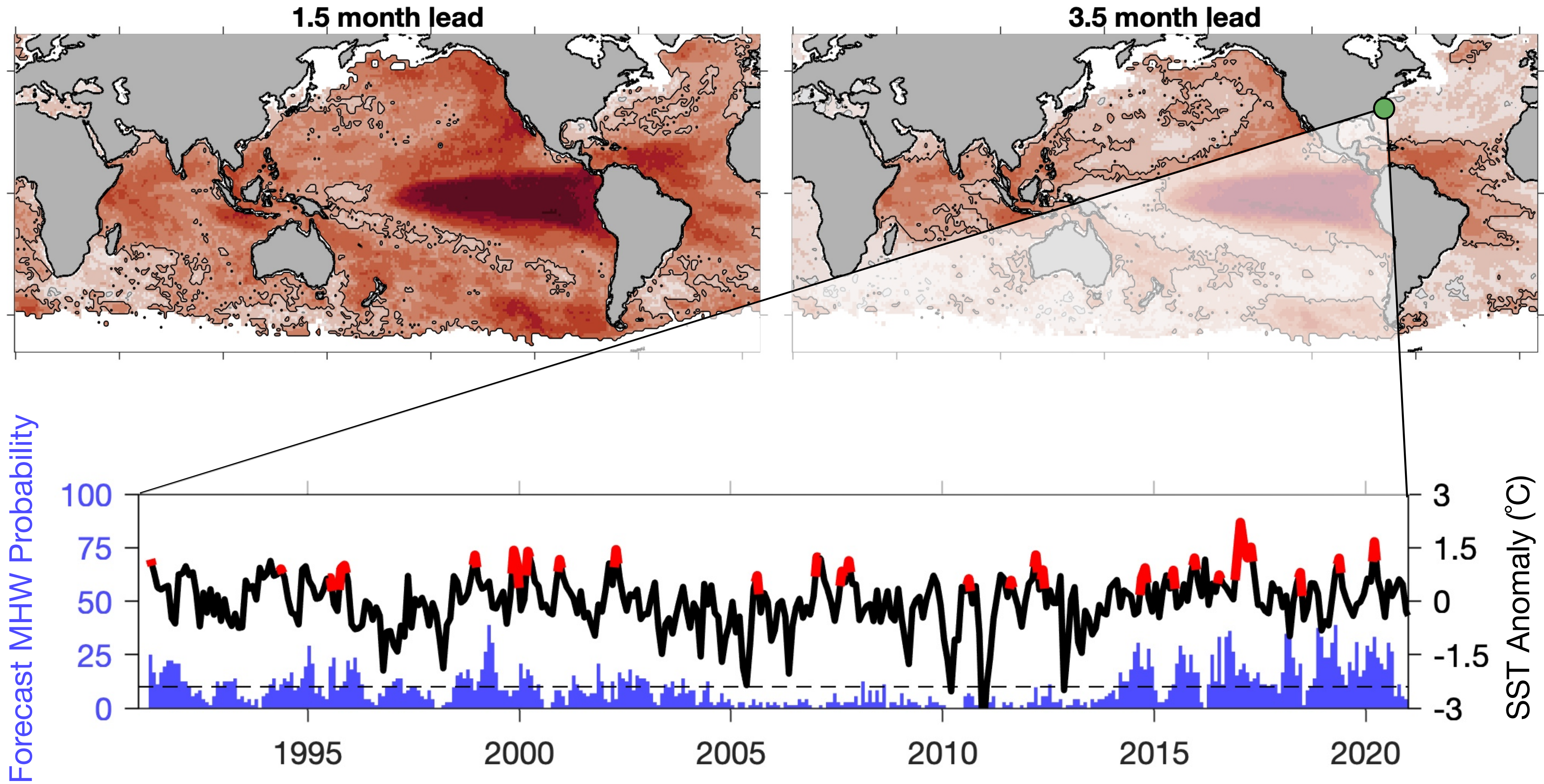
Jacox et al. (2022)

Marine heatwave forecast skill



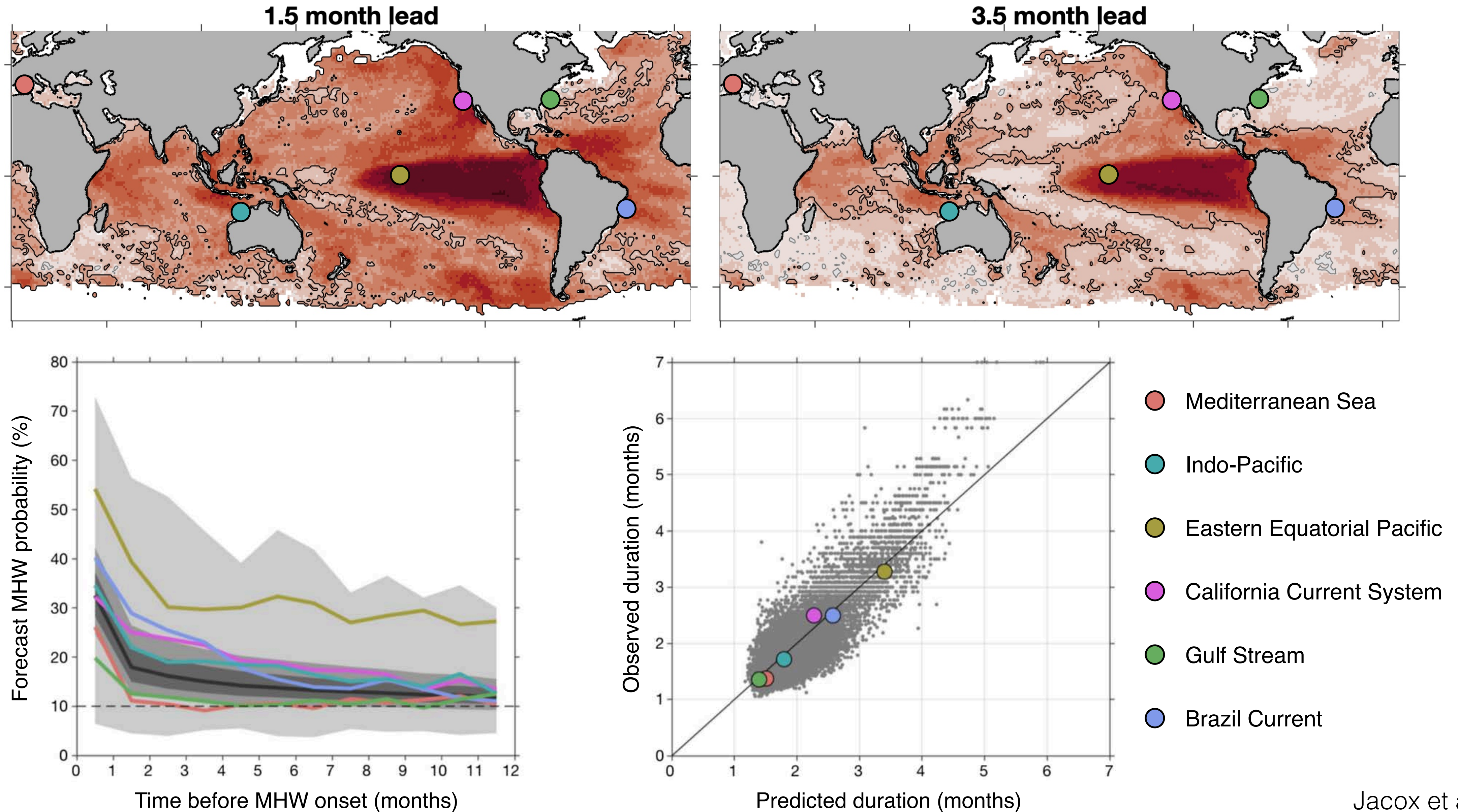
Jacox et al. (2022)

