Summary of Opportunistic Marine Mammal Sightings in Glacier Bay and Icy Strait 1994-1999

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ABSTRACT

Information on marine mammal distribution, habitat characteristics, numbers and group sizes in Glacier Bay is summarized from opportunistic sightings made by National Park Service biologists during humpback whale monitoring surveys 1994-1999. Seven marine mammal species are included: humpback whale (*Megaptera novaeangliae*), minke whale (*Balenoptera acutorostrata*), killer whale (*Orcinus orca*), sea otter (*Enhydra lutris*), Steller sea lion (*Eumetopias jubatus*), harbor porpoise (*Phocoena phocoena*), and harbor seal (*Phoca vitulina richardsii*), as well as infrequent sightings of Dall's porpoise (*Phocoenoides dalli*) and a single sighting of a gray whale (*Eschrichtius robustus*). Noticeable declines in harbor porpoise and harbor seal sightings in 1998-1999 highlight the need for regional population monitoring.

INTRODUCTION

From 1994 to the present, National Park Service (NPS) biologists have recorded all opportunistic marine mammal sightings made during humpback whale monitoring surveys in Glacier Bay and Icy Strait. Little information previously existed on the habitat characteristics, group size and distribution of most marine mammals in the Glacier Bay area although systematic studies of the distribution and abundance in Glacier Bay have been conducted for humpback whales since 1985 (Gabriele et al. 1999), sea otters since 1995 (Bodkin et al. 1999), harbor seals on land and ice haulouts throughout Glacier Bay since 1992 (Mathews and Pendleton 1999) and Steller sea lions at South Marble Island since 1994, (E. Mathews, pers. comm.). Harbor porpoise abundance in southeastern Alaska is also monitored every few years using line-transect methods (Dahlheim et. al. 1993, Waite and Hobbs 1999).

This report summarizes the geographic distribution, water depth, sea surface temperature, group size, and number of individuals observed during our opportunistic sightings of the 7 primary marine mammal species in the study area: humpback whale (*Megaptera novaeangliae*), minke whale (*Balenoptera acutorostrata*), killer whale (*Orcinus orca*), sea otter (*Enhydra lutris*), Steller sea lion (*Eumetopias jubatus*), harbor porpoise

(*Phocoena phocoena*), and harbor seal (*Phoca vitulina richardsii*). We also report on our infrequent sightings of Dall's porpoise (*Phocoenoides dalli*) and a single sighting of a gray whale (*Eschrichtius robustus*). The data summaries provided are intended primarily to be descriptive, although we provide limited interpretations of our findings. We intend that these descriptions serve as a reference to complement or inform the work of other marine scientists and resource managers concerned with the Glacier Bay marine ecosystem.

METHODS

StudyArea

All marine mammal sightings reported here were made during humpback whale monitoring surveys (see Gabriele et al. 1999 for full description of survey methodology). We used a 6 m vessel powered with a 60 hp outboard engine to conduct the surveys. We surveyed the main body of Glacier Bay (a rectangle defined by four corners: Bartlett Cove, Point Carolus, Geikie Inlet and Garforth Island) approximately 3 days per week, a different area each day (*e.g.* Lower Bay, East Side, West Side). We surveyed the upper bay intermittently when other vessels reported whale sightings. Upper bay surveys generally extended as far north as Russell Island in the West Arm and the mouth of Adams Inlet in the East Arm. Scidmore Bay and Hugh Miller Inlet were often included in Upper Bay surveys until 1996 when these waters were closed to motorized traffic (NPS 1995). We conducted Icy Strait surveys once or twice per week, with the greatest survey effort along the shoreline of Chichagof Island from Mud Bay to Burger Point. Several surveys included Lemesurier Island, Gull Cove, the mouth of Idaho Inlet and the north and west shorelines of Pleasant Island. Since whale surveys were focused on the main body of Glacier Bay and Icy Strait, sightings of marine mammals in the upper arms of Glacier Bay and the wilderness (non-motorized) waters of the Beardslee Islands are likely under-represented.

Lower Glacier Bay is crossed in transit from Bartlett Cove to all other survey locations. We control for this bias in humpback whale surveys by not stopping to photograph whales in anywhere except in the area that was targeted for a particular day's survey.

However, we recorded all opportunistic sightings of marine mammals throughout the study area. In order to compensate for over-sampling the lower bay and other areas transited on our way to whale survey areas, we recorded marine mammal sightings only on our outgoing transit from Bartlett Cove, and not on the return trip. This method samples randomly across visibility conditions and tidal cycles but is biased towards earlier times of day and towards lower sea states, as the afternoon westerly winds often degrade viewing conditions.

When searching for whales on the surveys, we piloted the vessel at varying distances from shore. However, because humpback whales are often found within one mile of shore in the study area, and because whale encounters can last for up to an hour, we likely spent more time in near-shore areas. Therefore, we had more opportunity to sight marine mammals near-shore as well, although their onshore-offshore distribution may have been more uniform than that of humpback whales.

Sighting Effort

Humpback whale monitoring effort in June, July and August of each year is relatively consistent at approximately 250-400 hours per year, although effort varies in the surrounding months (Table 1, see Gabriele and Doherty 1998 for more thorough examination of humpback whale survey effort). Therefore, the graphs and text of this report include data collected during June through August only. However, we included all available data, regardless of the month, in the maps of marine mammal geographic distribution.

Sighting Methods

We recorded all sightings of all marine mammals within 100 m of the survey vessel. The 100 m criterion was intended to ensure the accuracy of species identification and group size information; we felt that this could be guaranteed within only 100 m from our moving skiff. We occasionally approached and recorded marine mammals that were greater than 100 m from the vessel, if the sighting was notable in some way (*e.g*,. species in an area where they are not commonly sighted, or large number of animals). Along with humpback whales, we often approached and photographed minke and killer whales when they were sighted, for the purposes of individual identification. We did not begin recording harbor seal sightings until 1996, because in previous years we sighted harbor seals so often that if we had stopped to record each sighting, humpback whale monitoring effort would have been impacted.

After sighting and identifying a particular marine mammal, we recorded the sighting data on a specialized data sheet, including the location, group size, water depth, sea surface temperature and any noteworthy information on the animals' behavior. All relevant information from the datasheets was later entered into a Microsoft Access database. A group was defined as one or more individuals within several body-lengths of each other, exhibiting synchronous surfacings and a common direction of travel.

Table 1. Marine mammal search and encounter time: June - August 1994-1999

Year	Number of Hours Effort	Number of Days Effort
1994	261.0	45
1995	258.0	44
1996	374.0	58
1997	417.0	57
1998	397.0	52
1999	382.0	52

Data Analysis

Geographic distribution: We determined the latitude and longitude position of each sighting with a Global Positioning System (GPS) using the NAD27 datum. In 1992-1996, we used a Magellan NAV 1000 GPS. In 1997, we used a Trimble Pathfinder or a real-time differentially corrected Rockwell PLGR GPS. Each GPS reported the data in degrees minutes and decimal minutes; we later converted these values to decimal degrees (with 7 decimal places). We used ArcView Geographic Information System (GIS) software to plot marine mammal location data.

Habitat characteristics: We measured sea surface temperature and water depth with a Raytheon V850 dual-frequency (50 and 200 kHz) color video echo-sounder. Water depth measurements were recorded to the nearest meter and later rounded to the nearest 10 m category. The temperature sensor reported readings to the nearest 0.1^{o} C, but according to our calibrations with a scientific thermometer, it was only accurate within 1^{o} C. The temperature sensor was unreliable in 1996, so we discarded these data and did not include them in these analyses.

Group Size: In most cases, determining the number of individuals in a group was straightforward, but sometimes the observer had to estimate the number of animals, including those that might be underwater at the time the estimate was made. In the field, we recorded group size estimates using the "minimum/best/maximum" method. "Minimum" denoted that the observer saw at least this number of individuals, "best" represented the observers best guess as to how many animals were present, and "maximum" includes the largest number of individuals the observer believed could be in the group. We later extracted the integer recorded as the "best" group size because we had to reduce group size to a single number for the purposes of summarizing the data. In cases where the observer recorded "6-10" animals, for example, we used the midpoint, or 8, in this case, as the best group size. The best estimate of group size is the figure that is plotted on our graphs of group size and the number of individuals sighted.

Number of individuals sighted: We used database queries to summarize the marine mammal sightings in various ways: number of sightings, number of individuals sighted per day, month and year. The 'number of sightings' denotes how many times a species was sighted regardless of how many individuals were present at each sighting whereas the 'number of individuals sighted' is the actual number of animals sighted. We only considered the years 1996-1999 in these analyses because not all species were documented consistently prior to 1996.

We analyzed some species in greater detail than others. We didn't analyze Dall's porpoise sightings due to the extremely small sample size, nor numbers of harbor seals and sea lions that were hauled out on land and ice, because systematic counts of pinniped haulouts are being conducted by other researchers (Mathews and Pendleton 1999; E. Mathews, pers. comm.). We analyzed harbor porpoise and harbor seals in the water in detail because published and unpublished data indicate that these species may be declining in the study area (Prather et al. 1989, Mathews and Pendleton 1999). We were particularly interested in whether the number of days on which we saw no harbor seals or porpoise changed over the years. For these analyses, we omitted surveys less than 2 hours in length, to exclude incomplete surveys.

RESULTS

Humpback Whale

Humpback whales were widely distributed throughout Glacier Bay and Icy Strait, concentrating near shore but also utilizing areas farther off shore (Fig. 1a). Humpback whales were observed in a wide range of water depths, including waters greater than 100 m deep (Fig. 2a), although the majority of sightings occurred in waters 20-60 m deep (see also Gabriele et al. 1999 for inter-annual differences). Sea surface temperatures near humpbacks typically ranged from 8-10 ^{o} C (Fig 3a). Humpback whales were most often solitary, but also occurred frequently in pairs, and much less commonly in groups containing 5 to 10 whales (Fig. 4a). The number of humpback whales in the study area has increased slightly each year since 1996 (Table2, Fig. 5), as part of a gradual increase over the 1985-1999 period (Gabriele et al. 1999). Additional information on humpback whale distribution, abundance, behavior and feeding ecology from 1985-1999 is available in annual National Park Service whale monitoring reports.

Minke Whale

The geographic distribution of minke whales concentrated in Sitakaday Narrows and in central Icy Strait (Fig 1b). Only one minke whale sighting occurred north of Strawberry Island, although we have received anecdotal reports of minke whales in the upper West Arm. Over 60% of minke whale sightings occurred in water 30-50 m deep (Fig. 2b), with sea surface temperatures 5-8 ^{o} C, slightly cooler waters than most other species (Fig 3). Minke whales most often traveled alone and were not seen in groups larger than 2 animals (Fig 4b). The number of individual minke whales sighted has remained fairly consistent with 8 minke whales sighted in 1996, 1997, and 1999, and 5 sighted in 1998 (Table2, Fig. 5).

Table 2. **Number of marine mammal sightings per year 1996-1999**

Species	**1996**	**1997**	**1998**	**1999**	**Total Number of Individuals Sighted (# of sightings)**
Humpback Whale *	77 (244)	82 (252)	92 (359)	104 (307)	355 (1162)
Minke Whale	8 (8)	8 (7)	5 (5)	8 (7)	29 (27)
Killer Whale	50 (9)	36 (8)	58 (11)	88 (14)	232 (42)
Harbor Porpoise	378 (218)	359 (226)	137 (92)	183 (112)	1057 (648)
Dall's Porpoise	0	3 (1)	0	12 (2)	15 (3)
Steller Sea Lion	68 (38)	83 (41)	96 (46)	128 (37)	375 (162)
Harbor Seal	203 (174)	230 (130)	74 (70)	60 (49)	567 (423)
Sea Otter	340 (91)	433 (107)	497 (113)	496 (150)	1766 (461)

Note: Each cell contains the number of individual animals (number of sightings in parentheses) between June 1 and August 31 of each year 1996-1999. *Unlike data for other species, the number of individual humpback whales denotes the number of different individuals that were photographically identified, and the number of humpback whale sightings (in parentheses) reflects the number of times we approached whales for photographic identification. For all other species, the "number of individuals" does not account for the fact that some of the animals were likely sighted (counted) on more than one occasion.

