MARINE GEOLOGY OF BENTHIC BIOHABITATS IN GLACIER BAY, ALASKA

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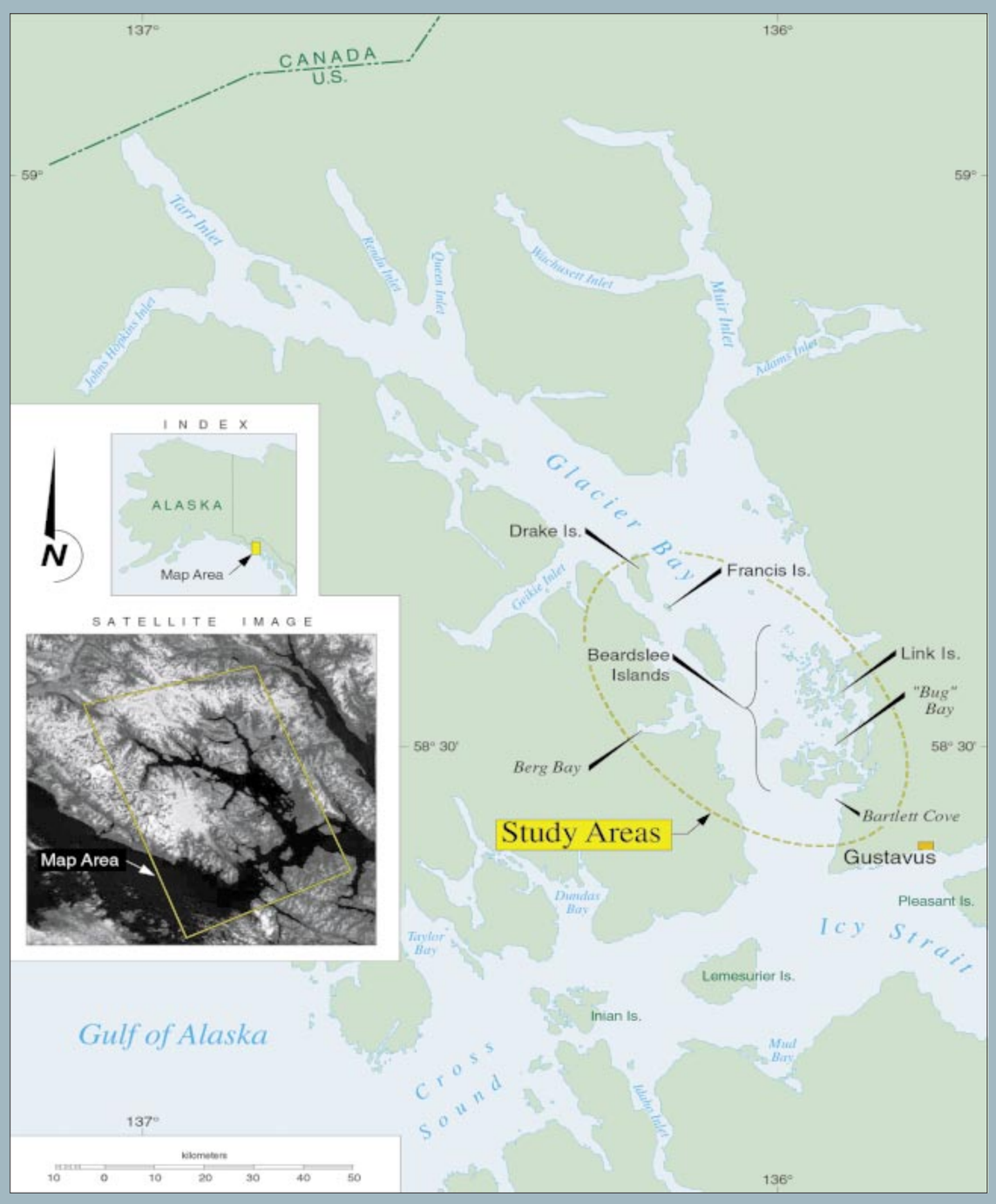
EXECUTIVE SUMMARY

