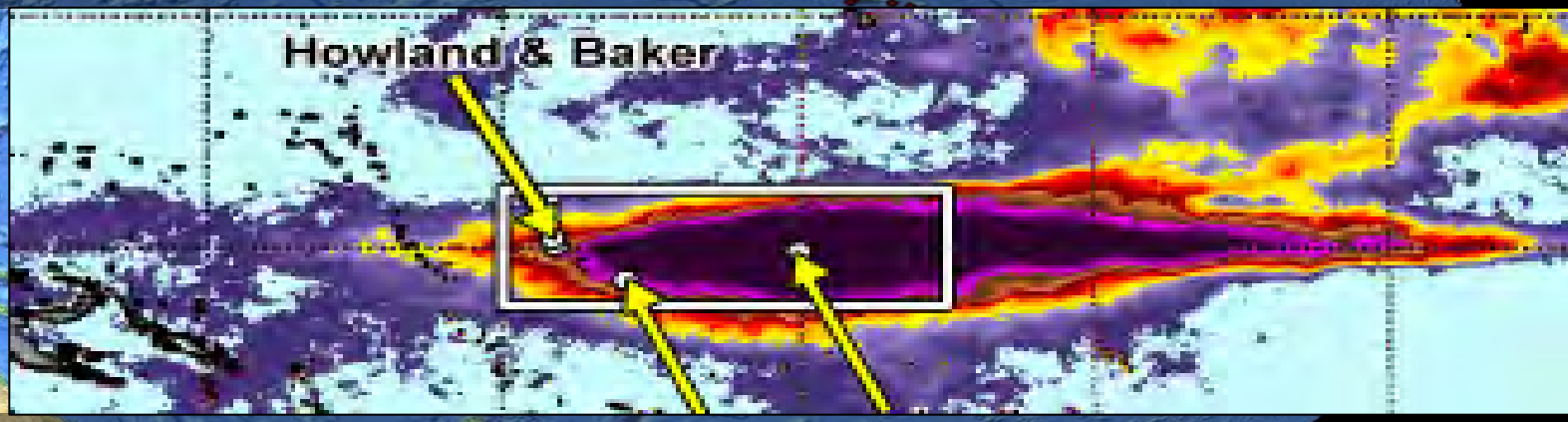
Ecological Impacts of the Extreme 2015-2016 El Niño in the Central Equatorial Pacific



Rusty Brainard[1], Tom Oliver[1], Mike McPhaden[2], Anne Cohen[3], Bernardo Vargas-Angel[4], Hannah Barkley[4], Roberto Venegas[4], Adel Heenan[5], Randi Rotjan[6], Sangeeta Mangubhai[7], Beth Flint[8], Susan Hunter [8], Phoebe Woodworth-Jefcoats[1], Keith Bigelow[1]

[1]NOAA Pacific Islands Fisheries Science Center, Honolulu, USA
[2]NOAA Pacific Marine Environmental Laboratory, Seattle,, USA
[3]Woods Hole Oceanographic Institution, Woods Hole, USA
[4]Joint Institute for Marine & Atmospheric Research, Univ of Hawaii, Honolulu, USA
[5]Bangor University, School of Ocean Sciences, Anglesey, UK
[6]Boston University, Boston, USA
[7]Wildlife Conservation Society, Suva, Fiji
[8]U.S. Fish & Wildlife Service, Marine Nat'l Monuments of the Pacific, Honolulu, USA

4th International Symposium on Effects of Climate Change on World's Oceans, Washington DC, June. 4-8, 2018

Outline

1. Background of El Niño in the Central Equatorial Pacific (CEQ)
2. Extreme 2015-2016 El Niño – CEQ
    1. Oceanographic – CEQ/Jarvis
    2. Ecological – CEQ/Jarvis
        1. Corals
        2. Productivity – Fish
        3. Seabirds
3. Climate Change and SST Trends in the CEQ (short/long term)
    1. Recent (1981-2017)
    2. Extended Range
4. Conclusions

5. ECOLOGICAL IMPACTS OF THE 2015/16 EL NIÑO IN THE CENTRAL EQUATORIAL PACIFIC

RUSSELL E. BRAINARD, THOMAS OLIVER, MICHAEL J. MCPHADEN, ANNE COHEN, ROBERTO VENEGAS, ADEL HEENAN, BERNARDO VARGAS-ÁNGEL, RANDI ROTJAN, SANGEETA MANGUBHAI, ELIZABETH FLINT, AND SUSAN A. HUNTER

Coral reef and seabird communities in the central equatorial Pacific were disrupted by record-setting sea surface temperatures, linked to an anthropogenically forced trend, during the 2015/16 El Niño.

Introduction. In the equatorial Pacific Ocean, the El Niño–Southern Oscillation substantially affects atmospheric and oceanic conditions on interannual time scales. The central and eastern equatorial Pacific fluctuates between anomalously warm and nutrient-poor El Niño and anomalously cool and nutrient-rich La Niña conditions (Chavez et al. 1999; McPhaden et al. 2006; Gierach et al. 2012). El Niño events are characterized by an eastward expansion of the Indo-Pacific warm pool (IPWP) and deepening of the thermocline and nutricline in response to weakening trade winds (Strutton and Chavez 2000; Turk et al. 2001). El Niño events are typically associated with significant decreases in primary productivity in the eastern and central tropical Pacific and corresponding increases in productivity in the western tropical Pacific (Boyce et al. 2010).

The IPWP has warmed and expanded in recent decades (Weller et al. 2016). The eastern Pacific cold tongue, on the other hand, has exhibited signs of a cooling trend over the past century (Deser et al. 2010). Newman and Wittenberg (2018) found that anomalously warm sea surface temperatures (SST) in the Niño-4 region (5°N–5°S, 150°E–150°W) of the central equatorial Pacific (CEP) during the 2015/16 El Niño were likely unprecedented and unlikely to have occurred naturally, thereby reflecting an anthropogenically forced trend. Lee and McPhaden (2010) earlier reported increasing amplitudes of El Niño events in Niño-4 that is also evident in our study region (Figs. 5.1b,c).

Remote islands in the CEP (Fig. 5.1a), including Jarvis Island (0°22'S, 160°01'W), Howland Island (0°48'N, 176°37'W), Baker Island (0°12'N, 176°29'W), and Kanton Island (2°50'S, 171°40'W), support healthy, resilient coral reef ecosystems characterized by exceptionally high biomass of planktivorous and piscivorous reef fishes due to the combined effects of equatorial and topographic upwelling (Gove et al. 2006; Williams et al. 2015). Coral reef communities at these islands are exposed to extended periods of thermal stress during El Niño events. Mass coral bleaching and mortality were reported in the Phoenix Islands during the moderate 2002/03 El Niño (Obura and Mangubhai 2011), and coral bleaching with limited mortality was reported at Howland and Baker Islands during the moderate 2009/10 El Niño (Vargas-Ángel et al. 2011). There were no observations of coral bleaching or mortality at these uninhabited islands during the major El Niño events of 1982/83 or 1997/98. Corals in the eastern equatorial Pacific (>7600 km to the east) did experience mass bleaching and mortality during those major El Niño events (Glynn 1984; Glynn et al. 2001).

We describe variations in SST and biological productivity to characterize the 2015/16 El Niño (McPhaden 2015) in relation to previous El Niño events in the CEP (Fig. 5.1a) and in the context of climate trends. We then describe some of the ecological responses, which were catastrophic at Jarvis and modest at Howland, Baker, and Kanton Islands.

Data and methods. The duration and magnitude of El Niño events for the period 1981–2017 for our region of interest (ROI; 5°N–5°S, 150°W–180°) were identified

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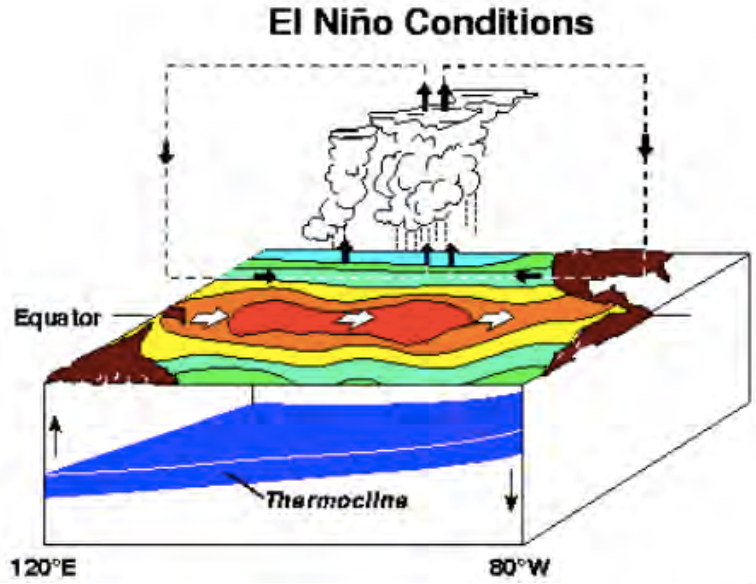
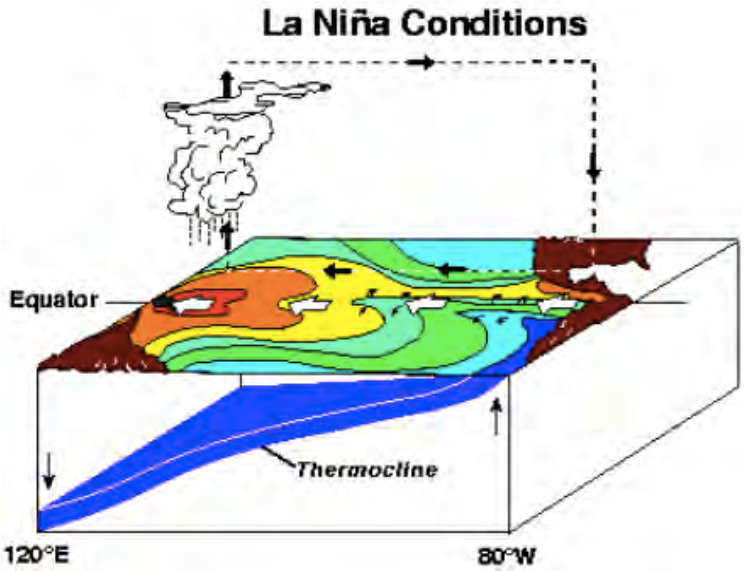
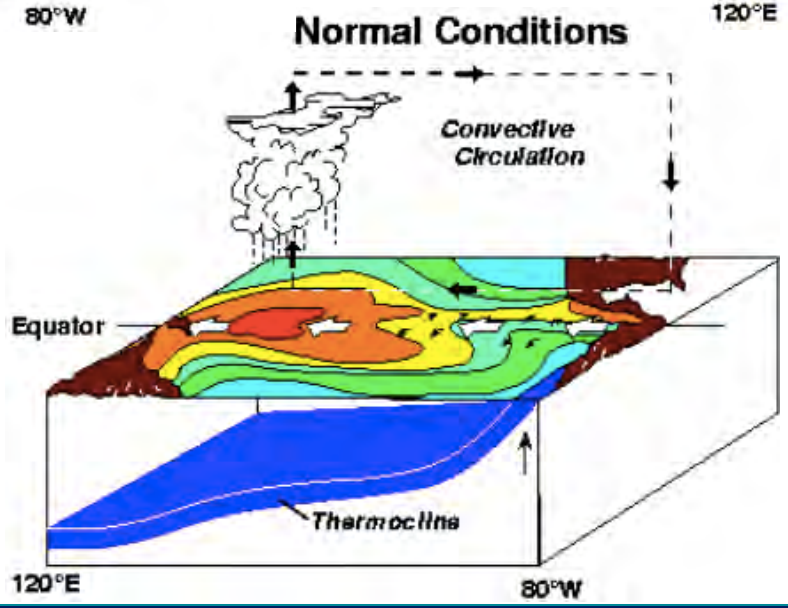
A supplement to this article is available online (10.1175/BAMS-D-17-0128.2)

