Reanalyses in Support of Fisheries and Marine Ecosystem Modeling

US CLIVAR Workshop
Future U.S. Earth System Reanalysis
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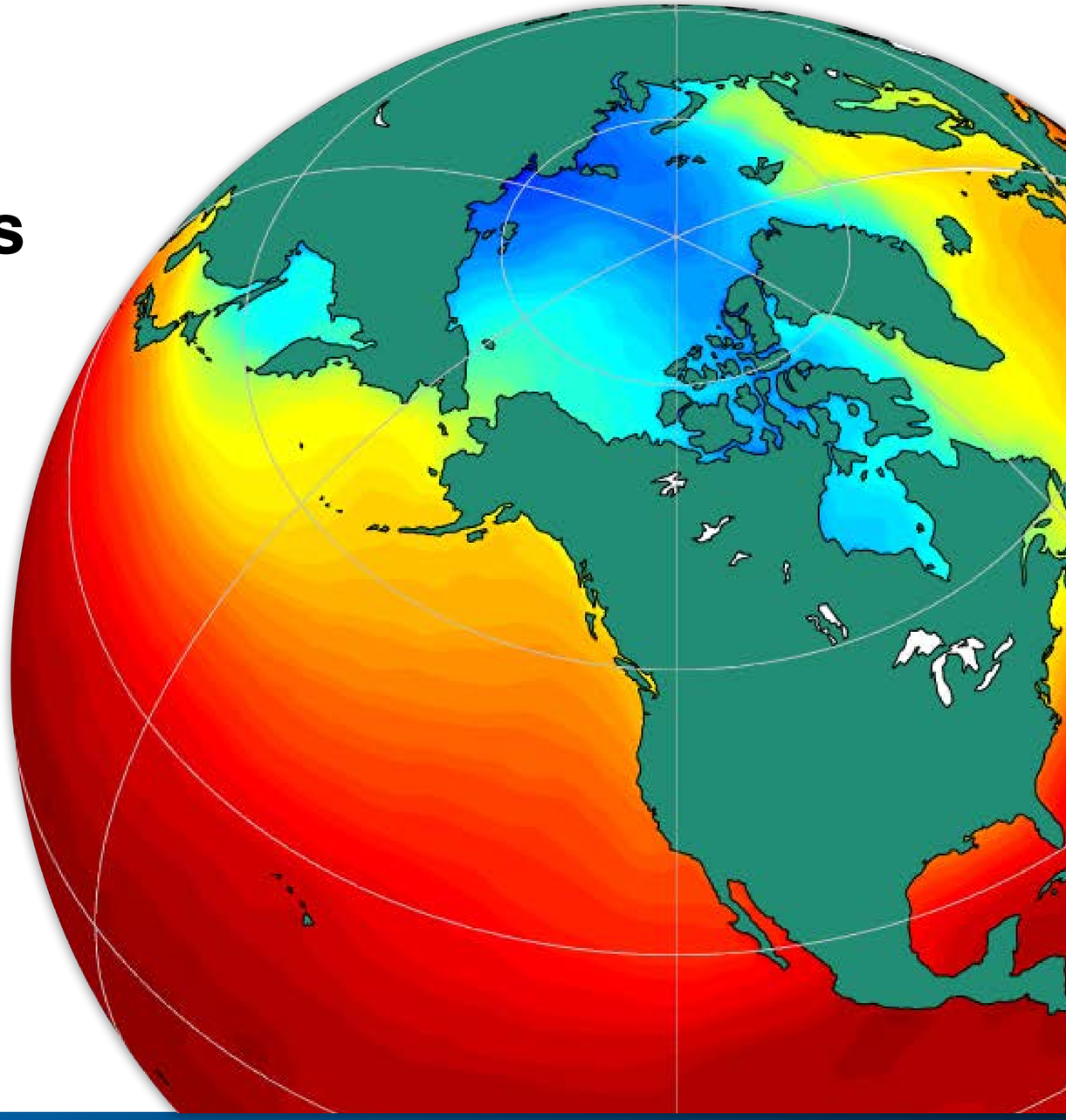
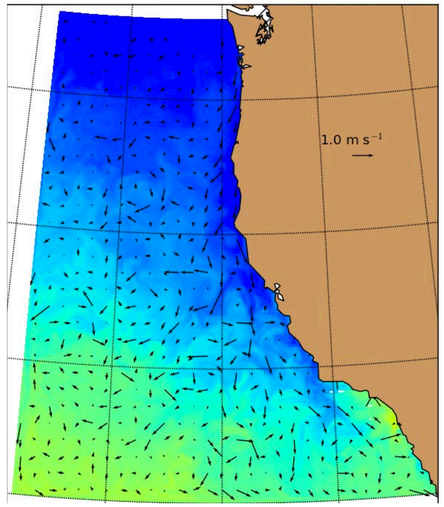
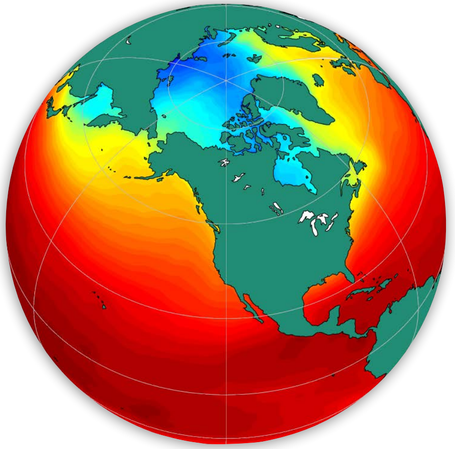
NOAA Earth System Research Laboratory



Use of ocean reanalyses in fisheries applications is increasing rapidly

Two products are currently used most in west coast fisheries applications:

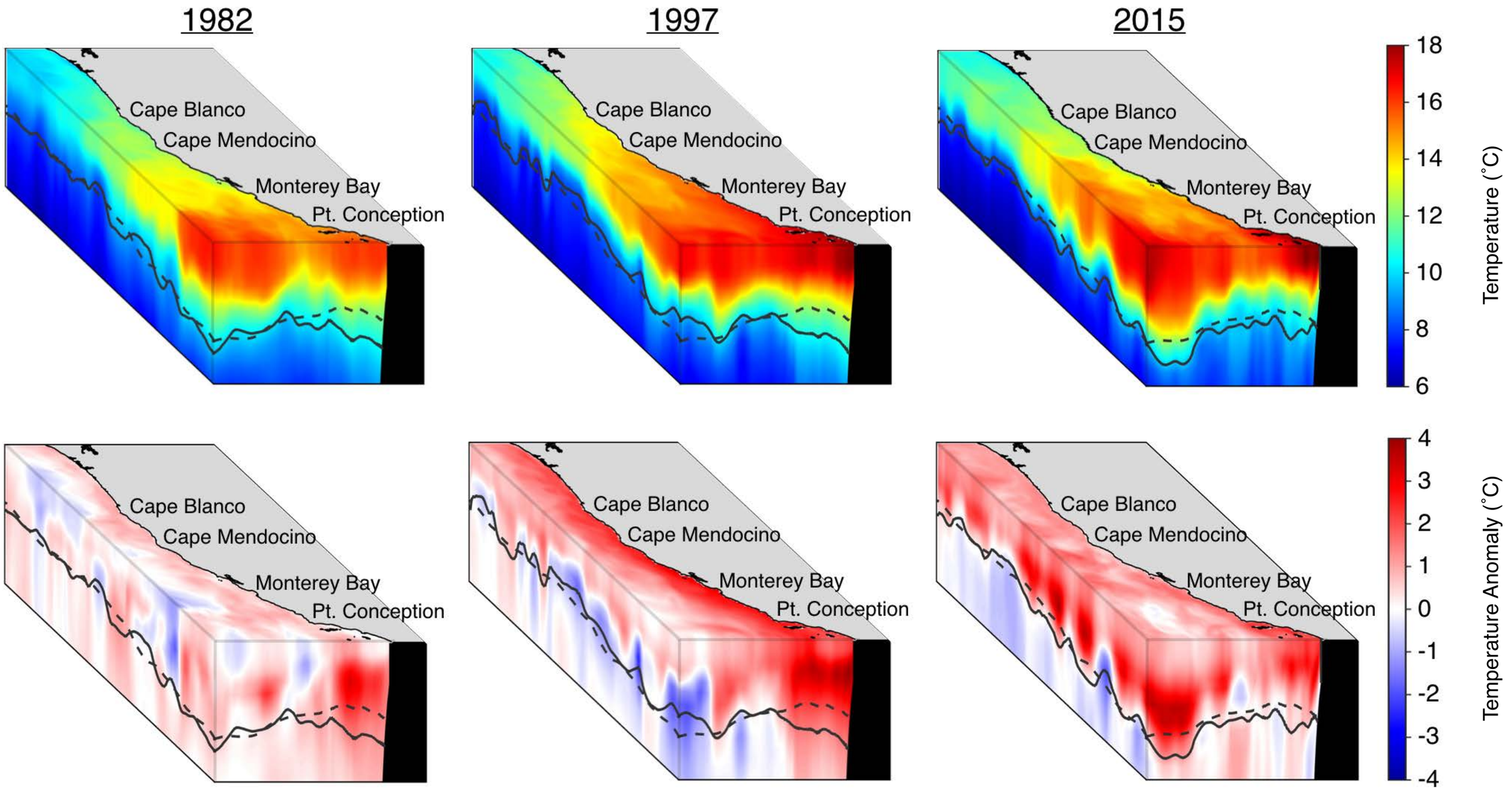




	CCSRA	GLORYS
Produced by	UC Santa Cruz	Mercator Ocean
Domain	US West Coast	Global
Resolution	1/10˚ (~10 km)	1/12˚ (~8 km)
Time period	1980-2010, 2011-present	1993-present

Other reanalyses have been used intermittently or indirectly (e.g., as forcing for regional ocean models)

Near-real-time monitoring: Impacts of El Niño



Jacox et al. (2016)

Near-real-time monitoring: Upwelling indices

Environmental Research Division

NOAA Fisheries - Southwest Fisheries Science Center

PRODUCTS

PRODUCTS → Upwelling Index → New West Coast Indices

New Upwelling Indices for the U. S. West Coast

Upwelling is a dominant driver of ecosystem productivity and variability in eastern boundary currents including the California Current System, which runs along the U.S. west coast. Given the importance of upwelling in these regions, estimates of upwelling strength (i.e., upwelling indices) are often used to help understand fluctuations in ecosystem properties ranging from temperature and density all the way to distributions and abundances of top predators.