On this pilot cruise of August 1996, in Glacier Bay we collected a total of 155 km of track line which provided SSS imagery and 3.5 kHz profiles in 5 study areas of the south bay. The acoustic portrayal of the bay floor showed significant changes in the bottom substrate characteristics from bay to bay and within each of the subareas investigated. Some of the morphologic and sedimentologic variations appear to have effects on the types of biota that inhabit the different environments of this bay floor that has only become ice free in the past 200 years. A wide variety of environments are included in this recently deglaciated bay complex. They include 1) moraines with varying sizes of boulders and cobbles, 2) moraines where the coarser larger cobbles and boulders appeared to be covered with finer sediment (sands and in some places muds) 3) relatively featureless muddy-bottom bays, where in some instances 4) isolated dropstones were present either fairly near the moraine proper or in some basins, completely separated. Other environments include 5) a submarine sandy delta front with well-defined bedforms encroaching on the basin floor mud of Bartlett Cove, off the Bartlett River, 6) rocky insular slopes, 7) shallow basins with thin recent sediment cover, 8) deeper basins (>20m) with soft sediment cover of variable thicknesses, and 9) some sediment accumulations that apparently contained free gas, probably methane were also imaged.

This project involves the characterization of seafloor habitats in lower Glacier Bay, including geomorphic, sedimentologic, and stratigraphic descriptions, based on acoustic imaging and profiling of the fjord floor. The goal has been to determine the bottom character of several field study sites to help explain distributions of Dungeness Crabs and Halibut. Studies of crab density have been conducted in the areas we profiled on this cruise. O'Clair et al (1995) reported density of crabs at the study sites to range from 78 to 2012 crabs/ha over three sampling periods from April, 1992 through April 1993. This pilot study of several areas in Glacier Bay provides physical characteristics of the bay floor to help answer some of the myriad of biological habitat questions.

