HARBOR SEAL FORAGING ECOLOGY INVESTIGATIONS

IN GLACIER BAY NATIONAL PARK

ANNUAL REPORT 2005

Jamie N. Womble[1,2], Scott M. Gende[1], and Gail M. Blundell[3]

Coastal Program, Glacier Bay Field Station, National Park Service[1]
3100 National Park Road
Juneau, Alaska 99801

Alaska Fisheries Science Center[2]
Auke Bay Laboratory
11305 Glacier Highway
Juneau, Alaska 99801

Alaska Department of Fish and Game[3]
Division of Wildlife Conservation
P.O. Box 240020
Douglas, Alaska 99824

INTRODUCTION

Glacier Bay National Park has historically supported one of the largest breeding populations of harbor seals in Alaska. Harbor seals are an important apex predator and the most numerous marine mammal in the park; however, harbor seals have declined by more than 70% in the park from 1992 to 2002 (Mathews and Pendleton 2006). The magnitude and rate of decline exceed all reported declines of harbor seals in Alaska, with the exception of that at Tugidak Island (Pitcher 1990), and show no signs of reversal. Data from the 2004 and 2005 trend survey of terrestrial sites in Glacier Bay indicate that the decline continues at a rate of 14.7% per year (ADF&G *unpublished data*). The cause of decline may be specific to the Park or nearby region: in contrast to the population trend in Glacier Bay, harbor seals in two other areas of southeastern Alaska (near Sitka and Ketchikan) are stable or increasing (Small et al. 2003). Glacier Bay resource management and Alaska Department of Fish & Game (ADF&G) list the harbor seal decline in the park as a top resource issue.

Little is known about the foraging ecology, life-history, movements, behavior, and trends in available prey of harbor seals in Glacier Bay, so it is difficult to discern the causal factors that are contributing to the decline, and even more difficult to develop effective management strategies. Hypothesized reasons for the decline include increased human disturbance, elevated rates of predation, and nutritional stress due to changes in prey base, disease, or contaminants (Mathews and Pendleton 2006).

Mathews (2002) conducted the only study that has examined the diet composition of harbor seals in Glacier Bay. Common prey types were primarily pelagic

or epi-pelagic fishes, including walleye pollock, juvenile salmon, capelin, herring, and cod. Near-shore species included sand lance. However, important habitat (locations within the park) of these prey species have not been identified, and annual variability in distribution and density has not been quantified.

Central to understanding the foraging ecology of harbor seals is the spatial (where in the park important prey species are located) and temporal (weekly, monthly, seasonal) distribution of available prey, which prey species are utilized by harbor seals, and which areas of the park represent critical foraging habitat. For other marine mammals, rate of population decline has been correlated with diet diversity (Merrick et al. 1997), and differences in energy density among prey species (including those utilized by harbor seals in Alaska) may reduce foraging efficiency sufficiently to reduce fitness (Rosen and Trites 2000).

A multi-agency collaborative study between the National Park Service (NPS), Alaska Department of Fish and Game, and Alaska Fisheries Science Center-Auke Bay Laboratory (AFSC-ABL) began in 2004, aimed at addressing hypotheses on harbor seal declines in Glacier Bay. The objectives are to (1) determine the location of important foraging habitat of seals that utilize ice and terrestrial substrate as haul outs; (2) determine foraging areas of seals relative to boat traffic and protected waters; (3) determine prey availability in areas where individual seals forage, and (4) determine prey availability near the two primary haulout areas (Johns Hopkins Inlet and Beardslee Islands). This report summarizes the 2004 and 2005 field season, and presents preliminary results, although data analysis is ongoing.

METHODS

Harbor Seal Captures and Instrument Deployment

For the foraging ecology portion of this study, harbor seals were captured during April 2004 and 2005 using multifilament stretch nylon nets at terrestrial sites and monofilament nets in ice habitats (Table 1). 28 harbor seals were fitted with VHF headmount transmitters (Advanced Telemetry Systems MM340) at terrestrial sites in 2004 and 2005 (Spider Reef Complex, Kidney Stone Island, Boulder Island, Geikie Rock) while 18 were fitted with headmount transmitters in Johns Hopkins Inlet in 2005 (Figure 1). A subset (n = 21) of these seals were also fitted with archival Time-Depth Recorders (MK9, Wildlife Computers) to assess dive behavior of harbor seals. Time-Depth Recorders were programmed to record depth, time, temperature, and light every 2 seconds. The resolution of the TDR was 0.5 m with an accuracy of ± 1 m. TDR's were shed during the annual molt and retrieved by boat, kayak, and floatplane.

Foraging Areas of Harbor Seals

Foraging areas were determined by conducting real-time VHF-tracking of seals from the R/V *Capelin* and from aerial surveys. Vessel surveys occurred every other week from May-July in 2004 (n = 25 days) and 2005 (n = 29 days). Aerial surveys occurred every other week from May-July in 2004 and opportunistically in 2005 (due to lower funding levels).