Killer Whale

Killer whales were often sighted in the offshore waters of Glacier Bay and Icy Strait but were also occasionally sighted near shore (Fig. 1c). Killer whales were sighted in a variety of water depths, but most often in depths greater than 100 m (Fig. 2c). They were most often found in water ranging in temperatures from 8-10 ^{o} C (Fig. 3c), and group size ranging from 1-30 individuals (Fig. 4c). Using the group size data with data on photographically-identified individuals, we determined that larger groups of killer whales (11-30) tended to be resident pods, while mid-size groups (5-10) were most often transient pods. Solitary animals were almost evenly divided between resident and transient types. The number of killer whales sighted was variable, ranging from 36-58 animals in 1996-1998 and increasing to 88 whales in 1999, due to the presence of a large pod (20-25 animals) of resident-type killer whales that frequented the study area.

Gray Whale

Gray whales are common along the Gulf of Alaska coast, but rare in the inside waters of southeastern Alaska (Braham 1984). One gray whale was sighted in Bartlett Cove in June 16, 1998. In mid-afternoon, several National Park Service staff who were on the park's main dock in Bartlett Cove reported that a gray whale surfaced next to the dock and then swam underneath it, heading out of the cove. Three of these individuals estimated the whale’s body length to be 30-35 feet. Due to the height of the dock, they had obtained an excellent view of the entire length of the animal. There were no further sightings of this whale reported. Because this was the single sighting of a gray whale, no further analyses were performed regarding its distribution, habitat characteristics or group size.

Dall’s Porpoise

Dall’s porpoise have been sighted in the study area 6 times since 1994, exclusively in Icy Strait (Fig. 1d). We documented the 3 Dall’s porpoise within the June through August study period in both shallow water (10 m) and deeper water (90-140 m), (Fig. 2d). Sea surface temperatures at these sightings ranged from 10 -12 ^{o}C (Fig 3d). Group sizes ranged from 3 to 9 animals (Fig 4d).

Sea Otter

Sea otters were distributed mostly in the near-shore areas of the Lower Bay, but appear to be moving further into the near-shore and mid-channel waters of the mid-Bay (Beardslee to Marble Islands) each year (Fig. 1e). We found the densest concentrations of sea otters near Flapjack Island, at the mouth of Idaho Inlet and along the coastline south of Berg Bay. Sea otters were found in a wide range of water depths, especially prevalent in shallower water of 20-70 m (Fig. 2e). The majority of sea otters we saw were in waters ranging from 8-9 ^{o}C (Fig. 3e), and in group sizes of 1 or 2 animals, although rafts of otters sometimes contained up to 50 animals (Fig. 4e). The numbers of sea otters we sighted increased from 340 in 1996 to almost 400 in 1998 and 1999 (Table2, Fig. 5) with a concomitant increase in the total number of sea otter sightings (Table 2).

Steller Sea Lion

Steller sea lions appeared to congregate near Point Adolphus, Flapjack Island, the mouth of the East Arm and, predictably, near their non-breeding haulout at South Marble Island (Fig. 1f). We did not systematically count hauled out sea lions on South Marble, although count data from this haulout are available (E. Mathews, pers. comm.). Aside from these concentrations, sea lions were distributed in both near-shore and offshore waters throughout the main body of Glacier Bay. Sea lion sightings were rare in Bartlett Cove, although one immature-sized sea lion hauled out on the Bartlett Cove dock for 10 hours or more in September 1999 (L. Dzinich, pers. comm.). Sea lions were scarce in the mouth of the Bay south of Sitakaday Narrows. We sighted sea lions in a wide range of water depths, but predominantly in waters greater than 100 m deep (Fig. 2f), a distribution quite similar to that of humpback whales (Fig. 2a).

Sea lions were most often in 8-10 ^{o}C water (Fig. 3f), and were found most often in groups of 1-2 animals when in the water, and in groups of 31-50 animals when hauled out (Fig. 4f). Almost all sightings of groups containing 10 or more animals in the water occurred near the South Marble Island haulout or near Point Adolphus. The number of Steller sea lions sightings remained consistent at roughly 40 sightings per year, although the number of sea lions sighted has increased each year, for a total of 88% between 1996 (n=68) and 1999 (n=128) (Table2, Fig. 5). Four sightings of greater than 10 animals near South Marble Island in 1999 contributed substantially to this trend.

In late October 1995, we observed a sea lion repeatedly attacking and eviscerating a lone harbor seal in Sitakaday Narrows. In 1997 and 1998 there were a total of 4 additional reports of sea lions preying upon harbor seals (E. Mathews, pers. comm.).

Harbor Porpoise

Harbor porpoise were distributed throughout lower to mid Glacier Bay and Icy Strait (Fig. 1g). We sighted harbor porpoise most often in Sitakaday Narrows, near Point Gustavus or the 32 m shoal south of Willoughby Island, all areas of strong tidal current. We found harbor porpoise in a wide range of water depths, most often 50-70 m, but also including waters greater than 100 m (Fig. 2g), and in water temperatures from 8-10 ^{o}C (Fig. 3g), and in group sizes of 1 or 2 animals (Fig. 4g).

The number of individual harbor porpoise sighted decreased from 378 in 1996 to 183 in 1999, with a low of 137 in 1998 (Table 2, Fig. 5). The greatest drop in numbers of individuals sighted occurred between 1997 (359 porpoise) and 1998 (137 porpoise), a 62% decrease. The number of harbor porpoise sightings decreased roughly 60% between these 2 years as well. The number of harbor porpoises sighted increased slightly from 1998 to 1999, but numbers were still much lower than in 1996 or 1997. The number of days on which no harbor porpoise were sighted was greater in 1998 and 1999 (17 and 20) than in 1996 and 1997 (11 and 5). The number of days on which we sighted more than 10 harbor porpoise was lower in 1998 and 1999 (0 and 7) than in 1996 and 1997 (15 and 12) (Fig. 6). The monthly distributions of harbor porpoise sightings were similar in 1996 and 1997, however 1998 was overall lower, and 1999 had notably fewer July sightings (Fig. 7). Annual maps of harbor porpoise distribution 1994-1999 (Figs. 10a –10f) show that harbor porpoise numbers declined somewhat uniformly throughout the study area, although perhaps their prevalence in the Beardslee Entrance and all areas north of Strawberry Island declined more than other areas in later years.

Harbor Seal

Harbor seals tended to congregate in the near-shore waters of the main body of Glacier Bay and Icy Strait (Fig. 1h). We sighted harbor seals in a large range of water depths, mostly from 20-50 m, but also in water greater than 100 m (Fig. 2h). Like most other species, we typically found them in waters ranging from 8-10 ^{o} C (Fig. 3h). And like sea lions, we most often saw solitary harbor seals in the water, but hauled out seals were commonly in larger groups containing 5-50 animals (Fig. 4h).

The number of harbor seals sighted declined from 203 in 1996 to 60 in 1999 (Table 2, Fig. 5). Similar to harbor porpoise numbers (Fig. 5), the greatest decline occurred between 1997 (230 seals) and 1998 (74 seals), a 68% decrease. The decrease in number of individuals sighted (68%) was greater than the percent decrease in number of sightings (46%), suggesting that in 1998 harbor seals tended to be sighted alone or in smaller groups than in 1997.

We investigated the number of harbor seals sighted per month because one might expect harbor seals to be sighted more frequently in July, outside the main pupping (June) and molting (August) seasons when seals are more often hauled out on land or ice. In 1996 and 1997 seal numbers peaked in July (Fig. 9). In 1998 and 1999, seal sightings were low in June (<30) and failed to rise in July as they had in 1996 and 1997. We also investigated the number of seals sighted per day. In 1998 and 1999, there were almost twice as many days with no harbor seal sightings (20 and 23 days, respectively) as in 1996 and 1997 (12 and 14 days, respectively) (Figure 8). More than 10 harbor seals were sighted on 7 and 6 days in 1996 and 1997, respectively, but no days in 1998 or 1999. Harbor seal sighting density along the coast from Point Gustavus to the southwestern edge of the Beardslee Islands was particularly high in 1996 (Fig. 11a), with far fewer seal sightings along this coast in 1997, 1998, and 1999 (Fig. 11b-11d). In 1996 and 1997, we sighted many harbor seals near Point Adolphus, in contrast with subsequent years (Fig. 11).

DISCUSSION

Geographic Distribution

Despite the potential bias toward near-shore survey effort, the geographic distributions of various species were discernable from each other (Fig. 1). All species, with the exception of killer whales and Steller sea lions, tended to be sighted most often in near-shore waters. The geographic distribution of all the species we studied is probably best explained by feeding strategies. For the acoustically-oriented killer whale, for example, we speculate that their apparent preference for offshore waters may indicate that the acoustic characteristics of deep water are advantageous for staying in contact with one another and for passively listening for the vocalizations of their prey, some of which are marine mammals. The offshore preference of transient-type killer whales may be due, in part, to the distribution of one of their main prey species, the Steller sea lion (Fig.1f).

Harbor porpoises are believed to affiliate with tidally-induced internal waves (which generate visible surface slicks) because of the prey-concentrating characteristics of these oceanographic features (Silber and Smultea 1990). The tendency we found for harbor porpoise to be sighted in areas of high tidal current is consistent with Silber and Smultea's (1990) hypothesis, although the prey items that harbor porpoise consume here might be slightly different from the market squid (*Loligo opalescen*s), northern anchovy (*Engraulis mordax*), cusk eel (*Chilara taylori*) and rockfishes (*Sebastes* spp.) that were the primary prey in the Monterey Bay study area (Sekiguchi 1995). However, in the anomalous gray whale sighting, there was no evidence of feeding. This individual's body size suggests that it was immature, and we interpret its visit to Bartlett Cove as either a mistake or perhaps a purposeful exploratory search for unoccupied habitat. For all species, there are undoubtedly many factors that influence their geographic distribution, including prey preferences, avoiding predation, locations of upwelling and tidal forces, as well as the physical attributes described below.

Habitat Characteristics

Each marine mammal species appeared to inhabit a wide range of water depths. Only the minke whale and Dall's porpoise (although the sample size is quite small) sightings suggested a preference for particular depths (Fig. 2). Additional insight into habitat use could be gained by segmenting a species' use of particular depths for specific activities, such as resting, feeding, and travelling.

We observed a wide variety of sea surface temperatures (5 to 17 ^{o}C) although temperatures above 14 ^{o}C were uncommon. We do not know what proportion of available waters exhibit a particular sea surface temperature, although there are some raw oceanographic data available (P. Hooge, pers. comm.). However, most marine mammal sightings occurred in water ranging in temperature from 8-10 ^{o}C. Minke whales were sighted more often in cooler water compared to other species, which suggests that they or their prey favor areas with a cold water source, perhaps due to oceanographic upwelling. Seasonal changes in water temperature do not seem to account for this observation because all the data in Fig. 3 were collected in June – August, moreover the timing of minke whale sightings within that time window seems equivalent to other species. A larger sample size with additional effort in characterizing the oceanographic features of minke whale habitat would be needed to elucidate this issue.

