March 2016

EcoCast: Real time data tools for dynamic fisheries management
Progress report: March 2016

Executive Summary

What we're doing: EcoCast is an exciting new fishery management tool that will predict in near real-time the spatial distributions of important highly migratory ocean species, including non-target species (such as leatherback sea turtles) and target catch (e.g. swordfish). Using this tool, fishers and managers will be able to evaluate how to best allocate fishing effort across space and time to improve fishery performance. EcoCast is being developed by a team of collaborators from several universities, NOAA, and non-profit sectors in direct collaboration with resource managers, fishing industry and other stakeholders.

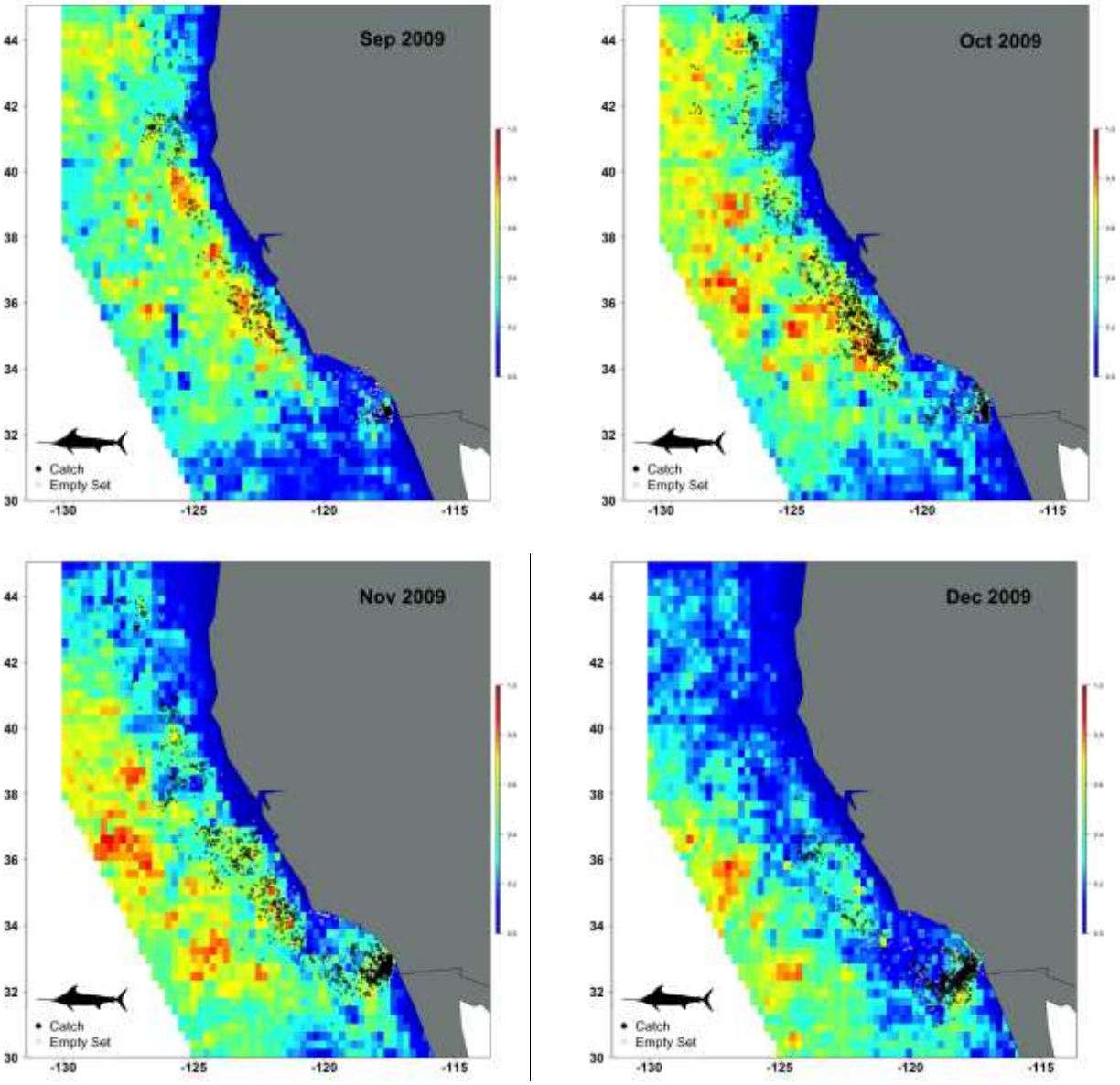
Why: The open ocean is a dynamic environment where ocean conditions, animals and fishing vessels move across space and time. Our project aims to put a powerful modelling tool into the hands of fishermen and managers that predicts the catch and bycatch probability in near real time, in an effort to support significant bycatch risk reduction. In time, this tool may allow managers to better balance ecological and economic objectives by improving accessibility to valuable swordfish fishing areas during times of low bycatch risk.