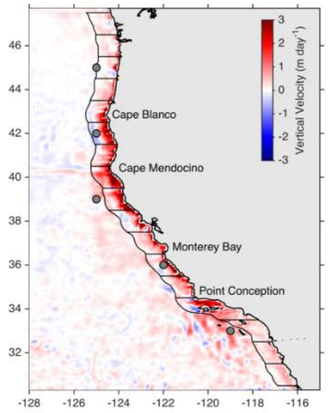
The **Coastal Upwelling Transport Index** (**CUTI**, pronounced "cutie") and the **Biologically Effective Upwelling Transport Index** (**BEUTI**; pronounced "beauty") are two new upwelling indices that leverage state-of-the-art ocean models as well as satellite and *in situ* data to improve upon historically available upwelling indices for the U.S. west coast.

CUTI provides estimates of vertical transport near the coast (i.e., upwelling/downwelling). It was developed as a more accurate alternative to the previously available 'Bakun Index'.

Explore CUTI

BEUTI provides estimates of vertical nitrate flux near the coast (i.e., the amount of nitrate upwelled/downwelled), which may be more relevant than upwelling strength when considering some biological responses.

Explore BEUTI



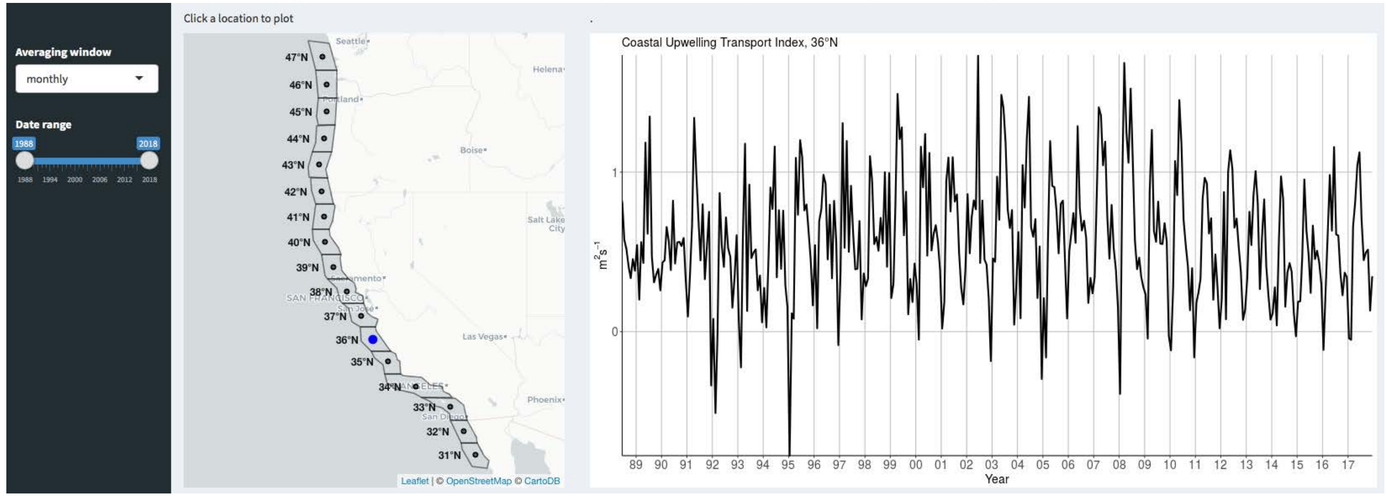
Mean spring/summer vertical velocity (upwelling in red, downwelling in blue). CUTI and BEUTI are calculated for 1° latitude bins, outlined in black. Gray dots are Bakun Index locations.

CUTI and BEUTI were developed in the Environmental Research Division of NOAA's Southwest Fisheries Science Center, in collaboration with the UC Santa Cruz Ocean Modeling Group.

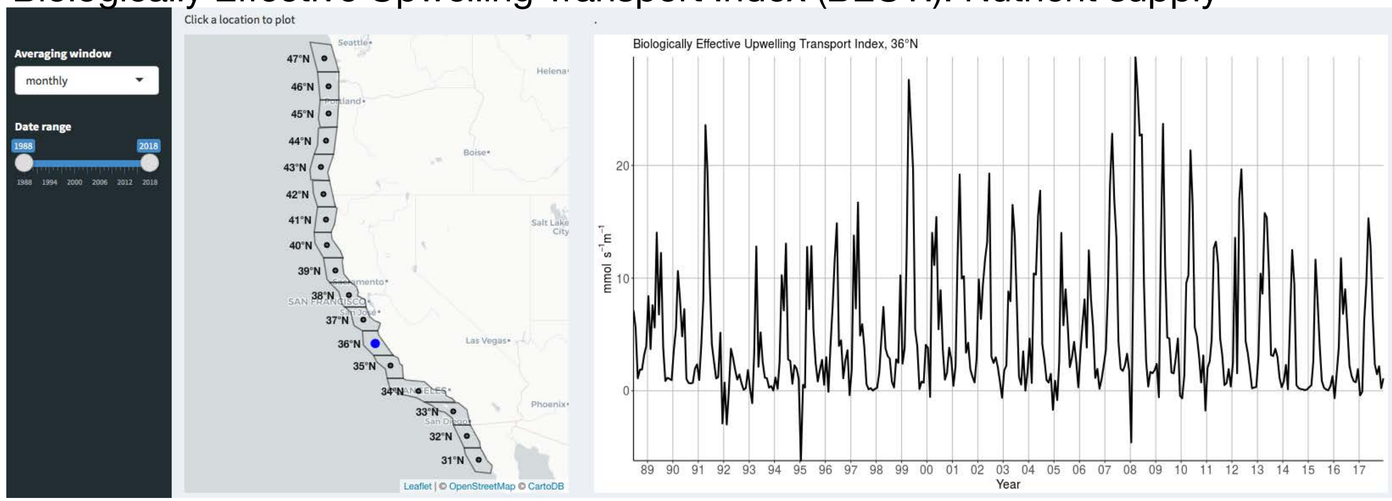
Further information, guidance, and downloads:

- **How is CUTI calculated?**
- **How is BEUTI calculated?**
- **How are CUTI and BEUTI different from the Bakun Index?**
- **Which index should I use?**
- **Download indices**

Coastal Upwelling Transport Index (CUTI): Upwelling strength



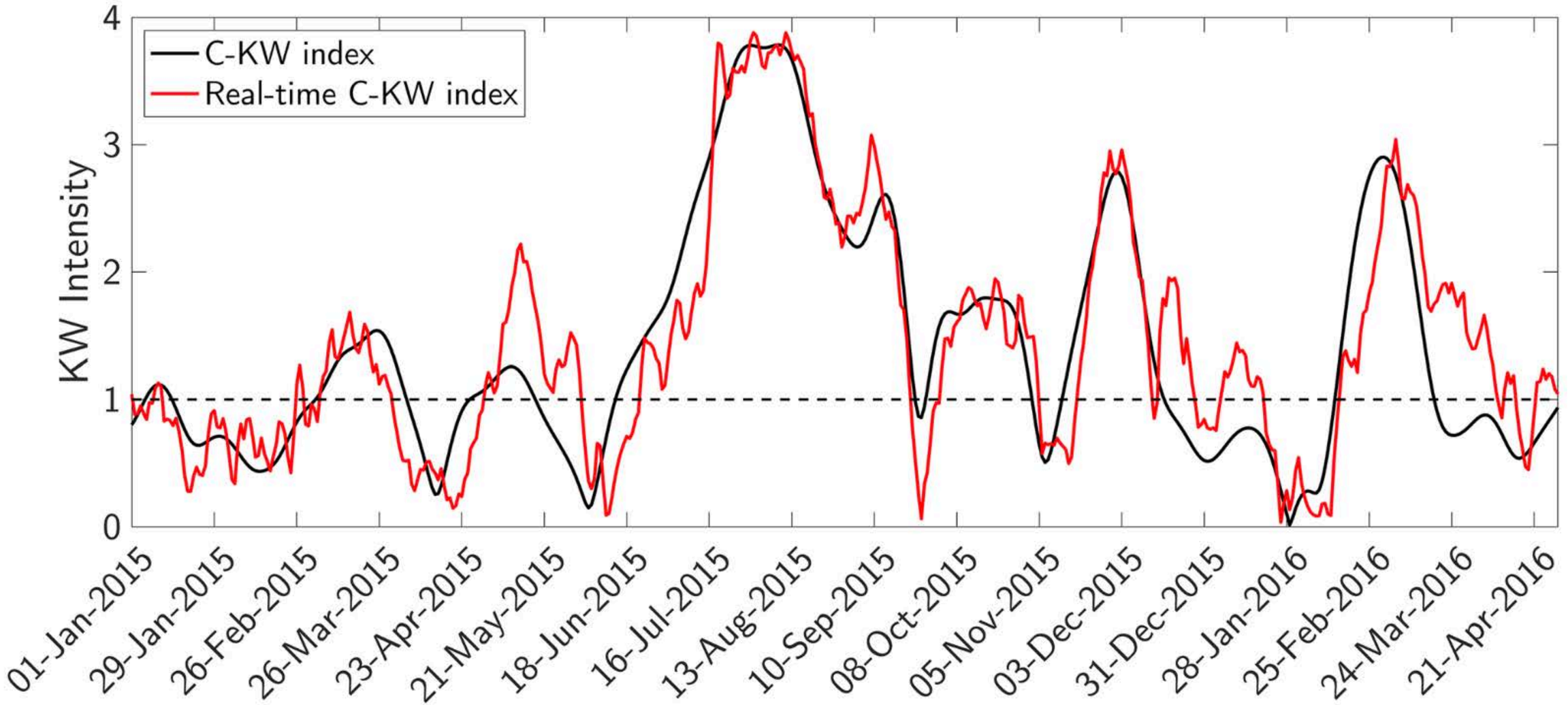
Biologically Effective Upwelling Transport Index (BEUTI): Nutrient supply



oceanview.pfeg.noaa.gov/products/upwelling

Jacox et al. (2018)

