NORTH PACIFIC RESEARCH BOARD PROJECT FINAL REPORT

Chiswell Ridge Habitat Mapping and Groundfish Assessment

NPRB Project 616 Final Report

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Abstract

This project collected high-resolution sidescan and multibeam sonar data to map the seafloor of the Chiswell Ridge; a biologically important area for groundfish species located along the north gulf coast the Kenai Peninsula. This effort expanded on an area previously mapped using multibeam sonar to provide a comprehensive inventory of rocky reef habitat for the area. The new delineation of rocky habitat improved prior estimates of available habitat by 47% that were previously based on low-resolution singlebeam and leadline bathymetry. Estimates of lingcod, *Ophiodon elongates* and yelloweye rockfish *Sebastes ruberrmius* abundance for the area consequently decreased by 34 and 26%, respectively. To extend the use of existing remotely operated vehicle ROV video footage, hydrocoral and sponge distributions were mapped and densities were estimated. Both hydrocoral and sponge densities were higher within the southern study area where the new sonar data were collected.

Key words

Seafloor mapping, multibeam sonar, sidescan sonar, ROV, Chiswell Ridge, lingcod, yelloweye rockfish, coral, sponge, benthic habitat.

Citation

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Study Chronology

Funding was received and the study was initiated in September, 2006. Mobilization of hydroacoustic gear began immediately following project initiation. Mapping surveys were completed on four separate legs originating from Seward, AK. Multibeam surveys were conducted from September, 4 to 7 and 12 to 14. A 300 kHz sidescan sonar survey was conducted from September, 24 to 25 and finally a 600 kHz sidescan sonar survey from October, 17 to 18. Processing of sonar data occurred in January, 2007 and ROV video footage was reviewed for coral and sponge enumeration in November and December of 2006. Progress reports were filed in December, 2006 and July, 2007. Analysis and final report writing occurred in September of 2006 with the contract ending in the same month.

Introduction

The density and distribution of benthic fishes are often strongly correlated with habitat type (Phillips 1959; Smith and Forester 1973; Jagielo 1988; O'Connell 1993). For structure oriented species, descriptions of the quantity and spatial distribution of available habitats are critical for designing surveys, estimating population parameters, and scaling harvest guidelines based on available habitat. Combining biological data and fish density estimates with the areal extent of available habitat is efficient and cost-effective, and can increase the precision of biomass estimates.

With knowledge that benthic habitat types can determine the occurrence of certain species of groundfish, an increased interest has developed in mapping and classifying habitats over broad areas (Able et al. 1987, Yoklavich et al. 1999, Nasby-Lucas et at. 2002). Sidescan and multibeam sonar have been used extensively for collecting the data necessary for characterizing mesoscale areas of the seabed. Habitat-based assessments take advantage of the affinity of fishes for particular habitat types by focusing sampling effort in preferred habitats. Habitat specific density estimates can then be integrated with habitat data from high-resolution sonar to obtain abundance estimates. These types of assessments are becoming more common, especially along the Pacific west coast and in Alaska (O'Connell and Carlile 1993, Fox et al. 2000, Karpov et al. 2001, O'Connell et al. 2003). Both submersibles and ROVs have been used to assess rockfish and other groundfish species on the scale of hundreds of km^2.

Lingcod and yelloweye rockfish are principal demersal groundfish species harvested in commercial and recreational fisheries along the outer coast of the Kenai Peninsula in the Alaska Department of Fish and Game (ADF&G), Cook Inlet Management Area (CIMA). The distribution and abundance of these species is strongly influenced by structurally complex benthic habitats (Miller and Geibel, 1973, Carlson an Straty 1981, Richards, 1986, Cass et al. 1990, Carr 1991, Stein et al. 1992, Krieger 1993). Due to the difficulty of assessing these species with traditional sampling methods, there are presently no stock assessments for the ADF&G, Central Region. This lack of assessment information has hindered development of fishery objectives and reference points. Lingcod and rockfish possess life history characteristics that make them particularly vulnerable to overexploitation, and rebuilding depleted populations can take many years. These issues underscore the urgency for developing cost-effective assessment methods.

