# Dynamical downscaling of future ocean climate for Mexican coastlines, towards the evaluation of future species ranges & ecosystem shifts
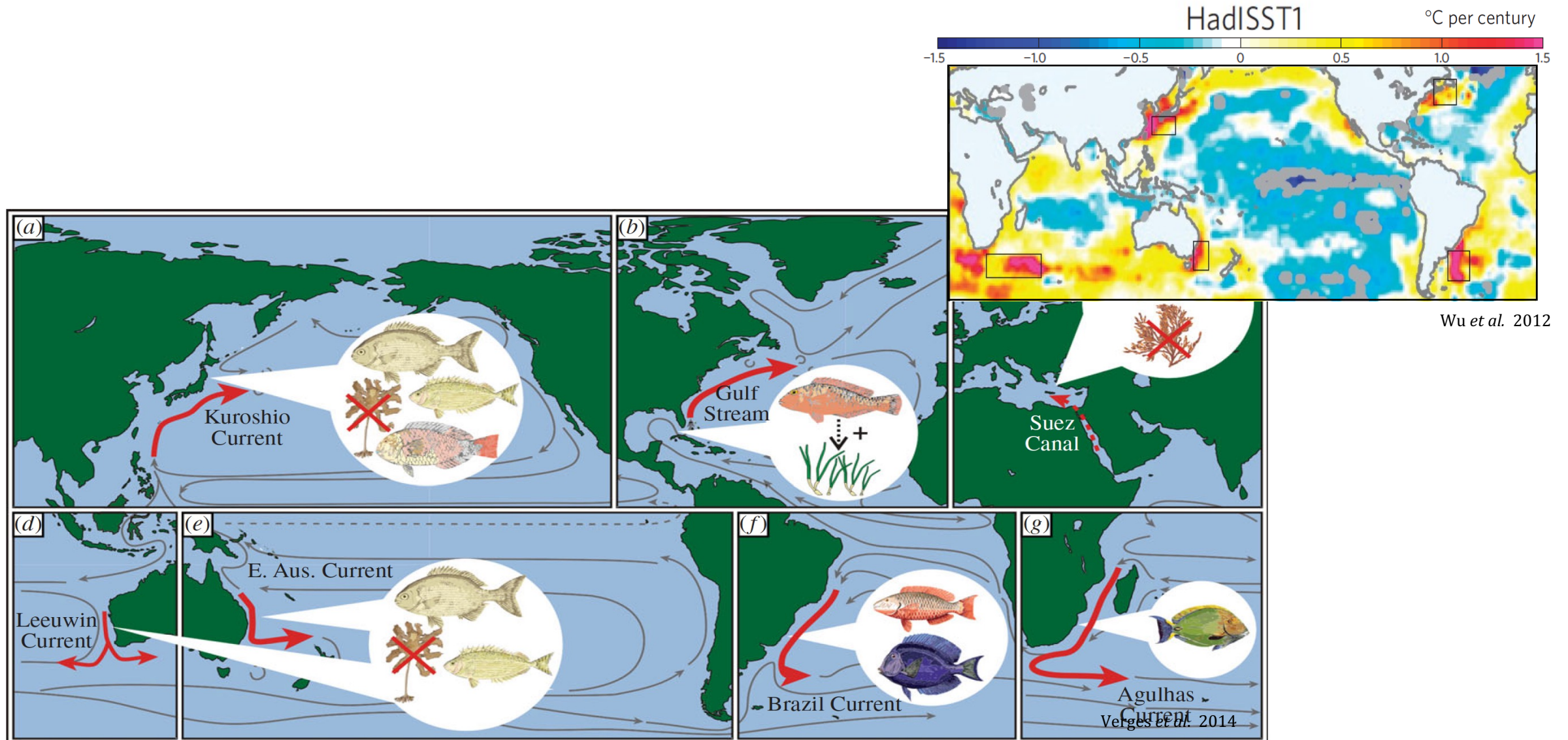
ICRC CORDEX 2023
September 25-31

