

# Recent ocean conditions off the US West Coast

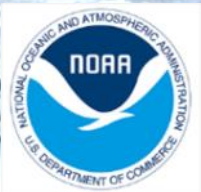
Pacific Salmon Commission, Jan 14, 2025

Laurie Weitkamp

NOAA Fisheries

Northwest Fisheries Science Center

[Laurie.Weitkamp@noaa.gov](mailto:Laurie.Weitkamp@noaa.gov)



# Today's talk

## 1. Physical environment drivers

- Global temperatures
- El Niño/La Niña
- Marine heat waves

## 2. Biological response

- Stoplight chart
- Columbia salmon forecasts
- Other observations

## 3. Forecasts

- El Niño/La Niña
- Sea surface temperatures



# **1. Physical environment drivers**



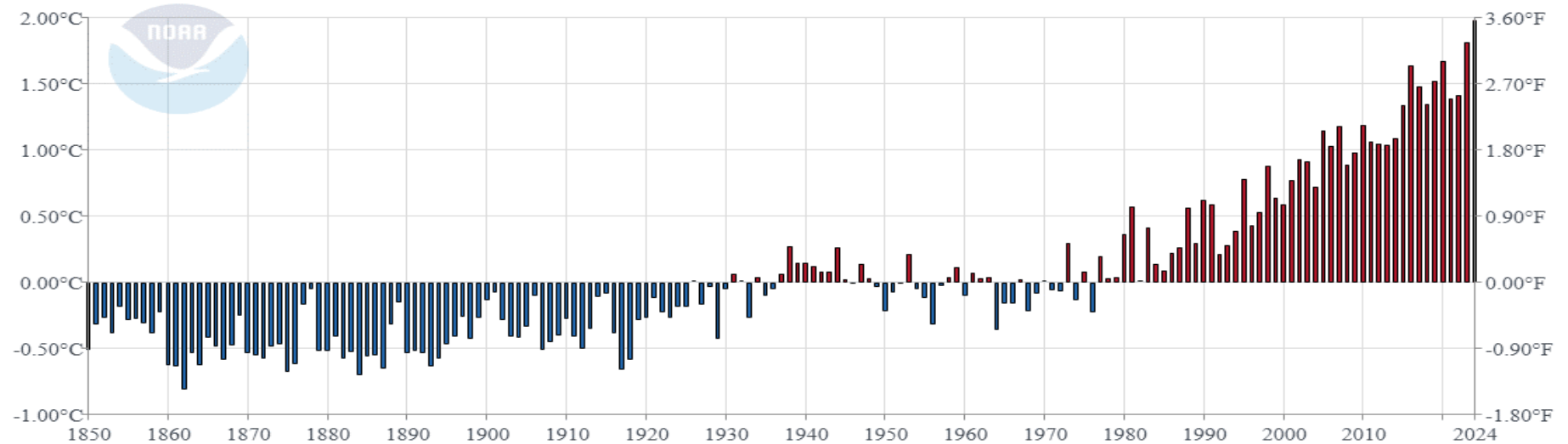
**Global temperatures**

**El Niño/La Niña**

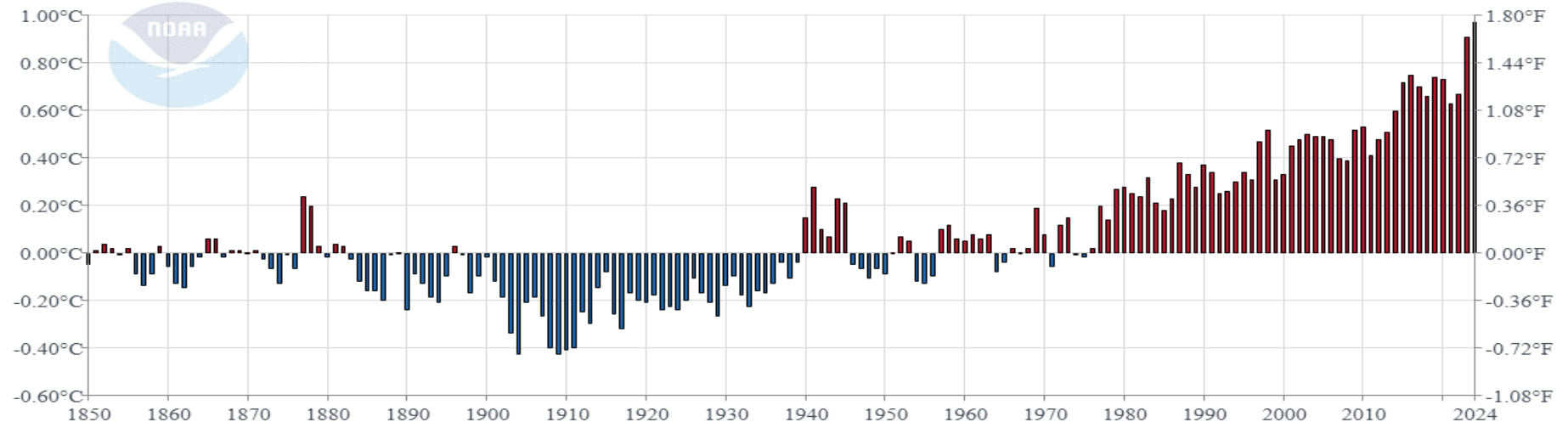
**Marine heat waves**

# Global temperatures: 2024 was the warmest year on record

Global Land  
(Jan-Dec)



Global Ocean  
(Jan-Dec)

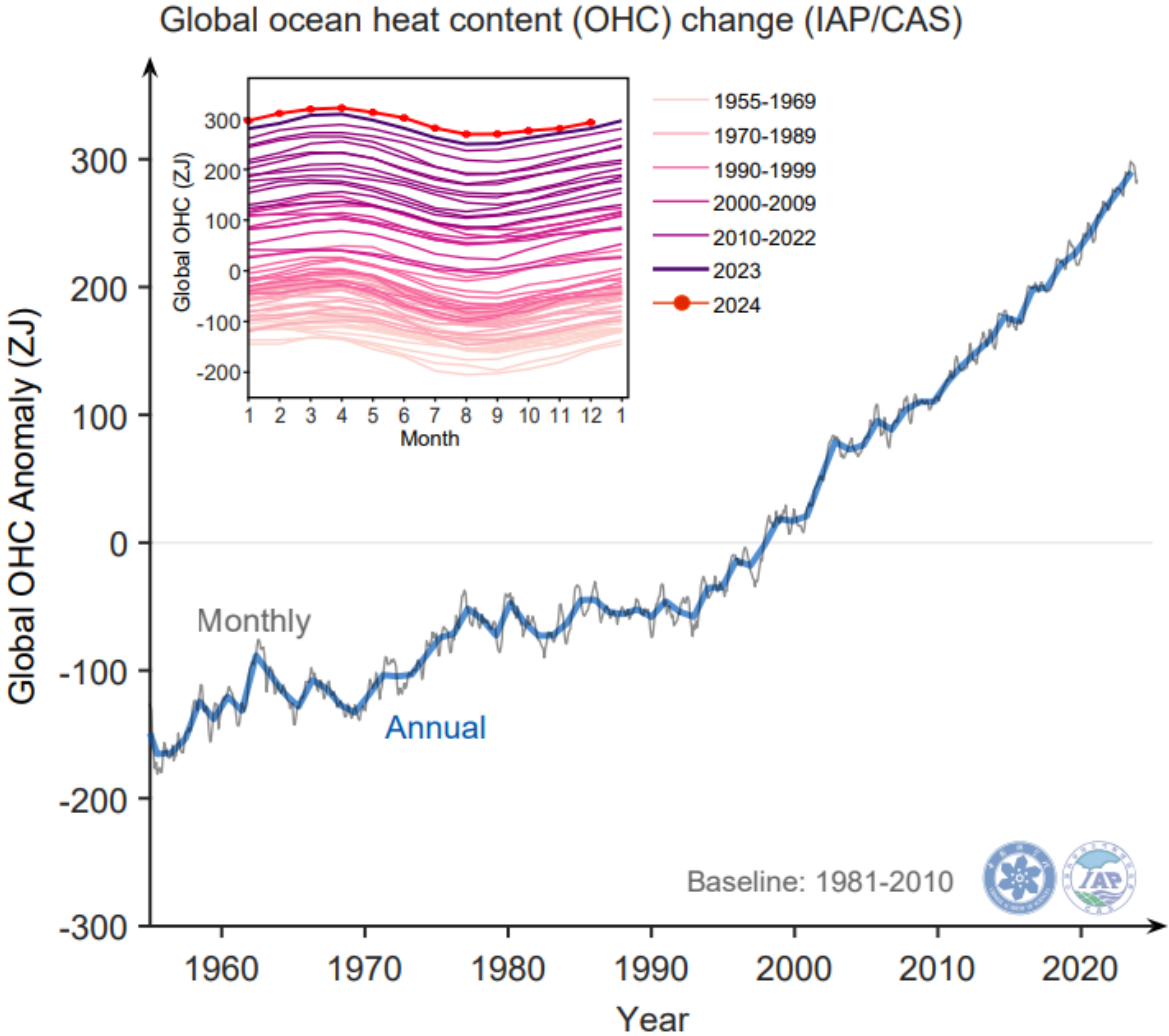


• Original Paper •

### Record High Temperatures in the Ocean in 2024

Lijing CHENG<sup>1</sup>, John ABRAHAM<sup>2</sup>, Kevin E. TRENBERTH<sup>3,4</sup>, James REAGAN<sup>5</sup>, Huai-Min ZHANG<sup>6</sup>, Andrea STORTO<sup>7</sup>, Karina VON SCHUCKMANN<sup>8</sup>, Yuying PAN<sup>1</sup>, Yujing ZHU<sup>1</sup>, Michael E. MANN<sup>9</sup>, Jiang ZHU<sup>1,2</sup>, Fan WANG<sup>10</sup>, Fujiang YU<sup>11</sup>, Ricardo LOCARNINI<sup>5</sup>, John FASULLO<sup>3</sup>, Boyin HUANG<sup>6</sup>, Garrett GRAHAM<sup>12</sup>, Xungang YIN<sup>6</sup>, Viktor GOURETSKI<sup>1</sup>, Fei ZHENG<sup>1</sup>, Yuanlong LI<sup>10</sup>, Bin ZHANG<sup>10,13</sup>, Liying WAN<sup>11</sup>, Xingrong CHEN<sup>11</sup>, Dakui WANG<sup>11</sup>, Licheng FENG<sup>11</sup>, Xiangzhou SONG<sup>14</sup>, Yulong LIU<sup>15</sup>, Franco RESEGNETTI<sup>16</sup>, Simona SIMONCELLI<sup>16</sup>, Gengxin CHEN<sup>17</sup>, Rongwang ZHANG<sup>17</sup>, Alexey MISHONOV<sup>5,18</sup>, Zhetao TAN<sup>1</sup>, Wangxu WEI<sup>1</sup>, Huifeng YUAN<sup>19</sup>, Guancheng LI<sup>20</sup>, Qiuping REN<sup>10</sup>, Lijuan CAO<sup>21</sup>, Yayang LU<sup>22</sup>, Juan DU<sup>1</sup>, Kewei LYU<sup>23</sup>, Albertus SULAIMAN<sup>24</sup>, Michael MAYER<sup>25,26</sup>, Huizhan WANG<sup>27</sup>, Zhanhong MA<sup>27</sup>, Senliang BAO<sup>27</sup>, Henqian YAN<sup>27</sup>, Zenghong LIU<sup>28</sup>, Chunxue YANG<sup>7</sup>, Xu LIU<sup>11</sup>, Zeke HAUSFATHER<sup>29</sup>, Tanguy SZEKELY<sup>30</sup>, and Flora GUES<sup>31</sup>

Ocean heat content reached  
record high in 2024,  
increasing at all depths  
(graph = top 2000m)



## nature climate change

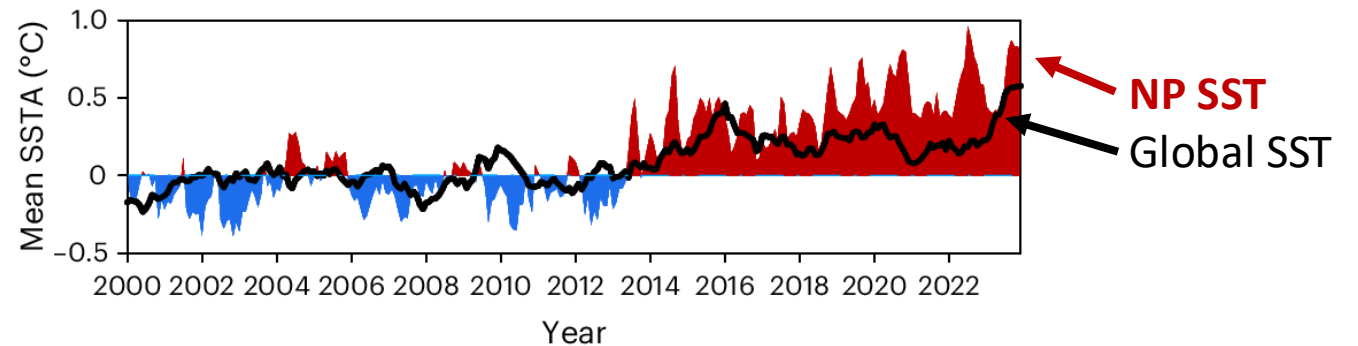
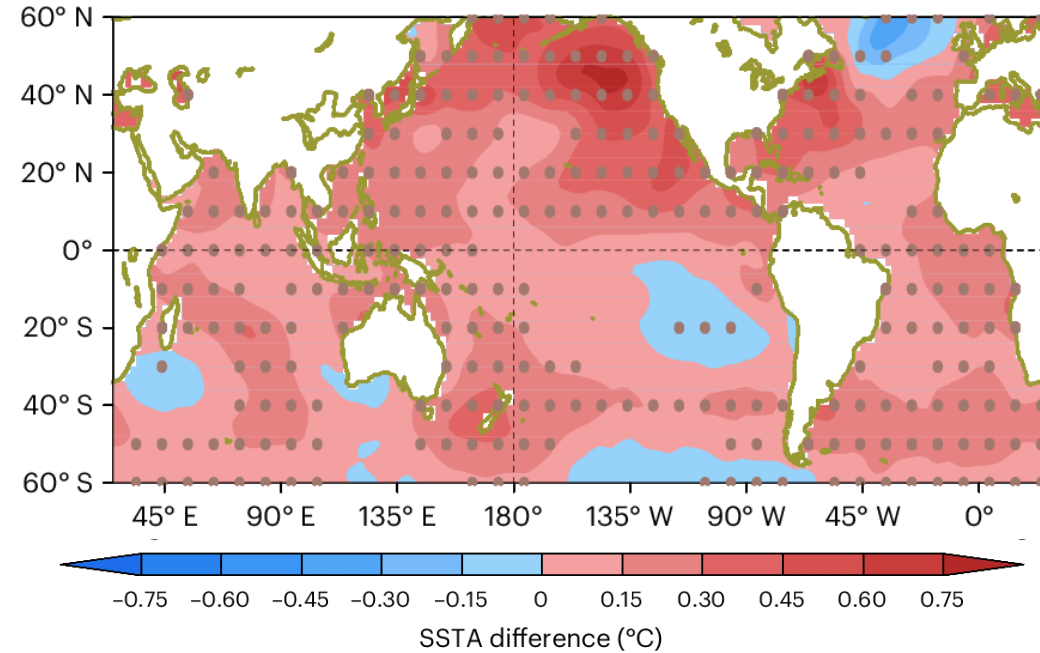
Brief Communication | Published: 23 July 2024

