

DEVELOPMENT OF SURVEY METHODOLOGY FOR LONG TERM MONITORING OF HARBOR SEALS IN WRANGELL-ST. ELIAS NATIONAL PARK AND PRESERVE, ALASKA

Karin Kozie, Bill Route, Resource Management Specialists,
Wrangell-St. Elias National Park and Preserve, PO Box 29,
Glennallen, AK. 99588

DATE: June 30, 1995

INTRODUCTION

Harbor seals (Phoca vitulina richardsi) inhabit coastal waters in Alaska from southeast Alaska to the Aleutian Islands and the Bering Sea (Hoover 1988). Although they were previously considered abundant, surveys during the 1980's indicated declines as great as 86% have occurred from southcentral to western Alaska (Pitcher 1986, 1989, 1990). While the rate of decline appears to have slowed, the numbers of seals in these areas are substantially lower than they were in the early 1970's (Hoover-Miller 1992). Census data for southcentral and southeast Alaska indicate statistically significant declines have occurred in the Prince William Sound and Ketchikan trend areas. Numbers have declined but not significantly in the Sitka trend area (Loughlin 1992, 1994).

Limited data is available on the status of harbor seals in Wrangell-St Elias National Park and Preserve (WRST), specifically Icy and Disenchantment Bays. A breeding population of up to several thousand seals was reported in Icy Bay and 700 to 900 seals were observed in Disenchantment Bay during 1992 (Kozie 1992). However, these numbers are based on incidental or casual observations. Seal populations were surveyed by the National Marine Fisheries Service (NMFS) during 1991-1993 in response to the alarming declines in parts of Alaska and as directed by the 1988 amendment to the Marine Mammal Protection Act. NMFS documented 907 seals in Icy Bay and 747 seals in Disenchantment Bay in mid-September 1993 (Loughlin 1994). These data may underestimate the population. A ten-fold reduction in seal populations occurred in Glacier Bay between mid-August and mid-September due to movements of seals outside the bay (Mathews 1993). Similar movements may have occurred in Icy and Disenchantment Bays. Additionally, while minimum population estimates are extremely important for baseline information, these surveys were not designed to detect statistically significant changes in population numbers between years.

Several factors that may affect seal populations in the Yakutat Bay area make trend data highly desirable (Yakutaga Area Management Plan, Alaska Dept. of Fish & Game). Local residents have described a decline in a related marine mammal, the Steller sea lion (Eumetopias jubatus), in Yakutat Bay. A year round sea lion rookery/haul out area along the Malaspina forelands (WRST)

supported about 200-300 animals in the early 1980s. K. Hundertmark, Alaska Department of Fish & Game, observed 150-250 sea lions at Sitkagi Bluffs (along the Malaspina Forelands) on December 4, 1982 (Alaska Dept Fish & Game Memorandum, 1982). This number gradually decreased to zero by 1991 (R. Mossman-NPS, G. Rainy-Fishing and Flying, pers commun). Harbor seals may be experiencing similar declines but no trend data are available for the Yakutat area. Trend data in nearby Prince William Sound indicate harbor seals have experienced significant declines there (Loughlin 1992).

Proposed development of the Icy Bay area could affect unstudied pinniped populations. Offshore oil drilling may occur west of Icy Bay and south of Yakutat Bay in 1995 (Minerals Management 1990). Marine mammals are at risk from potential oil spills and pollution if oil is developed in adjacent offshore areas. Logging is occurring along the east and west sides of Icy Bay. Expected increases in logging-related boat traffic may disturb seals. Increases in tourism in Icy and Disenchantment Bays by cruise ships trying to observe calving glaciers and kayakers may also disturb seals hauled out on ice flows since they are especially sensitive to vessel activity (Allen et al. 1984, Calambokidis et al. 1983). Commercial fishing occurs throughout Yakutat Bay and may affect seal populations. Because harbor seals are distributed within coastal waters, they are commonly caught incidental to commercial and subsistence net fishing operations (Hoover 1988). The degree of take is unknown but could be significant in some salmon and herring gill net and purse seine fisheries. An unknown number are also shot by commercial fisherman when they disrupt their nets.

The purpose of this study was to develop long term monitoring methods for harbor seal pup and population surveys in Icy Bay. The results of 1994 surveys and recommendations for 1995 are presented in this paper.

OBJECTIVES

- 1) Determine harbor seal adult/pup ratios in Icy Bay
- 2) Determine a minimum population estimate for harbor seals in Icy Bay
- 3) Develop survey methodology for monitoring long term trends in pup proportions and population levels of harbor seals in Icy Bay

STUDY AREA

Icy Bay (Fig 1) is located about 85 km west of Yakutat. Seal haul out habitat within the bay consists of glacial ice which varies in abundance and distribution throughout the summer breeding season. No land haul outs are present.

