NOAA Technical Memorandum NMFS F/NWC-66

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November 1984

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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December 1984

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ABSTRACT

Prey of humpback whales, *Megaptera novaeangliae*, were identified and hydroacoustically surveyed in the Glacier Bay-Icy Strait and Stephens Passage-Frederick Sound areas of southeastern Alaska in August and September 1983. Midwater trawls were used to identify the prey, which were either small fish or euphausiids. The prey were hydroacoustically quantified at whale foraging sites and indexed along the same transects surveyed during the Whale Prey Study in 1981 and 1982.

The few humpback whales observed in Glacier Bay during 1983 were in areas too confined (nearshore and less than 30-m depth) for quantitative hydro-acoustic surveys and net sampling. However, echo-sounder recordings at four feeding sites in Glacier Bay revealed the presence of small, dense fish schools.

Humpback-whale forage was quantified at six sites outside Glacier Bay. Pacific herring, *Clupea harengus pallasi*, were the prey at Point Adolphus in Icy Strait and near The Five Fingers islands in Frederick Sound, and their density was 60.6-145.5 g/m^3 at depths of 25-80 m. Euphausiids were the dominant prey at four sites in Stephens Passage, and their density was 0.7-4.3 g/m^3 at 60-130 m.

The spatial distribution of fish and micronekton along Glacier Bay transects in 1983 was similar to the distribution observed in 1982; however, mean backscattering density was higher in 1983 than 1982 because of increased' euphausiid densities near Geikie Inlet in 1983. A seasonal increase of backscattering density from early August to mid-September was also attributed to higher euphausiid densities near Geikie Inlet., The general distribution and abundance of prey along transects in Stephens Passage-Frederick Sound in

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September 1983 were similar to those observed in August 1982. During the 1983 surveys, fish and micronekton were less abundant in Glacier Bay than at whale feeding sites outside the Bay. The highest density of whale forage (0.1 g/m^3) assessed in Glacier Bay in 1983 was the euphausiid scattering layer near Geikie Inlet.

CONTENTS

INTRODUCTION

The humpback whale, *Megaptera novaeangliae*, is a major attraction each year for more than 120,000 visitors to Glacier Bay National Park. Because humpback whales are an endangered species, they are protected under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the National Park Service Organic Act. The latter Act directs the National Park Service to provide for visitor use and enjoyment of resources in Glacier Bay and to maintain those resources unimpaired for future generations. An apparent decline in the number of humpback whales using Glacier Bay as a summer foraging area is a concern of the National Park Service and may be symptomatic of widespread problems involving vessel traffic or natural changes in the distribution and abundance of feed for whales.

About 15,000 humpback whales were in the North Pacific population before exploitation by the whaling industry (NMFS 1983). Although completely protected since the late 1960's, the present population is estimated at 1,200 whales (NMFS 1983). During the last 5 yr, 365 humpback whales have been identified in the inside waters of southeastern Alaska (C. S. Baker, Kewalo Basin Marine Mammal Laboratory, University of Hawaii, Honolulu, HI 96814. Pers. commun., 1984). Although humpback whales range from Dixon Entrance northward, they are not uniformly distributed but concentrate seasonally in areas, such as Glacier Bay-Icy Strait and Frederick Sound-Stephens Passage, where their feed includes Pacific herring, *Clupea harengus pallasi*; capelin, *Mallotus villosus*; and euphausiids (Jurasz and Jurasz 1979). Humpback whale concentrations also occur along the outside coast and in southern portions of southeastern Alaska, but whale research and census has been very limited in these areas.

Some humpback whales return annually to the same foraging area and become residents within relatively small or localized home ranges (Baker 1983; Baker et al. 1983). Glacier Bay is one of these foraging areas. From 1973 through 1977, 10-24 humpback whales were seen in Glacier Bay each summer, and 10-21 were resident whales (i.e. , whales that foraged in the Bay for more than 4 weeks) (NMFS 1983). Since 1978, the use of Glacier Bay by resident humpback whales has changed. From 1978 through 1983, 10-23 whales have visited the Bay each year, but only 1-7 whales became residents (NMFS 1983; Baker 1983).

The decline in numbers of resident humpback whales in Glacier Bay coincided with an increase of vessel traffic by commercial tour ships, fishing vessels, and private pleasure boats in Glacier Bay (NMFS 1983) and a change in the predominant forage fishes of salmon in southeastern Alaska (Wing and Krieger 1983). Disturbance by vessels or a change in the trophic structure of the Glacier Bay ecosystem may cause a change in the whales' use of Glacier Bay. If the decline is primarily due to a change in the trophic structure, regulations affecting the number and type of vessels visiting Glacier Bay could be modified.

To reduce the potential adverse effects of vessel traffic on humpback whales, the National Park Service has restricted the number of vessels in Glacier Bay during summer (June through August) and regulated vessel speeds and traffic patterns where whales are most frequently found. Changes in these regulations would reflect the recommendations of the National Marine Fisheries Service (NMFS), under provisions of the Marine Mammal Protection and Endangered Species Acts. Present regulations depend on the number of whales entering Glacier Bay and the results of research on the causes of whale population changes in the Bay. To investigate the probable causes of these changes, the National Park Service, in cooperation with the National Marine

Mammal 'Laboratory of the Northwest and Alaska Fisheries Center (National Marine Fisheries Service), initiated a three-part research program in 1981 and 1982 describing 1) the acoustic environment of humpback whales in Glacier Bay and Frederick Sound (Malme et al. 1982; Miles and Malme 1983), 2) whale behavior in response to vessel traffic (Baker et al. 1982; Baker et al. 1983), and 3) the distribution and abundance of whale forage (Wing and Krieger 1983).

In 1982, the Auke Bay Laboratory, NMFS, assumed responsibility. for the' Whale Prey Study. The priorities of the Whale Prey Study in 1982 were to 1) determine seasonal and spatial distribution of potential whale forage along transects surveyed in 1981, 2) compare the distribution, relative abundance, and composition of prey in Glacier Bay and Frederick Sound-Stephens Passage with similar data from the summer of 1981, and 3) identify specific whale feeding sites within the study areas and characterize the distribution and abundance of prey at these sites. We found significant annual and spatial variation in the abundance of forage, and sites where humpback whales were feeding had high densities of forage. Each of the three specific feeding sites surveyed and sampled in 1982 was dominated by a different prey species (Wing and Krieger 1983).

The- Whale Prey Study was continued in 1983 with the priorities restructured to 1) identify and characterize specific feeding sites within the Glacier Bay area, 2) determine feeding depths of whales at foraging sites and ,-composition of prey populations at those depths, and 3) assess the general distribution and abundance of prey species for annual and seasonal comparisons. This report summarizes the results of the 1983 whale-prey research and describes whale behavior associated with prey.

METHODS

Vessels

In 1983, two vessels were used in the Whale Prey Study. The F/V Georgene, a 21-m (70-ft) trawler, was chartered to conduct hydroacoustic surveys, net sampling, and oceanographic observations. The Auke Bay Laboratory R/V Searcher (a 10-m [33-ft] modified gill-netter) and a 4-m (13-ft) aluminum skiff were used for tracking humpback whales in waters too shallow for the F/V Georgene.

Hydroacoustic Surveys

Hydroacoustic data on fish and zooplankton were collected with a Biosonics Model 101[1] echo sounder in conjunction with a 104-kHz 7.5° beam-angle Ross transducer. The transducer was mounted on the hull of the F/V Georgene approximately 3 m below the surface. The echo sounder is equipped with variable selection modes for transmit power, receiver gain, bandwidth, and pulse width. The echo-sounder settings for the collection of the whale-prey data in 1983 were -6 dB transmit power, +6 dB or +12 dB receiver gain, 2 kHz bandwidth, 0.7 ms pulse width, and 0.5 s pulse rate (source level was 228.0 dB, and receiver sensitivity was -144.7 dB referenced to l-m and 0-dB settings). The Time Varied Gain (TVG) of the echo sounder, which compensates for propagation loss, is accurate to +0.5 dB of the ideal TVG.

Equipment for analyzing and recording hydroacoustic data included a Biosonics echo integrator, an EPC graphic recorder, a TEAC analog tape recorder, and a Kaypro microcomputer. The integrator converts echo-sounder

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'Reference to trade names does not imply endorsement by the National Marine Fisheries Service-, NOAA.

data to density estimates. The graphic recorder provided visual recordings of the intensity and depth distribution of the acoustic targets. The analog tape recorder provided permanent records of the echo-sounder data that can be replayed through the integrator and chart recorder for reprocessing. The microcomputer stored the integrated output data on floppy disks.

The echo-sounder output was converted to biomass estimates by the echo-integration processing technique. Echo integration is based on the theory, confirmed by experimentation, that the average integrated acoustic intensity scattered from targets is proportional to the average density of the targets. The integrator was programmed to process echo-sounder returns for 30 discrete depth intervals and for 600 transmissions per sequence. The integrator digitizes the echo-sounder output, squares the voltage of the digitized signal, and calculates a sum-of-squares value for each depth interval of each sequence.

Hydroacoustic surveys of fish and micronekton were collected in three modes: 1) point estimates of prey density over feeding whales (g/m^2 and g/m^3), 2) area surveys to estimate total abundance of prey at whale feeding sites (g/m^2), and 3) area surveys duplicating index transects completed during the Whale Prey Study in 1981 and 1982 (backscatter/m^2) (Appendix Table 1). Relative backscattering densities, measures of the total sound energy scattered by all targets, are referenced to an arbitrary integrator scaling factor of 1.0. Absolute density estimates for abundance of single species require scaling factors dependent on the reflective properties of the species and physical properties of the acoustic system.. The reflective properties of each species were estimated from size distributions obtained from net samples.

Backscattering densities were used as indices of abundance of prey in each study area. The integrator provided estimates of backscattering density for each of twenty-nine 5-m strata for depths between 5 m and 145 m and for a single stratum for depths between 146 and 200 m (depths referenced to the transducer face). The backscattering densities for each interval were summed over all depths to obtain density per unit surface area (backscatter/m^2): Backscattering densities were estimated for transects by adding the interval densities and dividing by the number of intervals. To obtain mean area backscattering estimates, we weighted backscattering densities by length of the transects.

Absolute densities were determined for euphausiid layers and fish schools at humpback whale foraging sites. Analog recordings of food layers directly under foraging whales were replayed through the integrator. The integrator was programmed for 50-s sequences (100 pulses) and l-m depth intervals within the forage layers. The microcomputer converted the integrator data to absolute density estimates and added the values for all depths in the forage layers. The total density of a forage layer under 1-m^2 surface area was estimated in grams per square meter. Total density was divided by the depth range of the forage layer to estimate average density in grams per cubic meter.

Conversion of backscattering densities to estimates of numbers of organisms or biomass requires knowledge of the physical parameters of the hydroacoustic equipment and the reflective properties (target strengths) of the assessed organisms. In this study, the equipment parameters were obtained by standard calibration procedures before and after the fieldwork. Target strengths were selected from referenced papers. Pacific herring and capelin target strengths (TS) were derived by Halldorson et al. (1984) during *in situ* measurements at Iceland. Eupausiid TS's were derived by Beamish (1971) who calculated backscattering cross section of euphausiids in Saanich Inlet, and Greenlaw (1977) who measured preserved euphausiids in a tank. 'For the size of Pacific herring sampled during our study (mean length, 0.22 m; mean weight, 100 g), TS's are -46.4 dB/fish or -66.4 dB/g. Capelin sampled in 1982 (mean length, 0.09 m; mean weight, 8 g) have TS's of -56.9 dB/fish or -65.9 dB/g. For euphausiids sampled during our study (mean length, 15 mm; mean weight, .020 g), the TS is -85.0 dB/euphausiid or -68.0 dB/g.

Net Sampling

Acoustic targets were sampled with three types of nets and with herring jigs. The samples were used to verify species composition of whale forage, provide size composition for target-strength estimates, and quantify zooplankton abundance.

Fish schools were sampled with a modified Marinovich pelagic-fish trawl with a 6.1-m X 6.1-m (20-ft X 20-ft) opening and with herring jigs. The trawl was equipped with a 0.6-cm (a-in.) mesh cod-end liner and 272-kg (600-lb) Vee Otter doors. An EPSCO net sounder was used to monitor the depth of the trawl and the location of sonic targets in relation to the trawl mouth.

Micronekton was sampled with a 1.8-m (6-ft) Isaacs-Kidd midwater trawl (IKMWT) (Aron 1962) equipped with a Bendix Model T-l bathykymograph. The IKMWT was towed at 7.4 km/h (4 knots) for standardized tows of 15 or 30 min. Thirty-seven sets were made with the IKMWT during the 1983 whale-prey study (Appendix Table 2).

Zooplankton was sampled with a Tucker Trawl (Davies and Barham 1969) that had a 1-m^2 opening, a messenger-operated opening and closing system, three

0.5-mm mesh nets, and a Pacific Digital depth-temperature-speed telemetry system. Depth of the Tucker trawl was monitored with a telemetry system or by wire angle when the telemetry system was inoperative. All tows were at a vessel speed of about 2.8 km/h (1.5 knot). Twenty-seven sets were made with the' 1-m2 Tucker Trawl during the Whale Prey Study in 1983 (Appendix Table 3).

The IKMWT and Tucker Trawl samples of micronekton and zooplankton were preserved in 5-10% formaldehyde in seawater after removal of large jellyfish (e.g., Cyanea capillata, Aurelia labiata, Staurophora mertensii, and Aequorea sp.). Total displacement volumes of drained samples were obtained for all samples from successful tows. Subsequently, the 20 most numerous species were listed, and the number and size distribution of the predominant invertebrates in each tow (euphausiids, amphipods, chaetognaths, calanoid copepods) were estimated from subsamples. Large IKMWT samples were subsampled with a Folsom plankton subsampler (McEwen et al. 1954) or a box-type sample splitter (Motoda 1959). Subsamples ranged from one-half to one sixty-fourth of the total catch. All Tucker Trawl samples were subsampled with a Folsom subsampler. The subsamples ranged from one-half to one five-hundred-twelfth of the total catch. In both cases, at least 300 animals remained in the subsample.

Larger micronektonic species were measured to the nearest millimeter; smaller zooplankters were measured to the nearest tenth of millimeter with an eyepiece micrometer and dissecting microscope at magnifications of 10-45X. When euphausiids were too large for the microscope field-of-view, total length was estimated from the relationship between telson length and total length.

Each day that we sampled with the IKMWT or the Tucker Trawl, we obtained salinity and temperature profiles at net sampling sites with a Plessy

Environmental System's Model 9060 Graphic S/T/D profiling system (Appendix Table 4).

A C-tech model CDS-40 omni-sonar (38 kHz) was installed aboard the R/V Searcher to track diving humpback whales to their foraging depths. Attempts to record diving humpback whales proved unsuccessful, and use of the equipment was discontinued on 21 August.

Layers of food for humpback whales were identified in 1983 during the Whale Prey Study even though the omni-sonar was not functional. We encountered either monospecific schools of fish or swarms of euphausiids; therefore, chart recordings of the hydroacoustic system were adequate to' define the forage layers that whales.were feeding on. Profiles of, diving whales were occasionally recorded with this system.

