Modeling the California Current and its Ecosystem: Advances and (some) Promising Results

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Case Studies

- **Future** California Current Ecosystem (CCE) conditions (forced by an IPCC scenario)

- **Hindcast** of the CCE from lower trophic levels to sardines, anchovy and fleets.
Case 1: California Current

A future scenario
California Current Integrated Ecosystem Assessment (CC-IEA) simulation

- Simulation
  - 1970-2050 using 20th century climate (emissions) transitioning to RCP8.5
  - One way physical and BGC downscaling of CCS
  - Global to regional boundary conditions for both physics and BGC.
CC-IEA (one way downscale) simulation

- Global model: GFDL CM2.1mESM

- Atmosphere at 1°, ocean (MOM) at 1°

- BGC is COBALT (Carbon, Ocean Biogeochemistry And Lower Trophics)

- Regional model:

  - Physics: ROMS (7 km or ~1/12th deg), 40 vertical layers)

  - BGC: Enhanced CoSINE (C, Si, N Ecosystem model), including oxygen and full carbonate chemistry.
One-way downscaling: Physics and biology

GFDL

1st EOF: 44.21% of total variance
2nd EOF: 34.24% of total variance
3rd EOF: 7.14% of total variance
4th EOF: 5.03% of total variance
5th EOF: 1.75% of total variance
6th EOF: 1.51% of total variance

GFDL --> ROMS

1st EOF: 44.78% of total variance
2nd EOF: 33.55% of total variance
3rd EOF: 4.64% of total variance
4th EOF: 3.81% of total variance
5th EOF: 2.65% of total variance
6th EOF: 1.39% of total variance

EOFs of summer SSTs
Cumulative wind stress
Stronger winds in the downscaled solution and greater spatial structure

GFDL

GFDL --> ROMS
One-way downscaling: Physics (80 year simulation) conserve heat content and salinity, and cooling and freshening trend (southward expansion of Alaskan sub-polar gyre)

Temperature 0-1000m

Salt 0-1000m
Rich structures yet to be fully explored and uncertainties quantified as we move to “marine ecosystem scenarios”

Rykaczewski and Dunne (2010)

Taken from: “Guidance Note for Lead Authors of the IPCC Fifth Assessment Report”

Rykaczewski and Dunne (2010)
Case 2: California Current

From physics and lower trophic levels to sardine, anchovies and fishing fleets
Hypotheses for low-frequency variability

**Environmental conditions (bottom up)**
- Temperature controls population expansions and contractions via spawning behavior (e.g., Lluch-Belda et al., 1991).
- Reproduction success linked to mesoscale features (MacCall, 2002).
- Food availability and composition determines population success (e.g., Van der Lingen et al., 2001).

**Fishing pressure (top down)**
- Affects longevity--affects survival in adverse conditions.
- Differentially preserve more fecund older fish and their migratory behavior.
- Productivity depends on learned migratory behavior (Petigas et al., 2006).
Our approach: coupled climate-to-fishers model
Climate-to-fishers: Multi-species fish model

• Simulate 5-6 species with an individual based modeling approach.

• General food web: Species can compete for common prey and eat each other.

• Explicitly model growth, mortality, reproduction and movement.

• One species can represent a fishing fleet as individuals.
Climate-to-fishers: Why an IBM (Individual Based Model)?

- Natural unit in nature
- Allows for local interactions and complex systems dynamics
- Complicated life histories
- Plasticity and size-based interactions
- Conceptually easier movement
Climate-to-fish-to-fishers
...almost there - fluctuations captured (but not yet explained in space and time)

Rose *et al.* and Fiechter *et al.*
(in preparation, to be submitted to Prog. in Oceanography Special Issue)