Marine heatwave forecast skill



Jacox et al. (2022)

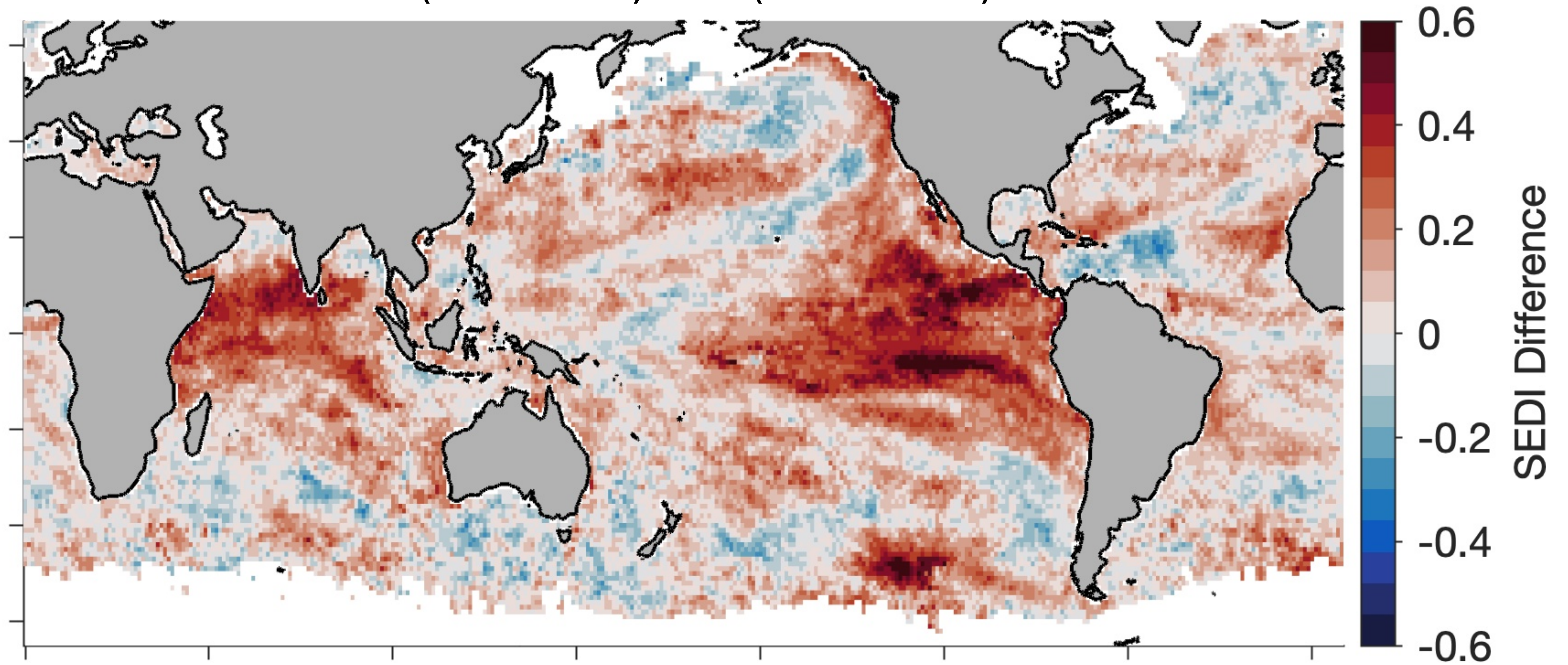
Marine heatwave forecast skill (onset and duration)



Jacox et al. (2022)

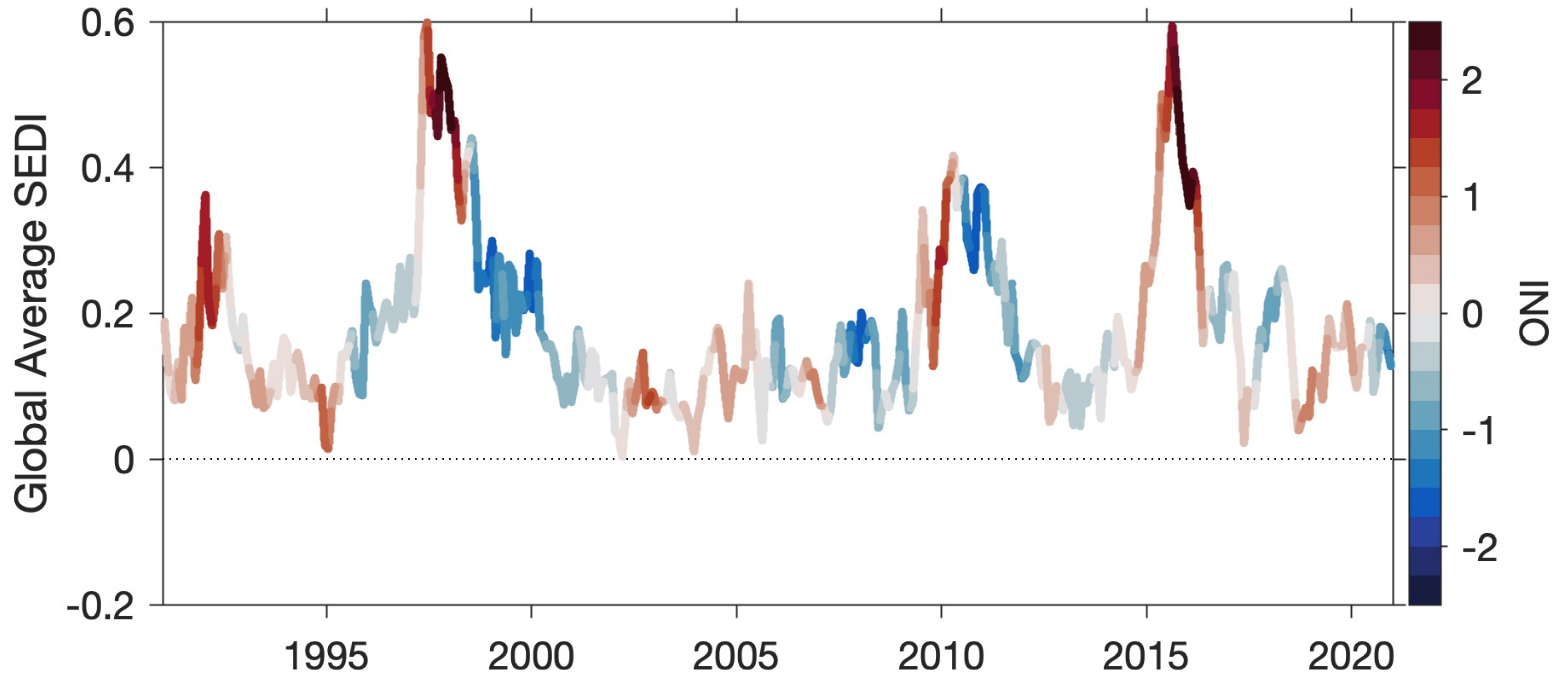
ENSO is a dominant driver of forecast skill

Skill (ENSO Active) - Skill (ENSO Neutral)