How: Our collaborative research team (SDSU, NOAA, Stanford, Old Dominion, University of Maryland) builds habitat models for pelagic species based on tagging and fishery observer data. We then overlay these models with oceanographic data (such as sea surface temperature, chlorophyll, bathymetry, etc.) to predict each animal's distribution under current environmental conditions.

Latest updates: We are roughly six months into Phase II of the project. In this update, we share the current predictive models for swordfish. Monthly predictions are shown for swordfish catch September-December 2009 using boosted regression trees (for more technical information on model development and selection see **Methods and Results, pg 3**). The red-blue color scale is probability of catch (high to low), the black points are sets where swordfish catch was recorded and the grey points are sets that did not catch swordfish based on observer data. These models have been reviewed by NOAA scientists and we continue to solicit feedback from other stakeholders as new models are generated.

Stakeholder engagement: Our analytical team has convened several expert panel reviews to members of the HMSMT, and other NOAA scientists. Participating scientists were given an opportunity to ask question, make suggestions and comments and provide comprehensive feedback on our team's progress. We will continue to bring our results and findings to the Council and other stakeholders to solicit input and expertise.

For more information on the project, contact rlewison@mail.sdsu.edu



Next steps We continue to refine analytical elements of the EcoCast product – building and validating the habitat model predictions for four focal species (shark, swordfish, sea lions and leatherbacks. Comparable models for blue sharks and California sea lions have been developed, and these models are being revised and refined. We are also embarking on generating predictive models for leatherback turtles that can be integrated with these data layers. As we continue to develop predictive models for our focal species, we will continue to incorporate new observer data, and plan to generate a fine-scale, reduced-variable model focused on the California Bight at daily to weekly scale, 4km resolution. A newly funded initiative which complements these modelling efforts is getting underway to create predictive models for hard-cap marine mammals using NOAA survey data (funded by SeaGrant, PI:Maxwell). Finally, we are working to integrate Regional Ocean Modeling System (ROMS) output into the EcoCast framework.

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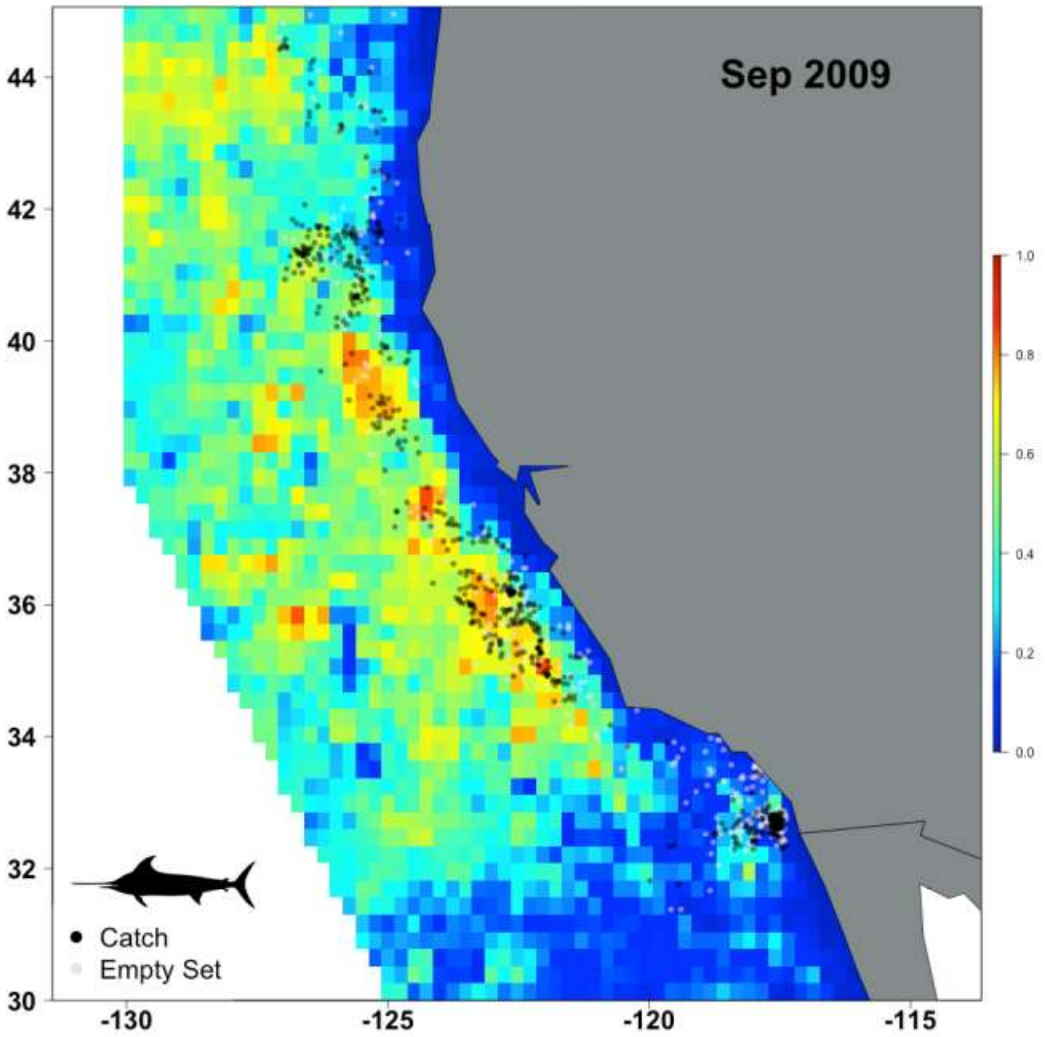
We are making excellent progress on our analyses and in the next quarter are working towards:

- resolving spatial resolutions, temporal frequency and coverage of oceanographic data
- incorporating time lags for a number of oceanographic variables (chlorophyll-a, wind, sea surface temp.)
- accounting for seasonal changes in animal behavior and distribution
- exploring ways to incorporate logbook data into our analyses

Methods and Results In this section, we provide technical details and information on model construction, assumptions and our methodological approach. Satellite data extraction continues to be a priority for the EcoCast project. We have developed a new satellite data extraction regime and have used this to obtain a suite of oceanographic data for our focal species using tracking data and NOAA observer data



Because the EcoCast model generates predictive models to estimate species distributions, model fitting and refinement has been a primary focus of our efforts. We have improved models for swordfish and blue sharks, testing model fit as we work to identify the most powerful set of oceanographic predictors for each species. Our model testing includes randomly select presence and absence points from 'cloud' of all presence (tracking) and as well as using correlated random walks (computer generated tracks that use movement metrics from actual tracks. For models based on tracking data, we model probability of presence using model diagnostics via cross-validation where we set aside some data to serve as training data (75% of data) while remainder is used as a testing data (25%). Our diagnostic metric Area Under the Curve (AUC) considers a comparison of i) training on training; ii) training on testing across 10 iterations of model fitting. For models that incorporate observer data, we use a jackknifing method where we omit data from a single year for the testing data for each model fit i.e. fit on 23 years' of observer data, test on hold-out year, repeat 24 times.

