Essential Fish Habitat project status report

Reporting date: 4/04/2008

Project number: 2006-01

Title: Mapping Long Term Equilibrium Impacts of Fishing and Evaluation of Impacts of Fishing on Fish Condition, Fish Distribution, and Fish Diet

PIs: Kerim Aydin, Angie Grieg, Al Hermann, Anne Hollowed, James Ianelli, Craig Rose, Paul Spencer, William Stockhausen, Tom Wilderbuer

Funding year: FY 2006

Funding amount: $6,000

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported?
Yes. The data have been reported in the following NOAA Technical Memorandum (a followup peer-review publication is planned):
Aydin, K.Y., B. Matta and T. Buckley. Trends in bioenergetic foraging potential for walleye pollock in the Bering Sea. AFSC Tech. Memo. (in internal review).

Results: What is the most important result of the study?

We have created a series of bioenergetic maps on a 20-km resolution for the Bering Sea, showing (quantifying) the projected growth rates at fixed ration of walleye pollock in the summer, and interannual variation in this “growth potential.” These maps are based on water temperature and the quality of prey (caloric contents) measured on this 20-km scale from 1984-2006. We have automated the method of creating these maps to update them annually in the future based on trawl-survey data. The maps are available in gridded form or in the ArcGIS format by request and through the Tech Memo. These maps will become an important component of the Bering Sea Integrated Research Project (BSIERP) modeling effort for spatial variation in fish production (FEAST – Forage Euphausiid Abundance in Space and Time). The automation of this method through database tools means we can extend our work to other species with minimal effort; specifically arrowtooth flounder and Pacific cod are planned as part of the BSIERP research.

Essential Fish Habitat project status report

Reporting date: 10/30/2007

Project number: 2006 - 2

Title: Modify trawls to reduce fishing impacts / Better characterize fishing's footprint

PIs: Craig S. Rose

Funding year: FY 2006

Funding amount: $49,860

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Results were presented to the ICES Boston Symposium on Fishing Technology in the 21st Century (10/30-11/3, 2006) and at the December 2006 meeting of the NPFMC. Rose, C. 2006. Development and evaluation of trawl groundgear modifications to reduce damage to living structure in soft bottom areas. Available NOAA Alaska Fisheries Science Center 7600 Sand Point Way NE, Seattle WA 98115.

Results:

Installing widely spaced disk clusters on the sweeps of bottom trawls reduces damage or disruption to sessile seafloor invertebrates without reducing the herding of flatfish into the trawl.

Essential Fish Habitat project status report

Reporting date: 9/05/2007

Project number: 2006-03

Title: Assessment of critical habitats for juvenile Pacific cod

PIs: Allan Stoner, Benjamin Laurel, Thomas Hurst, Alisa Abookire & Clifford Ryer

Funding year: FY 2006

Funding amount: $55,638

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported?
Yes. The data have been reported in two manuscripts:

Laurel, B.J., A.W. Stoner, C.H. Ryer, T.P. Hurst and A.A.Abookire. 2007. Comparative habitat associations in juvenile Pacific cod and other gadids using seines, baited cameras and laboratory techniques. J. Exp. Mar. Biol. Ecol. (in press)

Stoner, A.W., Laurel, B.J. and T.P. Hurst. Using a baited cameras to assess relative abundance of juvenile Pacific cod: field and laboratory trials. J. Exp. Mar. Biol. Ecol. (in review)

Results: What is the most important result of the study?
1) 2006 appears to have been an unusually strong year for recruitment of age-0 Pacific cod to the Kodiak system. This is despite a very weak spawning season shown by poor winter fishing success. [Indeed, comparative data from 2007 reveal that 2006 was an exceptional year for Pacific cod recruitment to the 0-year class.]
2) A baited camera is a highly efficient system for observing and quantifying age-0 Pacific cod in habitats not easily sampled with traditional gear. Results from July collections show a direct correlation between numbers of cod observed in camera sets and seines. Data from expanded sampling in August will better test the relationship. The baited system is also a good tool for surveying predatory species. Experiments show that Pacific cod are most attracted to baits, while walleye pollock are weakly attracted.
3) Age-0 Pacific cod, saffron cod and walleye pollock occur in close proximity in the nearshore habitats of Kodiak. However, their occurrences in seagrass, *Laminaria* beds, and deeper sand/mud habitats vary inter-specifically, and the relationships shifted with time and fish size over the summer. In July, the cod species were closely associated with the macrophytes beds, and then expanded to unvegetated and deeper habitats in August.

4) In laboratory experiments age-0 Pacific cod did not demonstrate significant preference for habitats (sand, boulder, seagrass, kelp) except in the presence of a predator, when shelter-seeking was exhibited.

Essential Fish Habitat project status report

Reporting date:

Project number: 2006-5 & 2007-2

Title: Habitat effects on growth and condition of northern rock sole

PIs: Hurst, Abookire, Heintz, & Short

Funding year: 2006 & 2007

Funding amount: $17,652 FY06; $28,865 FY07

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

The results of this work are reported in a manuscript submitted to Canadian Journal of Fisheries and Aquatic Sciences. The manuscript received positive reviews and will be accepted pending final minor revisions.

An electronic copy of the MS is attached. A final version of the manuscript will also be sent when accepted.

Results: What is the most important result of the study?

The most important results of the work are that the growth rates at our three focus study sites have maintained their rank order over the 3+ sampling seasons to date. Holiday Beach has consistently supported faster growing age-0 rock sole than Pillar Creek Cove and Shakmanof Beach. While growth variation is correlated with temperature variation, it is not the primary driver of growth variation in this system. Growth rates were not correlated with fish density. In addition, analyses indicate that size and time of settlement may be significant contributors to size variation.

Essential Fish Habitat project status report

Reporting date: September 4, 2007
Project number: EFH Project 2006-08
Title: Essential Fish Habitat Requirements for Skate Nurseries
PIs: Gerald R. Hoff
Funding year: FY 2006
Funding amount: $78,000
Status: ☒ **Complete** ☐ **Incomplete, on schedule** ☐ **Incomplete, behind schedule**
Planned completion date if incomplete:

Reporting: Have the project results been reported? YES **If yes, where were the results** reported? My Ph.D. dissertation (University of Washington, School of Aquatic and Fishery Sciences). Also results are being prepared in three manuscripts for submission in the primary literature during fall of 2007.

Results: What is the most important result of the study?
The research in 2006 confirmed the distribution of two previously known skate nursery sites for the Alaska and Bering skates, and located two additional sites for the Alaska and Aleutian skates. Seven nurseries located to date all occurred along the upper slope of the eastern Bering Sea. The nurseries were small in area (<2 km^2) and occurred over a narrow depth range (from 150 to 375 meters) on generally flat sandy to muddy bottom with little bottom structure or attached biota. Many sites were associated with canyon areas and were generally located in the upper portion of canyon heads. Nurseries were highly productive, with >100,000 viable eggs/km^2 occurring in some sites. Newly deposited embryos experienced mortality from snail predators with evidence of higher predation rates at northern sites, and evidence of multiple predators present within a single nursery site. At all sites Pacific halibut and Pacific cod showed evidence of consumption of newly hatched skates.

Conclusions drawn from this research suggest the shelf slope interface is an important habitat for successful skate reproduction possibly due to ample food availability and relatively warm constant bottom temperatures. In general the upper slope habitat is important for skate egg deposition and embryo development. However, nursery areas do not appear to be utilized by juvenile and sub-adult individuals. Evidence suggests these stages move to either shallower shelf waters (Alaska skate) or deeper waters (Aleutian and Bering skates) soon after emergence from the egg case.

Essential Fish Habitat project status report

Reporting date: 28 August 2009

Project number: 2006-11

Title: Convene a workshop to plan for the development of a habitat data inventory system for the AFSC.

PIs: Jon Heifetz, Bob McConnaughey, John Olson

Funding year: 2006[1]

Funding amount: $15,000

Status: ■ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule
The EFH Data Inventory Workshop was held 20-21 September 2007 in the Jim Traynor Conference Room at the AFSC in Seattle, Washington.

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported? McConnaughey, RA, JV Olson, MF Sigler. 2009. Alaska Fisheries Science Center Essential Fish Habitat Data Inventory. AFSC Processed Rep. 2009-01, 40 p.

Results: What is the most important result of the study? A total of 22 habitat-related data sets were summarized in a standard written format and orally presented to 27 individuals representing five AFSC Divisions, the Alaska Regional Office, the Alaska Department of Fish and Game and the environmental group Oceana. The Workshop thereby satisfied the primary objective to improve awareness of these data within the AFSC research community.

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[1] The workshop was not funded on the primary FY06 list of projects. The $15K travel money was allocated from national EFH money but was received too late in the fiscal year to be used. The funds were carried into FY07 with the assistance of the RACE and ABL Directors.

Essential Fish Habitat project status report

Reporting date: October 31, 2013

Project number: 2006-12, 2007-12, 2008-06

Title: **Overwinter habitat use and energy dynamics of juvenile capelin, eulachon, and Pacific herring**

PIs: J. Vollenweider, R. Heintz

Funding year: FY 2006-2008

Funding amount: 2006: $50,300; 2007: $57,900; 2008: $44,540

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Reporting: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Results:

Winter starvation mediated by low-levels of foraging is likely an important mechanism structuring recruitment success of juvenile forage fish. Over the course of two winters, we observed size-selective mortality in juvenile eulachon and capelin stemming from starvation in the smallest individuals. Between the fall and subsequent spring sampling periods, length frequency distributions of juveniles shifted towards larger individuals, which could either be indicative of a loss of smaller fish or growth (Figure 1). Growth overwinter is highly unlikely, however, as fish lost energy during this period and therefore surplus energy would not have been available for growth.

Winter energy deficits resulted from the loss of both lipid and protein energy. The magnitude of the deficit and relative depletion of lipid and protein were size dependent (Figures 2 and 3). Larger juveniles began winter with greater lipid reserves than smaller fish. During winter, larger fish depleted more of their pre-winter lipid reserves than smaller fish, and as a consequence, the contribution of lipid catabolism to the winter energy deficit increased with body size (Figure 4). Although the relative proportion of protein loss was independent of body size, the smallest fish lost more energy in the form of protein than lipid. By the end of the winter, the energy content of the smallest surviving juveniles was very near the energetic threshold, below which mortality occurs (Figure 5). Thus, the smallest juveniles were under extreme nutritional stress and were forced to metabolize protein to meet most of their metabolic demands, apparently as a consequence of exhausting lipid reserves.

Comparisons from two bays (Fritz Cove and Berners Bay) indicate that prey availability plays an important role in survival of juvenile fish that are on the brink of starvation in winter. Despite a general scarcity of prey during winter, what little forage juvenile fish could consume appeared to help stave off starvation. Nearly half the juvenile eulachon were feeding during the winter, as evidenced from stomach contents. Zooplankton prey species, particularly copepods, were more abundant in Fritz Cove than Berners Bay (Figure 6). Though juvenile eulachon in Fritz Cove were smaller and had lower energy reserves going into winter, they were in better condition than those from Berners Bay in the spring, suggesting that prey availability may help to preserve lipid reserves and thereby reduce starvation risk.

Collectively, these results indicate that the smallest eulachon and capelin do not store sufficient reserves of lipid for winter, are forced to metabolize protein, and may suffer a greater risk of winter mortality. Winter foraging, despite low prey abundance, may be crucial for survival. We suggest that disproportionately high rates of starvation among the smallest age-0 forage fish are important mechanisms influencing recruitment.

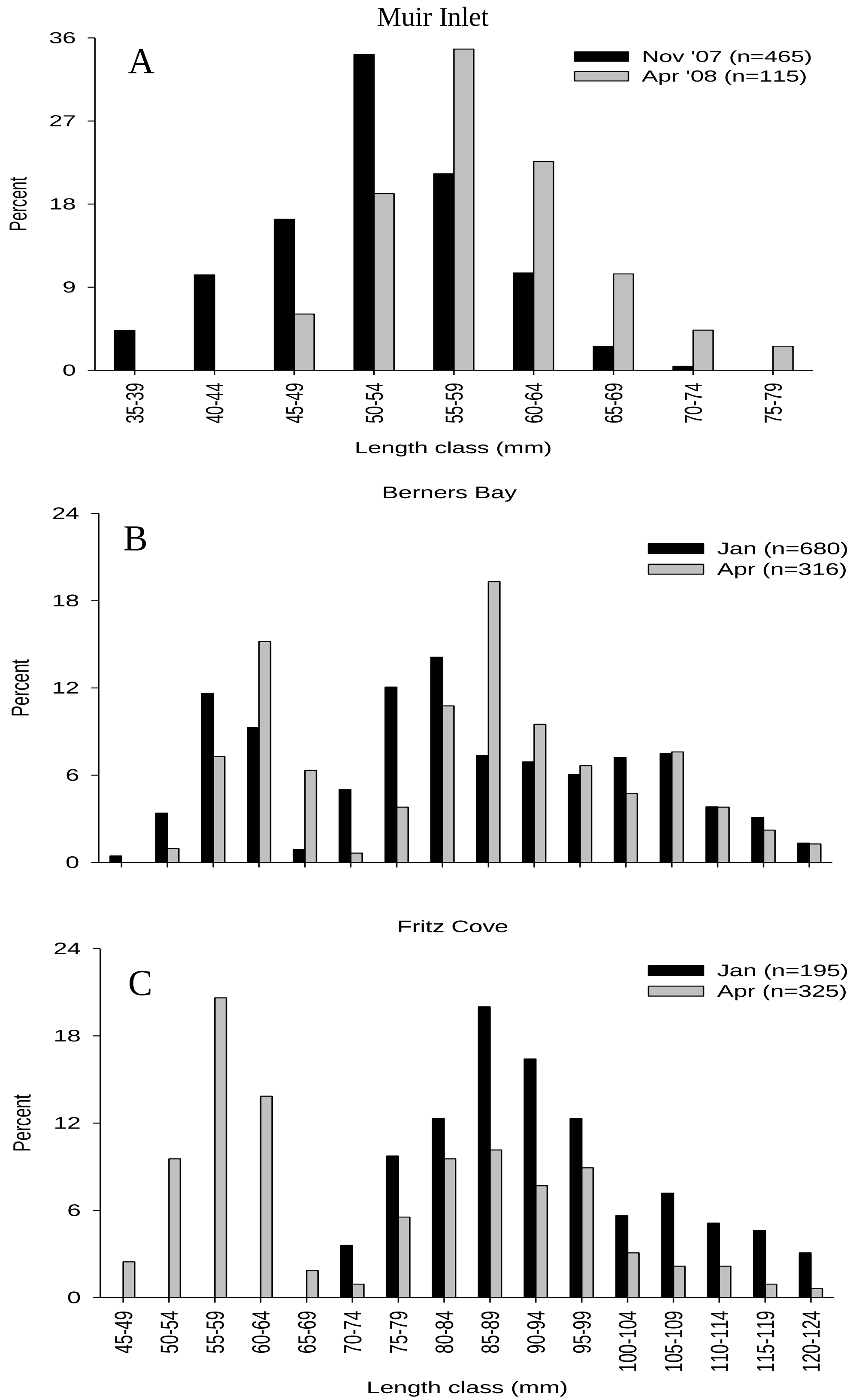

Figure 1. Shift in size distribution of juvenile capelin (A) and eulachon (B & C).

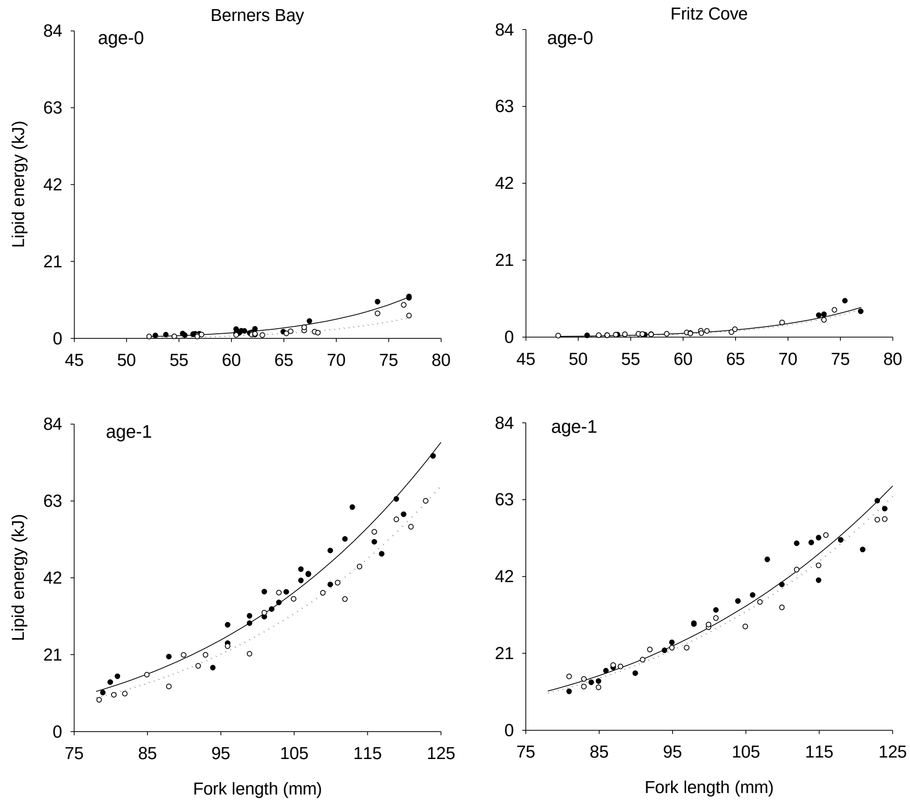

Figure 2. Energy allocated to lipid in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

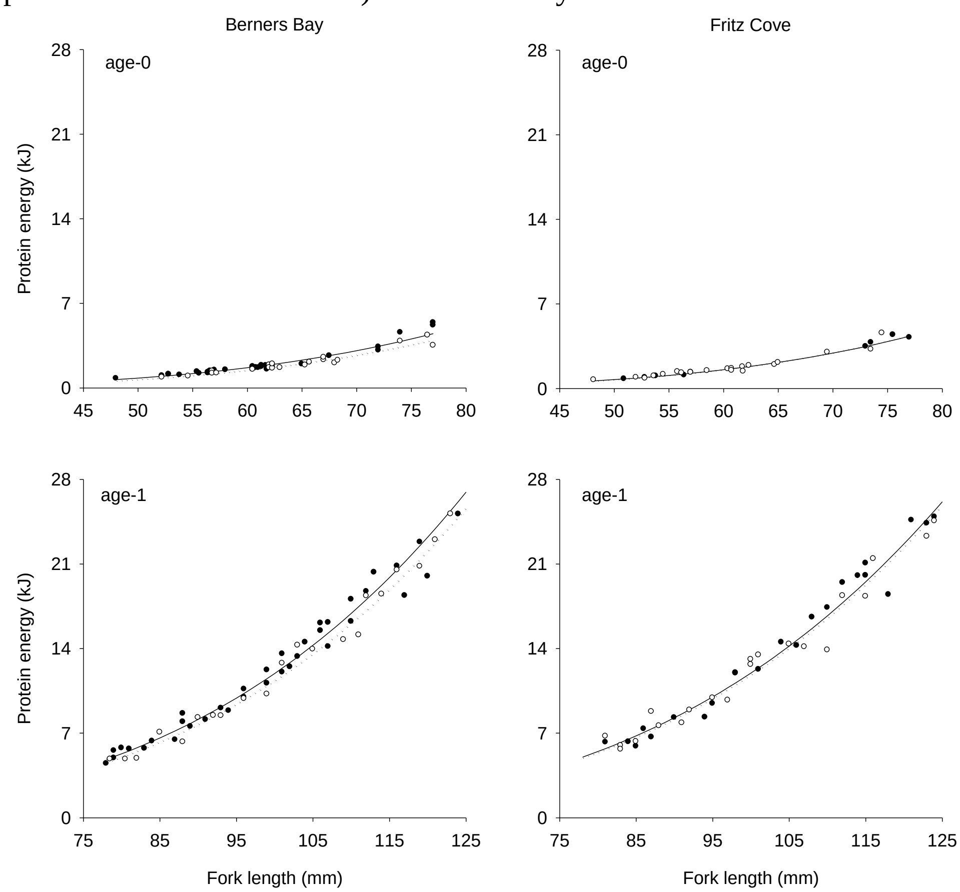

Figure 3. Energy allocated to protein in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

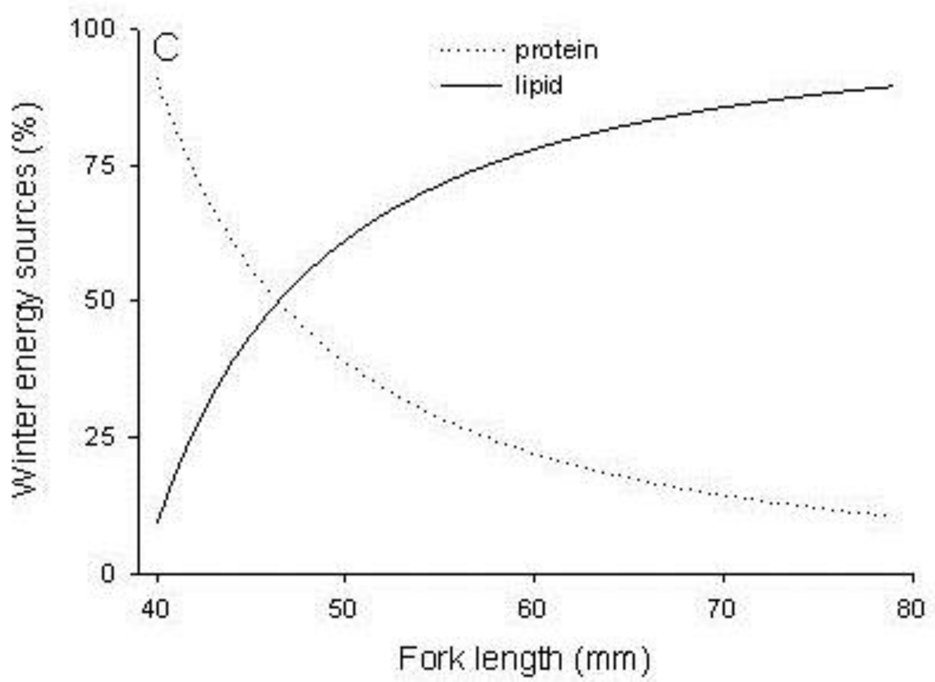

Figure 4. Modeled relationships between capelin fork length and the relative contribution of lipid and protein energy to the winter energy deficit.

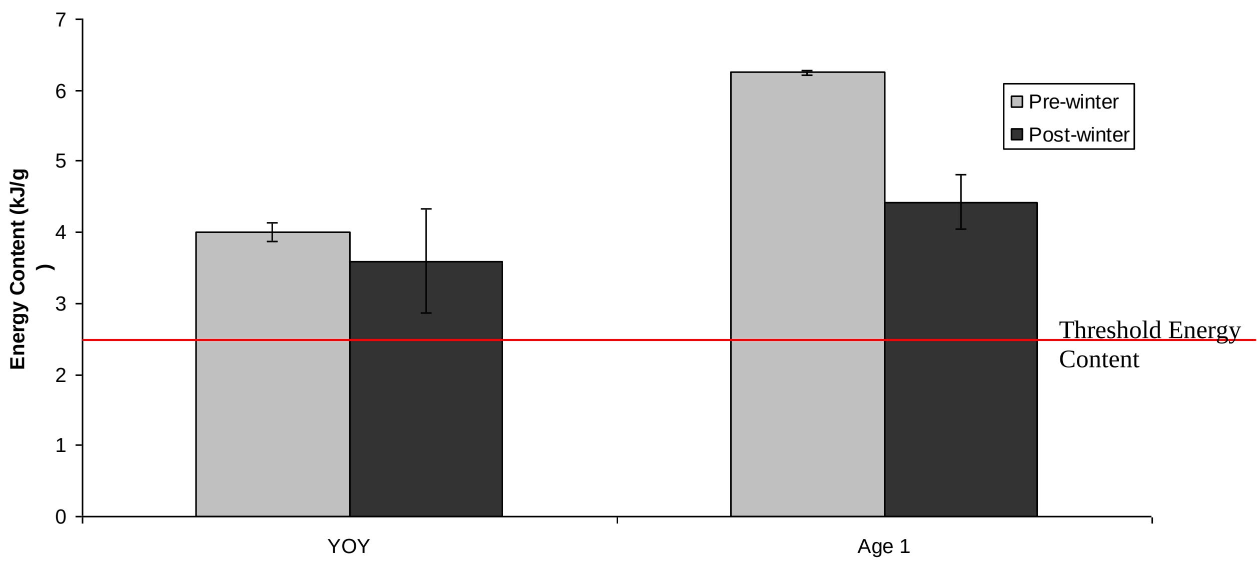

Figure 5. Overwinter energy loss (kJ g^{-1}) of juvenile capelin. Red line denotes the threshold energy content below which mortality occurs.

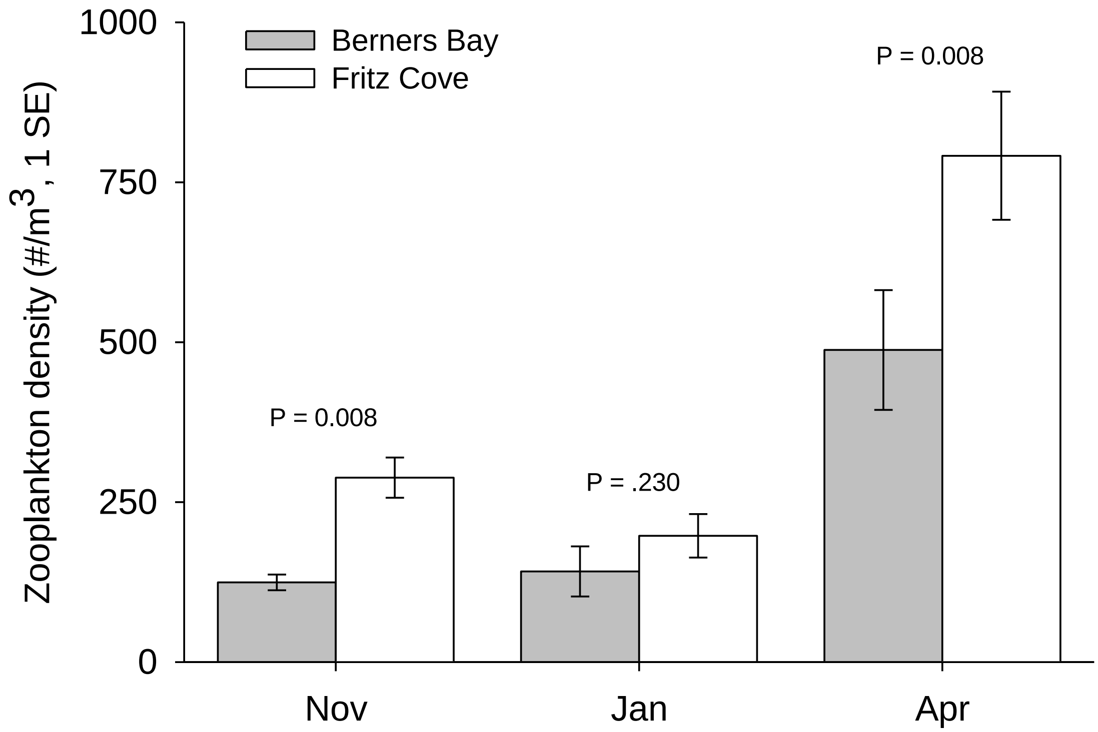

Figure 6. Zooplankton abundance in Berners Bay and Fritz Cove during winter 2006/2007. P-values are from Mann-Whitney U tests.

Essential Fish Habitat project status report

Reporting date: 10/13/2010

Project number: 2006-14

Title: Juvenile Rockfish Habitat Utilization

PIs: Pat Malecha

Funding year: 2006

Funding amount: $38,200

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Reporting: Results were reported at the 15^Th^ Western Groundfish Conference and in an oral presentation as part of the HEPR-themed AFSC seminar series. A manuscript is nearly complete and shall be submitted to an appropriate journal this fall/winter.

Results: Habitat preference trials indicate that quillback rockfish utilize coral more than any other habitat type particularly during daytime. Sponge and cobble are also preferred to gravel; however, the strength of association between rockfish and the various habitat types is considerably weaker at night. At night, quillback rockfish were more often in contact with bottom substrate and were less closely associated with emergent habitats. The pattern of quillback rockfish habitat utilization in the presence of a predator was remarkably similar except that rockfish utilized the coral, sponge and cobble habitats to a greater extent than when no predators were present. The lowest rate of predation was observed within coral habitat whereas, the highest rate of predation occurred in with gravel habitat. The average number of rockfish consumed per trial was about four times lower in the coral habitats than in the gravel habitats. Predation rate among the sponge and cobble habitats was intermediate to the rates among coral and gravel. The rate among sponge habitats was slightly lower than the rate among cobble habitats.

Essential Fish Habitat project status report

Reporting date: 8/29/08

Project number: 2006-16

Title: Nearshore Essential Fish Habitat–Seasonal Fish Use, Mapping, GIS Database

PIs: Johnson, Thedinga, Lindeberg, Harris

Funding year: 2006

Funding amount: $110,000

Status: [X] Complete [ ] Incomplete, on schedule [ ] Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported? Yes

1. Johnson et al. 2008. Seasonal Distribution, Habitat Use, and Energy Density of Forage Fish in the Nearshore Ecosystem of Prince William Sound, Alaska. Final report submitted to NPRB on 30 July 2008. Three peer-review publications will result from this final report.

2. Nearshore Fish Atlas of Alaska website (http://www.fakr.noaa.gov/habitat/fishatlas/) available to resource managers online; database includes fish catch by habitat type, fish size, species composition, fish and site photos, site coordinates, temperature, and salinity data for the Arctic, the Aleutian Islands, Cook Inlet, Prince William Sound, and southeastern Alaska.

Results: What is the most important result of the study?

1. Four species accounted for 92% of the total catch in Prince William Sound–Pacific herring, saffron cod, pink salmon, and capelin. Total catch (all spp.) increased seasonally in 2006 (4,653 fish in April, 5,274 fish in July, 7,861 fish in September); this indicates that fish occupy shallow, nearshore waters for at least several months a year. More importantly, species composition changed with season–pink salmon dominated catches in April, saffron cod and herring in July, and capelin in September. Catches differed among habitat types for some species–catches of saffron cod were greater in eelgrass than in bedrock or kelp, whereas catches of capelin were infrequent and mostly in kelp. Fish abundance was similar in eelgrass and kelp during day and night, but mean size of fish increased and number of fish species in kelp increased at night. Nearshore habitats are utilized by young-of-the-year herring and saffron cod as nursery areas to grow and to store energy before winter.

Essential Fish Habitat project status report

Reporting date: 9/6/07

Project number: 18

Title: Food habits and small scale habitat utilization of Atka mackerel in the Aleutian Islands, Alaska

PIs: Sandra Lowe

Funding year: FY 2006

Funding amount: $13,761

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported? Yes. An initial report is completed and we are revising this report for submission to the Alaska Fishery Research Bulletin.

Results: What is the most important result of the study? Atka mackerel feeding habits including diet composition and feeding intensity varied both spatially and temporally. Water column mixing and stratification seemed to play a significant role in feeding intensity at Seguam Pass and marginally near Amchitka Island. Trawl exclusion zone boundaries (disturbed and undisturbed habitat) appear to be significant in determining feeding intensity near Amchitka Island, as average stomach fullness was greater inside the trawl exclusion zones.

Essential Fish Habitat project status report

Title: Evaluation of Essential Fish Habitat Recovery at Log Transfer Facilities in southeastern Alaska by Katharine Miller, Stanley Rice, and John Hudson

Reporting date: 31 October 2007

Project number: 20 Funding year: 2006 Funding amount: $43,500

Status: Pilot study completed August 2006

Reporting: Have the project results been reported? If yes, where were the results reported? See attached report.

Results: What is the most important result of the study?

This was the first of a planned two-year study evaluating the recovery of Essential Fish Habitat impacted by log transfer facilities (LTFs) 10 to 30 years ago. The study focused on six LTFs and one log storage facility (LSF) located in estuaries and embayments on Baranof and Kruzof Islands in southeastern Alaska. The pilot year was designed as a survey to assess physical and biological recovery and to evaluate different sampling methods to assess recovery. Funding for a second more detailed study year was not received.

Recovery of physical habitat was noted at all LTFs, particularly with respect to bark degradation as divers often had difficulty identifying the edge of bark deposits. Non-recovery was observed at an LSF in Shulze Cove. Habitat at this site was highly impaired as evidenced by the presence of a 1 m deep gelatinous bacterial/organic layer that was anoxic and sulfide producing.

Fish and invertebrate abundance and species diversity differed between the facility sites and reference sites at six of seven locations, and the organic content of sediment samples was generally higher at LTFs than at adjacent reference sites. The results of nonparametric stepwise regression suggest that, for both fish and invertebrate assemblages, differences are correlated with a transition of species from outside to inside waters and with differences in organic content of the sediments

This pilot study indicates that benthic habitats impacted by LTFs are mostly in a recovering state, whereas habitat at the LSF has not yet begun. Additional time is needed for complete recovery at all sites and our findings suggest that biological recovery of the invertebrate and fish communities will lag behind physical recovery. The intense studies conducted 25 to 30 years ago by Shultz and Berg (1976) and O'Clair et al. (1988) should be repeated to determine the long term impacts of LTFs on essential fish habitat. This study attempted to evaluate recovery by spending one day assessing each site. A future study should spend several days at one site to evaluate recovery as a single day does not allow time for adequate study. We recommend that candidate sites for evaluation should be screened by assessing the bark content, depth, and water quality of sediments. For cost reasons, this study was restricted to a relatively small area; a more comprehensive study, not restricted to 10 field days, should focus on the most impacted sites in southeastern Alaska, as determined by volume of timber transferred to specific LTFs.

Evaluation of essential fish habitat recovery at Log Transfer Facilities in southeastern Alaska

Katharine Miller, Stanley D. Rice, and John Hudson

Introduction

Logging activities on the Tongass National Forest in southeastern Alaska were extensive from the 1950s to the 1980s, supporting two pulp mills and several saw mills for local development and export of lumber. Damage to essential fish habitat from harvest and road-building activities was obvious in the uplands as streams in affected watersheds suffered were denuded of buffer strips, and spawning and overwintering habitat was negatively impacted (USDA 1995). Less obvious were impacts to essential fish habitat at log transfer facilities (LTFs) where logs were placed into marine waters for transport to mills. These habitats were extensively surveyed in the late 1970s and early 1980s (Schultz and Berg 1976, Freese et al. 1988). These surveys revealed negative impacts to water quality and benthic communities within areas of bark deposition.

The purpose of this pilot study was to evaluate the physical, chemical, and biological characteristics of some of these log transfer facilities 25-30 years after closure. Information from this cursory study can be used to justify further study, and possibly the need for intervention in some habitats to support active restoration. Our general study design was to compare water quality, fish and invertebrate community composition, and substrate characteristics between an LTF zone of deposit and an adjacent Reference (REF) site. This study design was intended to evaluate the rate and effectiveness of natural recovery of benthic habitats near LTFs. Study methods were similar to those used in earlier studies with the addition of a fish community assessment component.

Study Approach and Site Selection

We chose six former LTFs located in estuaries and embayments on Baranof and Chichagof Islands in southeastern Alaska (Figures 1 and 2) based on the following criteria: 1) volume of timber transferred through the LTF when it was operational, 2) years since the LTF was operational, and 3) inclusion in prior studies (Schultz and Berg 1976; Freese et al. 1988). We also included a log storage facility (LSF[1]) in Schulze Cove in the study. Both the Alaska Department of Environmental Conservation and the U.S. Fish and Wildlife Service have documented habitat loss and water quality problems at this LSF.

At each location, a four person dive team and two surface biologists spent approximately one day measuring a variety of physical, chemical, and biological parameters at each LTF and a nearby REF site. After locating the zone of deposit (ZOD), the dive team marked

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[1]For simplicity, the Schulze Cove LSF is herein referred to as an LTF.

the ZOD boundary, measured bark depth, and collected pore-water samples along transects established across the ZOD. At the same time, a surface team in a skiff measured several water quality parameters at the LTF and REF sites. The fish community was sampled at LTF and REF sites with a small bottom trawl. Physical and biological data from each LTF site were compared to companion REF sites to determine if adverse effects were continuing, and where possible, comparisons were made to the surveys completed 25-30 years ago. The study was conducted in July and August 2006 during a single 10-day cruise aboard the M/V *Sundance*.

OBJECTIVES AND METHODOLOGY

1. Determine the extent of bark deposit at each site: At each site (Figures 1 and 2), the location of the ZOD was determined from latitude and longitude coordinates provided in the earlier reports and from visual inspection of the upland area. A four-person dive team working in pairs was deployed to delineate the bark ZOD. ZODs were delineated in the same manner as in the earlier studies. The two-person dive teams entered the water from shore and swam away from shore until bark was encountered. Each team then swam in opposite directions until reaching the edge of the ZOD. Next, the divers swam in opposite directions along the perimeter releasing marking buoys to demarcate the ZOD. Surface biologists in a skiff used the buoys as a guide to map the ZOD using a GPS unit. Divers did not attempt to delineate the Schulze Cove ZOD due to its large size.

2. Determine the sediment depth and sediment composition at each site: Bark depth was our primary means of evaluating habitat recovery at LTF sites because depths could be compared to those measured in previous studies. During this study it became apparent to the divers that depth measurements included intact and decomposed bark as well as natural underlying sediments. Therefore, depths from this study are likely not comparable to those from earlier studies. However, in this study, sediment samples were collected and analyzed in the lab to compare the organic matter content of sediment from LTF and REF sites. Bark and other plant matter was visually sorted from the largest size fractions of these samples while the smallest size fractions were burned to determine their ash-free dry mass content, a surrogate for bark content since bark from these fractions was too small to distinguish visually.

Once the bark zone of deposit (ZOD) was delineated, one or more transects were established along a depth contour within the center of the deposit. A REF site was selected near the LTF site in an area with similar bathymetric features. Buoys were used to establish a transect in the REF site at the same depth as in the LTF site. At each site except Schulze Cove, divers collected a minimum of five 250 ml sediment samples along each transect by scooping the top layers of sediment into collecting jars. The depth of the sediment at LTF sites was measured to the nearest centimeter by pushing a marked rod into the bottom to refusal. In the earlier reports, the sediment depth was equated to the depth of bark (Table 1). In this study we refer to "sediment" depth because divers could not determine to what degree they were measuring bark and natural underlying sediment. In our study, the percent organic content of the sediment was determined by dry sieving the sediment through .063, .500, 2.00, and 4.75 mm sieves. Sediment in the 2.00-4.75

mm and > 4.75 mm fractions was separated by hand with the aid of a dissecting microscope into mineral (rock and shell) and organic (bark and other organic debris) components. Each component was then weighed (0.001 g) and the percent organic fraction calculated. Percent ash-free dry mass (AFDM) was determined for the .063-.500 mm and .500-2.00 mm fractions by burning samples in a muffle furnace at 500°C for 5 to 19 hours. Because individual LTF and REF pairs were co-located within the same estuary, it is reasonable to expect that in the absence of a secondary source of organic material, the organic content of the sediment would be relatively similar at both the LTF and REF sites. Therefore, we used the difference in organic content in the smaller sediment size fractions (0.063-0.500 mm and 0.500-2.00 mm), rather than the substrate depth, to represent bark in these samples.

3. Determine water quality at each LTF and Reference site: Hydrogen sulfide concentration in sediment pore water was measured at each LTF and REF site. With the exception of Schulze Cove, pore-water samples were collected from well points inserted into the substrate at three locations along each dive transect. Immediately after inserting the point, two water samples were withdrawn into a 60 ml plastic syringe. The first sample was discharged and the second sample was retained in the syringe until analyzed. Water samples from the Schulze Cove LTF site were collected using a horizontal water sampler that was lowered into a 1 m layer of colloidal ooze overlying the natural bottom. Water samples were analyzed 2-6 hours after collection using a colorimetric test kit (Hach Company™ Model HS-WR). Dissolved oxygen (D.O.) and water temperature were measured at the sediment/water interface at three locations in each LTF and REF site with a YSI 55™ dissolved oxygen meter. Salinity and temperature profiles were obtained from the center of each site with a CTD profiler (SEACAT SBE 19 plus, Sea-Bird Electronics, Inc.).

4. Determine biological use on the surface of the bark deposit: A small-mesh otter trawl (3 m x 1 m) towed behind a skiff was used to sample fish and invertebrates near the bottom of each LTF and REF site. The trawl was towed at approximately 3 knots with a minimum of one haul in each direction along the same transect. Tow speed and bottom-time were recorded. Fish were identified, counted, and measured for length and invertebrates were identified and counted. To minimize variability between LTFs and their paired REF sites, trawl transects in the LTFs were selected to ensure the entire trawl occurred within the bark footprint or ZOD, and at a location roughly in the middle of the identified bark footprint while transects at the REF sites were selected to match the length and depth of the transects at the LTF sites as closely as possible. The length of the trawl transects at each LTF and REF site was calculated as the distance between the beginning and ending latitude and longitude coordinates of each transect.

Data Analysis:

The relationship of fish and invertebrates assemblages to water quality variables and sediment organic content were performed using nonmetric multidimensional scaling (NMDS) and step-wise analysis of weighted Spearman rank-correlations using the PRIMER 6® statistical software. Abundance data was transformed to the fourth root and standardized prior to calculation of Bray-Curtis similarity coefficients The Bray-Curtis coefficient calculates the similarity between the *j*th and *k*th samples using the following formula:

$$S_{jk} = 100 \frac{\sum_{i=1}^{p} 2 \min(y_{ij}, yi_k)}{\sum_{i=1}^{p} (y_{ij} + y_{ik})}$$

Where y_{ij} represents the *i*th row and *j*th column of that matrix of species abundances and y_{ik} is the *i*th species in the *k*th sample. S= 0 if the two samples have no species in common and 100 if they are identical (Clark and Warwick, 2001).

Because of the differences between fish and invertebrate assemblages at sites inside and outside Peril Strait, stepwise nonparametric regression on the ranked biotic and abiotic similarity matrices was conducted separately for each group. The analysis evaluates whether biologically similar sites also are similar in terms of the environmental variables.

A similarity matrix of water quality and sediment organic content was calculated using Euclidean distance. Environmental variables included average temperature, average percent saturation, ash free dry mass (AFDM) in the .063 to .500 mm and the .500 to 2 mm sediment samples, percent organic content by weight in the 2.00 to 4.75 mm and > 4.75 mm samples. Step-wise correlations between the environmental and biotic similarity matrices were conducted, and combinations of variables with the highest Spearman rank correlation coefficient (ρ) were considered to provide the best match to the fish and invertebrate assemblage data.

Results

Bark/Sediment depth and sediment size composition

Sediment analyses indicated that bark is still present at LTFs but is showing signs of decomposition. Mean sediment depths ranged from 4 to 11 cm (Table 1). Sediment depths measured during this study were lower than those reported in earlier studies at all locations except Appleton Cove and Camp Coogan Bay. Bark depths at Hanus Bay, Mud Bay, and Rodman Bay declined by 13 to 83% compared to earlier measurements. The organic content of sediment samples varied among size fractions and locations, but was usually greater in LTF sites than in REF sites (Figures 3 and 4). Organic content was lowest in Hanus Bay and Rodman Bay and highest in Mud Bay and St. John the Baptist Bay. At the latter two sites, LTF sediment less than 2.00 mm in diameter had 2.4 to 8.7 times more AFDM content than sediment from the adjacent REF site (Figure 3). Differences in the organic content of LTF and REF sediment were more extreme in the larger size fractions (Figure 4) where most organic matter consisted of bark fragments as well as other plant material. More than one-third and one-half of large sediment from

LTF sites at Mud Bay and St. John the Baptist Bay, respectively, consisted of organic material (Figure 4). In contrast, large sediment from REF sites contained less than 15% organic matter and the large sediment from several locations was devoid of organic material. Non-organic material in sediment samples consisted of sand, gravel, and shell fragments.

Sediment samples were not obtained from Schulze Cove where the bottom of the LTF site was covered by a 1 m thick layer of diffuse organic material. Divers were not able to retrieve sediment from below this layer, and attempts to obtain samples of the organic layer itself were unsuccessful. Because the purpose of this study was to compare LTF sites with adjacent reference sites, no sediment was collected at the Schulze Cove REF site.

Water Quality

Water quality at the Schulze Cove LTF site was poor within the layer of ooze. Sulfides were detected in this layer which did not contain any dissolved oxygen (Figure 5). Water samples from this layer smelled of rotten eggs and hydrogen sulfide levels in two samples measured 5.0 and 9.6 mg/L.

Water quality at other sites was good and there were no differences in water temperature or dissolved oxygen between the LTF and REF site pairs (Figure 5). Sulfide was not detected in pore water at other sites. Percent saturation of oxygen at the sediment/water interface ranged from 58% to 69%, exceeding 83% at Hanus Bay. Bottom water temperatures ranged from 10.2 C to 12.9 C. Temperature and salinity profiles at paired LTF and REF sites were nearly identical (Figure 6).

Fish and invertebrate assemblages

Approximately half of the fish and invertebrate species were caught at both LTFs and REF sites, with the remainder caught at either type of site. Because of differences in the size of trawl areas, we could not compare species diversity between LTF and REF sites. Twenty-two species of fish and 45 species of invertebrates were caught at the LTF and REF sites (Tables 2 and 3). The most commonly caught species of fish were yellowfin sole (*Limanda aspera*), snake prickleback (*Lumpenus sagitta*), and southern rock sole (*Lepidopsetta bilineata*) which were caught at both LTFs and REFs. Sunflower sea stars (*Pycnapodia helianthoides*) were the most common invertebrate followed by shrimp (*Heptacarpus sp*), sea cucumbers *(Parastichopus californicus*) and lyre crabs (*Hyas lyratus*). These species were caught at both LTF and REF sites.

With the exception of Appleton Cove, similarity coefficients for fish and invertebrate assemblages between paired LTF and REF sites were less than 50%. Fish and invertebrate assemblages also differed between sites with more direct access to the open ocean (outside Peril Strait) and those located in interior channels and bays. Eighteen fish species were found either at inside or outside sites but not both (Table 4). The average dissimilarity of fish groups inside and outside of Peril Strait was 95.5% (100% = total dissimilarity). Invertebrate assemblages showed less of a pattern of difference between inside and outside locations than fish assemblages (Figure 8) with 23 species captured at either outside or inside sites. As with the fish assemblage data, only the Appleton Cove LTF and REF sites are similar at a 50% or greater level.

For sites inside Peril Strait, the highest correlation between the ranked environmental and fish similarities occurred for the two-variable combinations of average AFDM and percent saturation, and average percent organic component and average temperature had the same correlation coefficient (ρ = .647). Temperature and percent saturation are highly correlated, so the inclusion of one or the other of these variables in the two-variable pairs is not surprising. Similar analysis on the correlation between fish assemblages and sediment grain size did not result in a high correlation coefficients (highest ρ = .172) suggesting that size of the sediment is not an important factor in determining fish assemblages. The analysis however suggests that, for sites inside Peril Strait, the presence of organic matter may be a factor affecting fish assemblages. Relatively high correlation between environmental variables and fish assemblages was not observed for sites outside Peril Strait. The highest correlation (ρ = .153) was associated with average AFDM. This correlation is slightly smaller than the correlation between the smallest two sediment size fractions (ρ = .172) and fish assemblages.

Invertebrate assemblages had a pattern similar to fish assemblages. Average organic content and average temperature had the highest correlation (ρ = .509) with invertebrates inside Peril Strait, followed by average AFDM and average temperature (ρ = .466). For invertebrate assemblages outside Peril Strait the highest correlation (ρ = .586) was for average percent saturation. Organic content of the sediment was correlated at ρ = .193 or below. Invertebrate assemblages also showed little correlation to sediment grain size (high of ρ = .102).

Discussion

LTF ZODs

Identifying and delineating the ZOD was difficult at most locations. Bark was not always easily identified and often merged or graded into natural sediments. With the exception of Hanus Bay and Appleton Cove, the seaward edge of the ZOD occurred in water that was too deep for divers to access. The inability to identify the seaward extent of the ZOD was a concern only for the placement of the REF sites, since we wanted these to be sufficiently close to the LTFs to reduce variability while still being outside the ZOD. At most sites, the area of the ZOD was sufficiently large to accommodate trawling. Only at Camp Coogan Bay did we encounter bark at the REF site while trawling. Sediment analyzed from this site confirmed that the LTF and REF sites were not sufficiently far apart. connected.

At some sites delineation was further complicated by the inability of divers to distinguish between highly decomposed bark and natural sediment. We suspect that ZOD boundaries were more obvious during the earlier studies since the bark was less decomposed at the time. Freese et. al. (1988) indicated that bark within the ZODs at some of the LTF sites they evaluated had deteriorated and some of the bark fragments were as small as 2 mm. Identifying the bark component of such fine sediment underwater was extremely difficult. This difficulty stimulated increased effort in analyzing sediment for organic content, a surrogate for bark depth.

Recovery and non-recovery

Diver observations and water quality measurements indicate that most LTF sites (6 of 7) are recovering. At most sites bark deposits were substantially degraded and sometimes difficult to delineate. Trawl catches indicated that fish and invertebrates use LTFs, and that there are subtle differences between fish and invertebrate assemblages at LTF and REF sites. The Schulze Cove LSF was a notable exception. Divers at this site encountered a strange layer of sediment. Approximately 1 meter in thickness, this layer consisted mostly of water, lacked dissolved oxygen, and water samples contained toxic sulfides. These poor habitat conditions appear to influence fish and invertebrate diversity which was only one-third of that found at the REF site.

Problems of species diversity measurements

The difference in species diversity between impacted sites and nearby reference sites has been widely used in ecology to assess recovery based on the assumption that fewer species occur in impacted sites than non-impacted sites. This assumption has been strongly criticized (Gray 2000), and research suggests that diversity indices are useful in differentiating between communities only when the impact is severe (Mouillot et. al. 1995; Rice 2000; Cao et. al 1996). Species diversity indices also are dependent on the size of the sample area, which in our study differed between sites as a result of differences in the size of the LTF ZODs. Therefore, we could not compare diversity between LTF and REF sites.

The multivariate analyses used here are widely used in benthic ecology and are becoming more common in estuarine and demersal fish research (Mueter & Norcross 1999). These approaches are useful in detecting change in community structure given sufficient sample size. In our study, we detected differences in species assemblages between inside and outer coast sites. Estuaries on the west side of Baranof and Chichagof Islands (outside Peril Strait) tend to have more direct access to ocean water than estuaries in Peril Strait and Hoonah Sound, and this appears to affect fish and invertebrate assemblage membership. Others also have noted clines of distribution in southeastern Alaska from north to south, and from east to west (Johnson et al. 2003). With only seven sites in our pilot study; 4 inside Peril Strait and 3 outside Peril Strait, the sample size is too small to separate potential LTF effects from natural geographic effects. Future studies should consider the transition of species from inside to outside waters in site selection. Additionally, multiple samples should be taken at each LTF and REF. This may require sampling over a period of weeks or months to adequately assess fish and invertebrate usage of individual sites.

Future evaluation of habitat recovery

Day-long site visits are too cursory for measurements of habitat recovery and determination of rates of recovery. The results of this study should be considered a screening procedure, and not detailed or intense enough to compare to the earlier studies by Shultz and Berg (1976) and Freese et al. (1988). To determine the impacts and status of recovery, measurements of biological processes and better measurements of habitat use by species are needed. Although costly, focusing on infauna and less mobile invertebrates may be a better way to assess long-term impacts. Further, measuring bark depths and the size of the ZOD as a means of evaluating habitat recovery has limitations. Measures of bark depth and the ZOD boundary can be accurately determined when the deposit is young; however, over time obtaining accurate measures becomes more difficult as the bark decomposes and/or is redistributed. Organic content, as well as a chemical marker surrogate for bark combined with systematic sampling would likely be a better measurement strategy. Future studies should include a large suite of sites selected based on the amount of timber transferred through the facility. Additionally, more time should be allocated to evaluating each site than was allowed in this study.

Evaluating candidate sites for restoration

One-day site visits using a remotely operated video camera and collection of water quality measures would probably be a satisfactory screening method for establishing a group of LTF and REF sites for further study. Specific attention should be given to sites similar to Schulze Cove to determine the factors that may be inhibiting recovery. This information may lead to recommendations on appropriate locations for siting such facilities in the future to adequately protect EFH. In addition to the type of data collected for this study, a future study should evaluate benthic communities as organisms living within and on the bottom directly exposed to the physical and chemical characteristics of bark deposits. The intense studies conducted 25 to 30 yeas ago by Shultz and Berg (1976) and Freese et al. (1988) should be repeated to determine the long term impacts of LTFs on EFH. These studies should include evaluation of benthic communities to determine whether they follow the same pattern as the fish and invertebrate assemblages in this study.

Conclusion

Most sites (86%) sampled in this study were recovering, as shown by difficulty in identifying the zone of deposit for bark, good water quality, and the presence of fishes and invertebrates. One-day site visits are not adequate to assess habitat recovery rates; a large-scale comprehensive survey of more sites is needed to better understand recovery of LTFs across the region. Benthic habitat at the Schulze Cove Log Storage Facility remains highly impaired, as evidenced by a 1 m layer of colloidal ooze and poor water quality. There are likely other sites like Schulze Cove where habitat recovery is not satisfactory.

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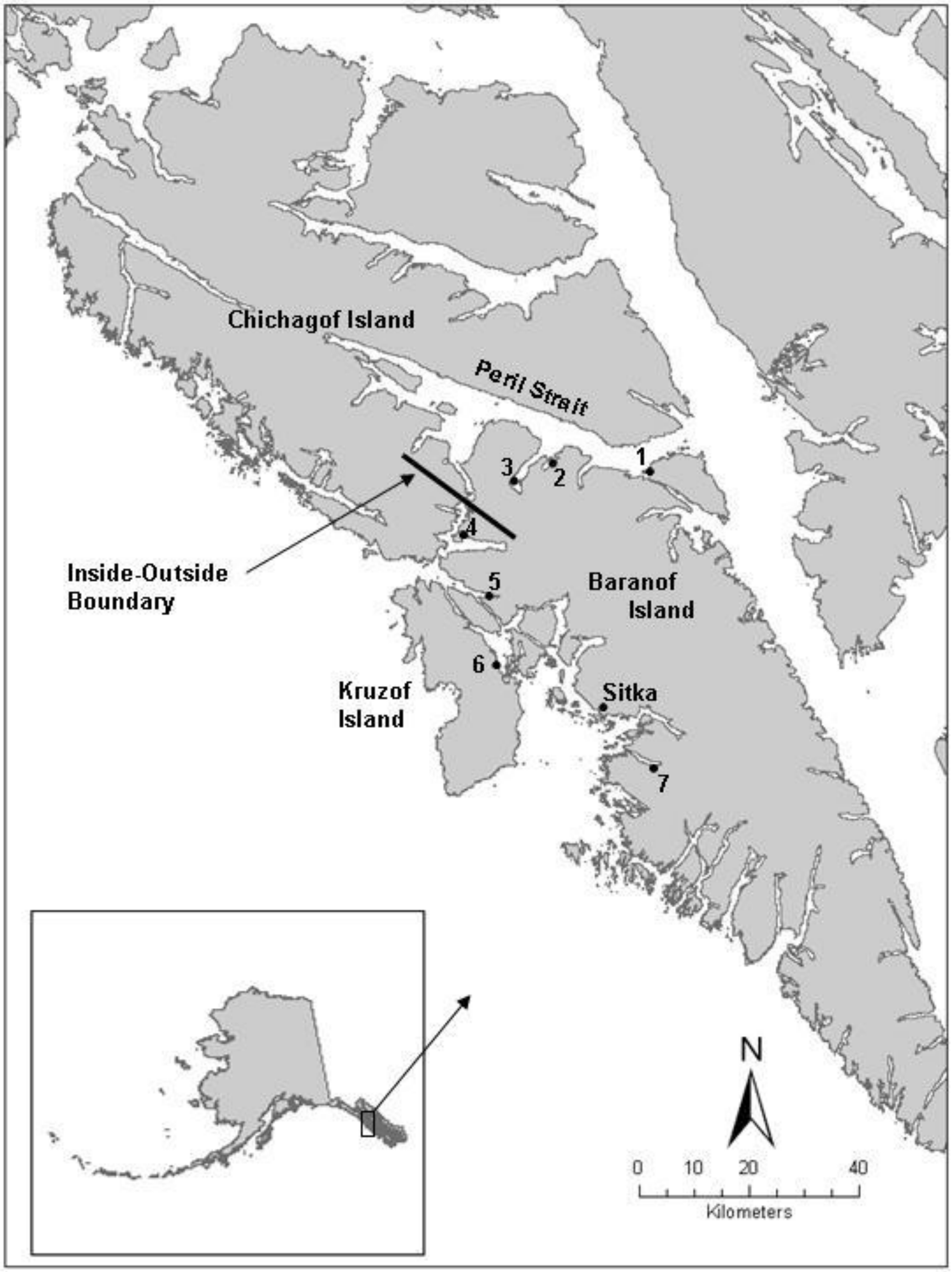
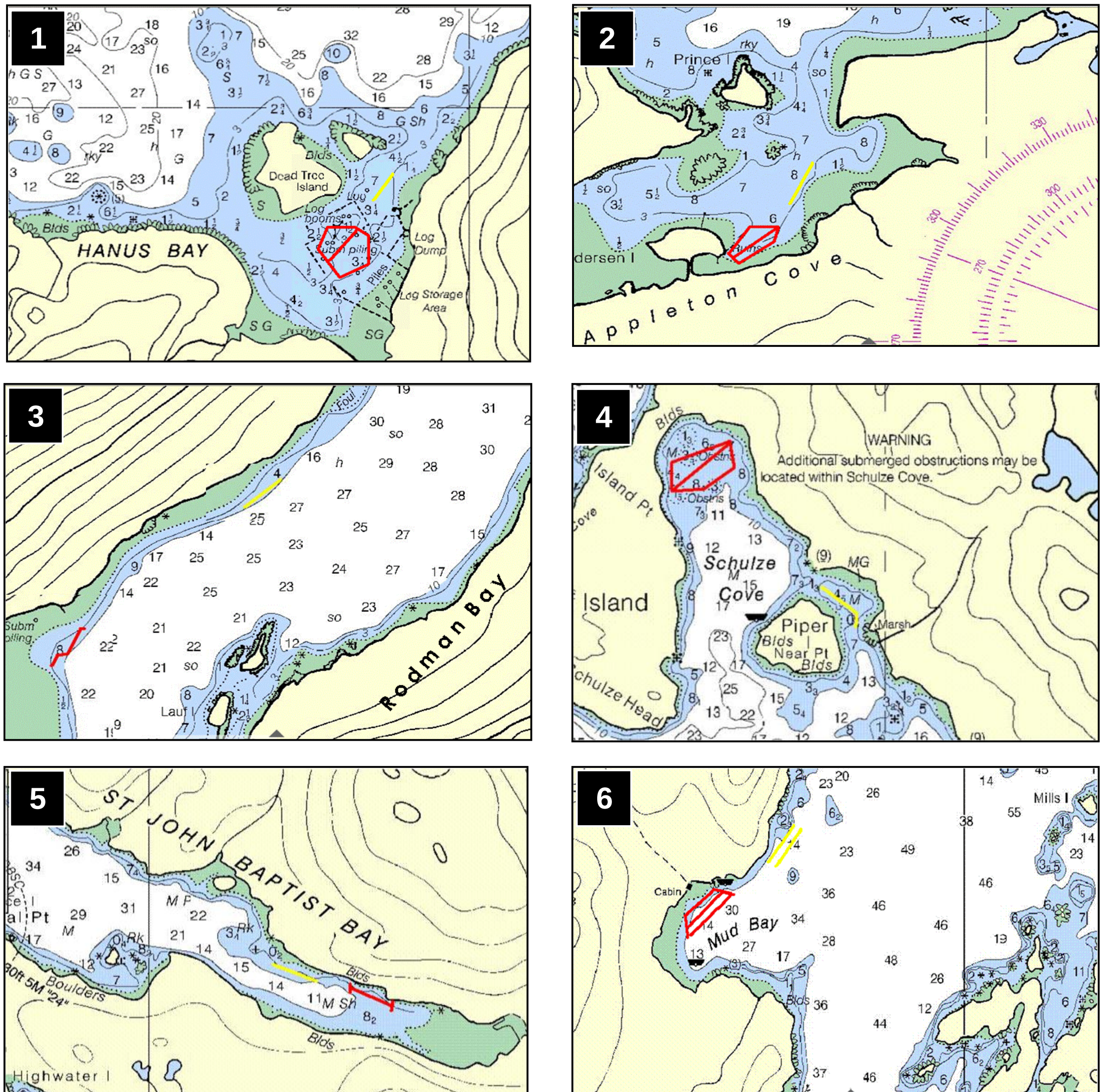


Figure 1. Map of the study area showing the location of study sites and the boundary between the outside and inside waters of Peril Strait. Log transfer facilities sampled in this study were located in Hanus Bay (1), Appleton Cove (2), Rodman Bay (3). Schulze Cove (4), St. John the Baptist Bay (5), Mud Bay (6), and Camp Coogan Bay (7).



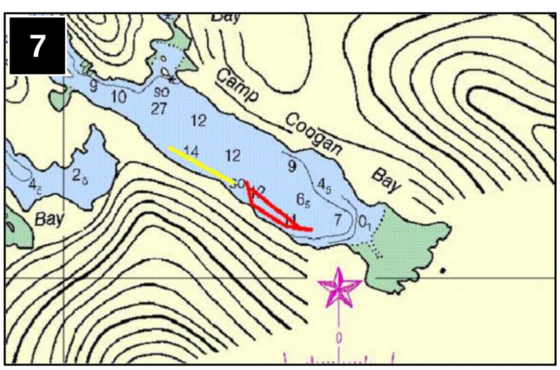


Figure 2. Study sites showing the log transfer facility (LTF) zone of deposit (red polygon) and location of trawl transects at each LTF (red line bisecting polygon) and REF (yellow line) site. Only a partial delineation of the ZOD was completed at sites 4 – 7. Hanus Bay (1), Appleton Cove (2), Rodman Bay (3), Schulze Cove (4), St. John the Baptist Bay (5), Mud Bay (6), and Camp Coogan Bay (7).

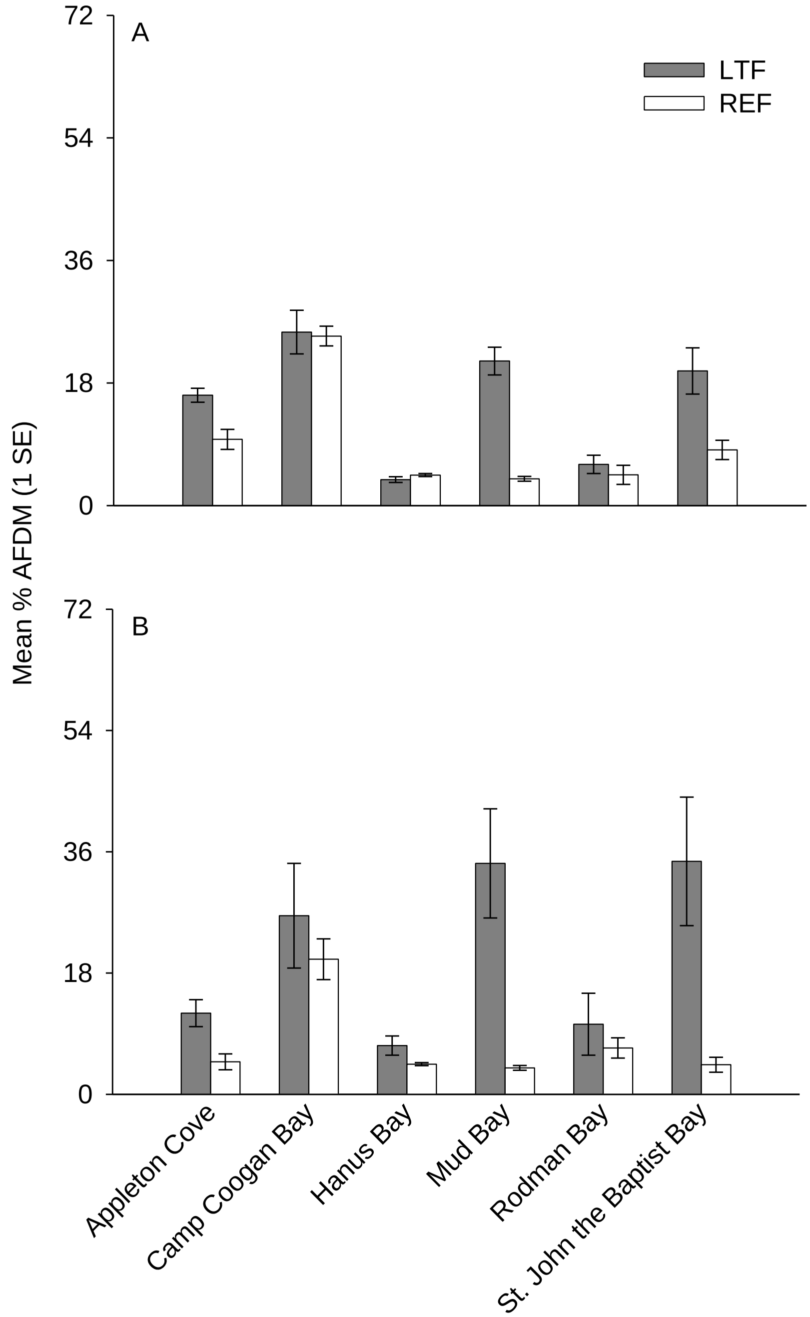


Figure 3. Ash-free dry mass content (%) of sediment (A, .063-.500 mm; B,.500-2.00 mm) collected from log transfer facility (LTF) and reference (REF) sites in July and August 2007 at six locations in southeastern Alaska. (SE = standard error)

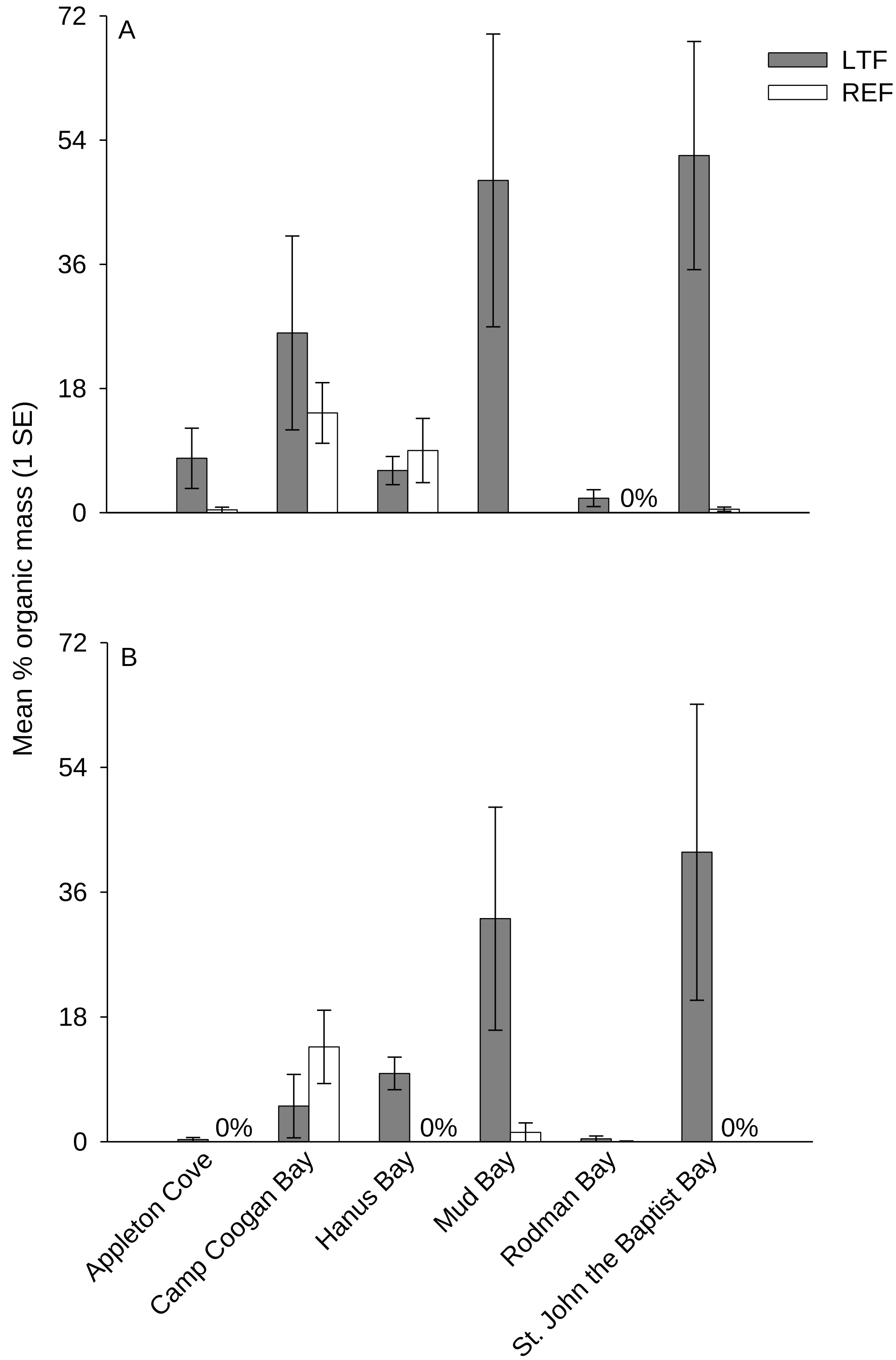


Figure 4. Percent organic mass of sediment (A, 2.00-4.75 mm; B, > 4.75 mm) collected from log transfer facility (LTF) and reference (REF) sites in July and August 2007 at 6 locations in southeastern Alaska. (SE = standard error)

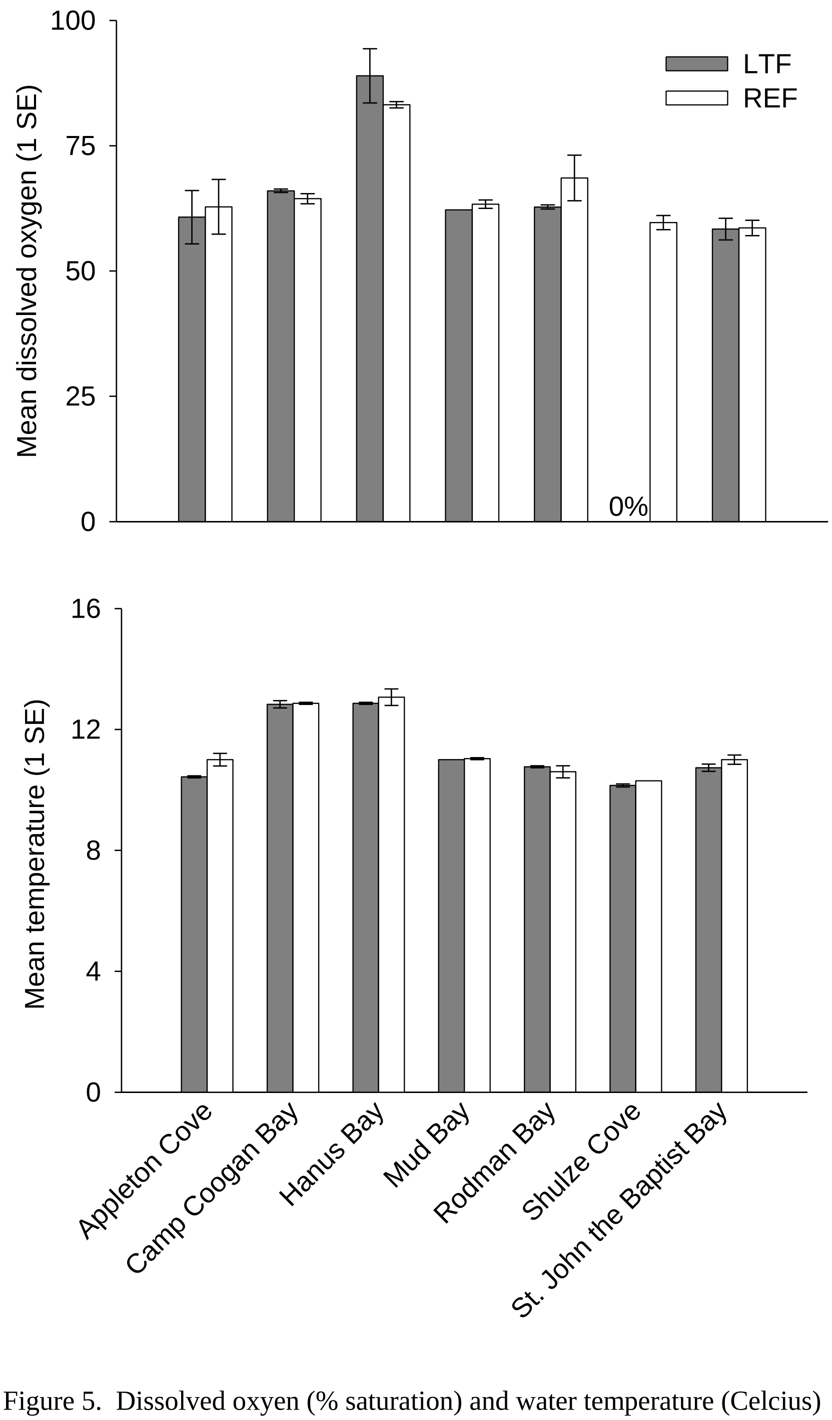


Figure 5. Dissolved oxyen (% saturation) and water temperature (Celcius) at the sediment/water interface of log transfer facility (LTF) and reference (REF) sites in July and August 2007 at six locations in southeastern Alaska. (SE = standard error)

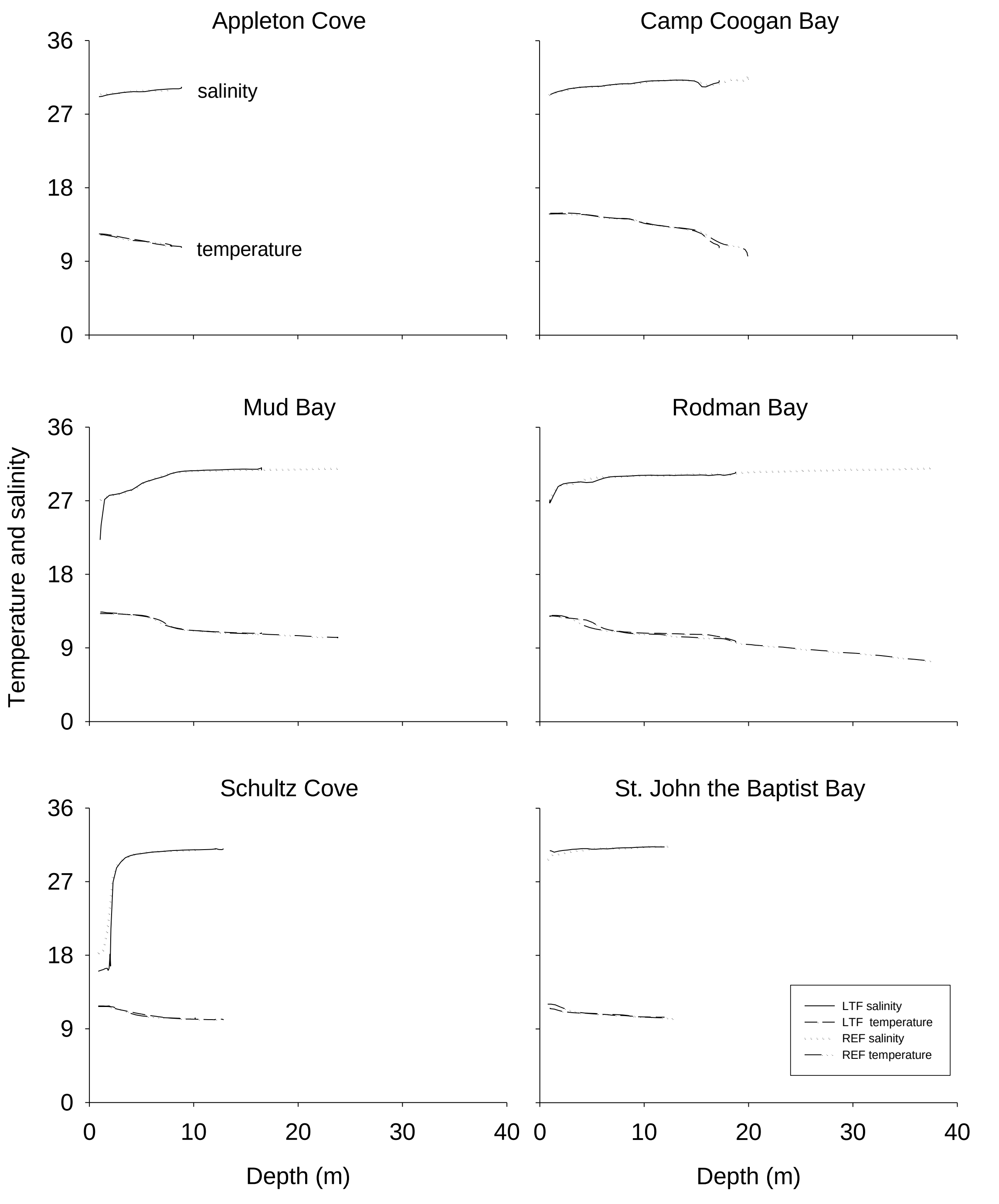


Figure 6. Salinity (parts per thousand) and water temperature (Celcius) profiles at log transfer facility (LTF) and reference (REF) sites studied in July and August 2007 at six sites in southeastern Alaska. Data from Hanus Bay were not available.

