Providing actionable information for climate-ready decision making

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MOM6 Community

Motivation:
Changes in ocean conditions and impacts

Environmental changes:

- Warming oceans
- Rising sea levels
- Ocean acidification
- Frequency and intensity of floods and droughts
- Loss of sea ice

Impacts:

- Changing habitats
- Shifts in species distribution
- Changing abundance
- Changing ocean uses

NOAA Climate, Ecosystems, and Fisheries Initiative (CEFI)

- Cross-NOAA effort to provide climate-informed advice
- Builds on NOAA investments
- End-to-end decision support system

1. Reliable delivery of forecasts

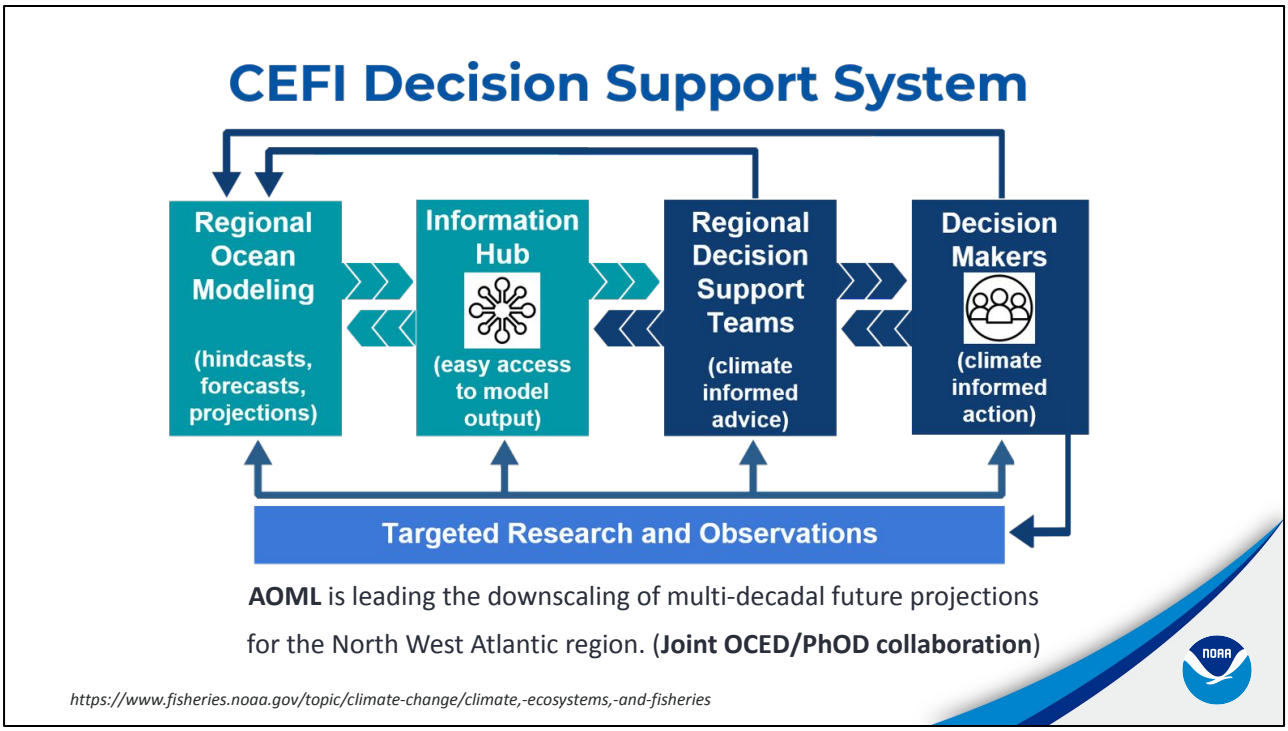
2. Operational production

3. Increased decision-making capacity

4. Research & observations

https://www.fisheries.noaa.gov/topic/climate-change/climate,-ecosystems,-and-fisheries

•Cross-NOAA line office partnership
•Develop national infrastructure to enhance NOAA's climate modeling and forecasting capabilities in support of the nation's living marine resources
•Extend Earth System components developed/applied at global scale to regional scales
•Stakeholder engagement (e.g. NOAA Sanctuaries, NOAA Fisheries)
•Data and products from CEFI will ultimately assist resource managers, coastal communities, and other stakeholders
• CEFI: https://www.fisheries.noaa.gov/topic/climate-change/climate,-ecosystems,-and-fisheries



To address these impacts, decision-makers need:

- Reliable forecasts of future ocean conditions
- Information on what's at risk
- Information on best strategies to reduce impacts and increase resilience

The CEFI System will provide government, business, and community decision-makers with actionable information for reducing risks and adapting to changing ocean conditions.

