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Deepwater Fish and Fisheries

The Role of Sidescan Sonar in Seafloor Classification with a Direct Application to Commercial Fisheries Management

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G) is using geophysical techniques to classify marine fish habitats for use in stock assessment of Demersal Shelf Rockfishes or DSR (Scorpaenidae: *Sebastes*). DSR are the target of an important shore-based fishery in the eastern Gulf of Alaska (560 mt allowable catch). These fishes are difficult to assess using traditional techniques as they are closely associated with complex rocky habitats. We have been using an occupied submersible to conduct line transects for estimating density of DSR since 1990. Biomass is derived as the product of estimated density (for all rocky habitats), the estimate of area of suitable habitat within the 200 m contour, and average weight of fish from port samples by management area. Currently the estimate of area of suitable habitat is based solely on the habitat description from U.S. NOAA National Ocean Service navigation/bathymetric charts -- seafloor classification in these charts is very limited. To improve our delineation of available habitat, we conducted a series of sidescan sonar surveys to identify areas of key habitat types in the area offshore of Kruzof Island, Alaska, an important fishing ground in the Central Southeast Outside (CSEO) management area. The result is a large mosaic encompassing 563 km^2 of the seafloor off Kruzof Island, approximately one fourth of the estimated DSR habitat in CSEO. The area is diverse in habitat, including areas of plutonic rock outcrop, boulders, gravel or pebble, and sand, plus an extended area of lava flows. These habitat characterizations have been groundtruthed with direct observations from a submersible.

Keywords: fisheries, habitat, rockfish, seafloor, Scorpaenidae, *Sebastes*, sidescan, sonar, stock assessment

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INTRODUCTION

The Alaska Department of Fish and Game (ADF&G), in collaboration with investigators from Moss Landing Marine Laboratories and Rutgers University, is currently involved in a research program to refine a stock-assessment method for demersal shelf rockfishes (DSR). Seven species of nearshore rockfish (Scorpaenidae: *Sebastes*) are managed on an assemblage basis in the Gulf of Alaska under the advice of the North Pacific Fisheries Management Council. Yelloweye rockfish (*Sebastes ruberrimus*) is the target of this commercial longline fishery (O'Connell and Fujioka 1991). Commonly used stock-assessment methods such as trawl surveys and mark and recapture studies are not readily applicable to this group (O'Connell 1991; O'Connell et al. 1998). The stock assessment method we are developing is based on association of DSR with specific habitat types. We have applied line-transect techniques, using in-situ fish counts from a research submersible, to estimate density of adult yelloweye rockfish over a variety of habitats, depth, and geographic areas (Buckland et al. 1993; Burnham, et al. 1980; O'Connell and Carlile 1993; O'Connell et al. 1998). Our work to date clearly indicates that for some species including yelloweye rockfish, there is a significant increase in density within rocky habitat as structural complexity increases. The highest densities of yelloweye rockfish occurred in boulder fields in deep water and the lowest densities occurred on soft bottom and fairly smooth, continuous rock bottom (Carlile and O'Connell 1992, O'Connell and Carlile 1993). The presence of refuge spaces is one key to the distribution of yelloweye (O'Connell and Carlile 1993), and it is therefore important to determine how these refuge spaces may be related to lithology in various geologic features and seafloor morphology.

In-situ research on habitat/fisheries relationships has been conducted for several species of fishes in both the Atlantic (Stubbs and Lawrie 1962; Able et al. 1987, 1993; Valentine and Lough 1991; Twichell and Able 1993; Auster et al. 1995; and Valentine and Schmuck 1995), and the Pacific (Richards 1986; Matthews 1991; Stein, et al. 1992; Krieger 1992; Yoklavich et al. 1992, 1995; O'Connell 1993; O'Connell and Carlile 1993; Greene et al. in press). Using *in-situ* or direct observation, we can define habitat characteristics on the scale of meters to tens of meters (categories such as boulder and cobble fields, and fractured rock outcrops) and determine densities of fishes within these habitat types. However, it is not possible to describe the entire Eastern Gulf of Alaska in terms of these detailed habitat categories. Therefore, we have used densities based on a generic categorization of "rocky bottom" to derive biomass and manage fisheries. Biomass is the product of fish density (#/km^2), average fish weight, and area of habitat. The area defined as rocky bottom was derived from the NOS data base (standard nautical charts) and included all areas defined as "rocky" within the 200 m contour (O'Connell and Carlile 1993 and O'Connell et al. 1998).