During vessel surveys, radio frequencies were scanned continuously. When the radio signal was detected we attempted to visually locate the seal on the surface of the water. The date, time, latitude and longitude was recorded using a global

positioning system (GPS). Seals were followed for at least 1 hour to ascertain whether or not they were foraging. During these 'focal follows', dive/surface intervals were recorded. All data were entered into an ACCESS database.

Assessment of Prey Availability

In 2005, we initiated a pilot study intended to asses prey availability to harbor seals by conducting large-scale and fine-scale acoustic surveys with assistance from Dr. Michael Sigler of the Alaska Fisheries Science Center-Auke Bay Laboratory. Large-scale acoustic transects were established in the Beardslee Entrance and in Johns Hopkins Inlet (Figure 2) to determine seasonal availability of pelagic prey in those areas given their proximity to harbor seal haulout sites. Systematic acoustic surveys were conducted at site each from May through August. Fine-scale acoustic surveys (n = 19) were conducted in conjunction with focal animal observations in areas where individual tagged seals were observed diving.

Acoustic data were collected using a portable 38-kHz Simard EK60 echo-integration system with a 12° beam angle, and stored on disk. The echo-sounder transducer was towed beside the *Capelin* at 5kt/hour. Location data from a GPS were collected simultaneously. The acoustic data were analyzed with an echo-integrator that was used to sum the returning echoes from fish observed beneath the vessel. Acoustic data were classified by 0.183-km length intervals and 10-m depth interval, and corrected for instrument calibration using the echo-integration software SonarData Echoview (Womble and Sigler *in press*, Sigler et al. 2004).

RESULTS AND DISCUSSION

Foraging Areas of Harbor Seals

45 of 46 (97.8%) harbor seals with head-mounted VHF transmitters were relocated in 2004 and 2005. A total of 638 VHF relocations were obtained in 2004 (n = 271) and 2005 (n = 367). 75 focal animal observations were conducted during 2004 and 2005 on 35 individual harbor seals (Figure 3). A subset of those observations (n = 19) also included fine-scale prey assessment data obtained from acoustic transects.

In general, most seals captured at terrestrial sites in the lower bay remained in the vicinity of haulouts in and around the Beardslee Island Wilderness Complex; however there were several large scale movements within the park. One pregnant adult female seal (PV04GB16), one yearling female (PV04GB23), and one yearling male (PV04GB09) moved from their haulout sites in the lower bay to Johns Hopkins Inlet. One subadult female (PV04GB26) moved to Adams Inlet. Each of these seals was later observed at haulouts in the lower bay later in the summer.

Harbor seals captured in Johns Hopkins Inlet (2005 only) traveled farther to foraging areas than harbor seals captured at terrestrial sites in the Beardslee Islands. In some cases, seals traveled over 100 km from Johns Hopkins Inlet to Sitakaday Narrows to forage. However, there were a few seals that foraged in glacial habitats: a subadult female (PV05GB32) was found repeatedly foraging near the face of Johns Hopkins and Gilman Glaciers. Three harbor seals (1 adult male, and 2 subadult females) that were captured in Johns Hopkins Inlet, were found foraging in Tarr Inlet. In particular, one adult male (PV05GB31) was found foraging in Tarr Inlet near the face of

the Grand Pacific Glacier, an area of known high-productivity (Robards et al. 2003). It also appeared that some individuals exhibited fidelity to certain foraging areas. For example, a female (PV05GB35) captured in Johns Hopkins Inlet was repeatedly located foraging in Tidal Inlet, and an adult male (PV05GB16) captured at Spider Island Reef Complex repeatedly foraged just south of Spider Island.

Time-Depth Recorder (TDR) Retrieval

17 of the 21 (81%) TDR's were retrieved between late June and mid-August in 2004 and 2005 after the instruments were shed during annual molt. Data analyses are currently ongoing with TDR data. These data will be analyzed to reconstruct three-dimensional dive behavior, and, coupled with observations of foraging seals, will elucidate insight into what prey types are used predominantly by seals and how this varies among individuals, locations, and seasons.

Prey Availability

Preliminary data analysis of large-scale acoustic surveys suggest that acoustic density (an index of prey availability) was higher at the Beardslee Entrance site than in Johns Hopkins Inlet in May, June, and July with peak density occurring in June. Acoustic density estimates were similar at both sites in August (Figure 4). In the Beardslee Entrance transect near Flapjack Island, we often observed dense aggregations of prey as shallow as 11 meters, including small schooling fishes (possibly sandlance and capelin). Acoustic density was greatest between 30-60 meters in the Beardslee Entrance In contrast, there were diffuse layers of fish available in Johns Hopkins Inlet between 60-75 meters and between 250 -320 meters (Figure 5). The

acoustic transects will provide information related to seasonal prey availability and density which is central to understanding the foraging ecology of harbor seals. Data analysis is ongoing and ultimately the locations of harbor seal foraging areas will be integrated with data from the TDRs (dive depth) and hydro-acoustic prey surveys and will provide fine-scale foraging ecology information for harbor seals in Glacier Bay.

