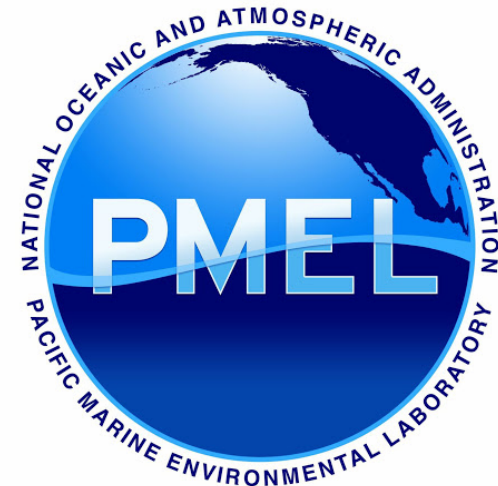


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Funding: NOAA Climate Program Office & North Pacific Research Board

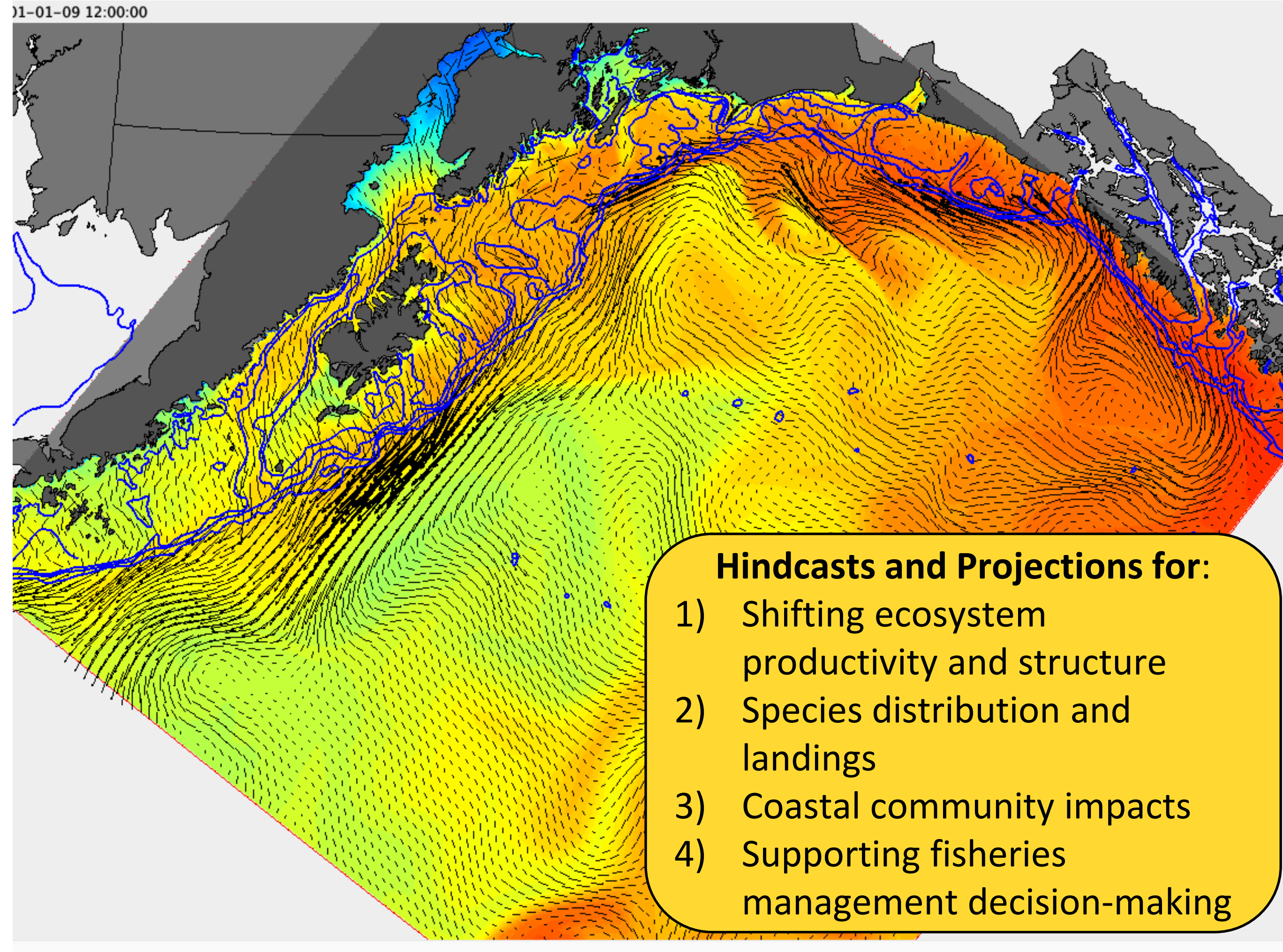
An operational suite of coupled socio-ecological models for climate fisheries hindcasts, forecasts, projections and management strategy evaluation



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From climate to communities in the Gulf of Alaska: using an integrated modeling approach to evaluate drivers of present and future system-level productivity and assess climate impacts on fishing-dependent communities

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Funding: NPRB: \$472K over 3 years, NOAA COCA funding: \$1.5M over 3 years, plus in kind support from NOAA IEA program, and NOAA Fisheries core funding.