Background of El Niño in the Central Equatorial Pacific

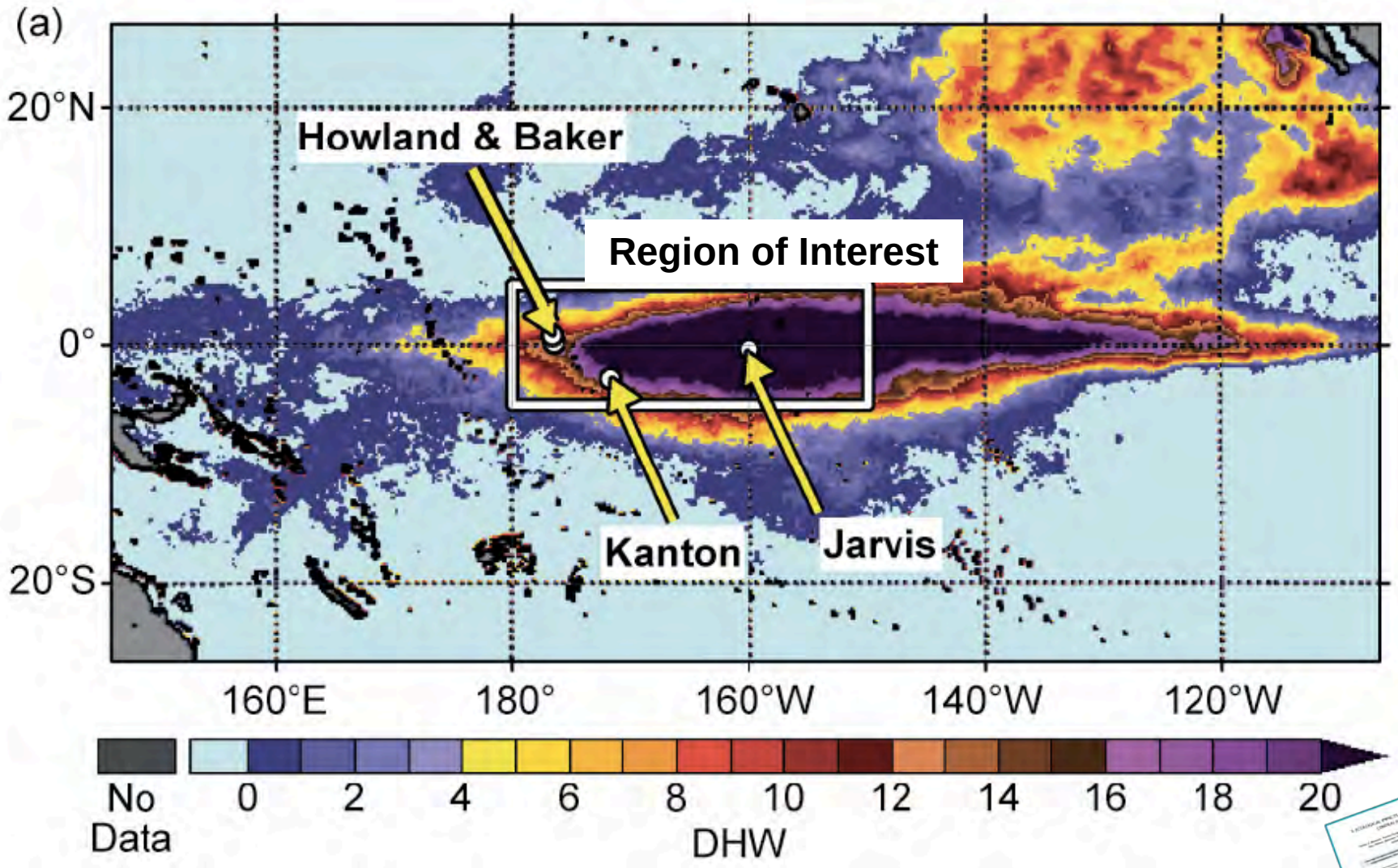


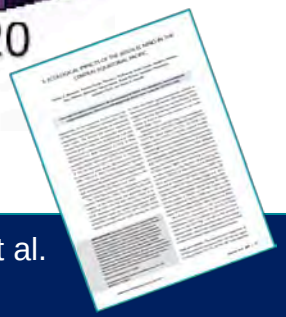




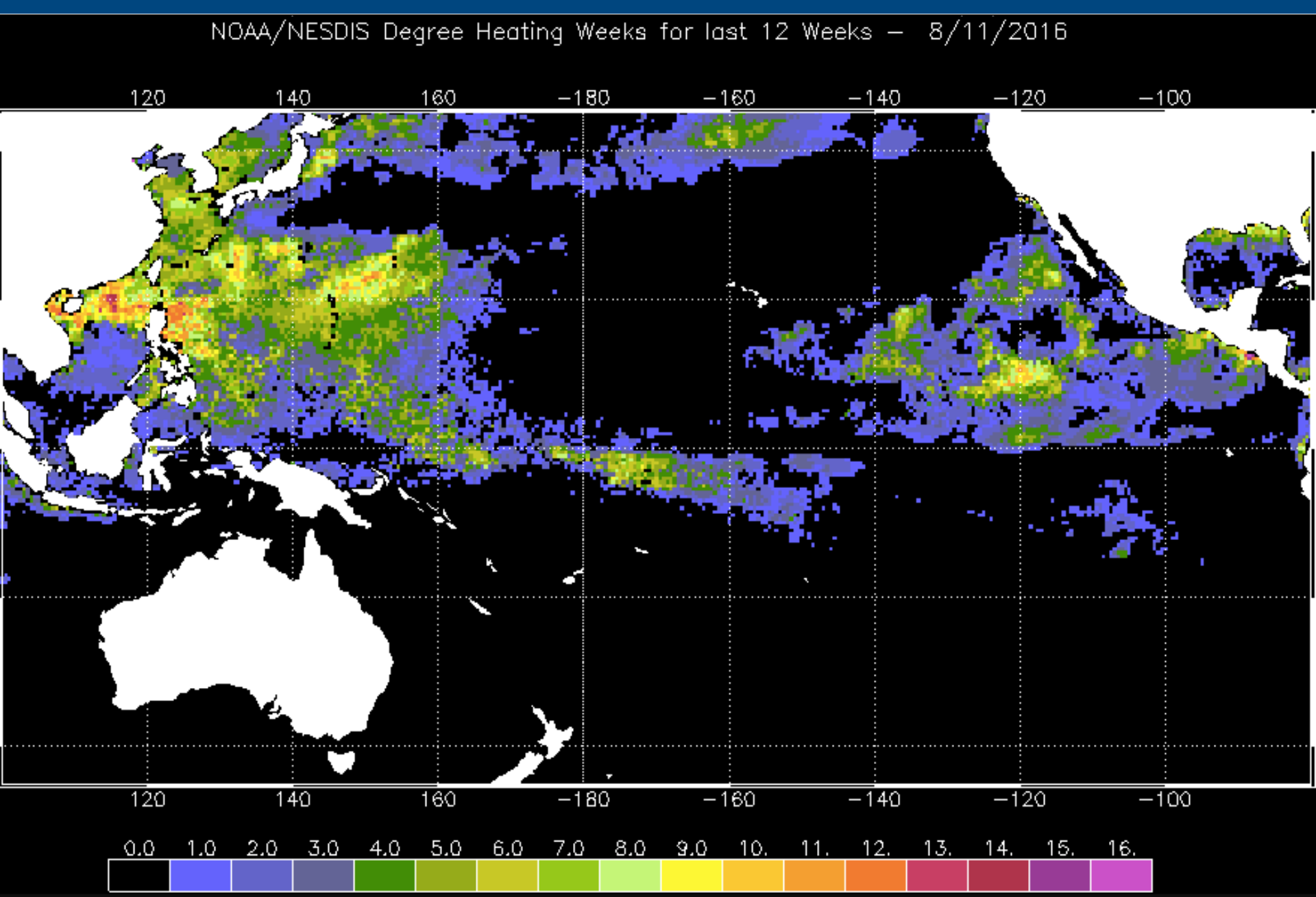
Extreme 2015-2016 El Niño - Oceanographic

Extreme 2015-2016 El Niño - Oceanographic

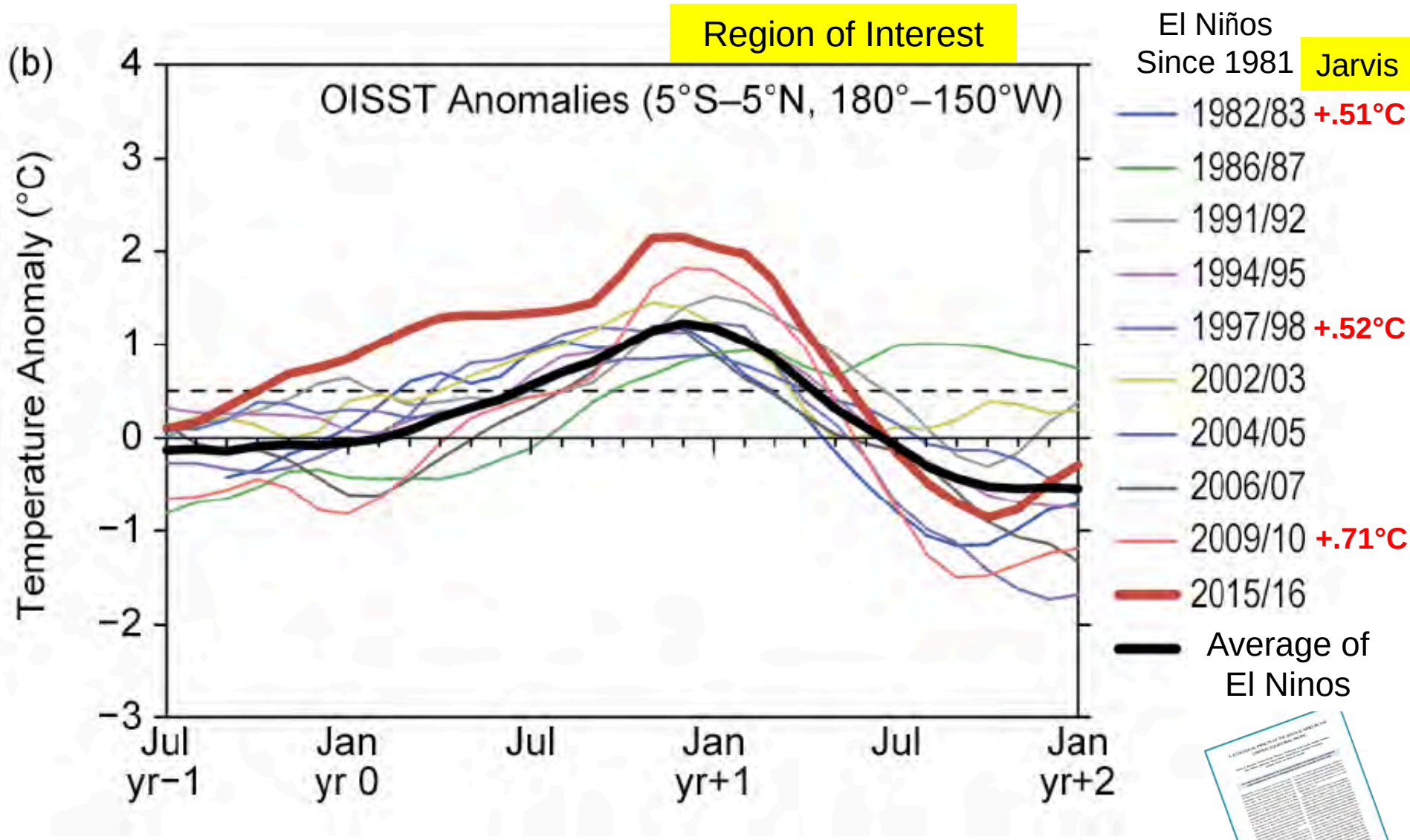




Brainard et al. (2018)