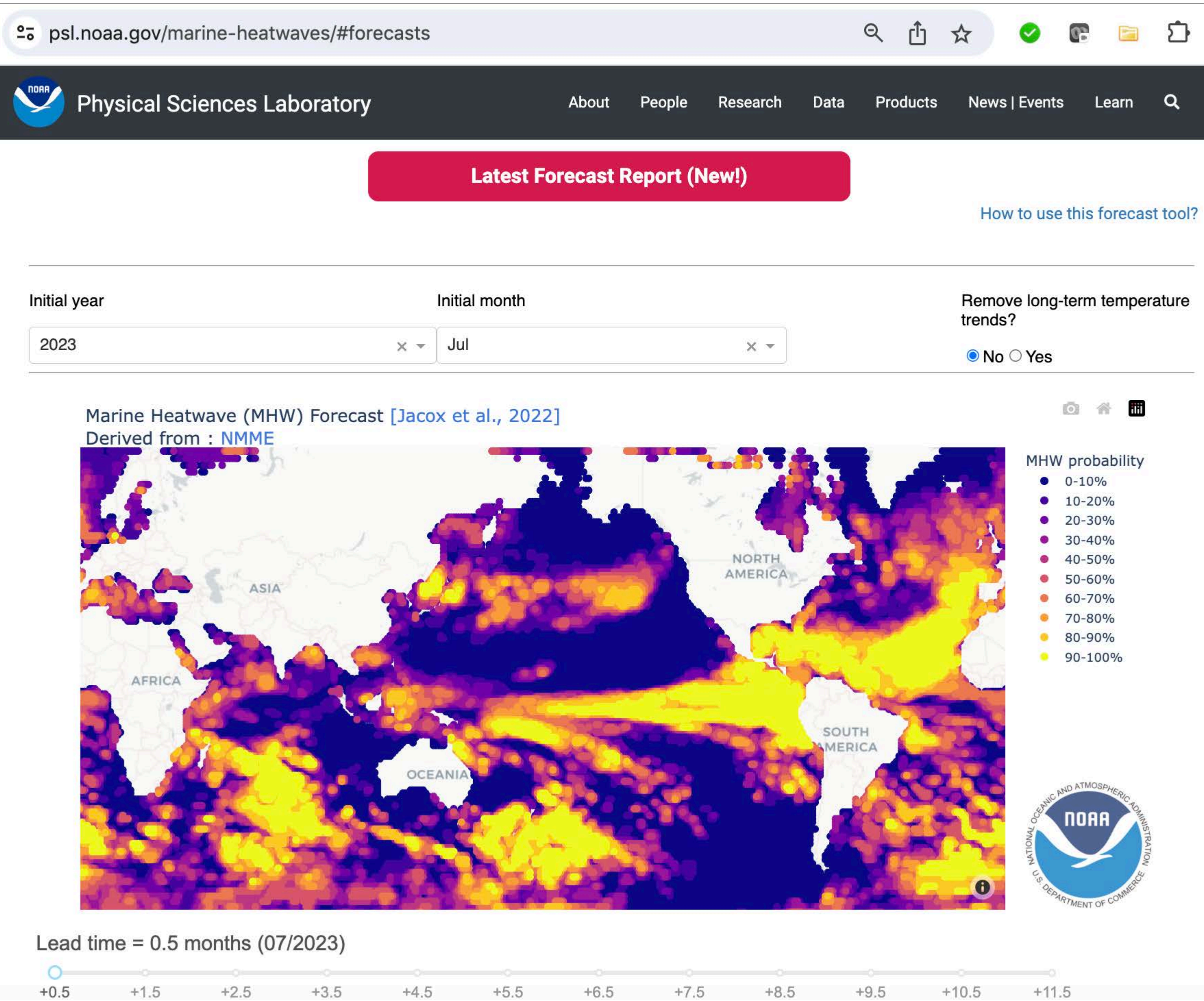
Jacox et al. (2022)

ENSO is a dominant driver of forecast skill



Jacox et al. (2022)