RESULTS

Whale Foraging Sites

During 1983, we observed foraging humpback whales in Glacier Bay, at Point Adolphus (adjacent to Glacier Bay), and in the Stephens Passage-Frederick Sound area. In this section, we describe observations of humpback whales and their prey at foraging sites in 1983 and report estimates of prey density at the sites in 1982 and 1983.

Glacier Bay

Between mid-June and mid-September 1983, only 15 humpback whales were documented in Glacier Bay, of which only one was a resident (Baker 1983). The maximum number of whales in Glacier Bay during August and September was four on 20 August. Because few whales were in Glacier Bay at any one time, considerable effort was required to locate whales. When we saw whales in Glacier Bay, they were either traveling between areas or were feeding in water too shallow for us to assess or sample their prey.

Because the whales were not surface feeding and the echo sounder could not track diving whales, we assumed a whale was feeding if 1) it dived repetitively and surfaced within 300 m of the descent location and 2) it spent a short time on the surface compared with the time spent in the dive. Based on these criteria, feeding whales were located on only 5 of the 13 days we were observing their distribution and behavior inside Glacier Bay. They were feeding at four sites: Flapjack Island, Leland Island, Lone Bush Island, and the entrance to Berg Bay (Fig. 1).

Flapjack Island--On 5 August from 0930 to 1130 h, two whales were repeatedly diving in the shallow waters east of Flapjack Island. Small schools of fish were recorded in this area but could not be associated with the diving whales.

Leland Island--On 16 August 1983, we observed a whale on the southwestern side of Leland Island. While we watched the whale from about 1000 h to 1130 h, it remained in water depths of 9.1-36.6 m (5-20 fathoms). A second whale was observed from 1146 to 1300 h repeatedly diving along the northwest side of Leland Island before it crossed the channel to the Marble Islands. During both periods, we observed scattered schools of fish on the bottom (Fig. 2).

Lone Bush Island--On 29 August, a whale was observed foraging from 0900 h to 1415 h in the shallow waters surrounding Lone Bush Island. At 1430 h, this whale moved to the reefs north of Flapjack Island where it remained near the shoreline in water less than 18.3-m (lo-fathom). deep before returning to the

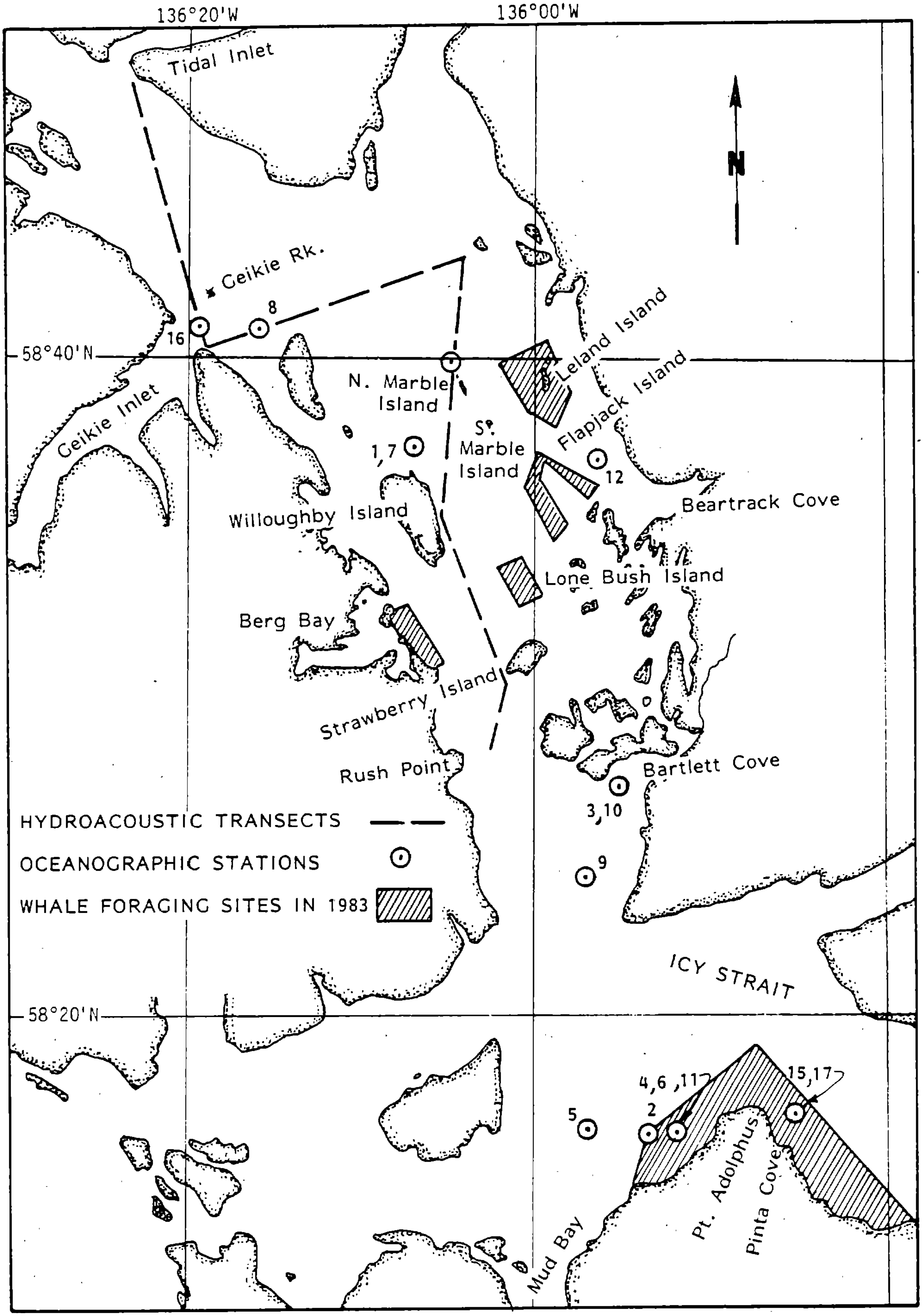

Figure 1.--Humpback whale foraging sites and hydrOacOuStlc transects in central Glacier Bay and Icy Strait, southeastern Alaska, 1981-83.

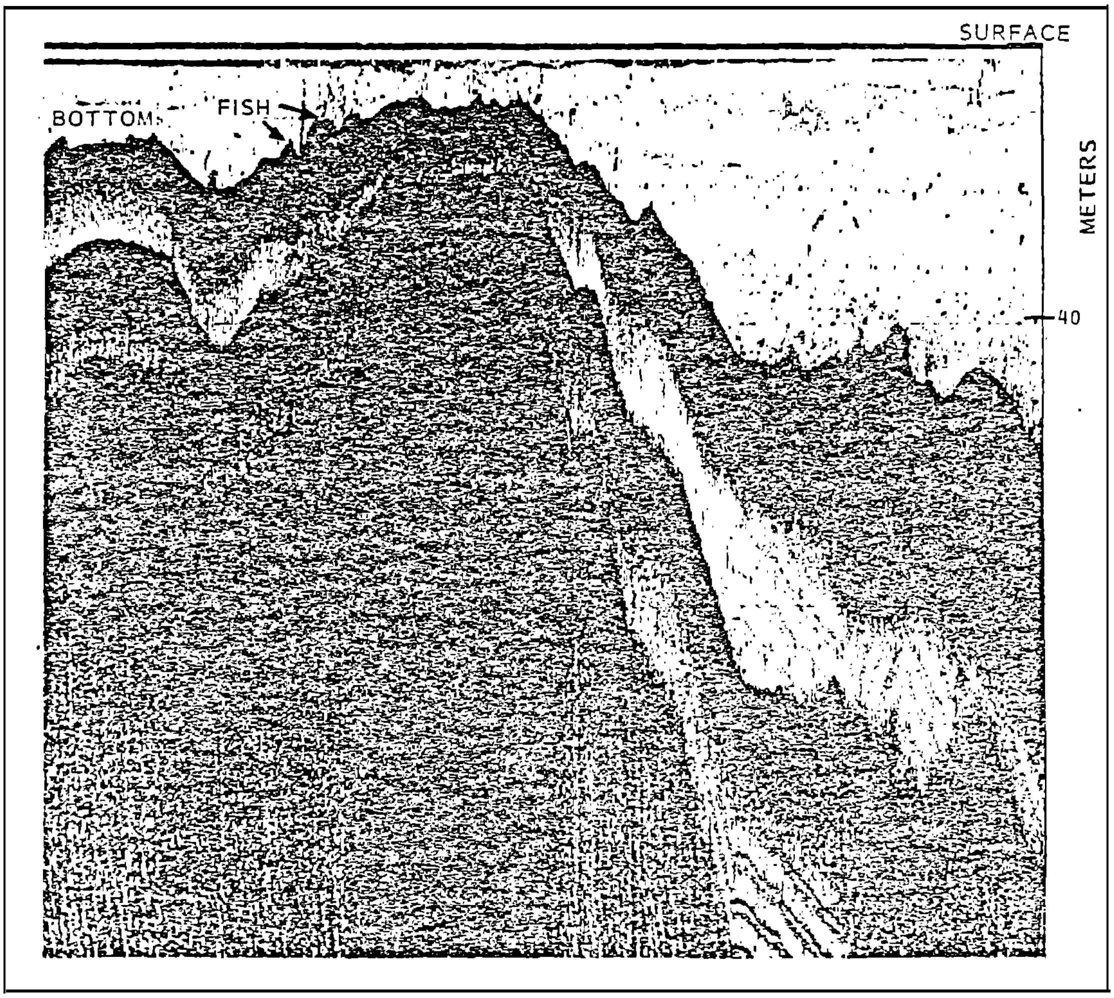

Figure 2. --Scattered fish schools recorded while following a humpback whale at Leland Island, 9 August 1983.

area south of Lone Bush Island at 1730 h. Small schools of fish were recorded in this area (Fig. 3).

Berg Bay Entrance--On the morning of 14 August, one whale was foraging at the entrance to Berg Bay, and two whales were inside the bay. We observed the single whale foraging at the entrance from 1120 to 1220 h and then followed it to the southern tip of Willoughby Island and across Glacier Bay toward Bear Track Cove. When we returned to Berg Bay at 1835 h, a whale was again feeding at the entrance to Berg Bay. Small, dense schools of fish were recorded near the foraging whales.

On 23 August from 1720 to 1900 h, a whale was feeding nearshore south of the Berg Bay entrance in the kelp beds where an echo-sounder recording could not be obtained. Small schools of fish were recorded outside the kelp beds.

Bartlett Cove--Bartlett Cove, at the entrance to Glacier Bay, was extensively used by foraging whales in 1982. The whales were feeding on capelin, which were hydroacoustically recorded and sampled with the pelagic fish trawl. Estimated capelin density (TS = -65.9 dB/g) in Bartlett Cove in 1982 was 23.7 g/m^3 (142.0 g/m^2) (Table 1). In 1983, however, very few whales entered Bartlett Cove, and no whales remained in the Cove to forage. We found no capelin schools during two hydroacoustic surveys of the Cove or during frequent echo soundings in 1983.

Hydroacoustic recordings of Bartlett Cove for 1982 and 1983 show-very few fish (except for capelin schools in 1982) and no plankton layers. Oblique sampling with the Tucker Trawl in Bartlett Cove produced higher volumes of zooplankton in 1982 than in 1983 (Table 2). The dominant copepods in the 1982 samples also dominated the stomach contents of the capelin sampled in 1982.

Point Adolphus--Point Adolphus was the only area in the Glacier Bay area where humpback whales were consistently observed in 1983. Two to six whales

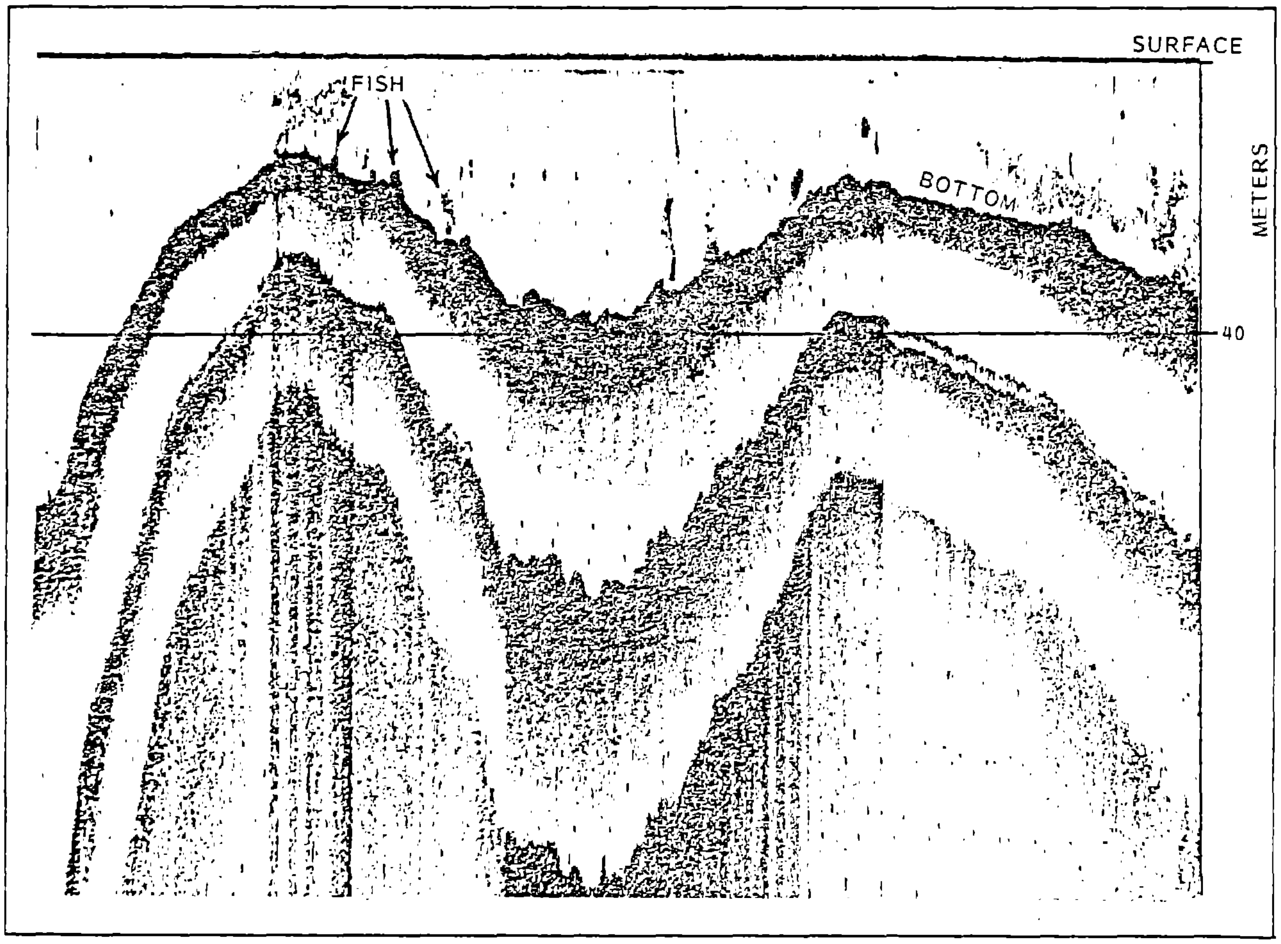

Figure 3.--Scattered fish schools recorded while we followed a humpback whale at Lone Bush Island, 29 August 1983.