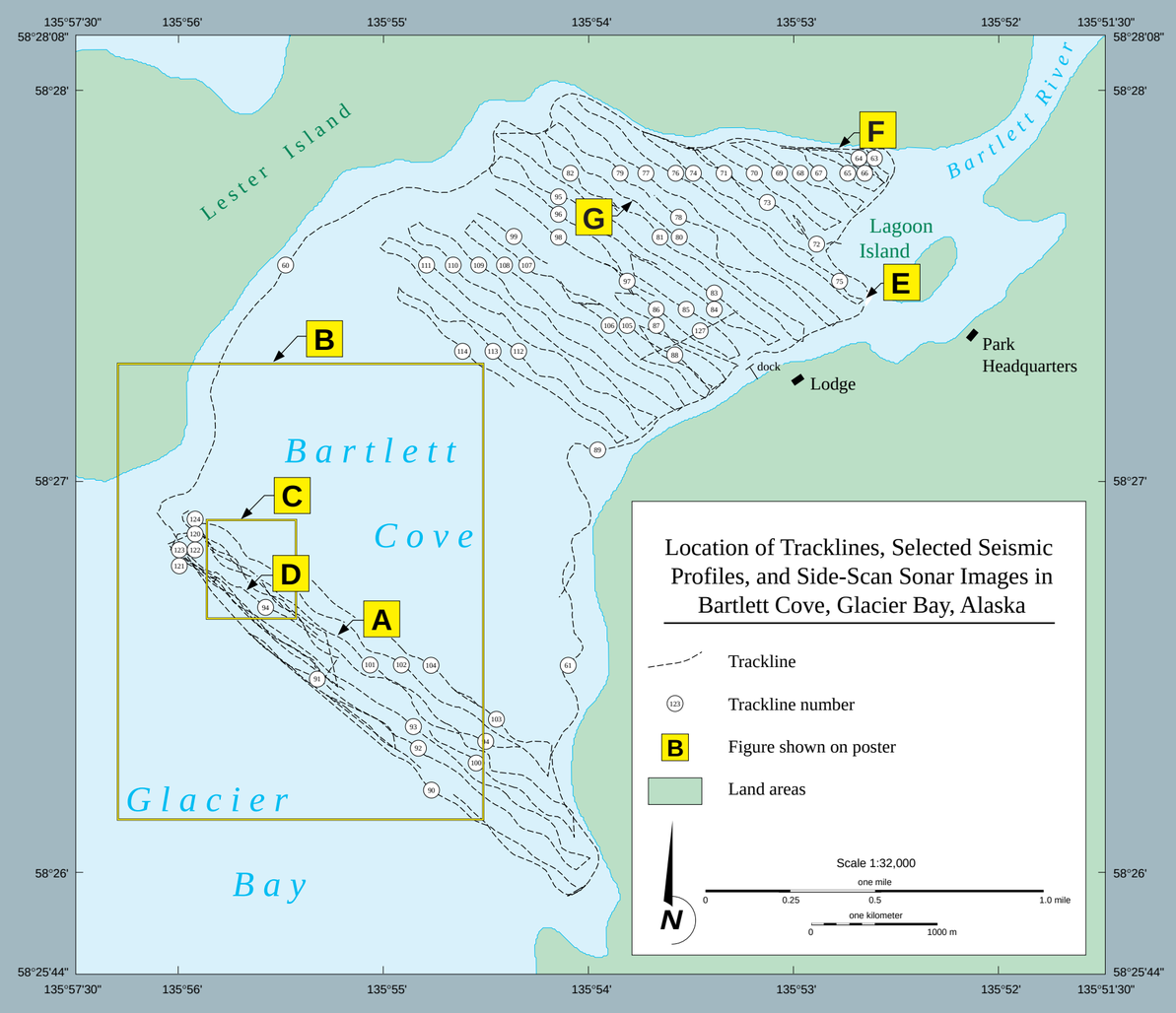
Glacier Bay

Glacier Bay National Park in southeastern Alaska, was proclaimed a National Monument in 1925, and was upgraded to National Park status in 1980. This 3.3 million acre park and preserve extends from Icy Strait on the south to Dry Bay in the northwest . In the past 200 years, retreat of the large glacier that filled Glacier Bay (commonly referred to as the time of the Little Ice Age) exposed an extensive fjord system about 100 km long from Icy Strait to the terminus of Johns Hopkins and Grand Pacific Glaciers in the West Arm and slightly less to Muir Glacier at the head of Muir Inlet to the east. This spectacular fjord system is the product of multiple glaciations over possibly longer than the past 100,000 years. As the most recent large glacier retreated, the newly exposed terrain and fjords have been undergoing rapid physical and biological transformations Because of the rapid changes, this national park is a spectacular scientific laboratory in which to study glaciology, fjord sedimentation, succession of terrestrial plants, and changes in terrestrial and marine biological communities. This study deals with bays and inlets in the lower 30 km of the main bay--specifically, Bartlett Cove, Berg Bay, three areas in the Beardsley Island complex, and two small areas in the main bay, one between Drake and Francis Islands and a second in the Sitakaday Narrows region.