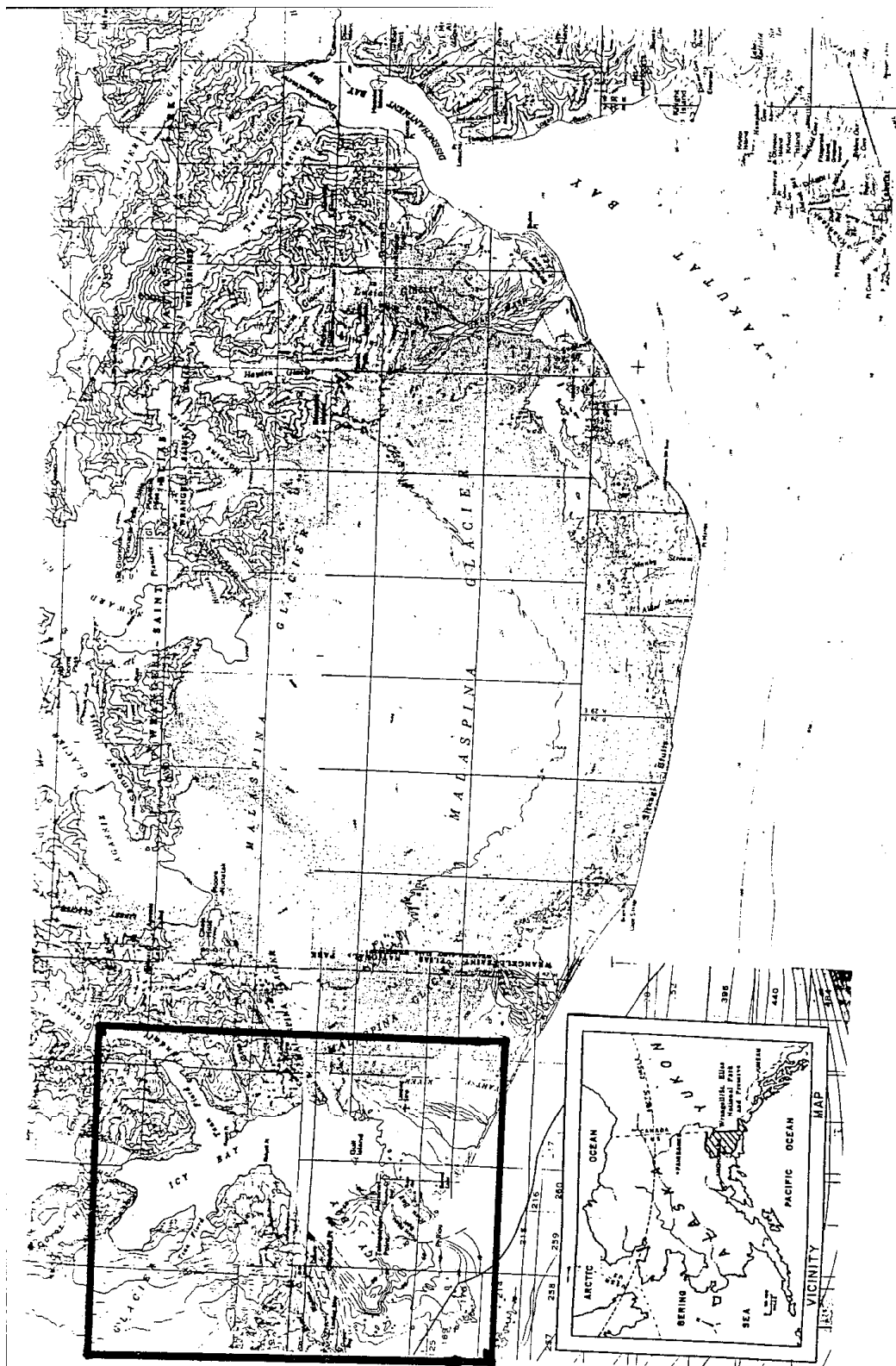


Figure 1. Location of study area, Icy Bay, Alaska.

METHODS

Pup Proportions

Adult\pup ratios were determined using methods developed by Mathews in 1993 (in press). Briefly, on June 15, 1994, R Mossman took a series of non-overlapping slide photographs (200 ASA) of seals hauled out on ice flows throughout Icy Bay (Fig 2). Seals were photographed through an open window of a piper supercub flying at 700-800 ft above sea level (ASL), using a Nikon 8008S camera with a 80-200mm zoom lens, motor drive and data back. A new roll of film was used for each aggregation of greater than 100 animals (Fig 2).

Pup proportions were determined by viewing the slides through a dissecting microscope and classifying seals as adults, pups, or unknown. Unknown age seals were excluded from calculations. A mean pup proportion and standard deviation were then calculated by averaging the percent pups from each roll of film.

POPULATION ESTIMATE

In 1993, we hired B. Mathews, Univ of Alaska - Southeast, to develop methods for surveying harbor seal populations in Icy Bay. B. Mathews has been working on developing standardized survey methodology for harbor seals in Glacier Bay which consists of counting seals hauled out on land and ice flows from elevated observation areas along the bay and aerial photography (Mathews 1992). Methods using land based observations could not be applied to Icy Bay because of the large size of the bay (e.g. there are no vantage points where an observer could view the entire bay or haul out area at a distance close enough to count seals). Further, aerial census of harbor seals on ice flows are complicated by the lack of land marks to distinguish which seals have been surveyed and which have not. Consequently, no methodology exists in the literature for surveying harbor seals hauled out on ice flows over a large area.

We contracted with J. Kern and L. McDonald in the fall of 1993 to analyze the data we collected during September 1993 and recommend changes in our methodology in an effort to develop a statistically valid sampling procedure for 1994.

Methods recommended by Kern and McDonald

Methods recommended by Kern and McDonald (in prep) consisted of systematic aerial line transects spaced $\frac{1}{2}$ mile apart throughout the main part of the bay and a zig-zag pattern in the fiords (Fig 3). The orientation of the survey lines in the main part of the bay was based on efficient coverage and safe flight paths. A starting point was selected for the first transect by randomly choosing a number between 1 and 5 from a random numbers table and then measuring that distance (e.g. 2=0.2 miles) from a randomly chosen area along the shoreline. For a 50% sampling intensity,

