Pages 33-56 *in* Small, R.J. (ed.). 1997. Harbor Seal Investigations in Alaska, Annual Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, 333 Raspberry Road, Anchorage, Alaska 99518

ABUNDANCE AND DISTRIBUTION OF HARBOR SEALS FROM ICY BAY TO ICY STRAIT, SOUTHEAST ALASKA DURING AUGUST 1996, WITH RECOMMENDATIONS FOR A POPULATION TREND ROUTE

Elizabeth A. Mathews[1,2] and Jamie N. Womble[3]

[1]Glacier Bay National Park, Resource Management Division
P.O. Box 140, Gustavus, Alaska 99826

[2]University of Alaska Southeast, Biology Department, ELAS
11120 Glacier Highway, Juneau, Alaska 99801

[3]P.O. Box 211382, Auke Bay, AK 99821

INTRODUCTION

Harbor seal *(Phoca vitulina richardsi)* numbers on Tugidak Island in the Gulf of Alaska declined by as much as 86% between the mid-1970s and the late 1980s (Hoover-Miller 1994, Pitcher 1990). Declines in harbor seal numbers have also been reported in Prince William Sound (Frost *et al.* 1995), in Bristol Bay, and along the Alaskan Peninsula (Withrow and Loughlin 1996). In contrast, harbor seal numbers in Southeast Alaska appear to be stable, or possibly increasing (Mathews 1995, Lewis *et al.* 1996). The causes of declines in harbor seal, as well as Steller sea lion *(Eumetopias jubatus)* and sea bird, populations are not fully understood, although they appear to involve changes in prey distribution, abundance, or age class structure (Loughlin and Merrick 1988; Merrick 1995, Springer 1993). Trends in numbers of harbor seals in Southeast Alaska are of interest both for their comparative value, as well as to ensure that a significant change in abundance can be detected early, should one occur.

In 1995, a multi-agency meeting sponsored by the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) was held in Fairbanks to discuss the status of, and monitoring methods for, harbor seals in Alaska (Small 1995). A primary goal of the meeting was to evaluate and standardize monitoring methods to ensure that appropriate and comparable data are collected across regions, years, and investigators. A topic of discussion at the meeting was whether or not additional aerial survey routes for estimating trends in harbor seal abundance should be established. Currently, four areas in Southeast Alaska have been surveyed regularly enough to be considered as trend routes (Table 1). These include three aerial survey routes of terrestrial haulouts near Ketchikan and Sitka and in Glacier Bay, and a fourth site in Johns Hopkins Inlet (a tidewater glacial fjord in Glacier Bay) where seals haul out on glacial ice. If trends in seal abundance from annual surveys of a subset of selected areas are closely correlated with trends in abundance throughout a region, they can be used to reduce the frequency (and cost) of region-wide surveys.

The 800 km or so of coastline from Icy Bay in the northeast Gulf of Alaska to Icy Strait in Southeast Alaska (Figure 1) is of particular interest as a potential trend route, not only because it is adjacent to the eastern edge of the region where declines have been documented (Pitcher 1990), but also because it includes several large tidewater glacial fjords (i.e., Icy and Disenchantment bays), productive river drainages (i.e., the Alsek and Dangerous rivers), and protected bays (i.e., Lituya Bay), as well as long stretches of exposed coastline. Although drifting icebergs from active tidewater glaciers appear to be preferred habitat during pupping and molting (Calambokidis *et al.* 1987, Mathews 1995), Johns Hopkins Inlet is currently the only tidewater glacier system where seal abundance has been regularly monitored in Alaska (Table 1). The inclusion of other glacially driven systems, such as Icy and Disenchantment bays, in a trend route should be considered in light of their use by large aggregations of seals. Changes in the trend in numbers of seals observed in the northeast Gulf might also provide an early indicator if the decline begins to move eastward.

Table 1. Areas in Southeast Alaska which have been surveyed for harbor seals during the late summer molt and which may be useful for monitoring trends in abundance. Shaded boxes represent years when a survey was flown, and the letters within the boxes correspond to the principal investigators' initials (see references below).

	Haulout Substrates		**Survey Years**																		
Area	terrestrial	glacial ice	75	76	77	78	...	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1) Ketchikan	yes							[illegible]	[illegible]				[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
2) Sitka	yes							[illegible]	[illegible]									[illegible]		[illegible]	[illegible]
3) Johns Hopkins In		yes	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4) Glacier Bay (excl. JHI)	yes																[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5) Icy Bay to Icy St	yes	yes																[illegible]			[illegible]

References
1) Calkins & Pitcher 1984 (CP); Pitcher 1986 (P1); Pitcher 1989 (P2); Loughlin 1994 (Lo);
2) Lewis 1996 (Le)
2) Calkins & Pitcher 1984; Pitcher 1986; Loughlin 1994; Lewis 1996
3) Streveler 1979 (S); Calambokidis *et al.* 1987 (C); Loughlin 1994; Mathews 1995 (M), 1996 & 1997
4) Mathews 1995 & Mathews & Pendleton 1997
5) Loughlin 1994; Mathews & Womble 1997 (MW)

The first region-wide aerial survey for harbor seals in Southeast Alaska, including Icy Bay to Icy Strait, was conducted in 1993 by the NMFS, National Marine Mammal Lab (NMML) (Loughlin 1994a). This survey was part of a large effort to obtain minimum population estimates for harbor seals throughout Alaska. Our August 1996 survey covered one of the seven areas included in the NMFS 1993 survey (Figure 1). The NMML surveys have been flown, or are scheduled to occur, every three to four years in each of four regions in the state (Withrow and Loughlin 1996). A second survey of Southeast Alaska occurred in 1997.

On six days in August 1996 we conducted aerial surveys of all or portions of the coast between Icy Bay and Icy Strait, south of Glacier Bay. The objectives of this aerial photographic survey were: 1) to establish a minimum population estimate (MPE) for the area, 2) to determine if all or a portion of the Icy Bay to Icy Strait route flown by the NMML in 1993 (Loughlin 1994a) might be a practical, trend route for monitoring seals at haulouts, and 3) to compare the distribution and abundance of seals from this August survey to that from the earlier survey of the same area in September 1993. In this report we present the results of the 1996 survey and compare the distribution of seals to that observed in September 1993. We also provide recommendations for a specific trend route within the study area.

