Project Title: **Ground truth the presence and abundance of coral habitat on the eastern Bering Sea slope both inside and outside canyon areas**
Associated NMFS Science Center/Regional Office: Alaska Fisheries Science Center, Alaska Regional Office
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Background and Justification

The eastern Bering Sea (EBS) slope and outer shelf is a region of enhanced primary and secondary productivity (the "Bering Sea Greenbelt") and attracts large numbers of fish, seabirds and marine mammals. Productivity is enhanced because of physical processes at the shelf break including intensive tidal mixing and transverse circulation and eddies in the Bering Slope Current which bring nutrients into the photic zone (Springer et al. 1996). About 40% of U.S. commercial fisheries catch originates from the eastern Bering Sea; some of these fisheries concentrate on the slope and outer shelf. The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) mandates NOAA to conduct scientific research to identify habitats essential for managed species and minimize the effects of fishing on essential fish habitat to the extent practicable. The MSFCMA also provides discretionary authority to fishery management councils protect deep-sea corals. Two of the largest submarine canyons in the world (Zhemchug Canyon and Pribilof Canyon) incise the EBS shelf break (Karl et al. 1996, Normarck and Carlson 2003) and are dominant geological features on the shelf break (Fig. 1).

In June 2013, the North Pacific Fishery Management Council (NPFMC) passed a motion requesting that field research be completed in 2014 to identify areas of relatively high coral abundance on the EBS slope and outer shelf (particularly in Pribilof and Zhemchug canyons) and to ground truth an existing coral presence/absence model (Sigler et al., in review) for the region using *in situ* camera operations (or similar activities). The existing coral model was developed based on existing data from bottom trawl surveys of the EBS slope and outer shelf and was presented to the NPFMC in June 2013 as part of an analysis undertaken to test whether Pribilof and Zhemchug canyons are unique features on the EBS slope. The predictor variables were variables collected during the bottom trawl survey (e.g., water temperature) and gross bathymetric features (e.g., seafloor gradient). The predicted variables were the presence or absence of deep-sea hard corals (from the families Primnoidae, Stylasteridae, Paragorgidae, Plexauridae and Isidelladae). A generalized additive model (GAM) (Hastie and Tibshirani 1990) was used to construct the relationships between predictor variables and predicted variables. The model output was on a 1 km^2 grid and made predictions of the probability of coral presence at each grid cell of the EBS slope and outer shelf (Fig. 1). We propose a 30-day charter aboard a commercial fishing vessel to survey this area using a stereo drop camera system. The images collected during the survey will be used to estimate abundance and size of coral in the region and to ground truth model predictions. This information will improve our understanding of Bering Sea coral presence, density, and their attributes and in turn will help to inform types of management measures for fisheries (e.g., gear modifications and area closures) which interact with these corals, should such management be necessary.

We also will collaborate with the Marine Conservation Alliance to conduct informal workshops with Bering Sea fishermen to gather their knowledge of specific locations where hard-bottom areas are found. The information from fishermen will be evaluated beside results of the visual survey and should complement the proposed fieldwork and model validation.

The primary objectives of the proposed 2014 research are:

- Gather information from fishermen on locations of hard-bottom areas
- Determine the presence/absence and density for major coral taxa at approximately 300 transects on the EBS slope using a stereo drop camera
- Measure the size and height of a subsample of the major coral taxa at each site
- Compare the presence or absence of coral at each site, information from fishermen and the probability of presence predicted by the existing coral model
- Apply the new information from fieldwork and fishermen in the coral model and produce revised predictions of coral locations and abundance

Secondary objectives are to determine the presence/absence and abundance of major sponge taxa at the sampled transects, to measure the fine-scale association of fish and crab with coral and sponge and to record evidence of fishing gear impacts.

Methodology

Approximately 300 transects will be sampled along the eastern Bering slope and outer shelf from Bering Canyon to Navarin Canyon (Fig. 1). This sample size was chosen based on a simulation of the effect of sample size on the performance of the coral presence/absence model as measured by the AUC-value, a test statistic used for evaluating GAM performance (Hosmer and Lemeshow 2005). Sample sizes ranging from 50 to 1000 were tested using the coral presence/absence model and an AUC-value of 0.78 was achieved for sample size of 300, about 85% of the value achieved for sample sizes of 1,000-2,000. AUC values of > 0.70 are considered acceptable and AUC values > 0.80 are considered excellent (Hosmer and Lemeshow 2005); therefore a sample size of approximately 300 stereo camera drops should result in a model with acceptable to excellent predictive power.