Group Size

Most marine mammals were predominantly solitary, with the exception of killer whales, hauled out sea lions and hauled out harbor seals, which were more often seen in groups. Humpback whale foraging strategies for particular prey species at particular locations seem to account for the relatively rare, large, stable groups of 5 or more whales that occur in Bartlett Cove and Point Adolphus (Perry et al. 1985, Gabriele et al. 1999). Our group size descriptions are valid given our definition of which animals are 'together', but it is notable that marine mammals in acoustic contact with one another over distances much greater than several body lengths may be coordinating their movements and behaving as a 'group'.

Number of Individuals

Numbers of opportunistic sightings of all species appear to be stable or increasing within the study area, with the exception of harbor porpoise and harbor seals. Harbor porpoise and harbor seal numbers in Glacier Bay appear to have declined greatly since 1997. Keeping in mind the limitations of using opportunistic data to evaluate numbers of animals, we offer the following interpretations of our results.

The data on humpback whale numbers was derived directly from systematic population monitoring efforts (Gabriele et al. 1999) and therefore corroborates the existence of local population increase. The increasing trend in the local humpback whale population is likely related to an increasing trend in the size of the North Pacific humpback whale population (Calambokidis et al. 1997) although an updated population estimate for the southeastern Alaska feeding herd (Straley and Gabriele 1995) is needed to place local observations in a regional perspective.

Although we have some evidence that individual minke whales return annually to the Glacier Bay area (NPS unpubl. data), we do not know how many different individuals use the study area. Efforts to catalog individual killer whales (Dahlheim et al. 1997, Ford and Ellis 1999, Matkin et al. 1999) and document their movements will help us to interpret annual changes in the composition of the local killer whale population. Our findings on sea otters are consistent with the results of standardized aerial surveys indicating that the numbers of sea otters occupying Glacier Bay has increased rapidly since 1995 (Bodkin et al. 1999). We believe that our sea lion sightings increased in 1999 because our survey effort near South Marble Island was higher than usual due to an aggregation of humpback whales there. However, to determine whether the number of sea lions might genuinely be increasing, the NPS should examine existing data on the daily number of sea lions observed at the South Marble haulout.

The declining number of opportunistic harbor seal sightings is consistent with the 11.4 % and 5.4% declines documented at terrestrial and glacial ice haulouts, respectively, in Glacier Bay from 1992-1998 (Mathews and Pendleton 1999). The glacial ice haulout in

Johns Hopkins Inlet, comprised of over 4,000 individuals, constitutes the largest harbor seal breeding colony remaining in Alaska (Mathews and Pendleton 1999).

Our opportunistic data also strongly suggest a decrease in harbor porpoise in the study area. The most recent population estimate for the southeastern Alaska stock of harbor porpoise is approximately 10,000 individuals (Waite and Hobbs 1999). Line transect studies conducted in 1991-1993 found the mouth of Glacier Bay to support some of the highest densities of harbor porpoise in southeastern Alaska (Dahlheim et al. 1993, Waite and Hobbs 1998).

The apparent importance of the Glacier Bay area to both harbor porpoise and harbor seals highlights the need to better understand the population changes that we observed. The ultimate causes of the observed changes in numbers of both species are almost certainly attributable to emigration, increased mortality or reduced birth rates. However, the proximate causes of these declines could be further divided into factors such as human disturbance, shifts in prey distribution or quality, decreased availability of suitable habitat, or a specific source of mortality.

Emigration: If emigration is the cause of the observed declines in harbor porpoise and harbor seals, we would first need to determine whether harbor porpoise and harbor seals have moved into unsurveyed waters within the study area or emigrated out of the Glacier Bay – Icy Strait entirely. The decline we observed using vessel-based sightings of seals in the water corresponds with the results of the more comprehensive and systematic aerial and shore-based counts of harbor seals, suggesting that there are either fewer harbor seals or they have emigrated out of the study area. For harbor porpoise, we have insufficient data to determine whether animals have moved to unsurveyed areas within the study area.

Additionally, region-wide surveys would be necessary to distinguish between population declines and emigration outside of the study area. The last National Marine Fisheries Service (NMFS) harbor porpoise surveys of southeastern Alaska were conducted in 1997 (Waite and Hobbs 1999), with the next set of surveys scheduled for summer 2002 (J.

Waite, pers. comm.). The NMFS also conducts harbor seal surveys statewide, covering southeastern Alaska every 3 to 4 years (Loughlin 1994), and the Alaska Department of Fish and Game has conducted annual surveys of two southeastern Alaska trend sites (Ketchikan and Sitka) every year since 1995 (Lewis et al. 1996). Comparison of Glacier Bay data with these region-wide efforts should be undertaken, as data become available.

Prey availability: The diet of harbor porpoises and harbor seals overlaps with the main prey species of humpback whales (herring, capelin, sand lance, pollock and euphausiids), and Steller seal lions (pollock, herring, and flatfish) in southeastern Alaska. If prey availability were responsible for the decline in harbor seal and porpoise numbers, humpback whale and sea lion sightings might be expected to have declined or shifted geographically as well. However, since different species use various prey capture strategies, the density of prey schools and their location in the water column could affect each predator species differently (Piatt et al. 1989). Conversely, it is also possible that competition for prey is responsible for the changes in the relative abundance of these four predators.

If the higher surface water temperatures during the El Nino Southern Oscillation in 1998-1999 caused redistribution of important harbor seal and harbor porpoise prey, the observed changes might reverse when oceanic conditions return to those more favorable for these species. This result might be analogous to the ecosystem effects of larger scale changes in predators and prey in the Gulf of Alaska (Anderson and Piatt 1999). Multi-year studies now being conducted on the distribution and abundance of forage fish and their predators may enlighten our present discussion of harbor porpoise and harbor seal numbers (Piatt et al. in prep., Bodkin et al., in prep.).

Human Disturbance: Human disturbance of harbor seals has been documented on land and ice haulouts in Glacier Bay (Mathews 1994; Mathews 1997; Lewis and Mathews 2000) and is thought to be a factor in the harbor seal declines observed at terrestrial haulouts (Mathews and Pendleton 1999). Harbor seals often flee into the water when kayaks or other vessels approach seal haulouts (on land or on floating icebergs) to view scenery, to land on an appealing beach, or to view seals (Lewis and Mathews 2000). Repeated disturbances of seals from their haulouts increase chances of mother/pup separation and may be detrimental to the overall condition of individuals (Streveler 1979; Calambokidis 1987; Mathews 1997).

Vessel disturbance is one of several habitat characteristics that may be a factor in the observed decline in harbor porpoise numbers. Harbor porpoise in Glacier Bay have been observed to avoid motor vessels (Taylor and Dawson 1984). Porpoise probably avoided our survey vessel as well, but would have avoided it equally throughout the study period (1993-1999), and not just beginning in 1998. The Park's Vessel Management Plan (NPS 1995), implemented a 28% increase in Glacier Bay vessel traffic beginning in 1996. Because harbor porpoise frequent lower Glacier Bay where all vessels must pass, the probability of porpoise coming into contact with vessels during the summer months is high.

Sources of mortality: Marked declines in harbor porpoise populations in the North Atlantic, Puget Sound and the Baltic Sea have been linked with many factors, including entanglement in fishing nets, exposure to pollutants such as polychlorinated biphenyls (PCBs), disturbance from motor boat traffic, declines in food, and entrapment under ice (Dawson and Taylor 1979, Woodley and Read 1991). Mortality of harbor porpoise due to entanglement salmon drift gill nets has been documented in Alaska (Hill *et al.* 1997), although gill nets are very uncommon in the study area. We have no evidence of an increase in the potential sources of harbor porpoise mortality in the study area, nor any data indicating increased harbor porpoise mortality.

Known sources of harbor seal mortality include hunting and interactions with commercial fisheries. Harbor seal take in gillnets has been documented in southeastern Alaska (Hill et al. 1997), but this type of fishery is rare in the study area. From 1,500 to 1,600 harbor seals were taken by native subsistence hunters in southeastern Alaska between 1992 and 1998 (Wolfe 1999). There is no indication that the yearly subsistence take of harbor seals has changed significantly from 1992-1998, although harbor seal takes in southeastern Alaska were greatest (over 1,800 seals per year) in 1995 and 1996 (Wolfe 1999).

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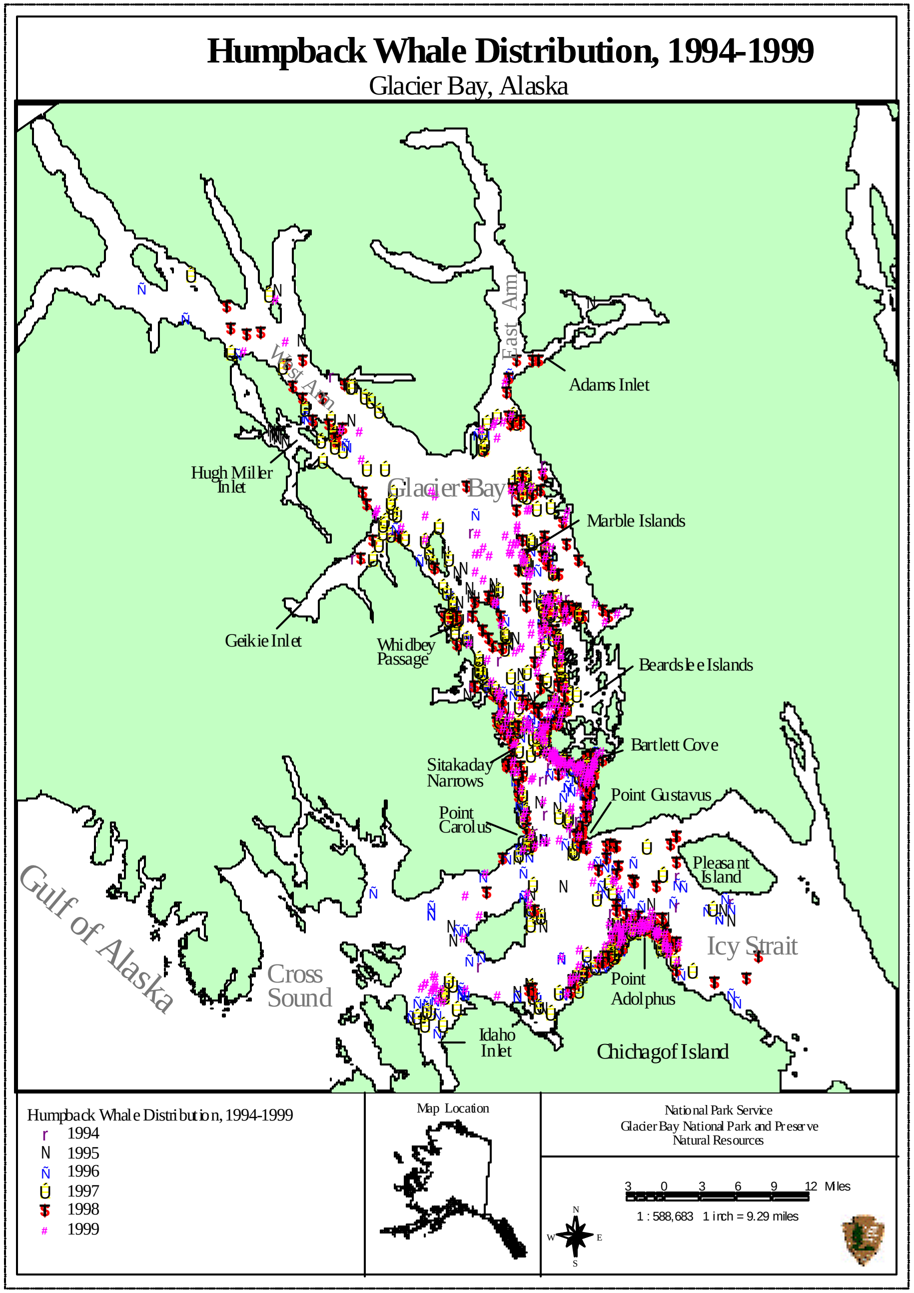

