HARBOR SEAL FORAGING ECOLOGY INVESTIGATIONS

IN GLACIER BAY NATIONAL PARK

ANNUAL REPORT 2006

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INTRODUCTION

Glacier Bay has historically supported one of the largest breeding populations of harbor seals in Alaska (Calambokidis et al. 1987, Hoover-Miller 1994). Harbor seals are the most numerous marine mammal in the park but have declined by up to 75% in Glacier Bay since 1992 when monitoring efforts began (Mathews and Pendleton 2006). The magnitude and rate of the decline exceed all reported declines of harbor seals in Alaska, with the exception of that at Tugidak Island (Pitcher 1990). Harbor seals in two other areas in southeastern Alaska (near Sitka and Ketchikan) are stable or increasing (Small et al. 2003), which suggests that the factors contributing to the decline may be specific to Glacier Bay or surrounding area.

Harbor seals are an upper trophic level predator and thus function as an important indicator of the health of Glacier Bay's marine ecosystem. However, little is known with respect to their life history, foraging ecology, movements, vital rates, body condition, health status, and behavior in Glacier Bay. Given that so little is known it is difficult to discern specific causal factors that may have contributed to the decline or inhibiting a recovery. Hypothesized reasons for the decline include interspecific competition, predation, emigration, decreases in reproductive rate, human disturbance, and nutritional stress due to changes in prey base, disease, or contaminants.

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 related to 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 is the first study of this nature to investigate harbor seal foraging ecology in a glacial fiord. This report summarizes the 2006 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 using multifilament stretch nylon nets at terrestrial sites and monofilament nets in ice habitats. In April of 2006, 24 harbor seals were captured and fitted with VHF headmounts for total of 70 harbor seals captured and fitted with VHF headmounts from 2004-2006 (Table 1). Of the 24 fitted with headmount transmitters, 14 were captured in Johns Hopkins Inlet (9 males, 5 females) and 10 from the Beardslee Islands (5 males, 5 females). A subset (n = 10) of these seals were also fitted with archival Time-Depth Recorders (TDRs)(MK 9, Wildlife Computers) to assess dive behavior. TDRs were programmed to record depth, time, temperature, and light every 2 seconds. The resolution of the TDRs was 0.5 m with accuracy of ± 1 m. TDRs were shed during the annual molt and retrieved by boat, kayak, and floatplane. All of the TDRs were successfully retrieved in 2006 (n = 10) for a total of twenty-seven retrieved since this study begin in 2004.

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), 2005 (n = 29 days), and 2006 (n= 35 days). To detect and track harbor seals at sea individual radio frequencies were scanned continuously during vessel surveys or the vessel approached within VHF range of the nearest haulout site. When the radio signal was detected we attempted to visually locate the seal on the surface of the water. Because saltwater occludes VHF signals, we were able to monitor pauses in the VHF signal to determine the dive/surface intervals of individual seals. The date, time, and location (latitude and longitude)

were recorded using a global positioning system (GPS). Seals were followed for at least 1 hour to ascertain whether or not they were foraging. In addition to collecting data on the focal seal, data were also collected on the presence of other seals, marine mammals, and foraging seabirds in the areas. All data were entered into an ACCESS database.

Assessment of Prey Availability

In 2005, we initiated a pilot study intended to asses prey availability 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 to determine seasonal availability of pelagic prey in those areas given their proximity to harbor seal haulout sites. Systematic acoustic surveys were conducted at each site from May through August. Fine-scale acoustic surveys 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 Simrad 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 Sonar Data Echoview (Womble and Sigler 2006, Sigler et al. 2004).

RESULTS AND DISCUSSION

Foraging Areas of Harbor Seals

69 of 70 (98.6%) harbor seals with head-mounted VHF transmitters were relocated between 2004 -2006. A total of 816 VHF relocations were obtained in 2004 (n = 271), 2005 (n = 352), and 2006 (n = 193). A total of thirty two focal animal observations were collected during 2006 (n = 14 for ice captured seals, n = 18 for terrestrially captured seals). A subset of those observations (n = 13) also included fine-scale information obtained from acoustic prey transects

in the areas where the tagged harbor seals were foraging. Between 2004 and 2006 we conducted a total of 110 focal animal observations with 32 of those including fine-scale information on prey availability.