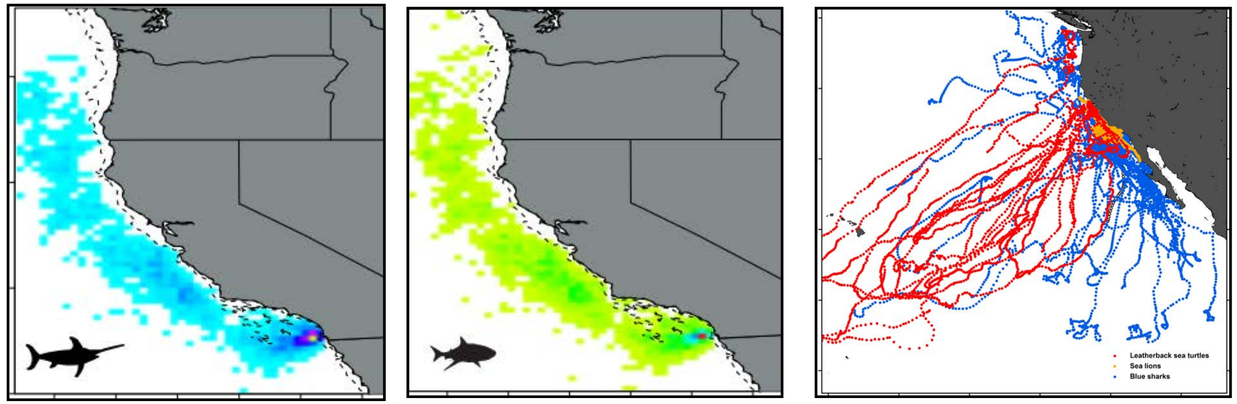
Near-real-time monitoring: Coastal trapped wave index



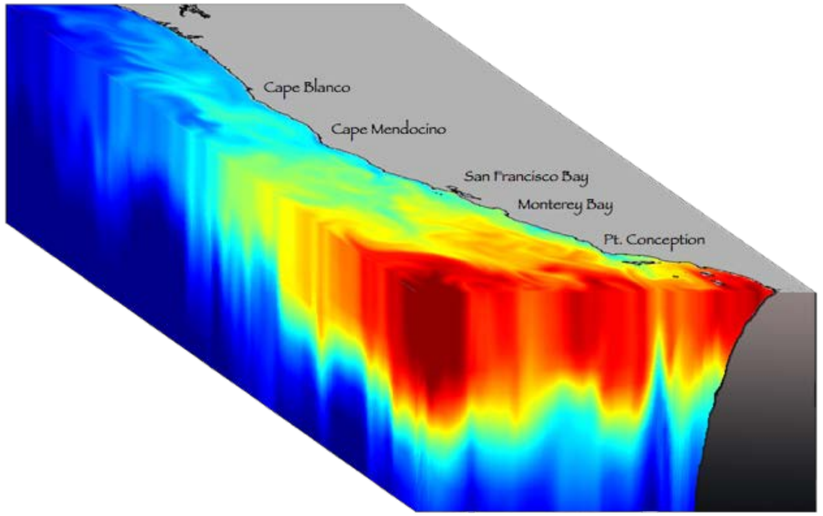
Amaya et al. (2022)

Ecological modeling: Species distributions

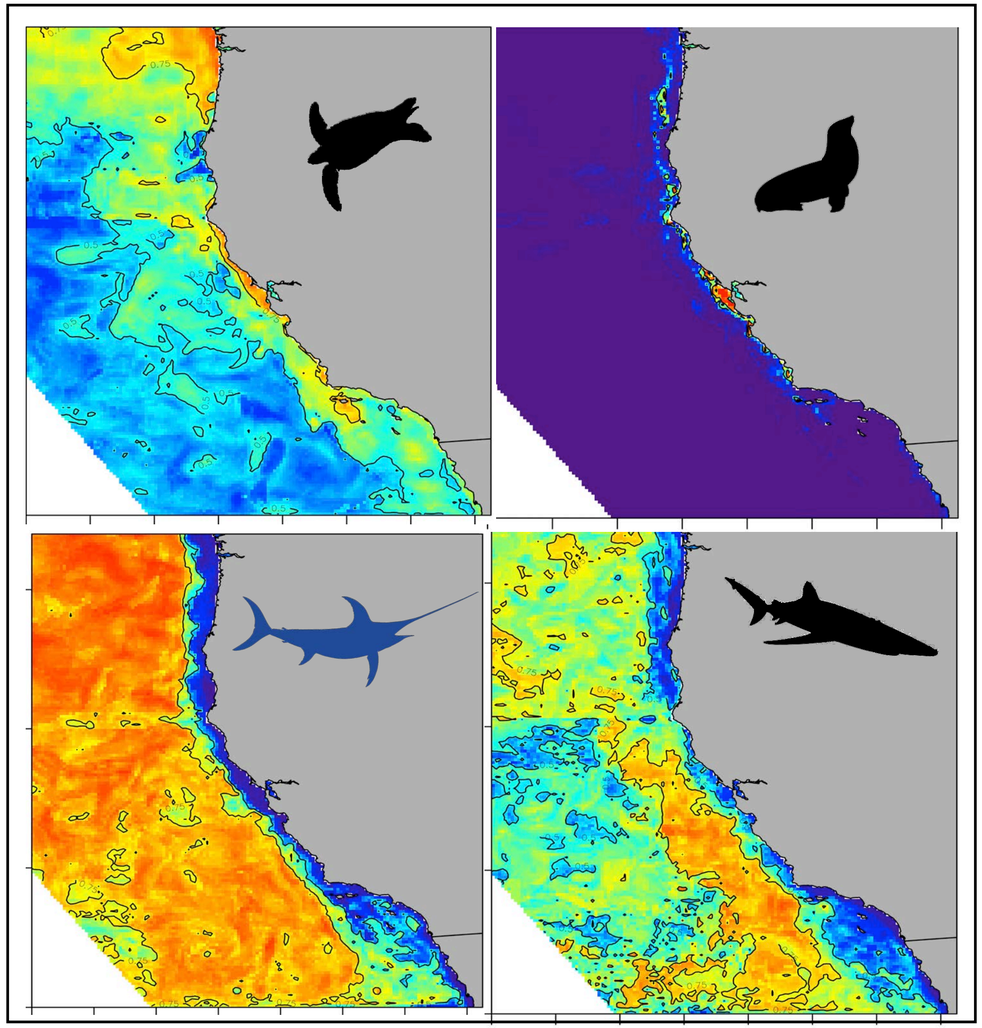
Species tracking and observer data



Environmental data from ocean models



Species Distribution Models



Ecological modeling: Species distributions

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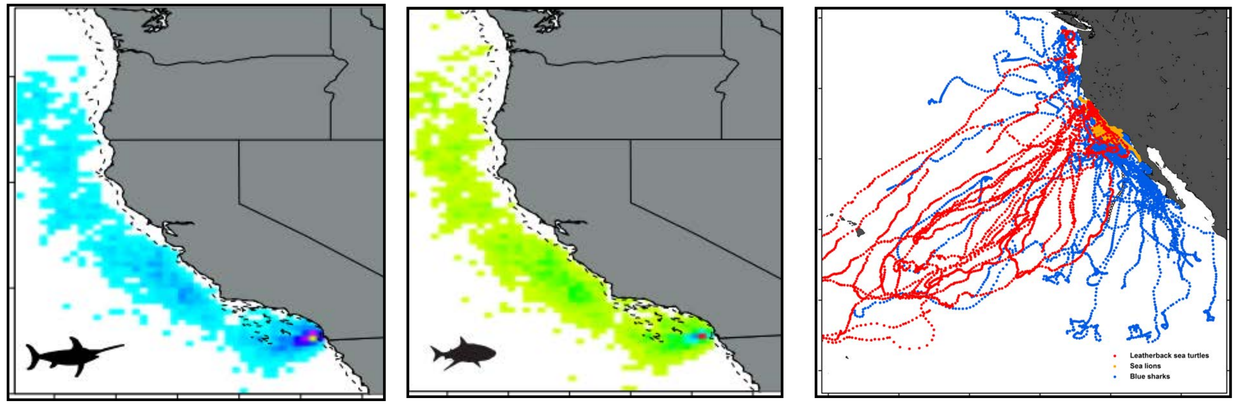