METHODS

Study Area

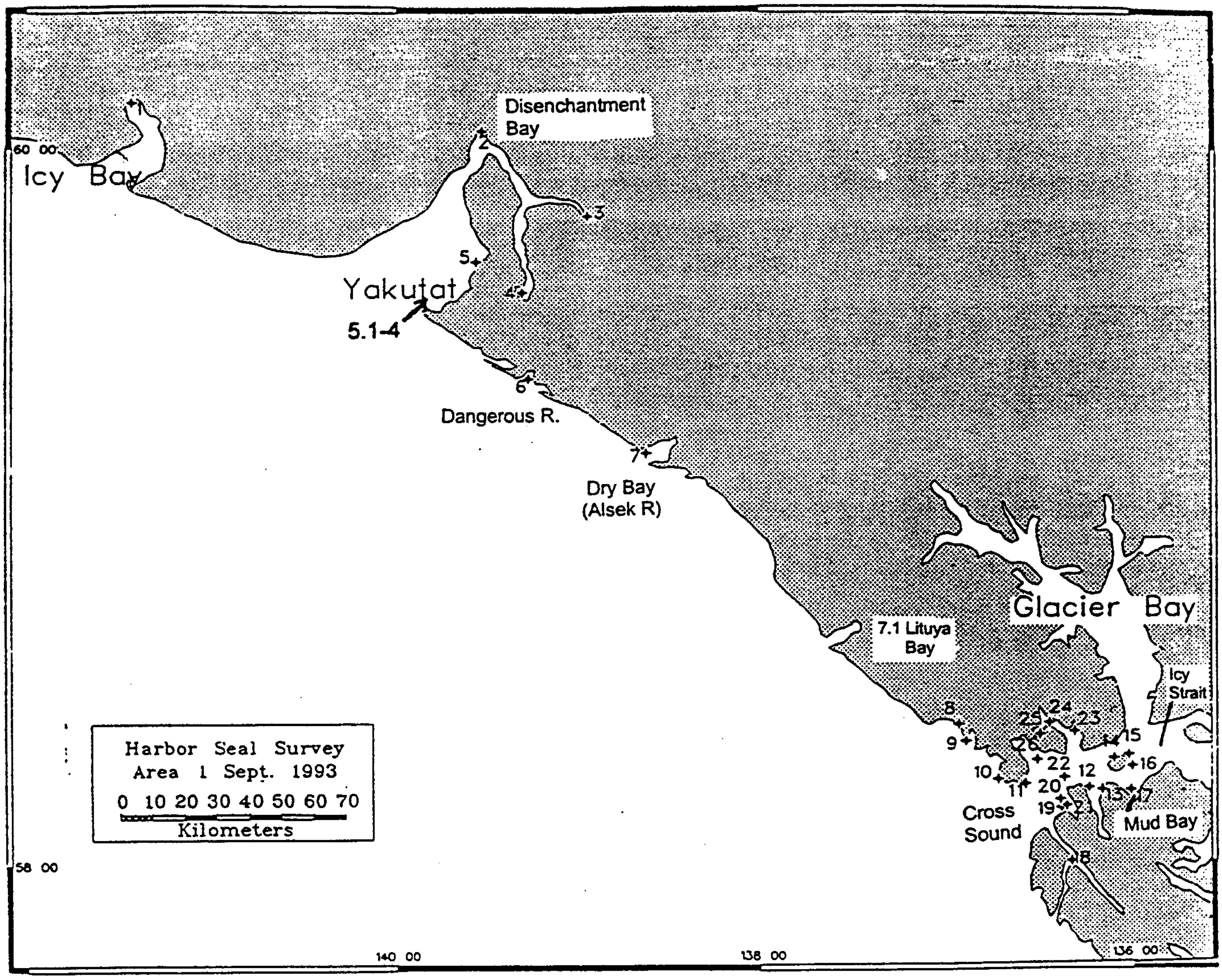
The northeast Gulf of Alaska from Icy Bay to Icy Strait includes at least 35 harbor seal haulouts on substrates ranging from glacial ice to rocky shores, sand reefs, and tidally-exposed rocks. From 18-27 August 1996, we conducted surveys between Icy Bay (59° 53'N, 141° 28'W) and Cape Spencer (58° 15'N, 137° 40'W) and in Cross Sound and Icy Strait, west of Mud Bay (136° W) (Figure 1). Surveys of the outer coast to Cape Spencer were conducted by Womble and originated in Yakutat. All but one of the surveys of the Icy Strait/Cross Sound area was conducted by Mathews from Gustavus as part of a survey of haulouts in Glacier Bay. Results from the Glacier Bay survey are included in a separate report (Mathews and Pendleton 1997).

Due to the large geographic area included between Icy Bay and Icy Strait, we could not reach all haulouts within two hours of low tide on a single flight nor without refueling. Consequently, we divided the route into three general areas (Figure 1):

a) glacial ice haulouts in Icy Bay and Disenchantment Bay (encompasses Hubbard and Turner glaciers[1]), and terrestrial haulouts in Yakutat Bay, and Russell and Nunatak Fjords (sites 1-5.4),
b) the outer coast from the Dangerous River to Cape Spencer (sites 6-11; 23-26), and
c) the Icy Strait/Cross Sound area east to Mud Bay (sites 12-22).

At tidally influenced terrestrial haulouts, seal numbers are typically highest during ebb or low tides (Calambokidis *et al.* 1987, Frost *et al.* 1996b, Pitcher and Calkins 1979). Surveys of areas b and c, predominately comprised of terrestrial haulouts, were accordingly scheduled to depart from the airport 2.5-3 hours before low tide. Weather conditions and early morning tides, however, did not always allow us to exactly follow these preferred protocols for tidally influenced haulouts. In Muir Inlet, a previously active tidewater glacier in Glacier Bay, the numbers of seals hauled out on glacial ice were relatively stable from mid morning (9:00) to late evening (21:00) during August

[1] We considered Hubbard and Turner Glaciers as separate haulout areas, since discreet groups of seals on ice were seen in front of both glaciers. In the Loughlin 1994 report, the 'Hubbard Glacier' counts appear to have included seals in front of Turner Glacier.



Site # and Name	Site # and Name	Site # and Name	Site # and Name	Site # and Name
1 Icy Bay	5.1 Otmeloi Island	8 Boussole Bay	13 Gull Cove	20.1 George Is
2 Hubbard Glacier	5.2 Foxy Reef	9 Astrolabe Rocks	14 Is. N of Lemesurier	21 Althorp Rocks
2.1 Turner Glacier	5.3 Knight Island (rk)	9.1 Graves Rocks	15 Lemesurier NE	22 Inian Islands
3 Nunatak Fjord	5.4 Redfield Cove	9.2 Dixon Harbor Rks	16 Lemesurier SE	23 Dundas River D.
4 Russell Fjord	6 Dangerous River	10 Polka Pen Rocks	17 Quartz Point	24 Dundas Bay Fork
5 Krutoi Island	7 Dry Bay (Alsek R)	11 Cape Spencer	18 Miner I (rocks)	25 Dundas Bay Is.
	7.1 Lituya Bay	12 Shaw Island	19 Three Hill Island	26 Taylor Bay
		12.1 Elfin Cove Rocks	20 Gaff Rock	

Figure 1. Area of survey coverage with haulout location numbers. (This map is a modified copy of Figure 2 from Loughlin 1994; with permission.) Haulouts denoted with whole numbers are from Loughlin 1994; sites denoted by a number with a decimal were occupied during surveys in 1996, but not during the surveys in 1993. (Location names are given in Table 3.)

Table 2. Time of surveys with optimal survey times for five areas from Icy Bay to Icy Strait during 1996. Optimal times for surveying seals at terrestrial haulouts are at low tides +/- two hours; for glacial haulouts counts may remain high from 9:00 – 21:00 (Calambokidis *et al.* 1983). The times for areas with several haulouts are from the middle of the survey section, and exact times are in Appendix I. (*: glacial ice haulout; *ns:* not surveyed due to bad weather conditions.)

