

Evaluating and Improving the Ability of an Adaptive Management Framework (FISHE) to Identify and Resolve Fishery Management Challenges related to Climate Change

Proposers:

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Client: Environmental Defense Fund

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I. Objectives:

The purpose of the proposed project is to evaluate and improve the ability of the Framework for Integrated Stock and Habitat Evaluation (FISHE) to identify and resolve fishery management challenges caused by climate change, using a multispecies case study from nearshore coral reef fisheries in Belize. Specific objectives are to:

1. Evaluate the ability of the FISHE to adequately identify climate-related fishery management problems, and to resolve them in ways that achieve desired biomass, yield, and profits given anticipated climate-driven changes in species growth, mortality, distribution, and recruitments.
2. Modify the FISHE to improve its performance given climate change.
3. Communicate findings to stakeholders.

II. Significance:

Climate change is already affecting fisheries by driving changes in range and productivity. Recent analyses suggest that implementing fishery management measures that are adequately adaptive to climate change can lead to increases in profit and biomass despite these climate-driven changes^[1]. Current fisheries management models do not yet account for variation caused by global climate change, which will make management strategies less effective going forward. Climate change scenarios suggest that there could be a significant decline in maximum sustainable yield (MSY) by 2100^[1]. This decline will need to be addressed through new, climate adaptive management strategies. The stakes are high in social, economic, and conservation terms. In addition to employing over 36 million people, the seafood industry provides 16% of

human dietary protein^[2], so adapting fisheries management as climate change takes hold will be crucial for the continued success and well-being of fishery stakeholders. As well as curbing projected loss in profit and harvests from climate change, new adaptive strategies could help to offset negative effects of climate change and bolster the resilience of marine ecosystems.

Our client, Environmental Defense Fund (EDF), will benefit from an evaluation of their principal adaptive management framework (FISHE) and its ability to identify and resolve issues related to climate change. Indeed, many of intervention efforts occurring in EDF's core geographies are using the current FISHE framework to guide management reforms. For example, the Mexican non-profit, Niparaja has used the framework to inform data collection methods in the San Cosme-Punta Corridor of Baja California. These new methods have helped to establish necessary conditions for successful sustainable fishing^[3]. A modifiable framework which includes key climate change parameters, such as sea temperature warming effects on species distribution, growth, natural mortality and recruitments would be essential to better fisheries management around the world. As the project becomes more complex, additional climate change parameters other than those mentioned above could be explored for use in the FISHE.

III. Background:

Our work will initially focus on Belizean fisheries, as EDF has ample data available for that area. Belize is home to the second largest barrier reef in the world, and is already experiencing major effects of climate change, including coral bleaching, increased frequency of high intensity storms, and sea level rise^[4]. Fisheries play an important role in the national Belizean economy, accounting for nearly 3% of the country's GDP. According to a 2013 survey, there are 2,946 full time and part time fishers, as well as 560 fishing vessels in Belize^[5].

EDF has developed an initial multispecies Mizer model based off of Belize Finfish fisheries. Mizer is a software package that allows for modeling of a community of individuals that grow and change trophic level during life, using the R statistical programming environment^[6]. The EDF developed Mizer model has been parameterized to analyze finfish data from the Port Honduras Marine Reserve and Glover's Reef Marine Reserve for 29 species^[7]. This model, however, does not account for impacts of climate change on fisheries, and EDF and others use this model to help inform guide decisions at several points during the development of a fishery intervention. While the model predicts biomass and yield - and is used in ways that help identify goals and evaluate performance, among others - climate change indicators are key to pinpointing an even more reliable multispecies Mizer model for these predictions. The expansion of the already developed Mizer model to include impacts of climate change on fisheries will be crucial to evaluate and improve the ability for FISHE to account for climate change.

EDF has also developed a management tool, FISHE, for fisheries managers to conduct simplified stock assessments to evaluate potential management options. FISHE currently consists of 11 steps to help fisheries managers choose management actions aimed at achieving stakeholder driven goals. The entire process is repeated on a regular basis to determine whether management changes are necessary, providing managers with the means to re-evaluate and adjust decisions periodically based on observations about fisheries conditions and learning from the outcomes of previous management decisions^[8]. However, the tool does not explicitly address the effects of global climate change. As climate change accelerates, this will lead to larger gaps in information. This will lead to less accurate modeling, but it may also lead to more foundational questions, such as the cause and effect of management actions. If the framework is unable to adequately account for ecosystem perturbation from climate change, it is very likely that management strategies developed with this framework will become less effective. As such, evaluating whether the FISHE framework can adequately incorporate climate change, and adapting the framework as necessary, will represent a significant advance in the ability for policy

makers, stakeholders, NGOs, and others to develop fishery interventions that are responsive to climate driven changes in distribution, abundance, and productivity.

IV. Available data:

EDF has immediately accessible multispecies data for several different regions that represent specific management units within Belize. This data will be used to develop a multispecies model using the Mizer package in R Statistical Software. This model, unlike previously developed models for these fisheries, will include average temperature increase to predict impact on species growth, mortality, distribution, and recruitments. Consequently, the climate-linked model will be used to help assess the effectiveness of the current and improved FISHE.