# Accelerated warming in the North Pacific since 2013

[Zeng-Zhen Hu](#) , [Michael J. McPhaden](#), [Boyin Huang](#), [Jieshun Zhu](#) & [Yunyun Liu](#)

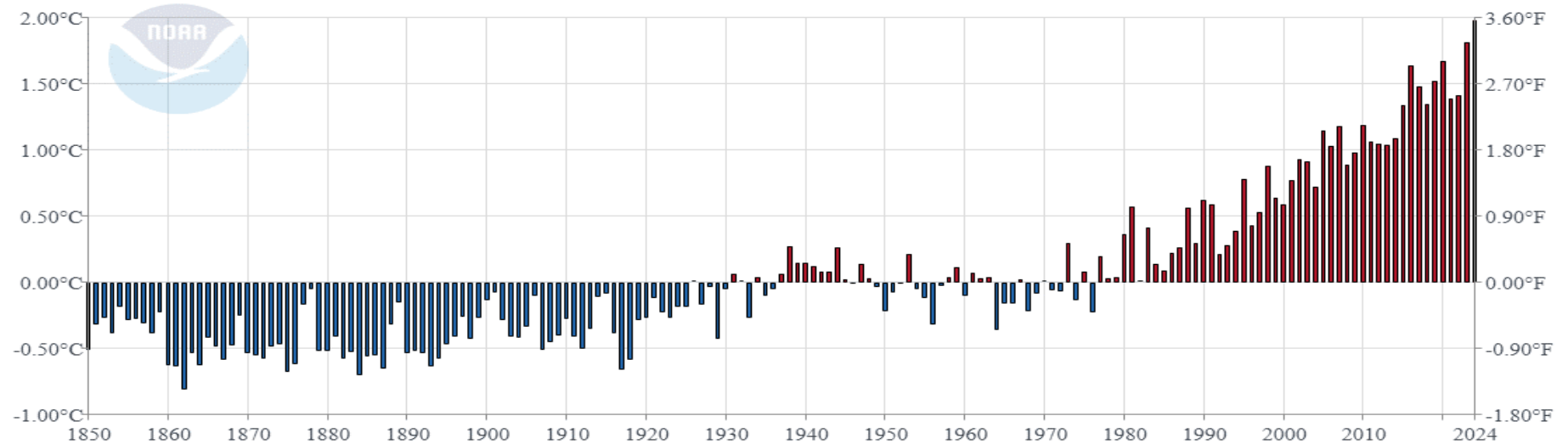
[Nature Climate Change](#) **14**, 929–931 (2024) | [Cite this article](#)

From 2013-2023 warming in the North Pacific was significantly higher than in other basins.

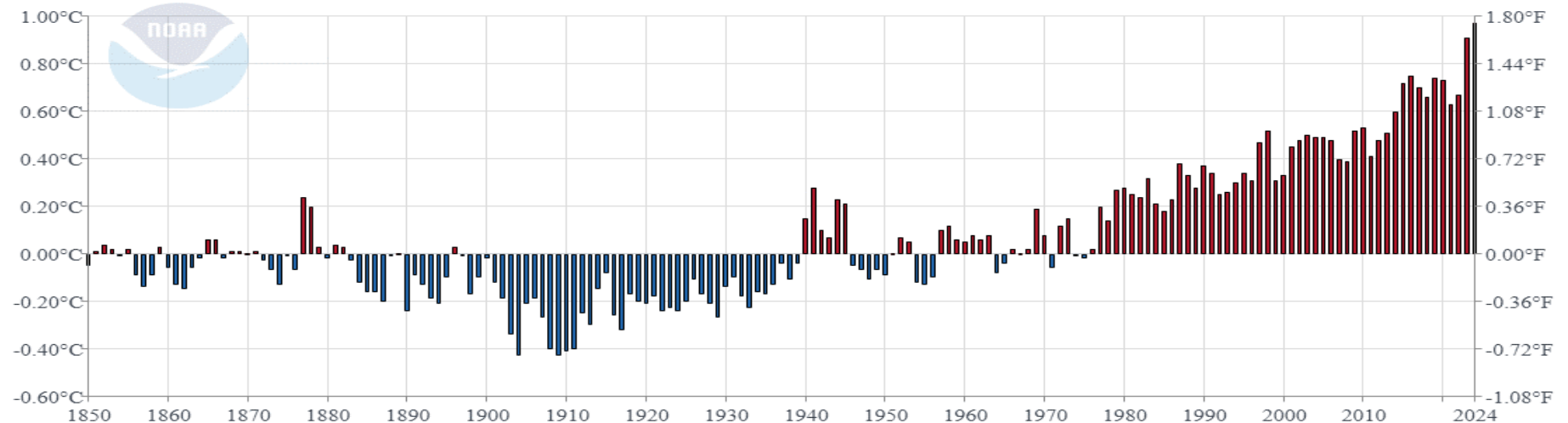


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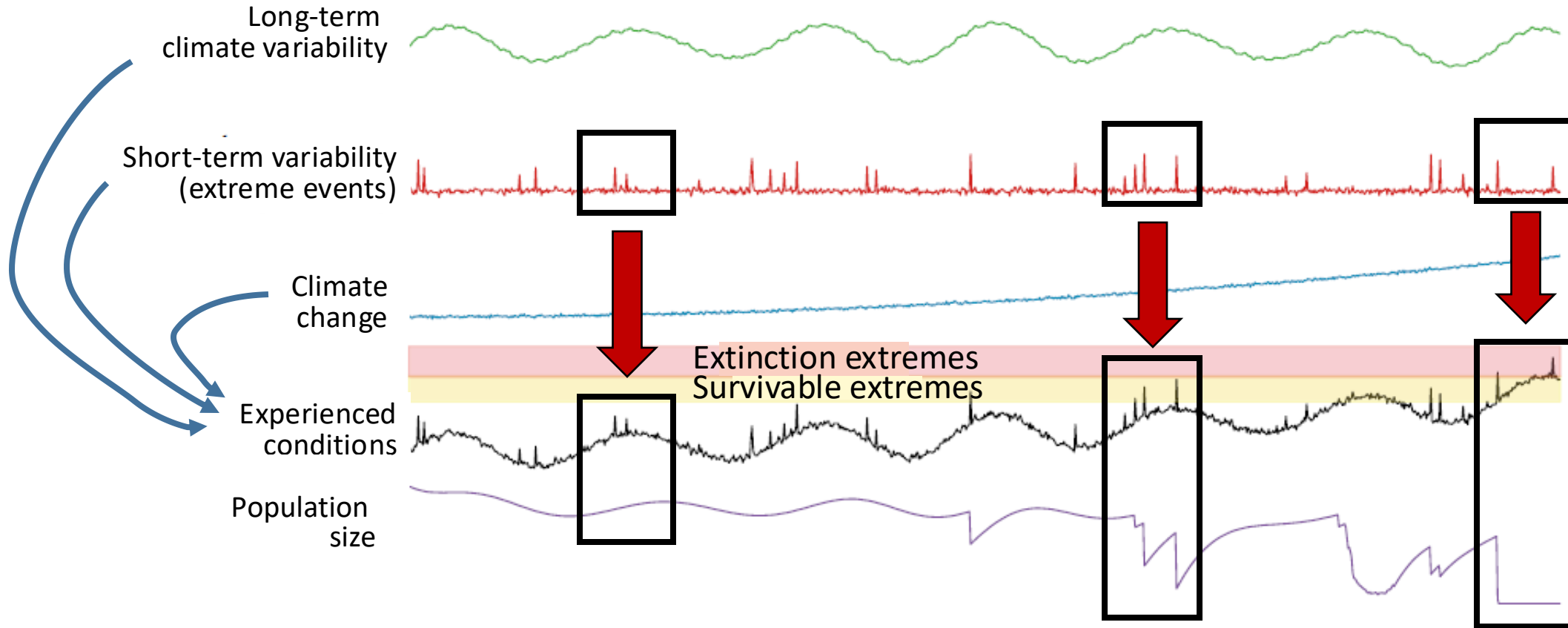


Global Ocean  
(Jan-Dec)



# Aside: “Press and pulse” of climate change

Press = gradual changes      Pulse = short term (extreme events)

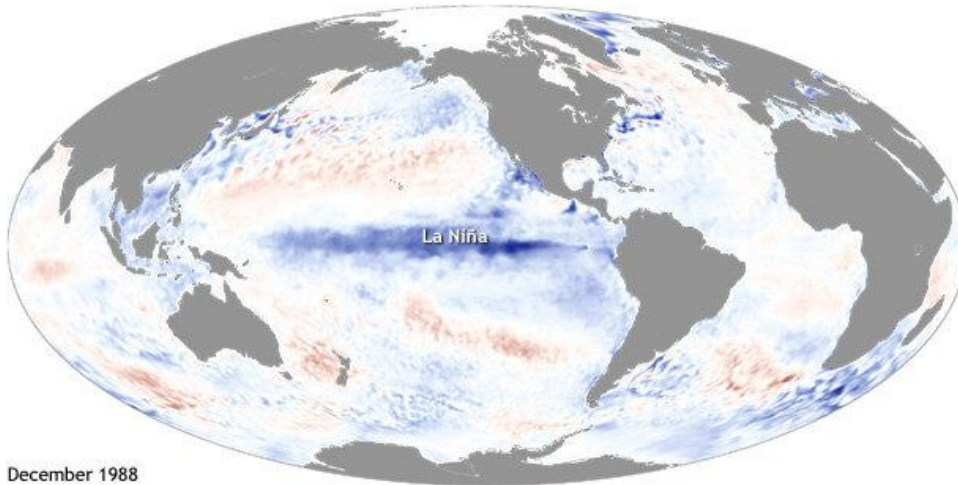


Harris et al. 2018. Biological responses to the press and pulse of climate trends and extreme events. *Nature Climate Change* 8:579–587. <https://doi.org/10.1038/s41558-018-0187-9>

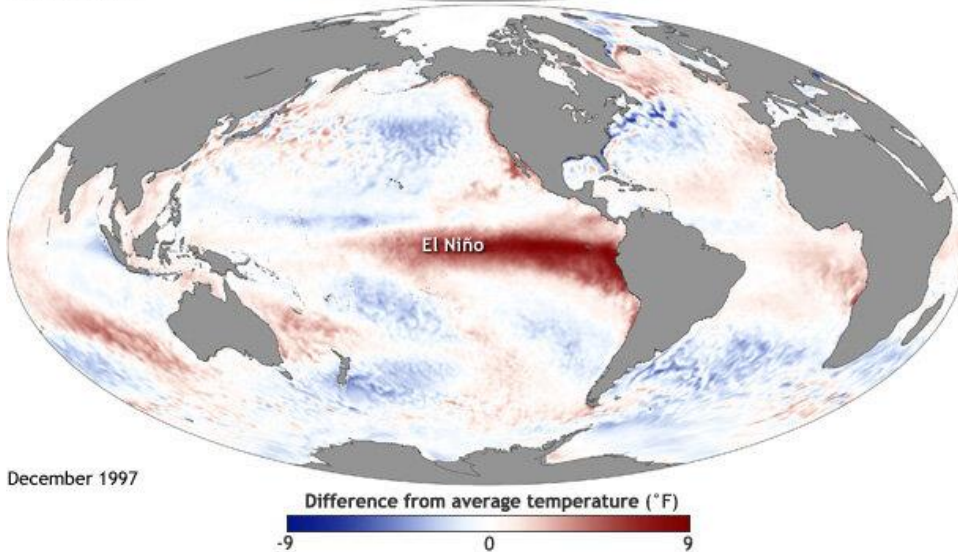
# El Niños/La Niñas

El Niños and La Niñas are tropical phenomena that impact global weather

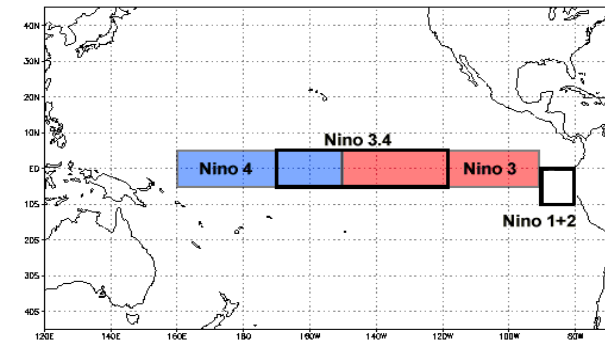
**La Niña**



**El Niño**



Measured in the Niño 3.4 area:



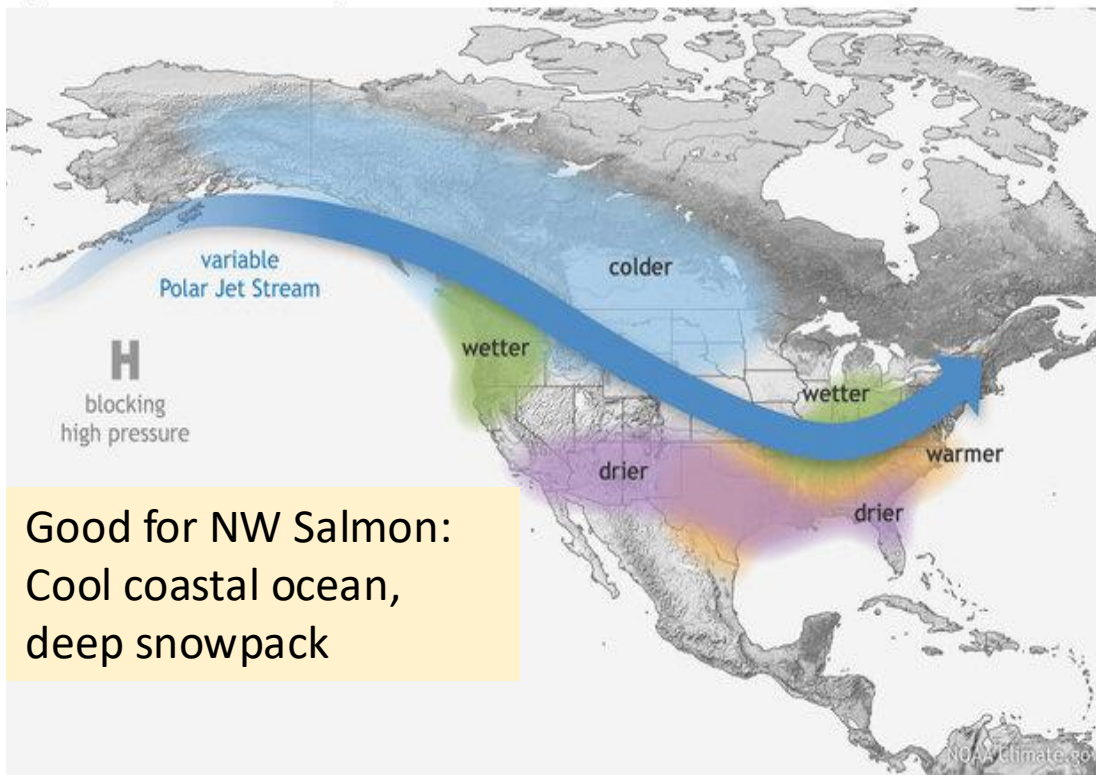
SST Anomalies above +0.5 (El Niño)  
or below -0.5 (La Niña) for specified  
amount of time

