Deep-Sea Coral Research and Technology Program

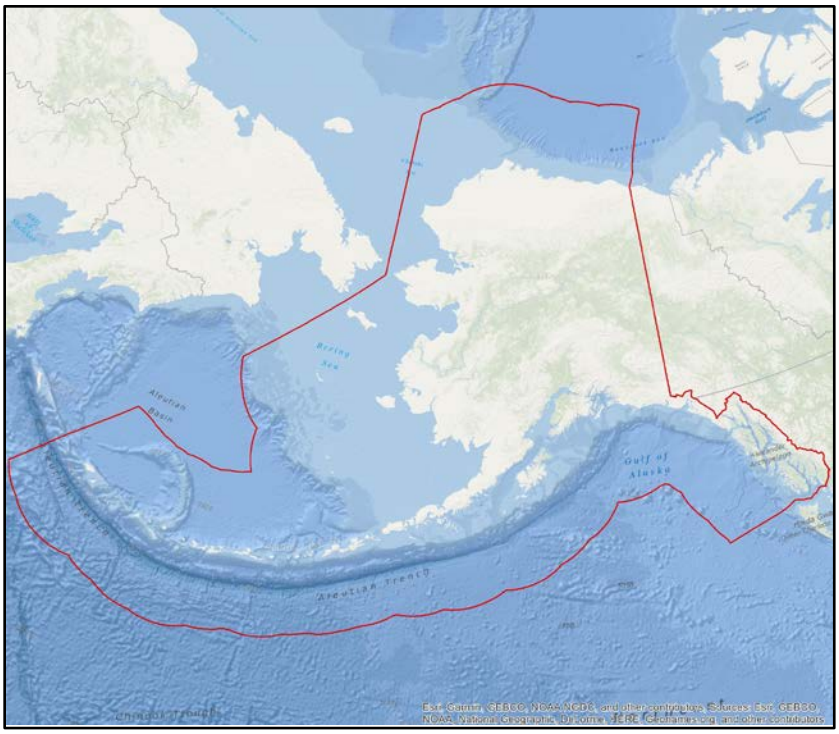
Workshop Report

Alaska Deep-Sea Coral and Sponge Initiative

2020-2023

Workshop Dates: 12-15 May 2020

Location: Virtual



Geographic area of interest (red polygon) for NOAA Deep Sea Coral Research and Technology Program's 2020-2023 Alaska Deep-Sea Coral and Sponge Initiative.

Editors

Jerry Hoff
Pat Malecha
Pam Goddard
Rachel Wilborn
Tom Hourigan
Chris Rooper
Jim Thorson
Mike Sigler
Steve MacLean
Caitlin Adams
Jodi Pirtle
Meredith Everett
John V. Olson
Heather Coleman

Executive Summary

The National Oceanic and Atmospheric Administration's (NOAA) Deep Sea Coral Research and Technology Program (DSCRTP) convened a 4-day virtual science priorities workshop on May 12-15, 2020. The workshop was originally scheduled to be held in Juneau, Alaska, but was held through Google Hangouts Meet due to the coronavirus (Covid19) pandemic and NOAA restrictions for non-essential travel and public health recommendations to socially distance. The purpose of the workshop was to build partnerships and set research priorities for the Program's 4-year Alaska Deep-Sea Coral and Sponge Initiative (AK DSCSI; 2020-2023). The workshop attracted an excellent mix of scientists and managers. A total of 59 scientists and managers, with relevant expertise from across Alaska and throughout the U.S. and Canada, participated in the workshop. Participants represented numerous NOAA offices, other federal agencies, non-government organizations, the commercial fishing industry, the Aleut Community of St. Paul Island, Fisheries and Oceans Canada, and academic institutions, totaling 29 entities. The workshop started with a welcome and introduction to both the DSCRTP and AK DSCSI. Once the purpose, structure, and goals of the initiative were summarized, other agencies active in deep-sea research provided overview presentations outlining their mission-specific goals and objectives, their previous and ongoing deep-sea coral and sponge (DSCS) research efforts, as well as the tools and technology available for potential AK DSCSI-aligned activities. After the Alaska DSCS research landscape was established, the majority of the remaining discussions took place during interactive breakout sessions.

Working in small groups, participants identified and discussed Alaska DSCS science and management priorities in six topic areas: 1) distribution; 2) populations dynamics, biology, and interactions; 3) diversity and genetics; 4) effects of climate change; 5) effects of human impacts; and 6) deep-sea mapping. During the breakout sessions participants highlighted the following research priorities:

1. *Distribution*: Prioritize validation of the Gulf of Alaska (GOA) coral and sponge distribution model (Rooper et al. 2017) by deploying visual surveys in the region, while also strengthening model predictions for all areas with improved species identifications and spatially-explicit biological data such as size and age structures of corals and sponges, and updated environmental covariate data.
2. *Population dynamics, biology, and interactions*: Research the functional role of coral and sponge habitat on the dynamics and productivity of managed species, such as fish and crab. Increase understanding of life history parameters of corals and sponges, including recruitment dynamics (settlement), growth, reproduction, maturity, and larval ecology. Increase understanding of coral and sponge susceptibility to, and recovery from, anthropogenic and environmental influences.
3. *Diversity and genetics*: Improve taxonomic and genetic identification of corals and sponges that facilitates improved models of distribution, connectivity, and diversity.

Environmental DNA (eDNA) is a valid tool for supporting novel and existing research that examines coral and sponge presence/absence and biodiversity, and could be paired with oceanographic data for modelling life history. Priority to collect and maintain time-series data on the community composition, production, and biomass of benthic invertebrates and vertebrate fauna.

4. *Effects of climate change*: Execute a Gulf of Alaska stereo camera survey to validate species distribution models of corals and sponges. Create a risk analysis of climate change effects that incorporates regional ocean models with both temperature (climate change) and carbon parameters (ocean acidification). Monitor ocean warming and ocean acidification. Lab experiments directed at understanding effects of ocean acidification, ocean warming, and marine heat waves on deep-sea corals and sponges.
5. *Effects of human activity*: Assess the impacts of bottom-contact fisheries (particularly longline and pot gear) on coral and sponge habitat, as well as subsequent trophic interactions as related to fishery disturbances. Assess sensitivity and recovery of corals and sponges as related to size. Investigate gear modifications and changes in fishing practices to reduce bycatch of corals and sponges. Evaluate efficacy of habitat closure areas to allow habitat recovery. Develop a GIS relational database for habitat, to include a historical time series of the spatial intensity of interactions between commercial fisheries and habitat. Validate GOA species distribution models and refine and improve models for Aleutian Islands (AI) and Bering Sea (BS).
6. *Deep-sea mapping*: Surveys in the Gulf of Alaska to validate coral and sponge distribution models. Surveys of untrawlable habitat in the Aleutian Islands and Gulf of Alaska. Surveys of understudied ridges in the Bering Sea and high Arctic slope. Surveys of areas where fishing occurs and areas (especially in the Arctic) where fish are likely to be moving. Addressing management priorities, creating usable products, and assimilating fishing industry knowledge. Data mining, combining old and new data sets to fill gaps, and ensuring adequate resource allocation for new data analyses. Partnering with BOEM to address their priorities (soon-to-be released as shapefiles), as well as volcanically and hydrothermally active areas north of the Aleutian Islands. Partnering with USGS and the Geological Survey of Canada to expand research in the Queen Charlotte Fault Zone.

A final summary session was held with participation of the breakout session leads and the AK DSCSI principal investigators focusing on identification of large and small research projects that integrate multiple themes in an attempt to maximize information from research efforts. Overall, there were multiple themes that were of highest priority within each breakout session, which will help guide development of the science plan for the AK DSCSI. Specifically, six priorities follow:

1. Model validation of Gulf of Alaska coral and sponge distribution models with visual surveys that collect environmental and spatially-explicit biological data;

2. Mapping of untrawlable habitats in the Gulf of Alaska and Aleutian Islands;

3. Collection of life history information on corals and sponges to support population modeling;
4. Use of eDNA for species distribution modelling and biodiversity studies, and other genetic techniques for taxonomy and connectivity modelling;
5. Development of risk assessment models for corals and sponges in the GOA, AI, and BS that take into account anthropogenic and climate effects;
6. Investigation of recovery and susceptibility rates of corals and sponges.

The immediate future plan is to conduct further discussions with the AK DSCSI steering committee to identify projects and principal investigators for high priority research activities in 2021-2022, and complete an AK DSCSI Science Plan using the results of this workshop and further discussions as a guide.

Introduction

Alaska Deep-Sea Coral and Sponge Initiative Priorities Workshop

Deep-sea corals and sponges (DSCS) can live for hundreds or thousands of years, creating important biogenic habitats and supporting remarkably complex communities in deep waters around the globe (Roberts et al 2009, Hourigan et al. 2017). Their habitat ranges from 50 meters (or sometimes shallower in cold Alaska waters) to more than 6,000 meters below the ocean surface. In the United States, deep-sea corals and sponges have been discovered in every region on continental shelves, slopes, canyons, and seamounts. Their full geographic extent is still unknown due to extensive seafloor areas lacking adequate exploration. Nationwide, complex structures created by corals and sponges provide habitat for many fish and invertebrate species, including commercially important rockfish, shrimp, and crab. In addition to their value as habitat, some deep-sea corals and sponges produce chemicals of great biomedical potential.

The National Oceanic and Atmospheric Administration (NOAA) established the Deep Sea Coral Research and Technology Program (DSCRTP) under the authority of the Magnuson-Stevens Fishery Conservation and Management Act, as reauthorized in 2007. The goal of the DSCRTP is to provide scientific information needed to manage and protect deep-sea coral and sponge ecosystems throughout the United States. To facilitate this mission, the DSCRTP works with partners to support multi-year regional fieldwork initiatives and targeted projects centered on conducting new research, assimilating historic data, and making results public in support of DSCS ecosystem management. Functionally, the DSCRTP supports a rotating initiative program across five U.S. National Marine Fisheries Service (NOAA Fisheries) Fisheries Science Centers on an approximate 6 year cycle. The DSCRTP has funded research initiatives in the U.S. South Atlantic (2009-2011), West Coast (2010-2012, 2018-2021), Alaska (2012-2014, 2020-2023), Northeast (2013-2015), Pacific Islands (2015-2017), and greater Southeast (U.S. South Atlantic, Gulf of Mexico & U.S. Caribbean; 2016-2020) regions. The regionally-led initiatives have included mapping and surveys to understand the distribution of DSCS habitats, research to understand their life-history and contribution to biodiversity, habitat suitability modeling, and assessing impacts of human activities, among other topics. A national-level data management infrastructure underlies the regional initiatives, allowing DSCRTP-supported data to be accessible to the public.

Workshop Opening Presentation Summaries

Deep-Sea Coral Research and Technology Program Overview

Presenter: Tom Hourigan (NOAA DSCRTP)

The DSCRTP is the nation's only federal research program dedicated to increasing scientific understanding of deep-sea coral and sponge ecosystems in support of management. The DSCRTP is authorized under the Magnuson-Stevens Fisheries Conservation and Management Act (Sec. 408). The DSCRTP is guided by the NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems to (1) support NOAA's role in managing fishing impacts by addressing threats to deep-sea coral ecosystems, (2) aid conservation of deep-sea ecosystems in national marine sanctuaries, and (3) integrate expertise and resources across NOAA.

Offshore industries that increasingly support the nation's blue economy, such as fishing, aquaculture, renewable energy, and potentially mining, present economic opportunities that require baseline data to inform management and mitigate potential ecosystem impacts. To address this need, the DSCRTP builds partnerships and supports research to increase scientific understanding of deep-sea coral habitats. The program leverages expertise and resources to enhance cost-effectiveness and operational efficiency across NOAA, other federal agencies, non-governmental organizations, academic scientists, fishing industries, and international partners. Administered by the Office of Habitat Conservation in NOAA Fisheries, the DSCRTP partners nationally with NOAA's National Centers for Environmental Information, Office of Ocean Exploration, Office of National Marine Sanctuaries, National Centers for Coastal Ocean Science, Fisheries Science Centers and Regional Offices, as well as regional fishery management councils, the Bureau of Ocean Energy Management, and the United States Geological Survey. In the Alaska region, the program also partners with tribal governments, Fisheries and Oceans Canada, the North Pacific Research Board, Oceana, and a number of universities and fishing industries.

A centerpiece of the DSCRTP is 3- to 4-year field research initiatives, complemented by targeted small projects in other regions and a robust data management enterprise. The regional initiatives are developed in consultation with regional fishery management councils, and designed to inform management decisions by complementing existing programs' regional mandates. NOAA's Alaska Fisheries Science Center led the first Alaska Deep-Sea Coral and Sponge Initiative (2012-14, see below).

We are now embarking on the second Alaska Initiative. This Research Priorities Workshop plays a key role during the initiative's 2020 initial planning phase – reviewing current work, creating or strengthening partnerships, and developing options for fieldwork. Fieldwork, including mapping, characterization, and specific research and process studies, will primarily be

conducted during the following two years (2021-22). The final year (2023) will focus on data analysis and working with partners to apply the research findings to management. Our goal is to support systematic survey efforts and defined data products that can support conservation and management, as well as peer-reviewed science.

To prepare for this initiative, workshop discussion centered around review of existing knowledge and current management, identification of information needed to inform management, and identification of options for priority activities. For example, where should mapping or research be targeted, what activities can we engage in to better understand the region's deepwater ecosystems, and how can we best contribute to Council and other resource management priorities? Also, how can we best partner to leverage resources and expand the scope of the science? Initiative activities are planned to address these questions and inform management decisions.

As the DSCRTP completes its first decade of operations, tremendous progress has been made in identifying and protecting many vulnerable habitats from fishing impacts, especially in Alaska. However, much about deep-sea coral and sponge ecosystems in the U.S. and in the region remains unknown. The North Pacific Fishery Management Council has taken conservation action based on science provided by the DSCRTP, and has encouraged NOAA to continue conducting deep-sea coral research to meet their priorities. With new challenges on the horizon, such as ocean acidification, climate change, and expanding human activities in the deep-sea, DSCRTP-sponsored advances will continue to inform conservation of these valuable and vulnerable ecosystems.

Where have we been: A summary of the Alaska Coral and Sponge Initiative (2012-2019)

Presenter: Chris Rooper (DFO)

Deep-sea coral and sponge ecosystems are widespread throughout most of Alaska's marine waters (Stone & Rooper 2017; DSCRTP map portal link here). In some places, such as the central and western Aleutian Islands, deep-sea coral and sponge resources may be among the most abundant in the world (Appendix C, Figures 1-3). The DSCRTP sponsored the first field research initiative in the Alaska region between 2012–2015, referred to hereafter as the AK DSCSI. The priorities for Alaska were derived from ongoing data needs and objectives identified by the DSCRTP, the North Pacific Fishery Management Council (NPFMC) and Alaska Essential Fish Habitat (EFH) Research Plans (Sigler et al. 2012, Sigler et al. 2017). In total, 15 projects were conducted using DSCRTP funds from 2012-2015. In all, nine research cruises conducted research over 109 at-sea days. The remaining projects either used data and samples collected by the three major fieldwork projects or were piggybacked onto existing research programs at the Alaska Fisheries Science Center (AFSC).

Primnoa Project- The suite of projects that examined *Primnoa pacifica* habitats and associated species in the eastern Gulf of Alaska provided significant new information about these communities. The study confirmed that *P. pacifica* habitat extends significantly beyond the areas currently closed to fishing as part of the habitat areas of particular concern (HAPCs) in the region (Figure 1) (Rooper et al. 2017). At a number of the unprotected sites there was evidence of damage to *P. pacifica* from longline fishing activity. Samples were collected using a remotely operated vehicle (ROV) and were used to examine reproductive ecology, feeding ecology, and genetic connectivity of *Primnoa pacifica*. Recruitment substrates were also deployed in the *P. pacifica* thickets, and the absence of new *P. pacifica* recruits after 22 months provided evidence of the episodic and rare nature of successful recruitment for this species. The settlement plates were redeployed for future retrieval.