Figure 7. Plots of the first two axes from an NMDS (multidimensional scaling) ordination of fish trawl catch for LTF and REF sites. Distances between two points in the ordination diagram approximately reflect their dissimilarity in terms of species composition.

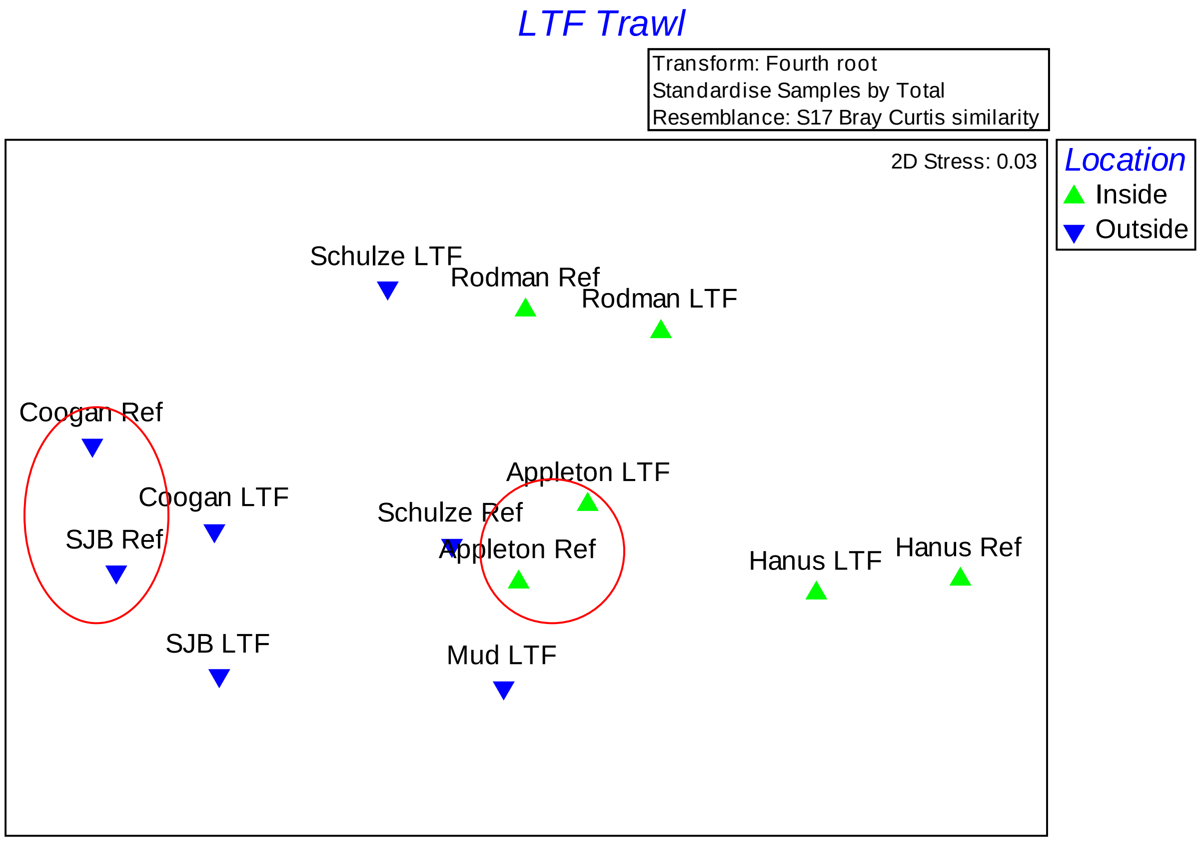


Figure 8. Plots of the first two axes from an NMDS (multidimensional scaling) ordination of invertebrate trawl catch for LTF and REF sites. Distances between two points in the ordination diagram approximately reflect their dissimilarity in terms of species composition.

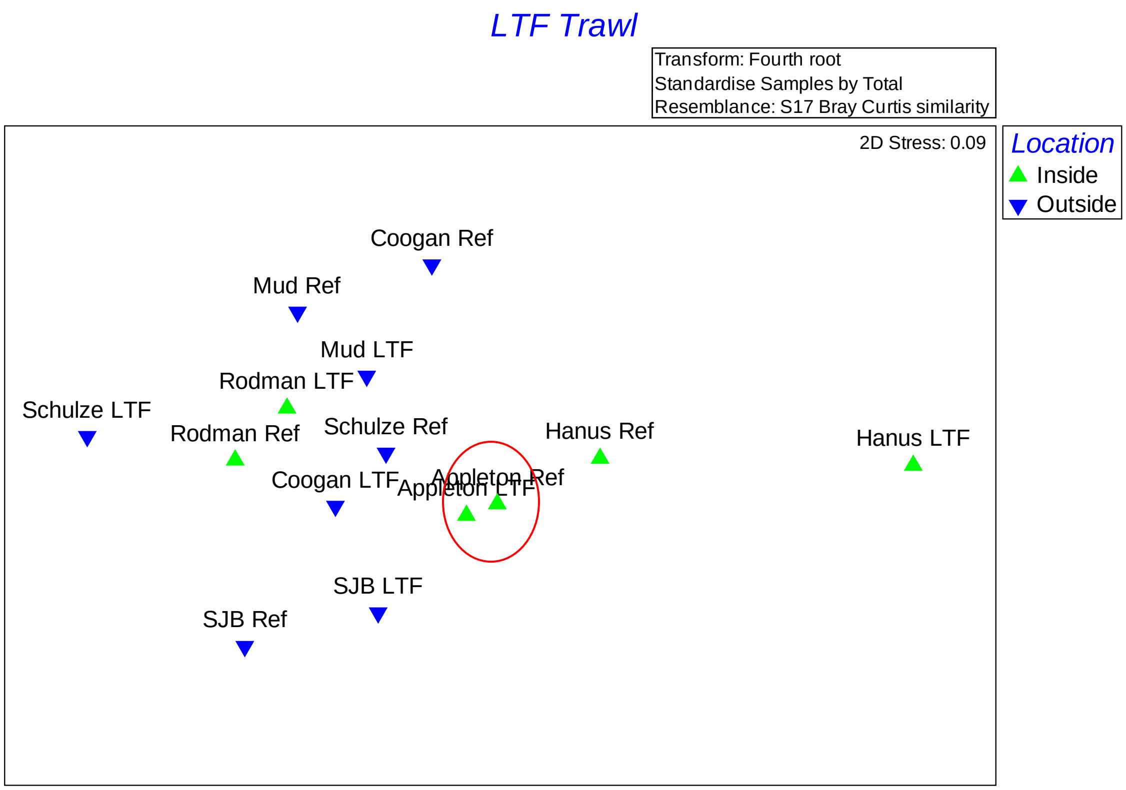


Table 1. Comparison of sediment depths at LTF sites in present study to bark depths reported from the same sites in earlier studies.

LTF Location	Present study mean sediment depth (cm, 1 SD)	Mean bark depth (cm)	
		Freese et. al. 1988	Schultz and Berg 1976
Appleton Cove	3.96 (2.29)		3
Camp Coogan Bay	10.67 (4.76)		2
Hanus Bay	3.43 (1.73)		20
Mud Bay	8.75 (2.94)	35	25
Rodman Bay	6.17 (2.39)	20	15
St. John the Baptist Bay	9.54 (3.92)		11

Table 2. Fish taxa collected at log transfer facility (LTF) and reference (REF) sites studied in July and August 2006 at seven locations in southeastern Alaska.

	Appleton Cove		Camp Coogan Bay		Hanus Bay		Mud Bay		Rodman Bay		Schulze Cove		St. John the Baptist Bay	
Taxon	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF
Aulorhynchus flavidus					x	x								
Citharichthys stigmaeus			x	x										x
Enophrys bison									x					
Eopsetta jordani									x					
Eumicrotremus orbis		x							x					
Gadus macrocephalus		x									x			
Glyptocephalus zachirus												x		
Hexagrammos decagrammus												x		
Lepidopsetta bilineata	x	x					x					x		
Limanda aspera	x								x	x	x	x		
Lumpenus sagitta		x	x									x	x	
Microstomus pacificus												x		
Myoxocephalus polyacanothocephalus		x					x					x		
Oligocottus maculosus	x	x			x									
Ophiodon elongatus												x		
Parophrys vetulus													x	
Podothecus accipenserinus											x			
Psychrolutes paradoxus	x	x												
Sebastes flavidus														x
Sebastes maliger			x										x	x
Stichaeus punctatus		x								x				
Theragra chalcogramma			x								x			

Table 3. Invertebrate taxa collected at log transfer facility (LTF) and reference (REF) sites studied in July and August 2006 at seven locations in southeastern Alaska.

	Appleton Cove		Camp Coogan Bay		Hanus Bay		Mud Bay		Rodman Bay		Schulze Cove		St. John the Baptist Bay	
Taxon	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF	LTF	REF
Amphipoda											X			
Actinaria	X													
Cancer gracilis	X		X				X		X					
Cancer magister		X										X		
Cancer oregonensis												X		
Chlamys spp			X	X			X	X						
corumba pacifica													X	
Crangon alaskensis	X	X	X	X		X								
ebasteria									X	X				
Platyhelminthes													X	
H. tenuissimus						X								
Heptacarpus carinatus						X								
Heptacarpus spp.	X	X	X			X	X	X	X	X		X		
Heptacarpus brevirostris						X								
Hyas lyratus	X	X				X						X	X	
hyppolyte spp						X								
Scyphozoa			X				X		X			X		
Lebbeus spp		X												
Lophopanopeus bellus									X	X	X			
Ophiura spp			X										X	X
Oregonia gracilis						X						X		
Paguridae		X			X					X				
Pandalus danae	X	X												
Pandalus goniurus	X	X												
Pandalus hypsinotus						X								
Pandalus platyceros						X								

Pandalus spp		x				x								
Parastichopus californicus	x							x	x	x		x		
Pluerobranchia spp.	x			x			x							
polychaete	x						x							
Pycnapodia helianthoides	x		x							x		x	x	x
scale worm	x	x					x						x	
Schlerocrangon boreas		x												
sipunculid														x
Solaster spp								x				x		
Strongylocentrotus spp			x	x				x				x		
Telemesus cheiraonus	x				x									
Tonicella lineata								x				x		
tunicate			x	x			x							

Table 4. Fish species collected inside and outside of Peril Strait in July and August 2006 in southeastern Alaska.

Species	Inside	Outside
Aulorhynchus flavidus	x	
Citharichthys stigmaeus		x
Enophrys bison	x	
Eopsetta jordani	x	
Eumicrotremus orbis	x	
Gadus macrocephalus	x	
Glyptocephalus zachirus		x
Hexagrammos decagrammus		x
Microstomus pacificus		x
Oligocottus maculosus	x	
Ophiodon elongatus		x
Parophrys vetulus		x
Podothecus accipenserinus		x
Psychrolutes paradoxus	x	
Sebastes flavidus		x
Sebastes maliger		x
Stichaeus punctatus	x	
Theragra chalcogramma		x

Essential Fish Habitat project status report

Reporting date:

Project number: 2006-5 & 2007-2

Title: Habitat effects on growth and condition of northern rock sole

PIs: Hurst, Abookire, Heintz, & Short

Funding year: 2006 & 2007

Funding amount: $17,652 FY06; $28,865 FY07

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

The results of this work are reported in a manuscript submitted to Canadian Journal of Fisheries and Aquatic Sciences. The manuscript received positive reviews and will be accepted pending final minor revisions.

An electronic copy of the MS is attached. A final version of the manuscript will also be sent when accepted.

Results: What is the most important result of the study?

The most important results of the work are that the growth rates at our three focus study sites have maintained their rank order over the 3+ sampling seasons to date. Holiday Beach has consistently supported faster growing age-0 rock sole than Pillar Creek Cove and Shakmanof Beach. While growth variation is correlated with temperature variation, it is not the primary driver of growth variation in this system. Growth rates were not correlated with fish density. In addition, analyses indicate that size and time of settlement may be significant contributors to size variation.

Essential Fish Habitat project status report

Reporting date: August 12, 2008

Project number: EFH 2007-5

Title: Habitat Specific Production of Pacific Ocean Perch in the Aleutian Islands

PIs: Rooper, Heintz

Funding year: 2007

Funding amount: 52,700

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported? Not reported

Results:

Juvenile Pacific ocean perch (POP; *Sebastes alutus*) were collected from two sites near the Islands of Four Mountains during early June 2008 and in August 2008. The two sites were sampled over two days using an AFSC bottom trawl and plankton net to collect both juvenile POP and their zooplankton prey. Juvenile POP were found at both locations in high abundances, with > 650 individuals captured during four tows of less than 5 minutes each in June, and similar abundances in August. This is the fourth year since 2003 that juvenile POP sampling has occurred at these sites and rockfish densities were higher in 2008 at the nursery sites than in preceding years. Fish dissections and analysis of stomach contents and fish condition are expected to take place during FY2009.

Six successful drop camera deployments (3 at each study site) using a stereo video drop camera system were also conducted over the two days in June. The video captured during the Islands of Four Mountains study shows many juvenile POP and other rockfish inhabiting boulder fields at the study site. There were significant amounts of coral and sponge observed in the study areas. Additionally, adult dusky rockfish (*S. variabilis*) and northern rockfish (*S. polyspinis*) schools were observed at one site. Analysis of the 6 hours of video collected at the study sites will be completed this fall.

Essential Fish Habitat project status report

Reporting date: 10/09/2009

Project number: 2007-6

Title: Recovery of a sessile invertebrate of the Bering Sea shelf from trawling

PIs: Craig S. Rose

Funding year: FY07

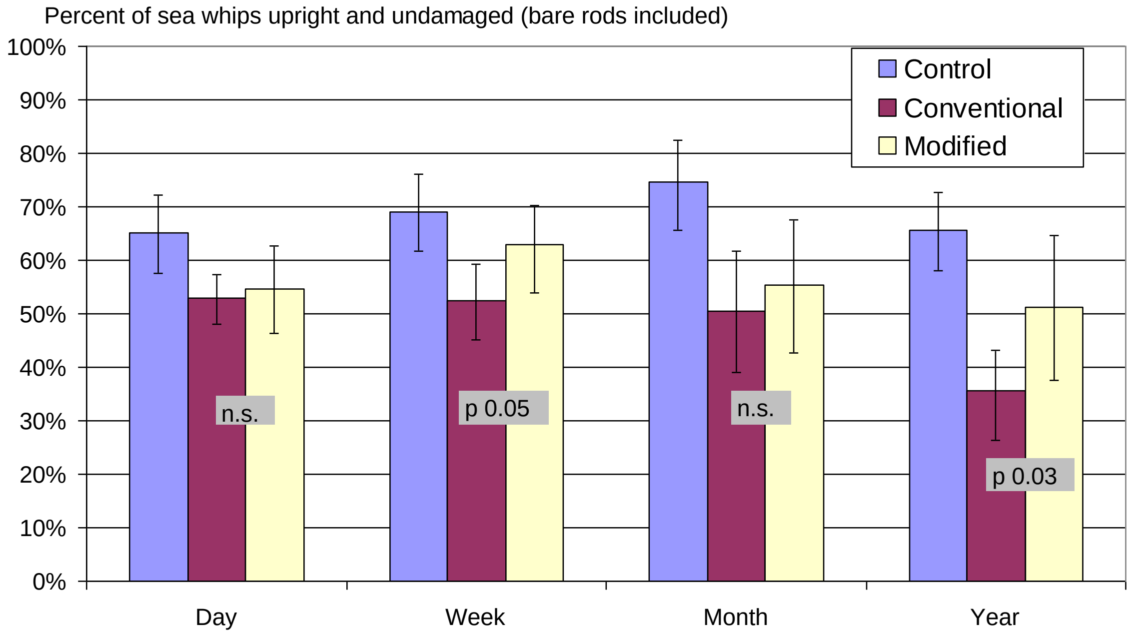
Funding amount: $9888

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: The results of this project were part of a presentation on the effectiveness of trawl sweep modifications in reducing impacts to sea whips. This was presented to the Alaska Marine Science Symposium and the North Pacific Fisheries Management Council. Slide 7 of the presentation is attached, indicating percent undamaged after one year.

Results: EFH funding allowed extension of a larger project to include observations of trawl impacts out to one year after trawling. There was no indication of recovery (increase in the percent of undamaged animals) after one year. Sea whips affected by the conventional sweeps had fewer undamaged animals than were observed at the day, week, and month periods, perhaps indicating delayed mortality. Those contacted by the modified sweeps showed no additional drop after a year relative to the shorter periods.



Percent of sea whips upright and undamaged (bare rods included)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
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Essential Fish Habitat project status report

Reporting date: 8/25/2008

Project number: 2007-07

Title: Temporal dynamics of habitat use in juvenile Pacific cod

PIs: Allan Stoner, Benjamin Laurel, Brian Knoth, Clifford Ryer & Thomas Hurst

Funding year: 2007

Funding amount: $46,317

Status: Complete

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported?
The results of this study have been reported in a manuscript entitled "Temporal and ontogenetic shifts in habitat use by juvenile Pacific cod" submitted to the Journal of Experimental Marine Biology and Ecology.

Results: What is the most important result of the study?
1) Comparisons in seine collections and baited camera surveys in two focal sites in Kodiak (20 permanent stations) showed that recruitment of age-0 Pacific cod in 2006 was approximately one order of magnitude larger than in 2007. The same trend also appears to be mirrored in the other gadid species i.e., walleye pollock and saffron cod. Despite low catches in 2007, the ontogenetic shift in habitat preference (i.e., eelgrass to Laminaria to open habitats) appears to be identical to the patterns observed in 2006.
2) The 2006 year class was prevalent as age-1 juveniles in the 2007 survey, allowing for a detailed examination of their distribution by depth and habitat complexity. Age 1 cod were seldom caught in the seine survey but were routinely surveyed in large numbers using a baited cameras set along various depth gradients.
3) Age-0 cod were most abundant in shallow (<3 m), inshore habitats, while age-1 cod were typically found deeper and they make diel movements inshore and offshore.
4) Laboratory experiments, designed to complement field observations showed that age-0 cod tolerate high light conditions, while larger cod avoid bright light.
5) Age-1 Pacific cod and saffron cod were moderately piscivorous but there was no evidence of predation on smaller conspecifics.
6) Despite the lack of apparent cannibalism, age-0 and age-1 gadids partition the habitat by both depth and by fine-scale temporal shifts in habitat.

Essential Fish Habitat project status report

Reporting date: October 23, 2007

Project number: 2007-9

Title: Mapping and fish utilization of coastal habitats vulnerable to disturbance from development and climate change

PIs: Johnson, Thedinga, Lindeberg, Harris

Funding year: FY 2007

Funding amount: $92,000

Status: [x] Complete [ ] Incomplete, on schedule [ ] Incomplete, behind schedule

Planned completion date if incomplete: Fall 2007

Reporting: Have the project results been reported? Yes. About 6,100 km of shoreline in southern southeastern Alaska (Dixon Entrance) were imaged with *ShoreZone* in 2007– within this mapped area, nine locations (30 seine sites) were sampled in June 2007 to determine fish utilization by habitat type. All data has been entered into an existing GIS database and online Fish Atlas (http://www.fakr.noaa.gov/habitat/fishatlas/) for reference by resource managers. Southeastern Alaska now has 20,076 km (60%) of shoreline imaged and 8,500 km mapped. Statewide, imagery has been collected for a total of 39,483 km of shoreline (about 20,190 km has been mapped). Both the mapping and GIS database (*ShoreZone*/Fish Atlas) will need continuous updating as more shoreline is mapped and fish distribution and relative abundance data is collected.

To address data deficiencies in the distribution and habitat use of nearshore fishes in the Arctic, we sampled nine sites in the Chukchi and Beaufort Seas with two gear types (beach seine and small bottom trawl). All data has been entered into an existing GIS database and online Fish Atlas (http://www.fakr.noaa.gov/habitat/fishatlas/) for reference by resource managers. Additional sampling (2008 and 2009) is planned at these sites to establish a baseline for monitoring changes in nearshore fish assemblages in a rapidly changing environment.

Results: What is the most important result of the study? Forage fish dominated catches in the Arctic. For example, juvenile capelin and Pacific sand lance were the most abundant species captured with a beach seine. Juvenile Arctic cod were one of the most abundant species captured with a trawl. All of these species are extremely important in the diet of other fishes, sea birds, and marine mammals and justify the need to protect nearshore areas from development.

Essential Fish Habitat project status report

Reporting date: 10/23/2015

Project number: 2007-10

Title: Juvenile Pacific Ocean Perch Habitat Utilization

PIs: Patrick Malecha, Andrew Gray, Chris Lunsford

Funding year: 2007

Funding amount: $89,300

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: Results from this work will be combined with with EFH project number 2008-9. A manuscript is currently in preparation.

Reporting: Preliminary results from this research were reported in an oral presentation as part of the HEPR-themed AFSC seminar series. A manuscript is currently in preparation.

Results: Surface trawling (up to 60 nautical miles offshore) with an aquarium codend (livebox) successfully captured 221 live juvenile slope rockfish ranging in size from 14-60 mm. Rockfish were transferred to behavior laboratory aquariums at Little Port Walter Marine Station and were acclimated to a modified photoperiod. Genetic determinations identified seven rockfish species including, Pacific ocean perch (POP), rougheye and redstripe rockfish. Habitat preference trials were performed although sample sizes were inadequate to identify statistical differences. Results from this work are being combined with EFH project number 2008-9.

Essential Fish Habitat project status report

Reporting date: 10/31/2008

Project number: 2007-11A

Title: Biological parameters to estimate the recovery of disturbed benthic habitat in Alaska, study A: Coral growth

PIs: Robert Stone (AFSC), Allen Andrews (Moss Landing Marine Laboratories)

Funding year: FY 2007

Funding amount: $45,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: October 31, 2008.

Reporting: Have the project results been reported? If yes, where were the results reported? The results are planned for presentation at the 4th International Symposium on Deep-sea Corals in December 2008 and a manuscript is in preparation.

Results: What is the most important result of the study?

Growth rate estimations were successful for bamboo corals but not for the gorgonian *Fanellia compressa*. Specimens of the latter species are currently being analyzed using C-13 and C-14 techniques by Dr. Tom Brown at the Center for Accelerator Mass Spectrometry (supplemental funding provided by the Alaska Regional Office – Habitat Conservation Division). Age and growth were determined for two bamboo corals (*Keratoisis* sp. B group and *Isidella* n. sp.) using lead-210 dating. The largest colony made available for this research was a *Keratoisis* sp. (B group) that measured 120 cm in height. Lead-radium dating provided an age of 116 ± 13 years with an average axial growth rate of 1.03 cm yr^{-1} (0.93-1.16 cm yr^{-1}, 2SE) for this colony. The *Isidella* n. sp. colony measured 72 cm in height and was aged at 53 ± 4 years; this colony grew most rapidly with a radial growth rate of 0.099 mm yr^{-1} and an average axial growth rate of 1.32 cm yr^{-1} (1.23-1.46 cm yr^{-1}, 2SE). Application of lead-210 dating to *Fanellia compressa* was not successful because measured lead-210 uptake was highly irregular at three points in the 67 cm colony; however, age was estimated at 47 to 57 years from growth zone counts in a skeletal cross section. Our findings of slow growth rates and high longevity compare favorably to those determined for bamboo corals from other regions of the Pacific Ocean and highlight the need for immediate conservation measures to protect these important members of deep-sea ecosystems.

Essential Fish Habitat project status report

Reporting date: 9/28/2009

Project number: 2007-11C

Title: Biological parameters to estimate the recovery of disturbed benthic habitat in Alaska, study C: Coral genetics

PIs: Robert Stone (AFSC), Scott France (University of Louisiana)

Funding year: FY 2007

Funding amount: $14,050

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, where were the results reported? No. We were not able to complete the project within the timeframe and with the funds received. The project will be completed with alternative funds being requested by Dr. France and will be reported at a later time.

Results: What is the most important result of the study? We developed microsatellite primers from *Primnoa pacifica* colonies collected in Tracy Arm, Holkham Bay. To our knowledge, this is the first attempt to develop microsatellite loci in *Primnoa pacifica* (or any other Alaskan octocoral). Initial tests of primers for four loci on 40 individuals from 4 separate collection sites reveal high levels of alleleic diversity within sites. More extensive optimization and testing will be required to further develop these loci (additional loci can likely be developed from the data we have already collected) for use in population studies of fjord corals. However, this preliminary study shows that this approach is likely to yield appropriate genetic markers to study fine-scale population processes of these cold-water corals.

A summary of the project history and findings to date follows:

Tissue samples for genetic analysis from 150 *Primnoa pacifica* colonies were collected in 2007 & 2008 from Tracy Arm and Endicott Arm, Holkham Bay. Our initial objective was to extract high molecular weight (HMW) DNA to be used to construct enrichment libraries for detecting and developing taxon-specific microsatellite markers. These markers typically show sufficient variation that they can detect fine-scale population structure and, if variation is present, would allow for an assessment of the relative contribution of asexual reproduction in patches of coral. Subsequent to the library construction, our objective is to screen sequenced clones for microsatellite loci, and test them for variability among the *P. pacifica* samples collected.

Objective 1: In March, 2007, 80 samples were collected from four sites. Although we were able to extract DNA from these samples, we did not have success obtaining the unsheared, HMW DNA required for the library construction. We concluded the problem may have been in the initial preservation of samples, i.e., DNA was degrading before tissues were preserved. The best solution was to resample colonies, paying particular care to rapid preservation, and this effort took place in May 2008 (70 samples from 5 sites). DNA extractions on a subset of these specimens did produce HMW DNA from multiple individuals.

Objective 2: HWM DNA from three extractions was sent to the SREL (Savannah River Ecology Lab) DNA Lab in September 2008 for construction of an enriched genomic library for microsatellite development. The following steps have been successfully completed by the SREL DNA Lab:

1) DNA digestion and linker ligation, cloning, double enrichment with biotinylated probes, and PCR amplification of inserts.
2) DNA sequencing of inserts from > 100 clones

DNA sequences of clones (>100) containing microsatellite motifs were delivered by SREL to UL Lafayette on 10/27/2008.

Objective 3: Examination of clone sequences revealed 6 repeat regions (4 tetra-, 1 tri- and 1 di-nucleotide repeat) that were suitable for PCR primer development (more such sequences are likely among the clones available and will be examined in our continuing research). We tested the 6 pairs of primers (= 6 presumptive microsatellite loci) initially on ≈10 colonies to determine whether the loci would amplify all individuals and to determine appropriate reaction conditions for optimal banding. All 6 loci produced reaction products in all individuals tested. We isolated and sequenced some of the reaction products to verify that we were amplifying the expected repeat regions (see locus and primer information below). Despite repeated manipulations of conditions, the dinucleotide repeat could not be effectively optimized, and was dropped from further analysis.

The remaining 5 loci were tested on 40 individuals from 4 collection sites within Tracy Arm, to look for variability (= multiple alleles) and if there were any preliminary evidence that this diversity might be structured within the fjord, i.e., differences in allele frequency among the collection sites. PCR reaction products were run out on 2.75% Metaphor agarose (Cambrex) gels to allow for discrimination of bands (alleles) between 160 and 300 nucleotides length. Four of five loci produced variable-size PCR products within an expected size range (based on the initial clone); the fifth locus included non-specific products and was not further analysed. For four loci we classified the products into allele classes, but acknowledge these could change somewhat when the products are amplified using a fluorescently-labeled primer and run on an automated sequencer for visualization; such methods provide higher spatial resolution among bands. All four loci showed high levels of band (presumptive allele) variation (Figure 1). Two of the loci (F10 and C01) produced sufficiently distinct bands to allow for further analysis of the scored alleles (loci H10 and C09 produced banding patterns that did not conform to the expected diploidy, i.e., there were as many as 3 alleles per individual. Without further analysis, we could not determine which bands were real.).

At loci F10 and C01, many more homozygotes, and fewer heterozygotes, were observed than expected. This may be the result of one or a combination of the following:

- incomplete resolution of allelic bands. Although the Metaphor gel system has high resolution in the size range we targeted, it is possible that alleles of heterozygotes that differed by a single repeat unit were not recognized as distinct and scored as homozygotes.
- There is a high level of inbreeding or asexual reproduction at each site.
- Colonies collected from single sites actually come from separate interbreeding populations ("Wahlund effect").

At locus F10, site 4 (farthest up the Tracy Arm) did show frequency differences to sites 1 & 2 (individuals from site 3 did not produce strong enough bands to score for this locus), suggesting perhaps a different origin of individuals compared to other sites, but this will need confirmation with additional colonies and loci before any confidence can be put in this interpretation.

Microsatellite locus and primer information

F10 Tetranucleotide repeat (CTGT)
Primer 1: F10f: GCATTTCTCGACTTTCATGT
Primer 2: F10rev: gttTGACCAAGAAACAACAGACACA
Number of alleles scored: 14
Expected number of homozygotes: 3.7627
Observed number of homozygotes: 22
Expected number of heterozygotes: 26.2373
Observed number of heterozygotes: 8

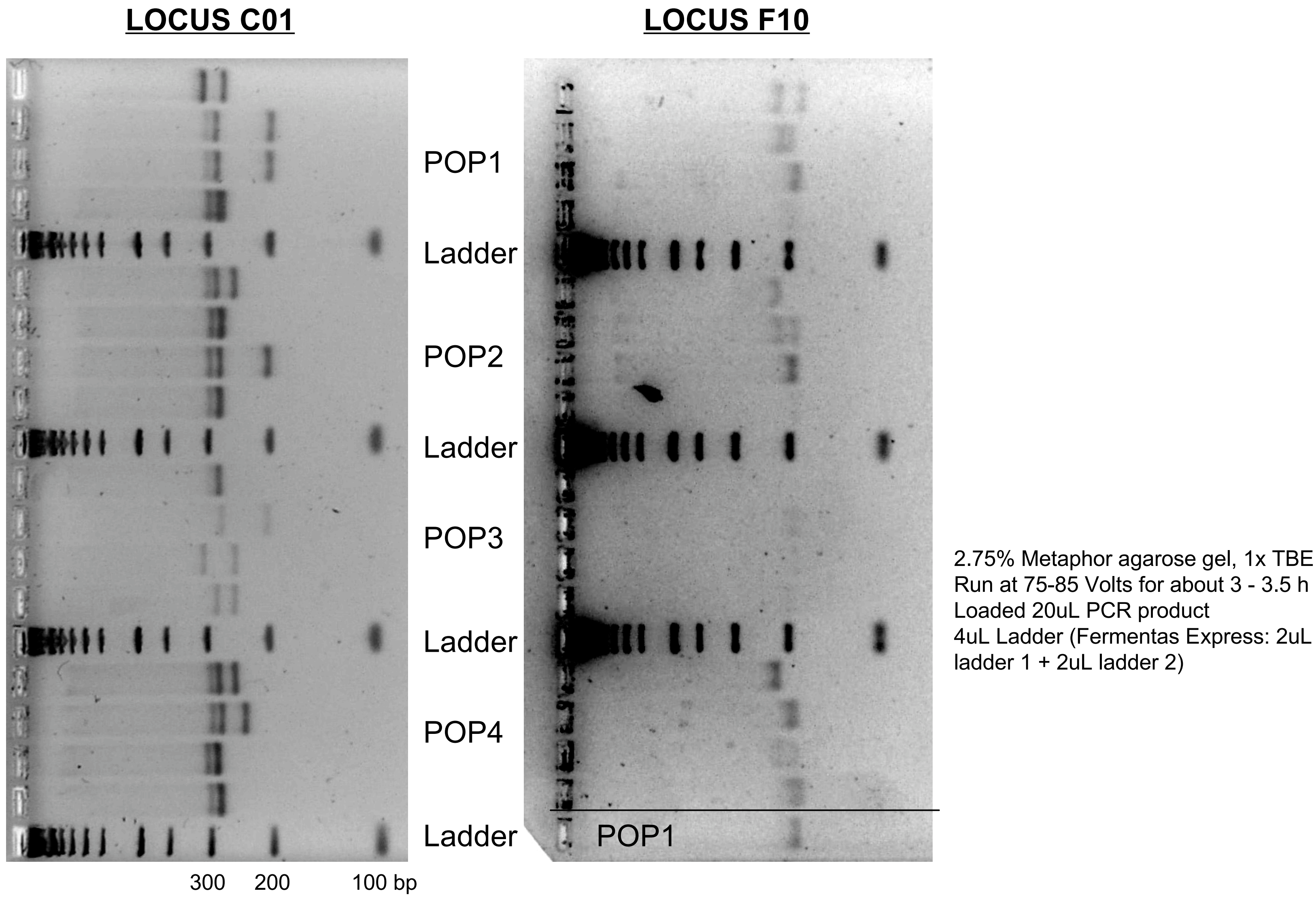
C01 Tetranucleotide repeat (GATT)
Primer 1: C01f: GCTGGCTACACAGGTCGTCT
Primer 2: C01rev: gTTTTTCCCGTGAACCCAAT
Number of alleles scored: 20
Expected number of homozygotes: 3.1688
Observed number of homozygotes: 21
Expected number of heterozygotes: 35.8312
Observed number of heterozygotes: 18

C09 Trinucleotide repeat (AGT)
Primer 1: C09f: GCGGCTTGGTATAGCTGATG
Primer 2: C09rev: gttTGATCCTGCTCCTATTCCTCT

H10 Tetranucleotide repeat (ACAG)
Primer 1: H10_P2f: CATTGTAGTGCCGGCCATC

Primer 2: H10_P2rev: gttTCTGTCTGTCTCTTGCTCTCT

B01 Tetranucleotide repeat (AACT)
Primer 1: B01f: aTGGCAGTGTAGCCACAGTA
Primer 2: B01rev: gtttGCAGAATCACAGACCACTCG



An example of size variability of PCR bands (presumptive alleles) for microsatellite loci C01 and F10. DNA extracted from individual colonies of *Primnoa pacifica* collected from four localities (POP1-4) in Tracy Arm, Holkham Bay were PCR amplified and run on the gels (migration from left to right); a different set of individuals is shown on each gel.

Essential Fish Habitat project status report

Reporting date: October 31, 2013

Project number: 2006-12, 2007-12, 2008-06

Title: **Overwinter habitat use and energy dynamics of juvenile capelin, eulachon, and Pacific herring**

PIs: J. Vollenweider, R. Heintz

Funding year: FY 2006-2008

Funding amount: 2006: $50,300; 2007: $57,900; 2008: $44,540

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Reporting: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Results:

Winter starvation mediated by low-levels of foraging is likely an important mechanism structuring recruitment success of juvenile forage fish. Over the course of two winters, we observed size-selective mortality in juvenile eulachon and capelin stemming from starvation in the smallest individuals. Between the fall and subsequent spring sampling periods, length frequency distributions of juveniles shifted towards larger individuals, which could either be indicative of a loss of smaller fish or growth (Figure 1). Growth overwinter is highly unlikely, however, as fish lost energy during this period and therefore surplus energy would not have been available for growth.

Winter energy deficits resulted from the loss of both lipid and protein energy. The magnitude of the deficit and relative depletion of lipid and protein were size dependent (Figures 2 and 3). Larger juveniles began winter with greater lipid reserves than smaller fish. During winter, larger fish depleted more of their pre-winter lipid reserves than smaller fish, and as a consequence, the contribution of lipid catabolism to the winter energy deficit increased with body size (Figure 4). Although the relative proportion of protein loss was independent of body size, the smallest fish lost more energy in the form of protein than lipid. By the end of the winter, the energy content of the smallest surviving juveniles was very near the energetic threshold, below which mortality occurs (Figure 5). Thus, the smallest juveniles were under extreme nutritional stress and were forced to metabolize protein to meet most of their metabolic demands, apparently as a consequence of exhausting lipid reserves.

Comparisons from two bays (Fritz Cove and Berners Bay) indicate that prey availability plays an important role in survival of juvenile fish that are on the brink of starvation in winter. Despite a general scarcity of prey during winter, what little forage juvenile fish could consume appeared to help stave off starvation. Nearly half the juvenile eulachon were feeding during the winter, as evidenced from stomach contents. Zooplankton prey species, particularly copepods, were more abundant in Fritz Cove than Berners Bay (Figure 6). Though juvenile eulachon in Fritz Cove were smaller and had lower energy reserves going into winter, they were in better condition than those from Berners Bay in the spring, suggesting that prey availability may help to preserve lipid reserves and thereby reduce starvation risk.

Collectively, these results indicate that the smallest eulachon and capelin do not store sufficient reserves of lipid for winter, are forced to metabolize protein, and may suffer a greater risk of winter mortality. Winter foraging, despite low prey abundance, may be crucial for survival. We suggest that disproportionately high rates of starvation among the smallest age-0 forage fish are important mechanisms influencing recruitment.

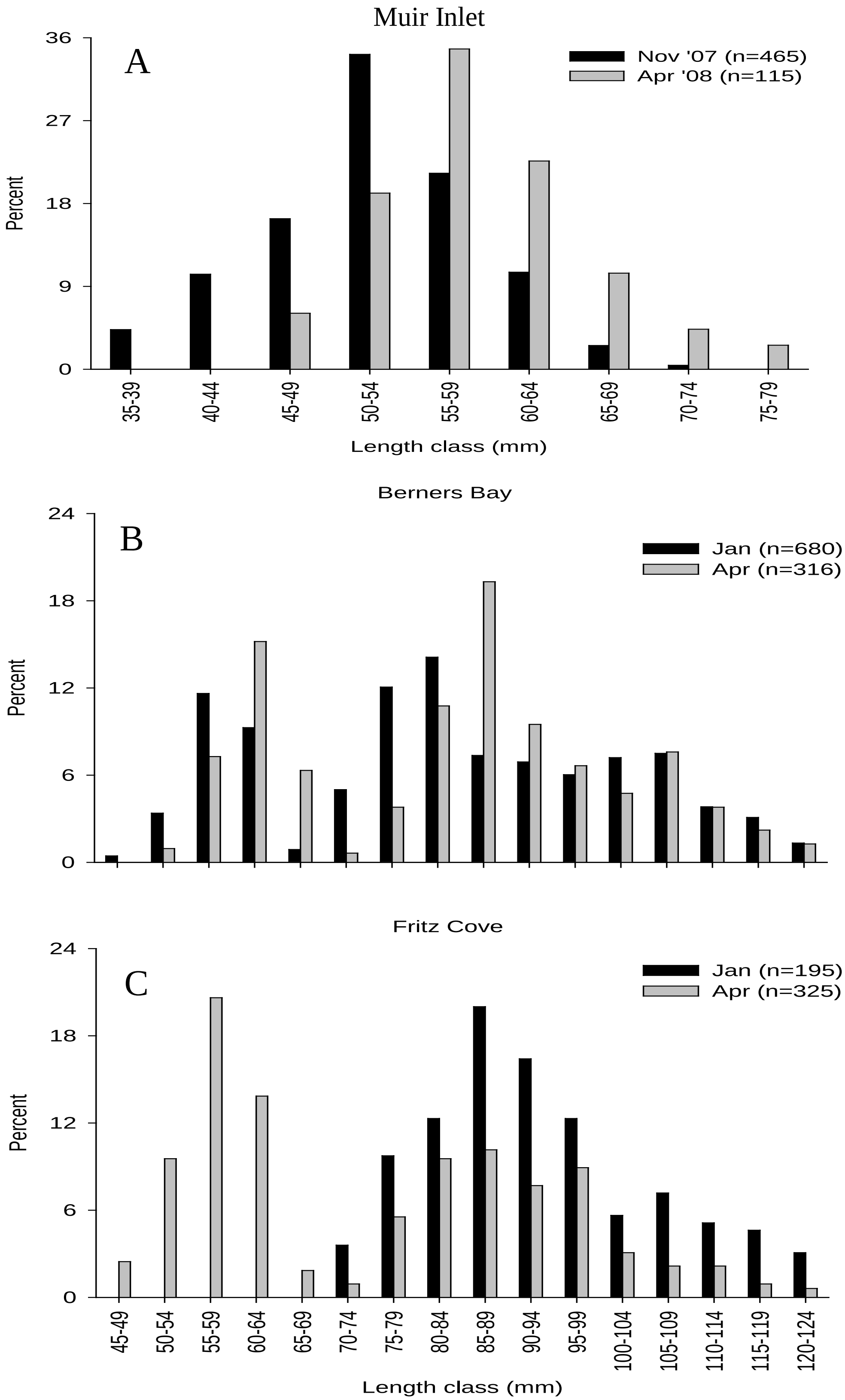


Figure 1. Shift in size distribution of juvenile capelin (A) and eulachon (B & C).

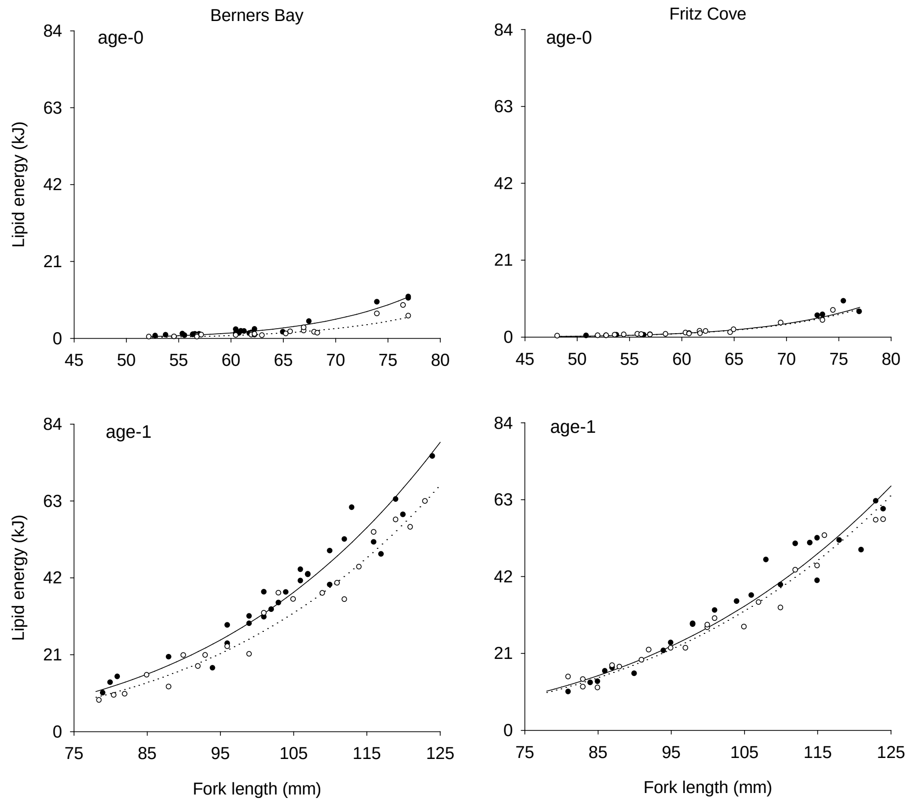


Figure 2. Energy allocated to lipid in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

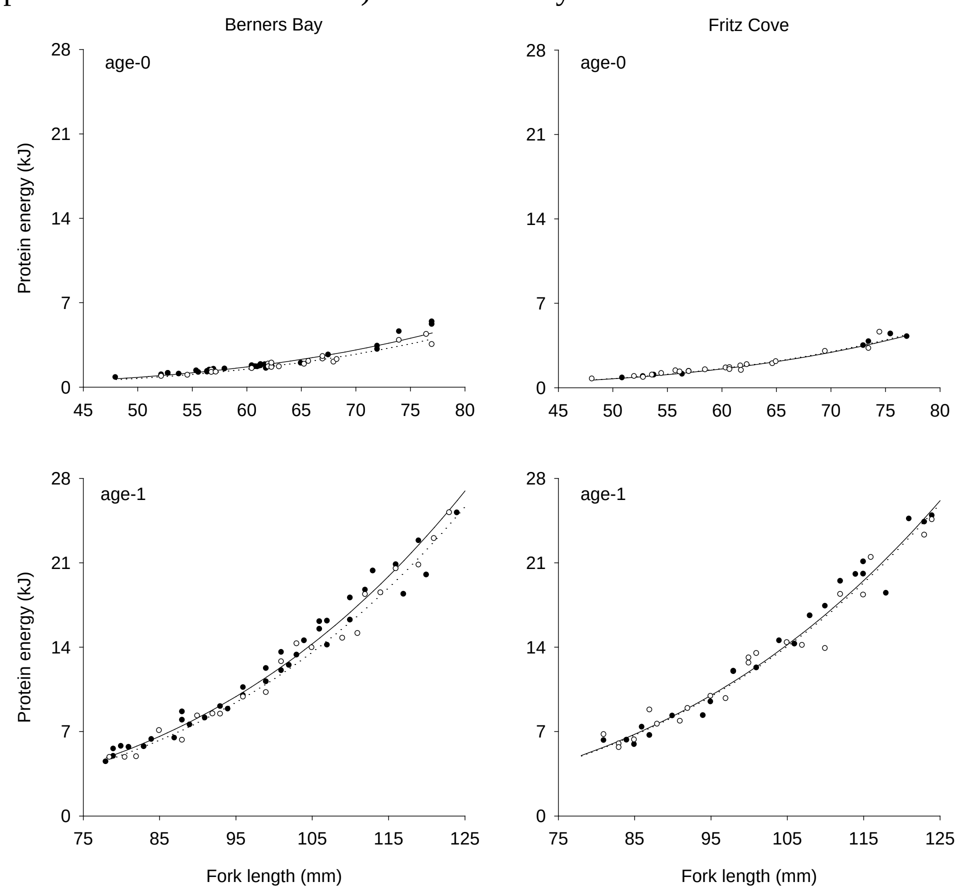


Figure 3. Energy allocated to protein in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

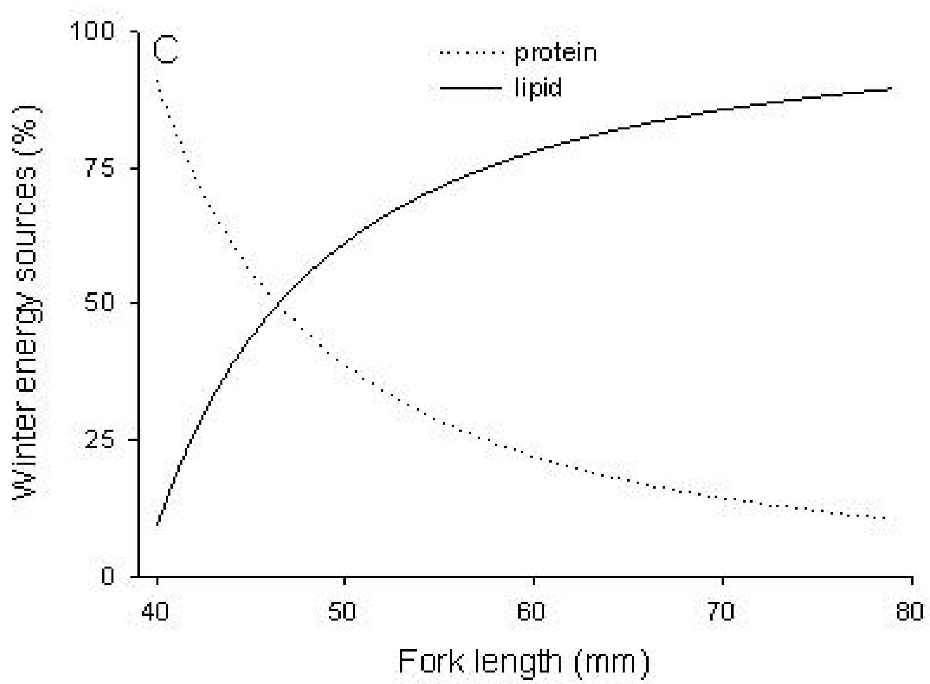


Figure 4. Modeled relationships between capelin fork length and the relative contribution of lipid and protein energy to the winter energy deficit.

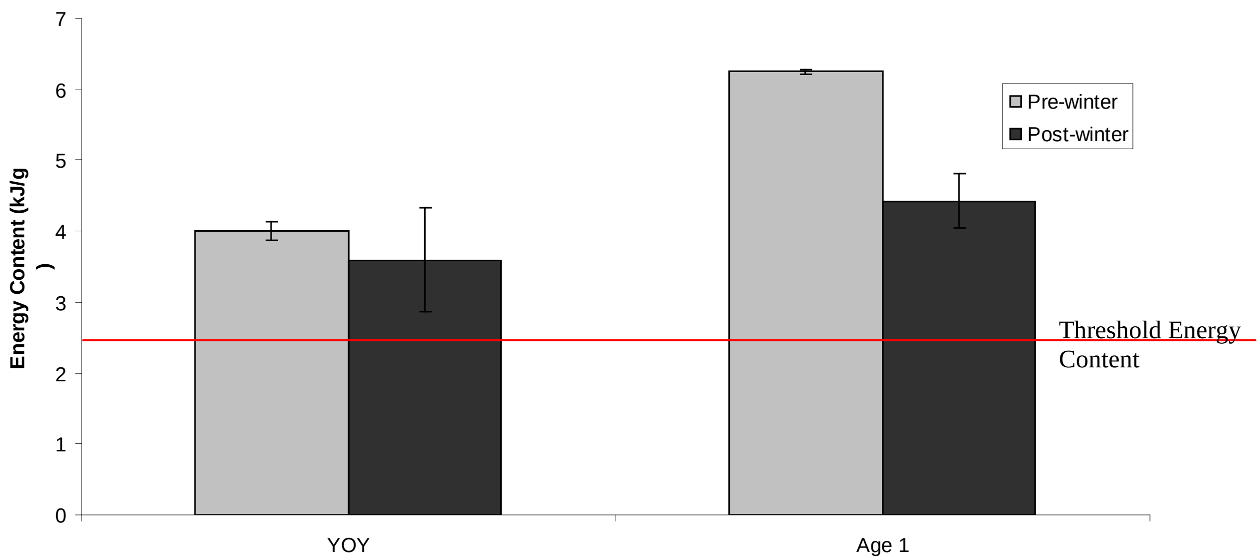


Figure 5. Overwinter energy loss (kJ g^{-1}) of juvenile capelin. Red line denotes the threshold energy content below which mortality occurs.

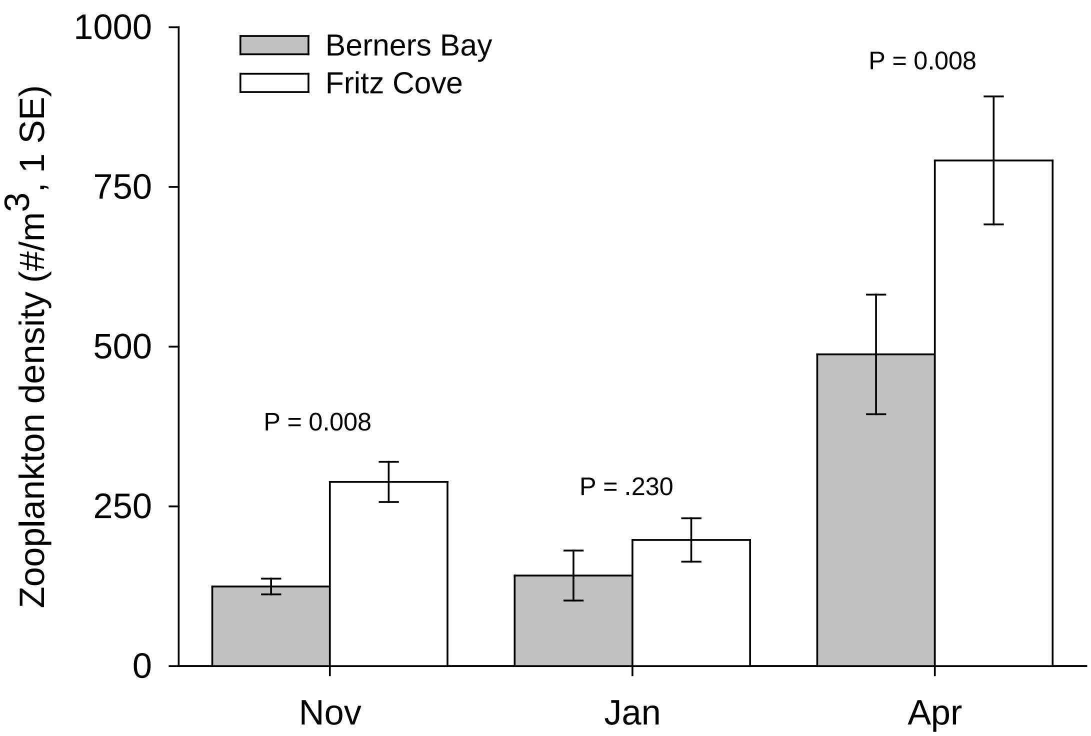


Figure 6. Zooplankton abundance in Berners Bay and Fritz Cove during winter 2006/2007. P-values are from Mann-Whitney U tests.

Essential Fish Habitat project status report

Reporting date: 10/2/12

Project number: 2008-01

Title: Nearshore Fish and Habitat Assessment

PIs: Johnson, Thedinga, Lindeberg, Harris

Funding year: FY08

Funding amount: $91K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Pat Harris has completed the eelgrass monitoring paper (see last year's status report).

Completed: NOAA Tech. Memo. (in press; will be available in November 2012).

Results: What is the most important result of the study?
We studied three eelgrass (*Zostera marina*) beds in the City and Borough of Juneau (CBJ), Alaska to track changes associated with coastal development. These beds were initially sampled as part of a baseline eelgrass inventory from 2004 to 2007. Between 2008 and 2011, beds were remapped and resampled for eelgrass variables (e.g., percent cover, faunal assemblage). Eelgrass area declined at all beds from baseline (2004 to 2007) to post-baseline (2008 to 2011) years. Areal loss of eelgrass was twice as great at the bed with the most recent and intense development (Auke Nu Cove, 61% loss) compared with losses at the previously developed Bay Creek (29%) and undeveloped Bridget Cove (30%) beds. The largest loss of eelgrass at Auke Nu Cove was along the seaward edge of the entire bed and was probably related to increased turbidity. In contrast, the seaward extent of eelgrass at Bay Creek and Bridget Cove remained relatively stable. Differences in eelgrass characteristics between baseline and post-baseline years and developed and undeveloped beds were also apparent. Mean percent eelgrass cover and shoot density declined from baseline to post-baseline years at all beds, but declines at developed beds (42 to 51%) were approximately twice those at the undeveloped bed (23 to 25%). Additionally, biomass declined (45 to 48%) at developed beds but increased (17%) at the undeveloped bed. Faunal assemblages changed with eelgrass loss. Coincident with the complete loss of eelgrass at one seine site, mean catch-per-unit-effort of fishes declined from 401 to 140, and the number of fish species declined from 19 to 16. Seine catch of green sea urchin (*Strongylocentrotus droebachiensis*) increased from baseline to post-baseline years at Auke Nu Cove; urchin grazing likely accounted for some of the observed loss in eelgrass at the cove. Monitoring of these three eelgrass beds will provide resource managers with useful information to evaluate possible effects of future coastal development upon this important nearshore habitat. We recommend biennial monitoring of these beds that includes, at a minimum, mapping seaward eelgrass boundaries and sampling percent eelgrass cover by tidal elevation. Coincidently, fauna should be sampled with a beach seine to monitor abundance of indicator fish and invertebrate species.

Essential Fish Habitat project status report

Reporting date: October 4, 2010

Project number: 2008-02

Title: Productivity habitat utilization and recruitment dynamics of Pacific cod.

PIs: Laurel, B.J., Ryer, C.H., Stoner, A., Knoth, B., Urban, D.

Funding year: 2008

Funding amount: $29,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Yes. See attached electronic copy:

Knoth B, Laurel BJ (2009) Dietary overlap and competitive interactions between juvenile gadids in coastal Alaska. Alaska Marine Science Symposium. Anchorage, AK (poster)

Results: What is the most important result of the study?

1) Age 1 and 2+ juvenile saffron and Pacific cod have a high degree of dietary overlap (driven mainly by the importance of mysids and gammarid amphipods). A high degree of dietary overlap suggests competition for food resources may occur if food supplies become limited. However, the diets of the two gadids varied noticeably outside the importance of mysids and amphipods which suggests these cod species are able to exploit different niches which may reduce competition.

2) Differences in the relative importance of secondary prey items (i.e. fish and decapods-Pacific cod vs isopods-saffron cod) may reflect small scale differences in habitat use by the juvenile gadids within the nursery areas.

3) Inter-cohort cannibalism does not appear to be a factor affecting cod survival in coastal nursery areas around Kodiak. However, the abundance of age 0+ cod in coastal Alaska can fluctuate greatly on a yearly basis and it is possible that cannibalism is a density-dependent phenomena in these regions.

4) Age – 0 juvenile cod were too few in number to bring back to the lab for experimental work. However, although not reported, all sites for the routine seining and baited camera survey were sampled (64 seines, 96 baited camera sets). These data will seed the synthesis paper following FY10 (final year of the intended 3 yr project).

Essential Fish Habitat project status report

Reporting date: Oct. 29, 2009

Project number: 2008-03, 2009-05

Title: Contrasting predation intensity and distribution in 2 rock sole nursery areas: a principle factor controlling nursery productivity - Component A: Contrasting predation.

PIs: Ryer, Laurel, Knoth

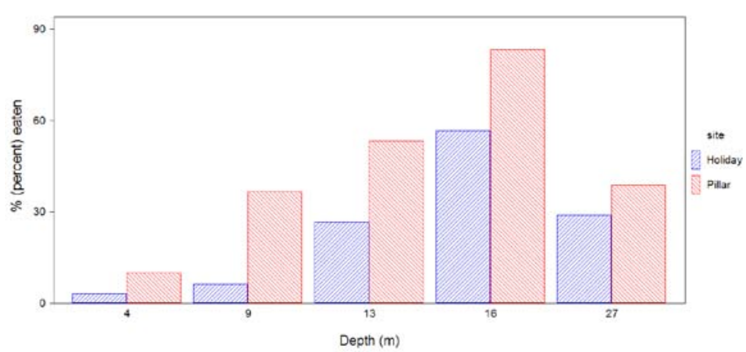
Funding year: 2009

Funding amount: $20,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. Thus far, one manuscript derived from this project has been submitted for publication to Marine Ecology Progress Series (see attached manuscript). We anticipate submitting either 3 or 4 additional manuscripts, supported in part by this and prior HEPR funding, during the course of the next 24 months.



Results: What is the most important result of the study? As in 2008, worm turf constituted a dominant habitat feature at Pillar Creek Cove, and to a lesser extent at Holiday Beach. However, unlike 2008, when the turf was extremely dense and contiguous, during 2009 the turf was less dense and more patchy. In 2008, fish were aggregated along the edge of the turf. In 2009 fish were most abundant within the sand patches within the turf. Tethering (15 min sets) revealed increasing predation risk with increasing depth at both sites. This was particularly evident as depth increased from 4 to 16m. Sixteen m corresponded to the shoreward edge of the worm turf, which then extended out to approximately 50m depth. Importantly, predation decreased significantly at 27m, at depth at which tethers were set in the worm turf proper. These result support one of our principle theories regarding use worm turf habitat by juvenile flatfish; worm turf provides protection from predators, but is avoided when it becomes so dense as to preclude unfettered access to the bottom and interferes with movement and burial.

A second important finding was that predation was uniformly lower at Holiday Beach than at Pillar Creek Cove. These results are consistent with our prediction stated in our original proposal to HEPR for 2008 funding. We had previously documented comparable predation rates at these 2 sites (see attached manuscript). These results suggest that the nursery value of these sites may vary from year to year. The significance of this data may become more clear as video survey data of predator abundance from 2002 – 2009 in completed this winter.

Lastly, as expected, predation upon juvenile flatfish was much lower at night than during the day.

Essential Fish Habitat project status report

Reporting date: Oct. 29, 2009

Project number: 2009-11

Title: Contrasting predation intensity and distribution in 2 rock sole nursery areas: a principle factor controlling nursery productivity - Component B: Monitor worm turf recovery and seasonal changes.

PIs: Ryer, Laurel, Knoth

Funding year: 2009

Funding amount: $13,000

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. We anticipate submitting a manuscript for peer-reviewed publication during the next 12 months.

Results: What is the most important result of the study? We are still analyzing video footage. However, disturbance of the worm turf habitat attributable to our simulated bottom trawling activity appears to have been relatively minor compared to the seasonal pattern of benthic disturbance driven by winter storm activity. Initially, scrape marks where worms were removed by our gear were readily evident along our disturbance tracts. Also, consistent with our results from component A, juvenile flatfish abundance increased in these disturbed tracts. However, within several months wave action began to erode away sections of the worm turf, so that by late winter/spring, the formerly contiguous turf had be reduced to a patchwork of turf habitat, and trawl disturbed tracts were no longer recognizably different from control areas. We suspect that excavations attributable to sea stars and/or sea otters constituted initial disturbances, which were subsequently expanded by bottom surge (much in the same way wave action expands small holes in mussel mats caused by log impacts in the inter-tidal). We will finish data analysis in the next 6 months and anticipate submitting a manuscript this year.

Essential Fish Habitat project status report

Reporting date: 10/5/09

Project number: 2008-04

Title: Physical and temporal aspects of pollock spawning habitat utilization

PIs: Kevin Bailey and Kung-sik Chan

Funding year: 2008

Funding amount: $33,980

Status: x☐ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: A draft manuscript has been completed. This manuscript is being revised. In the continuation funding for 2009, the modeling results will be refined.

Results: Our project examined the temporal and spatial aspects of occupation of spawning habitat by walleye pollock in the Gulf of Alaska as reflected by ichthyoplankton data. Larval hatchdate distributions are shaped by the inflow/outflow dynamics of spawning and mortality. We developed statistical modeling techniques using a 20 year time series of hatchdate distribution data, with which we were able to describe how habitat related variation in temperature and transport, harvesting and intervention effects (regime shift and oil spill) influenced the spawning time and survival of pollock larvae.

Essential Fish Habitat project status report

Reporting date: 10/18/2010

Project number: 2008-5

Title: Habitat characterization and utilization of early benthic phase red king crab

PIs: **Persselin, Stoner, Foy, Eckert**

Funding year: 2008

Funding amount: $45,166

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: The project data have not been formally reported at this time.

Results: What is the most important result of the study?

Field work was completed in spring 2010 to quantify larval supply and habitat use by early benthic juvenile red king crab. Larval supply was minimal and not high enough to test for any differences among Bays. At marginal pier in Women's Bay near Kodiak Island larval supply in shallow areas was lower than in deeper areas, however, the larval collection devices in shallow areas became covered with filamentous green algae that may have affected settlement of red king crab. Additionally, suction dredging did not capture a single juvenile red king crab suggesting that the recruitment processes to the benthic habitat in this region are extremely low. The photo survey was also completed in June 2010. The final analysis of the photos will be completed in the winter of 2011. These data will be incorporated into an ongoing project to assess red king crab habitat in nearshore areas of Kodiak Island.

As the total number of crabs captured either in the suction dredges or in the larval collection devices was low, no statistical analyses could be performed relating juvenile RKC to habitat. The habitat assessment by photos, which will quantify cover by both biogenic and non-biogenic structure, will give an annual progression of known juvenile red king crab habitat. In general, in shallow areas, macro-algae grew during the spring and summer and died back during the fall and winter, whereas there was no seasonal change in habitat in the deeper areas. This data will be generally useful for other projects examining temporal shifts in habitat in Alaskan waters.

Essential Fish Habitat project status report

Reporting date: October 31, 2013

Project number: 2006-12, 2007-12, 2008-06

Title: **Overwinter habitat use and energy dynamics of juvenile capelin, eulachon, and Pacific herring**

PIs: J. Vollenweider, R. Heintz

Funding year: FY 2006-2008

Funding amount: 2006: $50,300; 2007: $57,900; 2008: $44,540

Status: X Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Reporting: Two reports have been completed describing the overwinter energy allocation strategies of juvenile 1) eulachon and 2) capelin.

Results:

Winter starvation mediated by low-levels of foraging is likely an important mechanism structuring recruitment success of juvenile forage fish. Over the course of two winters, we observed size-selective mortality in juvenile eulachon and capelin stemming from starvation in the smallest individuals. Between the fall and subsequent spring sampling periods, length frequency distributions of juveniles shifted towards larger individuals, which could either be indicative of a loss of smaller fish or growth (Figure 1). Growth overwinter is highly unlikely, however, as fish lost energy during this period and therefore surplus energy would not have been available for growth.

Winter energy deficits resulted from the loss of both lipid and protein energy. The magnitude of the deficit and relative depletion of lipid and protein were size dependent (Figures 2 and 3). Larger juveniles began winter with greater lipid reserves than smaller fish. During winter, larger fish depleted more of their pre-winter lipid reserves than smaller fish, and as a consequence, the contribution of lipid catabolism to the winter energy deficit increased with body size (Figure 4). Although the relative proportion of protein loss was independent of body size, the smallest fish lost more energy in the form of protein than lipid. By the end of the winter, the energy content of the smallest surviving juveniles was very near the energetic threshold, below which mortality occurs (Figure 5). Thus, the smallest juveniles were under extreme nutritional stress and were forced to metabolize protein to meet most of their metabolic demands, apparently as a consequence of exhausting lipid reserves.

Comparisons from two bays (Fritz Cove and Berners Bay) indicate that prey availability plays an important role in survival of juvenile fish that are on the brink of starvation in winter. Despite a general scarcity of prey during winter, what little forage juvenile fish could consume appeared to help stave off starvation. Nearly half the juvenile eulachon were feeding during the winter, as evidenced from stomach contents. Zooplankton prey species, particularly copepods, were more abundant in Fritz Cove than Berners Bay (Figure 6). Though juvenile eulachon in Fritz Cove were smaller and had lower energy reserves going into winter, they were in better condition than those from Berners Bay in the spring, suggesting that prey availability may help to preserve lipid reserves and thereby reduce starvation risk.

Collectively, these results indicate that the smallest eulachon and capelin do not store sufficient reserves of lipid for winter, are forced to metabolize protein, and may suffer a greater risk of winter mortality. Winter foraging, despite low prey abundance, may be crucial for survival. We suggest that disproportionately high rates of starvation among the smallest age-0 forage fish are important mechanisms influencing recruitment.