Institutional partners

AFSC: Marine Mammal Laboratory, REFM, Auke Bay Laboratories.

CSIRO: Technical support and advice on Atlantis model development, Contact Beth Fulton.

DFO: Advice on ecosystem modeling, Contact Caihong Fu.

PMEL: ROMS modeling, Contact Al Hermann.

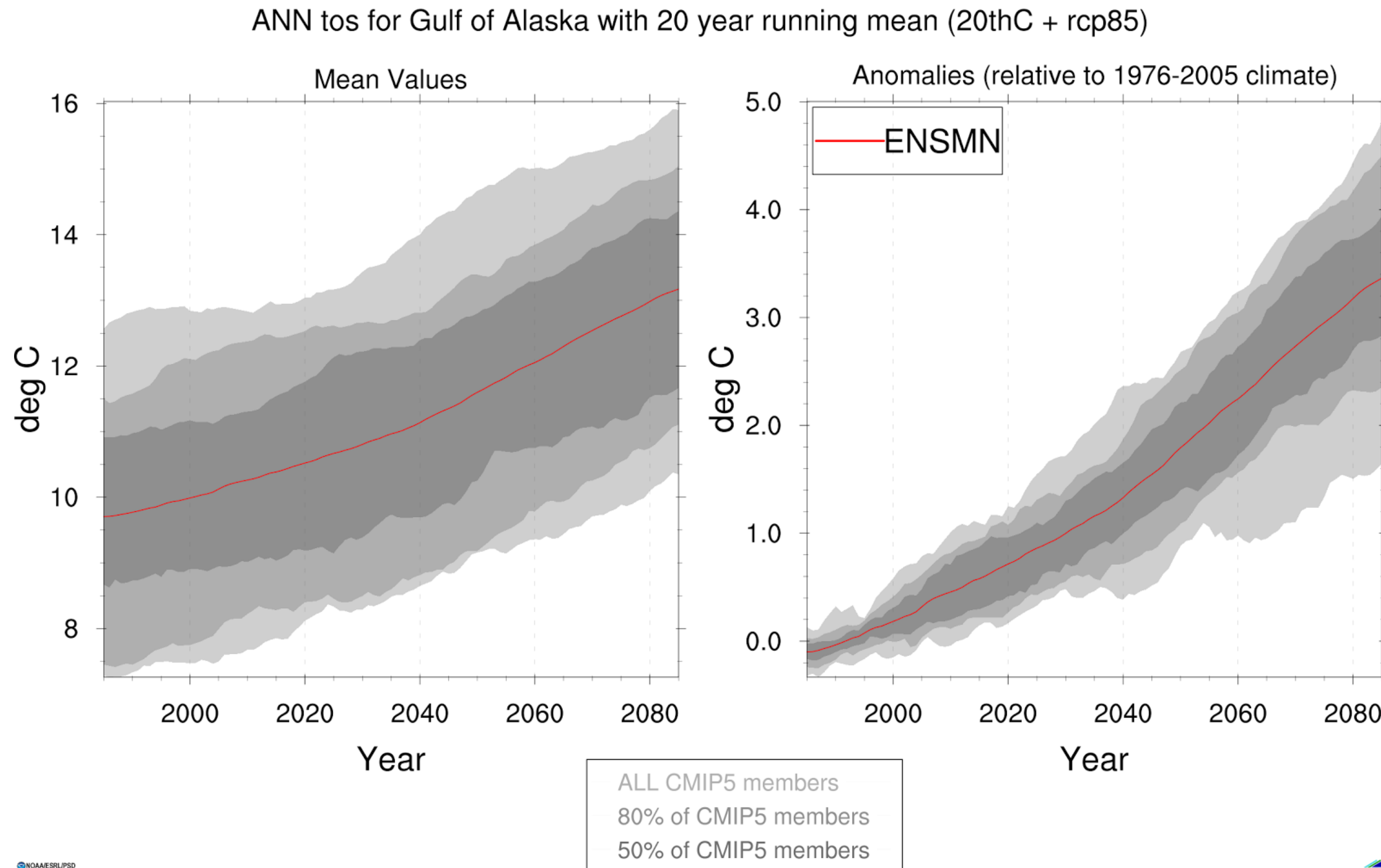
School of Aquatic and Fisheries Sciences/CICOES: Post-doctoral scholars Matthieu Veron—climate-enhanced single species models, Alberto Rovellini—Atlantis modeling, Gemma Carroll—food web spatial modeling, Adam Hayes—fleet dynamics modeler. Research scientist Liz McHuron—Sea lion foraging and bioenergetics.