The Chiswell Islands-Chiswell Ridge area has historically accounted for a disproportionately large portion of the recreational and commercial harvest of lingcod and yelloweye rockfish for the CIMA. An ROV habitat-based assessment was conducted in 2005 for these species along the Chiswell Ridge. Only rocky reef habitats were sampled and density estimates were multiplied by the available rocky habitat to obtain abundance estimates. The northern half of the ridge had been previously mapped using multibeam sonar by Fugro Pelagos under a contract from the National Oceanic and Atmospheric Administration (NOAA). From these data a more accurate estimate of the areal extent of available rocky substrate was obtained than had previously been available. However, estimates of the extent of rocky reef area south of the multibeam survey area had to be based on low-resolution singlebeam and pre-sonar bathymetric survey data. Due to the limitations of the singlebeam and leadline data, it was likely that other rocky reefs were undetected during this analysis and the boundaries of identified reefs were not precisely defined. Consequently, groundfish abundance estimates for the Chiswell Ridge were likely biased since density estimates can only be applied to uncertain rocky reef area estimates. Therefore, to address this problem the southern ridge was mapped using multibeam and sidescan sonar to inventory and delineate available rocky reef habitats with much higher precision, and hence improve estimates of lingcod and yelloweye rockfish abundance.

Structure forming invertebrates such as corals and sponges, can increase the complexity of substrates which can in turn increase the available habitat to demersal groundfish (Eastman and Eakan 1999, Heifetz 2002, Krieger and Wing 2002, Freeze and Wing 2003). A particular advantage of video based surveys is that there is a permanent record of the physical and living resources surveyed. Not only can the species of immediate interest be assessed, but many other organisms can be enumerated as well. These may directly influence the occurrence and distribution of the species of interest or act indirectly contributing to the larger community structure that they may depend upon. As an ancillary objective of this project, existing video records from an ROV survey were reviewed to enumerate coral and sponges occurring both within and adjacent to the habitat mapping area.

Objectives

This study had three main objectives:

1. Map the southern portion of the Chiswell Ridge with multibeam and sidescan sonar to quantify and characterize substrate types. Included was groundtruthing the acoustic data with visual observations collected from a previous ROV survey.
2. Estimate the density and abundance of lingcod and yelloweye rockfish within the study area based on new habitat delineation and compare those to previous estimates based on low-resolution singlebeam bathymetry.
3. Describe the coral and sponge distribution within and adjacent to the survey area and estimate densities based on visual observations collected from a previous ROV survey.

Methods

This study was conducted on the Chiswell Ridge, located along the north gulf coast of the Kenai Peninsula in the northern Gulf of Alaska (GOA) (Figure 1). The Chiswell Ridge is a prominent, relatively shallow seafloor feature oriented perpendicular to the coastline and is defined to the north, east, and west by deep fjords and slopes off to the south into deeper waters of the continental shelf. The Alaska Coastal Current impinges on the eastern boundary which contributes to the high productivity of the area.

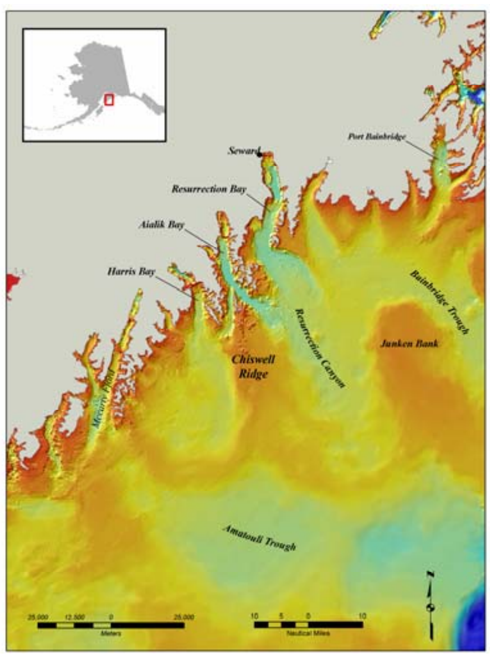

Figure 1. Chiswell Ridge and the north gulf coast of the Kenai Peninsula with colored shaded relief of bathymetry.

Objective 1. Habitat mapping

Mapping of the southern Chiswell Ridge was the primary objective of this project. This was accomplished using a combination of sidescan and multibeam sonar. A lower frequency 300 kHz sidescan sonar was used to survey the broad survey area in order to inventory the rocky substrates. A high frequency 600 kHz sidescan sonar and a multibeam sonar was than used to resurvey the rocky reef areas to obtain higher resolution images and bathymetry data. Golder and Associates supplied all the equipment, performed the field survey, cleaned and initially processed all the geophysical data. The survey area covered most the seabed within a 100 m curve south of Lone Rock (Latitude 59o 34’ 11’’) along the Chiswell Ridge (Figure 2). The area north of this had been previously mapped by a NOAA contractor using multibeam sonar. The areal coverage of the planned survey was approximately 125 sq. km. Typical depths ranged from 40 to 100 meters.