<https://www.climate.gov/enso>

# Typical El Niño/La Niña patterns in N. America

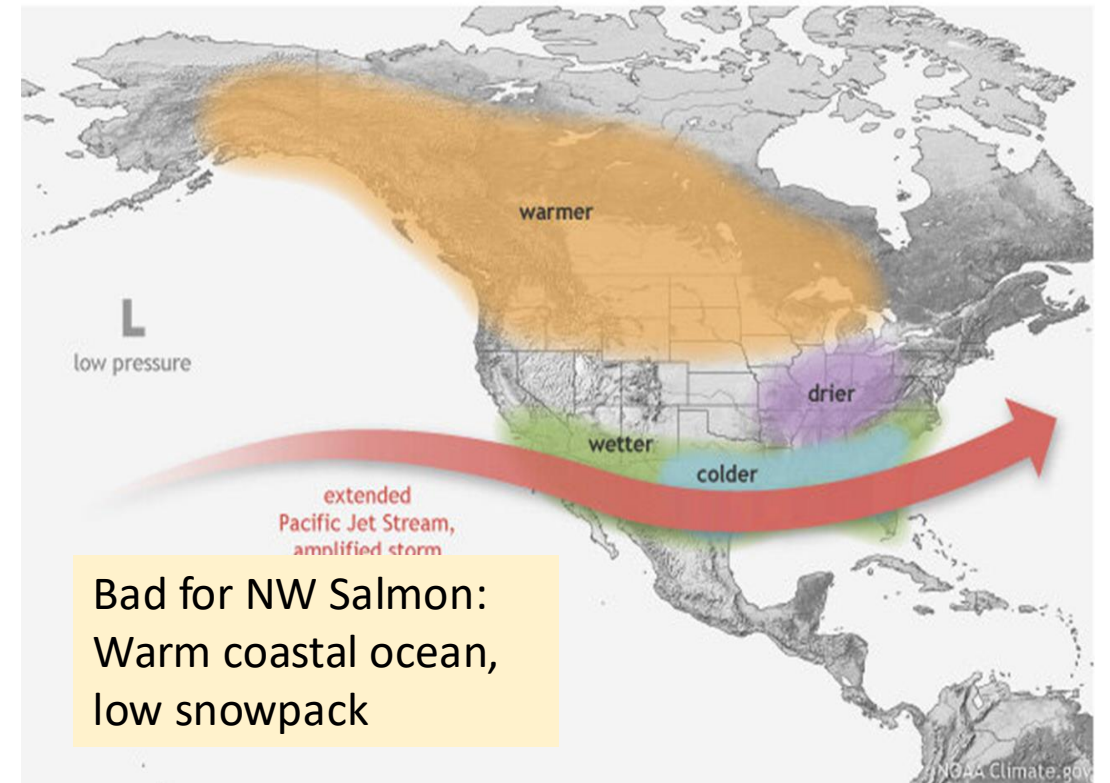
## La Niña

Typical winter La Niña pattern

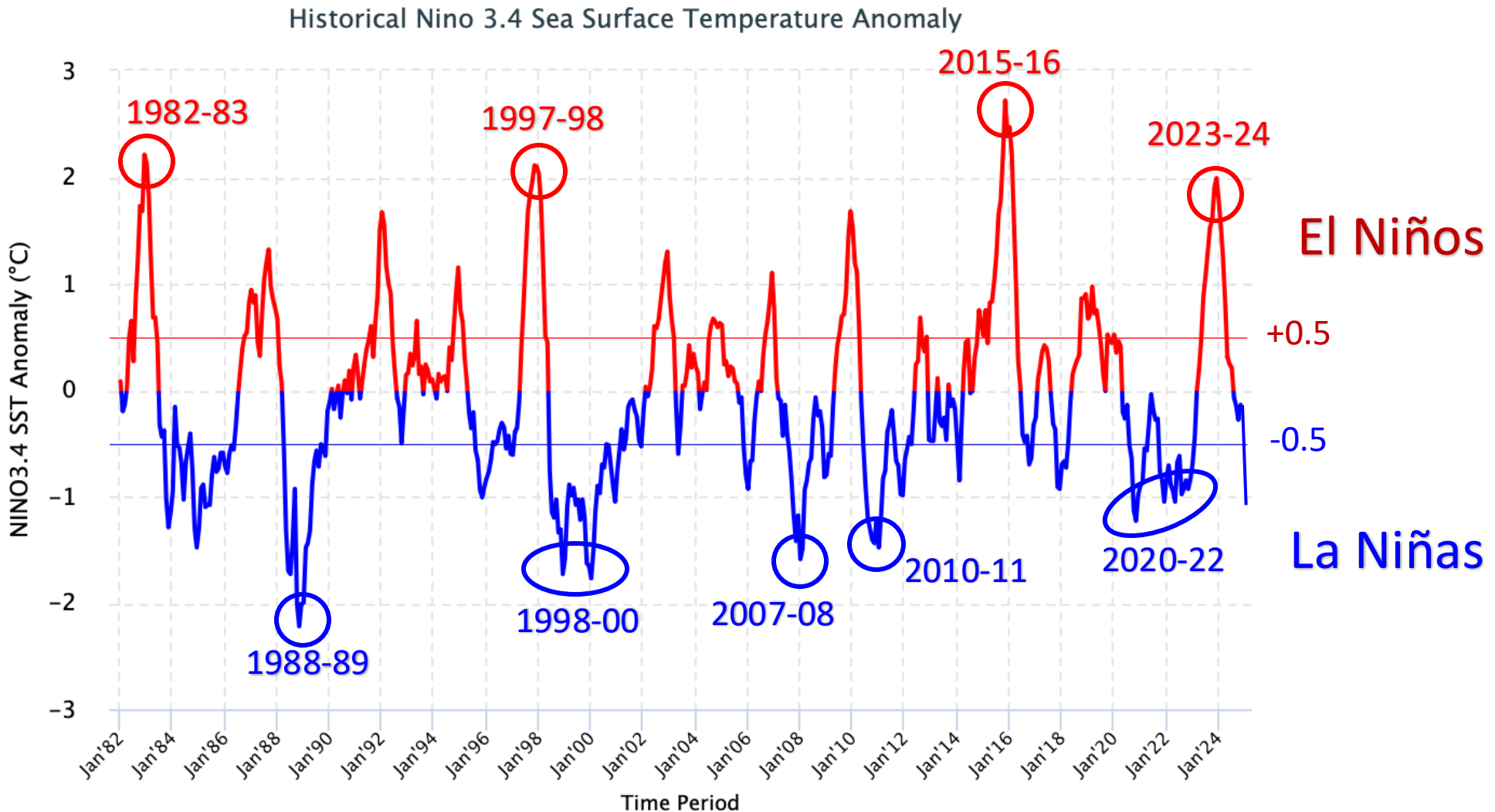


## El Niño

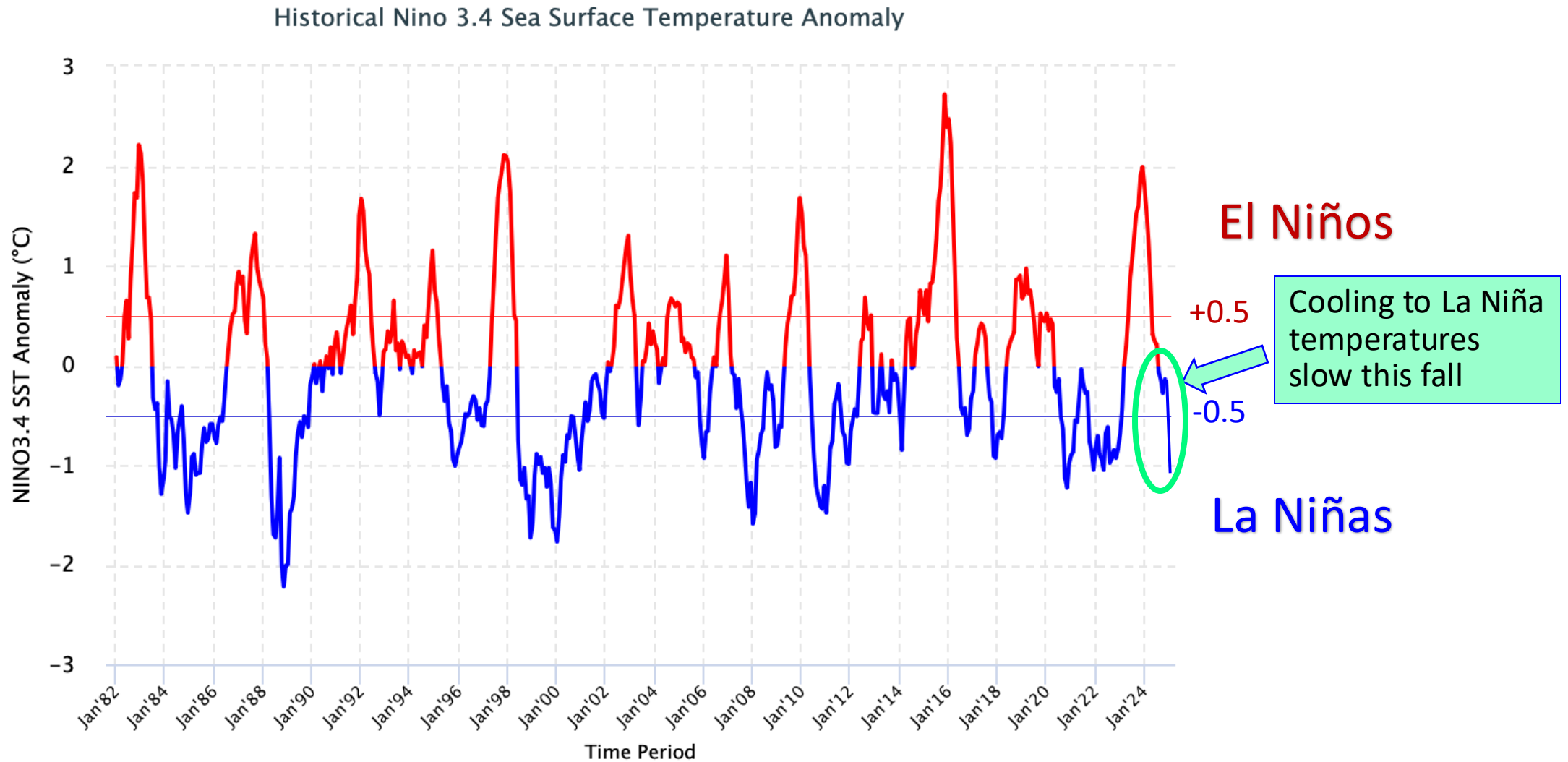
WINTER EL NIÑO PATTERN



# Recent El Niño/La Niña events



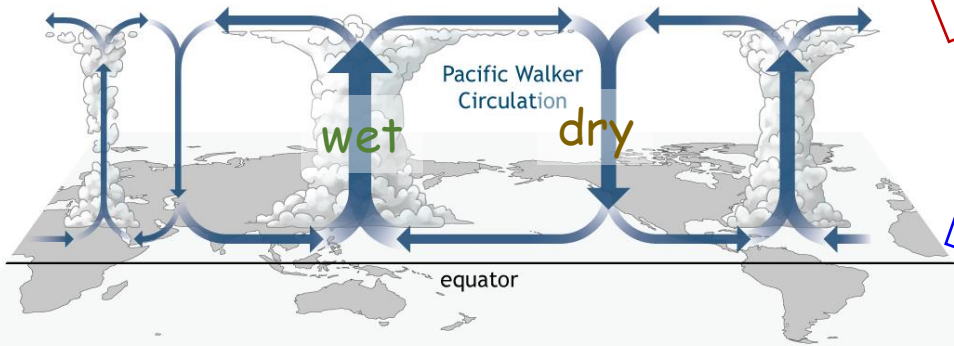
# Recent El Niño/La Niña events



# El Niños/La Niñas affect water temperature **and** Walker Circulation at equator

## Walker circulation

Neutral conditions

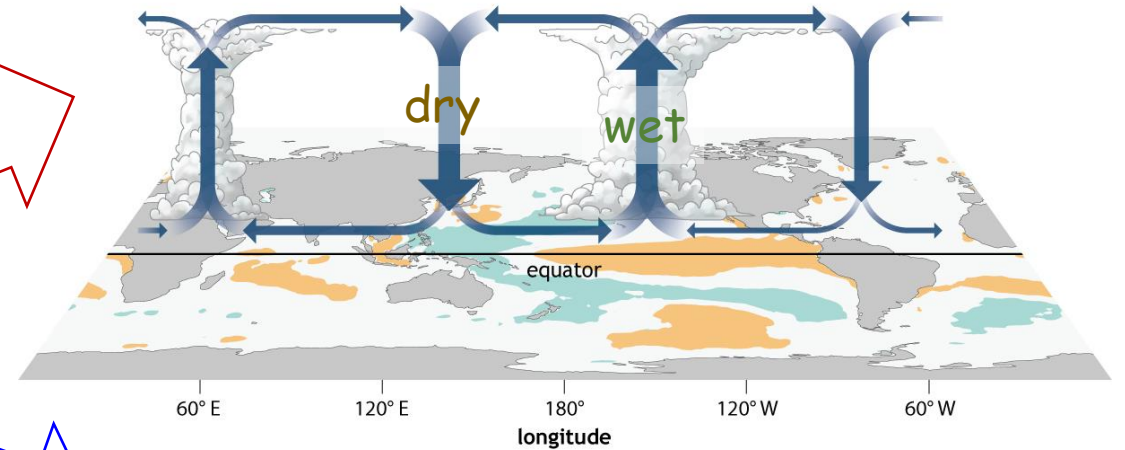


El Niño

La Niña

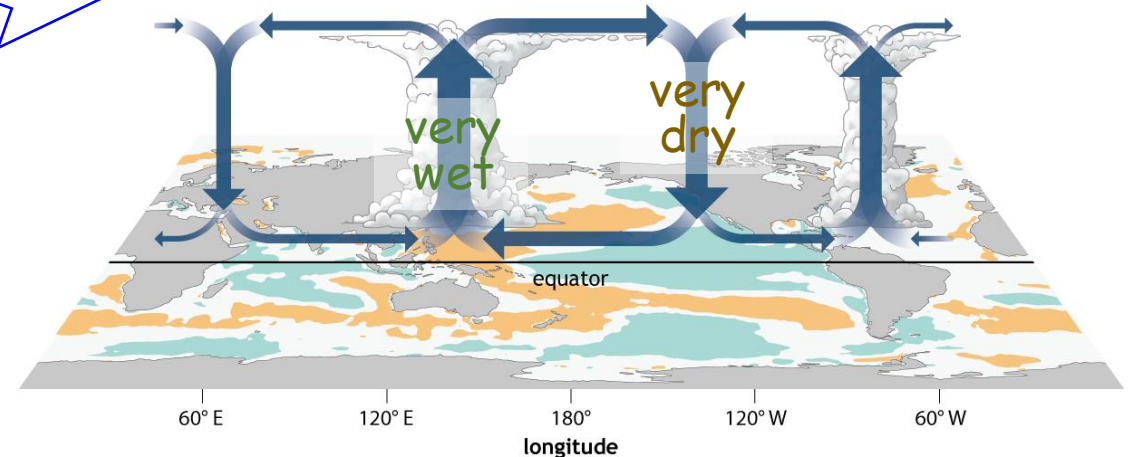
Despite warmish water at the equator, La Niña Walker conditions are present at the equator