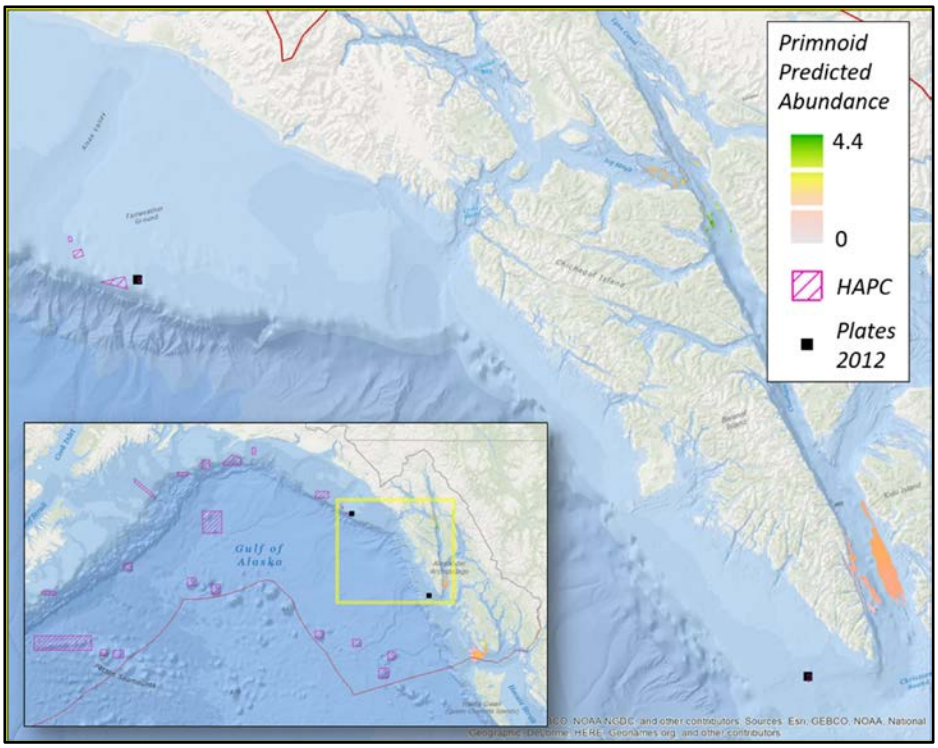


Figure 1. Map of settlement plates deployed in 2012, predicted Primnoidae abundance and Primnoa-related HAPCs in the Gulf of Alaska.

Coral Distribution Mapping and Validation Project- An important accomplishment of the previous AK DSCSI was the production of maps of predicted occurrence of corals and sponges on a 1 ha scale for each of the three major regions of Alaska. These maps and models (Figures 2 and 3) were validated (with the exception of the wider Gulf of Alaska) with visual observations in the field and indicated that coral and sponge ecosystems occur at predictable locations where hard bottom substrate is present. A component of the data from this fieldwork was height and density information for corals and sponges in the Aleutian Islands (AI) and eastern Bering Sea (EBS).

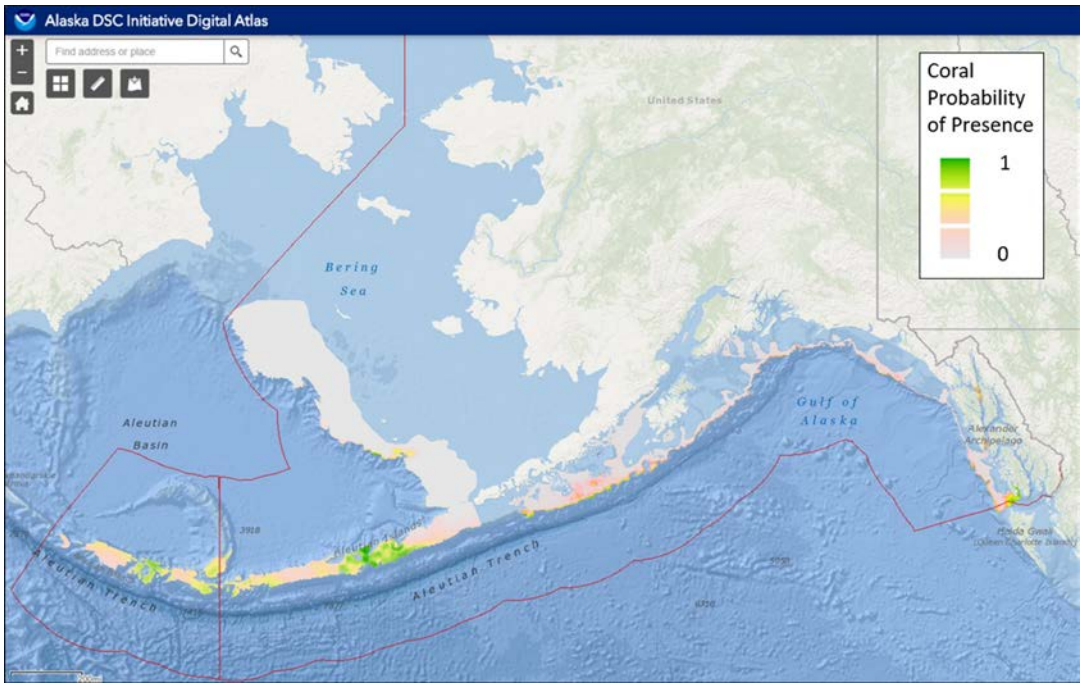


Figure 2. Map showing predicted probability of presence for corals in the Bering Sea Outer Shelf and Slope, Aleutian Islands, and Gulf of Alaska. Adapted from Sigler et al. (2015), Rooper et al. (2014), and Rooper et al. (2017).

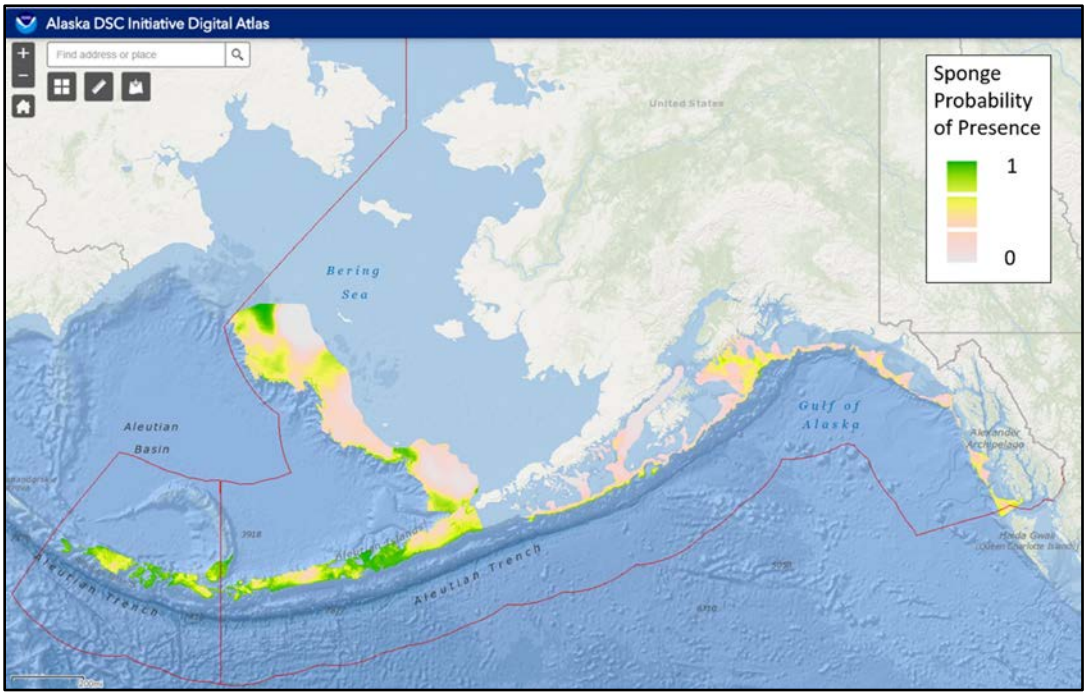


Figure 3. Map showing predicted probability of presence for sponges in the Bering Sea Outer Shelf and Slope, Aleutian Islands, and Gulf of Alaska. Adapted from Sigler et al. (2015), Rooper et al. (2014), and Rooper et al. (2017).

Habitat Use by Rockfish Project- During the AK DSCSI, researchers also tried to document the seasonal use and differences in fisheries productivity using a number of measures in different types of habitats (hard substrate with coral, hard substrate with no coral, and bare sand habitat). Densities of rockfish, especially juveniles and smaller rockfish species, were higher in coral habitat than the other types of habitat, and other measures of productivity, such as gonadosomatic index, relative fecundity, energetic content, and reproductive success, tended to be highest in the coral habitat (Conrath et al. 2019). Preliminary results indicate that for rockfish, there may be benefits to coral habitat in terms of fish productivity that exceed the benefits of the same type of substrate without coral.

Taxonomic Identification and Verification Projects- Samples collected during the first AK DSCSI resulted in the description of 23 new species of demosponges, as well as geographical range extensions for many species. Over 40 publications (Appendix E) were generated to date from the 3-year initiative and the analyses were incorporated into a number of management venues and decisions. Equally important, the first AK DSCSI raised new questions but also provided new techniques that can be used to inform future research in Alaska.

Linkages and lessons to share between essential fish habitat and deep-sea coral initiatives

Presenter: Jim Thorson (NOAA AFSC)

Habitat science is an essential part of the AFSC research and operations portfolio. Coral research is already connected with other habitat research, including the use of predicted coral densities for fish species distribution models (SDMs), and the general development and use of towed cameras. However, coral research could be better integrated with other council activities if coral research were synthesized to predict population-scale productivity (similar to level-4 designation of essential fish habitat). Interpretation of habitat-specific productivity requires synthesizing methods from stock assessment with SDMs currently used to predict densities, where both are informed by field monitoring and process research for corals.

This synthesis will require addressing three core challenges including (1) stage-structured effects, (2) nonlocal effects including movement via larval advection, and (3) mechanistic associations among covariates. Stage-structure can be addressed using existing stage-based SDMs, field measurements of coral size, and process research regarding growth rates. Movement can be addressed using circulation models and process research regarding larval development and duration. Mechanistic associations among covariates can be addressed using structural equation modelling techniques along with process research regarding covariates (e.g., regional ocean modelling systems). Some of these techniques have already been shown using spatial delay-difference models, so analytical techniques are feasible but not “off-the-shelf.” Interpreting habitat-specific productivity would provide a scientific basis for evaluating habitat-specific management using the same “common currency” (productivity and status) that is used for stock

assessment, and therefore would provide a basis for flexible and integrated discussions (with transparent evaluation of tradeoffs) between both spatial and nonspatial management actions.

Climate Change, Cold-water Corals and Alaska Fisheries

Presenter: Mike Sigler (NOAA AFSC retired)

Climate change may directly (ocean warming, ocean acidification, and marine heat waves) and indirectly (climate change effects on fisheries) affect corals and sponges on many levels. A conceptual framework for researching climate change effects on corals and sponges posits that ocean warming, ocean acidification, and marine heat waves affect deep-sea corals and sponges (direct effects) and likewise, climate change affects fisheries. However, in the short-term, the direct effects of climate change on corals and sponges are likely less than the impacts of climate change mediated by fisheries location and production shifts (indirect effects). Thus, the indirect effects (climate change effects on fisheries) likely will precede the direct effects (climate change effects on coral and sponge).

Recent events have highlighted the short-term impacts of climate change on fisheries, while the long-term effects on coral health and reproduction are still unknown. Loss of sea ice and marine heat waves have substantially affected Alaska marine ecosystems. A stanza of warm years (2002-2005) in the southeastern Bering Sea led to reduced large crustacean zooplankton density and overwinter survival of age-0 Alaska pollock (*Gadus chalcogrammus*) (Hunt et al. 2011, Sigler et al. 2016). The pollock catcher-processor fleet shifted northward and offshore during a subsequent stanza of cold years (Pfeiffer & Haynie 2012). Recent marine heat waves co-occurred with reduced Gulf of Alaska Pacific cod (*Gadus macrocephalus*) recruitment (Barbeaux et al. 2019) and increased Alaska sablefish (*Anoplopoma fimbria*) recruitment (Hanselman et al. 2019). Corals and sponges currently are exposed to these climate-mediated shifts in fisheries location and production (i.e., an indirect effect). In contrast, corals primarily are distributed below water depths where most ocean warming has occurred (Stone 2006), thus reducing their exposure to ocean warming. In addition, corals primarily are distributed in already corrosive water depths (calcium carbonate saturation less than 1) (Feely et al. 2004), and thus are already exposed to ocean acidification.

This conceptual framework implies that climate-related Alaska DSCS research should focus on knowing where corals and sponges are located, the current and forecasted fisheries footprint, and the current and forecasted EFH definitions, i.e., conduct a risk analysis (also termed a climate vulnerability assessment, e.g., Spencer et al. 2019). This effort depends on good maps of coral and sponge distribution. One region in particular, the Gulf of Alaska, needs improvement (i.e., a validation camera survey). In addition, a collaborative effort with Pacific Marine Environmental Lab (PMEL) scientists could establish study sites at one or more coral concentrations to monitor oxygen, salinity, nitrate, and temperature (and infer carbon parameters) (Evans et al. 2013) at these sentinel sites.

North Pacific Fisheries Management Council Priorities

Presenter: Steve MacLean (NPFMC Representative)

The North Pacific Fishery Management Council (NPFMC) has regularly addressed and considered DSCS ecosystems in their management actions (link here). In 2005, as part of a series of wide-ranging habitat actions, the NPFMC identified six Habitat Conservation Zones with especially high coral and sponge density in the AI and GOA. These "coral garden" areas, totaling 110 nm^2, are closed to all bottom-contact fishing gear and are essentially marine reserves. The Alaska Seamount Habitat Protection Areas encompass all 16 named seamounts in federal waters off Alaska and also prohibit all bottom-contact fishing gear (Figure 4). And in southeast Alaska, three sites with large aggregations ("thickets") of long-lived *Primnoa* coral are identified as HAPCs (Figure 4).

In recent years, the NPFMC considered areas of potential coral abundance in the EBS slope and canyons. In a nearly decade-long process, the NPFMC sought to understand the distribution and abundance of deep-sea corals in the EBS, and to determine whether protections for the deep-sea corals required the same sorts of protections that the council imposed in the AI and GOA. After Sigler et al. (2013) presented results of predicted coral habitat in the EBS, the NPFMC requested that NOAA Fisheries conduct a camera survey of the EBS slope and canyons to validate modeled predictions of DSCS habitat. The survey was conducted in August and September 2014, and results presented to the NPFMC in October 2015. After reviewing the report and all available scientific evidence, the NPFMC concluded that available data do not suggest that deep-sea corals in the EBS slope and canyons are at risk from commercial fisheries. The NPFMC did, however, request that NOAA Fisheries provide updated data on distribution, intensity, and depth of fishing in areas of coral habitat, and monitor coral communities in the EBS.

The NPFMC updates research priorities annually in June. Priority 239, available on the NPFMC website, identifies assessing the extent and spatial distribution of deep-sea corals, and conducting routine monitoring of these areas as a NPFMC priority.