Geophysical technologies have been increasingly employed in mapping of marine benthic habitats. Researchers have used a variety of geophysical methods to categorize and quantify fish habitat with sidescan sonar and multibeam echosounder swath-mapping systems receiving the greatest attention (Able et al 1987; Greene et al. 1995; Lough et al. 1992; Auster et al. 1995; O'Connell and Wakefield 1995; Valentine and Schmuck 1995; Yoklavich et al. 1995, 1997; Mayer et al. 1997). Most of this work has identified gross changes in habitat identifiable in soft-bottom types such as burrows (e.g., tilefish, Malacanthidae, Able et al. 1987, 1993) or gravel vs. soft bottom. Determination of habitat categories is somewhat more difficult in our case, because we are trying to categorize a suite of closely spced habitats in a hard-bottom region of extremely diverse morphology and lithology. As part of an ongoing program to refine our estimates of rocky habitat, resulting in more accurate estimates of fish biomass, we have conducted several sidescan sonar surveys to map bathymetry and classify benthic habitats in SE Alaska. These geophysical surveys of marine benthic habitats are being conducted during years that alternate with submersible dives series used primarily to conduct line transects for estimating the density of DSR. The submersible-based in situ observations, provide critical data on habitat associations in DSR and groundtruthing for sidescan surveys.

METHODS

In 1994, we conducted a pilot study in cooperation with United States Geological Survey (USGS) using an EG&G 56 kHz sidescan sonar system to survey a small area of the continental shelf off southwestern Kruzof Island and the Fairweather Ground (Figure 1), in two of four management areas in the Eastern Gulf of Alaska, East Yakutat (EYKT) and CSEO, respectively (Figure 2). These records, although useful evaluating the usefulness of sidescan sonar in describing the geology of the areas were not of a sufficient areal extent to use in surface-based DSR habitat classification (Greene, O'Connell, and Wakefield, unpublished data). In 1996, we used an AMS-150, 150 kHz sidescan (Williamson and Associates, Inc., Seattle) to map a significant portion (563 out of a total of 1,997 km^2) of the commercial fishing grounds in the CSEO management area, the area previously imaged in 1994 (Figure 2). The area surveyed is located offshore Kruzof Island (west of Sitka, Alaska), and accounts for almost 80% of the directed commercial landings of yelloweye rockfish within the CSEO area, and 35% of the total directed fishery landings for that species in Southeast Alaska. Additionally this area accounts for significant lingcod (Hexagrammidae: ***Ophiodon elongatus***) landings, and is an important fishing ground for Pacific Halibut (Pleuronectidae: ***Hippoglossus stenolepis***).

Geological Setting - The general geology and lithology of the offshore Edgecumbe lava field and environs has been described based on previous submersible dives, limited reconnaissance mapping with sidescan sonar (1994 pilot project), and review of the geological literature. The submarine Edgecumbe lava field lies west and southwest offshore of Kruzof Island. This relatively young (Pleistocene to Holocene) lava field (Brew, et al. 1969; Riehle et al. 1989) is located within the flysch and basalt assemblage of the Chugach terrane (Plafker et al. 1994). Here the pre-volcanic bedrock (Tertiary and Cretaceous) consists of the Cretaceous Sitka Graywacke and the early Tertiary

Kruzof Island plutonic rocks of light-colored granite, ganodiorite and adamellite (Reihle et al. 1989). These rocks are exposed on the continental shelf in the northern part of our study area.