Table 1.--Density estimates of capelin, herring, and euphausiids at selected whale feeding sites in Glacier Bay and Stephens Passage-Frederick Sound study areas.

Area	Date	Comments[1]	Forage	Depth of forage (m)	Density[2]		
					g/m^2	g/m^3	Number of targets/m^3
Glacier Bay:							
Bartlett Cove	12 Aug. 1982	WF	Capelin	32-38	142.0	23.7	3.0
Geikie Inlet	12 Sept. 1983	DSL	Euphausiids	65-95	3.3	0.1	5.0
Icy Strait:							
Point Adolphus	15 Aug. 1983	WF	Pacific herring	35-41	537.8	89.6	0.9
Point Adolphus	27 Aug. 1983	WF	Pacific herring	18-42	2,666.2	60.6	0.6
Point Adolphus	9 Sept. 1983	WF	Pacific herring	29-35	609.1	101.5	1.0
Stephens Passage:							
Entrance Island	3 Sept. 1983	WF	Euphausiids	80-110	22.2	0.7	40.0
South Island	7 Sept. 1983	WF	Euphausiids	70-100	39.9	1.3	66.4
Doty Cove	15 Sept. 1983	ADSL	Euphausiids	80-110	4.2	0.1	7.0
Doty Cove	15 Sept. 1983	WF	Euphausiids	58-88	34.0	1.1	56.8
Twin Point	16 Sept. 1983	WF	Euphausiids	92-130	162.3	4.3	213.5
Frederick Sound:							
Five Finger Islands	4 Sept. 1983	WF	Pacific herring	50-70	2910.2	145.5	1.5

[1] Comments: WF = whales foraging; DSL = densest 1983 euphausiid layer in Glacier Bay; ADSL = mean density in 5.6-km x 1.9-km (3-nmi x 1-nmi) area surveyed.

[2] Conversion factors:

	Capelin	Herring	Euphausiids
Target strength dB/g	-65.9	-66.4	-68.0
Target number/g	0.125	0.01	50.0

Table 2 .Zooplankton displacement volumes of Tucker Trawl samples from Glacier Bay entrance and Bartlett Cove in 1982 and 1983.

Area		Zooplankton volume	
		ml/10 m^2	ml/1000 m^3
	1982		
Glacier Bay Entrance		169.9	339.6
Glacier Bay Entrance		165.5	331.0
Bartlett Cove		178.7	297.9
Bartlett Cove		170.9	284.9
	Mean	171.3	313.5
	1983		
Glacier Bay Entrance		29.9	99.6
Glacier Bay Entrance		132.2	357.3
Glacier Bay Entrance		29.0	82.9
Glacier Bay Entrance		32.6	88.0
Bartlett Cove		25.6	61.7
Bartlett Cove		24.7	63.4
Bartlett Cove		63.5	167.0
Bartlett Cove		47.2	124.3
	Mean	48.1	130.5

were present over fish schools (Fig. 4) during each of 15 days we spent at Point Adolphus. These whales ranged from 11.1 km (6 nmi) east of Point Adolphus to 14.8 km (8 nmi) west of Point Adolphus but were most often within 1.9 km (1 nmi) of the Point and within 0.9 km (0.5 nmi) offshore. Ninety-five percent of the fish sampled with the pelagic-fish trawl were Pacific herring; the remainder were walleye pollock, Theragra chalcogramma.

Although five hydroacoustic surveys were conducted in the Point Adolphus area, we were unable to estimate total abundance of Pacific herring because the schools were continuously moving. We did, however, estimate the density and depth distribution of herring when the whales were feeding. Pacific herring density estimates (TS = -66.4 dB/g) for three different days were 89.6, 60.6, and 101.5 g/m^3 (Table 1). The highest Pacific herring density under 1 m^2 was 2,666.2 g/m^2 for a school extending from 18 to 42 m.

Stephens Passage-Frederick Sound Area

The number of whales in the Glacier Bay area in 1983 was too low to assess forage densities at sites other than Point Adolphus. We surveyed the Stephens Passage-Frederick Sound area in September 1983 to obtain additional density estimates at whale-forage sites. Humpback whales were feeding on either euphausiids or schooled fish at each of five sites in Stephens Passage-Frederick Sound: Doty Cove, South Island, Twin Point, Entrance Island, and The Five Fingers islands (Fig. 5). Most of the foraging was on deep scattering layers (DSL's). (In this report, DSL refers to sound-scattering layers associated with concentrations of zooplankton and micronekton.)

Doty Cove--At Doty Cove, about 20 whales were present on 7 September, and 8 whales were present on 15 September. On 7 September, the -whales were

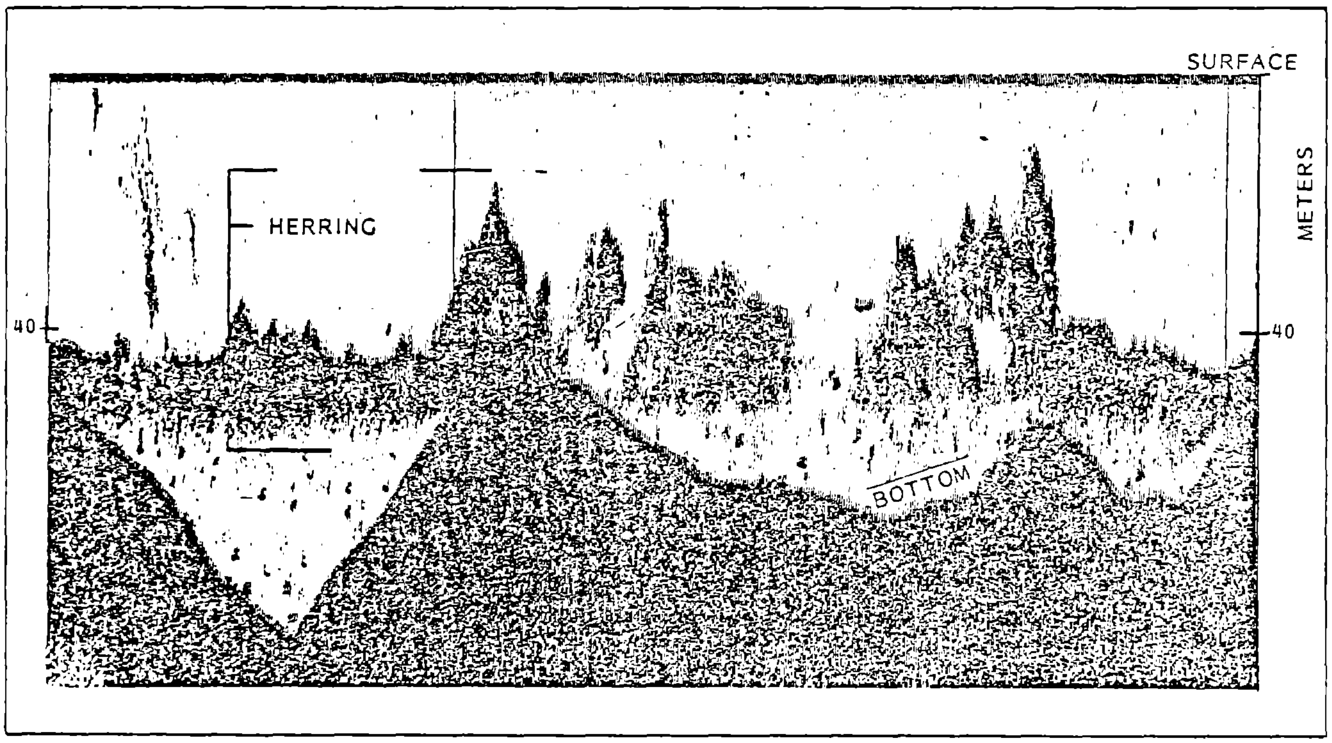

Figure 4. --Pacific herring schools where two humpback whales were feeding at Point Adolphus, 9 September 1983.

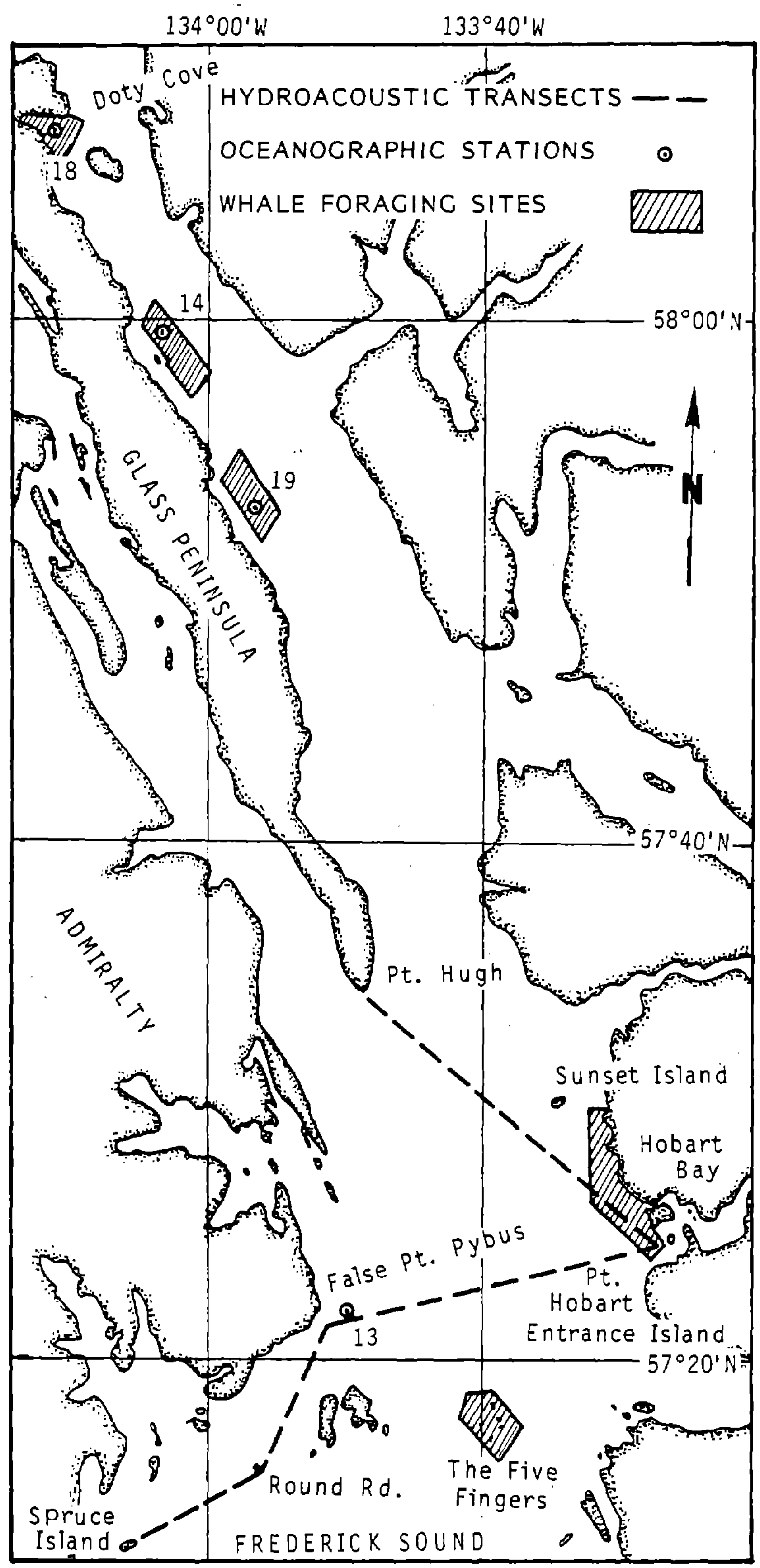

Figure 5.--Humpback whale foraging sites and hydroacoustic transects in the Stephens Passage-Frederick Sound area, 1981-83.

foraging on a DSL extending from 60 m to 120 m (Fig. 6). This layer, sampled with the IKMWT, yielded nearly pure catches of euphausiids, *Thysanoessa raschii*, that were 7-21 mm long (Table 3).

On 15 September, we hydroacoustically assessed and sampled a euphausiid layer where five whales were feeding. Using a TS of -68 dB/g, we estimated the density of euphausiids in the layer extending from 58 m to 88 m to be 1.1 g/m^3 (34.0 g/m^2). A 1.9-km (1-nmi) wide area extending from the head of Doty Cove southward 5.6 km (3 nmi) was surveyed to determine the extent of the euphausiid layer. The density of the layer averaged 0.1 g/m^3 (4.2 g/m^2) for the 10.3-km^2 (3-nmi^2) area (Table 1).

South Island--Whales were seen foraging in the South Island area on 3 and 7 September. On 3 September, seven whales were feeding close to shore on small schools of fish. The fish could not be sampled or their density assessed because the water was too shallow. Five whales were feeding in the same area on 7 September. These whales left the shallow waters in midmorning and began foraging on a DSL that extended from 70 to 120 m. The IKMWT catch from this layer was 88% euphausiids (10-23 mm long). Hydroacoustic assessment of the layer gave density estimates of 1.3 g/m^3 (39.9 g/m^2).

Twin Point--A concentration of at least 18 humpback whales was near Twin Point on 16 September. The hydroacoustic recordings (Fig. 7) showed a dense DSL of euphausiids (confirmed by the IKMWT samples; Table 3) that extended from 70 to 130-m depth. Hydroacoustic assessments of the layer produced densities of 4.3 g/m^3 (162.3 g/m^2).