Dynamical downscaling by the regional MOM6 model

Five US coastal regions

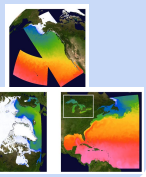
Northwest Atlantic (AOML)

Northeast Pacific

Arctic

Pacific Islands

Great Lakes



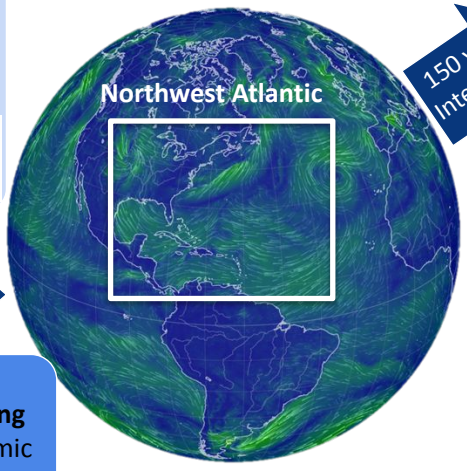
Input

CMIP6 Scenarios

Anthropogenic Radiative Forcing

Historical, Shared Socio-economic Pathways (SSP)-126, SSP-245, SSP-370, and SSP-585

Global Climate Models (GCMs)



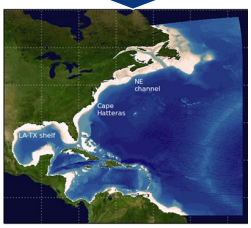
~ 100-200 km resolution

150 years Integration

Output from GCMs

Winds, Temperature, Ocean currents, Sea level height, Salinity, etc

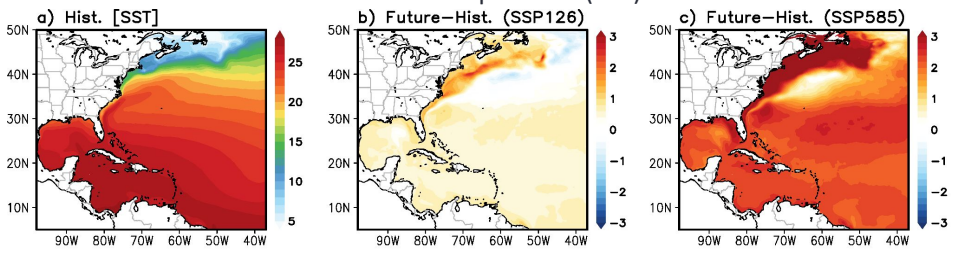
Forcing IC & BCs



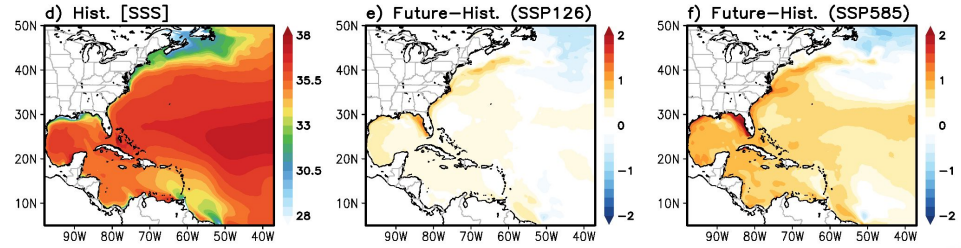
~ 1/12° (~ 8km) resolution

Future changes in Northwest Atlantic ocean

Sea Surface Temperature (SST)



Sea Surface Salinity (SSS)