Web-based marine heatwave forecasts



Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

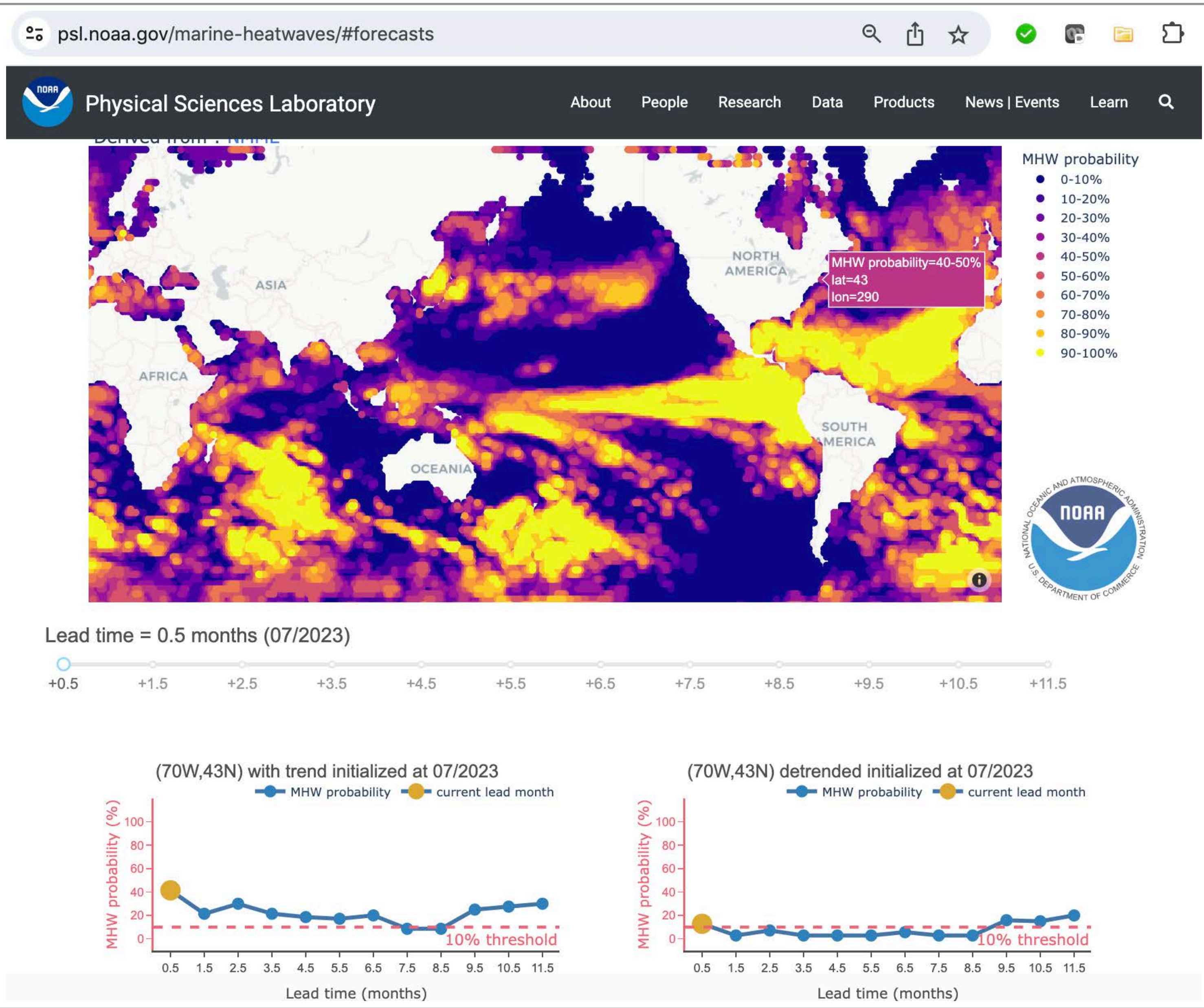
Forecasts issued monthly

Lead times up to one year

Current and past forecasts online

<https://psl.noaa.gov/marine-heatwaves>

Web-based marine heatwave forecasts



Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

Forecasts issued monthly

Lead times up to one year

Current and past forecasts online

<https://psl.noaa.gov/marine-heatwaves>

Web-based marine heatwave forecasts

The screenshot shows the NOAA Physical Sciences Laboratory website. The URL is psl.noaa.gov/marine-heatwaves/#forecasts. The page title is "Marine Heatwave Forecast Monthly Report". A prominent message states: "Marine heatwave forecasts are experimental and intended for research purposes". A button labeled "Back to the Interactive Forecasts" is visible. The forecast details are: "Forecast initial time July 2023" and "Forecast period July 2023 - June 2024". The main section is titled "Global Marine Heatwave Forecast Discussion" with a sub-note: "Observed and forecasted values include the effects of long-term warming. Values with the long-term warming trend removed are in brackets." Under "Current marine heatwave conditions:", it states: "Approximately 44% [25%] of the global ocean is currently experiencing MHWs, which ranks 1st [13th] among all months since 1991." It lists regions where MHWs are currently found: "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." Under "Marine heatwave forecasts:", it states: "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:" followed by three bullet points:

- **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.

Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

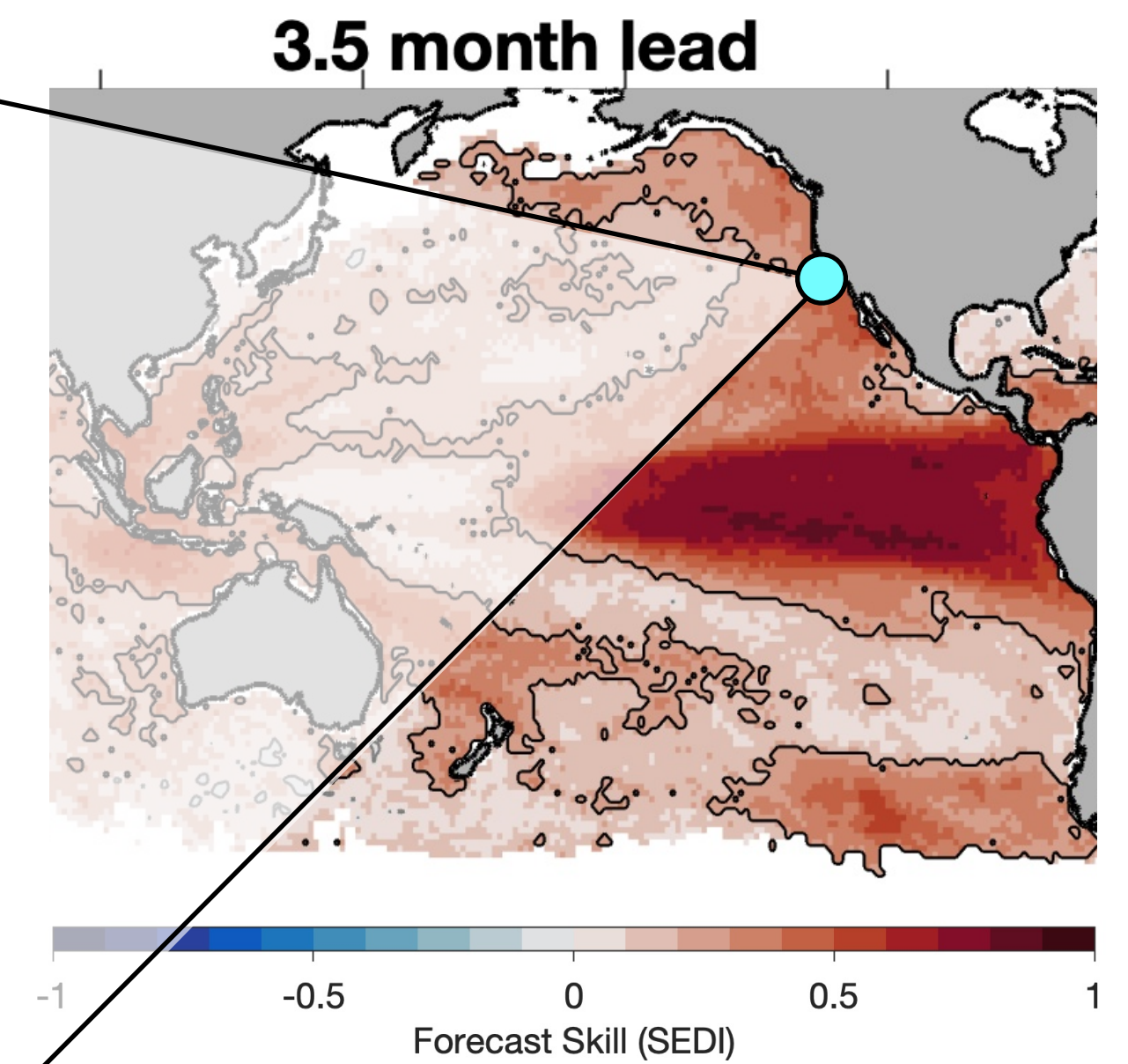
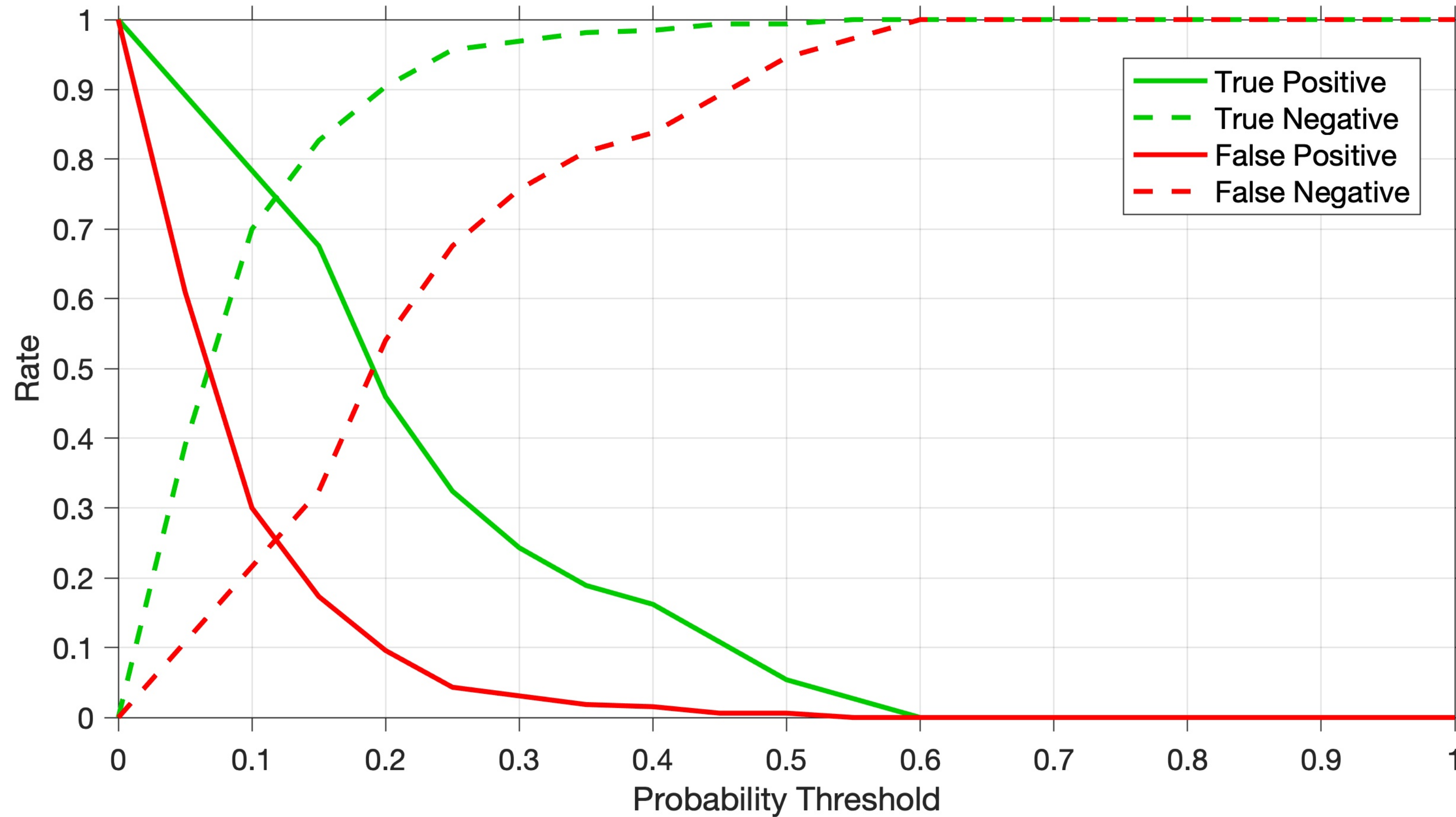
Forecasts issued monthly

