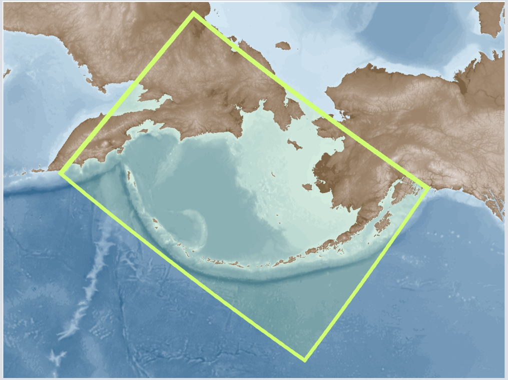
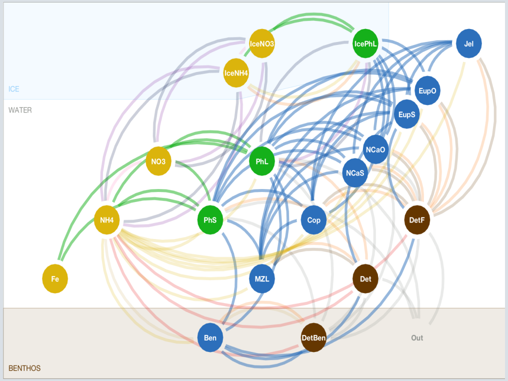
Bering 10K ROMS & ROMS-BESTNPZ models
Framework, status & simulations





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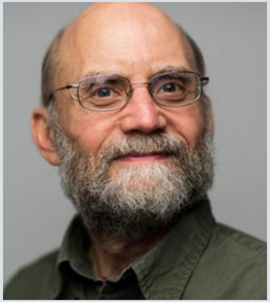
Bering 10K ROMS suite modeling team



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UW/JISAO
BESTNPZ v2

Ivonne Ortiz
UW/JISAO
Fish - FEAST

Kerim Aydin
AFSC/ NMFS/ NOAA
Lead integrated model
Fish - FEAST

Georgina Gibson
UAF
BESTNPZ

Framework and purpose

- Integrate survey data and best knowledge available, by consensus
- Research and management
- Downscale Global Climate Models (GCM)

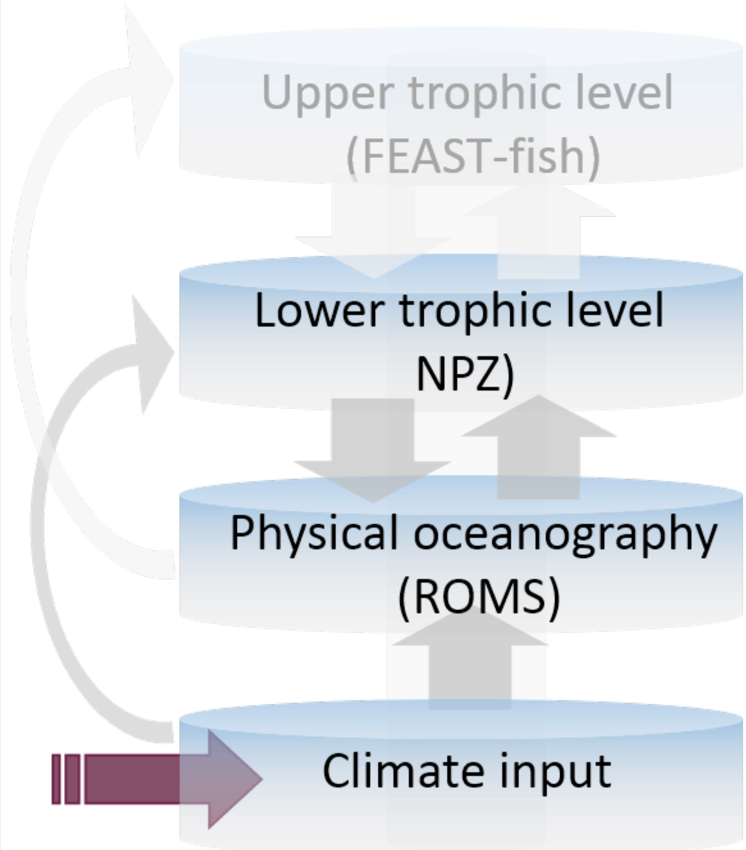
- Dynamical: run high resolution on subregional domain with boundary conditions from data or GCMs and reproduce local climate.