Date	Location	Time of Survey	Optimal Time	Within Optimal
Aug 18	a) Icy Bay*	9:00	9:00 - 21:00	yes
	a) Hubbard Glacier*	9:51	9:00 - 21:00	yes
	b) Dangerous Rvr	11:25	8:04 - 12:04	yes
	b) DryBay/Alsek Rvr	11:40	8:04 - 12:04	yes
	b) Cape Spencer Area	12:37	8:04 - 12:04	
	c) Icy St/Cross Snd	*ns*		
Aug 19	a) Icy Bay*	15:00	9:00 - 21:00	yes
	a) Hubbard Glacier*	14:15	9:00 - 21:00	yes
	b) Dangerous Rvr	9:03	8:36 - 12:36	yes
	b) DryBay/Alsek Rvr	9:23	8:36 - 12:36	yes
	b) Cape Spencer Area	10:20	8:36 - 12:36	yes
	c) Icy St/Cross Snd	*ns*		
Aug 20	*(other areas not surveyed due to bad weather)*			
	c) Icy St/Cross Snd	12:32	9:13 - 13:13	yes
Aug 21	*(other areas not surveyed due to bad weather)*			
	c) Icy St/Cross Snd	12:11	9:58 - 13:58	yes
Aug 22	a) Icy Bay*	17:25	9:00 - 21:00	yes
	a) Hubbard Glacier*	16:30	9:00 - 21:00	yes
	b) Dangerous Rvr	10:54	10:58 - 14:58	
	b) DryBay/Alsek Rvr	11:15	10:58 - 14:58	yes
	b) Cape Spencer Area	12:20	10:58 - 14:58	yes
	c) Icy St/Cross Snd	*ns*		
Aug 23	*(other areas not surveyed due to bad weather)*			
	a) Hubbard Glacier*	9:31	9:00 - 21:00	yes
Aug 24	a) Icy Bay*	*ns*		
	a) Hubbard Glacier*	10:59	9:00 - 21:00	yes
	b) Dangerous Rvr	14:17	13:41 - 17:41	yes
	b) DryBay/Alsek Rvr	14:35	13:41 - 17:41	yes
	b) Cape Spencer Area	15:38	13:41 - 17:41	yes
	c) Icy St/Cross Snd	*ns*		
Aug 25	a) Icy Bay	*ns*		
	a) Hubbard Glacier	13:20	9:00 - 21:00	yes
	b) Dangerous Rvr	15:24	14:54 - 18:54	yes
	b) DryBay/Alsek Rvr	15:38	14:54 - 18:54	yes
	b) Cape Spencer Area	16:25	14:54 - 18:54	yes
	c) Icy St/Cross Snd	*ns*		
Aug 27	a) Icy Bay*	12:24	9:00 - 21:00	yes
	a) Hubbard Glacier*	9:45	9:00 - 21:00	yes
	b) Dangerous Rvr	6:52	4:38 - 8:38	yes
	b) DryBay/Alsek Rvr	7:08	4:38 - 8:38	yes
	b) Cape Spencer Area	*ns*		
	c) Icy St/Cross Snd	*ns*		

counts (Calambokidis *et al.* 1983). We, thus, assumed that there was considerable latitude in the timing of daily flights over Icy and Disenchantment bays. Table 2 summarizes the actual and optimal times of flights for five broadly categorized survey areas along the route flown in 1996. Appendix I includes the specific survey times for each haulout.

Aerial Survey Methods

The surveys were flown in three different single engine Cessna 185 airplanes. On all but the last two of the survey days an observer assisted the photographer and pilot in looking for seals and recording data. While looking for haulouts we typically flew at about 303 m (1000 ft) at cruising speeds of 100-130 knots. When an occupied haulout was located, we reduced our altitude and speed from a distance to avoid disturbing seals. Photographs of haulouts were typically taken at an altitude of about 212 m (700 ft) and an air speed of about 80 knots. We avoided flying directly over a haulout as this is more likely to startle the seals. Some seals were startled into the water on August 24 when a different, louder plane was flown by the same pilot.

Seals on haulouts, or visible in the water near a haulout, were photographed through an open window using a 35 mm camera (Nikon 6006 or Nikon 8008) with either an 80-200 mm zoom lens or a 300 mm auto-focus lens. We used color slide film (400 ASA) shot at shutter speeds of 1/250 seconds or, preferably, faster. The date, time, location, altitude, frame numbers, and shutter speeds were recorded for each surveyed haulout, and the recorder included a general description of weather conditions (precipitation and cloud cover). In addition, we noted if haulouts were unoccupied (a '0' in the database). We also noted if we were not able to check a haulout because of inclement weather (a 'null' value in the database).

We photographed all terrestrial haulouts that were occupied, even if there were only a few seals present. Numbers of seals and sea lions tend to be under-estimated by observers (Withrow 1982, J. Lewis pers. comm., pers. obser.), and there can be variation with some over- and under-estimation among even experienced observers (Withrow 1982). An additional advantage of photographs is that they can be verified and archived for future use. We did, however, visually estimate numbers of seals at haulouts as a backup in the event of camera failure or film loss.

Groups of seals were usually small enough to fit into one field of view in the camera, although this was not the case at the glacial ice haulouts where 100s of seals were widely dispersed on icebergs. On most days, we took a series of overlapping photographs of seals on glacial ice that could then be matched edge to edge during assessment, but the degree of coverage of these photographs is not known and we believe that counts from them may underestimate total numbers. During the fourth and last flight over Icy Bay and Hubbard and Turner glaciers on August 27, seals were visually counted, rather than photographed. In Icy Bay, this approach was possible on this day because seals were distributed in a long narrow strip that could be counted in one continuous pass. That is, there were few enough seals along the long strip width that an observer could make a direct count.

During each survey, we checked all previously identified haulouts (Loughlin 1994) which could be approached except Miner Island (site 18) in Lisianski Inlet. Miner Island was excluded in order to keep our flight times within two hours of low tide, and because checking this one haulout would have required an additional 20-30 minutes of flight time (no other haulouts were identified along the route to Miner Island during the 1993 surveys). The photographer, observer, and pilot searched for unidentified haulouts along the route. On several days, when conditions and timing allowed, we surveyed and photographed seals at some of the haulouts along the outer coast (i.e., Dry Bay/Alsek River, Dangerous River, Dixon Harbor) twice in one day, once during the outbound leg of the survey and again on the return flight. The difference in time between these repeat surveys ranged from 1.5 to 3.75 hours (Appendix I).

Photographic Slide Analysis

We projected the sharpest slide (or slide series) with the clearest view of seals for each haulout onto sheets of mounted white paper and counted individual seals by marking their images on the paper. To count seals from slide series of the large haulouts, we used two projectors to determine where adjacent slides overlapped. Each slide was counted twice for verification, although verification counts of entire slide series were not done. The majority of verification counts were identical, but a few with more than 100 seals differed by 1-4 seals. In these cases the average of the two numbers was used. Labeled slides will be stored in archival boxes at Glacier Bay National Park.