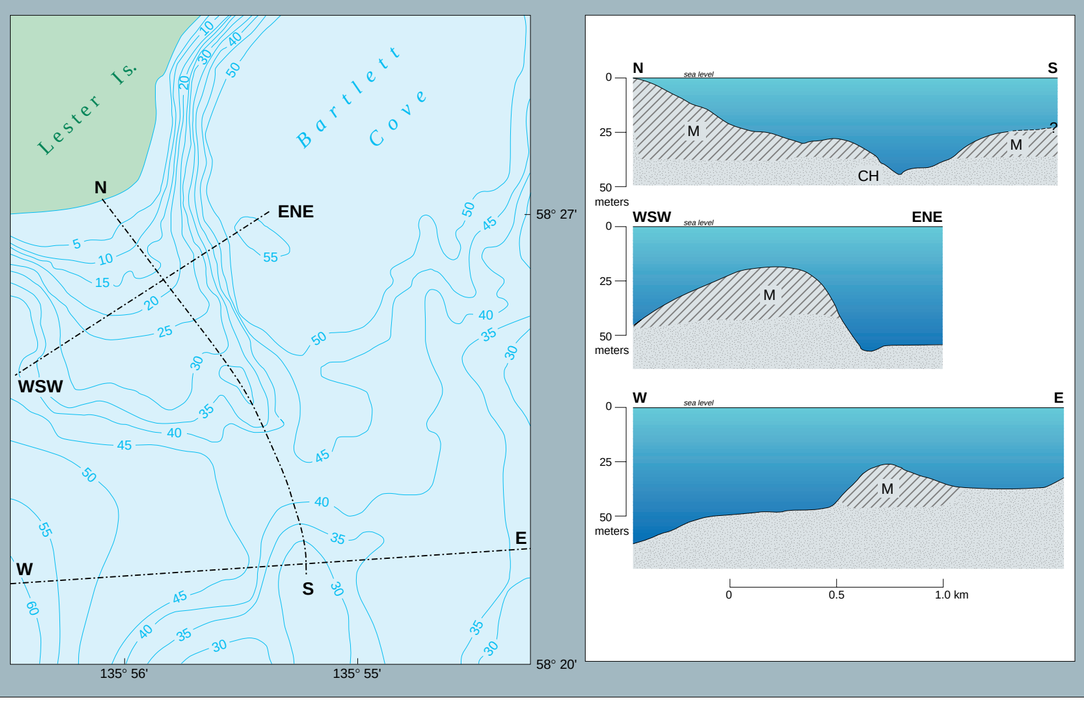


Bartlett Cove

This 5 km long reentrant on the east side of Glacier Bay, about 8 km north of the entrance, is the location of the park headquarters and lodge, thus the hub of tourist activities. We collected a total of 72 km of track lines, but, due to interruptions by the presence of whales, we only insonified about 2/3 of the cove. The shoreline of Bartlett Cove consists of Quaternary sediments. The northwest shoreline consists of the southern shore of Lester Island, the southern most of the Beardslee Island complex. The southern and eastern shorelines consist primarily of outwash deposited by the Bartlett River and contributed to by the rapidly retreating glacier that last covered this area about 200 years ago.