Sidescan Sonar - The AMS-150 is a lightweight, medium depth seafloor mapping system capable of generating co-registered backscatter imagery and bathymetry across a swath of up to 1,000 m. The towfish for the AMS-150 system is a two-body system using a depressor weight and a neutrally buoyant umbilical to decouple the towfish from ship heave, providing the stability needed for high quality imagery and bathymetry. The position of the towfish is monitored with an integrated navigation system combining an ORE Trackpoint II® acoustic tracking system and Differential Glopal Positioning System (DGPS).

AMS-150 Survey and Data Processing - The area surveyed with the AMS-150 was approximately 13 km east/west and 46 km north/south. The majority of the survey was conducted with tracklines spaced at 400 m, providing for overlapping swaths (when using an overall swath width of 1,000 m). Data from the AMS-150 was logged with the *GeoMAP*®, geophysical mapping and processing system (Williamson and Associates, Inc., Seattle). Post cruise processing of the backscatter imagery and bathymetry was completed by the contractor and included a complete hand constructed mosaic of the survey area complete with a bathymetric overlay and detailed digital mosaics of selected areas. Copies of the digitized sidescan and bathymetric data were forwarded to the Center for Habitat Studies at the Moss Landing Marine Laboratories (MLML), Moss Landing, California for use in developing the interpretive products.

Groundtruthing and Interpretation - Within a month of completing the sidescan survey, one member of our group (VMO), conducted a series of 14 groundtruthing dives with the research submersible DELTA in the area of the sidescan mosaic. Dive logs, video tapes, and rock samples from these dives were transferred to the Center for Habitat Studies at MLML for use in constructing a preliminary geological interpretation. The information from the 1996 dive series supplements an archive of dive logs, video tapes, and rock samples representing more than 150 submersible dives since 1989 from the Kruzof area and other sites within the region of SE Alaska.

A line-transect survey was scheduled for DSR in 1997, using the research submersible DELTA. The availability of the DELTA submersible provided an opportunity for directed dives within the area of the sidescan mosaic to confirm seafloor classifications used in the preliminary geological interpretation produced immediately after the previous year's sidescan survey. A group of geologists were invited to participate in the line-transect survey cruise for that portion of the cruise when the submersible would be diving in the CSEO area off Kruzof Island. Prior to the cruise, small-scale dive maps were prepared for seven areas that were identified as critical for groundtruthing. A total of thirty-six dives were completed in the Kruzof Island area of CSEO during 1997 with fourteen of those dives devoted solely to groundtruthing the moasic from the sidescan sonar survey.

To create interpretive geologic and habitat maps from the sidescan sonar mosaic, a composite of the mosaic and coordinates were used as a base for a mylar interpretive overlay, where all features were initially traced in pencil A second overlay was carefully registered and the features transferred, where they were compiled and coded to a specific seafloor composition. For the area of this investigation, we initially mapped fourteen distinct and different habitat types which were subsequently subsumed into nine benthic habitats types: sand, gravel or pebble fields, boulder fields, rugged volcanic rock outcrops (high reflectivity), fractured plutonic rock outcrops, ponded volcanic flows, and volcanic pinnacles.

The interpretation was digitized by hand using a Summagraphics digitizing board. All habitat interpretations were digitized at a 1:20,000 scale. Submersible dive tracklines from previous investigations of the area offshore of Kruzof Island were imported into the map of the study area as a separate layer as were maps of the location of rock samples. Additional data were digitized into the maps to support the interpretation, including regional geology of Kruzof Island (Reihle et al. 1989), USGS surveys and interpreted fault locations (Carlson et al. 1985), and shorelines from the NOAA navigational charts add weight to the interpretation. All digitizing and overlay were done using Mapgrafix®, and completed maps were exported to ArcInfo®.