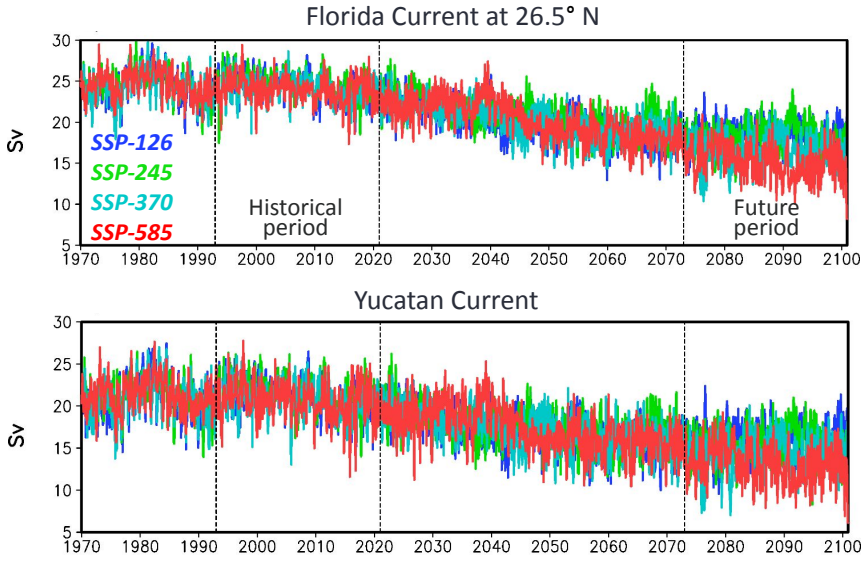


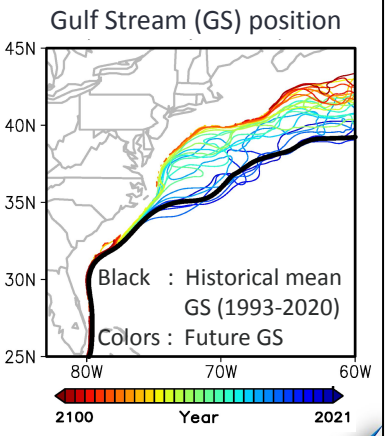
Warmer & saltier ocean

in the future

Kim et al. (in prep.)

Future changes in Northwest Atlantic ocean



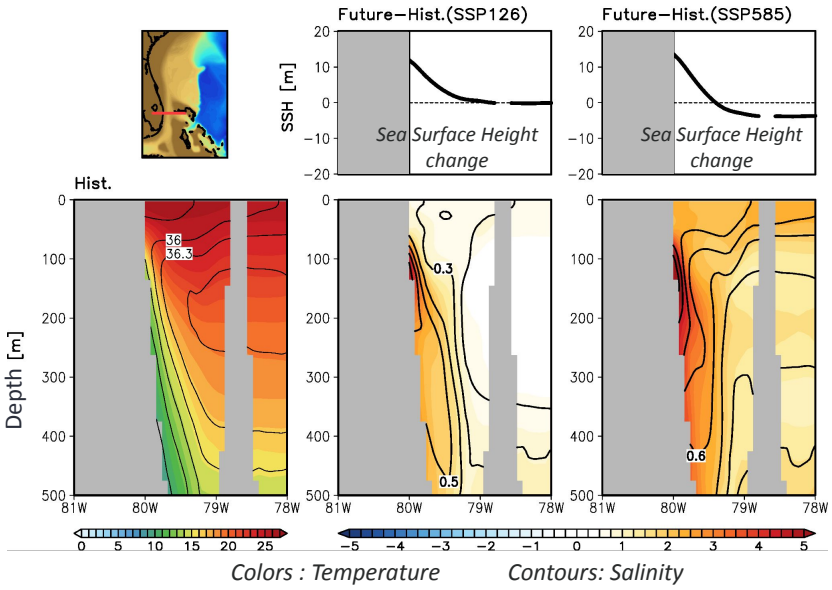


Weaker ocean circulation in the future

Kim et al. (in prep.)