Preliminary analyses of these data suggest that harbor seals tend to remain within GLBA (generally within 100 km of capture site) during the breeding season, with some occasional forays into adjacent Icy Strait (Figure 1). Periodic acoustic surveys for fish biomass suggest that seals are foraging in these areas as a result of higher prey densities, or possibly to minimize exposure to killer whales, rather than due to displacement from vessel traffic.

Harbor seals captured in Johns Hopkins Inlet traveled farther to foraging areas from capture sites than did seals captured at terrestrial sites in the Beardslee Islands (Figure 1). In some cases, seals traveled over 100 km from JHI to Sitakaday Narrows and Icy Strait to forage. Although several of the traveled outside of Johns Hopkins Inlet to forage, others were seen foraging near the face of Johns Hopkins, Gilman, Margerie, and Grand Pacific Glaciers. Furthermore, 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, an adult male (PV05GB16) captured at Spider Island Reef Complex repeatedly foraged just south of Spider Island, and an adult male captured at Kidney Reef (PV06GB20) was found repeatedly diving on several occasions on the south end of Strawberry Island (Figures 2 and 3). In addition, we observed one seal (PV05GB25) which appeared to follow a tidal front through Russell Passage (Figure 4). Acoustic surveys in Russell Passage during the focal animal observation revealed several dense aggregations of fish at depths of 20-50 meters.

Ultimately, the locations of harbor seal foraging areas will be integrated with data from the TDRs (dive depth) (Figure 3) and acoustic prey surveys and will provide fine-scale foraging ecology information for harbor seals in Glacier Bay. Movement and foraging data will continued to be analyzed this winter to determine whether seal foraging habitat (as identified by behavior during tracking and dive profiles from recovered TDR's) overlaps spatially and temporally with areas heavily utilized by vessel traffic, including cruise ships. Focal animal foraging observations will also be coupled with dive data and acoustic estimation of prey densities

to determine the dive frequency at particular depths relative to the proportion of prey at particular depths.

Prey Availability

Data analysis of large-scale acoustic surveys is currently ongoing. In both 2005 and 2006, along the Beardslee Entrance transect near Flapjack Island, we often observed dense aggregations of prey, including small schooling fishes (possibly sandlance and capelin) (Figure 5). Acoustic density was greatest between 30-60 meters in the Beardslee Entrance. In 2005 in the Beardslee Entrance, peak acoustic densities resulting from dense aggregations of small-schooling fish occurred during June; however, observations from 2006 suggest that dense aggregations of small-schooling fish arrived 3-4 weeks later than in 2005. In both years, the presence of dense aggregations of small-schooling fish, particularly near Flapjack Island, was accompanied by an increase in the number of harbor seals hauled at Flapjack as well as increased foraging activity by Steller sea lions, humpback whales, and seabirds in the vicinity. In Johns Hopkins Inlet in both 2005 and 2006, there were diffuse layers of prey available between 60-75 meters and between 250-320 meters. The acoustic transects will provide information related to seasonal prey availability and density which is central to understanding the foraging ecology of harbor seals.

ADDITIONAL FIELD ACTIVITIES AND OBSERVATIONS

We observed a Steller sea lion predation event on a juvenile harbor seal in Johns Hopkins Inlet in April 2006 (Figure 6). There have been several similar observations of this interspecific predatory behavior in Glacier Bay National Park over the last decade and we are currently in the process of compiling previous predation events for publication. In addition, a manuscript was recently published in Marine Mammal Science (Womble, J.N., Gende, S.M., and G. Blundell: Dive behavior of a harbor seal in the presence of transient killer whales in Glacier Bay National Park) describing the dive behavior of a harbor seal fitted with a Time Depth Recorder and VHF headmount during an attempted predation event by transient killer whales in Glacier Bay. Data from this project were presented in FY06 by Jamie Womble, Scott Gende, Gail Blundell, and various graduate students during separate oral presentations at the 16th Biennial

Conference on the Biology of Marine Mammals in December 2005 in San Diego and at the Wildlife Society 13th Annual Conference in Anchorage in September 2006. In addition, Jamie and Scott presented a synopsis of harbor seal research project in Glacier Bay to the NPS interpretive staff in April to the Alaska Discovery Kayak Guides in May. A presentation was also made by Gail Blundell to the Alaska Native Harbor Seal Commission.