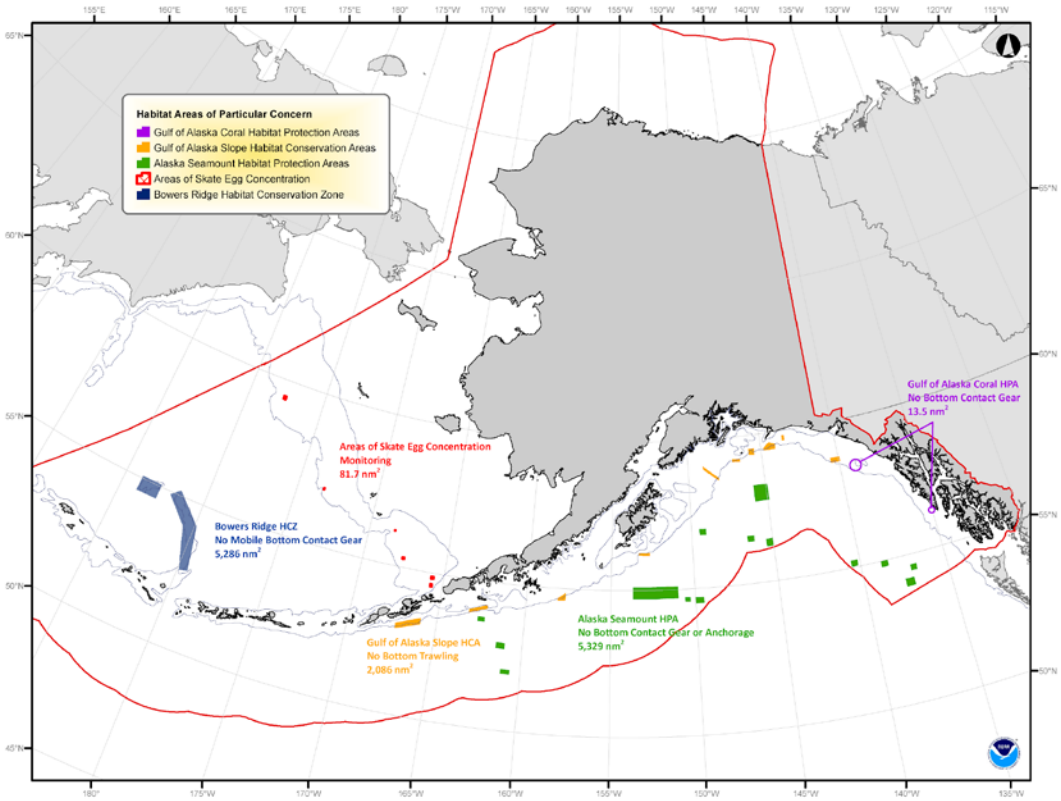


Figure 4. Habitat Areas of Particular Concern in Alaska waters.

Introduction to NOAA OER and Okeanos Explorer Operations

Presenter: Caitlin Adams (NOAA OER)

The NOAA Office of Ocean Exploration and Research (OER) is the only federal program dedicated to exploring our deep ocean, closing the prominent gap in our basic understanding of U.S. deep waters and seafloor, and delivering the ocean information needed to strengthen the economy, health, and security of our nation. Using the latest tools and technology, OER explores previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. OER uses a number of mechanisms to conduct ocean exploration including the dedicated exploration platform NOAA Ship *Okeanos Explorer* (Figure 5), the Ocean Exploration Cooperative Institute, cooperative research and development agreements, contracts, the National Oceanographic Partnership Program, and a competitive grants program.

Figure 5. NOAA Ship Okeanos Explorer in port in Norfolk, Virginia, following completion of the Windows to the Deep 2019 expedition. Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019.

The competitive grants program is an annual federal funding opportunity call that is announced early each summer and typically funded in the summer of the following fiscal year. Each call is organized under broad ocean exploration themes, and applicants from across the federal government and academia are encouraged to apply. Every year, the program funds approximately seven to nine projects for up to $750,000 each at an average of $3M total funding.

NOAA Ship Okeanos Explorer is the only federal vessel solely dedicated to exploring our largely unknown ocean for the purpose of discovery and the advancement of knowledge about the deep ocean. Such exploration supports key NOAA, national, and international goals to better understand and manage the ocean and its resources. Expeditions on the Okeanos Explorer are collaboratively planned using a community-driven process that incorporates input from partners and stakeholders with the goal of providing data about deepwater habitats, biology, and processes that will benefit NOAA, the scientific community, and the public. OER designs these expeditions to catalyze follow-on research, generate new hypotheses, and meet resource management needs, making open-access data available in real time (or near real time). To maximize the value of an expedition, the Okeanos Explorer is equipped with telepresence technology that allows scientists to guide and participate in expeditions from shore. Using telepresence technology, Internet-based collaboration tools, and a dedicated broadband satellite communications and data transmission system, data and information are quickly made available to interested parties on shore. This allows for any number of scientists, marine resource managers, educators, students, and the public to participate in expeditions in real time, strengthening and engaging the community of ocean explorers.

During *Okeanos Explorer* expeditions, data are collected using a variety of advanced technologies to explore and characterize unknown or poorly known deepwater ocean areas, features, and phenomena at depths ranging from 250 to 6,000 meters. The ship is equipped with four different types of sonars that collect high-resolution data about the seafloor and the water column, a dual-body ROV capable of diving to depths of 6,000 meters, and a suite of other instruments to help characterize the deep ocean. Expeditions typically consist of either 24-hour mapping operations or a combination of daytime ROV dives and overnight mapping operations.

In 2022, OER is planning to bring the *Okeanos Explorer* to Alaska waters for the first time. Planning is still in its initial phase, and OER will work closely with the AK DSCSI to identify exploration priorities and plan expeditions.

For a comprehensive review of the ship's capabilities, visit Ocean Exploration Capabilities of NOAA Ship *Okeanos Explorer*.

Breakout Session Summaries

Coral and Sponge Distribution

Moderator: Chris Rooper (DFO)

Note-taker: Amanda Netburn (NOAA OER)

Participants: John V. Olson (NOAA AKRO), Mike Sigler (NOAA retired), Chris Oliver, Rachel Wilborn (Lynker, NOAA AFSC), Sean Rooney (NOAA AFSC), Mark Mueller (BOEM), Jennifer Reynolds (University of Alaska, Fairbanks), Steve MacLean (NPFMC), Arliss Winship (NOAA), Matthew Baker (NPRB), Jon Warrenchuk (Oceana), Chris Caldow (NOAA Sanctuaries), Lauri Sadorus (IPHC), Gary Greene (Moss Landing Marine Lab), Cathy Coon (BOEM), Stephanie Madsen (At-Sea Processors Association)

Introductions and Summary of Previous Work

This breakout group began with a brief summary of the previous work that has been done to determine the distribution of DSCS in Alaska. This included modeling work for the GOA, AI, and EBS as well as camera surveys in the AI and EBS. In addition, there was a brief introduction of work done in southeastern Alaska on red tree coral (*Primnoa*) habitat, and some smaller regional studies in GOA and AI untrawlable habitat. Other research has been conducted by UAF-National Undersea Research Program and by Alaska Department of Fish and Game (ADFG) using a combination of ROVs and manned submersibles in the GOA and AI.

Identification of Objectives

There were a number of managers present in the group, so it was helpful to have them talk in broad terms about their objectives for distribution studies. There were concerns about site specific issues with DSCS habitat (BOEM) at specific locations where seafloor activities are being considered as well as regional concerns about mineral exploration, fishing interactions, and their potential impacts on DSCS habitat and fish productivity (NPFMC, IPHC, AKRO). Although there are no sanctuaries in Alaska, representatives from the Office of National Marine Sanctuaries in California were able to provide information about their objectives around DSCS distribution on different scales (place-based studies on specific impacts, and regional studies to provide context for impacts within a larger region). Specifically, region-wide models and data exist for many sanctuaries, so the question is, “Can smaller scale models and data be more accurate in specific areas?” In summary, the management objectives relevant to Alaska for DSCS follow:

1. Create broadscale distribution maps that can guide evaluation of risks and impacts, in particular around current activities (e.g., fishing) or proposed activities (e.g., critical minerals exploration).

2. Validate distribution models in GOA.

3. Investigate management objectives around unexplored areas in the north (Arctic) where fishing might shift.

4. Address the specific need for better place-based data to guide space-based decisions.

Research Priorities

The remaining time of the breakout session was dedicated to discussing and developing specific research priorities around the distribution of corals and sponges in Alaska. The final list of priorities can be roughly grouped into four main categories.

1. *Visual surveys* – There was strong agreement among the group to collect new visual surveys to further validate models and provide data that can be used to develop new models and test new approaches. This included completing the model validation for existing GOA coral and sponge models. In addition, there was discussion about modeling existing data in the Chukchi Basin and Beaufort Sea (as a baseline for where fish might be expected to redistribute under climate change); followed by visual surveys to verify predictions. Lastly, all were in agreement with the idea to collect spatially explicit biological data, such as size (and inferred age) structure for DSCS in any new visual surveys.

2. *Strengthening spatial and species resolution of existing models* – Participants focused on four main areas: 1) collect new visual survey data as well as improving covariate data; 2) better substrate maps and better substrate-coral/sponge relationships that could be used to infer DSCS distributions; 3) incorporate dynamic variables into modeling, which allows consideration of both static and dynamic variables and the interaction of these variables in the ecology and distribution of DSCS (for example, how does temperature interact with substrate type to change the suitable habitat for DSCS?); 4) application of new modeling approaches (such as trait-based modeling) or hierarchical modeling that could be applied to existing data.

3. *Species identification* – To obtain better species resolution and accurate distribution models, sponge and coral specimens should be collected to improve species ID/morphological groupings and get finer taxonomic resolution on species distributions. In addition, there is the possible use of eDNA methods to validate existing models through coordinated effort with visual surveys.

4. *Routine monitoring* – There are existing data streams that can or are being used as indicators of DSCS. These include maps of commercial fishing effort and bottom trawl survey time series of catches and bycatch recorded by observers in the commercial fishery. Spatially explicit population modeling may prove useful when mapping and predicting coral and sponge habitat, and is more in line with what is currently being done for fish populations. A time series of data on "sentinel sites" could be identified and collected. In this way, changes to populations could be separated among causes (fishing, climate change, etc.). There is also the opportunity to develop cooperative surveys with the fishing industry to routinely sample corals and sponges, as well as using fisheries knowledge to identify and do reconnaissance surveys of local "hotspots" of regional importance.

Ranking of Research Priorities

At the conclusion of the breakout session, members were asked to vote for and rank their top three choices of important priorities. Thirteen of the 19 participants in the breakout group voted on their priorities; the remaining six abstained. Visual surveys (specifically in the Gulf of Alaska) were the top priority both in terms of number of votes and ranking (Figure 6). Other priorities that scored well were ideas that strengthened existing predictive models through improving covariate data and collection of new data, improving species identification and resolution, and collecting spatially explicit biological data such as size and age structure for corals and sponges in Alaska.

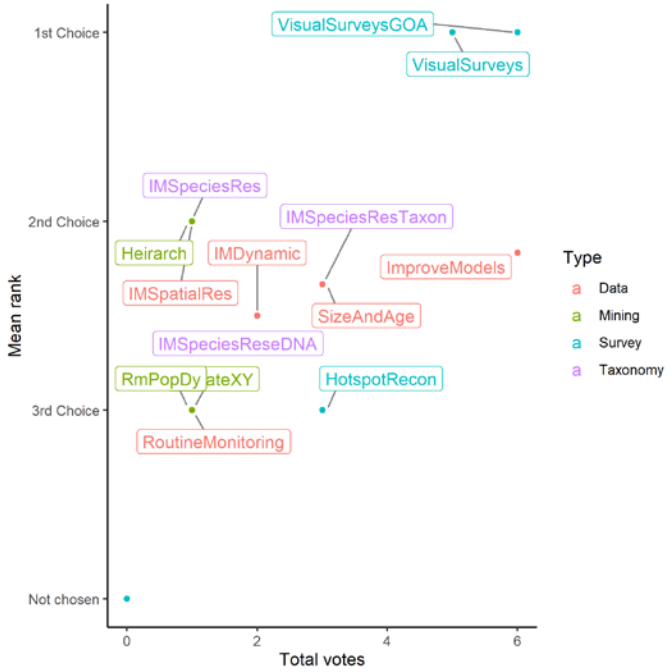


Figure 6. Tally of mean ranking and total votes cast for each of the priorities developed during the Coral and Sponge Distribution breakout group (n = 13 voters).

Coral and Sponge Population Dynamics, Biology, and Interactions

Moderator: Jodi Pirtle (NOAA AKRO)

Note-taker: Caitlin Adams (NOAA OER)

Participants: Julie Bonney (Alaska Groundfish Data Bank), Christina Conrath (NOAA AFSC), Lauren Divine (Aleut Community of St. Paul), Austin Estabrooks (At-Sea Processors Association), John Gauvin (Alaska Seafood Cooperative), Gretchen Harrington (NOAA AKRO), Tom Hourigan (NOAA DSCRTP), Pat Malecha (NOAA AFSC), Todd Miller (NOAA AFSC), Jim Thorson (NOAA AFSC), Rhian Waller (University of Maine)

Identification of Objectives

The goal of this session was to identify and rank research priorities to assess *coral and sponge population dynamics, biology, and biological interactions* in Alaska. In particular, this session intended to choose priorities that are regional in scale with results that can be integrated into other components of the AK DSCSI or those that directly address and impact management decisions. The outcome of this session was a ranked list of the top 5 research priorities in order of importance with potential study topics.

Introductions and Summary of Previous Work

We began the session with participant introductions and communicated individual interest in the session. Participation by NOAA staff and partners was nearly even, where partners included academia (University of Maine), tribal government (Aleut Community of St. Paul), and the fishing industry (Alaska Groundfish Data Bank, Alaska Seafood Cooperative, and At-Sea Processors Association). This diverse group allowed for creative and innovative discussion of research priorities and considerations.

Participants reviewed the following list of research that has been done to-date as an equitable baseline to begin discussion:

1. Coral growth plates deployed by Bob Stone in the Gulf of Alaska (not yet recovered);
2. Reproductive characteristics of red tree coral (Waller et al. 2019);
3. Growth and age of red tree coral (Williams et al. *in review*);
4. Fish associations with DSCS (Laman et al. 2015, Conrath et al. 2019, Rooper et al. 2019);

5. DSCS species distribution models of major coral taxa and sponge orders, coral family diversity indices, based on bottom trawl survey data, some model field validation, using drop camera transects (Guinotte & Davies 2013, Rooper et al. *multiple*, Chu et al. 2019);

6. Drivers of distribution, diversity, and height of DSCS (Wilborn et al. 2018).

Research Priorities

Our process to identify and rank research priorities began with discussion of *why* we need to know more about the topic of *coral and sponge population dynamics, biology, and biological interactions* in Alaska and *what* we need to know. Through inclusive discussion we identified the following research themes.

1. *DSCS/DSCS Ecosystem Function* – individual and ecosystem level function; association and resulting impact on productivity for fisheries management plan (FMP) species (i.e., harvested fish and invertebrate species);

2. *Basic Biology and Life History* – determine growth rates from a combination of lab experiments and marked individuals in the field. Reproduction (e.g., fertilization, and maturity schedules) and larval ecology should also be addressed, including responses of these to environmental conditions and anthropogenic impact. Basic life history is needed in particular for sponges;

3. *DSCS Productivity in Alaska Ecosystems* – productivity estimates/models by taxa;

4. *Population Dynamics* – including habitat-specific productivity and connectivity, to evaluate potential fishing and non-fishing impacts;

5. *Recruitment Dynamics* – settlement rates including environmental associations, circulation models predicting advection, source/sink dynamics, and population connectivity;

6. *Susceptibility to Damage and Mortality by Taxa* – i.e., non-lethal and lethal impacts;

7. *Recovery Rates from Damage and Recolonization after Mortality* – temporal scale of recovery of Alaska DSCS taxa;

8. *Species Associations with DSCS/DSCS Ecosystems* – i.e., associations with individual taxa and at ecosystem level, as related to FMP species e.g., seasonality and productivity.