El Niño conditions



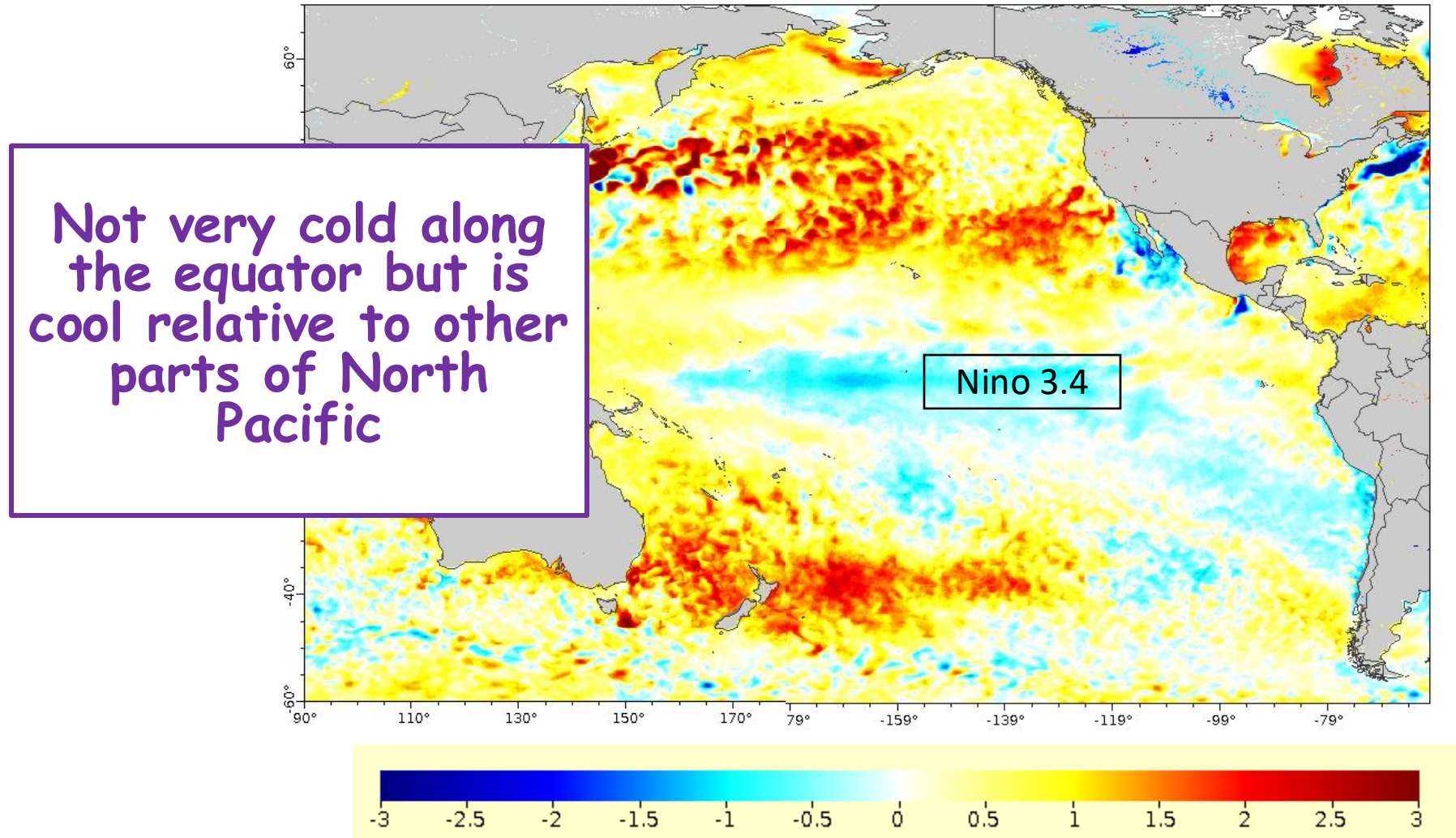
NOAA Climate.gov

La Niña conditions



NOAA Climate.gov

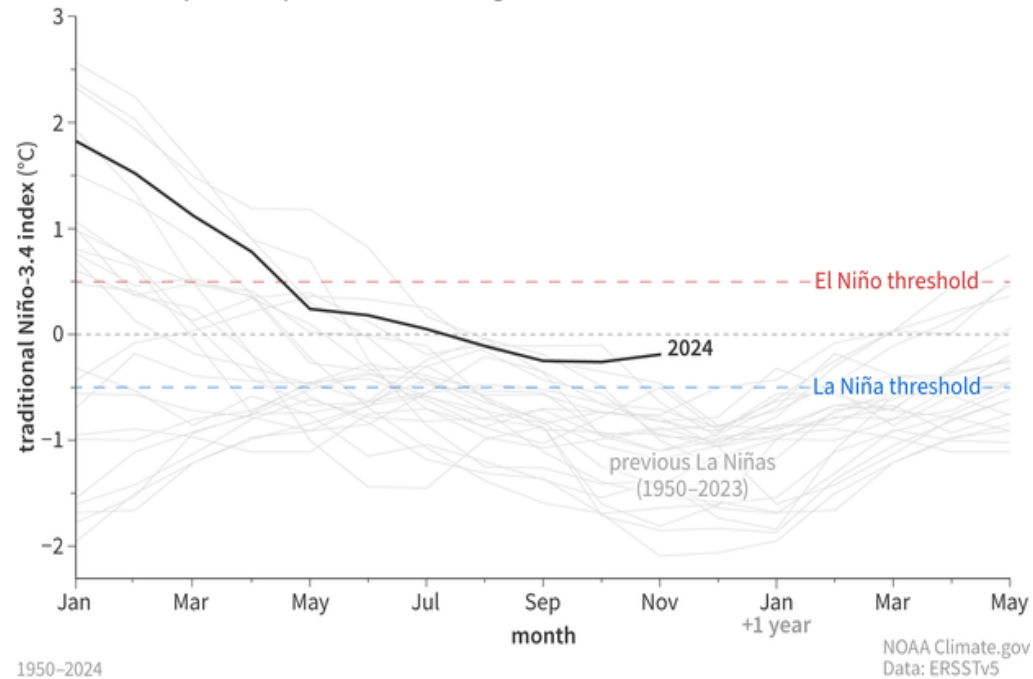
# Dec 2024 Monthly SST anomalies



# Relative Niño-3.4 index: Niño 3.4 compared to rest of tropical Pacific (not average of 1991-2020)

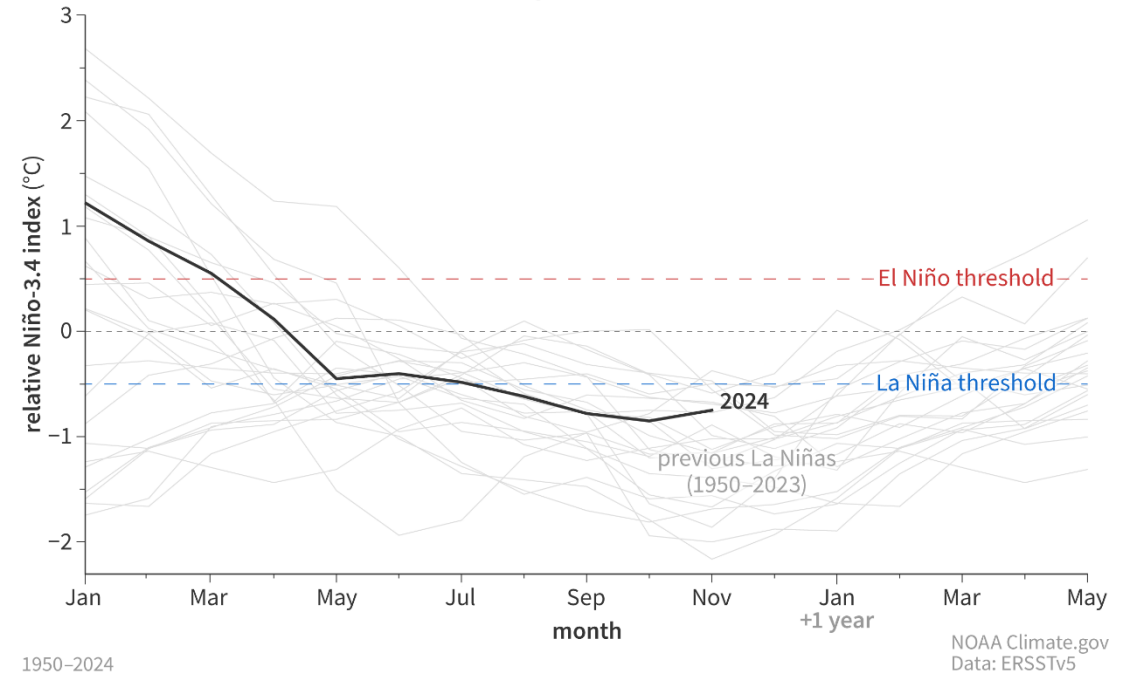
## Traditional Niño 3.4 index

How 2024 compares to past La Niñas using traditional Niño-3.4 index



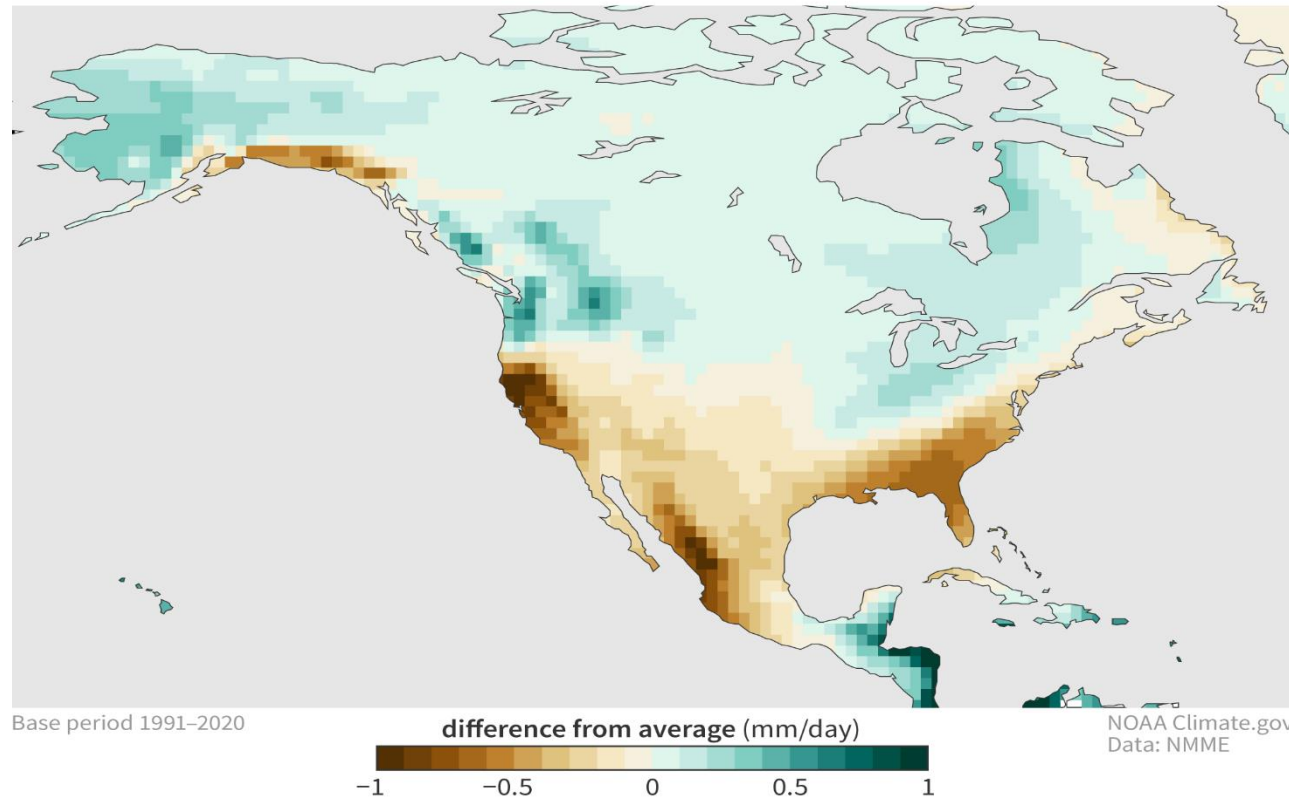
## Relative Niño 3.4 index

How 2024 compares to past La Niñas using relative Niño-3.4 index



# Precipitation forecast\* for this winter (Dec 2024-Feb 2025) looks stronger than traditional ENSO indicates (but consistent with Relative Niño 3.4)

NMME winter 2024-25

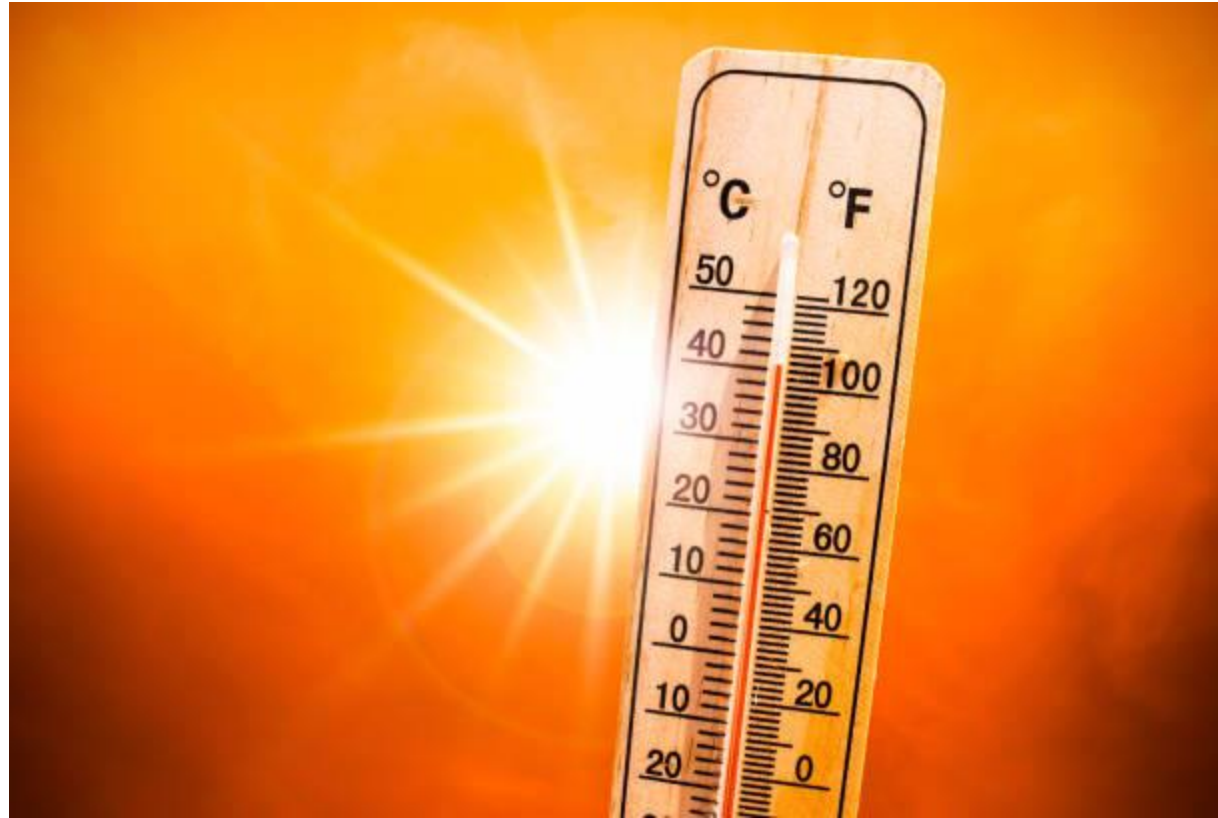


\*based on North American Multi-model Ensemble (NMME)