ADDITIONAL FIELD ACTIVITIES AND OBSERVATIONS

Harbor Seal Trend Surveys

Aerial photographic surveys were conducted on August 4, 7, and 8, 2005 at 36 sites including all known terrestrial haulout sites and one glacial ice site at McBride Inlet. The largest concentrations of harbor seals at terrestrial sites during August were at Spider Island Reef Complex, Flapjack Island, and Adams Inlet. Harbor seals were also documented at the Wachusetts outwash (~36 seals on Aug 4). The number of harbor seals on glacial ice in McBride Inlet was highly variable with only 13 harbor seals observed on August 5th, ~ 85 seals on August 7th, and ~190-200 seals on August 8, emphasizing the importance of multiple surveys under different conditions (tidal height, time of day, etc). Smaller concentrations (<25 seals) of harbor seals were also observed at Boulder Island, Leland Island, Geikie Inlet, Scidmore Inlet, and Queen Inlet outwash. No seals were seen at Kidney Reef, Hutchins Reef, or upper Muir Inlet during August trend surveys. The harbor seal trend survey data will provide trend data for abundance monitoring of harbor seals in Glacier Bay in relation to other areas in SEAK.

Predation Event By Transient Killer Whales on Tagged Harbor Seal

On June 27, 2005, killer whale researchers, Volker Deecke and Michael de Roos from the University of British Columbia (UBC) observed a possible predation event by transient killer whales on one of our radio-tagged harbor seals ~ 2 nautical miles NW of North Marble Island (58 41.295N, -136 07.665W). The radio-tagged seal was identified by the colors on its VHF-headmount and in digital images taken by the killer whaler researchers (Figure 3). It was identified as an adult male seal that was captured at Spider Island in April 2005. There were 4 transient killer whales, one of which was identified as T085. A humpback whale was also involved in the predation event and is a known whale (#1795) that has been documented in the park and Icy Strait by NPS. The harbor seal had been most recently observed diving in the nearshore area just east of the entrance to Secret Bay during the week of June 13-17, 2005. The UBC researchers were unable to confirm that the seal was actually killed and eaten; however, the researchers observed the killer whales repeatedly hitting the seal with their tail flukes making it unlikely that it survived. After the predation event we arrived on the scene and monitored the VHF frequency of the harbor seal for ~1 hour but did not detect a signal. We have not relocated the harbor seal since the predation event.

Dead harbor seal retrieved from Lester Island on August 2, 2005

On August 2, 2005, a dead juvenile harbor seal was retrieved from the shore of Lester Island (58.45942N, -135.92424W) in Bartlett Cove and frozen for later examination. The harbor seal was freshly dead as evidenced by the lack of decomposition. The

harbor seal was not marked or tagged . The only obvious external injuries were 2 holes along each side of the mid-lateral surface ~ 2.5 cm up from the base of the tail. One hole was approximately 1.1 X 0.8 cm and the larger hole was 2.6 X 1.4 cm. The frozen harbor seal carcass was transported to Juneau and stored in a freezer at University of Alaska Southeast. A marine mammal stranding report was filed with NMFS and NPS. 2 additional dead harbor seals were colleceted in Sitakaday Narrows and Bartlett Cove by NPS staff. On January 18, 2006, a harbor seal necropsy clinic was organized by Aleria Jensen of NOAA-Fisheries Office of Protected Resources and a post-mortem exam was conducted on 2 of the 3 seals by Dr. Kathy Burek (DVM) to determine the cause of death and obtain genetic, toxicology, and physiological samples. Complete necropsy reports will be made available to NPS and NMFS upon completion by Dr. Burek.

Videography with the Ocean Alaska Science and Learning Center and Alaska Sea Life Center

From July 6-9, 2005, Kelly O'Brien, a videographer from the Alaska Sealife Center participated in field activities with the intent of creating an educational video regarding the harbor seal research in Glacier Bay. Kelly is working with Jim Pfeiffenberger, the education coordinator at the Ocean Alaska Science and Learning Center (OASLC), located at Kenai Fiords National Park. The end product will be a video, approximately 5-25 minutes in length aimed at the general lay audience with an interest in wildlife and National Parks. Distribution would include National Park Service visitor centers, Alaska

public television, possibly the closed-circuit TV Systems on cruise lines, and other logical outlets. Segments of the video or narration may also be customized to target specific audiences, such as young elementary students, veterinary students, Park neighbors, fund providers, or other groups that may require a more specialized message. Footage will be supplemented by other filming efforts during the summer of 2006 and possibly the next capture trip in fall. During these visits by Jim, he will also film interviews with park and local staff (including Hoonah natives). Plans are currently being made for timing and duration of video efforts for this field season.

Acknowledgements

Justin Smith (R/V Capelin) provided essential boat and logistical support for the project. Bill Eichenlaub (NPS) provided database and GIS expertise. We thank Tomie Lee, Susan Boudreau, and Lewis Sharman the Glacier Bay Resource Management staff for support of this research. Numerous folks from ADF&G, Alaska Sealife Center, National Marine Mammal Lab, University of Alaska, and University of Wyoming participated in harbor seals captures. Jacques Norvell (Tal Air) was instrumental in providing air support for TDR retrieval and aerial surveys. Monica Becker (VIP) Carol Coyle (VIP), and Kevin White (ADF&G) volunteered during harbor seal tracking trips and provided essential field support. Research described in this permit was carried out under NOAA Fisheries Permit No. 358-1585-07 issued to the Alaska Department of Fish and Game and Glacier Bay National Park and Preserve Permit No. GLBA-2004-SCI-0013.