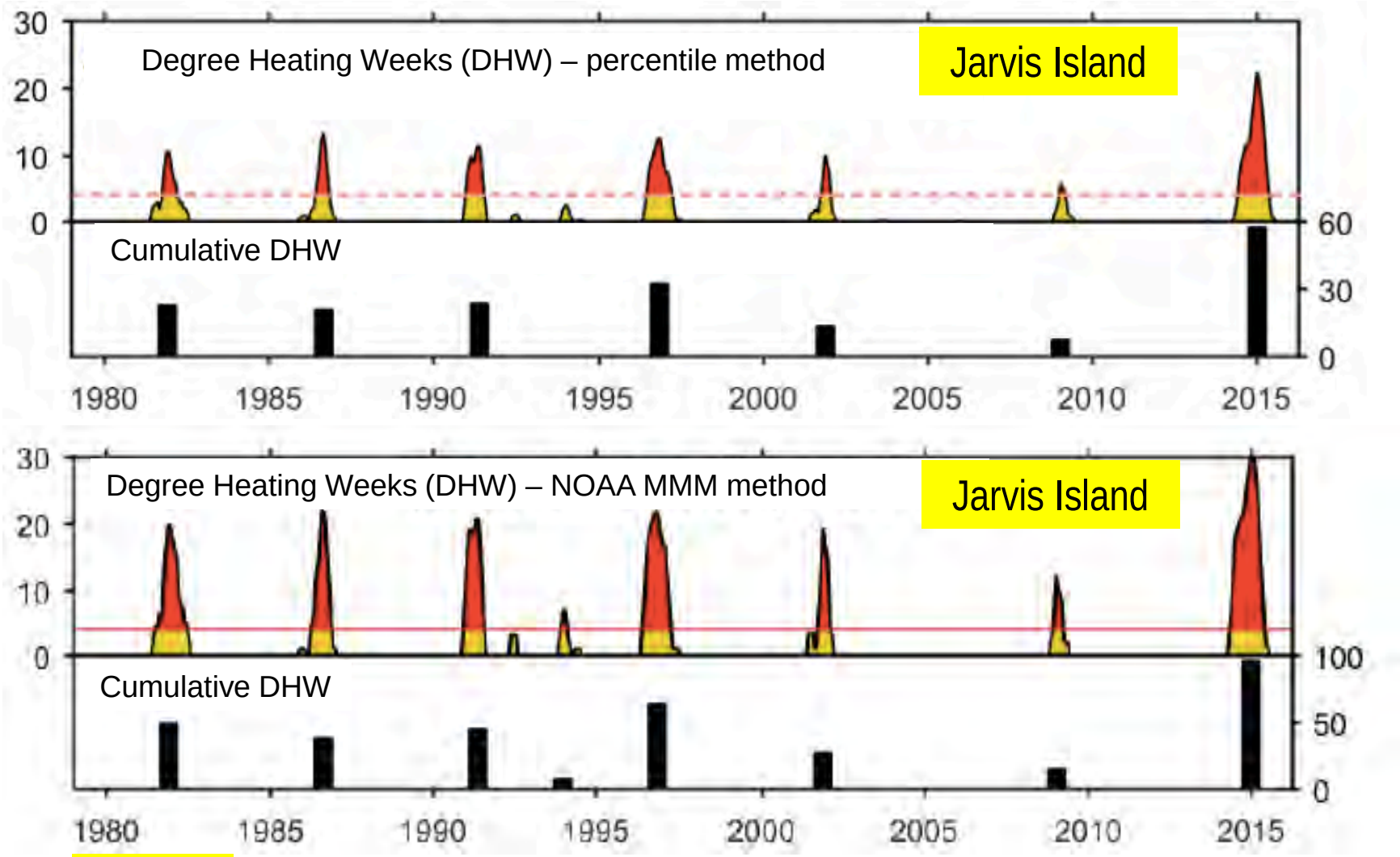

NOAA/NESDIS Degree Heating Weeks for last 12 Weeks – 8/11/2016
120
140
160
-180
-160
-140
-120
-100
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.
11.
12.
13.
14.
15.
16.

Extreme 2015-2016 El Niño - Oceanographic



Brainard et al. (2018)

Extreme 2015-2016 El Niño - Oceanographic



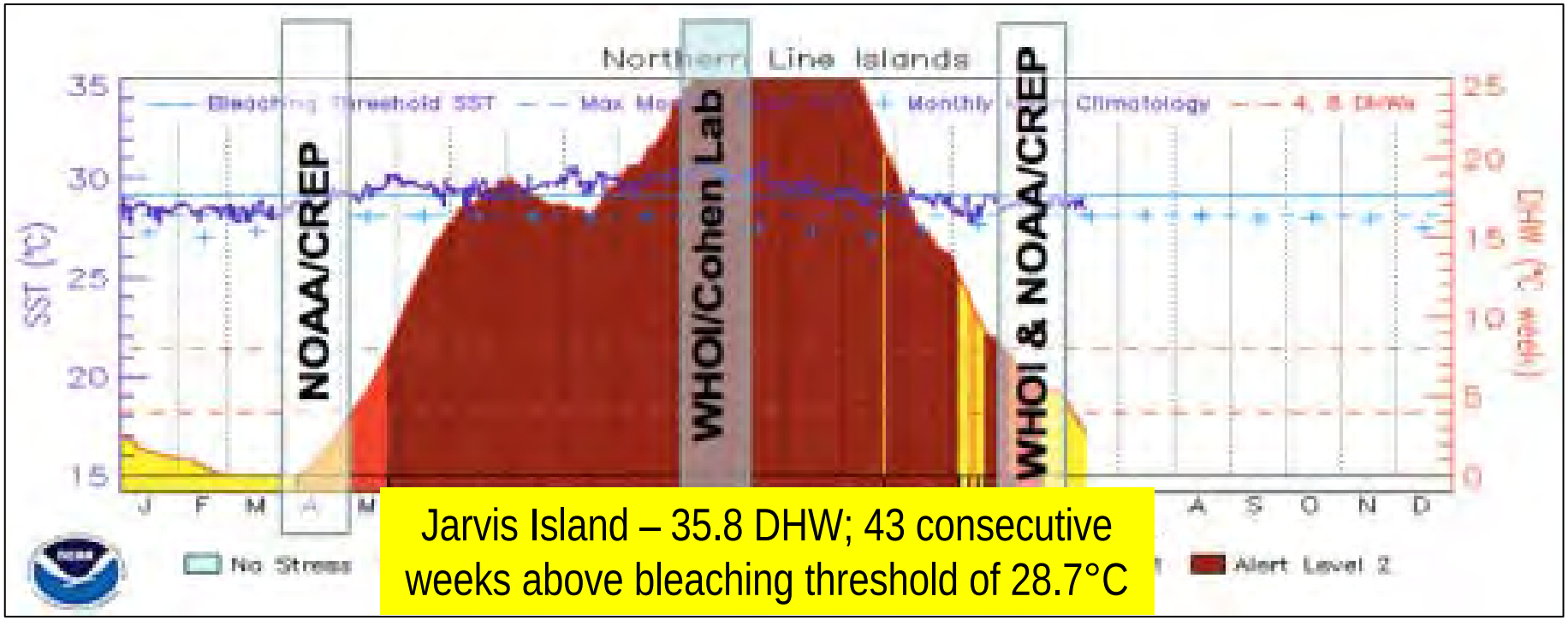
OISST

Title: 6 Decades of Coral Bleaching on a Central Pacific Reef

Authors: Hannah C. Barkley[1†‡], Anne L. Cohen[1*], Nathaniel R. Mollica[3], Russell E. Brainard[2], Hanny E. Rivera[3], Thomas M. DeCarlo[3¶#], Pat Lohmann[1], Elizabeth J. Drenkard[3§], Alice E. Alpert[3††], Charles W. Young[2,4], Bernardo Vargas-Ángel[2,4], Kevin C. Lino[2,4], Thomas A. Oliver[2,4], Kathryn R. Pietro[1], Victoria H. Luu[5]

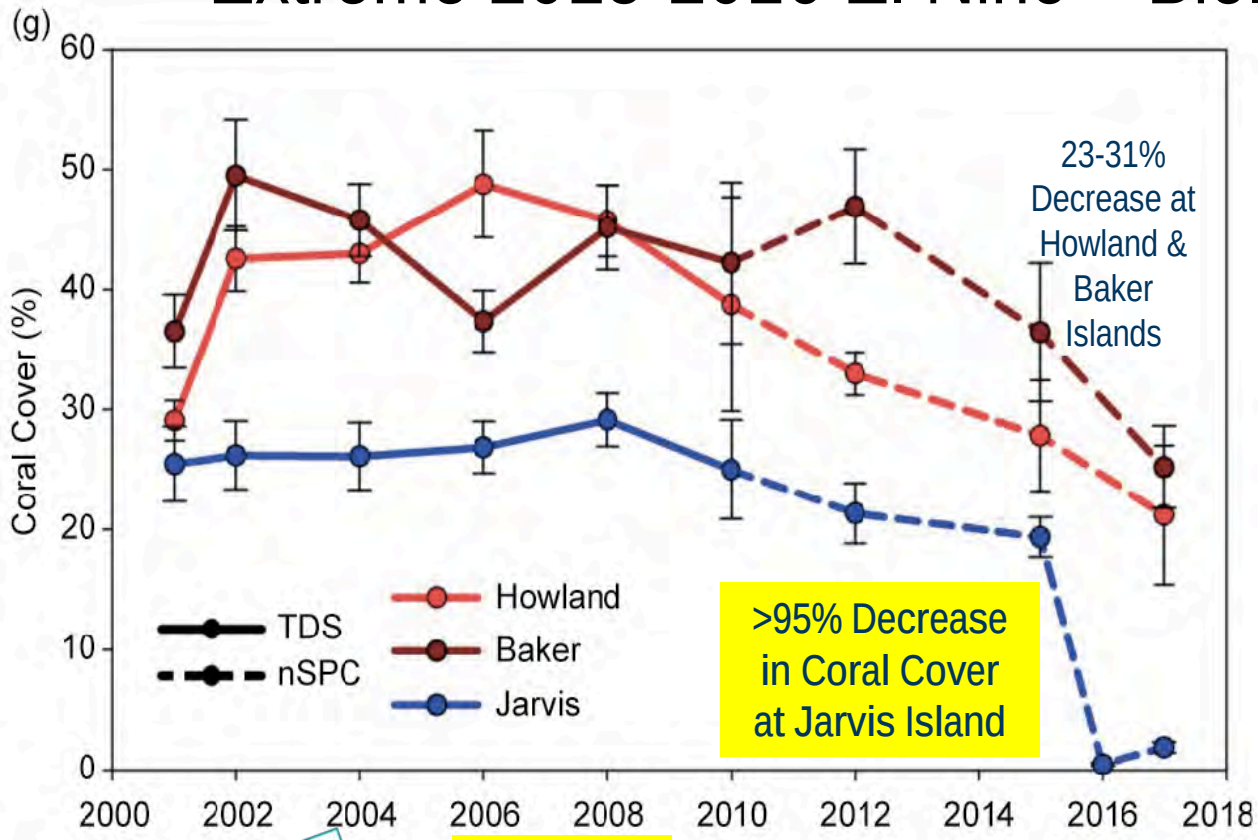
Barkley et al. (in revision, *NatCommsBio*)