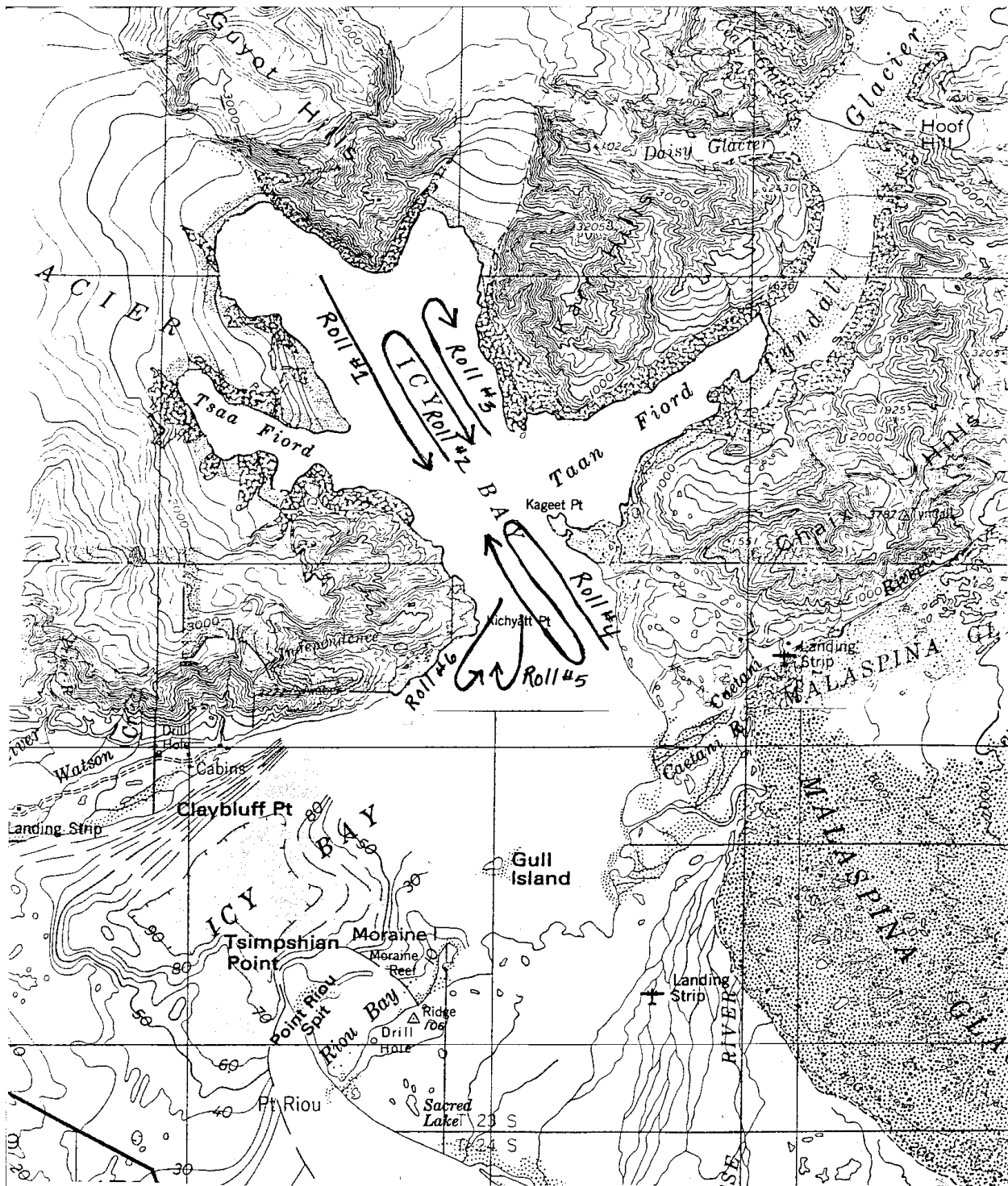


Figure 2. Flight pattern and associated film roll for pup proportion survey, June 15, 1994.



Figure 3. Flight lines and sampling routine for seal population surveys as recommended by Kern and McDonald (with the exception of the NE-SW lines 1-6 in North Guyot Fiord which represent flight lines used on August 16, 1994 to sample the aggregation). All other lines represent the sampling routine used all or in part on August 14 and 15, 1994. Lines 13-26 were not sampled since no ice was present in this area.