V. Possible approaches:

There are many potential approaches to achieve our objectives. Below is a potential roadmap:

1. Describe what is known about the ecological history of these stocks: e.g., were predators depleted resulting in prey release? Have catches been relatively stable or were they depleted early in the history of the fishery? What does the food web look like (who eats whom)? What are the known changes in habitat that supports targets, short and long term? Any changes in the interest in fishery targets?
2. Gather climate model projections and climate velocities (rate at which species are moving toward poles) to help infer how sea temperature change might affect species distribution and mortality and birth rates. Current distributions will be assessed using AquaMaps^[9] and forecasted sea surface temperature (SST) change will be assessed using the CMIP5 earth system projections.
3. Use abundance/unit area and length frequency composition data to estimate fishing mortality, SPR, and density.
4. Parameterize Mizer multispecies model for this fishery.
5. Modify the Mizer model to emulate the effects of climate change on species range and productivity. This will be done by allowing warming to alter the distribution and density of species in the model. We will also explore impacts of warming on mortality and recruitment.
6. Add a management strategy scenario to the Mizer Shiny app that emulates FISHE (measuring fishing mortality, F , in conjunction with target yields).
7. Vary frequency of adaptive management cycle (e.g., annually, once every two years, once every five years) to test effects on FISHE performance.
8. Evaluate each of the 11 FISHE steps and modify as appropriate to reflect climate change impacts. Provide rationale for what climate forcings to include in the modified FISHE.
9. Effectively communicate findings to key stakeholders.

VI. Deliverables:

Final deliverables for the Bren School will include the required presentation, poster, policy brief, and written report. Final deliverables for the client, EDF, will include:

1. Report on performance of FISHE relative to other management strategies (e.g., fixed F , size limits, MPA). If there is time, develop a manuscript for publication.
2. Bioeconomic model using Mizer methods that will emulate the effects of climate change and FISHE.
3. Report describing recommended modifications to FISHE and rationale (if there is time, it would be ideal to have edited web pages incorporating these modifications after they are vetted with EDF staff)

VII. Internship:

EDF is prepared to offer a single internship for the summer of 2019 with funding of \$5,000.

Supporting Materials:

References:

- [1] Gaines, S. D., Costello, C., Owashi, B., Mangin, T., Bone, J., Molinos, J. G., . . . Ovando, D. (2018, August 01). Improved fisheries management could offset many negative effects of climate change. Retrieved from <http://advances.sciencemag.org/content/4/8/eaao1378>
- [2] Tidwell, J. H., & Allan, G. L. (2001, November 01). Fish as food: Aquaculture's contribution. Retrieved from <http://embor.embopress.org/content/2/11/958>
- [3] Karr, K. (2015, February 10). FISHE: An Online Tool to Overcome Hurdle To Sustainable Fisheries. Retrieved from <http://blogs.edf.org/edfish/2015/01/28/fishe-an-online-tool-to-overcome-hurdle-to-sustainable-fisheries/>
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- [5] Part I Statistics and main indicators. (n.d.). Retrieved from <http://www.fao.org/fishery/facp/BLZ/en>
- [6] Scott, F., Blanchard, J. L., & Andersen, K. H. (2014). Mizer: An R package for multispecies, trait-based and community size spectrum ecological modelling. *Methods in Ecology and Evolution*, 5(10), 1121-1125. doi:10.1111/2041-210x.12256
- [7] McDonald, G., & Karr, K. (n.d.). Belize Multispecies Finfish Simulation. Retrieved from <https://kendrakarr.shinyapps.io/belize-finfish-master/>
- [8] Get started. (2018, April 23). Retrieved from <http://fishe.edf.org/get-started>
- [9] Kaschner, K., Kesner-Reyes, C., Garilao, J., Rius-Barile, T., Rees, & R. Froese. (2016). AquaMaps: Predicted range maps for aquatic species. World wide web electronic publication, Retrieved from www.aquamaps.org

Budget:

Item	Cost (USD)	Funding Source
Paid Internship	\$5,000	EDF
Printing	\$200-\$400	Bren
Presentation Materials	\$200-\$400	Bren



Group Project Committee
Bren School of Environmental Science and Management
University of California, Santa Barbara

January 24, 2019

RE: Evaluating and Improving the Ability of an Adaptive Management Framework (FISHE) to Identify and Resolve Fishery Management Challenges related to Climate Change

Dear Group Project Committee,

We are writing to express our support for the group project *Evaluating and Improving the Ability of an Adaptive Management Framework (FISHE) to Identify and Resolve Fishery Management Challenges related to Climate Change*. At EDF we have placed high strategic priority on the matter of climate change effects on fisheries, and we believe this project holds promise for helping us advance climate-ready fisheries management.

Our experience suggests that one of the most important approaches to climate-related fishery management will be implementation of adaptive management. Many of our intervention efforts are based on our adaptive management framework, titled the *Framework for Integrated Stock and Habitat Evaluation (FISHE)*. While this framework has proven to provide significant value to our intervention efforts to date, there are questions as to its suitability to address climate-related issues.

We believe this group project could provide important insight regarding the strengths and weaknesses of our FISHE framework to address climate-related issues. Any resulting improvements to this framework promise to have wide-ranging impacts as we continue to deploy FISHE to guide intervention efforts in several corners of the globe.

As part of our support we are prepared to offer a single internship with support of \$5,000.

Sincerely,

Dr. Rod Fujita
Director, Research and Development
Oceans Program

Merrick Burden
Director, Opportunities and Outcomes
Oceans Program