LITERATURE CITED

Mathews EA (2002) Diet of harbor seals at a glacial fiord and a terrestrial haulout in Glacier Bay 1996-2001. Unpublished report to Glacier Bay National Park. 17 pages.

Mathews EA, Pendleton GW (2006) Decline in harbor seal numbers in Glacier Bay National Park, Alaska 1992-2002. Marine Mammal Science 22: 170-191.

Merrick RL, Chumbley MK, Byrd GV (1997) Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a potential relationship. Can J Zool 54:1342-1348

Pitcher KW (1990) Major decline in the number of harbor seals (*Phoca vitulina*) on Tugidak Island, Gulf of Alaska. Marine Mammal Science 6: 121-134.

Rosen DAS, Trites AJ (2000) Pollock and the decline of Steller sea lions: testing the junk-food hypothesis. Canadian Journal of Zoology 78: 1243-1250.

Sigler MF, Womble JN, Vollenweider JJ (2004) Availability to Steller sea lions (*Eumetopias jubatus*) of a seasonal prey resource: a pre-spawning aggregation of eulachon (*Thaleichthys pacificus*). Canadian Journal of Fisheries and Aquatic Sciences 61: 1475 -1484

Robards M, Drew G, Piatt J, Anson JM, Abookire A, Bodkin J, Hooge P, and Speckman S (2003) Ecology of selected marine communities in Glacier Bay: zooplankton, forage fish, seabirds, and marine mammals. USGS Alaska Science Center, Biological Science Office, 1011 E. Tudor Road, Anchorage, AK 99503.

Small RJ, Pendleton GW, Pitcher KW (2003) Trends in abundance of Alaska harbor seals 1983-2001. Marine Mammal Science 19: 344-362.

Womble JN and Sigler MF (*in press*) Seasonal availability of abundant, energy-rich prey influences the abundance and diet of a marine predator, the Steller sea lion *Eumetopias jubatus.* Marine Ecology Progress Series.

Table 1. Harbor seal capture location, date, sex, and estimate age for each harbor seal fitted with head-mounted VHF transmitter.

Seal ID#	Capture Location	Capture Year	Sex	Est Age	VHF Hdmt	TDR	TDR retreived
PV04GB02	Kidney Reef	2004	F	AD	x	x	x
PV04GB03	Kidney Reef	2004	F	AD	x	x	x
PV04GB04	Kidney Reef	2004	F	AD	x	x	x
PV04GB05	Kidney Reef	2004	F	AD	x	x	
PV04GB06	Kidney Reef	2004	F	SA	x	x	x
PV04GB07	Kidney Reef	2004	F	YR	x	x	x
PV04GB08	Boulder	2004	F	AD	x	x	x
PV04GB10	Boulder	2004	M	AD	x		
PV04GB11	Boulder	2004	F	YR	x	x	x
PV04GB12	Boulder	2004	M	SA	x		
PV04GB13	Geikie Rock	2004	M	AD	x		
PV04GB14	Geikie Rock	2004	F	SA	x	x	x
PV04GB15	Leland Reef	2004	F	SA	x		
PV04GB16	Leland Reef	2004	F	AD	x	x	x
PV04GB27	Kidney Reef	2004	F	AD	x		
PV04GB29	Kidney Reef	2004	M	AD	x		
PV05GB02	Spider Reef	2005	F	YR	x		
PV05GB03	Spider Reef	2005	M	AD	x		
PV05GB05	Spider Reef	2005	M	AD	x		
PV05GB06	Spider Reef	2005	F	AD	x	x	x
PV05GB07	Spider Reef	2005	F	YR	x		
PV05GB10	Spider Reef	2005	F	YR	x		
PV05GB12	Spider Reef	2005	F	AD	x	x	x
PV05GB13	Spider Reef	2005	M	AD	x		
PV05GB14	Spider Reef	2005	M	AD	x	x	
PV05GB15	Spider Reef	2005	M	AD	x	x	x
PV05GB16	Spider Reef	2005	M	AD	x	x	x
PV05GB17	Spider Reef	2005	M	AD	x	x	x
PV05GB21	Johns Hopkins	2005	M	YR	x		
PV05GB22	Johns Hopkins	2005	F	YR	x		
PV05GB23	Johns Hopkins	2005	F	YR	x		
PV05GB24	Johns Hopkins	2005	F	SA	x	x	x
PV05GB25	Johns Hopkins	2005	F	SA	x	x	x
PV05GB26	Johns Hopkins	2005	F	YR	x		
PV05GB29	Johns Hopkins	2005	F	SA	x	x	x
PV05GB30	Johns Hopkins	2005	F	YR	x		
PV05GB31	Johns Hopkins	2005	M	SA	x		
PV05GB32	Johns Hopkins	2005	F	SA	x	x	
PV05GB33	Johns Hopkins	2005	F	YR	x		
PV05GB35	Johns Hopkins	2005	F	SA	x	x	
PV05GB37	Johns Hopkins	2005	F	YR	x		
PV05GB39	Johns Hopkins	2005	F	YR	x		
PV05GB41	Johns Hopkins	2005	M	AD	x		
PV05GB44	Johns Hopkins	2005	F	SA	x		
PV05GB45	Johns Hopkins	2005	F	YR	x		
PV05GB54	Johns Hopkins	2005	F	SA	x		