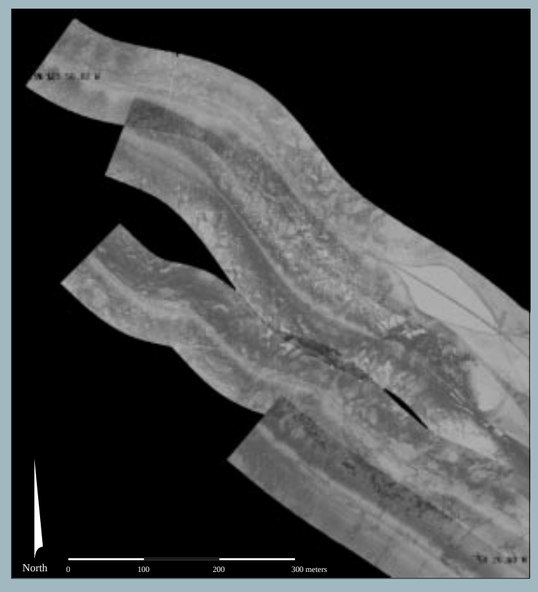


B Bathymetric Map and Profiles of Bartlett Cove Moraine



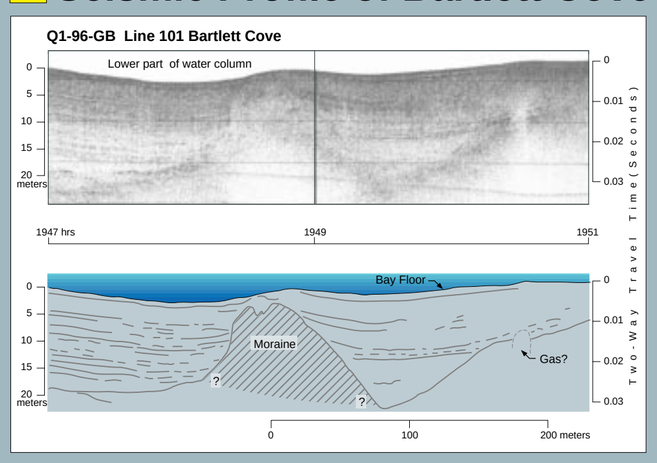
Bartlett Cove, partially protected from storm waves by a bay-mouth end moraine, provides a good anchorage for numerous fishing and pleasure craft. The moraine and Bartlett Cove sedimentary basin can be clearly seen on B. The moraine is nearly 3 km long and 1 km wide and has a relief of about 15-30 m. In the central part of the moraine a tidal channel has been cut that reaches a depth of about 50 m.

C D Side-Scan Sonar Images of Bartlett Cove Moraine



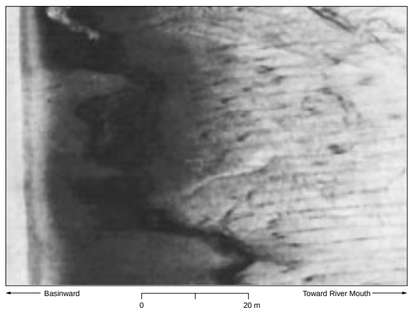
The SSS (side-scan-sonar) imagery (Figs. C & D above) was collected using a Klein SSS system which incorporated an attached 3.5 kHz profiler (see profile in Fig. A). These SSS images were obtained with a 500 kHz source that has a nominal swath width of 100 m. The SSS imagery of the moraine clearly shows the locations of some large boulders, and some patches of small boulders, cobbles and smaller gravel intermixed with finer sediment, probably sand. The side-scan sonar imagery exhibits the acoustic quality of the hard surface (dark reflections with white shadows) we expect from the boulder and cobble mix common on moraines. However, the portions of the SSS image that are lighter gray in color indicate areas that appear to be floored with finer sediment having lower reflectivity, probably sand.

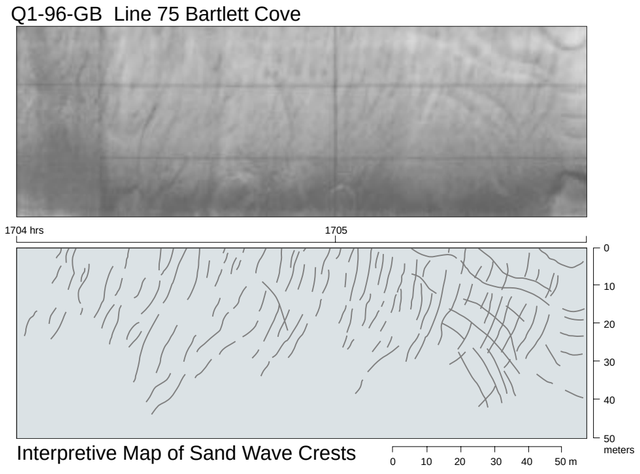
A Seismic Profile of Bartlett Cove Moraine



This 3.5 kHz acoustic profile shows part of the buried portion of the lateral moraine that marks the entrance to Bartlett Cove. The interpretive sketch shows well-bedded fine grained sediment (sandy to silty) from 2 to 20 m thick that covers the very irregular morainal surface. Note (GAS?) which marks the possible presence of gas-charged sediment. V.E. =~ 4 X.