<https://www.climate.gov/news-features/blogs/enso/can-little-la-nina-pack-big-precipitation-punch>

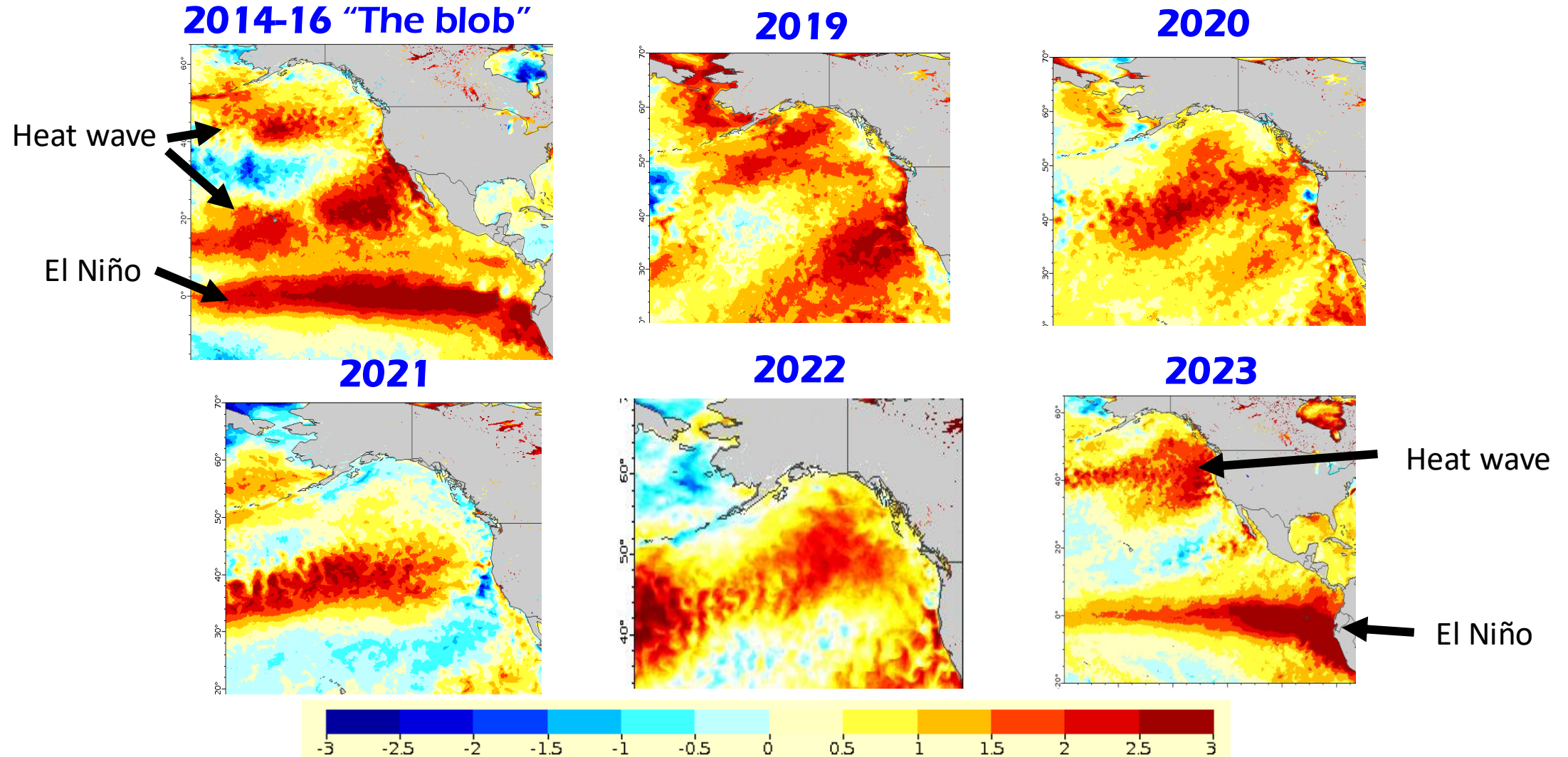
# Recent NE Pacific marine heat waves

Sea surface temperature (SST) anomalies in September



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Sea surface temperature (SST) anomalies in September

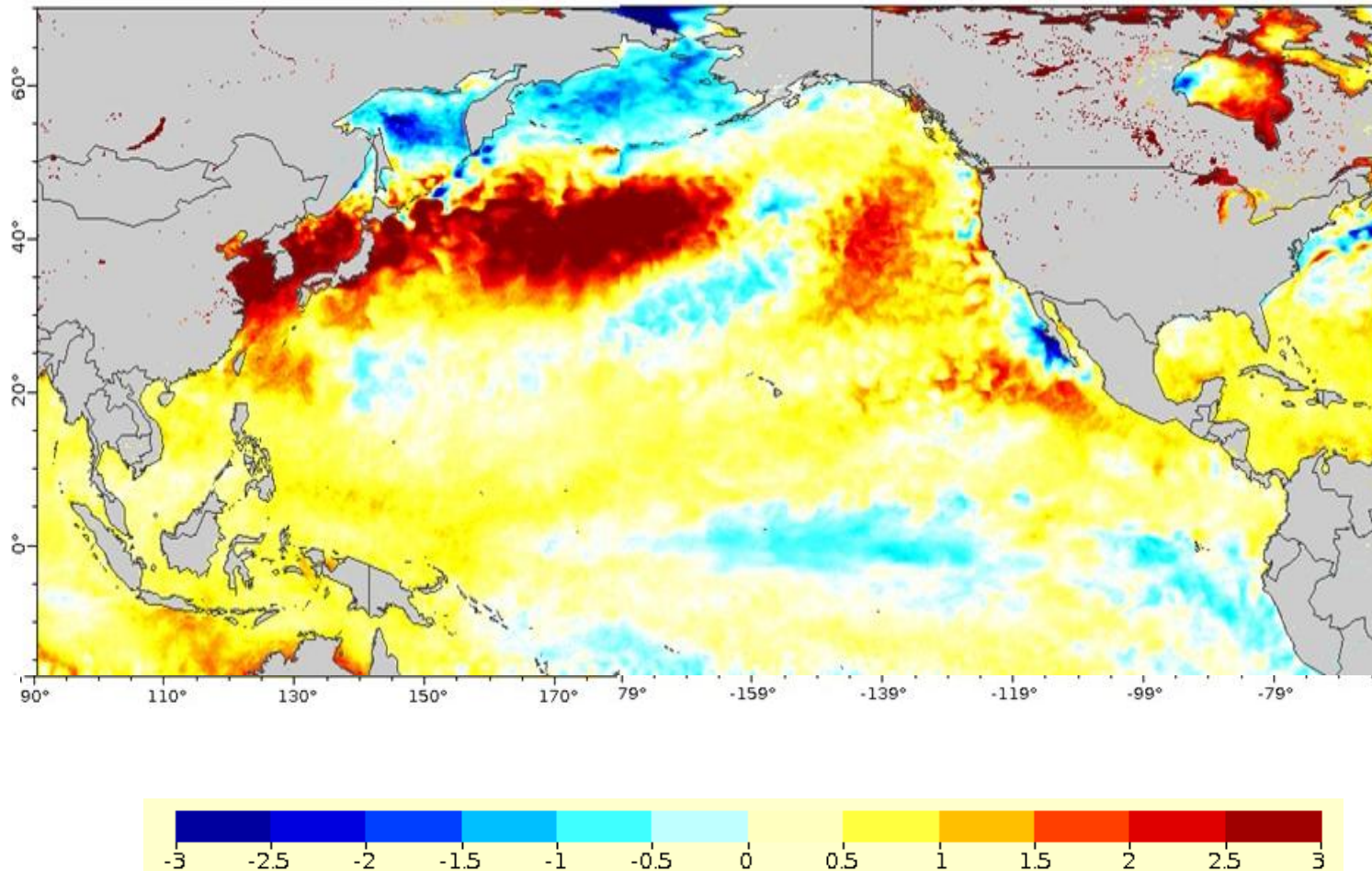


<https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker>

# Recent NE Pacific marine heat waves

Sea surface temperature (SST) anomalies in September

Sep 2024



<https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker>

## 2. Biological response



**NW/FSC stoplight chart**

**Other observations**

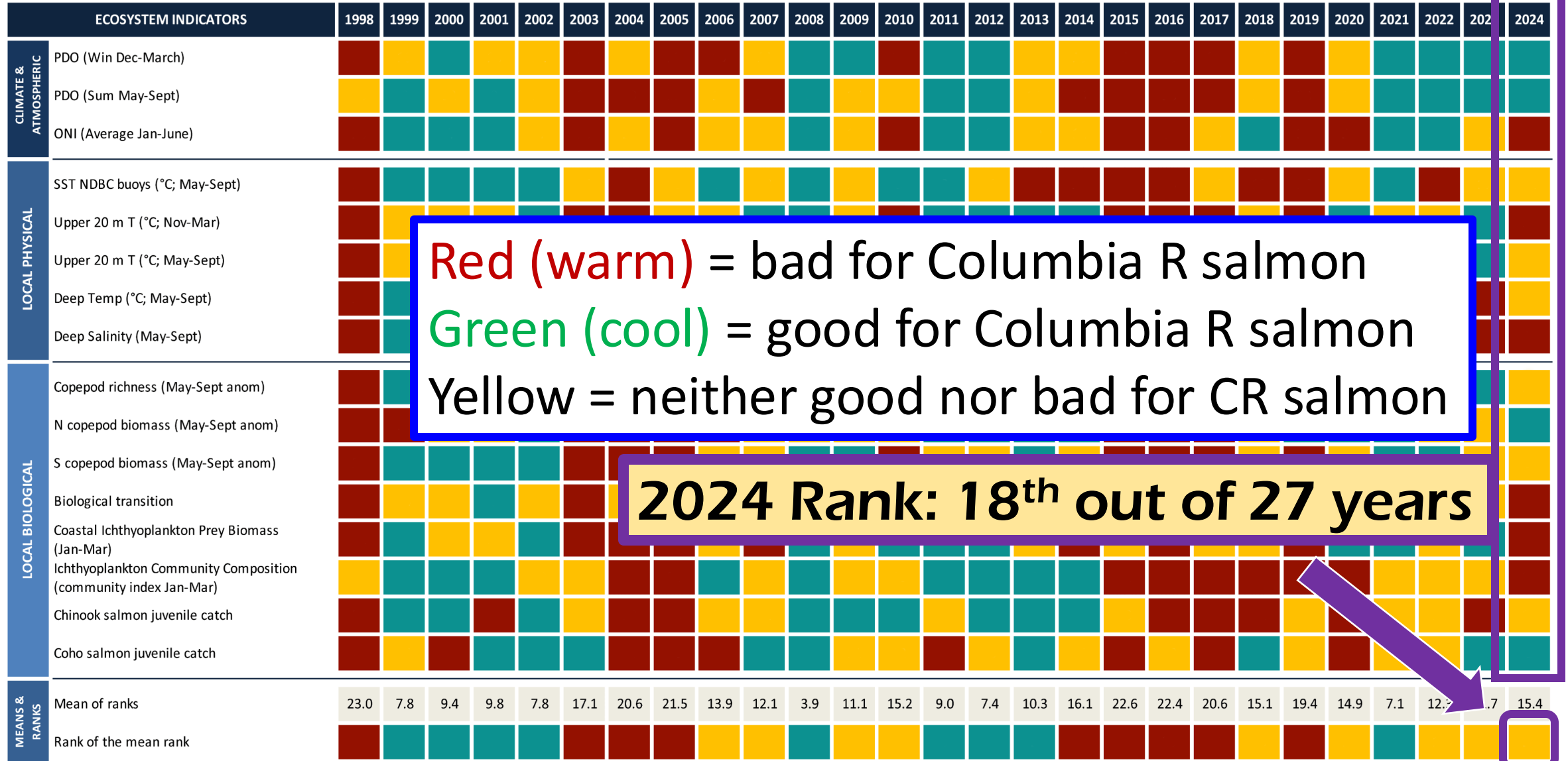
**Columbia River salmon forecasts**

# NW/FSC stoplight chart, ocean entry years 1998-2024

| ECOSYSTEM INDICATORS  |                             | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------------------|-----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| CLIMATE & ATMOSPHERIC | Ocean basin scale           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| LOCAL PHYSICAL        | Local physical Indicators   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| LOCAL BIOLOGICAL      | Local biological indicators |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MEANS & RANKS         | Ranks                       | 23.0 | 7.8  | 9.4  | 9.8  | 7.8  | 17.1 | 20.6 | 21.5 | 13.9 | 12.1 | 3.9  | 11.1 | 15.2 | 9.0  | 7.4  | 10.3 | 16.1 | 22.6 | 22.4 | 20.6 | 15.1 | 19.4 | 14.9 | 7.1  | 12.3 | 11.7 | 15.4 |
|                       |                             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

<https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern>

# NW/FSC stoplight chart, ocean entry years 1998-2024

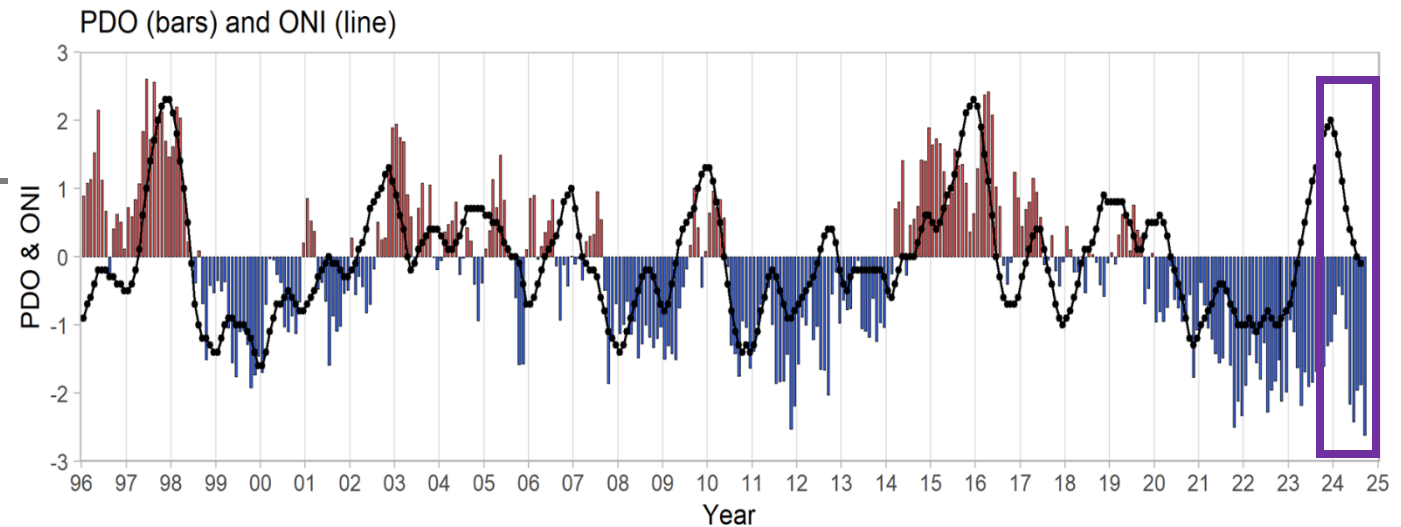


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# Ocean entry year 2024 explained

| Ocean basin scale           | ECOSYSTEM INDICATORS  |                                                           | 2024 |
|-----------------------------|-----------------------|-----------------------------------------------------------|------|
|                             | CLIMATE & ATMOSPHERIC | PDO (Sum Dec-March)                                       |      |
|                             |                       | PDO (Sum May-Sept)                                        |      |
|                             |                       | ONI (Average Jan-June)                                    |      |
| Local physical indicators   | LOCAL PHYSICAL        | SST NDBC buoys (°C; May-Sept)                             |      |
|                             |                       | Upper 20 m T (°C; Nov-Mar)                                |      |
|                             |                       | Upper 20 m T (°C; May-Sept)                               |      |
|                             |                       | Deep Temp (°C; May-Sept)                                  |      |
|                             |                       | Deep Salinity (May-Sept)                                  |      |
| Local biological indicators | LOCAL BIOLOGICAL      | Copepod richness (May-Sept anom)                          |      |
|                             |                       | N copepod biomass (May-Sept anom)                         |      |
|                             |                       | S copepod biomass (May-Sept anom)                         |      |
|                             |                       | Biological transition                                     |      |
|                             |                       | Nearshore Ichthyoplankton (Jan-Mar)                       |      |
|                             |                       | Near & offshore Ichthyoplankton (community index Jan-Mar) |      |
|                             |                       | Chinook salmon juvenile catch                             |      |
|                             |                       | Coho salmon juvenile catch                                |      |
|                             | MEANS & RANKS         | Mean of ranks                                             | 15.4 |
|                             |                       | Rank of the mean rank                                     |      |