The whale feeding activity decreased in the midafternoon (about 1400 h) and increased in the evening at about 1900 h. During the evening feeding period, the euphausiid layer rose from mid-day depth to the surface (Fig. 8). Whales probably continued feeding after dark as indicated by frequent surface

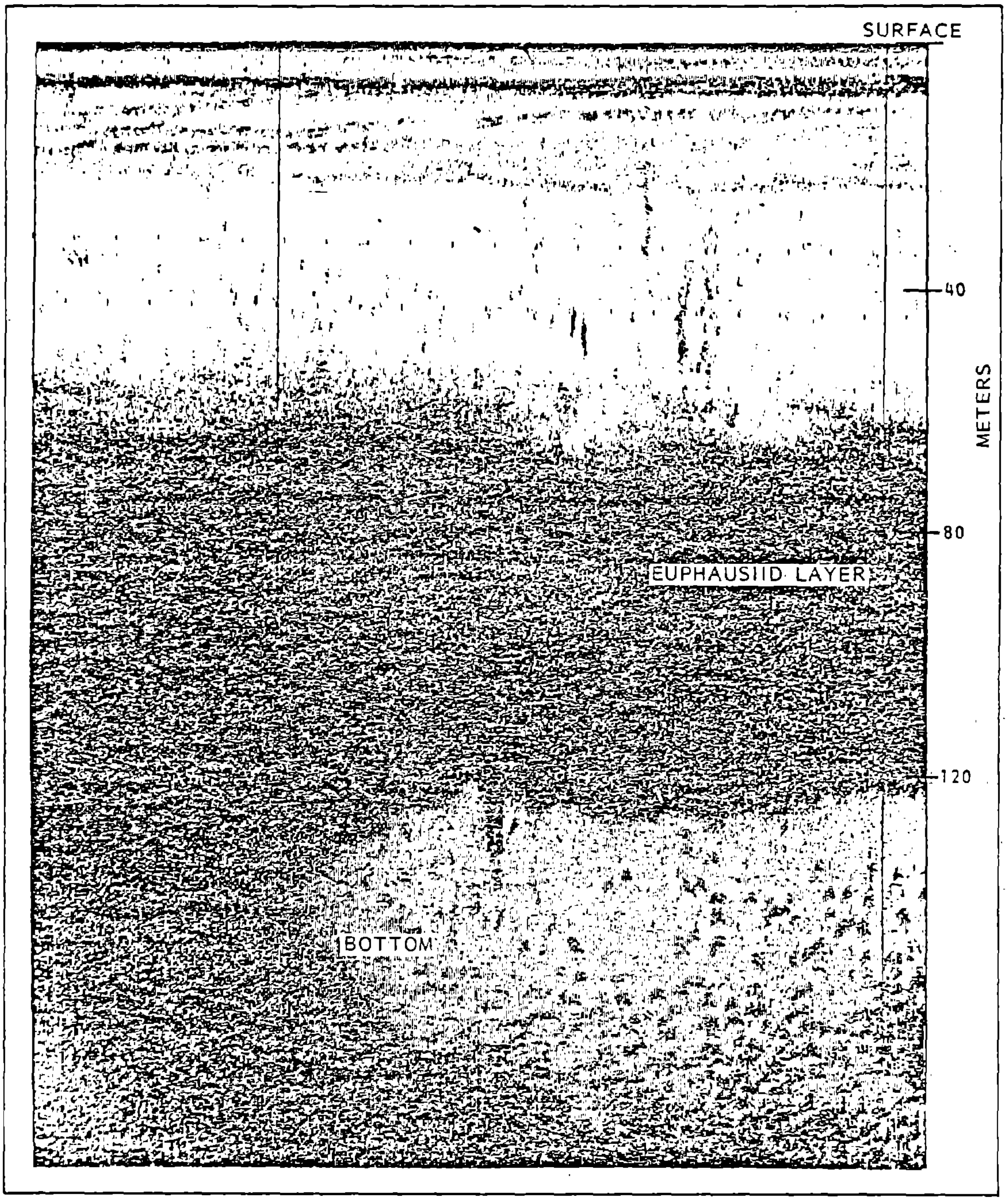

Figure 6.--Deep-scattering layer of euphausiids extending from 60 m to 120 m where six humpback whales were feeding at Doty Cove, 15 September 1983.

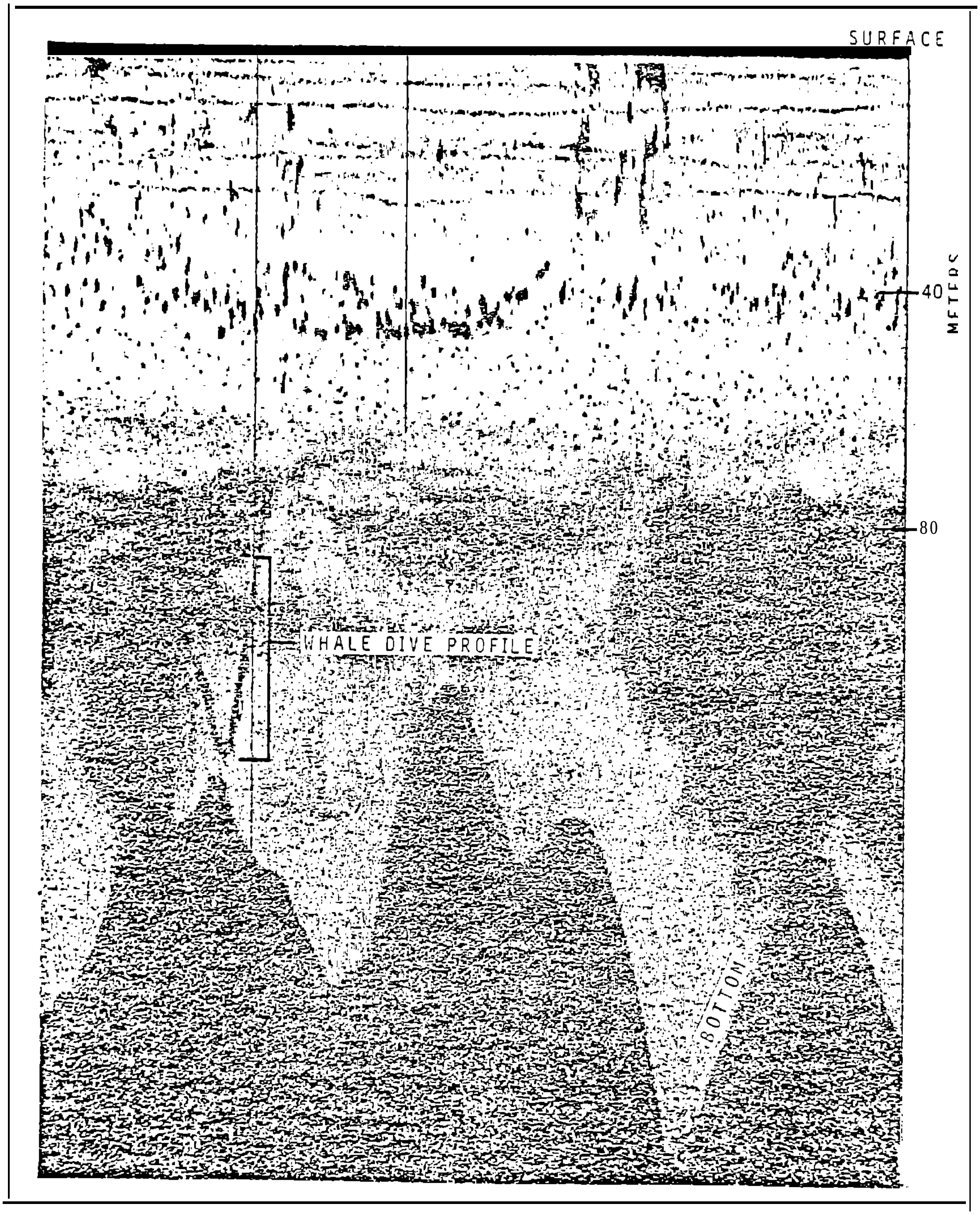

Figure 7.--Dive profile of a humpback whale and a deep-scattering layer of etiphausiids at Twin Point, 17 September 1983.

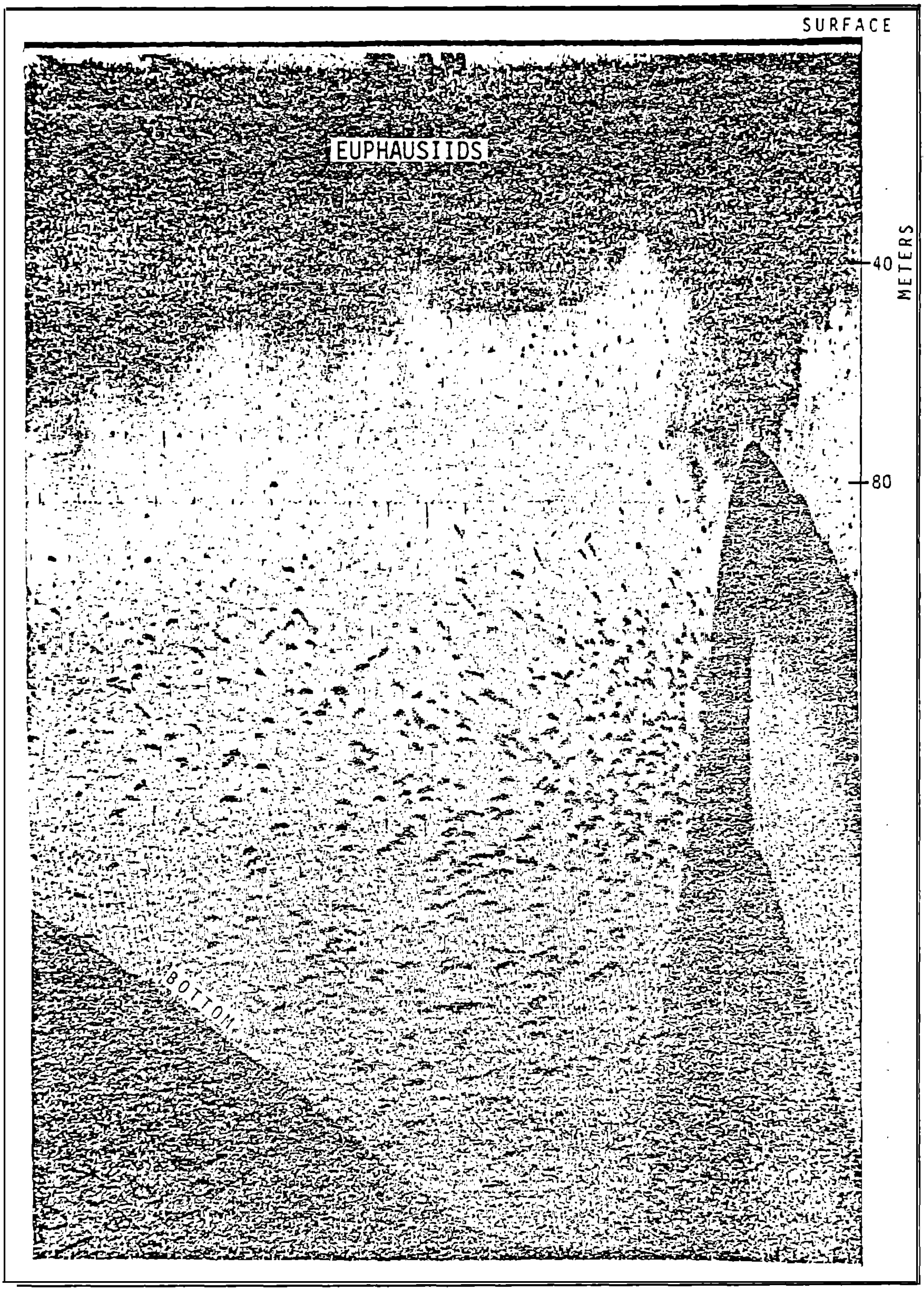

Figure 8. --Evening rise of a euphausiid deep-scattering layer on which humpback whales were feeding at. Twin Point, 16 September 1983.

Table 3.--Isaacs-Kidd midwater trawl catch composition and volumes from Glacier Bay, Icy Strait, and Stephens Passage areas in 1983.

Area	Tow	Position[1]	Count[2] (no./30 min)	Composition (% count) Euphausiids	*Sagitta elegans*	Other	Volume[2] (ml/30 min)
Glacier Bay:							
Geikie	6	A	199	9	66	25	2
Geikie	18	A	<10	0	0	100	2
Geikie	7	I	22,063	92	8	<1	1,143
Geikie	8	I	35,279	89	10	1	1,752
Geikie	19	I	41,196	87	13	<1	1,894
Geikie	33	B	15,755	75	21	4	792
Geikie	20	B	1,610	11	54	35	254
Willoughby	5	A	1,330	8	7	85	11
Willoughby	4	I	12,862	85	12	3	473
Willoughby	17	I	7,430	76	20	4	390
Marble Island	11	I	30,308	86	9	5	1,260
Marble Island	12	B	4,004	66	31	3	204
Bear Track Cove	27	B	3,819	6	37	55	186
Bartlett Cove	13	N	<10	10	0	90	4
Bartlett Cove	14	N	195	0	1	99	2
Bartlett Cove	15	N	204	0	0	100	2
Bartlett Cove	16	N	436	35	0	65	9
Bartlett Cove	21	N	144	1	13	86	3
Bartlett Cove	23	N	276	9	0	91	10

Table 3.--Continued.

Area	Tow	Position[1]	Count[2] (no./30 min)	Composition (% count) Euphausiids	Composition (% count) *Sagitta elegans*	Composition (% count) Other	Volume[2] (ml/30 min)
Icy Strait:							
Point Adolphus	1	A	1,872	42	30	28	9
Point Adolphus	3	A	0	0	0	0	<1
Point Adolphus	24	A	199	<1	2	97	4
Point Adolphus	9	I	3,926	36	27	37	340
Point Adolphus	25	I	36,371	91	8	<1	564
Point Adolphus	31	I	13,323	98	<1	1	111
Stephens Passage:							
Doty Cove	30	I	70,948	99	<1	0	3,266
Doty Cove	34	I	10,662	95	<1	5	588
South Island	29	I	13,347	88	0	12	1,017
Twin Point	35	A	<10	0	0	100	<1
Twin Point	36	I	25,717	98	0	1	1,346
Twin Point	37	I[3]	196,364	99	<1	<1	8,330
False Point Pybus	28	I	23,212	93	6	<1	931

[1] Position relative to the observed deep scattering layers. A = above; I = in; B= below; N = no scattering layer.
[2] Values are rounded to the nearest whole number.
[3] Night sample at 13 m.

blowing. The next morning, 17 September, the whales were distributed in smaller groups (3-6 whales) south of Twin Point towards Midway Point. In each case, the whales were concentrated over DSL's.

Entrance Island--Two feeding humpback whales were at the entrance of Hobart Bay near Entrance Island during our transects of the Stephens Passage area on 3 September. A euphausiid layer extended from 80 to 110 m at the site, and its estimated density was 0.7 g/m^3 (22.2 g/m^2), the highest density found during surveys along index transects of Stephens Passage.

We returned to the Entrance Island area on 5 September in search of the euphausiid layer recorded on 3 September. No euphausiid layer was found, but a whale was feeding on a small, dense school of fish. We recorded the school on eight of the nine times we positioned our vessel over the diving whale.

Six whales were feeding near Entrance Island on 6 September on a DSL extending from 120 m to 160 m. Samples or assessment of the forage were not obtained because of rough weather.

The Five Fingers--Six to eight whales in The Five Fingers area on 4 September were diving on schools of fish next to bottom at 40-80 m (Fig. 9). The fish appeared to be juvenile herring based on characteristics of the acoustic chart recordings (the bottom was too rough and confined to attempt trawling), and their density was estimated to be 145.5 g/m^3 (2910.2 g/m^2; TS = -66.4 dB/g).