E Side-Scan Sonar Images of Sandwaves near Mouth of Bartlett River

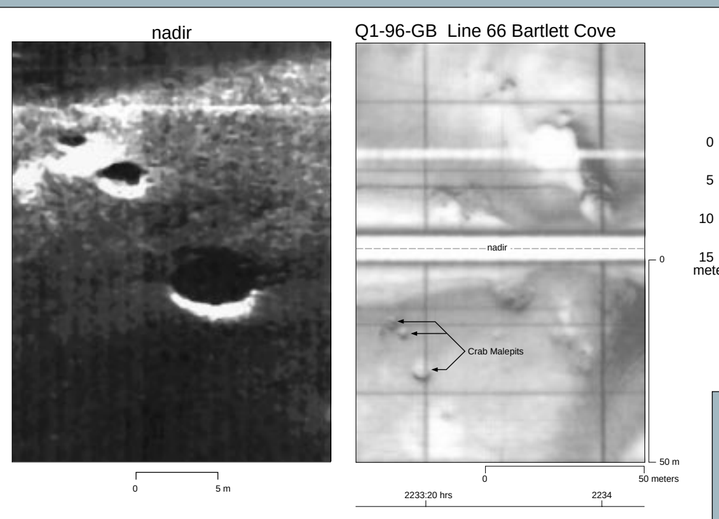


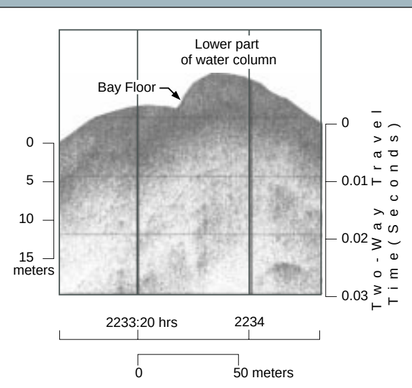


At the inner end of Bartlett Cove there is a delta building out from the Bartlett River. A SSS image collected near the entrance to the inner lagoon shows a wedge of delta sand impinging on the mud that floors the deeper part of the cove (Fig. E, left). Two sets of sand waves or megaripples can be seen on the image (Fig. E, right). The crests of the sand waves are about 5 m apart.

Bottom grab samples recently (10/97) collected in this area varied from coarse brown sand to dark fine silty sand. A 3.5 kHz profile collected over the deltaic shelf produced as many as four multiples, showing the hard reflective nature of the sandy delta surface.

F Side-Scan Sonar Images of Crab Pits

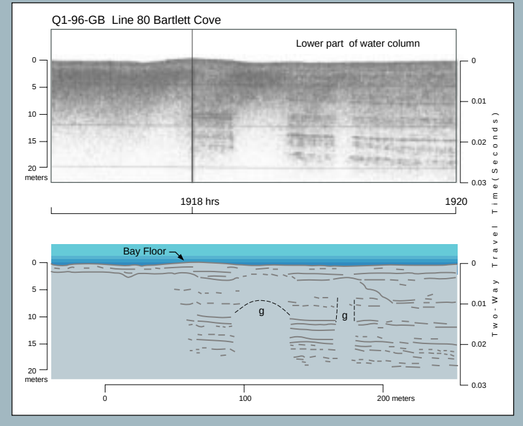




Pits shown on SSS image (F, center) from upper Bartlett Cove were apparently resting places for multiple male crabs seen during a dive in spring 1996. Pits are several meters wide.

Left image shows enlarged view of pits. Black and white have been reversed on image to give a somewhat different perspective of these pits. On this image white is high backscatter, shadow is black. Right image shows a 3.5 kHz profile that was collected simultaneously along nadir of SSS image. V.E. =~4 X.

G Seismic Profile of Gas-Charged Sediment



Disrupted sub-bottom reflections on some Bartlett Cove records (Figs. G & A) suggest that gas-charged sediment underlies at least some of the shallow soft-sediment-filled basin. Given the diver-observed, anaerobic conditions of the mud flooring much of the Cove (P. Hooge, oral communication, Oct. 20, 1997), methane deposits would not be a surprise. Gas in the sediment also is indicated by the presence of gas bubbles at the water surface in parts of Bartlett Cove (observed by P. Hooge and P. Carlson, Oct. 20, 1997). The question arises as to the affects of the gas on marine life in this environment? This could also be a problem in some of the other coves and bays within Glacier Bay National Park.