The harbor seal project hosted several visitors and volunteers during the 2006 field season Glacier Bay. During June, Julia Burrows, a graduate student from Moss Landing Marine Laboratory in California, served as a volunteer on the harbor seal project. Julia assisted in all aspects of data collection and was trained in techniques that we are currently using to study harbor seals in Glacier Bay including VHF telemetry and hydro acoustic surveys. In 2007, Julia will begin a vessel disturbance study of harbor seals in Glacier Bay under the supervision of Dr. Jim Harvey, professor of vertebrate ecology at Moss Landing Marine Laboratory at San Jose State University in California.

Dr. Jim Harvey also spent a week in June working with Jamie and Julia on the harbor seal foraging ecology project. During his visit, Dr. Harvey visited potential study sites for upcoming vessel disturbance study that will begin in 2007. Dr. Harvey has extensive research experience with harbor seals in the North Pacific and will provide guidance and graduate supervision to Julia Burrows. During his visit, Dr. Harvey delivered an evening presentation at the Glacier Bay Lodge for NPS staff and visitors. Dr. Harvey's presentation highlighted several aspects of his of harbor seal research in the North Pacific.

In July, Aleria Jensen, Alaska Marine Mammal Stranding Coordinator/Harbor Seal Co-Management Coordinator of the Protected Resources Division of NOAA Fisheries joined the harbor seal project to learn about ongoing harbor seal research in Glacier Bay as it relates to regional management concerns. The Glacier Bay harbor seal project works closely with Ms. Jensen with regards to marine mammal strandings that occur in Glacier Bay. In addition, movement (both VHF and satellite) and genetics data are being used by NOAA Fisheries and the Alaska Native Harbor Seal Commission in efforts to delineate harbor seal stock boundaries in Alaska.

We continued our efforts with Jim Pfeiffenberger, the education coordinator at the Ocean Alaska Science and Learning Center, to produce a video regarding harbor seal research in Glacier Bay. Visits were made to Glacier Bay in 2005 and 2006 to gather footage of harbor seal field research and to conduct interviews with NPS staff. The end product will be a video, 5-25 minutes in length aimed at the general lay audience with an interest in wildlife and National Parks. Distribution would include the NPS visitor center, Alaska Public television, and close circuit TV on cruise ships (among others).

Acknowledgements

Justin Smith (R/V *Capelin*) provided essential boat and logistical support for the project. We thank Lewis Sharman, Susan Boudreau, and Tomie Lee and the Glacier Bay Resource Management staff for support of this research. Mike Sigler and Dave Csepp (NOAA Fisheries-Alaska Fisheries Science Center) provided expertise and assistance with hydro acoustic surveys. Jacques Norvell (Tal Air) was instrumental in providing air support for TDR retrieval and aerial surveys. Numerous folks from ADF&G, Alaska Sealife Center, National Marine Mammal Lab, University of Alaska, and University of Wyoming participated in harbor seal captures. Monika Becker, Julia Burrows, Phoebe Vanselow, Carol Coyle, and Kevin White volunteered during harbor seal tracking trips and provided essential field support. Research described in this permit was carried out under NOAA Fisheries Permit No. 358-1787-00 issued to the Alaska Department of Fish and Game and Glacier Bay National Park and Preserve Permit No. GLBA-2006-SCI-0003.

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Table 1. Capture location, year, sex, estimated age, mass for each harbor seal fitted with head mounted VHF transmitter and Time Depth Recorder (TDR).

