Habitat modeling for 3 cetacean species within the KONA IEA

Principal investigators :

- Melanie Abecassis
Joint Institute for Marine and Atmospheric Research, University of Hawaii

- Jeffrey Polovina
Pacific Islands Fisheries Science Center

- Evan Howell
Pacific Islands Fisheries Science Center

Background

In 2010, the NOAA Kona Integrated Ecosystem Assessment (IEA) was started as a pilot program, to group and synthesize all research conducted in the region to address specific management goals in an integrated way involving all stakeholders. Some of those management goals are to understand and address the impacts of aquaculture projects, and define the critical habitats of charismatic megafauna.

Specifically, the growing development of aquaculture projects, in particular open-ocean cage farming, and ocean energy harvesting projects in the Kona region, on the west coast of the Island of Hawaii, poses complex management issues. The region is home to a number of charismatic species, including twenty four species of marine mammals (Cascadia Research collective), which are federally protected under the Marine Mammal Protection Act (MMPA). This requires any development project that could potentially harm marine mammals to conduct environmental assessments. For those to be pertinent, it is critical to have a good understanding of the areas occupied by each species of concern and to be able to define their regions of essential habitat.

Additionally, a small population of false killer whales, resident to the main Hawaiian Islands, was proposed for listing as endangered under the Endangered Species Act in 2010. If accepted, this listing will mandate NMFS to designate areas of critical habitat for false killer whales in the main Hawaiian Islands, including the Kona IEA region (Baird et al 2012).

Reliable assessments of range and habitat utilization are challenging for highly mobile and fast-moving species such as marine mammals. Visual surveys present important biases and are restricted to the oceanic regions and periods of the year that are accessible to the small boats typically used for such studies. When available, satellite tagging data potentially offer a more complete picture of animal movements and range and allow studying the relationships between environmental factors and movements (Abecassis et al 2012) more accurately. For example in Abecassis et al 2012, we used pop-up satellite tagging data to study the variation of swordfish daytime mean depth with environmental factors with Generalized Additive Models (GAMs, Hastie & Tibshirani (1990)). The results produced a predictive model of swordfish daytime mean depth to inform potential longline fishermen wishing to switch from night-time shallow sets which result in turtle bycatch.

Approach

We propose to use existing satellite tagging data deployed on three species of cetaceans and collected since 2006 to assess the relationships between population densities and environmental variables and to develop species-specific models in a similar way as used by Forney et al 2012 and Becker et al 2012. They built species-specific habitat models for encounter rates and group sizes based on visual line-transect survey data for several species of cetaceans using GAMs. Outputs of such models include predicted maps of population density for each species.

If deemed robust, those relationships translated into species-specific models, could allow managers to forecast seasonal areas of maximum probability of presence for each species studied, on a finer scale than that typically provided by visual transect surveys (Forney et al 2012).

Modeling approach :

We propose to :

i. use ocean model and remote sensing data to describe the oceanography of the Kona coast region
ii. use satellite tagging data to investigate how the individual animals interact with ocean features (Woodworth et al 2011)
iii. use satellite tagging data to estimate kernel densities of population for each species
iv. build species-specific GAM models to explain estimated cetacean densities (part iii) as a function of key oceanographic variables (identified in parts i and ii)
v. evaluate the robustness of the relationships identified by the model by setting aside parts of the data to validate the model : i.e. use one year of data to build the models and evaluate the accuracy of the predictions for another year of data, or use animals tagged in one location to build the models and see if they predict the population density of the remaining tagged individuals.

Available datasets :

- Satellite tagging data deployed by the Cascadia Research collective on false killer whales (n=27, 443 days of data), short-finned pilot whales (n=36, 431 days of data) and Blainsville beaked whales (n=10, 170 days of data), from 2006 to present, in the main Hawaiian Islands.
- Social grouping data for short-finned pilot whales as they exhibit very strong group fidelity (Robin Baird, pers. comm.) to address potential pseudo-replication issues (Baird et al 2012).
- Bathymetry data : 50 m resolution bathymetry data is available from the SOEST Hawaiian multibeam bathymetry synthesis project.
- cruise data : A research cruise, headed by Dr. Evan Howell, was conducted by the PIFSC in July 2011 as part of the Kona IEA program. CTD casts, acoustic data, water samples and net tows were collected at 11 nearshore and offshore stations along the Kona Coast.
- ocean general circulation model : The HYbrid Coordinate Ocean Model (HYCOM), adapted to the Hawaiian islands region by the International Pacific Research Center (IPRC), is available at a 0.04º spatial resolution with 20 vertical layers from 0 to 4000 m. Model outputs are available from May 2009. Variables of interest include temperature, currents, salinity, sea surface height and vertical velocity. This model has previously been used successfully in studies with Melon-headed whale offshore habitat and captures the cyclonic and anticyclonic eddies well (Woodworth et al. 2011).

Benefits

This work will contribute to the Kona IEA by providing estimated habitat maps for some important cetacean species. Further, the capacity to predict seasonal areas of maximum probability of presence for false killer whales will greatly assist in designating their critical habitats during the ESA process if the listing gets accepted. This approach can also be expanded to any species for which satellite tagging data is available and help inform environmental assessments and ocean projects planning processes.

Deliverables

Results will be communicated as :
- maps of cetacean critical habitat areas to resource managers
- a peer-reviewed publication
- presentations in international conferences and annual FATE science meetings

Statement of work

All data required for this project is readily available.
Work is expected to require two years, with Year 1 dedicated to false killer whales which is the most critical species in the region, with decision pending on its listing under the ESA.
In Year 2, once the approach is developed, the work will address the other two species for which satellite tagging data are available in the region : short-finned pilot whales and Blainsville beaked whales.

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