Pacific States Marine Fisheries Commission: Andrew Steinkruger - sociology post-doctoral scholar.

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Projected climate changes:

- Ocean warming
- Ocean acidification
- Oxygen limitation
- Changes in ocean circulation and stratification



Projected increases in sea surface temperature for the Gulf of Alaska (left) and future temperatures relative to historic means (right).

GOA-CLIM is an integrated research program that:

- 1) leverages ongoing research at the Alaska Fisheries Science Center,
- 2) is closely aligned with the successful eastern Bering Sea ALCIM project, and
- 3) represents a substantial step towards meeting the objectives of GOA Climate Science Regional Action Plan (Dorn et al. 2018) and the NMFS climate science strategy (Link et al. 2015).

Overarching research questions concern the drivers of system-level productivity under climate change, the ways that fisheries management can promote resilient fisheries in a changing climate, and development of a coupled modeling approach that extends from climate to communities to evaluate economic and social impacts of climate change on resource-dependent communities in the GOA.

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Presently funded ROMS simulations for the GOA include downscaling "time slices" of future conditions;

Under this project we would fill out those time periods with a continuous simulation of GOA dynamics at 3km resolution from the present through 2100 under multiple projections across ESMs and RCP scenarios to support climate enhanced ecosystem and stock assessment models.