Data Storage and Analysis

We entered the results of the slide counts as well as related information (date, time, location, air temperature, weather conditions, tide information, and comments) into a *Microsoft Access* database. *Microsoft Excel* files designed to meet analysis specifications of the ADF&G (Grey Pendleton, pers. comm.) were generated from the original database. A copy of the data will be submitted to ADF&G (Anchorage) on disk with the final report, and the data will also be archived at Glacier Bay National Park in Gustavus. Summary statistics for tables and graphs were generated using *Microsoft Access*, *Excel,* and *Deltagraph (DeltaPoint)* software.

RESULTS

Aerial Survey Results: Minimum Population Estimate

Daily counts of seals at each haulout are summarized in Table 3. The minimum estimate for August 1996 along this route was 4,342 harbor seals, the highest number of seals observed at haulouts during a single survey day (Table 3). We were not able to survey all haulouts on any one day, so this high count is clearly a conservative estimate for the area. The sums of the maximum and mean numbers of seals observed at each haulout were 5,279 and 3,079 (Table 3). Between day variance at several haulouts, particularly the glacial fjords, was quite high and generally higher than those observed during the September 1993 surveys (Table 3, Appendix II).

Table 3. Harbor seals counted at haulouts during aerial surveys in August 1996. Whole-number locations follow those presented by Loughlin (1994); haulout sites with a decimal extension had seals on them during surveys in 1996 but not in 1993.

	August 1996 Survey Days												
Site Number and Name	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**27**	**Max**	**Mean**	**SD**	**N**
1 Icy Bay	125	1053			219	1220			1350	1350	793	577.90	5
2 Hubbard Glacier	305	1232			493	430	229	770	351	1232	544	349.67	7
2.1 Turner Glacier		122							6	122	64	82.02	2
3 Nunatak Fjord	28				126	47	26	30	40	126	50	38.32	6
4 Russell Fjord	95	6			202	3	72	72	183	202	90	77.98	7
5 Krutoi Island	0	0			0	0	0	0		0	0		6
5.1 Otmeloi Island					6	1	0	2		6	2	2.63	4
5.2 Foxy Reef					27	12	6	4		27	12	10.40	4
5.3 Knight Island (rk)						25	0	5		25	10	13.23	3
5.4 Redfield Cove					5	0	0	0		5	1	2.50	4
6 Dangerous River	33	56			41		44	19	67	67	43	16.88	6
7 Dry Bay (Alsek)	801	938			739		163	847	967	967	743	296.24	6
7.1 Lituya Bay	22	56			0		7		22	56	21	21.58	5
8 Boussole Bay	0	0			0		0			0	0		4
9 Astrolabe Rocks	59	84			0		57	32		84	46	31.80	5
9.1 Graves Rocks	27	18			0		42	25		42	22	15.27	5
9.2 Dixon Harbor Rks							18	4		18	11	9.90	2
10 Polka Pen Rocks	0	0					0			0	0		3
11 Cape Spencer	0	93					54	70		93	54	39.55	4
12 Shaw Island		15		0						15	8	10.61	2
12.1 Elfin Cove Rocks				20						20	20		1
13 Gull Cove		0		0						0	0		2
14 Is. N of Lemesurier		123	215	171						215	170	46.01	3
15 Lemesurier NE		88	74	37						88	66	26.35	3
16 Lemesurier SE		31	0	17						31	16	15.52	3
17 Quartz Point		138	30	72						138	80	54.44	3
18 Miner I (rocks)	(not included in 1996 survey)												0
19 Three Hill Island		0		0						0	0		2
20 Gaff Rock		43		9				25		43	26	17.01	3
20.1 George Is				24						24	24		1
21 Althorp Rocks		44		45						45	45	0.71	2
22 Inian Islands		40		45				70		70	52	16.07	3
23 Dundas River D.	0	0					0	0		0	0		4
24 Dundas Bay Fork	0	26					26	10		26	16	12.79	4
25 Dundas Bay Is.	0	26					32	30		32	22	14.88	4
26 Taylor Bay	0	110					0	0		110	28	55.00	4
Totals =	1495	**4342**	319	440	1858	1738	776	2015	**2986**	5279	3079		

Comparison of Counts from 1996 and 1993

The maximum number of seals counted on a single day (Table 3, Appendix II) and the sum of the daily maximum counts and means for each haulout (Table 4, Figure 2) were all higher during the August 1996 survey compared to the September 1993 survey. Because the high counts for each haulout occurred on different days, the sum of maximum counts overestimates the number of seals resting on haulouts on any given day during the survey period. The highest number of seals observed during a single survey day in August 1996 was 4,342 (Figure 2, Table 3), whereas the highest count in September 1993 was 3,124 (Figure 2, Appendix II). The highest count from the September 1993 survey was quite close to the second highest count from a single day during the August 1996 survey (3,234 vs. 2,986) (Table3, Appendix I).

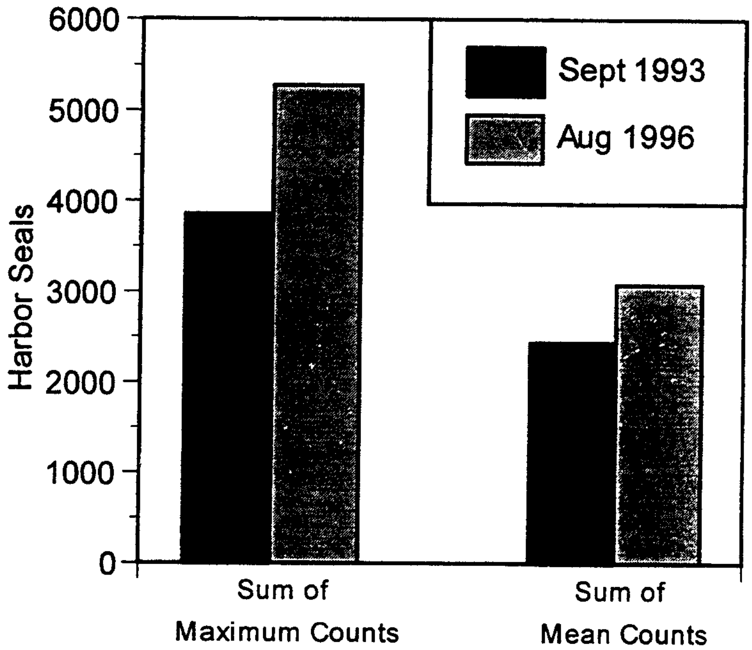
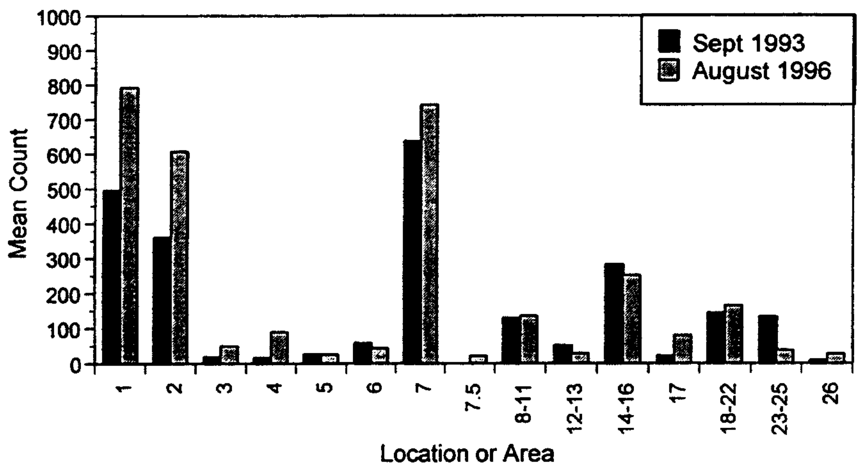


Figure 2. Sum of maximum and mean counts for each haulout from surveys in September 1993 (Loughlin, 1994) and August 1996. These figures do not include corrections for differences in survey timing or tide height.