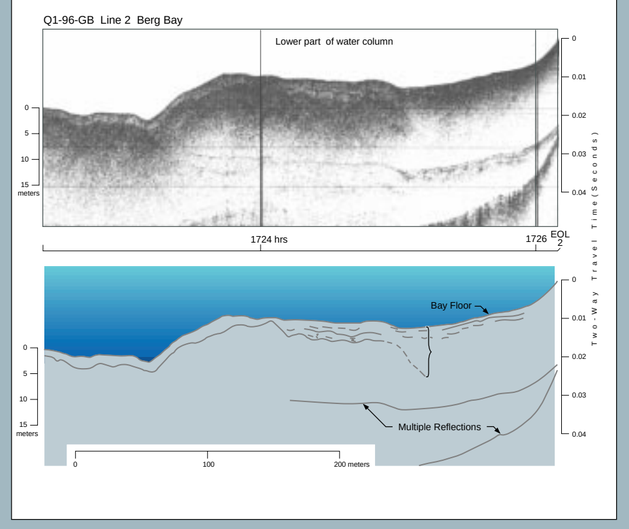
R/V QUILLBACK

Other Localities

In addition to Bartlett Cove, other areas in Glacier Bay were insonified with the combination of 3.5 kHz acoustic profiler and side-scan sonar system that used two different frequencies (500 and 100 kHz)

These areas, see location map, are the sites of continuing studies of life history, distribution, and abundance of halibut and Dungeness crab. Bottom characteristics and bathymetry have been hypothesized to have affects on the distribution, abundance and behavior of these species. By combining sidescan and subbottom profiling with population sampling (including sonic tracking of individuals) as well as dive sampling, we hope to better understand the distribution, abundance and behavior of both halibut and crab.

H Seismic Profile of Berg Bay

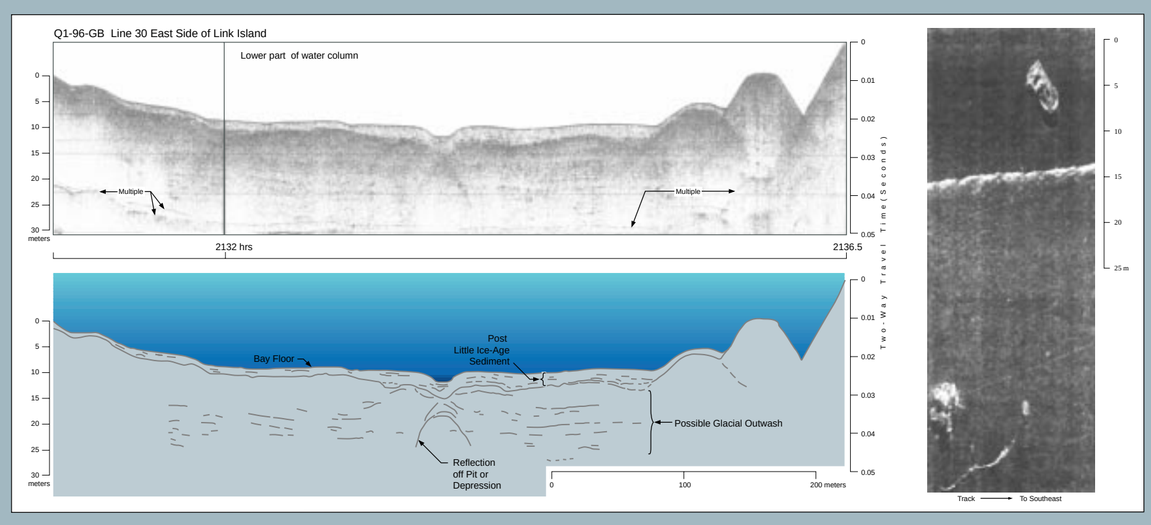


Interpretation of 3.5 kHz profile from Berg Bay showing types of variations in sediment pile. Because 3.5 profile is attached to SSS, vertical scales do not indicate water depths. Surface bounce reflection was used to recognize subbottom reflections shown in interpreted profile. A possible explanation for small amount of penetration, other than glaciated surface which would be hard and allow little penetration, might be presence of methane in sediment which At the inner end of Bartlett Cove there is a delta building out from the Bartlett River. A SSS image collected near the entrance to the inner lagoon shows a wedge of delta sand impinging on the mud that floors the deeper part of the cove (Fig. E, left). Two sets of sand waves or megaripples can be seen on the image (Fig. E, right). The crests of the sand waves are about 5 m apart.