Ranking of Research Priorities

Moderated group discussion continued to identify study topics under each research theme. We then voted to identify our top 5 research priorities. Voting was accomplished during

the session by an anonymous online poll with complete participation. We discussed the results and arrived at shared understanding and agreement of the final outcome (Table 1).

Table 1. Top 5 Research Priorities in Order of Importance.

1	DSCS Basic Biology and Life History
2	DSCS Susceptibility to Adverse Impacts and Recovery Rates
3	FMP Species Associations with DSCS/DSCS Ecosystems
4	DSCS/DSCS Ecosystem Function for FMP Species Life History and Productivity
5	DSCS Recruitment Dynamics

We provided the AK DSCSI steering committee with the following list of our top-ranked research priorities and study topics.

1. *DSCS Basic Biology and Life History* (Theme 2; DSCRTP priority) –
    a. Growth rates from lab experiments and marked individuals in the field.
    b. Larval ecology, fertilization, maturity (responses of these to environmental conditions and anthropogenic impacts through lab and field experiments).
    c. Meta-analysis to infer life-history parameters for poorly studied taxa, based on phylogeny and known traits, used to guide future prioritization of lab studies.
    d. Trophic functioning and source production in response to climate change, loss of sea ice (LOSI), etc. Projects under this topic could include shifts in benthic-pelagic coupling with LOSI.
    e. Basic life history of a variety of species. Less, well-studied taxa should be included, rather than a focus on commonly studied taxa only (i.e., the “big players” such as a Paragorgia).
2. *DSCS Recovery Rates and Susceptibility to Adverse Impacts* (Cross-cutting among several themes; NPFMC #184, #217; Alaska EFH Research Plan priority (Sigler et al. 2017)) –
    a. Measures of growth and reproductive output obtained from growth rates measured in lab experiments or marked individuals in the field, which can be used as a measure of health and/or susceptibility.

b. Population (e.g., life-cycle) dynamics including habitat-specific productivity and connectivity, to evaluate potential fishing and non-fishing impacts (e.g., larval supply, ecology, and dispersal).

c. Comparison of abundance, diversity, size, and damage between areas open and closed to fishing (and within and outside the current fishing footprint).

3. *FMP Species Associations with DSCS/DSCS Ecosystems* (i.e., the nature of the associations and with what taxa and morphologies) (Theme 1, 8; NPFMC #183) –

a. Species associations with DSCS/DSCS ecosystems, including the nature of the associations and with what taxa and morphologies (can be extended to include progress on 4a - as related to FMP species seasonality/productivity).

b. Determine the importance of small and/or soft corals and sponges as habitat for FMP species versus large, habitat forming gorgonian corals and sponges.

c. Determine the spatial extent of DSCS/DSCS ecosystems in areas that are not well surveyed (e.g., untrawlable habitats, inshore areas).

4. *DSCS/DSCS Ecosystem Function for FMP Species Life History and Productivity* (Theme 1; NPFMC #183, #217) –

a. Association and resulting impact on productivity for FMP species.

5. *DSCS Recruitment Estimates by Taxon* (Themes 4, 2; NPFMC #239, #244) –

a. Settlement rates including environmental associations.

b. Circulation models and/or individual-based biophysical models predicting advection and population connectivity from spawners to recruits.

c. Interfaces with Theme 2, i.e., to understand recruitment, one must understand life history. Population dynamics modeling for taxa where size/age, abundance, and recruitment estimates can be made.

d. Integrating population dynamics, life-history, and connectivity with future SDMs and existing coral distribution models.

Conclusions and Next Steps

Our top ranked research priorities are linked with the research themes that we identified through group discussion, either encompassing individual themes or cross-cutting between two or more themes. The research priorities and topics for study development are regional in scale and can be broadly integrated with other research aspects of the AK DSCSI. Session research priorities are responsive to the priorities of the DSCRTP, Alaska EFH Research Plan (Sigler et

al. 2017), and NPFMC, where studies have the potential to directly address and impact management decisions.

Session participants were very engaged. Participants affiliated with the AFSC expressed interest in partnering with the AK DSCSI research and existing surveys, including those by ABL (Miller, Malecha) and RACE (Conrath). It was requested that the area around the Pribilof Islands be considered among possible Bering Sea study locations (Divine). Participants representing academia (Waller), tribal government (Divine), and the fishing industry (Bonney, Estabrooks, Gauvin) would like to develop cooperative research and outreach for the AK DSCSI with NOAA to meet shared goals and interests.

Coral and Sponge Diversity and Genetics

Moderator: Elizabeth Clarke (NOAA NWFSC)

Note-taker: Meredith Everett (Lynker, NOAA NWFSC)

Participants: Jerry Hoff (NOAA AFSC), Erica Fruh (NOAA NWFSC), Abi Powell (Lynker, NOAA NWFSC), Heather Coleman (NOAA DSCRTP), Katrin Iken (University of Alaska, Fairbanks), Bryan Costa (NOAA NCCOS), Wes Larson (NOAA AFSC), Anna Simeon (IPHC), Sean Rooney* (NOAA AFSC)

*Contributed priorities for discussion remotely as he was participating in a parallel session

Identification of Objectives

The discussion highlighted how the need to clearly identify species and biodiversity will underlie many of the other efforts, and that it provides great opportunities for collaboration across multiple NOAA offices and with other partners including academia, Fisheries and Oceans Canada (DFO) and other agencies such as the International Pacific Halibut Commission (IPHC), Marine Biodiversity Observation Network (MBON), and BOEM. The group discussed the state of knowledge and resources from previous efforts including specific collections and guides that came out of the last initiative as well as ongoing work such as trawl survey collections. This discussion covered research priorities, following possible priorities outlined by the steering committee to promote discussion.

Research Priorities

Four primary and interconnected research priorities were identified during the course of this breakout session.

1. *Environmental DNA (eDNA)* – eDNA studies were a clear priority. eDNA has the potential to help assess biodiversity during multiple field efforts, and can be used to examine both coral and sponge biodiversity as well as diversity of fishery priority

species. Discussions included specific mechanics of potential eDNA collections, including ideas for developing new sampling methodologies. There is interest in collecting these samples as part of NOAA's trawl survey and investigating the potential for this type of sampling as part of a trawl as well as alternatives such as individual daily CTD or single water bottle casts. There is an existing strategy to potentially incorporate eDNA sampling into regular surveys carried out by NOAA Ship *Oscar Dyson*, so it is a potential platform for collections of eDNA samples relevant to the AK DSCSI. This platform conducts multiple types of surveys in Alaska waters and has CTD rosette capabilities that could be paired with camera systems (particularly camera systems mounted directly on the CTD) and could expand the eDNA sampling efforts for the AK DSCSI through partnerships with existing surveys such as during fisheries-oceanography coordinated investigations surveys. eDNA efforts could also focus on clarifying the parameters for this type of sampling, such as relationship to habitat and oceanographic conditions. Specific experiments should be designed to support other research questions such as model validation or biodiversity surveys of specific habitats while providing data on overall coral biodiversity in Alaska and supporting visual identification efforts such as camera surveys. eDNA sampling should be paired with other data when possible so that the methods can validate one another, as well as collecting complementary data. NOAA Ship *Okeanos Explorer* is setting up an eDNA program and any work conducted by this vessel for the AK DSCSI should include ROV-based eDNA sampling.

2. *Species Guide* – The need for new, additional species guides for both corals and sponges was discussed. There was a desire to create these resources from a coastwide effort including Alaska, Canada, and the west coast, possibly to Mexico as there are shared species coastwide in the Eastern Pacific. These efforts would focus also on developing common nomenclature for morphotypes where clear taxonomic identification may not yet exist as well as parallel genetic resources that may help resolve taxonomy. The group agreed that a coastwide guide should be made available in such a way that it can be used for multiple applications including future surveys, observer programs, and academic work such as MBON and UAF research cruises. This guide could start using existing species lists for the regions as a framework to collect materials.

3. *Species identification and distribution* – Additional taxonomic and genetic work to clarify species distributions and identifications was discussed as well as the relationship to other biodiversity priorities. There is much undescribed biodiversity of coral and sponge taxa in the Alaska region, and additional ongoing genetic and taxonomic identification is needed. This effort can include samples obtained through multiple methods ranging from trawl surveys to bycatch and ROV surveys. eDNA research is dependent on having comprehensive voucher libraries and can be iterative, identifying potential targets for future collection as unique eDNA haplotypes are discovered. This taxonomic and genetic identification will also feed into the identification guide, providing

specific identifications and clarification on morphogroups and identifying cryptic variation.

4. *Population connectivity* – Additional population connectivity studies are needed. Types of data such as restriction site associated (RAD) sequencing could be used to both examine population connectivity and clarify taxonomy using similar data. Pairing genetic connectivity data with oceanographic data can also help address life history questions for corals as well as source and sink populations. Part of this discussion included what was known about coral life history, including spawning events. As this area is poorly understood for most species, measuring connectivity indirectly through genetic studies, especially paired with oceanographic data, can start answering questions about larval transport.

5. *Other priorities* **–** Additional other priorities were also discussed.

    a. How biodiversity surveys could relate to management. This topic included discussion on how the fishing community could be involved through local knowledge to identify previously unsurveyed coral and sponge communities. Also, collection of corals and sponges through the observer program could be frozen aboard and used for taxonomic identification and identification of regional diversity hotspots.

    b. Temporal sampling can help identify recruitment events, and address coral and sponge growth rates and response to environmental changes. There is potential for using the AK DSCSI to set up monitoring stations for future research.

    c. The need to conduct surveys through multiple habitat types was discussed, and a need for additional work in the Arctic was highlighted. Surveys provide valuable data for modeling, and taking eDNA samples in these regions can contribute additional data on “absence” and can examine coral and sponge biodiversity both in and out of protected areas. NPFMC input should be sought on priority geographic areas for biodiversity surveys.

    d. The potential to discover corals/sponges with biomedical uses as a result of sample collection was also highlighted, with potential contacts identified (i.e., Scripps Institute of Oceanography).

    e. Data needs for biodiversity modeling such as the importance of environmental data taken on the appropriate scale, and the need for presence-absence data rather than just presence data, were discussed.

    f. There was also discussion about how these research priorities could contribute and fit in with other priorities identified as part of the workshop.

Research Projects

1. *eDNA* – Expand and develop the use of eDNA methods to examine both coral and sponge biodiversity as well as diversity of fishery priority species.

    a. Collect eDNA samples on existing surveys (e.g., trawl survey, oceanographic surveys, drop camera surveys).

    b. Develop new methods to more easily deploy eDNA sampling on existing surveys.

    c. Collect associated environmental data, and where possible validation samples of fauna during eDNA sampling.

    d. Design specific experiments to support other research questions, such as model validation or biodiversity surveys.

2. *Species Guide* – Create a coastwide guide that can be used for multiple applications including future surveys, observer programs, and academic work such as MBON and UAF research cruises.

    a. Use existing species lists for the regions as a framework to collect materials.

    b. Develop a guide in collaboration with partners in Canada and Mexico as well as those in Washington, Oregon, and California so that a coastwide guide can be developed.

3. *Species identification and distribution* – Collect additional samples to support taxonomic and genetic work to clarify species distributions.

    a. Develop protocols to collect samples obtained through multiple methods ranging from trawl surveys to bycatch and ROV surveys.

    b. Develop an online collection needs list that can be used throughout the region by multiple investigators.

4. *Population connectivity* – Conduct additional population genetic studies to determine population connectivity.

    a. Pair genetic connectivity data with oceanographic data, which can also help address life history questions for corals as well as source and sink populations.

    b. Use methods such as restriction site associated DNA (RAD) sequencing to examine both population connectivity and clarify taxonomy using similar data.

5. *Other Projects* – Facilitate additional biodiversity understanding and modeling.

a. Expand collections to include presence/absence data.

b. Sample the widest possible range of habitats.

c. Consider establishment of monitoring sites so that temporal as well as spatial information can be collected.

Effects of Climate Change on Coral and Sponge

Moderator: Mike Sigler (NOAA retired)

Note-taker: Peter Etnoyer (NOAA NCCOS)

Participants: Arliss Winship (NOAA NCCOS), Carol Ladd (NOAA PMEL), Christina Conrath (NOAA AFSC), Darren Pilcher (NOAA PMEL), Lauren Divine (Aleut Community of St. Paul), Mark Mueller (BOEM), Rachel Wilborn (Lynker, NOAA AFSC), Rhian Waller (University of Maine), Robert McGuinn (NOAA NCEI), Austin Estabrooks (At-Sea Processors Association) Chris Oliver (Alaska Seafood Cooperative), Jessica Cross (NOAA PMEL), Lauri Sadoris (IPHC)

Conceptual Framework for Session

This breakout group discussed a conceptual framework for addressing climate effects on corals and sponges, developed research questions, and developed and prioritized research project ideas. This framework posits that ocean warming, ocean acidification, and marine heat waves affect deep-sea corals and sponges (direct effects) and likewise, climate change affects fisheries; however, in the short-term, the direct effects on corals and sponges likely are less than impacts of climate change mediated by fisheries location and production shifts (indirect effects). Indirect effects could occur if climate change prompts fisheries using coral and sponge damaging gear to move into new areas of coral or sponge habitat.Thus the indirect effects (due to climate change effects on fisheries) likely will precede the direct effects (due to climate change effects on coral and sponge). The breakout group agreed that fisheries displacement will have short-term implications that precede direct effects of climate change on corals and sponges, but added that perturbations like marine heat waves may ‘break through’ this paradigm.

The group therefore amended the conceptual framework with the question: Do episodic events (e.g., marine heat waves) have the potential to overcome the effects of shifts in fisheries location and production (proceeding faster than direct effects of ocean warming and ocean acidification)?

Research Questions

The climate effects breakout group created several research questions.

1. What are the current and future effects of climate change on corals and sponges in

Alaska? Consider direct episodic (e.g., marine heatwaves) and gradual (e.g., ocean acidification) effects as well as indirect effects (location changes in fisheries due to climate change). Sub-question: Are there linkages to either fisheries production or community structure? Consider both sub-lethal (e.g., reproductive) and lethal effects. In general, address climate effects on the role of corals and sponges in the ecosystem.

2. Due to the increased variability in climate, do episodic events (e.g., marine heat waves) have the potential to significantly add to the effects of shifts in fisheries location and production proceeding faster than direct effects of ocean warming and ocean acidification?

3. Do anomaly effects at depth (i.e., exposure) supersede sensitivity thresholds of corals and sponges?

4. Are corals acting as recorders of short-term climate events or long-term environmental changes?

5. Will coral and sponge distributions change? Will protection areas remain protective? Will fisheries overlap with coral and sponge changes?

6. Can responses of deepwater corals in Alaska under current conditions serve as an analog for future impacts to ocean acidification conditions for corals in other regions? Do they represent a bellwether effect?

Research Priorities

The climate effects breakout group recommended five research projects. The list includes a brief description of each project. The meeting notes include more information and some discussion.

1. *Gulf of Alaska stereo camera survey* (NPFMC priority) – Validation (stereo camera) survey of the Gulf of Alaska. Including environmental measurements such as temperature and salinity on the camera frame will improve inference.