Coral Bleaching and Mortality events: Pacific Islands



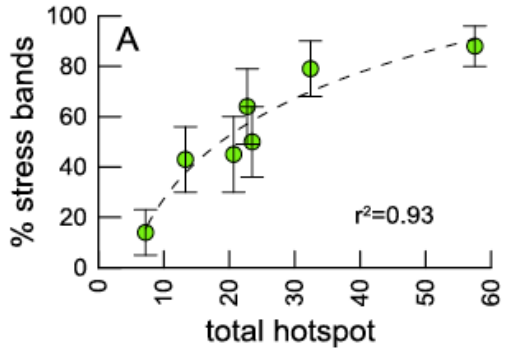
Jarvis Island – 35.8 DHW; 43 consecutive weeks above bleaching threshold of 28.7°C

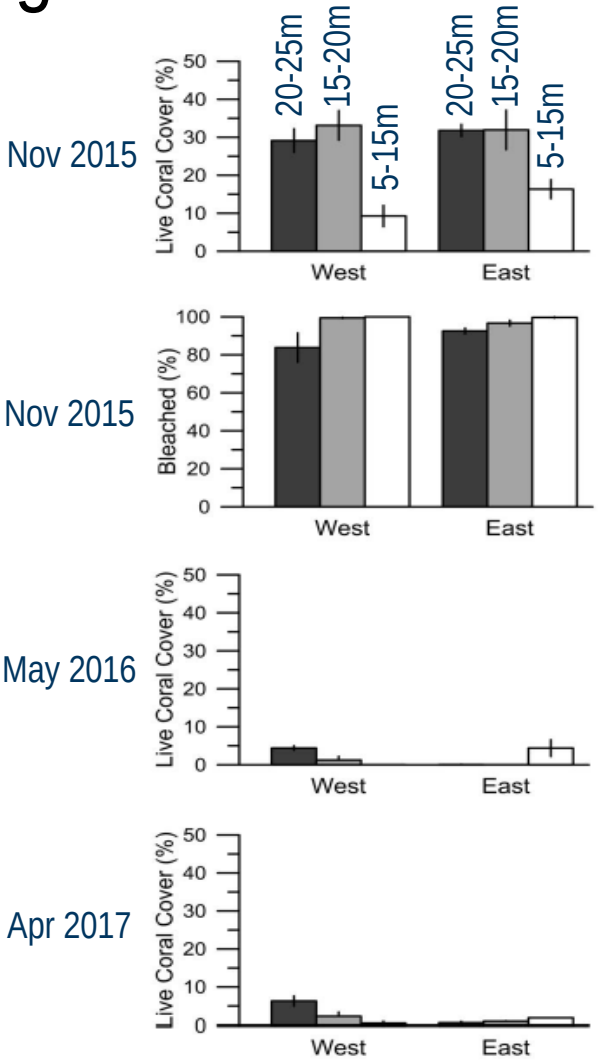
Extreme 2015-2016 El Niño – Biological - Corals



Brainard et al. (2018)

For more detail on responses of corals by depth and taxa, see Vargas-Angel et al. (in review)





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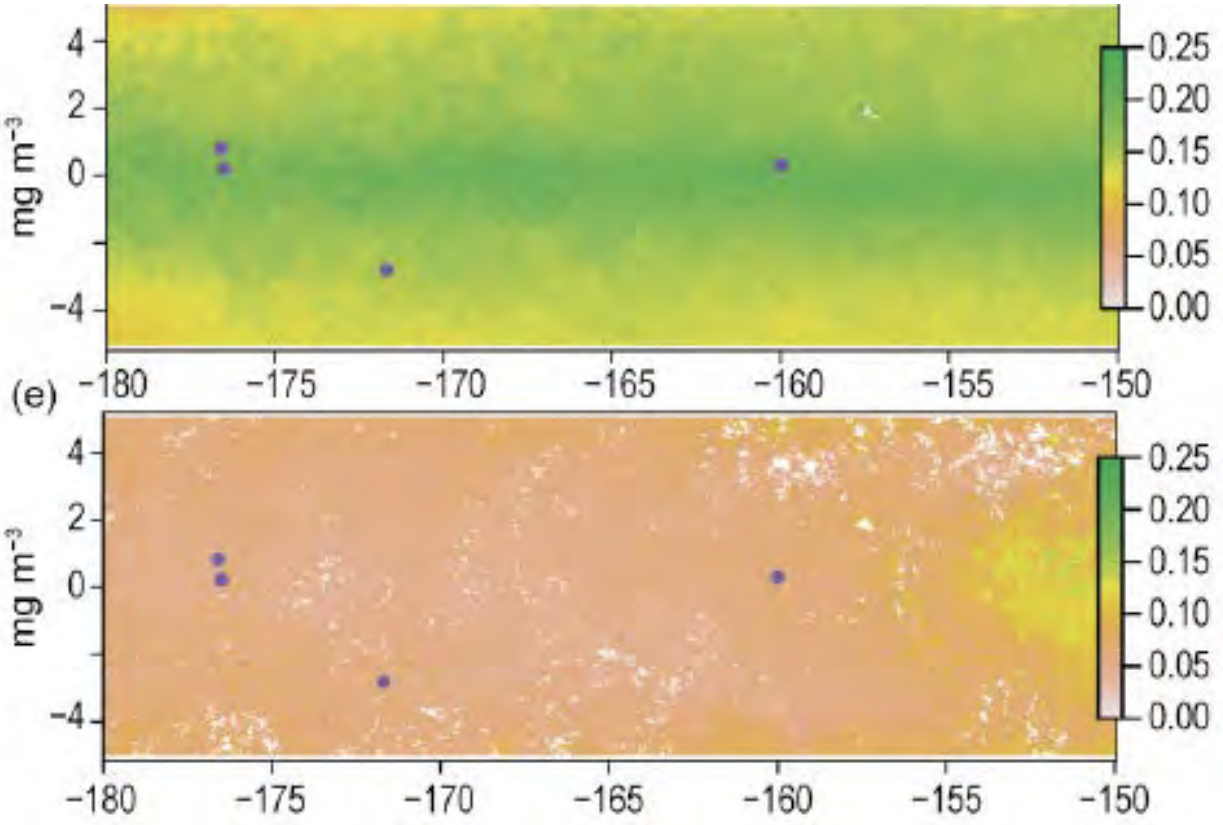
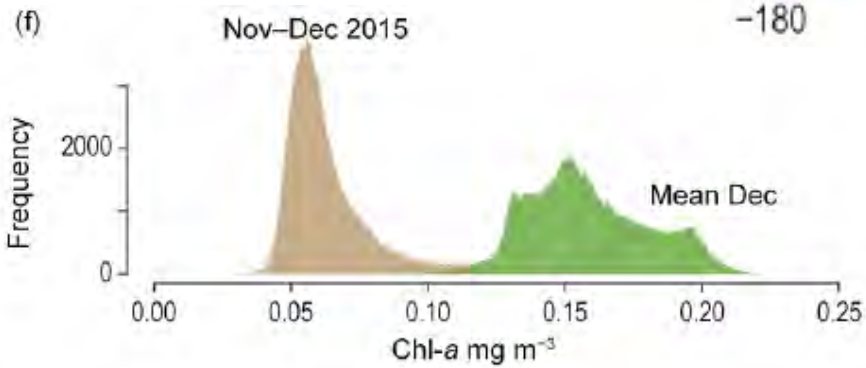
Extreme 2015-2016 El Niño – Oceanic Productivity