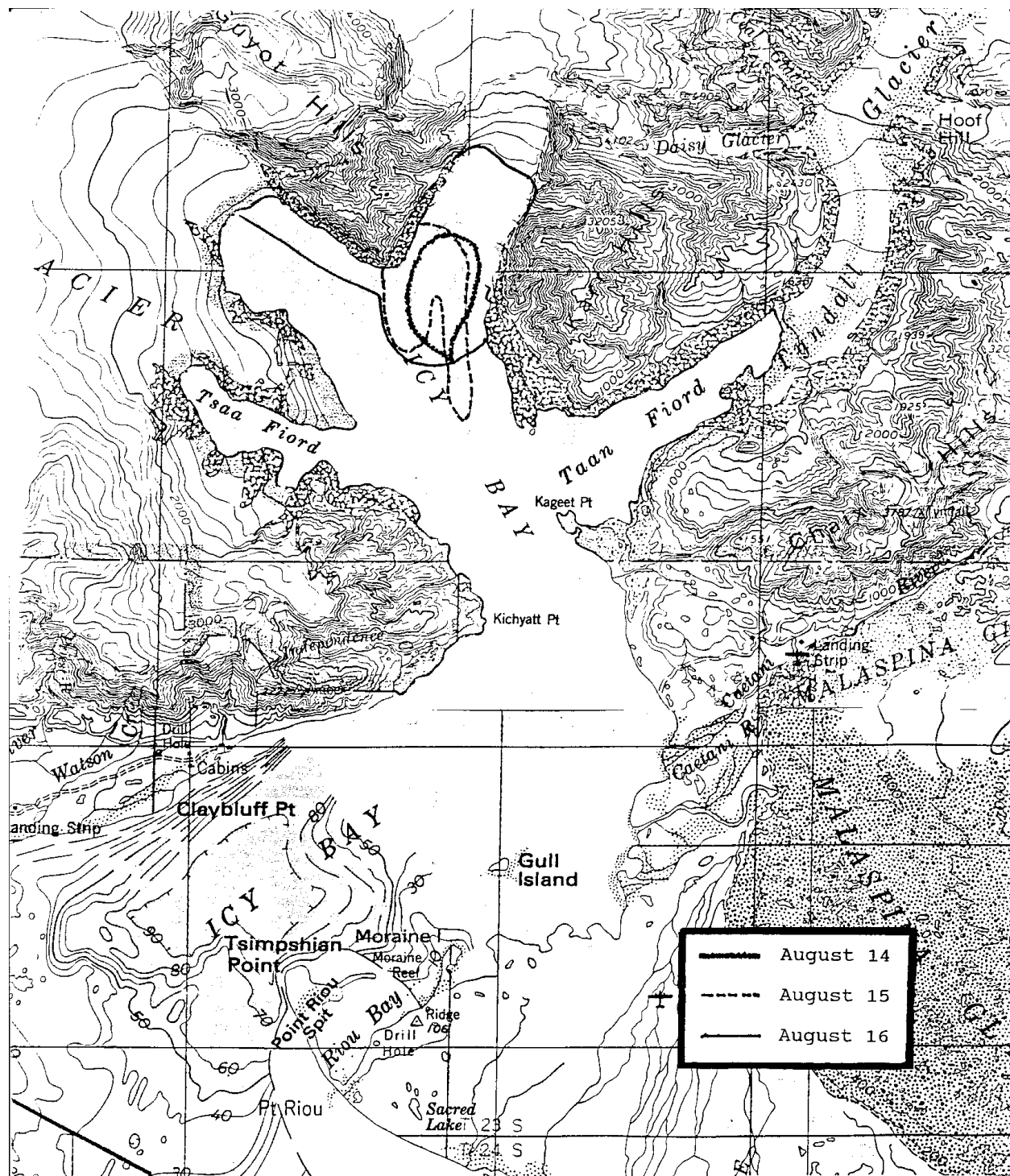


Figure 4. Location of seal aggregation in Icy Bay, August 14-16, 1994.

one line in each of two adjacent lines was randomly selected (1 or 2, 3 or 4, etc.) by tossing a coin. Further, the side of the plane the observer counted seals from was randomly chosen by the flip of a coin. The zig zag pattern in the fiords was constructed by drawing a line across the bottom of the fiord and randomly choosing a number between 1 and 10 (e.g. 1=0.1 mile) to determine a random starting point. The route that the plane flew in the fiord was chosen by using an angle that would allow for safe turning of the plane and adequate coverage of the fiord. For safety, it was recommended that a single 1/8 mile strip be flown along the perimeter of the bay to count seals hauled out on rocks, beaches, or ice along the shore. To correct for visibility bias, Kern and McDonald (in prep) recommended recording the number of seals and their distance from the airplane (1/8, 1/4, and 1/2 mile) as determined from markers along the wing struts.

We attempted to implement the methods they recommended in August 1994 but it became apparent when we reached the survey area that the methods recommended by Kern and McDonald (in prep) were not adequate due to the following factors: 1) seal distribution was highly clumped rather than evenly dispersed throughout the bay and the recommended 50% coverage did not adequately sample the main aggregation; 2) we were unable to collect distance data because of the high numbers of seals encountered in a short period of time; and 3) high winds and limited fuel supply decreased survey time and access into some fiords where seals were aggregated. During the 3 survey days, we evaluated 4 different survey procedures in an effort to develop a safe and efficient survey method that would provide adequate coverage of seals in Icy Bay.

Methods used in population surveys, August 14-16

The best minimum population estimates are obtained during the annual molt, which extends from late July to September in Glacier Bay (Mathews 1992). Molt periods in Icy Bay were assumed to be on a similar schedule and population surveys in Icy Bay were flown on August 14, 15, and 16, 1994. B. Route was the observer and M. Sharp the pilot in a piper supercub. Flights took place between 1000-1400 hours during the maximum haul out period (Calambokidis et al 1987).

1) Transects

On August 14, we attempted to follow the recommended survey methodology as closely as possible. Ice distribution was determined from a high altitude (3000 ft) pre-survey flight. The bay was stratified into high, medium, and low ice density. Pre-determined random transects were flown at 700 ft ASL in a piper supercub based on recommendations by Kern and McDonald (in prep). The observer recorded transect number or letter, number of seals per observation, and distance from plane in two categories (0-1/8 mile, 1/8-1/4 mile), into a hand held tape recorder. He was not

able to clearly observe seals $>1/4$ mile from the plane, so seals beyond this distance were not recorded. One of every two adjacent transects in the main part of the bay was randomly selected for survey, resulting in a 50% effort. All fiords, with the exception of the north Guyot and the Taan, were surveyed in a zig zag pattern as recommended. High winds and low fuel prevented surveys in north Guyot and Taan fiords, respectively. Consequently, only a small portion of one randomly selected survey line passed through the bulk of the seals which were aggregated mainly in north Guyot fiord (Fig. 4). No perimeter survey was flown since no seals were observed using this area and fuel was limited.

On August 15, seal rather than ice distribution was determined from a high altitude (3000 ft) pre-survey flight since ice density did not necessarily correlate with seal numbers. The bay was stratified into high, medium, and low seal density. We repeated the transects in the main part of the bay using the same methodology as the previous day. All fiords were circled for complete coverage at 1200 ft ASL (for safety reasons). We found that circling provided complete coverage of the fiords and was safer and easier to implement than the original zig zag pattern.

On August 16, we concentrated our efforts on counting the main aggregation since it was clear from the previous two days that 95% of the seals in Icy Bay were there (Fig. 4). We flew a random sample of 6 out of 12 parallel lines (50% coverage) spaced $1/4$ mile apart at 1200 ft ASL through the aggregation. The strut marker was recalibrated to $1/8$ mile at the beginning of the flight. The higher altitude allowed us to count seals at a slower rate than on previous days which we felt allowed more accuracy. The side of the plane seals were counted from was randomly chosen for each line by flipping a coin.

2) Minimum Count

We circled the aggregation intensively at 700 ft ASL on August 14 to obtain a minimum count. A population estimate can be calculated for the entire bay using the minimum count of the aggregation and adding the estimate from the line transect survey for areas of the bay with low seal density (e.g. everything except the large aggregation).

3) Double Count

We also attempted a double sampling survey where we did a total minimum count of the aggregation from 1200 ft. We then went back and recounted a smaller area (about $1/4$ of the total area of the aggregation) at a higher intensity to get a correction factor (Gasaway et al 1986).

4) Aerial Photography

We took 72 overlapping slide photographs on August 15 at 3000 ft

ASL to obtain a composite of the entire aggregation. We then dropped to 1000 ft ASL and took 20 additional non-overlapping photographs to get a sample of the aggregation within this composite. By calculating the average number of seals on the low altitude slides, and determining the approximate area of the low altitude slides in relation to the high altitude slides, we hoped to determine a statistically valid population estimate.

RESULTS AND DISCUSSION

Objective 1: Determine harbor seal adult/pup ratios in Icy Bay.

The proportion of harbor seal pups in Icy Bay during 1994 appeared higher than 1993 (Table 1) although sample sizes were smaller and this may have affected pup proportions. We will attempt to collect a larger data set in 1995.