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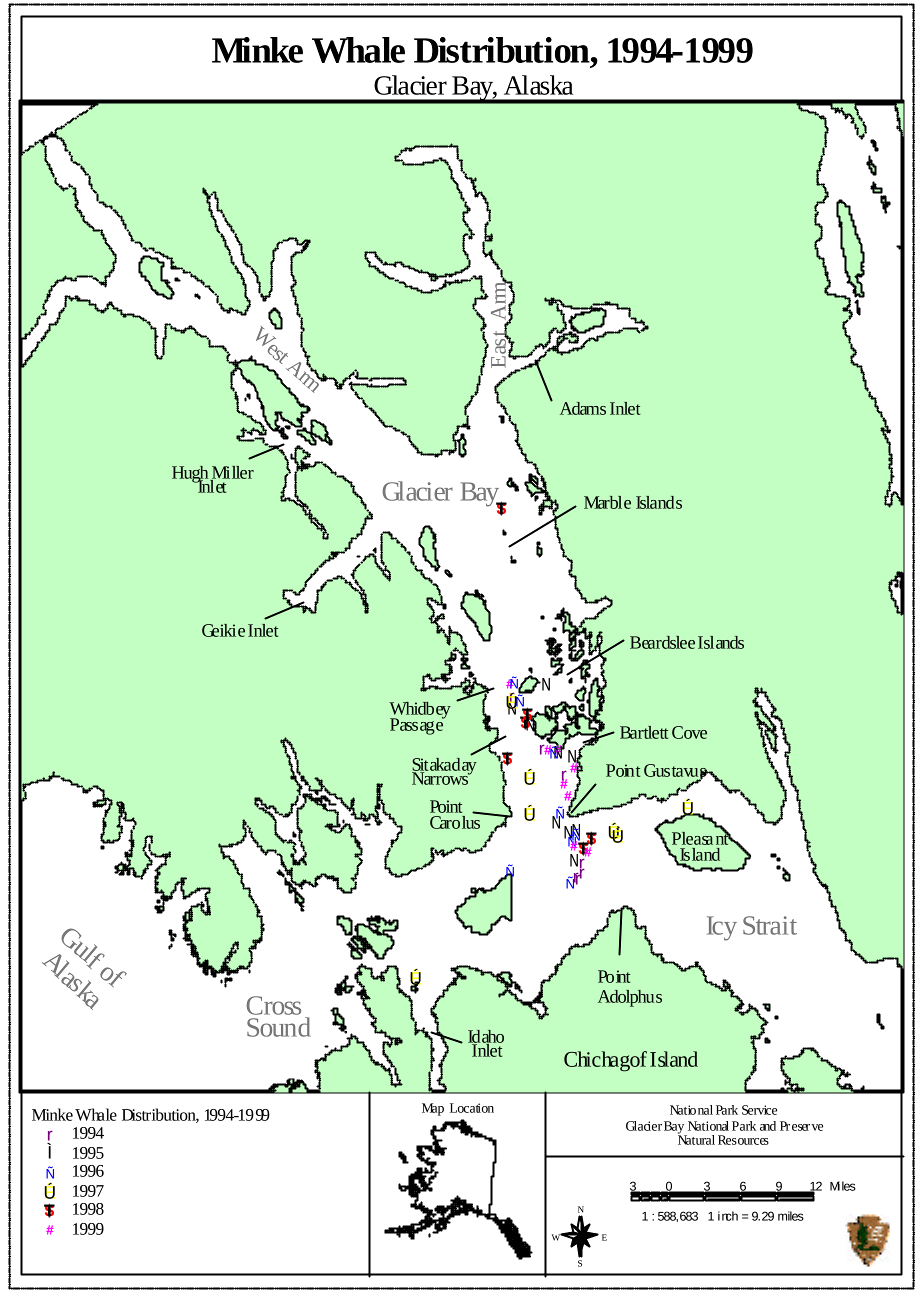

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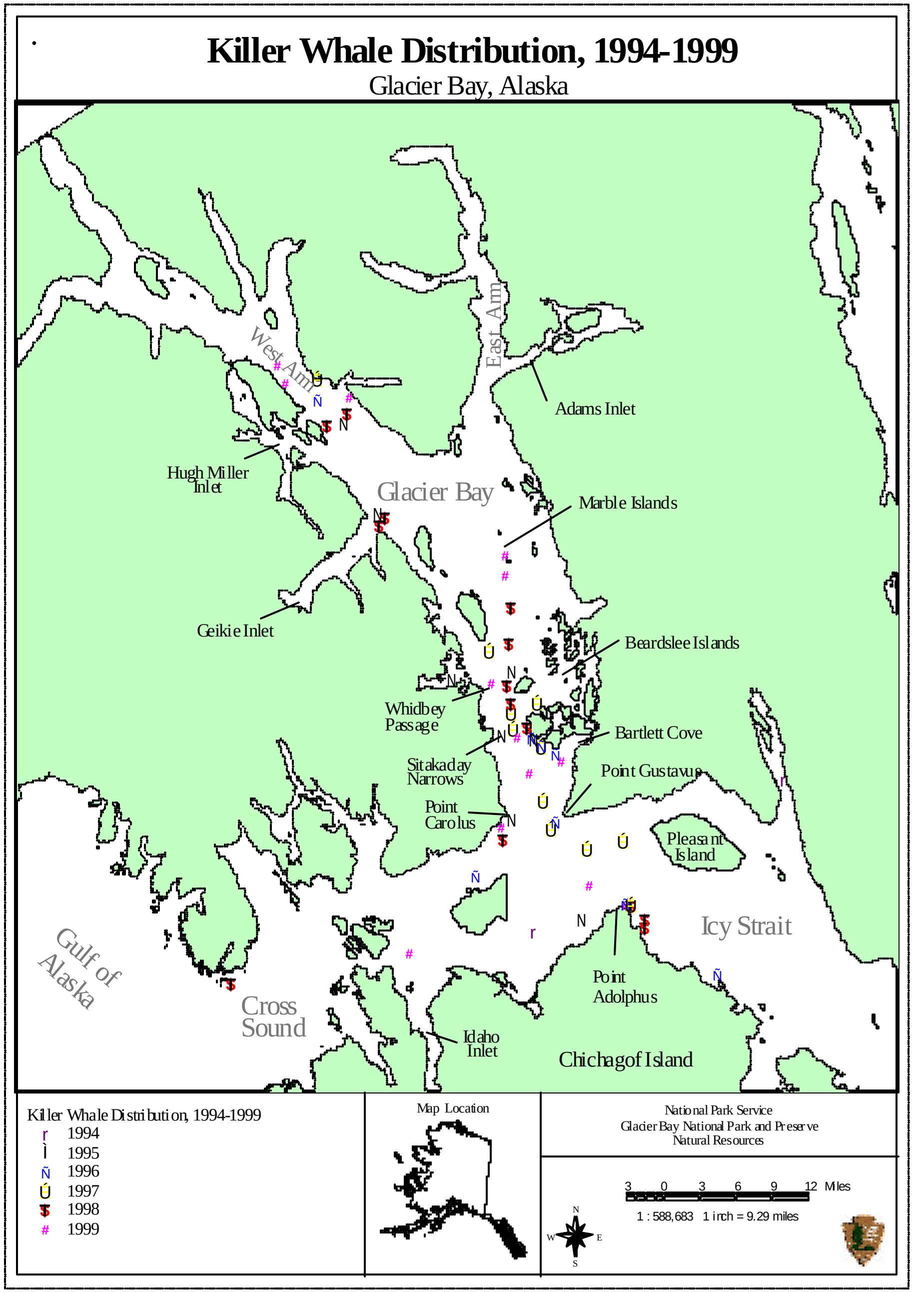

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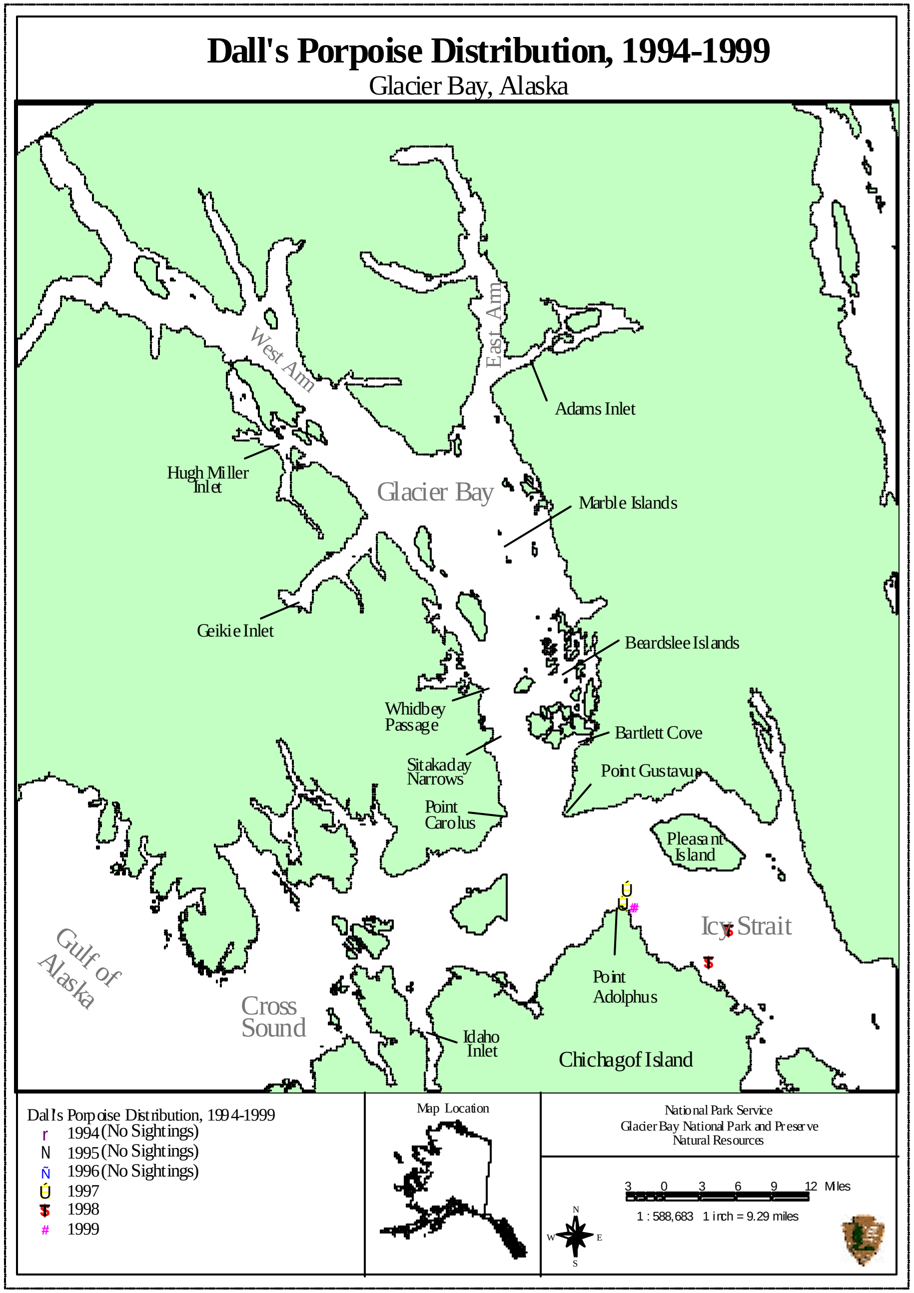