FIGURES

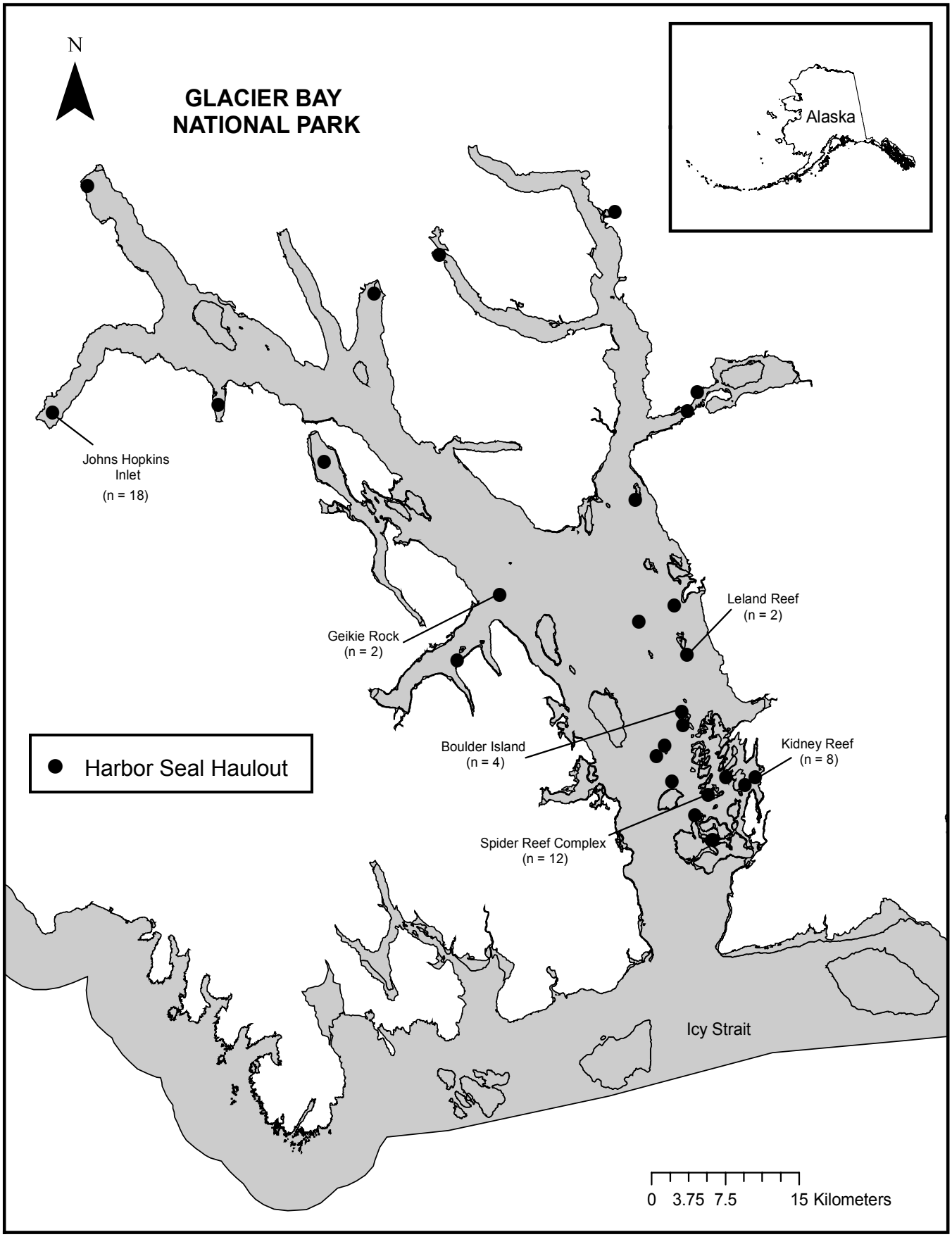

Figure 1. Caputre locations of harbor seals in Glacier Bay that were fitted with head-mounted VHF transmitters.