Hydroacoustic Surveys and Plankton Sampling

Hydroacoustic surveys and plankton sampling were conducted in Glacier Bay to determine forage densities in the area. The hydroacoustic survey transects (Fig. 1) duplicated the transects used in 1981 and 1982 (Wing and Krieger 1983). Stations sampled with the IKMWT and Tucker opening-and-closing trawls

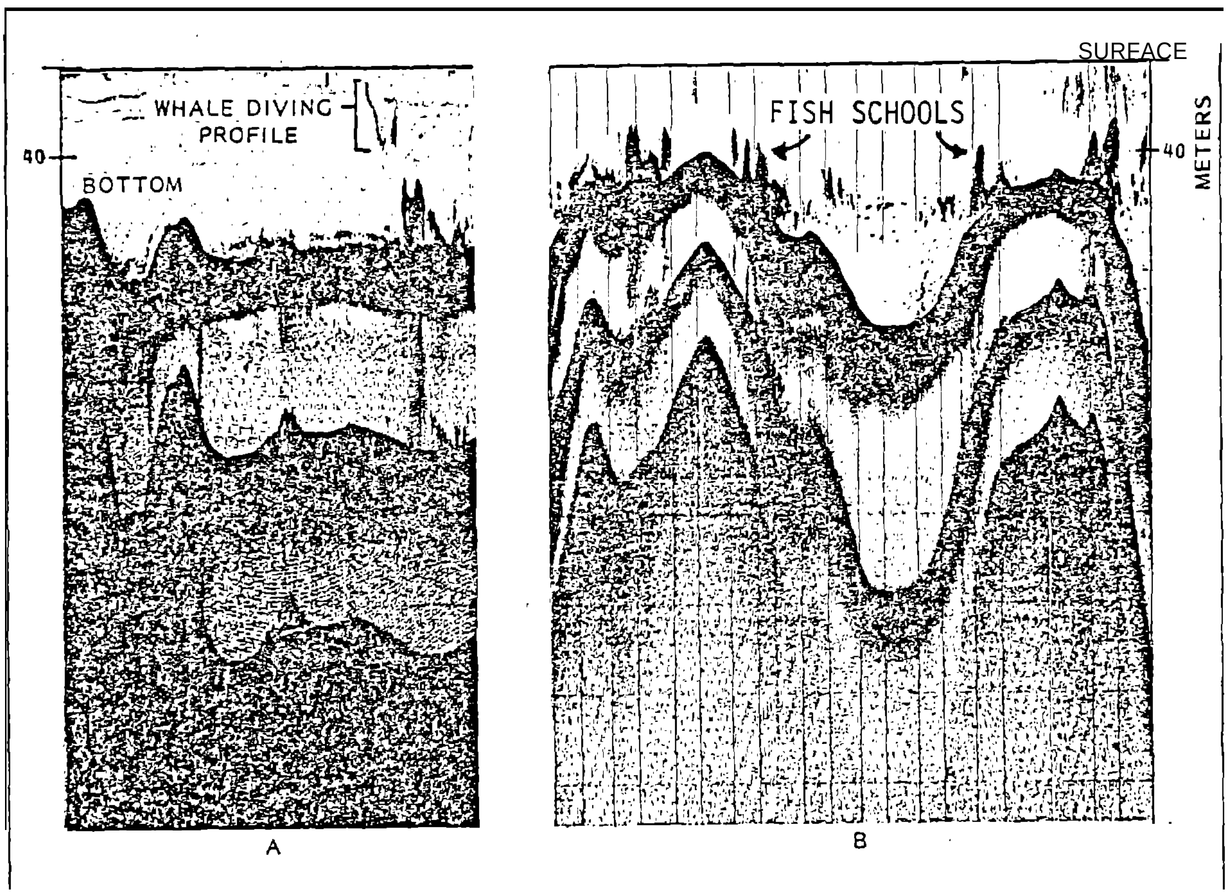

Figure 9.--Schools that were probably juvenile Pacific herring near The Five Fingers islands; 4 September 1983: (A) Dive profile of a humpback whale over the school and (B) clusters of schools over reefs.

were usually near the stations sampled in 1982. Only data from the 1982 and 1983 hydroacoustic surveys are compared in this report because the 1981 survey was made with a different hydroacoustic system and considerable time and effort would be needed to reformat the data to the 1982 and 1983 format.

In 1983, net sampling was directed towards the DSL. Improved hydroacoustic recordings of the DSL allowed precise placement of the nets in the most concentrated portions of the DSL. Consequently, the 1983 IKMWT catches average larger displacement volumes and more micronekton than the 1982 samples. Also, the 1983 catches more clearly show the differences in relative concentration and composition of micronekton above, in, and below the DSL's (Table 3).

Glacier Bay

We conducted hydroacoustic surveys in Glacier Bay on 5 August, 25 August, and 12 September 1983. These three surveys are compared with surveys on 12 August and 27 August 1982. Although Figure 10 displays only the 25 August 1983 transects, the spatial distribution of fish and plankton targets remained essentially the same during the study period of both years. The targets on Transects 1 and 2 were mainly individual fish. Transect 3 had mixed patches of plankton, schooled fish, and individual fish. Transects 4 and 5, the richest areas surveyed, had a continuous layer of plankton and schools of small fish in the DSL and many large fish below the DSL.

Although the distribution of targets was similar on all three 1983 surveys, the average backscattering densities increased as the season progressed (Table 4) mainly because the densities of the DSL increased near Geikie Inlet where Transects 4 and 5 join. Sampling of the' DSL with the IKMWT yielded-catches dominated by euphausiids. Thysanoessa raschii was the

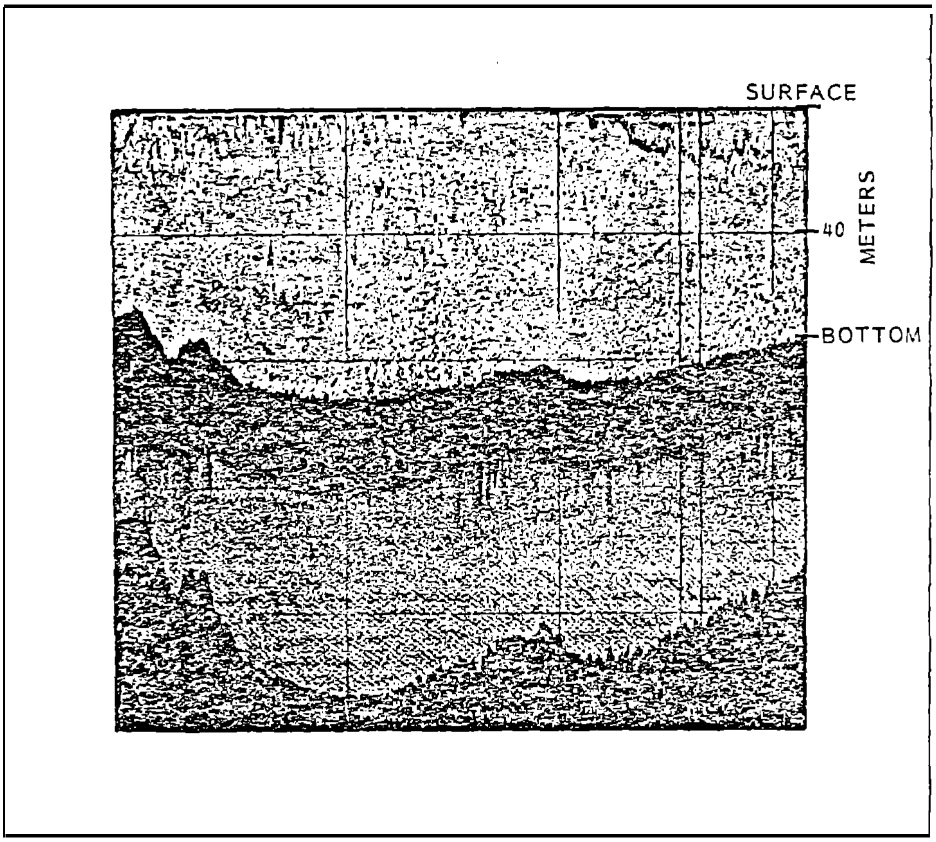

Figure 10.--Representative hydroacoustic recordings along Glacier Bay transects, 25 August 1983: (A) Transect 1, Strawberry- Island to Rush Point.

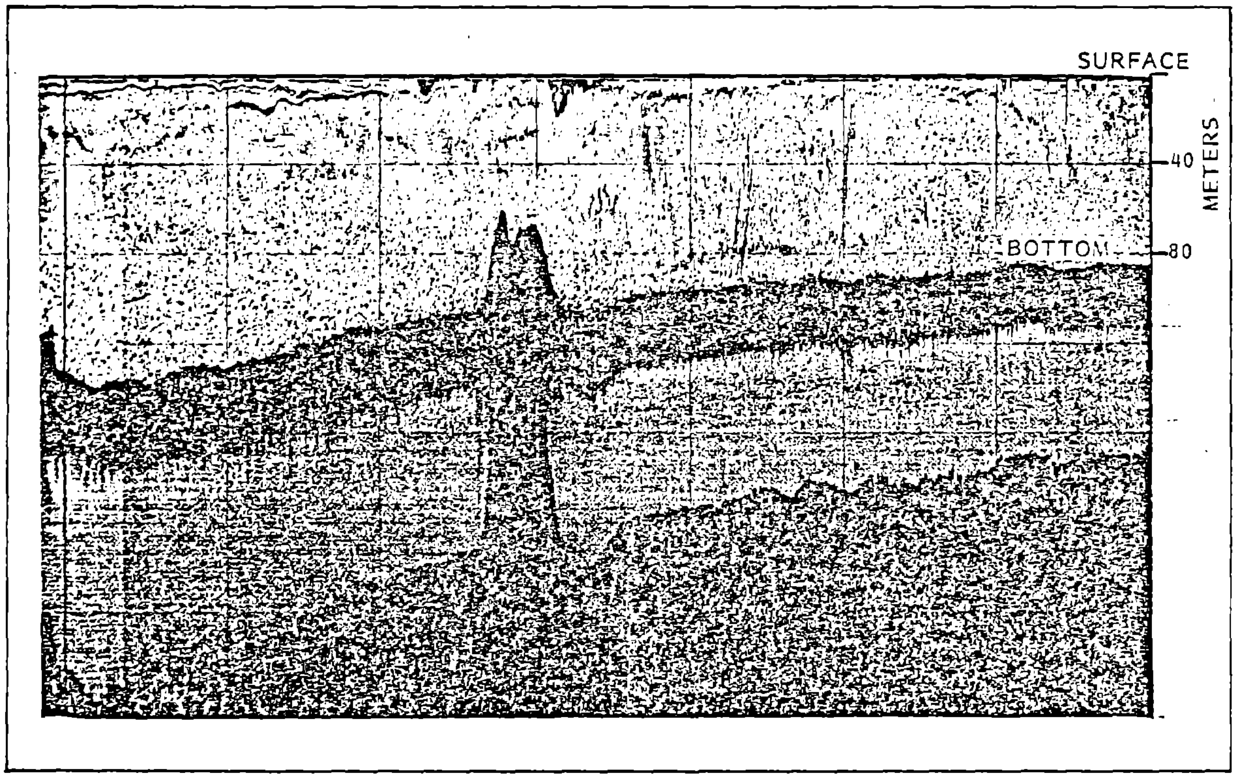

Figure 10--Continued. (B) Transect 2, Willoughby Island to Strawberry Island.

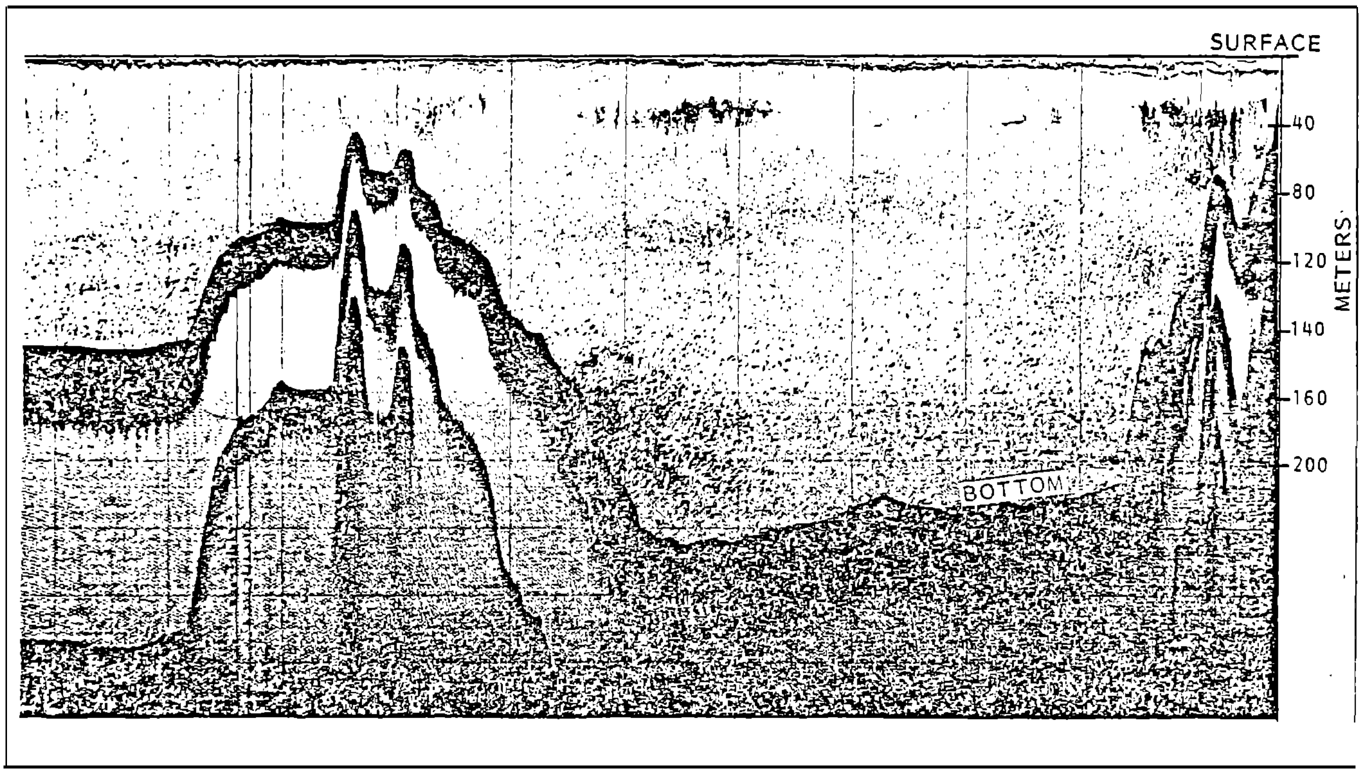

Figure 10--Continued. (C) Transect 3, Sturgess Island to Willoughby Island..