RESULTS AND DISCUSSION

The 1996 sidescan sonar survey resulted in a large seafloor mosaic, encompassing 563 km^2 of the seafloor off Kruzof Island, approximately one fourth of the estimated DSR habitat in CSEO. Groundtruthing based on a multi-year series of submersible dives in the area of the sidescan mosaic yielded a geological interpretation, showing a diverse array of marine benthic habitats, including areas of plutonic rock, boulders, gravel or pebbles, and sand, plus an extended area of lava flows (Figure 3). The lava surface, representing 46% of the study area, exhibits well defined and little eroded áá and pahoehoe lava, lobate lava fronts, collapsed lava tubes, volcanic cones (pinnacles) and fault scarps.

The diversity and distribution of rockfish species, as observed through direct observation from the submersible, appears to be related to habitat and depth, with the presence of suitably sized refuge spaces a key to the occurrence of demersal rockfish. Density of yelloweye rockfish is 2.3 and 1.4 times greater in boulder-fields and broken-rock substrates, respectively, compared to an average density across all hard-bottom substrates. Using the identified habitat-specific densities and accurate quantification of habitat, the commercial catch quota would be 17% greater, then a quota simply based on the areal extent of habitat derived from the navigation / bathymetric charts (Figure 4).

Considerations of habitat-specific density will not always lead to a quota increase. For the Fairweather Ground, another valuable fishing area for DSR in the EYKT management area (Figure 2) in the Eastern Gulf of Alaska, a preliminary submersible-based examination of the areal extent of rock habitat has lead to a different result. On the basis of habitat descriptions from U.S. NOAA National Ocean Service navigation/bathymetric charts and commercial longliner's logbook data, ADF&G estimated the amount of available rocky habitat on the Fairweather Ground at 1,132 km^2. In 1997, we used a grid of bathymetric transects obtained with the ship's precision depth recorder and groundtruthed with the submersible DELTA to develop an improved inventory of benthic habitats. For 1998, the estimated amount of available habitat was reduced from 1,132 to 448 km^2 with a concomitant drop in the allowable catch (Figure 5). During the summer of 1998, we plan to return to the Fairweather Ground and conduct a detailed seafloor-mapping effort with the AMS-150 sidescan sonar. Ultimately, our ocean mapping efforts will provide a permanent record of the seafloor for use in the management of living resources within the region.

CONCLUSIONS

The use of a combination of geophysical methods and in situ direct observations have allowed us to characterize habitats critical to management of the DSR resource. In addition, our recent work, resulting in production of a large seafloor image (mosaic) affords us the unique opportunity to begin the process of seafloor characterization on a scale meaningful to fisheries management in the Eastern Gulf of Alaska. By defining habitats in categories based on sonographs and bathymetry we will be able to refine our estimates of density over a large area. Understanding the geology of this area is also integral to our application of fisheries management through habitat associations.