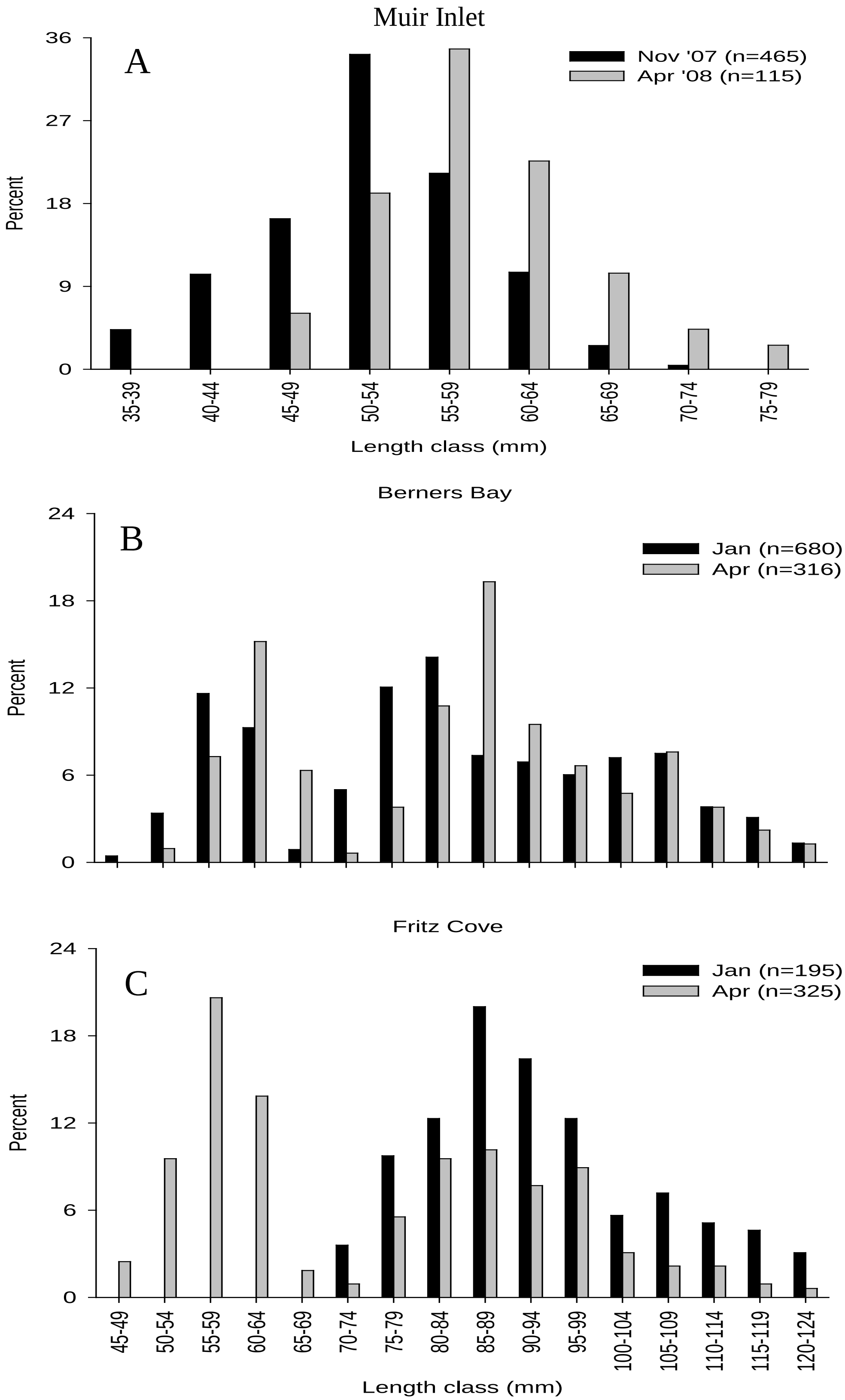


Figure 1. Shift in size distribution of juvenile capelin (A) and eulachon (B & C).

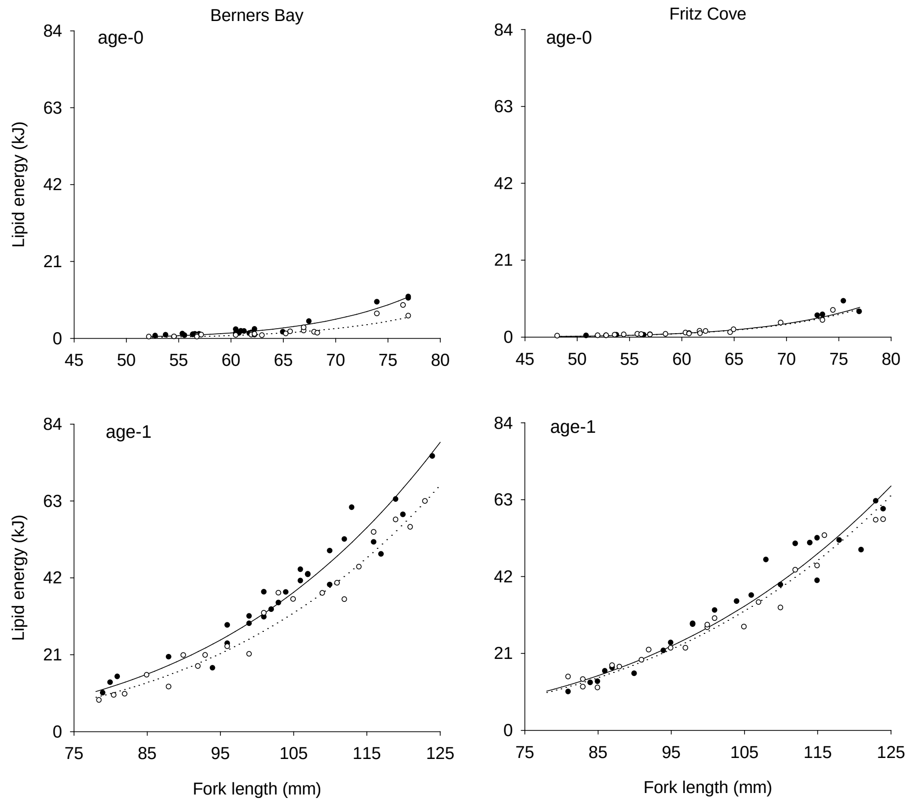


Figure 2. Energy allocated to lipid in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

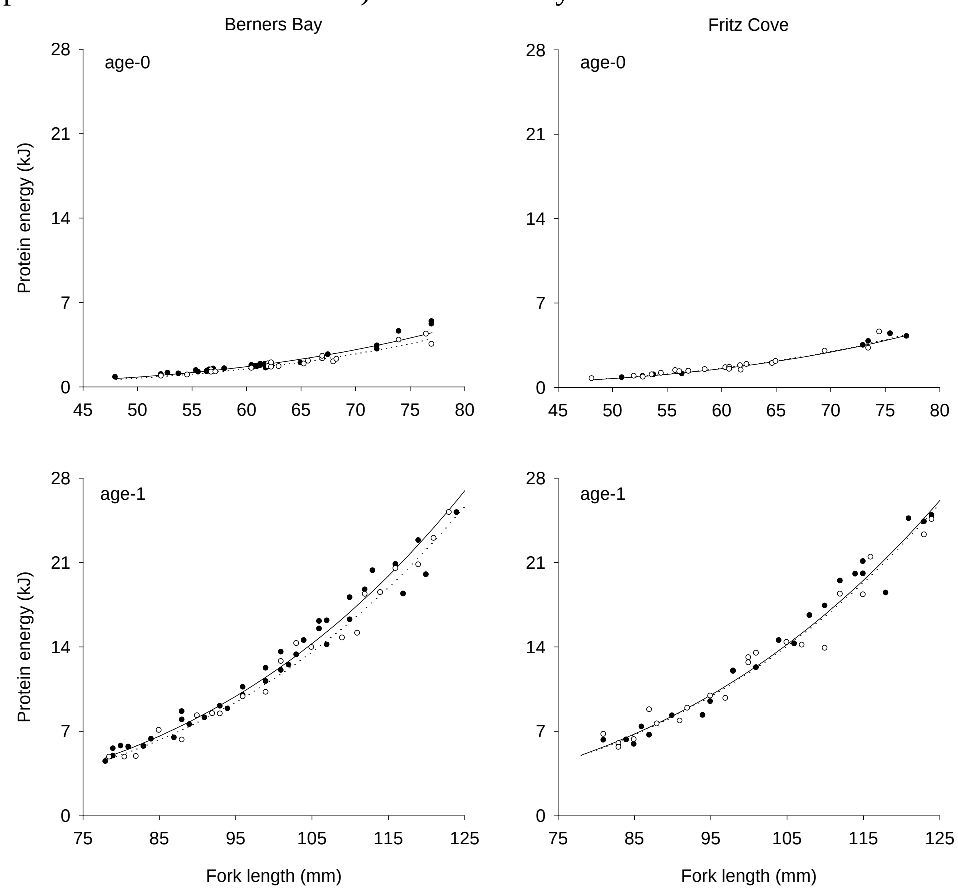


Figure 3. Energy allocated to protein in age-0 and age-1 eulachon in January (solid circles and lines) and April (open circles and dashed lines) in Berners Bay and Fritz Cove.

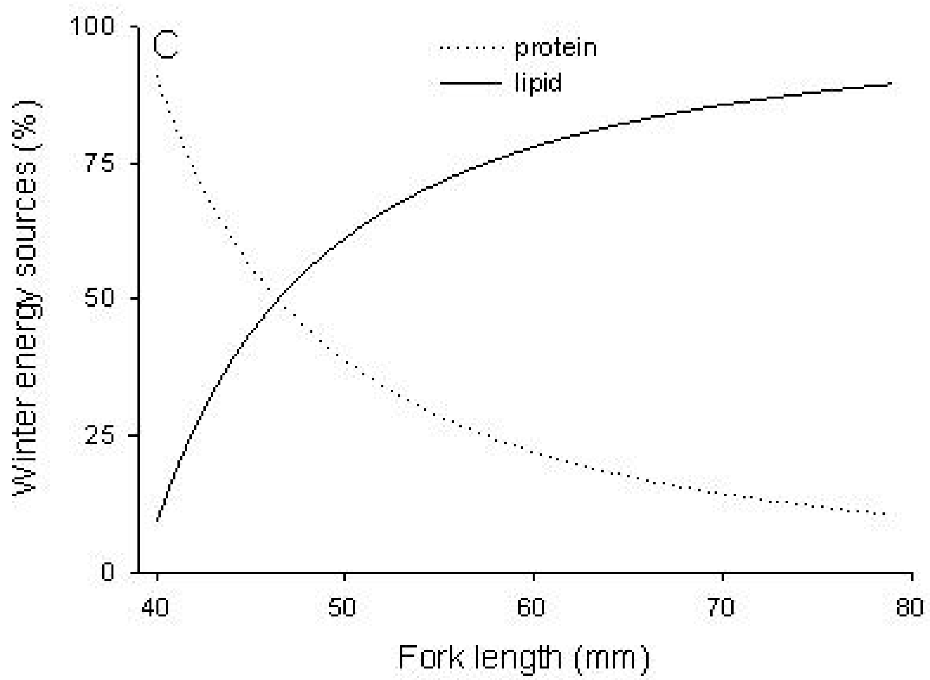


Figure 4. Modeled relationships between capelin fork length and the relative contribution of lipid and protein energy to the winter energy deficit.

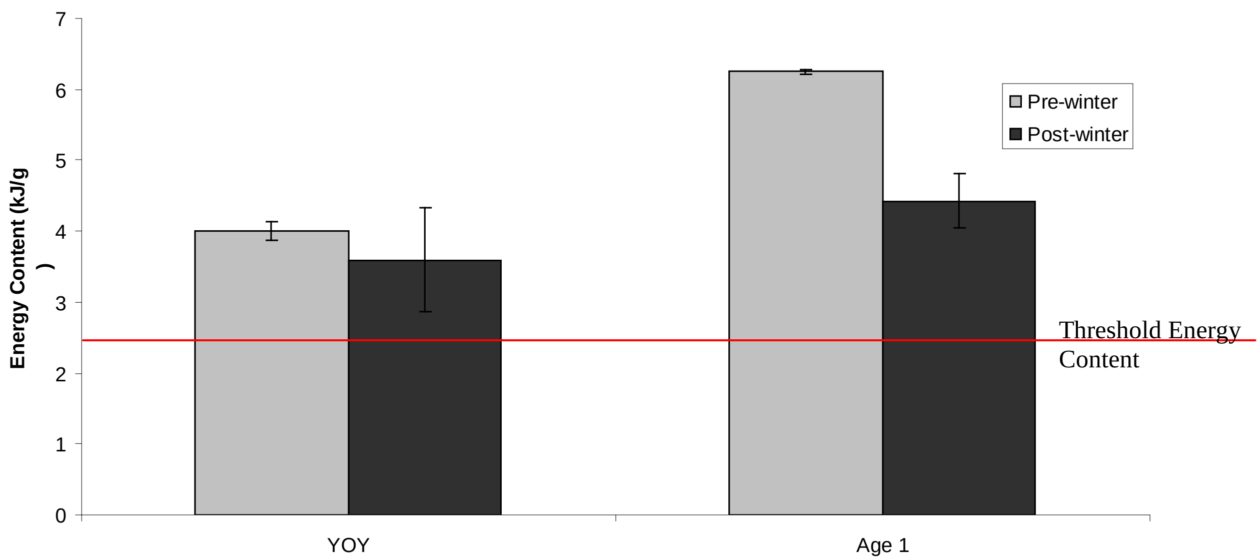


Figure 5. Overwinter energy loss (kJ g^{-1}) of juvenile capelin. Red line denotes the threshold energy content below which mortality occurs.

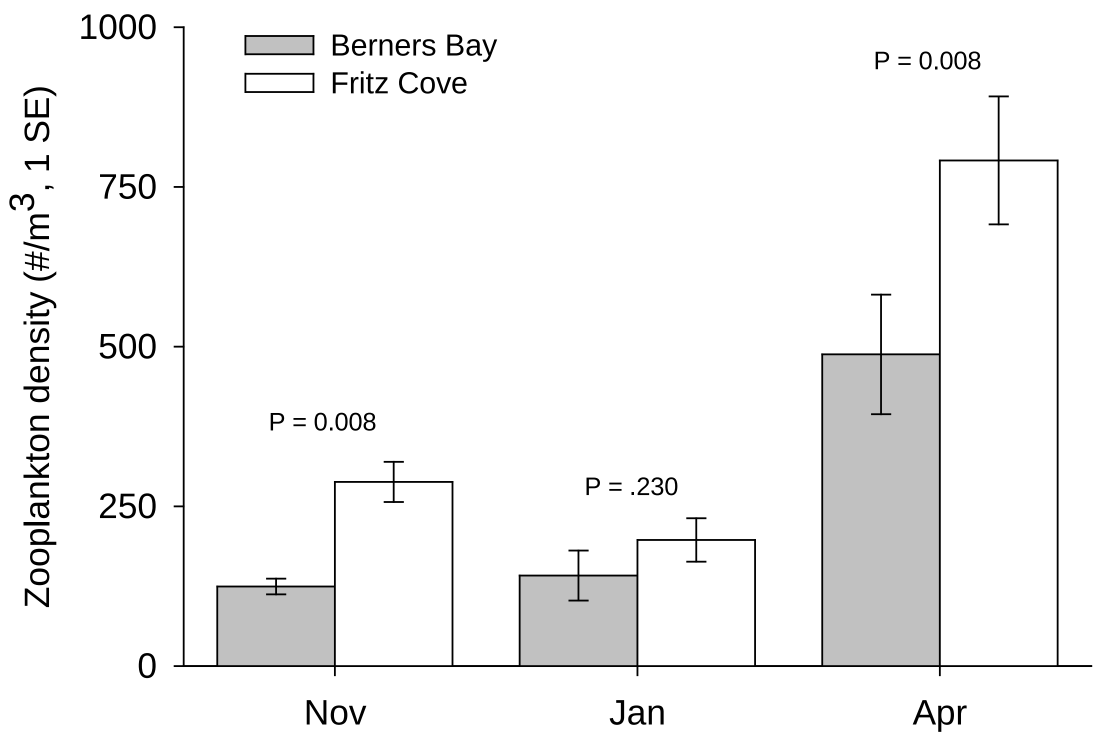


Figure 6. Zooplankton abundance in Berners Bay and Fritz Cove during winter 2006/2007. P-values are from Mann-Whitney U tests.

Essential Fish Habitat project status report

Reporting date: September 17, 2009

Project number: 2008-07

Title: Rockfish abundance and diurnal habitat associations on isolated rocky habitat in the eastern Bering Sea

PIs: Gerald R. Hoff, Chris Rooper

Funding year: 2008

Funding amount: $90,850

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: June 2009

Reporting: Have the project results been reported? Yes
If yes, where were the results reported?

Rooper, C.N., G.R. Hoff, and A. DeRobertis (in review) Assessing habitat utilization and rockfish biomass on an isolated rocky ridge using acoustics and stereo image analysis. Canadian Journal of Fisheries and Aquatic Sciences

Results: What is the most important result of the study?

During July 11-17 of 2008 a study was conducted aboard the FV/*Vesteraalen* on two unique rocky ridge habitats in the southern Zhemchug Canyon region. Acoustic data for biomass estimates as well as bottom topography and substrate type were collected along transects on each ridge using an EK60 single beam (38 kHz) echosounder during daylight hours and during nighttime hours. A stereo-video drop camera system was used to collect species and length composition data on fish and invertebrate species and their habitat associations at 15 transects.

EK60 transects conducted during daylight and nighttime hours along the same tracklines showed adult fish and larger juveniles were in the water column during the daylight hours and on bottom during nighttime. Video analysis from camera drops concurred by showing rockfish to be predominantly benthic during night, when fish were observed lying directly on the bottom and not visible to hydroacoustic methods. During daylight hours fish were demersal to pelagic forming large active schools above the bottom shown both by EK60 and video analysis. The distribution of rockfish on the ridges showed that while in the water column they were observed primarily on the southern side of the two ridges and found predominantly over the ridges in contrast to an adjacent flat sandy area.

Hydroacoustic and video data showed the rocky ridges to be highly productive as rockfish habitat and the ridges possessed an abundance of HAPC species such as coral and sponges, unlike the surrounding eastern Bering Sea slope habitat. We estimated 15,447 t of adult rockfish (predominantly northern rockfish) and 916 t of juvenile rockfish (predominantly POP). This is a much larger biomass of northern rockfish than has previously been estimated for the eastern Bering Sea shelf or slope. This research produced a habitat-based biomass estimate for fishes in an untrawlable area using acoustics as the primary tool for measuring fish biomass and stereo video for estimating both species composition and fish length.

Essential Fish Habitat project status report

Reporting date: 10/31/09

Project number: 2008-08

Title: Characterization of Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea

PIs: Cynthia Yeung, Mei-Sun Yang, Robert McConnaughey

Funding year: 2008

Funding amount: $66,500

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Benthic sampling and stomach collection were the two requisite field elements in this project. Benthic sampling planned for this project was not completed in 2008 because the designated research vessel, the NOAA ship *Fairweather*, was unable to sail on schedule. Only 3 of 31 planned benthic stations were sampled in the single working sea-day salvaged. Stomach collection was completed in August 2008 as a special project on the annual eastern Bering Sea (EBS) bottom-trawl survey. Missing the benthic samples, the objective of investigating the spatial correspondence among fish diet, infauna community and sediment properties was not achievable.

All research elements of this roject were instead put into a new EFH project that was funded in 2009 (EFH Project No. 6: Characterization of Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea - Reduced plan, $77,800). This project is therefore considered complete. Funds originally for processing stomach, sediment, and infauna samples in this project were applied to the new project. A separate project status report is submitted for the new project.

Reporting: Have the project results been reported? If yes, where were the results reported?

No.

Results: What is the most important result of the study?

One of three passes on one of six planned acoustic transects and three of 31 planned grab stations were sampled in this project (Fig. 1). We requested the collection of 15 stomachs per fish species (6) per station at 27 of the 31 planned infauna and sediment grab stations (Fig. 1) on the 2008 EBS bottom trawl survey (total stomachs requested=1620). If possible, the 15 stomachs for each species were to be obtained from three length classes (<20 cm, 20-40 cm, >40 cm) in equal numbers (5 from each class). Collection was not requested at all 31 stations because effort was a concern. Actual numbers obtained were: 229 Alaska plaice (AKP); 260 yellowfin sole (YFS); 286 northern rock sole; 215 flathead sole (FHS); 70 long head dab (LHD); 10 spinyhead sculpin (SHS); (total stomachs collected=1,070). The number of stomachs collected from target groundfish species at each grab station is given in Table 1.

Without a concurrent set of sediment and infauna data to correlate with the stomach data, it was agreed by the EFH program and grantees that the processing of the stomach samples should be postponed indefinitely. Instead, those 2008 funds for processing stomach samples should be applied to the new project in 2009, when concurrent sets of stomach and benthic data would be collected. Likewise, the 3 infauna samples and the chemistry of the 3 sediment samples were not analyzed in order to redirect funds to 2009, when the complete set of 31 grab samples would be collected. However, granulometric analysis of the 3 sediment samples has been completed (Table 1). These would serve as replicates for analyzing the spatial-temporal variability of granulometry in the vicinity of those 3 stations.

Table 1. Classification of sediments collected in July-August 2008 with van Veen grab on the NOAA ship *Fairweather*, and the corresponding numbers and species of stomach samples collected in the same period during the bottom trawl survey on FV *Arcturus* and *Aldebaran*.

Sediment							Stomachs						
station	lat	lon	type	%gravel	%sand	%mud	station	LHD	AKP	NRS	YFS	FHS	SHS
A02	55.00	166.95	SM	0.0	48.8	51.2	A02	0	0	0	0	15	11
X10*	56.44	164.44	MS	0.0	62.5	37.5	E06	0	2	15	10	0	0
F07	56.67	164.00	MS	0.0	59.8	40.2	F07	0	15	15	15	0	0

*~17 km (~9 nmi) NE of E06 in same trawl cell; see Fig. 1
type – SM=sandy mud; MS=muddy sand

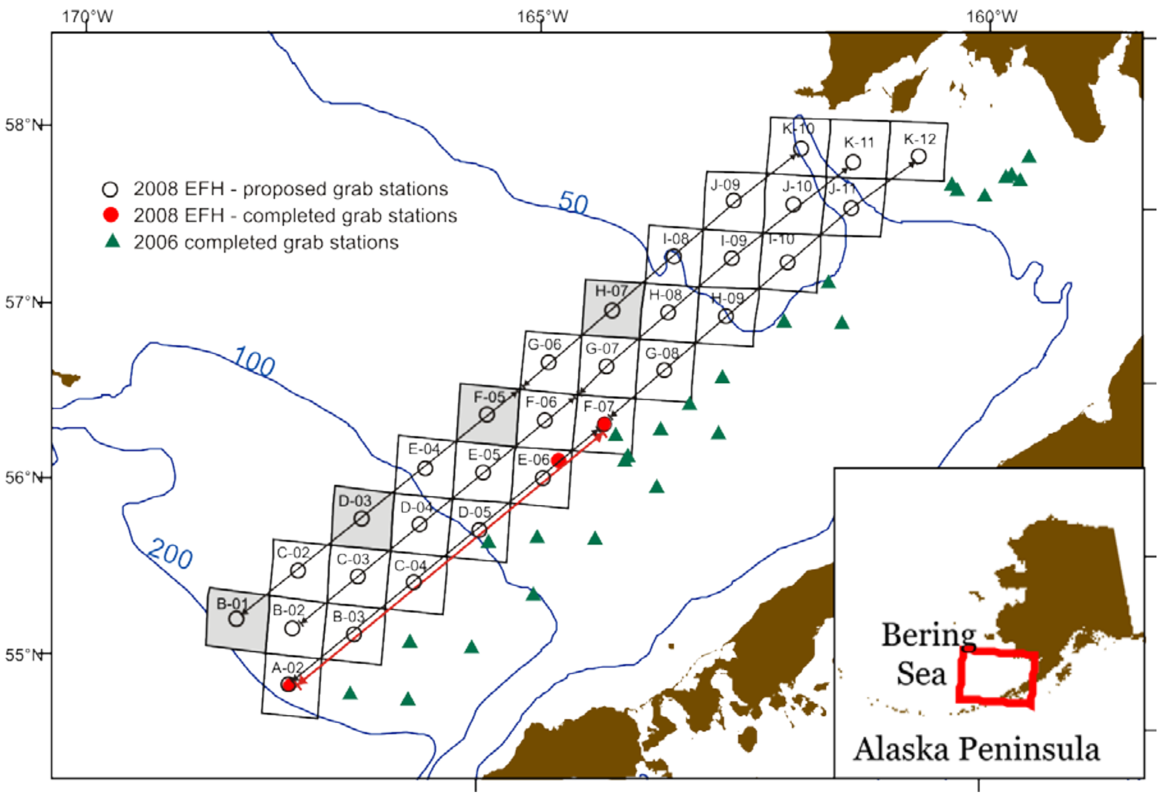


Figure 1. Map of EBS study area proposed in the 2008 EFH project, and the trawl survey grid cells involved. Solid black lines represent acoustic transects proposed in the project; solid red line represents the one actually completed. Stomachs were collected at all trawl stations, except ones in the shaded cells.

Essential Fish Habitat project status report

Reporting date: 10/23/2015

Project number: 2008-9

Title: Juvenile Slope Rockfish Habitat Utilization

PIs: Patrick Malecha, Andy Gray, Chris Lunsford, Dave Clausen

Funding year: 2008

Funding amount: $93,300

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: A manuscript is in preparation and shall be submitted for publication in 2016.

Reporting: Preliminary results from this research were reported in an oral presentation as part of the HEPR-themed AFSC seminar series. A manuscript is currently in preparation.

Results: Surface trawling (up to 60 nautical miles offshore) with an aquarium codend (livebox) successfully captured over 1200 live juvenile rockfish. Live specimens were transferred to the TSMRI wet laboratory with minimal mortalities. A genetic analysis was completed and identified five distinct rockfish species among the captured specimens. The two most abundant species were Pacific ocean perch (POP, *Sebastes alutus*) and yellowtail rockfish (*Sebastes flavidus*). Suitable observational arrays were obtained and installed in the TSMRI wet laboratory and all fish were acclimated to a modified photoperiod before habitat preference and predation trials were completed. Great sculpin (*Myoxocephalus polyacanthocephalus*) were acquired near Little Port Walter, transferred to the TSMRI wet laboratory, and used as predators.

Habitat utilization of POP and yellowtail rockfish was determined in laboratory aquariums under daytime and nighttime conditions. Young-of-the-year (YOY) were observed in side-by-side comparisons of four habitat types (coral, sponge, cobble, and gravel) to determine habitat preference. POP and yellowtail rockfish preferentially utilized emergent habitats versus gravel during daylight hours but were less associated with these habitats at night (Figs. 1a and 1b). POP utilized coral and cobble equally whereas yellowtail rockfish preferred to utilize coral more than any other habitat. The percentage of rockfish in contact with either the bottom or with an emergent habitat was significantly greater during nighttime observations than daytime. Habitat-mediated predation rate of YOY POP was examined within the four habitats utilizing great sculpin as predators. Predation of POP was highest in gravel compared to emergent habitats (Fig. 2). This work explores the behavior of juvenile slope rockfish and their relationship with benthic habitats and provides evidence for the importance of emergent habitats to juvenile slope rockfish.

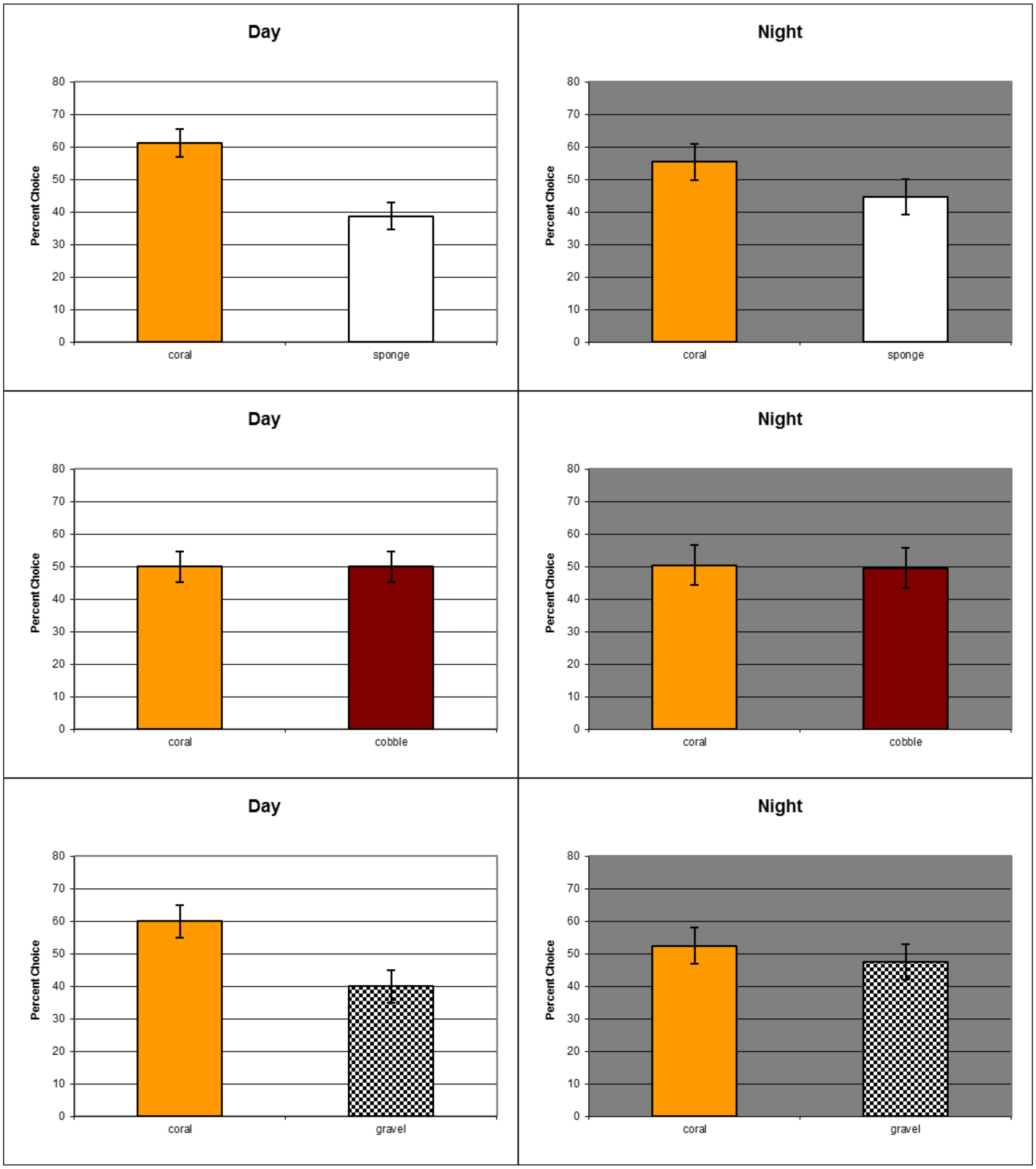


Figure 1a. Habitat preference of young-of-the-year Pacific ocean perch (POP) during daytime and nighttime conditions. Preference is reported as the percentage of POP occupying each habitat type.

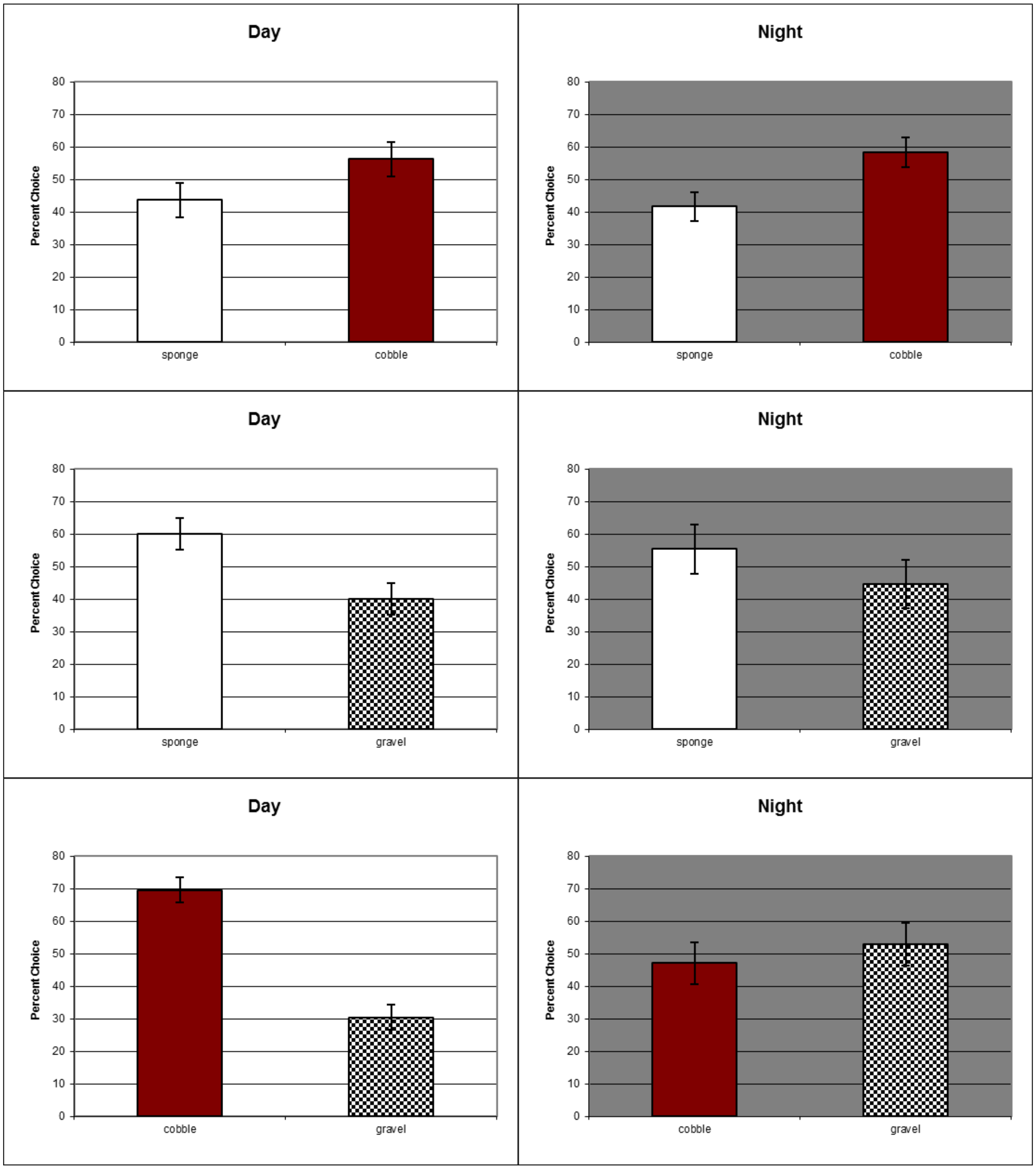


Figure 1b. Habitat preference of young-of-the-year Pacific ocean perch (POP) during daytime and nighttime conditions. Preference is reported as the percentage of POP occupying each habitat type.

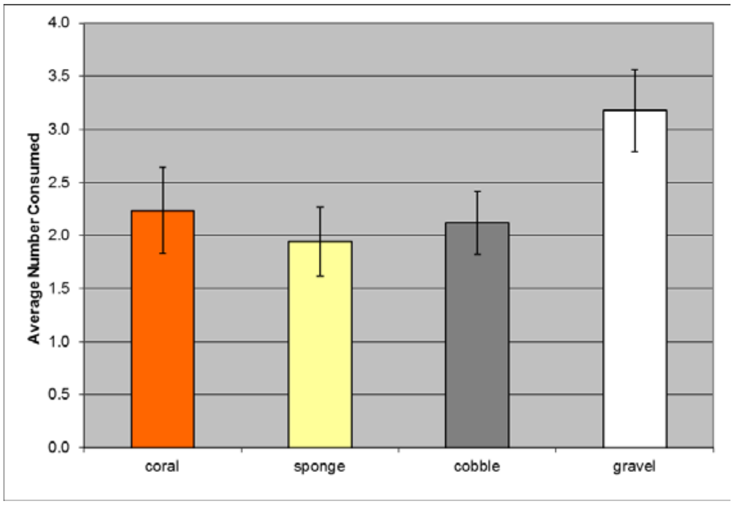


Figure 2. Predation of young-of-the-year Pacific ocean perch (POP) by great sculpin within four habitats. Predation is reported as the average number of POP consumed per trial. Nineteen trials were completed for each habitat type.

Essential Fish Habitat project status report

Reporting date: 10/17/2013

Project number: 2009-1

Title: Recovery of deep water sponges and sea whips from bottom trawling

PIs: Pat Malecha, Jon Heifetz

Funding year: 2009

Funding amount: $105,900

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: A manuscript submitted to Marine Ecology Progress Series is currently in review. See attached.

Results: Much research has examined short-term effects of bottom trawls on seafloor habitat. We characterize long-term recovery dynamics of deepwater sponges by revisiting, in 2009, sites of a 1996 experimental trawling study. The study sites had been sampled previously; benthic organisms were assessed immediately after trawling and 1 yr post-trawling. Thirteen years post trawling we found the density of sponges was 31% lower and the incidence of sponge damage was 64% higher in trawled versus reference areas. The incidence of damage among sponges in trawled areas decreased compared to earlier observations but the difference in sponge density, between trawled and reference areas, grew larger. Delayed mortality or reduced recruitment are possible explanations for the reduced relative density of sponges in trawled areas. Average sizes of 7 out of 8 sponge species were larger in reference areas than in trawl areas but the differences were not significant on an individual species basis. The persistence of damage and the potential resultant changes to benthic community structure provide rationale for cautious management of bottom trawling in areas where deepwater habitat-forming biota are present.

Long-term effects of bottom trawling on sponges in the Gulf of Alaska

Patrick Malecha* and Jonathan Heifetz

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***email: pat.malecha@noaa.gov**

Abstract

Much research has examined short-term effects of bottom trawls on seafloor habitat. We characterize long-term recovery dynamics of deepwater sponges by revisiting, in 2009, sites of a 1996 experimental trawling study. The study sites had been sampled previously; benthic organisms were assessed immediately after trawling and 1 yr post-trawling. Thirteen years post trawling we found the density of sponges was 31% lower and the incidence of sponge damage was 64% higher in trawled versus reference areas. The incidence of damage among sponges in trawled areas decreased compared to earlier observations but the difference in sponge density, between trawled and reference areas, grew larger. Delayed mortality or reduced recruitment are possible explanations for the reduced relative density of sponges in trawled areas. Average sizes of 7 out of 8 sponge species were larger in reference areas than in trawl areas but the differences were not significant on an individual species basis. The persistence of damage and the potential resultant changes to benthic community structure provide rationale for cautious management of bottom trawling in areas where deepwater habitat-forming biota are present.

Keywords
Trawling, Sponge, *Mycale loveni*, Benthic habitat

Introduction

Sponges are broadly distributed throughout the Gulf of Alaska, Bering Sea, and along the Aleutian Islands region (Malecha et al. 2005). Individually and collectively these organisms form high-relief complex habitat that is thought to foster increased biological diversity and productivity by providing cover and food aggregations for juvenile and adult fish, especially rockfish (e.g. Freese & Wing 2003, Stone et al. 2005, Marliave et al. 2009, Beazley et al. 2013). Deepwater habitat-forming biota, such as sponges, are sensitive to anthropogenic disturbance. The interaction between bottom trawls and seafloor habitat has been the focus of much research (for reviews see Watling & Norse 1998, Auster & Langton 1999, Collie et al. 2000, National Research Council 2002). The relative effect of bottom trawls on benthic habitat depends on many factors including gear configuration, the geological characteristics of the seafloor, depth, and sensitivity of the habitat-forming species present (Collie et al. 2000). Deepwater habitats experience low levels of natural disturbance, are more susceptible to trawl effects and recover more slowly than shallow water habitats (Kaiser et al. 2002). The response of sessile benthic epifauna to trawl disturbance varies among taxa. In the short-term, deepwater sponges are particularly sensitive to trawl disturbances (Sainsbury et al. 1997, Freese et al. 1999, Freese 2001, Wassenburg et al. 2002). Little is known, however, about the long-term effects of trawl-induced damage to these important deepwater habitat-forming invertebrates.

In the Gulf of Alaska, near Salisbury Sound (Fig. 1), the immediate effects of trawling on large benthic invertebrates were documented by Freese et al. (1999). In 1996 the authors conducted individual trawl tows in areas where little or no trawling had occurred in the recent past, then compared the density of sponges (number m^{-2}) and the incidence of damage within trawl paths to adjacent untrawled reference areas. Roughly 1 yr later, the study site was revisited to evaluate medium-term effects of trawling on sponges (Freese 2001). The objective of the present study is to characterize the long-term effects of trawling by assessing the density and condition of sponges at the original trawl locations 13 yr post-trawling.

Methods

In 1996, 11 distinct locations were trawled with a single pass of a 4-seam, high-opening polyethylene Nor-eastern bottom trawl equipped with tire gear similar to that used in the commercial rockfish *Sebastes* spp. fishery (Freese et al. 1999). The study site (Fig. 1) was selected after consulting commercial fishing records that identified areas where zero or minimal trawling had occurred since the 1970s. Before the experimental trawls were conducted, the submersible *Delta* surveyed the seafloor to confirm the absence of trawl evidence (seafloor gouging, striations, displaced boulders, etc.). In 1998, the entire eastern Gulf of Alaska, including Salisbury Sound, was officially closed to trawling. Commercial longlining and crab pot fishing are still allowed in the study area but are likely to affect trawled and reference areas equally.

The study site is located on a moderate slope approximately 22 km southwest of Salisbury Sound in the eastern Gulf of Alaska near the continental shelf break between

207-212 m depth. The seafloor around Salisbury Sound consists mainly of sand, pebbles, and cobble with a few scattered boulders and the site supports an array of large erect sponge species. Generally, the geological characteristics of the site are representative of the habitat preferred by numerous rockfish species including Pacific ocean perch *S. alutus*, northern rockfish *S. polyspinis*, and redstripe rockfish *S. proriger* (Love et al. 2002). Rougheye *S. aleutianus*, blackspotted *S. melanostictus* and shortraker rockfish *S. borealis* occupy similar habitats but usually at deeper depths and on steeper slopes (Krieger & Ito 1992).

To enable comparison with previous studies, similar methods to those employed by Freese et al. (1999) and Freese (2001) were used in 2009. As in the previous studies, we used the submersible *Delta* to complete video transects along the seafloor. The 2-person *Delta* traveled at an average speed of 2.01 kmh^{-1}, maintained near constant contact with the seafloor, and was equipped with an oblique-facing camera and halogen lighting. Parallel lasers 20 cm apart, connected to the oblique camera, provided a scaling measure on the recorded video for determining sponge sizes in the laboratory. An observer inside the submersible narrated the videotape in real-time by verbally describing biota and geological features passing through the camera's field of view. This narration was invaluable for interpreting video in the laboratory, particularly for identifying species and determining sponge damage.

During the original study, efforts were made to trawl along isobaths over uniform bottom. However, the seafloor along a few of the sites was extremely rugged, with sheer drop-offs and exposed bedrock. Due to this topography, trawl contact with the bottom was inconsistent and difficult to confirm during submersible observations in the more rugged areas. Consequently, Freese et al. (1999) used data from only 8 of the 11 trawled sites where *in situ* observations confirmed consistent trawl contact with the seafloor. At each of the confirmed sites, the *Delta* was used to place numbered flags, fitted to lead weights, on the seafloor at the beginnings and ends of the individual trawl paths. Differential global positioning system (DGPS) coordinates of flag locations and compass bearings between flags were noted to facilitate relocation of those sites and allow subsequent observations.

Of the 8 sites analyzed by Freese et al. (1999), a few had very low densities of sponges. With limited time at depth available in 1997 (1 yr after the initial study), Freese (2001) prioritized 3 trawl paths for relocation due to the high density of sponges previously observed in these areas. These sites were revisited in 1997 to document the "medium-term" trawl effects on sponges. In 2009 (13 yr after the initial study), we completed 16 dives with the *Delta* submersible in an attempt to revisit 7 of the original trawl sites. We found 12 of 14 markers demarcating the paths of those trawls. Relocation of the trawl markers was difficult because the flags had fallen off the fiberglass poles they were attached to, making the markers that were still upright very similar in appearance to living sea whips *Halipteris willemoesi*. A few other markers had fallen over and were partially buried by sedimentation. To facilitate future research, we deployed new markers adjacent to the old markers. The new markers consist of a 25 cm spherical trawl float attached to a 10 pound cannonball with ½" groundline. Since we could not locate 1 marker on each of 2 trawl paths, we only analyzed videotape from the 5 sites where both markers were located and where we had confidence that our trawl transects were within the paths of the original trawls. Strip transects were completed inside and outside the trawled areas. Transects within the trawled areas followed a course from one marker to another along a designated bearing; reference transects were completed a distance of 100 m away from the trawl transects along a parallel bearing. The tender vessel, R/V *Medeia*, actively tracked the submersible on the seafloor and provided course corrections between markers as necessary.

In the laboratory, video from strip transects was reviewed to determine sponge density and compared between trawled and reference areas with an exact permutation test (Noreen 1989, Odiase & Ogbonmwan 2007). The test statistic was the *t* -statistic generated from one-sided paired *t*-test. The permutation test was used because of the small sample size and therefore unknown distribution of the density estimates. The conventional paired *t*-test assumes that the density estimates are normally distributed. Specimens < 20 cm were more difficult to identify and evaluate, therefore, only specimens >20 cm in any dimension were counted. Light and visibility at the depth of the study site is limited, thus, similar to the previous studies, only sponges within 5 m of the submersible were enumerated. Area sampled was estimated by multiplying transect distance, as determined from GPS coordinates, by transect width (5 m). Sponges were categorized into 3 groups; 1) undamaged, i.e. erect and intact, 2) erect but with torn, necrotic, or missing tissue, and 3) tipped over with torn or intact tissue. The categories were identical to those used in the previous studies. Tears, necrosis, or missing tissues were only noted if the damage was longer than 10% of the specimen's longest axis. Frequency of damage observed on strip transects was compared between pooled trawled and reference data with *G*-tests of independence (Sokal & Rohlf 1995).

In addition to the strip transects, a second set of observations were completed in the trawl and reference areas to obtain close-up video of individual sponges. These observations were made so that injuries and damage could be characterized in greater detail. On the dives in the trawled areas, the submersible would begin at one flag and proceed on a bearing toward the opposite flag, approaching individual sponges along the way. The submersible completed full circles around each specimen encountered to obtain a 360° view of its full extent. Once the circle was complete, the submersible would continue on its original bearing. Close-up observations were also obtained in a similar manner in reference areas by maneuvering the submersible 100 m outside of the trawled areas and completing observations on a bearing parallel with the trawl path. Video from the close-up observations was reviewed in the laboratory where damage to each sponge was categorized using the same criteria used for strip transect analysis. In addition, sponges were evaluated for the percentage (relative to the intact individual) of necrotic and missing tissues and the size (longest axis) of each sponge was visually estimated using the scaling lasers. Since close-up observations were not completed in a standardized fashion and the area observed is unknown, statistical comparisons of sponge densities were not made between reference and trawl areas. However, using pooled data, the frequency of damage was compared between reference and trawled areas with *G*-tests of independence and the percentages of necrotic and missing tissues and sponge sizes were compared between areas with 2-sample *t*-tests (Sokal & Rohlf 1995).

Identification of sponges from visual observations is problematic since they often take many shapes and sizes within a single species and definitive visual keys for sponge species in the Gulf of Alaska are lacking. Determining species often requires comparison of spicules under magnification (Stone et al. 2011). For these reasons, Freese et al. (1999) and Freese (2001) grouped sponge species by shape and size in order to facilitate analyses. In our observations, we identified 7 sponge species (larger than 20 cm) on strip transects and an eighth species was observed during close-up observations. Our tentative identifications are somewhat different from what the previous studies reported. As such, we feel it necessary to discuss the differences and explain how our identifications relate to the previous studies.

Since the current and previous studies occurred in the exact same locations and likely observed many of the same long-lived specimens, it is unlikely that different species were actually observed and more likely that the same specimens were identified differently. In the years since the first studies were completed, the field of experienced taxonomists and the taxonomic literature describing many deepsea sponges has expanded. We, therefore, believe our identifications to be more accurate than those in the previous publications. The previous studies identify the demosponges (Class Demospongiae) *Mycale* sp., *Geodia* sp., and *Esperiopsis* sp. They also identify the glass sponges (Class Hexactinellida) *Rhabdocalyptus* sp. and an unidentified “morel” sponge. We agree that the study site contains many *Mycale* sp., presumably *Mycale loveni* (Fig. 2). However, based on the images and species descriptions presented in Freese et al. (1999) and Freese (2001), we disagree with the identification of the *Geodia* sp. and *Esperiopsis* sp. specimens. Based on spicule examination, we believe that the majority of the specimens previously identified as *Geodia* are likely *Poecillastra tenuilaminaris* (Fig. 3) and those specimens identified as *Esperiopsis* sp. are *Isodictya quatsinoensis* (Fig. 4) (H. Lehnert, personal communication). The previously unidentified “morel” sponge is likely *Farrea occa occa* (Fig. 5) and the sponge previously identified as *Rhabdocalyptus* sp. is now identified as *Acanthascus (Rhabdocalyptus) dawsoni dawsoni* (Fig. 6). We also observed *Acanthascus koltuni* (Fig. 7); a reference specimen was collected and its identity verified under magnification (H. Reiswig, personal communication). This species has only recently been described (Reiswig & Stone 2013). Freese et al. (1999) observed many "finger sponges" that were tentatively identified as *Leuconia* sp. We believe this species to be *Axinella rugosa* (Fig. 5), which was very abundant in the study area but since most specimens were smaller than 20 cm, they are nearly absent in our reported observations. One other large sponge species, *Aphrocallistes vastus*, was observed in the study area in limited numbers.

Results

A total of 12,733 m^2 of seafloor was observed on strip transects in trawled areas, compared to 13,049 m^2 observed in reference areas. We observed 393 sponges larger than 20 cm in trawled areas compared to 591 sponges in reference areas. Sponge density was greater on each reference transect than its corresponding trawl transect and average sponge density for all species combined was 3.01 individuals 100 m^{-2} in trawled areas versus 4.37 individuals 100 m^{-2} in reference areas for pooled data (Table 1). Based on the permutation test the density of sponges was significantly greater ($P = 0.031$) in reference transects than in the trawled transects. The most abundant sponge species in both trawl and reference strip transects was *Acanthascus (Rhabdocalyptus) dawsoni dawsoni*. This species accounted for 62% of all reference area sponges and 47% of all trawl area sponges. However, since *Mycale loveni* occupies a large volume due to its basket-like shape and can grow to greater than a meter in 3 dimensions, this species appears to dominate the seafloor landscape in the study area. Average density of *Acanthascus (Rhabdocalyptus) dawsoni dawsoni* was 1.43 individuals 100 m^{-2} in trawl transects compared to 2.73 individuals 100 m^{-2} in reference transects (Table 2). *Mycale loveni* and *Poecillastra tenuilaminaris* were the next most abundant sponge species. The density of these 2 species was nearly equal in trawl and reference transects. Density of less commonly observed sponge species did not differ much between trawl and reference areas. These species included *Axinella rugosa, Isodictya quatsinoensis,* and *Acanthascus koltuni*. However, the density of *Farea occa occa* was almost twice as great in reference areas (0.23 individuals per 100 m^2) than in trawl areas (0.14 individuals 100 m^{-2}).

Thirteen years after trawling took place, trawl evidence, including seafloor gouging, boulder displacement, and sponge damage, was still readily apparent on some trawl transects. Damaged sponges were also observed in the reference areas. However, the frequency of damaged sponges differed significantly ($P < 0.001$) between trawl and reference strip transects. For all sponges combined, the percentage of damaged sponges (categories 2 and 3) was 5.4 % for reference areas and 15.0 % for trawled areas (Table 3). The percentage of damaged sponges that were erect (category 2) was 1.3% in reference areas and 6.4% in trawled areas for all sponge species combined. The percentage of prone sponges (category 3) was 4.1% in reference areas and 8.6% in trawled areas. For each sponge species observed on strip transects, with the exception of *Farea occa occa*, the percentage of damaged sponges was greater in trawled areas than in reference areas. The differences, however, were only statistically significant ($P < 0.05$) on an individual species basis for *Mycale loveni* and *Acanthascus* (*R.*) *d. dawsoni*.

The sponge species that exhibited the highest rate of damage was *Isodictya quatsinoensis*. Of the 11 *Isodictya quatsinoensis* specimens we observed on strip transects (reference and trawl areas combined), 5 individuals were damaged, 4 of which were prone and 1 had torn tissues. This vase-shaped species is supple and quite fragile and was mostly observed attached to small rocks by a short holdfast. These characteristics may combine to make the species extremely vulnerable to natural and anthropogenic disturbances, as the relatively large vase creates a disproportionate drag on the sponge's small anchor, which may result in the sponge tipping over even in modest currents. The percentage of damage among *Mycale loveni* specimens was about 4 times higher within trawled areas compared to reference areas. On the trawl transects, 17.3 % of *Mycale loveni* had tissue damage (category 2) and 7.1 % were prone (category 3). In contrast in reference transects, only 5.8 % of *Mycale loveni* specimens exhibited tissue damage and none were prone. About twice as many damaged *Acanthascus* (*R.*) *d. dawsoni* and *Poecillastra tenuilaminaris* specimens were observed in trawl transects compared to reference transects. All of the damaged *Acanthascus* (*R.*) *d. dawsoni* specimens we observed were prone. The only sponge species that exhibited a higher rate of damage in reference areas than in trawl areas was *Farea occa occa*. However the rate of damage was very low and only one specimen, out of the 31 observed in the reference area, had damaged tissue; none of the 18 specimens in the trawled area was damaged.

During close-up observations, we observed 271 individual sponges in reference areas and 272 sponges in trawled areas. For all sponge species combined, the frequency of damage (categories 2 and 3) was greater in trawled areas than in reference areas ($P < 0.001$). In trawled areas, 40.8% of all sponges were damaged, while 10.7% of reference area sponges were damaged (Table 4). The frequency of damage among trawl area sponges was significantly ($P < 0.05$) greater for 4 species, *Mycale loveni*, *Acanthascus* (*R.*) *d. dawsoni*, *Acanthascus koltuni*, and *Farea occa occa.* The rate of damage observed for each of the 4 other sponge species seen during close-up observations was greater in trawled areas than corresponding reference areas, but the differences were not statistically significant on an individual species basis.

Overall, the average percentage of flesh damage (necrotic and missing tissues combined) was higher within trawled areas (6.3%) than within reference areas (2.2%) for all sponge species combined (Table 5). The average percentage of missing tissue for all sponges combined was 3.6% for trawl areas versus 0.9% for reference areas ($P < 0.001$). The percentage of necrotic tissue among trawl area sponges was 2.7% while the percentage among reference area sponges was 1.3% ($P = 0.05$). *Poecillastra tenuilaminaris* (7.1%) and *Mycale Loveni* (7.0%) displayed the highest percentages of missing tissue while *Farrea occa occa* (23.0%) had the highest percentage of necrotic tissue. For every sponge species, except *Isodictya quatsinoensis,* average sponge size was slightly larger for reference area sponges than for trawl area sponges (Table 6). However, the differences were not significant on an individual species basis. For all species combined, average size was significantly ($P < 0.001$) larger in reference areas (33.5 cm) than in trawled areas (29.3 cm) but the species compositions differed slightly so this comparison may not be legitimate

Discussion

For the most part, the densities of sponges we observed in 2009 (13 years post-trawling) were comparable in magnitude to the densities observed in 1996 (immediately post-trawling; Freese et al. 1999) and 1997 (1 yr post-trawling; Freese 2001) (Fig. 10). However, sponge density in reference areas was higher than in 1996 and 1997 and this contributed to a greater difference between trawled and reference area densities than previously observed. Immediately after trawling took place, the density of sponges was 16% lower in trawled areas than in reference areas (3.15 sponges 100 m^{-2} vs. 3.73 sponges100 m^{-2}; Freese et al. 1999). About 1 yr later, the difference between trawled and reference areas had increased such that sponge density in trawled areas was 21% lower (2.76 sponges 100 m^{-2} vs. 3.50 sponges 100 m^{-2}; Freese 2001). In 2009, 13 yr post-trawling, we found the disparity between trawled and reference sites had increased further and the density of sponges at trawled sites was 31% less than in reference sites (3.01 sponges 100 m^{-2} vs. 4.37 sponges 100 m^{-2}).

Despite our best intentions to collect data in an identical manner as previous studies, one could attribute the increased density we observed in reference areas to subtle differences in data collection protocols or video interpretation. However, if methodological differences were to blame for the increase over time, one would expect the effect to manifest in both reference and trawl observations in a like manner, i.e. sponge densities in trawled areas would also be higher than previous observations. Since we did not see an appreciable increase in trawled areas, it is likely that the increased density we observed in reference areas may be a result of higher sponge recruitment and/or growth in those areas.

Immediately post-trawling, 67% of “vase” sponges in trawl transects were damaged (Freese et al. 1999); 1 yr later, the percentage of damaged sponges decreased to 47% (Freese 2001). The rate of damage we observed among sponges on strip transects (15%) was considerably less than the earlier observations in 1996 and 1997. Taken alone, the decreasing percentage of damaged sponges observed over time could indicate significant recovery processes occurred. However, since the difference in overall sponge density between trawl and reference sites has increased over time (Fig. 10), it is more likely that damaged sponges have simply been lost from the population through delayed mortality.

The incidence of missing and necrotic tissues and the number of prone sponges was greater within trawled areas than reference areas. However, we did observe a higher rate of damage (both category 1 and 2) in reference areas than previous studies did. Freese et al. (1999) reported damage to 2% of reference area sponges, while Freese (2001) found that just 1% of reference area sponges were damaged. In the present study, we observed damage among 5% of the reference area sponges on strip transects. It is unknown if there is a greater amount of background disturbance in the area or if our criteria and judgment regarding damage differed from the previous studies. Trawling was prohibited in the area in 1998 but longlining and pot fishing are legal and could have an adverse effect on sponges. However, these activities would likely impact both the trawl and reference areas equally. For reference, in the central Aleutian Islands where commercial fishing, including bottom trawling, is allowed, Heifetz et al. (2009) estimated that 21% of sponges were damaged.

The percentage of damaged sponges we observed in trawled areas was 15% on strip transects and 41% on close-up observations. The rate of damage we observed in both reference and trawl areas during close-up observations was generally greater than that observed during strip transects. This result is not surprising given the more thorough observations we were able to complete during close-up observations. A full 360° revolution around individual specimens, compared with a passing observation at items up to 5 m distant on strip transects, provided more opportunity to identify partially damaged biota. Close-up observations may be a superior method for identifying less obvious damage and probably provides the most accurate determination of sponge condition. However, it is more appropriate to use the results from our strip transect observations for comparison with previous studies since those methods closely replicated earlier protocols.

Few studies have documented long-term effects of a single trawl pass on sponge populations. Van Dolah et al. (1987) found immediate reductions in sponge density on hard-bottom areas following trawling off the southeastern U.S. but contrary to our results, 1 yr later, sponge densities had returned to pre-trawl levels or greater. Differences in recovery rates between the 2 studies may be related to the fact that the sponges in the Van Dolah et al. (1987) study are generally smaller than those in the present study and the study sites occur at vastly different depths (20 m vs. >200 m) and latitudes (31.6° N vs. 57.4° N). The nature and extent of sponge damage from trawling is influenced by the size and shape of individual specimens. Sponges that extend upward from the seafloor are more vulnerable to damage than low-lying encrusting type sponges (Wassenberg et al. 2002). Also, the skeletal structure of sponges varies by species and some are more fragile than others. For instance, the friable nature of *Farrea occa occa* makes them more prone to damage as they are unable to absorb impact or bend under the force of mobile fishing gear. Therefore, a sponge of this type would likely be reduced to rubble when impacted by mobile fishing gear and little evidence of the intact sponge would remain.

Freese (2001) noted that no new colonization or evidence of repair or regrowth of sponges had occurred after 1 yr. The sponges observed with damaged tissue in that study all had jagged wounds and there was no evidence of rounding or smoothing of damaged tissues that would have indicated healing. We observed many sponges with necrotic and/or missing tissues. Some of the specimens with missing tissues appeared to have smooth edges where it is possible that tissue may have been removed at an earlier point and then subsequently, jagged edges had “healed” (Fig. 9). However, we feel it speculative to acknowledge or quantify repair or regrowth without confirmed observations of individual specimens over multiple occasions. Van Dolah et al. (1987) observed many sponges (mainly *Cliona* sp.) with damaged tissues immediately after trawling. However, 1 yr later, the damage was not readily apparent since divers could not distinguish between damaged and undamaged specimens. The authors cautioned that although the *Cliona* sp. in that study were able to regenerate damaged tissues, it may take several years for the damaged specimens to recover to their original size given the slow inherent growth rate of the species.

We found the effects of bottom trawling on large erect sponges in the Gulf of Alaska to be persistent and likely compounding. Our results suggest that sponges damaged by trawls may experience delayed mortality over the course of many years. Therefore, immediate observations may not characterize the full effect of trawling on deepwater sponge species. Damaged sponges that do survive may suffer secondary effects that are manifested in ways more difficult to observe. For instance, damaged sponges have less ability to defend themselves from predators and compete for resources (Henry and Hart 2005). It is believed that regeneration in sponges occurs by reorganization of cells rather than growth of new tissues (Korotkova 1963, Reiswig 1973). In tropical waters, this *modus operandi* allows rapid repair and helps deter overgrowth and fouling and may prevent a total disruption of the physiological processes necessary for a sponge's survival (Hoppe 1988). Damaged sponges in tropical waters can be resilient and survive significant injuries (Duckworth 2003, Hoppe 1988) but the physiological cost of tissue regeneration often comes at the expense of somatic growth and reproduction which can ultimately lead to reductions in biomass, fecundity, and recruitment (Henry & Hart 2005). This mechanism provides an alternative hypothesis for explaining the increasing difference in sponge density we observed between trawled and reference areas, as reproduction and growth may have been depressed in the trawled areas as a result of past injuries. Indeed, for all but one species we observed, average sponge size was smaller in trawl areas than reference areas. The differences were not statistically significant, but given the extremely slow growth rates that are assumed for these species, it would take a long time to see large differences.

The descriptions of trawl effects detailed in this paper, as well those described in Freese et al. (1999) and Freese (2001) characterize the effect of a single trawl pass. It is common practice, however, for fishers to repeat successful trawl tows over roughly the same paths along the seafloor. In the Bering Sea and Gulf of Alaska, many areas were trawled more than 5 times per year and one area was trawled 17 times per year between

1997 and 2001 (Rose & Jorgensen 2005). Similar rates have been reported in heavily trawled areas on both sides of the Atlantic Ocean as well (Floderus & Pihl 1990, Auster et al. 1996). The net result of concentrated trawl effort tends to accumulate effects on benthic organisms. Moran & Stephenson (2000) estimated that a single pass of a demersal trawl "destroyed" 15.5% of benthic organisms larger than 20 cm; after 4 trawl passes the density of these organisms was reduced by about half. Over time, repeated disturbance to these long-lived organisms may alter species compositions and ultimately benthic communities. Sainsbury et al. (1997) postulates that this already occurred during a period of intensive trawling on the northwest Australian shelf. Epibenthic organisms, including sponges, greatly decreased concomitantly with decreases in targeted fish populations. Meanwhile, non-targeted, low value, fish populations increased. The theory is reinforced by the fact that the abundance of fish and benthos increased in areas subsequently closed to trawling but decreased in areas that remained open to trawling.

In higher latitudes and deepwater, little is still known about the basic life history and recovery dynamics of many benthic habitat-forming organisms. Growth, recruitment and recovery rates of these deepsea biota are essential pieces of information for quantifying impacts and determining the sustainability of anthropogenic seafloor disturbances, such as bottom trawling. Results from this study help resolve questions about the persistence of damage in the benthic ecosystem and could provide managers greater insight when evaluating fishery impacts. Using these results to parameterize fishing impact models, such as that of Fujioka (2006), will aid in decision making when contemplating habitat conservation measures, such as, area closures that mitigate and/or protect essential fish habitat. The persistence of damage and the potential resultant changes to benthic community structure provide rationale for cautious management of bottom trawling in areas where deepwater habitat-forming biota, such as sponges, are present.

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Reference to trade names does not imply endorsement by the National Marine Fisheries Service.

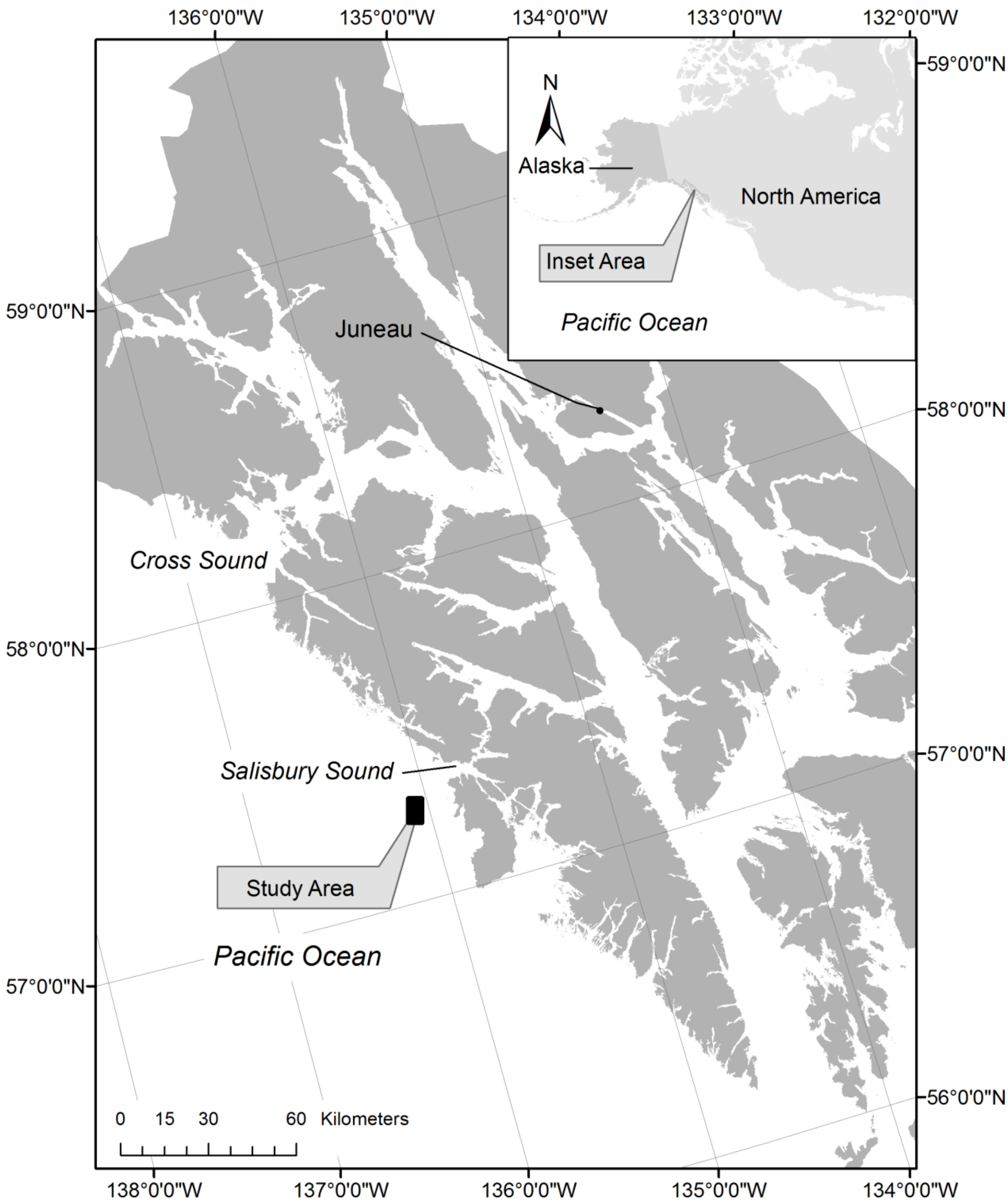


Fig. 1. Map of Southeast Alaska including the study area approximately 22 km southwest of Salisbury Sound.

Fig. 2. *Mycale loveni* with a spot prawn *Pandalus platyceros* (foreground) and a rosethorn rockfish *Sebastes helvomaculatus* (background).

Fig. 3. A basket-shaped *Poecillastra tenuilaminaris* (left) lying prone at the base of a *Mycale loveni* specimen (right).


Fig. 4. *Isodictya quatsinoensis* lying prone on the seafloor.

Fig. 5. A morel sponge *Farea occa occa* with a finger sponge *Axinella rugosa* (right). The chelipeds of a squat lobster *munida quadrispina* protrude from underneath.

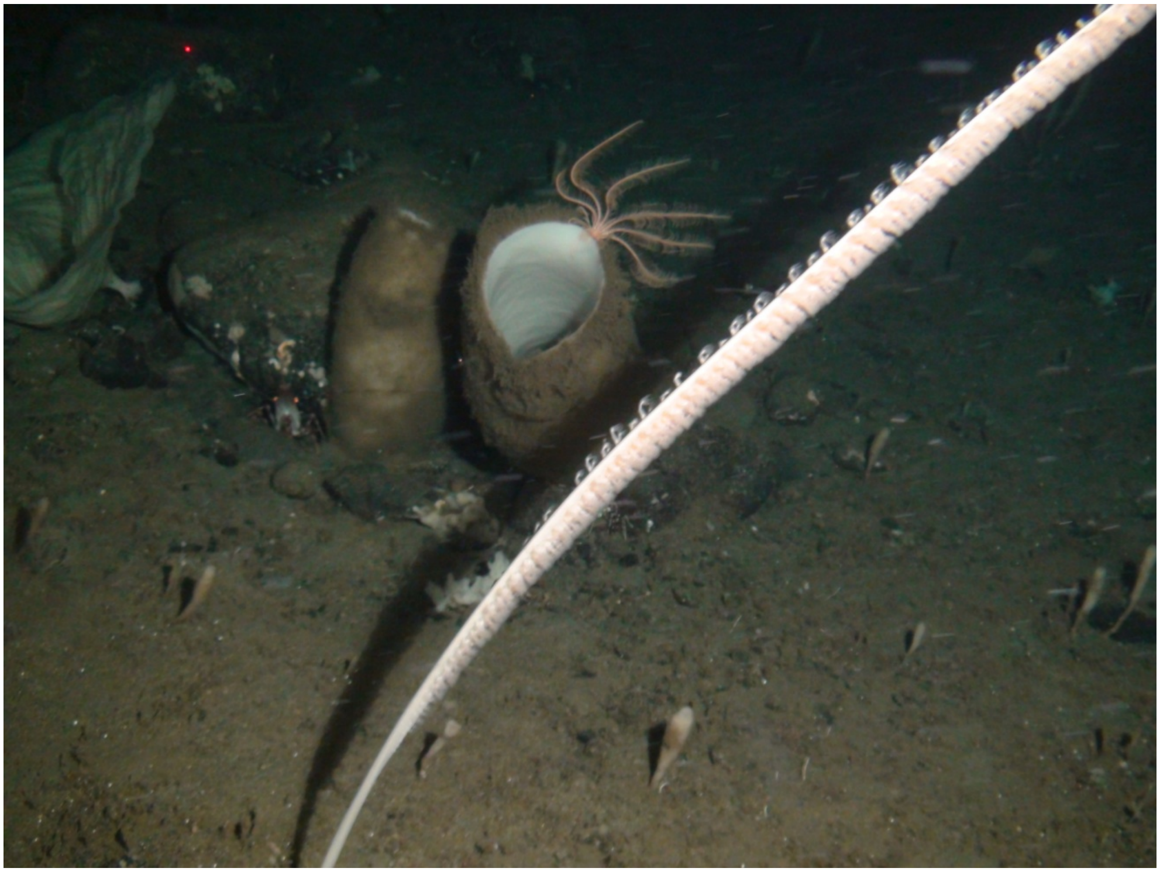


Fig. 6. Two *Acanthascus* (*Rhabdocalyptus*) *dawsoni dawsoni* (center) with a crinoid attached to one specimen. Also pictured is the sea whip *Halipteris willemoesi* (foreground) and *Isodictya quatsinoensis* (left background). Several small *Axinella rugosa* are scattered throughout the frame.

Fig. 7. *Acanthascus koltuni*.