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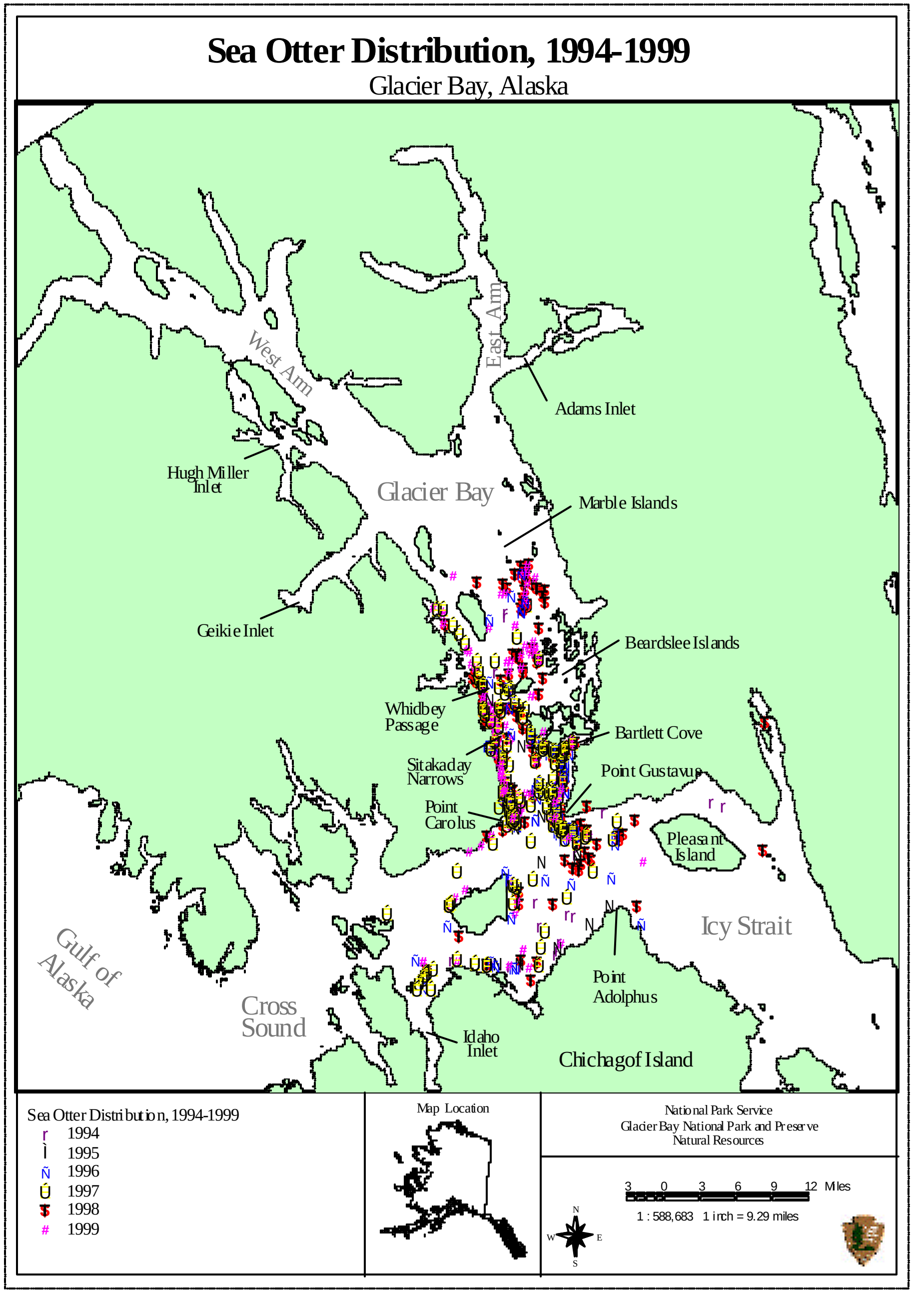

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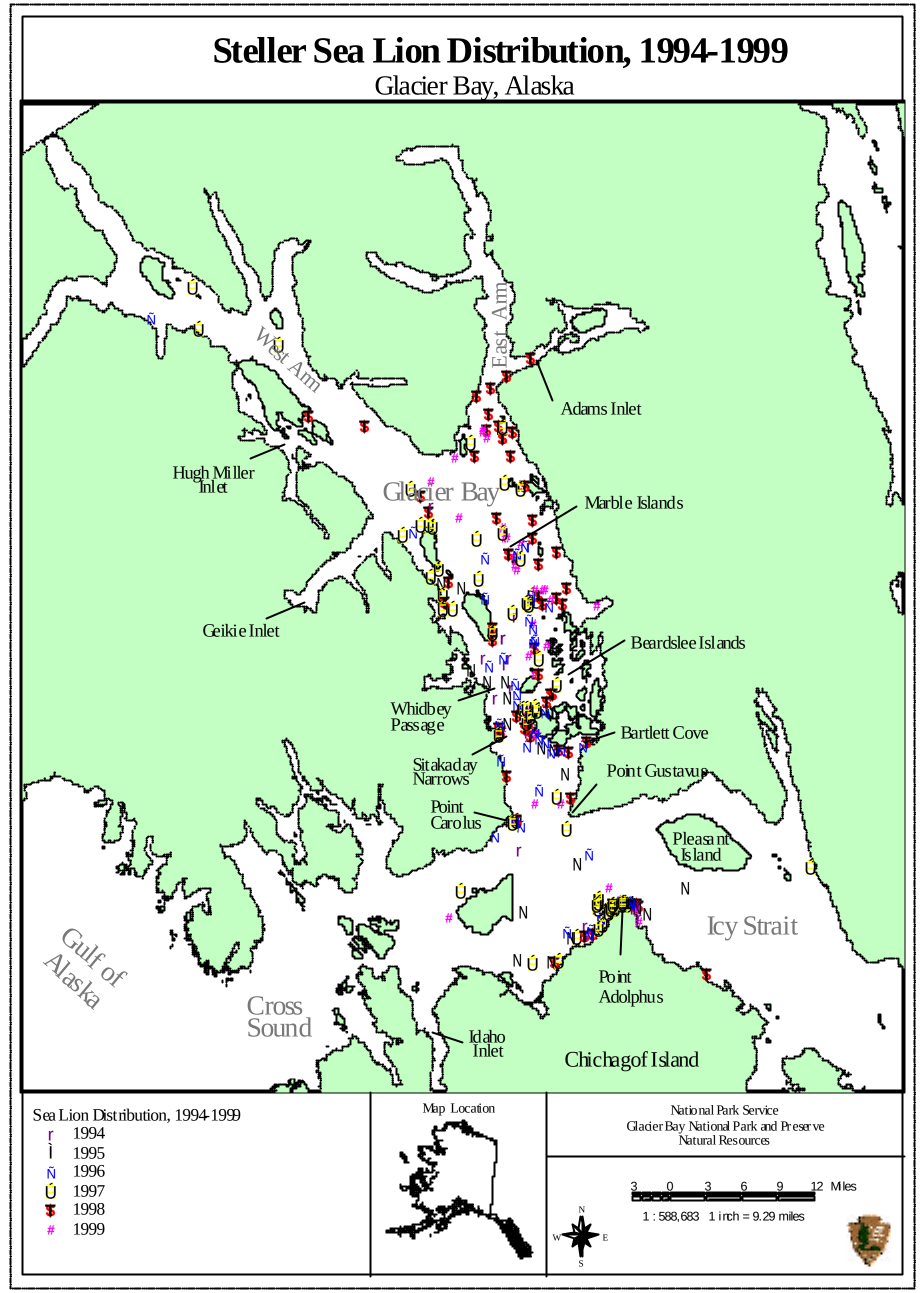

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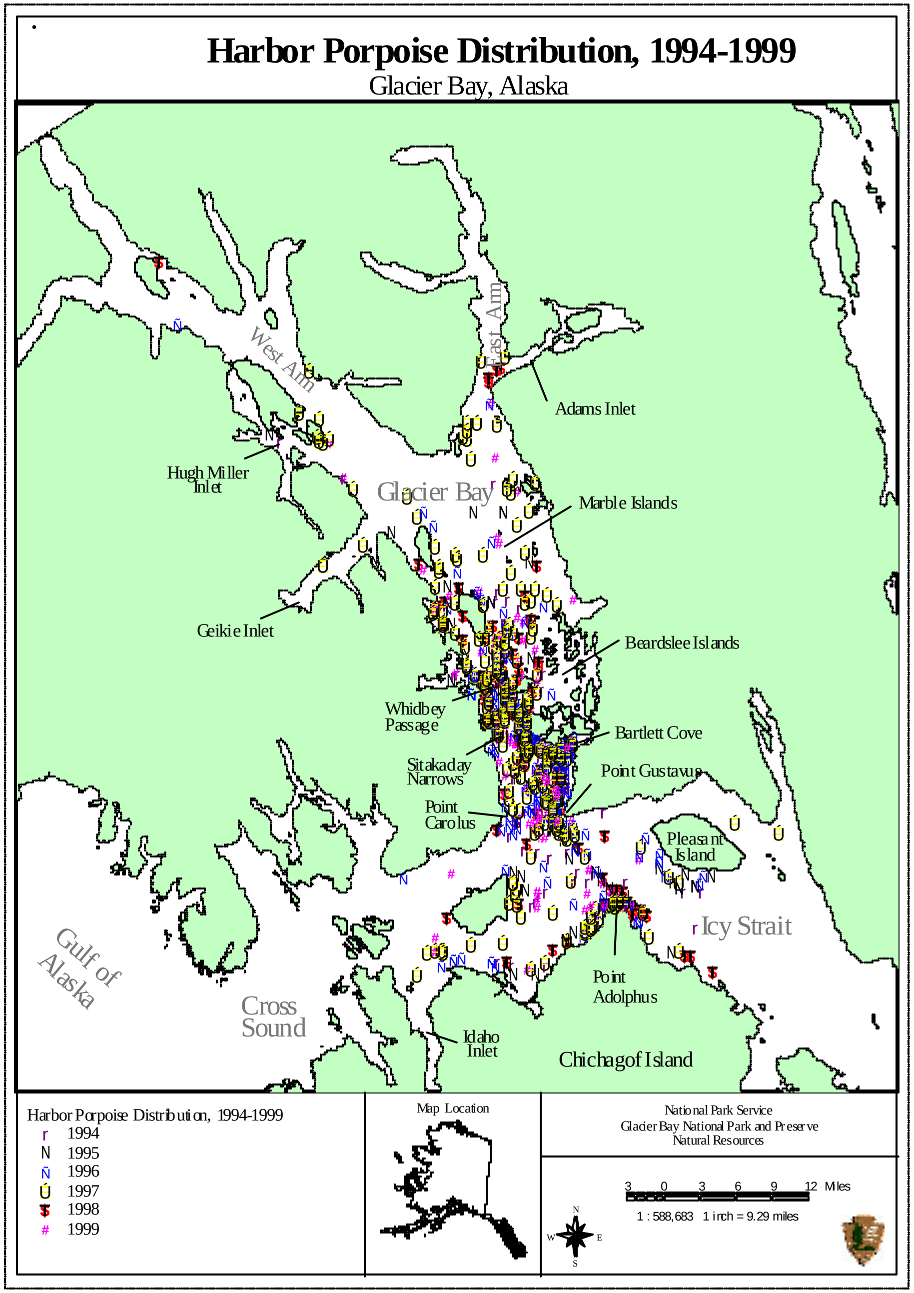