Table 1. The proportions of harbor seal pups in Icy Bay, 1993-1994.

AREA	YEAR	ROLLS OF FILM	# OF ADULTS	# OF PUPS	TOTAL SEALS PHOTOGRAPHED	MEAN % PUPS	SD
Icy Bay	1993	8	916	269	1185	25	7.1
Icy Bay	1994	6	231	81	231	34	4.9

Objective 2: Determine a minimum population estimate for harbor seals in Icy Bay.

We estimated seal numbers using five different methods (Table 2).

Table 2. Population estimates of harbor seals in Icy Bay, August 14-16, 1994 using all methods.

DATE	POPULATION ESTIMATE	80% CI	90% CI	METHOD
8/14/94	1851	--	--	Strip Transect of Total Bay
8/16/94	3804	+/-850	+/-1092	Strip Transect of Aggregation Only
8/14/94	1054	--	--	Min Count of Aggregat +Strip Transct of low
8/16/94	1331	--	--	Double Count +Strip Transct of low
8/15/94	21098 ^a	+/-5899	+/-7581	Aerial photography

^a Suspect sampling bias or an unknown error in area calculation resulted in an over estimate.

1) Transects

Total Bay

A minimum population estimate for August 14 was 1864 seals based on strip transect methodology and stratification on seal density (versus ice density) (Table 3). There is no confidence limit on this estimate since only a small part of one survey line went through the high density seal aggregation. High winds prevented further sampling in the north Guyot fiord where the seals were aggregated.

Table 3. Population estimate of harbor seals in Icy Bay on August 14, 1994 based on line transect surveys.

DATE	AREA	LINE	SEAL DENSITY	MI ²	#SEALS	SEALS/ MI ²
8/14/94	ICY BAY	A	LOW	0.75	1	1.33
8/14/94	ICY BAY	G	LOW	0.53	0	0.00
8/14/94	ICY BAY	H	LOW	0.47	0	0.00
8/14/94	ICY BAY	I	LOW	0.34	0	0.00
8/14/94	ICY BAY	J	LOW	0.34	0	0.00
8/14/94	ICY BAY	5	LOW	3.01	3	1.00
8/14/94	ICY BAY	6	LOW	2.42	8	3.31
8/14/94	ICY BAY	9	LOW	0.86	0	0.00
8/14/94	ICY BAY	3A	LOW	0.08	0	0.00
8/14/94	ICY BAY	3C	LOW	1.55	0	0.00
8/14/94	ICY BAY	3B	HIGH	0.23	149	647.83
Term			Low	High	Total	
Total area			77.45	2.81	80.26	
Sampled area			7.92	0.23	8.15	
% sample			0.15	0.08	0.14	
Total survey lines			12.00	8.00	20.00	
Lines sampled			10.00	1.00	11.00	
Mean			0.56	647.83		
Variance			0.96	----	^a	

Low: $0.56 \text{ seals/mi}^2 \times 77.45 \text{ mi}^2 = 43.37$

High: $647.00 \text{ seals/mi}^2 \times 2.81 \text{ mi}^2 = \underline{1820.40}$

$1863.77 = \text{Best Estimate}$

^a n = 1 for high strata provided no variance.

The tape did not work correctly on August 15, and part of the line transect data was lost. No estimate could be calculated for August 15 using partial data from the line transect methodology.

Aggregation Only

The total estimate of seals in the large aggregation on August 16 was 3804 (90% CI+/- 1092, 80% CI+/- 850) (Table 4). The wide confidence intervals on our data suggest a greater sampling effort is needed (e.g. 100% versus 50%) in areas where seals are

aggregated.

Table 4. Population estimate of harbor seals in Icy Bay on August 16, 1994 based on transect surveys of the high density seal aggregation.

DATE	AREA	LINE	MI ²	# SEALS	SEALS/ MI ²	EST # SEALS
8/16/94	ICY BAY					
8/16/94	ICY BAY	1	0.09	27	300	3540
8/16/94	ICY BAY	2	0.34	204	600	7080
8/16/94	ICY BAY	3	0.38	112	295	3478
8/16/94	ICY BAY	4	0.61	204	334	3946
8/16/94	ICY BAY	5	0.61	206	338	3985
8/16/94	ICY BAY	6	0.5	59	118	1392
				AVG =	331.0	3904.0
				STD =	141.5	1669.2
				TOTAL AREA =		11.5
				TOTAL ESTIMATE =		3804
				90% CI+/-		1092
				80% CI+/-		850

2) Minimum Count of the Aggregation + Strip Transect for Low Density Seal Areas

A minimum count of 1011 seals was obtained on August 14 by intensively circling the large aggregation. It was difficult to differentiate boundaries within the 2.81 mi² ice pack which may have resulted in some double counting or missed seals. However, we feel we missed more seals than double counted so this should be considered a minimum count. By adding the estimate obtained from the low density transects (described above), a total estimate for Icy Bay would be 1054 seals (1011 in the aggregation + 43 in the remainder of the bay).

3) Double Count of the Aggregation + Strip Transect for Low Density Seal Areas

A minimum count of 1288 seals was obtained on August 16 by using the double count technique. As with the minimum count, it was difficult to differentiate boundaries within the aggregation. By adding the estimate obtained from the low density transects (described above), a total estimate for Icy Bay would be 1331 seals (1288 in the aggregation + 43 in the remainder of the bay).

4) Aerial Photography

Estimates from the aerial photography taken on August 15 were difficult to calculate because of the unknown area of a low altitude slide. We originally thought we could calculate the area of the low altitude slides by identifying them on a

composite from the high altitude slides but this was not possible. We then attempted to calculate the area of the low altitude slides by estimating the average length of a harbor seal (Byrden 1972) and extrapolating the number of harbor seals across the length and width of each slide to calculate the area. This resulted in a gross over estimate of 21,228 seals (90% CI+/- 7581, 80% CI+/- 5899) (Table 5).

Table 5. Population estimate of harbor seals in Icy Bay on August 15, 1994 based on aerial photography.