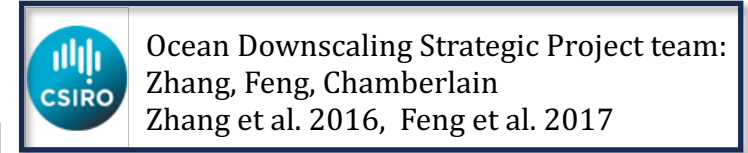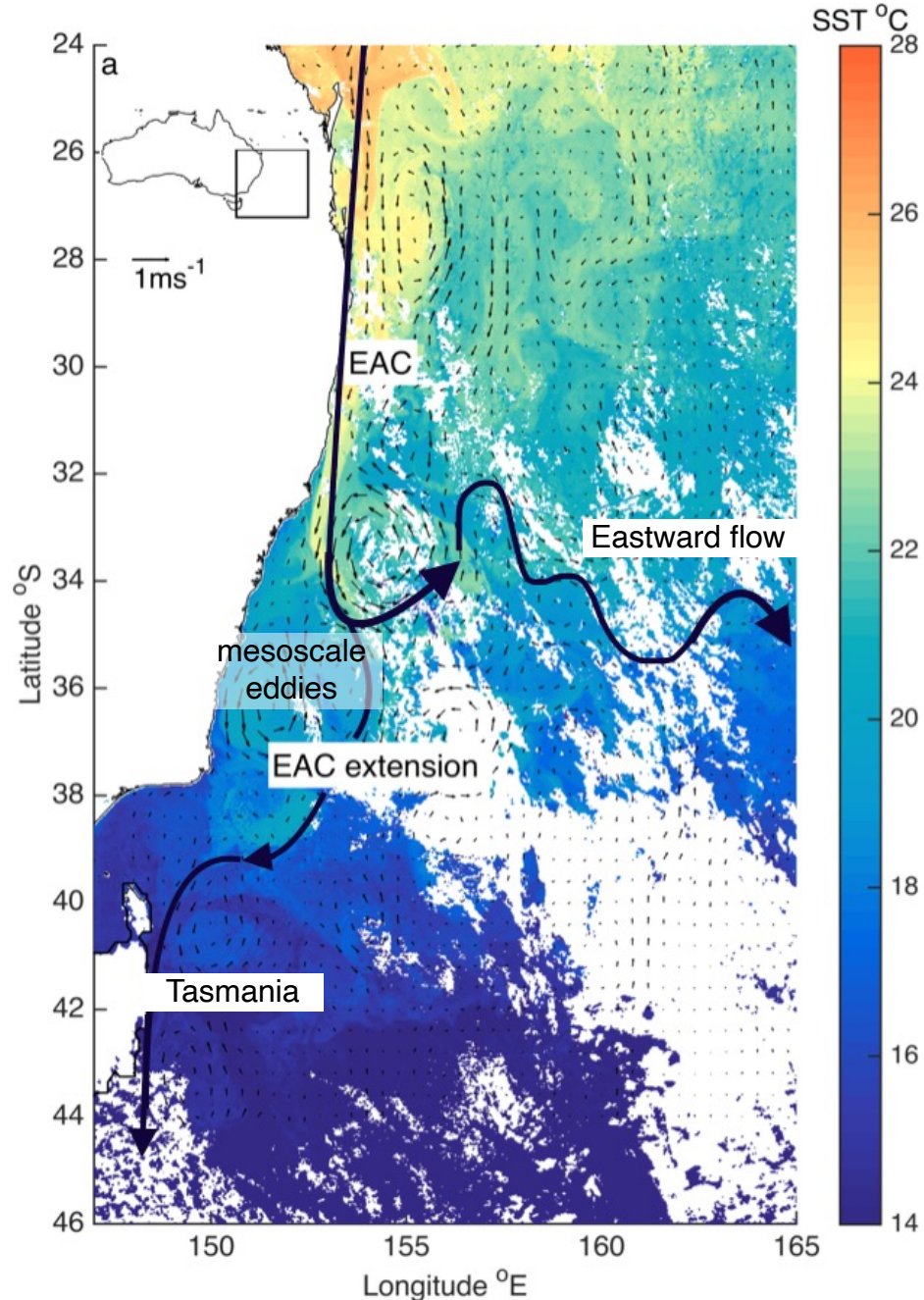P Cetina Heredia