ACKNOWLEDGEMENTS

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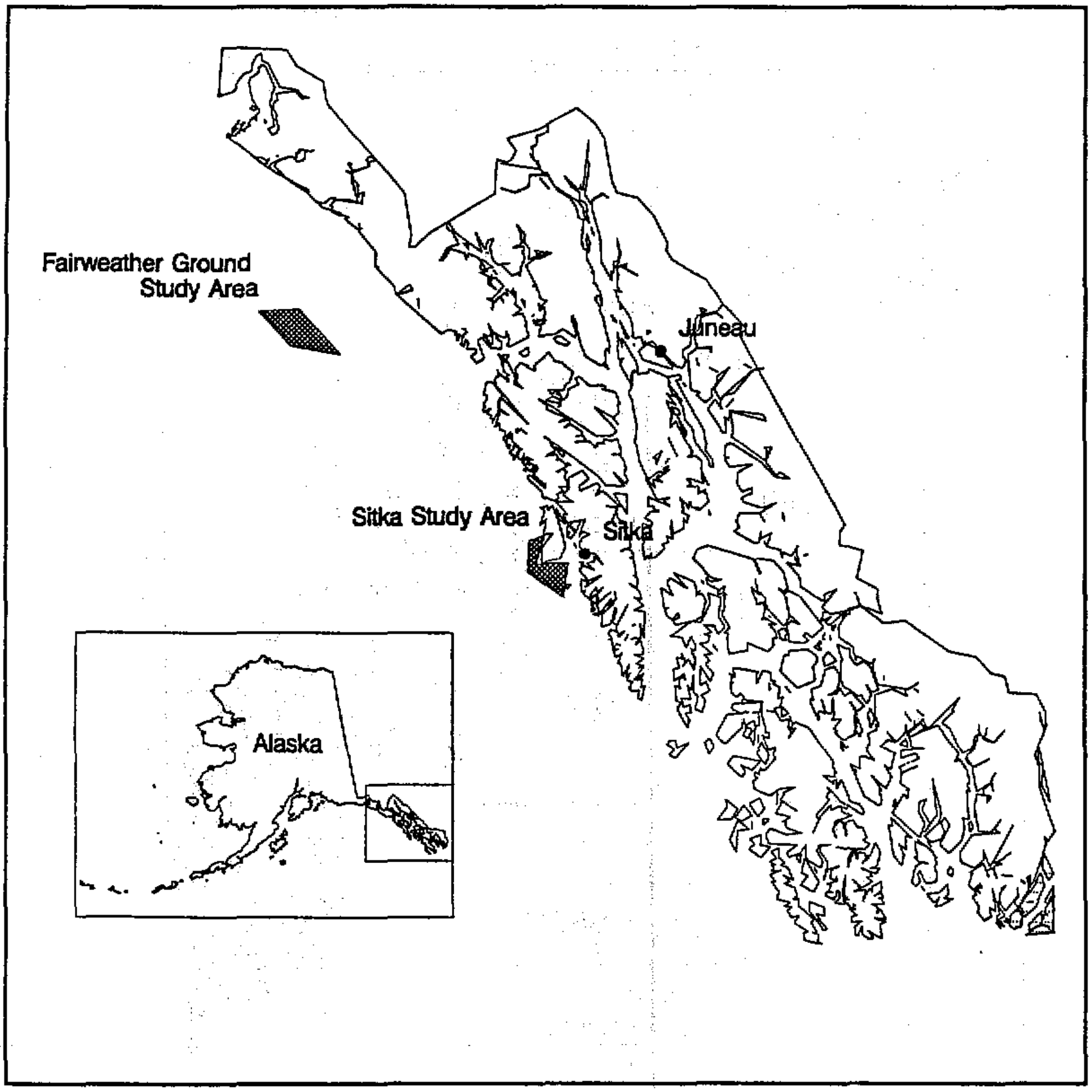

Figure 1. Study sites for sidescan sonar and research submersible survey of marine benthic habitats in the Eastern Gulf of Alaska.