Lead times up to one year

Current and past forecasts online

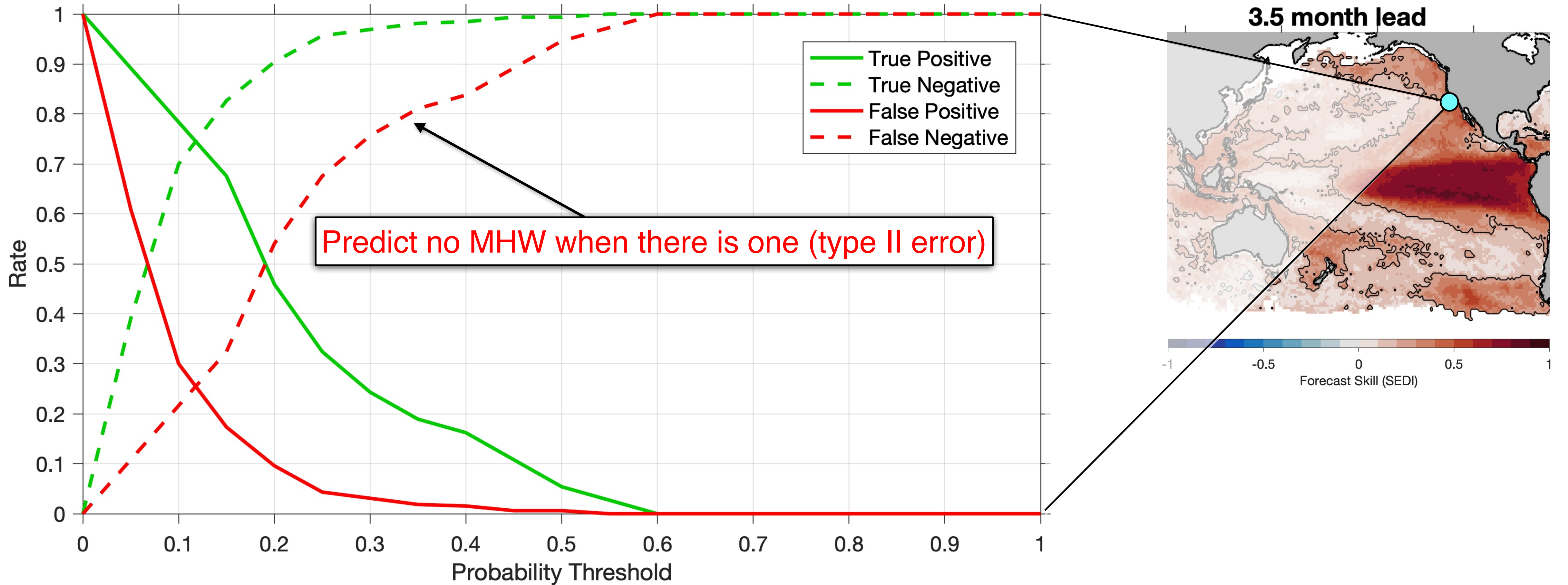
<https://psl.noaa.gov/marine-heatwaves>

Turning probability forecasts into decision thresholds