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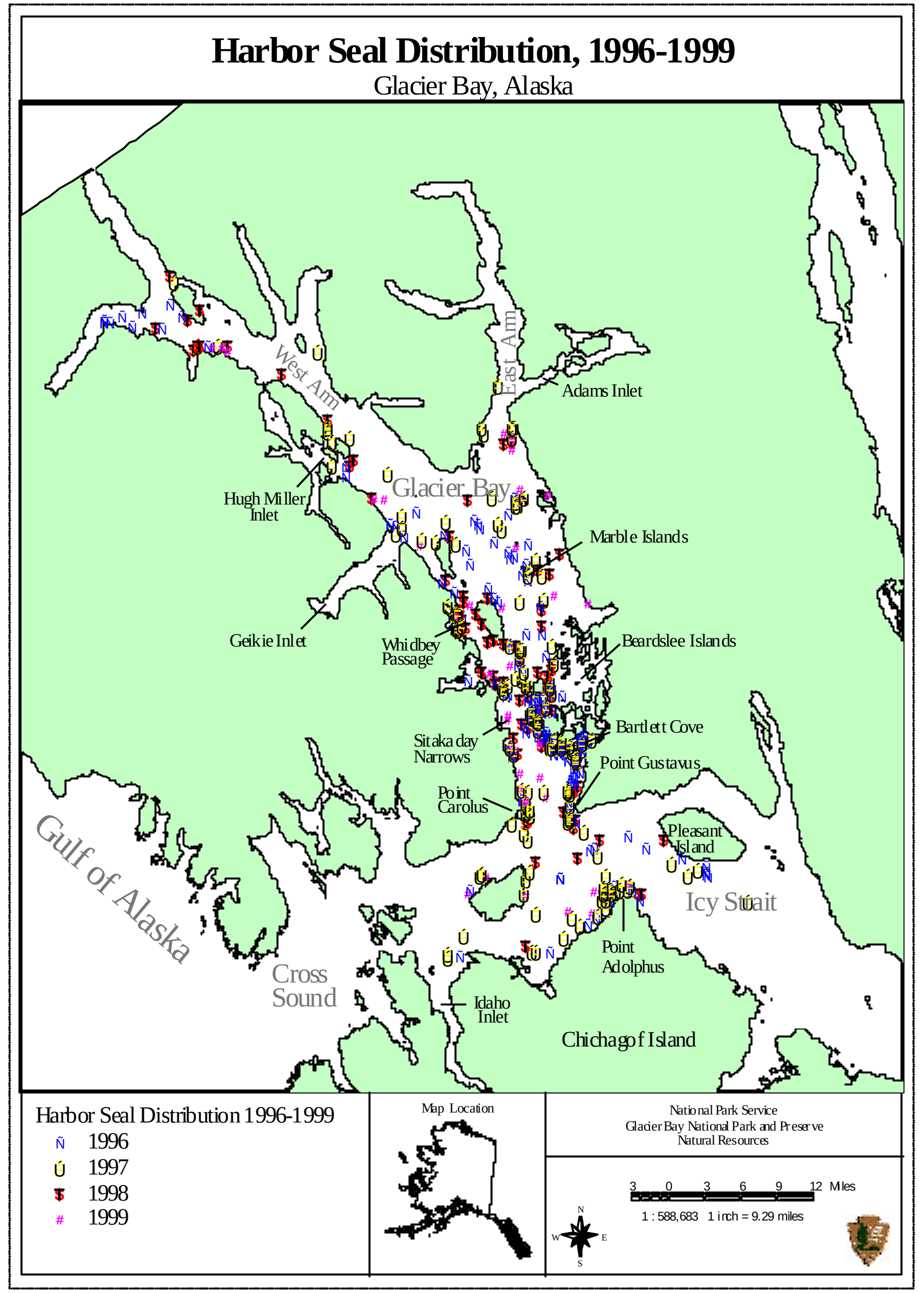

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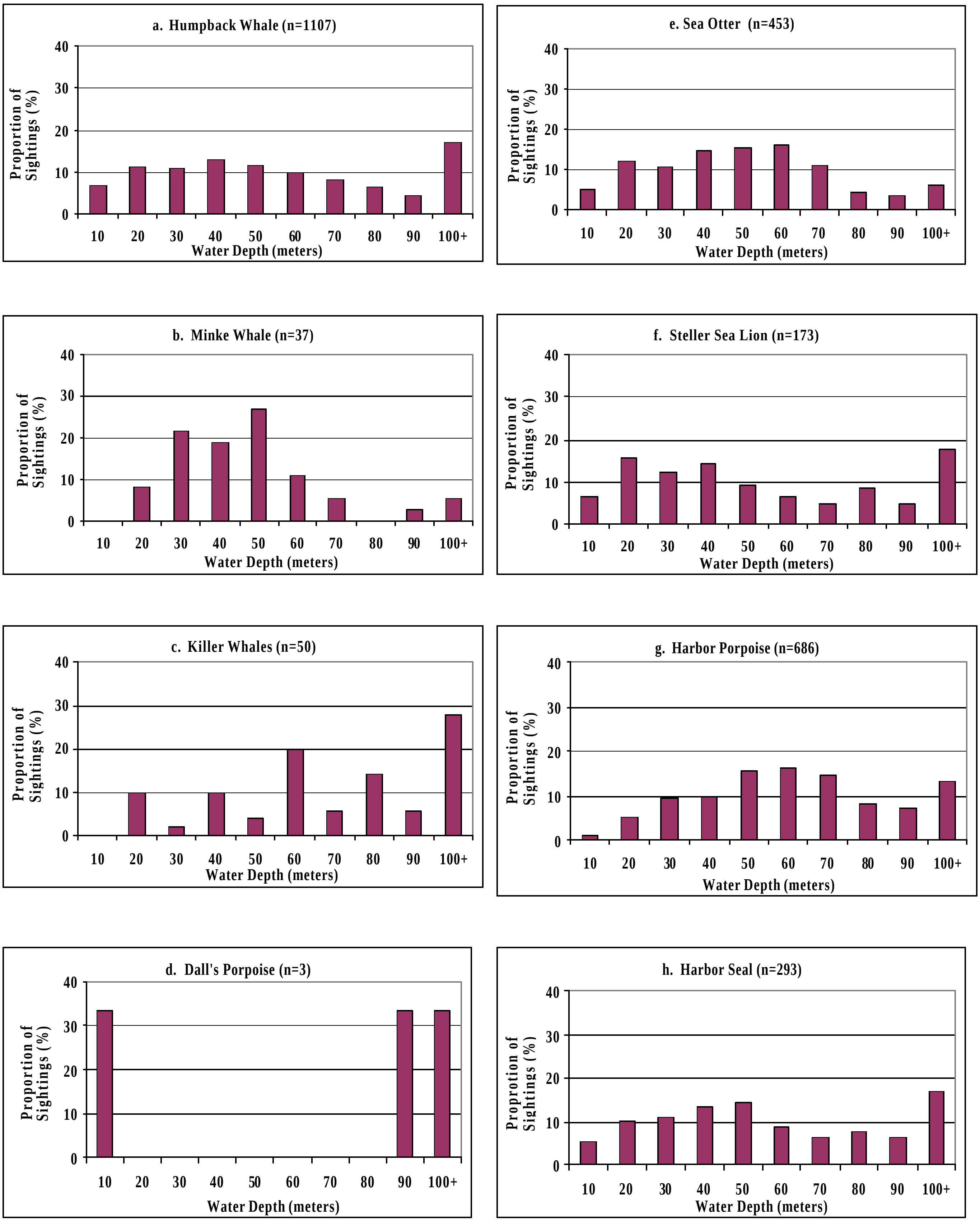


Figure 2. Distribution of Marine Mammal Sightings by Water Depth

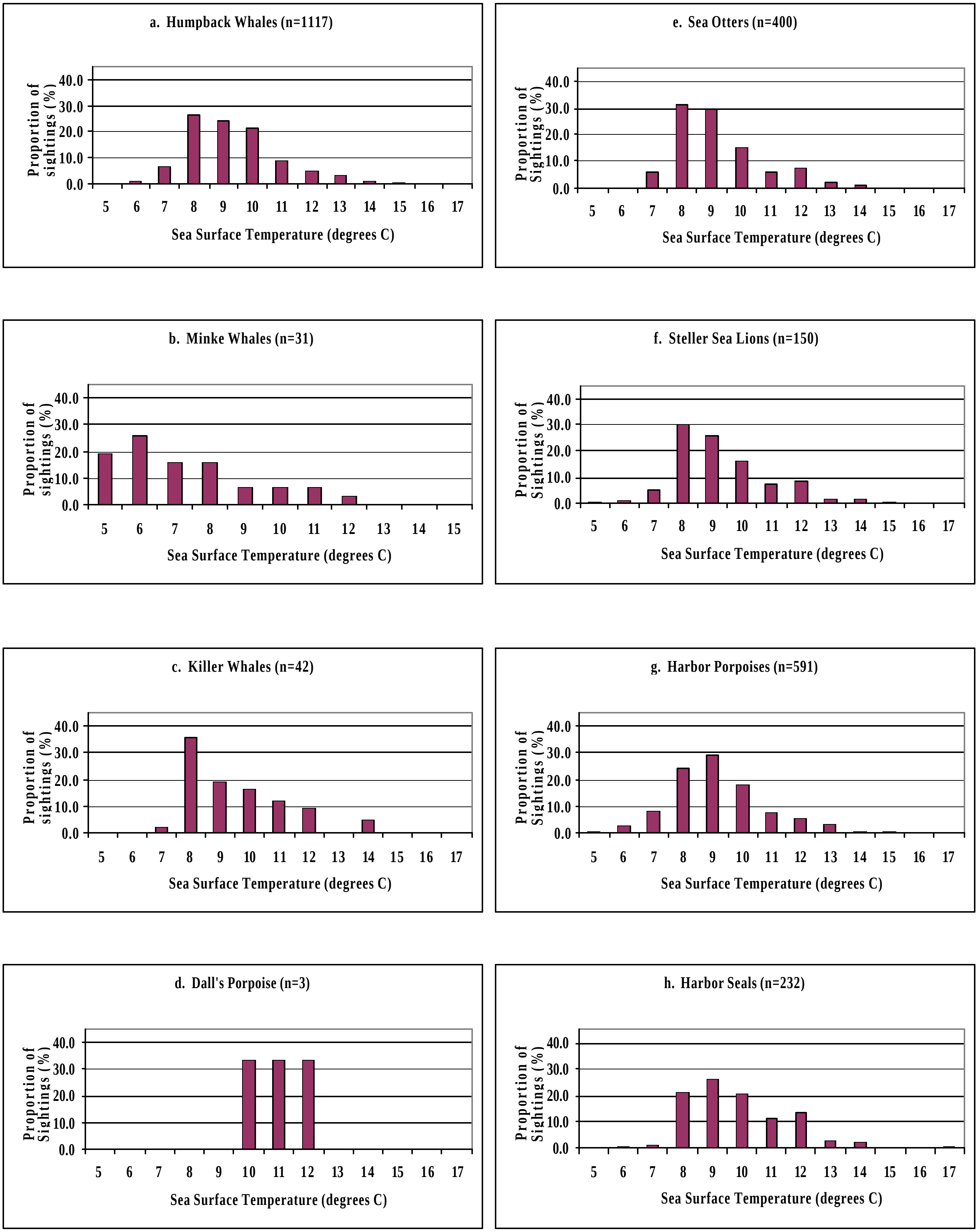


Figure 3. Distribution of Marine Mammal Sightings by Sea Surface Temperature.
Note: 1996 data not included.