Seal ID#	Capture Year	Capture Location	Sex	Est Age	Mass (kg)	VHF Headmount	TDR	TDR Retrieved
PV04GB02	2004	Kidney Reef	F	AD	81.3	x	x	x
PV04GB03	2004	Kidney Reef	F	AD	85.7	x	x	x
PV04GB04	2004	Kidney Reef	F	AD	53.5	x	x	x
PV04GB05	2004	Kidney Reef	F	AD	102.6	x	x	
PV04GB06	2004	Kidney Reef	F	SA	45.1	x	x	x
PV04GB07	2004	Kidney Reef	F	YR	29.3	x	x	x
PV04GB08	2004	Boulder	F	AD	108.4	x	x	x
PV04GB10	2004	Boulder	M	AD	118.0	x		
PV04GB11	2004	Boulder	F	YR	33.2	x	x	x
PV04GB12	2004	Boulder	M	SA	74.9	x		
PV04GB13	2004	Geikie Rock	M	AD	101.0	x		
PV04GB14	2004	Geikie Rock	F	SA	71.3	x	x	x
PV04GB15	2004	Leland Reef	F	SA	57.9	x		
PV04GB16	2004	Leland Reef	F	AD	99.2	x	x	x
PV04GB27	2004	Kidney Reef	F	AD	69.1	x		
PV04GB29	2004	Kidney Reef	M	AD	87.1	x		
PV05GB02	2005	Spider Reef	F	YR	26.8	x		
PV05GB03	2005	Spider Reef	M	AD	105.1	x		
PV05GB05	2005	Spider Reef	M	AD	88.0	x		
PV05GB06	2005	Spider Reef	F	AD	96.7	x	x	x
PV05GB07	2005	Spider Reef	F	YR	38.7	x		
PV05GB10	2005	Spider Reef	F	YR	24.0	x		
PV05GB12	2005	Spider Reef	F	AD	55.6	x	x	x
PV05GB13	2005	Spider Reef	M	AD	98.2	x		
PV05GB14	2005	Spider Reef	M	AD	95.6	x	x	
PV05GB15	2005	Spider Reef	M	AD	108.6	x	x	x
PV05GB16	2005	Spider Reef	M	AD	93.6	x	x	x
PV05GB17	2005	Spider Reef	M	AD	82.6	x	x	x
PV05GB21	2005	Johns Hopkins	M	YR	32.0	x		
PV05GB22	2005	Johns Hopkins	F	YR	26.0	x		
PV05GB23	2005	Johns Hopkins	F	YR	31.0	x		
PV05GB24	2005	Johns Hopkins	F	SA	41.0	x	x	x
PV05GB25	2005	Johns Hopkins	F	SA	39.0	x	x	x
PV05GB26	2005	Johns Hopkins	F	YR	25.0	x		
PV05GB29	2005	Johns Hopkins	F	SA	35.0	x	x	x
PV05GB30	2005	Johns Hopkins	F	YR	30.0	x		
PV05GB31	2005	Johns Hopkins	M	SA	66.9	x		
PV05GB32	2005	Johns Hopkins	F	SA	44.9	x	x	
PV05GB33	2005	Johns Hopkins	F	YR	34.5	x		
PV05GB35	2005	Johns Hopkins	F	SA	37.3	x	x	

