**APPENDIX A**

**Predicting outcomes to management changes: combining ecological foraging theory and game theory to understand fishermen effort allocation over space**

**Purpose**

We are developing a mechanistic framework to understand fishermen’s location choice at an individual vessel level. This work will benefit U.S. West Coast fisheries management directly by providing an understanding of how alternative fisheries management actions (e.g., trawl rationalization) and ocean use plans (e.g., fishery closures, wind/wave energy, etc.) are likely to affect fishing effort (and associated socio-economic indicators like profits) for individual fisheries. Importantly, our research will also provide insights about fishing behavior across multiple fisheries, thus providing context for the fishery ecosystem plan currently under development at the Pacific Fisheries Management Council (http://www.pcouncil.org/ecosystem-based-management/fep/).

Existing methods for understanding fishing behavior revolve around discrete choice random utility models which are calibrated to a certain fishery at a certain time. While these statistical models can provide reasonable approximations of the calibrated fleet dynamics, they are phenomenological and present problems for out-of-sample prediction. Without mechanistic rules it’s not clear how context specific these location choice models are, i.e. would a random-utility model calibrated for Northeastern groundfish be valid for Pacific Coast groundfish fisheries? We are motivated to build an empirically validated predictive framework for how fleet dynamics (in particular, allocation of fishing effort over space) should vary with the ecology of the targeted species, management, and gear used. Achieving this aim would provide a way to broadly understand and predict how fleet dynamics should change as management, gear or targeted species change.

**Motivation**

There is a broad need to better incorporate fishermen behavior into design and evaluation of new management approaches. There is also a mandated need to understand how different fisheries and regions use fish resources differently in order to comply with MSA requirements that the ‘needs of fishing communities’ be addressed. Further, fishery management is becoming increasingly ecosystem-based (http://www.pcouncil.org/ecosystem-based-management/fep/) where the impacts on target species, non-target and protected species, habitat, and fishing communities all must be considered in the design and implementation of new management. Fishermen behavior is central, as it will mediate how changes in management translate into changes in the marine environment. While this research is not at the explicit request of a management agency, the results will address the need of incorporating fishermen behavior into management design and analysis.

**Approach**

We plan to couple catch data found in PacFIN fish ticket and logbook data to VMS data for individual vessels to examine how fleet dynamics vary across fisheries. This approach is novel in that previous location-choice modeling attempts consider a single fishery at a single point in time. With our focus on comparing across fisheries, we are in a unique position to search for ways in which fleet dynamics vary systematically across ecologies, management types and gear used. In particular we will focus on how ecology of target species, management regime, gear type, and price of catch relate to the distribution of search effort and catch.

**Spatial resolution**

For this work it is sufficient to have general statistical areas of catch, but we would require specific data related to the ports which vessels left and returned to. While our analysis takes place at the level of individual vessels, our focus is generating predictions for how fleets will respond to changes in management. For the purposes of public presentation and/or publication, results will be aggregated to a minimum of 3 vessels in any particular strata such that no individual vessel can be identified.

Examples of aggregated results include general statistics of how clumped vessels are in space and time in a given fishery or how the proportion of time vessels spend cruising versus fishing varies from fishery to fishery. Maps of fishing intensities may be made, but these will be aggregated to the level of a fishery and will include a minimum of three vessels such that no individual vessel’s tracks can be identified.

**Temporal resolution**

We need daily resolutions of PacFIN data in order to match it to the VMS data which is at approximately hourly increments. Without daily resolution we cannot match trips recorded in our VMS data set with catch records in the PacFIN data. Our results will be presented in weekly, monthly, or yearly intervals. No individual date will be presented in our results.

**Temporal extent**

January 2009 – present

**Models**

We will apply Hierarchical Bayesian models using Hidden Markov processes to a combined dataset that includes VMS and PacFIN data. These models will be used to back out behavioral states (i.e. fishing, traveling) from the fishermen’s movement trajectory. This allows us to quantify how fishing strategy (defined as the proportion of the time a vessel is fishing versus traveling versus handling fish) varies with ecology of targeted species, management, and gear.

**Fishery data requirements***:*

Our request includes both table and header information from the PacFIN database for all west coast fisheries. We are hoping to get 4 data files that include the fields listed in the attached excel workbook: fish ticket data, logbook data, coast guard registration data, and state vessel registration data.

**Research products**

The intended outcome of this research is methodology to mechanistically understand and predict location choice of fishermen. This research will provide a new technique to evaluate how spatial allocation of effort will change with new management, including trawl rationalization and spatial regulations such as those related to Rockfish Conservation Areas and Essential Fish Habitat.

We anticipate publishing in peer-reviewed journals, presentations at national and international conferences, university and agency seminars, and in meetings with interested fishery stakeholders. In particular we are interested in reporting results in a format which is accessible to fishery managers.

Prior to presenting any PacFIN data publicly, we will request review from NMFS, CDFW, PSMFC, and PacFIN colleagues to ensure that confidentiality restrictions are met.

**Data security**

We will store the data locally at the Northwest Fisheries Science Center, which is also subject to strict confidentiality requirements. Data will not be held locally on laptops. Only individuals authorized by NOAA will have access to this server.

**Time Line**

[Please add a brief description of your time line for this project.]

**APPENDIX B**

PacFIN Fish Ticket Data for California

Statewide data for 2009 to 2013

PacFIN Vessel Registration Data for California

Statewide data for 2009 to 2013; vessel registration records including vessel IDs and attributes

California Trawl Logbook Data

Statewide data for 2009 to 2013; includes 4 types of data (trip [=log]; ftid [=receipt]; tow; and catch [species])