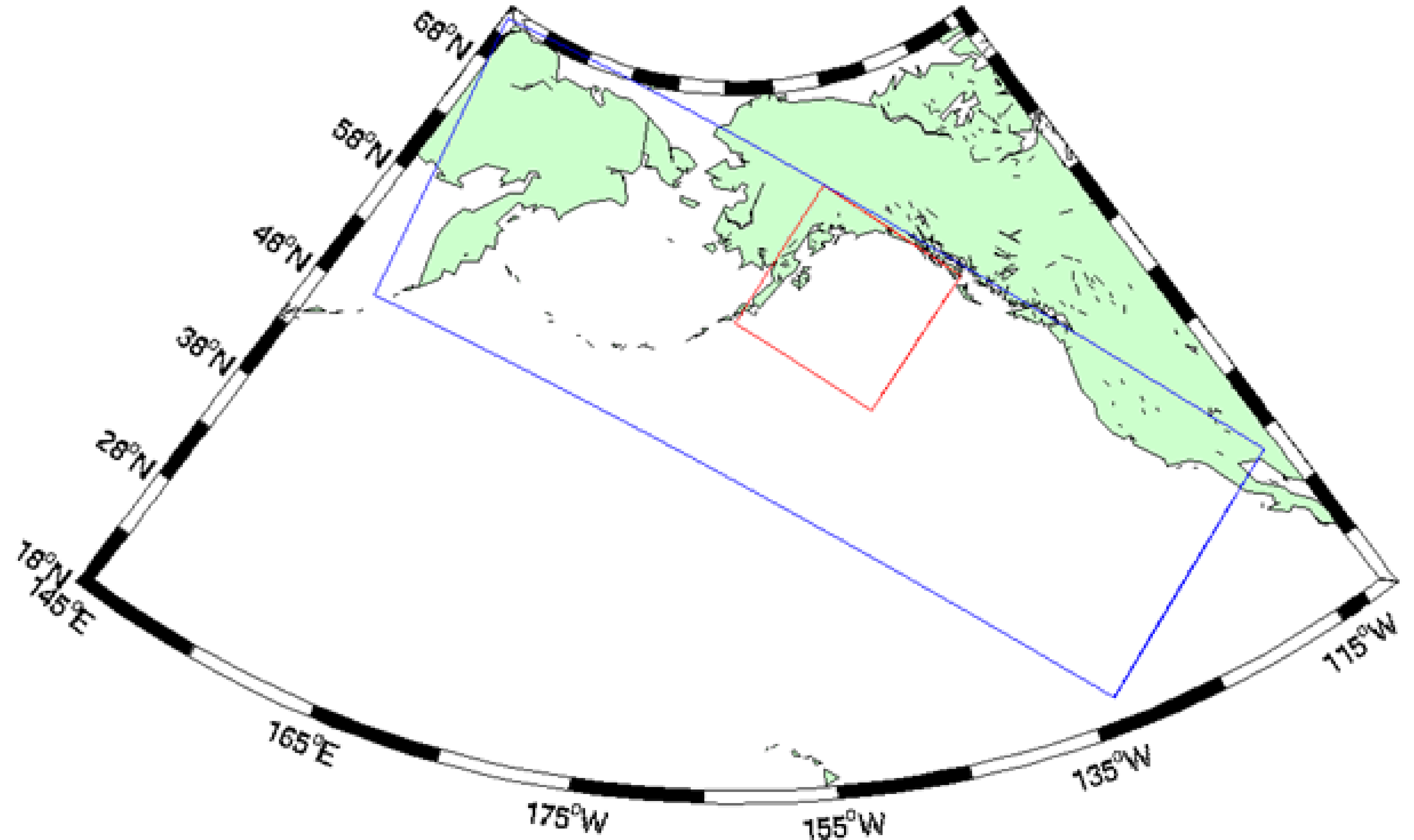


Figure 1. Spatial domain of the GOA-3K model (red outline) shown using the Lambert conformal conic projection. The GOA-3K model is embedded in NEP-10K model (blue outline).

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Three research pathways:

- Research pathway 1: Development and application of the Atlantis model as an element of a multi-model ensemble to evaluate fisheries management strategies in a changing climate.
- Research pathway 2: Evaluate and predict the impacts of major environmental anomalies to the endangered Western DPS population of Steller sea lions
- Research pathway 3: From Climate to Communities. Building the tools and knowledge-base to couple the ecosystem models to regional economic models to evaluate the impacts of climate change on resource-dependent communities.

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Research pathway 1: Development and application of the Atlantis model as an element of a multi-model ensemble to evaluate fisheries management strategies in a changing climate

- Build, develop input data sets, including ROMS output, for, and calibrate an Atlantis end-to-end ecosystem model for the Gulf of Alaska.
- Other candidate models for the multi-model ensemble: CEATTLE multi-species model (Grant Adams PhD), climate-enhanced single species models (Matthieu Veron postdoc), Ecopath with Ecosim Bridget Ferriss, Szymon Surma UAF postdoc
- Conduct model experiments to evaluate the drivers of present and future ecosystem-level productivity in the GOA, focusing on the impact of the marine heat wave, and climate projections to 2100.
- Apply a multi-model approach to evaluate the current OY range in the GOA, taking into account model uncertainty

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Primer on optimum yield

- The optimum yield for groundfish in the GOA is specified as a range (140,000–800,000 t), which provides both lower and upper limits on total groundfish removals (with the expectation that catches will be at least as high as the lower limit).
- The OY upper limit was estimated in 1987 early in the history of Federal fisheries management as the sum of the single species estimates of MSY and reduced to account for ecosystem considerations and uncertainty.
- Unlike the BSAI 2 million ton cap, the upper limit in the Gulf of Alaska has never been constraining, suggesting that the original estimate was inaccurate.
- The GOA Groundfish FMP notes that “The Magnuson-Stevens Act requires Councils to “review on a continuing basis, and revise as appropriate, the assessments and specifications made ...with respect to the optimum yield.”

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Research pathway 2: Evaluate and predict the impacts of major environmental anomalies to the endangered Western DPS population of Steller sea lions.

- This pathway will build on the ecosystem modeling tools developed in the first pathway
- Output from the ROMS/NPZ, CEATTLE and Atlantis models will be used to evaluate changes in ecosystem structure and function prior to and during the 2013-2016 marine heat wave in the GOA. Mechanisms underlying observed SSL population-level responses will be tested.
- A second approach is to develop new bioenergetic models for SSLs to test how the marine heatwave affected energy consumption and estimate the level of prey reductions that could have led to the observed reproductive failure.
- Goal is to provide climate-informed management guidance for this protected species.

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Research pathway 3: From Climate to Communities. Building the tools and knowledge-base to couple the ecosystem models to regional economic models to evaluate the impacts of climate change on resource-dependent communities.

- This pathway will also build on the ecosystem modeling tools developed in the first pathway
- There are three projects:
 - A fleet dynamics model. Modeling fleet dynamics and fishery landings responses to ecosystem and management change
 - A sociological project to examine how individuals, families, and communities across GOA adapt to climate variability and associated changes in fisheries and marine ecosystems
 - Community Economic Modeling. Regional Computable General Equilibrium models for borough and census areas in the GOA