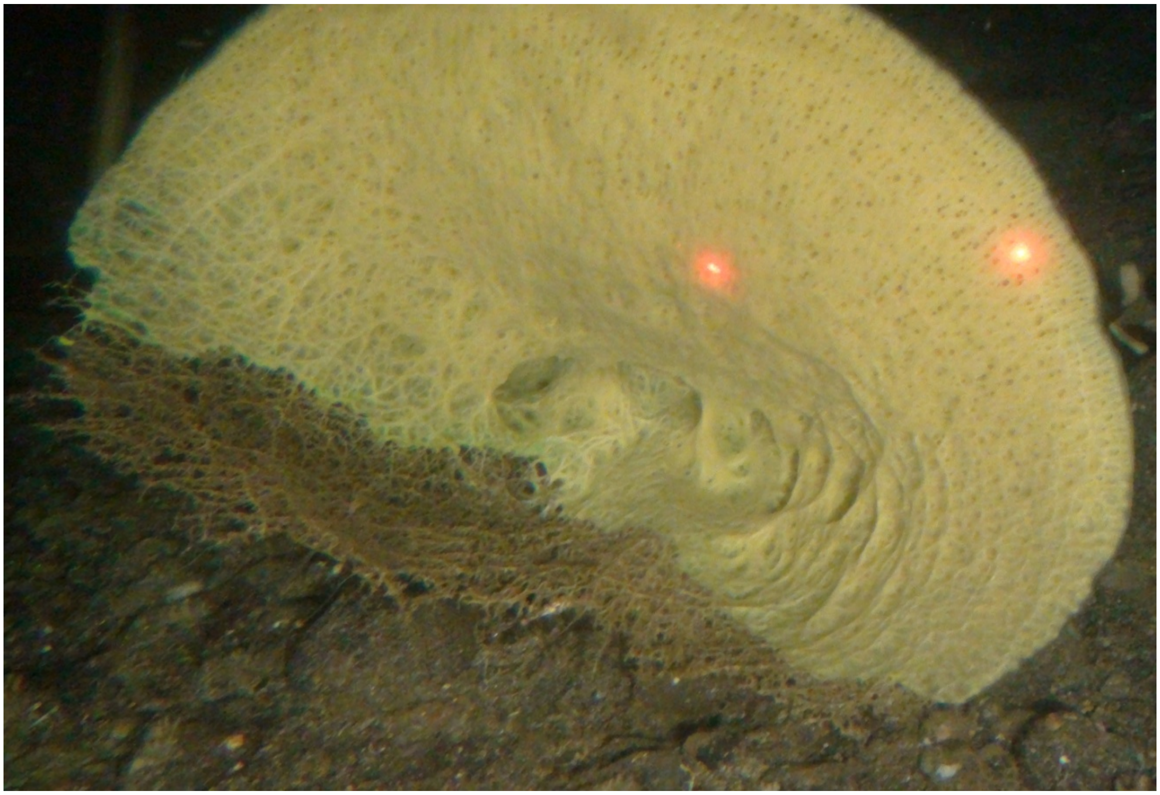


Fig. 8. Partially necrotic *Mycale loveni* lying in a prone position. Distance between lasers is 20 cm.

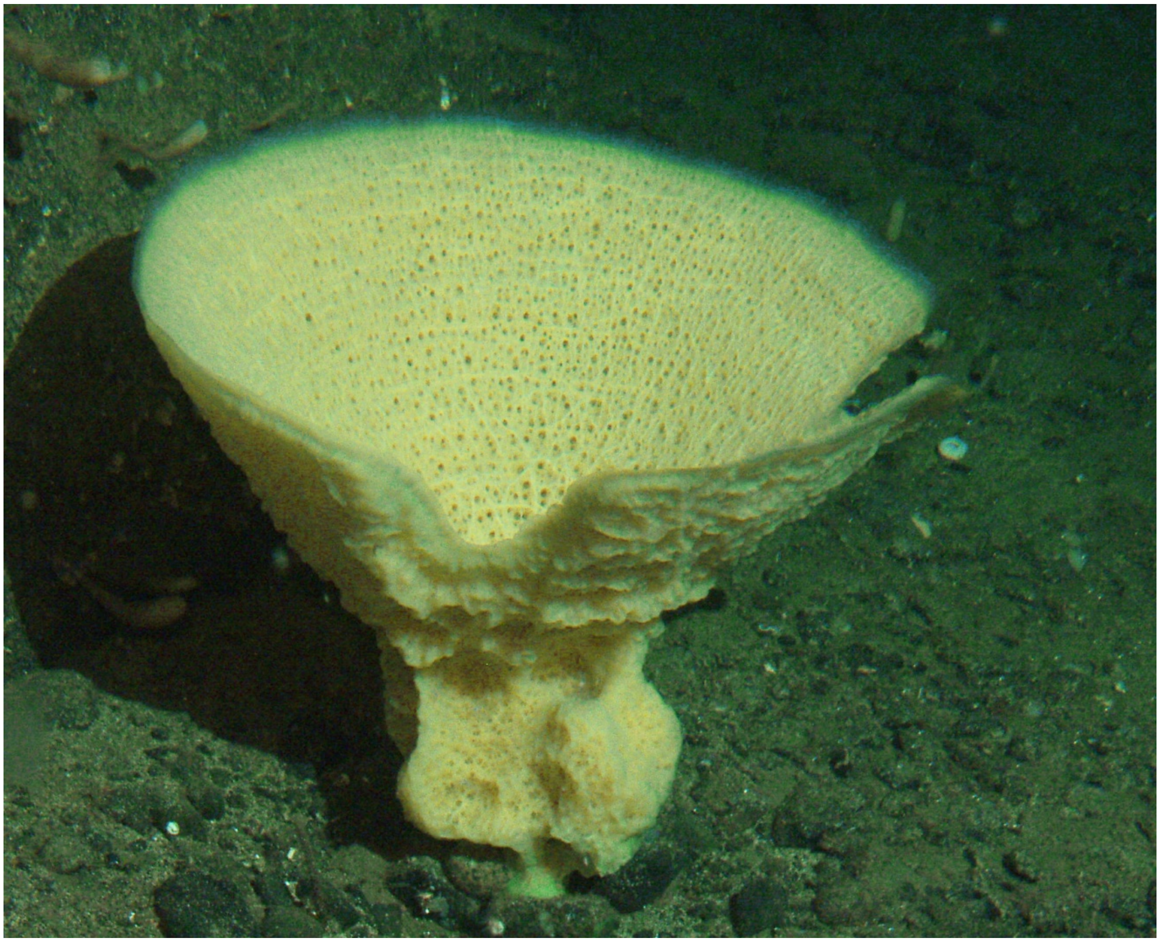


Fig. 9. *Mycale loveni* with missing tissue in two locations on upper margin. Note smooth edges of tissue where flesh is absent.

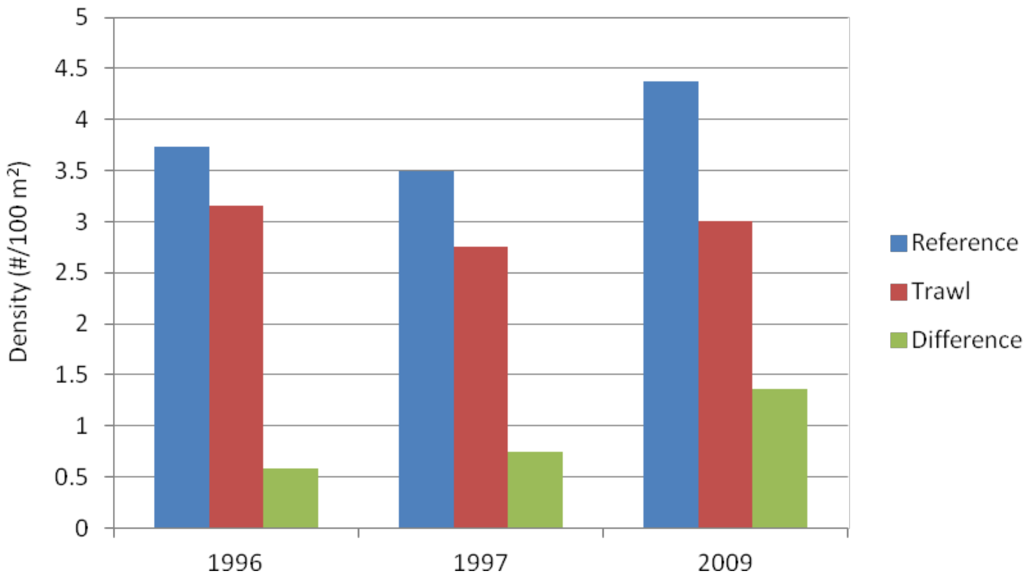


Figure 10. Density (number 100 m^{-2}) of sponges in reference and trawled areas near Salisbury Sound and the density differences immediately after trawling (1996), 1 yr post-trawling (1997) and 13 yr post-trawling (2009).

Table 1. Density (number 100 m^{-2}) of sponges (all species combined) on strip transects in reference and trawled areas near Salisbury Sound 13 yr post-trawling.

Transect	Reference	Trawl
A	3.17	1.49
B	9.78	5.16
C	3.73	3.10
D	2.75	2.71
E	3.94	3.51
Pooled data	4.37	3.01

Table 2. Density (number 100 m^{-2}) of sponges and total number observed by species in trawled and reference areas near Salisbury Sound, 13 yr post-trawling. Densities were calculated with pooled data from five strip transects in each area.

	Average density		Total number observed	
	Reference	Trawl	Reference	Trawl
Axinella rugosa	0.01	0.04	1	5
Isodictya quatsinoensis	0.03	0.05	4	7
Acanthascus (*R.*) *d. dawsoni*	2.73	1.43	369	186
Poecillastra tenuilaminaris	0.51	0.50	69	65
Mycale loveni	0.76	0.75	103	98
Farrea occa occa	0.23	0.14	31	18
Acanthascus koltuni	0.10	0.11	14	14
All species combined	4.37	3.01	591	393

Table 3. Total number of sponges observed and percentage damaged on strip transects in trawled and reference areas near Salisbury Sound, 13 yr post-trawling. Percent damaged is the sum of percent torn (category 2) and percent prone (category 3). Percentages were calculated with pooled data from 5 strip transects in each area.

	Total # observed		Percent damaged		Percent torn		Percent prone	
	Ref	Trawl	Ref	Trawl	Ref	Trawl	Ref	Trawl
Axinella rugosa	1	5	0	0	0	0	0	0
Isodictya quatsinoensis	4	7	25.0	57.1	0	14.3	25.0	42.9
Acanthascus (*R.*) *d. dawsoni*	369	186	4.6	9.7	0	0	4.6	9.7
Poecillastra tenuilaminaris	69	65	10.1	18.5	1.4	9.2	8.7	9.2
Mycale loveni	103	98	5.8	24.5	5.8	17.3	0	7.1
Farrea occa occa	31	18	3.2	0	3.2	0	0	0
Acanthascus koltuni	14	14	0	7.1	0	7.1	0	0
All species combined	591	393	5.4	15.0	1.3	6.4	4.1	8.6

Table 4. Total number of sponges individually observed during close-up observations and percentage of damaged specimens in trawled and reference areas near Salisbury Sound, 13 yr post-trawling. Percent damaged is the sum of percent torn (category 2) and percent prone (category 3). Percentages were calculated with pooled data.

	Total # observed		Percent damaged		Percent torn		Percent prone	
	Ref	Trawl	Ref	Trawl	Ref	Trawl	Ref	Trawl
Aphrocalistes vastus	1	2	0	0	0	0	0	0
Axinella rugosa	0	3	NA	100	NA	0	NA	100
Isodictya quatsinoensis	8	6	37.5	100	0	16.7	37.5	83.3
Acanthascus (*R.*) *d. dawsoni*	85	90	4.7	26.6	0	2.2	4.7	24.4
Poecillastra tenuilaminaris	19	42	26.3	50.0	15.8	21.4	10.5	28.6
Mycale loveni	116	89	12.9	48.3	7.8	27.0	5.1	21.3
Farrea occa occa	4	10	0	70.0	0	70.0	0	0
Acanthascus koltuni	38	30	5.2	23.3	2.6	10.0	2.6	13.3
All species combined	271	272	10.7	40.8	4.8	16.9	5.9	23.9

Table 5. Average percentage of missing and necrotic tissue of sponges individually observed during close-up observations in trawled and reference areas near Salisbury Sound, 13 yr post-trawling. Percentages were calculated with pooled data.

	Average percent missing		Average percent necrotic		Percent missing & necrotic	
	Ref	Trawl	Ref	Trawl	Ref	Trawl
Aphrocalistes vastus	0	0	0	0	0	0
Axinella rugosa	0	0	0	0	0	0
Isodictya quatsinoensis	0.6	0.8	0	1.7	0.6	2.5
Acanthascus (*R.*) *d. dawsoni*	0	0.3	0	0	0	0.3
Poecillastra tenuilaminaris	3.7	7.1	3.2	2.4	6.9	9.5
Mycale loveni	1.6	7.0	2.3	4.1	3.9	11.1
Farrea occa occa	0	0	0	23.0	0	23.0
Acanthascus koltuni	0	0.8	0.3	1.0	0.3	1.8
All species combined	0.9	3.6	1.3	2.7	2.2	6.3

Table 6. Average size (cm) and standard deviation of sponges individually observed on close-up observations in trawled and reference areas near Salisbury Sound, 13 yr post-trawling. Size was estimated by comparison to scaling lasers and was recorded as the longest axis of each individual. Averages were calculated with pooled data.

	Average size (cm)		Standard deviation		Sample size	
	Reference	Trawl	Reference	Trawl	Reference	Trawl
Aphrocalistes vastus	20.0	12.5	—	3.5	1	2
Axinella rugosa	NA	10.0	NA	0.0	0	3
Isodictya quatsinoensis	21.3	22.5	4.4	4.2	8	6
Acanthascus (*R.*) *d. dawsoni*	25.6	23.6	10.4	8.0	85	90
Poecillastra tenuilaminaris	32.4	27.3	11.5	7.9	19	42
Mycale loveni	41.3	38.6	14.2	14.7	116	89
Farrea occa occa	20.0	19.5	8.2	8.6	4	10
Acanthascus koltuni	32.1	29.5	15.6	10.2	38	30
All species combined	33.5	29.3	14.7	12.9	271	272

Essential Fish Habitat project status report

Reporting date: October 2, 2012

Project number: 2009-2

Title: Invertebrate colonization of PMEL moorings

PIs: Mark Zimmermann NMFS,
William Floering OAR PMEL,
Bob Van Syoc, California Academy of Sciences,
Phyllis Stabeno, OAR PMEL

Funding year: Funding provided in 2009.

Funding amount: So far $12,000 has been spent out of a budget total of $12,000.

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting:
All field work and lab analysis is complete.
A final report describing the colonizing of mooring substrates has been submitted by the California Academy of Sciences to NMFS.
We are examining the results to determine if we can submit a Note about the colonization results to a peer-reviewed journal.

Results:
We have attempted to quantify colonization of benthic substrates as a proxy for estimating the recovery of damaged seafloor areas. Our project has been hampered by difficulties with the substrates and a conflict between the industrial nature of the mooring recoveries and the extremely delicate nature of the colonizing benthos.

This was an extremely low budget effort to tackle a difficult scientific question. I am hopeful that we can distill our results into something that advances our understanding of this topic.

The most interesting result of the project is the variability in colonization per substrate, with recruitment of individual taxa ranging up to >30,000 recruits, surface area ranging from <1 mm to approximately half of a substrate, and sometimes large number of encrusting taxa (eg. 16) and non-encrusting taxa (7) occurring on the same substrate.

Essential Fish Habitat project status report

Reporting date: 10/20/2015

Project number: 2009-03, 2010-01, 2011-02, 2014-03

Title: Recruitment and response to damage of an Alaskan gorgonian coral (*Calcigorgia spiculifera*)

PIs: Patrick Malecha, Dr. Kalei Shotwell, Erika Ammann

Funding year: 2009, 2010, 2011, 2014

Funding amount: FY2009 $38,000, FY2010 $32,900, FY2011 $16,700, FY2014 $17,700

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:
Image analyses of *in situ* scuba observations were completed in October 2015. Data analysis is currently underway and a draft manuscript is in preparation. Genetic analysis of coral recruits and adults is ongoing.

Reporting: No reporting has occurred yet.

Results:
Video analysis was completed in October 2015. Data generated from the video observations includes colony survival, branch growth, and tissue regeneration rates.

Seventy-nine percent of all tagged corals were alive and upright after five years of observations. Survival over the entire experiment was 63%, 70%, 88%, and 100% for the trawl, control, cut, and scrape treatment groups, respectively. Survival was not related to the damage treatments on any of the sampling events.

Average branch growth over the five-year period was 0.0216 mm/day for all corals combined. This translates into an annual branch growth rate of 7.88 mm. However, growth rates varied by season as growth during a 3-month summer period averaged 0.0424 mm/day.

Branches that were scraped of their overlying gorgonin tissue demonstrated a variety of responses. Some colonies regrew their missing gorgonin layer within about a year, while on other colonies, a portion of the scraped branches became necrotic and eventually disappeared. However, the growth of undamaged branches among corals in the cut and scraped treatments was on average greater than among corals in the trawl and control groups perhaps indicative of compensatory processes that focused energy on somatic rather than reproductive output.

Coral recruits were found on 18 of the 96 tiles collected and at least 60 individual recruits were identified. These observations document coral recruitment for the first time in Alaska. The

majority of recruits were small single- or two-polyp organisms, presumably less than one year old. There were also some very small potential recruits that lacked definitive structural characteristics of coral polyps but were pigmented similarly to *Calcigorgia spiculifera*. These specimens are currently undergoing genetic analyses to determine their identity. If these are indeed coral recruits, they would likely be only days or weeks old. There were also a few multi-polyp colonies that were probably more than a year old. Thus it is apparent that coral recruitment happened in multiple years. A rate of recruitment will be estimated based on the different sizes or "age classes" of the recruits. Tiles were placed on the seafloor on varied dates and thus were "seasoned" *in situ* for different amounts of time. The original tiles were in place for five years, while the most recently installed tiles were on the seafloor for 35 months. Recruits were found on tiles of all ages. Genetic analyses, to explore the relatedness between recruits and adults and to examine genetic diversity and dispersion potential, are ongoing.

Essential Fish Habitat project status report

Reporting date: 9/12/11

Project number: 2009-04

Title: Nearshore Fish Assemblages in the Arctic: Establishment of Monitoring Sites in a Rapidly Changing Environment from Energy Development and Climate Change

PIs: Johnson and Thedinga

Funding year: FY09

Funding amount: $65K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

NOAA Tech. Memo. NMFS-AFSC-210 (attached)

Results: What is the most important result of the study?

Species occupying coastal waters of the Beaufort Sea have remained relatively unchanged the last 25 years; Arctic cod remain a dominant species, whereas capelin appear to be more widespread and abundant. Continued warming conditions in the Arctic Ocean will likely result in a reorganization of nearshore community structure–new fish species are expected to migrate to the Arctic with unknown consequences to existing stocks and food webs.

Essential Fish Habitat project status report

Reporting date: Oct. 29, 2009

Project number: 2008-03, 2009-05

Title: Contrasting predation intensity and distribution in 2 rock sole nursery areas: a principle factor controlling nursery productivity - Component A: Contrasting predation.

PIs: Ryer, Laurel, Knoth

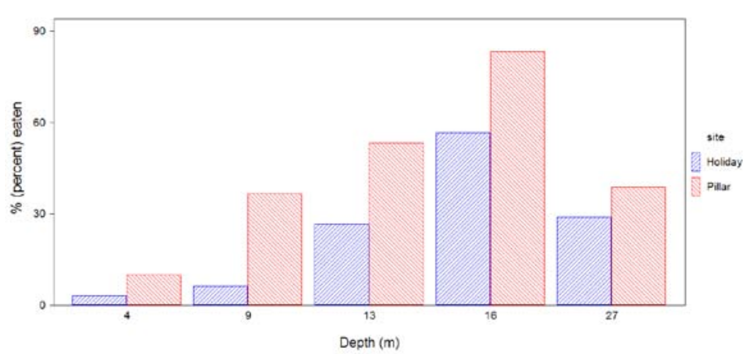
Funding year: 2009

Funding amount: $20,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. Thus far, one manuscript derived from this project has been submitted for publication to Marine Ecology Progress Series (see attached manuscript). We anticipate submitting either 3 or 4 additional manuscripts, supported in part by this and prior HEPR funding, during the course of the next 24 months.



Results: What is the most important result of the study? As in 2008, worm turf constituted a dominant habitat feature at Pillar Creek Cove, and to a lesser extent at Holiday Beach. However, unlike 2008, when the turf was extremely dense and contiguous, during 2009 the turf was less dense and more patchy. In 2008, fish were aggregated along the edge of the turf. In 2009 fish were most abundant within the sand patches within the turf. Tethering (15 min sets) revealed increasing predation risk with increasing depth at both sites. This was particularly evident as depth increased from 4 to 16m. Sixteen m corresponded to the shoreward edge of the worm turf, which then extended out to approximately 50m depth. Importantly, predation decreased significantly at 27m, at depth at which tethers were set in the worm turf proper. These result support one of our principle theories regarding use worm turf habitat by juvenile flatfish; worm turf provides protection from predators, but is avoided when it becomes so dense as to preclude unfettered access to the bottom and interferes with movement and burial.

A second important finding was that predation was uniformly lower at Holiday Beach than at Pillar Creek Cove. These results are consistent with our prediction stated in our original proposal to HEPR for 2008 funding. We had previously documented comparable predation rates at these 2 sites (see attached manuscript). These results suggest that the nursery value of these sites may vary from year to year. The significance of this data may become more clear as video survey data of predator abundance from 2002 – 2009 in completed this winter.

Lastly, as expected, predation upon juvenile flatfish was much lower at night than during the day.

Essential Fish Habitat project status report

Reporting date: Oct. 29, 2009

Project number: 2009-11

Title: Contrasting predation intensity and distribution in 2 rock sole nursery areas: a principle factor controlling nursery productivity - Component B: Monitor worm turf recovery and seasonal changes.

PIs: Ryer, Laurel, Knoth

Funding year: 2009

Funding amount: $13,000

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. We anticipate submitting a manuscript for peer-reviewed publication during the next 12 months.

Results: What is the most important result of the study? We are still analyzing video footage. However, disturbance of the worm turf habitat attributable to our simulated bottom trawling activity appears to have been relatively minor compared to the seasonal pattern of benthic disturbance driven by winter storm activity. Initially, scrape marks where worms were removed by our gear were readily evident along our disturbance tracts. Also, consistent with our results from component A, juvenile flatfish abundance increased in these disturbed tracts. However, within several months wave action began to erode away sections of the worm turf, so that by late winter/spring, the formerly contiguous turf had be reduced to a patchwork of turf habitat, and trawl disturbed tracts were no longer recognizably different from control areas. We suspect that excavations attributable to sea stars and/or sea otters constituted initial disturbances, which were subsequently expanded by bottom surge (much in the same way wave action expands small holes in mussel mats caused by log impacts in the inter-tidal). We will finish data analysis in the next 6 months and anticipate submitting a manuscript this year.

Essential Fish Habitat project status report

Reporting date: 10/22/12

Project number: 6

Title: Characterization of Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea - Reduced Plan

PIs: Yeung, C, Yang, M.-S., McConnaughey, R.A.

Funding year: 2009

Funding amount: $77,800

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Yang, M.-S. and Yeung, C. Habitat-associated diets of some flatfish in the southeastern Bering Sea. Abstract. 8th International Symposium on Flatfish Ecology. November 7-11, 2011, IJMuiden, the Netherlands.

Yeung, C., Yang, M.-S., Jewett, S.C., Naidu, A.S. Polychaete assemblage as prey availability index for eastern Bering Sea flatfish habitat suitability. 17th Western Groundfish Conference. February 6-10, 2012. Seattle, Washington, USA.

Yeung, C., Yang, M.-S., Jewett, S.C., Naidu, A.S. 2012. Polychaete assemblage as surrogate for prey availability in assessing southeastern Bering Sea flatfish habitat. Journal of Sea Research. xxx:xxx-xxx. (uncorrected proofs attached) http://dx.doi.org/10.1016/j.seares.2012.09.008 (online)

Results: What is the most important result of the study?

Alaska plaice and northern rock sole primarily feed on polychaetes in the eastern Bering Sea. Their stomach contents averaged about 60% polychaetes by weight. Yellowfin sole have a more diverse diet averaging about 25% polychaetes by weight. Bivalves, amphipods, and echinoderms are the other prey groups for all three flatfish. Competition among these co-occurring species may be mitigated by spatial distributions that are slightly offset from each other due to physiological or prey preference. For example, Alaska plaice, the more cold-tolerant polychaete-feeder, are known to be distributed further offshore over the middle shelf. The middle shelf has high benthic production and a sandy-mud habitat that favor polychaetes in the infauna. The coarser-grained inner shelf sediments are dominated by bivalves. In 2009 - a cold year in the EBS in which the cold pool of bottom water spread extensively over the middle shelf, all three flatfish were concentrated on the inner shelf. It is hypothesized that extreme cold bottom temperature alters flatfish response to habitat and prey, and increases competition by shrinking suitable habitat. Where competition for food among flatfish is low, through spatial-temporal partitioning of habitats or abundance of prey, polychaetes may be the choice prey because of its higher energy content than other infauna groups. Bioenergetics studies and habitat modeling are key to examining these hypotheses.

8th International Symposium on Flatfish Ecology. November 7-11, 2011, IJMuiden, the Netherlands. Abstract.

Habitat-associated diets of some flatfish in the southeastern Bering Sea
M.-S. Yang and C. Yeung

A total of 886 Alaska plaice (*Pleuronectes quadrituberculatus)*, northern rock sole (*Lepidopsetta polyxystra*, and yellowfin sole (*Pleuronectes asper*) stomachs collected from 27 stations in the eastern Bering Sea in 2009 were analyzed. Grab samples were collected in each of the 27 stations. The habitat types for the stations were categorized, from northeast to the southwest of the study area, as sandy (%sand ≥80), muddy sand (50 ≤%sand <80), sandy mud (50 ≤%mud <80), and muddy (%mud ≥80). The objective of this study is to correlate the diets of the small-mouth flatfish with their specific habitats in the eastern Bering Sea area. The main diet of Alaska plaice included clams and polychaetes. In the sandier stations (northeast of the study area), Alaska plaice consumed high proportions (≥ 49% by weight) of clams (mainly Tellinidae). Toward southwest muddier stations, the diet of Alaska plaice shifted to higher proportions of deposit-feeing polychaetes (Ampharetidae, Terebellidae, and Trichobranchidae). Comparing with the benthic data, we found diet-shift from the sandier stations to the muddier stations matched relatively well with the shift of the benthic data. The main food of northern rock sole included clams, polychaetes, and amphipods. Diet variations were also found among different habitat stations. In the muddier stations, polychaetes Terebellida and Sabellida comprised higher proportions in the stomach contents of northern rock sole. On the contrary, more bivalves were consumed by northern rock sole in the sandy stations. Yellowfin sole diet included clams (mainly *Macoma sp*.), gammarid amphipods, polychaetes, ophiurids (mainly *Ophiura sarsi* and *Amphipholis sp*.) and sand dollars (Clypeasteroida). More polychaetes (Phyllodocida, Terebellida, and Sabellida) were consumed by yellowfin sole collected in the southwest muddier stations whereas more Tellinidae clams were consumed in the northeast sandier stations. Diets varied among different predators, between different size-groups of the same predator, and in different habitats. The interesting finding was the diet shifted from different habitat to habitat, even for the same predator species. The results indicate that it is important to combine

the habitat information with the food habits study to get better understanding of the predator-prey relationships in the marine ecosystem.
17th Western Groundfish Conference. February 6-10, 2012. Seattle, Washington, USA. Abstract.

Polychaete assemblage as prey availability index for eastern Bering Sea flatfish habitat suitability
C. Yeung, M.-S. Yang, S. C. Jewett, A. S. Naidu

Yellowfin sole, northern rock sole, and Alaska plaice in the eastern Bering Sea prey mainly on infauna. Spatial correspondence between their stomach contents and infauna assemblages across habitat types were examined to identify potential indices of prey availability for habitat quality assessment and characterization. Benthic samples and stomachs were collected at 31 stations along three cross-shelf transects in the southeast near the Alaska Peninsula. Polychaetes and clams were the most dominant infauna groups, each comprising 35-60% by weight in each infauna sample. These two were the only prey groups that frequently averaged >50% of stomach contents. Clams dominated the infauna biomass on the inner shelf (0-50 m depth). The middle shelf (50-100 m) had the highest infauna biomass, which was dominated by deposit-feeding polychaetes. Prey availability appeared to be the main factor in prey choice. Alaska plaice and rock role are known to prey primarily on polychaetes, and yellowfin sole on amphipods. In this study, the diet compositions of these flatfish varied spatially in correspondence with the infauna assemblage. The diet composition of Alaska plaice, in particular, showed significant spatial correspondence with the assemblage of polychaete families. Polychaete assemblage could be a good surrogate for the infauna for characterizing habitat or prey environment of these flatfish. The dominance of polychaetes in flatfish diets and in the infauna, and their high nutritional value implicate polychaete biomass as an index of habitat quality for flatfish. Different proportional consumption of polychaetes among the three co-occurring flatfish may be a result of interspecific competition. Unconstrained by interspecific competition, all three flatfish may maximize polychaete consumption. Polychaete-rich habitat would thus be high quality flatfish habitat. Since predation on polychaetes is apparently not taxon-specific, assessment may be based simply on the aggregate polychaete group without taxonomic resolution, or on dominant polychaete families.

Essential Fish Habitat project status report

Reporting date: September 15, 2010

Project number: 7

Title: Assessing the physical and temporal aspects of spawning pollock habitat utilization in Shelikof Strait, Gulf of Alaska (Year 2)

PIs: Kevin Bailey and Kung-sik Chan

Funding year: 2010

Funding amount: $34,446

Status: x☐ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Completion date: July 2010.

Reporting: Four manuscripts are attached, 2 are directly related to the project and are both published in Marine Ecology Progress series, and two were offshoots of the project, one in published in Fisheries Oceanography and the other in Marine Ecology progress series, are attached.
Results: We used general additive models to show that the spatial extent of occupation of spawning habitat as reflected by egg distribution is influenced by biological and harvest related parameters and by environmental factors. As spawning biomass declines, the egg distribution shrinks at its periphery. Increasing transport results in a dislocation of eggs, and increasing temperature is related to an expansion of egg distribution further up Shelikof Strait. In another model, which we believe represents a conceptual breakthrough, we used a time series of the hatchdate distributions of larval pollock, to uncover the role of population age structure (and by implication, the effect of harvesting), biomass levels and environment on the timing of spawning.

Essential Fish Habitat project status report

Reporting date: 10/21/2009

Project number: 2009-08

Title: Productivity, habitat utilization and recruitment dynamics of Pacific cod

PIs: Laurel, Ryer, Stoner, Knoth, Parrish, Urban

Funding year: 2009

Funding amount: $41,600

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Project has been fully reported. Results and details are found in the following manuscript submitted for peer-review:

Copeman LA, Laurel BJ, Parrish C (submitted) Effect of temperature on rates of terrestrial short chain PUFA uptake in two juvenile gadids: Pacific cod (*Gadus macrocephalus*) and walleye pollock (*Theragra chalcogramma*). Canadian Journal of Fisheries and Aquatic Sciences.

Results: What is the most important result of the study?

1) Age-3 cod were observed on the baited camera for the first time, suggesting high survival from the abundant 2006 year class.

2) Fatty acid (FA) biomarker experiments were successfully completed using both juvenile Pacific cod and walleye pollock (see above submitted manuscript). Experiments were conducted at two temperatures using both a marine and terrestrial signal. Dietary biomarkers showed high temporal sensitivity across temperatures, and were evident in all fish tissues after only one wk of feeding. Cod held at 9ºC had a significantly higher rate of terrestrial biomarker uptake in the liver, but this effect diminished from wk 1 to wk 8 as fish tissue reached FA saturation. The proportion of terrestrial biomarker uptake was also significantly higher in liver than in heart tissue or flesh.

   Together, the differential uptake of terrestrial polyunsaturated fatty acids (PUFAs) among tissues (e.g., FA in liver:FA in heart) provide two important pieces of information: 1) they provide a signature for linking juvenile fish to nursery regions and 2) they provide a means of determining the timing of offshore-inshore nursery migrations (both to and from).

3) Stomachs from age 1+ Pacific and saffron cod were also collected and frozen for the ongoing examination of cannibalism in these species. Three years of stomach data are now collected and archived at the KFRC and will be used in future syntheses led by co-PI Knoth.

Essential Fish Habitat project status report

Reporting date: 10/11/2011

Project number: 2009-09

Title: Characterize habitat utilization and productivity for rockfish species

PIs: Rooper, Heintz, Aydin, Boldt

Funding year:FY09

Funding amount: $23,200

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: A manuscript was completed and submitted for internal review in May 2011 and was submitted to Fishery Oceanography in early October 2011for consideration as a research article. The citation is:

Rooper, C.N., J.L. Boldt, S. Batton & C. Gburski. In review. Growth and production of Pacific ocean perch (*Sebastes alutus*) in nursery habitats of the Gulf of Alaska. Submitted to Fish Ocean

Results:
Nursery areas for juvenile fishes are often important for determining recruitment in marine populations by providing habitats that can maximize growth and thereby minimize mortality. Pacific ocean perch (POP, *Sebastes alutus*) have an extended juvenile period where they inhabit rocky nursery habitats. We examined POP nursery areas to link growth potential to recruitment using field data collected in 2003, 2004, 2007 and 2008. FY09 project #9 provided funding for analysis of samples collected in 2007 and 2008.

During FY11, aging analyses were completed on juvenile POP collected from two sites near the Islands of Four Mountains during all four years. Analysis of otoliths was completed in March 2011, which allowed us to estimate growth for POP nursery areas during the summers of 2004 and 2008. Juvenile POP growth rates ranged from -0.19 $g*d^{-1}$ to 0.60 $g*d^{-1}$ based on differences in size between June and August. Predicted growth rates from a bioenergetics model ranged from 0.05 $g*d^{-1}$ to 0.49 $g*d^{-1}$ and were not significantly different than observed rates. Substrate preferences and the distribution of their preferred habitats were utilized to predict the extent of juvenile POP nursery habitat in the Gulf of Alaska. Based on densities of fish observed on underwater video transects and the spatial extent of nursery areas, we predicted 278 and 290 million juvenile POP were produced in 2004 and 2008. Growth potential for juvenile POP was reconstructed using the bioenergetics model, spring zooplankton bloom timing and duration and bottom water temperature for 1982 to 2008. When a single outlying recruitment year in 1986 was removed, growth potential experienced by juvenile POP in nursery areas was significantly correlated to the recruitment time-series from the stock assessment, explaining ~30% of the variability. This research highlights the potential to predict recruitment using habitat-based methods and provides a potential mechanism for explaining some of the POP recruitment variability observed for this population.

Essential Fish Habitat project status report

Reporting date: October 15, 2010

Project number: FY09-10

Title: Natural and man-made disturbance of eelgrass beds in northern southeastern Alaska: damage and recovery

PIs: Patricia Harris

Funding year: FY09

Funding amount: $8K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Preliminary results were reported on a poster presented at CERF (Coastal and Estuarine Research Federation) meeting November 2009. A NOAA Tech. Memo. is in preparation comparing five eelgrass beds sampled from 2007-2010 with baseline data collected from 1998-2006.

Results: In 2010, we resampled eelgrass *(Zostera marina)* beds at Funter Bay and Crab Bay in southeastern Alaska to examine changes in eelgrass characteristics and associated fish assemblages from earlier years. Eelgrass was sampled again at Auke Nu Cove, Bay Creek, and Bridget Cove near Juneau, but we did not resample fish assemblages at those sites in 2010.

Eelgrass bed areas did not change appreciably at Crab Bay, Bay Creek, and Bridget Cove from 2009 measurements. The Funter Bay bed, however, was reduced by approximately 4.2 hectares from 2009 measurements, apparently by the grazing of green urchins (*Strongylocentrotus droebachiensi*). At the west, seaward margin of the bed, we found numerous urchins with bare ground seaward of them and relatively dense eelgrass above them on the beach. Since 2009, the Auke Nu Cove bed area has been further reduced. The entire portion of the south bed and a large portion of the bed seaward of the -0.5 m tide height on the northern side of the bed were bare in 2010. The cause for the reduced area at Auke Nu was not apparent.

In 2010, eelgrass dry biomass was similar to baseline values in undeveloped beds (Crab Bay, Funter Bay, and Bridget Cove), but reduced in developed beds (Auke Nu Cove and Bay Creek). Eelgrass densities in 2010 were significantly lower in all beds except Bridget Cove, and percent cover was lower in all beds in 2010 when compared with 2009 values. Canopy height remained the most stable eelgrass variable.

In 2010, fish catch per unit effort (CPUE) at Funter Bay was close to the mean CPUE for baseline years (2001-2003), but declined in the portion of the bed with the most dramatic decline in eelgrass cover (68 percent cover in 2009 to 1 per cent in 2010). At Crab Bay, CPUE remained at depressed levels, especially in the area where eelgrass percent cover remained low. In portions of both beds where catch was low, species richness was also lower than baseline values.

Given the high variability of eelgrass characteristics and fish assemblages from year to year, long-term or even moderately long-term changes in eelgrass communities are best evaluated by multi-year sampling. The paper in preparation will compare baseline data 2001-2003 (Crab Bay, Funter Bay), 2004-2006 (Auke Nu Cove, Bay Creek, and Bridget Cove) with 2008-2010 data.

Essential Fish Habitat project status report

Reporting date: 10/22/2012

Project number: 2009 - 11

Title: Contrasting predation intensity and distribution in 2 rock sole nursery areas: a principle factor controlling nursery productivity – Component B..

PIs: Ryer, Laurel, Knoth

Funding year: 2009

Funding amount: $13,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: This project is now fully complete and reported out. Find attached a manuscript published in Marine Ecology Progress Series (Laurel et al. 2012, MEPS 466:193-203). A brief summary of results is included below.

Results: What is the most important result of the study?

Over the short term, trawl disturbance appears to alter worm tube habitat in a manner that facilitates use by rock sole. Beam trawl data collected 5 hours after the disturbance indicated an increase in age 0 flatfish density across all 4 paired lined comparisons ($p<0.001$; Figure 1). However, longer term monitoring of the experiment (Fig. 2; 141 days) showed a significant interaction in survey time and the treatment effect (trawled or control) at both the worm tube transition depth (15-19.9m) and heavy worm tube depth regions (20-30 m). Analyzed by date, significant effects were restricted to the first sampling period (i.e., 5 hrs after the intervention) i.e., flatfish density

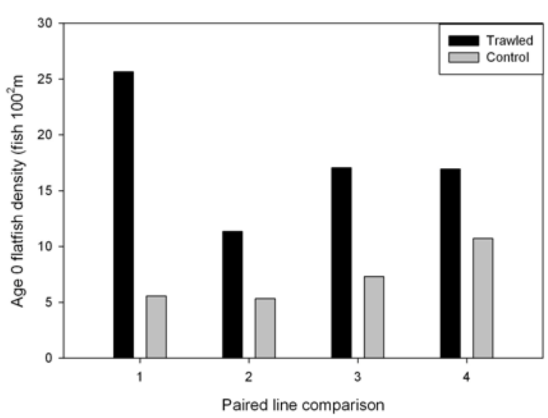


Figure 1. Density of juvenile flatfish from beam trawls towed along paired transects.

increased in trawled areas both at the worm tube transition depths (15-19.9m; $F_{1,194}$=6.697, p=0.003) and heavy worm tube depths (20-30 m; $F_{1,500}$=8.938, p=0.003

To further explore this data we modeled the effects of treatment, patchiness and depth. The effects of patchiness largely overwhelmed depth effects, which generally occurred in regions between 15-20 m (Fig. 3). Worm tube patchiness was relatively higher at intermediate depths (18-22m) at the worm tube transition area in the trawled sites, but this pattern disappeared after 3wks when all sites began to resemble one another. Deeper areas where worm tube density was highest appeared to be relatively unaffected by the trawl disturbance during the entire period.

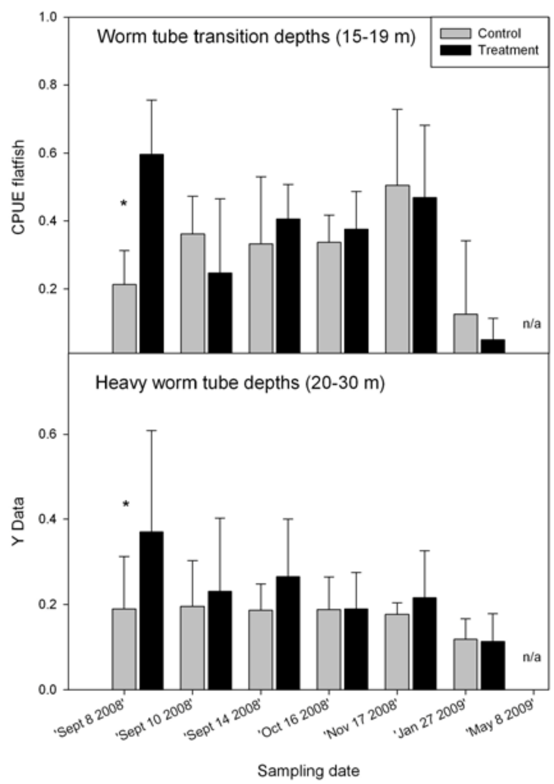


Figure 2. Mean catch per unit effort (CPUE ±SE) for control and disturbed tracts over 8 months over both transitional worm tube seafloor and heavy worm tube seafloor.

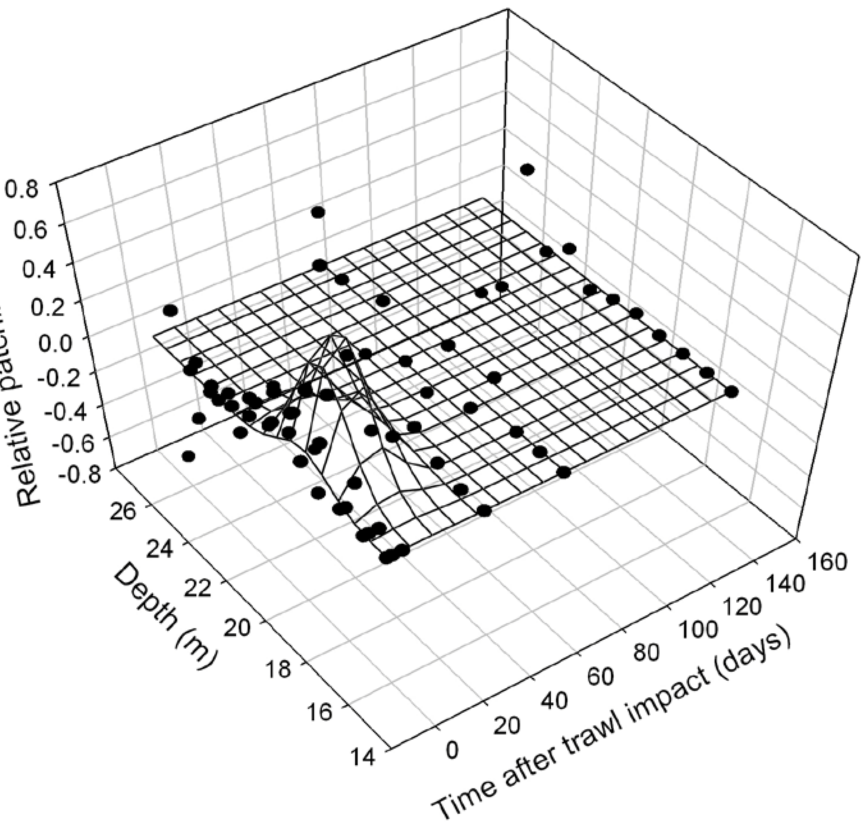


Figure 3. A non-linear 3D regression Gaussian model (f=0.722*exp(-.5*(((x-14.589)/b)^2 + ((y-19.626)/-1.104)^2)); $F_{4,67}$=3.299, p=0.0161) indicates the relative worm tube patchiness (i.e., trawl – control) as a function of time and depth is largely restricted to shallow depth regions and during the first 3-wks of the experiment. High values indicate higher patchiness in trawled regions vs paired control areas whereas values near 0 indicate similar patchiness among sites.

These results indicate that worm tube habitat is susceptible to trawl disturbance, but this is dependent upon worm density. Where worms are dense, simulated trawl gear slides over the bottom, producing only moderate impact, i.e. increased patchiness. In contrast, where worm tubes are sparse or patchy, the simulated trawl gear disturbs the bottom to a greater degree. Juvenile fish, which normally avoid dense worm tube habitat, will infiltrate into these areas after trawling, as a consequence of sand patches being created.

Essential Fish Habitat project status report

Reporting date: October 31, 2012

Project number: 2009-12

Title: Utilization of nearshore habitat by fishes in Nushagak and Togiak Bays (Bristol Bay)

PI: Olav A. Ormseth (AFSC/REFM)

Funding year: 2009

Funding amount: $68,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: N/A

Reporting: Have the project results been reported?

Yes. A draft NOAA Tech memo (attached) has been completed and is in review with Dan Cooper, Tom Hurst, and Sandra Lowe of the AFSC. Although there will likely be at least one journal article based on this project, this Tech memo serves as the main reporting vehicle for the results of the survey.

Results: What is the most important result of the study?

Below are the conclusions stated in the Tech Memo:

1) Habitats varied between Nushagak Bay and the Togiak area. Substrates in Nushagak Bay consisted only of sand and gravel, while Togiak area substrates varied from sand to rock. Vegetation (kelp and eelgrass) occurred only in the Togiak area. Waters in Nushagak Bay were warmer and less saline than those in the Togiak area.

2) Crangonid shrimps and rainbow smelt *Osmerus mordax* were the most ubiquitous and abundant species in the surveyed area.

3) Most of the fishes captured appeared to be young-of-the-year or juvenile life stages.

4) Species composition and community diversity indices varied substantially among hauls, subareas, and locales. While slightly more species were encountered in the Togiak area, diversity and evenness were higher in Nushagak Bay.

5) The abundance and mean size of species was more strongly related to geographic location than to temperature or salinity, although broad differences in water column characteristics among locations likely influenced the spatial distribution of species.

6) Nushagak Bay experiences dramatic changes in temperature and particularly salinity over the course of a tidal cycle. The degree and nature of these changes varies with location inside the bay.

7) Substantial variability in habitat and fauna exists at both of the main spatial scales examined during this study.

Essential Fish Habitat project status report

Reporting date: August 23, 2010

Project number: 13

Title: Nearshore Fish Assemblages in Coastal Areas Facing Development in Southcentral Alaska

PIs: Eagleton, Johnson

Funding year: FY09

Funding amount: $19K

Status: [X] Complete [ ] Incomplete, on schedule [ ] Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Results have been reported to AKRO:
Auke Bay Laboratories. Nearshore fish assemblages in Upper Cook Inlet, Alaska. Trip report for August 18, 2009. (Attached)

Auke Bay Laboratories. Nearshore fish assemblages in Resurrection Bay, Alaska. Trip report for August 20, 2009. (Attached)

Auke Bay Laboratories. A survey of fish assemblages in nearshore waters of Passage Canal, Alaska. Trip report for August 21, 2009. (Attached)

Results: What is the most important result of the study?

The shallow nearshore provides habitat for many commercially important and forage fish species. Climate change and the vulnerability of shallow-water habitats to shoreline development or an oil spill justifies the need to better understand, protect, and manage these valuable nearshore habitats.

Essential Fish Habitat project status report

Reporting date: 10/20/2015

Project number: 2009-03, 2010-01, 2011-02, 2014-03

Title: Recruitment and response to damage of an Alaskan gorgonian coral (*Calcigorgia spiculifera*)

PIs: Patrick Malecha, Dr. Kalei Shotwell, Erika Ammann

Funding year: 2009, 2010, 2011, 2014

Funding amount: FY2009 $38,000, FY2010 $32,900, FY2011 $16,700, FY2014 $17,700

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:
Image analyses of *in situ* scuba observations were completed in October 2015. Data analysis is currently underway and a draft manuscript is in preparation. Genetic analysis of coral recruits and adults is ongoing.

Reporting: No reporting has occurred yet.

Results:
Video analysis was completed in October 2015. Data generated from the video observations includes colony survival, branch growth, and tissue regeneration rates.

Seventy-nine percent of all tagged corals were alive and upright after five years of observations. Survival over the entire experiment was 63%, 70%, 88%, and 100% for the trawl, control, cut, and scrape treatment groups, respectively. Survival was not related to the damage treatments on any of the sampling events.

Average branch growth over the five-year period was 0.0216 mm/day for all corals combined. This translates into an annual branch growth rate of 7.88 mm. However, growth rates varied by season as growth during a 3-month summer period averaged 0.0424 mm/day.

Branches that were scraped of their overlying gorgonin tissue demonstrated a variety of responses. Some colonies regrew their missing gorgonin layer within about a year, while on other colonies, a portion of the scraped branches became necrotic and eventually disappeared. However, the growth of undamaged branches among corals in the cut and scraped treatments was on average greater than among corals in the trawl and control groups perhaps indicative of compensatory processes that focused energy on somatic rather than reproductive output.

Coral recruits were found on 18 of the 96 tiles collected and at least 60 individual recruits were identified. These observations document coral recruitment for the first time in Alaska. The

majority of recruits were small single- or two-polyp organisms, presumably less than one year old. There were also some very small potential recruits that lacked definitive structural characteristics of coral polyps but were pigmented similarly to *Calcigorgia spiculifera*. These specimens are currently undergoing genetic analyses to determine their identity. If these are indeed coral recruits, they would likely be only days or weeks old. There were also a few multi-polyp colonies that were probably more than a year old. Thus it is apparent that coral recruitment happened in multiple years. A rate of recruitment will be estimated based on the different sizes or “age classes” of the recruits. Tiles were placed on the seafloor on varied dates and thus were “seasoned” *in situ* for different amounts of time. The original tiles were in place for five years, while the most recently installed tiles were on the seafloor for 35 months. Recruits were found on tiles of all ages. Genetic analyses, to explore the relatedness between recruits and adults and to examine genetic diversity and dispersion potential, are ongoing.

Essential Fish Habitat project status report

Reporting date: 10/11/2011

Project number: 2010-02

Title: Characterize Collection of field data to support modeling bottom trawling impacts and subsequent recovery rates of sponges and corals in the Aleutian Islands, Alaska

PIs: Rooper

Funding year:FY10

Funding amount: $64,700

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: The results of this project were reported in the attached publication:
Rooper, C.N., M.E. Wilkins, C. Rose & C. Coon. 2011. Modeling the impacts of bottom trawling and the subsequent recovery rates of sponges and corals in the Aleutian Islands, Alaska. Cont. Shelf Res. 31:1827-1834

Results: In August 2010, a six day cruise was carried out in the eastern and central Aleutian Islands aboard the charter vessel F/V *Sea Storm*. Video was collected along overlapping bottom trawl tow paths using a stereo video drop camera at 18 sites from Amukta Island to Atka Island (Figure 1). These sites have previously been towed using the GOA/AI bottom trawl survey net (poly'Noreaster) on multiple survey years. The video collected at these sites was analyzed to determine an empirical estimate of the amount of hard bottom seafloor *(h)* suitable for colonization by sponges and corals. Assuming that prior to fishing removals the population was in equilibrium at each of the study sites the original biomass at each site (B_0) can be estimated as:

$$B_0 = K * h$$

where h is the amount of hard bottom seafloor suitable for colonization by sponges and corals

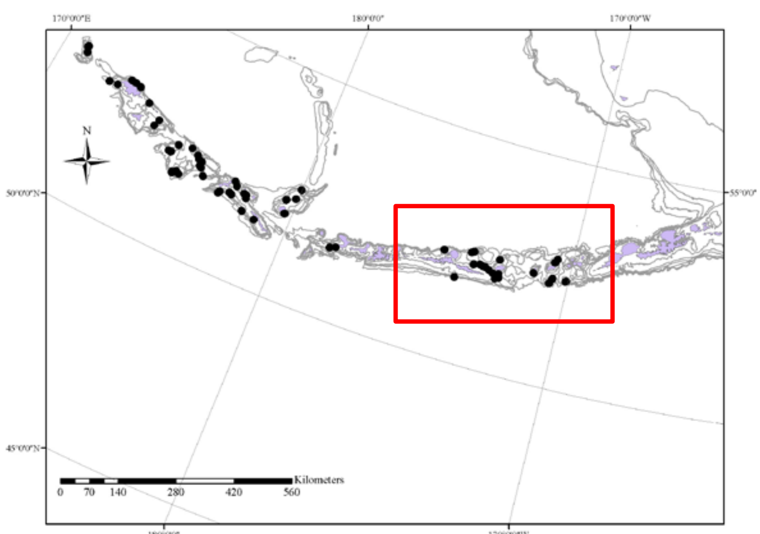


Figure 1. Map of the Aleutian Islands showing 18 study sites where underwater video was collected (inside red box)

and K is the carrying capacity for benthic invertebrates (per unit area). The data on h collected during this study was used in a model of invertebrate population growth and recovery rates that models the population abundances of sponge and coral at the 18 study sites over time. The video analysis and modeling was completed in fall 2010, with a manuscript published in 2011.

Essential Fish Habitat project status report

Reporting date: 9/06/2012

Project number: 2010-03

Title: Reproductive ecology of the red tree coral (*Primnoa pacifica*)

PIs: Stone, Waller, Mondragon

Funding year: 2010

Funding amount: $48,804

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: This project was initially delayed by 3 months because the EFH funds were not available in time to secure a vessel charter for the initial sampling period scheduled for June 2010. Field cruises were completed in September 2010, December 2010, March 2011, June 2011, September 2011, and January 2012. During the initial field cruise in September 2010 we tagged 38 colonies. For a subset (N = 10) of those colonies we physically removed approximately 1/3 of the colony in manner consistent with and in an effort to simulate damage from contact with fishing gear; the remaining colonies were left in a pristine condition so that we can examine differences between the two groups for the reproductive parameters. During each sampling period we sampled a small section of each of these colonies (except September 2011 when only 50% of the colonies were sampled due to extremely poor visibility). All samples (N = 171) have now been processed and data is being systematically analyzed. Results will be submitted for peer review publication in the next few months.

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Results have been presented at two venues – The 2011 American Academy of Underwater Sciences Meeting in Portland, Maine (Reproduction of Red Tree Corals in the Southeastern Alaskan Fjords: Implications for Conservation and Population Turnover – Waller RG, Stone RP, Mondragon J, Clark CE) and as an invited Keynote to the 4th International Deep Sea Coral Symposium in Amsterdam, Netherlands (A Deepwater emerged species in the Alaskan Fjords: Reproduction and development of Red Tree Corals. Waller RG, Stone RP, Mondragon J). Results are presently being analyzed and being written up for peer review publication.

Results: What is the most important result of the study?

Results of this study show prolonged continuous reproduction, low fecundities and novel protected development – life history strategies more concurrent with K-strategists. Yet paradoxically, the environment they inhabit, a fjord with two tidewater glaciers, is highly unstable over relatively short time scales (tens of years in this area), potentially making these thickets ephemeral populations. The life history traits observed also make this species particularly susceptible to mechanical damage from fishing gear, which might crop colonies and result in even lower fecundities, affecting natural population turnover.

Essential Fish Habitat project status report

Reporting date: August 23, 2010

Project number: 4

Title: Nearshore Fish Assemblages in Coastal Areas Facing Development in upper Cook Inlet and Prince William Sound, Alaska

PIs: Johnson, Eagleton

Funding year: FY10

Funding amount: $9.5K

Status: [X] Complete [ ] Incomplete, on schedule [ ] Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Results have been reported to AKRO:
Auke Bay Laboratories. Nearshore fish assemblages in Upper Cook Inlet, Alaska. Trip report for July 14, 2010. (attached)

Auke Bay Laboratories. Fish fauna in nearshore waters of Port Valdez, Alaska. Trip report for 12-13 July 2010. (attached)

Results: What is the most important result of the study?

The presence of longfin smelt and juvenile salmon in August 2009 and July 2010, suggests that these species may occupy nearshore waters of Upper Cook Inlet for several weeks during the summer, and be important prey for other fish, seabirds, and marine mammals.

In Port Valdez, the abundance of saffron cod in nearshore waters was noteworthy. Saffron cod have not been reported in Prince William Sound (PWS) until recently in the western Sound. In western PWS, saffron cod are a dominant species in nearshore waters. The abundance of saffron cod in Port Valdez (central PWS) is evidence that this species is likely widely distributed throughout PWS. Possible ecological implications of saffron cod in nearshore waters include competition for food and space and increased predation risk to commercially important and forage fish species.

Essential Fish Habitat project status report

Reporting date: 10/15/2010

Project number: 2010-05

Title: Productivity, habitat utilization and recruitment dynamics of Pacific cod

PIs: Laurel, Ryer, Stoner, Knoth, Parrish, Urban

Funding year: 2010

Funding amount: $42,800

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Project complete with manuscript in review:

Results: What is the most important result of the study?

Age-0 fish that successfully transition through early life stages may be the earliest reliable indicators of year class strength, yet few survey data are available to test these predictions for commercially important groundfish species in Alaska. Over the past five years, we examined trends in annual abundance, growth and mortality in age-0 Pacific cod (*Gadus macrocephalus*) across multiple fixed-site locations in two nursery embayments in Kodiak Island, Alaska, USA using beach seines (n=320 hauls) and baited cameras (n=410 deployments) (Fig. 1). The beach seine targeted age-0 fish in 2-4 m depth whereas the baited camera targeted older conspecifics (age 1 – 2) across a broader range of depths (2 – 20 m) adjacent to seine site locations. We used these survey data to address the following questions: (1) does post-settlement growth and mortality vary annually, and if so, (2) what processes control such variation? and (3) can bay-resident populations of age-1 and age-2 juvenile cod be predicted from age-0 abundance in the prior year or do post-settlement processes mask initial recruitment signals?

Question 1: The interannual abundance of age-0 recruiting to nurseries was highly variable, but variability was highly positively correlated among co-occurring gadids, age-0 saffron cod *Eleginus gracilis* (r^2 = 71%; Fig 2a) and age-0 walleye pollock *Theragra chalcogramma* (r^2 = 69%; Fig 2b). These patterns suggest a common mechanism regulates pre-settlement survival and/or successful delivery of larvae to coastal nurseries.

Question 2: Two notable trends emerged from the size and growth data. First, size-at-settlement was positively related to spring temperatures experienced by larvae, but more importantly, these differences in size were directly related to post-settlement mortality in the nursery (r^2 = 47%, p = 0.047; Fig. 3) i.e., larger fish in July were more likely to survive to late Augusts in that year. Second, although age-0 density did not appear to impact mortality (Fig 4a) there was a negative impact on post-settlement growth (r^2 = 65%; Fig 4b), suggesting nurseries may have limited resources (e.g., habitat, food) and could be a population bottleneck in years of high age-0 abundance.

Question 3: The regression analysis of age-0 abundance on subsequent year class strength yielded mixed results. For Pacific cod, age-0 abundance significantly predicted age-1 and age-2 abundance ($p<0.05$ in all instances) and there was model improvement using late estimates of age-0 abundance from August compared to July. However, all the regressions were highly leveraged by the abundant 2006 year class in Anton Larsen Bay (h_{ii} = 0.76 – 0.93). The removal of this data point resulted in no significant relationship between age-0 and age-1 or age-0 and age-2 abundance ($p>0.05$). A more cautious interpretation is that age-0 estimates of low abundance (using beach seines) are reliable indicators of relatively low year class strength in subsequent years whereas abundant year classes may still be prone to high rates of mortality to be considered sound indicators of recruitment strength.

Conclusion: Collectively, these data suggest age-0 Pacific cod abundance is a reasonable predictor of year class strength of resident juveniles in nearshore habitats, but post-settlement sources of mortality (e.g., overwintering, predation, etc.) may be significant enough to consider the existence of additional critical periods in juvenile gadids resident to Kodiak coastal areas. Further studies will undoubtedly need to determine how the population dynamics of juvenile cod in coastal nurseries integrate with the broader population dynamics of the Gulf of Alaska. With additional time series data, an examination of parallels between coastal and offshore abundance data (e.g., age-0 seine data vs age-3 trawl data) will be one means of examining such links. In the mean time, the supporting vital rate information (derived in coastal nurseries) could be used for provisional estimates of growth and natural mortality where other such data are absent or assumed in the Gulf of Alaska stock assessment.

Associated manuscript:

Laurel BJ, Knoth B, Ryer CH (in review) Density-dependent growth, mortality and recruitment signals in age-0 gadids settling in coastal Alaskan nursery areas. Can J Fish Aquat Sci.

FIGURE CAPTIONS:

Figure 1: Sampling for juvenile Pacific cod caught by a) beach seine and b) baited camera across multiple fixed-site locations in Kodiak. The survey occurred over two sampling periods (mid-July and late-August) across 5 years (2006 – 2010).

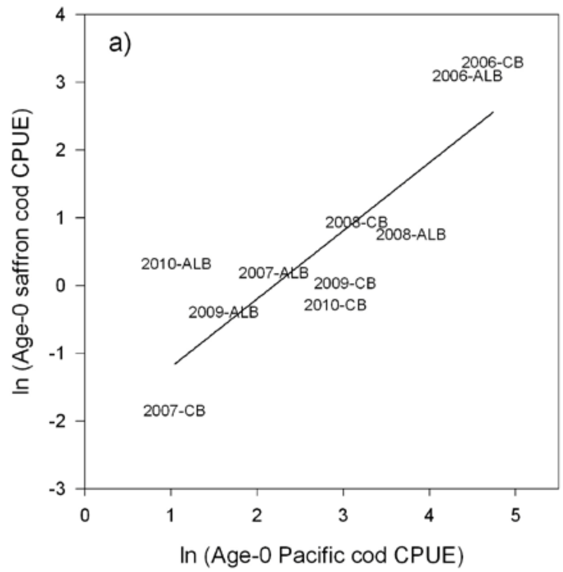
Figure 2: Interannual regional abundance of age-0 Pacific cod compared to a) age-0 saffron cod and b) age-0 walleye pollock during the same period and region. Data are based on seine catches of age-0 fish in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010).

Figure 3: Influence of settlement size on mortality in age-0 Pacific cod over a 6 wk period in two Kodiak nurseries areas. Size data (x-axis) are based on mean size of age-0 Pacific cod collected in mid-July in seines at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010). Mortality estimates are based on relative change in abundance (catch-per-haul) from mid-July to late August respectively

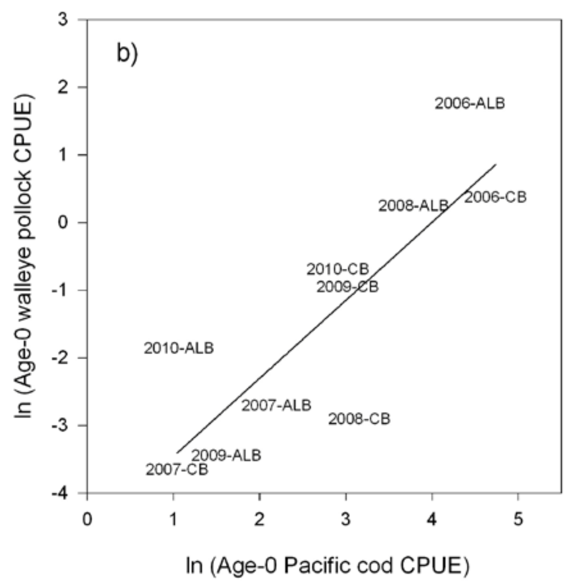
Figure 4: Influence of annual age-0 Pacific cod abundance on a) growth and b) mortality over a 6 wk period in two Kodiak nurseries areas. Abundance data (x-axis) are based on seine catches of age-0 Pacific cod in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-yr period (2006-2010). Growth and mortality estimates are based on relative change mean length and abundance from mid-July to late August respectively.

Fig 1:

Fig 2:

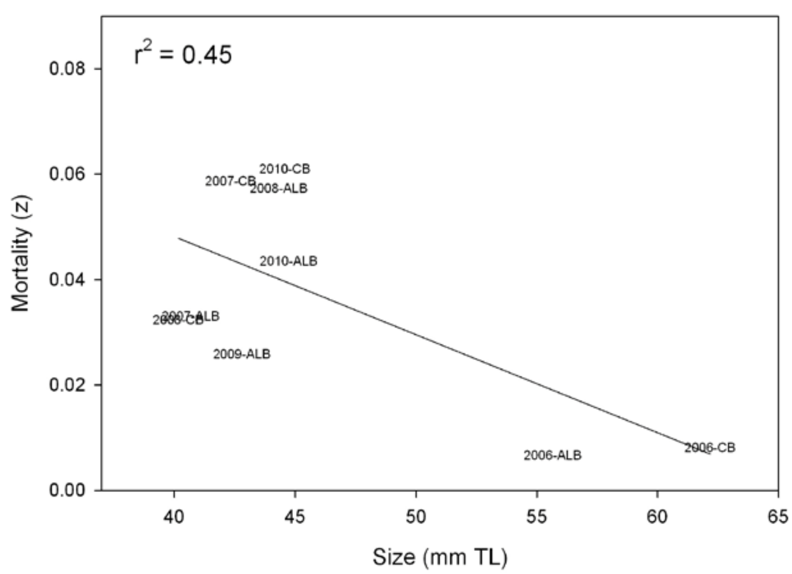


a)
2006-CB
2006-ALB
2008-CB
2008-ALB
2010-ALB
2007-ALB
2009-CB
2009-ALB
2010-CB
2007-CB
ln (Age-0 saffron cod CPUE)
ln (Age-0 Pacific cod CPUE)



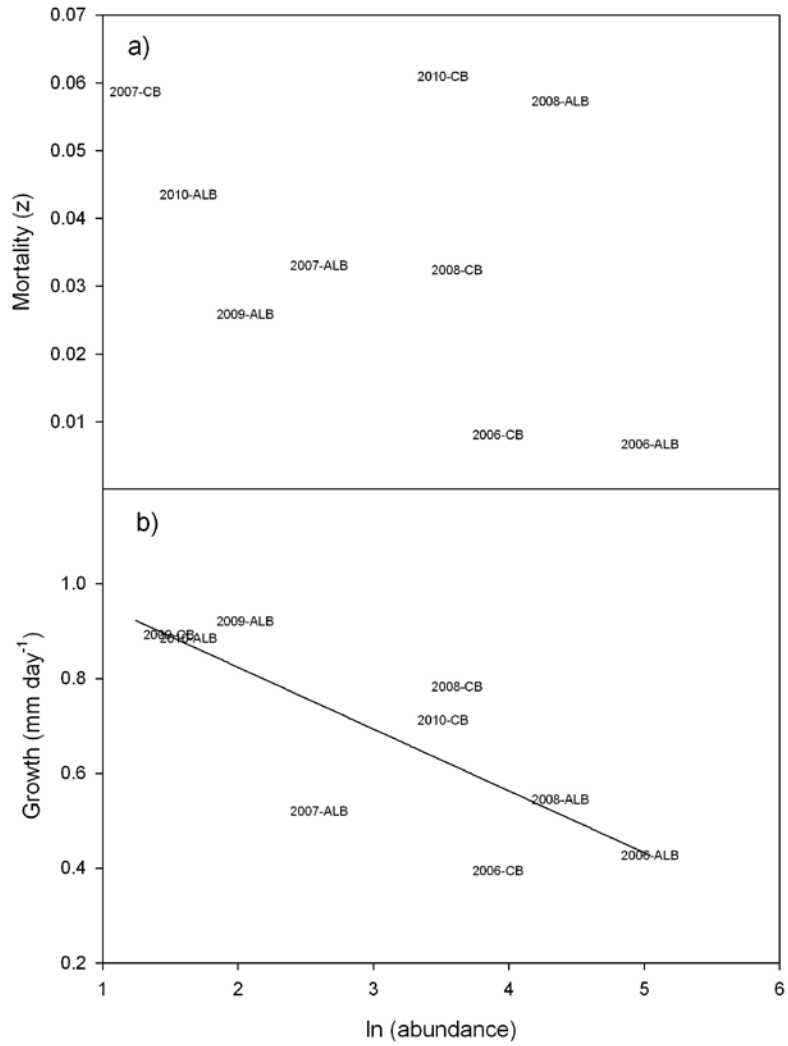
b)
2006-ALB
2008-ALB
2006-CB
2010-CB
2009-CB
2010-ALB
2007-ALB
2008-CB
2009-ALB
2007-CB
ln (Age-0 walleye pollock CPUE)
ln (Age-0 Pacific cod CPUE)

Fig 3:



r² = 0.45
0.08
0.06
0.04
0.02
0.00
Mortality (z)
2010-CB
2007-CB
2008-ALB
2010-ALB
2007-ALB
2009-ALB
2006-ALB
2006-CB
40
45
50
55
60
65
Size (mm TL)

Fig 4:



a)
b)
Mortality (z)
Growth (mm day-1)
ln (abundance)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1.0
0.8
0.6
0.4
0.2
1
2
3
4
5
6
2007-CB
2010-CB
2008-ALB
2010-ALB
2007-ALB
2008-CB
2009-ALB
2006-CB
2006-ALB
2009-ALB
2009-CB
2010-ALB
2008-CB
2010-CB
2008-ALB
2007-ALB
2006-ALB
2006-CB

Essential Fish Habitat project status report

Reporting date: 10/25/13

Project number: 6

Title: Northern Bering Sea habitat suitability for benthic-feeding flatfishes

PIs: Yeung, Cynthia, Yang, Mei-Sun.

Funding year: 2010

Funding amount: $96,300

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Yeung, C., M.-S. Yang. (ms). Benthic habitat and infauna prey availability for flatfishes in the northern Bering Sea. In AFSC internal review.

Results: What is the most important result of the study?

The recent trend of ocean warming fuels speculations of southeastern Bering Sea (EBS) fish stocks expanding their distribution range into the northern Bering Sea (NBS). Three flatfishes valuable in the EBS bottom trawl fisheries: yellowfin sole (*Limanda aspera*; YFS), northern rock sole (*Lepidopsetta polyxystra*; NRS), and Alaska plaice (*Pleuronectes quadrituberculatus*; AKP), are also found in the NBS. We conducted the first assessment of NBS habitat suitability for these benthivorous flatfishes from the perspective of prey availability during the inaugural bottom trawl survey of the NBS in 2010. Benthic samples for sediment and infauna analysis were collected at twelve trawl stations along a meridional transect extending from 60.5°N to 64.5°N east of St. Lawrence Island (SLI) (Fig. 1). Stomach contents from the flatfishes were concomitantly collected to relate diets to prey fields. Along the transect, the sediment type is muddy sand ($0.5<\text{sand:mud}<0.9$) and well-sorted with little variation. However, infauna biomass was higher north of SLI, and polychaetes, bivalves, and amphipods dominated the infauna in different proportions south and north of SLI. Amphipods were dominant in abundance and bivalves were dominant in biomass in the north; polychaetes were dominant in both abundance and biomass in the south. Amphipods were the most frequently present in all the stomachs (90%), followed by polychaetes (88%) and bivalves (44%). Polychaetes were the primary prey in terms of mean percentage stomach weight of AKP at all twelve stations, and at eight of the stations for NRS. For YFS, amphipods were the primary prey at seven of the stations. Overlap in prey usage was high, especially between AKP and NRS, and between NRS and YFS. Overlap between AKP and YFS was the lowest. There was no significant correlation between the diet of any of the flatfishes and the infauna composition except for YFS. The spatial mismatch between diet and infauna compositions suggests that prey availability is high in the NBS. Another indication that the NBS may have a richer prey environment is the low consumption of bivalves - which have much lower organic content than polychaetes and amphipods - relative to the EBS. The flatfishes generally have versatile diets, but compared to the EBS, they were more selective of their prey in the NBS. For example, polychaetes were the primary prey of all flatfishes in the northern end of the transect although amphipods were dominant in the infauna. Infauna biomass and abundance along the transect were at least comparable to the EBS. Although niche overlap is high, competition for food is likely lower than in the EBS with the lower density of flatfish in the NBS. Bottom temperatures in the NBS and the EBS were in the same range during the 2010 survey. The NBS appears presently to be suitable flatfish habitat in terms of prey availability. Although the effects of climate warming on the prey environment and fish biomass are complex and unpredictable, a shift to milder winter conditions in the NBS will presumably increase this suitability.