	MM	M	FT
Seal length (actual)	1550.000	1.550	5.084
Seal length (slide)	5.875	0.006	0.019
Projected slide length on wall	700.000	0.700	2.296
Projected slide width on wall	466.000	0.466	1.528
Scale (1 mm on slide =)	263.830	0.264	0.865
Dimensions of photo: Length	184680.800	184.681	605.753
Dimensions of photo: Width	122944.600	122.945	403.259
	M ²	KM ²	MI ²
Area of photo	22705.520	0.022705	0.008766
	AVG	STD	N
Seals per slide	25.150	28.370	27.0
		KM ²	MI ²
Estimated density		1107.580	2868.630
Total Area		19.170	7.400
Total population = 21,228 Seals			
90% CI +/- = 7,581 Seals			
80% CI +/- = 5,899 Seals			

Objective 3: Develop survey methodology for monitoring long term trends in pup proportions and population levels of harbor seals in Icy Bay

Pup Proportions

Surveys should be flown mid-day (1000-1400 hours) when the greatest number of seals are hauled out (Calambokidis et al 1987). Seal distribution will be determined from a high altitude (3000 ft) pre-survey flight. The distribution and a rough estimate of the percent of the population in each aggregation (in increments of 10) should be recorded on a base map Appendix 1. The aggregations may not necessarily total 100% if some seals are spread out in the bay. For example, if there are 3 seal aggregations, group 1 may comprise about 20%, group 2 about 40%, and group 3 about 30%, for a total of 90% in the 3 groups. The remaining 10% are singles or small groups less than 100 scattered throughout the bay.

Each aggregation that contains more than 100 seals should be sampled for pup proportions. Up to ten rolls (24 exposures per roll) of non-overlapping slide photographs (100 or 200 ASA Kodachrome film depending on light conditions) of seals hauled out on ice flows will be taken in proportion to the distribution of seals throughout the bay. Each increment of ten represents one roll of film so if 40% of the population is in one aggregation, the observer would take 4 rolls of film. Ideally, each roll will be flown along a corresponding transect. If the configuration of the aggregation limits the number of transects to less than the required rolls of film, the observer may need to decrease the increment of time between shots (e.g. every 10 seconds to every 3 seconds) so 2 rolls can be taken along one transect. Since film needs to be changed mid-transect in this situation, the pilot should note the latitude and longitude on the GPS and a compass bearing so the plane can return to that location and continue along the same transect. The observer may feel it is difficult to be sure he/she can maintain non-overlapping photographs in some aggregations but as long as the observer and pilot make a reasonable effort to keep the transects as separate as possible, the probability of over-lapping slides, especially in large aggregations, is minimal, since the area of each slide is very small (e.g. there are usually only 1-3 seals per slide).

The location of transects, the roll number, the beginning time for photographing each aggregation, and a rough estimate of the number of seals in each aggregation using the following categories (e.g. 100-500, 500-1000, 1000-2000, 2000-4000, 4000+) should also be recorded on the base map (Appendix 1). Each roll of film and mailing envelope (which is returned with the slides) should be labeled with the date and the roll number.

Seals are photographed through an open window of the plane flying at 1000 ft above sea level (ASL), using a Nikon 8008S camera with an 80-200mm zoom lens, motor drive and data back. All photographs should be shot as close to vertical as possible so the entire slide is in focus and at the fastest speed (1/1000-1/250 second). If the camera is tilted, a portion of the slide becomes blurred. E Mathews has written directions for camera use during the survey. A copy is stored with the camera in Yakutat and an additional copy is in the harbor seal files in the Resource Management Office in Glennallen.

In groups with sparse seal distribution, a photograph should be taken each time a seal is observed through the view finder. The observer should wait until the seal moves across the field of view before taking the photograph. For example, if the plane is traveling north, the observer will first view a seal at the north end of the view finder but should wait to take a photograph until the seal has reached the south end of the view finder. This helps decrease the potential bias of photographing adults with pups, which are easier to see than lone adults (E Mathews, pers

commun).

In areas of dense seal distribution, the observer should space photographs every 3-10 seconds depending on the size of the aggregation. The number of seconds between frames should be maintained on each transect but may be changed between transects if it appears the interval is too short or long for the size of the aggregation. The observer should take the first photograph at the edge of the aggregation and then begin counting "one-one thousand, two-one thousand, etc...". When the desired interval is reached, the observer should locate the first seal along the north edge of the frame, wait to photograph it until it reaches the south edge of the frame, and then begin counting again (E Mathews, pers commun).

Pup proportions will be determined by viewing the slides through a dissecting microscope for ice haul outs (and by projecting slides onto a white background for land haul outs) and classifying seals as adults, pups, or unknown (Mathews 1992). Unknown age seals are excluded from calculations. A mean pup proportion is then calculated by averaging the percent pups from each aggregation and reporting the standard deviation between aggregations.

Due to large increases in cruise ships in Disenchantment Bay, pup proportion and population surveys will also be conducted there in 1995. Methodology will be the same as for Icy Bay with the exception of surveying land haul outs. Land haul outs should be surveyed by taking slide photographs (200-400 ASA film) of the entire haul out. In many cases, 1 or 2 photographs can cover the entire haul out. If several photographs are required, slides **should be overlapping**. If more than 1 aerial pass must be made to photograph a haul out, the pilot should make a wide turn rather than a tight circle, to limit disturbance. Seals hauled out on land can be difficult to distinguish in slides. The observer should adjust the camera so there is a slight overexposure of 1/2-1 F stop (as much as possible without losing film speed) (E Mathews, pers commun). Survey dates for Disenchantment Bay should be scheduled for days when low tide occurs between 1000-1400 hours so the greatest number of seals will also be present on land haul outs.

Population Surveys

Neither the minimum count or double count of the aggregations provided methodology that was precise enough to detect trends in seal populations. We recommend these methods are discontinued in 1995.

General recommendations for all population survey methods

Seal distribution is an important factor in determining survey methodology. Distribution was highly clumped during the August

14-16, 1994 surveys but may vary within the season or between years. Sampling effort should be based on seal distribution since ice density did not correlate well with seal numbers in 1994. Seal distribution should be determined from a high altitude (3000 ft) pre-survey flight. Seals should be stratified into high, medium, and low density areas on a map each day. If seals are tightly aggregated similar to 1994, high and low categories will be sufficient. To obtain a more accurate map in areas of the bay where landmarks are limited, the pilot should track the outline of the aggregation using GPS locations. These locations can later be plotted and the area measured using a digital planimeter.