Seal ID#	Capture Year	Capture Location	Sex	Est Age	Mass (kg)	VHF Headmount	TDR	TDR Retrieved
PV05GB37	2005	Johns Hopkins	F	YR	27.3	x		
PV05GB39	2005	Johns Hopkins	F	YR	26.3	x		
PV05GB41	2005	Johns Hopkins	M	AD	83.6	x		
PV05GB44	2005	Johns Hopkins	F	SA	35.2	x		
PV05GB45	2005	Johns Hopkins	F	YR	36.5	x		
PV05GB54	2005	Johns Hopkins	F	SA	44.6	x		
PV06GB01	2006	Johns Hopkins	M	YR	37.8	x		
PV06GB02	2006	Johns Hopkins	M	YR	27.7	x		
PV06GB04	2006	Johns Hopkins	M	SA	43.8	x		
PV06GB05	2006	Johns Hopkins	F	YR	29.8	x	x	x
PV06GB08	2006	Johns Hopkins	M	AD	69.1	x		
PV06GB09	2006	Johns Hopkins	M	AD	52.3	x		
PV06GB10	2006	Johns Hopkins	M	SA	47.6	x		
PV06GB11	2006	Johns Hopkins	F	SA	34.9	x	x	x
PV06GB13	2006	Johns Hopkins	F	AD	83.8	x	x	x
PV06GB14	2006	Johns Hopkins	F	AD	106.0	x	x	x
PV06GB15	2006	Johns Hopkins	M	AD	96.5	x		
PV06GB16	2006	Johns Hopkins	M	SA	57.6	x		
PV06GB18	2006	Johns Hopkins	F	SA	47.3	x	x	x
PV06GB19	2006	Johns Hopkins	M	SA	50.4	x		
PV06GB20	2006	Kidney Reef	M	AD	80.0	x	x	x
PV06GB21	2006	Kidney Reef	M	SA	42.3	x		
PV06GB22	2006	Kidney Reef	M	YR	27.6	x		
PV06GB23	2006	Kidney Reef	F	AD	98.7	x	x	x
PV06GB24	2006	Kidney Reef	F	SA	50.3	x	x	x
PV06GB25	2006	Kidney Reef	F	YR	32.8	x	x	x
PV06GB26	2006	Spider (2)	M	SA	62.3	x		
PV06GB27	2006	Kidney Reef	F	YR	29.6	x		
PV06GB28	2006	Spider (2)	M	AD	89.3	x	x	x
PV06GB29	2006	Kidney Reef	F	YR	30.6	x		