← PDO still strongly negative (doesn't reflect local conditions like it used to)  
 ← Tail end of strong 2023/24 El Niño



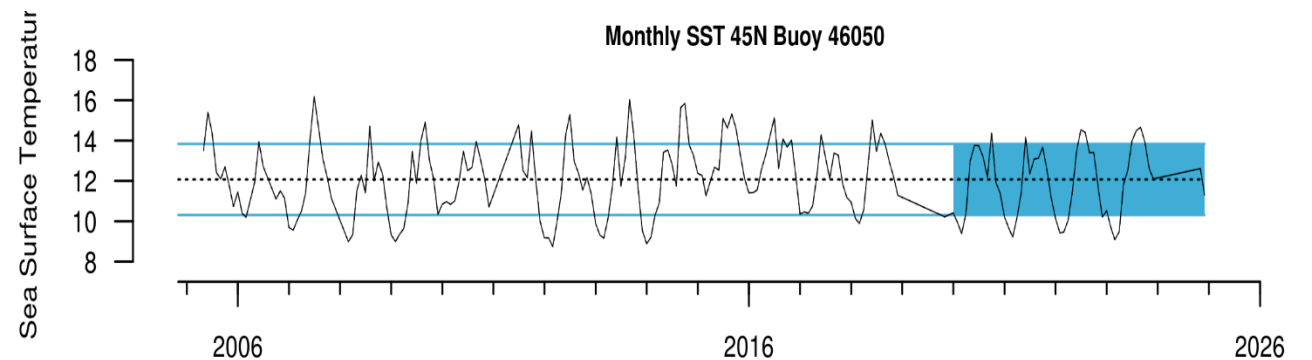
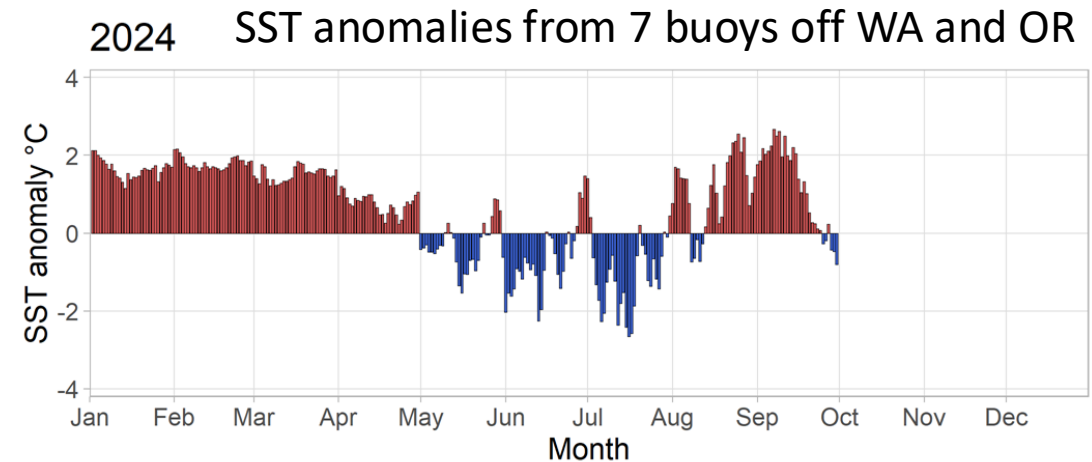
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|                             | Rank of the mean rank |                                                           |      |

Warmish water temperatures at all depths from strong 2023/24 El Niño, upwelling modest and ended early



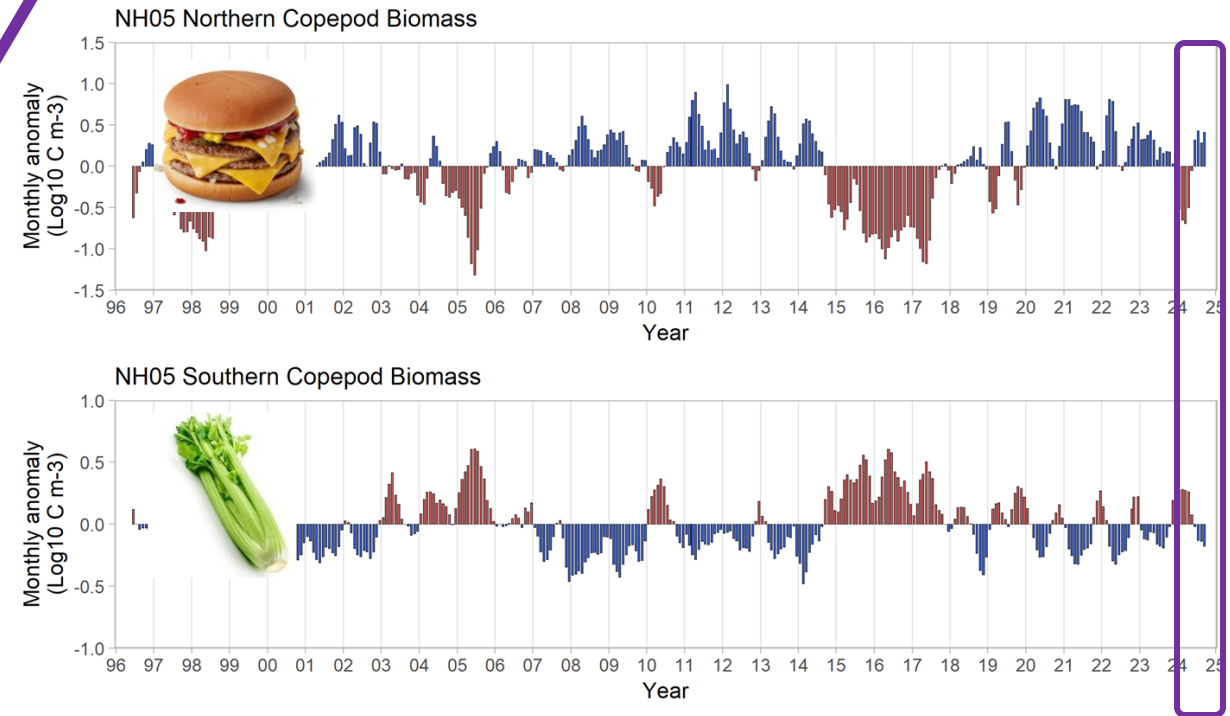
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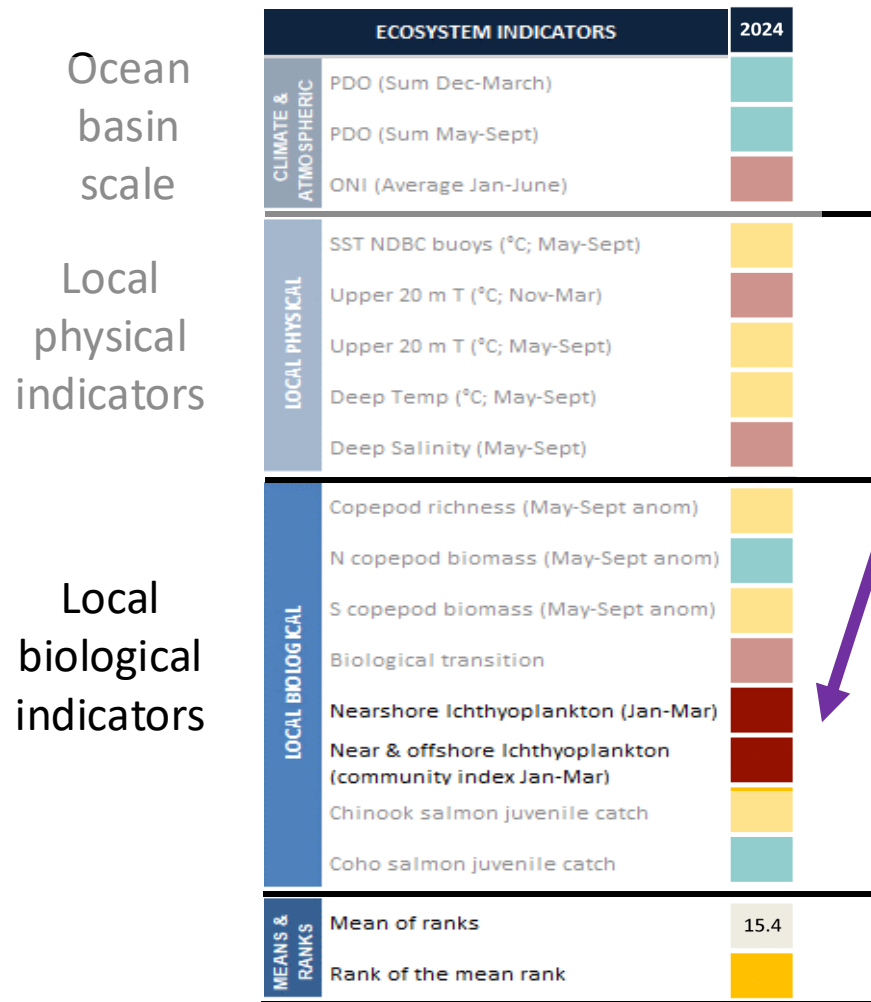
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|                             |                       | Rank of the mean rank                                     |      |

Unusual mixed summer copepod community: above average N copepods and average S copepods  
Late biological spring transition (winter → summer community)

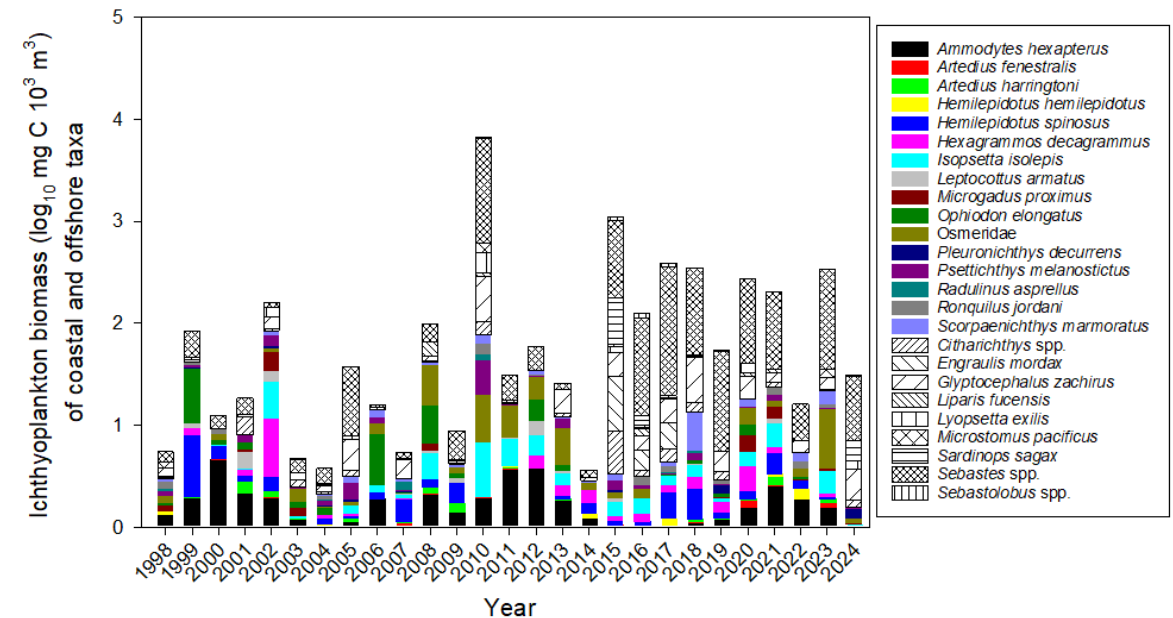


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# Ocean entry year 2024 explained



Extremely low catches of coastal larval fish in early spring, mainly offshore species present



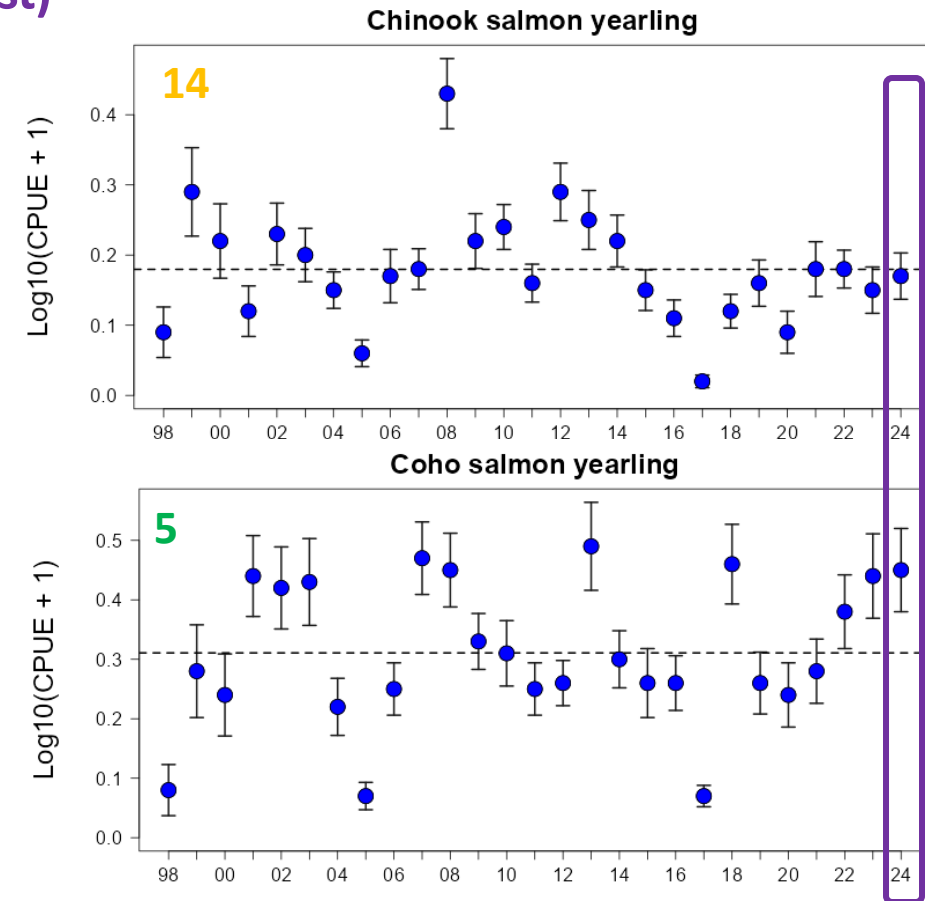
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# Ocean entry year 2024 explained