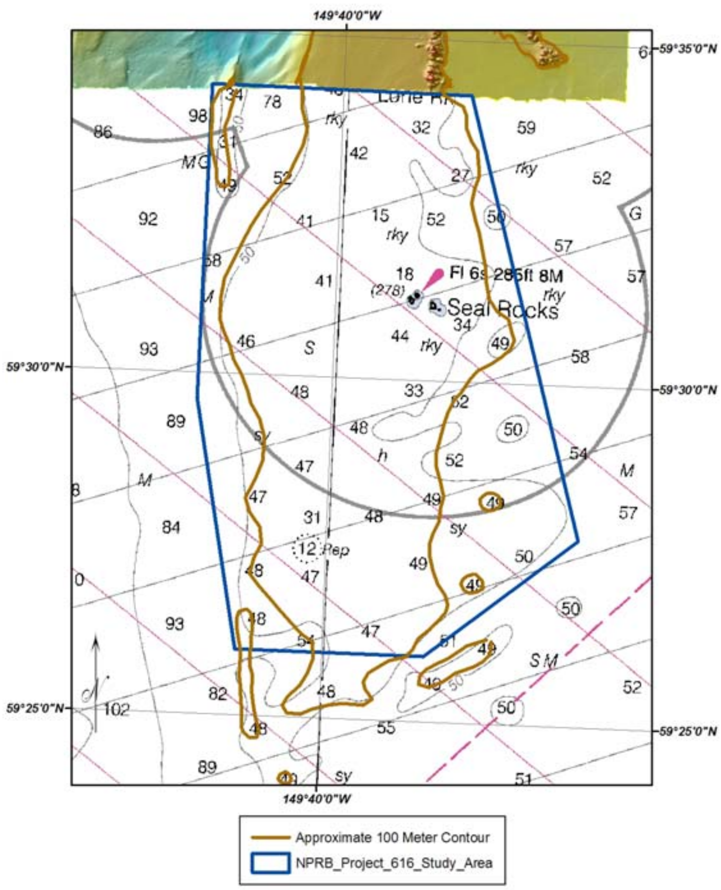

Figure 2. The southern Chiswell Ridge habitat mapping area. To the north is existing NOAA multibeam bathymetry.

Bathymetry data were collected using a Reson 8124 multibeam echosounder. The multibeam system was integrated with a motion sensor for determining heave, pitch, and roll and a gyro to determine yaw and ship heading relative to the trackline. All data was georeferenced with a Trimble Ag 132 differential GPS receiver using satellite correctors for positioning. The multibeam system underwent a patch test at the start of each survey day. Sound velocity and tide table files were generated and applied to the depth data. Final editing and binning of the data was done using Hypack, Inc., HySweep® software.

The sidescan sonar data was acquired using a 300 and 600 kHz MarineSonics system. Towfish position was calculated using setback measurements. Sidescan data were edited and converted to XTF standard format and mosaiced and georeferenced using Chesapeake Technology, Inc., SonarWiz software. Additionally, imagery collected using the 600 kHz system was edited to clip the area of the nadir to the trigger pulse and to adjust gains producing smoother mosaic imagery with more consistent contrast and brightness levels. Sidescan sonar data was incorporated into ArcGIS 9x as GeoTIFF data layers while cleaned, multibeam point data were imported into ArcGIS and processed to 1-meter horizontal resolution ESRI raster GRID format files.

The sidescan sonar data was used to identify any rocky reefs within the study area. The rocky reef polygons were delineated using on-screen digitizing based upon 1-meter gridded multibeam bathymetry displayed with shaded relief terrain modeling and through examination of slope characteristics. This is consistent with the methods used to delineate reef areas in the Northern portion of the Chiswell Ridge area. In additions, visual characterizations of the substrate based on ROV transect footage was used to confirm soft and rocky substrates.

Objective 2. Lingcod and yelloweye rockfish population estimation

Areal estimates of rocky substrates were first made prior to this study using historical NOAA singlebeam and leadline bathymetry data (GEODAS). These data are very old, dating back to the 1920's, and are good to only 100 to 500 m resolution (Figure 3). Probable rocky reefs were identified using of heads-up digitizing of what appeared to be rocky reef areas based on gridded bathymetry of shaded relief benthic terrain. The digitized reef polygons were then compared to available bottom sample data to confirm the existence of hard bottom types.