Table 4. Summary of maximum and mean counts for each haulout surveyed in September 1993 (Loughlin 1994) and August 1996. (The sum of means from 1993 is lower in this table than in Loughlin 1994 due to the inclusion of '0' seals vs. no data reported at Gull Cove and Quartz Point on Sept. 16 in an updated database.)

Site		September		1993		August	1996		
No.	Site Name	Max	Mean	SD	N	Max	Mean	SD	N
1	Icy Bay (ice)	907	496	323	4	1350	793	578	5
2	Hubbard Glacier (ice)	747	361	260	5	1232	544	350	7
2.1	Turner Gl. (ice)					122	64	82	2
3	Nunatak Fiord	29	19	12	5	126	50	38	6
4	Russel Fiord (ice)	67	17	27	6	202	90	78	7
5	Krutoi Is.	53	27	18	4	0	0		6
5.1	Otmeloi Is.					6	2	3	4
5.2	Foxy Reef					27	12	10	4
5.3	Knight Is.					25	10	13	3
5.4	Redfield Cove					5	1	3	4
6	Dangerous River	75	59	20	5	67	43	17	6
7	Dry Bay (Alsek)	879	748	231	5	967	743	296	6
7.5	Lituya Bay (ice)					56	21	22	5
8	Boussole Bay	17	8	9	4	0	0		4
9	Astrolabe Rocks	72	39	30	4	84	46	32	5
9.1	Graves Rks					42	22	15	5
9.2	Dixon Harbor					18	11	10	2
10	Polka Pen rocks	30	15	12	4	0	0		3
11	Cape Spencer	120	68	34	5	93	54	40	4
12	Shaw Is.	58	38	15	4	15	8	11	2
12.5	Elfin Cove Rk					20	20		1
13	Gull Cove	31	14	13	4	0	0		2
14	Lemesurier, Is to N	194	140	49	4	215	170	46	3
15	Lemesurier, Is to NE	236	110	88	4	88	66	26	3
16	Lemesurier, Is to SE	67	34	25	4	31	16	16	3
17	Quartz Point	49	22	20	4	138	80	54	3
18	Miner Is (not surveyed in 1996, so excluded)								0
19	Three Hill Is.	10	9		2	0	0		2
20	Gaff Rock	36	25		2	43	26	17	3
20.5	George Is.					24	24		1
21	Althorp Rocks	26	24		2	45	45	1	2
22	Inian Island	31	23		2	70	52	16	3
23	Dundas River D.	49	44		2	0	0		4
24	Dundas Bay, fork	33	33		2	26	16	13	4
25	Dundas Bay, Is	52	27		2	32	22	15	4
26	Taylor Bay, Is. S.	36	23		2	110	28	55	4
	Sums =	3904	2422			5279	3079		

Out of 15 haulouts or haulout areas counted in both years, nine had higher mean counts and 10 had higher maximum counts during the August 1996 compared to the September 1993 survey. Fewer seals were observed in August 1996 than in September 1993 at the other sites or areas (Figures 3a and 3b). None of these comparisons include corrections for differences in survey timing or tide height. Six haulouts that had been used during the September 1993 survey were not used during the August 1996 survey (Table 4). Ten additional haulouts, including four small haulouts in Yakutat Bay which were only exposed at low tides (sites 5.1 - 5.4), were occupied during the August 1996 survey but not during the September survey (Appendix II).



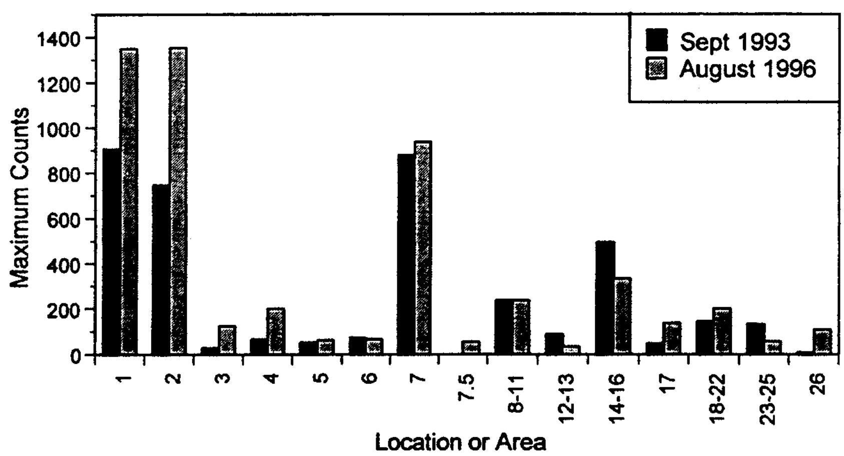


Figure 3. 3a) Comparison of mean and **3b)** maximum counts of harbor seals at 14 different haulouts or haulout areas from surveys in September 1993 and August 1996. Location numbers correspond to haulouts listed in Table 3, and the survey sites are ordered by location, from northwest to southeast (left to right).

DISCUSSION

Minimum Population Estimate and Count Variance, August 1996

Without corrections for incomplete coverage or differences in tide height at the time of surveys, the most conservative estimate for the minimum number of seals at haulouts along the route is 4,342 seals, the high count from a single day (August 19, 1996). This is 1,218 seals higher than the high count for September 1993 (3,124 seals, Appendix II), however this should not be construed as an increasing trend since no corrections have been made for differences in the dates of the surveys or environmental factors (i.e., tide height or time). Because of the differences in survey timing (13-20 September, 1993 vs. 18-27, August 1996) and the three year interval between annual surveys, we did not feel that it was appropriate to conduct an analysis for trends in seal numbers at this time. In addition, our high count was 1,356 seals higher than our next highest count on August 27, 1996. If we had not been able to survey on August 19, 1996, our maximum and mean counts would have been more similar to those obtained by NMFS in September 1993.