2. *Risk analysis of climate change effects* – Risk analysis of climate change effects for corals and sponges in the Aleutian Islands, Gulf of Alaska, and eastern Bering Sea slope. Specifically, construct forecasts of fisheries footprint, EFH, and coral and sponge distributions. Builds on existing models (EFH, coral and sponge, fisheries footprint) and incorporates climate forecasts. (Winship)

3. *Monitor ocean warming and ocean acidification* –
a. Monitor oxygen, salinity, nitrate, and temperature (and infer carbon parameters) (Wiley et al. 2013) at (one or two) accessible coral concentrations (preferably open water). (Cross, Ladd, Pilcher)

b. Use proxies (e.g., coral samples) as an alternative measurement of ocean warming. Dry skeletons of *Primnoa*, *Isidella*, and *Stylaster* have growth patterns and biogeochemistry that make them useful for radio- and stable isotope studies at a fine temporal resolution. Colonies collected as bycatch can be distributed to collaborating scientists. (P Etnoyer, NOAA; R Waller, U Maine; L Robinson, U Bristol; B Williams, Claremont College)

4. *Lab experiments* – Lab experiments directed at understanding effects of ocean acidification, ocean warming, and marine heat waves. Recommended study species are *Primnoa pacifica* and *Stylaster* spp. A research group needs to be identified to conduct these experiments; a good first choice is the NOAA AFSC Kodiak lab, which currently conducts ocean warming and ocean acidification experiments (the latter is highly technical). (Malecha, Long (Kodiak lab), Laura Robinson (U. Bristol), Waller (U. Maine))

5. *Regional ocean models* – Represents both temperature and carbon parameters. PMEL scientists are interested in partnering with specific coral projects. This model is integral to project 2. (Ladd, Cross, Pilcher, Hermann)

Ranking of Research Priorities

The climate effects breakout group voted on project priority. Each participant named first, second and third choices (Table 2). The Gulf of Alaska survey received the most first place votes, the project to monitor 1-2 coral concentrations received the most second place votes, and risk analysis (climate change) received the most third place votes. Each vote also was weighted to determine a total score, which slightly changes the ranking (risk analysis and monitoring concentrations switch places).

Table 2. Ranked prioritization of research themes.

Project	1st (3 pts)	2nd (2 pts)	3rd (1 pt)	Score
Gulf of Alaska stereo camera survey	6	1		**20**
Risk analysis (climate change)	3	3	4	**19**
Monitor 1-2 coral concentrations	1	5	3	**16**
Ocean warming/acidification lab experiments	3	1	4	**15**
Regional ocean modeling		3	2	**8**

Effects of Human Activities on Coral and Sponge

Moderator: John V. Olson (NOAA AKRO)

Note-taker: Chris Rooper (DFO)

Participants: Sean Rooney (NOAA AFSC), Steve MacLean (NPFMC), Meredith Everett (Lynker, NOAA NWFSC), Stephanie Madsen (At-Sea Processors Association), John Gauvin (Alaska Seafood Cooperative), Jim Thorson (NOAA AFSC), Cathy Coon (BOEM), Jon Warrenchuk (Oceana), Amanda Netburn (NOAA OER), Bob McConnaughey (NOAA AFSC), Tom Hourigan (NOAA DSCRTP), Elizabeth Clarke (NOAA NWFSC), Pat Malecha (NOAA AFSC), Gretchen Harrington (NOAA AKRO), Matt Baker (NPRB)

Objectives

Adverse anthropogenic effects on DSCS communities in Alaska can be direct (e.g., commercial fishing, critical element mining, telecommunication lines) or indirect (e.g., climate change and ocean acidification). The effects of human activity breakout group discussed direct effects largely focusing on identifying and minimizing the effects of fishing on DSCS.

Discussion Summary and Research Questions

Discussion during this breakout group focused in four general areas: coral and sponge models, assessing the effects of fishing, fishing gear and technology improvements, and data mining.

1. *Coral and sponge models* – Predictive habitat modeling can serve as a valuable input to management decisions, allowing managers to extrapolate distributions of corals and sponges over areas relevant to managers (Winship et al. 2020). Aleutian Island and Bering Sea models have been validated with independent field surveys; however, Gulf of Alaska models have not. The group agreed GOA validation is a top priority. Existing models should be updated with new data and environmental covariates, at a specific interval or as they become available. The potential for collecting eDNA samples during research surveys, i.e., dropcam, trawl- or longline-mounted may be possible, and the West Coast region has developed an eDNA collection protocol being used on a number of surveys to assist with species identification. Establishing accessible reference sites (eg., Kodiak, Southeast AK) could enable collection of visual time series. The Northwest Fisheries Science Center has established several sites to study recruitment/growth rates.

2. *Assessing the effects of fishing* – bottom trawl, bottom-set longline, and pot fisheries throughout Alaska were identified as the primary source of impacts to DSCS (Stone and Shotwell 2007). A fishing effects model was developed by NOAA Fisheries during the last EFH 5-year review, but multiple inputs to the model could be updated. The model

did not adequately incorporate impacts of coral and sponge habitats, and excluded consideration of coral and sponge habitats shallower than 300m, even though the highest density Aleutian coral and sponge gardens occur predominantly from 80-300m. This list includes: 1) refining impact estimates by hook-and-line, bottom trawl, and pot fisheries; 2) validating fishing effects output with visual data; 3) establishing which habitats are fished with which gears; 4) adding validated coral/sponge models as a covariate; 5) adding size structure/selectivity as a covariate; 6) and better estimating susceptibility and recovery of DSCS. Before-after-control-impact studies are difficult to implement both in terms of cost and practicality, but sites exist in the GOA and AI that may provide opportunities to study recovery (Freese 2001, Malecha and Heifetz 2017, Steller sea lion critical habitat) independent of whether they were designed as habitat protection closures. Regression designs for ship-based sampling and rotational closures was also discussed.

3. *Assessing the efficacy of habitat protection closures* – The widespread use of vessel monitoring systems in Alaska allows for more accurate fishery footprint delineation but does not cover all sectors equally. Changing fishing practices can have unintended consequences (i.e., fishing off-bottom for Pacific ocean perch (*Sebastes alutus*) can increase salmon bycatch), highlighting differences in DSCS bycatch composition between fishery and surveys due to fishing practices and areas fished. There is a NPFMC priority to assess the efficacy of fishery closures, and analysis of these closures could be important as species expand or contract their ranges due to climate change. Finally, it was suggested that a management strategy evaluation approach could be implemented for DSCS management.

4. *Data mining projects with wide applicability* – Many sources of imagery were identified across a wide range of institutions, such as AFSC, ADFG, OER, and UAF. Processing existing imagery with the Sebastes software package would provide benefits for validating DSCS, fishing effects, and species distribution models, as well as adding to bathymetry and sediment records.

Research Projects

The group did not develop and vote on a list of projects during the session. The following includes a brief description of potential projects that were a focus of discussions.

1. *Gulf of Alaska stereo camera survey* (NPFMC priority) – Validation (stereo camera) survey of the Gulf of Alaska. Including environmental measurements such as temperature and salinity on the camera frame will improve inference. Camera information can also be used to validate fishing effects and EFH SDMs. Incorporating eDNA sampling methods to camera surveys would provide additional taxonomic information.

2. *Risk analysis of fishing impacts* – Risk analysis of fishing effects for coral and sponge in the AI, GOA, and EBS slope. There are numerous examples of this type of risk analysis (i.e., Clark et al. 2014, Hobday 2011) and the data required for a quantitative assessment, as framed by the Clark methodology, are currently available.

3. *Incorporating coral and sponge model covariates into the fishing effects model* – The current iteration of the fishing effects model was developed before the availability of validated DSCS models in the Bering Sea and Aleutian Islands. Output from the DSCS models could provide valuable inputs to assessing impacts of fishing activities on DSCS resources.

4. *Effectiveness of existing closure areas* (NPFMC priority #184) – Closures have been implemented to minimize bycatch of non-target species, reduce gear conflicts, and protect habitat. Most closures apply to non-pelagic trawling only, and some have been in place for over 20 years. These areas could be potential sites for examining recovery. Rooper et al. submitted an NPRB proposal that would address the issue of effectiveness of existing closure areas.

5. *Refine impact (susceptibility and recovery) estimates* – Susceptibility of DSCS to fishing gears has been quantified in the fishing effects model; however, estimates for impacts from trawling have been the emphasis of most research. Hook-and-line longline, longline fish and crab pots, and single fish and crab pots have been studied relatively little in Alaska. Technology has been developed for hook-and-line gears in Australia (Welsford et al. 2014) and fish pots in Canada (Doherty et al. 2017) that would provide improved estimates of impact for these gears. The AFSC longline survey could provide a pilot platform for cameras.

6. *Data mining* – AFSC staff have been processing video using the Sebastes analysis package (Williams et al. 2016). Other sources of archived data need to be identified/cataloged, and then prioritized for processing. Alaska Pacific University's Fisheries, Aquatic Science, and Technology lab processed the backlog of ADFG Camsled imagery and is a potential source to process archived imagery that is unable to be processed within the AFSC.

Deep-Sea Mapping

Moderator: Heather Coleman (NOAA DSCRTP)

Note-taker: Bryan Costa (NOAA NCCOS)

Participants: Jerry Hoff (NOAA AFSC), Rachel Medley and Caitlin Adams (NOAA OER), Robert McGuinn (NOAA NCEI), Alden Denny (BOEM Marine Minerals Division), Julie

Bonney (Alaska Groundfish Data Bank), Jennifer Reynolds (UAF), Gary Greene (Moss Landing Marine Lab)

Objectives

Coming into this workshop, participants were most interested in deep-sea mapping as a tool to inform habitat maps, explore and fill knowledge gaps, and better understand mineral and energy potential. To a lesser degree, they were also interested in mapping to plan visual surveys, guide management decisions, inform DSCS models, and better understand untrawlable habitat. Participants were most interested in mapping deepwater areas off the Aleutian Islands, Gulf of Alaska, Arctic Ocean, and Bering Sea (in decreasing order of importance). Planned research should be contextualized with cross-cutting NOAA and National Ocean Mapping, Exploration, and Characterization Strategy priorities, and align with planned OER surveys where possible.

Research Priorities by Region

A few themes crossed regions to become considerations for research and exploration during the AK DSCSI generally, including the following areas.

1. Management relevance is important for project prioritization.
    a. Studying habitat inside and outside of protected areas is an important opportunity to consider.
    b. Research should concentrate on areas currently fished, primarily shallower than 1000 m. However, these areas may shift as species move with climate change.
    c. Products created during and following the AK DSCSI should be ready for use by resource managers.
2. Mapping results are critical to inform many other purposes, such as visual surveys, coral and sponge collections, connectivity research, habitat suitability modeling, etc.
3. Partnerships are also critical in guiding AK DSCSI research. There are substantial overlaps between DSCRTP's spatial interests and priorities of a number of other programs, such as:
    a. OER and other NOAA offices' mandates to map and characterize unexplored deep seafloor (with NOAA Ship *Okeanos Explorer* expected in Alaska waters in 2022);
    b. BOEM's critical minerals and hydrothermal system interests;
    c. Fishing industries' knowledge of DSCS habitats;
    d. Universities' research programs and existing un-analyzed data; and
    e. Philanthropic organizations' resources.

4. Resolution limits the extent to which we can use existing data and in which areas we may need new data collected. A guiding principle of collecting acoustic data with the highest resolution possible (in some cases ideally 10 meters) was proposed, noting that 10 meter resolution may not be ideal in all areas, nor is it always practical depending on water depths and sensors used. More discussion is warranted on the topic of what resolution is needed in discrete locations and for what purpose.

5. Backscatter data are very useful for habitat mapping, and should always be requested coincident with multibeam mapping data.

6. Data mining and suturing old and new datasets would be useful across Alaska to fill gaps and standardize data acquisition. Sufficient funds and analysis time should be dedicated for this purpose.

Aleutian Islands

The Aleutian Islands have the richest deep-sea coral and sponge habitats in Alaska. In the previous Alaska Initiative, coral habitat suitability models were completed and validated (although further validation could still be helpful) in Aleutian waters. Therefore other research themes are prioritized in this region, as follows.

7. Discovering and analyzing existing data is very important for the task of defining priority areas and informing predictive habitat models. Connecting these data mining efforts to existing high resolution maps could help fill important gaps in our understanding and increase modern bathymetric coverage.

8. Fishery management designations, especially HAPCs, are important mapping targets, especially to improve understanding of habitat inside and outside protected areas.

9. Seamounts with potential volcanoes and hydrothermal systems are very important for BOEM to locate, map, and understand. In particular, the backside of the ridge in this region is not as well covered by systematic surveys. Like in the Gulf of Alaska, tectonically active areas are mostly un-mapped or poorly explored and are often good substrate for corals, setting up a promising AK DSCSI partnership. BOEM is also looking for seamounts along the island chain and inter-island basins (for example, Buldir Basin), and is interested in studying fresh volcanics for endemic species and distribution research.

10. The group recommended working with fishing industries to supplement distribution information, particularly by asking where fishermen get stuck and haul up deep-sea corals and sponges.

Gulf of Alaska

In the Gulf of Alaska, multibeam surveys have covered small discrete areas so far, and mapping representative deep-sea coral and sponge habitats is needed.

11. A top priority for this region is creating a good basemap to help plan visual surveys that inform and validate deep-sea coral habitat suitability models. Data mining is also an important component of this process in the Gulf, since this region needs additional analyses completed before choosing the most appropriate mapping sites.

12. Fishery management designations, especially HAPCs, are important mapping targets in the central Gulf of Alaska, since they could potentially benefit the most from updated acoustic mapping.

13. Benthic habitat and substrate characterization (and sometimes standardized sub-bottom information) is also important for BOEM's interests in critical mineral assessments and tectonically active areas (especially the Queen Charlotte Fault Zone).

14. Mapping untrawlable areas is a priority for informing visual surveys, especially in the Central Gulf and along the shelf break. Such areas have significant hard bottom substrate and would be a good match for the capabilities of *Okeanos Explorer.* A good example is the Icy Point to Dixon Entrance area in the Queen Charlotte Fault Zone shelf break to upper slope, as it is unexplored, rugged, contains carbonate substrate, is geologically and potentially biologically dynamic, and seismically active with new volcanic cones and fluid expulsion along the fault.

15. Partnering to better inform NOAA Fisheries longline surveys (lacking bathymetry) is also an opportunity to consider, although these areas may have more degraded coral and sponge habitats.

Arctic Ocean

The Arctic Ocean is the least understood region in Alaska waters, and therefore has enormous research and exploration potential. AFSC staff have made progress mapping the region, but need more funding to complete their work. Deepwater areas of the upper slope are especially understudied. Also, Arctic waters are a likely destination for species moving due to climate change. Arctic seafloor protections exist but are temporary, making this region lower priority now but important when considering the need to prepare for potential policy changes in the future. Areas most likely to be fished deserve special attention. It is important to note, however, that the Alaska Arctic appears to be very species poor in terms of corals (only two genera of soft corals, *Gersemia/Alcyonium* and cf. *Anthomastus*, and an unidentified sea pen documented to date) and a few sponges.

Bering Sea

Bering Sea upper slope areas and ridges between Zhemchug Canyon and Pribilof Canyon were noted for their pinnacles containing large numbers of rockfish and DSCS relative to other surveyed areas in the EBS shelf and slope. Exploration of these areas would significantly benefit from incorporating fishing industry knowledge and expertise. There has also been a request for a marine reserve to be created around St. George Island since hard substrate is rare in this region.

Research Priorities: Overall Seafloor Mapping

The mapping breakout session's participants underscored the following projects and considerations (not rank-ordered).

- Addressing management priorities, creating usable products, and assimilating fishing industry knowledge.
- Data mining, combining old and new data sets to fill gaps, and ensuring adequate resource allocation for new data analyses.
- Partnering with BOEM to address their priorities (soon-to-be released as shapefiles), as well as volcanically and hydrothermally active areas north of the Aleutian Islands.
- Partnering with USGS and the Geological Survey of Canada to expand research in the Queen Charlotte Fault Zone.
- Surveys in the Gulf of Alaska to validate habitat suitability models.
- Surveys of untrawlable habitat in the Aleutian Islands and Gulf of Alaska.
- Surveys of understudied ridges in the Bering Sea and high Arctic slope.
- Surveys of areas where fishing occurs and areas (especially in the Arctic) where fish are likely to be moving.