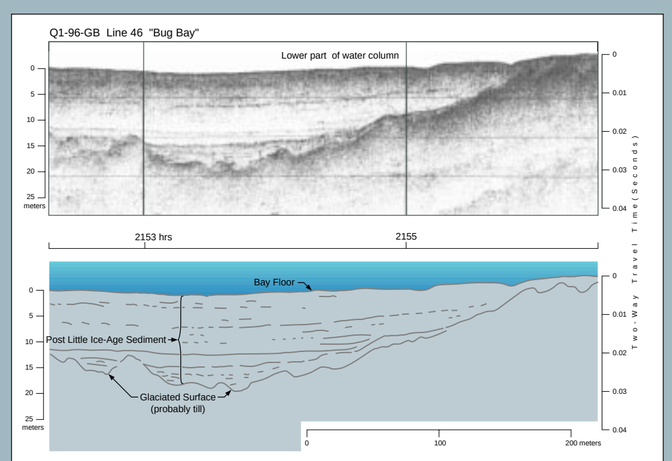
Bottom grab samples recently (10/97) collected in this area varied from coarse brown sand to dark fine silty sand. A 3.5 kHz profile collected over the deltaic shelf produced as many as four multiples, showing the hard reflective nature of the sandy delta surface greatly impedes penetration.

Beardslee Islands

I Seismic Profile J Side-Scan Sonar Image



K Seismic Profile of "Bug" Bay



3.5 kHz profile (Fig. I) northeast of Link Island. About 5 m of soft sediment overlies deeper reflections; may be part of glacial outwash plain formed as ice sheet retreated. Well-defined pit is apparent in middle of profile. Side-scan image across area shows no elongation of feature, ruling out a channel.

Side-scan sonar image (J) of sunken skiff (note dark outline of the skiff and its acoustic "shadow" in white) and crab pots in 40-50 m of water south of Kidney Island. Skiff was collecting crab traps a couple years ago when water turned rough and heavily loaded skiff sank. At lower left note elongate irregular blob or mound; probably pile of crab traps that fell off as boat sank. Near bottom of figure, elongate double-arced line may be buoy line leading from a crab pot. Image illustrates side-scan sonar system resolution.

3.5 kHz profile and interpretation (Fig. K) of sediments underlying southeastern part of "Bug Bay." Note thick sediment fill and underlying hummocky glacial surface.

Further Studies

After a cove is completely insonified and mosaiced, georeferenced images are created, diver sampling will be able to ground truth the patterns seen in the images which can then be extrapolated to the entire coverage area. This data layer will provide a tool to stratify sampling and to overlay abundance patterns. This method will prove useful in combining with the coastal mapping database being built at Glacier Bay to determine the depth and extent of this biologically important habitat. The NPS and USGS-BRD Field Station are jointly mapping the geomorphology and biota of the coast into a Geographic Information System using scanned and GPS georeferenced infrared aerial images as well as ground-truth samples. The extent of the intertidal and nearshore benthic environment has been a distinct missing piece to this mapping effort.

Combining this database with the side-scan sonar mosaic, distribution of sediment type, and an improved bathymetric model will provide a resource for many coastal research projects as well as resource management issues. An example of one such issue is the determination of oil spill sensitivity within the park.

A second cruise in October 1997, provided complete coverage of Bartlett Cove, extended coverage of "Bug Bay" and coverage of a new site, "Secret Bay", also in the Beardslees. We also collected a few bottom samples to provide some ground truth in Bartlett Cove. The biologists plan to take additional grab samples to further ground truth the bottom sediment in conjunction with their dive cruises.

A third cruise is in the planning stage for late April of 1998. We plan to insonify some halibut study sites in Muir Inlet. Because of the deep water (>300 m), we will use the 100 kHz SSS fish extensively.