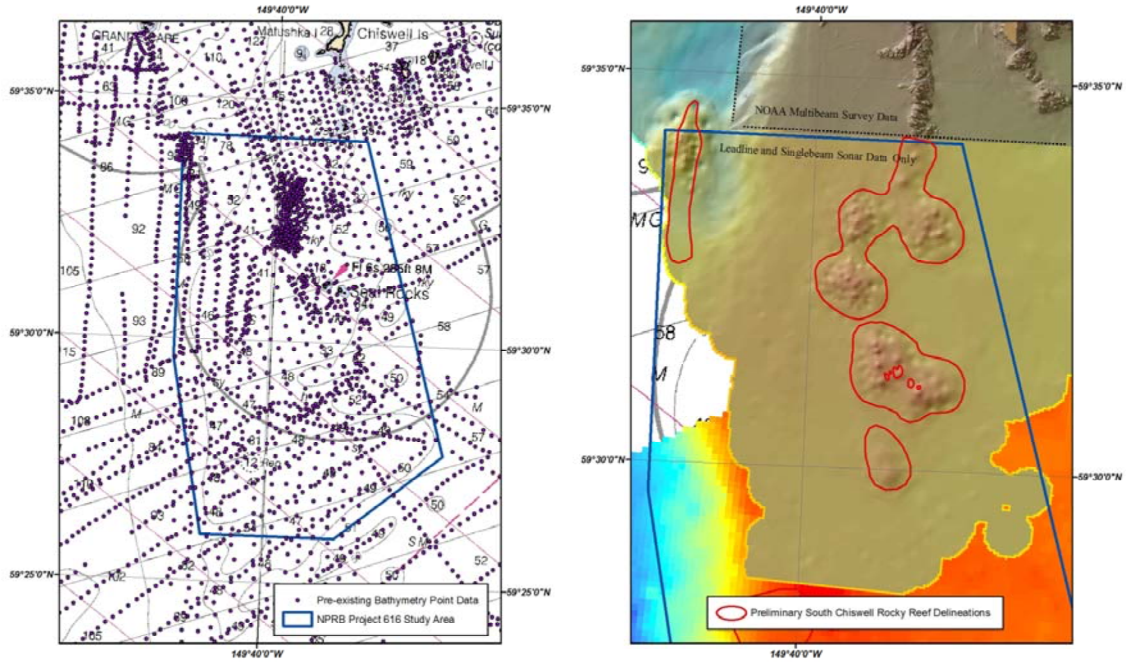

Figure 3. Best available bathymetry data for the survey area prior to surveying with sidescan and multibeam sonar and probable rocky reef delineation.

The areal extent of the newly delineated rocky reef areas from the multibeam and sidescan sonar survey were used to rerun lingcod and yelloweye abundance estimates. Estimates were only for the area within the delineated rocky reefs (Byerly, 2005). Those lengths of transect that fell outside of the delineated area were not included in the analysis. Lingcod density D and abundance τ were then compared to the earlier estimates to evaluate the percent change.

Objective 3. Coral and sponge distribution and density estimation

Video data from the 2005 Chiswell Ridge ROV survey was reviewed to enumerate coral and sponge occurrence following Byerly (2005). Twenty-two of the sixty-two transects reviewed, occurred within the habitat mapping study area, while twenty-six occurred in an adjacent area to the north in the Chiswell Islands, and fourteen occurred in Harris Bay to the northwest. The only coral group that could be enumerated with relative certainty of satisfying detectability assumptions was hydrocorals. These were counted as colonies regardless of colony size. Due to the difficulty of positively identifying sponges from video images, they were grouped by morphological similarity. Only pipe shaped or tubular sponges as categorized in Bizzarro (2002) were enumerated.

Results

High wind and wave conditions persisted during the month of allotted time for completing the survey. Do to the excessive sea conditions, the mapping survey work was completed on four separate surveys. The first survey was conduced from September 4 to 7, 2006 and consisted of multibeam mapping of probable rocky reef areas identified by ADF&G from existing NOAA single beam bathymetry. Polygons were drawn around reefs in ArcGIS with a conservative buffer and survey planed lines were drawn and transited to cover these areas. Approximately 60% of the probable reefs were mapped during this first leg with the remaining being mapped from September 12 to 14, 2006. The third survey, using a 300 kHz sidescan sonar, was conducted September, 24 to 25, 2006 and covered most survey area. The remaining areas were surveyed from October 17 to 18 using a 600 kHz sidescan sonar. During this leg the 600 kHz unit was also used to resurvey the rocky reef areas to obtain higher resolution images. Approximately 75% of the previously identified rocky reef areas were surveyed with the 600 kHz sidescan sonar before weather conditions deteriorated and the survey ended.

The resulting sidescan sonar mosaics covered approximately 90% of the defined study area, while the multibeam mosaics covered most parts of the identified rocky reefs (Figure 4). Some of the rocky reef areas next to Seal Rocks were not surveyed with multibeam due to safety concerns and resulted in some gaps in the coverage. Sea conditions caused excessive acceleration and yawing of the towfish which resulted in a reduction in the quality of the sidescan sonar imagery. Imagery was adequate for detecting soft and hard rocky habitats but not for further classification of substrate type. No other rocky reefs outside of those originally identified using the historic single beam bathymetry were found.