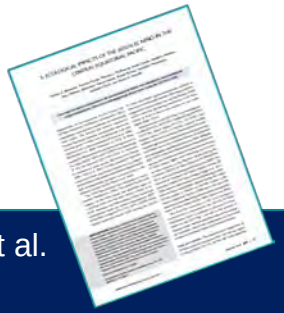
Mean Chl a – all Decembers 2002-2016

Mean Chl a –Nov - Dec 2015



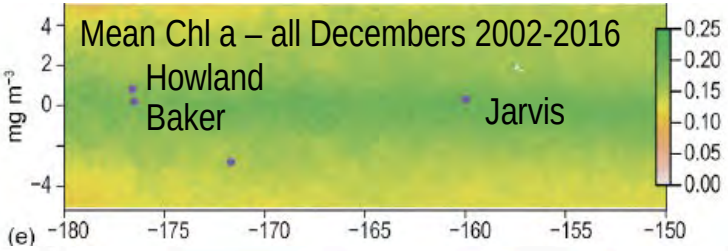
Region of Interest

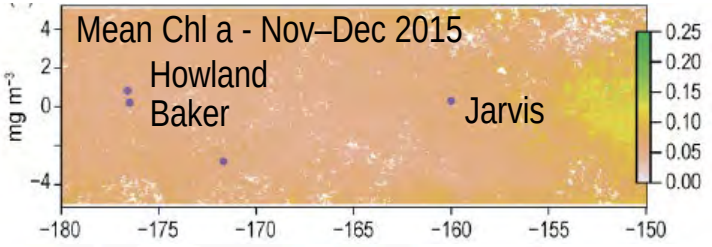


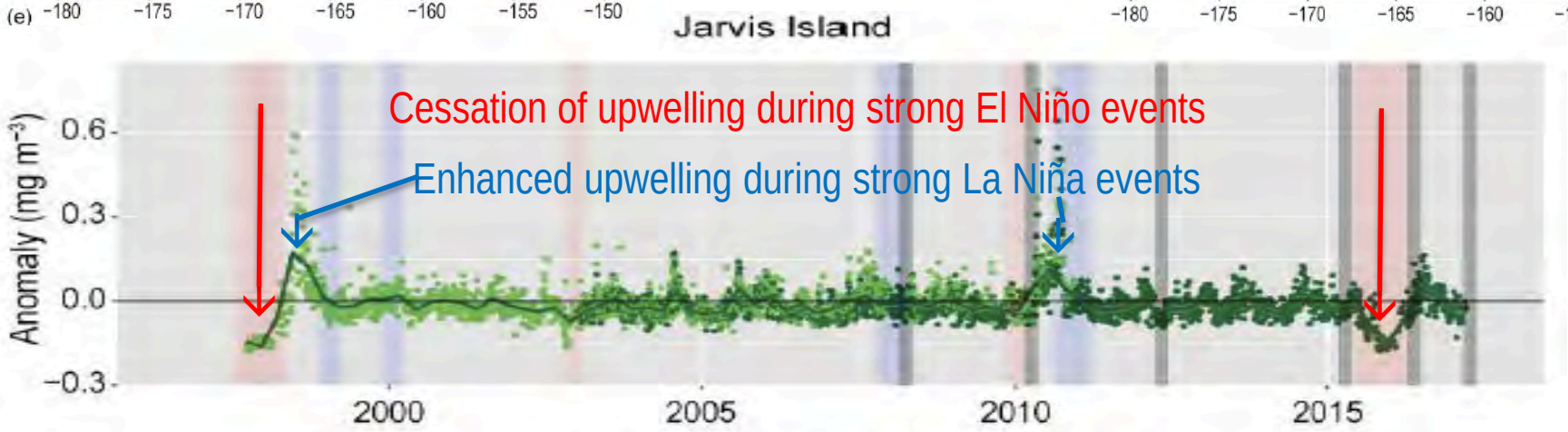


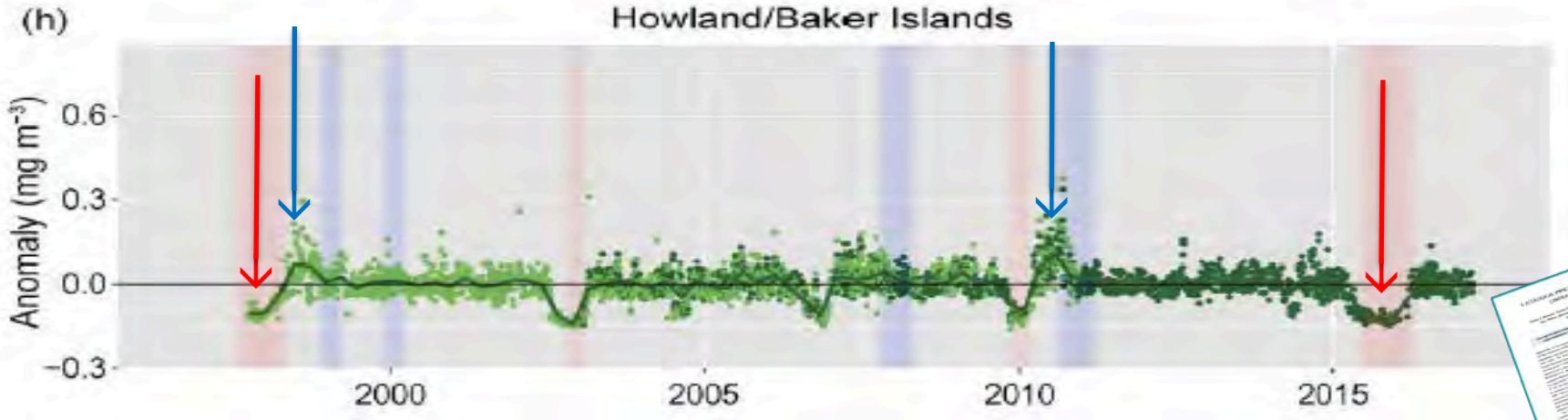
Brainard et al. (2018)

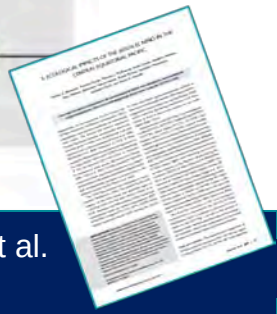
Extreme 2015-2016 El Niño – Oceanic Productivity





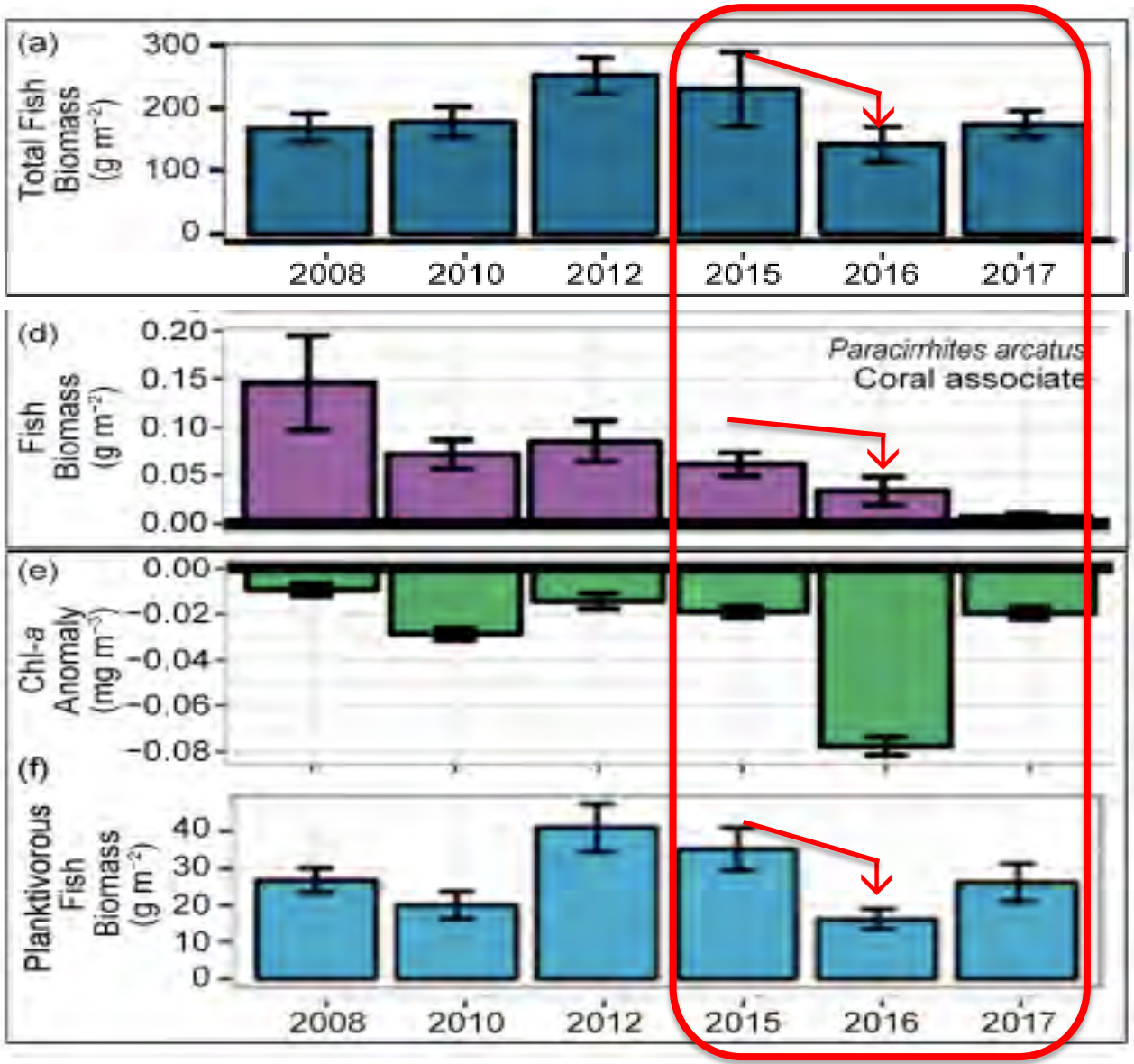




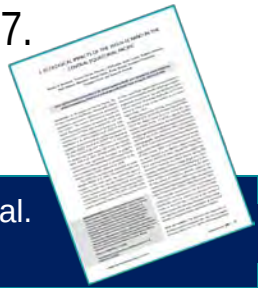


Brainard et al. (2018)

Extreme 2015-2016 El Niño – Biological – Productivity/Fish



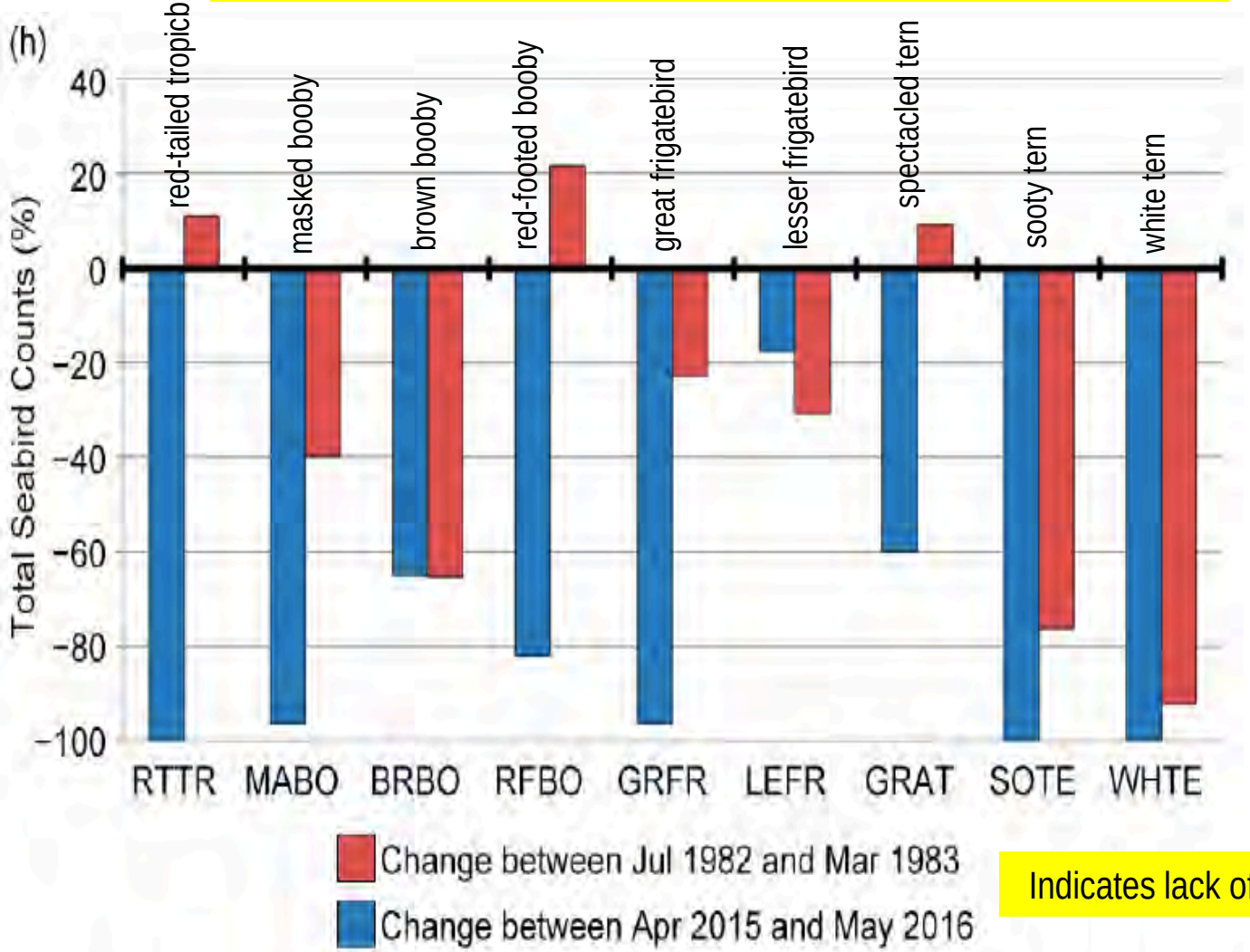
- Total reef fish biomass had small decline during 2015-16 El Niño, but recovering by 2017
- Coral associated fish biomass had significant decline following 96% loss of coral
- Chl a (productivity) plummeted during 2015-16 El Niño, but recovered by 2017.
- Plankitvorous fish plummeted during 2015-16 El Niño, but recovered by 2017.