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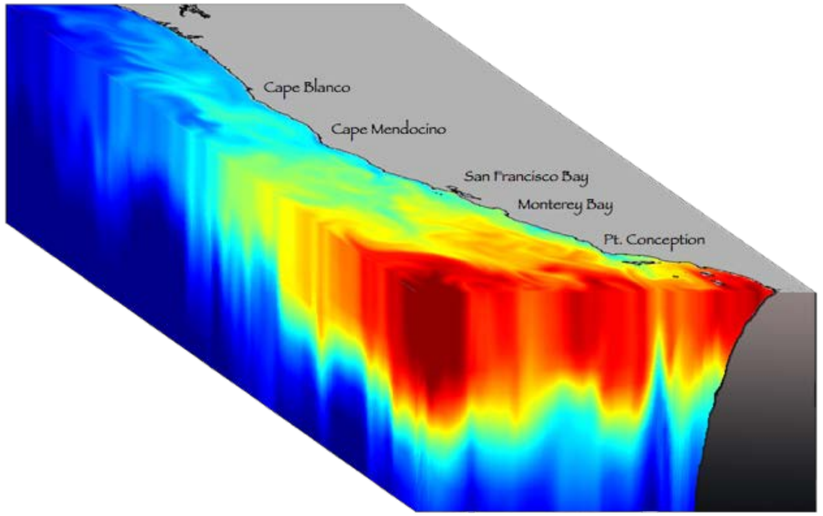
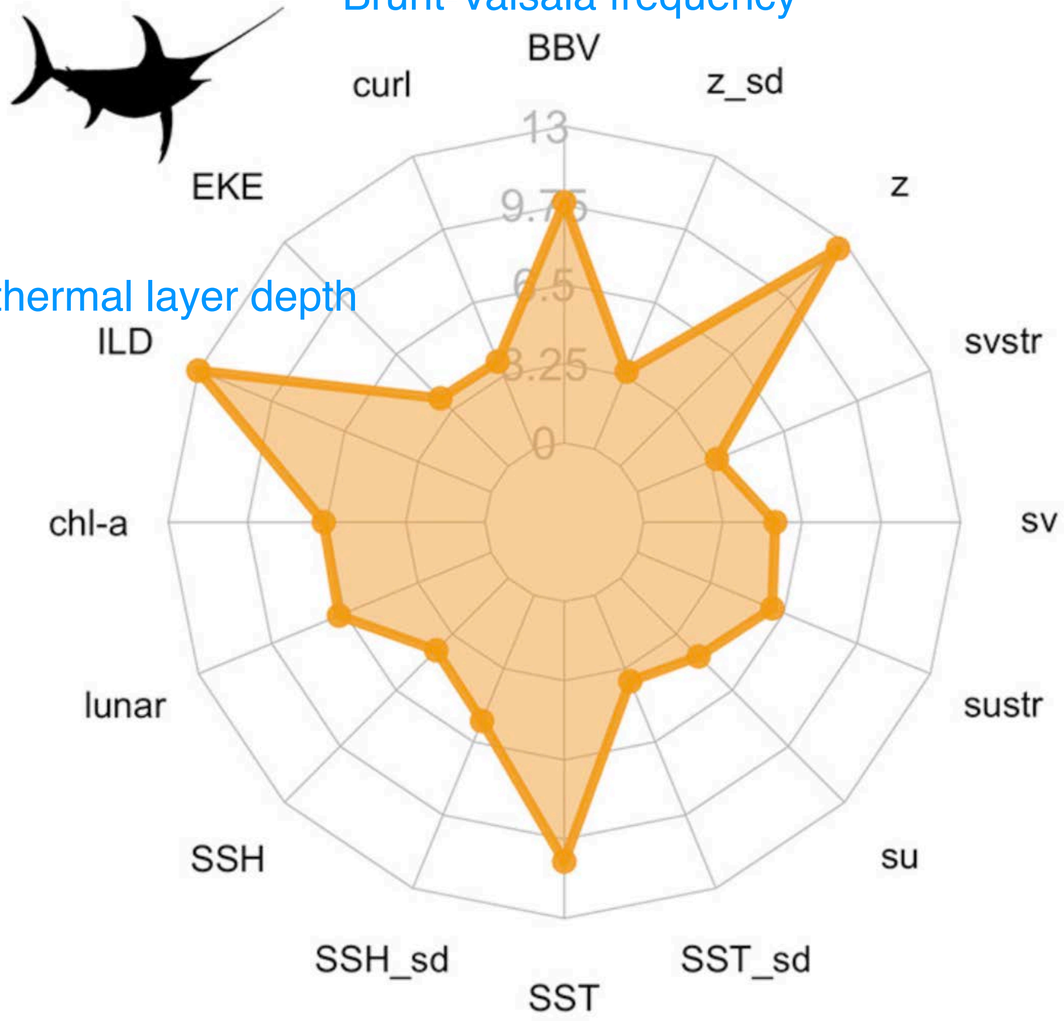
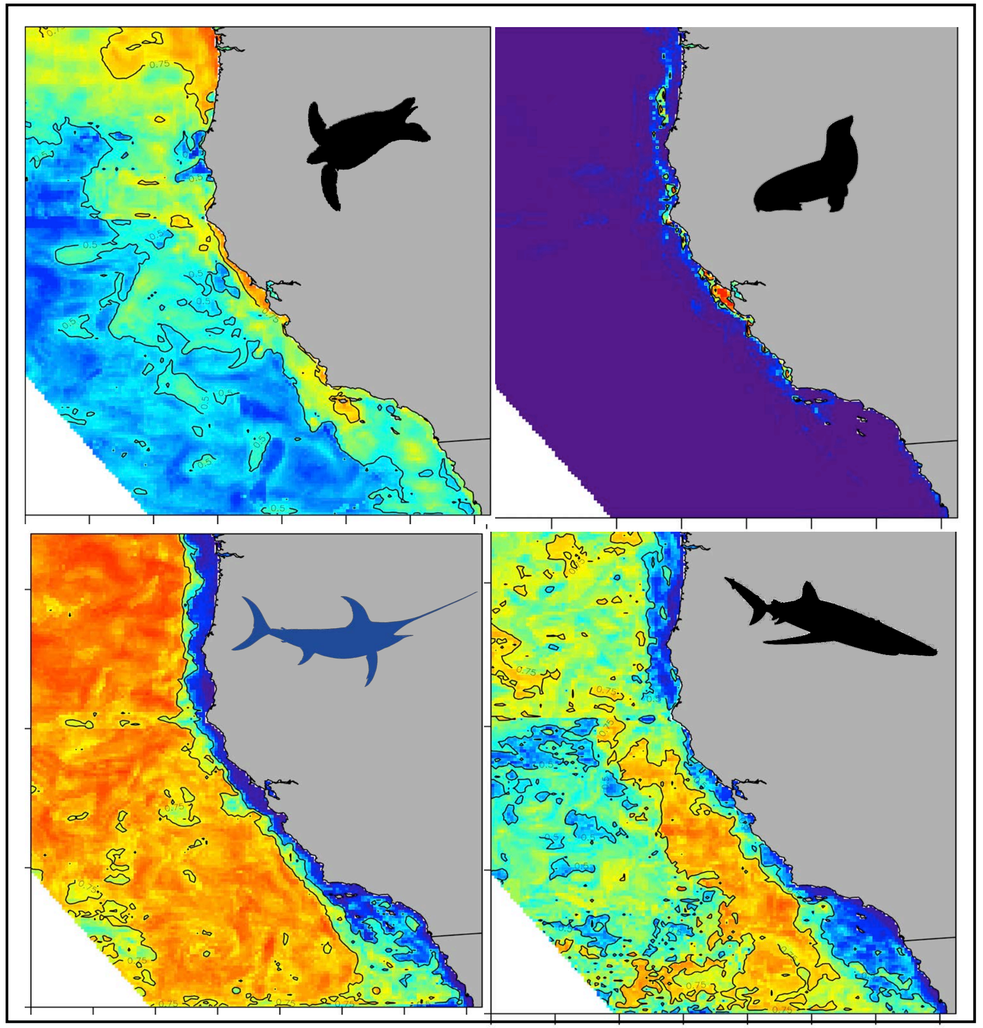