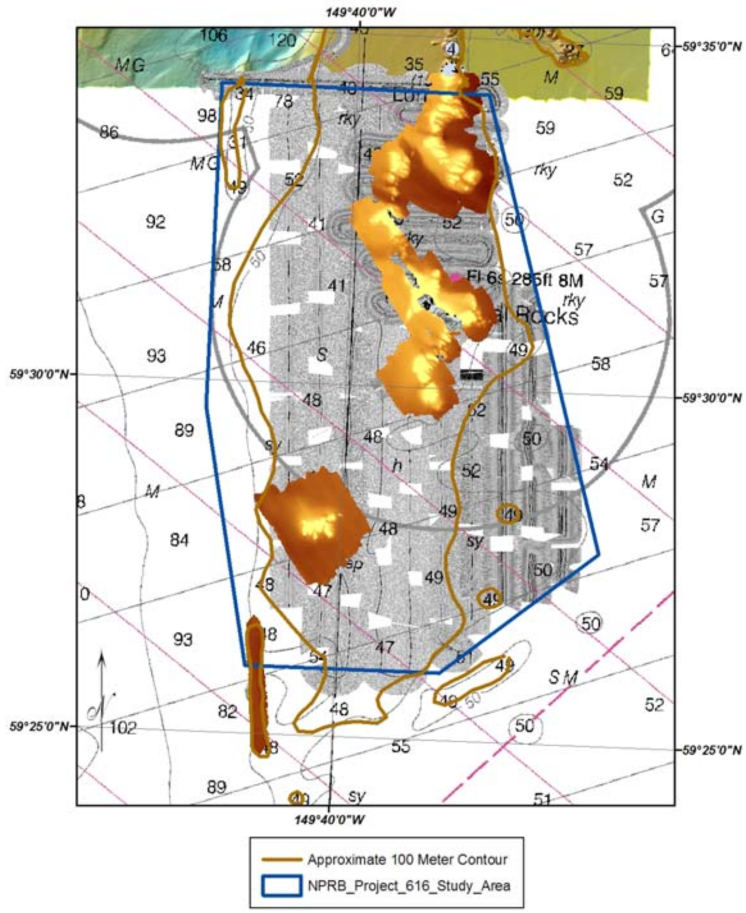

Figure 4. Multibeam sonar bathymetry and sidescan sonar imagery collected and processed during the Chiswell Ridge habitat mapping surveys.

The new estimate of rocky reef area for the southern Chiswell Ridge was 8.66 km^2, down from the original estimate of 16.52 km^2 based on the historical NOAA data (Figure 5). The resulting lingcod and yelloweye rockfish abundance estimates decreased by 47.6 % for the southern Chiswell area, using the new habitat delineations (Tables 1 & 2). Variance estimates remained the same as the new area estimates served to rescale the abundance only, although variance estimates for the entire Chiswell Ridge did change slightly with the new delineations. With the decrease in available habitat, the estimated abundance of lingcod remained higher in southern Chiswell Ridge, but yelloweye rockfish were estimated to be more abundant in the northern Chiswell Ridge. No lingcod or yelloweye rockfish occurred outside of the new habitat delineations.