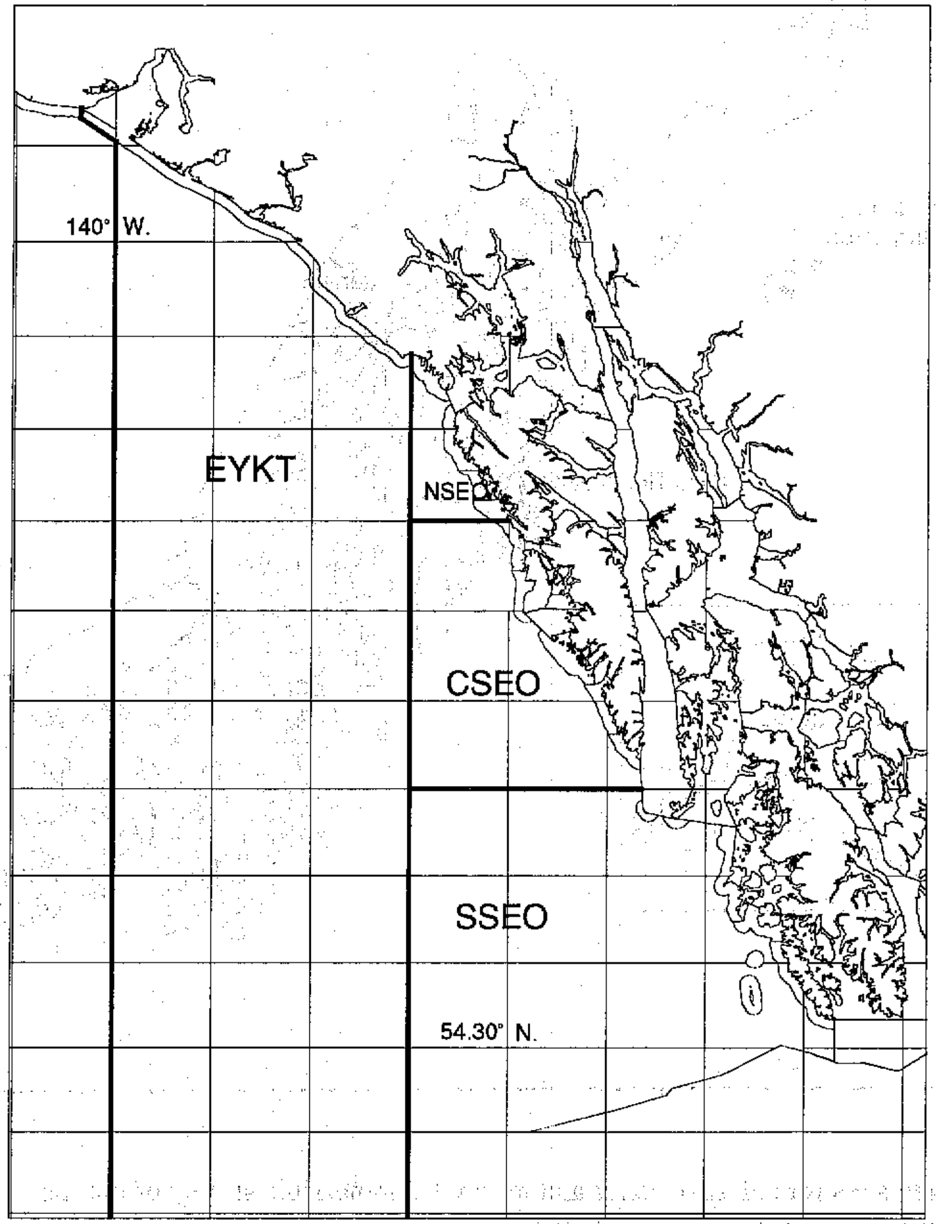

Figure 2. The eastern Gulf of Alaska with Alaska Department of Fish and Game Groundfish Management Areas: the EYKT (East Yakutat), NSEO (North), CSEO (Central), and SSEO (South) sections comprise the Southeast Outside (SEO) Subdistrict.