Transects will be placed randomly and their density will be proportional to the predicted probability of presence from the existing coral model (Fig. 1), so that areas with higher predicted probability of presence will be sampled more frequently. Based on the predicted spatial distribution of coral presence (Fig. 1), we anticipate the following sample sizes by areas of the Bering Sea slope and outer shelf: Bering Canyon 10; Bering-Pribilof intercanyon 10; Pribilof Canyon 38; Pribilof-Zhemchug intercanyon 41; Zhemchug Canyon 11; Zhemchug-Pervenets intercanyon 28; Pervenets Canyon 13; Pervenets-Navarin intercanyon 10, Navarin Canyon 29; outer shelf 110.

Each transect location will be sampled with a stereo drop camera (Fig. 2) like that described in Williams et al. (2010). A computer simultaneously triggers two cameras and four strobe lights, so that paired images are recorded every second. The cameras, strobes and computer are all mounted within an aluminum frame connected to the surface via a coaxial cable and winch. The image feed from a single camera is sent via the coaxial cable and slip ring to a monitor at the surface and is used to navigate the camera sled. In addition, an Aanderaa Instruments Seaguard attached to the aluminum frame will record depth, temperature, salinity, pH, oxygen and turbidity every 7 seconds. At each station location, a vessel crane will lift the camera system over the side suspended by a block and a winch will lower the camera system to the seafloor where images will be collected for a 15 minute duration drift/tow. The vessel will either drift with the current, or if no current is present, maintain ~ 1 knot of headway on the camera in a randomly chosen direction. A scientist will view images and control the winch to maintain the camera system off bottom (~1 m). A transect typically is 500-m long and 2.5 m wide for an area swept of 1,250 m^2. GPS-based position and seafloor backscatter from the vessel's Simrad ES60 38kHz echosounder will be continuously recorded during the cruise.

A post-cruise image analysis will determine substrate types, species abundance and composition and size. Substrate type will be determined using a standard methodology that has been applied on the west coast and Alaska (Stein et al. 1992, Yoklavich et al. 2000, Rooper et al. 2007). It consists of a two-letter coding of substratum type denoting a primary substratum (>50% coverage of the seafloor bottom) and possibly a secondary substratum (20-49% coverage of the seafloor bottom). In this classification scheme, there are seven substratum types: mud (M), sand (S), pebble (P, diameter <6.5 cm), cobble (C, 6.5 < diameter < 25.5 cm), boulder (B, diameter >25.5 cm), exposed low relief bedrock (R), and exposed high relief bedrock and rock ridges (K). In addition, evidence of fishing gear impacts, including trawl furrows, lost gear and broken coral or sponge will be recorded.

Each stereo image pair will be examined to identify and count the species of coral present. Many corals will not be identifiable to species when viewed underwater; these corals will be pooled into family groups (Primnoidae, Stylasteridae, Paragorgidae, Plexauridae and Isidelladae). We also will identify and count sponges (class Hexactinellida) which typically are found in the same habitats as these coral taxa; we will complete the same data collection, analysis and modeling for this sponge taxa as for the coral taxa. A random selection of 20 individuals from each taxa and transect will be measured for height and width. While not measurable from visual surveys, rigidity of each taxa from previous collections of in-hand samples (e.g., trawl surveys) will be considered when considering approaches to managing impacts to these taxa. The observation area of the camera will be measured from a random selection of 30 paired images from each transect and the average value used to compute taxa densities for each transect. These 30 images also will be used to measure the fine-scale association of fish and crab with corals and sponges; the distance from fish (and crab) to the nearest coral (or sponge) will be measured.