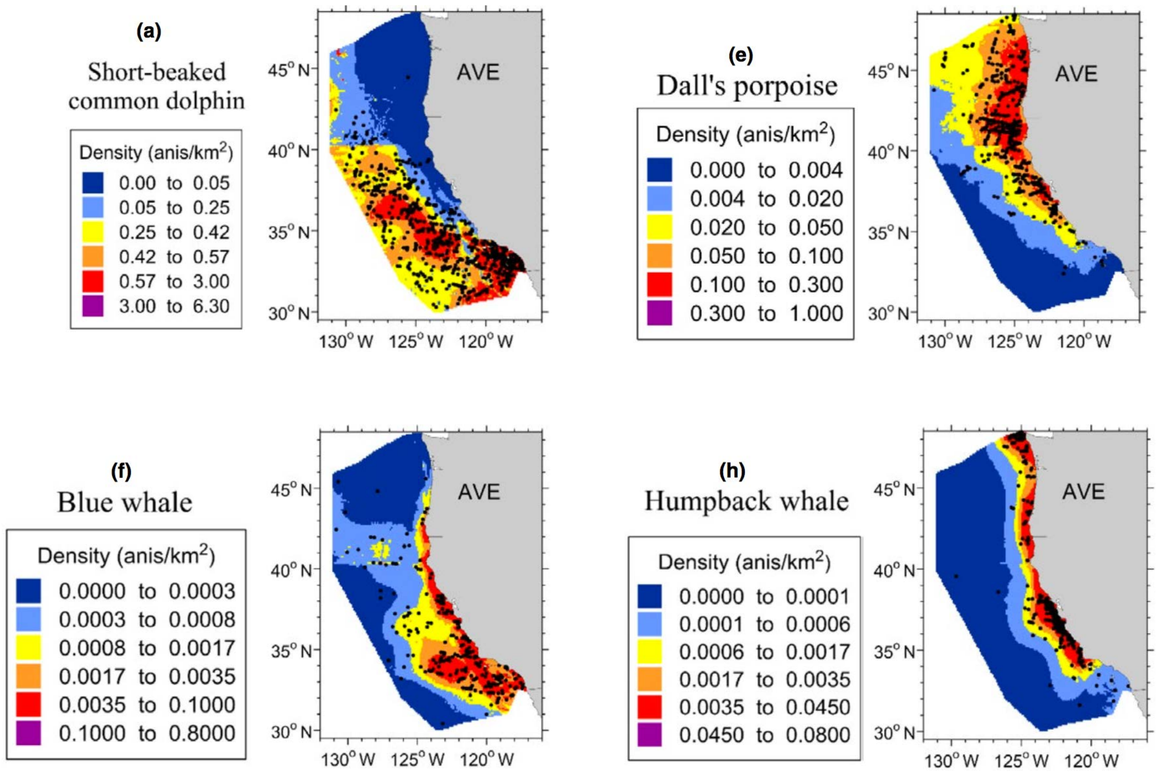


Brodie et al. (2018)

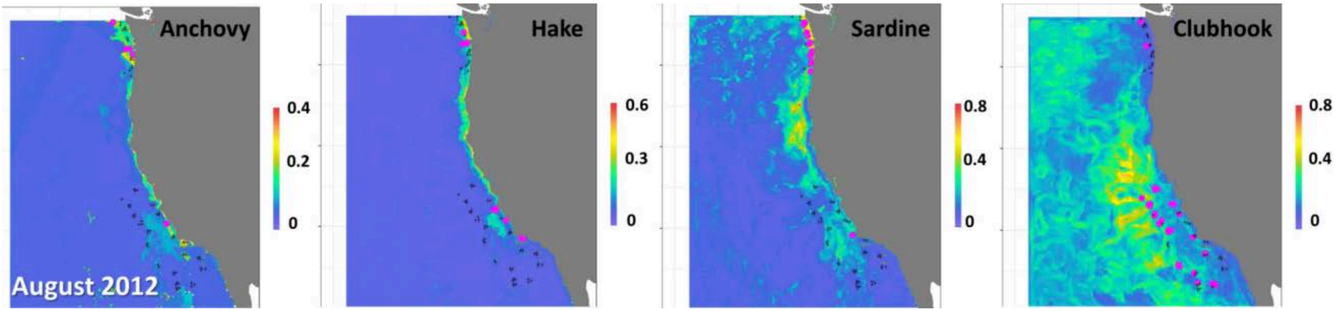
Ecological modeling: Species distributions



Hazen et al. (2018)
Welch et al. (2019)



Becker et al. (2019)



Muhling et al. (2019)

Ecological modeling: Groundfish recruitment

Hypothesized environmental drivers

Female preconditioning (50–1,200 m)

(–) DD_{pre}

Cold water is associated with higher system productivity and lower metabolic costs making more energy available for reproduction

Eggs (300–825 m)

(+) CST_{egg}

Onshore transport maintains larvae near settlement habitat

(+) DD_{egg}

Faster development in warm water

Yolk-sack (1000–1200 m)

(+) LST_{yolk}

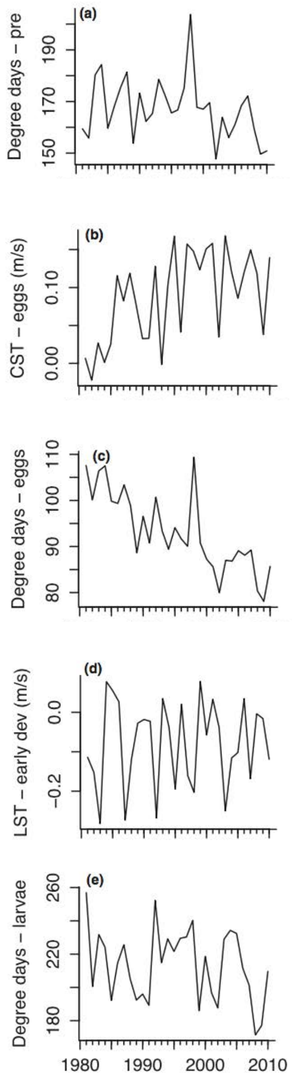
Transport to the north results in better feeding later on northern zooplankton

Pelagic larvae (surface waters)

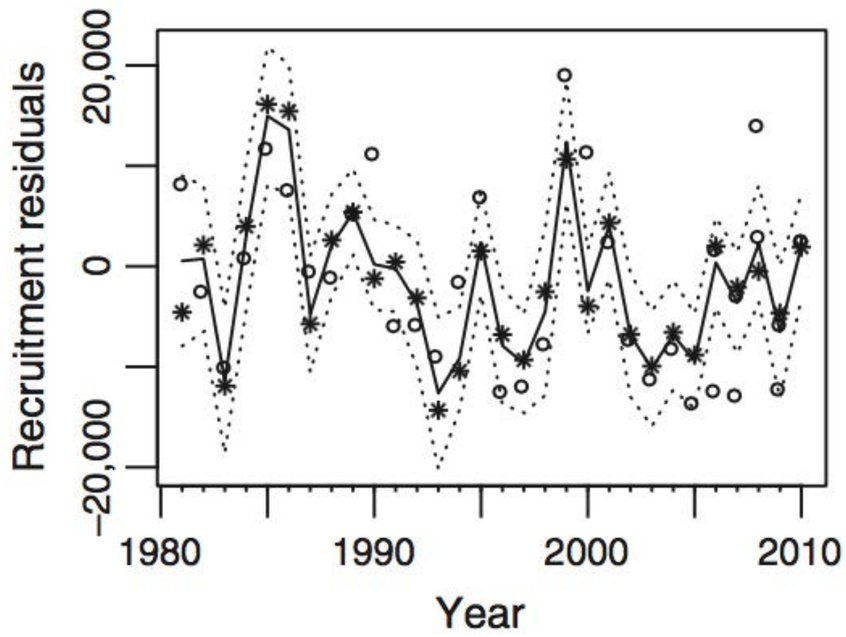
(–)DD_{larv}

Cold water is associated with higher system productivity and lower chance of starvation

Time series from reanalysis

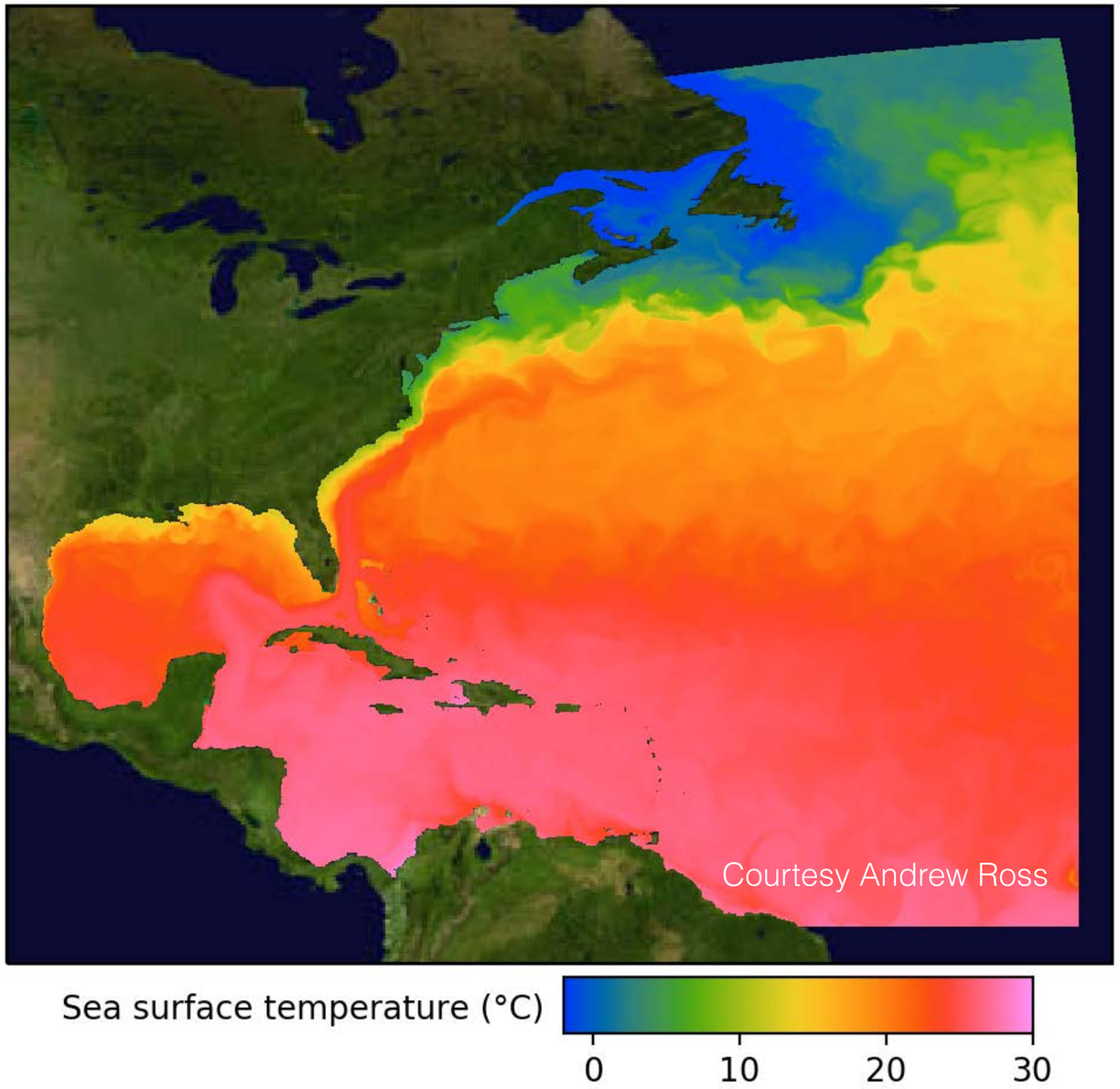


Sablefish recruitment estimates



Tolimieri et al. (2018)