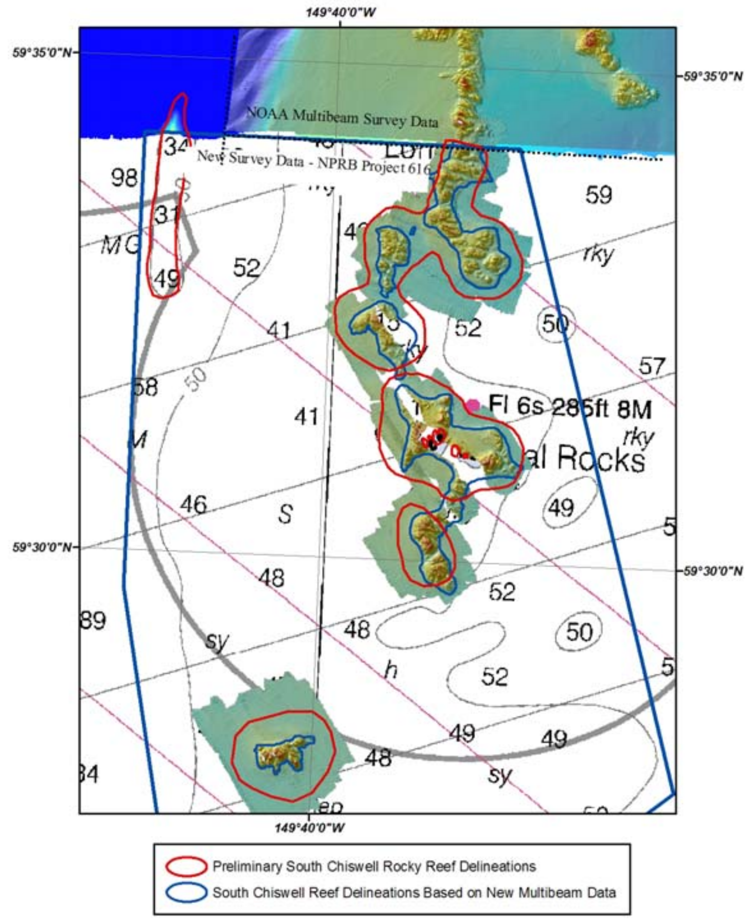

Figure 5. Rocky reef habitat delineations based on pre and post survey data.

Table 1. Lingcod population estimates for the 2005 Chiswell Ridge ROV survey.

	Chiswell North		Chiswell South				Chiswell Ridge		
Mapping data & Source		NOAA - Multibeam		NOAA - Singlebeam, Leadline	This study - Multibeam, SSS		NOAA - Multibeam, Singlebeam, Leadline	This study & NOAA - Multibeam, SSS	
Area (km^2)		13.38		16.52	8.66		29.90	22.04	
	D^ (km^2)	τ^	D^ (km^2)	τ^	τ^	% Change	τ^	τ^	% Change
Estimate	1,927	25,779	3,789	62,612	32,827	-47.6%	88,390	58,605	-33.7%
Bootstrap Mean	1,982	26,520	3,792	62,650	32,847		89,170	59,367	
Bootstrap stdev	528	7,071	1,066	17,614	9,235		19,049	11,689	
90% LCI	1,313	17,567	2,476	40,909	21,448		65,523	44,677	
90% UCI	2,681	35,878	5,170	85,416	44,783		113,628	74,174	
Estimated bias	55	741	2	38	20		780	761	
CV	27%	27%	28%	28%	28%		22%	20%	

Table 2. Yelloweye rockfish population estimates for the 2005 Chiswell Ridge survey.

	Chiswell North		Chiswell South				Chiswell Ridge		
Mapping data & Source		NOAA - Multibeam		NOAA - Singlebeam, Leadline	This study - Multibeam, SSS		NOAA - Multibeam, Singlebeam, Leadline	This study & NOAA - Multibeam, SSS	
Area (km^2)		13.38		16.52	8.66		29.90	22.04	
	$\hat{D}$ (km^2)	$\hat{\tau}$	$\hat{D}$ (km^2)	$\hat{\tau}$	$\hat{\tau}$	% Change	$\hat{\tau}$	$\hat{\tau}$	% Change
Estimate	2,540	33,981	2,485	41,057	21,526	-47.6%	75,038	55,507	-26.0%
Bootstrap Mean	2,566	34,331	2,490	41,133	21,566		75,465	55,897	
Bootstrap stdev	743	9,942	544	8,983	4,710		13,410	11,008	
90% LCI	1,688	22,593	1,829	30,216	15,842		58,634	42,301	
90% UCI	3,546	47,455	3,201	52,894	27,732		93,346	70,234	
Estimated bias	26	350	5	77	40		427	390	
CV	29%	29%	22%	22%	22%		18%	20%	

Figure 6 illustrates examples of the hydrocorals and sponges included in the analysis. Hydrocorals and sponges both occurred more frequently among ROV transects in the southern Chiswell Ridge than the northern (Figure 7). The highest individual hydrocoral transect density of 0.61 colonies / m^2 occurred in the southern Chiswells. The highest individual transect density of sponges also occurred in the southern Chiswells (0.17 / m^2) but just outside of the mapping area where two other transects had relatively high densities along the same disjunct reef. Estimated hydrocoral density was higher in the southern Chiswell Ridge though not significantly (Table 3). Variance in sponge estimates was higher due to their more contagious distribution. Even with the wider confidence intervals, sponge density was significantly higher in the southern Chiswell Ridge.

Hydrocorals

Sponges

Figure 6. Examples of the hydrocorals and pipe shaped or tubular sponges encountered during the 2005 Chiswell ridge ROV survey.