T Cavazos

S Estrada-Allis

A Pares

J Sheinbaum

# Motivation

Global climate change has induced an intensification of Western Boundary Currents (WBCs) & warming along them



HadISST1                                     °C per century

Wu *et al.* 2012

Climate driven changes in species distribution has led to tropicalization of temperate ecosystems along WBC

# Downscaled global climate; application along southeast Australia



**Downscaled ocean model**

Ocean Downscaling Strategic Project team:
Zhang, Feng, Chamberlain
Zhang et al. 2016, Feng et al. 2017

Projections of future climate under the Representative Concentration Pathway 8.5 (RCP8.5 run) during **2006–2101**, spatial resolution **1/10°** (eddy resolving)

Merged atmospheric forcing
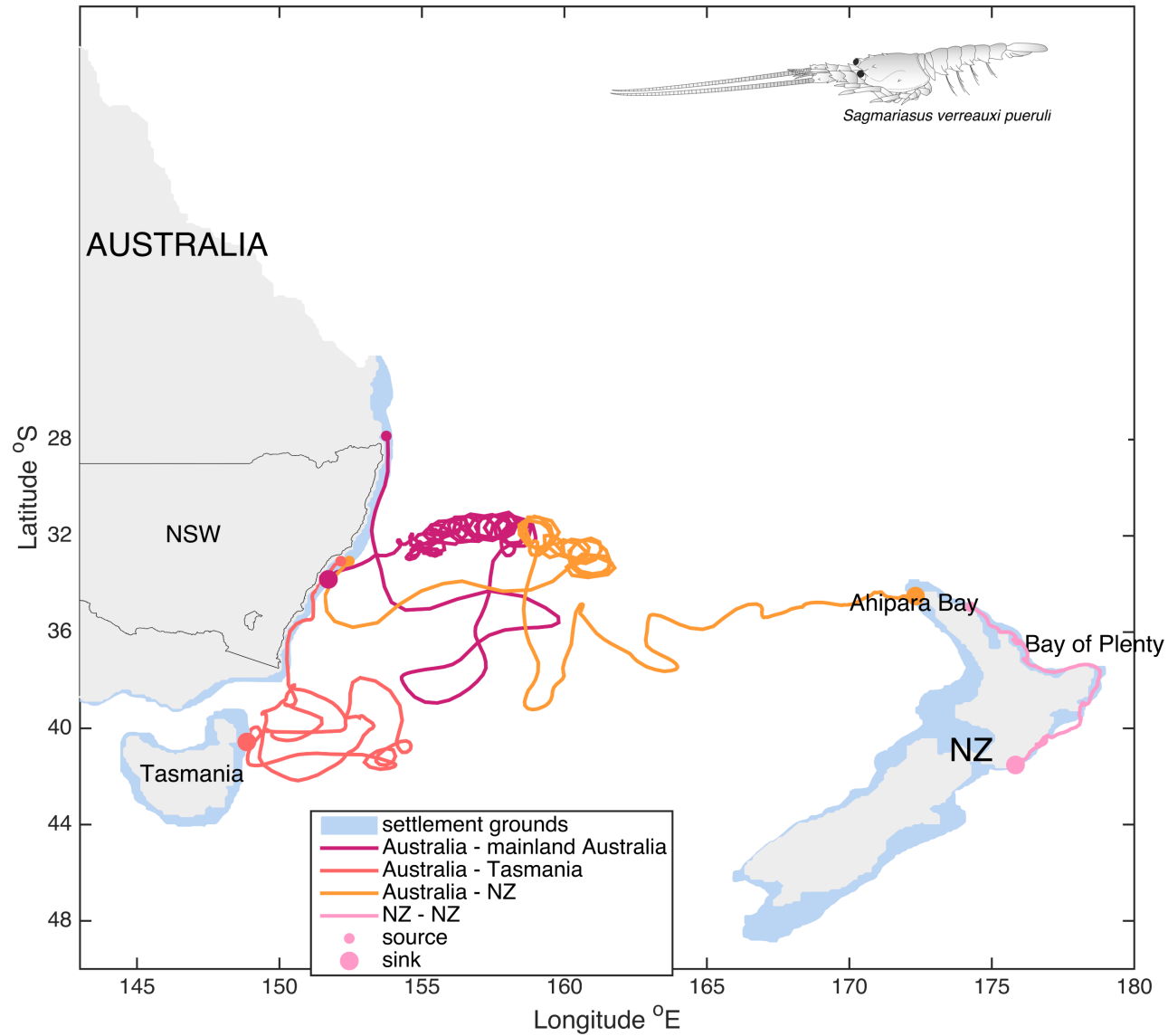long-term climate change signals:
**ensemble of 17 CMIP5 climate models**