Average catches of juvenile spring Chinook and relatively high catches of juvenile coho in June ocean survey (WA-OR coast)

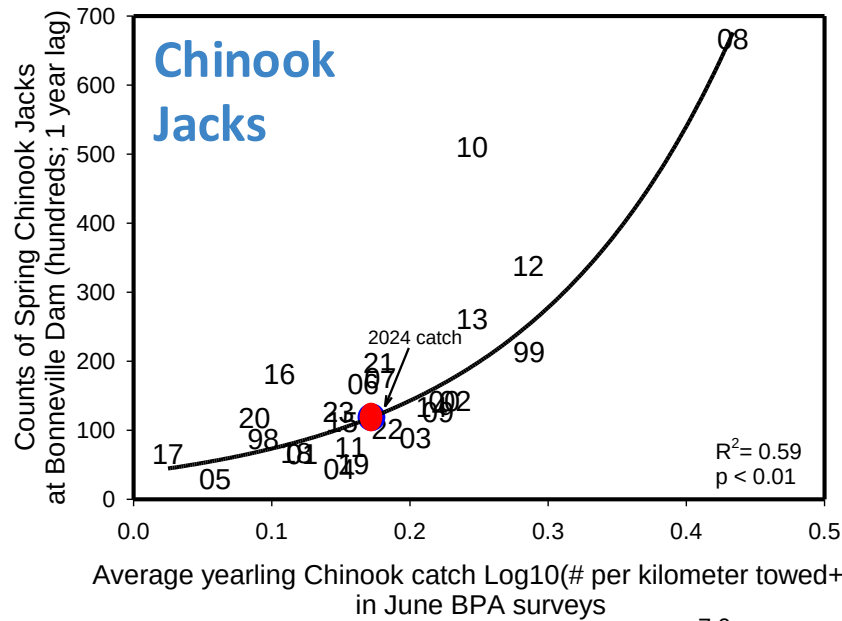
| Ocean basin scale           | ECOSYSTEM INDICATORS  |                                                           | 2024 |
|-----------------------------|-----------------------|-----------------------------------------------------------|------|
|                             | CLIMATE & ATMOSPHERIC | PDO (Sum Dec-March)                                       |      |
|                             |                       | PDO (Sum May-Sept)                                        |      |
|                             |                       | ONI (Average Jan-June)                                    |      |
| Local physical indicators   | LOCAL PHYSICAL        | SST NDBC buoys (°C; May-Sept)                             |      |
|                             |                       | Upper 20 m T (°C; Nov-Mar)                                |      |
|                             |                       | Upper 20 m T (°C; May-Sept)                               |      |
|                             |                       | Deep Temp (°C; May-Sept)                                  |      |
|                             |                       | Deep Salinity (May-Sept)                                  |      |
| Local biological indicators | LOCAL BIOLOGICAL      | Copepod richness (May-Sept anom)                          |      |
|                             |                       | N copepod biomass (May-Sept anom)                         |      |
|                             |                       | S copepod biomass (May-Sept anom)                         |      |
|                             |                       | Biological transition                                     |      |
|                             |                       | Nearshore Ichthyoplankton (Jan-Mar)                       |      |
|                             |                       | Near & offshore Ichthyoplankton (community index Jan-Mar) |      |
|                             |                       | Chinook salmon juvenile catch                             |      |
|                             |                       | Coho salmon juvenile catch                                |      |
|                             |                       | Mean of ranks                                             | 15.4 |
|                             |                       | Rank of the mean rank                                     |      |



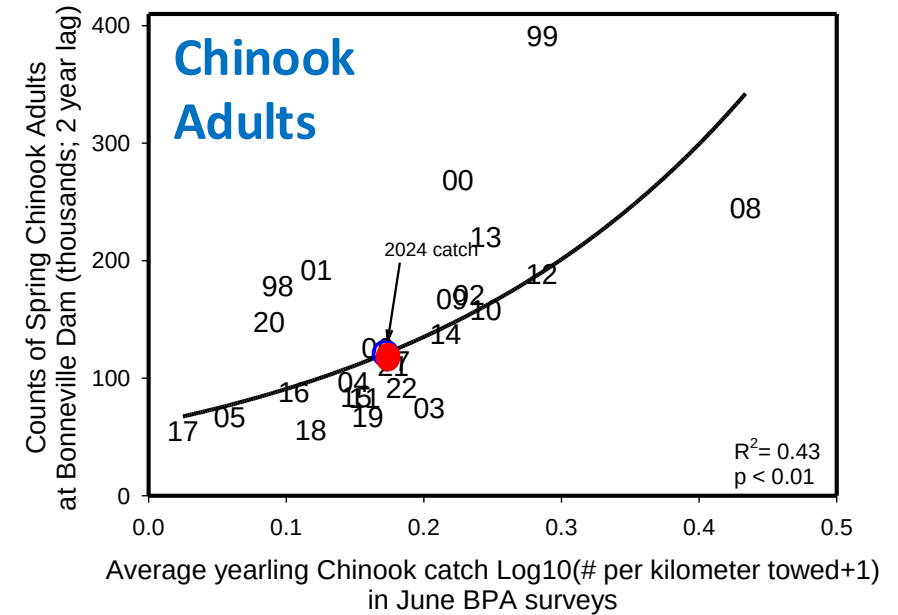
<https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern>

<https://www.fisheries.noaa.gov/feature-story/annual-ocean-indicators-point-varied-conditions-pacific-salmon>

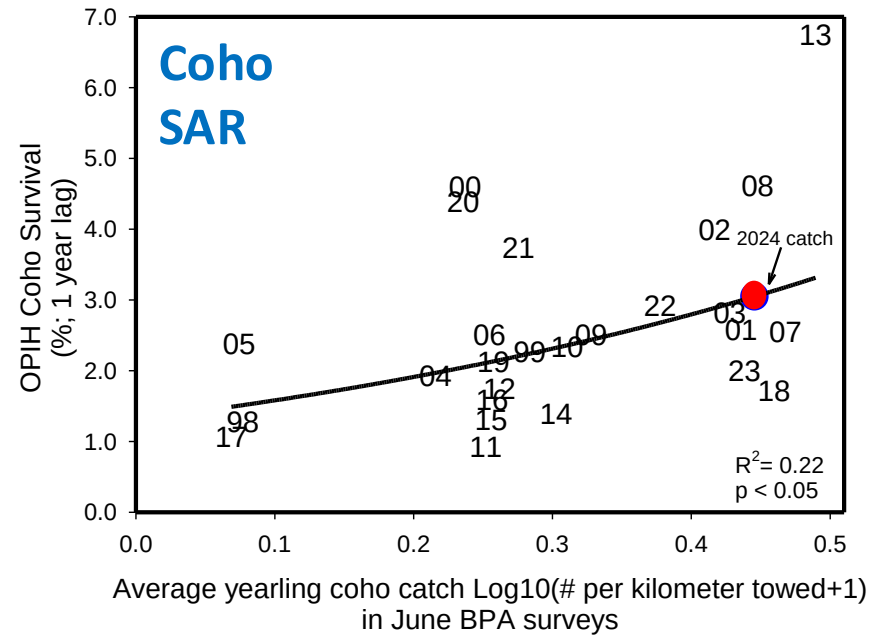
# June Catches of Yearling Chinook and coho related to adult returns



Suggests  
modest  
Chinook  
returns in  
2026

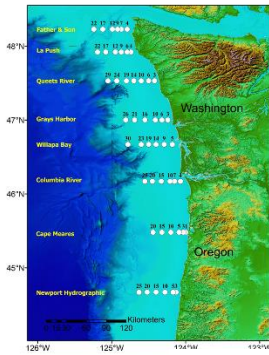


Suggests  
High Coho  
returns in  
2025



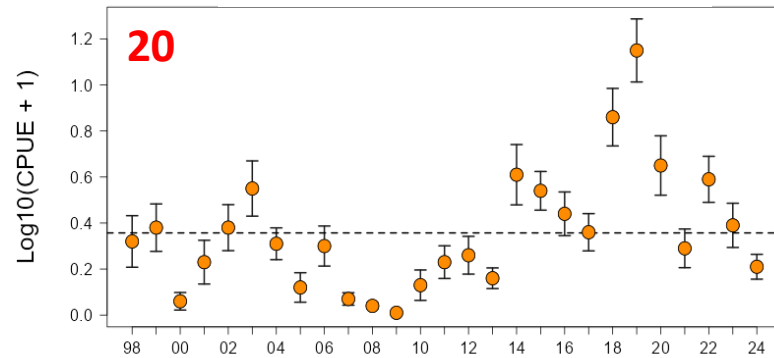
# Other observations

Catches of other fish and invertebrates in survey back to long term averages, others elevated

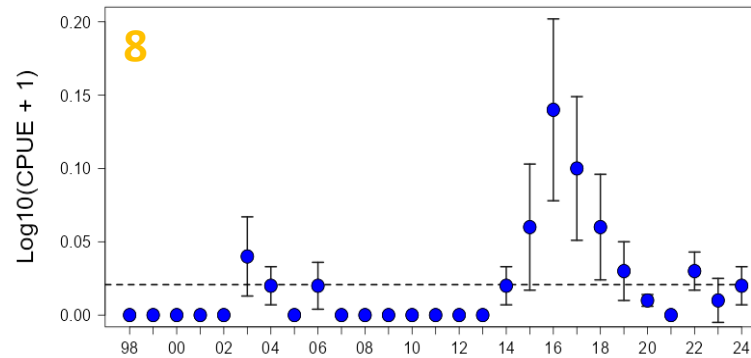


“Average”

California market squid

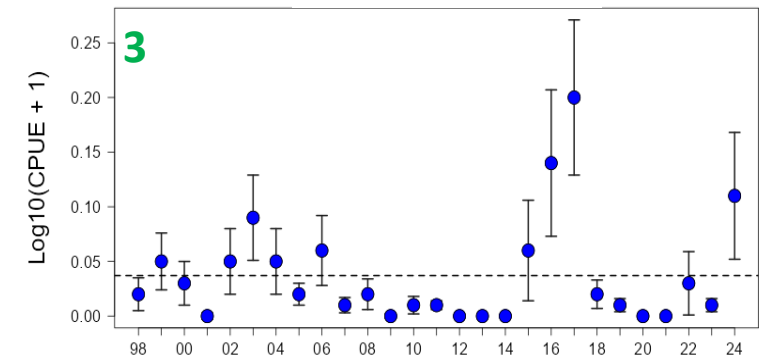


Pacific pompano

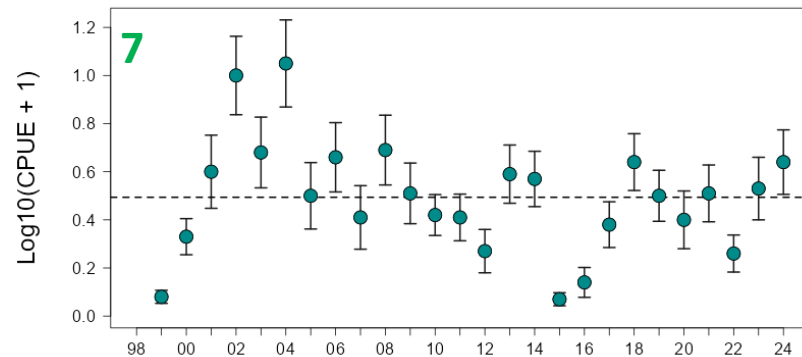


Above average

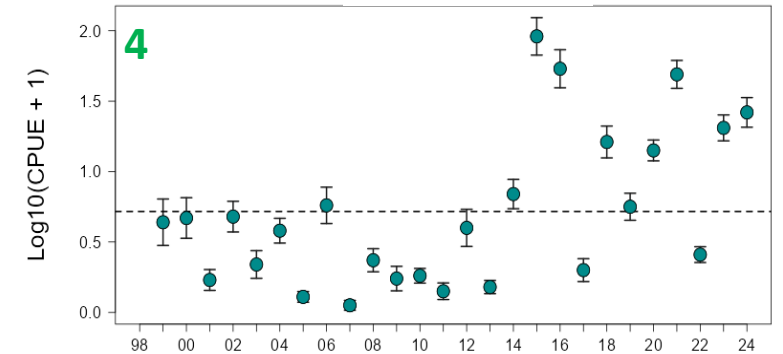
Jack mackerel



Sea nettle



Water jelly



# Brian Burke's predictions for Columbia River Chinook and steelhead returns (based on dynamic regression using stoplight chart PCI)

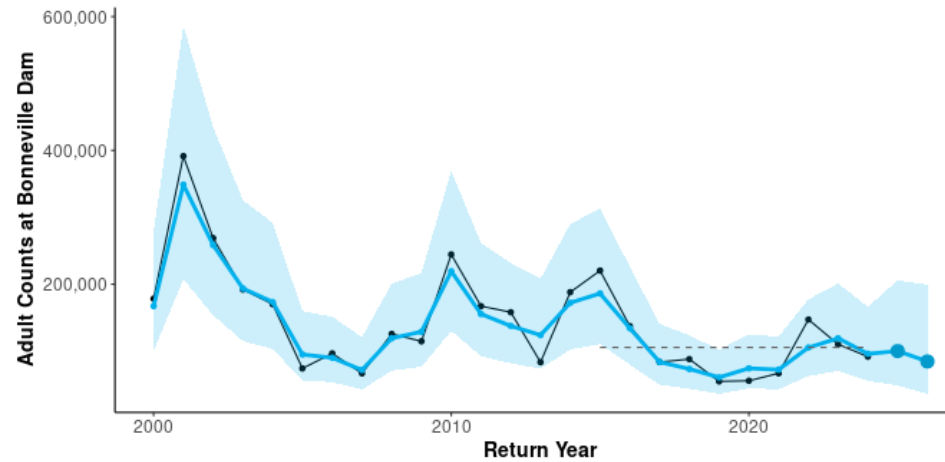


Brian Burke on May 2023  
juvenile salmon survey

## Spring Chinook

Output from a Dynamic Linear Model

Forecast for 2025 = 100K  
Forecast for 2026 = 84K



## Fall Chinook

Output from a Dynamic Linear Model

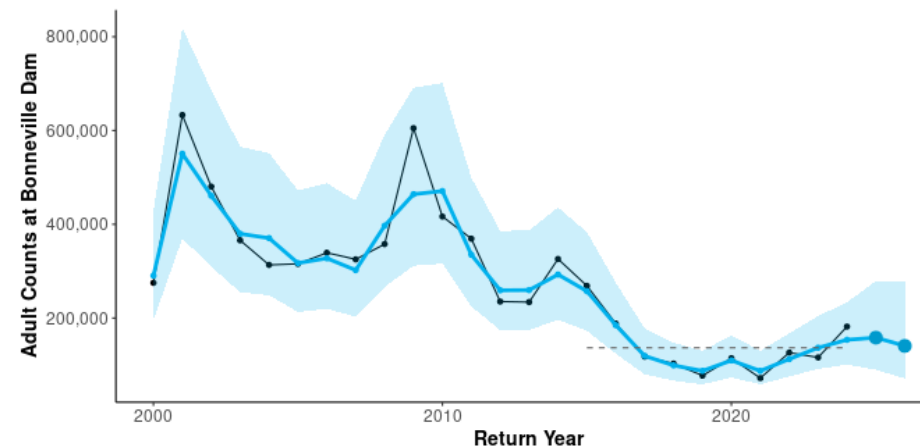
Forecast for 2025 = 512K  
Forecast for 2026 = 416K