The high day to day variance in seals observed on glacial ice in Icy Bay may be due to rapid changes in substrate availability. Such extreme (five-fold) fluctuations are rare in Johns Hopkins Inlet in Glacier Bay during mid August surveys, although two-fold changes are occasionally observed (Mathews 1995). Icy Bay is more open and may be subject to greater extremes in currents as well as a more erratic production of ice than near the face of Johns Hopkins glacier. On August 22, when only 219 seals were observed in Icy Bay, there was less ice than on other days surveyed, but this survey was also the latest one (17:25) flown during the month. The relative stability in numbers of seals resting on ice observed by Calambokidis *et al.* (1983) off Muir Glacier may not apply in Icy Bay. In Aialik Bay, Kenai Fiords National Park, Hoover (1983) observed more seals on glacial ice in the two days following a storm. The August 22 low count followed a day of bad weather (rain, fog), yet this does not appear to have had the effect observed in Ailek Bay, perhaps because the weather we experienced was not specifically a storm. In summary, we are not certain of the cause for the extreme variability from day to day in Icy Bay, but we suspect that it is largely driven by patterns of ice production and movement. Such high variance will presumably decrease the sensitivity of detecting changes in trends in this area.

Proposed Trend Route: Options for the Northeast Gulf of Alaska

The primary goal of this work was to determine if a subsection of the route between Icy Bay and Icy Strait might serve as a practical, informative trend route for monitoring harbor seal abundance and distribution. If a section of this coast is to become a trend route, we recommend that the route include the haulouts from Icy Bay to either Dry Bay and the Alsek River or to Cape Spencer (sites 1-7 or 1-11, Figure 1), depending upon the survey plane's cruising speed, survey route, and budget considerations. We minimized coverage of haulouts in Cross Sound and western Icy Strait because full coverage of this area would make the route too long to bracket low tides during a single day in most single engine aircraft. These sites also encompass habitat more similar to that found in the lower portions of Glacier Bay and in the Ketchikan and Sitka routes. If desired, the haulouts in the Icy Strait/Cross Sound area not included in our proposed route could be efficiently surveyed from Gustavus, but this would require a second survey team in order for surveys to bracket low tide cycles.

The route includes the three areas (Icy Bay, Hubbard and Turner glaciers, and the Dry Bay/Alsek River) with the largest aggregations of seals observed both in 1996 and in 1993 (Table 4). On August 19, 1996 more the 50% of the 4,342 seals observed were in Icy and Disenchantment bays, with an additional 22% observed on sandbars in or near Dry Bay and the Alsek River. Similarly, more than 50% of the 3,124 seals observed on September 19, 1993 were observed in these same glacial fjords, with about 77% in the fjords and at the Dry Bay/Alsek areas combined (Loughlin 1994, Appendix II)

The proposed trend route encompasses important habitat including tidewater glacial fjords where logging activities and cruise ship and tour boat traffic are increasing, and where oil drilling is proposed (Kozie *et al.* 1996). The route includes substantial river drainages (i.e., the Dry Bay/Alsek River) with eulachon *(Thaleichthys pacificus)* and commercially and subsistence harvested salmon *(Oncorhynchus spp.)* runs that attract large numbers of seals (M. Sharp pers. comm.). It also includes haulouts separated by open coast habitat not represented in the four other trend routes in Southeast Alaska, and a large proportion of the coastline bordering Glacier Bay National Preserve – a section of the national park in which commercial and subsistence fishing and hunting are legislatively permitted.

In order for a survey route to serve as a practical trend route, it needs to be possible to reach all tidally influenced haulouts along the route within about a four hour period, bracketing the low tide cycle by about two hours. With Yakutat airport as the starting point, eight terrestrial haulouts (sites 4-6 and 8-11) and Lituya Bay (site 7, a relatively small glacial ice haulout along the route) and possibly a few representative sites in Cross Sound and western Icy Strait could be surveyed within this time (in a single engine Cessna 185 or comparable fixed wing aircraft). Additional time would be needed for the straight-line flight back to the airport (Appendix III. Tables A-1 and A-2). The average flight time during our August 1996 surveys (excluding time to land and refuel) was about 5.5 hrs with a maximum of 6.5 hrs, however we were never able to survey all sites due to bad weather so these are minimum estimates.

The route could be flown one of two general ways:

1) Fly the terrestrial sites from Yakutat to Gustavus on the first day, with an overnight in Gustavus. Repeat the terrestrial sites on the next day from Gustavus to Yakutat and survey the glacial sites after refueling in Yakutat. This model assumes that the low tides are in the morning, but it could be modified to accommodate later tides by picking up the glacial haulouts before flying from Yakutat to Gustavus. In this case, the three glacial sites (Icy Bay, Hubbard and Turner glaciers) would be surveyed every other survey day, at most.

2) With possibly fewer sites covered in Cross Sound and Icy Strait or a faster plane, the glacial sites could be surveyed each day with a stop to refuel in Yakutat in between the terrestrial haulout sites and the glacial ice sites.

As mentioned, if haulout patterns in Icy Bay and other tide-water glacial fjords are similar to those observed by Calambokidis *et al.* (1983) in Muir Inlet (Glacier Bay), then high counts should be obtained during surveys conducted between 9:00 a.m. and early evening, either before or after the terrestrial haulouts, depending upon whether the low tide is in the morning or afternoon. This flexibility in survey timing for Icy Bay (and Disenchantment Bay) can be used to allow for refueling, as well as a crew break, in between areas. However, there is some suggestion that seal numbers may not remain stable in Icy Bay as they did in Muir Inlet, so this assumption needs to be tested.

<u>Comments on the Reliability of Aerial Surveys of Seals on Glacial Ice</u>

Although systematic counts from an elevated observation site can be used to reliably count several thousand seals in glacial fjords (Streveler 1979, Calambokidis *et al.* 1987, Mathews 1995), there is not currently a reliable or confirmed aerial method for surveying large numbers of seals that are widely dispersed on shifting glacial ice. Kozie, *et al.* (1996) describe a stratified sampling method for estimating seal abundance from aerial surveys in Icy and Disenchantment bays, but the accuracy and precision of this technique remain to be tested.

We found that seals in Icy and Disenchantment bays (Hubbard and Turner glaciers) could be counted visually (with an unknown level of accuracy) or photographed for later counting in some circumstances, depending upon how many there were and on their distribution on the ice. If there were only a few hundred animals hauled out in a fjord or area, direct or photographic counts, or a combination of the two methods, are possible. Reliable counts from the air are less feasible when there are large (i.e. >1,000) numbers of seals widely distributed across a fjord. However, if seals happen to be distributed along a band of ice narrow enough to fit into one field of view and parallel to a safe flight route, a series of overlapping photographs can be used to obtain a direct, verifiable count of all visible seals. One of us (Womble) experimented with this technique in Icy Bay on August 19 when 1,053 seals were photographed, however we suspect that this count may be an underestimate. This method does require that the seals be (fortuitously) distributed in a long, narrow band. On August 27, a visual count of 1,350 seals was made in Icy Bay, but such a count cannot be confirmed (as compared to the slide series).

Fjords fed by active tidewater glaciers appear to be preferred habitat for breeding and molting (Streveler 1979, Calambokidis *et al.* 1987, Mathews 1995), so they need to be included where population trend routes encompass them. We recommend that in addition to testing the reliability of stratified sampling estimates (Kozie *et al.* 1996), experiments with higher altitude, medium or large format cameras and sensitive film be explored as a method to improve the reliability and accuracy of seal counts in tidewater glacial fjords. One such experiment was conducted in Johns Hopkins Inlet in July 1997.