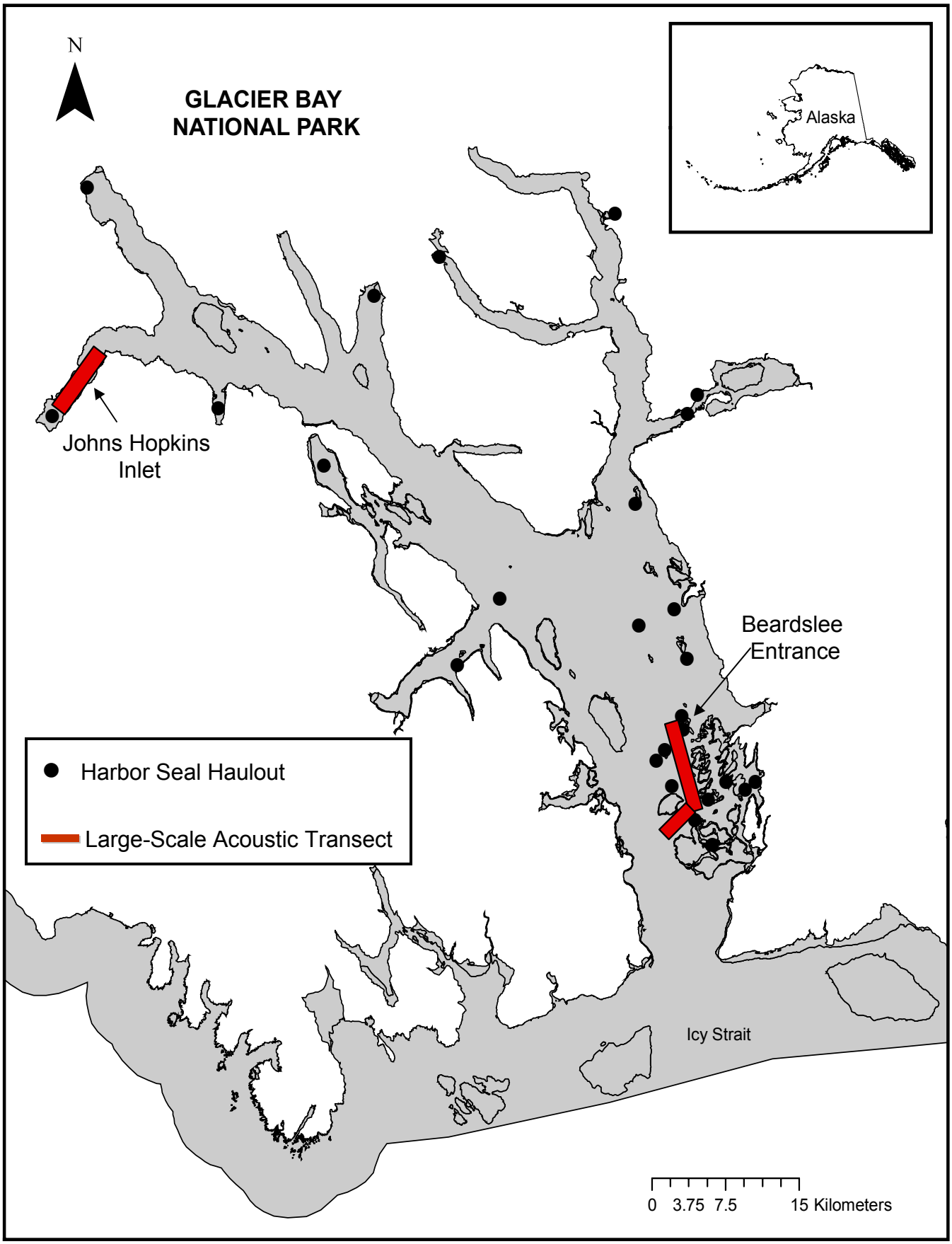

Figure 2. Locations of large-scale acoustic survey areas in Johns Hopkins Inlet and Beardslee Entrance in Glacier Bay National Park