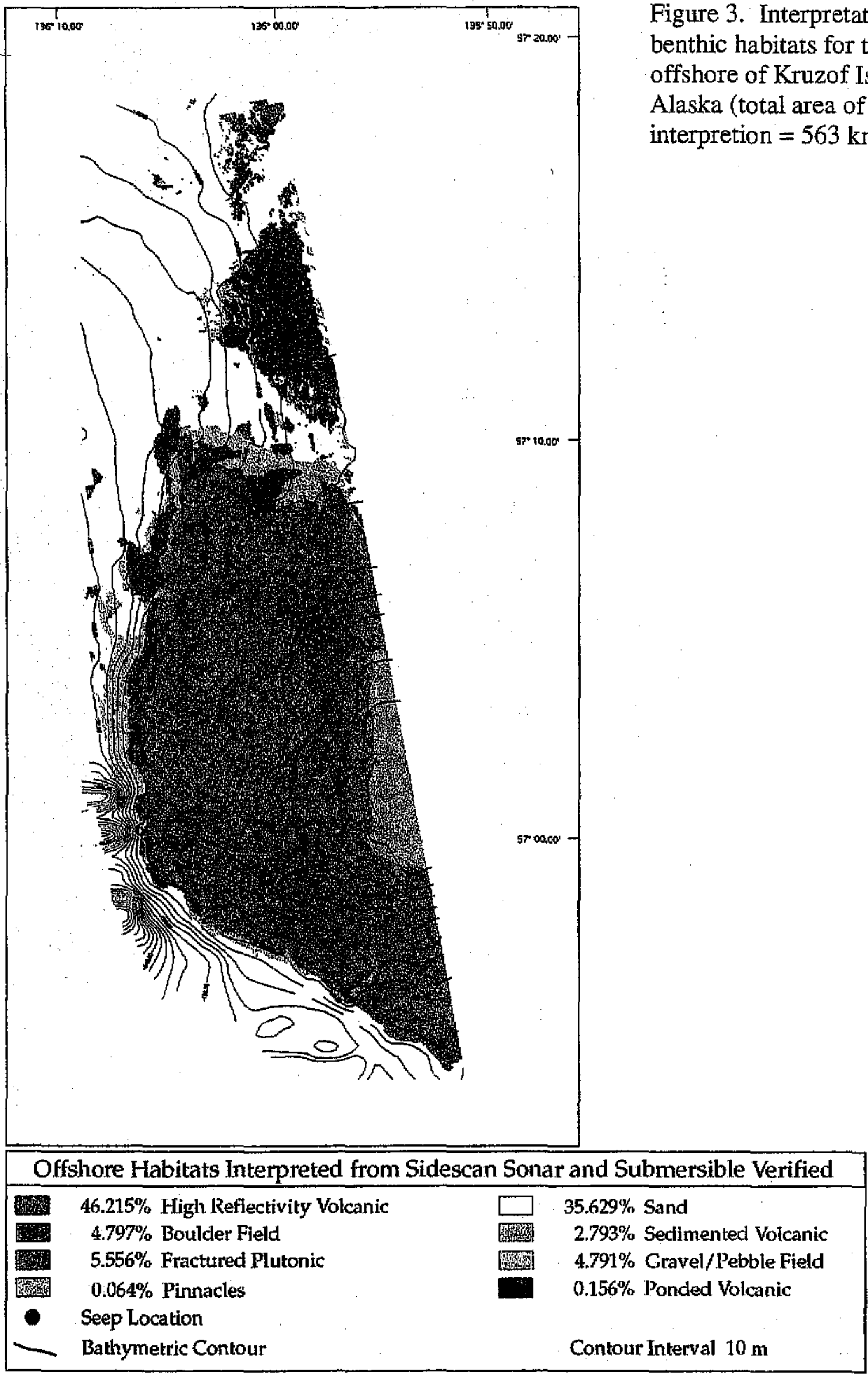

Figure 3. Interpretation of benthic habitats for the area offshore of Kruzof Island, Alaska (total area of the interpretion = 563 km^2).