high frequency component (cutoff period 7 years):
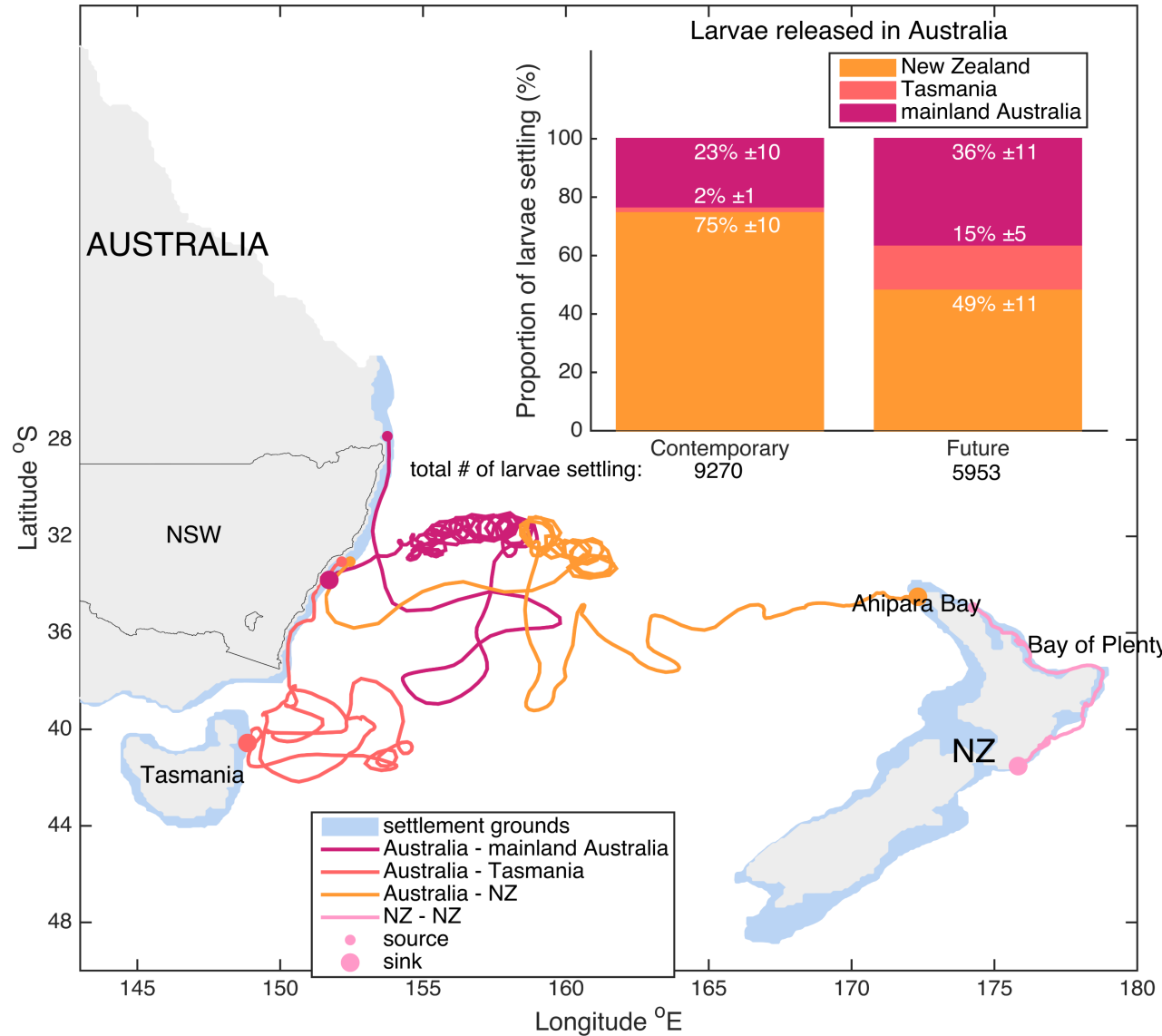**JRA-55 1981–2012**