Weakening ocean currents link to US East coasts

26.5°N vertical cross section along the east Florida

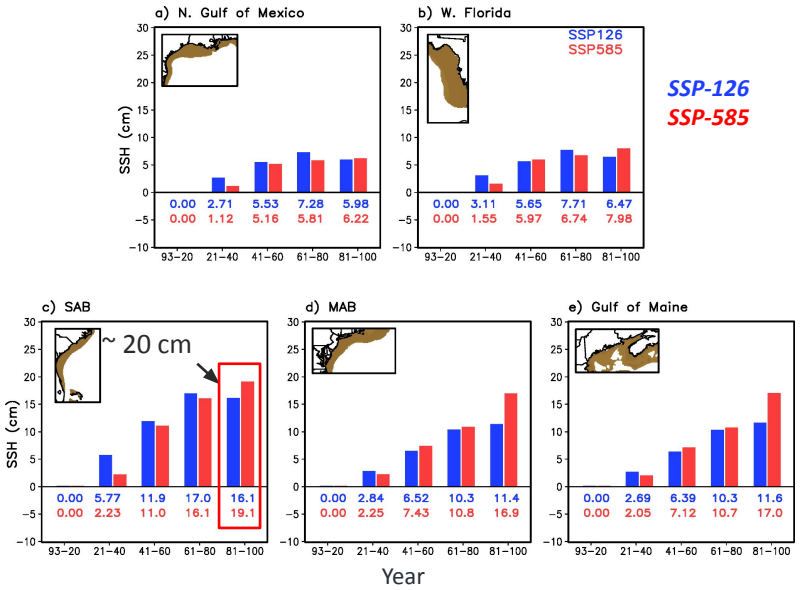


Due to the **weakening of Gulf Stream**, the associated coastal **upwelling** across the South Atlantic Bight also **weakens**.

Kim et al. (in prep.)

Weakening ocean currents link to US East coasts

Dynamic sea level change in five US east coastal regions



SSP-126

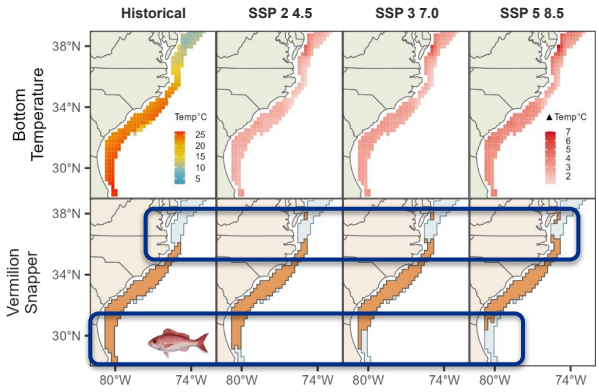
SSP-585

Dynamic sea surface height (SSH) is projected to **increase** in all coastal areas.

Kim et al. (in prep.)

Linking climate models and ecological data

"Potential habitat shifts of snapper and grouper species in response to projected bottom warming along the U.S. Atlantic Coast"



Purpose

Pair global **climate models** with **ecological data** to estimate **bottom thermal habitat shifts**

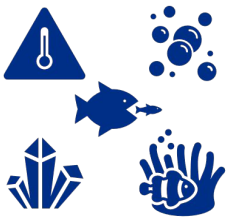
Takeaways

- Regional models at finer resolution necessary
- Potential for species' movement into novel management areas

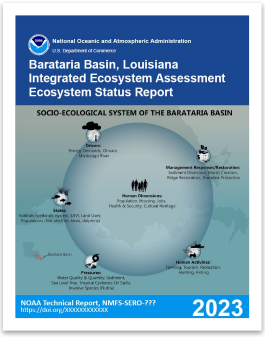
Troast et al., (internal review)