FIGURES

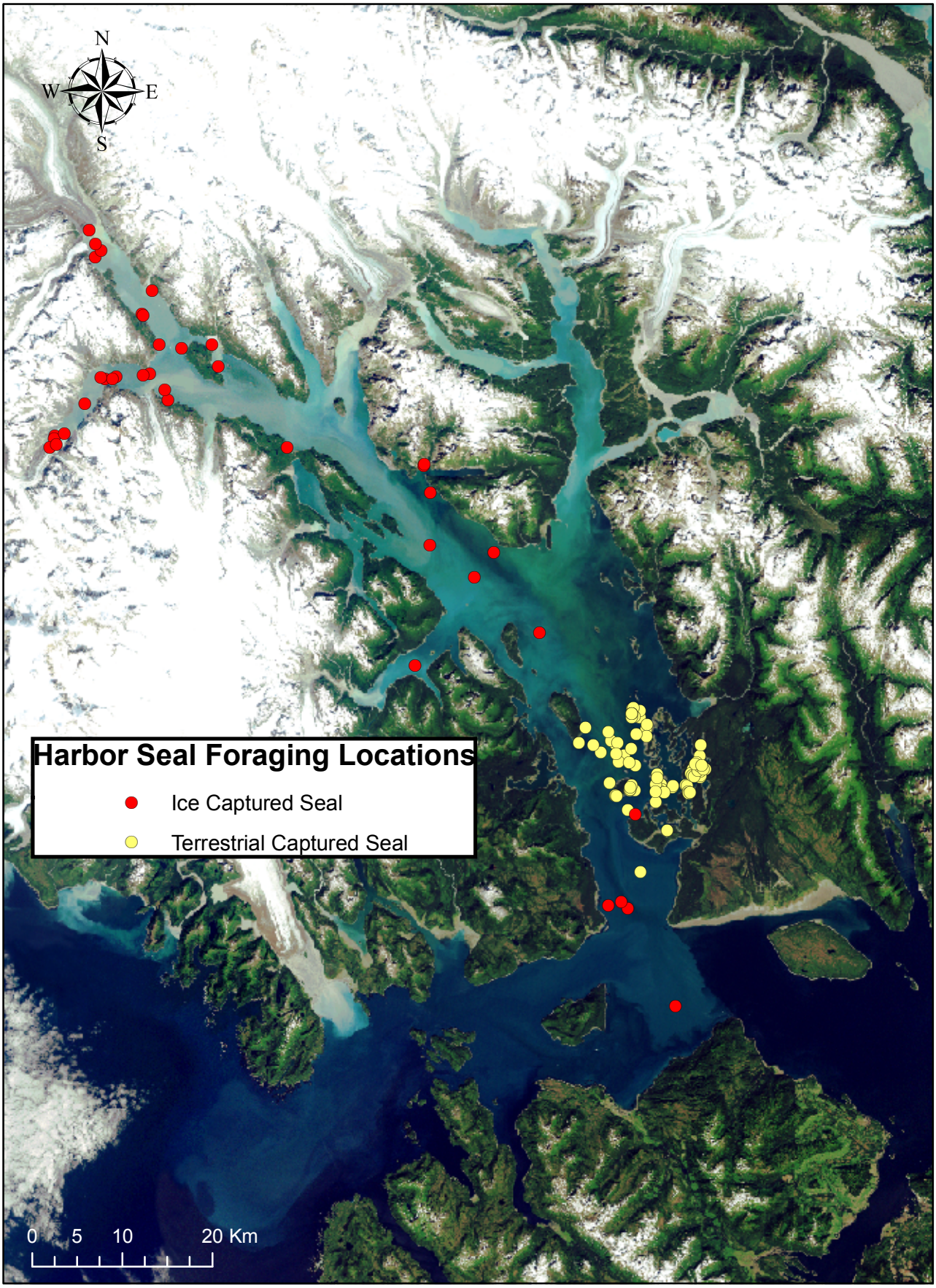

Figure 1. Foraging locations of harbor seals (May-August) captured at glacial ice and terrestrial sites from 2004-2006.

Figure 2. Focal animal observation and acoustic transect from seal # PV06GB20 on August 9, 2006 at south Strawberry Island.