**State of the art model (ensemble / high resolution)** Feng et al. 2017

# Downscaled global climate; application along southeast Australia



Changes to dispersal and settlement of Eastern Rock Lobster, the highest priced fishery in New South Wales

# Downscaled global climate; application along southeast Australia



Changes to dispersal and settlement of Eastern Rock Lobster, the highest priced fishery in New South Wales

The proportion of larvae settling in New Zealand diminishes & that settling in Tasmania and Mainland Australia increases

Since less larvae are exported to New Zealand, management rules within Australia are expected to have a clear local impact

It is suggested to open the fishery of ERL in Tasmania

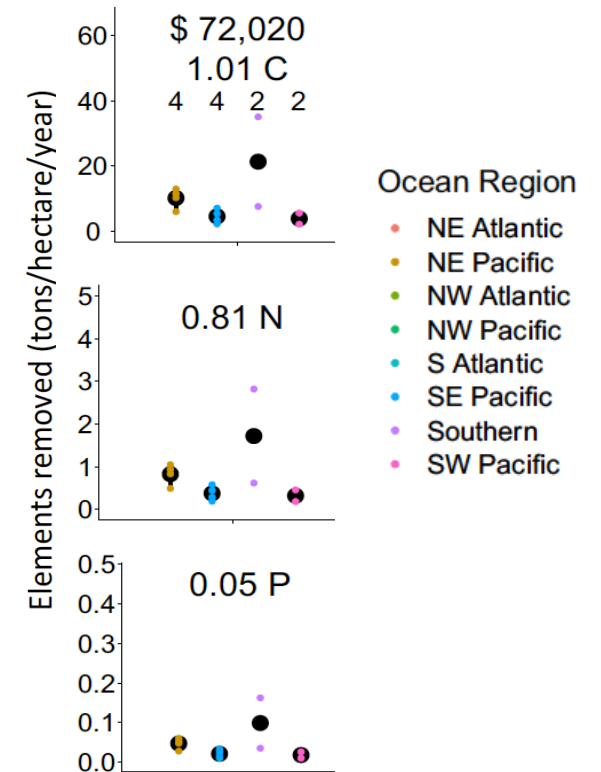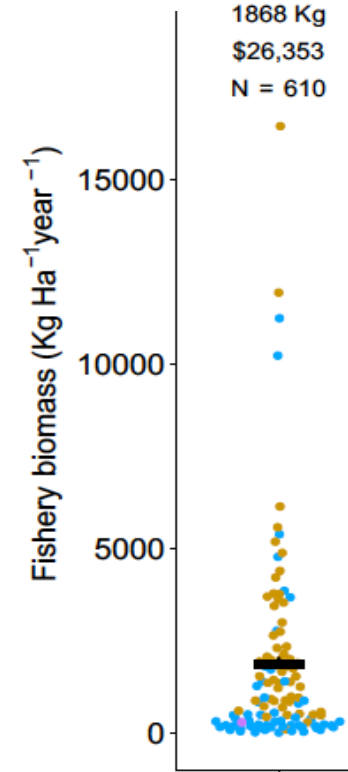# Downscaling global climate for Baja California, motivation

Along north American coastlines other climate-driven processes have influenced marine ecosystems



https://eos.org/articles/kelps-carbon-sink-potential-could-be-blocked-by-coastal-darkening

Kelp forests extend from Alaska across California and into Baja California ~ 27°N