- Statistical: 2-step

i) develop statistical relationship local climate variables - large scale predictors
ii) apply relationships to GCM output to simulate local conditions

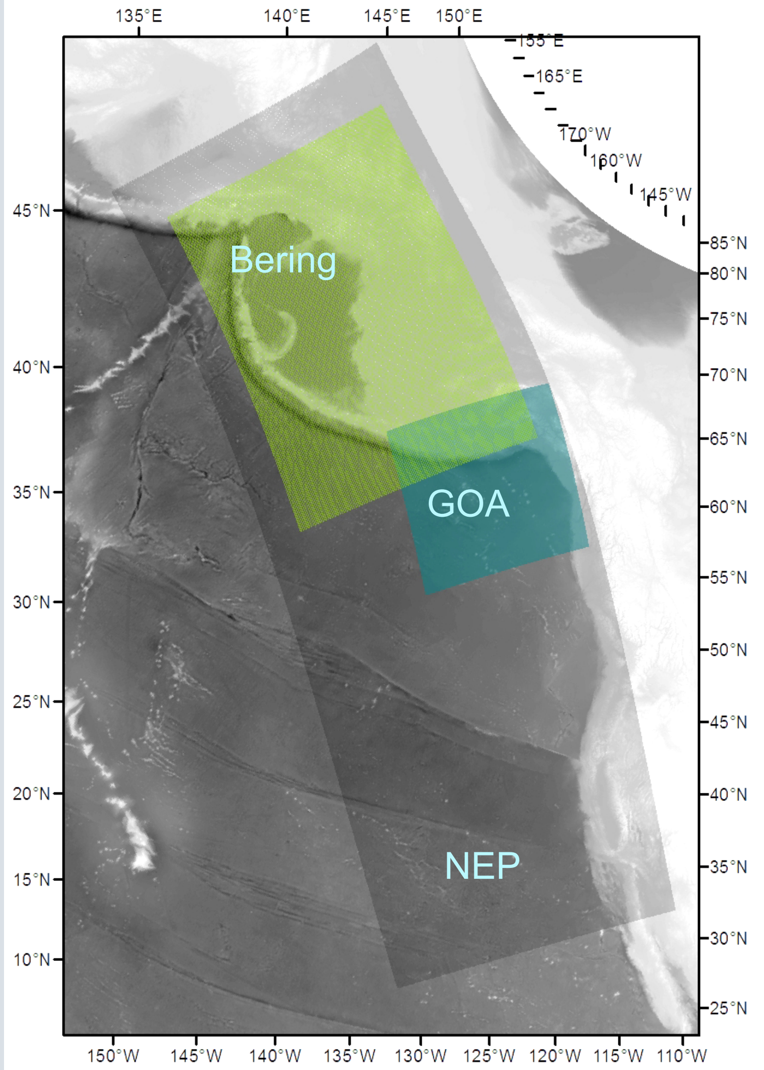
Integrated model

- Subgrid of NEP
- 10km resolution
- Regular grid
- Fixed no. vertical layers 10/30, regardless of depth
- timestep 10 min
- Output: daily, weekly, monthly
- Starts from initial conditions and continues with forcing files, no data assimilation, no fitting