Surveys should be flown mid-day (1000-1400 hours) when the greatest number of seals are hauled out on ice flows (Calambokidis et al 1987). Survey dates for Disenchantment Bay should be scheduled for days when low tide occurs between 1000-1400 hours so the greatest number of seals will be present on land haul outs as well as ice flows.

Specific recommendations for specific survey methods

1) **Transects**

If seals are aggregated in one to several groups of >100 animals, survey lines, spaced $\frac{1}{4}$ mile apart, should be flown at 1200 ft ASL through the aggregation(s). Coverage should be 100%. A transparency with lines marked $\frac{1}{4}$ mile apart should be randomly placed over the aggregation. Direction of survey lines should be based on safety considerations and the most efficient coverage of the aggregation. Only the portion of the survey lines going through the aggregation are flown. The observer should consistently count from the same side of the plane for each aggregation. The remainder of the Bay (that is covered with ice) should be flown according to recommendations by Kern and McDonald (in prep) with the following changes. A laminated map with survey lines spaced $\frac{1}{2}$ mile apart should be used to survey the main part of the bay at 50% coverage (every other survey line with the first line, 1 or 2, being randomly chosen). The $\frac{1}{8}$ mile strip along the perimeter of Icy Bay should not be flown since seals were rarely seen in this area and fuel and time are limited. All fiords should be circled for complete coverage at 1200 ft ASL. Circling provides more complete coverage and is safer and easier to implement than the original zig zag pattern. The observer should only count out to $\frac{1}{8}$ mile since it is difficult to categorize seals beyond this distance in high density areas.

If seals are dispersed throughout Icy Bay, methods should follow the recommendations of Kern and McDonald (in prep) with the changes noted above. In Disenchantment Bay, we did not draw the $\frac{1}{2}$ mile transects on the base (laminated) map since we were unsure what the safest flight direction might be on any

particular day. A transparency with transects 1/2 mile apart should be placed over the main part of Disenchantment Bay if seals are dispersed. It should be taped onto the base map and photocopied when the observer returns to the office. Only areas with ice need to be surveyed at 50% coverage.

Surveys (and analysis) of land haul outs in Disenchantment Bay should follow the same methodology (aerial photography) as described for pup proportion surveys. Surveys (and analysis) of ice haul outs should follow the same methodology as Icy Bay population surveys.

Surveys occurring over a short period of time (e.g. 3 days) may miss cohorts of the population which haul out at different times during the season (E Mathews, pers commun). This may have occurred in 1994. Surveys in 1995 should span over a longer period. There should be a minimum of 3 surveys between August 10 - 25, with at least 2 days between surveys if possible. Additional surveys should be flown if funding and weather allow.

2) Aerial Photography

Aerial photography will also be used and should consist of at least 30 non-overlapping slides of each seal aggregation. Prior to the survey, the observer should take slides of a marked area using the same flight altitude (1000 ft ASL) and camera focal length (200 mm) that will be used in the actual survey. Three markers should be placed 200 ft apart. This will allow for later interpretation of the area of the slides. The average number of seals per slide (e.g. per known area) can then be extrapolated to the total area of the aggregation to obtain a population estimate. Despite problems with this method in 1994, we feel it holds good potential for assessing seal numbers as well as leaving a permanent data record.

LITERATURE CITED

- Allen, S.G., D.G. Ainley, G.W. Page and C.A. Ribic. 1984. The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California. Fish Bull 28:493-500.
- Byrden MM. 1972. Growth and development of marine mammals. Pages 2-79n IN: RJ Harrison, ed. Functional anatomy of marine mammals. Vol 1. Academic Press, New York. 451pp.
- Calambokidis J, BL Taylor, SD Carter, GH Steiger, PK Dawson, LD Antrim. 1987. Distribution and haul-out behavior of harbor seals in Glacier Bay, Alaska. Can J Zool 65(6): 1391-1396.
- Calambokidis J, LE Healey, and GH Steiger. 1983. Behavior of harbor seals and their reactions to vessels in Glacier Bay, Alaska. Abstract IN: Proceedings of the Fifth Biennial Conference on the Biology of Marine Mammals. 27 Nov - 1 Dec.

1983. Boston, MA.
- Gasaway WC, SD DuBois, RD Boetjie, DJ Reed, and SJ Harbo. 1986. Estimating moose population parameters from aerial surveys. Biol Paper No. 22, Univ of Alaska, Fairbanks.
- Hoover AA. 1988. Harbor Seal (Phoca vitulina). IN: Lentfer JW, ed. Selected Marine mammals of Alaska: Species accounts with research and management recommendations. Marine Mammal Commission, Wash. D.C. pp.125-157.
- Hoover-Miller AA. 1992. The Harbor Seal in Alaska. IN: Lentfer JW, ed. Revised Marine mammals of Alaska: Species accounts with research and management recommendations. Marine Mammal Commission, Wash. D.C. 78 pp.
- Kozie KD. 1993. Coastal wildlife survey - seabirds and marine mammals along the Malaspina Forelands 1992. Rep to Natl Park Serv., Glennallen, AK
- Loughlin TR. 1994. Abundance and distribution of harbor seals (Phoca vitulina richardsi) southeastern Alaska during 1993. Rep to NMFS, Seattle, WA. 42 pp.
- Loughlin TR. 1992. Abundance and distribution of harbor seals (Phoca vitulina richardsi) in Bristol Bay, Prince William Sound, and Copper River Delta during 1991. Annual Report for 1991, NMFS, MMPA Popul. Assessment Program. Office of Protected Resources, NMFS, Silver Spring, MD. 27 pp.
- Mathews EA. 1992. Harbor seal censuses in Glacier Bay National Park and Preserve: a comparison of aerial and land-based and aerial censusing. NPS Report. Glacier Bay National Park and Preserve, Gustavus, AK 99826.
- Mathews EA. 1995 (in press). Long term trends in the abundance of harbor seals (Phoca vitulina richardsi) and development of monitoring methods in Glacier Bay National Park, southeast Alaska. NPS Report. IN: D. Engstrom (ed) Proc from 3rd Glacier Bay Sci Symposium, Sept., 1993.
- Mathews EA and BP Kelly. (in press). Extreme temporal variation in harbor seal (Phoca vitulina richardsi) numbers in Glacier Bay, a glacial fiord in Southeast Alaska. Mar Mamm Sci.
- Mineral Management Service. 1990. Outer continental shelf natural gas and oil resource management comprehensive program 1992 to 1997. US Dept Inter, Mineral Management Serv, Washington, D.C.
- Pitcher KW. 1986. Assessment of Marine mammal-fishery interactions in the western Gulf of Alaska and Bering Sea: population status and trend of harbor seals in the southeastern Bering Sea. Final report to NOAA, National