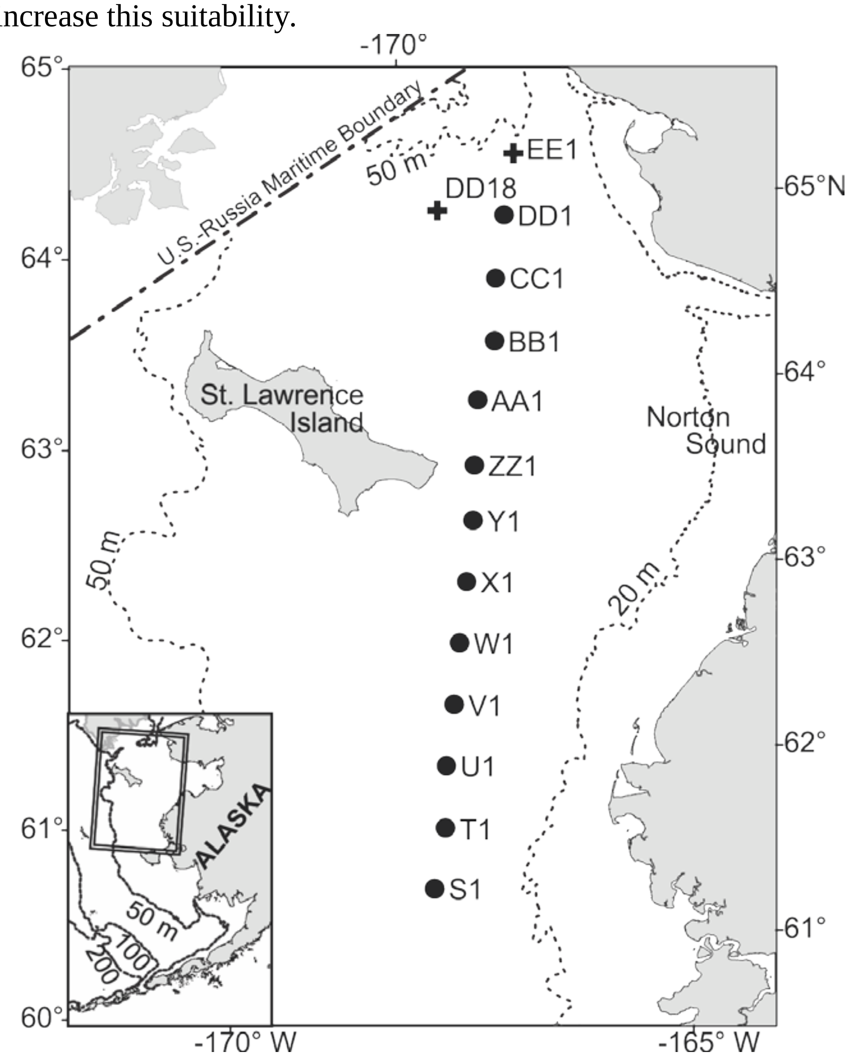


Fig. 1. Map of study area and transect of stations where benthic samples and flatfish stomachs were collected (•), and additional stations where only stomachs were collected (+).

Essential Fish Habitat project status report

Reporting date: 10/15/2012

Project number: 7

Title: Identification of high relief living structures in the Gulf of Alaska slope areas

PIs: Rooper, Hoff, Wilkins

Funding year:FY10

Funding amount: $112,250

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Yes

Results: In August 2010, we conducted an eight day cruise aboard the chartered fishing vessel *Sea Storm* to investigate three slope areas in the western Gulf of Alaska (Figure 1). These slope areas were identified by fishers to potentially contain high relief, living structure such as coral and sponges (HAPC organisms) in virtually pristine states, as fishing has not typically occurred in these areas. As part of regulatory provisions enacted in 2005, these areas were closed to bottom contact mobile gear. The objective of our study was to use video to determine whether sponges and corals occurred in each of the three slope areas and to collect data that would allow predictive modeling of the distribution of sponges and corals in the three closed areas. This modeling could potentially be expanded to provide distributional maps for slope areas throughout the Gulf of Alaska.

The analysis was carried out using a generalized additive modeling methodology. We used presence or absence of coral or sponge observed in camera drops at the three sites as the dependent variable. At each of the Unalaska and Sanak areas, 30 random locations for camera drops were chosen at depths < 350 m. In the deeper Shumagin area, only 13 randomly selected locations were sampled using the camera (Figure 1). Camera drops consisted of three to nine minutes of video collected 1-2 m off the seafloor. The camera sled was drifted over the seafloor at a target rate of 1-2 knots. For each of these camera drops the presence or absence of coral and upright sponges (providing vertical relief off the seafloor) was recorded, the substrate type, as well as any other invertebrates or fishes. The number of individual corals or sponges was also recorded where possible, or the percentage of the seafloor covered by corals and sponges in cases where they were too numerous to count individually.

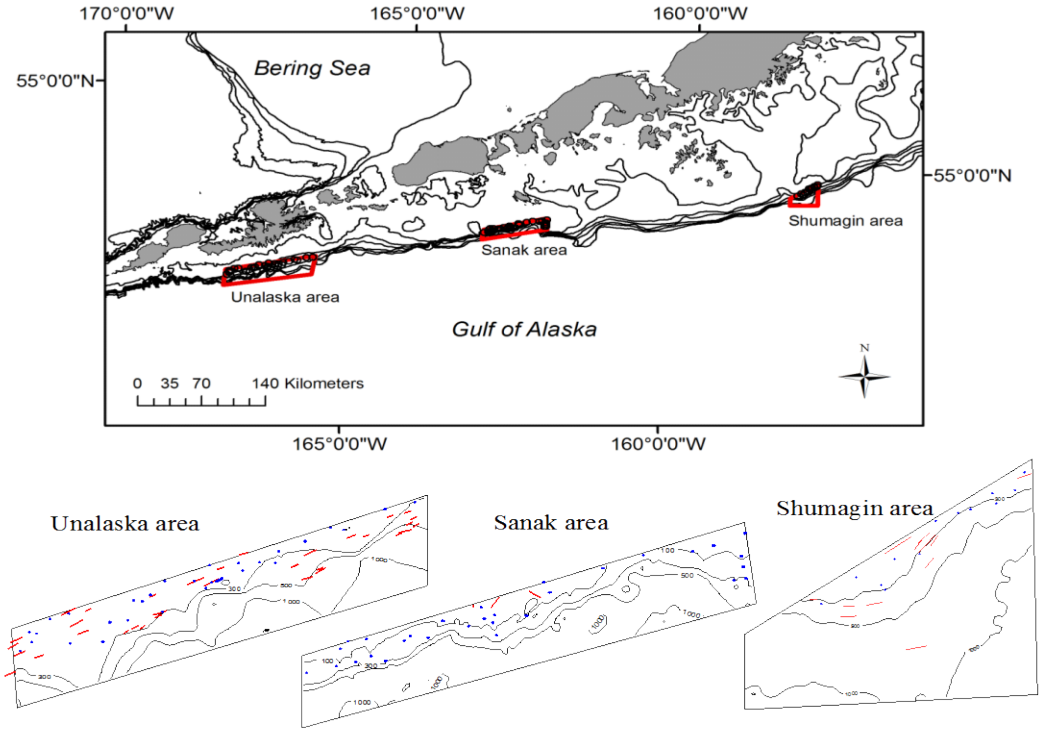


Figure 1. Map of the study areas showing the location of each of the three study sites (Unalaska, Shumagin and Sanak) and survey tows (red lines) and camera drops (blue lines).

Figure 1. Map of the study areas showing the location of each of the three study sites (Unalaska, Shumagin and Sanak) and survey tows (red lines) and camera drops (blue lines).

Four explanatory variables were utilized to predict the distribution of coral and sponge in the closed areas. These four variables were 1) bottom depth, 2) bottom slope, 3) seafloor roughness, and 4) seafloor hardness. Bottom depth was measured by a continuous depth recorder attached to the camera sled during deployment, the other three variables were all derived from the acoustic returns from the vessel echosounder. Each of these variables was interpolated onto a grid overlayed on the three closed areas.

The best-fitting model for both coral and sponge were used to make predictions of presence or absence on the 100 m^2 grid cell coverages of each of the closed areas. The model predictions were assessed by comparing them to the observed values where observations occurred. A second validation method used data collected in each of the closed areas during biennial bottom trawl surveys of the Gulf of Alaska. Tracklines for bottom trawl hauls occurring in each of the closed areas in the survey years since 1993 were overlayed on the model prediction grid. The model predictions of presence or absence integrated over the trawl path were compared to the bottom trawl catches to determine if presence of coral and sponge was accurately predicted in the bottom trawl survey catches.

The patterns in explanatory variables varied within each of the closed areas (Figure 2). For example, seafloor roughness was generally lower in the Unalaska area, while it was highest in the Shumagin area, where peak values were observed in deeper waters in the center of the closed area. Bottom hardness was observed to be higher in the Unalaska area, and harder areas generally occurred where depth was shallower.

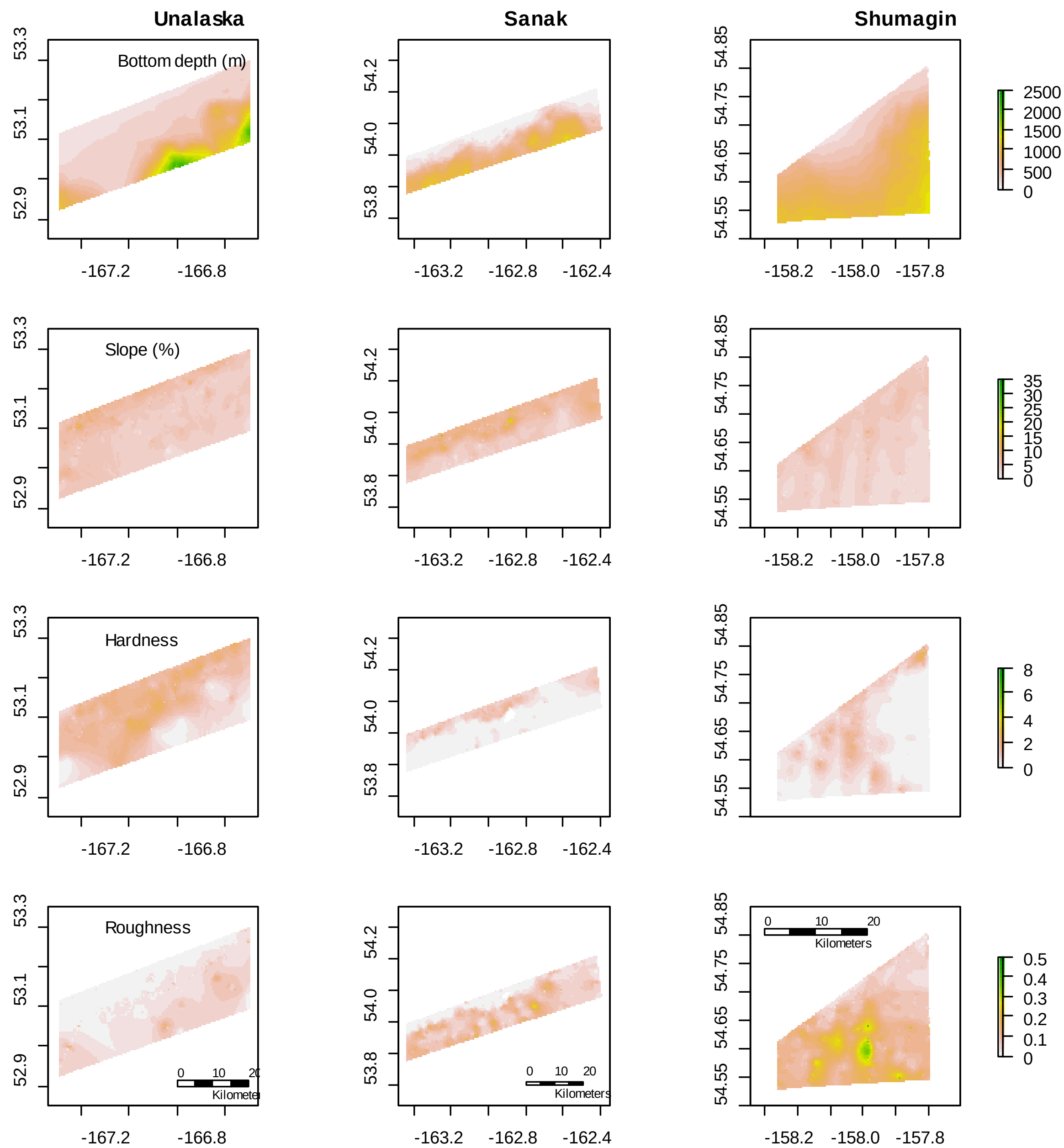


Figure 2. Distribution of explanatory variables, depth (m), slope (%), seafloor hardness and seafloor roughness from each of the three closed areas (Unalaska, Sanak, and Shumagin).

Upright sponges (vase or arborescent morphology) occurred at all three closed areas, although there were relatively few occurrences at the Unalaska and Shumagin areas Deepwater corals were not found in the Shumagin area and were observed only at one site in Unalaska. Coral occurred at 13 of 30 sites in the Sanak area. Sponges were distributed across all depths where video was recorded, while corals were distributed only at the shallowest locations (< 150 m) in the closed areas. The most common corals observed were gorgonians. *Fanellia fraseri* was the most abundant species, although a few other species such as *Calcigoria spiculifera* and some unidentified species were observed. All observed corals had an upright fan type morphology.

Table 1. Predicted and observed coral and sponge presence or absence from the model for camera drop transects (n=73) and bottom trawl survey hauls (n=30).

	Camera drop transects		**Bottom trawl survey trawls**	
Sponge	Predicted absent	Predicted present	Predicted absent	Predicted present
Observed absent	34	5	12	8
Observed present	5	29	6	4
Coral	Predicted absent	Predicted present	Predicted absent	Predicted present
Observed absent	57	2	21	5
Observed present	1	13	2	2

The best fitting model predicted coral presence or absence included depth, slope and seafloor hardness as explanatory variables. The probability of coral presence was highest at shallow depths and areas of flat seafloor (Figure 3). Probability of coral presence increased with increasing seafloor hardness as well. The model predictions agreed with the observed data for coral presence or absence in 96% of the 73 camera drops (Table 1).

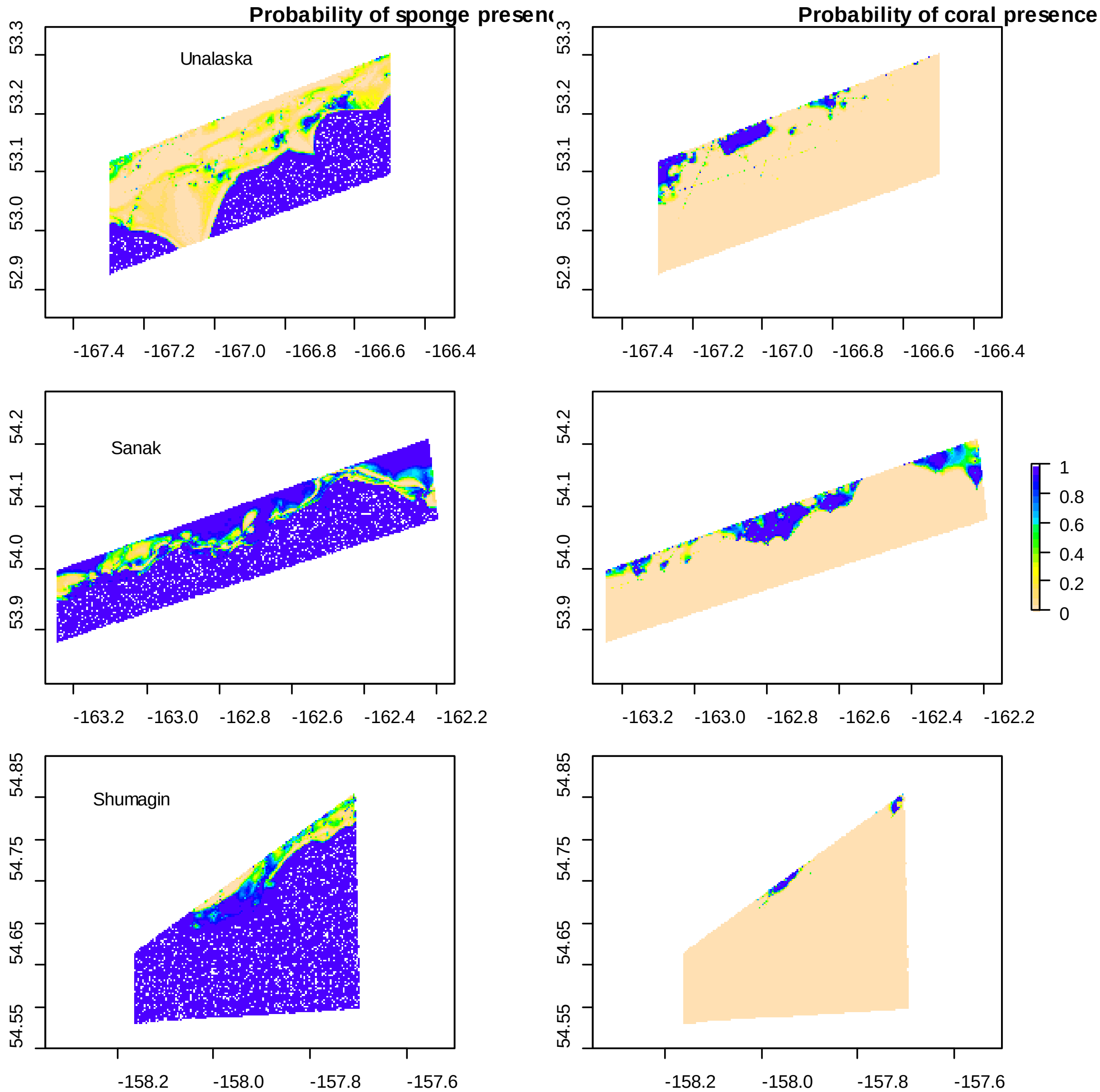


Figure 3. Model predictions for the probability of presence of sponge and coral for the three closed areas (Unalaska, Sanak and Shumagin).

The best fitting model for sponge included depth, slope and seafloor roughness. Similar to the coral model, the probability of sponge presence decreased sharply with depth to ~150 m. However, unlike for the coral model, there was an increase in the probability of sponge presence at depths > 300 m (Figure 3). The probability of sponge presence increased with increasing roughness and generally increased with increasing slope (greater than 4 %). The model predictions agreed with the observed data for sponge presence or absence at 86% of the camera drop locations. The mean probability of sponge absence at camera drop locations where sponge was observed to be absent was also below 0.5, however there were not the distinct differences in the mean probability between sites with observed sponge presence or absence as was seen for the case of coral.

When the best fitting coral GAM model was used to predict the presence of absence of coral across each of the three study areas, coral was predicted to occur in only a small fraction of the total area of the three sites In total 3.9%, 14.5%, and 1.2% of the Unalaska, Sanak and Shumagin areas respectively were predicted to have suitable coral habitat.

For sponge, the story was much different, as much of the area in the HAPC closures were predicted to have habitat suitable for sponge presence. However, much of the area predicted to have sponge present was at depths greater than 350 m. This was probably a result of the absence of samples from these depths. In total, 57% of the Unalaska site was predicted to have suitable sponge habitat while 88% and 94% of the Sanak and Shumagin areas were predicted to have suitable sponge habitat.

The best fitting coral model also performed reasonably well in predicting the occurrence of coral in the bottom trawl survey catch (Table 1). The model predicted the correct presence or absence in 77% of the cases. The best fitting model for sponge did not perform well at predicting the presence or absence of sponge in the bottom trawl hauls. The best fitting model was successful in only 16 of 30 cases (53% accuracy, Table 1).

A manuscript for peer-review is being prepared that describes these results. It is anticipated to go into the internal review process by October 31st, 2012.

Essential Fish Habitat project status report

Reporting date: 9/12/11

Project number: 8

Title: Reproductive Biology of Pacific Sand Lance near Juneau, Alaska: Spawn Timing and Location, and Larval Distribution

PIs: Harris

Funding year: FY10

Funding amount: $19K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Summer 2012

Reporting:
Field work has been completed. Laboratory work (oocyte measurement and gonad histology) and data analysis have yet to be completed. Preliminary results were reported in a slide presentation at the 2011 National AFS meeting. A manuscript is in preparation.

Results:
Preliminary results include:

1. Pacific sand lance use burying habitat in the Mendenhall River estuary during gametogenesis.
2. In the Auke Bay area, it appears that most sand lance spawn during late November and early December. Juneau spawning is later than the early October spawn documented in Kachemak Bay and on Kodiak Island.

Essential Fish Habitat project status report

Reporting date: 10/19/2013

Project number: 2010-09
Title: Recruitment, post-settlement processes and habitat utilization by Tanner crab Chionoecetes bairdi

PIs: Ryer, Long, Spencer

Funding year: 2010

Funding amount:
$48,000
Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Results reported in manuscript submitted to RACE editorial review process. Anticipated submission to Fish Bull in fall 2013.

Results: What is the most important result of the study?
Three principle goals were itemized in our proposal:

Goal #1 Develop improved gear: We modified an existing camera sled, equipping it with a codend, to allow collection of juvenile Tanner crabs. This gear scrapes off the upper 2 cm of sediment and deposits it in a 3mm mesh codend. To examine the utility of this gear as a mainstay for studying crabs/habitat associations, we conducted synoptic sampling, during each of 3 months, using the crab scrape data, diver quadrats and 2m beam trawl. Preliminary analysis indicates that the scrape is as efficient as diver enumerated quadrats and approximately 6 times more efficient than the 2m beam trawl at collecting age-0 Tanners. Importantly, the video capability of the scrape allows for quantification of habitat features.

Goal #2-Tanner settlement: During 2010 we conducted 331 crab scrapes at 2 sites, over a range of depth. Data clearly indicate that juvenile Tanners preferentially settle at depths of 10 to 40m. Settlement depth varies between embayments; crabs tend to settle deeper in embayment with high wave energy exposure (and coarse sediments) than in more protected embayment with finer sediments. The distribution of crabs tends to mirror that of worm turf habitat during May and June, but this relationship is weak compared to the effect of depth. Data further indicate that the density of juvenile Tanners decreases at depth beyond 40 m, indicating sedimentary bottom at depths of 10 – 40 m likely constitutes EFH/nursery habitat for this species in the GOA.

Goal #3-Tanner post-settlement processes: Field sampling suggests that, subsequent to their settlement, crabs begin to migrate to deeper water (>40m) during the months of July and August. Crab growth also differs between embayments. In August we sampled crabs from Womens Bay and Kalsin Bay, in addition to our normal Pillar Creek Cove and Holiday Beach sites. Crabs at Womens and Kalsin were significantly larger than those at Pillar and Holiday. This was manifest in Women and Kalsin crabs being one molt stage larger, in their development, at Womens and Kalsin, than at Holiday and Pillar. In addition, for each molt stage, crabs at Womens and Kalsin were significantly larger.

In support of field work examining post-settlement processes, approximately 1000 live Tanner crabs were shipped back to Newport for laboratory experimentation. Lab experiments demonstrated that 1) age-0 Tanner prefer fine sediments to coarser gravels and pebble bottoms, 2) burial is facilitated by finer grain sediments and the ability to successfully bury increases with crab size, 3) crabs bury deeper when they perceive predation risk, 4) juvenile Tanners demonstrate a preference for simulated worm tube habitat, as opposed to bare sediment, and 5) dense worm tube habitat renders juvenile Tanners less vulnerable to cod predation, compared to bare sediment.

Essential Fish Habitat project status report

Reporting date: 10/21/2014

Project number: 2010-10

Title: Seasonal habitat use and over wintering habits of juvenile Pacific cod in coastal nursery areas

PIs: Brian Knoth, Christina Conrath, Dan Urban, Ben Laurel, and Carrie Worton

Funding year: 2010

Funding amount: $43,450

Status: ☒ Complete Incomplete, on schedule Incomplete, behind schedule

Reporting: Results from this project have been presented at the AFSC 2012 Coastal Cod Workshop. A manuscript is in preparation with the final results of this project (Knoth et al., Seasonal habitat use and over wintering habits of juvenile Pacific cod in coastal nursery areas).

Results: What is the most important result of the study?

In 2011, we completed laboratory trials examining the effects of tag implantation on juvenile cod. The laboratory trial showed that intra-peritoneal tag implantation is a valid tagging technique for juvenile Pacific cod. In the laboratory, we implanted dummy transmitters in 5 juvenile cod and monitored the fish for up to six months. The cod continued to feed and grow throughout the trial and an examination of the fish revealed that the incisions healed with no visible signs of infection.

Figure 1. Pacific cod transmitter incision wound after 103 days.

During the summer and fall of 2011, we were successful in tagging seven juvenile cod with acoustic transmitters. In mid-August, we installed the passive acoustic gate at the entrance of Anton Larsen Bay. We periodically tracked the cod throughout the late fall/early winter months and removed the passive array in March 2012. In 2012, we successfully tagged 14 additional juvenile cod in Anton Larsen Bay during late August/early September. At this time, we re-installed the acoustic gate to document cod movements and out migrations and began active tracking of the cod. We continued periodic active tracking of the cod through November. At the end of November, we ceased operations and removed the acoustic receivers before weather conditions deteriorated and hindered our ability to access the bay. In 2013, we conducted camera drops at the cod detection locations (both active and passive) in order to assess habitat use of juvenile cod and ground truth a habitat map of the bay. The depth range and habitat use of juvenile cod during the fall months was highly variable. The depth range of re-located tagged cod ranged from 3.5 to 26.4 m. At these depths, the drop camera revealed the bottom substrate varied from a bare sediment/shell mix in the deeper depths to a combination of the bare sediment/shell mix and kelp (*Agarum cribrosum* and *Laminaria* sp.) in the shallower depths.

Juvenile cod exhibited variable nearshore residency throughout the fall and winter. The majority of cod immediately departed the detection range of the passive acoustic "gate" at the mouth of the bay during out migration. In 2011 and 2012, cod out migrations occurred from late August to November, but the majority occurred in September. It appears that cod out migrated earlier in 2012 than 2011 (Figure 2). The majority (17 of 19) of cod left the bay during an ebb or slack tide, but they did not show a preference for diel stage (Table 1). There was no evidence of any cod over-wintering within Anton Larsen Bay. However, a small percentage of cod in 2011 remained in the nearshore waters of the mouth of Anton Larsen Bay throughout the winter.

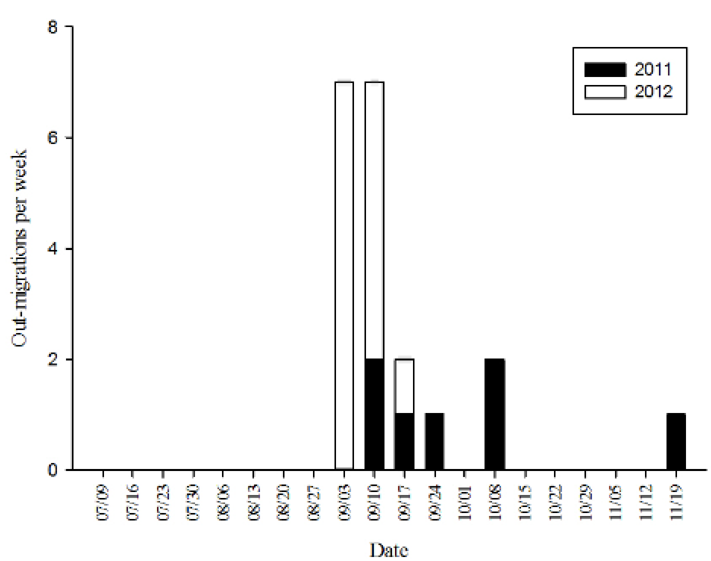


Figure 2. Juvenile cod out migration timing

Table 1. Juvenile cod out migration date, time, diel stage and tidal stage.

Year	Tag number	Date	Time	Diel stage	Tidal stage
2011	1656	9/3/11	23:05:38	night	ebb
	1654	9/7/11	16:34:39	day	ebb
	1655	9/14/11	20:21:04	day	ebb
	1653	9/21/11	21:21:04	night	slack
	1657	10/3/11	22:22:26	night	ebb
	1676	10/4/11	19:51:14	dusk	slack
	1658	11/14/11	18:35:03	night	ebb
2012	1674	8/30/12	19:19:04	day	ebb
	1673	8/30/12	21:58:42	dusk	flood
	1671	8/31/12	10:47:48	day	flood
	1666	8/31/12	18:08:40	day	ebb
	1673	9/1/12	4:29:54	night	ebb
	1670	9/2/12	4:00:36	night	slack
	1663	9/4/12	7:37:37	day	ebb
	1665	9/7/12	10:52:36	day	ebb
	1668	9/7/12	11:58:26	day	ebb
	1662	9/9/12	15:03:20	day	slack
	1661	9/10/12	3:03:18	night	ebb
	1660	9/12/12	1:20:47	night	ebb
	1667	Na			
	1669	Na			
	1672	Na			

Essential Fish Habitat project status report

Reporting date: 10/19/2013

Project number: 2011-1

Title: Determinants of juvenile tanner crab growth from different nursery embayments

PIs:Ryer, Spencer, Iseri, Ottmar, Copeman

Funding year:2011

Funding amount: $83,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Results have been reported in a manuscript submitted to the RACE editorial committee, with anticipated submission to FISH BULL in fall 2013. A second manuscript, specifically dealing with lipids, will be submitted in 2014.

Results: What is the most important result of the study?

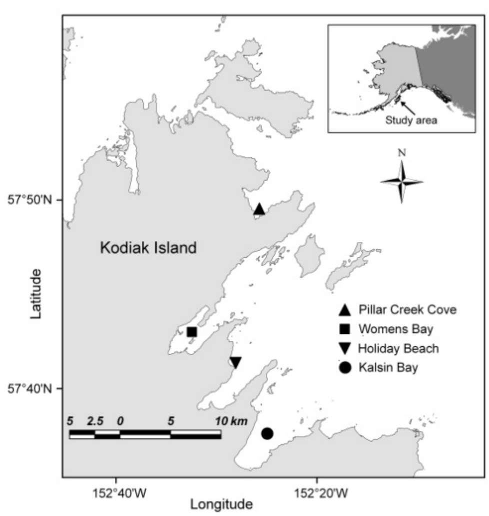


Figure 1. Location of study sites.

Our 2011 research grew out of research from the prior year demonstrating age-0 yr Tanner crabs recruiting to different Kodiak embayments may be experiencing differing growth rates. We had sampled crabs from 4 Kodiak embayments; Pillar Creek Cove, Holiday Beach, Kalsin Bay and Women's Bay Fig. 1). By July 2010 age-0 Tanner crabs from Women's and Kalsin were one molt stage larger than those in Pillar and Holiday. Larger size at the end of the first summer could provide increased fitness to Women's Bay crabs as they are less vulnerable to predation. Further, because growth in Tanner crabs is determinate, 1 molt stage difference in growth equates to maturation 1 year earlier.

Understanding how nursery/habitat influences growth and size/age at maturity provides a direct linkage between essential fish habitat and stock productivity (HEPR_EFH Level 3 & 4).

Our 2011 HEPR funded research addressed 4 specific hypotheses as possible reasons for this difference in size:

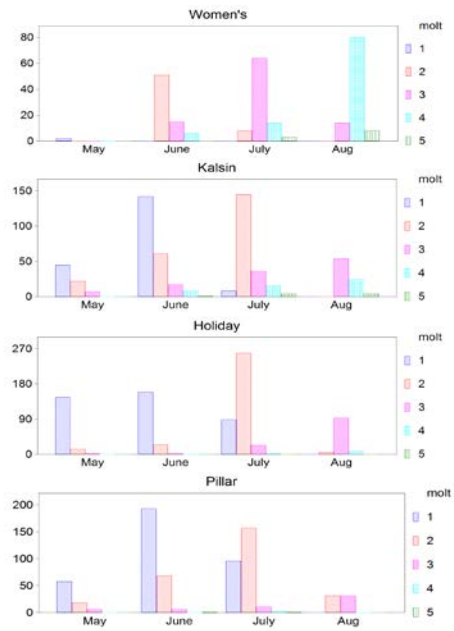


Figure 2. Relative size frequency distributions of age-0 yr Tanners from each site, May – August**.**

1) Timing of recruitment (settlement)*: *Megalopae recruit earlier to Kalsin and Women's Bay, allowing for greater cumulative growth. We compared the May size-frequency distributions in all 4 embayments (Fig. 2, G = 32.57, df = 12, P = 0.001). The major difference involved Women's, where age-0 crabs (C1-C3) were nearly absent in May. Yet by mid June, crabs appearing at Women's were already C2 or larger; 1 molt > than other sites. This molt advantage persisted throughout the summer. There were other minor differences in size between populations, perhaps suggesting some differences in timing of recruitment. For example, crabs at Kalsin were somewhat large than the other sites, with more C2 and even C3 crabs. However, the major effect in the data remains the size disparity between site in June and onwards. If anything, crabs at Women's appear to have recruited somewhat later than at the other sites. Hence, early recruitment cannot explain their great size in June.

*2) **Size selective predation: High predation upon smaller crabs at Womens and Kalsin truncates the size frequency distribution.*** Recruitment was largely complete by July (Fig. 2). Hence, population changes from July to August are due to mortality or emigration/immigration. Neither Women's nor Kalsin experienced significant population declines from July to August (Fig. 3, Women's: Wilcoxon, P = 0.413, Kalsin: P = 0.204). At Pillar, crab abundances declined significantly (Wilcoxon U, P = 0.040). Decline at Holiday was not significant (Wilcoxon, P = 0.419). Crabs

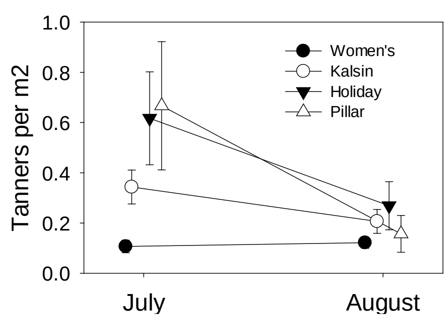


Figure 3. July to August population size changes at each site.

were surviving and remaining in residence at Women's and Kalsin, and to a lesser extent Holiday, but dying and/or emigrating at Pillar. This pattern of population change is not consistent with the hypothesis as stated, which would entail greater population changes at Women's and Kalsin, not Holiday and Pillar. Therefore, we can reject the size selective predation hypothesis, as an explanation for larger crabs at Women's and Kalsin Bay.

3) ***Environmental control of growth: Higher temperatures at Kalsin and Women's Bay accelerates growth.*** Our temperature mediated growth clearly indicates that higher temperature significantly accelerated Tanner growth in the lab (Fig. 4). The most relevant temperatures that relate to field temperatures during May and June are 6^{o}C and 9^{o}C . So for this discussion we ignore the results for the 2^{o}C and 12^{o}C treatments. The C2-C3 intermolt period was 46 days at 6^{o}C, but only 30 days at 9^{o}C. Similarly, the C3-C4 intermolt period was 56 days at 6^{o}C, but 43 days at 9^{o}C. This clearly indicates that 3 degrees of temperature differential can markedly influence growth at this time of year. However, temperature loggers from 2011 at each site (~15m depth) indicated only minor temperature differences. During the early summer, when crabs at Women's underwent accelerated growth, the average delta T between all sites was only 0.3^{o}C. However, our temperature loggers were at approximately 15m at each site. Crabs tended to be found in more shallow water in the more protected sites (Womens and Kalsin), where they were also larger. With lessened wave action, these sites may have experience warmer temperatures in the shallows as well, accelerating growth. Thus, we cannot rule out temperature as a significant contributor to the deviations in growth between populations.

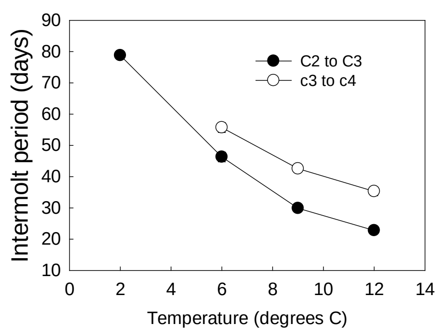


Figure 4. Influence of temperature on C2-C3 and C3-C4 intermolt periods.

4) ***Food quality/quantity control of growth: Higher food quality at Kalsin and Women's Bay accelerates growth/ improves crab condition.***. Significant differences occurred in the amount of storage lipid in crabs from the three coves. Pillar crabs had significantly lower storage lipid (triacylglyercols, ~8%) compared to Holiday and Women's ~20%). Women's crabs had consistently higher levels of fresh diatom fatty acid biomarkers than crabs from the other embayments. More specifically, the levels of 20:5n-3 was significantly higher in crabs from Women's Bay. This specific essential fatty acid biomarker has previously been demonstrated to accelerate growth in larval Pacific cod (Copeman & Laurel 2011), larval rock sole (Copeman et al. in prep), and wild red king crabs juveniles (Copeman et al. 2011). Not only was this essential fatty acid and diatom marker found at higher levels in Women's Bay, it was strongly correlated with the carapace widths of juvenile C3 crabs across the three embayments (Fig. 5, r^2 = 0.60). These result indicate that forage quality/quantity likely plays a role in growth deviations between populations.

In summary, our data thus far have refined our thinking and allowed us to focus in on 2 potential hypotheses to explain the patterns of crab size in the 4 embayments. First, lipid and fatty acid data suggest that crabs at Women's are consuming food with a strong diatom signal. This same fatty acid has been shown to accelerated growth in other species. We therefore consider it likely that nutrition, perhaps in the form of benthic diatoms, plays a major factor in controlling growth in the various embayments. The lower wave energy at Women's and, to a lesser extent Kalsin, may allow establishment of benthic diatoms in the shallows, which supports crab growth. Also, lower wave action may allow for the accumulation of settling planktonic diatoms. Interestingly, in both Women's and Kalsin crabs tend to be found at shallower depths than the other 2 sites. If these protected waters are warmer in the shallow, temperature could also play a role in explaining difference in growth.

A second question, dealing with different July – August rates of population decline, also needs to be resolved. We hypothesize that there is a generalized behavior innate to age-0 yr Tanner crab that leads them to seek deeper water as they grow through the course of their first summer. This hypothesis is supported by some limited data collected in 2010 and 2011. This could be further resolved by more focused sampling at Pillar Creek Cove, where there is a gently sloping bottom that reaches depths of 70m in Monashka Bay. Interestingly, the retention of crabs in Women's Bay may be a function of the shallow sill (~11m) at the Bay's entrance. This may preclude juveniles from emigrating out, leading to the large number of age-1 yr crabs, as well as the subsistence fishery for Tanners that is supported in Women's Bay. Women's bay may be a good model system for understanding the larger Fiords that are prevalent in southeast Alaska.

Essential Fish Habitat project status report

Reporting date: 10/20/2015

Project number: 2009-03, 2010-01, 2011-02, 2014-03

Title: Recruitment and response to damage of an Alaskan gorgonian coral (*Calcigorgia spiculifera*)

PIs: Patrick Malecha, Dr. Kalei Shotwell, Erika Ammann

Funding year: 2009, 2010, 2011, 2014

Funding amount: FY2009 $38,000, FY2010 $32,900, FY2011 $16,700, FY2014 $17,700

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:
Image analyses of *in situ* scuba observations were completed in October 2015. Data analysis is currently underway and a draft manuscript is in preparation. Genetic analysis of coral recruits and adults is ongoing.

Reporting: No reporting has occurred yet.

Results:
Video analysis was completed in October 2015. Data generated from the video observations includes colony survival, branch growth, and tissue regeneration rates.

Seventy-nine percent of all tagged corals were alive and upright after five years of observations. Survival over the entire experiment was 63%, 70%, 88%, and 100% for the trawl, control, cut, and scrape treatment groups, respectively. Survival was not related to the damage treatments on any of the sampling events.

Average branch growth over the five-year period was 0.0216 mm/day for all corals combined. This translates into an annual branch growth rate of 7.88 mm. However, growth rates varied by season as growth during a 3-month summer period averaged 0.0424 mm/day.

Branches that were scraped of their overlying gorgonin tissue demonstrated a variety of responses. Some colonies regrew their missing gorgonin layer within about a year, while on other colonies, a portion of the scraped branches became necrotic and eventually disappeared. However, the growth of undamaged branches among corals in the cut and scraped treatments was on average greater than among corals in the trawl and control groups perhaps indicative of compensatory processes that focused energy on somatic rather than reproductive output.

Coral recruits were found on 18 of the 96 tiles collected and at least 60 individual recruits were identified. These observations document coral recruitment for the first time in Alaska. The

majority of recruits were small single- or two-polyp organisms, presumably less than one year old. There were also some very small potential recruits that lacked definitive structural characteristics of coral polyps but were pigmented similarly to *Calcigorgia spiculifera*. These specimens are currently undergoing genetic analyses to determine their identity. If these are indeed coral recruits, they would likely be only days or weeks old. There were also a few multi-polyp colonies that were probably more than a year old. Thus it is apparent that coral recruitment happened in multiple years. A rate of recruitment will be estimated based on the different sizes or "age classes" of the recruits. Tiles were placed on the seafloor on varied dates and thus were "seasoned" *in situ* for different amounts of time. The original tiles were in place for five years, while the most recently installed tiles were on the seafloor for 35 months. Recruits were found on tiles of all ages. Genetic analyses, to explore the relatedness between recruits and adults and to examine genetic diversity and dispersion potential, are ongoing.

Reporting date: 10/22/2012 (Update from 10/15/2011)

Project number: 2011-03

Title: The role of benthic habitat in larval rock sole settlement dynamics – Yr 1 of 2

PIs: Laurel and Stoner

Funding year: 2011

Funding amount: $42,740

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Sept 2012

Reporting: Field work was successful in 2011 and all proposed elements are now complete with a manuscript anticipated in FY13. We originally proposed to characterize rock sole distribution (towed sled), sediment (PONAR benthic grab) and predator distribution (baited camera) at two Kodiak sites (Pillar Cove and Holiday beach) by depth (2 – 25 m) from settlement (May) through post-settlement (June, July and August). All four sampling trips were carried out in 2011 and all towed sled sampling was fully completed and analyzed. Baited camera assessment were not conducted in 2011 but were conducted in 2012 as part of combined fieldwork with Ryer et al. examining juvenile tanner crabs in the same region. Replicate deployments (n=3) were conducted at 5 depths across 3 months (May, July and Aug) at both Pillar Cove and Holiday Beach. These data were needed to test the hypothesis that settlement patterns trend with changes in predation risk.

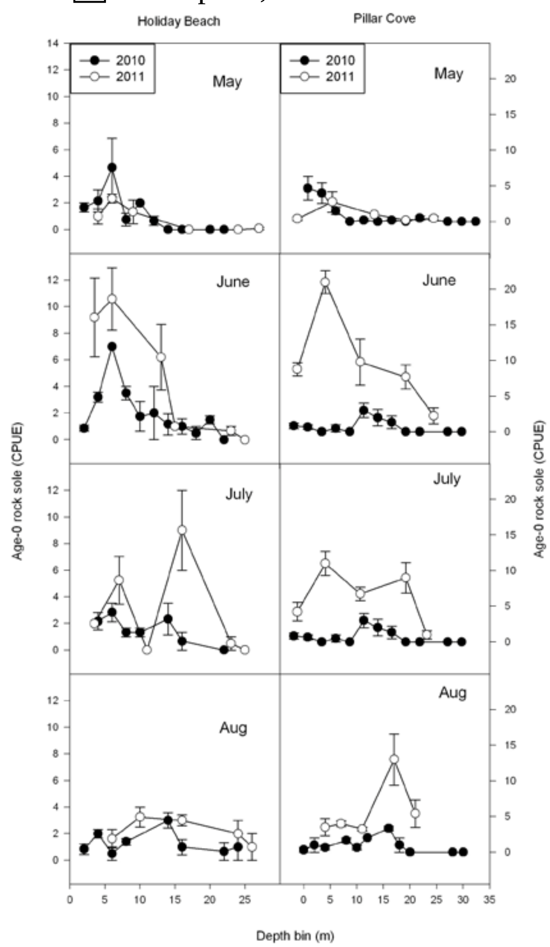


Figure 1: Seasonal distribution of age-0 juvenile rock sole at two sites (Pillar Cove and Holiday Beach) during 2010 and 2011 in coastal Kodiak. May sampling shows a narrow depth band in which newly settled juvenile rock sole are distributed.

All laboratory experiments are now complete. NRS eggs were successfully collected and cultured from Program broodstock in spring FY11 (see Laurel and Blood 2011 for protocols) and larvae were reared across multiple temperatures (2 – 12° C) to ensure a variety of sizes and ages were available for the proposed settlement experiments. Approximately 1200 larvae survived through metamorphosis over a period of 120 rearing days, and 603 of these larvae were used in settlement trials.

We originally designed experiments to test: 1) if larval rock sole choose habitat during settlement, 2) whether habitat variables mediate the rate of settlement i.e., water depth and sediment size, and 3) how pigmentation and sediment associations interacted to regulate predation rates. Components 1 and 2 were examined in FY11 and Component 3 was conducted as part of experimental work in FY12. As a value added component, we quantified and included the interactive effects of growth (mass- and length-based), condition, development (e.g., eye migration, pigmentation, etc) and age in the settlement models.

A manuscript using laboratory and field data is in currently slated for FY13. Working title is:

Laurel BJ, Basillio A, Danley C (in prep) The role of habitat on settlement timing in Northern rock sole (*Lepidopsetta polyxystra*). Mar Ecol Prog Ser

In addition, an NSF-REU student (Research Experiences for Undergraduates) Anthony Basilio reported and presented his research results to the REU chair and faculty at the Hatfield Marine Science Center in August 2011.

Results: What is the most important result of the study?

1) Fish densities were higher in 2011 than in 2010, but the patterns in settlement over the sites were identical (Fig. 1), suggesting that these settlement dynamics are an important and consistent characteristic in this species. NRS initially settled in shallow water (~5 m) and gradually occupied deeper water substrates through the course of the season. Given the consistency of the pattern, no further towed sled survey is proposed for 2012.

2) The most important findings from the first series of laboratory experiments were that 1) pre-settled larvae chose habitat during settlement, 2) pre-settlement habitat choices were size-dependent i.e., smallest pelagic larvae choose finer substrate whereas larger larvae had a wider range of occupation and 3) there was no difference in habitat selection between pre-settled and post-settled rock sole (Fig. 2). Newly settling flatfish were capable of burial only in the finest substrates, and agreed with the size-based logistic burial model proposed by Stoner and Ottmar (2003).

3) The most important findings from the 2nd was that settlement rates were size-dependent and best described by a logistic model (Fig. 3). All settlement occurred between the sizes of 12 – 18 mm TL in our experiment. However, two interesting findings were found around the size-dependent model. First, larvae exposed to preferred habitat (fine sediments) settled at smaller sizes compared to those exposed to gravel (Fig. 3). Secondly, variance around each of the size-dependent habitat models (as examined

by residual analyses) was explained by differences in growth and condition. That is, larvae that were growing fast and in good condition delayed settlement compared to fish on slow growth trajectories and in poor condition

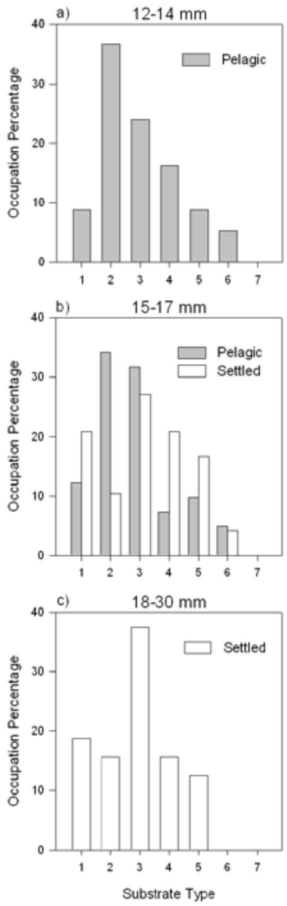


Figure 3 Habitat use (%) of rock sole introduced to aquaria as a) small pelagic larvae (12-14 mm TL) , b) medium-sized pelagic and settled larvae (15-17 mm) , and c) large settled larvae (18 - 30 mm). Sediment types listed from finest to largest (muddy sand (1) - pebble (7))

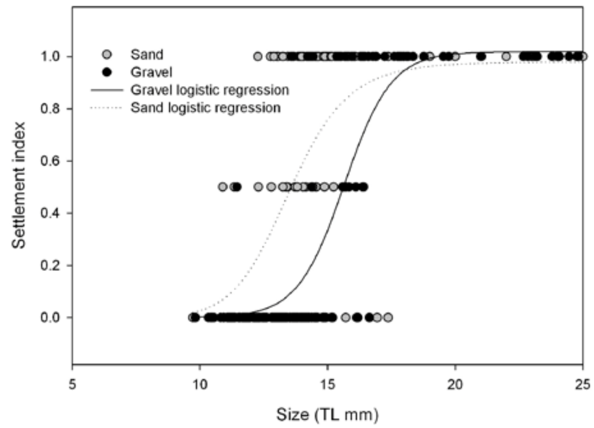


Figure 2: Size-dependent settlement model varies with habitat for northern rock sole (Component #2). The settlement index (y-axis) indicates whether a larvae did not settle (0), occasionally settled (0.5) or settled and remained on the substrate (1) over a 24 hr behavioral trial. Data based on 273 individual trials.

Essential Fish Habitat project status report

Reporting date: 10/28/15

Project number: 4

Title: Quantifying flatfish habitat quality in the eastern Bering Sea by infauna prey density

PIs: Yeung, Cynthia and Yang, Mei-Sun.

Funding year: 2011

Funding amount: $124,000

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Yeung, C. and M.-S. Yang. Coastal habitat quality of the southeastern Bering Sea for juvenile yellowfin sole and northern rock sole from diet and prey relationship. Draft manuscript in internal review.

Results: What is the most important result of the study?

There is very little information on the location and characteristics of juvenile flatfish habitat in the eastern Bering Sea (EBS). The quantity and quality of habitat are critical to the fitness of juvenile fish and ultimately to fisheries recruitment. We examined the relationship between prey availability and juvenile habitat quality across the shallow coastal shelf at the Alaska Peninsula boundary of the EBS from Unimak Island to Bristol Bay (south coastal EBS, Figure 1) using the platform of the bottom trawl survey.

The quantity and quality of prey were not significant factors in the distribution of juvenile northern rock sole (NRS) and yellowfin sole (YFS) in the south coastal EBS. Overall, prey availability was not limiting across the area, allowing fish to select for prey presumably to maximize net energy gain.

The body condition of juvenile NRS was higher in Bristol Bay – where they shared spatial and dietary niches with juvenile YFS - than in the west (Unimak Island) section - where juvenile YFS were largely absent. This suggests that habitat quality may be higher in Bristol Bay.

Stomach contents analysis and stable isotopes analyses of fish muscle indicate an ontogenetic diet shift from amphipods to polychaetes from juvenile to adult in NRS. In contrast, amphipods seemed to remain the primary prey and polychaetes the least important prey from juvenile to adult in YFS.

On the scale of the entire EBS, habitat for juvenile flatfishes with similar prey availability as the south coastal area should be extensive. The distribution of juvenile YFS in 2011 did indeed extend northward from Bristol Bay along the inner domain to Nunivak Island, but juvenile NRS distribution was mainly limited to south of Cape Newenham.

Abiotic factors, particularly ocean currents and water temperature, may be more significant than prey availability in juvenile habitat selection. Changes in the hydrographic and thermal regime of the EBS are thus likely to impact juvenile habitats and productivity.

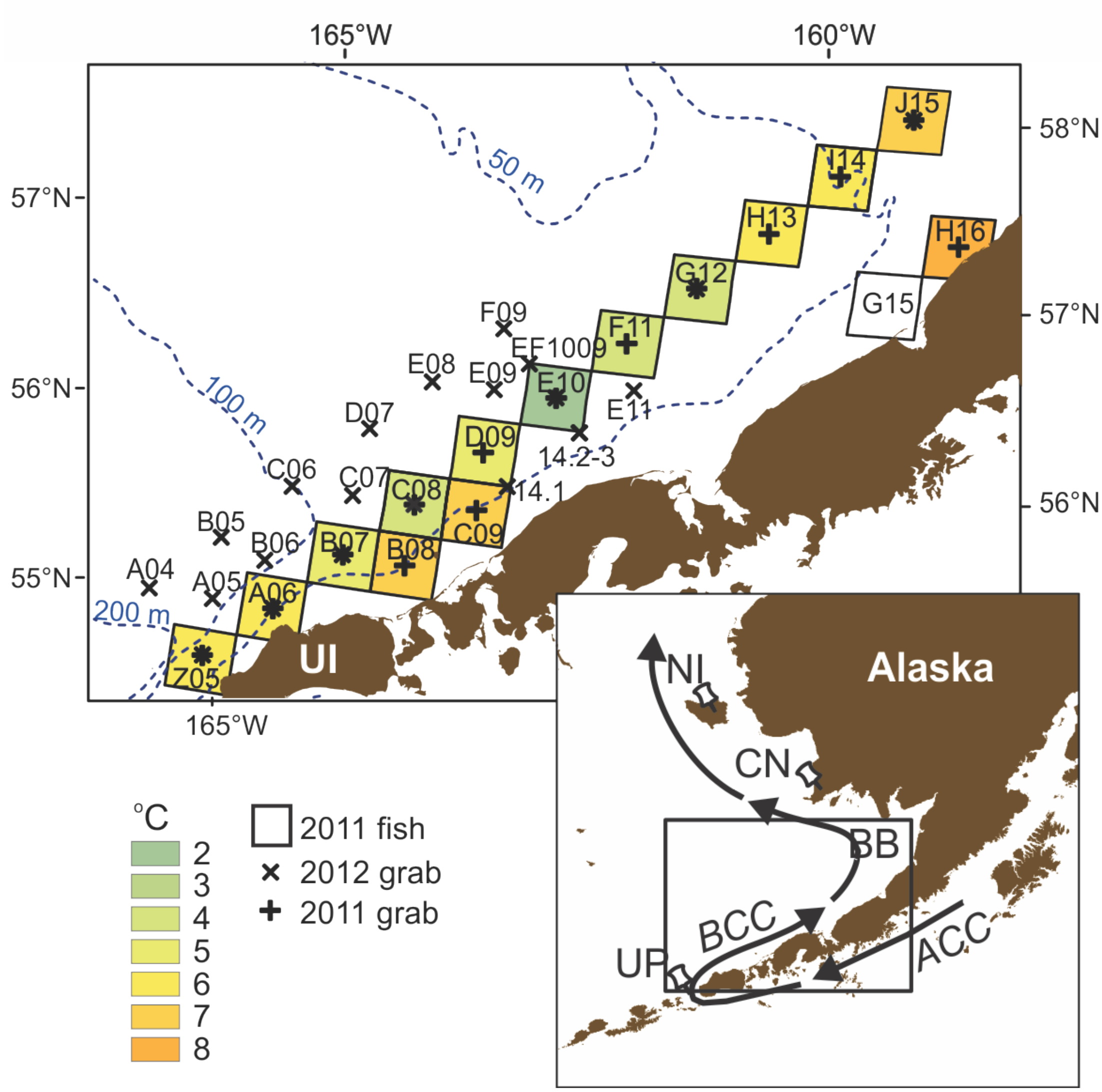


Figure 1. The study area (upper map) showing the bottom trawl grid cells from which fish samples were collected (near center of cell) in 2011, and the locations of benthic grab samples in 2011 and 2012. Bottom temperature at the sampling stations in 2011 is depicted on a colorscale. The relative location of the study area is delineated in the eastern Bering Sea region (lower map), where the mean circulation is indicated (BCC – Bering Coastal Current; ACC - Alaska Coastal Current; UI – Unimak Island; UP – Unimak Pass; BB – Bristol Bay; CN – Cape Newenham; NI – Nunivak Island).

Essential Fish Habitat project status report

Reporting date: October, 2012

Project number: 2011-5

Title: Collection of seafloor imagery during AFSC bottom trawl surveys

PIs: Rose, McEntire

Funding year: 2011

Funding amount: $11,900

Status: [X] Complete Incomplete, on schedule [ ] Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.
NO.

Results: What is the most important result of the study?

The camera pressure housing, optics, batteries, lighting and control circuitry operated as expected. It was demonstrated that images of the seafloor and identifiable invertebrates can be acquired during standard AFSC surveys with minimal to no impact on operations.

The prototype system was deployed on RACE groundfish survey cruises in the summer of 2012 on two chartered vessels. A total of 36 trawl tows were conducted with the camera mounted on the Port side trawl door. Initially testing in 2011 was conducted aboard the FV Sea Storm in SE Alaska and this year the FV Aldeberan deployed the system in the Bering Sea and FV Alaska Knight operated in the Chukchi Sea. Images acquired during these at sea trials were acquired at a rate of one image per minute.

System description:
The autonomous underwater camera system consisted of a clear cast acrylic pressure housing that acted as both the optical port for the imaging lens and a window for the strobe light. An internal delrin chassis incorporated o-rings pressure seals and served to hold the camera, batteries and strobe light as an integral unit. Working depth of the 10mm thick housing was calculated at 1,000 meters seawater.
A Pentax G3 camera with a generic off camera flash unit was optically coupled to the camera for strobe triggering and sync. Power for the strobe light was provided by a 7.2 volt, 4 Ahr, NiMh rechargeable battery pack while the internal camera battery provided direct camera power. Time lapse control was accomplished with the cameras built in

time lapse controller set to the desired rate and all other camera controls were set to manual mode.

Camera Mounting on the Trawl Door:

The pressure housing was cradled within a number of low profile steel guard rails and then pinned between two steel 1.5" x1.5" pieces of angle iron welded to the face of the trawl door. A central area of the trawl door was selected that was expected to receive minimal impacts during fishing operations. It was not possible to locate the camera in a fully protected area on the trawl door while the door was stowed on the side of the ship. This required that the camera be removed between tows by releasing two holding bolts.

Image quality:

The all in one cast acrylic tube provided for a simple and rugged pressure housing but lacked optimal water correcting optical properties. The images proved to be "OK" showing the seafloor when fishing on harder rather than a very soft sea bottom. Many of the images from Chukchi Sea appeared to be on very soft bottom with a billowing mud cloud partially obscuring the images. On one of the later tows numerous invertebrates are visible in the images, but it is not clear if this imagery was due to a harder sea floor or different camera settings. The camera operator reported that they were still experimenting with camera settings.

The images from the Bering Sea appear to show a slightly harder sea floor and camera settings were consistent from tow to tow. The images show the sea floor and identifiable invertebrates. Many of the images have some backscatter resulting from relatively close proximity of the light to the camera. All images had a telltale internal reflectance from the strobe light.

Field tests of the system demonstrated that images of the sea floor can be acquired during standard RACE survey trawl tows and invertebrates and bottom substrate can be identified to a limited degree. Though no images of large rocks or even gravel were acquired during testing it is thought that these items and bottom type would be discernible. The distinction and identification of soft bottom or grain size is not possible with the current system resolution and distance to target except as a general description. The presence of mud clouds in front of the doors is an indicator of a very soft bottom while a smooth featureless bottom indicates moderately soft substrate. The recognition of invertebrates is similar, with identification being possible of large animals or those with distinct morphological features.

The spatial distribution of invertebrates and bottom features was apparent when sequentially browsing acquired images from each. The distinction of patchiness and groups or the lack of objects in the images is visually evident. This descriptor is not evident from the usual haul data, where the entire catch is examined in total as a single sample. The image data showed that the catch sampling is from a lineal expanse of sea bed with considerable heterogeneity at times.

Improvements

A significant improvement in image quality could be achieved by incorporated a simple optical or dome port into the housing. The original proposal was to use an SLR type camera with a high quality manual lens. If this type of camera lens were to be used, the overall size of the system would increase substantially, requiring it to be mounted on the back side of the trawl door. It is not clear if the increase in image quality would justify the much greater degree of modification to the door.

As with most underwater imaging systems, more light would likely improve image quality. The amount of light available in this system is directly related to the size of the battery pack. Since the system was removed from the door after each deployment and not kept operating for long periods, a larger light could be incorporated without increasing the current battery size. If the system were kept in place for several tows, the image acquisition rate would have to be decreased to save power for greater lighting. The addition of a depth trigger into the control system would save on deck battery drain.

Mounting position on port trawl door, angle iron visible under the rail.

View of Starboard trawl door.


06/06/2012 08:04AM


06/11/2012 01:05PM


06/10/2012 07:48PM

Soft bottom with mud cloud from trawl door.

Essential Fish Habitat project status report

Reporting date: 10/2/12

Project number: 2011-06

Title: Coastal fishes of Alaska: A synthesis of over a decade of nearshore marine surveys

PIs: Johnson, Thedinga, Lindeberg

Funding year: FY11

Funding amount: $39K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Yes…NOAA Tech. Memo. (will be published later this month)

Results: What is the most important result of the study?

Our major findings include:

1. Nearshore marine waters support an abundant and diverse array of fishes; we captured an estimated 718,345 fish representing at least 121 species from 29 families.
2. Four commercially important species (walleye pollock, *Theragra chalcogramma*; Pacific herring, *Clupea pallasii*; pink salmon, *Oncorhynchus gorbuscha*; and chum salmon, *O. keta*) accounted for 55% of our total overall catch.
3. Species distribution patterns varied greatly among regions; only two species (pink salmon and threespine stickleback, *Gasterosteus aculeatus*) were caught in all nine regions.
4. Abundance and species richness varied by region; mean catch-per-unit-effort (CPUE) ranged from 124 fish in Southcentral Alaska to 1,202 fish in the Aleutian Islands, and species richness ranged from 17 species in Bristol Bay to 67 species in Southeast – Northern Inside.
5. Species assemblages differed among habitat types in most regions, and mean CPUE and species richness were usually greatest in eelgrass or kelp.
6. Species composition by habitat type was unique in some regions (e.g., sand, Bristol Bay), largely the result of the presence of a few species (e.g., rainbow smelt) that were absent in other regions.
7. Most fishes captured were juveniles, highlighting the importance of the nearshore to critical early life-history stages of managed and ecologically important species.
8. Forage species (e.g., Pacific herring and Pacific sand lance, *Ammodytes hexapterus*) may be the most susceptible fishes to shoreline disturbance because of their use of nearshore habitats for feeding and shelter as juveniles and for spawning as adults.
9. The high abundance and diversity of fishes in eelgrass and kelp warrant special protection of these habitats in the event of an oil spill or other shoreline disturbance, especially if these habitats are known spawning areas (e.g., Pacific herring).
10. Our nearshore dataset is extremely important to managers responsible for oil spill response, natural resource damage assessment, essential fish habitat identification, and long-term monitoring.

Essential Fish Habitat project status report

Reporting date: November 19, 2014

Project number: 2011-07

Title: Low-cost multibeam mapping to support habitat based groundfish assessment and deepwater coral research in the Gulf of Alaska

PIs: Chris Wilson, Chris Rooper, Tom Weber, Jon Heifetz, Jodi Pirtle (Postdoc)

Funding year: FY11

Funding amount: $67,400

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Reporting: The final results of this project are reported in a manuscript that has been prepared for publication in a peer-reviewed journal. The manuscript is attached to this final report and the title and abstract are included below.

Title: Assessment of trawlable and untrawlable seafloor using multibeam-derived metrics.

Abstract: Groundfish that associate with rugged seafloor types are difficult to assess with bottom-trawl sampling gear. Simrad ME70 multibeam echosounder (MBES) data and video imagery were collected to characterize trawlable and untrawlable areas, and to ultimately improve efforts to determine habitat-specific groundfish biomass. The data were collected during two acoustic-trawl surveys of the Gulf of Alaska (GOA) during 2011 and 2012 by NOAA Alaska Fisheries Science Center (AFSC) researchers. MBES data were collected continuously along the trackline, which included parallel transects (1-20 nmi spacing) and fine-scale survey locations in 2011. Video data were collected at camera stations using a drop camera system. Multibeam-derived seafloor metrics were overlaid with the locations of previously conducted AFSC bottom-trawl (BT) survey hauls and 2011 camera stations. Generalized linear models were used to identify the best combination of multibeam metrics to discriminate between trawlable and untrawlable seafloor for the region of overlap between the camera stations or haul paths and the MBES data. The most discriminatory models were chosen based on the Akaike information criterion (AIC). The two best models were developed using data collected at camera stations with either oblique incidence backscatter strength (S_b) or mosaic S_b in combination with bathymetric position index and seafloor ruggedness and described over 54% of the variation between trawlable and untrawlable seafloor types. A map of predicted seafloor trawlability produced from the model using mosaic S_b and benthic-terrain metrics demonstrated that 58% of the area mapped (5,987 km^2) had $\geq$ 50% probability of being trawlable and 42% of being untrawlable. The model predicted 69% of trawlable and untrawlable haul locations correctly. Successful hauls occurred in areas with 62% probability of being trawlable and haul locations with gear damage occurred in areas with a 38% probability of being trawlable. This model and map produced from multibeam-derived seafloor metrics may be used to refine seafloor interpretation for the AFSC BT surveys and to advance efforts to develop habitat-specific biomass estimates for GOA groundfish populations.

Essential Fish Habitat project status report

Reporting date:
October 28, 2013

Project number:
2012 – 01

Title:
The role of benthic habitat in larval rock sole settlement dynamics – Yr 2 of 2

PIs:
Benjamin J. Laurel and Allan Stoner

Funding year:
2012

Funding amount:
$42,740

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: The results of this work is spread across two scientific publications (attached). They are titled:

1) Laurel, B.J., Basilio, A.J., Danley, C., Ryer, C.H., Spencer, M. (submitted) Substrate preference and delayed settlement in northern rock sole larvae (*Lepidopsetta polyxystra*) Marine Ecology Progress Series

2) Laurel BJ, Zimmerman T, Iseri P, Gilbert M, Ryer CH, Haines S (in prep) Ontogenetic dispersal of juvenile northern rock sole (*Lepidopsetta polyxystra*) across varying environments. Marine Ecology Progress Series

Results: What is the most important result of the study?

1) Laboratory experiments indicated habitat selection in NRS was initiated at the time of settlement, with a preference for finer substrates.

2) NRS larvae can delay settlement when preferred substrates are unavailable, resulting in a significant increase in the size-at-settlement.

3) Despite behavioral control in settlement, larger scale processes (e.g., wind, thermoclines, currents) may ultimately limit access to preferred habitats at the time of settlement in Northern rock sole.

4) Immediately following settlement, dispersal is temperature-dependent but this shifts to a size- and habitat-dependent rate after 1 – 2 months post-settlement.

5) Predator presence had no significant effect on the dispersal of juvenile flatfish.

Submitted to: Marine Ecology Progress Series

Substrate preference and delayed settlement in northern rock sole larvae (*Lepidopsetta polyxystra*)

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ABSTRACT

We addressed the hypothesis that larval flatfish have behavioral control over the timing and habitat in which they settle. Northern rock sole (*Lepidopsetta polyxystra*) larvae were reared and exposed to varying substrates in the laboratory to determine: 1) the earliest ontogenetic stage of habitat selection and 2) if settlement was delayed when preferred habitats were unavailable. These results were compared to seasonal field distributions of newly settled rock sole across varying depths and sediments in two nursery areas around Kodiak, Alaska. Laboratory experiments indicated habitat selection was initiated at the time of settlement, with a preference for finer substrates. Exposure to coarse substrates delayed settlement, resulting in a significant increase in the size-at-settlement. However, field data indicated newly settled rock sole were restricted to shallow water regions of the nursery (~5m) where sediments were indistinguishable from surrounding sediment types and notably coarser than the deepest areas of the nursery. At 1 – 2 months post-settlement, the distribution of juvenile rock sole shifted to deeper regions of the nursery as predicted by habitat selection experiments from the laboratory. Therefore, despite evidence of behavioral control in settlement, larger scale processes (e.g., wind, thermoclines, currents) may ultimately limit access to preferred habitats at the time of settlement in Northern rock sole.

KEYWORDS: Flatfish • Metamorphosis • Nursery area • Habitat selection • Delayed settlement • Larval behavior • Dispersal

In Prep to: Marine Ecology Progress Series

Ontogenetic dispersal of juvenile northern rock sole (*Lepidopsetta polyxystra*) across varying environments

Benjamin J. Laurel*[1] Tara Zimmerman[2], Paul Iseri[1], Morgan Gilbert[3], Clifford H. Ryer[1], Scott Haines[1]

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ABSTRACT

Northern rock sole (*Lepidopsetta polyxystra*) is a model species for understanding transport mechanisms and habitat use within coastal nurseries in the Bering Sea and Gulf of Alaska. However, newly settled rock sole are sometimes found in areas not predicted by post-settlement habitat models. In this study, we experimentally examined whether dispersal to favorable habitats are limited by local environmental conditions (temperature, habitat mosaic and predator risk) and/or the individual state of the fish (development, size and condition). Using large-scale flume tanks in the laboratory, groups of juvenile rock sole at varying size and ontogenetic stages were allowed free access to preferred habitats under varying environmental conditions. Results indicated that temperature and size of fish were positively linked with dispersal rates, but only at early and late post-settlement phases respectively. Fish that had not fully metamorphosed dispersed further than equally sized metamorphosed individuals, possibly by way of transport in the water column rather than horizontal movement along the bottom substrate. Surprisingly, the presence of a predator did not impact dispersal rates, but fish introduced to 'risky' habitat, in which the individuals could not bury (coarse gravel), resulted in significantly increased dispersal compared to preferred habitats i.e., fine sand. Although these experiments only provide a relativistic understanding of post-settlement dispersal for northern rock sole, these results suggest a variety of mechanisms by which access to preferred habitats can be differentially impacted such that current habitat models may not work across a broad range of environmental conditions and ontogenetic stages.

KEYWORDS: Settlement, flatfish, habitat selection, gap crossing, predator risk, metamorphosis

Essential Fish Habitat project status report

Reporting date: 11/12/2015

Project number: 2015-2

Title: Physiological response of red tree corals (*Primnoa pacifica*) to low pH scenarios in the laboratory.

PIs: Robert Stone (NOAA, AFSC, Auke Bay Lab); Robert Foy (NOAA, AFSC, Kodiak Lab); Rhian Waller (University of Maine); Stephen Cairns (Smithsonian Institution); Ian Enochs (UM/CIMAS, NOAA/AOML)

Funding year: 2015

Funding amount: $47,200

Status: Incomplete, behind schedule. Funding for this project was not received in time to charter a research cruise to collect specimens as planned in March 2015. The team decided to postpone the cruise until January 2016 so the project is essentially 10 months behind schedule. Ideally specimens should be collected during the winter months when underwater visibility is optimal for collection and air temperatures are less stressful on collected animals during holding and transport.

Planned completion date if incomplete: The laboratory work is scheduled for completion in January 2017. Final analyses will be completed by July 2017 except for the endpoint processing of the reproduction and skeletal density samples that will require additional funding. A proposal has been submitted to the EFH Program 2016 Request for Proposals to cover the costs of these final analyses. Should those funds be awarded then all analyses will be completed by July 2017 and at least two manuscripts will be submitted for publication by November 2017.

Reporting: Have the project results been reported? NO

Results: Phase I of this work is scheduled to begin in January 2016. We additionally secured AFSC Cobb-replacement funds in 2015 to supplement this project. Using the two sources of funds we were able to schedule a 5-day charter to collect specimens, purchase water chillers for the laboratory, provide project support for the duration of the laboratory study, and contracted the University of Maine to assist with specimen collection, experimental set-up, sample preparation, and to conduct initial analyses of the reproduction samples.

Essential Fish Habitat project status report

Reporting date: 11-18-13

Project number: 2012-03

Title: Essential fish habitats of juvenile Pacific cod, yellowfin sole, and northern rock sole along the Alaska Peninsula

PIs: Hurst, Cooper, Duffy-Anderson, and Stoner

Funding year:2012

Funding amount: $72,300

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

The first of 2 anticipated manuscripts resulting from this work have been submitted for review prior to journal submission. The manuscript on habitat use of age-0 Pacific cod is attached. A second manuscript describing habitat use of northern rock sole and yellowfin sole is anticipated in FY 2013.

Results: What is the most important result of the study?

This project allowed us to evaluate the primary habitat associations of age-0 Pacific cod across the Bering Sea. To date, analysis had focused only on the portion of the popualtion using pelagic habitats over the SEBS shelf. Our work demostrates that inshore waters less than 50 m deep along the Alaska Peninsula appear to be the primary nursery habitat for this important species. Nursery habitat use in the Bering Sea appears to differ from that observed in the Gulf of Alaska and other parts of the species range.

Essential Fish Habitat project status report

Reporting date: October 30, 2015

Project number: 2012-4, 2013-1

Title: Otolith microchemical fingerprinting: Assessing juvenile Pacific cod habitat utilization in the Gulf of Alaska

PIs: Mary Elizabeth Matta, Jessica Miller, Thomas E. Helser, Olav Ormseth, and Thomas Hurst

Funding year: FY2012-2013

Funding amount: $32,267 (FY2012); $38,235 (FY2013)

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: Project 2012-4: by end of FY2016. Project 2013-1: unknown (further progress is dependent on results of 2012-4).

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Preliminary project results were reported in the Oct-Nov-Dec 2012 AFSC Quarterly Report, available at http://www.afsc.noaa.gov/Quarterly/OND2012/divrptsREFM14.htm

A manuscript based on Project 2012-4 is currently in preparation and will be submitted to a peer-reviewed journal such as *Transactions of the American Fisheries Society*.

Results: What is the most important result of the study?