Brainard et al. (2018)

Extreme 2015-2016 El Niño – Biological - Seabirds

19 seabird counts from 1973–2016 showed a negative relationship between the abundance of most species and the Niño-3.4 index.



RTTR – *Phaethon rubricauda* (red-tailed tropicbird)

MABO – *Sula dactylatra* (masked booby)

BRBO – *S. leucogaster* (brown booby)

RFBO – *S. sula* (red-footed booby)

GRFR – *Fregata minor* (great frigatebird)

LEFR – *F. ariel* (lesser frigatebird)

GRAT – *Onychoprion lunatus* (spectacled tern)

SOTE – *O. fuscatus* (sooty tern)

WHTE - *Gygis alba* (white tern)

Indicates lack of reproduction

Brainard et al. (2018)

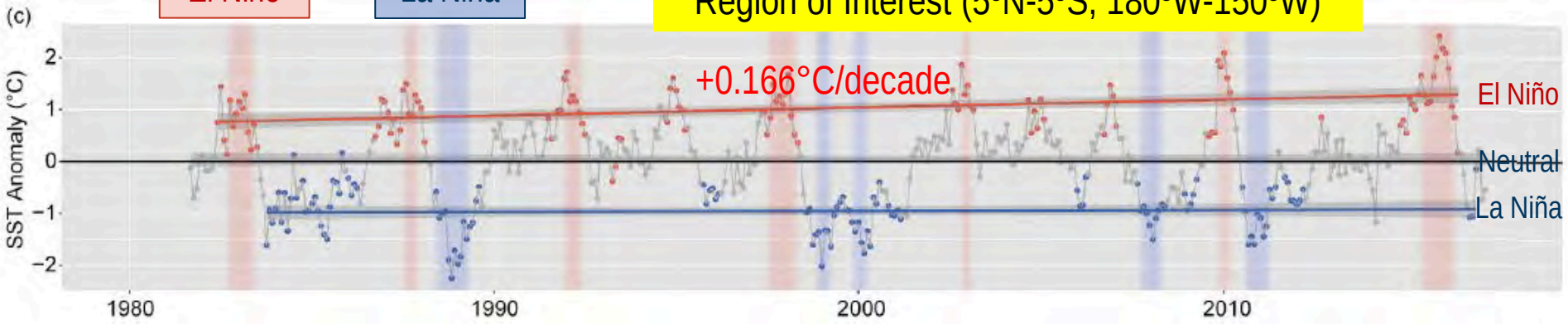
Climate Change and SST Trends (1981-2017)

OISST Anomalies & Trends

El Niño

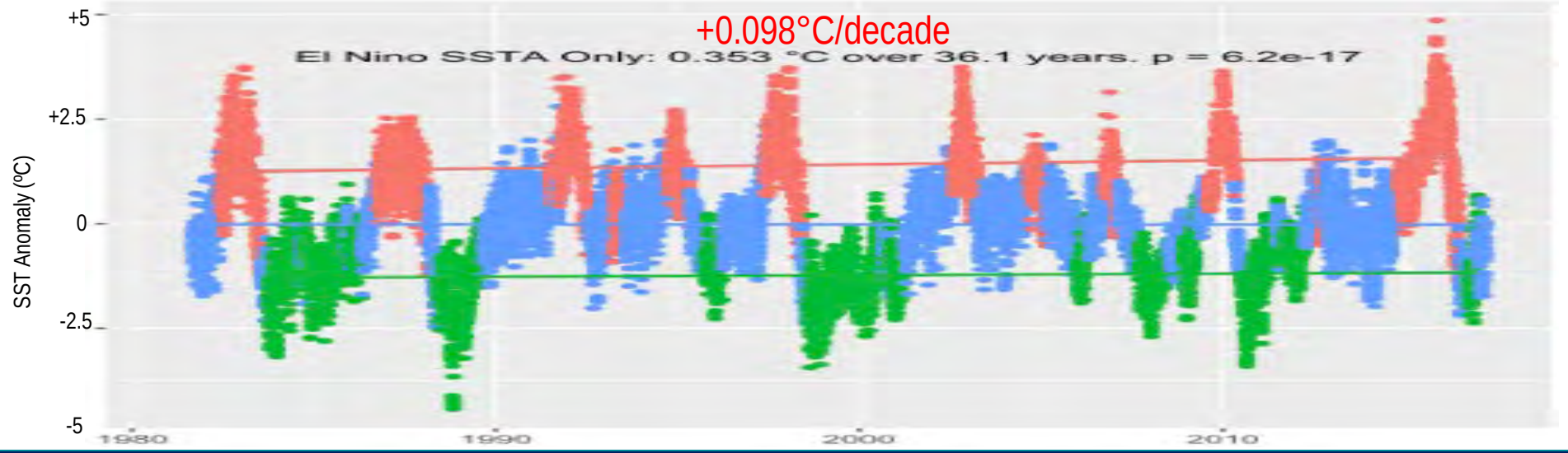
La Niña

Region of Interest (5ºN-5ºS, 180ºW-150ºW)



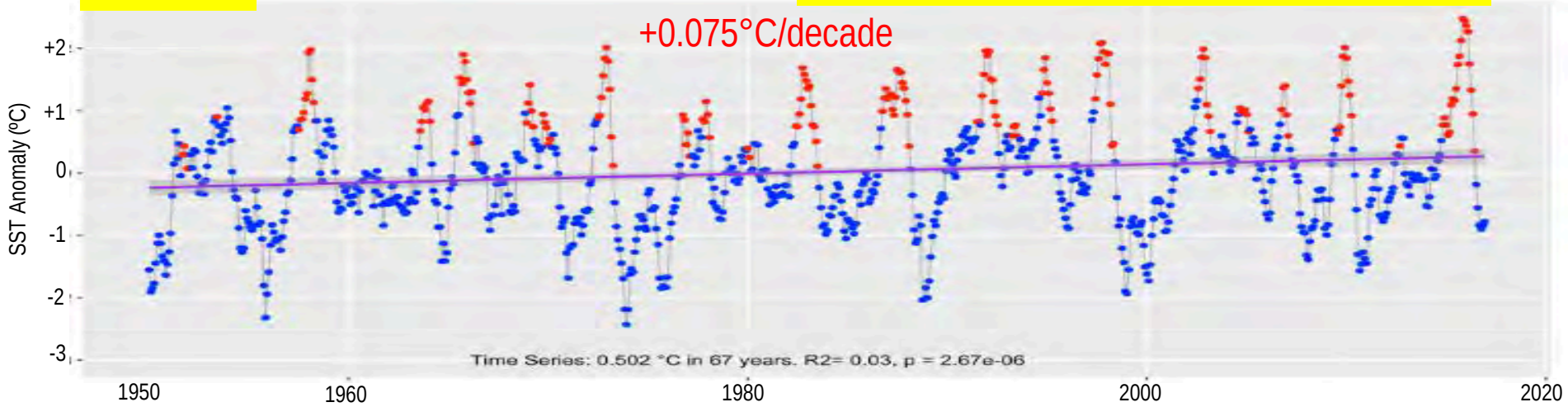
OISST Anomalies & Trends

Jarvis Island (0.63°N–1.37°S, 159°–161°W)

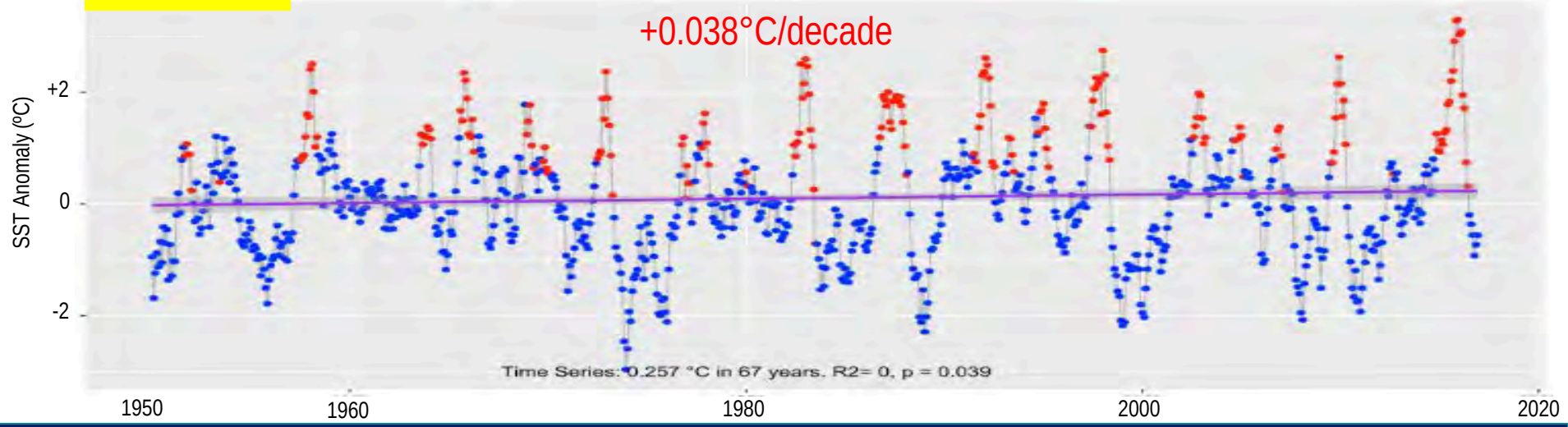


Climate Change and SST Trends (1950-2017)