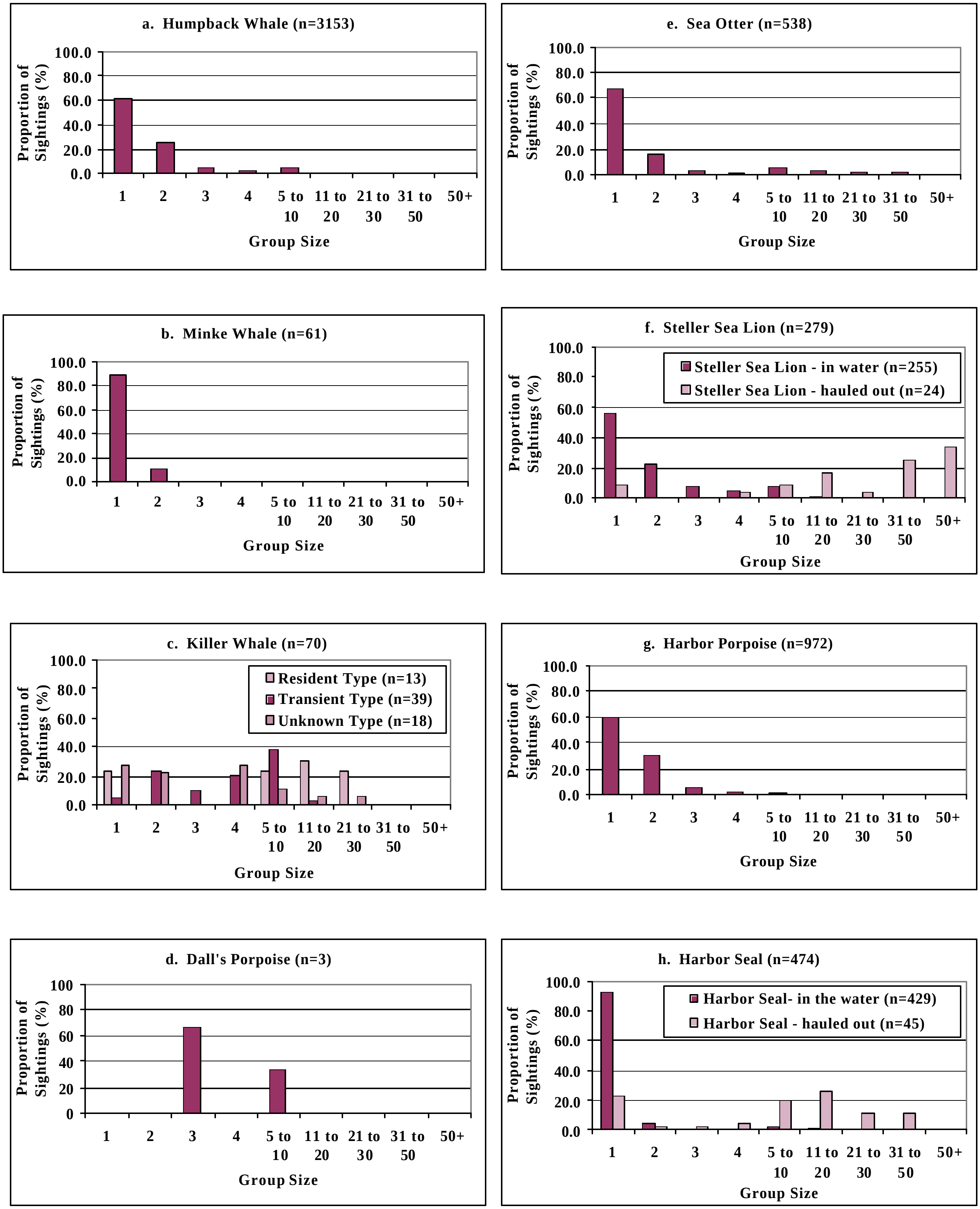


Figure 4. Distribution of Marine Mammal Sightings by Group Size

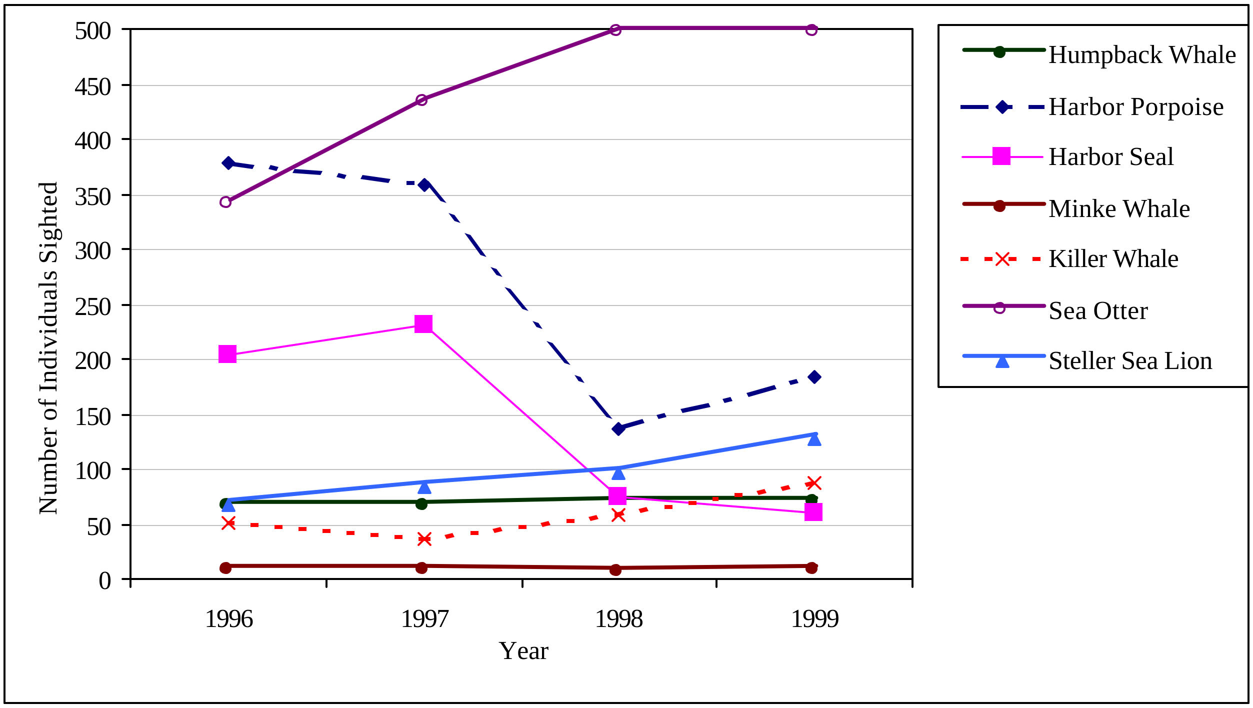


Figure 5. Number of Marine Mammals Sighted per Year: 1996-1999

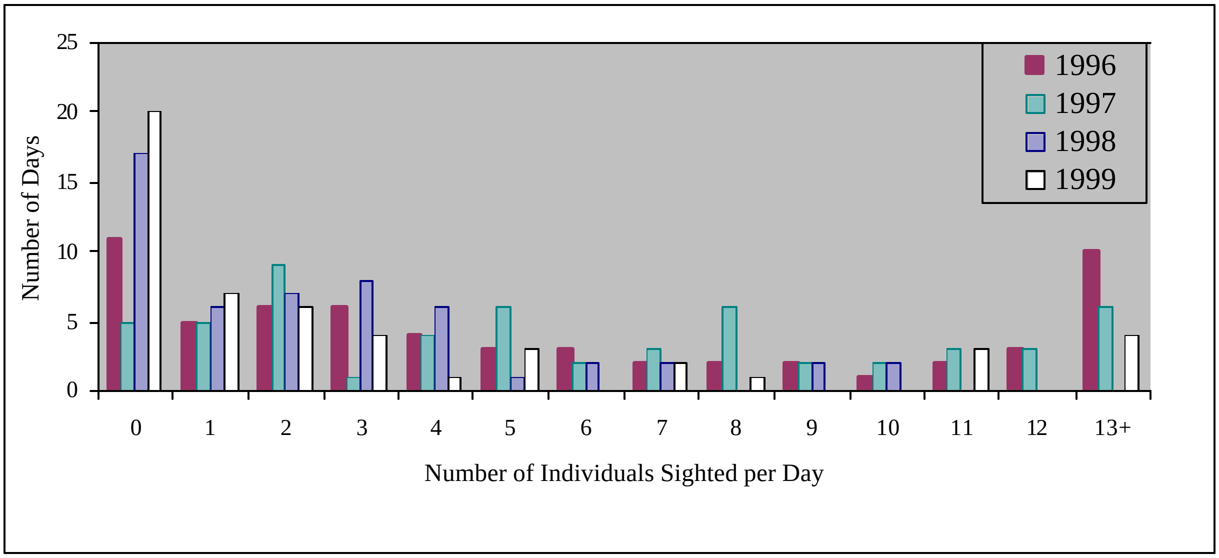


Figure 6. Number of Harbor Porpoise Sighted per Day by Year

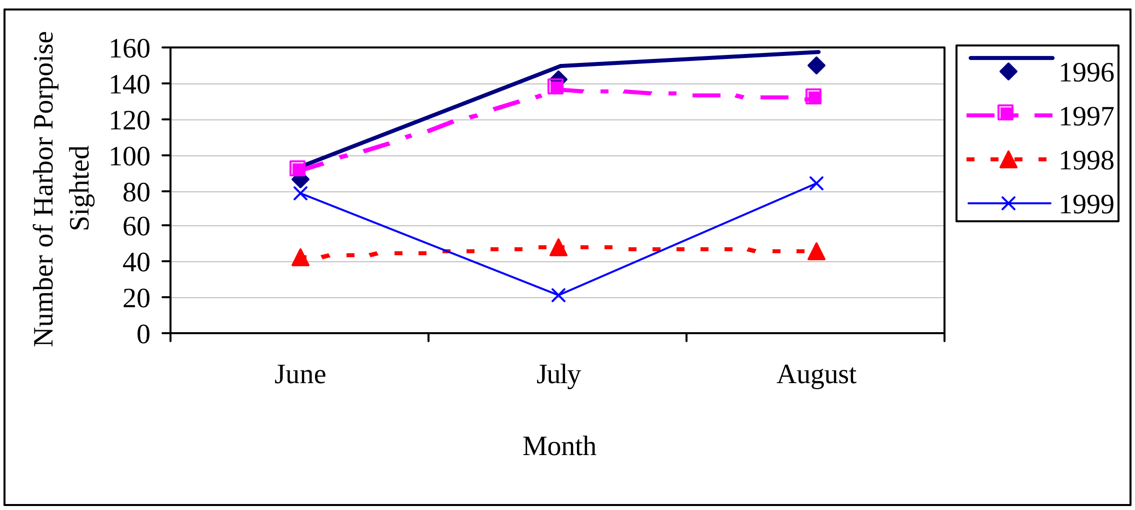


Figure 7. Number of Harbor Porpoise Sighted per Month by Year