Boundary conditions for regional ocean models

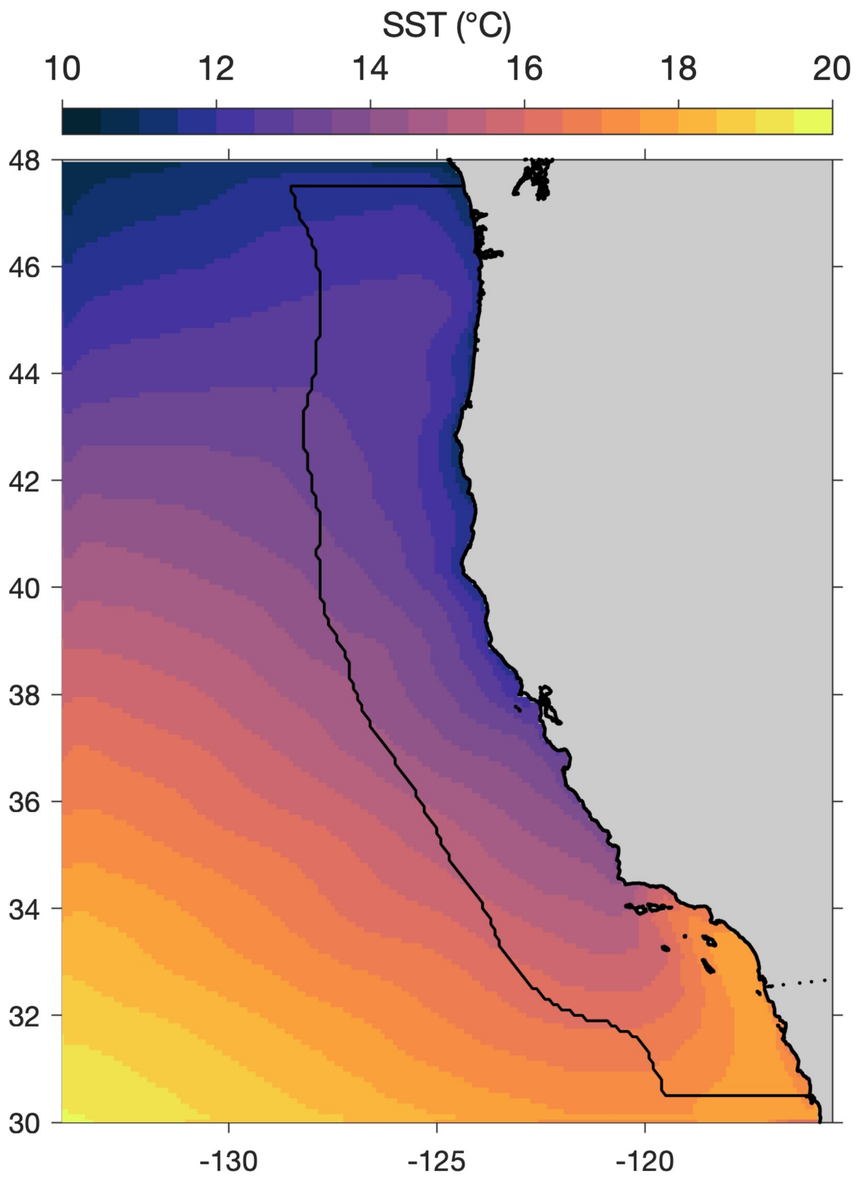


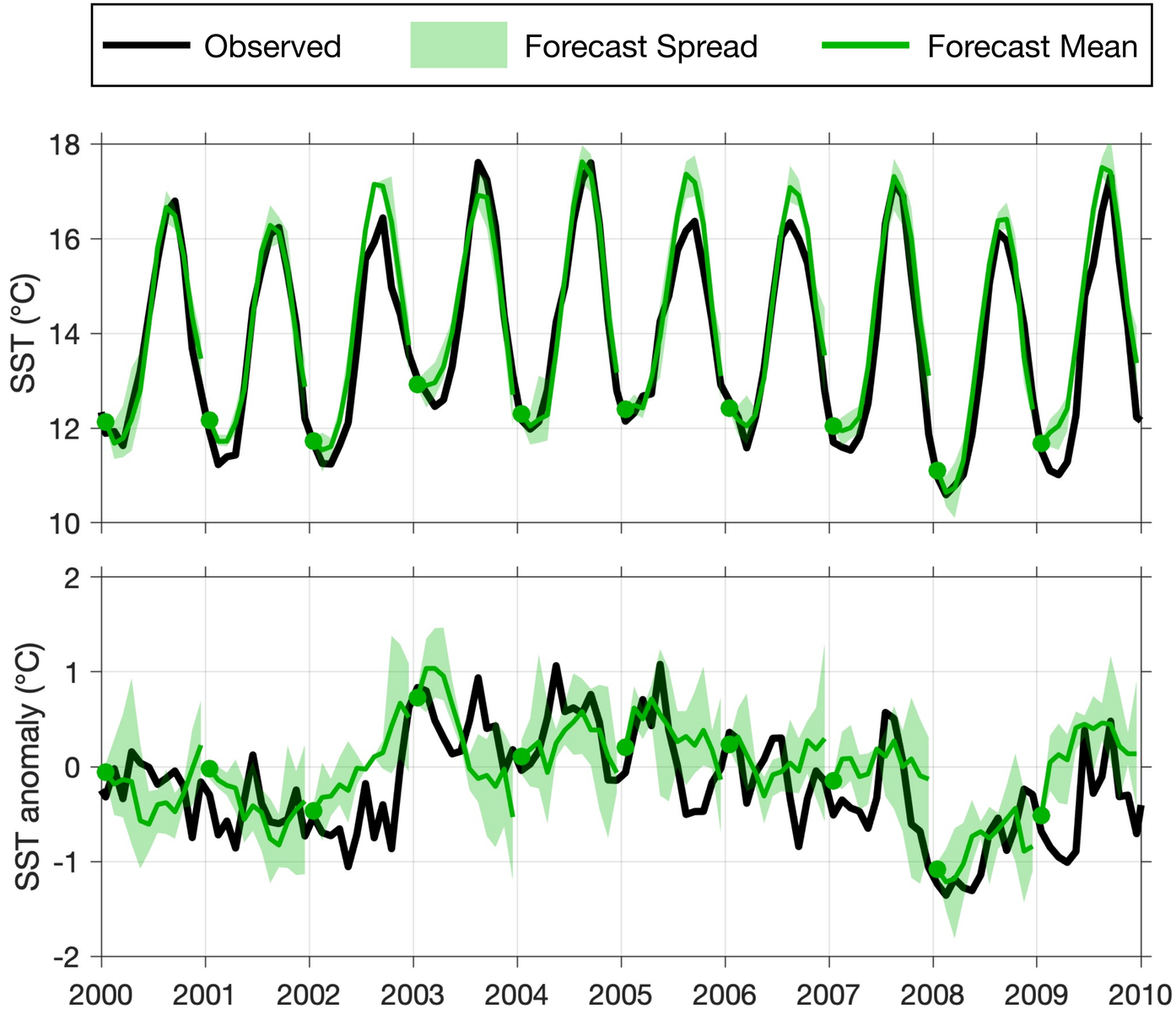
Ocean
Sea surface height
Temperature (3D)
Salinity (3D)
u and v currents (3D)

Atmosphere
Near-surface temperature
Near-surface winds
Sea level pressure
Humidity
Shortwave radiation
Longwave radiation