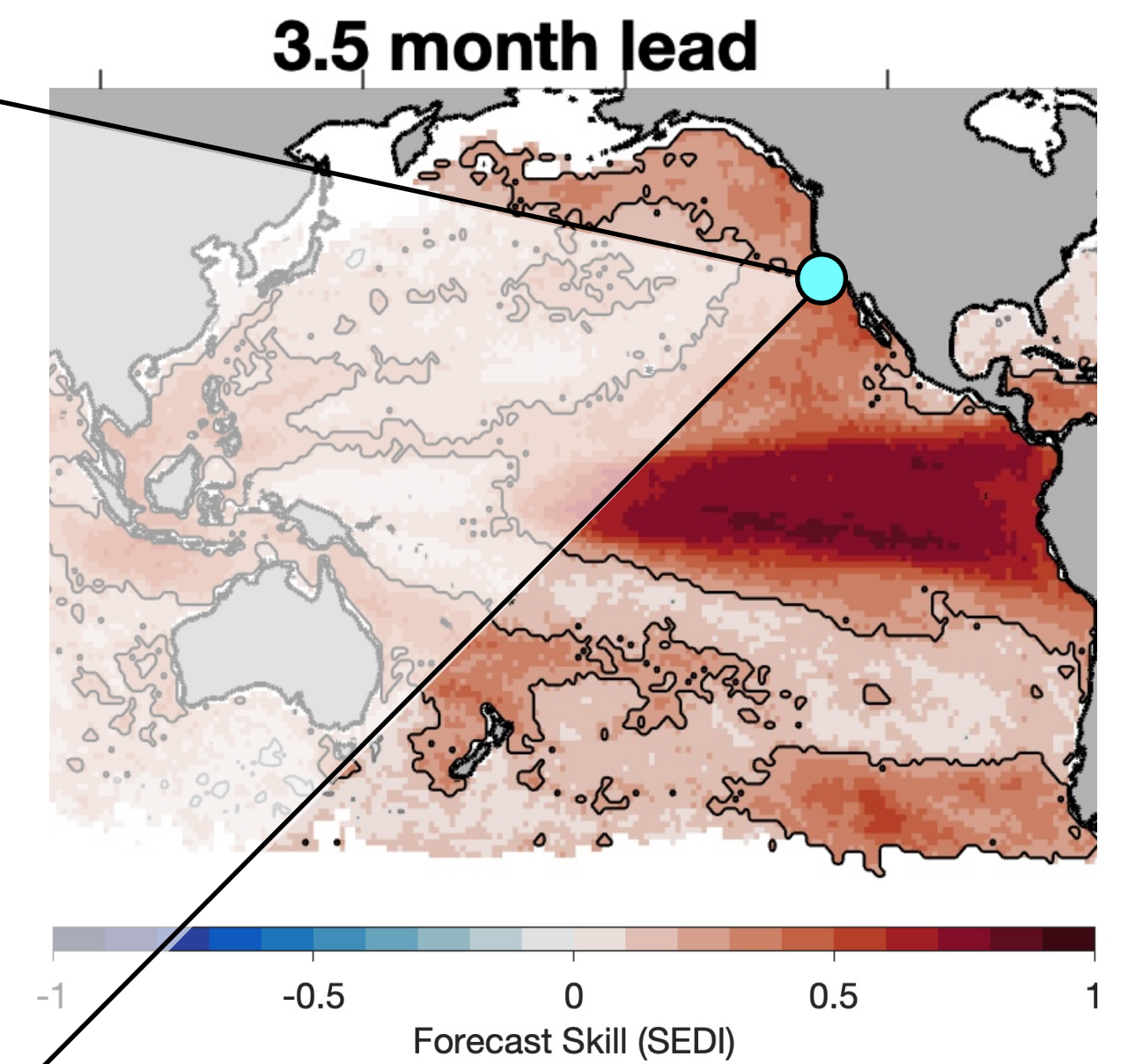
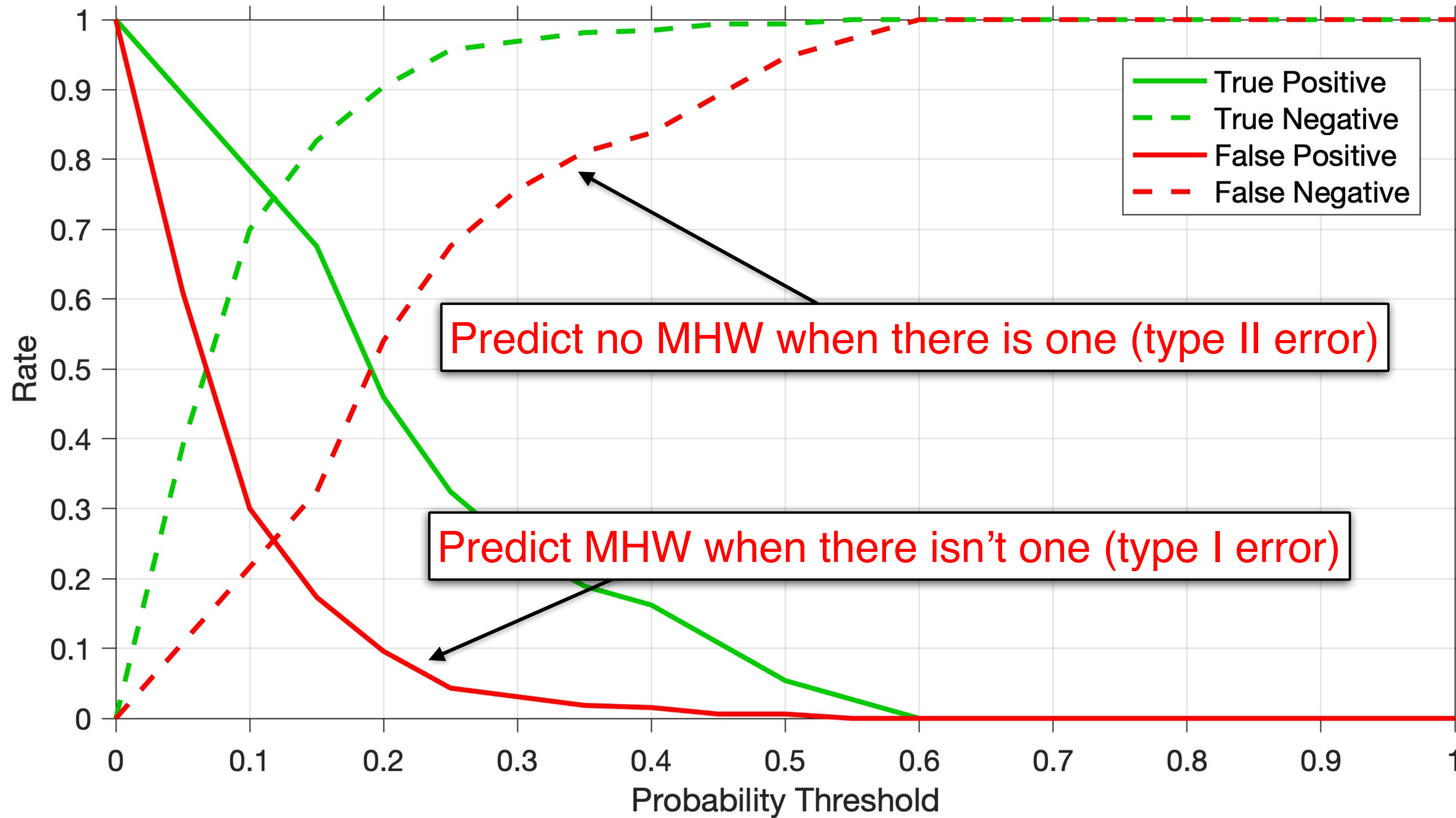
Jacox et al. (2022)

Turning probability forecasts into decision thresholds



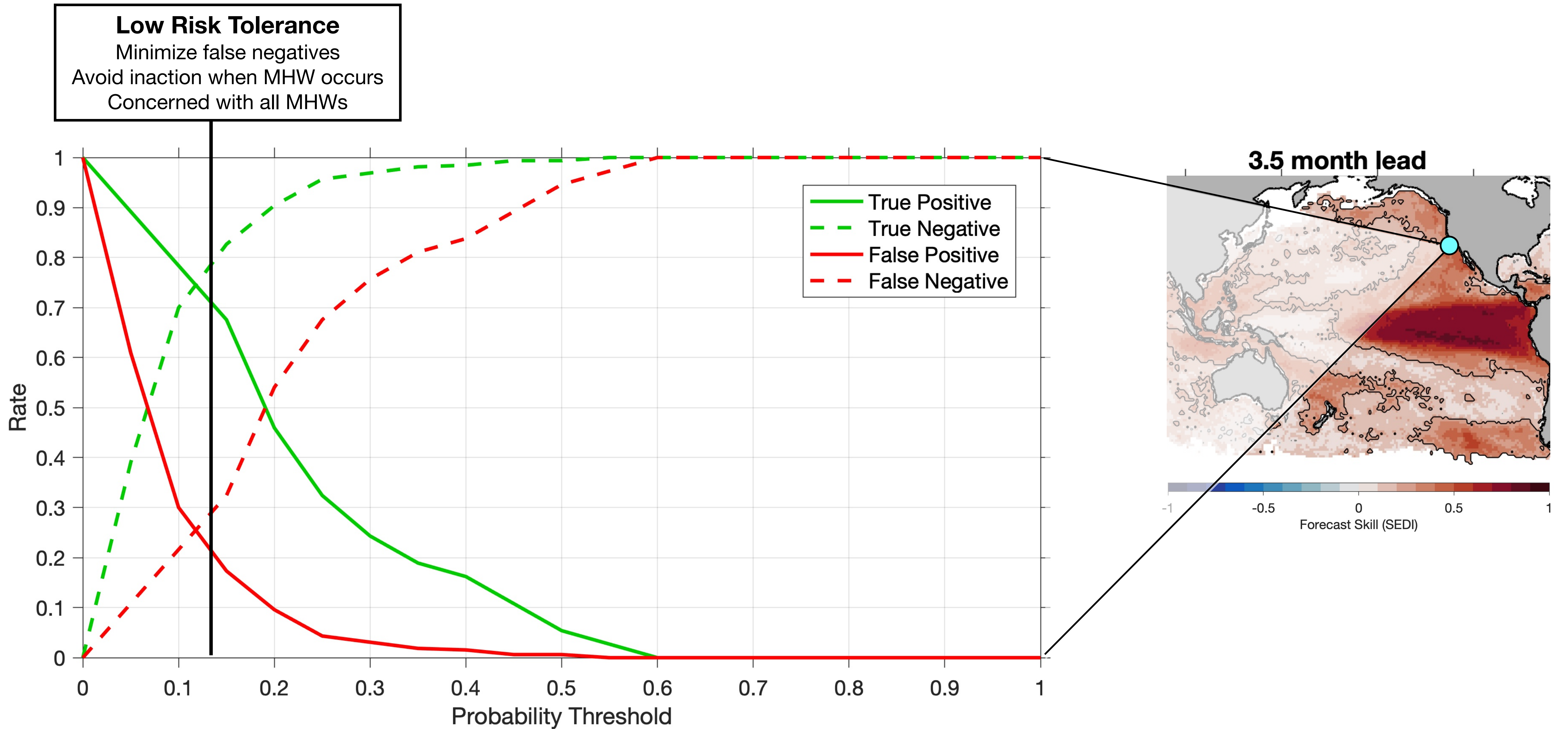
Jacox et al. (2022)