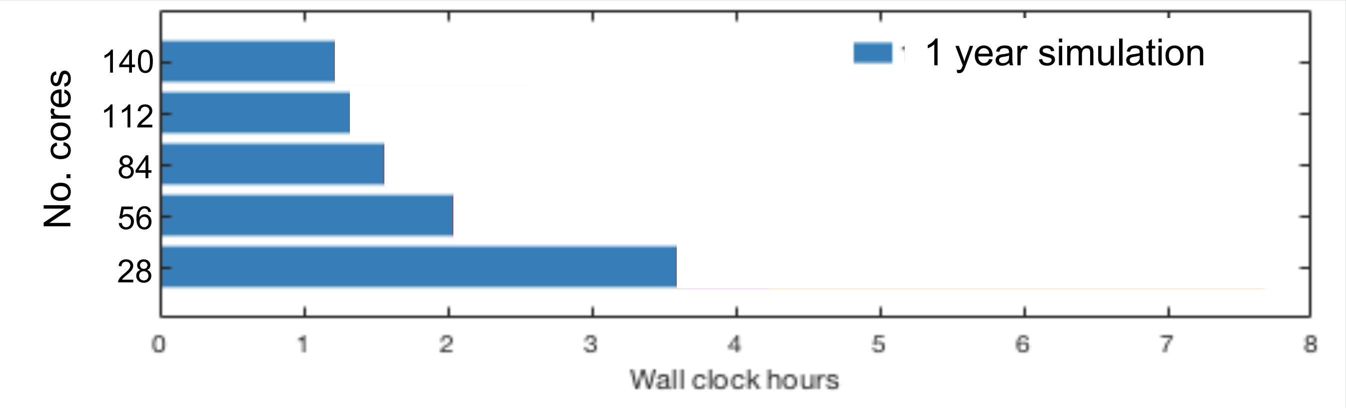
Extent & scale

- Subgrid of NEP
- 10km resolution
- Regular grid
- Fixed no. vertical layers 10/30, regardless of depth
- timestep 10 min
- Output: daily, weekly, monthly
- Starts from initial conditions and continues with forcing files, no data assimilation, no fitting



Basic hardware, prep & runtime

- Dynamic downscaling requires high performance computing
- Minimum 84 cores
- Prep time for boundary/ forcing files 1 month per GCM
- Runtime:10 layer model 1 simyear: 1.5 wall clock hours (84 cores); 100 yr run = 6.25 calendar days



Bering 10k ROMS-NPZ simulations available used for EBFM and stock assessment related

- Multidecadal hindcast: 1970-2018; 10 & 30 layer (3 versions)

- Seasonal forecast (9 mo.):

Oct-Jul 1 next yr (2014-18); forcing CFS

- NO 1-5 yr forecasts (physics not available)

- Multidecadal projections

CMIP3 – forcing 3 GCM models/1 scenario 2005-2040

CMIP5 – forcing 3 GCM models/ 2 scenarios/RCPs, 2012-2100

CMIP6 – planned (waiting files from GCMs)

History & Funding

- Started NSF-NPRB, continued by AFSC/IEA, current diversified funding; ~ 3 Full time employees equivalent/yr

LENFEST OCEAN PROGRAM

JISAO

NOAA FISHERIES

INTEGRATED ECOSYSTEM ASSESSMENT

PMEL
Pacific Marine Environmental Laboratory

FATE
Fisheries and the Environment

ACLIM

NOAA OAR

AFSC

CLIMATE PROGRAM OFFICE
ADVANCING SCIENTIFIC UNDERSTANDING OF CLIMATE, IMPROVING SOCIETY'S ABILITY TO PLAN AND RESPOND

Applications: Type and timescale

- Different types: EBFM & stock assessment oriented
- Hindcast: for evaluating model skills and providing historical context/retroactive studies
- Seasonal forecast: projections for tactical use
- Multidecadal projections: strategy evaluation, future conditions
- Current applications: Essential Fish Habitat, ecosystem indicators, past environmental conditions, cold pool forecast

EBFM

Current applications:

- Hindcast:
  Essential Fish Habitat, ecosystem indicators, past conditions; ocean acidification module (Pilcher et al 2018)
- Seasonal forecast:
  cold pool index
- Multidecadal projections:
  future conditions, EFH, ecosystem indicators

Under development/ planned

- Hindcast:
  pollock for N. Fur Seal (FEAST); foraging success for salmon in Norton Sound
- Seasonal forecast:
  EFH, ecosystem indicators, cold pool & sea ice (more GCMs & dates), maybe OA
- Multidecadal projection:
  OA module; pollock availability for NFS (NFS Conservation Plan)

Stock assessment, MSE oriented

Current applications:

- Hindcast:
  training models
- Seasonal forecast:
  CEATTLE
- Multidecadal projections:
  CMIP3 vulnerability analysis
  CMIP3 & CMIP5 - CEATTLE

Under/planned development:

- Hindcast:
  crab models, disMELS (larvae),
- Seasonal forecast:
  crab models, disMELS
- Multidecadal projection:
  CMIP5 & CMIP6 - Ecopath, FEAST, economics model, size spectrum model, CEATTLE, single sp stock assessment pollock, yfs, atf, crab models, disMELS

Ad hoc uses

It has strong supportive use (best available science) for developing EBS cod story.