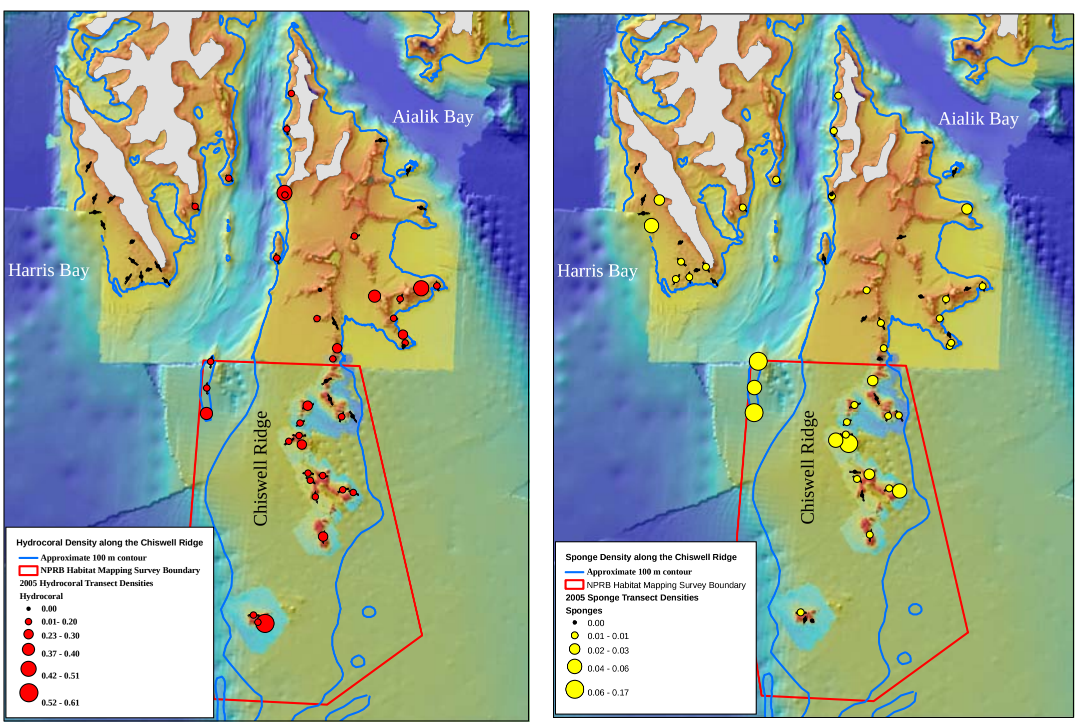

Figure 7. Hydrocoral and sponge distribution and density from the 2005 Chiswell Ridge ROV survey.

Table 3. Hydrocoral and sponge density estimates (colonies of hydrocoral or individual sponges / m^2) for the 2005 Chiswell Ridge ROV survey.

	Hydrocoral		Sponge	
	Northern	Southern	Northern	Southern
Estimate	0.084	0.128	0.003	0.029
Bootstrap Mean	0.085	0.128	0.003	0.029
Bootstrap stdev	0.026	0.024	0.002	0.010
90% LCI	0.053	0.099	0.001	0.017
90% UCI	0.118	0.160	0.005	0.043
Estimated bias	0.001	0.001	0.000	0.000
CV	31%	19%	54%	34%

Discussion

Though the quality of the sidescan sonar data was compromised due to high sea conditions during the mapping survey, the main goal – to delineate the available rocky reef habitat – was attained. Further analysis of the raw sonar files will likely yield more texture data that may make some classification of the rocky habitats possible in the future.

The increase in precision of the rocky reef delineations improved the groundfish abundance estimates. The choice of only sampling within the rocky habitats during the ROV survey was made in attempt to increase the efficiency of the survey, both in terms of sampling in the field and precision of estimates. In the ROV survey design, transects were selected randomly within the reef polygons. Transects began outside of the polygons where they adjoined them (the outside portion was later truncated for the analysis), and no lingcod or yelloweye rockfish were observed in the outside area. In this study the polygons were further reduced and still none were observed outside of the new delineations. Lingcod and to a lesser extent yelloweye rockfish do occur outside of rocky habitats and the proportion of the population in this assessment is unknown. However, this makes the population estimate conservative for the entire Chiswell Ridge area since density estimates were only scaled up to the estimate of available rocky habitat. Additionally, the mapping from this survey further reduced the estimated population size by more precisely delineating the available rocky habitat. The broad scale sidescan sonar survey found no other rocky reef structures outside of those previously mapped using the singlebeam data. This further adds assurance that available rocky habitat was adequately inventoried. Given the low inherent productively of yelloweye rockfish populations, it is important management is conservative, and if management is based on population estimates, that those estimates be accurate, and hence reliable as possible.

The maps produced during this survey have already proved essential in the planning for additional surveys in the area. In August, 2007 we returned to the Chiswell Ridge to perform an experimental ROV survey. Our ROV sampling protocols call for transects to be traveled upslope to provide the least angle of incidence between the video camera lens and the substrate. This greatly improves video quality and hence increases the detection of organisms, improves transect width estimation, and improves species identification. All of these are essential for producing an effective survey and cannot be readily achieved without high-resolution maps of the seafloor.