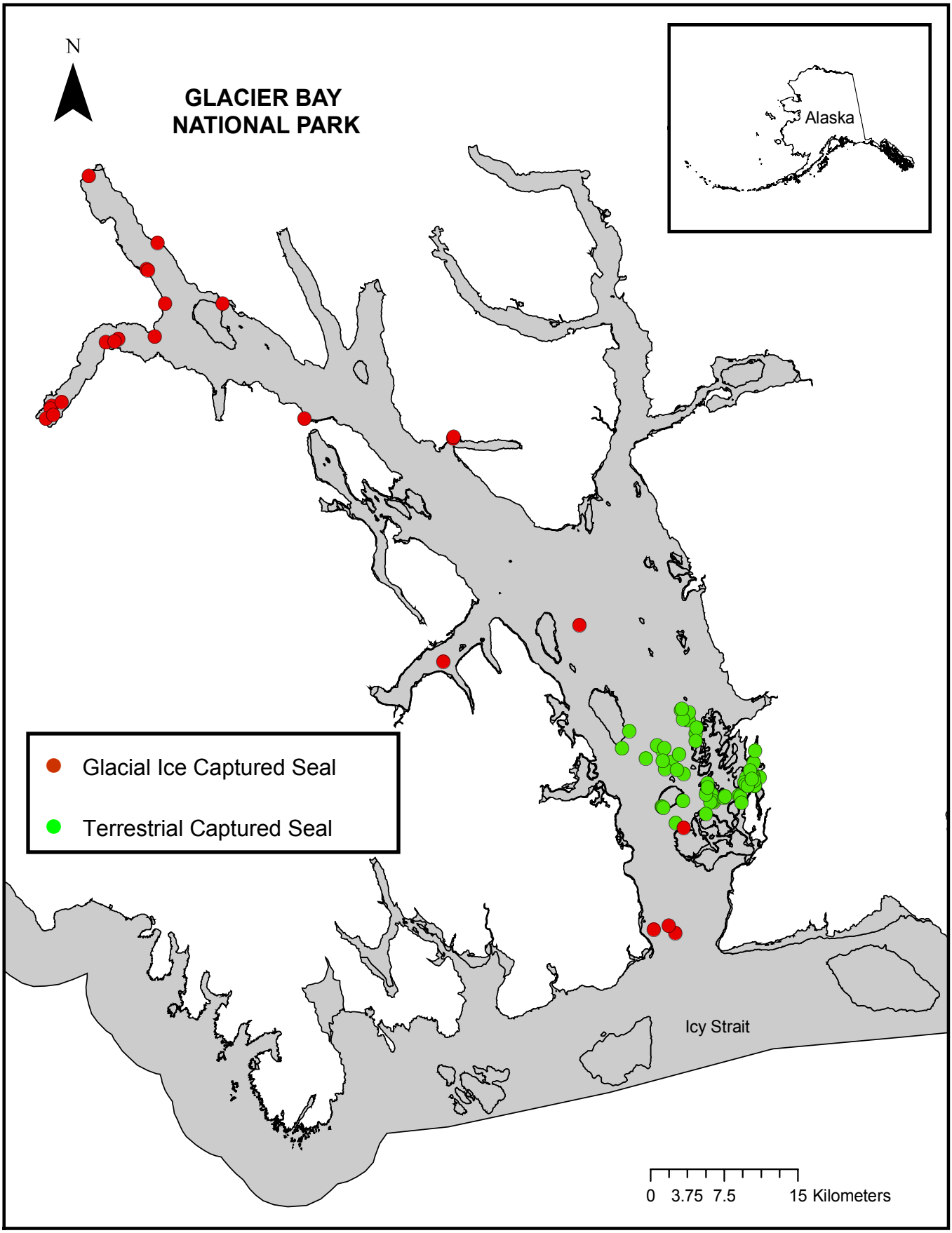

Figure 3. Foraging locations of harbor seals captured at glacial ice and terrestrial haulout sites in 2004 and 2005 (n = 75 observations).