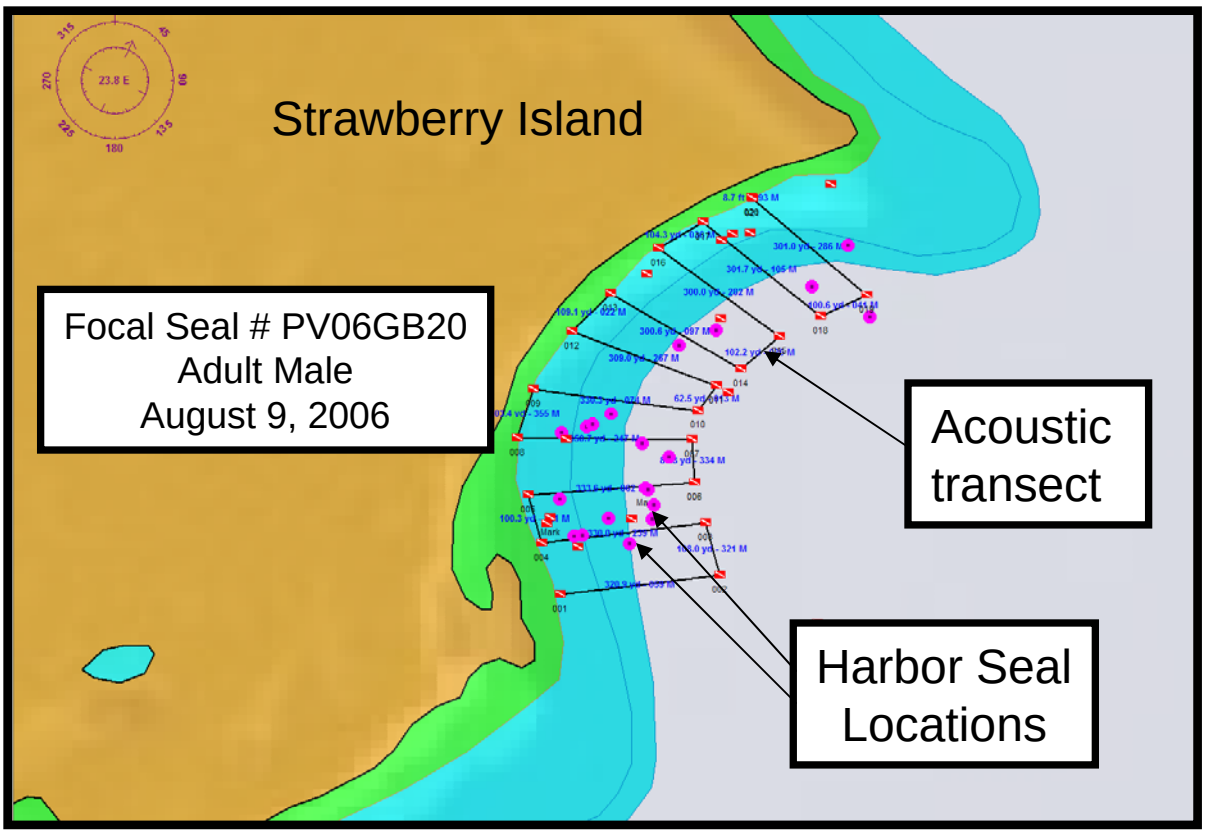

Figure 3. Dive profile of seal # PV06GB20 from Time-depth recorder (TDR) on August 9, 2006 at south Strawberry Island.

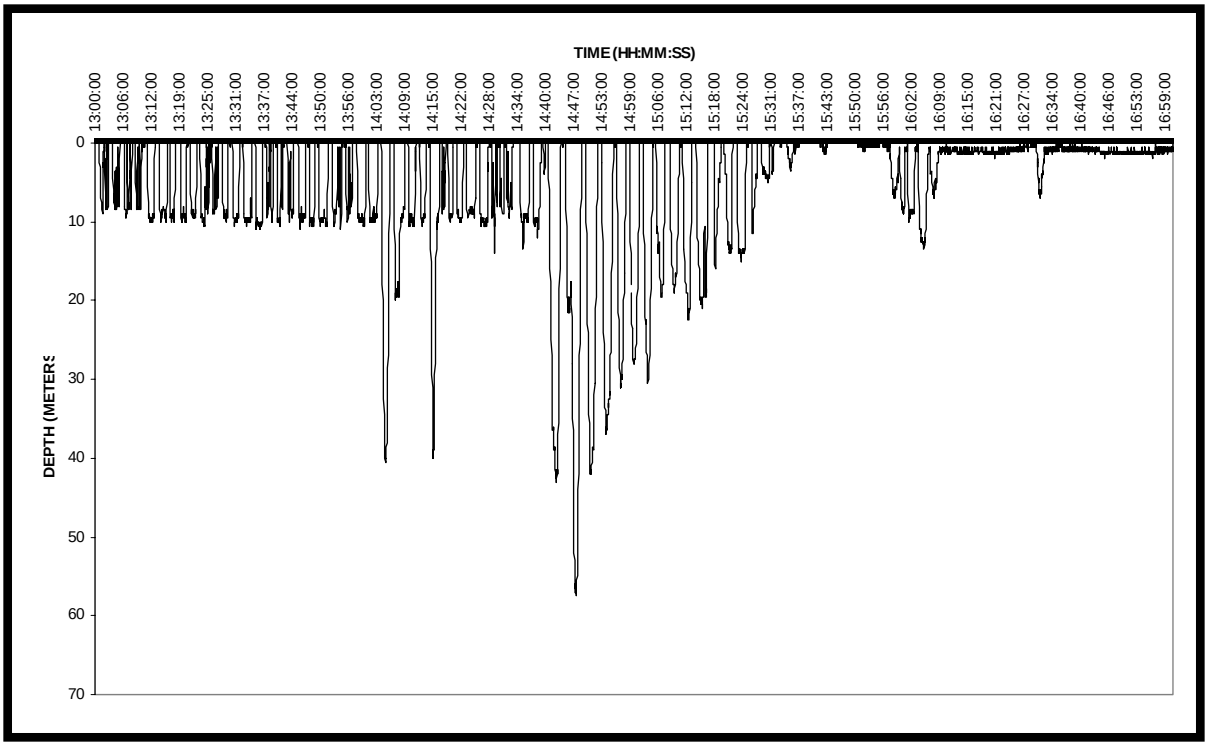

Figure 4. Focal animal observation and acoustic transect from seal # PV05GB25 on July 8, 2005 in Russell Passage.