Project 2012-4:

Project Summary: In this project, we evaluate the potential of otolith elemental signatures to determine whether habitats of juvenile (age-0) Pacific cod are chemically unique within two large regions: the Eastern and Western Gulf of Alaska (GOA). By sampling nearshore sites within each region, we also assess whether it is possible to discriminate among nursery bays and whether individuals can be correctly assigned to their early juvenile habitat sites. The temporal persistence of otolith signatures within sites is assessed by comparing a subset of samples collected during summer with those collected during fall.

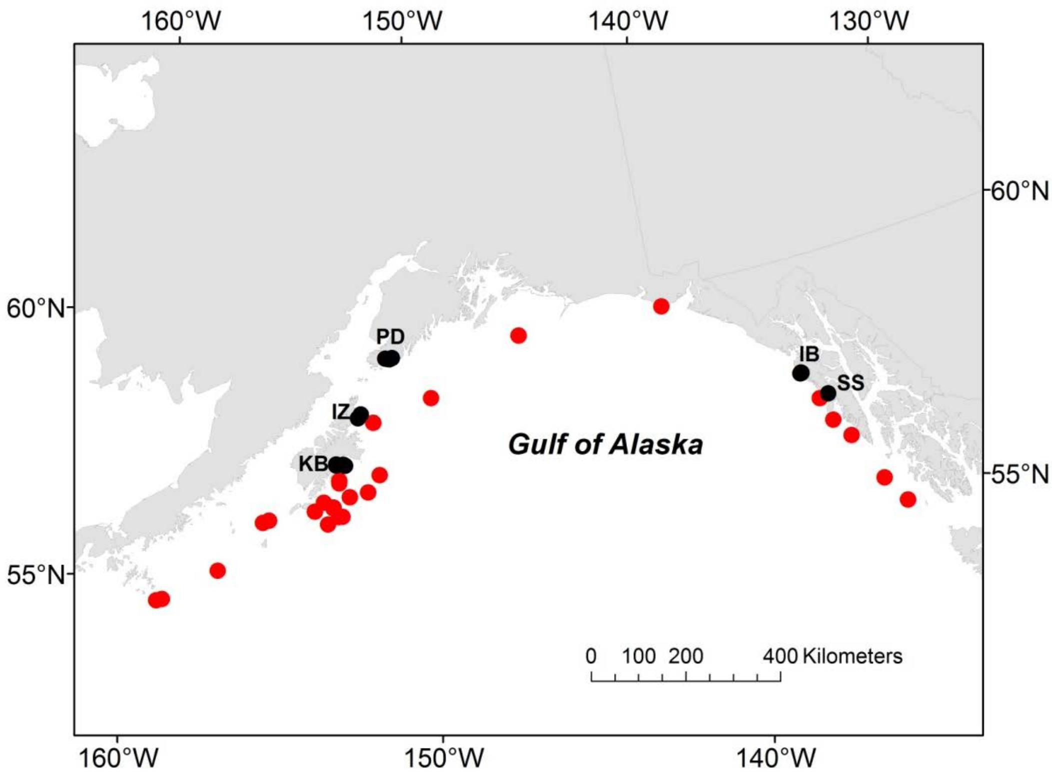


Figure 1. Collection sites of age-0 Pacific cod in 2011 (Project 2012-4; black circles; n=384) and age-2 Pacific cod in 2013 (Project 2013-1; red + black circles; n=195). Abbreviations represent GOAIERP MTL study sites (KB=Kiliuda Bay, IZ=Izhut Bay, PD=Port Dick, IB=Islas Bay, SS=Salisbury Sound).

Tasks Completed: Pacific cod were sampled opportunistically by purse seine during nearshore surveys of the Middle Trophic Level (MTL) component of the North Pacific Research Board's Gulf of Alaska Integrated Ecosystem Research Project (GOAIERP) in 2011. Fish were collected from 2 bays in the eastern GOA and 3 bays in the western GOA during summer (July-August) and fall (Sept-Oct); within each bay, up to three subsites were sampled (Fig. 1). Two bays (Kiliuda Bay and Port Dick) were sampled in both summer and fall (Fig. 1). During the survey, temperature and salinity data were also recorded during 6-7 CTD casts taken throughout each bay.

Two transects within each otolith were analyzed by laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS). The first transect ("life-history transect") ran from the sulcus through or near the core to the distal edge of the otolith to evaluate changes in elemental signatures over the lifetime of the fish (Fig. 2). The second transect ("edge transect") ran parallel to the otolith edge (averaging the most recent ~10-20 days of life) to characterize the environment the fish was exposed to at time of capture (Fig. 2).

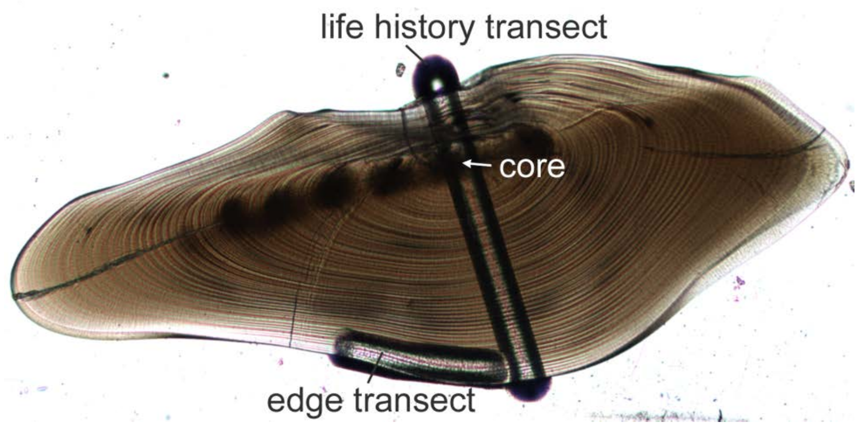


Figure 2. Transverse otolith thin section from age-0 Pacific cod, post-ablation.

Because otoliths were collected over a period of several months, we took steps to ensure spatial comparisons are made over temporally similar periods. Daily rings were used to identify the portion of the life history transect deposited during the period of July 6-15, corresponding approximately to the edge transect of the earliest caught fish. Two different comparisons were made: 1) signatures based on edge transect (representing the most recently deposited material, presumably representative of habitat at time of capture), and 2) signatures based on contemporaneous 100-micron portions of the life history transect, to ensure appropriate temporal comparisons are made for fish captured in different months.

Isotopes measured in otolith scans included ^{7}Li, ^{11}B, ^{24}Mg, ^{25}Mg, ^{43}Ca, ^{52}Cr, ^{55}Mn, ^{59}Co, ^{65}Cu, ^{66}Zn, ^{85}Rb, ^{86}Sr, ^{111}Cd, ^{138}Ba, ^{139}La, and ^{208}Pb. Of these, boron, magnesium, calcium, manganese, zinc, strontium, and barium were consistently above background levels and therefore are included in further analyses. Post-processing and error-checking of raw trace element data were completed using TRACE ELEMENTS, an algorithm developed by Jon Short (AFSC) during FY2013-2015 for this and other AFSC otolith microchemistry projects. Isotopic counts were converted to elemental concentrations reported relative to calcium (µg g^{-1} Ca).

Variation in otolith elemental concentrations was quantified with univariate and multivariate analyses. Data were assessed for normality using probability-probability (P-P) plots and the Shapiro-Wilk test, and for homoscedascity using Levene’s test. Elemental data were subjected to Box Cox transformations to meet assumptions of parametric statistical analyses.

Results indicate differences among sites for some elements (Fig. 3). Within bays that were sampled twice in 2011 (Kiliuda Bay and Port Dick), significant differences were found between untransformed summer and fall concentrations of all analytes (Mann-Whitney test; $p < 0.01$), except manganese in Port Dick. Boron, magnesium, copper, and zinc significantly decreased from summer to fall, while strontium increased markedly (Fig. 4). Manganese also decreased significantly in Kiliuda Bay, but no significant change was seen in Port Dick (Fig. 4). Interestingly, barium significantly decreased in Kiliuda Bay but increased slightly in Port Dick from summer to fall (Fig. 4). Because the edge signatures are representative of the environments from which the fish were captured and were only two months apart in time, differences indicate high temporal variation in these areas. Principle component analysis (PCA) of transformed elemental concentrations at the otolith edge also provides evidence of some separation among sites and seasons, with strontium, magnesium, and barium driving most of the variation in the leading principle component (Fig. 5).

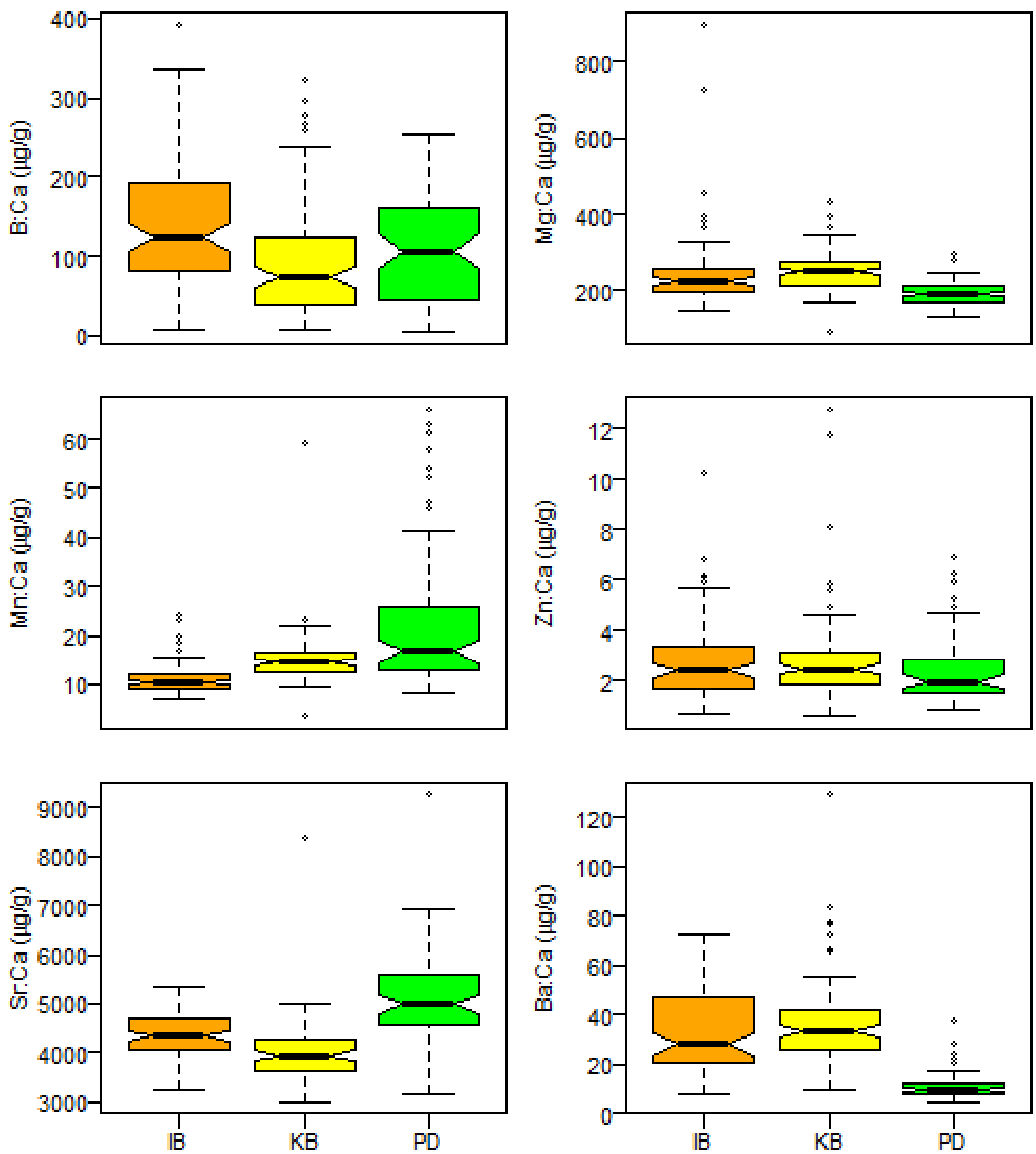


Figure 3a. Boxplots of elemental concentrations (relative to Ca) measured at the edges of otoliths collected in summer in bays in the eastern (Islas Bay, IB) and western (Kiliuda Bay, KB; Port Dick, PD) Gulf of Alaska.

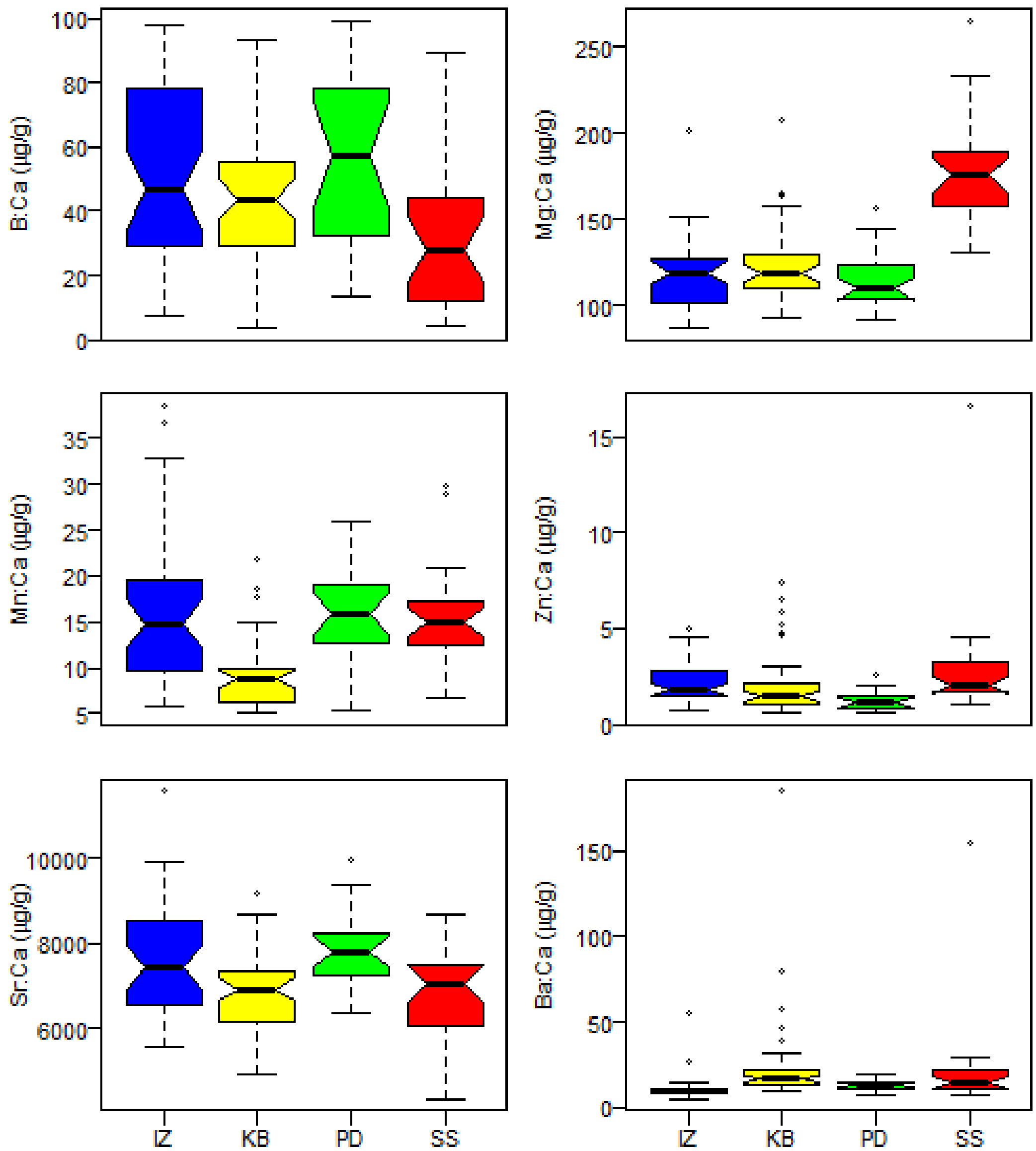


Figure 3b. Boxplots of elemental concentrations (relative to Ca) measured at the edges of otoliths collected in fall in bays in the eastern (Salisbury Sound, SS) and western (Izhut Bay, IZ; Kiliuda Bay, KB; Port Dick, PD) Gulf of Alaska.

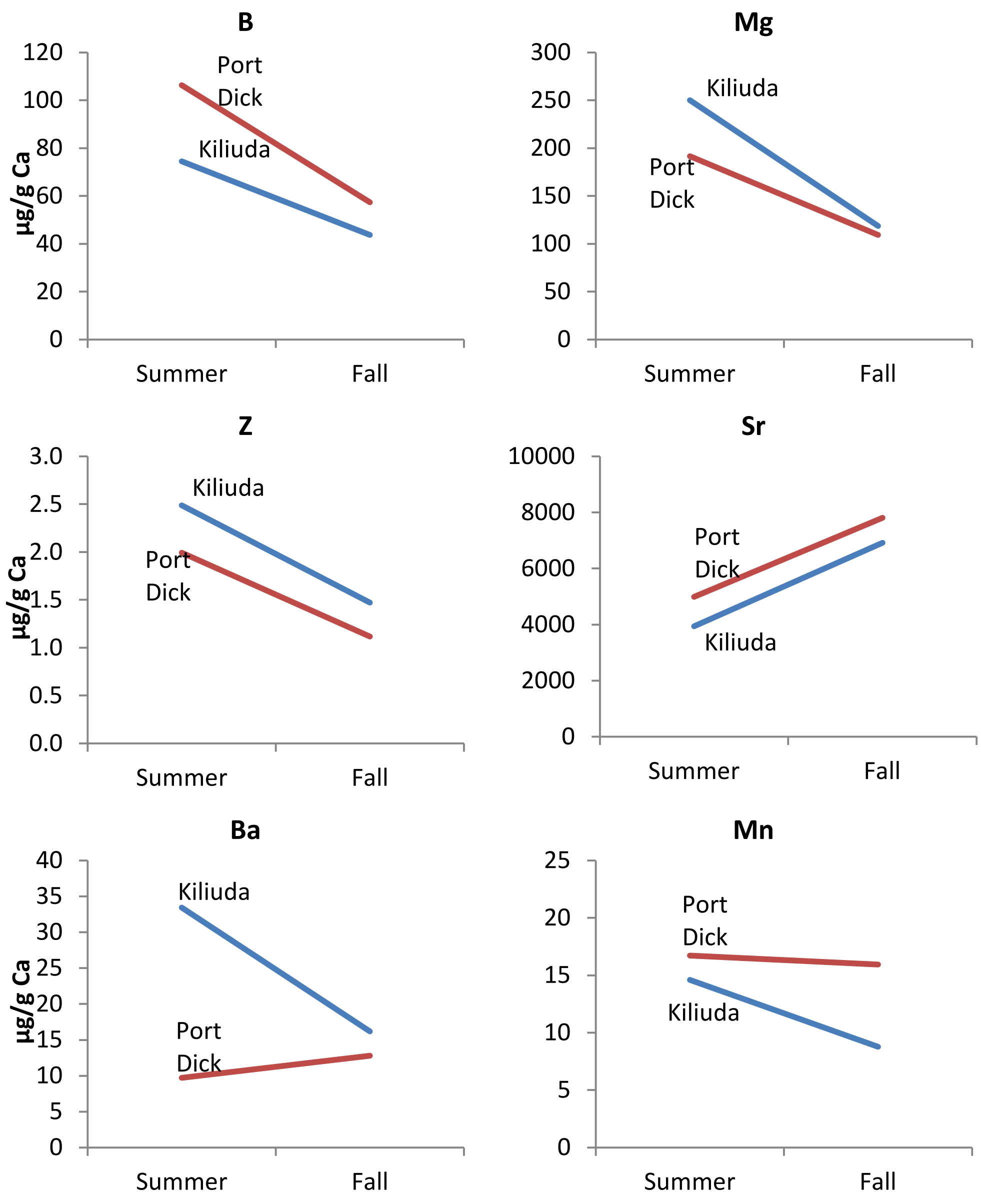


Figure 4. Temporal differences (summer vs. fall) in otolith edge element concentrations (means, relative to Ca) measured in Kiliuda Bay and Port Dick.

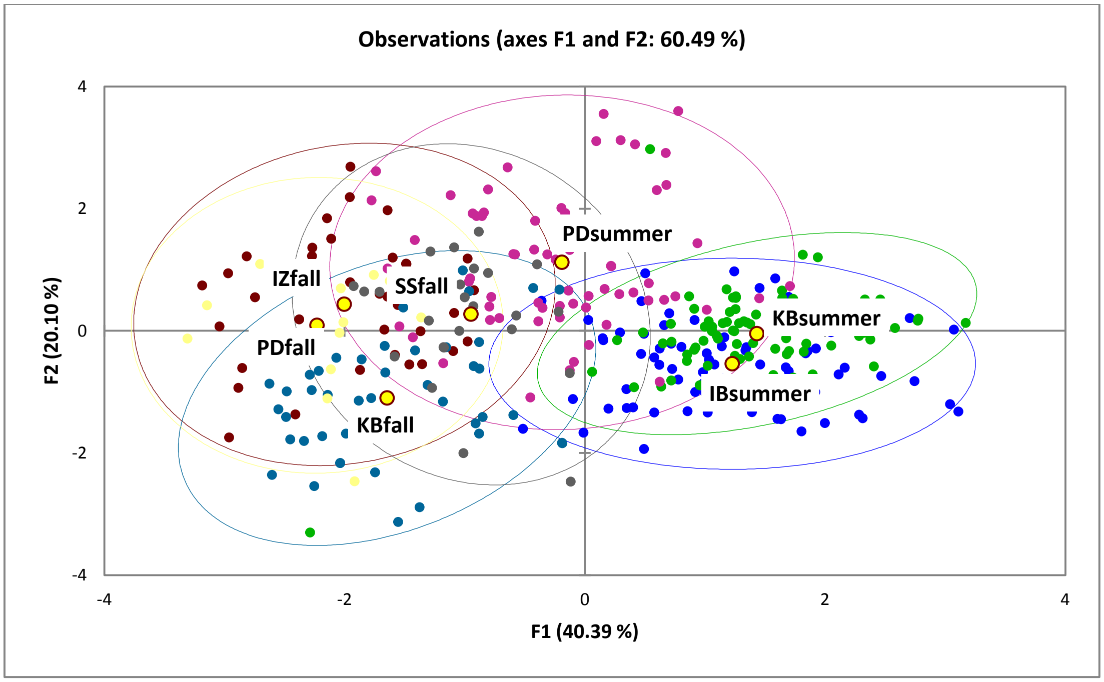


Figure 5. Principle Component Analysis of otoliths collected in summer and fall from Islas Bay (IB), Izhut Bay (IZ), Kiliuda Bay (KB), Port Dick (PD), and Salisbury Sound (SS), based on elemental concentrations of B, Mg, Mn, Zn, Sr, and Ba at otolith edge.

Significant differences in fish length were detected among bays in summer (Kruskal-Wallis K = 44.854, df = 2, p <0.0001) and fall (Kruskal-Wallis K = 31.893, df = 3, p <0.0001). However, linear regressions demonstrated no consistent effect of fish length on elemental concentration for any of the analytes examined. Thus, we concluded that fish size does not significantly impact elemental signatures.

Tasks Remaining: Preliminary analysis of life history transects indicates that some elements may prove useful in identifying key life events or variation in the external environment. A large peak in barium noted in some specimens may correspond to upwelling events or freshwater run-off into nursery bays. Thus far, barium appears to be the element that varies the most frequently throughout the life of the fish, suggesting it may be most sensitive to environmental influences.

Regional and temporal variation in otolith edge and contemporaneous trace element signatures will be assessed using MANOVA. Relationships between environmental variables recorded at time of capture (temperature, salinity, and oxygen concentration) and edge elemental signatures will be described. Discriminant function analysis (DFA) will be used to determine whether fish can be correctly classified to their capture locations based on their contemporaneous elemental signatures.

A manuscript tentatively entitled "Spatial and temporal variation in otolith elemental signatures of age-0 Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska" is in preliminary draft form, and will be submitted for publication in a peer-reviewed journal.

Project 2013-1:

Project Summary: In this project, we assess whether a given cohort of Gulf of Alaska Pacific cod can be retrospectively linked to nursery habitats utilized during the first year of life through spatially unique otolith microchemical signatures. Furthermore, we seek to identify whether measured physical characteristics within these habitats are related to differences in growth rates and otolith chemical properties.

Tasks Completed: Otoliths from 195 age-2 Pacific cod belonging to the same cohort (birth year: 2011) as the age-0 fish were collected during the 2013 summer GOA bottom trawl survey (n=159) and GOAIERP MTL sampling platform (n=36) (Fig. 1). These otoliths were prepared for analysis at Oregon State University (OSU) and sampled by LA-ICPMS from the core to the edge ("life history transect") at the OSU Keck Collaboratory in August 2014.

Tasks Remaining: We will conduct post-processing of raw data and spatial analysis of transformed data. The portion of the life history transect that occurs within the first annulus and corresponds to time spent in young-of-year habitat will be matched to signatures of the age-0 fish analyzed in Project 2012-4. The entire transect will also be examined to assess whether movement from nearshore nursery habitat to offshore habitat can be identified from changes in elemental signatures. Elements such as strontium, manganese, and barium may be good potential indicators of this shift in habitat use, since they are known to vary with temperature, salinity, and upwelling events.

Further progress on this project is pending completion of Project 2012-4. As in Project 2012-4, MANOVA will be used to test for differences at the regional and site level among otolith elemental signatures. DFA will be used to classify age-2 fish to putative source habitats (based on the baseline DFA conducted on age-0 fish in Project 2012-4). A manuscript on connectivity between nearshore habitat and the offshore stock of GOA Pacific cod based on otolith elemental signatures will be produced and submitted for publication in a peer-reviewed journal.

Essential Fish Habitat project status report

Reporting date: November 4, 2015

Project number: 2012-5

Title: Reproductive ultrastructure of red tree corals from Tracy Arm Fjord, Southeast Alaska: delving deeper into recovery dynamics

PIs: Robert Stone & Rhian Waller

Funding year: 2013

Funding amount: $52,816

Status: ☐ Complete ☐ Incomplete, on schedule **X Incomplete, behind schedule**

Planned completion date if incomplete:

Funding for this project was not made available in time to collect the samples in 2012 as originally proposed. A research cruise was completed in early January 2013 and all field work and collections were successfully completed. Processing and analysis of data have been delayed due to medical issues, however everything is now moving forward. Processing of samples is almost complete and analysis will begin in the next month. Expected completion of analysis and manuscript preparation is January 2016, with publication of results following shortly thereafter.

Reporting:

Results have not yet been reported.

Results:

The specific objectives of this proposal were:

1. To describe the formation and function of gametes in male and female *P. pacifica* and assess for differences attributable to mechanical damage carried out in September 2010 to ten of our colonies.

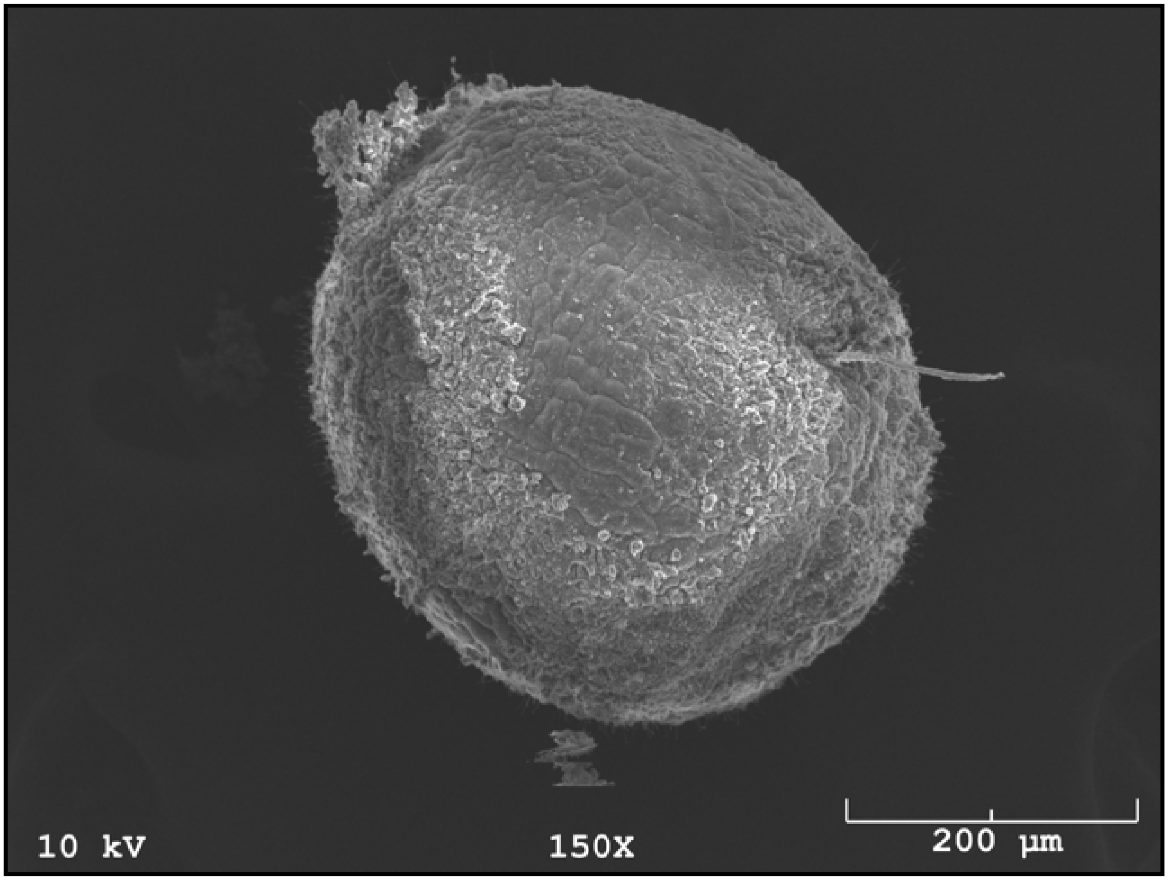
2. To assess fertilization potential of gametes, and stages of larval development from both ‘pristine’ and our artificially ‘damaged’ colonies.

3. Use ultrastructure data (in addition to our histological and growth data) to determine how often successful reproduction and recruitment may occur, and thus determine rates of habitat recovery from damaging influences.

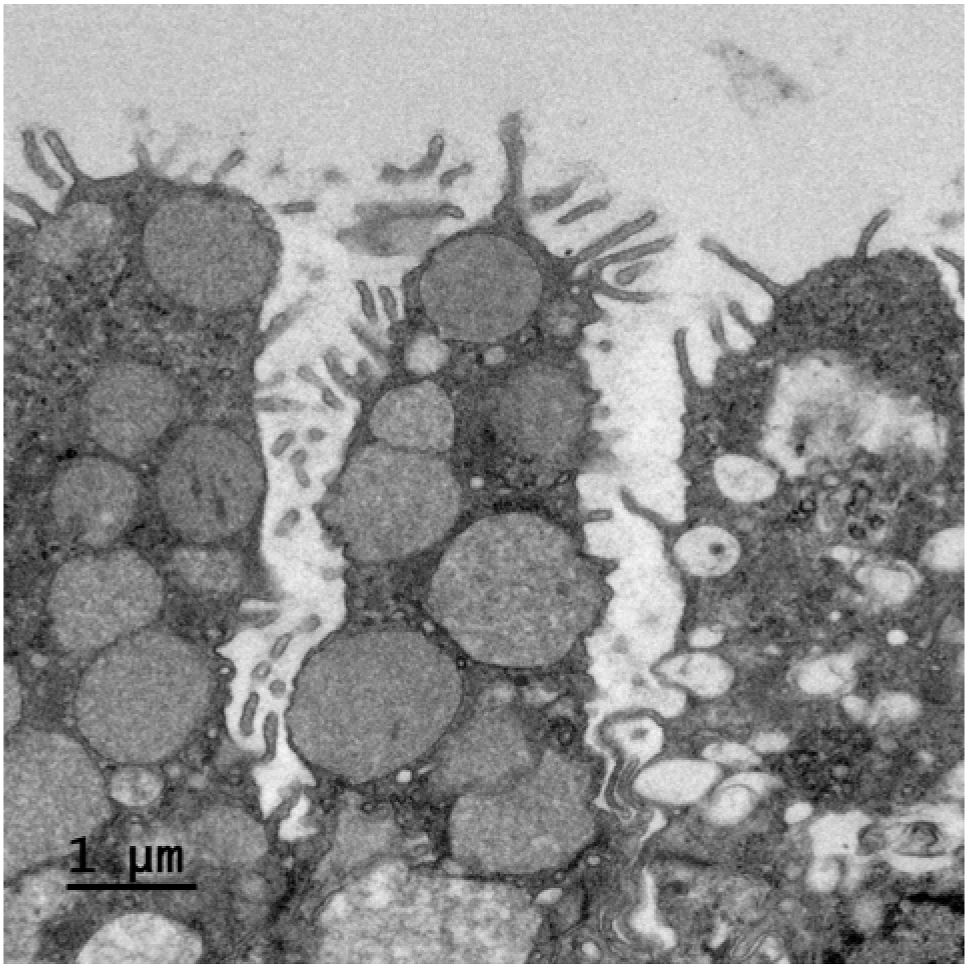
A research cruise in January 2013 was carried out and TEM samples (gametes and single polyps) and SEM samples (whole polyps and small pieces of branches) were preserved and catalogued for all 38 colonies at our Tracy Arm research site. In total over 100 sample lots were preserved and sent back to the University of Maine for analysis. In addition some limited experiments were conducted to assess fertilization and oocytes from 5 individuals appeared to be fertilized, potentially to first or second cell division stage. Experiments onboard were hampered by lack of steady temperatures, but all experiments were preserved for future TEM sampling after 48 hrs incubation. These samples have yet to be fully analyzed (see below), but if indeed they did fertilize, they will be the first examination of fertilization processes in a cold-water coral, leading to unique insights into reproduction, population survival and recovery from damage.

Samples for both TEM and SEM were preserved in glutaraldehyde and post-fixed in osmium tetroxide while in the field. They were serially dehydrated to 80% ethanol and shipped cold to the Waller Laboratory at the University of Maine. Sixty samples (males, females and potential larvae) have been embedded in polyacrylic resin and thin sectioned using a diamond knife. Thin sections have been placed on polyformvar grids and are awaiting analysis under the University of Maine's Philips EM201 TEM. Thick sections examined thus far show good preservation of structure, thus we are hoping for good yield from the samples processed. There are still further samples preserved as back up, should we not get necessary information for publication. Ten samples each of males, females and potential larvae have been critically point dried, stubbed and sputter coated and will shortly be analyzed using the University of Maine's AMRay 1820 SEM. All samples will be analyzed by R. Waller using the TEM and SEM, alongside undergraduate and graduate students learning EM techniques.

We expect two publications will result from this work – one on spermatogenesis and one on oogenesis – and hope for fertilization success to describe larval processes in a further publication, as well as further investigation into a unique brood area structure discovered during wax histological analysis.



An oocyte being fertilized during the fertilization experiment.



Invaginations and microvilli on the surface of a brood area in a female polyp.
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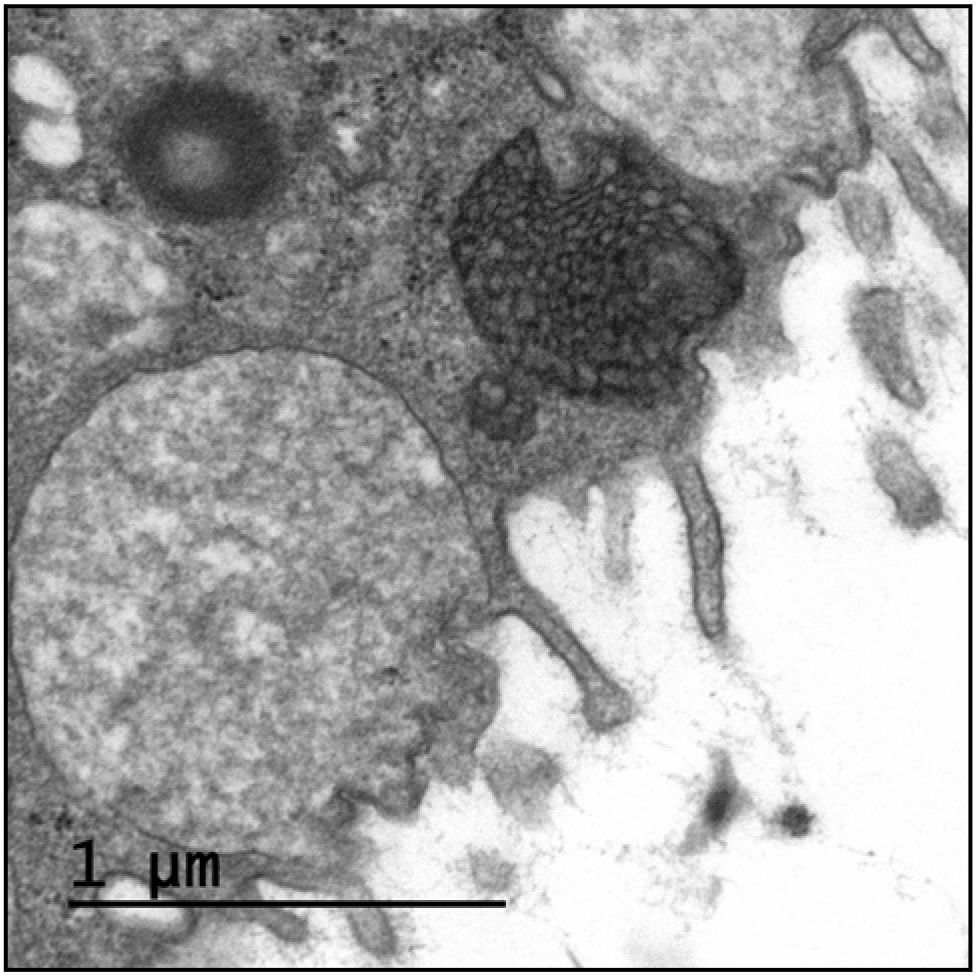


Microvilli and secreting cells within the endodermis of a female polyp.

Essential Fish Habitat project status report

Reporting date: September 2015

Project number: 2012-06

Title: A photographic guide to nearshore marine fishes of Alaska: a beach seiner's handbook

PIs: Lindeberg, Johnson (retired), and Neff (contractor)

Funding year: FY11

Funding amount: $11.5 K

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:
n/a

Reporting: *Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.*

This project is complete with final publication available as a pdf online and limited copies of a printed field guide on water resistant paper (see figures 1-2).

- Link to online pdf:
  http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-293.pdf
- Citation:
  Johnson, S. W., A. D. Neff, and M. R. Lindeberg. 2015. A handy field guide to the nearshore fishes of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-293, 211 p.

Results: *What is the most important result of the study?*

We have developed a photo-rich guide as a tool to help all user groups identify nearshore fishes of Alaska without going through extensive taxonomic keys in the field. This guide culminated from years of research on the importance of the nearshore marine environment to fishery resources in Alaska. The guide includes photos and other useful information (e.g., distribution and habitat use) on 113 fish species. For the more common species, photos are included of all life-history stages (larvae to adults) which are largely missing from other field guides. Our guide is not meant to replace the many excellent identification guides available to researchers, but is intended to supplement these other guides with a portable and waterproof photo catalog to aid in fish identification in the field. The photographic richness of our handy field guide, in combination with the online

Nearshore Fish Atlas of Alaska, provides researchers, managers, and the public with a unique and comprehensive synopsis on the nearshore fishery resources of Alaska.

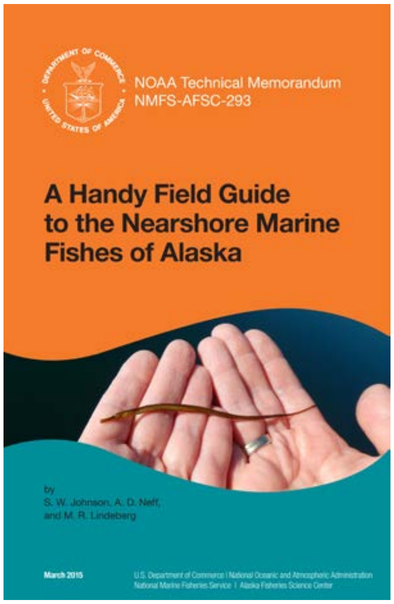
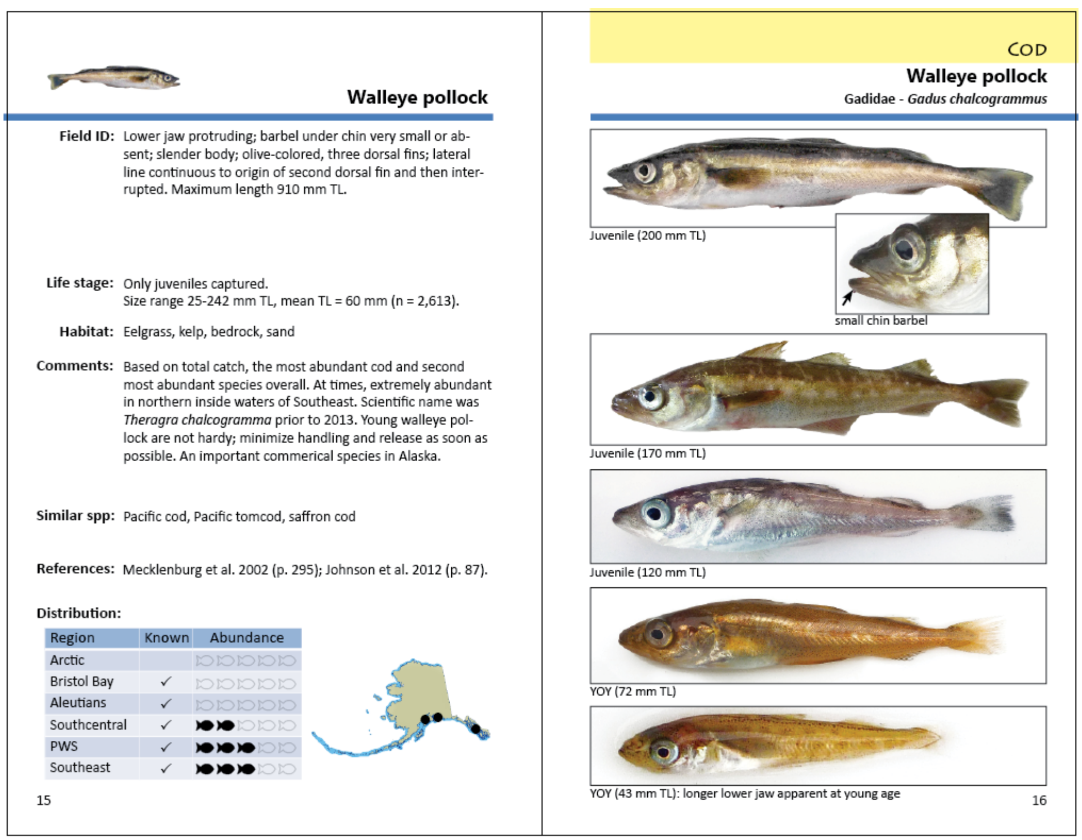


Figure1. Image of field guide cover.



Walleye pollock

Field ID: Lower jaw protruding; barbel under chin very small or absent; slender body; olive-colored, three dorsal fins; lateral line continuous to origin of second dorsal fin and then interrupted. Maximum length 910 mm TL.

Life stage: Only juveniles captured.
Size range 25-242 mm TL, mean TL = 60 mm (n = 2,613).

Habitat: Eelgrass, kelp, bedrock, sand

Comments: Based on total catch, the most abundant cod and second most abundant species overall. At times, extremely abundant in northern inside waters of Southeast. Scientific name was *Theragra chalcogramma* prior to 2013. Young walleye pollock are not hardy; minimize handling and release as soon as possible. An important commerical species in Alaska.

Similar spp: Pacific cod, Pacific tomcod, saffron cod

References: Mecklenburg et al. 2002 (p. 295); Johnson et al. 2012 (p. 87).

Distribution:

Region	Known	Abundance
Arctic		○○○○○
Bristol Bay	✓	○○○○○
Aleutians	✓	○○○○○
Southcentral	✓	●●○○○
PWS	✓	●●●○○
Southeast	✓	●●●○○

15

COD

Walleye pollock

Gadidae - *Gadus chalcogrammus*

Juvenile (200 mm TL)

small chin barbel

Juvenile (170 mm TL)

Juvenile (120 mm TL)

YOY (72 mm TL)

YOY (43 mm TL): longer lower jaw apparent at young age

16

Figure 2. Sample pages from field guide.

Essential Fish Habitat project status report

Reporting date: October 30, 2015

Project number: 2012-4, 2013-1

Title: Otolith microchemical fingerprinting: Assessing juvenile Pacific cod habitat utilization in the Gulf of Alaska

PIs: Mary Elizabeth Matta, Jessica Miller, Thomas E. Helser, Olav Ormseth, and Thomas Hurst

Funding year: FY2012-2013

Funding amount: $32,267 (FY2012); $38,235 (FY2013)

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: Project 2012-4: by end of FY2016. Project 2013-1: unknown (further progress is dependent on results of 2012-4).

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Preliminary project results were reported in the Oct-Nov-Dec 2012 AFSC Quarterly Report, available at http://www.afsc.noaa.gov/Quarterly/OND2012/divrptsREFM14.htm

A manuscript based on Project 2012-4 is currently in preparation and will be submitted to a peer-reviewed journal such as *Transactions of the American Fisheries Society*.

Results: What is the most important result of the study?

Project 2012-4:

Project Summary: In this project, we evaluate the potential of otolith elemental signatures to determine whether habitats of juvenile (age-0) Pacific cod are chemically unique within two large regions: the Eastern and Western Gulf of Alaska (GOA). By sampling nearshore sites within each region, we also assess whether it is possible to discriminate among nursery bays and whether individuals can be correctly assigned to their early juvenile habitat sites. The temporal persistence of otolith signatures within sites is assessed by comparing a subset of samples collected during summer with those collected during fall.

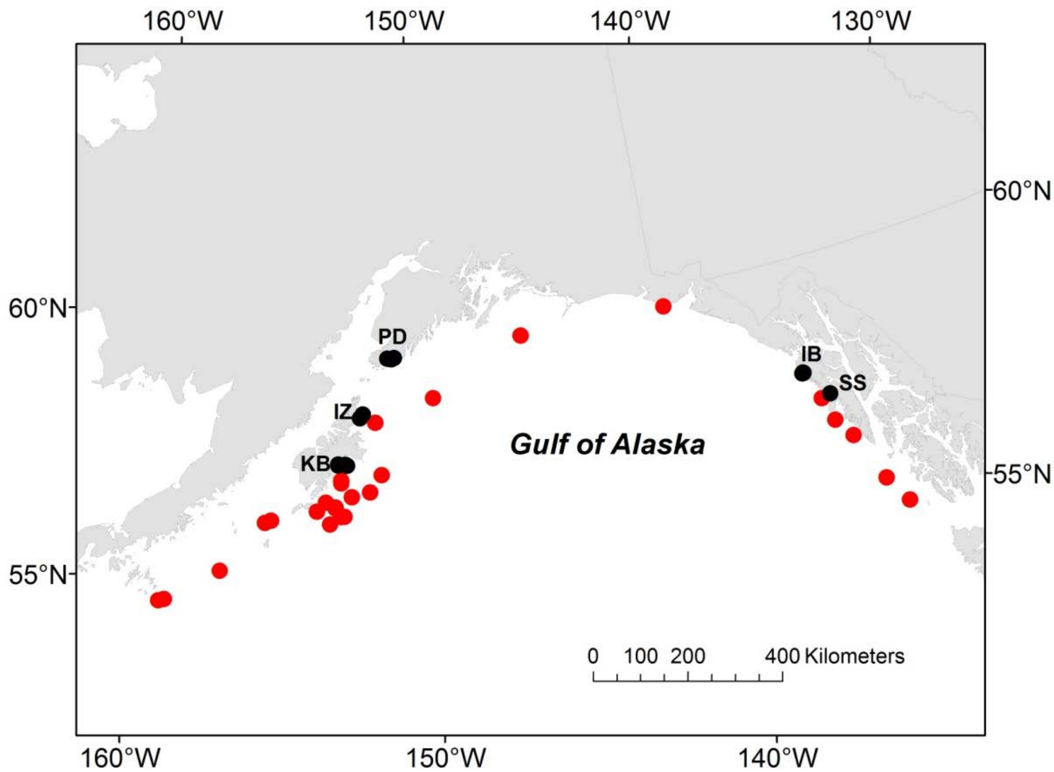


Figure 1. Collection sites of age-0 Pacific cod in 2011 (Project 2012-4; black circles; n=384) and age-2 Pacific cod in 2013 (Project 2013-1; red + black circles; n=195). Abbreviations represent GOAIERP MTL study sites (KB=Kiliuda Bay, IZ=Izhut Bay, PD=Port Dick, IB=Islas Bay, SS=Salisbury Sound).

Tasks Completed: Pacific cod were sampled opportunistically by purse seine during nearshore surveys of the Middle Trophic Level (MTL) component of the North Pacific Research Board's Gulf of Alaska Integrated Ecosystem Research Project (GOAIERP) in 2011. Fish were collected from 2 bays in the eastern GOA and 3 bays in the western GOA during summer (July-August) and fall (Sept-Oct); within each bay, up to three subsites were sampled (Fig. 1). Two bays (Kiliuda Bay and Port Dick) were sampled in both summer and fall (Fig. 1). During the survey, temperature and salinity data were also recorded during 6-7 CTD casts taken throughout each bay.

Two transects within each otolith were analyzed by laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS). The first transect ("life-history transect") ran from the sulcus through or near the core to the distal edge of the otolith to evaluate changes in elemental signatures over the lifetime of the fish (Fig. 2). The second transect ("edge transect") ran parallel to the otolith edge (averaging the most recent ~10-20 days of life) to characterize the environment the fish was exposed to at time of capture (Fig. 2).

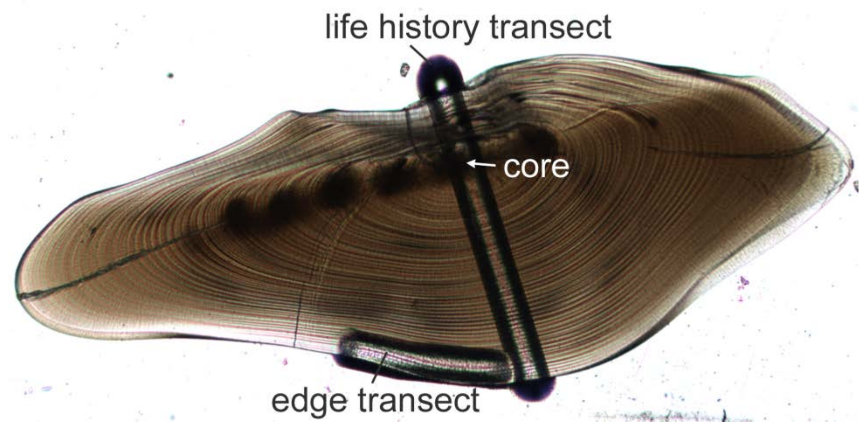


Figure 2. Transverse otolith thin section from age-0 Pacific cod, post-ablation.

Because otoliths were collected over a period of several months, we took steps to ensure spatial comparisons are made over temporally similar periods. Daily rings were used to identify the portion of the life history transect deposited during the period of July 6-15, corresponding approximately to the edge transect of the earliest caught fish. Two different comparisons were made: 1) signatures based on edge transect (representing the most recently deposited material, presumably representative of habitat at time of capture), and 2) signatures based on contemporaneous 100-micron portions of the life history transect, to ensure appropriate temporal comparisons are made for fish captured in different months.

Isotopes measured in otolith scans included ^{7}Li, ^{11}B, ^{24}Mg, ^{25}Mg, ^{43}Ca, ^{52}Cr, ^{55}Mn, ^{59}Co, ^{65}Cu, ^{66}Zn, ^{85}Rb, ^{86}Sr, ^{111}Cd, ^{138}Ba, ^{139}La, and ^{208}Pb. Of these, boron, magnesium, calcium, manganese, zinc, strontium, and barium were consistently above background levels and therefore are included in further analyses. Post-processing and error-checking of raw trace element data were completed using TRACE ELEMENTS, an algorithm developed by Jon Short (AFSC) during FY2013-2015 for this and other AFSC otolith microchemistry projects. Isotopic counts were converted to elemental concentrations reported relative to calcium ($\mu g\ g^{-1}$ Ca).

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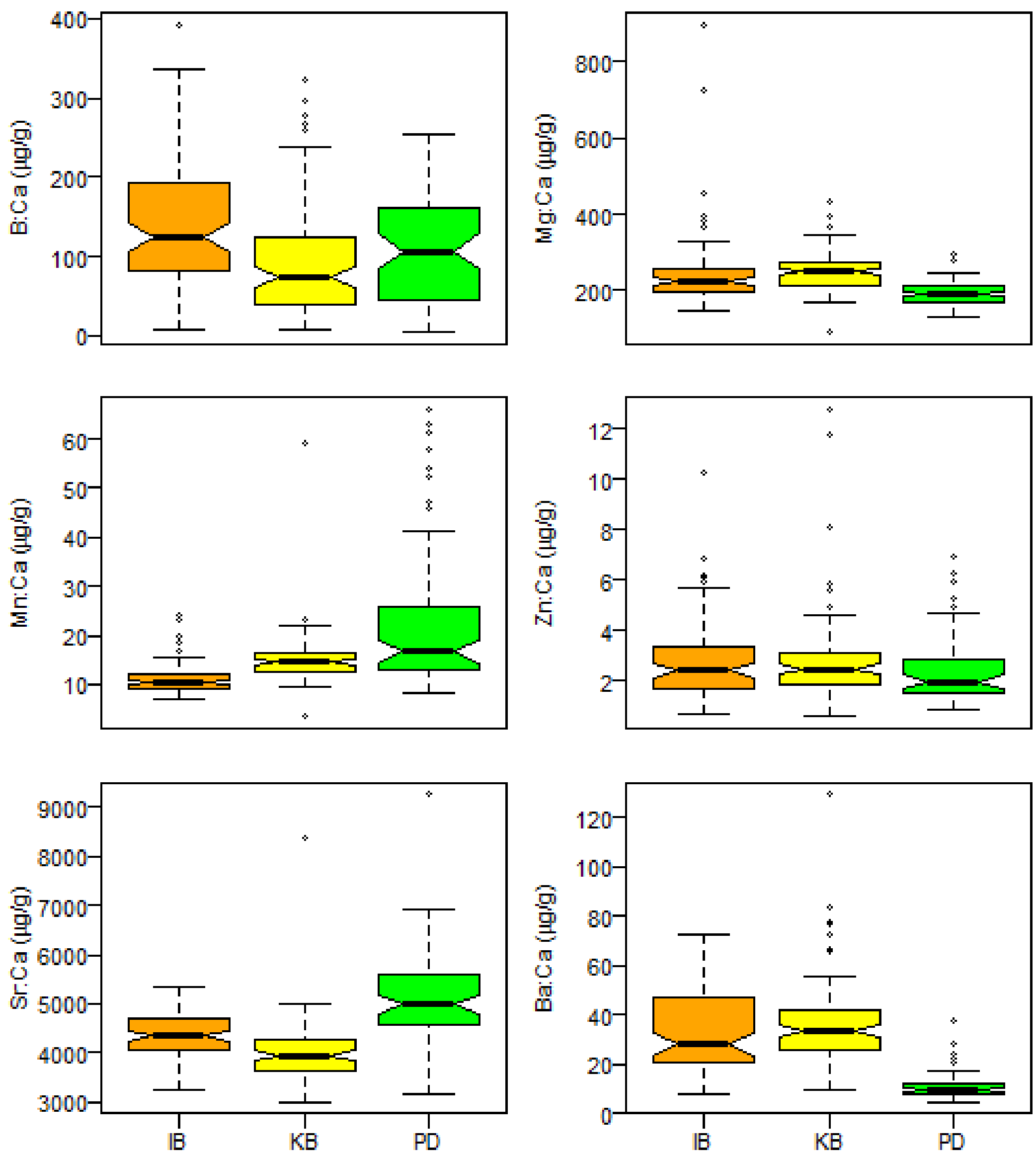

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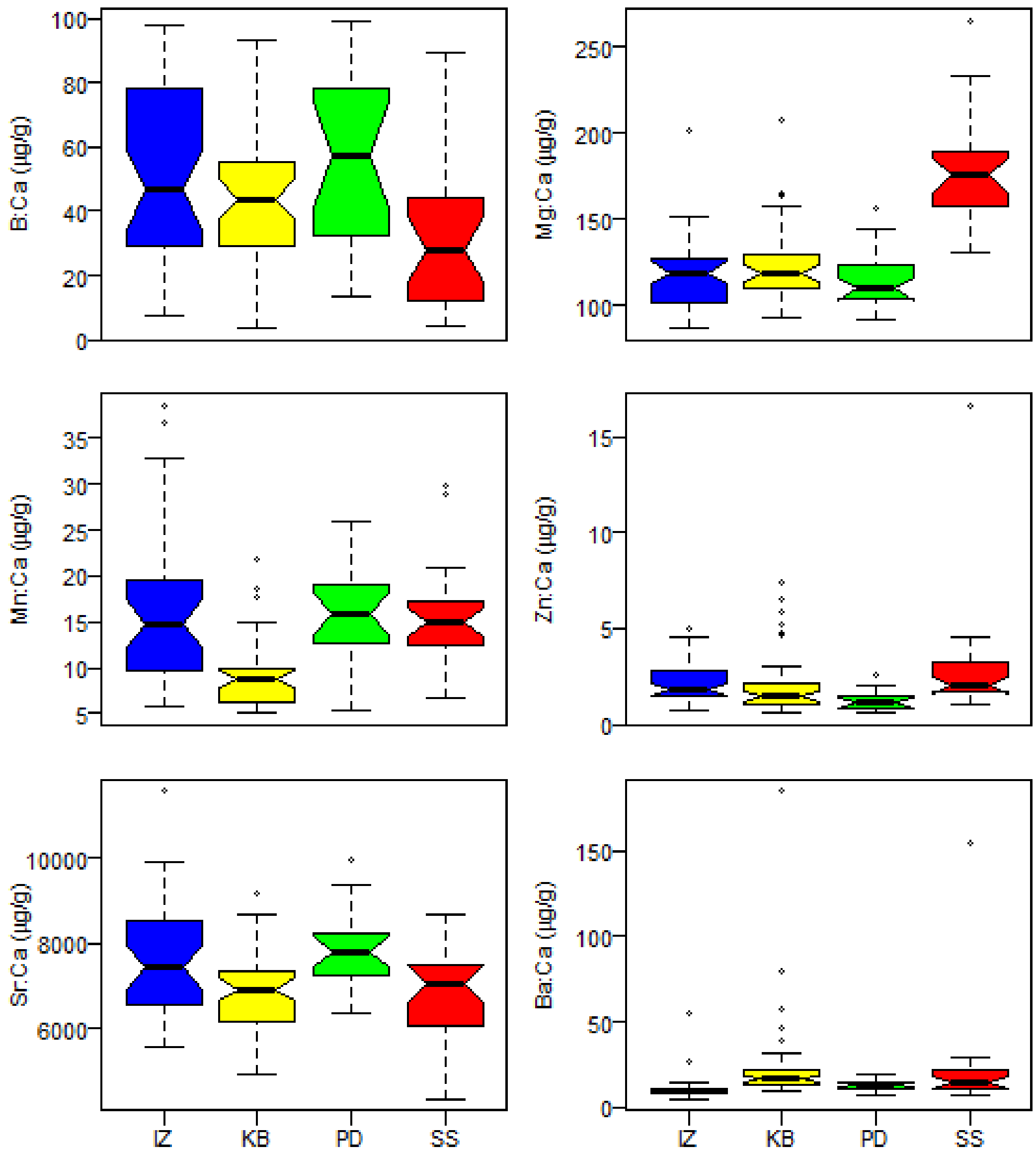

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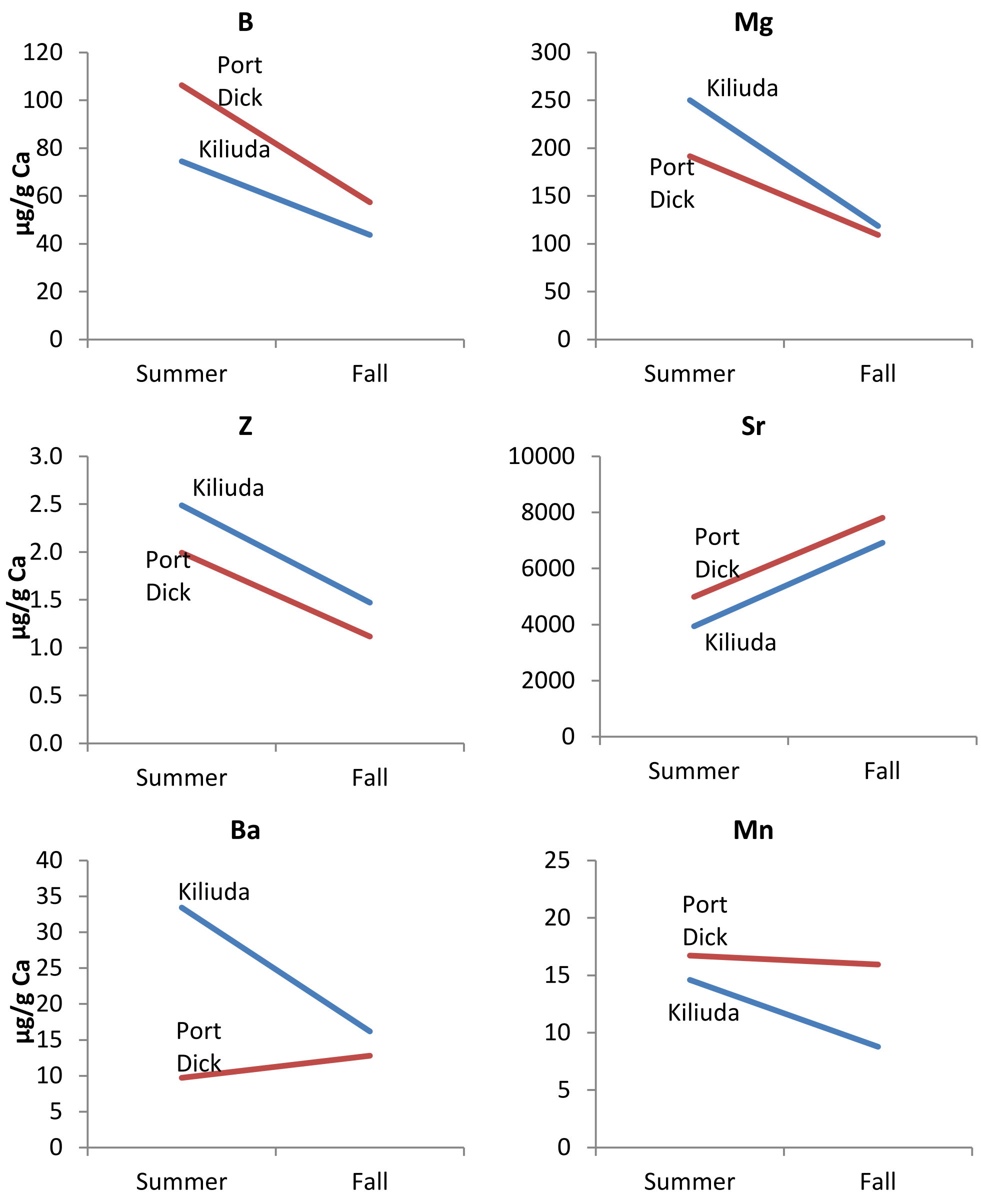

Figure 4. Temporal differences (summer vs. fall) in otolith edge element concentrations (means, relative to Ca) measured in Kiliuda Bay and Port Dick.

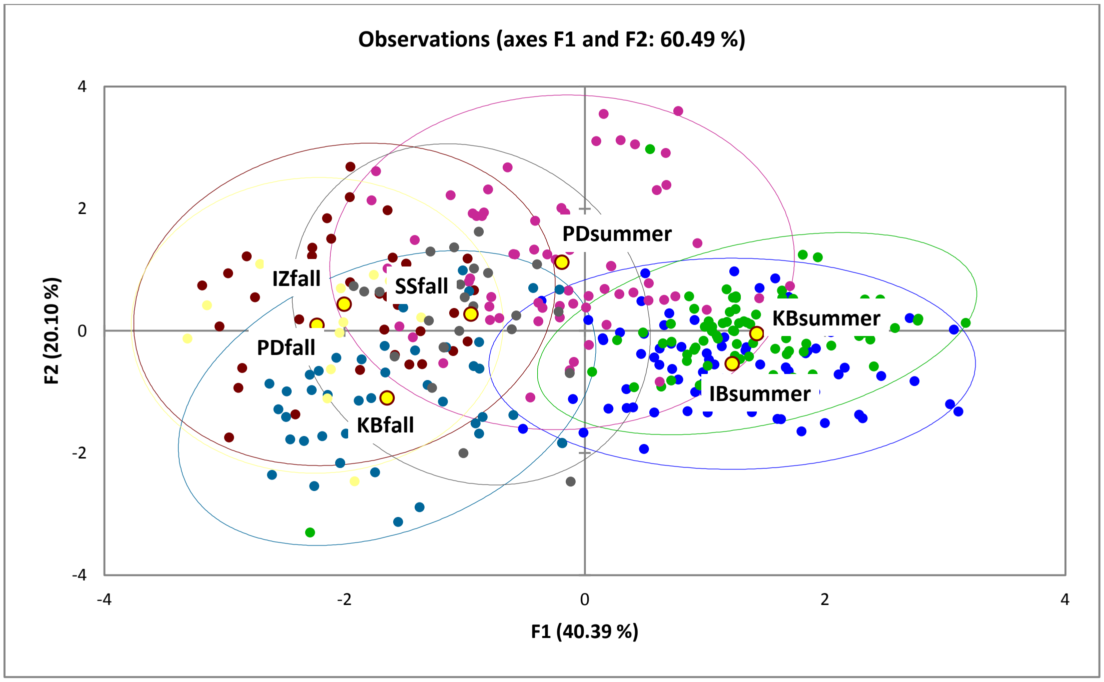

Figure 5. Principle Component Analysis of otoliths collected in summer and fall from Islas Bay (IB), Izhut Bay (IZ), Kiliuda Bay (KB), Port Dick (PD), and Salisbury Sound (SS), based on elemental concentrations of B, Mg, Mn, Zn, Sr, and Ba at otolith edge.

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<u>Project 2013-1</u>:

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Tasks Completed: Otoliths from 195 age-2 Pacific cod belonging to the same cohort (birth year: 2011) as the age-0 fish were collected during the 2013 summer GOA bottom trawl survey (n=159) and GOAIERP MTL sampling platform (n=36) (Fig. 1). These otoliths were prepared for analysis at Oregon State University (OSU) and sampled by LA-ICPMS from the core to the edge ("life history transect") at the OSU Keck Collaboratory in August 2014.

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Further progress on this project is pending completion of Project 2012-4. As in Project 2012-4, MANOVA will be used to test for differences at the regional and site level among otolith elemental signatures. DFA will be used to classify age-2 fish to putative source habitats (based on the baseline DFA conducted on age-0 fish in Project 2012-4). A manuscript on connectivity between nearshore habitat and the offshore stock of GOA Pacific cod based on otolith elemental signatures will be produced and submitted for publication in a peer-reviewed journal.

Essential Fish Habitat project status report

Reporting date: October 6, 2014

Project number: 2013-02

Title: Bathymetry and substrate compilation from smooth sheet charts

PIs: Mark Zimmermann

Funding year: 2013

Funding amount: $57,388

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: We created an AFSC web page for reporting our results; http://www.afsc.noaa.gov/RACE/groundfish/bathymetry/

The Aleutians Island bathymetry and sediment data sets and metadata were published http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Aleutians.htm along with a tech memo http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-250.pdf

A smooth sheet methods tech memo was published http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Smooth_sheets.htm along with a tech memo http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-249.pdf

The Cook Inlet bathymetry, sediments, features, shoreline and metadata were published; http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Cook_Inlet_1.htm along with a tech memo http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-275.pdf

Results: We are contributing to a number of AFSC research projects, including Coral prediction maps, untrawlable work, EFH research and the GOA and AI bottom trawl surveys by providing the best bathymetry in Alaskan waters.

Essential Fish Habitat project status report

Reporting date: 11/16/2015

Project number: EFH 2013-03

Title: The distribution and productivity of commercially important rockfish species in coral and sponge habitats of the Gulf of Alaska

PIs: Christina Conrath, Brian Knoth, and Chris Rooper

Funding year: 2013

Funding amount: $31,800

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: 08/15/2015
Funds for this project were requested to pay for sample processing contracts through the ABL bioenergetics and the REFM food habits laboratory. These funds were transferred in FY13 for samples that were to be collected in August 2013. However, due to the late arrival of funds from the Deep Sea Coral Research and Technology program and difficulties in securing a contract with the vessel that bid on the solicitation to conduct this research, the directed sample collection was not completed until May 2014. All diet and zooplankton samples for this project have been processed. Energetic samples from the August 2012 cruise and the December 2014 cruise have been processed; samples from the May 2014 cruise are currently being processed. It is anticipated that all sample processing associated with this project will be completed by February 2015.

Reporting: The initial results from the first cruise associated with this project were presented at the 2014 and 2015 AMSS meetings. Results from this project have been reported at the 2015 AFS conference. Two presentations about this research will be presented at the 2016 AMSS conference, one presentation on energetics and diet by an ABL researcher and one on reproductive productivity. A presentation focused specifically on habitat use and site diversity will be given at the 2016 Western Groundfish conference. The NPRB project associated with this research will be completed in August 2016 and two manuscripts are in preparation.

Results: The first cruise associated with this project was conducted from August 15th-21st, 2012. Two additional cruises were completed in May and December 2014. The primary study site was located at the 49 Fathom Pinnacle on the continental slope offshore of Albatross Bank. A secondary study site was identified at Snakehead Bank southwest of the 49 Fathom Pinnacle site and was sampled during the last two cruises. Utilizing a stereo drop camera system, we identified three habitat regions within each of these sites. The coral habitat at the 49 Fathom Pinnacle site was dominated by *Stylaster* corals in each season. Hexactinellid sponges were also frequently observed. In contrast, the coral habitat at the Snakehead site was dominated by soft corals like the gorgonian coral, *Fanellia frasieri.* Rockfish density from the SDC video drops indicate significant differences in rockfish density among habitats, with highest densities in the boulder and coral habitats at both sampling sites. Trawl catches at the 49 Fathom Pinnacle site consisted predominately of adult dusky and northern rockfish throughout this sampling area though Pacific ocean perch occur along the deeper edges of this site. The Snakehead Bank area had a much larger abundance of small rockfish including juvenile Pacific ocean perch, juvenile northern rockfish, juvenile redstripe rockfish, and juvenile and adult small rockfish species including harlequin and pygmy rockfish.

In addition to differences in species composition at the two sites, there were differences in the prey availability. Preliminary examination of the diet of northern and dusky rockfish collected within these habitats emphasize the importance of both copepod and euphausiids as prey items. Results from plankton sampling indicate there were higher abundances of prey species like copepods and euphausiids at the 49 Fathom Bank sampling site. At both sites, prey availability was highest during the spring season with very few prey species captured during the winter season.

Preliminary energetic analyses from the August 2012 and December 2014 cruise indicate differences in the energy density among species with northern rockfish having higher energy densities than dusky rockfish. Adult dusky rockfish were collected at both sites; but adult northern rockfish were only found at the 49 Fathom Pinnacle site. Dusky rockfish energy density was highest at the 49 Fathom Pinnacle site. At the 49 Fathom Pinnacle site energy densities of both dusky and northern were highest in the identified low relief habitat site with similar but slightly lower energy densities in the higher relief habitats.

Analysis of reproductive productivity is on-going but there is evidence in northern rockfish of reproductive anomalies including some non-fertilization of eggs and degeneration of ovarian tissue indicating a portion of these fish would have experienced partial or complete reproductive failure. There is some indication of this for dusky rockfish as well though it appears to be much less common. Analysis of reproductive development, seasonality, and fecundity for these samples will continue in the upcoming months. These metrics will be compared between seasons (representing two reproductive years), sites, and habitat types. It is anticipated all samples for this project will be processed by early spring and data analyses will be completed by summer 2016.