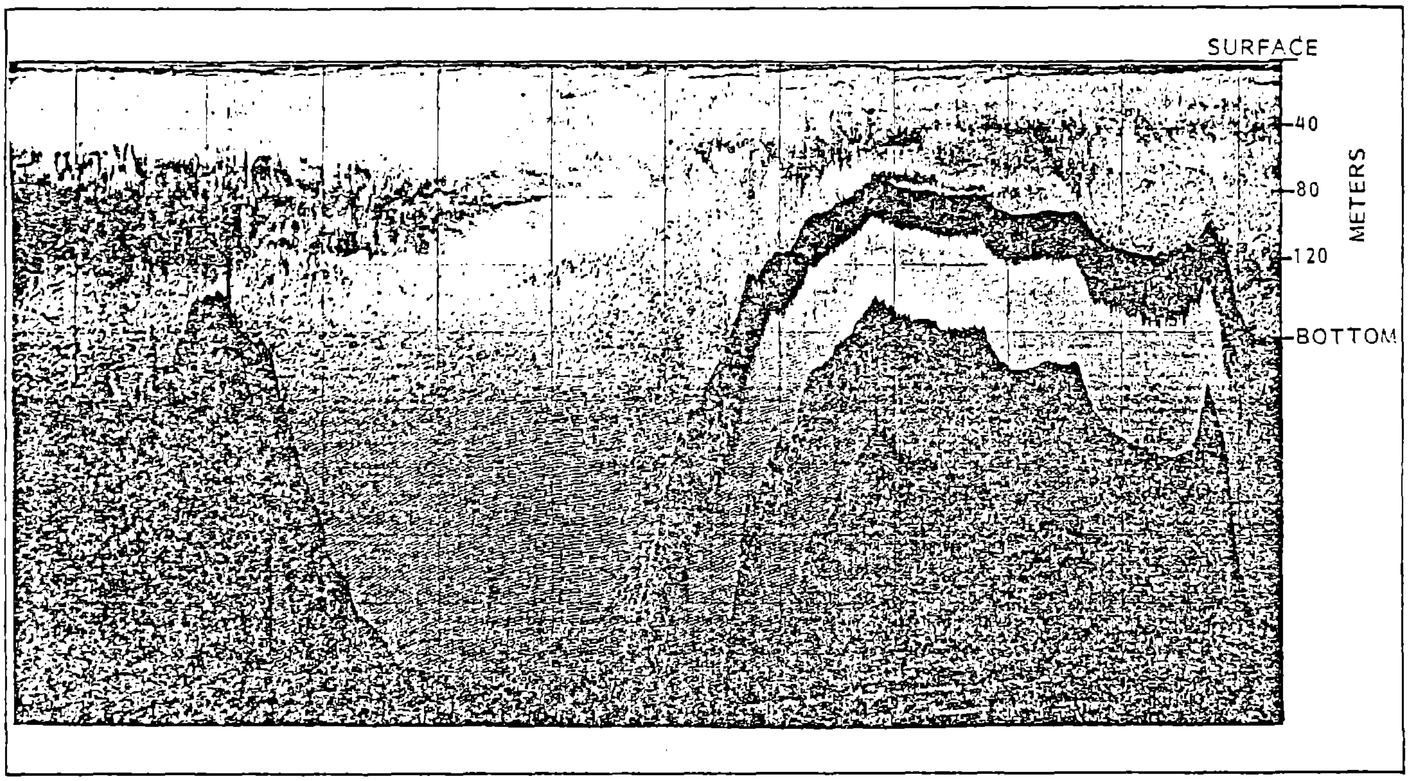

Figure 10--Continued. (D) Transect 4, Geikie Inlet to Sturgess Island.

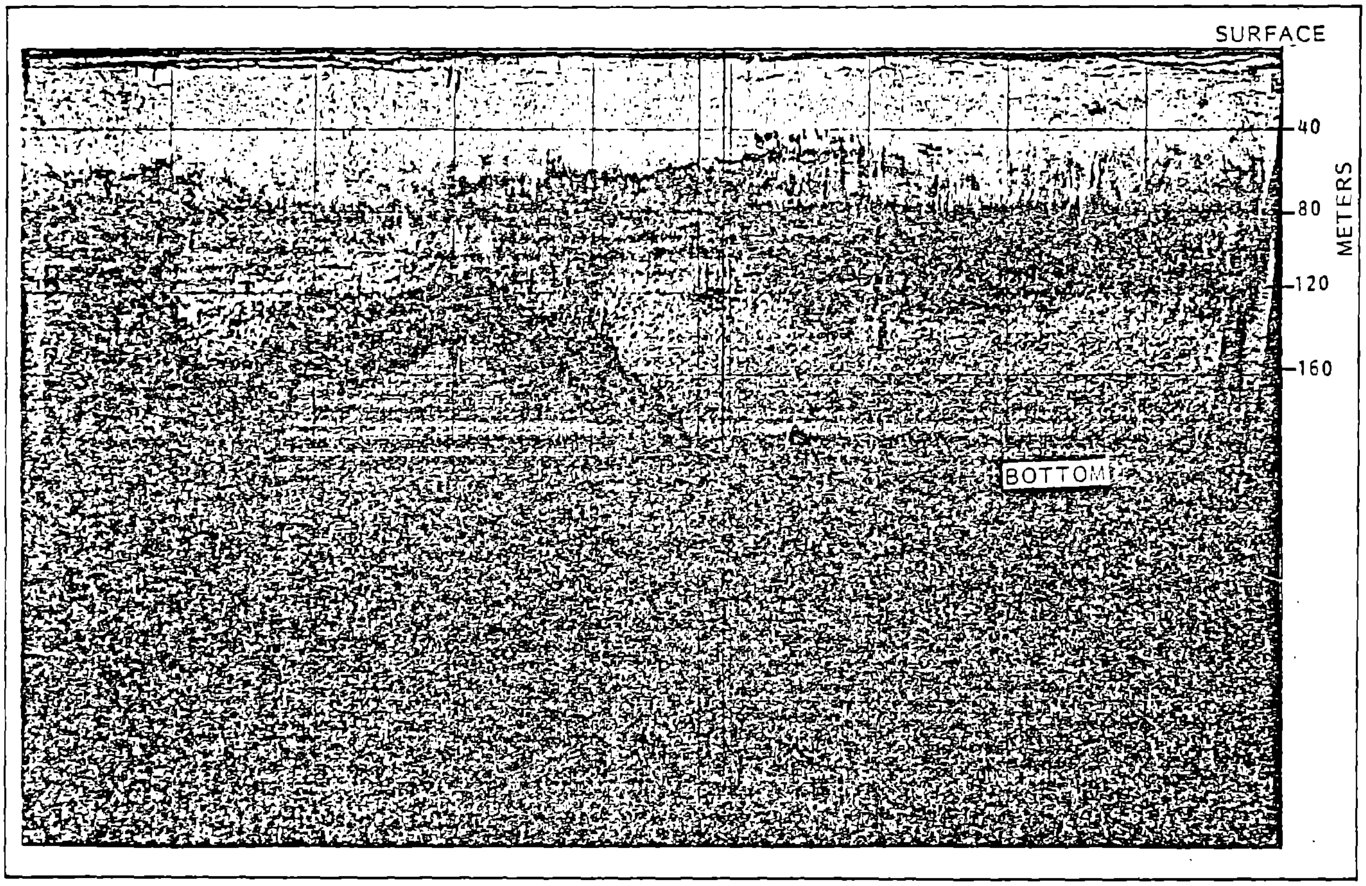

Figure 10--Continued. (E) Transect 5, Tidal Inlet to Geikie Inlet.

Table 4.--Backscattering density (backscatter/m^2) estimates from hydroacoustic transects in Glacier Bay surveyed in 1982 and 1983.

Area	12 Aug. 1982	20 Aug. 1982	5 Aug. 1983	25 Aug. 1983	12 Sept. 1983
Transect 1:					
Rush Point--Strawberry Is.	0.3	0.2	1.2	0.4	1.0
Transect 2:					
Strawberry Is.--Willoughby Is.	1.6	0.6	1.6	1.5	2.5
Transect 3:					
Willoughby Is.--Sturgess Is.	4.8	5.7	4.2	3.8	5.6
Transect 4:					
Sturgess Is.--Geikie Inlet	2.4	4.8	4.2	6.0	5.6
Transect 5:					
Geikie Inlet--Tidal Inlet	3.6	3.4	4.5	7.3	9.1
Transects 1-5:					
Rush Point--Tidal Inlet	3.1	3.5	3.8	4.7	5.4

dominant species on 14 August and 25 August, and Euphausia pacifica was the dominant species on 12 September. Sampling above and below the DSL yielded catches dominated by arrowworms (Sagitta elegans).

Higher mean backscattering densities were observed in Glacier Bay in 1983 than in 1982 (Table 4) mainly because densities in the DSL's on Transects 4 and 5 increased in late August and mid-September 1983. An estimate of the most dense portion of the DSL on 12 September 1983 was 0.1 g/m^3. The IKMWT catches for the Glacier Bay-Icy Strait DSL's in 1983 were 82% euphausiids.

Stephens Passage-Frederick Sound

One hydroacoustic survey of Stephens Passage-Frederick Sound (Fig. 5) was conducted in 1983, and vertical and areal distribution of targets were similar to those of three surveys in 1982. The only difference was schooled fish that were present between Round Rock and Spruce Island in 1982 were absent in 1983. The backscattering density for Transect 4 was also lower in 1983 than in 1982 (Table 5).

Salinity and Temperature Profiles

Although oceanographic observations are not synoptic, they do provide some clues to the causes of the DSL distribution. Furthermore, areas with complex water-column structure frequently have large quantities of forage because productivity is high or large quantities of plankton are imported from adjacent areas.

Salinity and temperature profiles were least complex at the mouth of Glacier Bay and in Bartlett Cove where the water column is mixed by strong currents over shallow bottoms. At the mouth of Glacier Bay, salinities and

Table 5.--Backscattering density (backscatter/m^2) estimates from hydroacoustic transects in Stephens Passage-Frederick Sound surveyed in 1982 and 1983.

Area	3 Aug. 1982	4 Aug. 1982	20 Aug. 1982	3 Sept. 1983
Transect 1:				
Pt. Hugh--Entrance Is.	8.9	9.4	15.5	12.0
Transect 2:				
Entrance Is.--False Pt. Pybus	19.8	13.1	9.8	10.5
Transect 3:				
Falst Pt. Pybus--Round Rock	4.9	1.2	2.7	4.5
Transect 4:				
Round Rock--Spruce Is.	2.1	2.5	7.6	0.9
Transects 1-4:				
Pt. Hugh--Spruce Is.	9.9	8.1	10.5	8.7

temperatures were nearly uniform from the surface (30.78°/00 8.47°C) to the bottom (30.80°/00 8.38°C at 50 m) (Fig. lla).

On 26 August 1983, salinities were slightly lower (29.88°/oo at the surface, 30.25°/00 at 40 m) and temperatures slightly higher (9.0°C at the surface, 8.42" at 20-40 m) inside Bartlett Cove than at the mouth of Glacier Bay (Fig. lla). Bartlett Cove, partially isolated from the Glacier Bay entrance, is protected from most winds and receives some fresh water; thus, it should develop a weak surface stratification and have lower salinities and higher summer temperatures than the broad, open entrance to Glacier Bay. Similar conditions were observed in 1982. In both years, a distinct DSL was absent in these areas.

The central portion of Glacier Bay in August 1983 was characterized by a surface pycnocline extending to about 20 m (Fig. lla). In this pycnocline, salinities and temperatures were 23°/00 . and 9.6°C near the surface and 30°/oo and 7.8°C at 20 m. Below the pycnocline, salinities gradually increased, and temperatures decreased. At depths of 100-250 m, salinities were, 30.72-31.02°/oo and temperatures were 6.92-5.88°C. Salinities and temperatures within the surface pycnocline were similar in August 1982 and 1983. In both years, the 28°/oo salinity isoline was usually between 5 m and 8 m (euphausiids rarely occur in salinities <28°/oo: Mauchline and Fisher 1969). However, below the surface pycnocline in 1983, salinities were 0.3-0.7°/oo lower than those in 1982, and temperatures were 1.O-2.5°C higher.

Salinity and temperature profiles of the Point Adolphus area were complex. Generally, three to five layers were recognizable between the surface and the bottom (75-125 m) (Fig. llb). Salinities and temperatures were 24-29°/oo and 9.3-11.3°C at the surface, and 3O.45-31.8°/oo and 6.5-8.O°C at 125 m. Both salinity and temperature profiles had multiple inflexion

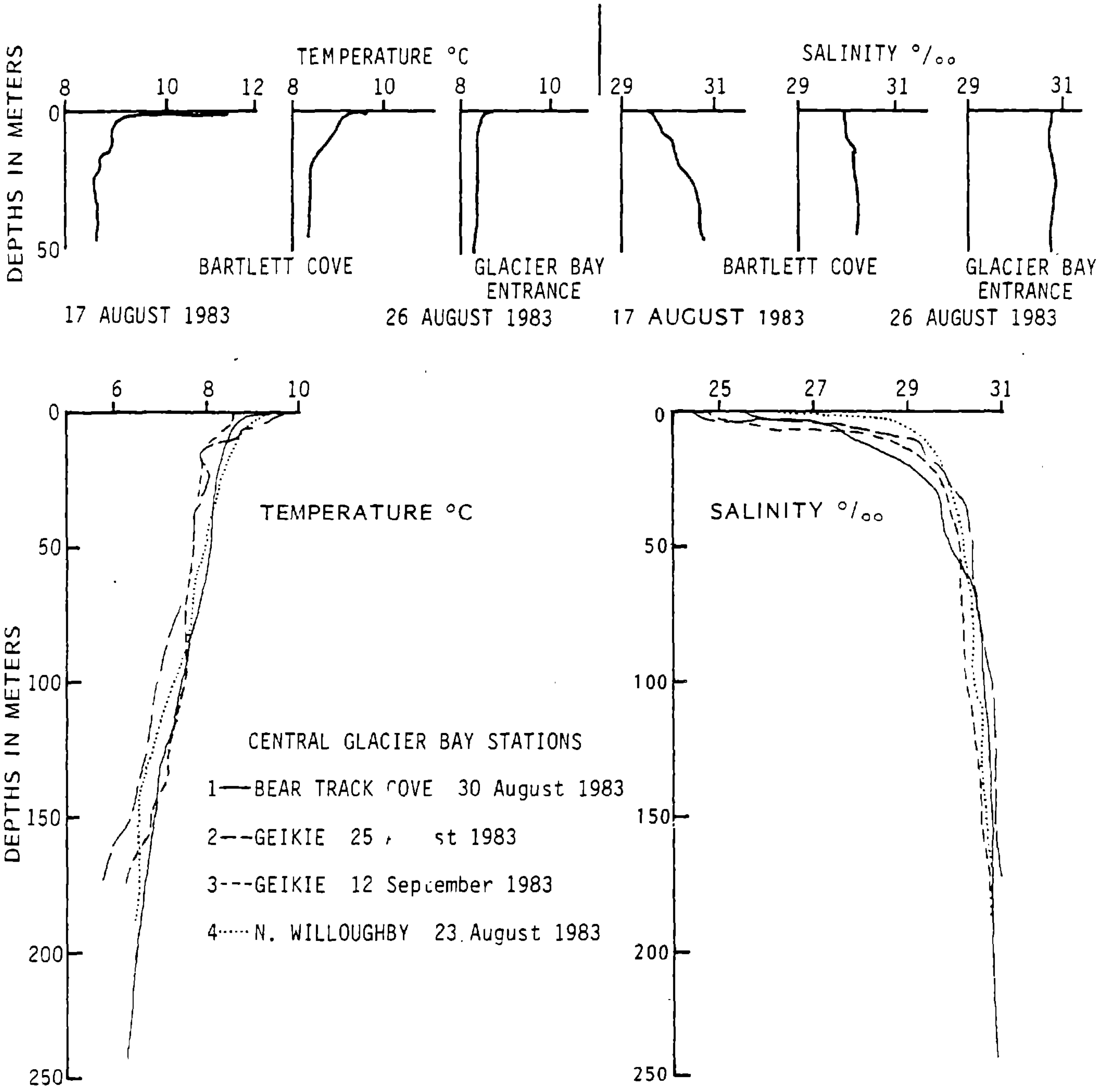

Figure 11.--Representative salinity and temperature profiles obtained in 1983: (A) Glacier Bay entrance; Bartlett Cove, and central Glacier Bay stations.