Marine Mammal Lab, Seattle, WA. (Contract No.
NA-85-ABH-00029, 12pp.

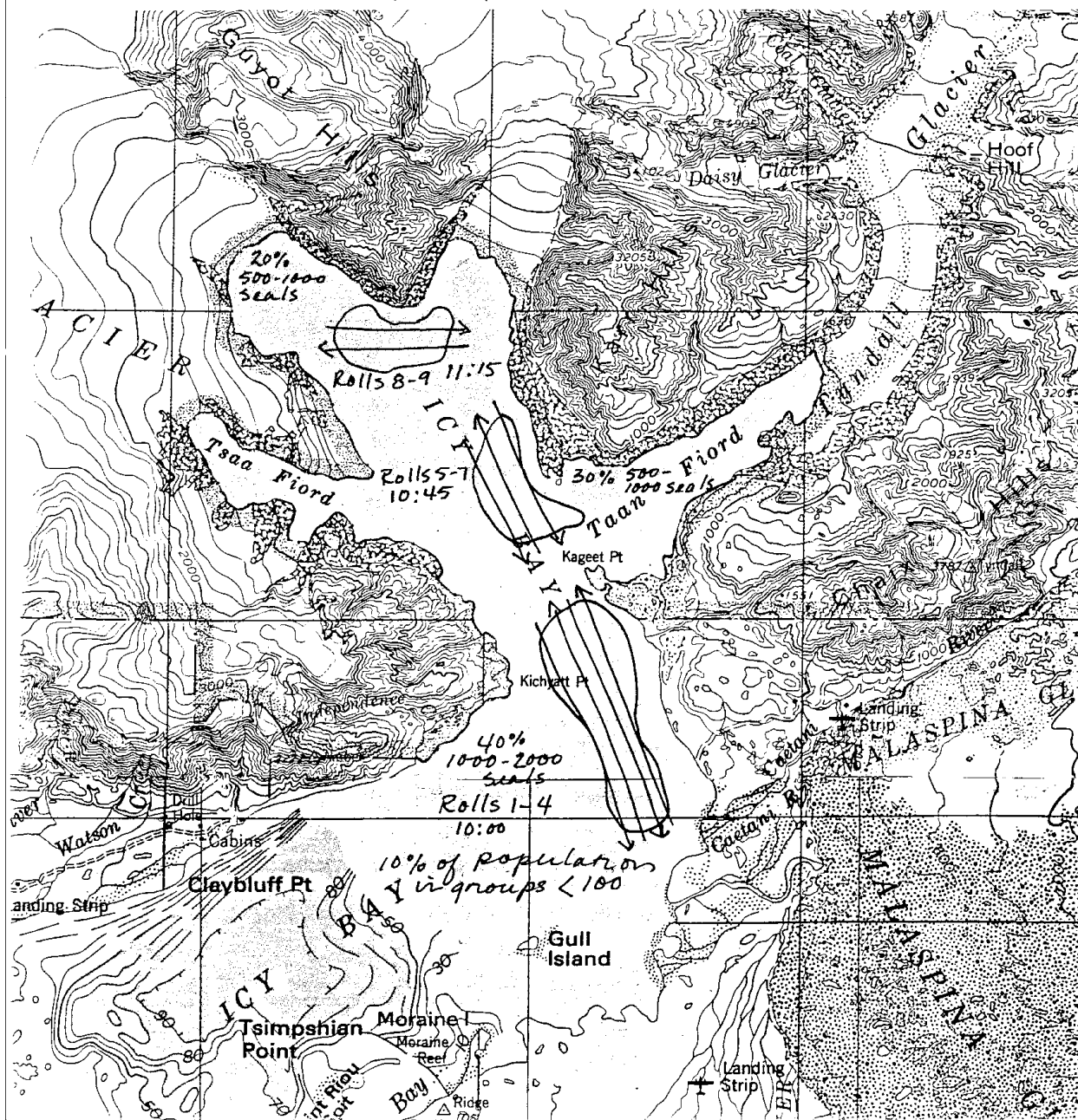
Pitcher KW. 1989. Harbor seal trend count surveys in southern
Alaska, 1988. Final report to Marine mammal commission,
Washington, D.C. Contract MM4465853-1,

Pitcher KW. 1990. Major decline in number of harbor seals
(Phoca vitulina richardsi) on Tugidak Island, Gulf of
Alaska, Mar Mamm Sci, 6(2):121-134.

Appendix 1.

Example of data recording for pupping surveys in Icy Bay.

1. Location of aggregations and percent of the total population in each aggregation (in increments of 10);
2. Location of photographic transects; 3. Roll number(s) of film for each aggregation; 4. Beginning time for photographing each aggregation; and 5. Rough estimate of the number of seals per group (100-500, 500-1000, 1000-2000, 2000-4000, 4000+).



Data Analysis

Multiple surveys (a minimum of 3 separated by at least 2 days) were recommended during the molting season to estimate the total number of "seal days". A seal day is defined as 1 seal hauled out on 1 day during the survey period that could be potentially counted if a survey were conducted.

The average number of days a seal is hauled out must be estimated to use this method. This information is currently unknown and would likely require radio-tagging animals. However, data can be collected annually and calculations corrected in the future when this data does become available.