The entire workshop audience was presented with a streamlined list and voted on possible priorities to produce the following research activity ranking.

1. Untrawlable areas in the Gulf of Alaska and Aleutian Islands (26%).
2. Model validation in the Gulf of Alaska (19%).
3. Work with industry to identify sites rich in corals (11%).
4. Bering Sea ridges between Zhemchug and Pribilof Canyons (10%).
5. Data-mining (8%).

6. Partnering with BOEM/USGS (8%).
7. Continuing Arctic mapping (7%).
8. Fishery management areas in the central Gulf (4%).
9. Tectonically active areas and cold seeps (4%).
10. Partnering with NMFS longline surveys (3%).

Resources

- The AK DSCSI's Digital Atlas (produced by the National Centers for Coastal Ocean Science) is an interactive map designed to let partners explore seafloor mapping and deep-sea coral and sponge data in Alaska. This digital atlas is still in the early stages of development, but intends to aid in identification of priorities for seafloor mapping and visual surveys in Alaska waters. It also facilitates effective coordination of assets, and efficiently guides future seafloor mapping, research, and exploration activities during the AK DSCSI field seasons.
- US Mapping Coordination SeaSketch Website.
- State of Alaska 2019 Mapping Prioritization.
- NOAA Bathymetry Gap Analysis.
- NOAA/NCEI multibeam mapping database.
- Seabed 2030 mapping effort.
- USGS/Canada effort to map the southeast Gulf of Alaska shelf break includes past data (promising for data mining) and planned work in 2021 (contact: Gary Greene - greene@mlml.calstate.edu and Danny Brothers - dbrothers@usgs.gov).
- Aleutians Islands - Remotely Operated Platform for Ocean Sciences transects are promising for data mining and should be a priority to analyze (contact: Jennifer Reynolds - jrreynolds@alaska.edu and Gary Greene - greene@mlml.calstate.edu).
- Opportunistic mapping effort at AFSC longline survey stations (contact: Jodi Pirtle - jodi.pirtle@noaa.gov).
- AFSC and AKRO priorities under the Presidential Memo (contact: Bob McConnaughey - bob.mcconnaughey@noaa.gov).
- Priority areas for BOEM marine minerals program including areas of interest for the assessment of seamounts with potential hydrothermal systems, mostly located in un-mapped or poorly explored areas (contact: Alden Denny - alden.denny@boem.gov).

Wrap-up Discussion and Expected Products

After breakout sessions concluded, a facilitated wrap-up discussion was held with the breakout session leads and members of the Steering Committee. The discussion reviewed each breakout session's research priorities and compiled a combined list of priorities for all groups. From the combined list, commonalities were recognized and several research avenues were identified as high priorities. Validation of coral and sponge distribution models in the GOA with visual surveys was a very high priority. Along with validation of the GOA models, it was recognized that distribution models, including validated models of coral and sponge in the BS and AI, could benefit from updated covariate data, such as temperature, salinity, and current speed, as well as spatially-explicit data on size and age of corals and sponges. Mapping untrawlable habitats in the GOA and AI was identified as a priority to determine coral and sponge habitats and guide future seafloor explorations. As the basis for quality research products, the importance of improved and consistent taxonomic species identifications of corals and sponges was also recognized. Thus, an effort to create a detailed field guide for corals and sponges for the entire northeastern Pacific was prioritized. Several groups recommended eDNA sampling to further the understanding of coral and sponge biodiversity and their associations with managed fish and crab species. It was also noted that eDNA data could be explored as input into species distribution models. Targeted collections of specimens and genetic techniques could also be used with oceanographic data to infer population connectivity of important coral and sponge taxa. Risk assessments that examine anthropogenic (fishing, resource extraction, etc.) and direct and indirect climate effects on coral and sponge were also identified as priorities. Further, the need for a better understanding of recovery rates and susceptibility, as well as recruitment dynamics, of corals and sponges was prioritized. Along those lines, multiple groups advocated retrieving settlement plates placed on the seafloor during the last AK DSCSI, as well as establishing sentinel sites for long-term monitoring of corals and sponges. Finally, priority was determined for mining existing datasets to supplement modelling efforts and guide future seafloor explorations.

Expected products (in no particular order) stemming from research priorities identified at the AK DSCI workshop may include the following.

1) Visually validated coral and sponge distribution models for the GOA.
2) Taxonomic field guide for corals and sponges for the entire northeastern Pacific.
3) eDNA-derived biodiversity indices for coral and sponge ecosystems.
4) New life history data on settlement, recruitment, growth, and recovery rates of corals and sponges from *in situ* and *in vivo* observations.
5) Enhanced species distribution models for corals and sponges that include updated environmental covariates and biological data.
6) Inventory of existing datasets on coral and sponge distribution.

7) High resolution multibeam bathymetry and backscatter maps of untrawlable habitats for identifying the distribution and biodiversity of corals and sponges.
8) Risk assessments for the effects of fishing and climate change on corals and sponges.
9) Assessment of the effects of longline and/or pot fishing gear on corals and sponges.
10) Assessments of associations and/or productivity between coral and sponge and managed fish and crab species.
11) Biodiversity and genetic connectivity surveys of coral and sponge communities on Alaska seamounts.

Concluding Remarks

The Alaska Deep-Sea Coral and Sponge initiative conducted from 2012-2014 was an extremely successful endeavour and set a precedent for the amount of quality research conducted in a challenging and costly location. Our intention is to conduct the current AK DSCSI 2020-2023 in a similar manner with a goal of maintaining the high level of quality research previously completed. Our focus for this initiative is to address research priorities from a number of entities including the Deep Sea Coral Research and Technology Program, North Pacific Fishery Management Council, and the Alaska Fisheries Science Center. We acknowledge the lost opportunities to connect with workshop participants face-to-face as scheduled in Juneau, Alaska, however we feel the virtual format workshop was well attended and participants were engaged and helped produce a meaningful and useful list of research priorities as a starting point.

Acknowledgements

We thank the AK DSCSI steering committee and breakout session facilitators for their input during the planning and execution of this workshop, making it a productive event. In addition to all the participants, we also acknowledge and thank the people who played supportive roles: Chris Rooper for sharing his experience as the previous AK DSCSI Principal Investigator and participating in the current initiative; Mike Sigler for sharing his wisdom and experience in leading a followup session focusing on producing a more cohesive research plan; and Bryan Costa for creating an interactive map displaying data from the DSCRTP national database. We also thank the presenters at the workshop for preparing material to share with the attendees about their respective agencies or institutions. A special thanks to the NOAA DSCRTP for supporting the workshop which allowed all of the thoughtful, cross-cutting discussions to take place to help prepare the steering committee for science plan development. And a special thanks goes to Tom Hourigan and Heather Coleman for their helpful guidance throughout the entire process.

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Appendix A - Workshop Participants

Workshop Participants		
Name	Professional Affiliation	Workshop Role
John Gauvin	Alaska Seafood Cooperative (Industry)	
Caitlin Adams	NOAA- OER	Steering Committee, Presenter, Note Taker
Matt Baker	North Pacific Research Board	
Julie Bonney	Alaska Groundfish Data Bank (Industry)	
Sean Burrill	DOI BOEM	
Chris Caldow	NOAA - National Marine Sanctuaries	
Liz Clarke	NOAA Fisheries - NWFSC	Steering Committee, Breakout Lead
Heather Coleman	NOAA DSCRTP	Steering Committee, Breakout Lead
Christina Conrath	NOAA Fisheries - AFSC Kodiak	
Cathy Coon	DOI BOEM	
Adrienne Copeland	NOAA OER	
Bryan Costa	NOAA NCCOS	Steering Committee, Note Taker
Jessica Cross	NOAA PMEL	
Lauren Divine	Aleut Community of St. Paul Island Tribal Government	
Austin Estabrooks	At Sea Processors (Industry)	
Peter Etnoyer	NOAA Fisheries - NCCOS	Note Taker
Meredith Everett	NOAA Fisheries - NWFSC	Note Taker
Robert Foy	NOAA Fisheries - Regional Office	
Erica Fruh	NOAA Fisheries - NWFSC	
Pam Goddard	NOAA Fisheries - AFSC Seattle	Co-coordinator

Workshop Participants		
Name	Professional Affiliation	Workshop Role
Gary Greene	California State University	
Gretchen Harrington	NOAA Fisheries - AK Regional Office	
Jerry Hoff	NOAA Fisheries - AFSC Seattle	Co-lead, Presenter
Tom Hourigan	NOAA DSCRTP	Steering Committee, Presenter
Katrin Iken	University of Alaska Fairbanks	
Carol Ladd	NOAA PMEL	Steering Committee
Wes Larson	NOAA Fisheries - AFSC Juneau	
Jennifer Le	NOAA Fisheries - SE Regional Office	
Steve MacLean	NPFMC Representative	Presenter
Stephanie Madsen	Pacific Seafood Processors (Industry)	
Pat Malecha	NOAA Fisheries - AFSC Juneau	Co-lead
Norm McCarthy	NOAA DSCRTP	student
Bob McConnaughey	NOAA Fisheries - AFSC Seattle	
Susanne McDermott	NOAA Fisheries - AFSC Seattle	
Robert P. McGuinn	Northern Gulf Institute, NOAA Cooperative Institute	
Rachel Medley	NOAA OER	
Todd Miller	NOAA Fisheries - AFSC Juneau	
Mark Mueller	DOI BOEM	
Amanda Netburn	NOAA OER	Steering Committee, Note Taker
Christopher Oliver	Alaska Seafood Cooperative (Industry)	
John Olson	NOAA Fisheries - AK Regional Office	Steering Committee, Breakout Lead

Workshop Participants		
Name	Professional Affiliation	Workshop Role
Jay Orr	NOAA Fisheries - AFSC Seattle	
Darren Pilcher	NOAA PMEL	
Jodi Pirtle	NOAA Fisheries - AK Regional Office	Breakout Lead, Breakout Lead
Abi Powell	NOAA Fisheries - NWFSC	
Susan Pultz	NOAA Habitat Protection Deputy Chief	
Jennifer Reynolds	University of Alaska Fairbanks	
Sean Rooney	NOAA Fisheries - AFSC Kodiak	
Chris Rooper	Fisheries and Oceans Canada	Steering Committee, Breakout Lead, Note Taker, Presenter
Lauri Sadorus	International Pacific Halibut Commission	
Mike Sigler	NOAA Fisheries - AFSC (retired); Teaching Faculty, Shoals Marine Lab	Breakout Lead
Ned Sigler	NOAA Fisheries - AFSC Seattle	
Anna Simeon	International Pacific Halibut Commission	
Duane Stevenson	NOAA Fisheries - AFSC Seattle	
Jim Thorson	NOAA Fisheries - AFSC Seattle	Presenter
Rhian Waller	University of Maine	
Jon Warrenchuk	Oceana (NGO)	
Rachel Wilborn	NOAA Fisheries - AFSC Seattle	Co-coordinator
Ben Williams	NOAA Fisheries - AFSC Juneau	
Kresimir Williams	NOAA Fisheries - AFSC Seattle	
Arliss Winship	NOAA NCCOS	

Appendix B. - Workshop Agenda

Deep-Sea Coral and Sponge Alaska Initiative Workshop Agenda

May12th - 15th, 2020

Location: Google Meet (Virtual Workshop)

Day 1: Tuesday, May 12th, 10am - 1pm (PDT)

10:00-10:10 *Jerry Hoff*- Welcome, logistics, and intros

10:10-10:30 *Tom Hourigan*- "Overview of Deep Sea Coral Research and Technology Program"

10:30-10:50 *Chris Rooper*- "Where have we been: A summary of the Alaska Coral and Sponge Initiative (2012–2019)"

10:50- 11:10 *Jim Thorson*- (EFH-HEPR) "Linkages and lessons to share between essential fish habitat and deep-sea coral initiatives"

11:10-11:25 -- 15 minute BREAK--

11:25-11:45 *Mike Sigler*- "Climate Change, Cold-water Corals and Alaska Fisheries"

11:45-12:05 *Steve MacLean*- NPFMC Council Priorities

12:05-12:25 *Caitlin Adams*- (Okeanos Explorer) "Introduction to NOAA OER and *Okeanos Explorer* Operations"

12:25-12:45 *Pat Malecha*- wrapup, logistics

12:45-1:00 Questions

Day 2: Wednesday, May 13th, 10am - 1pm (PDT) Concurrent Breakout Sessions

1. **Coral and sponge distribution**: *Chris Rooper (Amanda Netburn)*

2. **Coral and sponge pop. dynamics, biology, and interactions**: *Jodi Pirtle (Caitlin Adams)*

3. **Coral and sponge diversity**: *Liz Clarke (Meredith Everett)*

Day 3: Thursday, May 14th, 10am - 1pm (PDT) Concurrent Breakout Sessions

4. **Effects of climate change**: *Mike Sigler (Peter Etnoyer)*

5. **Effects of human activity**: *John Olson (Chris Rooper)*

6. **Deep-sea mapping**: *Heather Coleman (Bryan Costa)*

Day 4: Friday, May 15th, 10am - 1pm (PDT) Workshop Wrap Up

10:00-10:15 Pat Malecha- Thank you

10:15-10:30 Chris Rooper (Distribution)

10:30-10:45 Jodi Pirtle (Population Dynamics)

10:45- 11:00 Liz Clarke (Genetics and Diversity)

11:00-11:15 --15 minute BREAK--

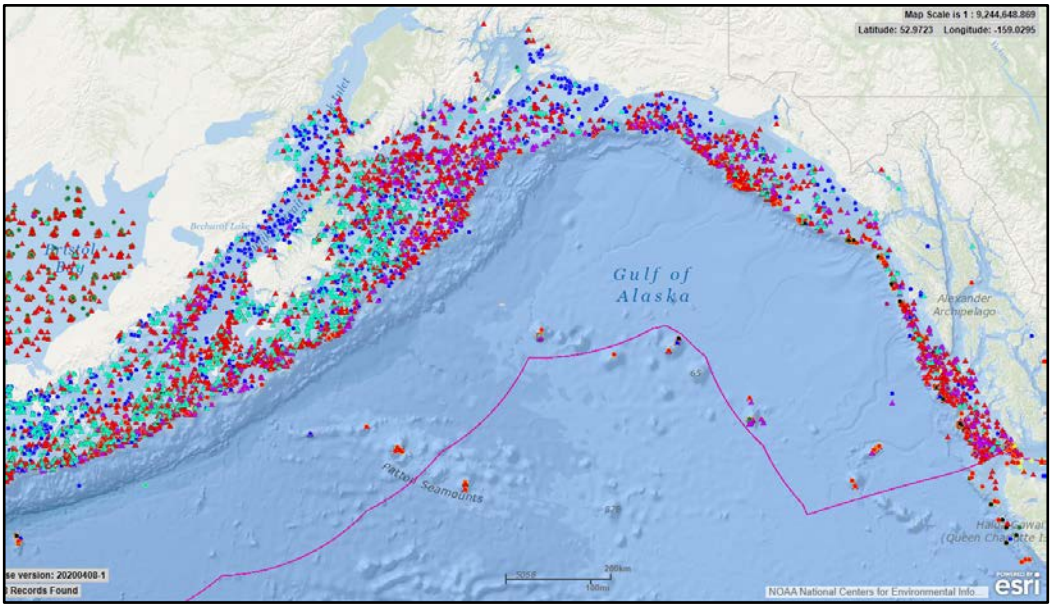
11:15-11:30 Mike Sigler (Climate Change)

11:30-11:45 John Olson (Fishing Impacts)