## Steelhead

Output from a Dynamic Linear Model

Forecast for 2025 = 158K  
Forecast for 2026 = 141K



[https://connect.fisheries.noaa.gov/  
Salmon\\_Indicators/](https://connect.fisheries.noaa.gov/Salmon_Indicators/)

# 3. Forecasts

**El Niño/La Niña  
Ocean temperatures**



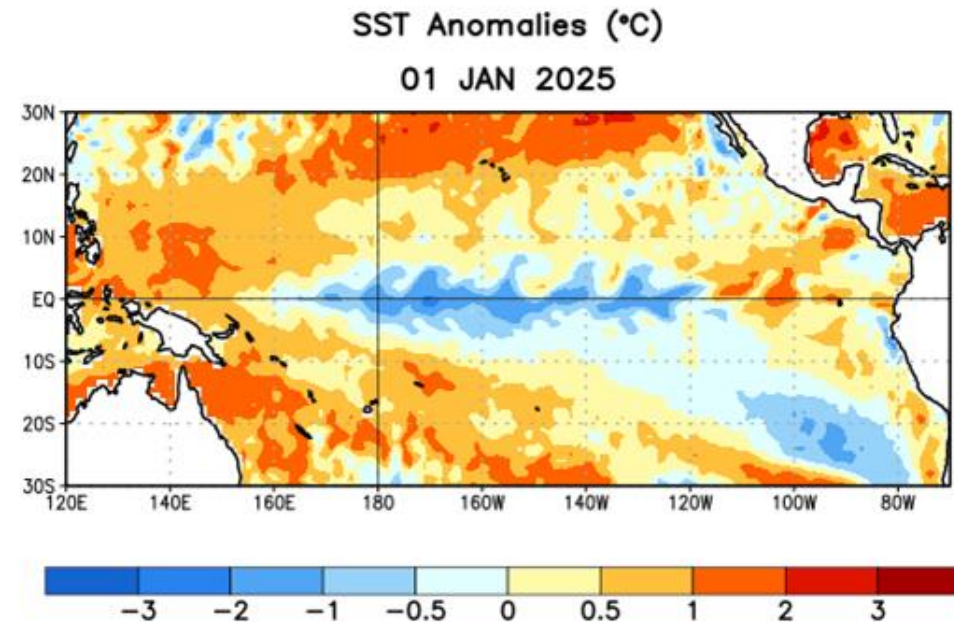
# El Niño

9 January 2025

## ENSO Alert System Status: La Niña Advisory

La Niña conditions are present at the equator.

They are expected to persist through February-April 2025 (59% chance), with a transition to ENSO-neutral likely during March-May 2025 (60% chance).



<https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#discussion>

# El Niño model forecasts

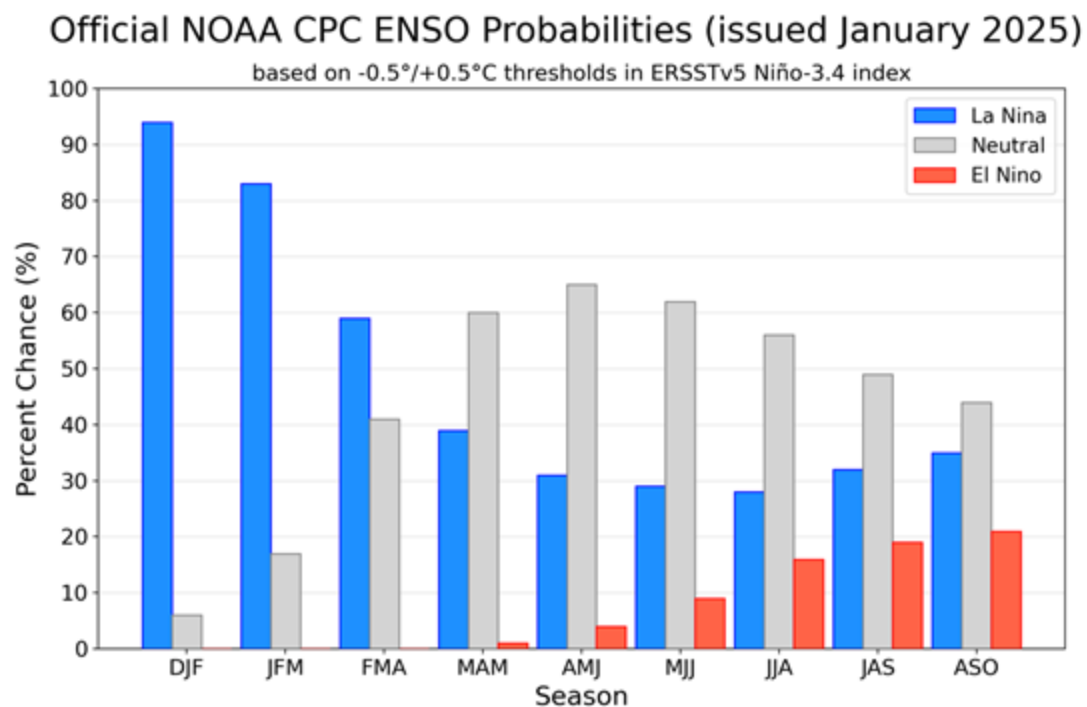
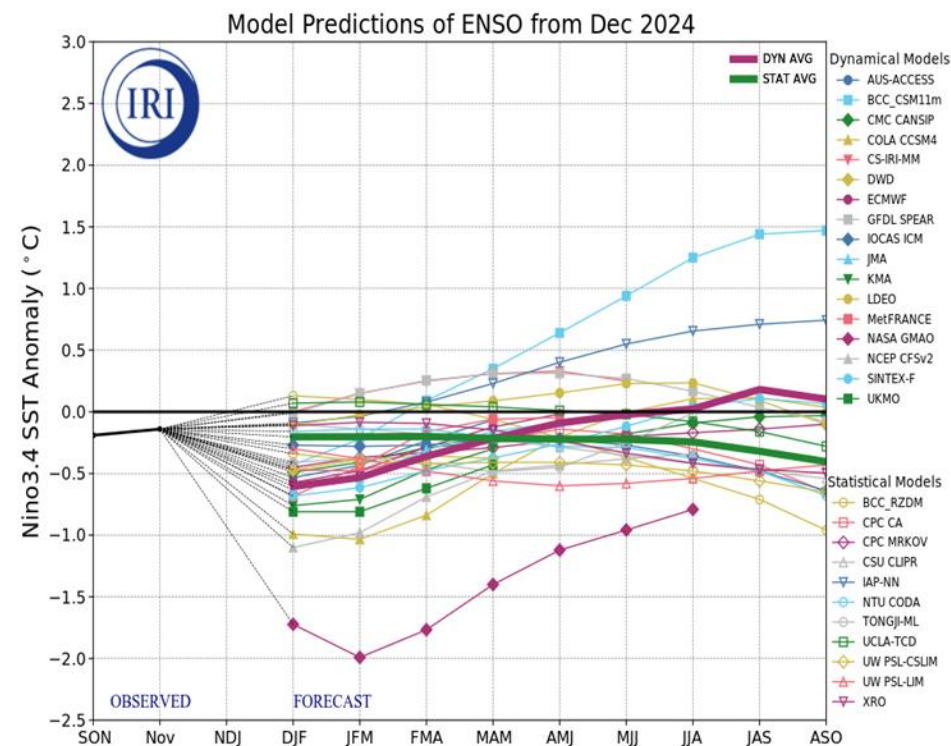
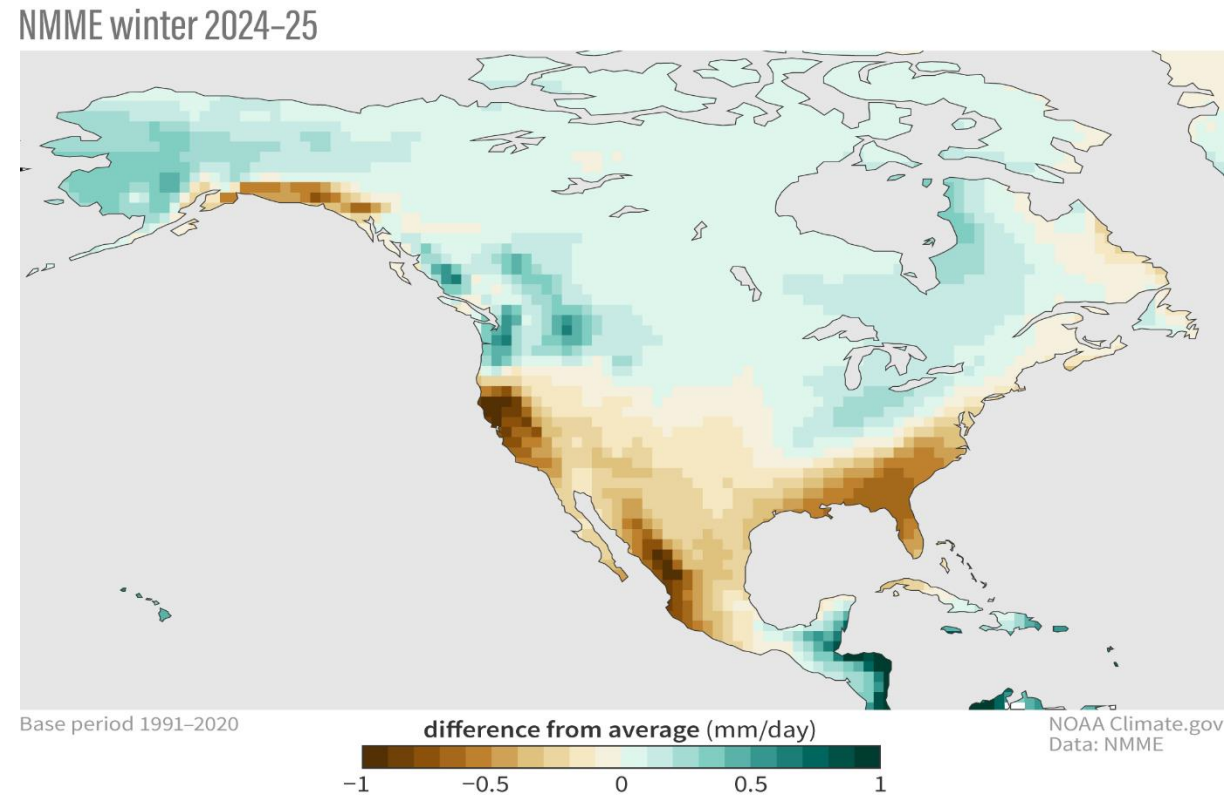


Figure issued 9 January 2025



[https://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/enso\\_advisory/index.shtml](https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.shtml)

# Precipitation forecast\* for this winter (Dec 2024-Feb 2025)

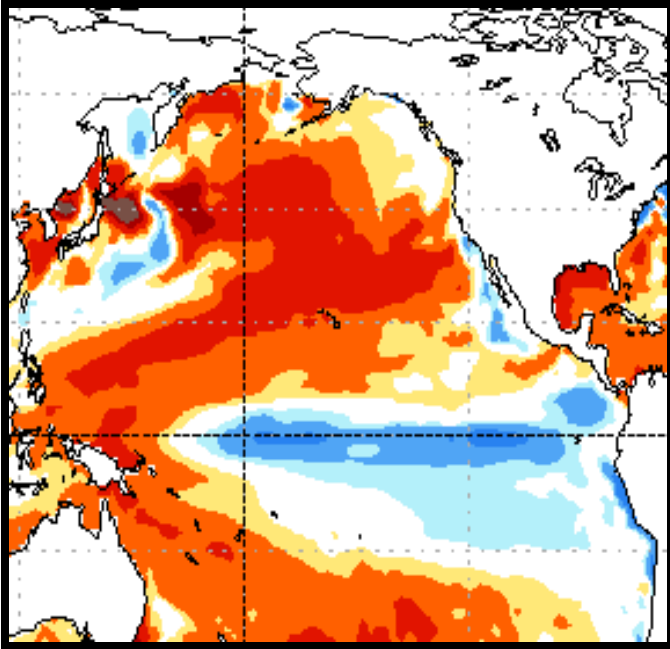


\*based on North American Multi-model Ensemble (NMME)

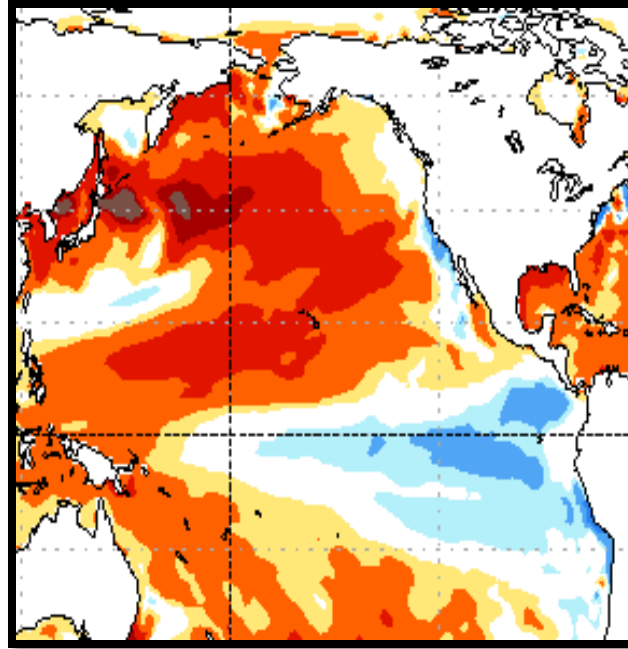
<https://www.climate.gov/news-features/blogs/enso/can-little-la-nina-pack-big-precipitation-punch>

# Forecast SST anomalies for 2025 suggest a warm North Pacific but average temperatures along W Coast

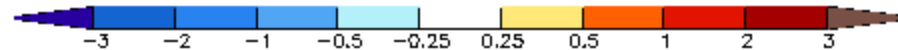
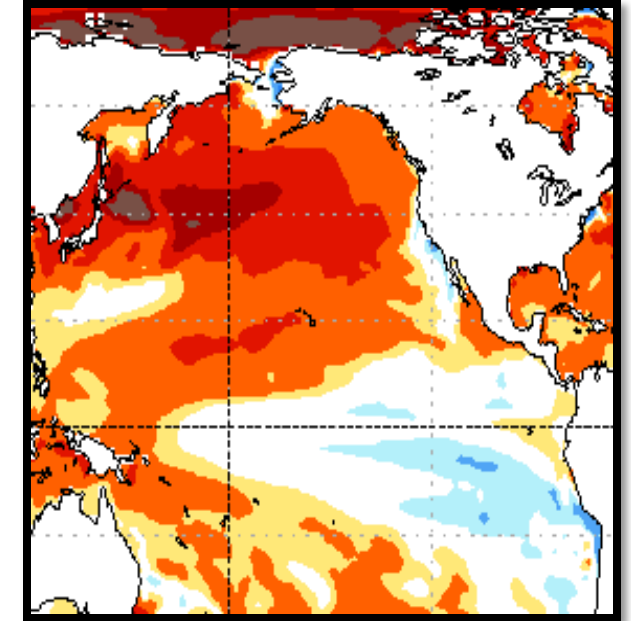
Feb-Mar-Apr



Apr-May-Jun



Jun-Jul-Aug



<https://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2fcst/htmls/glbSSTe2Sea.html>