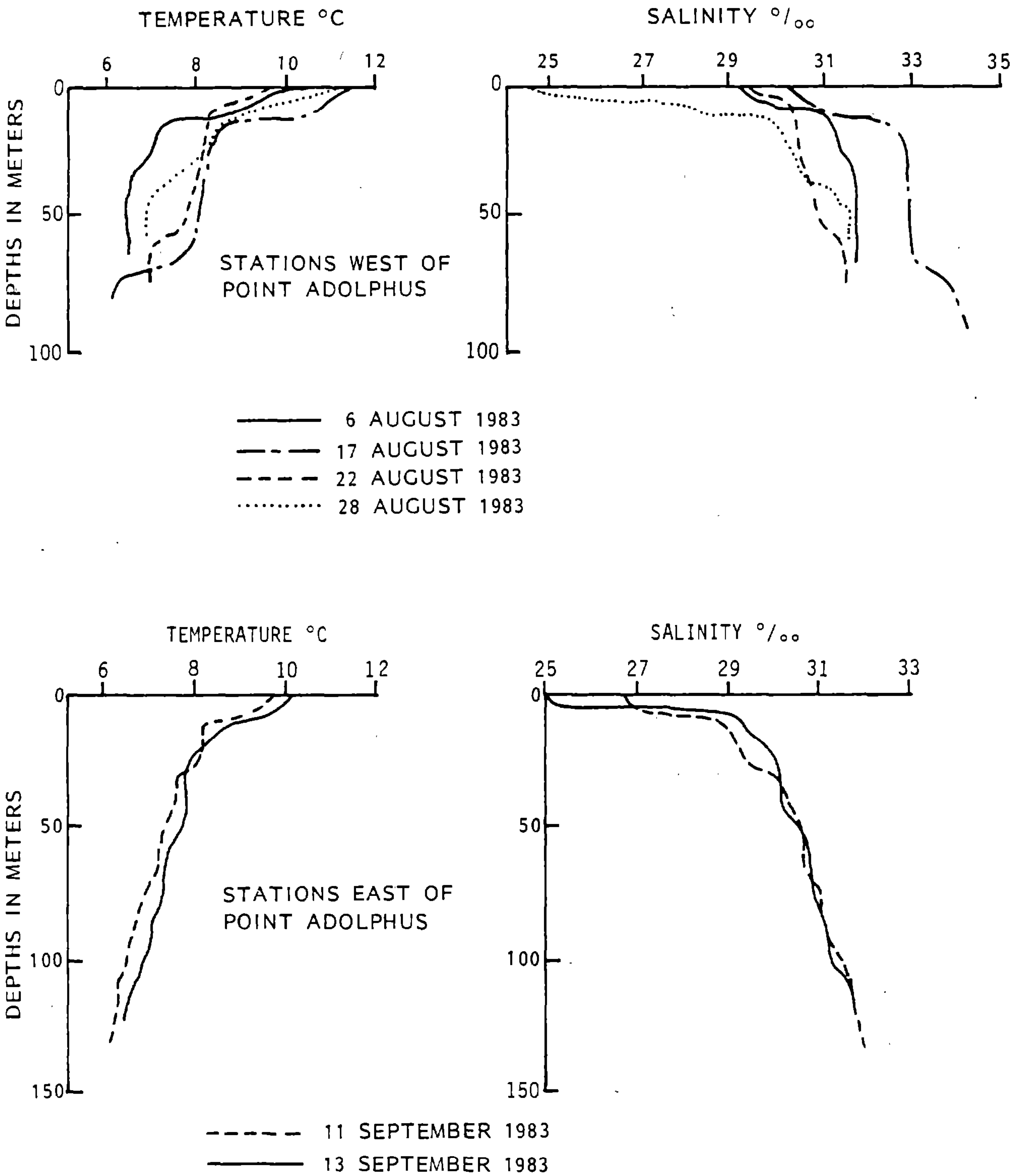

Figure 11--Continued. (B) Point Adolphus area.

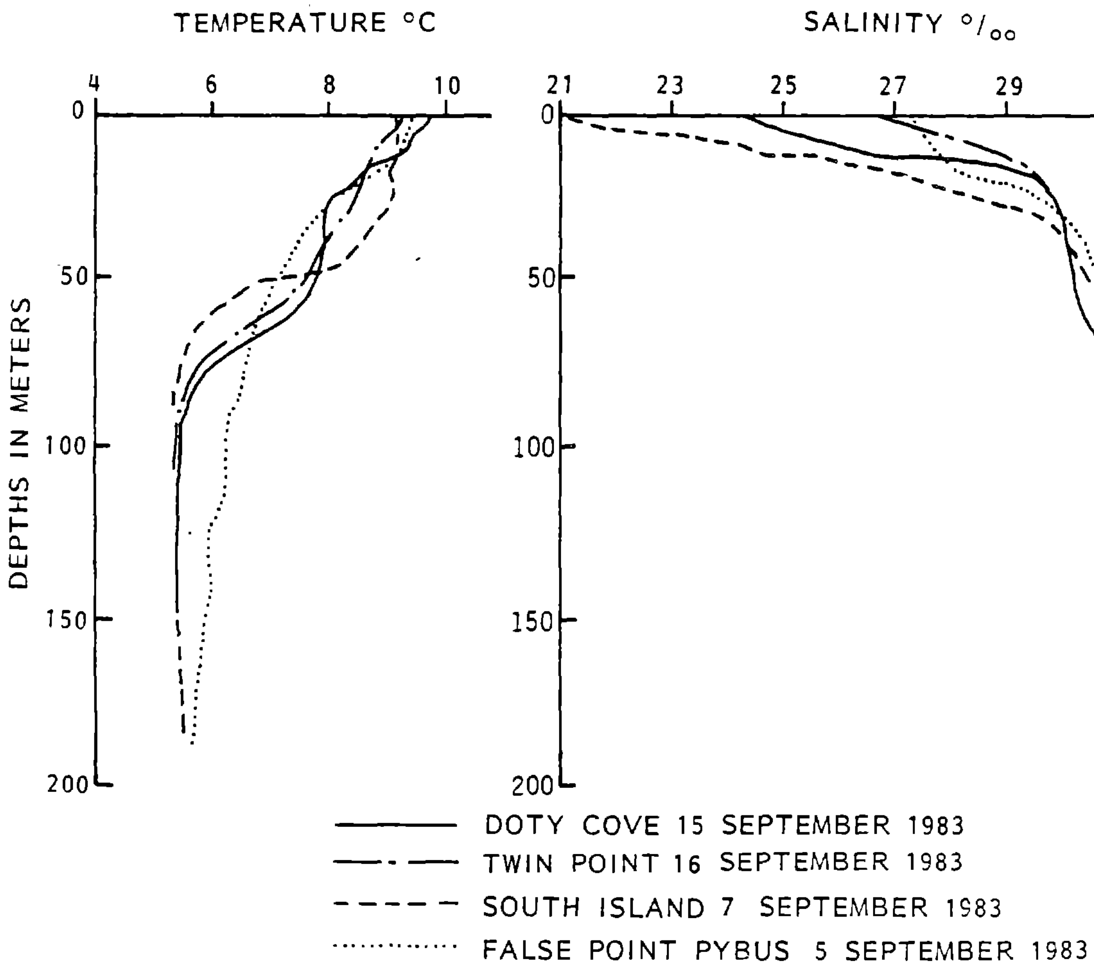

Figure 11--Continued. (C) Stephens Passage.

points, which indicate complex structuring of the water column probably caused by tidal mixing of surface waters flowing out of Glacier Bay, surface waters from eastern Icy Strait, and deep waters from Icy Strait. The degree of mixing and resultant layering depends on the density of each water source, phase of tidal cycle, weather conditions (especially winds), and the position of the observational stations. The consistent presence of marine mammals, sea birds, salmon, and schools of small fish indicate that Point Adolphus is an area rich in forage.

The Stephens Passage-Frederick Sound area had a three-layered water column (Fig. 11c) in contrast to the two-layered column in Glacier Bay. The top layer or surface pycnocline extended to 15-25 m. Surface salinities were 19.4-27.4°/oo, and surface temperatures were generally more than 9.0°C. Salinities in the second layer, which extended to about 75 m, were 29.5-30.5°/oo, and temperatures were 7.4-8.6°C. A sharp thermocline near 75 m formed the upper boundary of the third layer in which temperatures (5.4-6.0°C) and salinities (31.6-32.6°/oo) did not change rapidly with increasing depth.

During daytime sampling at Doty Cove, South Island, and Twin Point, the DSL was centered at or just below the deep thermocline. At False Point Pybus, where the structure of the water column was not well defined, the DSL was above the weakly developed third layer. During night sampling at Twin Point, the DSL rose to at least the lower half of the surface pycnocline in which salinities exceeded 28°/oo.

The frequency, time, and location of stations in Stephens Passage precluded direct comparison of 1982 and 1983 oceanographic observations. Mean salinities and temperatures below 50 m in September 1983 differed slightly from those of August-September 1982 (salinities were lower; temperatures were higher). However, the temperature differences are similar or less than hourly and daily differences observed in Chatham Strait (Garrison and Linger 1960).

DISCUSSION

Identification of Whale Forage

Identifying humpback whale forage is difficult because feed is often not visible, and stomachs are not available from whaling operations. Several methods have been used to identify whale forage in the past (analysis of, stomach contents and feces, and visual observations of feeding), but data from these methods are limited.

Analysis of humpback whales stomach contents in southeastern Alaska are limited to a few samples. Andrews (1909) listed euphausiids as the major forage of commercially harvested whales in southeastern Alaska. The stomach contents of two recently beached humpback whales included large quantities of euphausiids and herring and small quantities of a variety of invertebrates and fish (R. E. Haight, Northwest and Alaska Fisheries Center Auke Bay Laboratory, P.O. Box 210155, Auke Bay, AK 99821. Pers. commun., 1984).

Humpback whale prey have been identified from fecal matter. Supposedly, when humpback whales feed on euphausiids, the feces are red or purple; when they feed on fish, the color is gray or white. We have examined humpback whale feces, one purple and one gray-brown, and both were almost pure euphausiid remains. The dark feces consisted of telsons, antennal scales, and some ommatidea. The light feces consisted of mostly antenna, thoracic limbs, and a few oral appendages. Whale feces cannot be routinely gathered, and the identification of forage based on fecal color is questionable.

Humpback whales have been observed feeding on the surface, and the food can sometimes be accurately identified by visual observations. The observations are limited, however, by weather, water color, and the infrequent feeding near the surface.

Our research the last two seasons has shown echo sounding to be a valuable tool for qualitative and quantitative assessments of whale forage over large areas. Echo-sounder recordings, which show both the vertical distribution and horizontal patchiness of targets, were used to place nets on specific whale forage. Relative densities of forage were obtained that are comparable from year to year and between areas. The absolute densities of whale forage were based on approximate target strengths of each species and should be considered preliminary estimates.

Forage Density at Feeding Sites

Dense concentrations of feed were present at all humpback whale foraging sites assessed in 1983. The whales fed mostly on dense DSL's of euphausiids in Stephens Passage and on schooled herring at Point Adolphus and The Five Fingers islands. The prey at feeding sites inside Glacier Bay could not be sampled, but echo-sounder recordings showed small dense schools of fish, possibly capelin or Pacific sand lance, *Ammodytes hexapterus*.

Estimates of Euphausiid Density

In 1983, we did not observe humpback whales feeding on the DSL's in Glacier Bay. Maximum density of euphausiids in Glacier Bay near Geikie Inlet was 0.1 g/m^3, which is below the 0.7-4.3 g/m^3 observed where whales were feeding in Stephens Passage. The DSL's in Stephens Passage usually extended for several kilometers, and whales were concentrated at the densest sections of the DSL.

Estimates of Fish Density

Density estimates of fish at whale forage sites were 145.5-60.6 g/m^3 for herring and 23.7 g/m^3 for capelin. We were able to locate the fish because humpback whales positioned themselves over schools before diving. At Point Adolphus, we frequently observed humpback whales diving directly over schooled herring although the schools were constantly moving. Similarly, a humpback whale in Stephens Passage consistently dove on a small moving school of fish when no other feed was evident.

Changes in Whale Feeding Patterns in Glacier Bay

We have noticed two changes of humpback whale feeding behavior inside Glacier Bay. In 1981-83, whales surface feeding on euphausiids were not documented, and a forage site heavily used in 1982 was not used in 1983.

Surface Feeding on Euphausiids

Humpback whales were surface feeding on euphausiids in Glacier Bay in 1976 and 1977 (Earle 1979a, 1979b; Jurasz and Jurasz 1979) but were not observed during the Whale Prey Studies in 1981-83. Euphausiids are rarely found in water with salinity less than 28°/oo (Mauchline and Fisher 1969). During our studies in Glacier Bay and Stephens Passage-Frederick Sound, the 28°/oo, isoline has generally been 5 m or deeper. If the 28°/oo, isoline never approached the surface, euphausiids probably were not at the surface in Glacier Bay in 1981, 1982, or 1983. Humpback whales were surface feeding on euphausiids in Frederick Sound in 1982 and 1983 (Dawson and Taylor 1982; Wing and Krieger 1983; Giddings 1984). Although we have no salinity measurements in Frederick Sound when whales were surface feeding, a surface salinity of 27.9°/oo was observed 4 days before the whales were seen surface feeding on euphausiids during the evening of 20 August 1982.

Feeding Inside Bartlett Cove

Bartlett Cove was the most intensively used foraging site in Glacier Bay in 1982. Four whales were resident in Bartlett Cove during most of July and August 1982, and an additional nine whales were known to visit the Cove (Baker et al. 1983). During 1982, capelin was identified as the forage in Bartlett Cove. In 1983, whales rarely entered Bartlett Cove, and no concentrated forage could be found in the Cove. Plankton sampling in the Cove showed a lower abundance of copepods (a major capelin forage) in 1983 than in 1982, which may account for decreased whale forage in Bartlett Cove.

Humpback Whales and Vessel Interactions

Baker et al. (1983) suggest that available prey and feeding strategies are important variables in determining the response of humpback whales to vessel traffic. Some of our 'observations of whales during the 1983 season seem to support this hypothesis. When whales were feeding, they apparently did not respond to our presence. On two occasions, we altered our course- and reversed engines to avoid collision courses with humpback whales. We were attempting to position our vessel over herring schools at Point Adolphus, and the whales appeared to be searching for the same school. Similarly, on 20 August 1982, we had to alter course while assessing near-surface euphausiid swarms in Frederick Sound when the humpback whales were actively surface feeding on the same swarms.

When whales were resting on the surface, or in other nonfeeding modes, they usually reacted to our presence by moving away from the vessel as we approached and sometimes by breaching. On one occasion, a whale appeared to be drawn to our vessel. While we drifted with the engines running, the whale approached the bow, moved slowly along the starboard side, around the stern, and came to a holding position on the port side. This whale remained at the surface within 2 m of the vessel for about 5 min.

SUMMARY

The objects of the Whale Prey Study in 1983 were to 1) identify and characterize whale foraging sites in Glacier Bay, 2) determine the feeding depths of whales at these sites and the composition of prey at those depths, and 3) assess the general distribution and abundance of prey in Glacier Bay for comparisons between years and within seasons. Hydroacoustic recordings of fish schools and DSL's, supplemented with net sampling, were our basic observational data. Survey transects for between- and within-season comparisons were the same as those established for the Whale Prey Study in 1981 and 1982 for Glacier Bay and the Stephens Passage-Frederick Sound area.