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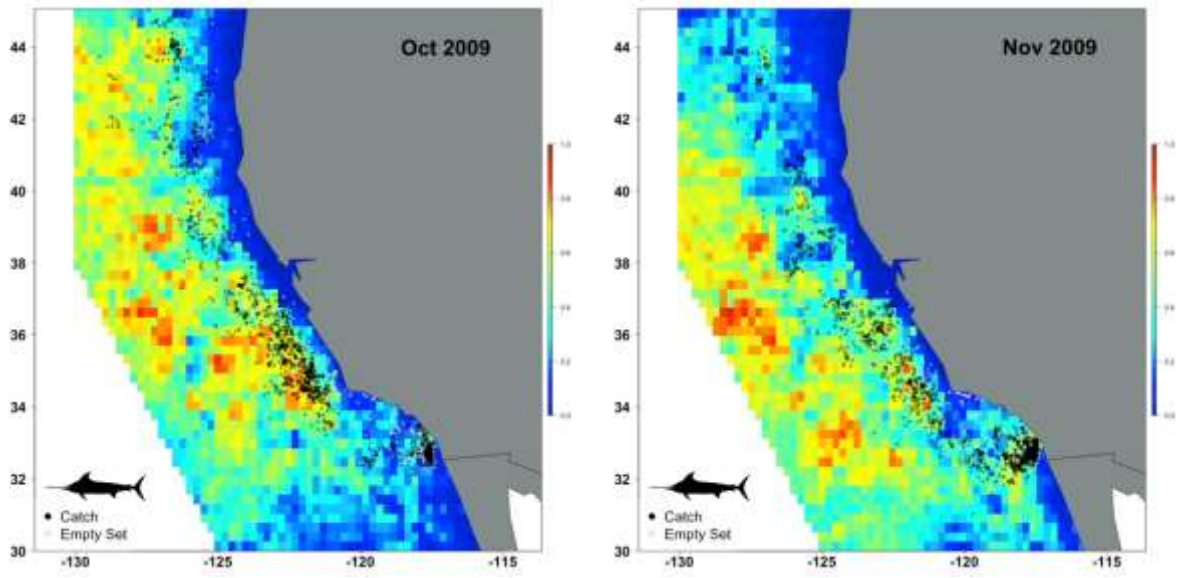
We have continued to test multiple modelling approaches including generalized additive mixed models and boosted regression trees, using both presence/absence and density (number of individuals per location) as the ouput parameter. We have concluded that boosted regression trees yield the most robust results for our focal species thusfar, and that presence-absence predictions are likely to be the most useful for EcoCast.

Our most developed model to date is for swordfish. In these Figures, we show predicted swordfish density in September-December 2009 where red represents higher probability of swordfish presence and blue represents lower probability. The black dots represent observed sets where a swordfish was caught versus the grey dots which represent observed sets where no swordfish was caught. We include a larger image of September 2009 to make the image easier to view.



These models had an AUC value of .881, suggesting that the model performed well and correctly classified swordfish presence at specific locations. Areas in which swordfish were more likely to be caught were found to vary among months as ocean conditions changed. The oceanographic variables found to be most influential in the swordfish model included SST, SSH, bathymetry and latitude. Lunar phase was also found to be an influential variable. The model response curves are shown below.

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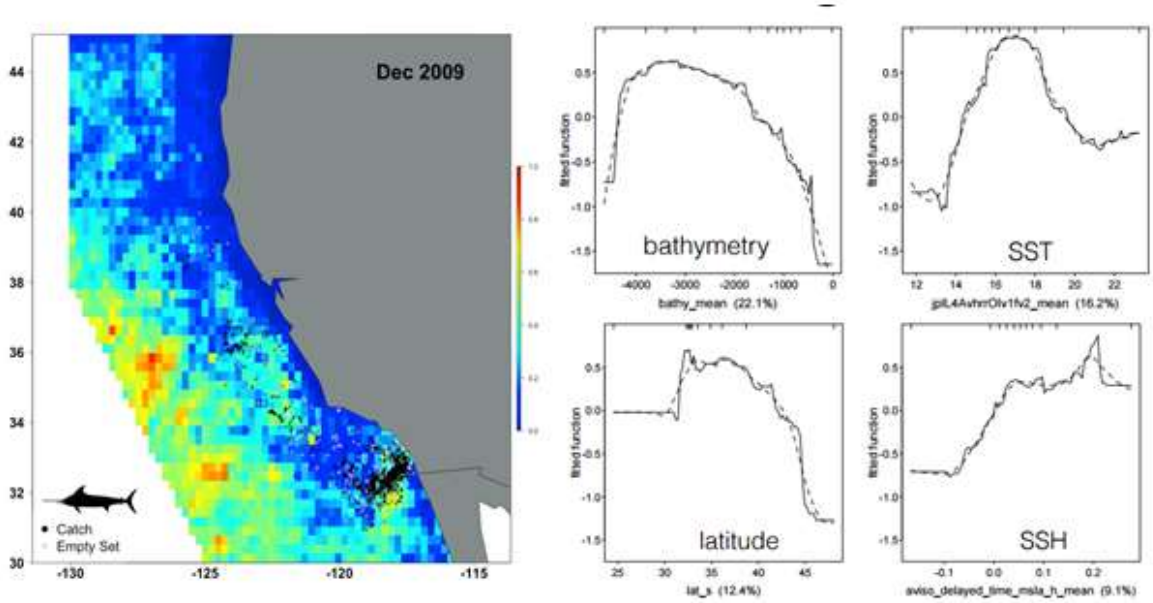

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