The results from this work were very promising; a report comparing the results and costs of aerial photographs to those of land-based counts will be available at a later date.

Because Icy and Disenchantment bays are used by a majority of seals in the area for pupping and molting, we recommend that they be included as part of the route, despite the current use of opportunistic and experimental counting methods. If these glacial ice haulouts are not monitored and a decline (or increase) in seal abundance of up to 50% in adjacent waters is observed, it would not be possible to distinguish whether the change was due to an area-wide decline, or caused by an influx of seals into (or exodus from) Icy or Disenchantment bays. In addition, the large daily variance observed in the numbers of seals in Icy Bay (Table 3) makes this an important area to monitor, since numbers in glacial fjords could be inversely correlated with those at nearby land haulouts. Clearly, improved aerial photography or other methods are needed for monitoring tide-water glacial haulouts.

Timing of the Proposed Aerial Survey Route

During the annual molt, harbor seals spend more time resting (Johnson and Johnson 1979), so counts tend to be higher during active stages of molt (Bishop 1967). Determining the optimal period of time during late summer for flying the northeast Gulf of Alaska route remains to be fine-tuned, although the results from this report and from other areas in Southeast Alaska (Calambokidis *et al.* 1987, Mathews and Kelly 1996, Streveler 1979) suggest that more seals are likely to be observed at haulouts during August low tide cycles than in September. While our results support this observation, they are potentially confounded by the three year interval between the two surveys.

If the goal is to count a higher proportion of the seals present, as is the case for a minimum population estimate, then we need to know when the peak in the molt cycle occurs. Very little work on harbor seals has been done along the northeast Gulf coast, so the timing of the molt cycle is not specifically known. In Glacier Bay, higher numbers at land and ice haulouts have typically been observed in August compared to September (Mathews and Kelly 1996), and it is assumed that the timing of the molt cycle for seals in this adjacent area would be similar. To verify this assumption, it would be valuable to regularly survey the selected trend route (or possibly a representative portion of it) in one year from August through September, perhaps every two or three days.

Comparison of Counts from 1996 and 1993

The single-day high count and the sums of the mean and maximum counts for each haulout were all higher during the August 1996 survey compared to the September 1993 survey (Figure 2, Tables 3 and 4). However, none of the survey days in either year included coverage of all of the haulouts, and no corrections have been made for partial coverage or differences in survey timing or tide height. Some of the difference in seal numbers observed between the two survey years may be due to the later date (month) of the 1993 survey. In other parts of Southeast Alaska, the numbers of seals observed at haulouts during mid-September have been up to 85% lower than observed in late August (Mathews and Kelly 1996). Similarly, Withrow and Loughlin (1995) found that 67%

(CV=4.7%) of harbor seals equipped with radio tags near Cordova, Alaska in 1995 were hauled out during mid August compared to 39% (CV=14%) during early September surveys.

CONCLUSIONS

The results from several years of surveys of the coast between Icy Bay and Dry Bay or Cape Spencer that are conducted at the same time of year using comparable methods should increase our ability to monitor trends in abundance of harbor seals in the northeast Gulf of Alaska, although improved methods of counting seals on glacial ice are needed. Statistical models designed to reduce the variance between daily counts of seals by controlling for differences in survey timing, tide height and time, as well as other environmental or observer differences have been developed (Frost *et al.* 1996a, Lewis *et al.* 1996) and could be applied to improve the sensitivity of trend data for detecting changes in numbers of harbor seals at haulouts between Icy Bay and Icy Strait.

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Appendix I. Data from aerial surveys in August 1996

Site #	Site	Date	Time	# Seals
101	Icy Bay	8/18/96	9:00	125
101	Icy Bay	8/19/96	15:00	1053
101	Icy Bay	8/22/96	17:25	219
101	Icy Bay	8/23/96	10:03	1220
101	Icy Bay	8/27/96	12:24	1350
102	Hubbard Gl	8/18/96	9:51	305
102	Hubbard Gl	8/19/96	14:15	1232
102	Hubbard Gl	8/22/96	16:30	493
102	Hubbard Gl	8/23/96	9:31	430
102	Hubbard Gl	8/24/96	10:59	229
102	Hubbard Gl	8/25/96	13:20	770
102	Hubbard Gl	8/27/96	9:45	351
102.1	Turner Glacier	8/19/96	14:22	122
102.1	Turner Glacier	8/27/96	9:48	6
103	Nunatak Fjord	8/18/96	10:12	28
103	Nunatak Fjord	8/22/96	16:12	126
103	Nunatak Fjord	8/23/96	9:17	47
103	Nunatak Fjord	8/24/96	10:48	26
103	Nunatak Fjord	8/25/96	13:07	30
103	Nunatak Fjord	8/27/96	9:32	40
104	Russell Fjord	8/18/96	10:29	95
104	Russell Fjord	8/19/96	13:55	6
104	Russell Fjord	8/22/96	13:38	202
104	Russell Fjord	8/23/96	9:01	3
104	Russell Fjord	8/24/96	10:32	10
104	Russell Fjord	8/24/96	11:31	72
104	Russell Fjord	8/25/96	12:53	72
104	Russell Fjord	8/27/96	9:15	183
105	Krutoi Island	8/18/96	10:35	0
105	Krutoi Island	8/19/96	14:30	0
105	Krutoi Island	8/22/96	13:50	0
105	Krutoi Island	8/23/96	12:27	0
105	Krutoi Island	8/24/96	11:18	0
105	Krutoi Island	8/25/96	13:53	0
105.1	Otmeloi Island	8/22/96	13:52	6
105.1	Otmeloi Island	8/23/96	12:28	1
105.1	Otmeloi Island	8/24/96	11:19	0
105.1	Otmeloi Island	8/25/96	13:55	2
105.2	Foxy Reef	8/22/96	13:55	27
105.2	Foxy Reef	8/23/96	12:25	12
105.2	Foxy Reef	8/24/96	11:20	6
105.2	Foxy Reef	8/25/96	13:52	4
105.3	Knight Island (rk)	8/23/96	12:37	25
105.3	Knight Island (rk)	8/24/96	11:18	0
105.3	Knight Island (rk)	8/25/96	13:47	5
105.4	Redfield Cove	8/22/96	14:00	5
105.4	Redfield Cove	8/23/96	12:41	0
105.4	Redfield Cove	8/24/96	11:22	0
105.4	Redfield Cove	8/25/96	13:53	0
106	Dangerous R	8/18/96	11:25	33
106	Dangerous R	8/19/96	9:03	56
106	Dangerous R	8/22/96	10:54	0
106	Dangerous R	8/22/96	13:20	41
106	Dangerous R	8/24/96	14:17	44
106	Dangerous R	8/24/96	18:01	42
106	Dangerous R	8/25/96	15:24	13
106	Dangerous R	8/25/96	18:25	19
106	Dangerous R	8/27/96	6:52	44
106	Dangerous R	8/27/96	9:06	67
107	Dry Bay (Alsek)	8/18/96	11:40	801
107	Dry Bay (Alsek)	8/18/96	14:38	642
107	Dry Bay (Alsek)	8/19/96	9:23	938
107	Dry Bay (Alsek)	8/22/96	11:15	739
107	Dry Bay (Alsek)	8/24/96	14:35	163
107	Dry Bay (Alsek)	8/24/96	17:50	38
107	Dry Bay (Alsek)	8/25/96	15:38	847
107	Dry Bay (Alsek)	8/25/96	18:13	391
107	Dry Bay (Alsek)	8/27/96	7:08	823
107	Dry Bay (Alsek)	8/27/96	8:34	867
107.1	Lituya Bay	8/18/96	12:14	22
107.1	Lituya Bay	8/19/96	9:58	56
107.1	Lituya Bay	8/22/96	12:43	0
107.1	Lituya Bay	8/24/96	15:07	7
107.1	Lituya Bay	8/27/96	7:36	22
108	Boussole Bay	8/18/96	12:30	0
108	Boussole Bay	8/19/96	10:05	0
108	Boussole Bay	8/22/96	12:16	0
108	Boussole Bay	8/24/96	15:35	0
109	Astrolabe Rcks	8/18/96	12:37	59
109	Astrolabe Rcks	8/19/96	10:20	84
109	Astrolabe Rcks	8/22/96	12:20	0
109	Astrolabe Rcks	8/24/96	15:38	57
109	Astrolabe Rcks	8/25/96	16:25	32