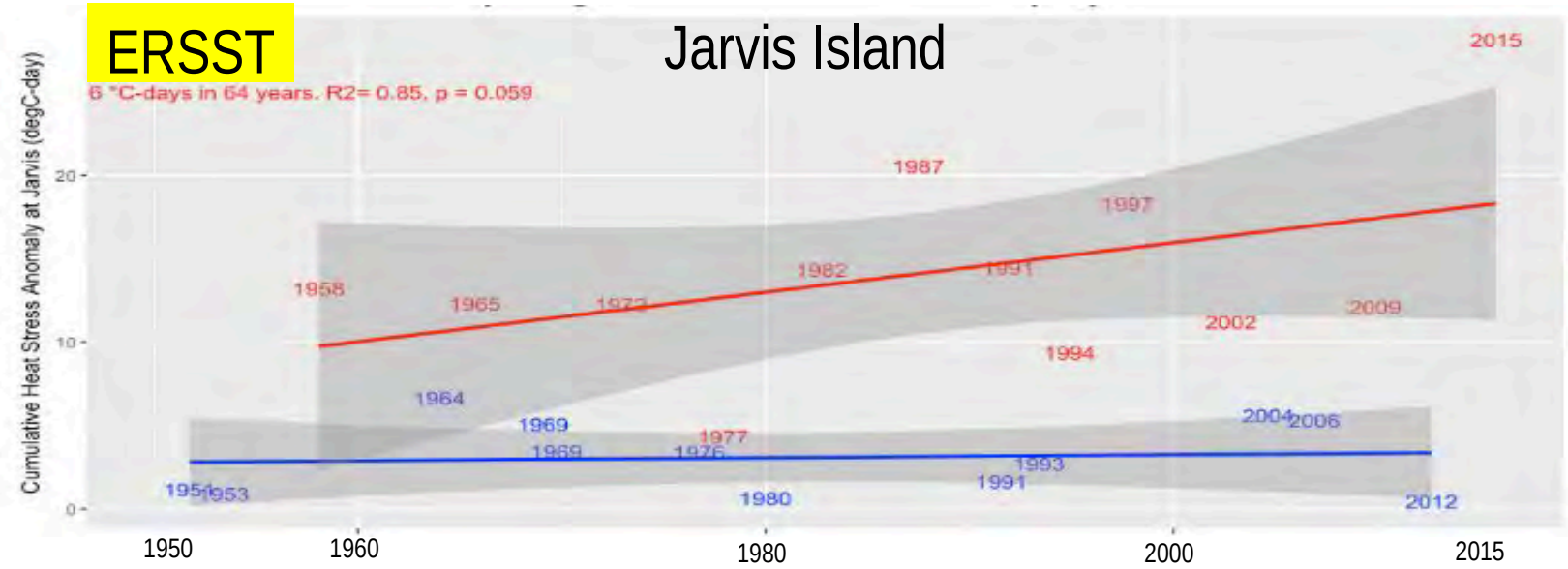
ERSST Anomalies & Trends — Jarvis Island (0.63°N–1.37°S, 159°–161°W)

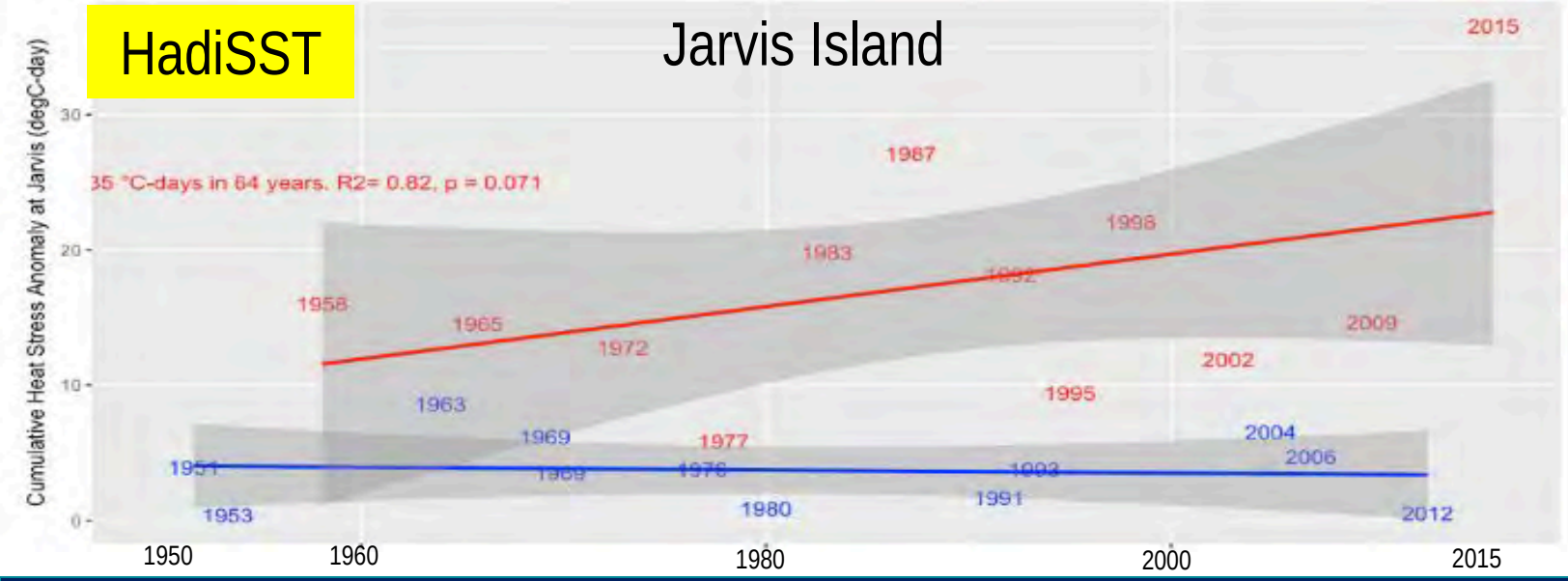


HadiSST Anomalies & Trends — Jarvis Island (0.63°N–1.37°S, 159°–161°W)



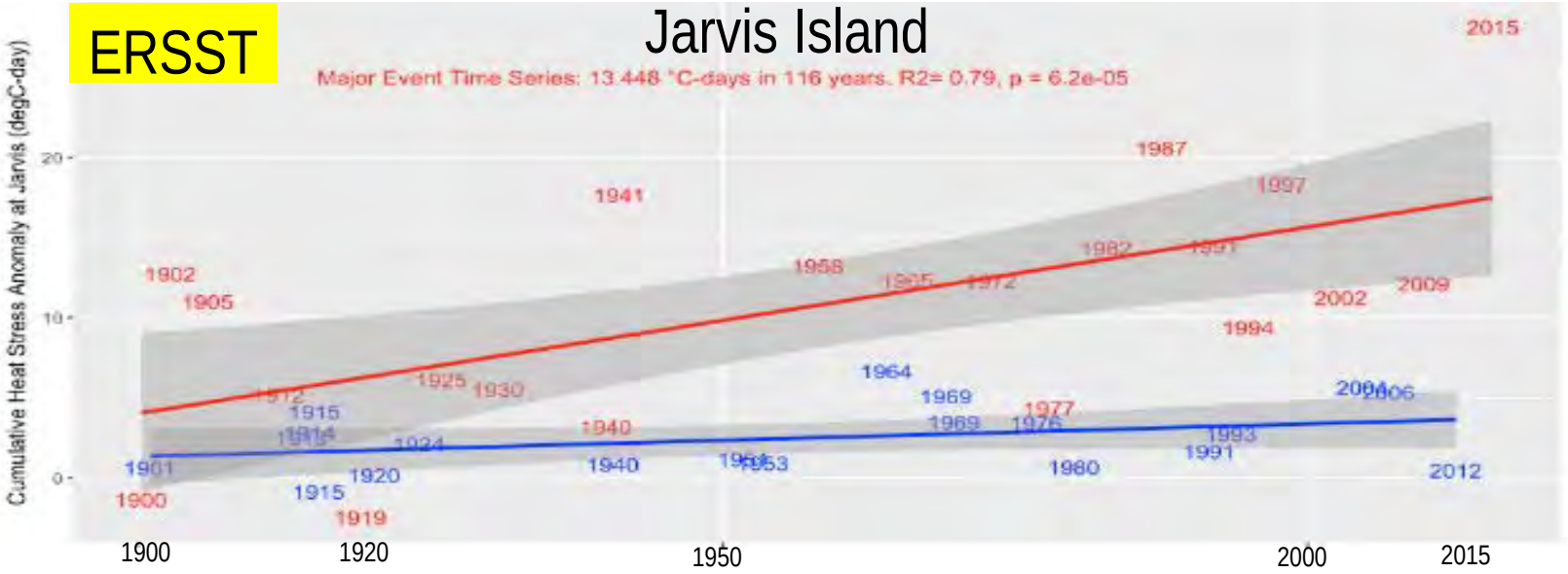
Climate Change & Cumulative Heat Stress Trends (1950-2017)



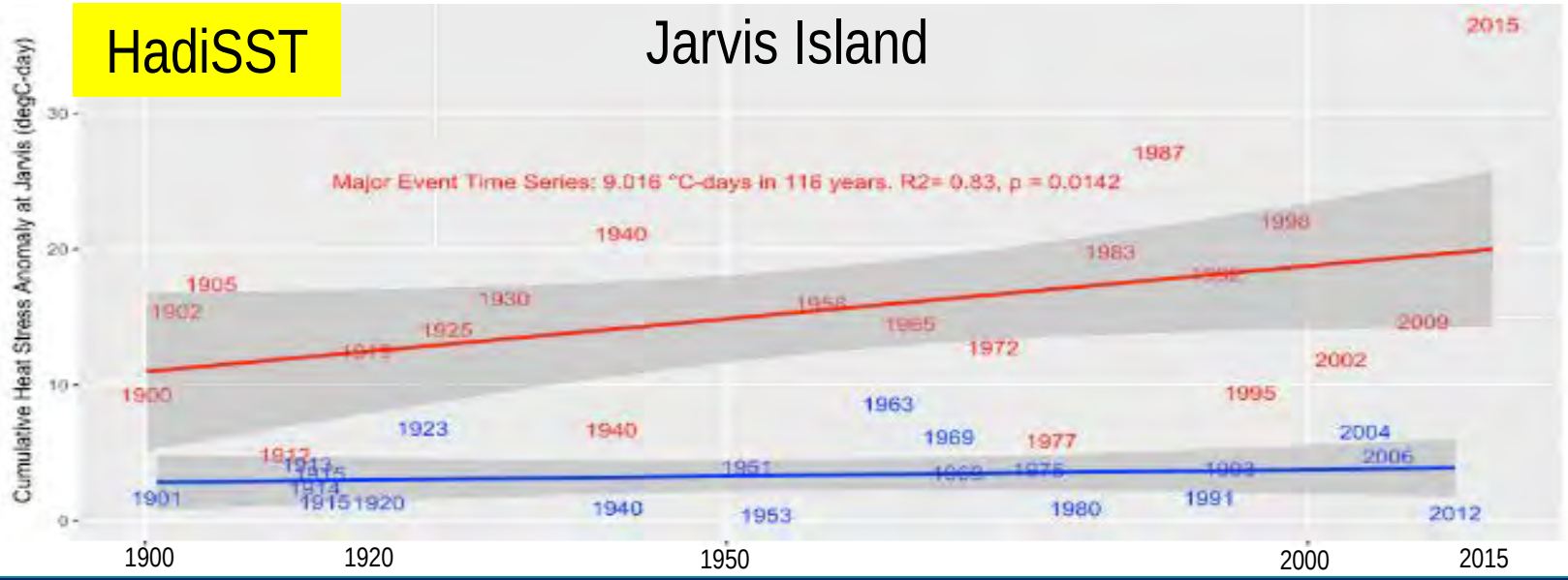


Climate Change & Cumulative Heat Stress Trends (1900-2017)