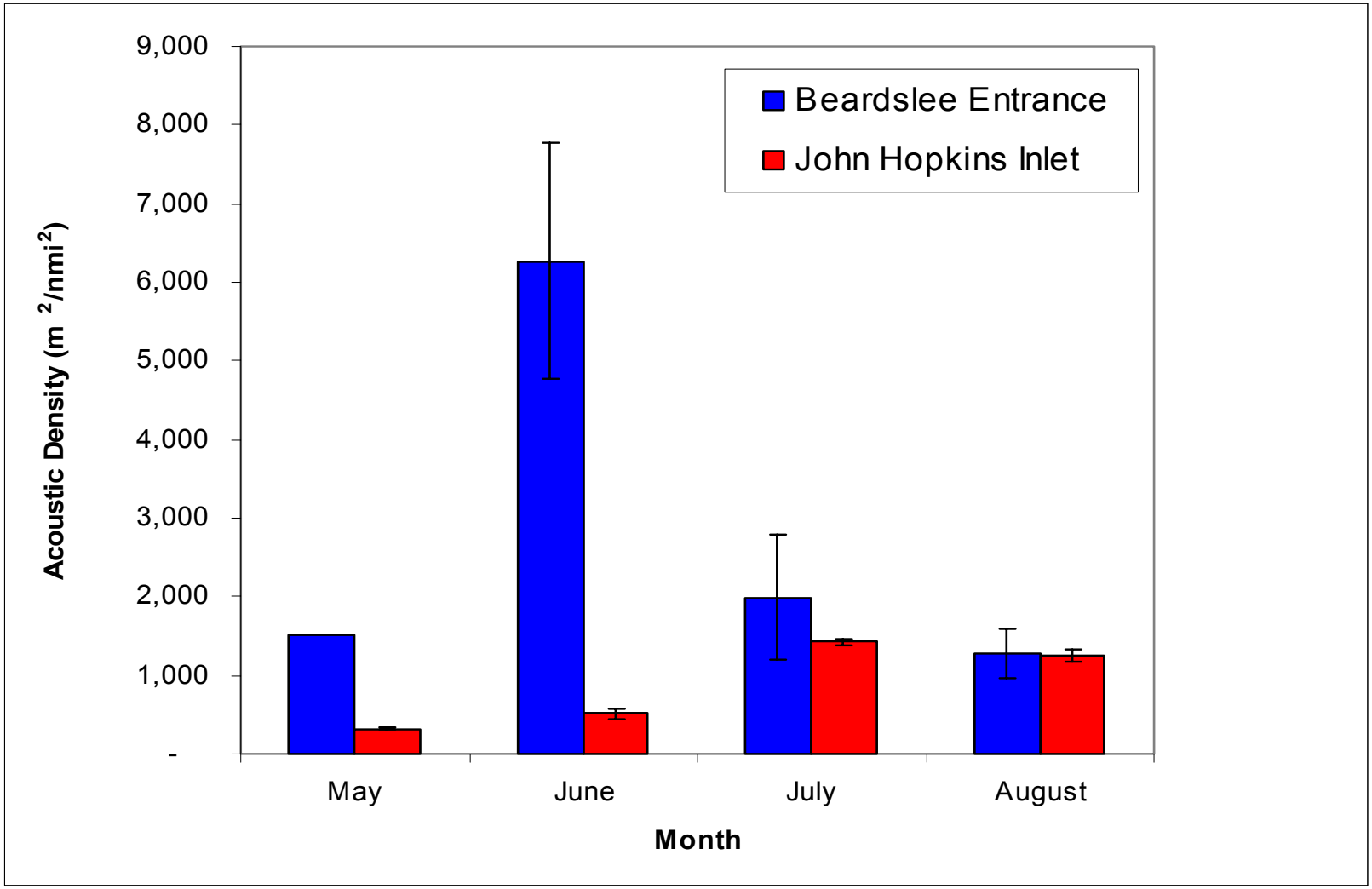

Figure 4. Acoustic density estimates from large-scale acoustic surveys in Beardslee Entrance and Johns Hopkins Inlet, May-August 2005.

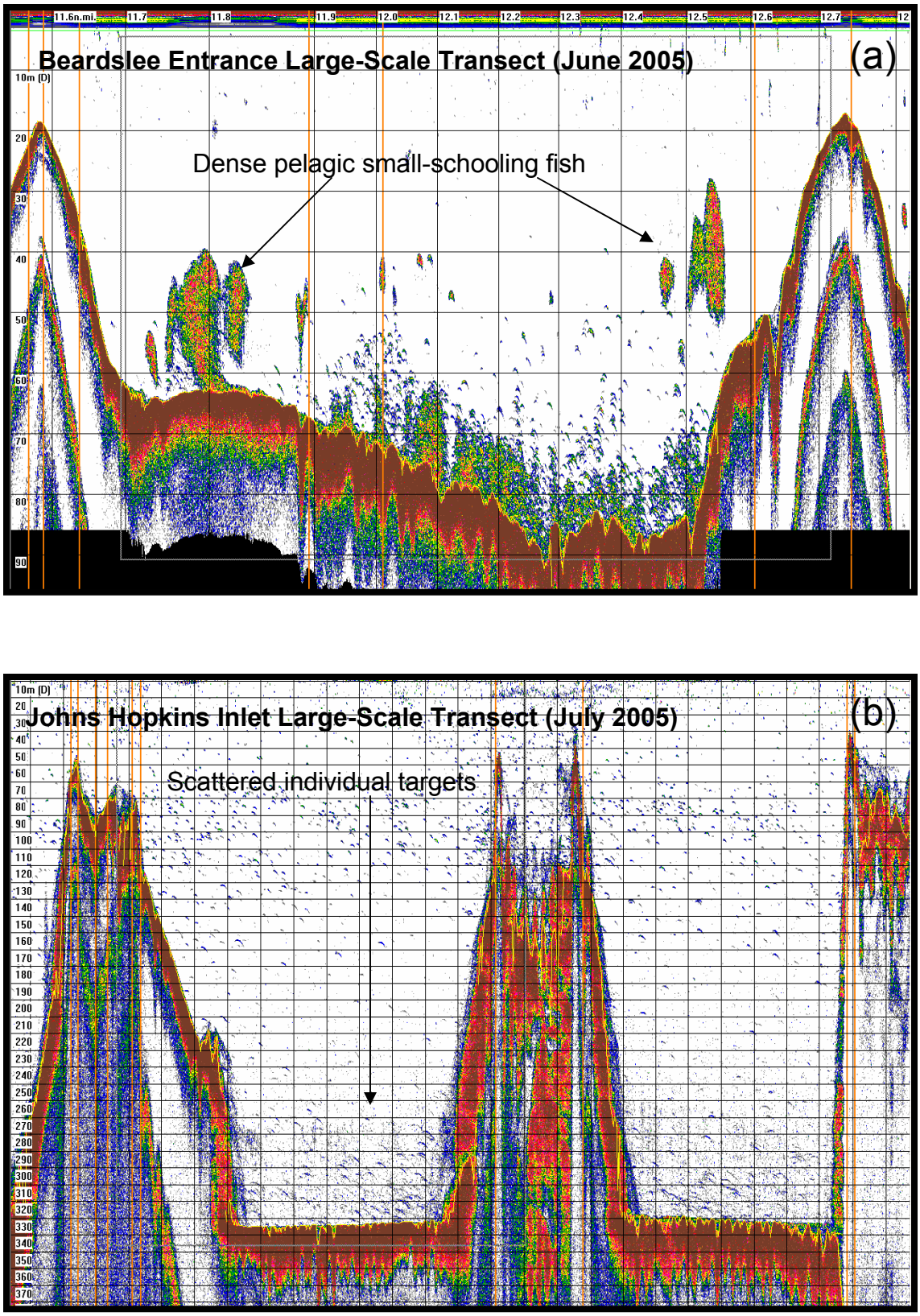

Figure 5. Echograms from large-scale acoustic surveys in (a) Beardslee Entrance and (b) Johns Hopkins Inlet in 2005.