Provide valuable ecosystem services with significant economic value

Play a significant role on carbon (C) sequestration

**PROGRAMS**
- PISCO
- REEF CHEK
- MEXCAL-UABC
- COBI-STANFORD

NCA
CCA
SCB
BCS

1868 Kg
$26,353
N = 610

Fishery biomass (Kg Ha$^{-1}$year$^{-1}$)

15000

10000

5000

0

$ 72,020
1.01 C
4  4  2  2

60
40
20
0

0.81 N

5
4
3
2
1
0

0.05 P

0.5
0.4
0.3
0.2
0.1
0.0

Elements removed (tons/hectare/year)

**Ocean Region**
- NE Atlantic
- NE Pacific
- NW Atlantic
- NW Pacific
- S Atlantic
- SE Pacific
- Southern
- SW Pacific

*Macrocystis*

Eger et al. 2021

# Downscaling global climate for Baja California, motivation

Along north American coastlines other climate-driven processes have influenced marine ecosystems



https://eos.org/articles/kelps-carbon-sink-potential-could-be-blocked-by-coastal-darkening

Kelp forests extend from Alaska across California and into Baja California $\sim$ 27°N

Provide valuable ecosystem services with significant economic value

Play a significant role on carbon (C) sequestration



PROGRAMS
- PISCO
- REEF CHEK
- MEXCAL-UABC
- COBI-STANFORD

**Extreme Marine Heatwaves Alter Kelp Forest Community Near Its Equatorward Distribution Limit**

Nur Arafeh-Dalmau[1,2,3]*, Gabriela Montaño-Moctezuma[4]*, José A. Martínez[3], Rodrigo Beas-Luna[3], David S. Schoeman[5,6] and Guillermo Torres-Moye[3]

Before

After

# Downscaling global climate for Baja California, motivation

Along north American coastlines other climate-driven processes have influenced marine ecosystems



https://eos.org/articles/kelps-carbon-sink-potential-could-be-blocked-by-coastal-darkening

Kelp forests extend from Alaska across California and into Baja California ~ 27°N

Provide valuable ecosystem services with significant economic value

Play a significant role on carbon (C) sequestration



**PROGRAMS**
- PISCO
- REEF CHEK
- MEXCAL-UABC
- COBI-STANFORD



Advances in Ecological Research
Volume 17, 1987, Pages 243-279

El Niño Effects on Southern California Kelp Forest Communities

Mia. J. Tegner, Paul. K. Dayton

## Persistence of southern California giant kelp beds and alongshore variation in nutrient exposure driven by seasonal upwelling and internal waves

James J. Leichter[1]*, Lydia B. Ladah[2], P. Ed Parnell[1], M. Dale Stokes[1], Matthew T. Costa[3], James Fumo[4] and Paul K. Dayton[1]

# Downscaling global climate for Baja California, motivation

Along north American coastlines other climate-driven processes have influenced marine ecosystems


https://eos.org/articles/kelps-carbon-sink-potential-could-be-blocked-by-coastal-darkening

Kelp forests extend from Alaska across California and into Baja California ~ 27°N

Provide valuable ecosystem services with significant economic value

Play a significant role on carbon (C) sequestration


BCS

Underpins environmental conditions behind decline and recovery of kelp forests (*e.g.,* upwelling, MHWs, California Current System)