The analysis will pool the data into family taxonomic groupings. Presence/absence and abundance (numeric density) data will be directly compared to the predictions of the existing coral model based on bottom trawl data using the AUC-value and the correlations between observations and predictions. We also will complete this comparison for the existing sponge model. Additional refinement of the models will be carried out if necessary and will incorporate the habitat measurements (e.g., oxygen) collected during the fieldwork. The final models of presence/absence and abundance will be used to calculate predictions for 100 by 100 m square blocks (a finer grid than the existing model) in the EBS and will be provided to Alaska Region Managers and the North Pacific Fishery Management Council. The diversity (number of families on each transect) and size (by taxa) data will be provided in a map format and will be modeled using a GAM to provide a continuous map coverage for the EBS.

Prior to the fieldwork, workshops will be conducted with Bering Sea fishermen to gather their knowledge of specific locations where hard-bottom areas are found. MCA will take the lead in developing a standardized framework, questions, and process for the workshops and coordinate with the different fishing associations that use the Bering Sea slope. Similar workshops previously have been conducted for the Gulf of Alaska and Aleutian Islands and were organized by member organizations of MCA, who also will organize these workshops. Fishermen attending the workshops will be informed from the outset that the next step will be to conduct video surveys in the areas of relatively high coral abundance (based on the existing coral model) and see how well their information represents what is seen from the fieldwork. In these workshops, fishermen will be asked to identify general areas of hard bottom and then to fill in fine-scale features such as banks and isolated rocks using their knowledge, charts and vessel plotter records. Workshops likely will be held separately for different gear types and fisheries because of differences in where each fishes. This information will be processed as geo-referenced overlays, compared to the results from the fieldwork and used as additional habitat information to revise these models.

The timeline and deliverables are:

1. Conduct workshops (November 2013 - January 2014)
2. Complete cruise aboard chartered fishing vessel (sometime during May to August 2014)
3. Complete image analysis (April 2015)
4. Complete ground truth comparisons and model revisions (May 2015)
5. Deliver report on comparison of model predicted presence, abundance, and diversity to observations and revised predictive model parameters to Alaska Region managers and NPFMC (June 2015)
6. Deliver maps of the predicted presence, abundance, size and diversity of coral and sponge to overlay with fishing activity in these regions to Alaska Region managers and the NPFMC (June 2015)

Linkage to MSRA Section 318 Priority Area(s)

This study is linked to MSRA Section 318 priority area 4 (conduct project … relevant to conservation of habitat) and MSRA Section 408 (conduct research, including cooperative research … on deep sea corals) because this research focuses on deep sea coral habitat and this study has been requested by the NPFMC in managing conservation of habitat that support eastern Bering Sea fisheries. Nearly 40% of U.S. commercial fisheries landings originate from the eastern Bering Sea.

National applicability/implementation that cuts across multiple regions

The field and modeling approaches of this study are applicable across multiple regions. Coral presence/absence models currently exist for all 6 NMFS Regions. However there has been little or no systematic validation for most of these efforts. For example, a habitat suitability model for *Lophelia* spp. banks has been developed and could be used to guide HAPC designations in the Southeast Region if sufficient ground truth data were available. The research proposed here will provide a methodology for improving existing models and ground truthing these models in other regions. Additionally, incorporating an evaluation of the utility of information available from fishery participants for predicting coral abundance has never been done formally before (to the best of our knowledge) and holds promise for increasing the knowledge base for coral abundance in a cost-effective manner.

Qualifications of Investigators

See attached curriculum vitae.

Detailed Budget

	Description	Coop. Res.: Natl.	Coop. Res.: Regional	EFH	DSCRTP
1150	Overtime			$16,463	
1200	Benefits			$1,317	
2100	Travel			$7,000	
2200	Transportation			$3,400	
2300	Rents (charter)	$200,000	$100,000		
2500	Contracts			$110,240	
2600	Supplies				$3,749
3100	Equipment				$40,800
	Total	$200,000	$100,000	$138,420	$44,549