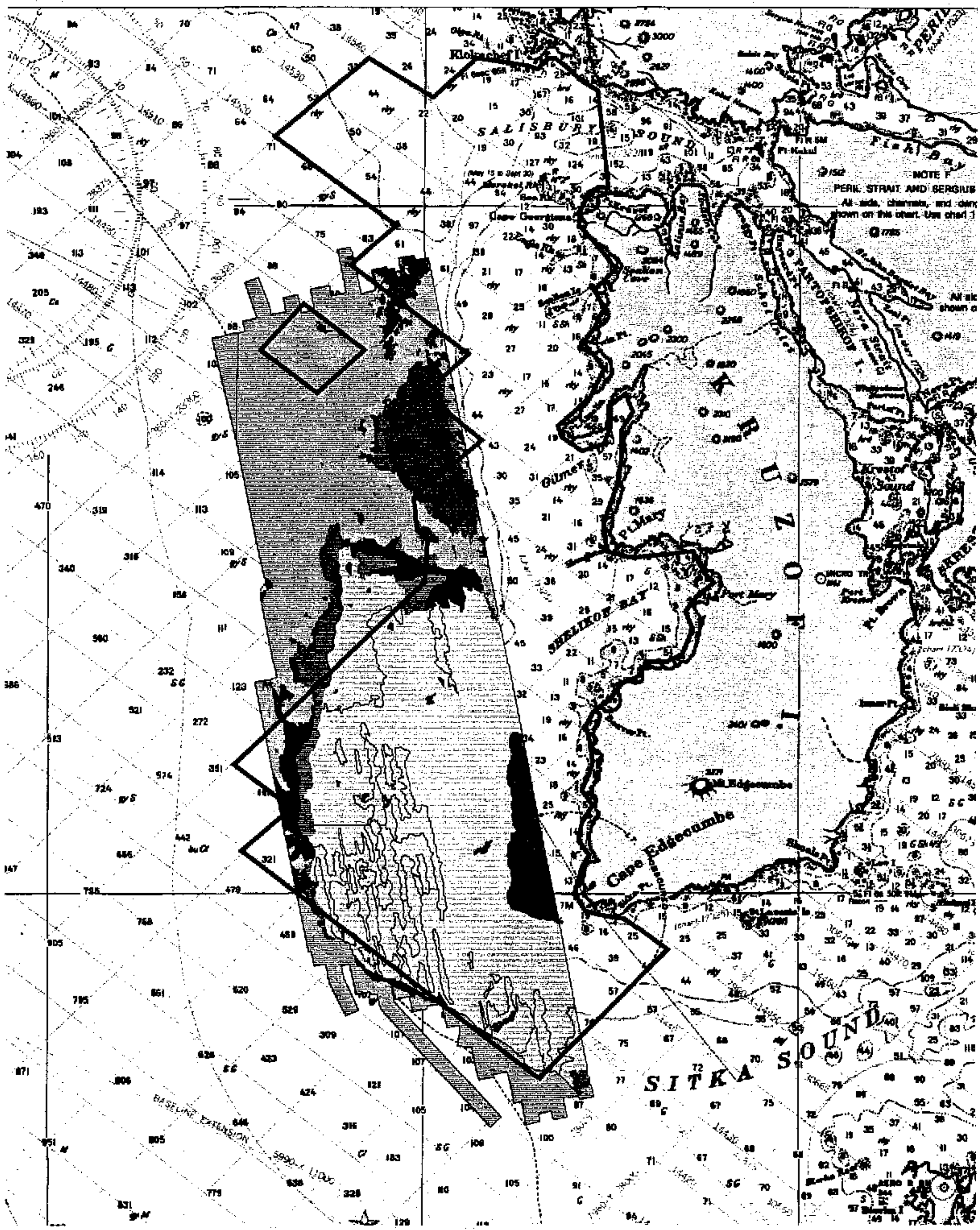

Figure 4. A comparison of the delineation of rocky habitat (within the 200 m depth contour) in the study area off Kruzof Island, Alaska developed from two different sources of information: 1) a combination of submersible dives, sidescan sonar surveys, and a review of the geological literature (refer to Figure 3), and 2) descriptions from U.S. NOAA National Ocean Service navigation/bathymetric charts and longliner's logbook information (indicated by area within bold angular polygons).

Figure 5. A comparison of the delineation of rocky habitat (within the 200 m depth contour) in the area of the Fairweather Ground, Alaska developed from two different sources of information: 1) a grid of bathymetric transects obtained in 1997 with the submersible support ship's precision depth recorder and groundtruthed with the submersible DELTA to develop an inventory of benthic habitats (curvilinear outlines), and 2) habitat descriptions from U.S. NOAA National Ocean Service navigation/bathymetric charts and commercial longliner's logbook data (angular polygons).