Turning probability forecasts into decision thresholds



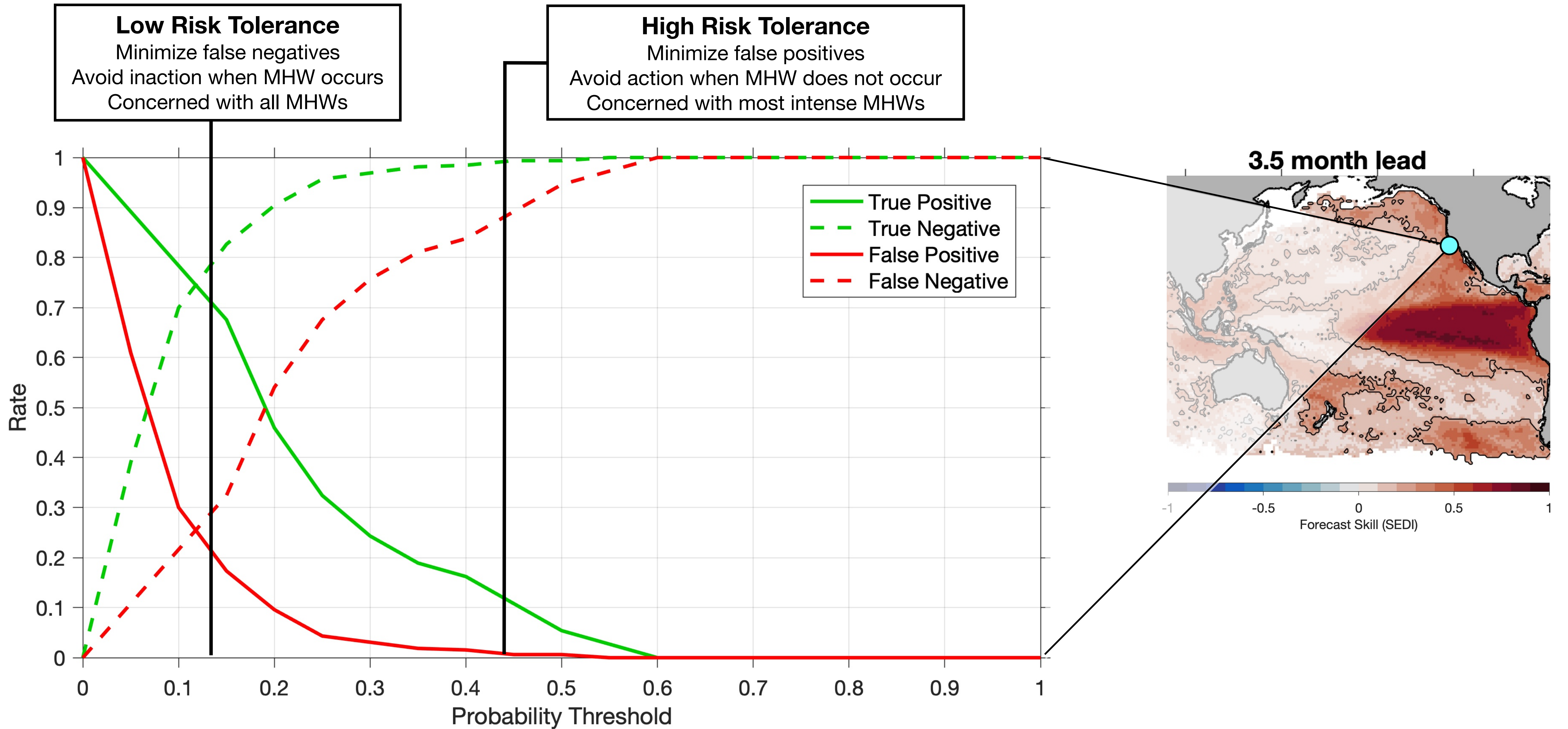
Jacox et al. (2022)

Turning probability forecasts into decision thresholds



Jacox et al. (2022)

Turning probability forecasts into decision thresholds



Jacox et al. (2022)

Tailoring forecasts for ecological thresholds

Marine Heatwaves

Loggerhead Turtle Bycatch

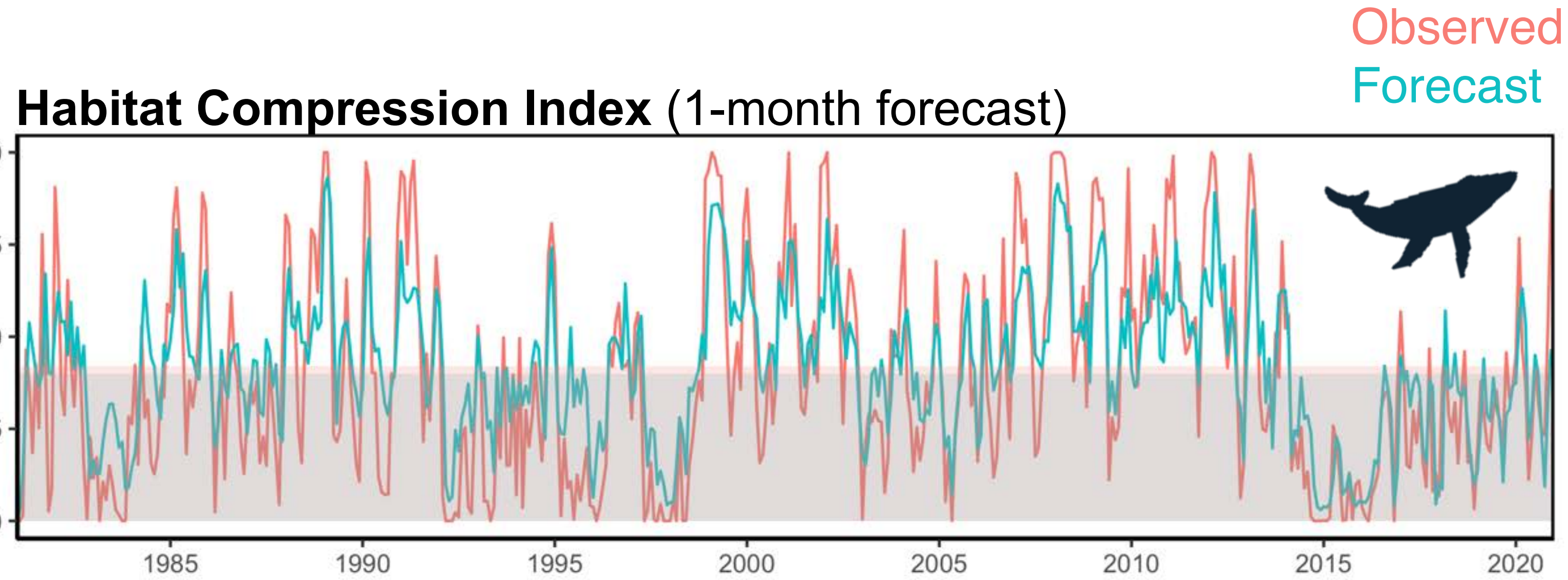
The screenshot shows the NOAA Coastwatch website for Loggerhead Turtle Bycatch. The page features a navigation bar with links for HOME, DATA ACCESS, TOOLS & TRAINING, ABOUT, PROJECTS, and QUICK LINKS. Below the navigation is the NOAA logo and the text "NOAA COASTWATCH WEST COAST REGIONAL NODE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION". A "TOTAL" section includes tabs for Background, Closure Rules, Conservation Area Status, and Data Dashboard. A large image of a loggerhead turtle swimming in the ocean is displayed, with a photo credit to Ralph Pace. Below the image, the text reads "Supporting turtle conservation and sustainable fisheries with dynamic ocean management". Three main sections are visible: "Turtle Bycatch Overview", "Conservation Area Status", and "Historical Data Dashboard".