Appendix I. Data from aerial surveys in August 1996 (cont.)

Site #	Site	Date	Time	# Seals
109.1	Graves Rocks	8/18/96	13:00	27
109.1	Graves Rocks	8/19/96	10:37	18
109.1	Graves Rocks	8/22/96	12:25	0
109.1	Graves Rocks	8/24/96	16:14	42
109.1	Graves Rocks	8/25/96	16:43	25
109.2	Dixon Harbor Rks	8/24/96	15:47	18
109.2	Dixon Harbor Rks	8/24/96	17:12	13
109.2	Dixon Harbor Rks	8/25/96	16:30	4
110	Polka Pen Rocks	8/18/96	13:12	0
110	Polka Pen Rocks	8/19/96	10:49	0
110	Polka Pen Rocks	8/24/96	16:20	0
111	Cape Spencer	8/18/96	13:15	0
111	Cape Spencer	8/19/96	11:38	93
111	Cape Spencer	8/24/96	16:22	54
111	Cape Spencer	8/25/96	16:50	70
112	Shaw Island	8/19/96	11:49	15
112	Shaw Island	8/21/96	11:40	0
113	Gull Cove	8/19/96	11:47	0
113	Gull Cove	8/21/96	11:38	0
114	Is N of Lemesurier	8/19/96	12:29	123
114	Is N of Lemesurier	8/20/96	12:32	215
114	Is N of Lemesurier	8/21/96	12:11	171
115	Lemesurier NE	8/19/96	11:22	88
115	Lemesurier NE	8/20/96	12:17	74
115	Lemesurier NE	8/21/96	11:28	37
116	Lemesurier SE	8/19/96	11:31	31
116	Lemesurier SE	8/20/96	12:19	0
116	Lemesurier SE	8/21/96	11:31	17
117	Quartz Point	8/19/96	11:36	138
117	Quartz Point	8/20/96	12:23	30
117	Quartz Point	8/21/96	11:35	72
119	Three Hill Island	8/19/96	12:09	0
119	Three Hill Island	8/21/96	11:53	0
120	Gaff Rock	8/19/96	12:13	43
120	Gaff Rock	8/21/96	11:45	9
120	Gaff Rock	8/25/96	17:23	25
120.1	George Is	8/21/96	11:48	24
121	Althorp Rocks	8/19/96	12:05	44
121	Althorp Rocks	8/21/96	11:54	45
121.1	Elfin Cove Rocks	8/21/96	11:59	20

Site #	Site	Date	Time	# Seals
122	Inian Islands	8/19/96	11:56	40
122	Inian Islands	8/21/96	12:02	45
122	Inian Islands	8/25/96	17:20	70
123	Dundas River D.	8/18/96	13:22	0
123	Dundas River D.	8/19/96	11:18	0
123	Dundas River D.	8/24/96	16:50	0
123	Dundas River D.	8/25/96	17:14	0
124	Dundas Bay Fork	8/18/96	13:20	0
124	Dundas Bay Fork	8/19/96	11:09	26
124	Dundas Bay Fork	8/24/96	16:35	26
124	Dundas Bay Fork	8/25/96	17:05	10
125	Dundas Bay Is.	8/18/96	13:23	0
125	Dundas Bay Is.	8/19/96	11:03	26
125	Dundas Bay Is.	8/24/96	16:44	32
125	Dundas Bay Is.	8/25/96	17:09	30
126	Taylor Bay	8/18/96	13:12	0
126	Taylor Bay	8/19/96	10:52	110
126	Taylor Bay	8/24/96	16:30	0
126	Taylor Bay	8/25/96	17:03	0

Appendix II. Harbor seal survey results from September 1993

Harbor seals counted at haulouts during aerial surveys in September 1993. Data are from Loughlin (1994), but include some differences (shaded numbers) from a more recent database than that in the 1994 report.

	1993 Survey Dates										
Location	**9/13**	**9/14**	**9/15**	**9/16**	**9/17**	**9/18**	**9/19**	**9/20**	**Max**	**Mean**	**SD**
1 Icy bay (ice)			159		340		907	578	907	496	323.29
2 Hubbard Glacier	116		299		155		747	488	747	361	260.49
3 Nunatak Fjord	26		29		16		24	0	29	19	11.66
4 Russell Fjord, Is	67		0		0	30	0	3	67	17	27.32
5 Krutoi Is, E reef			18	16	20		53		53	27	17.58
6 Dangerous River		75	71	26		68	56		75	59	19.87
7 Dry Bay (Alsek)		879	530	708		846	778		879	748	138.55
8 Boussole Bay			14	17		0	0		17	8	9.03
9 Astrolabe Rocks			72	49		0	35		72	39	30.14
10 Polka Pen rocks			15	30		0	16		30	15	12.26
11 Cape Spencer		75	69	28		49	120		120	68	34.33
12 Shaw Island		26		42		27	58		58	38	15.06
13 Gull Cove		11		0		31	13		31	14	12.84
14 Lemesurier N		86		113		194	165		194	140	48.94
15 Lemesurier NE		73		35		236	97		236	110	87.63
16 Lemesurier SE		15		15		67	37		67	34	24.62
17 Quartz Point		22		0		49	18		49	22	20.24
18 Miner Is. (area not surveyed in 1996, so counts of 64 and 32 not included in this summary)											
19 Three Hill I.		10		8					10	9	1.41
20 Gaff Rocks (GI)		14		36					36	25	15.56
21 Althorp Rocks		26		22					26	24	2.83
22 Inian Island		31		15					31	23	11.31
23 Dundas River D.		49		38					49	44	7.78
24 Dundas B. forks		33		33					33	33	0.00
25 Dundas B island		52		2					52	27	35.36
26 Taylor Bay		9		36					36	23	19.09
Totals:	209	1486	1276	1269	531	**1597**	**3124**	1069	3904	2422	