Direct qualitative uses (e.g. indicators and the Dorn table)

Survey planning, allows additional funding requests

Qualitative uses of quantitative results

Output can be incorporated into models part of SAFE reports

Future Essential Fish Habitat

Chris Rooper, Ivonne Ortiz, Ned Laman, Al Hermann (Rooper et al, *in prep*)

Used Slope, SE Bering Sea shelf and Northern Bering Sea data to build EFH models 1982-2017 except when noted

1) AK plaice
2) Arrowtooth flounder (1993-)
3) flathead sole
4) Northern rock sole (2001-)
5) Pacific cod
6) Walleye pollock
7) Red king crab (1996-)
8) Snow crab
9) Tanner crab
10) Yellowfin sole

Variables used: depth, slope, maximum tidal current, sediment grain size, mean bottom ocean current, bottom temperature

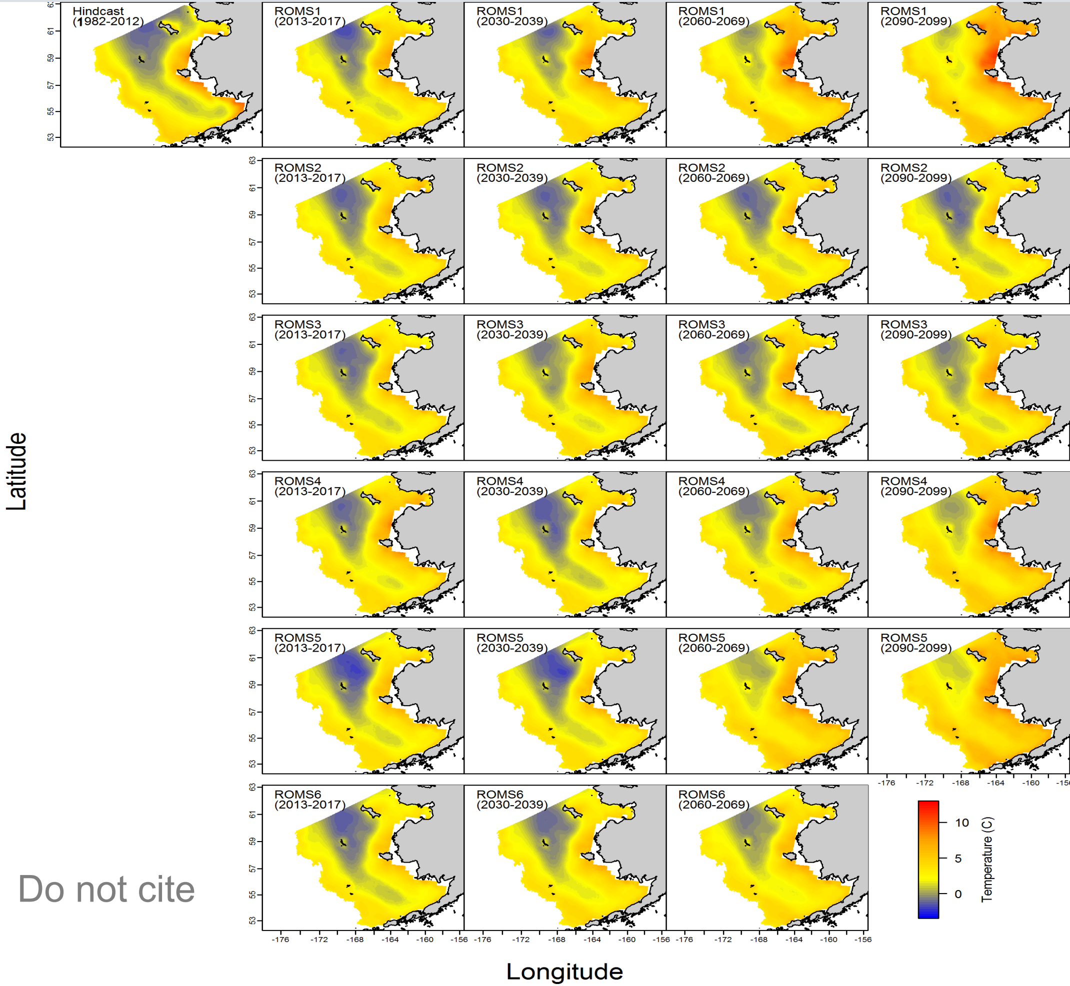
Future Essential Fish Habitat

Deviance explained by model

1) AK plaice	50%	6) Walleye pollock	27%
2) ATF flounder	47%	7) Red king crab	45%
3) Flathead sole	34%	8) Snow crab	51%
4) N rock sole	53%	9) Tanner crab	28%
5) Pacific cod	25%	10) Yellowfin sole	60%

Variables used: depth, slope, maximum tidal current, sediment grain size, mean bottom ocean current, bottom temperature

bottom temp



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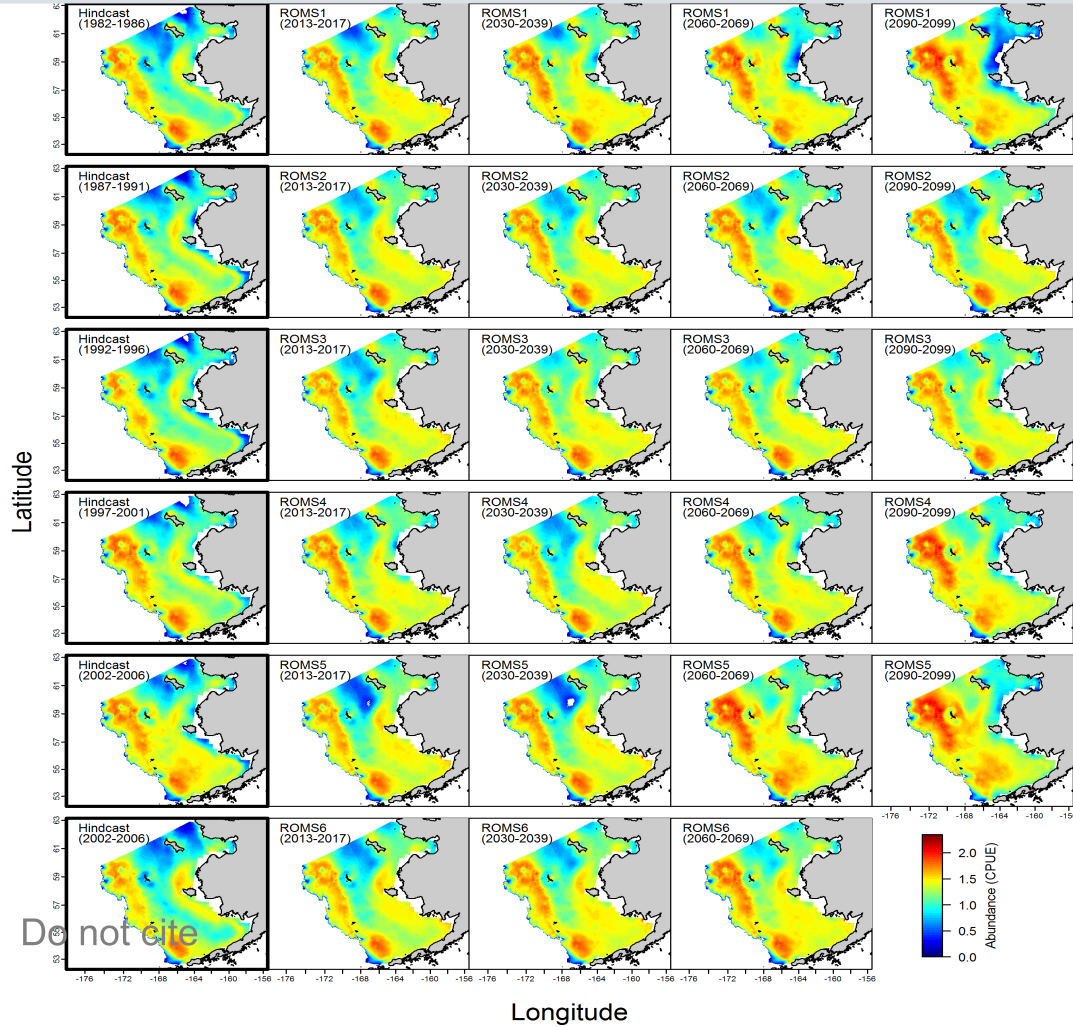