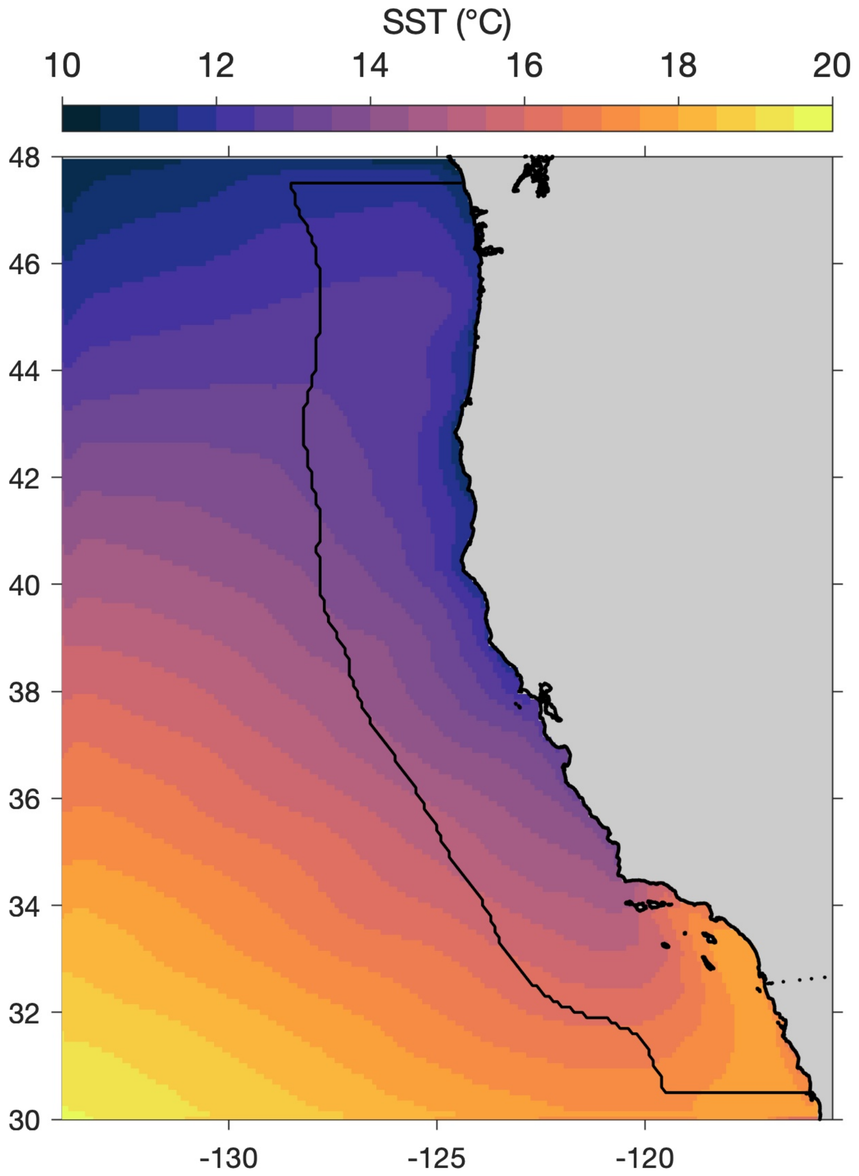
Many different ocean and atmospheric reanalyses have been used for regional downscaling

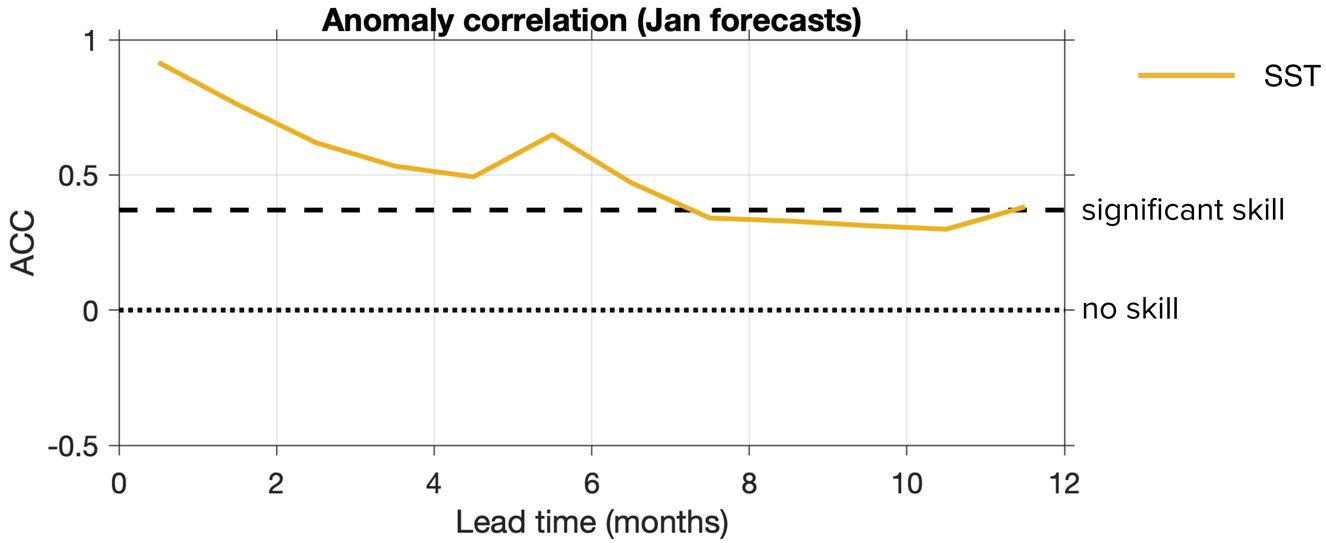
Forecast initialization and verification





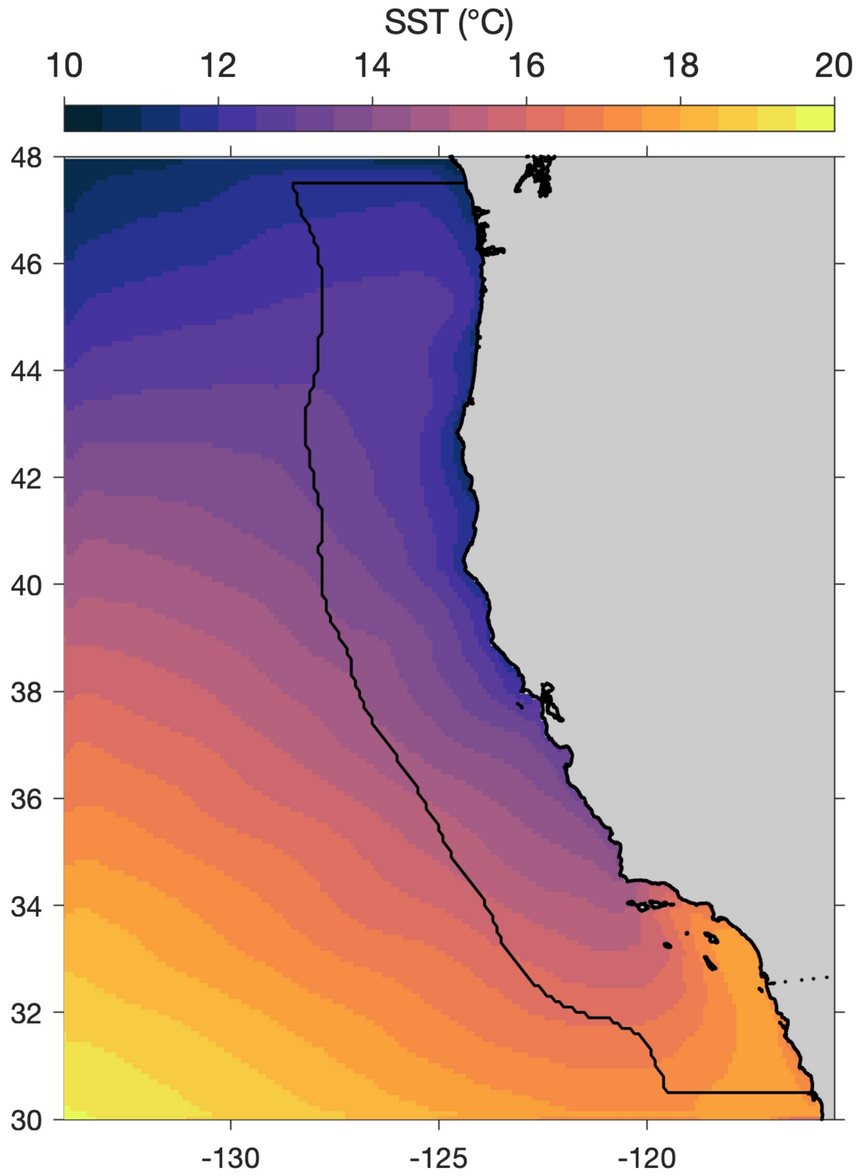
Forecast initialization and verification

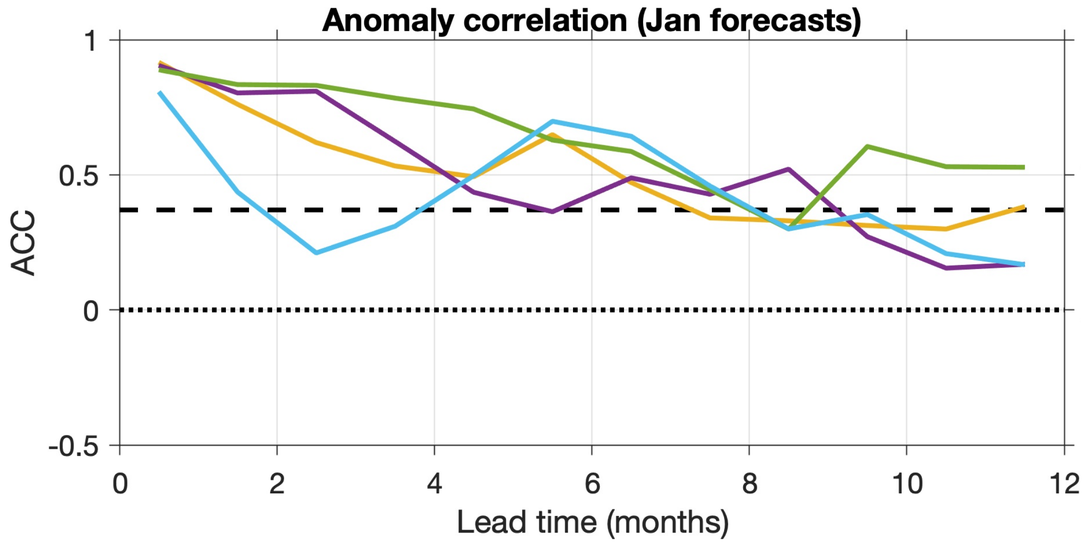




Jacox et al. (in prep)