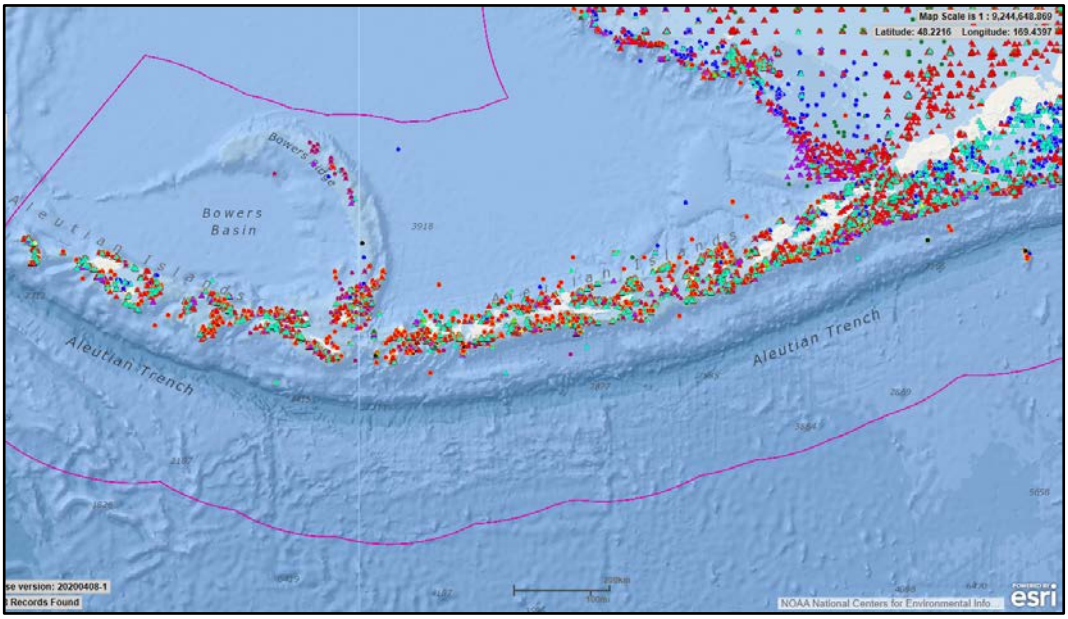
11:45-12:00 Heather Coleman (Deep-sea Mapping)

12:00-1:00 Questions and Discussion

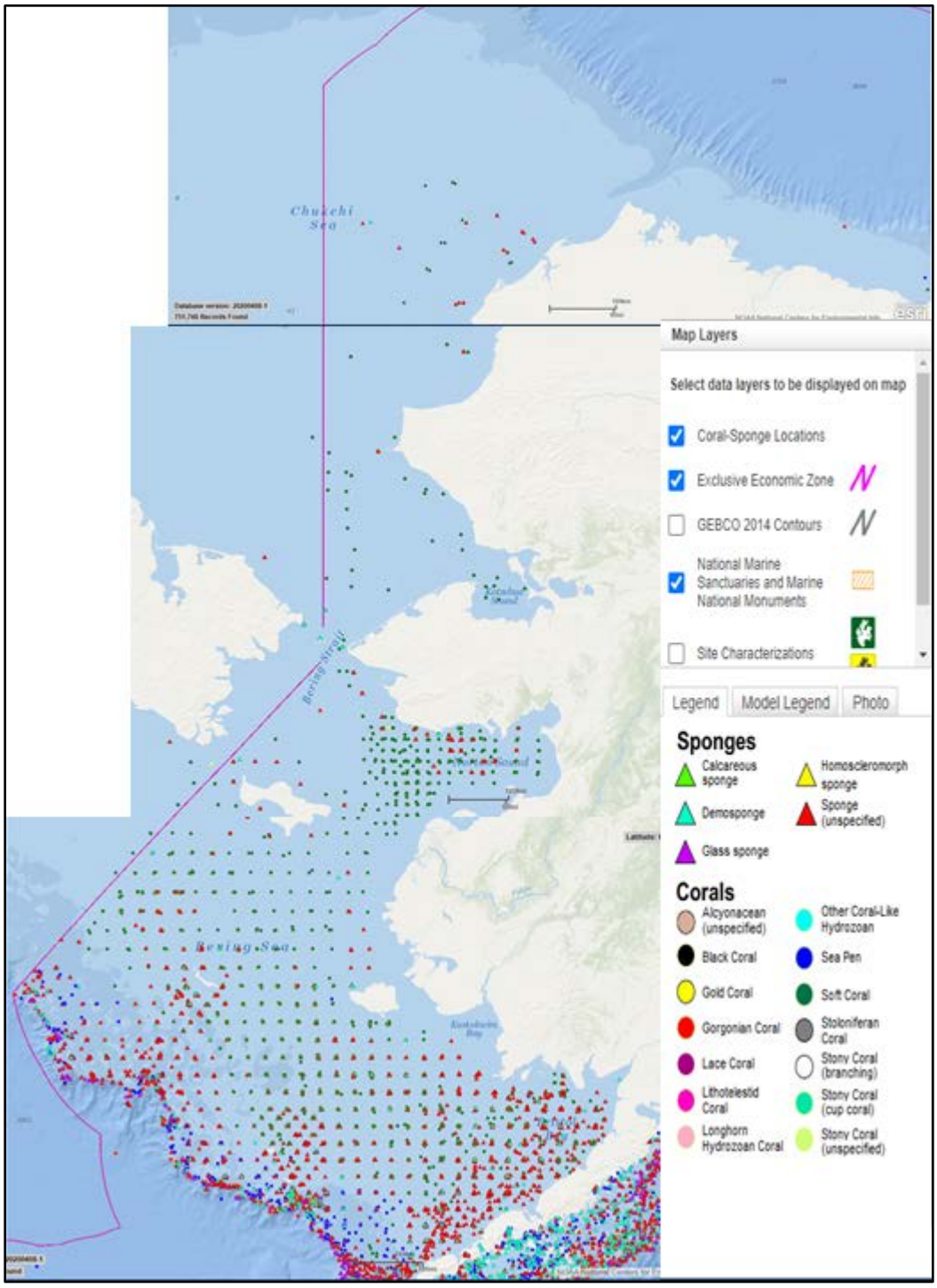
Appendix C. - Relevant Maps



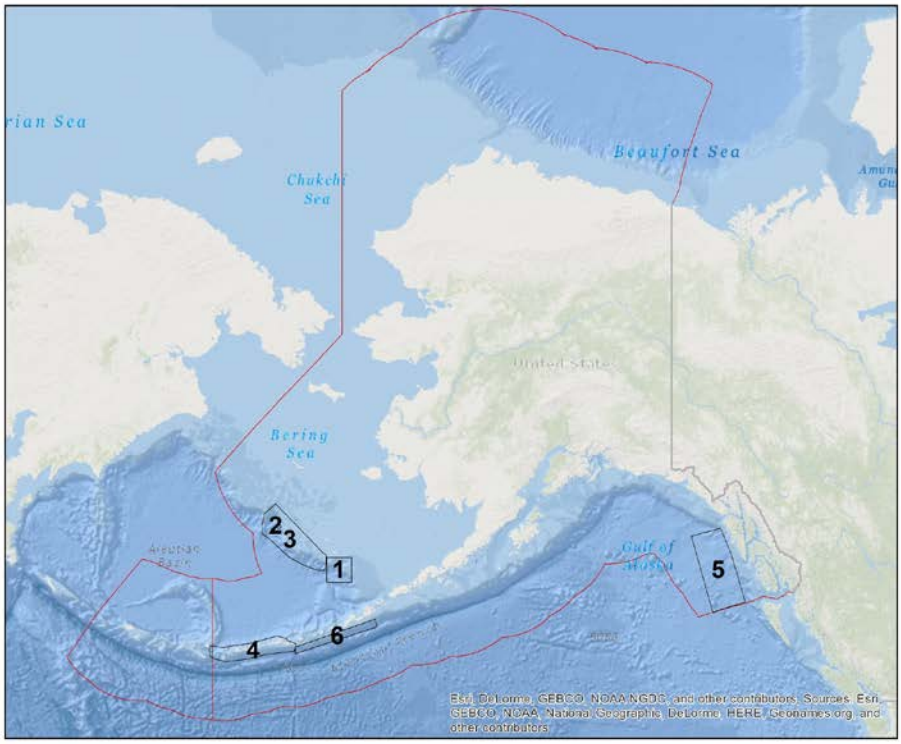
Appendix C. Figure 1. *Map showing deep-sea coral and sponge* ***presence*** *in the Gulf of Alaska. Markers are* ***not an indication of abundance****. Legend is attached to Appendix Figure 3. Adapted from NOAA DSCRTP Deep-Sea Coral and Sponge National Database.*



Appendix C. Figure 2. *Map showing deep-sea coral and sponge* ***presence*** *in the Aleutian Islands. Markers are* ***not an indication of abundance****. Legend is attached to Appendix Figure 3. Adapted from NOAA DSCRTP Deep-Sea Coral and Sponge National Database.*

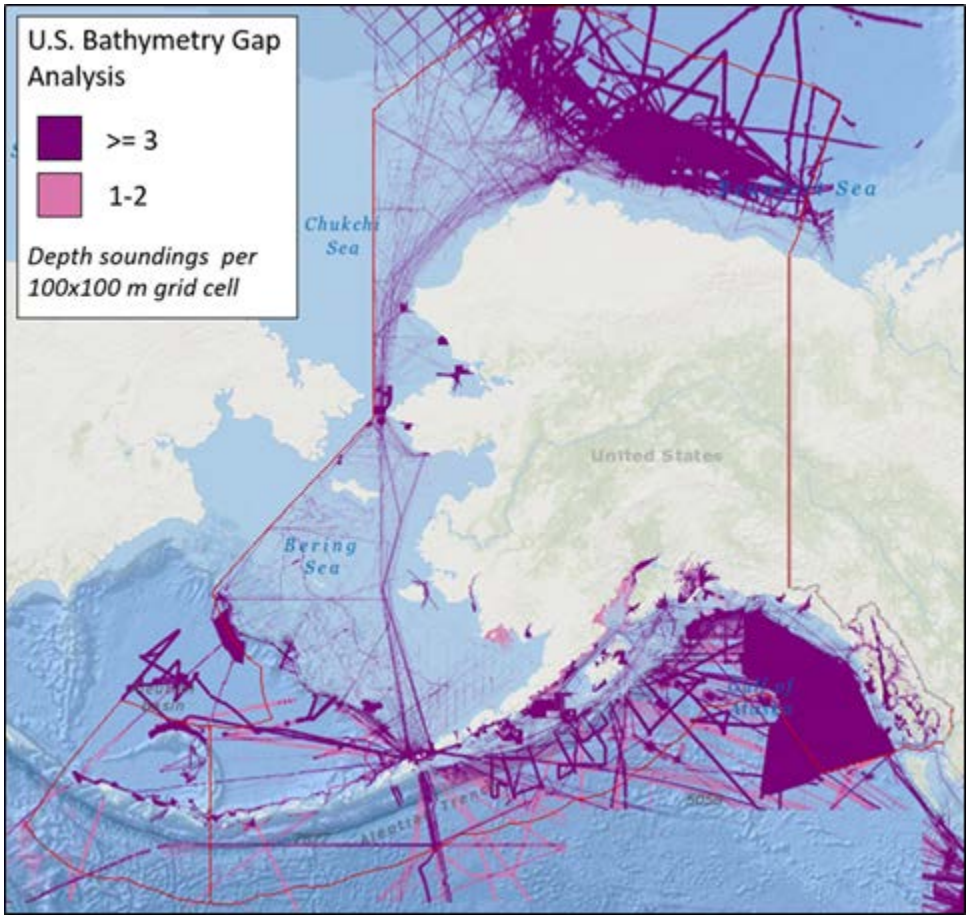


Appendix C. Figure 3. *Map showing deep-sea coral and sponge* ***presence*** *in the Bering and Chukchi Seas. Markers are* ***not an indication of abundance****. Adapted from NOAA DSCRTP Deep-sea Coral and Sponge National Database.*

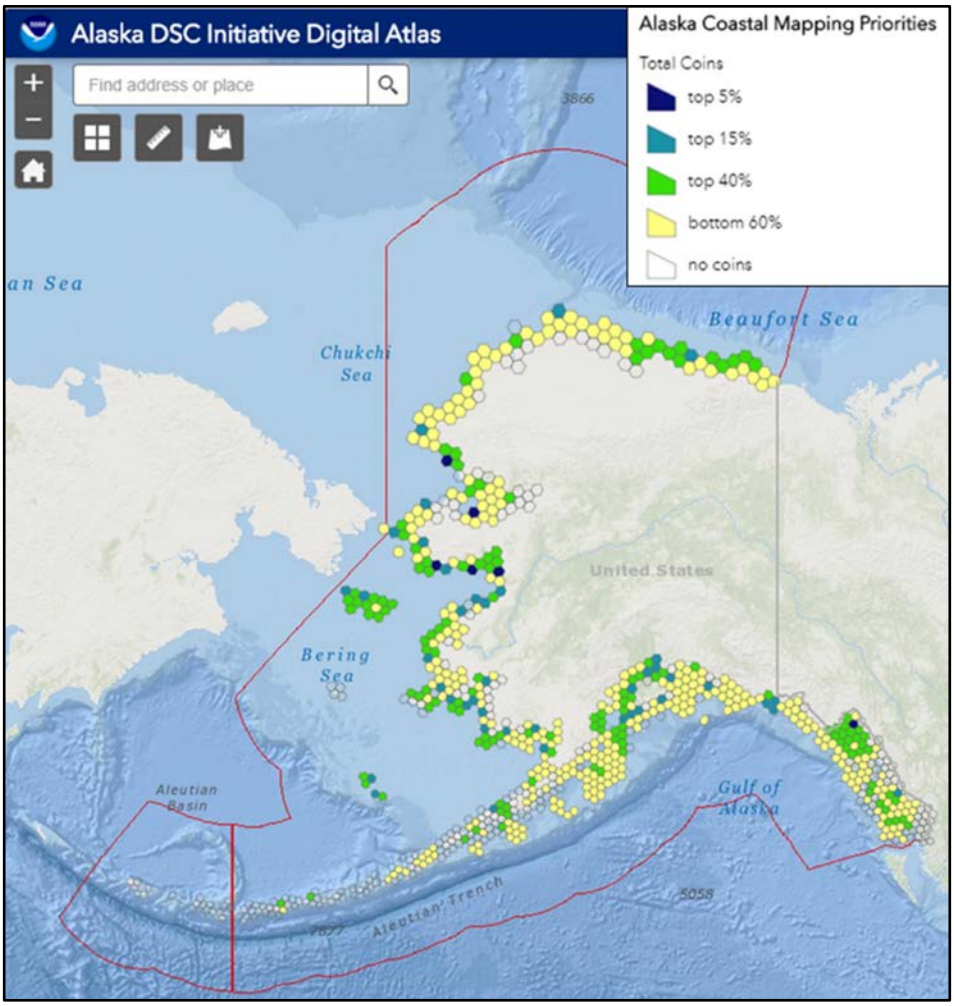


Numbe	Who	What	When	Why
1	U. Alaska (J. Reynolds)	MBES completed (16 m)	2021-2022	Hydrographic Survey. Available on NCEI: https://www.ngdc.noaa.gov/nos/H12001-H14000/H12115.html
2	NOAA AFSC (J. Hoff)	MBES needed	2021-2022	High DSCS area, high rockfish abundances
3	NOAA AFSC (J. Hoff)	MBES needed	2021-2022	High DSCS area, high rockfish abundances
4	U. Alaska (J. Reynolds)	MBES, Habitat Maps needed	2021-2022	17 coral study sites with multibeam + ROV/sub dives + Rooper's new camera drops.
5	CalState MLML (G. Greene)	MBES, ROV needed	2021-2022	Existing USGS-CGS Queen Charlotte fault MBES surveys; possible DSCS exploration.
6	CalState MLML (G. Greene)	MBES, ROV needed	2021-2022	Location of volcanic edifices and pinnacles are located; possible DSCS exploraiton.