Essential Fish Habitat project status report

Reporting date: 9-25-15

Project number: 2013-04

Title: Essential fish habitats of juvenile Pacific cod, yellowfin sole, and northern rock sole along the Alaska Peninsula

PIs: Hurst, Cooper, Duffy-Anderson, and Miller

Funding year: 2013

Funding amount: $73,858

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Ferm, N.C., J.T. Duffy-Anderson, and T.P. Hurst. Using life history to infer temporal shifts in foraging behavior of juvenile flatfish from an Alaskan nursery habitat. American Fisheries Socoety Meeting, Portland, OR.

A manuscript describing the distribution of flatfishes along the Alaska Peninsula is currently in revision for the Journal of Sea Research. Shallow-water habitat use by Bering Sea flatfishes along the central Alaska Peninsula by Thomas Hurst.

Results: What is the most important result of the study?

The planned stomach content analyses are completed, and data analysis and synthesis is currently underway. Preliminary observations suggest important spatial differences in the diets of age-0 Pacific cod associated with the use of demersal inshore and pelagic offshore habitats. For example, pteropods and copepods were important prey items only for fish in offshore waters, whereas mysid shrimp and gammarid amphipods were important in the coastal habitats. Flatfish diets varied by species and appeared associated with depth distribution and activity level of the predator.

We completed otolith increment analysis of laboratory reared Pacific cod to calibrate daily increment widths to fish growth rates. We also completed analysis of otholith growth rates from field-caught fish to examine spatial variation in recent growth. These analyses will be used in conjunction with temperature and diet data (described above) to fully describe the growth environment of juvenile Pacific cod across habitat types in the Bering Sea.

Essential Fish Habitat project status report

Reporting date: 10/24/15

Project number: 2013-03

Title: Simulation modeling of sustainable removals of Primnoa in the Gulf of Alaska based on field studies of size structure and recruitment rates

PIs: Rooper, CN, Etnoyer, P, Stone, RS

Funding year: 2013

Funding amount: $52,500

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: The results have not been reported, but will be reported to the DSCRTP by June 2016.

Results: There were two primary objectives for the fieldwork funded by this EFH project during FY13. They were to collect stereo images of *Primnoa* colonies along transects at each of four study sites to be used in determining size structure of colonies and to deploy 8 settlement plate arrays at two *Primnoa* thicket sites (Cape Ommaney and the Fairweather Ground). Both of these objectives were accomplished during FY13 fieldwork. Image analysis has been completed as well. Data analysis and reporting are in progress, with reporting anticipated in FY16.

In August 2013 a joint cruise with two vessels, the ADF&G research vessel *Medeia* and a chartered fishing vessel, the *Alaska Provider* were conducted at the study sites. The primary task of the *Medeia* was to deploy the settlement plates at the Cape Ommaney and the Fairweather Ground study sites and to use the additional time to conduct stereo drop camera transects to determine size structure of *Primnoa* colonies. Four settlement plate arrays were successfully deployed in *Primnoa* thickets at both sites and should be relatively easy to locate for retrieval in FY14 (Figure 1). Two arrays at each site in FY15 were recovered using funds from NOAAs Deep-sea Coral Research and Technology Program. Three additional transects to measure *Primnoa* size structure were completed at the Cape Ommaney site and four size structure transects were completed at the Fairweather Ground site.

Aboard the *Alaska Provider* an ROV was used to conduct exploratory transects. We equipped this vehicle with an additional stereo camera system for measuring size structure of *Primnoa* colonies. One transect was completed by the ROV at the Dixon Entrance site in a *Primnoa* thicket. At the Prince of Wales site no *Primnoa* thickets were found, so no size information was collected. The ROV completed an additional four transects for size structure of *Primnoa* at the Cape Ommaney site as well. In addition a number of whole colonies were collected at Cape Ommaney and Dixon Entrance to determine a size-biomass ratio at 2 study sites.

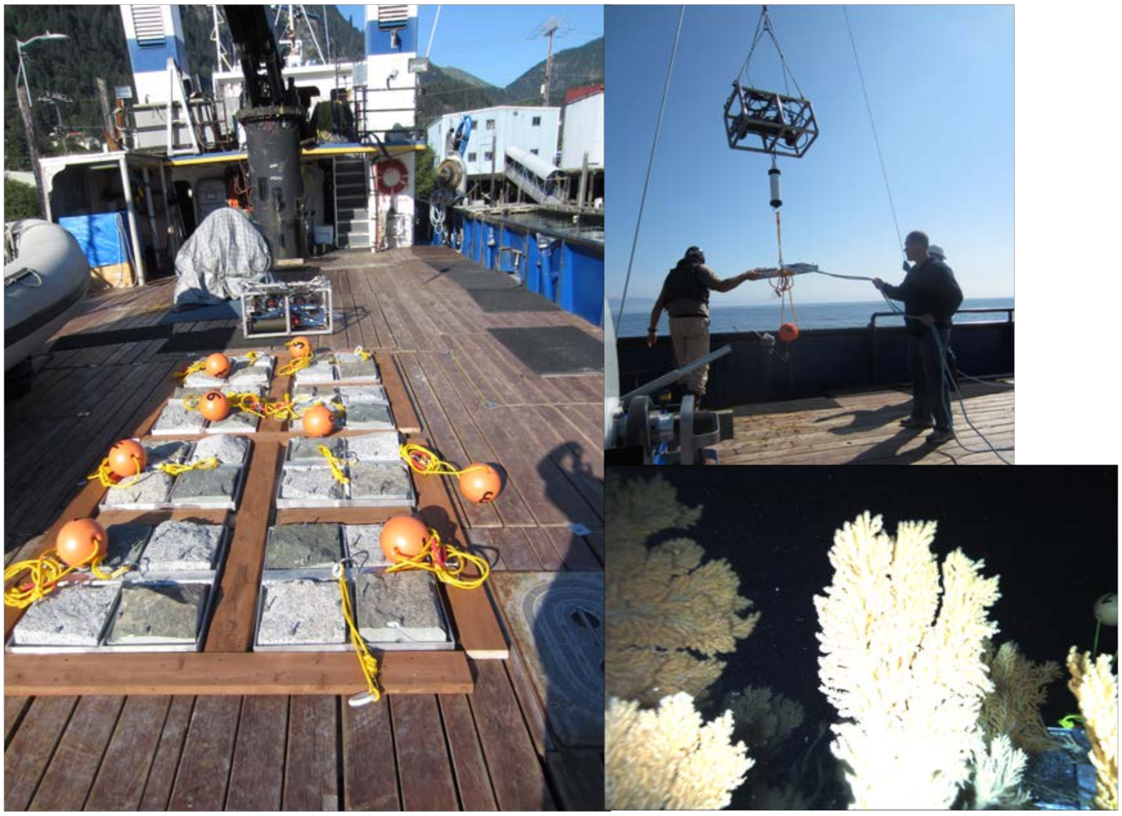

Figure 1. Clockwise from left. Settlement plates (8) on the deck of the *Medeia*, deployment using the drop camera and acoustic release, and settlement plate as deployed in a *Primnoa* thicket.

Essential Fish Habitat project status report

Reporting date: September 23, 2015

Project number: 2014-01

Title: Ground truth the presence and abundance of coral habitat on the eastern Bering Sea slope both inside and outside canyon areas

PIs: Rooper, Sigler, Hoff

Funding year: 2014

Funding amount: $138,420

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Preliminary results were reported to the North Pacific Fisheries Management Council by Chris Rooper in October 2014. A final report was transmitted to the North Pacific Fisheries Management Council in June 2015 (attached).

Results: What is the most important result of the study?

In summer 2014 we conducted a survey of the eastern Bering Sea slope and outer shelf using an underwater stereo camera at 250 randomly selected transects. The objective of this survey was to verify distribution models of coral, sponge, and sea whips that were based on bottom trawl survey data that had been presented to the North Pacific Fishery Management Council in June 2013. Additionally, we collected data on invertebrate density, height, and fish associations and documented the presence of fishing gear and damage to invertebrates. Presence or absence models of coral, sponge and sea whips were also constructed from the camera survey data and were compared to previous coral, sponge, and sea whip models constructed from bottom trawl survey data. The model of coral presence or absence based on bottom trawl survey data was generally accurate in predicting coral presence or absence in the camera survey. The bottom trawl survey models were also accurate in predicting sponge and sea whip presence or absence, but to a lesser degree than for coral. Corals were found at 32 of 250 transects, most of which were located in Pribilof Canyon and the slope area to the northwest. Overall, the densities of corals were low, averaging 0.005 individuals*m^{-2} and ranging from 0 to 0.28 individuals*m^{-2}. The low densities were consistent with the absence of hard substrates for coral attachment in most areas of the eastern Bering Sea. Densities of corals were generally highest in Pribilof Canyon and corals were largest in the slope area to the northwest of Pribilof Canyon. For sponges, densities and heights were highest surrounding Pribilof Canyon, north of Bering Canyon, and in some locations in Zhemchug Canyon. Sea whip densities and heights were highest on the outer shelf between Pribilof and Zhemchug Canyon and in an area to the south of Pribilof Canyon. There were significant positive relationships between fish density and the presence of coral and sponge for some rockfish species and king crabs. There were significant negative relationships for grenadiers and *Chionoecetes* crabs. Direct evidence of fishing gear occurred at 12.8% of transects. Individual demosponges (0.3%), Isididae corals (2.9%) and sea whips (9.0%) were observed to be damaged. Vulnerability of benthic invertebrates was estimated from the field data on invertebrate density and height and was modeled for the entire eastern Bering Sea outer shelf and slope. Based on height and density, the areas that appeared to be most vulnerable for coral occurred in narrow areas of the two arms of Pribilof Canyon and in deeper areas to the northwest along the slope. For sponge and sea whips, the most vulnerable areas were centered around the shelf break and extended from Pribilof Canyon to the north for sponge and from Bering Canyon to the north for sea whips. Although combining the bottom trawl survey models and the camera survey models only exhibited some improvement over bottom trawl survey data-based models alone, the combined models were able to integrate both bottom trawl and camera data into a single map of the probability of invertebrate presence and from this a prediction of density of invertebrates for the eastern Bering Sea slope and outer shelf.

NSRKC Essential Fish Habitat project status report

Reporting date: 9/11/2014

Project number: 2014-02

Title: Examining the effects of offshore marine mining activities on Norton Sound red king crab habitat

PIs: Olson, Foy, Harris

Funding year: 2014

Funding amount: $77,300

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: 5/2015 → 8/2016

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. **No**

Results: What is the most important result of the study?

A second year of this study was funded in early 2015, with field work carried out in July 2015. The objectives and deliverables of the first phase of the Norton Sound work have largely been completed (the literature review continues to be updated), but the majority of this work has been expanded to Phase 2. It is expected that the timeline for Phase 1 of this work will be aligned with Phase 1 and completed in August 2016.

Objectives:

- Develop literature-based mining effects susceptibility and recovery matrices
- Describe spatial distribution of winter mining effort
- Develop and test acoustic-video methods for sampling and mapping seabed complexity
- Develop and test methods for monitoring "by-catch" in suction dredging operations.

Deliverables:

- systematic literature review of the impacts of seabed mining on benthic complexity
- mining effects susceptibility and recovery matrices
- descriptions and maps of winter mining effort along with descriptive analyses of water and seabed characteristics (if possible)

- acoustic camera imagery and stereo video demonstrating the efficacy of DIDSON for surveying rugosity
- Norton Sound mining area benthic rugosity measure
- a descriptive assessment of "by-catch" in suction dredging operations.

Timeline:

The mining effects literature review and susceptibility/ recovery matrices will be completed by September 2014. The DIDSON sonar and video sampling and "by-catch" monitoring will be conducted between May and September 2014. Data preparation, DIDSON imagery and video analyses will be ongoing from August 2014 - November 2014. Owing to the late funding award date (April-May 2014) the winter mining effort sampling and analysis will occur during March-April 2015. Our final report will be completed in May 2015. Our aim is to produce a peer-reviewed publication detailing the use of DIDSON for quantifying seabed complexity.

Essential Fish Habitat project status report

Reporting date: 10/20/2015

Project number: 2009-03, 2010-01, 2011-02, 2014-03

Title: Recruitment and response to damage of an Alaskan gorgonian coral (*Calcigorgia spiculifera*)

PIs: Patrick Malecha, Dr. Kalei Shotwell, Erika Ammann

Funding year: 2009, 2010, 2011, 2014

Funding amount: FY2009 $38,000, FY2010 $32,900, FY2011 $16,700, FY2014 $17,700

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:
Image analyses of *in situ* scuba observations were completed in October 2015. Data analysis is currently underway and a draft manuscript is in preparation. Genetic analysis of coral recruits and adults is ongoing.

Reporting: No reporting has occurred yet.

Results:
Video analysis was completed in October 2015. Data generated from the video observations includes colony survival, branch growth, and tissue regeneration rates.

Seventy-nine percent of all tagged corals were alive and upright after five years of observations. Survival over the entire experiment was 63%, 70%, 88%, and 100% for the trawl, control, cut, and scrape treatment groups, respectively. Survival was not related to the damage treatments on any of the sampling events.

Average branch growth over the five-year period was 0.0216 mm/day for all corals combined. This translates into an annual branch growth rate of 7.88 mm. However, growth rates varied by season as growth during a 3-month summer period averaged 0.0424 mm/day.

Branches that were scraped of their overlying gorgonin tissue demonstrated a variety of responses. Some colonies regrew their missing gorgonin layer within about a year, while on other colonies, a portion of the scraped branches became necrotic and eventually disappeared. However, the growth of undamaged branches among corals in the cut and scraped treatments was on average greater than among corals in the trawl and control groups perhaps indicative of compensatory processes that focused energy on somatic rather than reproductive output.

Coral recruits were found on 18 of the 96 tiles collected and at least 60 individual recruits were identified. These observations document coral recruitment for the first time in Alaska. The

majority of recruits were small single- or two-polyp organisms, presumably less than one year old. There were also some very small potential recruits that lacked definitive structural characteristics of coral polyps but were pigmented similarly to *Calcigorgia spiculifera*. These specimens are currently undergoing genetic analyses to determine their identity. If these are indeed coral recruits, they would likely be only days or weeks old. There were also a few multi-polyp colonies that were probably more than a year old. Thus it is apparent that coral recruitment happened in multiple years. A rate of recruitment will be estimated based on the different sizes or "age classes" of the recruits. Tiles were placed on the seafloor on varied dates and thus were "seasoned" *in situ* for different amounts of time. The original tiles were in place for five years, while the most recently installed tiles were on the seafloor for 35 months. Recruits were found on tiles of all ages. Genetic analyses, to explore the relatedness between recruits and adults and to examine genetic diversity and dispersion potential, are ongoing.

Essential Fish Habitat project status report

Reporting date: 10/14/15

Project number: 2014-4

Title: Optimal thermal habitats of gadids in Alaskan waters

PIs: Ben Laurel, Cliff Ryer and Louise Copeman

Funding year: FY14

Funding amount:

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

The project results on growth are reported in Polar Biology (see attached). Additional results on will be reported in peer-reviewed publications in FY16. These include a publication on temperature-dependent lipid allocation (Copeman et al.) and another comparing temperature-dependent growth in two populations of age-0 juvenile walleye pollock. Key figures from both those are also attached.

Results: What is the most important result of the study?

There are several important results from the study.

1) Gadids have widely varying thermal habitat preference based on growth performance and condition response (Table 1 and Figure 1; Laurel et al. 2015)
2) We provide the first evidence suggesting there are population differences in thermal habitat optima in walleye pollock. Puget Sound pollock had compared to Gulf of Alaska pollock (Figure 2). Extending the growth model, GOA pollock are predicted to have ~20% growth potential at 16 °C than PT pollock.
3) Growth and lipid allocation were generally positively correlated within each species, although Arctic cod generally allocated even (high) amounts of lipid in muscle and liver across all thermal habitats in which they could maintain positive growth (Figure 3)

Table 1: Parameter estimates for temperature-dependent growth model for four species of gadids: Arctic cod *Boreogadus saida*, saffron cod *Eleginus gracilis*, Pacific cod *Gadus macrocephalus* and walleye pollock *Gadus chalcogrammus*. The model predicts growth (G, % wet weight d-1) at a maximum food ration. Mean values are based on duplicate tanks (n = 2) of three fish per tank for each species at each temperature.

Species	**T (°C)**	***G* (% d^{-1})**	**Parameter estimates** $G = y_o + aT + bT^2 + cT^3$				
			y_o **Mean ± SE**	***a* Mean ± SE**	***b* Mean ± SE**	***c* Mean ± SE**	R^2
Arctic cod	0	0.729	0.8290 ± 0.1282	0.1638 ± 0.1050	-0.0054 ± 0.0189	-0.0005 ± 0.0008	0.96
	5	1.348					
	9	1.387					
	16	-0.152					
Saffron cod	0	0.098	0.0979 ± 0.1803	0.0787 ± 0.0876	0.0117 ± 0.0115	-0.0007 ± 0.0004	0.88
	5	0.702					
	9	1.279					
	16	1.684					
	20	1.143					
Pacific cod	0	0.249	0.2494 ± 0.1251	0.3216 ± 0.0608	-0.0069 ± 0.0080	-0.0004 ± 0.0003	0.97
	5	1.634					
	9	2.290					
	16	1.941					
	20	0.622					
Walleye pollock	0	0.202	0.2023 ± 0.1507	0.0992 ± 0.0732	0.0335 ± 0.0096	-0.0019 ± 0.0003	0.97
	5	1.296					
	9	2.413					
	16	2.490					
	20	0.194					

*Population sourced from Puget Sound, WA (Port Townsend)
**Population sourced from Beaufort Sea, AK (Prudhoe Bay)

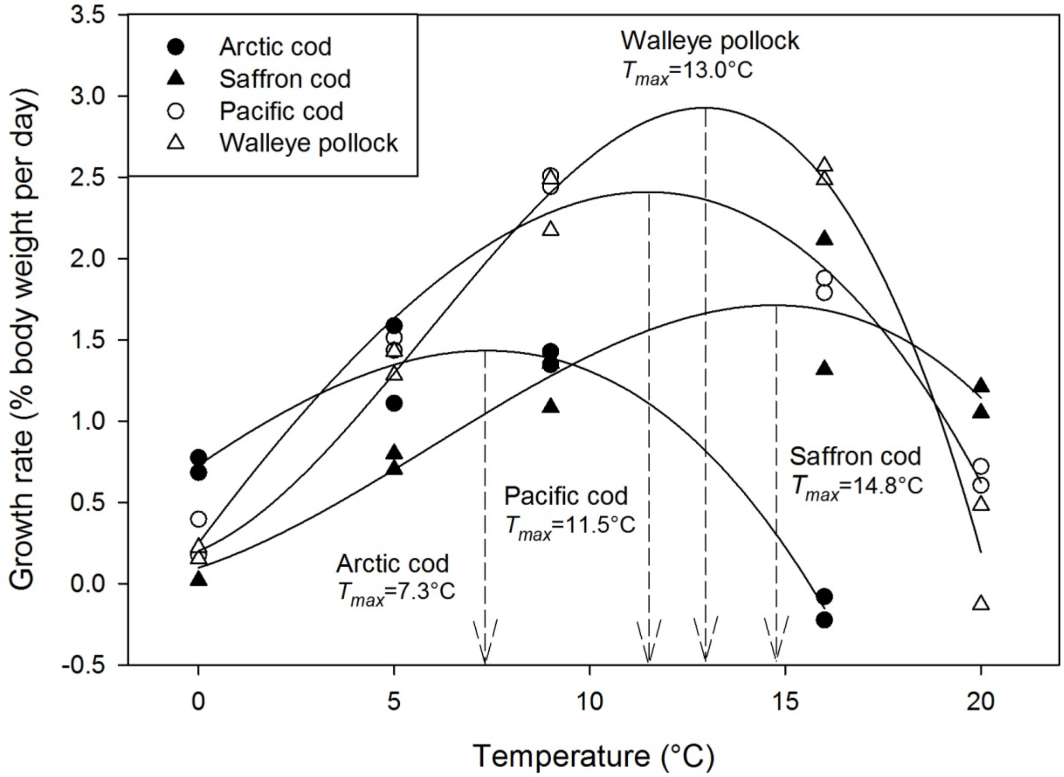

Figure 1: Temperature-dependent growth model fits for four species of gadids; Arctic cod *Boreogadus saida*, saffron cod *Eleginus gracilis*, Pacific cod *Gadus macrocephalus* and walleye pollock, *Gadus chalcogrammus*. The 3-parameter model predicts growth (G, % wet weight d^{-1}) at a maximum food ration. Dotted arrows indicate the temperature of maximum growth (T_{max}) for each species. Mean values are based on replicate tanks (n = 2) of 3 fish per tank for each species at each temperature. Model and parameter values for each species are listed in Table 1. Note, walleye pollock were collected from Port Townsend, WA and represent a genetically distinct Puget Sound population (see Fig. 2).

Figure 2:

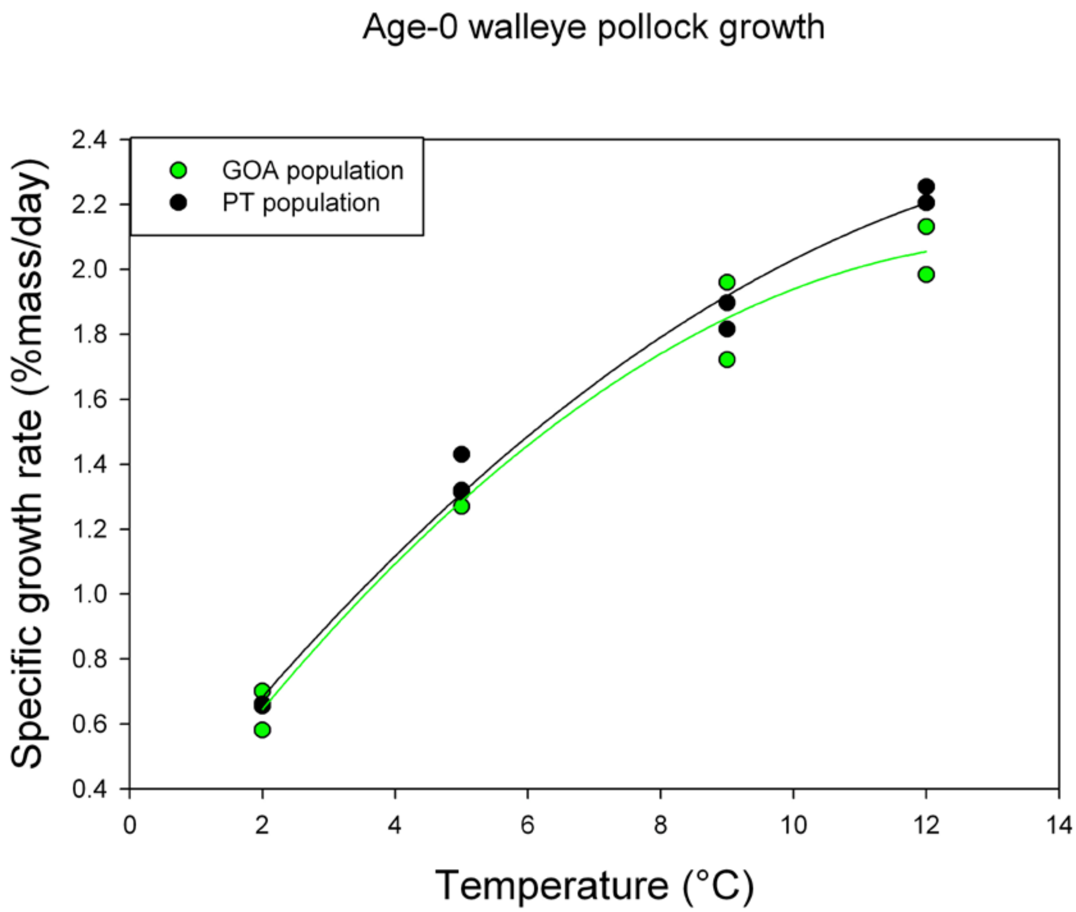

Figure 2: Temperature-dependent growth model fits for captive growth studies on two populations of walleye pollock *Gadus chalcogrammus*. Populations were sourced from Kodiak, AK (GOA, green) and Port Townsend, WA (PT, black). These are the first data to indicating southern populations (PT) have better growth potential at warmer temperatures than northern populations (GOA) (Laurel et al. in prep).

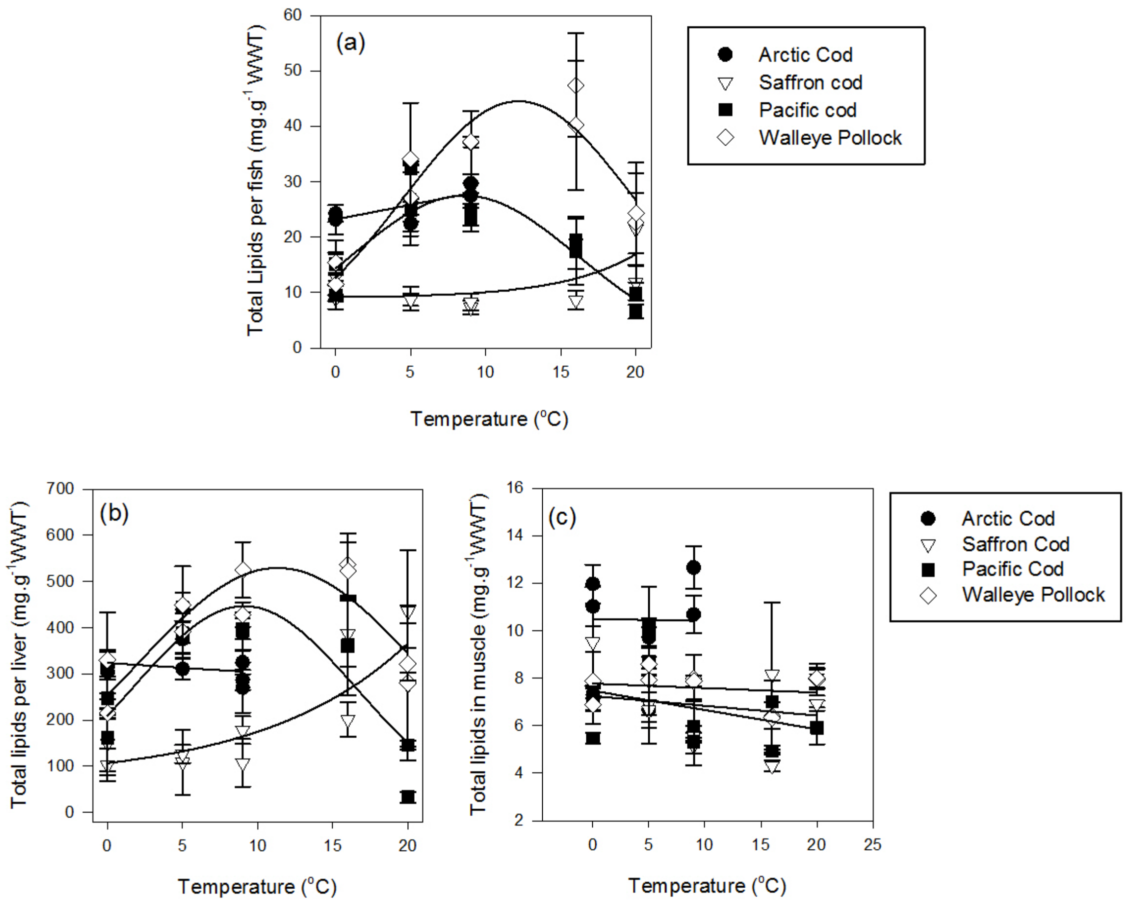

Figure 3: Distinct temperature-dependent tissue-specific lipid storage models for four species of juvenile gadids (80-110 mm SL): Arctic cod *Boreogadus saida*, saffron cod *Eleginus gracilis*, Pacific cod *Gadus macrocephalus* and walleye pollock *Gadus chalcogrammus*. Figure from Copeman et al. in review.

Essential Fish Habitat project status report

Reporting date: October 2, 2015

Project number: 5

Title: Bathymetry and substrate compilation from smooth sheets: Gulf of Alaska and Norton Sound

PIs: Mark Zimmermann

Funding year: 2014

Funding amount: $62,772 (out of $72,572)

Status: ☒ Complete ☐ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting:
We decided to expand the coverage to include the Yakutat area, which is beyond what we described in the grant proposal (Kodiak/Kenai/ Prince William Sound). A tech memo describing the bathymetry and features of the central Gulf of Alaska was published (Zimmermann and Prescott 2015: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-287.pdf), and it was added to our web page.

All 6 multibeam data sets were processed and 3 of these were incorporated into the CGOA bathymetry. The other 3 will be incorporated into the WGOA data set.

The Norton Sound bathymetry was also published as a tech memo (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-298.pdf) and added to our web page.

Additional work was done on the wGOA compilation at the end of the grant period.

In response to a reviewer comment, I created a web-based, interactive map displaying and making our data sets available, so that people could explore our data without needing GIS software:
http://noaa.maps.arcgis.com/apps/MapSeries/?appid=c41002831ed34ce0b63727ed7d3636cc

Results: Our methods of careful bathymetry editing are producing the best available seafloor maps in Alaskan waters.

Essential Fish Habitat project status report

Reporting date: 10/28/15

Project number: 6

Title: High prey availability defines juvenile flatfish habitat quality in the eastern Bering Sea

PIs: Cynthia Yeung, Mei-Sun Yang, Dan Cooper

Funding year: 2014

Funding amount: $50,730

Status: ☐ Complete ☐ Incomplete, on schedule ☒ Incomplete, behind schedule

Planned completion date if incomplete: June 2016

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. No

Results: What is the most important result of the study?

The objective of the study is to investigate the quality of juvenile habitat for yellowfin sole (YFS) and northern rock sole (NRS) on the northeastern inner shelf of the eastern Bering Sea (EBS), near Nunivak Island. Prey availability is hypothesized to be a key factor in determining habitat quality. The diet of juveniles is examined in correspondence to the prey field and other habitat characteristics. The results will be compared to a similar study of juvenile flatfish habitat in 2011 on the southern inner shelf, near Bristol Bay and the Alaska Peninsula.

Field sampling was conducted as a special project in the 2014 EBS bottom trawl survey. Infauna and sediment samples were collected at eleven trawl stations near Nunivak Island (Fig. 1). Granulometric analysis shows that the bottom type at all the stations was sandy (>90% sand), except for the deepest (31 m) station, J4 (84% sand). Identification of infauna is 90% completed.

Juvenile NRS and YFS were sampled from the trawl catch at 14 stations (Fig. 1) – where benthic samples were taken and also opportunistically at some stations neighboring the benthic stations that had juvenile YFS and/or NRS in the trawl catch. Stomach contents of the juveniles were analyzed (Table 1). Juvenile NRS were absent from the sampled trawl catch at four of the 14 stations. Juvenile YFS were also absent from the sampled trawl catch at four of the 14 stations, but not the same four where NRS were absent. The observations suggested that juvenile NRS were less abundant and more patchy in distribution than juvenile YFS in the study area (Fig. 1). The diets of juvenile NRS and YFS were very similar, consisting mostly of polychaetes, clams, and amphipods by percentage weight, in descending order (Table 1).

The year 2014 marked the turning point when the EBS shifted from a cold to a warm period. Bottom temperature mapped during the survey indicates that 2014 was an anomalously warm year

– the 6th warmest in the 33-year time series of the EBS bottom-trawl survey. The cold pool of ≤2°C bottom water was mostly confined to the northeastern middle shelf (Fig. 1). In 2015, bottom temperatures were even warmer. This key shift in the physical environment will likely confound the effects of prey availability and other biotic factors on juvenile habitat quality and suitability. Time series analysis of trawl data (1982-2014) shows that the annual mean center of the distribution of juvenile NRS shifts north during warm years. In contrast, there is no relationship between annual mean EBS summer bottom temperature and annual mean center of the distribution of juvenile YFS. Interspecific comparison and long-term observations at potential habitats are crucial to understanding the impact of thermal regime shifts on habitat distribution and quality.

Table 1. Diet composition of juvenile northern rock sole (NRS) and yellowfin sole (YFS)

		NRS	YFS
Fish total length (cm)		6.3 - 16.1	7.8 - 14.8
No. of empty/non-empty stomachs		0/132	41/104
Prey Composition (% count/% weight):			
	Clams	46/21	38/19
	Polychaetes	32/55	20/40
	Amphipods	15/10	29/16
	Shrimps	4/11	3/8
	Cumaceans	3/3	3/2

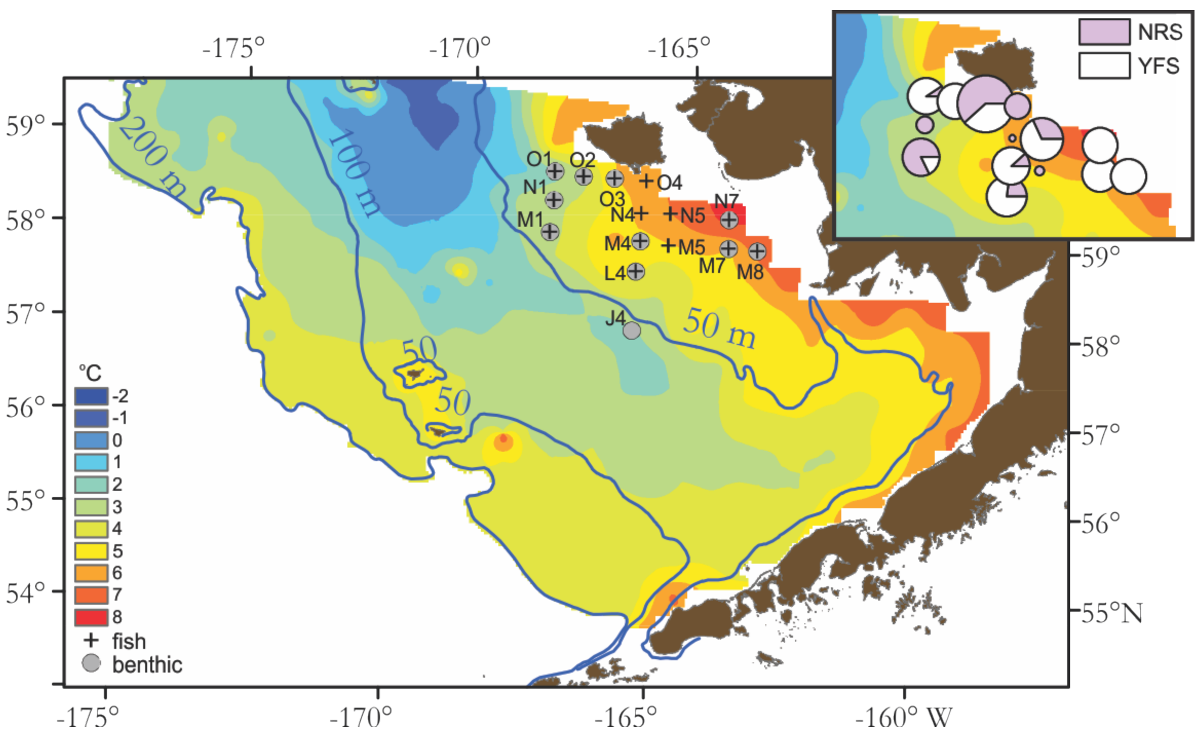

Figure 1. Large map - Eastern Bering Sea bottom-trawl survey stations where fish (+) and/or benthic (◯ infauna and sediment) samples were collected for the 2014 EFH juvenile flatfish habitat study. Small map – Relative numbers of yellowfin sole (YFS) and northern rock sole (NRS) collected at each EFH fish sampling station. Pies are sized proportional to sum of both species collected, ranging from 1 at N4 to 78 at O3. Color contours show 2014 bottom temperature.

Essential Fish Habitat project status report

Reporting date: September 23, 2015

Project number: 2014-7

Title: Coral and sponge diversity along the EBS slope with a focus on Pribilof and Zhemchug Canyons

PIs: Jerry Hoff and Robert Stone

Funding year: 2014

Funding amount: $20,750

Status: ☐ Complete ☐ Incomplete, on schedule ☒ **Incomplete, behind schedule**

Planned completion date if incomplete:

The 2014 Bering Sea slope trawl survey was cancelled so this project is now behind schedule to accommodate the collection and identification of specimens planned for collection during the 2016 survey.

Reporting: None of the results of this work have been reported yet.

Results: We administered a contract for $15,000 for the sponge taxonomic work that included the identification of 30 specimens and the formal description of undescribed species. To date we have identified 14 specimens from the 2013 and 2014 Bering Sea shelf collections comprising 11 species. Five of the eleven species represent new records for the Bering Sea including the first record of the hadromerid demosponge *Weberella bursa* from the North Pacific Ocean or Bering Sea.

Additional sponge specimens were collected from the 2015 Bering Sea shelf survey and will be targeted for formal identification if needed. Additional funds are being sought through the EFH program to cover the costs of identifying the sponge specimens we anticipate collected during the 2016 slope survey.

Oceanographic data loggers have been updated and calibrated and will be used during the 2016 EBS slope survey to correlate oceanographic conditions with sponge and coral habitats.

Essential Fish Habitat project status report

Reporting date: 9/23/2015

Project number: 2014-8

Title: Matching pieces of the puzzle: validating the reproductive ecology of red tree corals in Gulf of Alaska habitats with extensive studies in shallow water.

PIs: Robert Stone & Rhian Waller (UMaine)

Funding year: 2014

Funding amount: $48,326

Status: ☐ Complete ☒ **Incomplete, on schedule** ☐ Incomplete, behind schedule

Planned completion date if incomplete: June 30, 2016

Reporting: Have the project results been reported? NO

Results: We successfully collected samples from 50 or more specimens at each of the three main study sites (Fairweather Ground, Shutter Ridge, and Dixon Entrance) in the eastern Gulf of Alaska during ROV cruise in August 2013 and June 2015. Samples are currently being processed at the University of Maine, Darling Marine Center and should be completed by January 2016.

NSRKC Essential Fish Habitat Project 2 - status report

Reporting date: 11/15/2015

Project number: 2

Title: Examining the effects of offshore marine mining activities on Norton Sound red king crab habitat – phase 2

PIs: Olson, Foy, Harris, Boswell

Funding year: 2015

Funding amount: $80,707

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: 08/2016

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. **No**

Results: What is the most important result of the study?   As detailed in the proposal, the proposed work items were addressed as follows:

Assessing the Persistence of Benthic Mining Alterations

Assessing persistence of features will be conducted by comparing 2014 oblique view multibeam images (since it produces detailed still images) to 2015 downward view (and its ability to collect high-resolution bathymetry) and see if there are any similar features from year. Post-processing of these images is in process. A Python script was created to extract variables as follows: Image_ID, Sed1, Sed2, Sed3, Lat, Long, Heading, Bio, Geo, Scour, Scour depth, Vertical relief, Vertical relief height.

Mapping a NSRKC Recruitment Area- Utilizing methods developed in July 2014, the ASV was deployed along transects extending perpendicular from the beach beginning in a few feet of water and extending up to 2 km offshore. Transect spacing was based on water depth to ensure acoustic sampling overlap for mosaic swath-mapping. The sonars sampled a 45* (oblique) position to produce detailed still images elucidating benthic structures with acoustic shadows. Imagery from the sonar units is being processed to generate high-resolution study area mosaics.

There were numerous technical and weather issues in July of 2015 but we mapped10km more in 2015 than 2014 in western public mining area in deeper water. After reviewing the different M3 angles and the forward/sideward DIDSON from each year, we will determine which will be more suitable for mapping a recruitment area..

Tagging to Identify Spawning and Larval Settlement Areas

Bob Foy and Scott Kent (ADFG) determined that tagging work would be done during the fall 2015 ADFG survey. However, AFSC is having issues with tags already deployed in the Bering Sea not deploying so this work is on hold until tag issues can be worked out with manufacturer.

Expected Products:

Deliverables: 1) comparison of benthic structures in the western public mining area between 2014 and 2015, 2) assessment of benthic structures in the Cape Nome study area and 3) assessment of locations of adult NSRKC spawning and areas of potential larval settlement. Our aim is to produce a peer-reviewed publication detailing the use of high-resolution acoustics for quantifying seabed structures.

Timeline: The fieldwork will be conducted between May and October 2015. ASV imagery and video analyses will be ongoing after October 2015 and satellite tag data analysis will be completed as available in the spring and summer of 2016. Our final report will be completed in August 2016.

Essential Fish Habitat project status report

Reporting date: 10/24/15

Project number: 2015-02

Title: Defining EFH for Alaska Groundfish Species using Species Distribution Modeling

PIs: Chris Rooper, Ned Laman, Dan Cooper (RACE Division, AFSC)

Funding year: 2015

Funding amount: $96,533

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: 12/31/2015

Reporting: N/A (Draft NOAA Tech. Memo's are in progress for each region.

Results: EFH maps were produced for 83 species-region combinations. In total over 400 individual models were created. Egg and larval distributions appeared to be most commonly related to SST. Juvenile and adult distributions in the bottom trawl survey data were highly related to depth and relative geographic location, as well as current speed in the Aleutian Islands. Adult distributions in the commercial fisheries generally reflected the distribution of fishing effort in all regions. This exercise pointed out gaps in information for ELH and seasons other than summer

Essential Fish Habitat project status report

Reporting date: October 2, 2015

Project number: 2015-03

Title: Bathymetry compilation: Eastern Bering Sea slope

PIs: Zimmermann

Funding year: 2015

Funding amount: $84,312

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: July 2016.

Reporting: Work started on August 1.

Results: The most important results will be validating and improving habitat impacts model; beginning to develop geographic-based database for offshore habitat data.

Essential Fish Habitat project status report

Reporting date: October 31, 2015

Project number: 2015-04

Title: Improving base model EFH definitions for Gulf of Alaska groundfish species using combined species distribution models with high-resolution regional habitat metrics

PIs: Jodi L. Pirtle, S. Kalei Shotwell, Christopher N. Rooper

Funding year: 2015

Funding amount: $90,662

Status: ☐ Complete X Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete:

Reporting: Project results have not been reported.

A project results package will be provided to the Alaska Fisheries Science Center (AFSC) Habitat Conservation Division (HCD) in November, 2015 to support the five-year Essential Fish Habitat (EFH) update for the North Pacific Fishery Management Council (NPFMC). This product will include habitat suitability model results and maps that were developed for this project for a selection of Fishery Management Plan (FMP) groundfish species demersal life stages for the Gulf of Alaska (GOA) region. A final manuscript will be produced that describes the results of the groundfish habitat suitability models and maps. Products of this study will be incorporated into the stock-specific ecosystem considerations (SEC) section in the stock assessment reports (SAFEs) for these groundfish species. Model results may also be used to identify priority species for habitat assessment in the Habitat Assessment Prioritization process for the AFSC and the NPFMC (NMFS, 2011).

Results:

This study will refine basic EFH definitions for FMP groundfish species demersal life stages in the GOA region. Our objectives were to 1) conduct a literature synthesis of habitat requirements for focal species demersal life stages; 2) develop a set regional-based habitat metrics for the GOA that may inform EFH for these species; and 3) develop habitat suitability models and maps that describe the spatial extent of predicted suitable habitat for these species in the GOA region. The evaluation of these models with species data from multiple sources that go beyond the AFSC Resource Assessment and Conservation Engineering (RACE) Division GOA bottom-trawl (RACE GOA BT) survey for groundfish, combined with examining the contribution of a set of habitat metrics developed specifically for the GOA region, should allow for developing refined EFH descriptions for these FMP species.

Groundfish Species

Groundfish species included in the habitat suitability models for the GOA region were selected based on management priority and the potential for updated habitat information to improve assessment for those species. The focal species were sablefish (*Anoplopoma fimbria*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*G. chalcogrammus*), arrowtooth flounder (*Atheresthes stomias*), Northern rock sole (*Lepidopsetta polyxystra*), flathead sole (*Hippoglossoides elassodon*), Pacific ocean perch (POP) (*Sebastes alutus*), sharpchin rockfish (*S. zacentrus*), shortspine thornyhead (*Sebastolobus alaskanus*), Longnose skate (*Raja rhina*), and Big skate (*Raja binoculata*). Length-based breaks between demersal life-stages were established from the literature synthesis and expert advice (Table 1). At least two habitat suitability models were developed for each species, including one adult stage model and one juvenile stage model. However, for many species two juvenile-stage models were possible due to clear breaks between early juvenile and late juvenile stages.

Due to a paucity of occurrence data for certain species life stages, there was a need to compile sample locations from multiple sources and use those data in a presence-only modeling approach to develop predictive maps of suitable habitat. In addition, because some groundfish species and life stages occur in habitats that are not well-sampled by the RACE GOA BT survey, habitat suitability models for these species may be improved by going beyond this standardized survey as a sole source of sample locations. Catch and observation data were assembled for the models from fishery stock-assessment surveys and research programs that sampled marine habitats at coastal, inshore, and offshore locations on the continental shelf and slope of the GOA, using various gear types such as hand-jigging, beach and purse seines, bottom-trawls, and images from underwater visual assessment (Table 2).

Sample locations from static gear types were interpreted as the position of the survey vessel or the nearest point deeper than MLLW from shore-based gear. Sample locations from underwater visual surveys were the position of the survey vessel at the time of the observation. Sample locations from bottom-trawl surveys were the start position of the survey vessel during the on-bottom portion of the tow, which were corrected when possible based on the length of wire out, seafloor depth, and haul direction (*sensu* Rooper *et al.*, 2014).

Haul performance is characterized by the RACE GOA BT survey as successful, marginally-successful, or failed, based on the level of gear damage sustained from seafloor contact (Von Szalay *et al.*, 2010). Successful hauls do not sustain gear damage and provide an acceptable catch sample. Marginally-successful hauls are those with some gear damage, but where the damage was judged to not affect the catch. Failed hauls have extensive gear damage, or the damage was located in an area of the net where the catch was judged to be affected and would not be used for population estimates. Models that describe trawlable and untrawlable seafloor types in the GOA region based on RACE GOA BT survey haul locations and seafloor terrain metrics with multibeam acoustic seafloor scattering strength, demonstrate that successful hauls occurred in areas with different seafloor types than marginally-successful and failed hauls with gear damage (Pirtle *et al.*, 2015). Catch from successful and marginally-successful haul locations were included as focal species samples in the models. Because presence-only modeling requires species observations only, failed hauls with gear damage that contained focal species catch were also included as sample locations to incorporate observations from certain untrawlable habitat types encountered by the RACE GOA BT survey.

Habitat Metrics

Bathymetry data were compiled for the GOA region from a collection of hydrographic mapping surveys and digitized NOS smooth sheets for the GOA-IERP and used for the current project (Zimmermann and Benson, 2013; Zimmermann and Prescott, 2014a). This effort produced a collection of depth soundings of varied spatial resolution (100-3000 m apart) across the GOA study area. These point data were gridded using spatial interpolation to produce a smoothed bathymetry raster surface, using natural neighbor interpolation (ArcGIS 10.2.1, ESRI). Areas of land were removed using a mask (Alaska DNR coastline) and the surface was clipped to the 1000 m depth contour, the seaward extent of the species data available to model. The gridded bathymetry surface and other derived habitat metrics were produced as 100 m^2 resolution raster grids projected in the North American Datum 1983, Alaska Albers equal-area conic projection (NAD 1983 AK Albers EAC) with the following spatial extent: Top 1284578.22 m, Right 1376749.02 m, Bottom 466178.22 m, and Left -563950.98 m.

Seafloor Terrain

Habitat predictor variables were developed to describe habitat for the focal groundfish species demersal life stages in the GOA region. Depth was used directly from the gridded bathymetry data and several terrain metrics were derived from the bathymetry surface that describe attributes of seafloor morphology in the GOA study area. Seafloor terrain metrics were derived using neighborhood-based terrain analysis methods that were applied in ArcGIS, using the extensions DEM Surface Tools (Jenness, 2013) and Benthic Terrain Modeler (Wright *et al.*, 2012). All metrics used a 3x3 neighborhood of grid cells (1-central cell and 8-neighbors), with the exception of bathymetric position index (BPI) that requires a circular neighborhood around a central cell (Guisan *et al.*, 1999). The following seafloor terrain metrics were included as habitat predictor variables.

Slope: Seafloor slope is the rate of change in bathymetry over a defined area (Horn, 1981).

Aspect: Aspect identifies the orientation of the maximum value of slope, the rate of change in bathymetry from each cell to its neighbors. The output value of aspect derivation is angular compass direction. Aspect can be decomposed into sine (east-west; eastness) and cosine (north-south; northness) components of the compass angles that can be used as predictor variables in models. Aspect eastness and northness were derived from the aspect surface. Aspect can be a proxy for current flow over and around seafloor terrain features (Wilson *et al.*, 2007). Indices of current flow may describe spatial variation in larval fish settlement to benthic habitats and prey delivery for demersal species.

Curvature: Curvature is the second derivative of the bathymetry surface, the slope of the slope (Schmidt *et al.*, 2003). Curvature highlights concave and convex slopes and defines sloping terrain along features. Two metrics of curvature were derived including profile and plan curvature. Profile curvature is parallel to the maximum direction of slope. Plan curvature is perpendicular to the maximum direction of slope. Curvature is another proxy for current flow over and around seafloor features. For example, concave areas may provide refuge from high current and convex areas may direct current flow (Dolan *et al.*, 2008).

Bathymetric Position Index: BPI is the equivalent of topographic position index, which describes the elevation of one location relative to the mean of neighboring locations (Guisan *et al.*, 1999). BPI will emphasize features that are shallower or deeper than the surrounding area, such as ridges and valleys and abrupt changes in slope. BPI is derived from a circular neighborhood around a central cell. BPI can be derived at several spatial scales to highlight terrain features of different scale. BPI was derived from the GOA bathymetry data using 0.3, 0.5, 0.9, 1.7, 3.3, and 6.5 km-radius neighborhoods that represent fine, medium, and broad-scale terrain features, respectively (Figures 1-2). BPI at more than one spatial scale will be correlated when combined in a predictive model. The optimal scale of BPI for each species demersal life stage was selected during model tuning and evaluation.

Due to the multi-resolution nature of the bathymetry data set, metrics of terrain complexity, such as rugosity and seafloor ruggedness were derived and used in exploratory modeling but were not included in the final modeling process.

Seafloor Substrate

Seafloor substrate data were compiled for the GOA region from a collection of sediment samples and rocky feature locations. Sediment data with multiple attributes, such as mean grainsize was compiled by the US Geological Survey (USGS) for the GOA-IERP and used for the current project (USGS, usSEABED). Rocky features and sediments were digitized from NOS smooth sheets during bathymetry data processing for the GOA and Cook Inlet (Zimmermann and Prescott, 2014a; Zimmermann and Prescott, 2014b). Additional rocky features were available from sediment data processing by USGS. These substrate data sets have the following spatial extent, which is smaller than the extent of the GOA region bathymetry data: Top 1284603.03 m, Right 1221116.37 m, Bottom 691403.04 m, and Left -132483.62 m (NAD 1983 AK Albers EAC). Although the substrate data do not cover the full extent of the bathymetry data and other derived habitat predictors developed for the GOA region, a substrate predictor variable was included in the habitat models because of the potential to improve suitable habitat predictions for the focal groundfish species.

Most available seafloor substrate data for the GOA region were collected using grabs and cores that were designed to extract samples of unconsolidated, fine-grainsize sediments. These traditional methods likely under-sample areas with rocky substrate, such as rock ridge and grainsizes larger than small cobbles (6.5-25.5 cm) (Wentworth, 1922). Substrate information from non-traditional sources may improve understanding of the spatial extent of certain rocky substrate types in the GOA region. Underwater image locations from visual assessment surveys conducted by AFSC ABL MESA (e.g., Stone and Brown, 2005) and RACE (Pirtle *et al.*, 2015) were characterized for the purpose of this study as rocky, based on the presence of rock ridge or mixed grainsizes larger than coarse gravel (>2 cm), or non-rocky, and included as substrate feature locations. RACE GOA BT survey hauls that incurred gear damage from seafloor contact were included as locations where rocky features were encountered by the survey, using the corrected start and end positions of the on-bottom portion of the tows. In addition, the RACE GOA BT survey selects bottom-trawl haul locations at stations within survey strata, using a grid of 5x5 km cells that is populated with qualitative information about the seafloor relative to conducting a successful haul based on past survey experience at those locations. Grid cells that indicate the presence of rocky features (e.g., pinnacles, snags, rocky) were added to the substrate data set for the GOA region, using the centroids of those cells.

A substrate predictor variable was developed for the GOA region groundfish habitat suitability models that represented a continuous gradient from areas with rocky substrate to areas without rocky substrate (Figure 3). This surface was based on a combination of rocky features and sediment attributes that represented rocky seafloor types, including percent gravel (50-100%), rock membership ($\geq$1), and sheer stress ($\geq$2.9), and sediment attributes that represented locations without rock (the opposite of the rocky attribute selection). Although this surface was not comprehensive to all rocky and non-rocky areas in the GOA, the data were useful to represent spatial trends of relative substrate rockiness in the GOA seafloor landscape. For example, known rocky areas such as the continental shelf near Cape Ommaney and the Fairweather Grounds were represented. Areas with high occurrence of glacial drop-stones of varied grainsize from gravel to large boulders, including the continental shelf off of the Kenai Fjords, Icy Bay and Yakutat Bay were also represented. Because many groundfish species tend to associate with rocky structure or do not, or associate with mixed substrate types in proximity to rock, this substrate classification should be useful to predict patterns of habitat suitability influenced by relative seafloor rockiness for focal groundfish species.

Biogenic Structure

Structure-forming invertebrate presence and absence were modeled for the GOA region using generalized additive models for upright sponges, corals, and sea whips (Figure 4). Data for the models were invertebrate bycatch observations from the RACE GOA BT survey for groundfish and regional-based habitat predictors (e.g., Rooper *et al.*, 2014). Models were produced for each structural invertebrate group and the output surfaces were used as habitat metrics for the GOA region groundfish habitat models. Structure-forming invertebrates provide biogenic habitat for groundfish species with an affinity for structure or co-occur with groundfish species in certain habitat types (Stone *et al.*, 2005; Tissot *et al.*, 2006). Structure-forming invertebrate presence may also be a proxy for the presence of rocky substrate required for attachment by sponges and corals or fine-grainsize sediments preferred by sea whips, in addition to other biophysical attributes of the GOA environment.

Biophysical Environment

Bottom Temperature: The Regional Ocean Modeling System (ROMS) was adapted for the GOA with 3 km horizontal resolution and 30 vertical levels (Dobbins *et al.*, 2009; Hermann *et al.*, 2009). Bottom temperature values (°C) from May-September 1996-2011, were extracted from the deepest (closest to the seafloor) depth bin at each point of the ROMS 3 km grid and averaged to produce a gridded (natural neighbor interpolation) climatology surface of mean modeled bottom temperature for the GOA region (Georgina Gibson, UAF) (Figure 5).

Productivity: Primary productivity data were collected for the US GLOBEC program in the central GOA region and adapted to a regional lower trophic level ecosystem model (GOANPZ) embedded in the ROMS 3 km model (Coyle *et al.*, 2012). Primary productivity values (mg C m^{-3} d^{-1}) from 1996-2011, were extracted from the surface layer at each point of the ROMS 3 km grid and averaged to produce a gridded climatology surface of mean modeled primary productivity for the GOA region (Ken Coyle, UAF).

Bottom Current Speed: Bottom current speed values (m s^{-1}) were extracted from the deepest depth bin at each point of the ROMS 10 km grid and averaged to produce a gridded climatology surface of mean modeled bottom current speed for the GOA region (Chris Rooper, AFSC; *sensu* Rooper *et al.*, 2014).

Tidal Current Speed: Tidal current speed maximum values (cm s^{-1}) were modeled for each RACE GOA BT survey haul location over a 1-year cycle, to produce a gridded surface of maximum modeled tidal current speed for the GOA region (Chris Rooper, AFSC; *sensu* Rooper *et al.*, 2014)

Model Methods

MaxEnt Presence-only Models

Maximum Entropy Modeling (MaxEnt) for presence-only response data was applied to generate habitat suitability models for groundfish species demersal life stages in the GOA region. MaxEnt is a predictive modeling method that uses presence-only species occurrence data with environmental variables to derive potential suitable habitat or probability of species occurrence (Phillips *et al.*, 2006; Elith *et al.*, 2011). MaxEnt begins the model-building process with a uniform distribution of probability values over predictor space, the species occurrence locations, and a random sample of background points. Model fit is iteratively improved through a random-walk optimization routine to produce a final output that can be mapped to visually represent the spatial extent of the predicted probability of suitable habitat for the study area.

MaxEnt uses certain parameter settings that control model complexity and the relationships of the predictor variables in the model. MaxEnt uses a regularization multiplier β that will control model complexity and adjust the relative emphasis of sample locations. This is a smoothing function, where higher values result in simpler models with fewer parameters and lower values will result in more complex models that may lead to overfitting. The default value for β is 1 (Phillips *et al.*, 2006). MaxEnt defines the relationships of the predictor variables in the model, using relationship classes called feature types. MaxEnt will model the predictors in raw form, and then model the predictors for the specified feature types as separate parameters, and choose the most appropriate relationship for each predictor during the model iteration process. Feature types include linear and quadratic features (LQ) (linear coefficients and squared predictor values), hinge features (H) (combined linear and step functions), product features (P) (product of two variables), and threshold features (T). The default setting is an automatic selection process among all user-specified feature-types (e.g., LQHPT) (Phillips *et al.*, 2006). Although MaxEnt was designed as a machine-learning method, the process may be guided through stepwise tuning and evaluation stages to optimize predictor variables and parameter settings (Warren and Siefert, 2011).

Model Tuning and Evaluation

MaxEnt models of groundfish habitat suitability were developed separately for each focal species demersal life stage, using available species occurrence data and the habitat predictor variables developed for the GOA region. Two sets of models were produced because the spatial extent of the substrate data was less than the other habitat metrics. These included models produced using all habitat metrics with the bathymetry data extent (habitat suitability models; HSM) and models produced with a reduced spatial extent using all habitat metrics and substrate rockiness (HSM with substrate).

MaxEnt models were implemented in R, using the dismo and raster packages (R Core Team) (Hijmans *et al.*, 2014a; Hijmans *et al.*, 2014b). Species observations were partitioned into training and test data sets (70% and 30% of observations) and applied to each model iteration (*n*

= 1,000) over randomly selected background locations from the habitat predictor variables (*n* = 100,000). The GOA models for each species demersal life stage were developed and evaluated in three stages, to select the optimal spatial scale of the terrain metric BPI, the value of regularization multiplier β, and feature types, using the Akaike Information Criterion for small sample sizes (AICc).

The following parameter levels were evaluated: BPI-scale (0.3, 0.5, 0.9, 1.7, 3.3, and 6.5 km); β (0.5, 1, 1.5, 2, 2.5, and 3), and feature types (LQ, H, LQH, LQHP, and LQHPT). One model and a prediction map were produced for each spatial scale of BPI, using the default value for β (1) and automatic feature selection with all possible types. BPI-scale was selected for the final model by extracting the prediction values from the output grid, calculating the log likelihood for each grid cell value, determining the number of parameters used by the models, calculating AICc, and selecting the scale of BPI that corresponded to the model with the smallest AICc value. This process was repeated in the next stage to select the value of β, using the BPI-scale that was selected from the first stage and automatic feature selection. Feature types were selected, using the BPI-scale and value of β that were selected from the previous stages.

Final models were produced using k-fold crossvalidation ($k = 5$) of the best combination of parameters determined from step-wise selection. Model fit was evaluated using the area under the receiver operating characteristic curve (ROC) (AUC), where sensitivity is the proportion of presences correctly predicted and specificity is the proportion of absences correctly predicted by the model. The AUC value ranges from 0-1, where values ≥ 0.7 was considered acceptable, ≥ 0.8 was good, and ≥ 0.9 was excellent (Hosmer and Lemeshow, 2005). Jackknife analysis was applied to determine habitat predictor variables with the greatest contribution to the final models, using models with individual metrics and models with a combination of all metrics. A threshold value that represented equal training sensitivity and specificity was used to evaluate the predicted suitable ranges of habitat predictor variables.

Habitat Suitability Maps

Maps were produced from the output of the final model replicates for each set of models (HSM and HSM with substrate) that represented the mean and standard deviation (SD) of the predicted probability of suitable habitat for the GOA study area. Final maps were produced, where overlapping areas from the HSM and HSM with substrate models were averaged to produce a mosaic of the mean predicted probability of suitable habitat for each species demersal life stage. Final surfaces were displayed on a continuous scale (0-1), where highly suitable habitat is represented by values close to 1 and habitat of low predicted suitability by values close to 0. A mosaic of the SD of the mean probability of suitable habitat was also produced, and displayed on a continuous scale that highlighted variation in areas of relative uncertainty in the replicated model results.

Results

Habitat suitability model results are presented for two species as examples, including early juvenile stage sablefish and sharpchin rockfish adults.

Sablefish (*Anoplopoma fimbria*)

The size range of early juvenile sablefish in the models was 150-399 mm FL, which encompasses the stage from settlement through residence in nursery habitats. Sablefish catch locations were included from inshore surveys that used several gear types, the RACE GOA BT survey for groundfish, and the AFSC Auke Bay Laboratories (ABL) Marine Ecology and Stock Assessment (MESA) sablefish tagging program (Figure 6).

An annual sablefish tagging program is conducted by AFSC ABL MESA and has been ongoing from 1972-present (AFSC ABL MESA, 2015). As part of this program, juvenile sablefish in southeast Alaska were captured by jigging, tagged, and released on site (1985-present). This data set represents an exclusive source of occurrence records for sablefish juvenile stages. Additional sample locations from the central and western GOA were added by the program in 2015. These new locations will be included in the next iteration of the sablefish early juvenile stage model.

Habitat Suitability Model

Parameters selected based on AICc as a result of model tuning and evaluation were bathymetric position index (BPI) at a spatial scale of 6.5 km, β = 3, and the following feature types: linear and quadratic (LQ); hinge (H); product (P); and threshold (T).

A total of n = 760 presence records were included in the model with n = 531 used for training and n = 227 used for testing. Model distribution was determined from n = 100,301 point locations from the spatial extent of the habitat predictor variables.

Final model results were averaged over replicate model runs (k = 5) (Test AUC = 0.81 ± 0.02 (mean ± SD)) (Figure 7). Habitat predictor variables with the greatest contribution to replicated models to predict sablefish early juvenile stage habitat, included tidal current speed (30.2%), bottom temperature (21.3%), sponge presence (11.1%), depth (10.2%), coral presence (9.2%), and BPI (6.5 km) (8%). The contribution of other habitat metrics was minimal (< 5%).

Habitat metrics with the greatest contribution to describe sablefish nursery habitat included lower maximum tidal speeds, mean bottom temperature (May-September) (5.9-9.9 °C), sponge and coral absence, depth (9-286 m), and BPI (6.5 km) (bathymetric lows) (Figure 8).

Habitat Suitability Model with Substrate

Parameters selected based on AICc as a result of model tuning and evaluation were BPI at a spatial scale of 1.7 km, β = 3, and feature types = LQHPT.

A total of n = 581 presence records were included in the model with n = 406 used for training and n = 173 used for testing. Model distribution was determined from n = 100,105 point locations from the extent of the habitat predictor variables.

Final model results were averaged over replicate model runs (k = 5) (Test AUC = 0.81 ± 0.02) (Figure 7). Habitat predictor variables with the greatest contribution to models that included seafloor substrate to predict sablefish early juvenile stage habitat were bottom temperature (29.7%), tidal speed (27.2%), bottom current speed (8.4%), sponge presence (7.3%), whip presence (7.1%), substrate rockiness (5.2%), and BPI (1.7 km) (4.7%). The contribution of other habitat metrics was minimal (< 4%).

Habitat metrics with the greatest contribution to describe sablefish nursery habitat for models with seafloor substrate, included mean bottom temperature (May-September) (6.1-9.6 °C), lower maximum tidal speeds, lower bottom current speeds, sponge and whips absent, and low-lying areas with low occurrence of rocky substrate features (Figure 9).

A mosaic of the mean probability of suitable habitat from the final model surfaces is displayed on a continuous scale (0-1), where highly suitable habitat is represented by values close to 1 and habitat of low predicted suitability by values close to 0 (Figure 10). A mosaic of the SD of the mean probability of suitable habitat highlights areas of variation in the replicated model results with a range of 0-0.25 (Figure 11). Areas of suitable habitat in Kiliuda Bay on Kodiak Island are highlighted by the map inset, including the main channels of the bay and other inshore areas on the continental shelf.

The model results for early juvenile stage sablefish, demonstrate that lower current speeds and bottom-temperature were important to describe habitat for this species. Overall model fit was not improved by adding substrate as a habitat predictor. However, the addition of substrate reduced the role of depth and broad-scale BPI in the models. Biogenic habitat metrics were among the most descriptive predictors in models with and without substrate and may have reduced the importance of substrate alone to describe habitat for this life stage. Early juvenile stage sablefish habitat is predicted to occur within a depth range of 9-286 m, including coastal, inshore, and continental shelf areas such as channels and bays with lower current speeds and reduced occurrence of biogenic and rocky structure.

Sharpchin Rockfish (*Sebastes zacentrus*)

The size range of adult sharpchin rockfish included in the models was >250 mm FL. Underwater video and optical images from surveys using a submersible, ROVs, and drop-cameras were useful to provide observations for this species that may not be well-sampled by the RACE GOA BT survey for groundfish. Adult sharpchin rockfish presence locations in the models were observations from underwater images and catch locations from inshore surveys in the GOA and the RACE GOA BT survey for groundfish (Figure 12). RACE GOA BT survey haul locations with adult sharpchin rockfish catch included 297 successful and marginally-successful hauls, and an additional 68 hauls that were characterized by the survey as marginally-successful (55) or failed (13) due to gear damage from contact with the seafloor.

Habitat Suitability Model

Parameters selected based on AICc as a result of model tuning and evaluation were bathymetric position index (BPI) at a spatial scale of 6.5 km^2, regularization multiplier (β) = 1.5, and features = linear (L), quadratic (Q), hinge (H), product (P), and threshold (T).

A total of n = 566 presence records were included in the model with n = 452 used for training and n = 114 used for testing. Model distribution was determined from n = 100,171 point locations from the spatial extent of the habitat predictor variables.

Final model results were averaged over replicate model runs (k = 5) (Test AUC = 0.89 ± 0.01) (Figure 13). Habitat variables with the greatest contribution to replicated models, included depth (33.1%), sponge presence (19.6%), whip presence (19%), BPI (6.5 km) (14.6%), and bottom current speed (5.2%). The contribution of other habitat metrics was minimal (< 5%).

Habitat metrics with the greatest contribution to describe adult sharpchin rockfish habitat suitability were depth (136-410 m), sponges present, whips absent, bathymetric highs in the seafloor landscape, and lower bottom current speeds (Figure 14).

Habitat Suitability Model with Substrate

Parameters selected based on AICc as a result of model tuning and evaluation were BPI at a spatial scale of 1.7 km, $\beta = 2$, and features = LQHPT.

A total of $n = 468$ presence records were included in the model with $n = 374$ used for training and $n = 94$ used for testing. Model distribution was determined from $n = 100{,}719$ point locations from the spatial extent of the habitat predictor variables.

Final model results were averaged over replicate model runs ($k = 5$) (Test AUC = 0.92 ± 0.01) (Figure 13). Habitat predictor variables with the greatest contribution to models that included seafloor substrate to predict adult sharpchin rockfish habitat were sponge presence (28.8%), depth (25%), whip presence (20.3%), substrate rockiness (6.9%), BPI (1.7 km) (4.4%), and bottom current speed (4.4%). The contribution of other habitat metrics was minimal (< 4%).

The model results for adult sharpchin rockfish describe suitable habitat as broad-scale bathymetric rises with rocky substrate and sponges present in areas with lower bottom current speeds, occurring at depths between 132-414 m along the continental shelf and upper slope (Figure 15). Overall model fit was improved with the addition of substrate rockiness, whereas the contribution of BPI was reduced. The spatial scale of BPI decreased with the addition of substrate.

A mosaic of the mean probability of suitable habitat from the final model surfaces is displayed on a continuous scale (0-1), where highly suitable habitat is represented by values close to 1 and habitat of low predicted suitability by values close to 0 (Figure 16). A mosaic of the SD of the mean probability of suitable habitat highlights areas of variation in the replicated model results with a range of 0-0.22 (Figure 17). Areas of suitable habitat near Cape Ommaney are highlighted by the map inset, an area known for rocky substrate features.

Timeline

November, 2015: Project results package provided to AFSC HCD to support the five-year EFH update for NPFMC.

May, 2016: Final manuscript complete.

TBD, 2016: Incorporate project results into the stock-specific ecosystem considerations (SEC) section in the SAFEs for these groundfish species. Model results may also be used to identify priority species for habitat assessment in the Habitat Assessment Prioritization process for the AFSC and the NPFMC.

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Table 1: FMP groundfish species and demersal life stages for the GOA region, where a presence-only habitat suitability model was developed. Life stage breaks are provided between stages (mm).

Species	Early juveniles	Late juveniles	Adults
Sablefish *Anoplopoma fimbria*	≤ 390	391-550	>550
Walleye pollock *Gadus chalcogrammus*	≤ 140	141-370	>370
Pacific cod *Gadus macrocephalus*	≤ 150	151-420	>420
Northern rock sole *Lepidopsetta polyxystra*	≤ 140	141-300	>300
Flathead sole *Hippoglossoides elassodon*	≤ 140	141-290	>290
Arrowtooth flounder *Atheresthes stomias*	≤ 160	161-350	>350
Pacific ocean perch *Sebastes alutus*	≤ 200	201-250	>250
Sharpchin rockfish *Sebastes zacentrus*	-	≤ 250	>250
Shortspine thornyhead *Sebastolobus alaskanus*	-	≤ 210	>210
Longnose skate *Raja rhina*	-	≤ 1020	>1020
Big skate *Raja binoculata*	-	≤ 1250	>1250

Table 2: Catch and observation data sources for groundfish species demersal life stages that were used in presence-only habitat suitability models for the GOA region, including survey; location with GOA sub-region (western (w), central (c), eastern (e), and all (a)) and marine province; gear type; and sample dates included.