What can we expect under future climate? (*e.g.,* Identify ideal areas for outplanting, obtain future estimates of carbon sequestration)
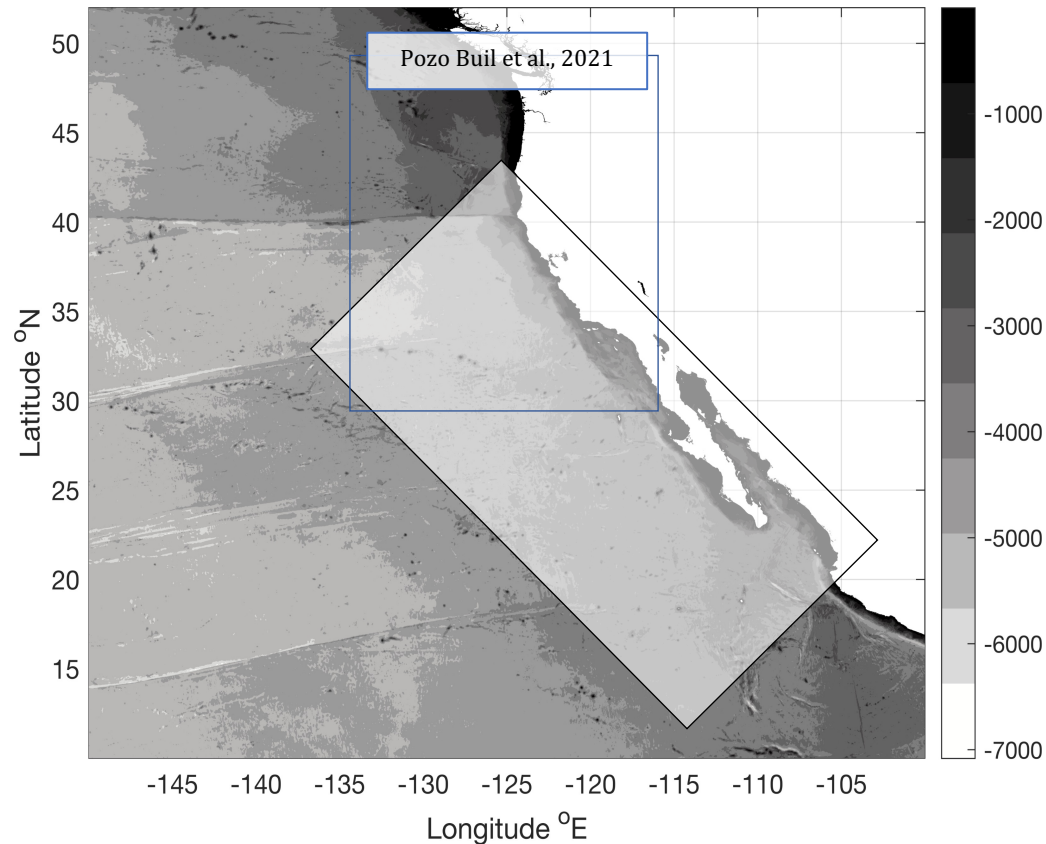
# Dowscaling global climate for Baja California, proposed model

For Baja California, spanning the California Current System

Historic & future time periods 1980 - 2050
Short and long temporal variability (ENSO), daily outputs
Sufficient spatial resolution to reproduce processes that determine stratification, mixed layer depth 1/12°



Ensemble of CMIP6 scenario that considers policy of minimum restrictions on carbon emissions SSP2-4.5

Coupled with a Biogeochemical model for Carbon (ROMS-Nemuro)

CICESE

T Cavazos
S Estrada-Allis
A Pares
J Sheinbaum
L Andrade

UNIVERSITY OF CALIFORNIA
SANTA CRUZ

M Pozo-Buil

MEXCAL

# Dowscaling global climate for Baja California, proposed model & forcing

The climate model provides surface and ocean boundary conditions in one-way

"Time-varying delta" approach to reduce bias in the climate model historical simulation

| Projected variable 1980-2100 | = | Reanalysis low frequency signal, i.e., 1980-2010 climatology | + | Reanalysis high frequency or sub-monthly signal, i.e., removing 30-day mean (1980 -2010) | + | Climate model (1980 – 2100) high & low frequency removing historic climatology (1980 - 2010) |

Retains the observed historical climatology and high frequency variability (not resolved by the climate model)

Inherits the long-term change and interannual variability of the climate model

Observed signals are repeated to encompass the future time period

T Cavazos
S Estrada-Allis
A Pares
J Sheinbaum
L Andrade

CICESE

UNIVERSITY OF CALIFORNIA
SANTA CRUZ    M Pozo-Buil

MEXCAL

# Final remarks

Long term project / line of research

CORDEX framework for Ocean Regional Climate Modelling

Starting point?
- domain
- past and/or future projections
- long time slice or specific events

Model selection (Climate model / Scenario)

Biogeochemical coupling