Corals form complex structures that can serve as habitat for many groundfish species. This is particularly true for some of the larges species such as red tree coral *Primnoa spp*. (Risk et al., 1988, Krieger and Wing, 2002), but also for hydrocorals as well (Heifietz 2002). Juvenile rockfishes utilize sponges as habitat in northern GOA (Freese and Wing, 2003). Whether the densities of hydrocorals and sponges observed in the Chiswell Ridge area are important to determining fish distribution or occurrence is unknown. Though the position of fishes relative to hydrocorals and sponges was not measured or categorized, some species of rockfish were frequently observed next to sponges and the larger hydrocoral colonies and sometimes inside of the larger sponges. The density estimates generated from this study can serve for comparison to other areas of the GOA and Pacific west coast. This study demonstrates the utility of deriving additional information from existing video collected from ROV or submersible surveys.

Conclusions

By completing a comprehensive inventory of available groundfish habitat on the Chiswell Ridge the ADF&G will move towards achieving a long-term goal of monitoring the abundance of important groundfish species at key locations within the Cook Inlet and Prince William Sound Management Areas. In order to monitor population abundance and evaluate harvest rates of demersal rockfish and lingcod, the ADF&G has developed a long-tern plan to map the bottom habitat of select areas important to these species. Once mapped, local population abundances may be estimated using ROV transect surveys. The Chiswell Ridge was one area identified for monitoring and the first to be mapped. Since this is a long-term goal, the mapping data collected during this project will serve for designing future ROV surveys and groundfish assessments along the Chiswell Ridge.

Publications

None at this time.

Outreach

A three minute film on the ADF&G, Central Region habitat-based groundfish assessment program was produced by Frontier Media. This short film details the reason and need for the assessment approach, and how it is being carried out. It will be shown at the Islands and Oceans, Visitor Center in Homer as a Kachemak Bay Research Reserve ongoing educational video display. It will also be used by Kenai Fjords Tours as an educational tool to introduce tourist to the research being conducted within the region.

Acknowledgments

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Project Synopses

Introduction: Lingcod and yelloweye rockfish are bottom oriented fishes that have an affinity for rocky substrates. Assessing their population levels has historically been difficult since many times traditional fishery sampling methods do not work well in these habitats. Habitat-based assessments using a combination of seafloor mapping and video transect surveys has been proven as a quantitative means of assessing and monitoring population abundance for species such as these.

Why we did it: Lingcod and yelloweye rockfish are much sought out by fishermen in southcentral, Alaska. They, especially yelloweye rockfish, have life history characteristics that leave they're populations vulnerable to overharvest. Lack of quantitative information of the status of these populations has made fishery managers rely on fishery catch statistics and various biological characteristic for making management decisions, leaving them with a level of uncertainty. This study helped in the development of a habitat-based assessment for lingcod and yelloweye rockfish, through mapping the seafloor of the Chiswell Ridge; a highly productive area with lots of quality habitat for both these species.

How we did it: Multibeam and sidescan sonar were used to map the seafloor of the Chiswell Ridge. The combination of these two techniques provided a synoptic look at the seafloor in which to inventory and delineate rocky reef habitat. Both these techniques produce high-resolution images that provide infinitely more detail than traditional singlebeam mapping methods. The area of available rocky reef habitat was than multiplied by estimates of the density of lingcod and yelloweye rockfish obtained from a pervious remotely operated vehicle survey, to estimate the number of individuals within the study area. In addition to counting groundfish, hydrocoral and sponges were enumerated to better understand their distribution and relative densities.

What we discovered: The new seafloor maps provided much more detail than what was previously available from historic bathymetry sources. The area estimates of rocky reef habitat improved by 47% and in turn greatly reduced the original fish abundance estimates. This has implications in fishery management, since the target harvest rates for species such as yelloweye rockfish are much lower compared most other fish species. Any acceptable harvest rate should be based on the best population estimates available.

What's next: This was the first of many areas to be mapped along the north gulf coast of the Kenai Peninsula and outer Prince William Sound. The long-term goal of this project is to map the bottom habitat of select areas important to these species, thereby having a network of study areas. By following up with ROV transect surveys to estimate fish density, population trends can be monitored and harvest rates evaluated.

Outreach: A three minute film on the ADF&G, Central Region habitat-based groundfish assessment program was produced for this project. This short film details the reason and need for the assessment approach, and how it is being carried out, with the goal of introducing the public to the fisheries research and conservation efforts being initiated within the region.

The big picture: Habitat-based assessment methods are efficient in design and have the ability to provide relatively precise fish population estimates. This of course is dependant accurate estimates of available habitat. High-resolution mapping with multibeam and sidescan sonar can produce maps that can provide the detail needed to accurately delineate the available habitat.