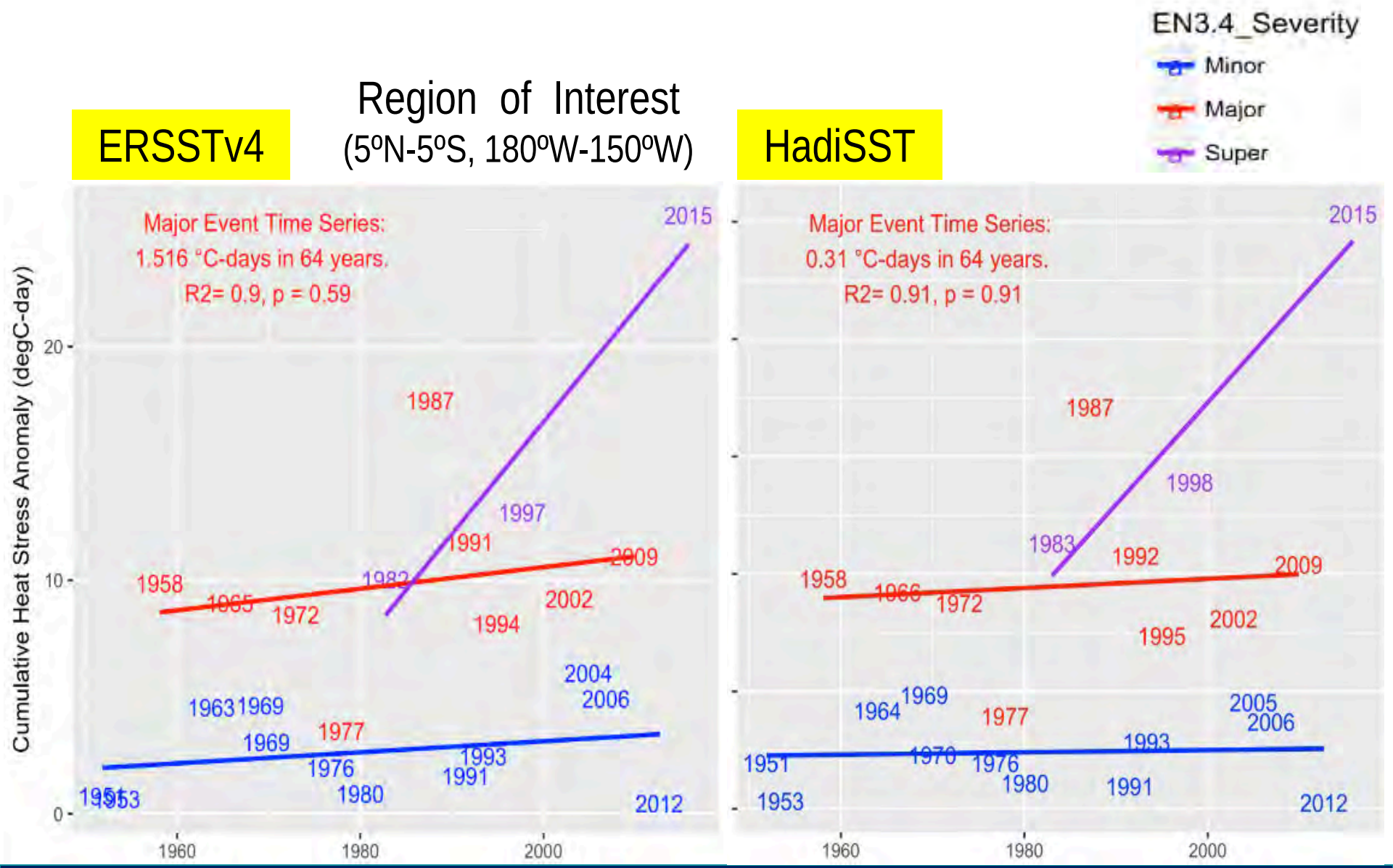
ERSST



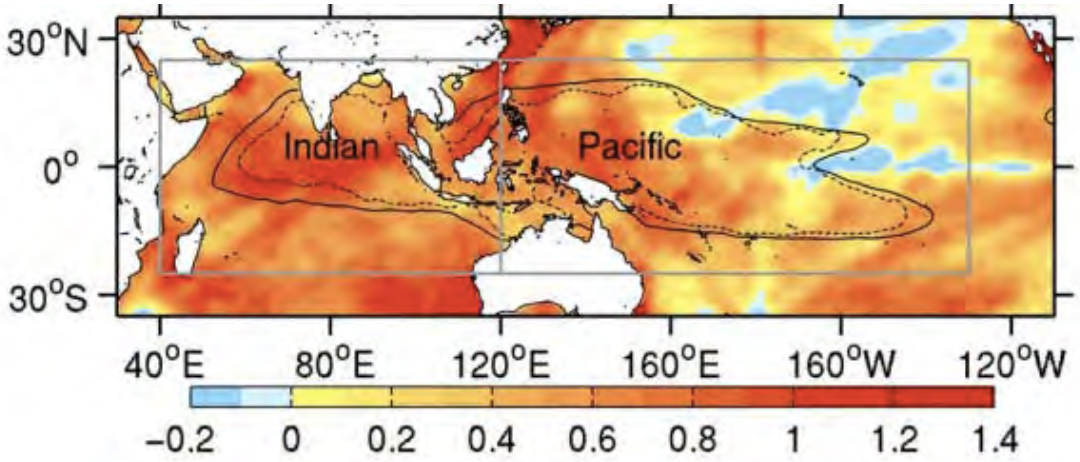
HadiSST



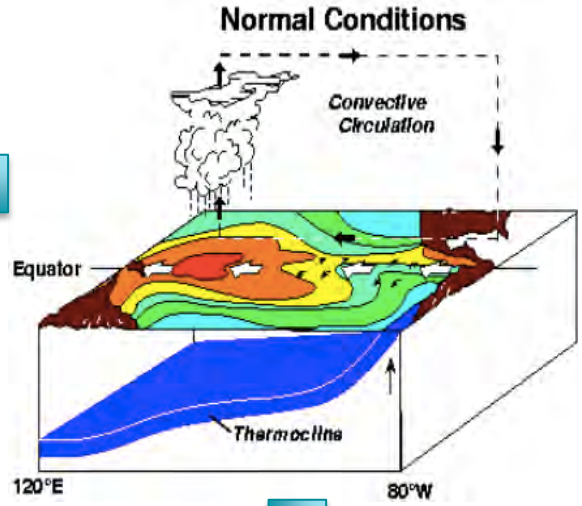
Climate Change & Cumulative Heat Stress Trends (1950-2017)

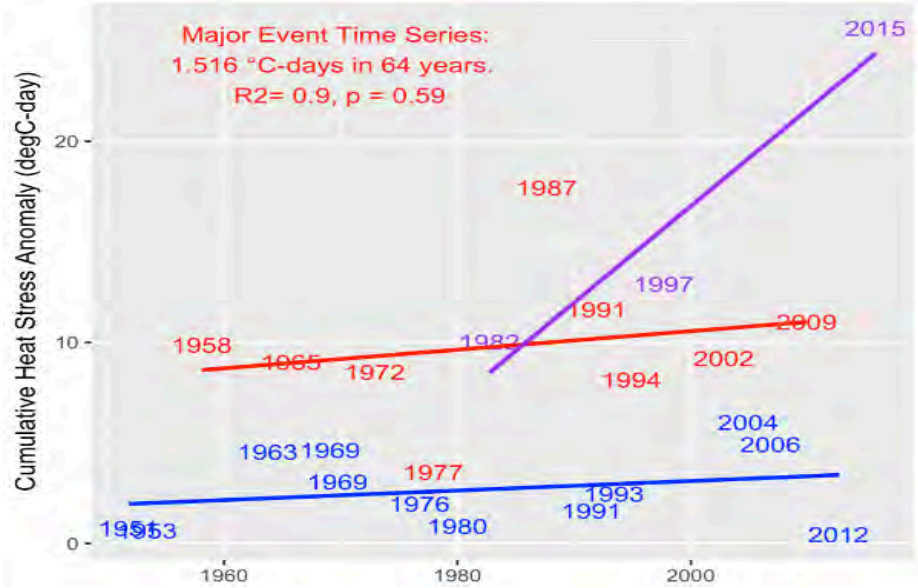


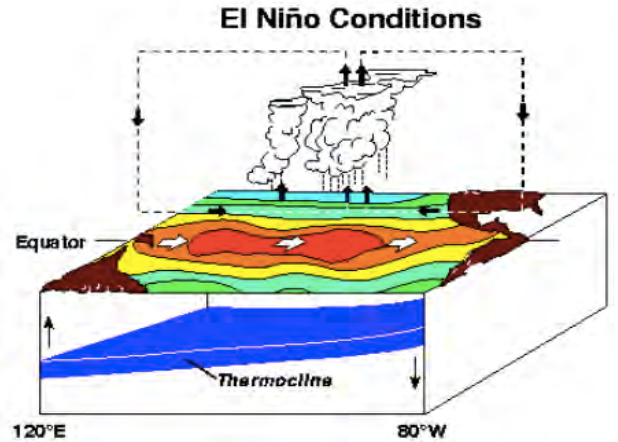
Climate Change is Driving More Extreme El Niños in CEP



Weller et al. (2016) *Sci Adv*



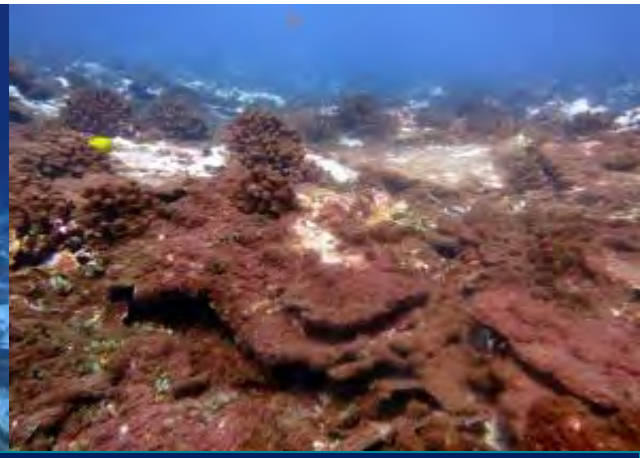




Conclusions

- Long-term warming trend in the Indo-Pacific Warm Pool
- Corresponding warming trend across the CEP during major El Niño events,
- Record high SST and Chl-*a* anomalies across the CEP in association with the extreme 2015-2016 El Niño
  - disrupted coral reef and seabird communities,
  - especially at Jarvis Island, where catastrophic coral bleaching and mortality were observed





Next Steps

1. Barkley et al. – Coral core thermal stress bands over the past 60 years
   a) Jarvis (in review)
   b) Howland and Baker Islands (June 2018)
2. Monitoring coral reef recovery and resilience
   a) Jarvis Island (July 2018 and beyond)
   b) Howland and Baker Islands (June 2018 and beyond)
3. Examining relationships between tuna and other pelagic fisheries and increasingly strong El Niño events in CEP associated with climate change
4. Examining effects of increasingly strong El Niño events in CEP on driving ecological impacts of ocean acidification
5. Examining effects of increasingly strong El Niño events in CEP on seabird populations

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