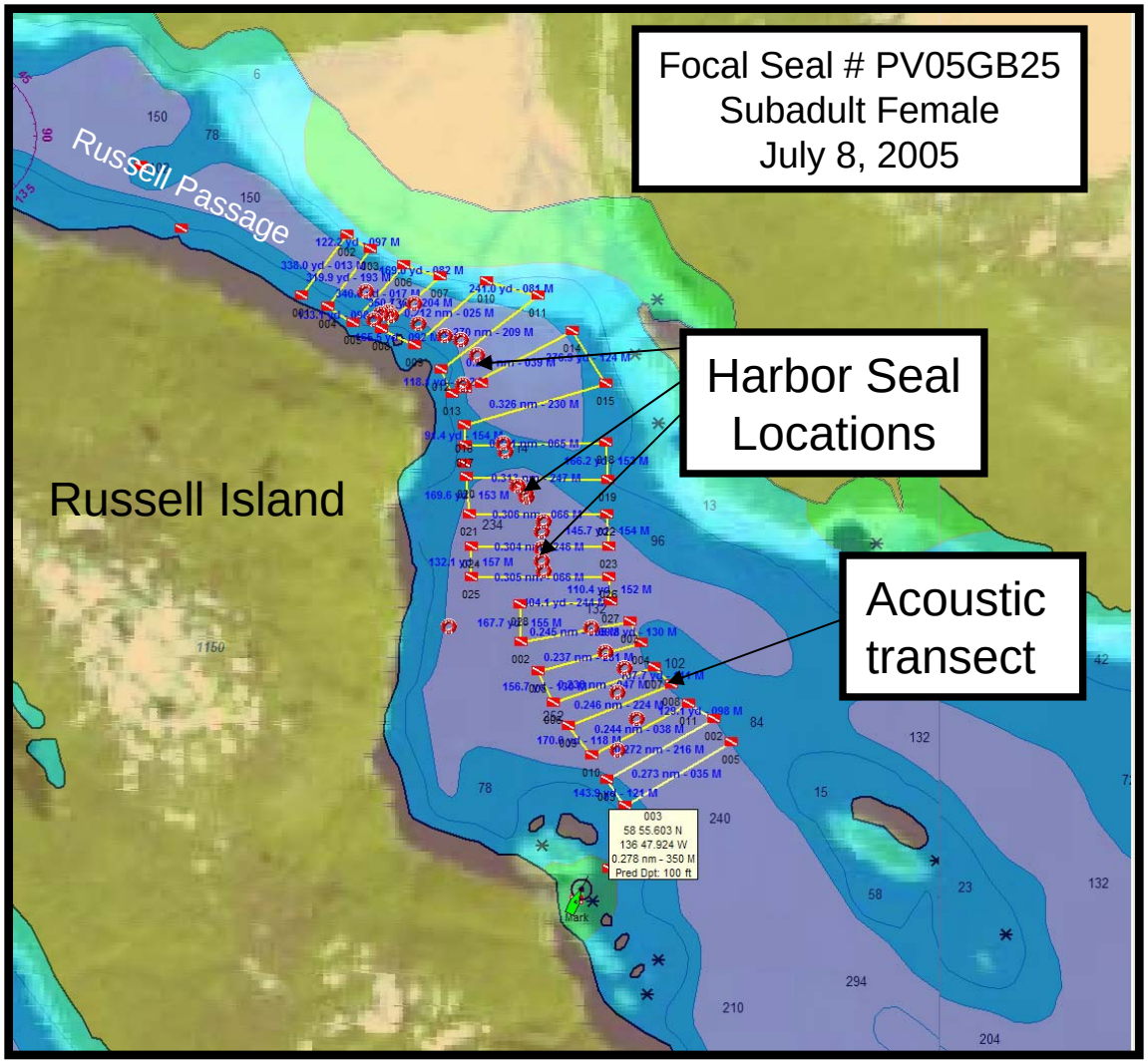

Figure 5. Fish school adjacent to harbor seal haulout site on the southern end of Flapjack Island on August 2, 2006.

Figure 6. Steller sea lion predation event on a juvenile harbor seal in Johns Hopkins Inlet in April 2006.