Forecast initialization and verification





SST

Bottom temp

SSH

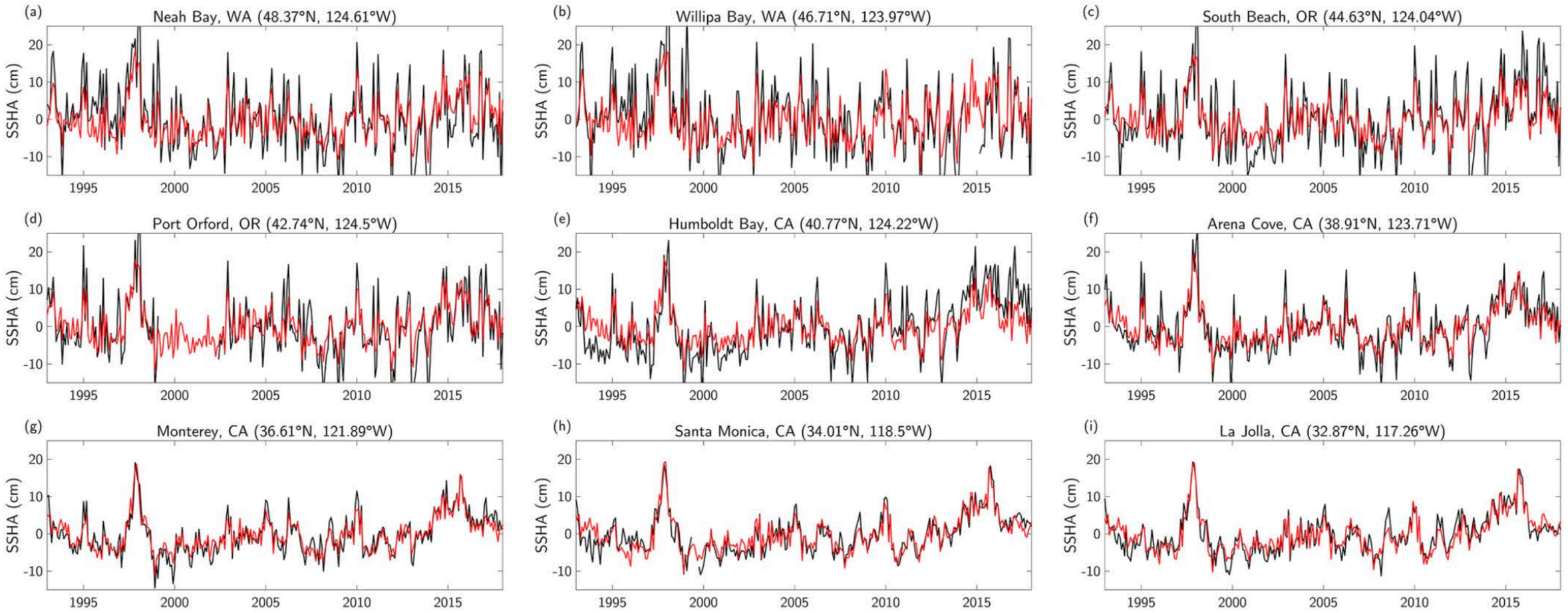
Buoyancy frequency (stratification)

Jacox et al. (in prep)

To what extent can reanalyses be treated as observations?

GLORYS
Observations

Sea surface height anomaly (cm)



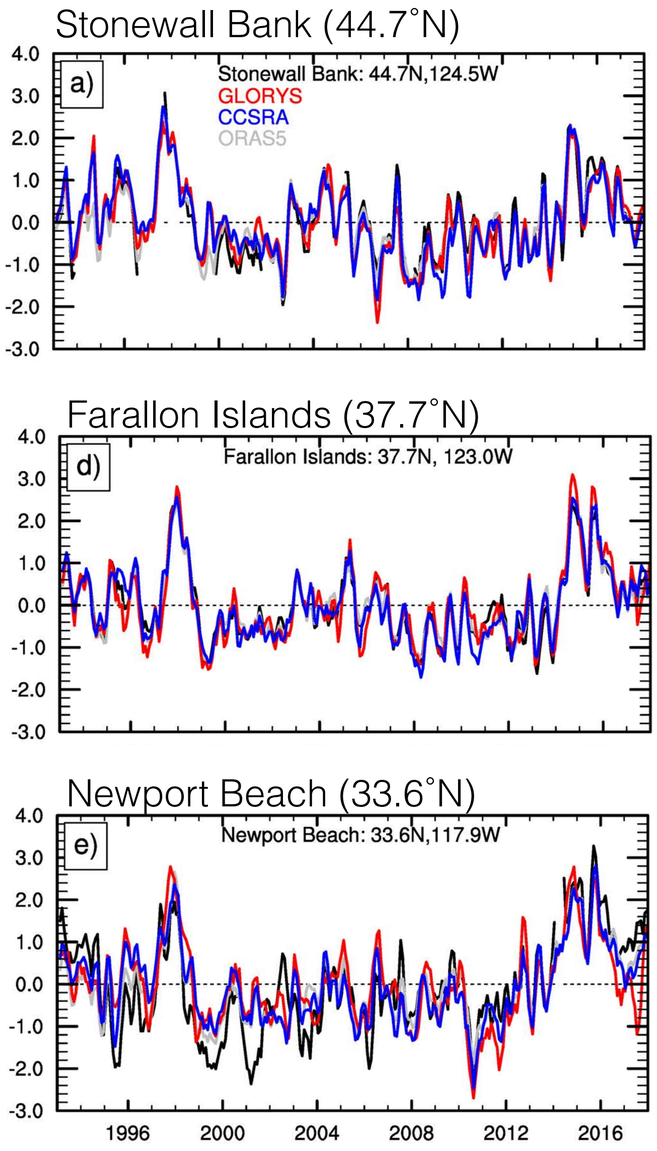
r = 0.74-0.84 (daily) r = 0.84-0.91 (monthly)

Amaya et al. (2022)

To what extent can reanalyses be treated as observations?

GLORYS
CCSRA
Observations

Surface temperature anomaly (˚C)

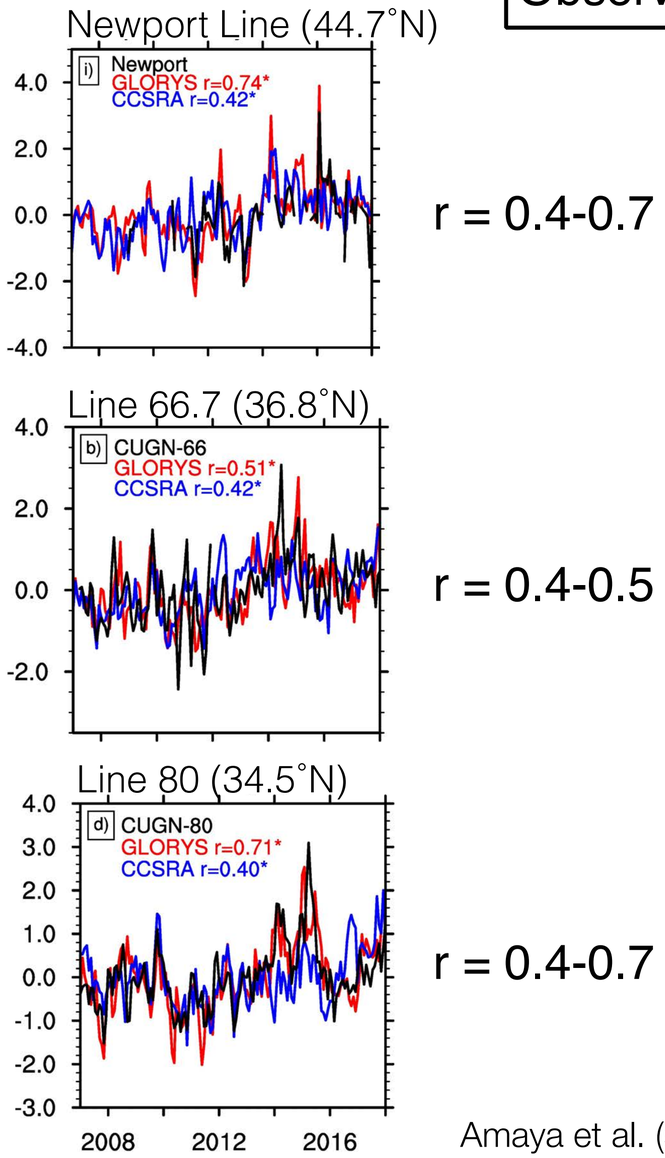


r > 0.9

r > 0.9

r = 0.7-0.9

Bottom temperature anomaly (˚C)



r = 0.4-0.7

r = 0.4-0.5

r = 0.4-0.7

Amaya et al. (submitted)

Considerations for future reanalyses: A marine ecosystems perspective

Concerns

Fidelity to nature: which variables can we trust, and where

Discontinuities/inconsistencies between historical products or between delayed time and near real time products

Reliable delivery, especially for near real time applications

Dynamical consistency is less of a concern at present, but there is interest in e.g., heat budgets during marine heatwaves

Desires

Resolution: daily, O(10 km) or better

Multi-decadal historical coverage

Near-real-time availability

Ocean variables for physical and ecological applications (e.g., 3D temperature, SSH, mixed layer depth, upper ocean stratification)

Atmosphere and ocean variables for regional model boundary conditions

Biogeochemistry