Funding will be requested from three sources: Cooperative Research, Essential Fish Habitat (EFH) and Deep Sea Coral Research and Technology Program (DSCRTP). Field work will involve travel ($7,000), 30 vessel charter days including fuel ($300,000), overtime ($16,463) and transport of equipment and supplies from Seattle to Dutch Harbor and return. The request for Cooperative Research funds will be shared between the National ($200,000) and Regional ($100,000) sources because National requests are capped at $200,000. We also request contract funds to cover 12 months of contractor time to analyze the images ($110,240), based on current contract prices and anticipated processing time. We anticipate that 300 transects of 15-min duration will be collected during the project and processing time usually is 5-7 hours per transect. Funds for equipment ($40,800) will cover a winch to deploy and retrieve the underwater camera. The camera and associated winch cable were purchased with FY 2013 AFSC funds ($25,820). We also request funds for connectors for the winch and monitor, underwater ethernet connections for the camera sled, shipping cases, and routine equipment replacement costs based on costs from previous years ($3,749).

Figure 1. Probability that coral is present by 1 x 1 km grid cell for the eastern Bering Sea shelf and outer slope based on generalized additive modeling. The x-axis label is easting and the y-axis label is northing and the unit is meters (Alaska Albers Equal Area Conic projection with center latitude = 50° N and center longitude = 154° W).

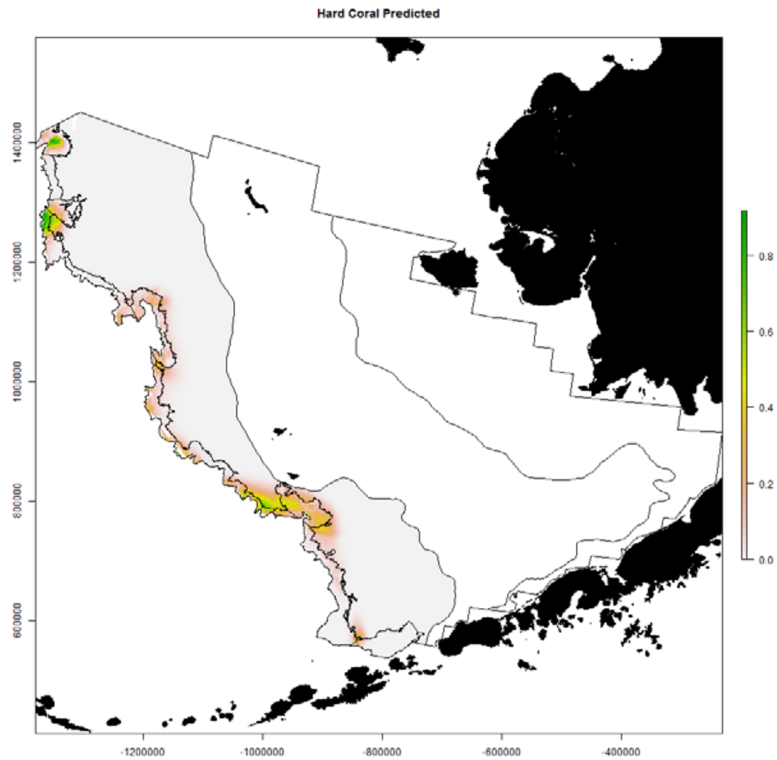
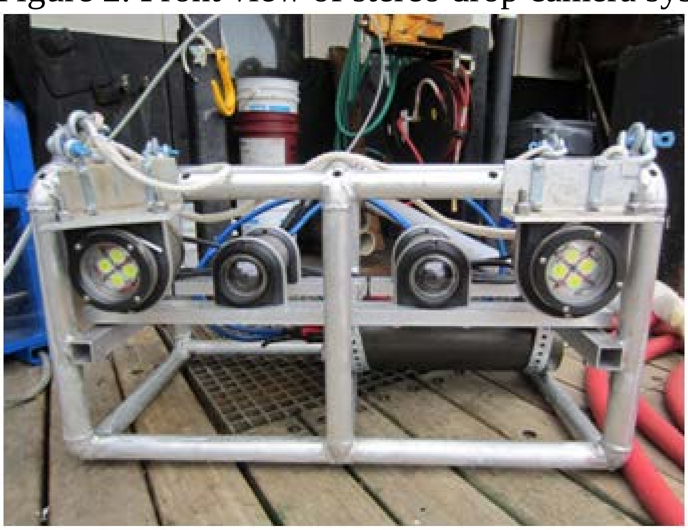


Figure 2. Front view of stereo drop camera system.



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