Habitat Compression (whale entanglement)

The screenshot shows the NOAA Integrated Ecosystem Assessment website for Habitat Compression. The page features a navigation bar with links for INDICATORS, WHALE ENTANGLEMENT MAPS, and CRAB FIS. Below the navigation is the IEA logo and the text "California Current Integrated Ecosystem Assessment". A "Select data view:" section includes tabs for INDICATORS, WHALE ENTANGLEMENT MAPS, and CRAB FIS. Below this is the "Habitat Compression" section, which includes a whale icon and the text "Whale icon represents key events and environmental conditions during 2016 (tap whale for info) (Select Indicators from top left menu)". The main content area displays a line graph titled "Habitat Compression Index 35.5-40 N (fraction below monthly threshold)". The graph shows the HCI (Habitat Compression Index) from 2010 to 2020, with a y-axis ranging from 0 to 1. The graph is divided into three horizontal bands: low (green, 0.6-1.0), medium (yellow, 0.4-0.6), and high (red, 0.0-0.4). A whale icon is placed on the graph at approximately 2016, indicating a key event. The graph shows a significant increase in HCI starting around 2016, reaching a peak of 1.0 in 2020.

Brodie et al. (in review)

Tailoring forecasts for ecological thresholds



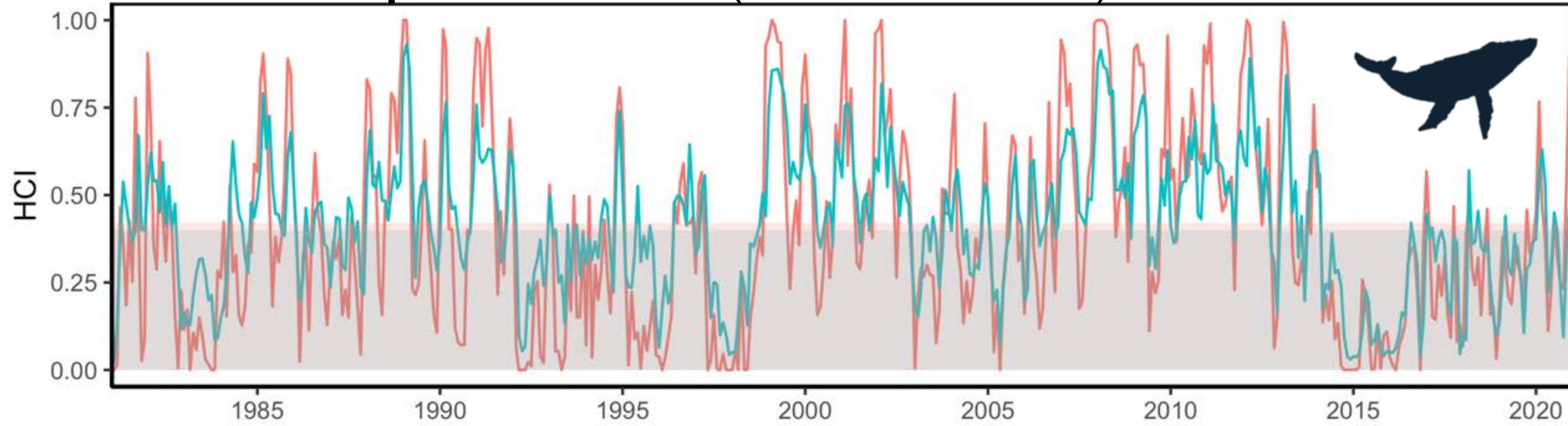
High compression in 2005 could have been predicted 1-2 months in advance.

Persistent habitat compression 2014-2016 was predictable months in advance.

Tailoring forecasts for ecological thresholds

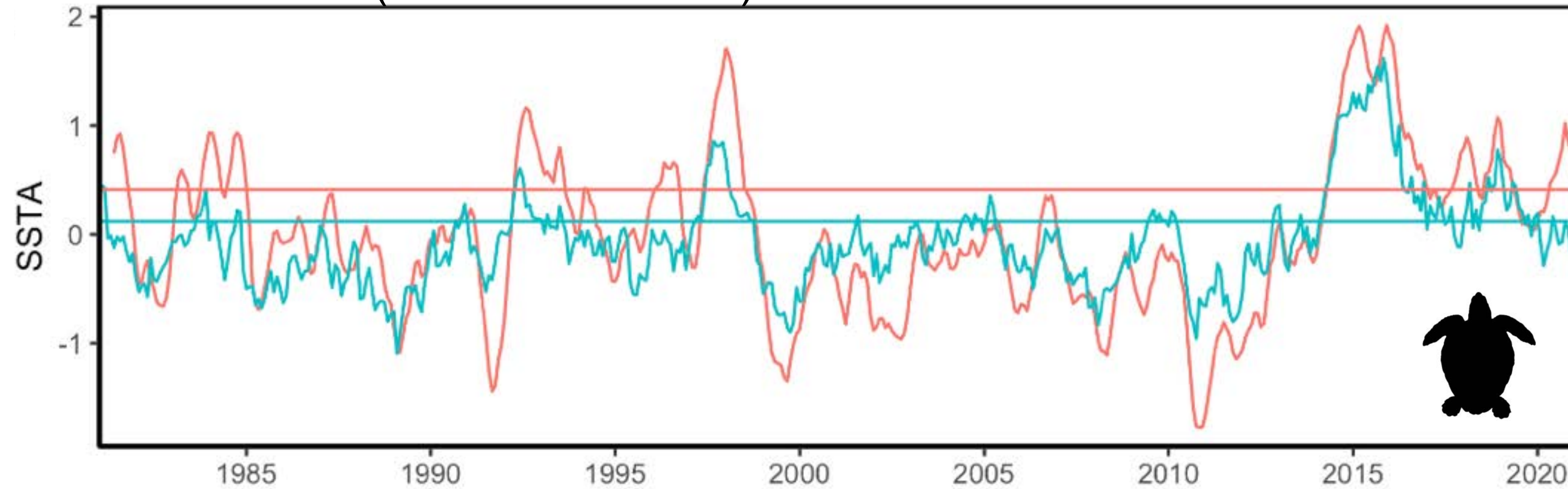
Observed
Forecast

Habitat Compression Index (1-month forecast)



Persistent habitat compression 2014-2016 was predictable months in advance.

TOTAL Tool (6-month forecast)



Fishery closures were enacted in the summers of 2015 and 2016.

These closures could have been predicted at least 6 months in advance.

Brodie et al. (in review)