Hindcast (1982-1986)
ROMS1 (2013-2017)
ROMS1 (2030-2039)
ROMS1 (2060-2069)
ROMS1 (2090-2099)
Hindcast (1987-1991)
ROMS2 (2013-2017)
ROMS2 (2030-2039)
ROMS2 (2060-2069)
ROMS2 (2090-2099)
Hindcast (1992-1996)
ROMS3 (2013-2017)
ROMS3 (2030-2039)
ROMS3 (2060-2069)
ROMS3 (2090-2099)
Hindcast (1997-2001)
ROMS4 (2013-2017)
ROMS4 (2030-2039)
ROMS4 (2060-2069)
ROMS4 (2090-2099)
Hindcast (2002-2006)
ROMS5 (2013-2017)
ROMS5 (2030-2039)
ROMS5 (2060-2069)
ROMS5 (2090-2099)
Hindcast (2002-2006)
ROMS6 (2013-2017)
ROMS6 (2030-2039)
ROMS6 (2060-2069)
Latitude
Longitude
63
61
59
57
55
53
-176
-172
-168
-164
-160
-156
Abundance (CPUE)
2.0
1.5
1.0
0.5
0.0
Do not cite

Extra slide (Zooplankton analyses)

- **Danielson 2011**-

Temporal correlations between relevant ecosystem indicator time series and the principal components: see Table 6 for details,
Average annual condition index (summer) for walleye Pollock
Average annual condition index (summer) for Pacific cod
Total net primary production (May–November) over southeastern Bering Sea shelf
Estimated onset of spring bloom over inner shelf
Estimated onset of spring bloom near mooring M2
Walleye pollock size−at−age anomalies during summer for the first age that is adequately sampled by summer trawl survey
Recruitment of age 1 walleye pollock by year class
Residuals from a spawner−recruitment relationship for walleye pollock
Estimated onset of spring bloom over southeast Bering shelf based on SeaWiFS

- **Gibson & Spitz 2011 -**

Sensitivity analysis -Mesozooplankton productivity was not correlated with water temperature, but a shift towards a system in which smaller zooplankton undertake a greater proportion of the secondary production as the water temperature increases appears likely.

- **Hermann et al 2013** -

Multivariate analysis (including biological variables) (Fig 14)
model results vs (modified) Oscillating Control Hypothesis (Fig 19)

- **Hermann et al 2016 -**

Forecast of Large crustacean zooplankton (2030-2039) under 3 GCM part of CMIP3 (Fig 17)
Coherence of seasonal anomalies for vertically averaged (100m) ocean temperature with seasonal anomalies of euphausiid biomass (Fig 19)

- **Ortiz et al 2016 -**

Compared biomass of Zooplankton with and without FEAST (differences due to fish actual zooplankton prey consumption vs closure term) (Fig 9)
Weekly climatology of zooplankton biomass by group and region (Fig 12)
Weekly anomalies of euphausiid biomass (total H2O column) & depth averaged temperature anomaly 1971-2009, by region (F 13).
Seasonal consumption of copepods, euphausiids and pollock by pollock (by size) (Fig 14)

- **In prep**

Kirstin: correlation CEATTLE model pollock, pcod and ATF recruitment (age 1) PLK: fall zoop, spring zoop, Bottom Temp. and cold pool predict age 1 rec in following year (ricker. R^2= 0.47 and 0.53); PCOD: SST, Winter Zoop, and Summer Zoop --> R2 = .57, and .63; ATF: some weak covariate weights for cross shelf transport and salinity (not convincing relationship)
Kerim: pollock bionenergetic and survival over fall and winter based on zooplankton prey availability.