Survey	Location	Gear Type	Dates Included
NOAA AFSC ABL, Fish Atlas, inshore surveys to characterize habitat of FMP fish species	aGOA, coastal, inshore	beach seine (3.2-32 mm mesh)	1998-2012
GOA-IERP, inshore fish surveys, targeting sablefish, Pacific cod, pollock, sablefish, arrowtooth flounder, POP, and forage fish	aGOA, coastal, inshore, continental shelf	beach and purse seines, bottom and mid-water trawls, jigging	2011-2012
NOAA AFSC ABL MESA, sablefish tagging program and supplemental studies (Rutecki and Varosi, 1997)	eGOA, inshore	jigging	1985-2014
Alaska Department of Fish and Game (ADFG), small mesh bottom-trawl survey for shrimp and forage fish	ceGOA, inshore, continental shelf	small-mesh bottom-trawl (3.2 cm mesh)	1989-2005
NOAA AFSC RACE and ADFG, joint small mesh bottom-trawl survey for shrimp and forage fish	ceGOA, inshore, continental shelf	small-mesh bottom-trawl (3.2 cm mesh)	2005-2012
NOAA AFSC RACE, GOA biennial bottom-trawl survey for groundfish	aGOA, inshore, offshore, continental shelf and slope	bottom-trawl (3.2-12.7 cm mesh, bobbin rollers)	1993-2013
NOAA AFSC ABL (Carlson *et al.*, 1982), Southeast Alaska survey of demersal marine life	eGOA, inshore, continental shelf	bottom-trawl (varied mesh)	1969-1981
NOAA AFSC ABL (Rutecki and Haynes, 1989), Prince William Sound survey of demersal marine life	cGOA, inshore, continental shelf	bottom-trawl (varied mesh)	1989
NOAA AFSC ABL and RACE, underwater visual surveys of demersal groundfish and habitat resources	aGOA, offshore, continental shelf and slope	*Delta* submersible and deployed camera systems	2005, 2011-2012

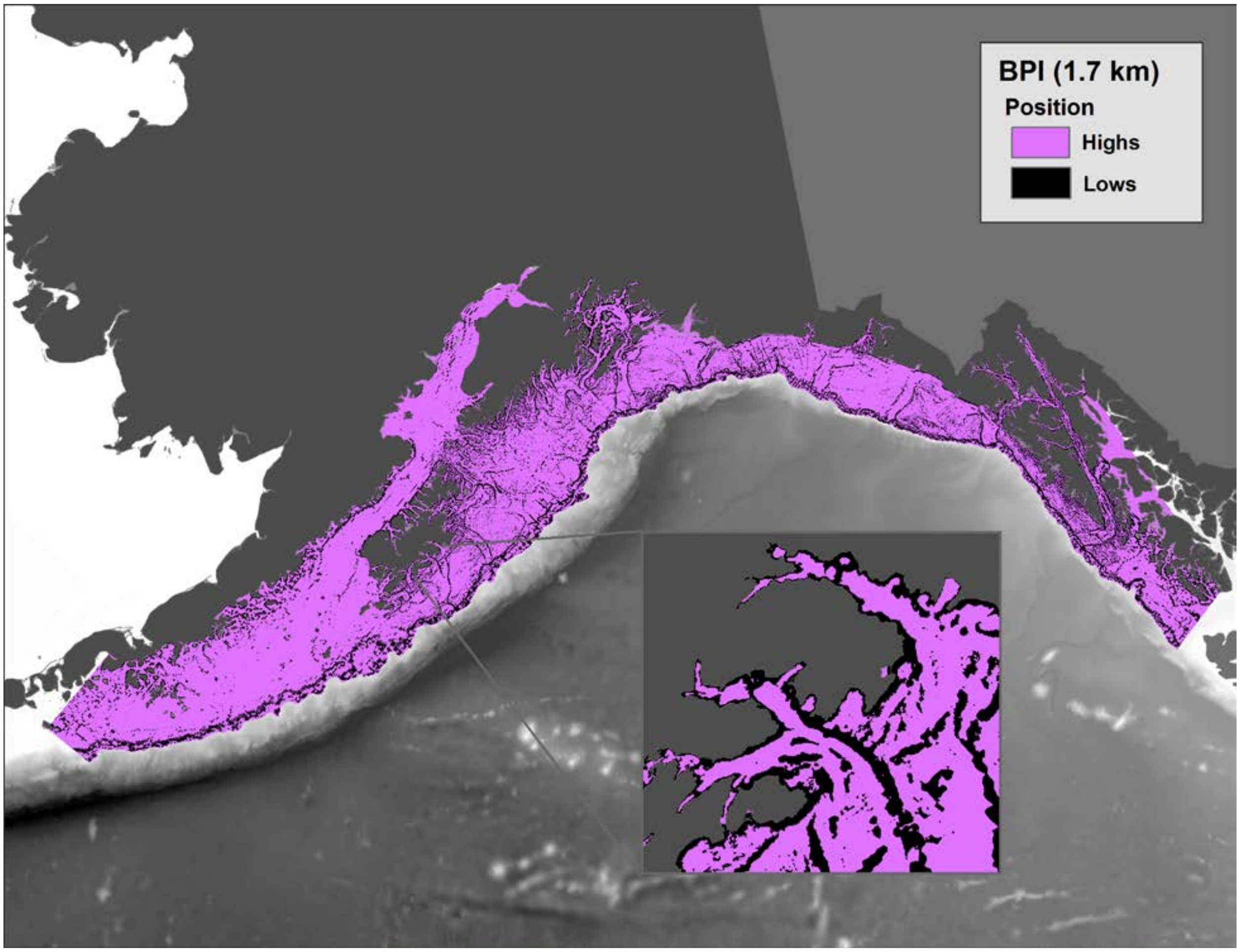

Figure 1: Bathymetric position index (BPI) (1.7 km) derived from gridded bathymetry data (100 m^2) with Kodiak Island inset showing variation in bathymetric highs (black) and lows (pink) within fjords on the continental shelf with post-glacial sills and troughs.

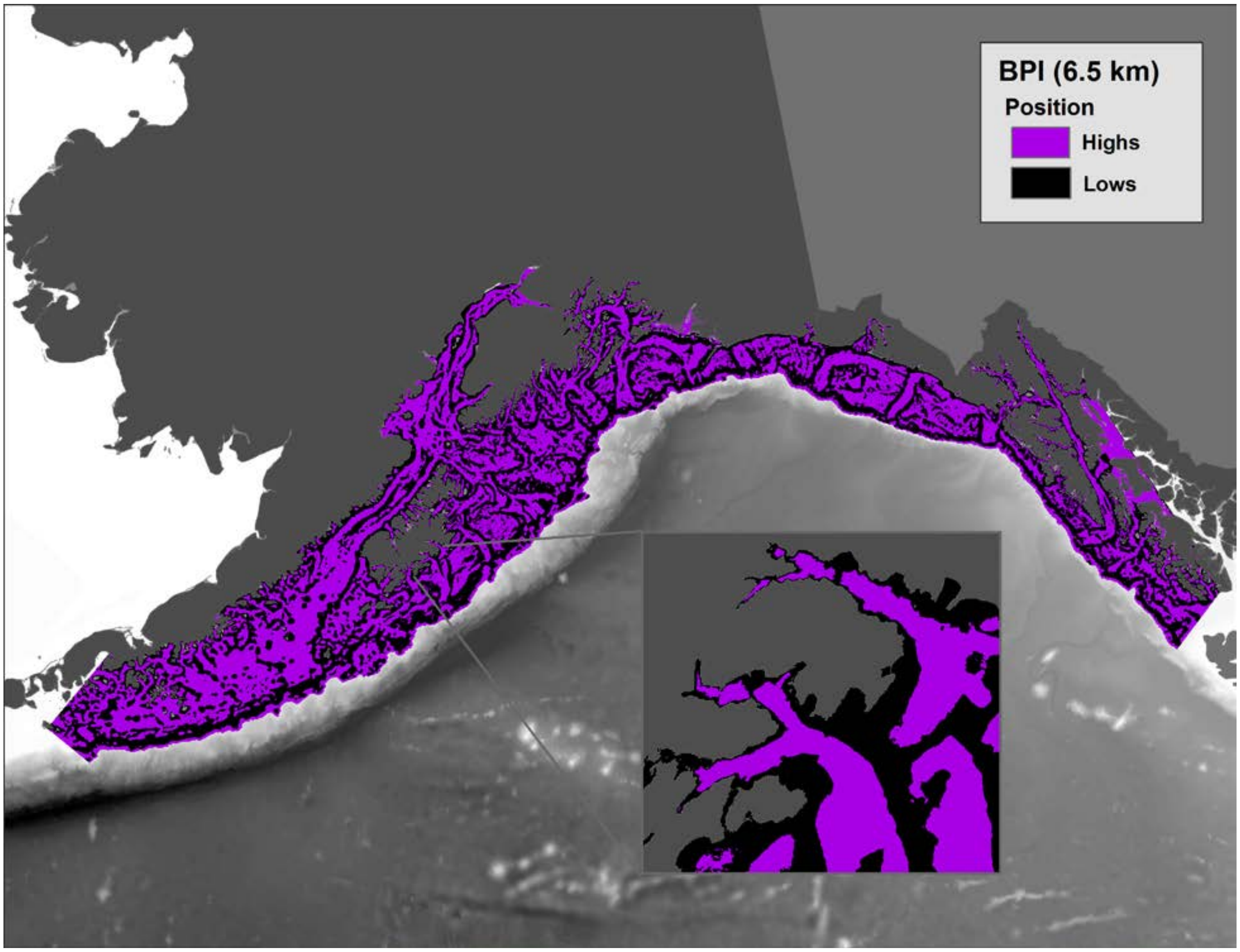

Figure 2: Bathymetric position index (BPI) (6.5 km) derived from gridded bathymetry data (100 m^2) with Kodiak Island inset showing variation in bathymetric highs (black) and lows (pink) within fjords on the continental shelf with post-glacial sills and troughs.

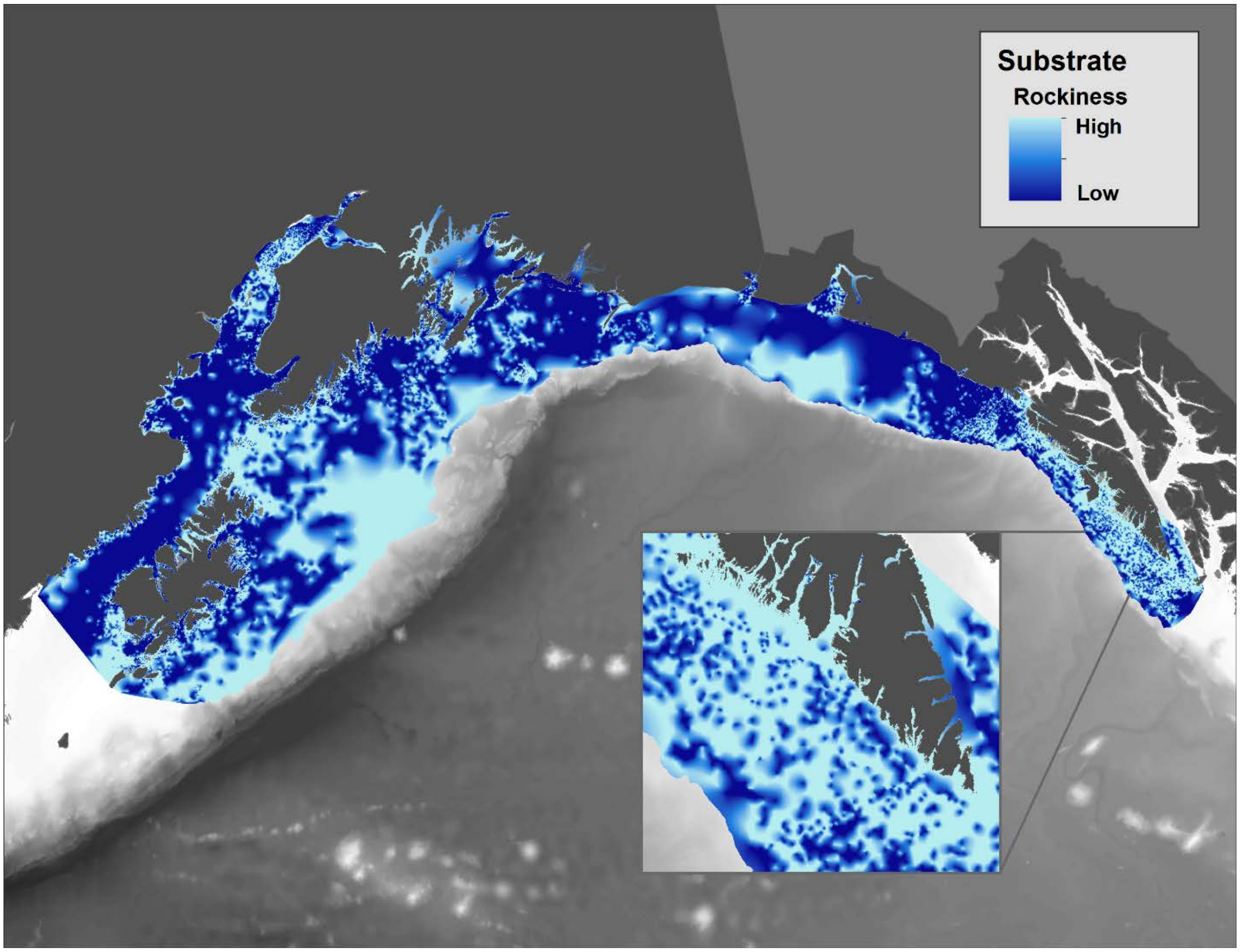

Figure 3: Substrate rockiness (100 m^2) derived from attributes of sediment and substrate data for the GOA region with Cape Ommaney inset showing areas with high presence of rocky substrate features (light blue) and low presence of rocky features (dark blue) on a continuous scale.

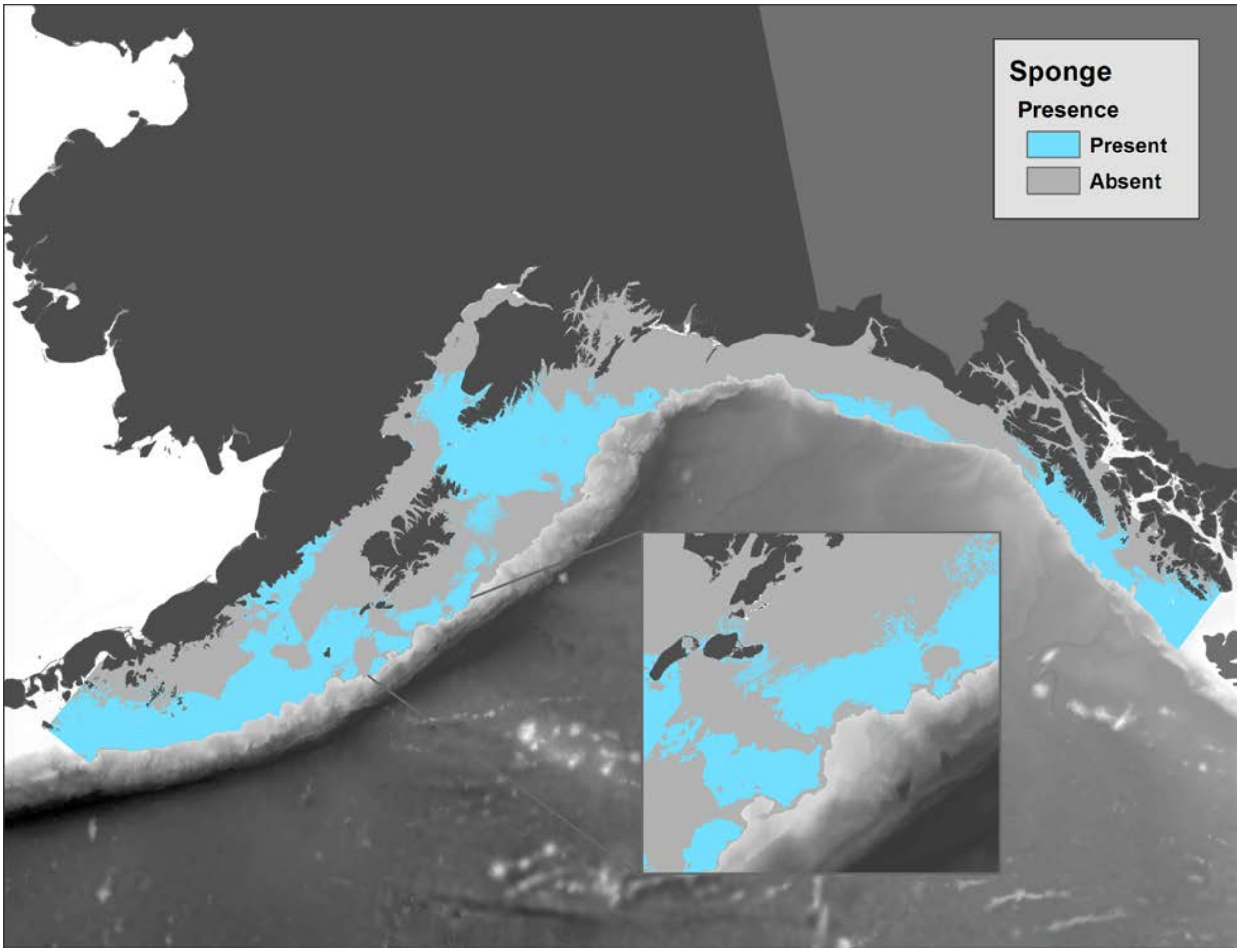

Figure 4: Sponge presence (blue) and absence (gray) for the GOA study area predicted from a generalized additive model using upright sponge bycatch observations from the AFSC bottom-trawl survey for groundfish and regional-based habitat predictors. An inset of the continental shelf south of Kodiak Island provides greater detail.

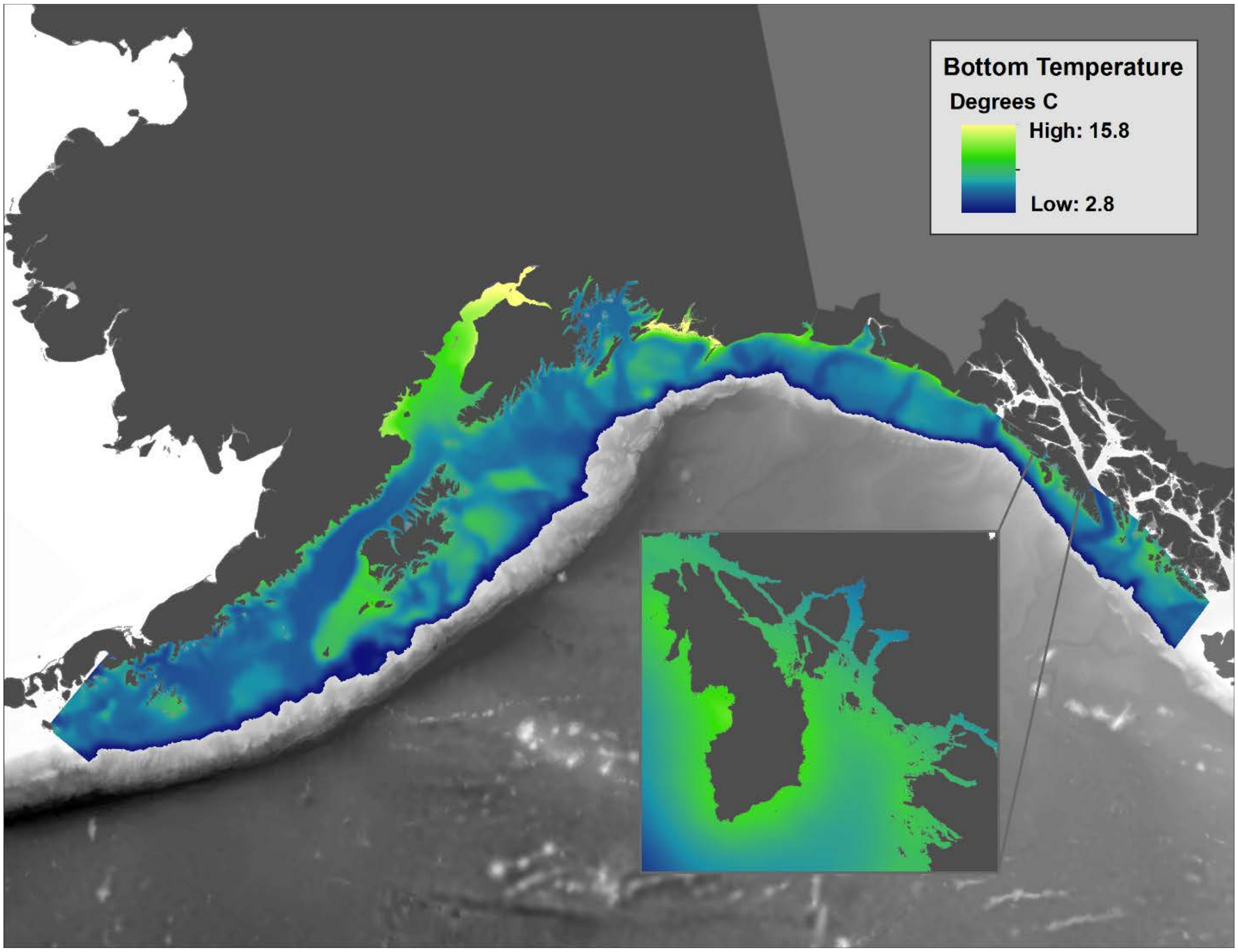

Figure 5: Bottom temperature (°C) long-term average, during May-September from the ROMS 3 km model, displayed on a continuous scale from high (yellow) to low (dark blue) values with a detail inset for Sitka Sound in the eastern GOA.

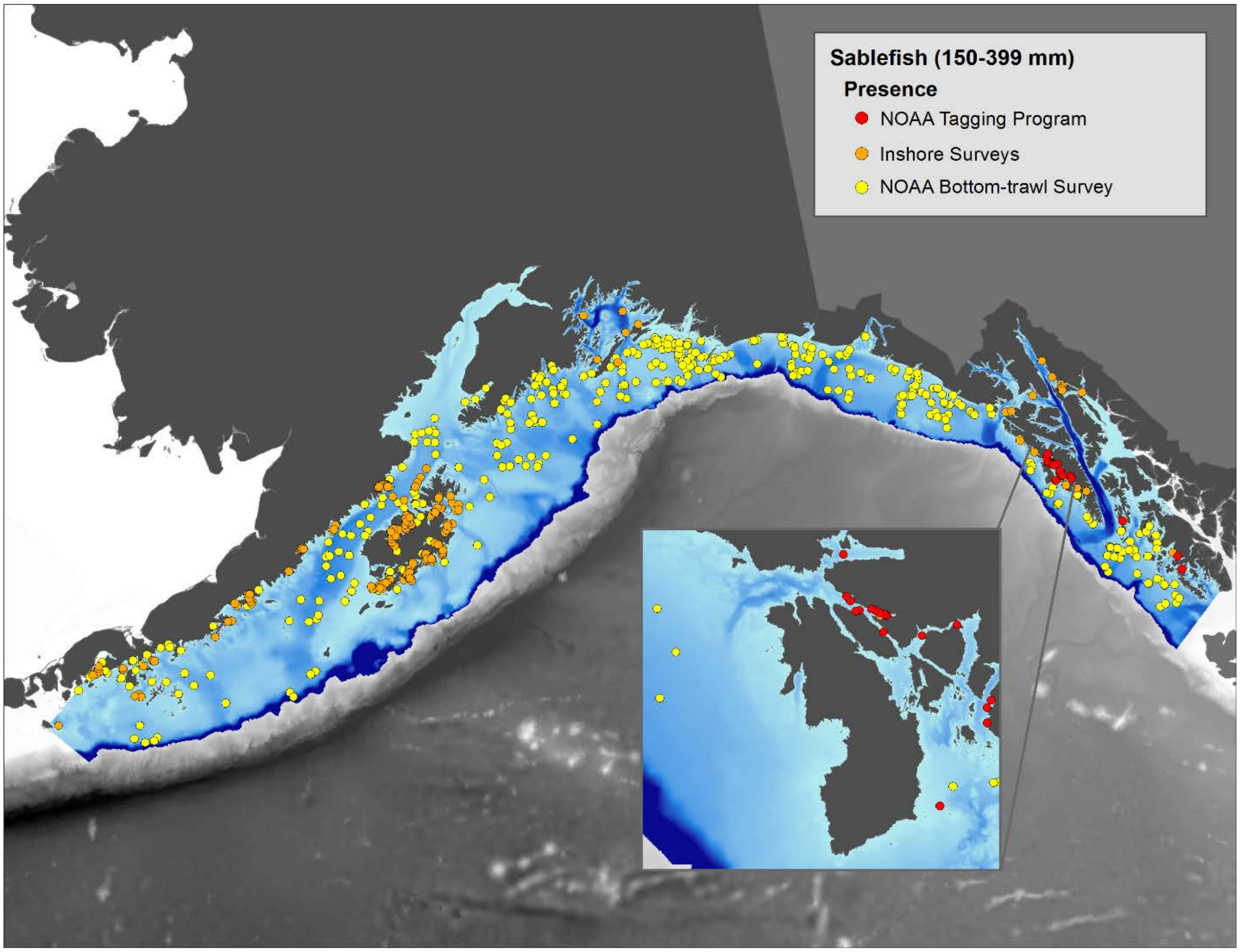

Figure 6: Sablefish presence locations for the demersal settlement stage and early stage juveniles resident in nursery areas (150-399 mm). Catch locations from NOAA AFSC sablefish tagging program are shown in red, other inshore surveys are shown in orange, and locations from the NOAA AFSC bottom-trawl survey for groundfish are shown in yellow. Catch location detail for the continental shelf and bays near Sitka Sound in the eastern GOA are highlighted by the inset.

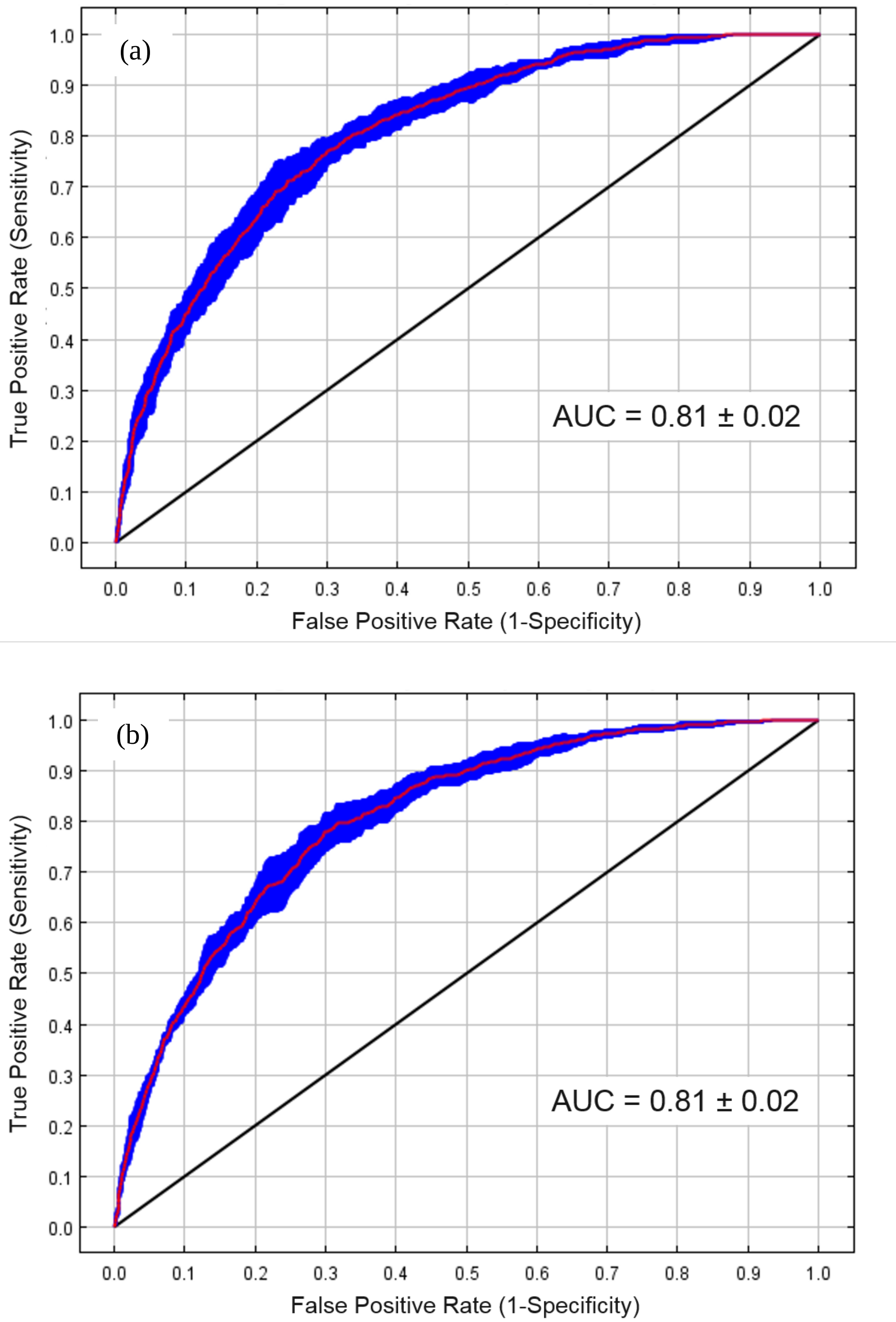

Figure 7: Receiver operating characteristic (ROC) curves for sablefish early juvenile stage habitat suitability models, using k-fold crossvalidation of model replicates (k = 5). Including, a) habitat suitability models (AUC test = 0.81 ± 0.02 (mean ± SD)) and b) habitat suitability models with substrate (AUC test = 0.81 ± 0.02).

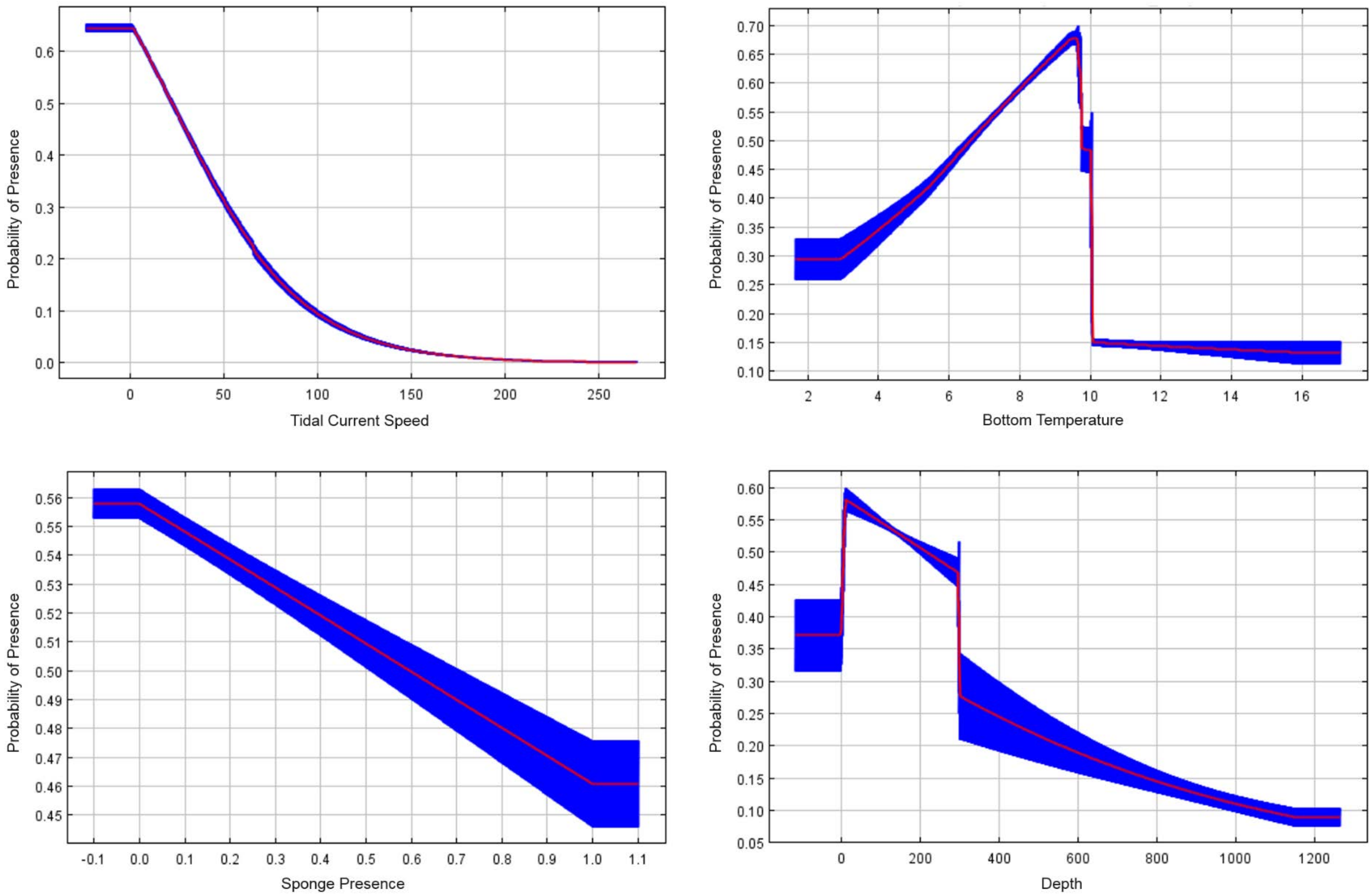

Figure 8: Response (mean ± SD) of the four most influential habitat metrics in replicated models to predict sablefish early juvenile stage habitat suitability in the GOA, including (clockwise from top left) tidal current speed (maximum), bottom temperature (long-term mean May-September), sponge presence, and depth.

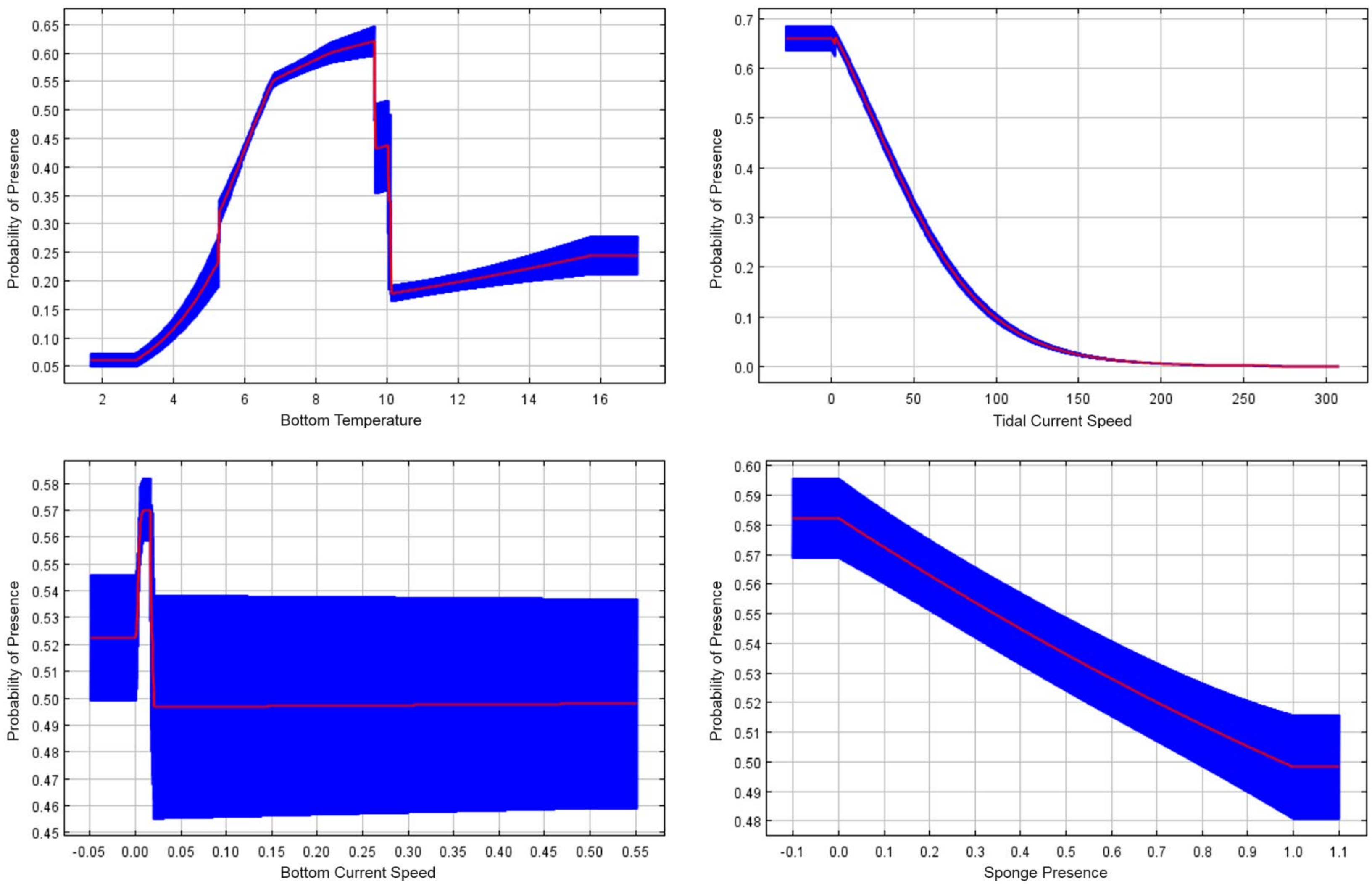

Figure 9: Response (mean ± SD) of the four most influential habitat metrics in replicated models that included substrate rockiness as a metric to predict sablefish early juvenile stage habitat suitability in the GOA, including (clockwise from top left) bottom temperature (long-term mean May-September), tidal current speed (maximum), bottom current speed, and sponge presence.

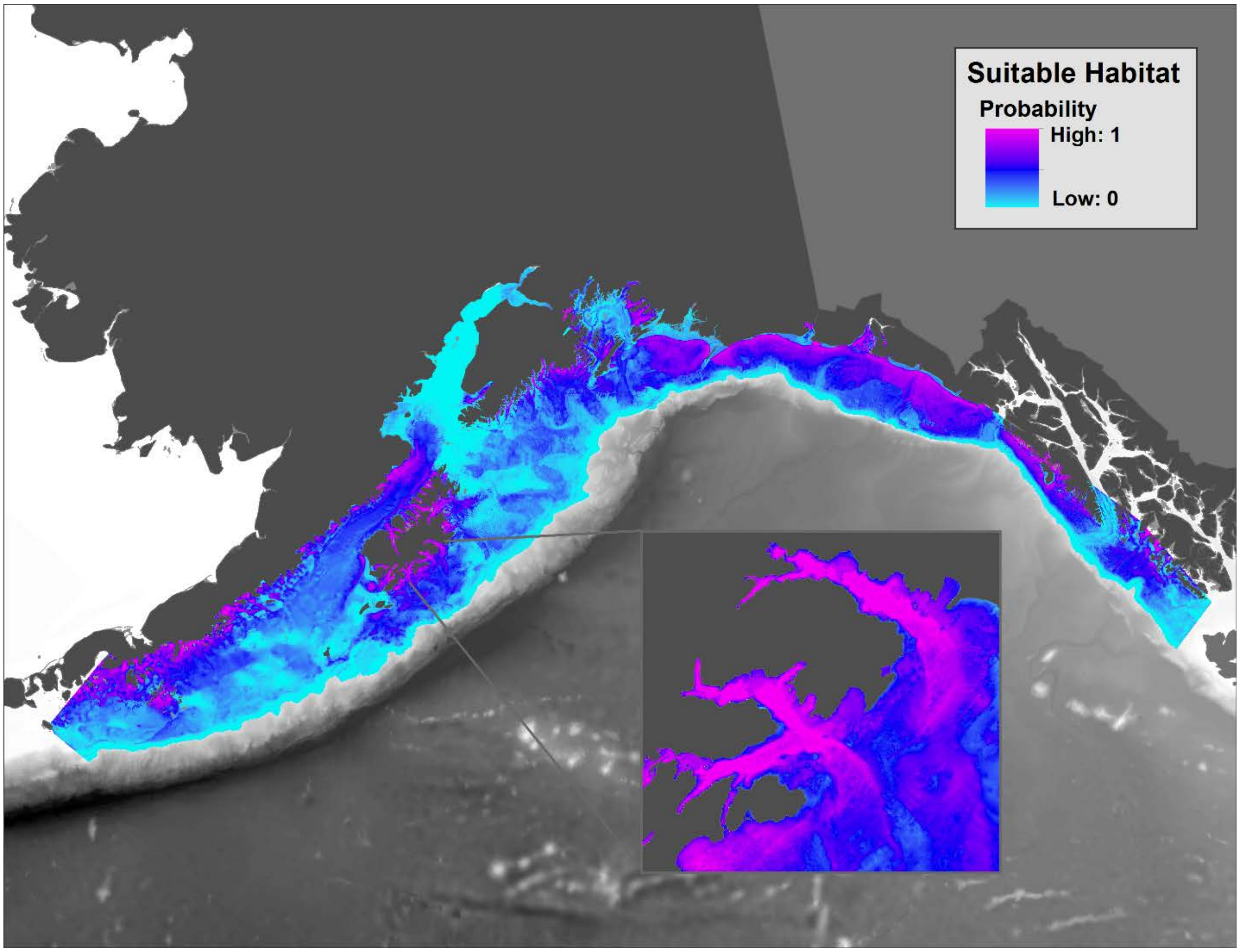

Figure 10: Sablefish habitat suitability model map (MaxEnt) based on presence locations for the demersal settlement stage and early stage juveniles resident in nursery areas (150-399 mm). Predicted probability of suitable habitat is shown on a continuous scale, where high suitability habitat is pink and low suitability habitat is turquoise. The inset highlights Kodiak Island bays where suitable habitat is predicted to occur.

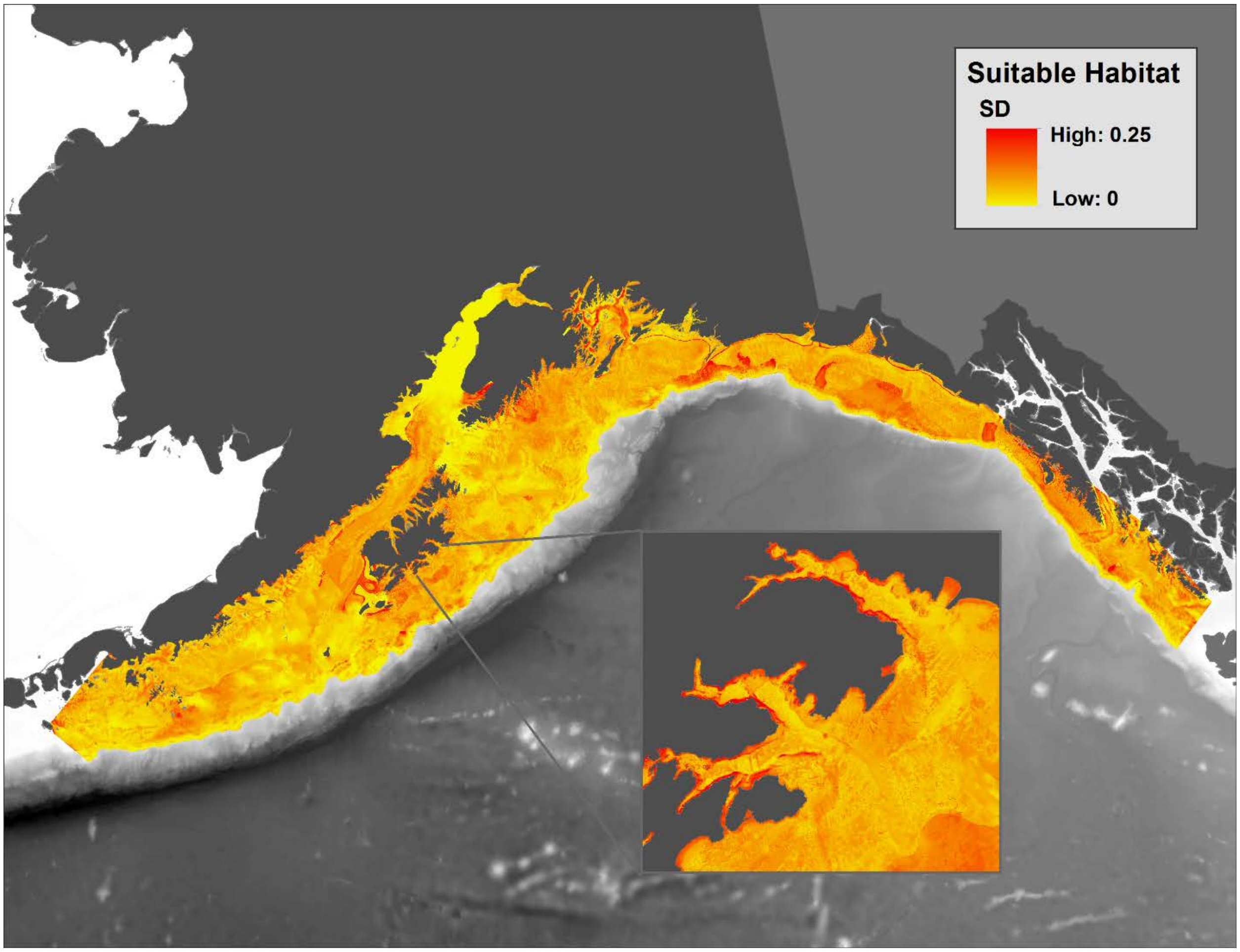

Figure 11: Sablefish habitat suitability model map (MaxEnt) based on presence locations for the demersal settlement stage and early stage juveniles resident in nursery areas (150-399 mm). Standard deviation of the mean predicted probability of suitable habitat is shown on a continuous scale, where higher values are red and lower values are yellow.

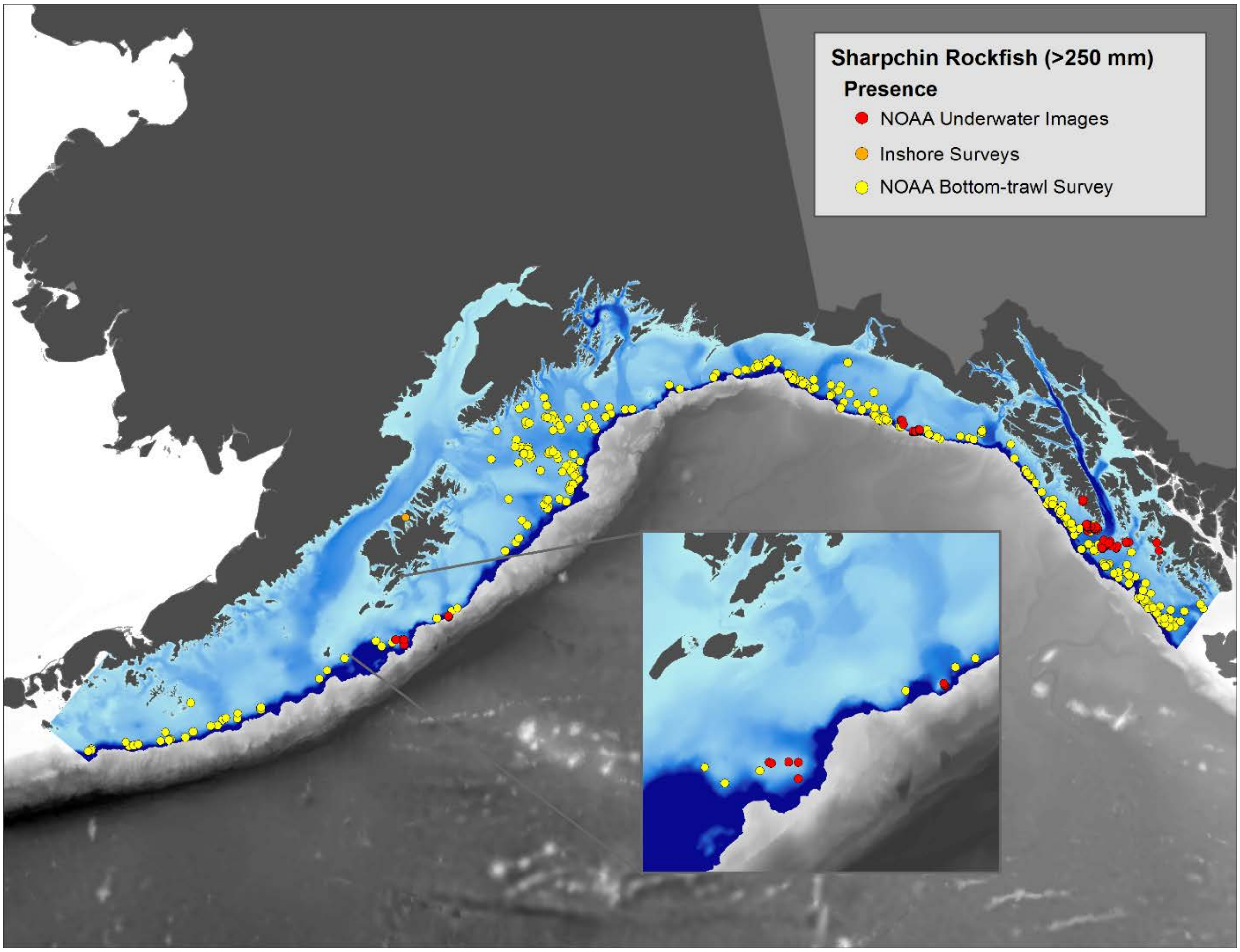

Figure 12: Sharpchin rockfish presence locations for adults (>250 mm). Observations from NOAA AFSC underwater video and camera surveys are shown in red. Catch locations from inshore surveys are shown in orange and locations from the NOAA AFSC bottom-trawl survey for groundfish are shown in yellow. Catch location detail for the continental shelf south of Kodiak Island is highlighted by the inset.

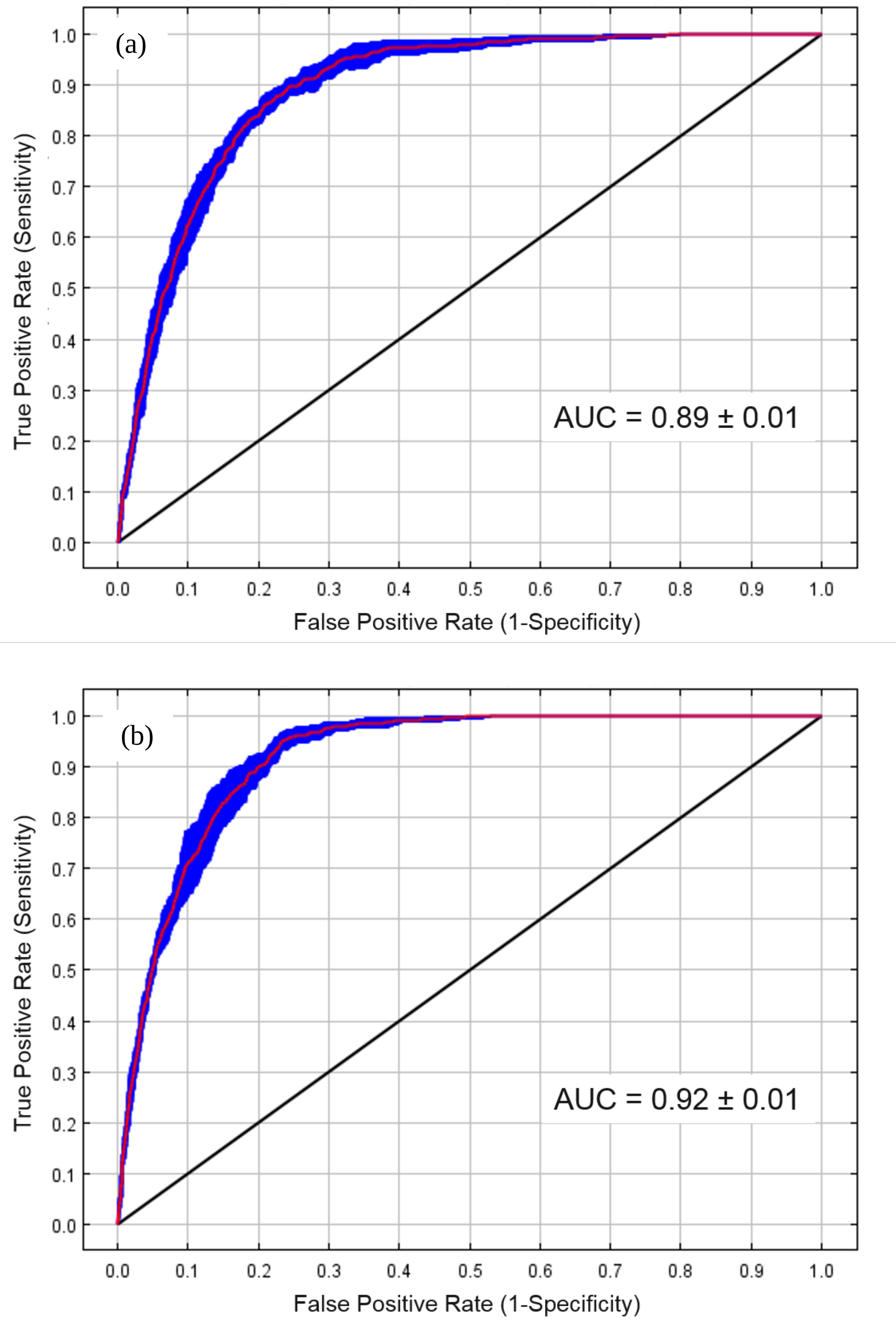

Figure 13: Receiver operating characteristic (ROC) curves for sharpchin rockfish adult habitat suitability models, using k-fold crossvalidation of model replicates (*k* = 5). Including, a) habitat suitability models (AUC test = 0.89 ± 0.01 (mean ± SD)) and b) habitat suitability models with substrate (AUC test = 0.92 ± 0.01).

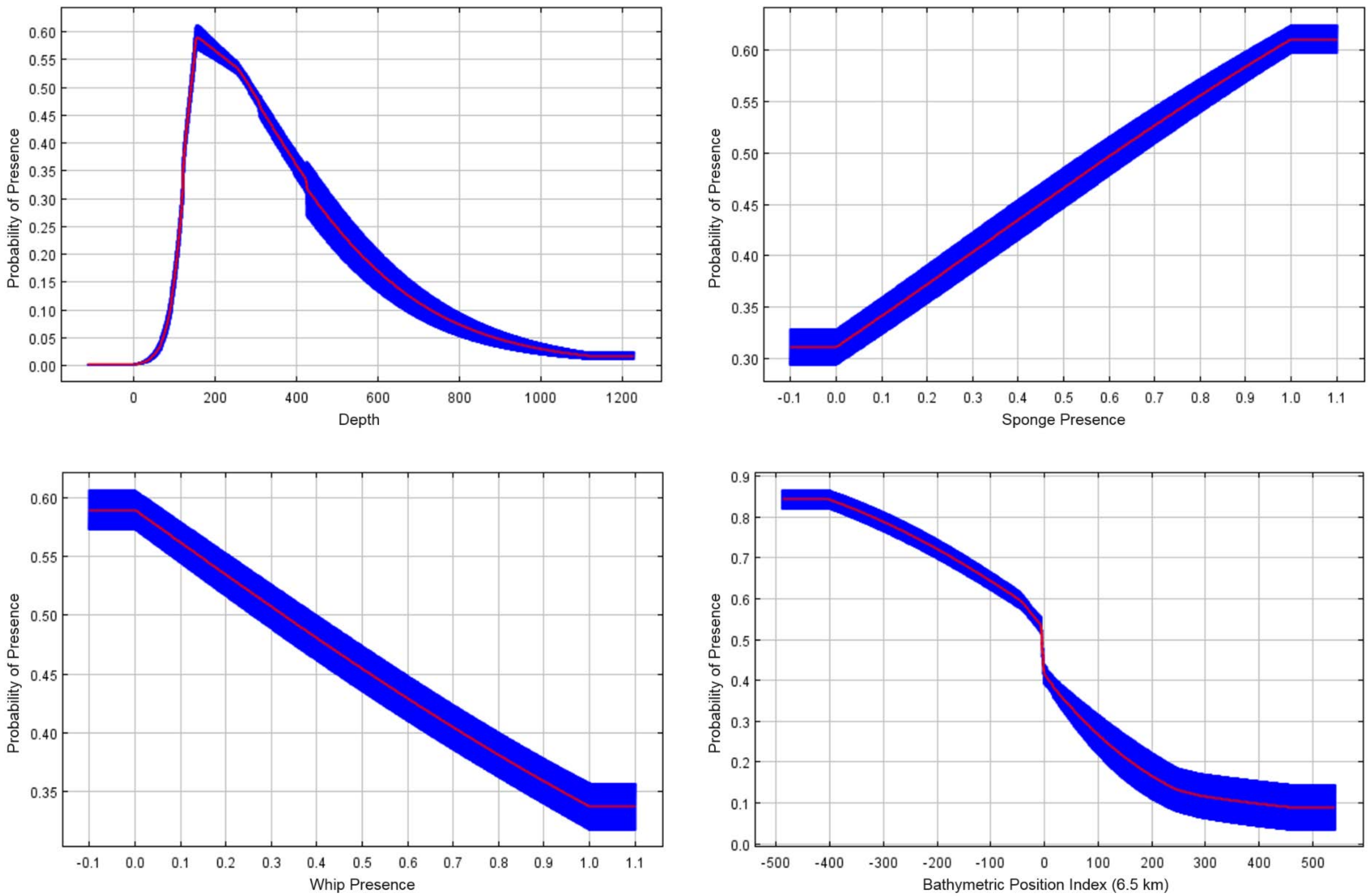

Figure 14: Response (mean ± SD) of the four most influential habitat metrics in replicated models to predict sharpchin rockfish adult habitat suitability in the GOA, including (clockwise from top left) depth, sponge presence, whip presence, and broad-scale bathymetric position index (6.5 km).

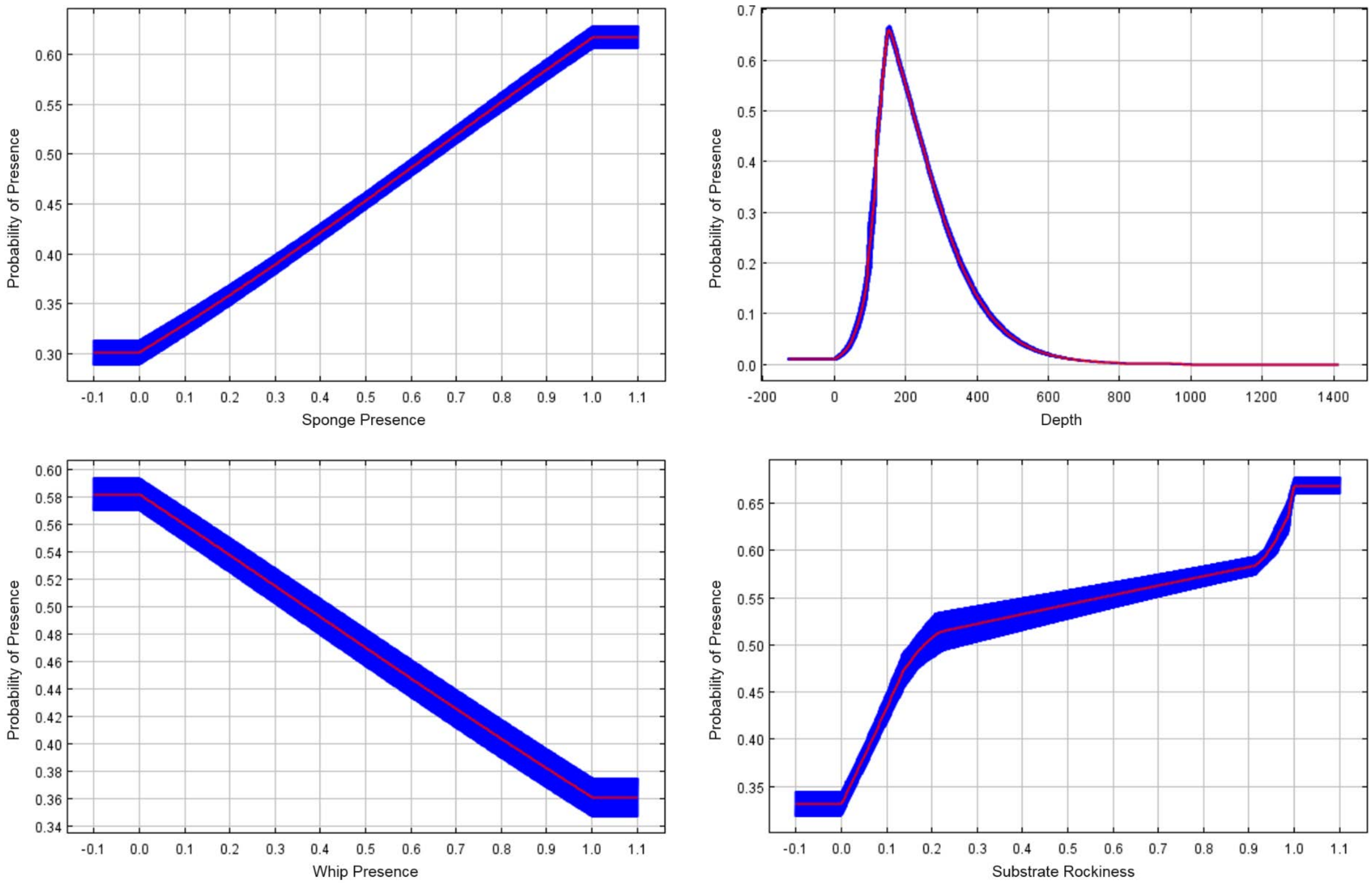

Figure 15: Response (mean ± SD) of the four most influential habitat metrics in replicated models that included substrate rockiness as a metric to predict sharpchin rockfish adult habitat suitability in the GOA, including (clockwise from top left) sponge presence, depth, whip presence, and substrate rockiness.

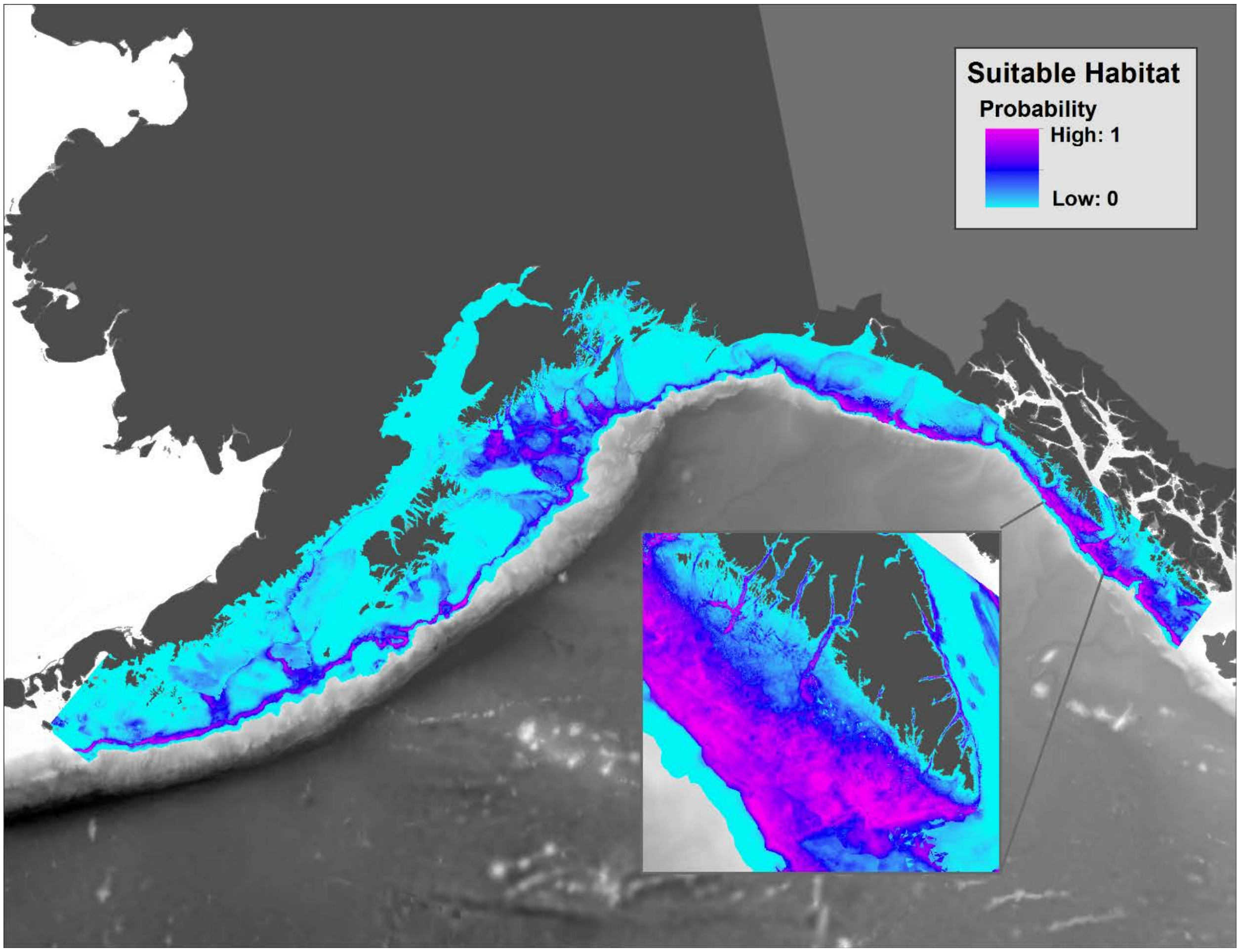

Figure 16: Sharpchin rockfish habitat suitability model map (MaxEnt) based on presence locations for adults (>250 mm). Predicted probability of suitable habitat is shown on a continuous scale, where high suitability habitat is pink and low suitability habitat is turquoise. The inset highlights the Cape Ommaney area in southeast Alaska.

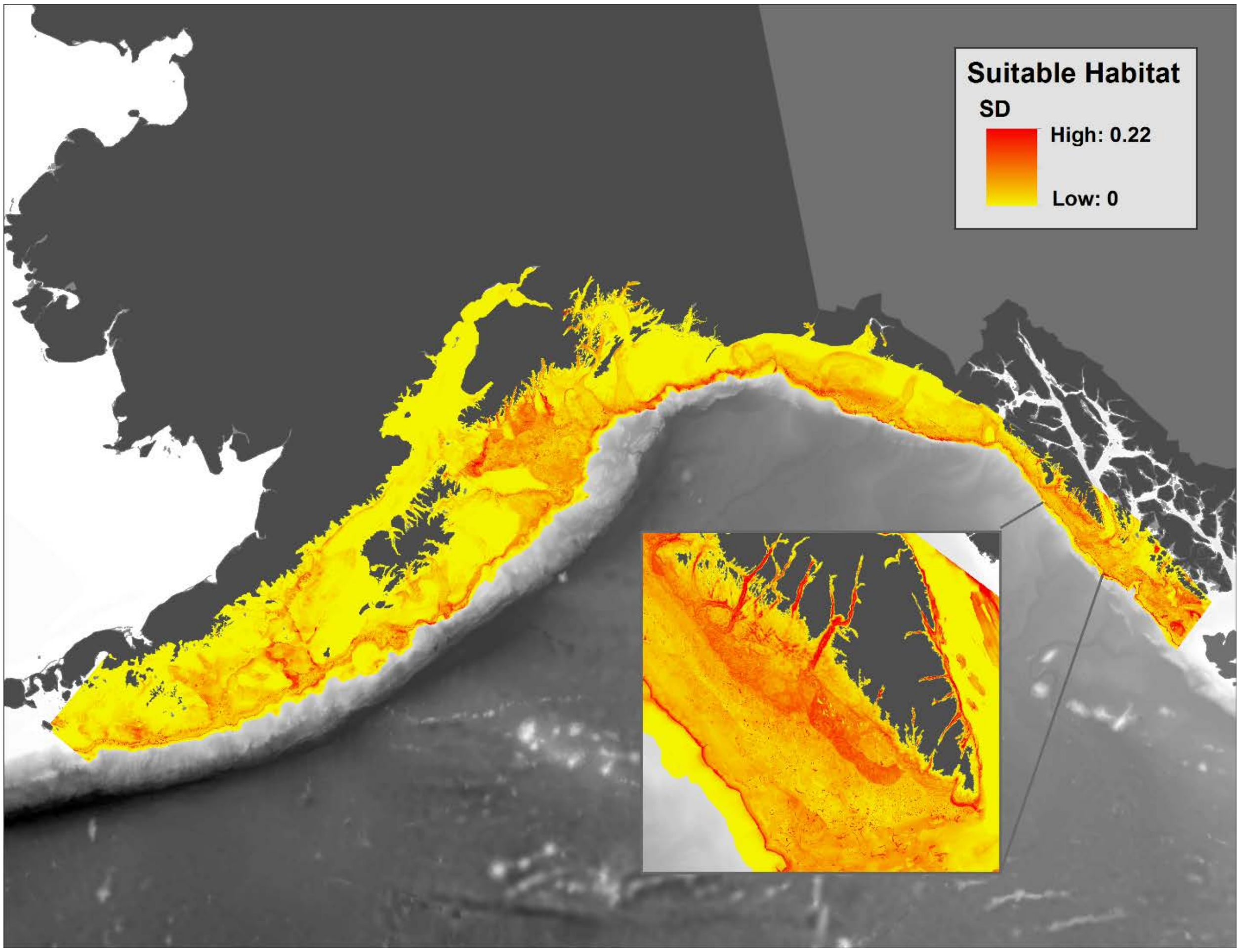

Figure 17: Sharpchin rockfish habitat suitability model (MaxEnt) based on presence locations for adults (>250 mm). Standard deviation of the mean predicted probability of suitable habitat is shown on a continuous scale, where higher values are red and lower values are yellow.

Essential Fish Habitat project status report

Reporting date: Oct 31, 2015

Project number: 2015-05

Title: **Optimal thermal habitats of FMP crab species in relation to the Bering Sea cold pool**

PIs: Ryer, Copeman, Laurel

Funding year:2014/15

Funding amount:$76500

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: Oct 31, 2016

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report. No reported result to date

Results: What is the most important result of the study?

During 2014 and 2015 female snow crabs and Tanner crabs were collected and transported to RACE facilities in Newport OR. Female were held until spring/summer when they released first stage zoea larvae. Larvae of both species were reared to the first crab (C1) stage. Crabs were then placed into growth chambers for the main experiment. This entailed 10 replicate crabs of each species, reared at temperatures of 0, 2, 3.5, 5, 9, 12, and 16^{o}C. These experiments are ongoing. However, one surprising preliminary result is that snow crab appear to grow very well at higher temperature. It had been hypothesized that newly settled snow crabs are highly stenothermic, and would fair poorly at temperatures of 5^{o}C and above. However, these juvenile appear to thrive and grow rapidly at 5^{o}C, and also fair well at 9^{o}C, albeit, with somewhat higher mortality. This suggests that juvenile stenothermy may not be a principle factor controlling the southern range of snow crab.

Crabs reared at 2 and 5^{o}C were also reared in groups and sampled periodically to characterize the temporal progression of lipid storage/utilization during the course of the first intermolt period.

Crabs collected from the 2014 BASIS cruise in the eastern Bering Sea are awaiting finalization of genetic techniques to differential snow crabs from Tanner crabs and their hybrids. The genetic work is being done by Michael Canino of RACE. We anticipate that in several weeks we will be able to begin identification of crabs, with subsamples reserved for both genetic and lipid analysis.

We anticipate that all components of the project will be completed by October 2016, with a manuscript produced in the subsequent year.

Essential Fish Habitat project status report

Reporting date: 11/12/2015

Project number: 2015-06

Title: Physiological response of red tree corals (*Primnoa pacifica*) to low pH scenarios in the laboratory.

PIs: Robert Stone (NOAA, AFSC, Auke Bay Lab); Robert Foy (NOAA, AFSC, Kodiak Lab); Rhian Waller (University of Maine); Stephen Cairns (Smithsonian Institution); Ian Enochs (UM/CIMAS, NOAA/AOML)

Funding year: 2015

Funding amount: $47,200

Status: Incomplete, behind schedule. Funding for this project was not received in time to charter a research cruise to collect specimens as planned in March 2015. The team decided to postpone the cruise until January 2016 so the project is essentially 10 months behind schedule. Ideally specimens should be collected during the winter months when underwater visibility is optimal for collection and air temperatures are less stressful on collected animals during holding and transport.

Planned completion date if incomplete: The laboratory work is scheduled for completion in January 2017. Final analyses will be completed by July 2017 except for the endpoint processing of the reproduction and skeletal density samples that will require additional funding. A proposal has been submitted to the EFH Program 2016 Request for Proposals to cover the costs of these final analyses. Should those funds be awarded then all analyses will be completed by July 2017 and at least two manuscripts will be submitted for publication by November 2017.

Reporting: Have the project results been reported? NO

Results: Phase I of this work is scheduled to begin in January 2016. We additionally secured AFSC Cobb-replacement funds in 2015 to supplement this project. Using the two sources of funds we were able to schedule a 5-day charter to collect specimens, purchase water chillers for the laboratory, provide project support for the duration of the laboratory study, and contracted the University of Maine to assist with specimen collection, experimental set-up, sample preparation, and to conduct initial analyses of the reproduction samples.

Essential Fish Habitat project status report

Reporting date: 11/16/15

Project number: 2015-07

Title: Estimating Rockfish Abundance as a Function of Habitat in the Gulf of Alaska

PIs: Darin Jones, Chris Wilson, Chris Rooper, Paul Spencer, Dana Hanselman (AFSC), Tom Weber (CCOM, University of New Hampshire)

Funding year: 2015

Funding amount: $50,000

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: October 31, 2016

Reporting: No

Results: This project had two components; 1) a field component that collected multibeam bathymetry and backscatter, fisheries acoustic data and image data at paired trawlable and untrawlable sites during the 2015 GOA acoustic-trawl survey for walleye pollock and 2) a laboratory component that analyzed the image data collected during the field season.

Component #1 was funded by the NMFS Habitat Assessment Improvement Plan (HAIP) and the fieldwork was successfully carried out at 45 paired trawlable and untrawlable sites during the 2015 survey. Multibeam bathymetry data (ME70), mini-acoustic transects (EK-60), and underwater stereo camera transects to verify targets were successfully collected at the paired sites. The EK-60 data is almost completely analyzed, preliminary analyses of the ME70 data has begun.

Component #2 (EFH Project #2015-07) is funding a contractor to examine the images collected from stereo camera transects and identify and measure the fishes (primarily rockfishes) that were captured in the images. A highly experienced contractor is in place and will begin working with the images ~January 1, 2016. A total of 89 stereo camera transects were collected in 2015. The contractor will also complete analyses on an additional ~5 stereo camera transects from 2013. It is expected that the image analysis will be complete on schedule by June 2016. A final report for this project is expected in October 2016.