Climate-Informed Community Analysis & Species Distribution Modeling

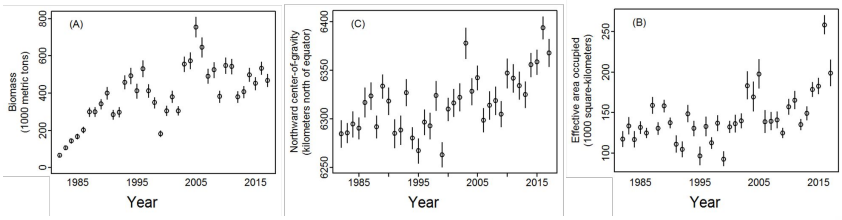
Key Stressors & Extremes



Community Composition

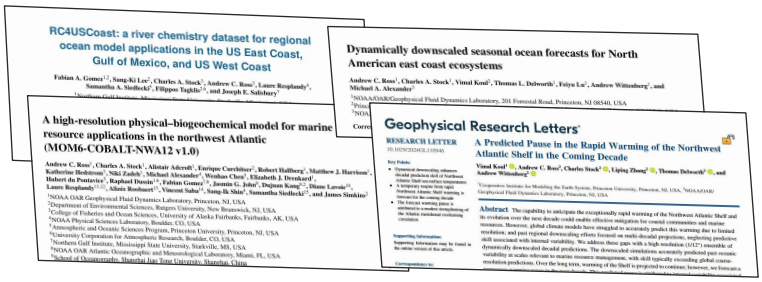


Species Distribution

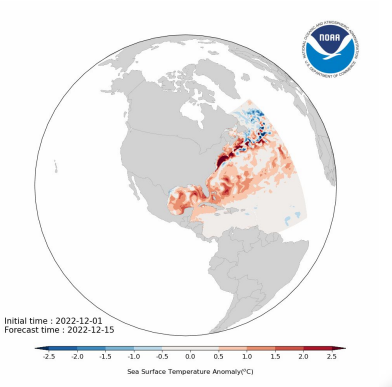


Predictive Ecosystem Indicators

Key CEFI NorthWest Atlantic Accomplishments



- **CEFI portal** (led by PSL)



- ***Hindcast*** *(AOML & GFDL co-authors)*

  Gomez et al. (2023), Ross et al. (2023)
- ***Seasonal and decadal forecasts*** *(led by GFDL)*

  Ross et al. (2024), Koul et al. (2024)
- **Future projections** *(led by AOML)* **and link to Fisheries**

  Troast et al. (internal review), Kim et al. (in prep.)

CEFI has accomplished a lot in a short timeframe (2022-2024).
Successfully developed and run

1) a hindcast simulation with ocean biogeochemistry and incorporating a new river chemistry dataset for the NorthWest Atlantic
2) seasonal and decadal forecasts for the NorthWest Atlantic
3) physics-only future projection for the NorthWest Atlantic
4) pilot/proof of concept using global climate model output to investigate changes in species distribution along the US Atlantic Coast

CEFI portal is online - key variables from the hindcast NWA12 simulation are available publicly.

- ○

What's Next?

- **Future Plans**
  - ***Couple physics to ocean biogeochemistry*** for dynamically downscaled North West Atlantic future projections
  - ***Customize regional outlooks*** for decision support teams and other users.
  - ***Utilize and expand*** upon CEFI core simulations to investigate extremes and stressors, North Atlantic circulation (large ensembles), explore marine carbon dioxide removal mitigation strategies, coastal vulnerability.

- **Relevance of CEFI**
  - NOAA's mission of science, service, and stewardship
  - Supports growing demands for information on what's changing, and what's at risk in our marine environment, e.g.:
    - Vital living marine resources
    - Blue Economy

(Image credit: NOAA)

- **CEFI relevance**
  - NOAA's mission of science, service, and stewardship to protect our lands, waters, resources, and people
  - Growing demands for information on what's changing, and what's at risk.
    - Blue Economy (fisheries, aquaculture, shipping, energy, tourism, businesses, coastal communities).
    - Vital living marine resources (fish stocks, protected species, habitats).

References

- ***Hindcast*** *(AOML & GFDL co-authors)*
  - Gomez et al. (2023): RC4USCoast: a river chemistry dataset for regional ocean model applications in the US East Coast, Gulf of Mexico, and US West Coast, Earth Syst. Sci. Data, 15, 2223–2234, https://doi.org/10.5194/essd-15-2223-2023, 2023.
  - Ross et al. (2023): A high-resolution physical–biogeochemical model for marine resource applications in the northwest Atlantic (MOM6-COBALT-NWA12 v1.0), Geosci. Model Dev., 16, 6943–6985, https://doi.org/10.5194/gmd-16-6943-2023, 2023.
- ***Seasonal and decadal forecasts*** *(led by GFDL)*
  - Ross et al. (2024): Dynamically downscaled seasonal ocean forecasts for North American east coast ecosystems, Ocean Sci., 20, 1631–1656, https://doi.org/10.5194/os-20-1631-2024, 2024.
  - Koul et al. (2024): A predicted pause in the rapid warming of the Northwest Atlantic Shelf in the coming decade. Geophysical Research Letters, 51,e2024GL110946. https://doi.org/10.1029/2024GL110946, 2024.
- **Future projections (*led by AOML*) and link to Fisheries**
  - Kim et al. (in prep.): Future changes in the Northwest Atlantic Ocean under CMIP6 scenarios.
  - Troast et al. (internal review): Potential habitat shifts of snapper and grouper species in response to projected bottom warming along the U.S. Atlantic Coast.