Appendix C. Figure 4. *Priority locations identified by workshop participants for potential seafloor mapping during the AK DSCI.*



Appendix C. Figure 5. *Map showing seafloor bathymetry data gaps in the U.S. Exclusive Economic Zone around Alaska. This analysis was completed to inform a U.S. ocean and coastal mapping strategy for U.S. waters and contribute to the international Seabed 2030 initiative. Adapted from NOAA NCEI 2020 (click here).*



Appendix C. Figure 6. *Map showing seafloor mapping priorities identified during Alaska 2019 Coastal Mapping Prioritization. Adapted from Kumle et al. 2019 (click here).*

Appendix D. - Publications from 2010-2014 AK DSCSI

2020

1. Wilborn, R.E., C.N. Rooper, P. Goddard, K. Williams, and R. Towler. (2020). Benthic zooplankton community sampling in disparate habitats using an autonomous, deep-water plankton pump. Journal of Plankton Research. doi/10.1093/plankt/fbaa030/5863446

2. Williams B., E. Choy, K. Watanabe, P. Etnoyer, R. Stone, E. Druffel, T. Lorenson, and M. Knaak. (*in review*.) Understanding growth and age of red tree corals (*Primnoa pacifica*) in the North Pacific Ocean. PLoS One.

3. Winship, A.J., J. Thorson, E. Clarke, H.M. Coleman, B. Costa, S. Georgian, D. Gillett, A. Grüss, M. Henderson, G. Hoff, T.F. Hourigan, D. Huff, N. Kreidler, J. Pirtle, J.V. Olson, M. Poti, C.N. Rooper, A. Shelton, M. Sigler, S. Viehman, and C. Whitmire. 2020. Good practices for spatial predictive modeling of deep-sea corals and sponges: data collection, analysis, validation, and communication. Frontiers in Marine Science. https://www.frontiersin.org/articles/10.3389/fmars.2020.00303/full

2019

4. Chu, J.W.F., J. Nephin, S. Georgian, A.Knudby, C.N. Rooper, A. Knudby, and K.S.P Gale. 2019. Modeling the environmental niche space and distributions of cold-water corals and sponges in the Canadian northeast Pacific Ocean. *Deep Sea Research Part I: Oceanographic Research Papers*. https://doi.org/10.1016/j.dsr.2019.06.009

5. Conrath, C.L., C.N. Rooper, R.E. Wilborn, B.A. Knoth, and D.T. Jones. 2019. Seasonal habitat use and community structure of rockfishes in the Gulf of Alaska. *Fisheries Research*. https://doi.org/10.1016/j.fishres.2019.105331

6. Rooper, C.N., P. Goddard, and R.E. Wilborn. 2019. Are fish associations with corals and sponges more than an affinity to structure: Evidence across two widely divergent ecosystems? *Canadian Journal of Fisheries and Aquatic Sciences*. doi.org/10.1139/cjfas-2018-0264

7. Stone, R.P., H. Lehnert, and G.R. Hoff. 2019. Inventory of the eastern Bering Sea sponge fauna, geographic range extensions and description of *Antho ridgwayi* sp. nov. *Zootaxa*. 4567(2): 236-250. http://dx.doi.org/10.11646/zootaxa.4567.2.2

8. Waller, R.G., R.P. Stone, L.N. Rice, J. Johnstone, A.M. Rossin, E. Hartill, K. Feehan, and C.L. Morrison. 2019. Phenotypic plasticity or a reproductive dead end? *Primnoa pacifica* (Cnidaria: Alcyonacea) in the southeastern Alaska region. *Frontiers in Marine Science*. doi: http://dx.doi.org/10.3389/fmars.2019.00709.

2018

9. Goldsmith, D.B., C.A. Kellogg, C.L. Morrison, M.A. Gray, R.P. Stone, R.G. Waller, S.D. Brooke, and S.W. Ross. 2018. Comparison of microbiomes of cold-water corals *Primnoa pacifica* and *Primnoa resedaeformis*, with possible link between microbiome composition and host genotype. *Scientific Reports*. https://doi.org/10.1038/s41598-018-30901-z

10. Horvath, E.A. and R.P. Stone. 2018. Another unusual new gorgonian (Anthozoa: Octocorallia: Plexauridae) from the Aleutian Islands of Alaska. *Zootaxa*. http://dx.doi.org/10.11646/zootaxa.4524.1.8

11. Park, H., N. Tuan, J. Oh, Y. Son, M. Hamann, R. Stone, M. Kelly, S. Oh, and M. Na. 2018. Sesterterpenoid and steroid metabolites from a deep-water Alaska sponge inhibit Wnt/β-Catenin signaling in colon cancer cells. *Marine Drugs*. https://doi.org/10.3390/md16090297

12. Wilborn R.E., C.N. Rooper, P. Goddard, L. Li, K. Williams, and R. Towler. 2018. The potential effects of substrate type, currents, depth and fishing pressure on distribution, abundance, diversity, and height of cold-water coral and sponge in temperate, marine waters. *Hydrobiologia*. https://doi.org/10.1007/s10750-017-3492-9

13. Williams, B., K. McMahon, S. Barnes, D. Parks, E. Kim, T. Srebotnjak, and P. Etnoyer. 2018. Impact of skeletal heterogeneity and treatment method on interpretation of environmental variability from the proteinaceous skeletons of deep-sea gorgonian octocorals. *Chemical Geology*. https://doi.org/10.1016/j.chemgeo.2017.12.019

2017

14. Cairns S.D., R.P. Stone, E.A. Berntson, and S.A. Pomponi. 2017. Species discovery of deep-water corals and sponges in U.S. Waters (2007-2015), p. 57-92. In: T.F. Hourigan, P.J. Etnoyer, and S.D. Cairns (editors), p. 56-91. The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD.

15. Lehnert, H. and R.P. Stone. 2017. Description of a new species of Trichogypsiidae (Porifera, Calcarea) and first record of the genus in the Pacific Ocean. *Zootaxa*. http://dx.doi.org/10.11646/zootaxa.4312.2.13

16. Lehnert, H. and R.P. Stone. 2017. Two new species of Suberitida (Porifera, Heteroscleromorpha) from the Bering Sea. *Zootaxa*. http://dx.doi.org/10.11646/zootaxa.4338.3.9

17. MacLean, S.A., C.N. Rooper,and M.F. Sigler. 2017. Corals, canyons, and conservation: Science based fisheries management decisions in the eastern Bering Sea. *Frontiers Marine Science* 4: 1-5.

18. Rooper, C.N., R.P. Stone, P. Etnoyer, C. Conrath, J. Reynolds, H.G. Greene, B. Williams, E. Salgado, C. Morrison, R. Waller, and A. Demopoulos. 2017. Deep-Sea Coral Research and Technology Program: Alaska Deep-Sea Coral and Sponge Initiative Final Report. NOAA Technical Memorandum. NMFS-OHC-2, 65 p.

19. Rooper C.N., R.E. Wilborn, P. Goddard, K. Williams, R. Towler, and G.R. Hoff. 2017. Validation of deep-sea coral and sponge distribution models in the Aleutian Islands, Alaska. *ICES Journal of Marine Science*. 75(1):199-209.

20. Rooper, C.N., M. Zimmermann, and M. Prescott. 2017. Comparisons of methods for modeling coral and sponge distribution in the Gulf of Alaska. *Deep Sea Research Part II* 126:148-161.

21. Saenger, C., R.I. Gabitov, J. Farmer, J.M. Watkins, and R.P. Stone. 2017. Linear correlations in bamboo coral δ13C and δ18O sampled by SIMS and micromill: Evaluating paleoceanographic potential and biomineralization mechanisms using δ11B and Δ47 composition. *Chemical Geology* 454:1-14. http://dx.doi.org/10.1016/j.chemgeo.2017.02.014

22. Stone, R.P. and S.D. Cairns. 2017. Deep-sea coral taxa in the Alaska region: depth and geographical distribution. In: T.F. Hourigan, P.J. Etnoyer, and S.D. Cairns (editors). The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. https://deepseacoraldata.noaa.gov/library/2015-state-of-dsc-report-folder/NOAA_DSC-Species-List_Alaska_Stone-Cairns_2017.pdf

23. Stone, R.P. and C.N. Rooper. 2017. State of deep-sea coral and sponge ecosystems in the Alaska Region, p. 39-55. In: T.F. Hourigan, P.J. Etnoyer, and S.D. Cairns (editors), The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. https://deepseacoraldata.noaa.gov/library/2015-state-of-dsc-report-folder/Ch3_Stone-Rooper_Alaska.pdf

24. Stone R.P., P.W. Malecha, and M.M. Masuda. 2017. A five-year, in situ growth study on shallow-water populations of the gorgonian octocoral *Calcigorgia spiculifera* in the Gulf of Alaska. *PLoS ONE*. 12(1):e0169470. https://doi.org/10.1371/journal.pone.0169470

25. Wilborn R.E., C. Conrath, B. Knoth, and C.N. Rooper. 2017. Results from the underwater camera survey of the 49 Fathom Pinnacle and Snakehead Bank sites near Kodiak Island, Alaska. U.S. AFSC Processed Report. 2017-06, 75p

2016

26. Goddard P., R.E. Wilborn, C.N. Rooper, K. Williams, R. Towler, M. Sigler, and P. Malecha. 2016. Results of the 2014 underwater camera survey of the eastern Bering Slope and Outer Shelf. U.S. Dep. Commer., NOAA Technical Memorandum. NMFS-AFSC-313, 304p

27. Golden, N.E., J.A. Reid, M. Zimmermann, E.N. Lowe, and A.S. Hansen. 2016. Digitized seafloor characterization data from the Gulf of Alaska: U.S. Geological Survey data release, https://doi.org/10.5066/F7CV4FT9.

28. Kelly, M., C. Sim-Smith, R. Stone, T. Samaai, H. Reiswig, and W. Austin. 2016. New taxa and arrangements within the family Latrunculiidae (Demospongiae, Poecilosclerida). *Zootaxa*. 4121(1):001-048. http://dx.doi.org/10.11646/zootaxa.4121.1.1

29. Lehnert, H., and R.P. Stone. 2016. A comprehensive inventory of the Gulf of Alaska sponge fauna with the description of two new species and geographic range extensions. *Zootaxa*. 4144:365-382. http://dx.doi.org/10.11646/zootaxa.4144.3.5

30. Rooper C.N., M.F. Sigler, P. Goddard, P. Malecha, R. Towler, K. Williams, R. Wilborn, and M. Zimmerman. 2016. Validation and improvement of distribution models for structure-forming invertebrates in the eastern Bering Sea with an independent survey. *Marine Ecology Progress Series*. 551:117-130.

2015

31. Laman, E.A., S. Kotwicki, and C.N. Rooper. 2015. Correlating environmental and biogenic factors with abundance and distribution of Pacific ocean perch (*Sebastes alutus*) in the Aleutian Islands, *Alaska Fisheries Bulletin, U.S.* 113:270-289. https://www.st.nmfs.noaa.gov/spo/FishBull/1133/laman.pdf.

32. Lehnert, H. and R.P. Stone. 2015. New species of sponges (Porifera, Demospongiae) from the Aleutian Islands and Gulf of Alaska. *Zootaxa*. 4033:451-483. doi:http://dx.doi.org/10.11646/zootaxa.4033.4.1.

33. Sigler, M.F., C.N. Rooper, G.R. Hoff, R.P Stone, R.A. McConnaughey, and T. K. Wilderbeur. 2015. Faunal features of submarine canyons on the eastern Bering Sea slope. *Marine Ecology Progress Series*. 526:21-40.

34. Stone, R., D. Stevenson, and S. Brooke. 2015. Assessment of a pilot study to collect coral bycatch data from the Alaska commercial fishing fleet. U.S. Dep. Commer., NOAA Technical Memorandum NMFS-AFSC-296, 45 p. (.pdf, 5.4 MB).

2014

35. Lehnert, H., and R.P. Stone. 2014. Aleutian Ancorinidae (Porifera, Astrophorida): Description of three new species from the genera Stelletta and Ancorina. *Zootaxa*. 3826:341-355. doi:http://dx.doi.org/10.11646/zootaxa.3826.2.4.

36. Lehnert, H., R.P. Stone, and D. Drumm. 2014. *Geodia starki* sp. nov. (Porifera, Demospongiae, Astrophorida) from the Aleutian Islands, Alaska, USA. *Journal of the Marine Biological Association of the United Kingdom*. 94:261-265. https://doi.org/10.1017/S002531541300101X

37. Rooper, C.N., M. Zimmermann, M. Prescott, and A. Hermann. 2014. Predictive models of coral and sponge distribution, abundance and diversity in bottom trawl surveys of the Aleutian Islands, Alaska. *Marine Ecology Progress Series*. 503:157-176. doi: 10.3354/meps10710

38. Waller, R.G., R.P. Stone, J. Johnstone, and J. Mondragon. 2014. Sexual reproduction and seasonality of the Alaskan red tree coral, *Primnoa pacifica*. *PLoS ONE*. 9(4): e90893. https://doi.org/10.1371/journal.pone.0090893.

2013

39. Lehnert, H., and R.P. Stone. 2013. Four new species of Haplosclerida (Porifera, Demospongiae) from the Aleutian Islands, Alaska. *Zootaxa*. 3700:573–582. doi:http://dx.doi.org/10.11646/zootaxa.3700.4.5.

40. Zimmermann, M., M.M. Prescott, and C.N. Rooper. 2013. Smooth sheet bathymetry of the Aleutian Islands. U.S. Dep. Commer., NOAA Technical Memorandum NMFS-AFSC-250, 43 p. (.pdf, 2.4 MB).

Appendix E. - Acronyms

Alaska Deep-Sea Coral and Sponge Initiative	AK DSCSI
Alaska Department of Fish and Game	ADFG
Alaska Fisheries Science Center	AFSC
Alaska Regional Office	AKRO
Aleutian Islands	AI
Auke Bay Laboratories	ABL
Autonomous underwater vehicle	AUV
Bureau of Ocean Energy Management	BOEM
Conductivity-Temperature-Depth	CTD
Deep Sea Coral Research and Technology Program	DSCRTP
Deep-sea coral and sponge	DSCS
Department of Interior	DOI
Eastern Bering Sea	EBS
Environmental DNA	eDNA
Essential Fish Habitat	EFH
Essential Fish Habitat Conservation Areas	EFHCA
Essential Fish Habitat-Environmental Impact Statement	EFH-EIS
Exploration Vessel	*E/V*
Fisheries and Oceans Canada	DFO
Fisheries Management Plan	FMP
Gulf of Alaska	GOA
Habitat Area of Particular Concern	HAPC
International Pacific Halibut Commission	IPHC
Loss of sea ice	LOSI
Marine Biodiversity Observation Network	MBON
National Centers for Coastal Ocean Science	NCCOS
Non-government organizations	NGO
National Centers for Environmental Information	NCEI
National Marine Sanctuaries	NMS
National Oceanic and Atmospheric Administration	NOAA
National Ocean Service	NOS
North Pacific Fishery Management Council	NPFMC
North Pacific Research Board	NPRB
Northeast Fisheries Science Center	NEFSC
Northwest Fisheries Science Center	NWFSC
Ocean acidification	OA
Oceanic and Atmospheric Research	OAR
Office of Coast Survey	OCS

Ocean Exploration and Research	OER
Pacific Islands Fisheries Science Center	PIFSC
Pacific Marine Environmental Lab	PMEL
Remotely Operated Vehicle	ROV
Resource Assessment and Conservation Engineering	RACE
Restriction site associated DNA	RAD
Southeast Fisheries Science Center	SEFSC
Southwest Fisheries Science Center	SWFSC
Species Distribution Model	SDM
United States Geological Survey	USGS
University of Alaska	UAF
West Coast Deep-Sea Coral Initiative	WC DSCI