The two to four humpback whales in Glacier Bay during our study were difficult to locate because they were moving throughout the Bay. When whales were thought to be foraging in Glacier Bay, they were in areas too confined (nearshore and less than 30-m depth) for hydroacoustic surveys and net sampling. However, fathometer chart recordings at four whale feeding sites showed small fish schools.

During the 1983 surveys, fish and micronekton were less abundant in Glacier Bay than at whale feeding sites outside of the Bay. Outside Glacier Bay, whale forage was identified and quantified at six sites. Herring was the prey at Point Adolphus and near The Five Fingers islands, and density estimates ranged from 145.5-60.6 g/m^3. Euphausiids were the prey at four whale feeding sites in Stephens Passage where densities ranged from 0.7 to 4.3 g/m^3. Because only one type of prey (herring or euphausiids) was -abundant at each site, we conclude that foraging depth corresponds to the depth-distribution of the herring or the euphausiids: 25-80 m for herring and 60-130 m for euphausiids.

General distribution and abundance of prey were assessed three times in Glacier Bay and once in Stephens Passage-Frederick Sound in 1983. The spatial distribution of fish and micronekton along the Glacier Bay transects was similar in 1982 and 1983. The most dense forage layer assessed in Glacier Bay (0.1 g/m^3) in 1983 was a euphausiid DSL near Geikie Inlet. Mean backscattering density was higher in 1983 than 1982 because of increased densities of euphausiids near Geikie Inlet in 1983. A seasonal increase in backscattering density from early August to mid-September 1983 was also attributed to the increased density of euphausiids near Geikie Inlet. General distribution and abundance of prey along the Stephens Passage-Frederick Sound transects were similar in August 1982 and September 1983.

ACKNOWLEDGMENTS

In all research programs, the work is accomplished with the aid of many associates. We wish particularly to recognize the assistance of Lawrence Cook (master), Richard Cook (engineer), and Frank Roechant (cook-seaman) of the F/V Georgene for varied and always accommodating assistance during the field season. John Boettnor (Sea Quest consultant) assisted in collection of hydroacoustic data. Yogi Endo (University of Alaska, Juneau, School of Fisheries and Science) and Kendra Daly (University of Washington, School of Oceanography) provided timely analyses of micronekton and zooplankton samples necessary for estimating hydroacoustic target strengths. The Northwest and Alaska Fisheries Center Resource Assessment and Conservation Engineering (RACE) Division staff at Sand Point, Seattle, Washington, assisted us in obtaining vital equipment for the field work. Staff at the Auke Bay Laboratory have assisted in many ways, particularly in meeting critical deadlines of equipment readiness and report preparation.

Special recognition is due to the Glacier Bay National Park and Preserve and the Glacier Bay Lodge staffs for assistance in locating whales inside Glacier Bay, aiding in equipment repairs, and generally providing a hospitable research environment. The major portion of the research was funded by the Alaska Regional Office of the National Park Service through an interagency agreement.

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APPENDIX

Table 1. Location, dates, and types of hydroacoustic observations in 1983.

Table 2. Dates, locations and sample data for Isaacs-Kidd midwater trawl samples taken in 1983.

Table 3. Dates, locations and sample data for Tucker trawl samples.

Table 4. Dates, locations, depths, and times of salinity and temperature profiles taken in 1983.

Table 1.--Location, dates, and types of hydroacoustic observations in 1983.

Survey area	Date	Type of survey
1. Glacier Bay (Rush Pt. to Tidal Inlet)	Aug. 5	index transects
2. Pt. Adolphus	Aug. 12	standard transects
3. Pt. Adolphus	Aug. 12	whales feeding
4. Bear Track Cove	Aug. 13	standard transects
5. Pt. Adolphus	Aug. 15	whales feeding
6. Bartlett Cove	Aug. 17	index transects
7. Pt. Adolphus	Aug. 17	standard transects
8. Pt. Adolphus	Aug. 22	standard transects
9. Pt. Adolphus	Aug. 22	whales feeding
10. Glacier Bay (Berg Bay entrance)	Aug. 23	whales feeding
11. Glacier Bay (Bear Track Cove)	Aug. 24	standard transects
12. Glacier Bay (Rush Pt. to Tidal Inlet)	Aug. 25	index transects
13. Bartlett Cove	Aug. 26	standard transects
14. Pt. Adolphus	Aug. 27	standard transects
15. Pt. Adolphus	Aug. 28	whales feeding
16. Glacier Bay (Lone Brush Is.)	Aug. 29	whales feeding
17. Stephens Passage (South Is.)	Sept. 3	whales feeding
18. Stephens Passage- Frederick Sound (Pt. Hugh to Spruce Is.)	Sept. 3	index transects
19. Stephens Passage (Five Fingers)	Sept. 4	whales feeding
20. Stephens Passage (Entrance Is.)	Sept. 5	whales feeding
21. Stephens Passage (Hobart Bay)	Sept. 6	whales feeding
22. Stephens Passage (South Is.)	Sept. 7	whales feeding
23. Pt. Adolphus	Sept. 9	whales feeding
24. Pt. Adolphus	Sept. 10	standard transects
25. Pt. Adolphus	Sept. 10	whales feeding
26. Pt. Adolphus	Sept. 11	whales feeding
27. Glacier Bay (Rush Pt. to Tidal Inlet)	Sept. 12	index transects
28. Stephens Passage (Doty Cove)	Sept. 15	whales feeding
29. Stephens Passage (Doty Cove to Twin Pt.)	Sept. 16	whales feeding
30. Stephens Passage (Twin Pt. to Pt. Hugh)	Sept. 17	whales feeding

Table 2.--Dates, locations and sample data for Isaacs-Kidd midwater trawl samples taken in 1983. MWO = meters wire out; WL°=wire angle; and Z = sampling depth.

Tow	Date	Time	Station	Target depth	MWO	WL°	Z	Time at depth (min)	Comments
1	6 Aug.	1915	Pt. Adolphus	45	170	72	49	16	light catch
2	12 Aug.	1408	Pt. Adolphus	35	120	70	41	10	struck bottom
3	12 Aug.	1448	Pt. Adolphus	30	90	70	31	10	water haul
4	13 Aug.	1455	Willoughby	46	140	71	52	15.5	
5	13 Aug.	1533	Willoughby	30	84	69-70	30	20	
6	14 Aug.	1442	Geikie	36	100	70	27	16	
7	14 Aug.	1508	Geikie	65	190	72	59	20	
8	14 Aug.	1549	Geikie	90	263	72	81	21	*Cyanea* discarded
9	15 Aug.	1453	Pt. Adolphus	60	185	72	57	24.5	
10	16 Aug.	1342	Marble	33	100	70	34	29	
11	16 Aug.	1427	Marble	55	160	71	52	30	
12	16 Aug.	1514	Marble	99	290	74	80	31	
13	17 Aug.	1127	Bartlett	9	27	64	12	16	*Cyanea* discarded
14	17 Aug.	1152	Bartlett	18	53	68	20	14.8	*Aurelia* discarded
15	17 Aug.	1217	Bartlett	27	83	67	32	14.7	*Cyanea* discarded
16	17 Aug.	1241	Bartlett	36	135	71	44	15.5	*Cyanea* discarded
17	23 Aug.	1454	Willoughby	50	170	71	~71	15	
18	25 Aug.	1233	Geikie	36	208	70	37	30	
19	25 Aug.	1328	Geikie	90	300	72	93	30	
20	25 Aug.	1424	Geikie	140	540	75	139	30	
21	26 Aug.	1625	Bartlett	20	53	65	22	15	
22	26 Aug.	1655	Bartlett	36	85	60	36	15	hit bottom
23	26 Aug.	1715	Bartlett	36	85	68	31	15	
24	28 Aug.	1054	Pt. Adolphus	32	90	70	31	31	
25	28 Aug.	1149	Pt. Adolphus	47	136	69	49	30	
26	28 Aug.	1237	Pt. Adolphus	70	210	70	73	30	hit bottom
27	30 Aug.	1246	Bear Track	144	420	72	130	20	
28	5 Sept.	1118	False Pt. Pybus	108	425	75	110	20	
29	7 Sept.	1321	South I.	91	265	~70	150-100	44	
30	7 Sept.	1643	Doty Cove	65	190	70	65	15	
31	11 Sept.	1413	Pinta Cove	41	125	70	43	20	*Cyanea* discarded
32	11 Sept.	1459	Pinta Cove	100	324	72-77	100-123	31	hit bottom
33	12 Sept.	1535	Geikie	120	388	70	132	30	
34	15 Sept.	1536	Doty Cove	82	250	70	86	15	

Table 2.--Continued.

Tow	Date	Time	Station	Target depth	MWO	WL°	Z	Time at depth (min)	Comments
35	16 Sept.	1305	Twin Pt.	55	190	71	62	30	
36	16 Sept.	1351	Twin Pt.	126	390	72	121	39	
37	16 Sept.	2116	Twin Pt.	10	30	65	13	15	

Table 3.--Dates, locations and sample data for Tucker trawl samples. MWO = meters of wire out; WL° = wire angle; Z = depth in meters.

Sample	Area	Date	Time	MWO	WL°	Z	Comments	Samples Kept	Samples Processed
1	Geikie	14 Aug.	1630	0		0		3	3
			1635	100	57	55			
			1640	130	62	58			
			1645	0		0			
2	Pt. Adolphus	15 Aug.	1251	0		0		1	1
			1256	96	58	51	failed to trip		
			1301	96	58	51	failed to trip		
			1306			0			
3	Pt. Adolphus	15 Aug.	1336	0		0		3	3
			1340	110	57	60			
			1353	110	57	60			
			1356	0		0			
4	Willoughby	16 Aug.	1617	0		0		3	3
			1620	80	60	40			
			1625.5	80	60	40			
			1628	0		0			
5	Willoughby	16 Aug.	1653	0		0		3	3
			1701	130	52	52			
			1708	130	62	61			
			1713	0		0			
6	N. of Mud Bay	22 Aug.	1452	0		0		3	0
			1456	--		50	hit bottom		
			1501	--		50			
			1505	0		0			
7	N. of Mud Bay	22 Aug.	1653	0		0		2	2
			1655	--		66	sample jar broken		
			1702	--		66			
			1705	0		0			

Table 3.--Continued.

Sample	Area	Date	Time	MWO	WL°	Z	Comment	Samples	
								Kept	Processed
8	Willoughby	23 Aug.	1423	0		0		3	1
			1429	--		100			
			1436	--		100			
			1442	0		0			
9	Willoughby	23 Aug.	1506	0		0		3	1
			1510	--		55			
			1505	--		55			
			1520	0		0			
10	Geikie	25 Aug.	1537	0		0		3	1
			1547	--		135			
			1555	--		135			
			1602	0		0			
11	Geikie	25 Aug.	1638	0		0		3	1
			1646	180	60	90			
			1653	180	60	90			
			1700	0		0			
12	Geikie	25 Aug.	1722	0		0		1	0
			1725	--		35			
			1731	--		35			
			1734	0		0	2nd messenger failed		
13	Bartlett	26 Aug.	1204	0		0		3	1
			1210	--		30			
			1214	--		37			
			1218	0		0			
14	Bartlett	26 Aug.	1251	0		0		3	1
			1254	--		35			
			1301	--		37			
			1304	0		0			

Table 3.--Continued.

Sample	Area	Date	Time	MWO	WL°	Z	Comments	Samples Kept	Samples Processed
15	M. Glacier	26 Aug.	1357	0		0		3	1
			1402	--		38			
			1407	--		39			
			1412	0		0			
16	M. Glacier	26 Aug.	1443	0		0		3	1
			1447	--		38			
			1453.5	--		38			
			1456	0		0			
17	Pt. Adolphus	28 Aug.	1359	0		0		0	0
			1407	252		270	hit bottom/net torn		
18	Bear Track	30 Aug.	1106	0	52-65	0		3	1
			1112	217	61	105			
			1119	217	62	100			
			1129	0		0			
19	Bear Track	30 Aug.	1158	0		0			
			1206	170	64	75		3	1
			1212	170	64	75	#2 chain hung		
			1219	0		0	net 2/3 open		
20	False Pt. Pybus	5 Sept.	0910	0		0			
			0926	293	~70	100	messengers	3	0
			0936	293	~64	130	hanging up		
			0944	0		0			
21	False Pt. Pybus	5 Sept.	1019	0		0		3	0
			1028	326	~72	100	hit patch		
			1035	326	~72	100	miss patch		
			1047	0		0	miss patch		

End use of Pacific Digital Telemetry Unit   Deck unit broken

Table 3.--Continued.

								Samples	
Sample	Area	Date	Time	MWO	WL°	Z	Comments	Kept	Processed
22	Geikie	12 Sept.	1403	0		0		3	1
			1408	110	63	50			
			1415	110	63	50			
			1420	0		0			
23	Geikie	12 Sept.	1435	0		0		3	1
			1447	250	65	106			
			1453.5	250	65	106			
			1502	0		0			
24	Pinta Cove	13 Sept.	0926	0		0		3	2
			0931.5	95	62	45			
			0938.5	85	62	45			
			0942	0		0			
25	Pinta Cove	13 Sept.	1011	0		0		0	0
			1021	208	61	<100	hit bottom		
			1025	0		0			
26	Pinta Cove	13 Sept.	1120	0		0		1	1
			1128	208	62	100	hit bottom		
			1135	208	62	<100			
			1142	0		0			
27	Doty Cove	15 Sept.	1452	0		0		3	1
			1458	180	62	84			
			1504	180	62	84			
			1512	0		0			

Table 4. --Dates, locations depths, and times of salinity and temperature profiles taken in 1983.

Cast	Date	Stations/area	Maximum depth (m)	Local time (PDT)
1	6 Aug.	N. Willoughby Is./Glacier Bay	190	1158
2	6 Aug.	Pt. Adolphus/Icy Strait	68	1826
3	17 Aug.	Bartlett Cove/Glacier Bay	45	1310
4	17 Aug.	Pt. Adolphus/Icy Strait	82	1730
5	22 Aug.	N. of Mud Bay/Icy Strait	68	1442
6	22 Aug.	Pt. Adolphus/Icy Strait	75	1710
7	23 Aug.	N. Willoughby/Glacier Bay	183	1356
8	25 Aug.	W. Geikie/Glacier Bay	170	1515
9	26 Aug.	Mouth of Glacier Bay	55	1533
10	26 Aug.	Bartlett Cove/Glacier Bay	45	1608
11	28 Aug.	Pt. Adolphus/Icy Strait	50	1335
12	30 Aug.	Bear Track Cove/Glacier Bay	233	0942
13	5 Sept.	False Pt. Pybus/Stephens Passage	180	0950
14	7 Sept.	South Island/Stephens Passage	193	1419
15	11 Sept.	Pinta Cove/Icy Strait	130	1550
16	12 Sept.	W. Geikie/Glacier Bay	175	1338
17	13 Sept.	Pinta Cove/Icy Strait	130	0910
18	15 Sept.	Doty Cove/Stephens Passage	150	1608
19	16 Sept.	Twin Point/Stephens Passage	110	1243