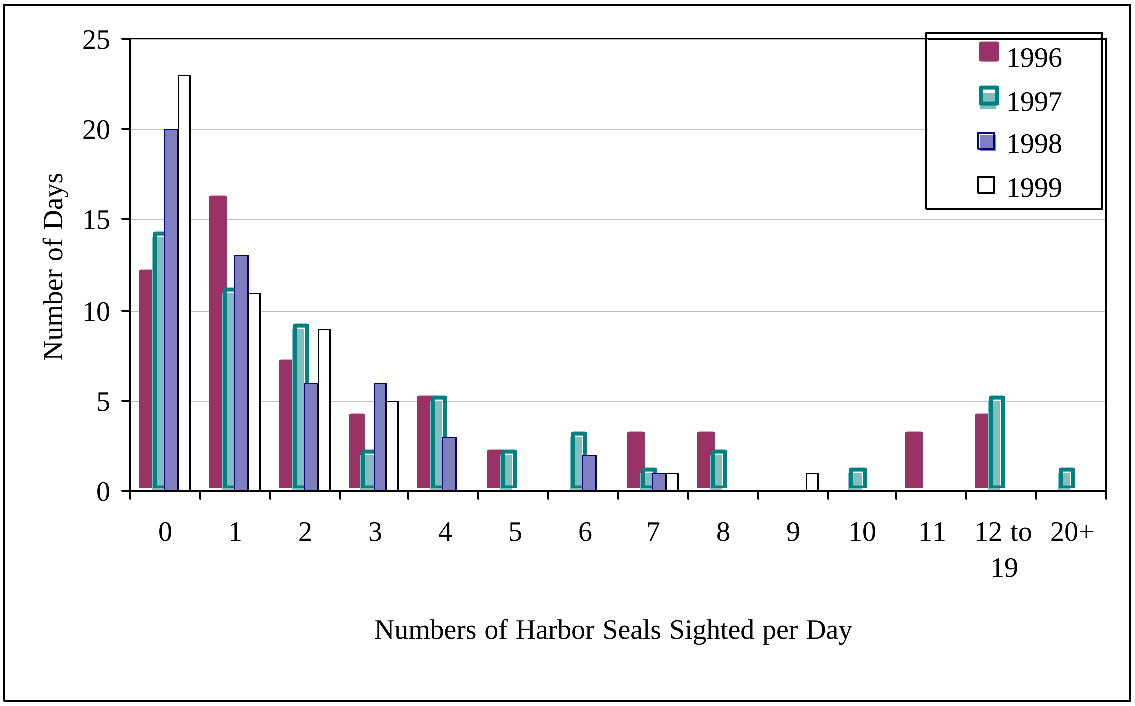


Figure 8. Number of Harbor Seals Sighted per Day by Year

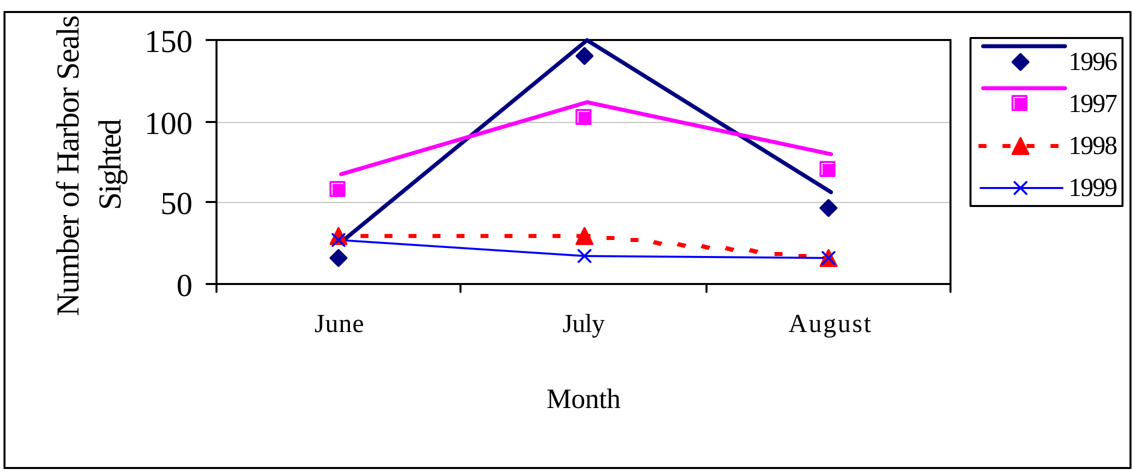
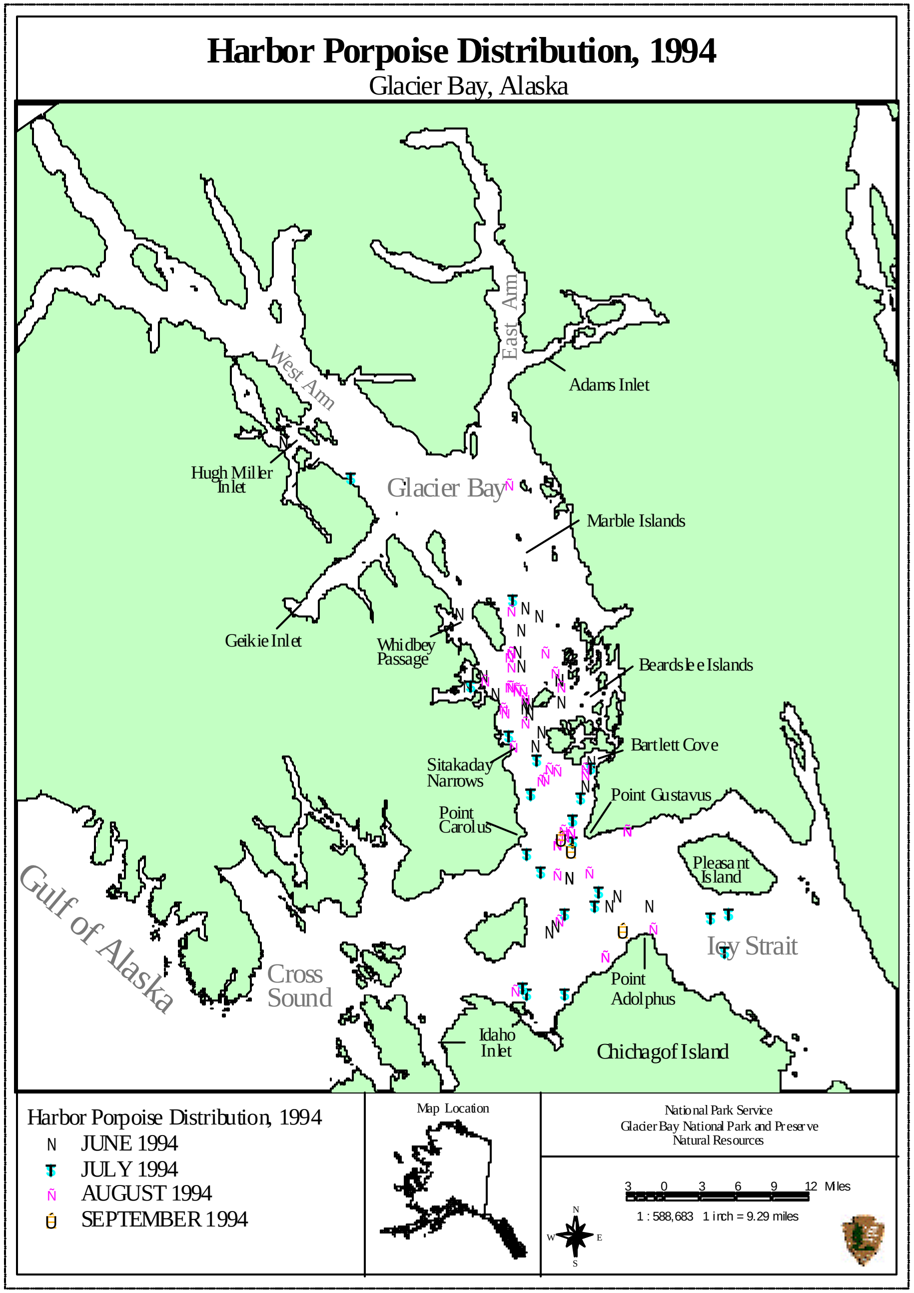


Figure 9. Number of Harbor Seals Sighted per Month by Year



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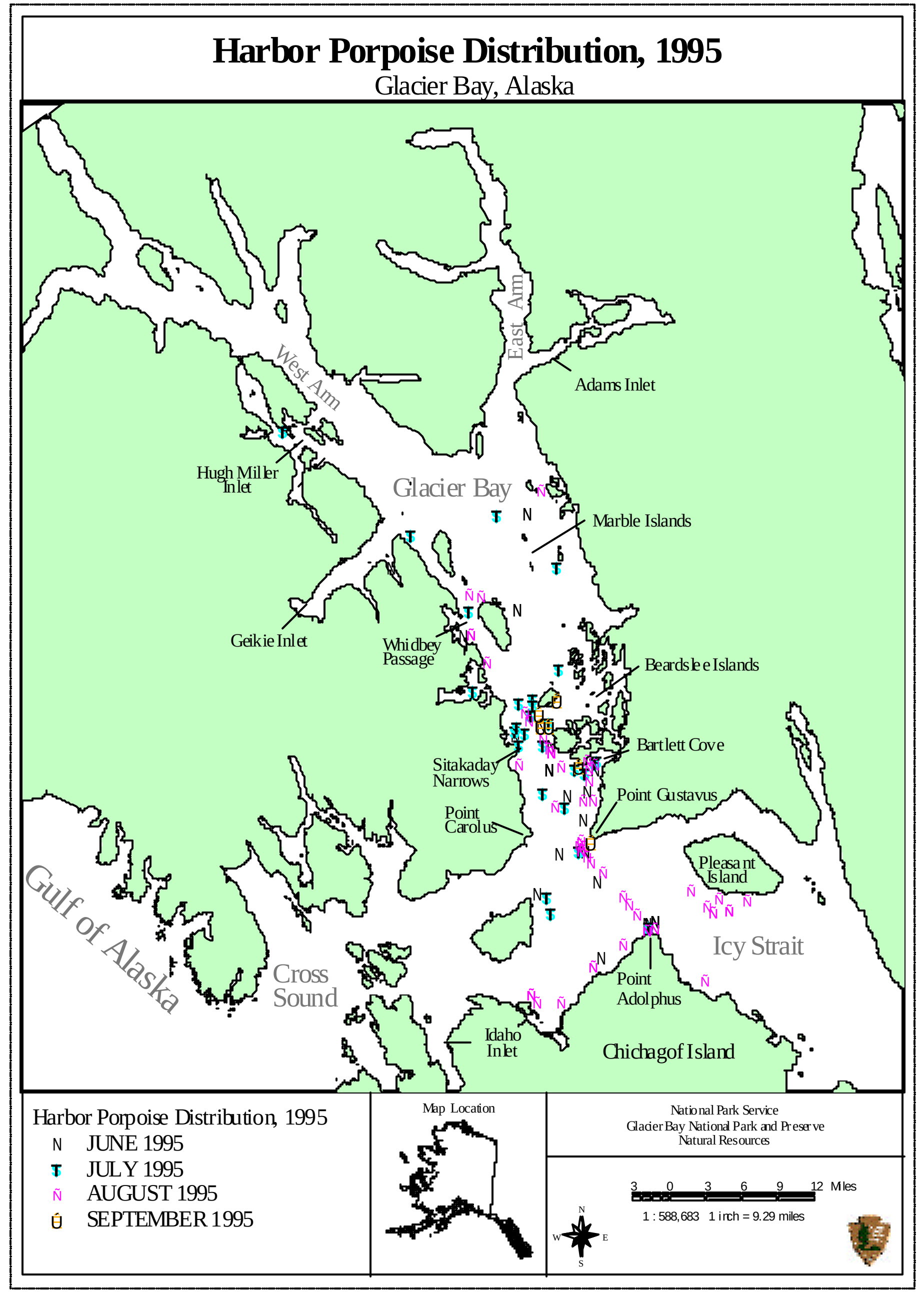

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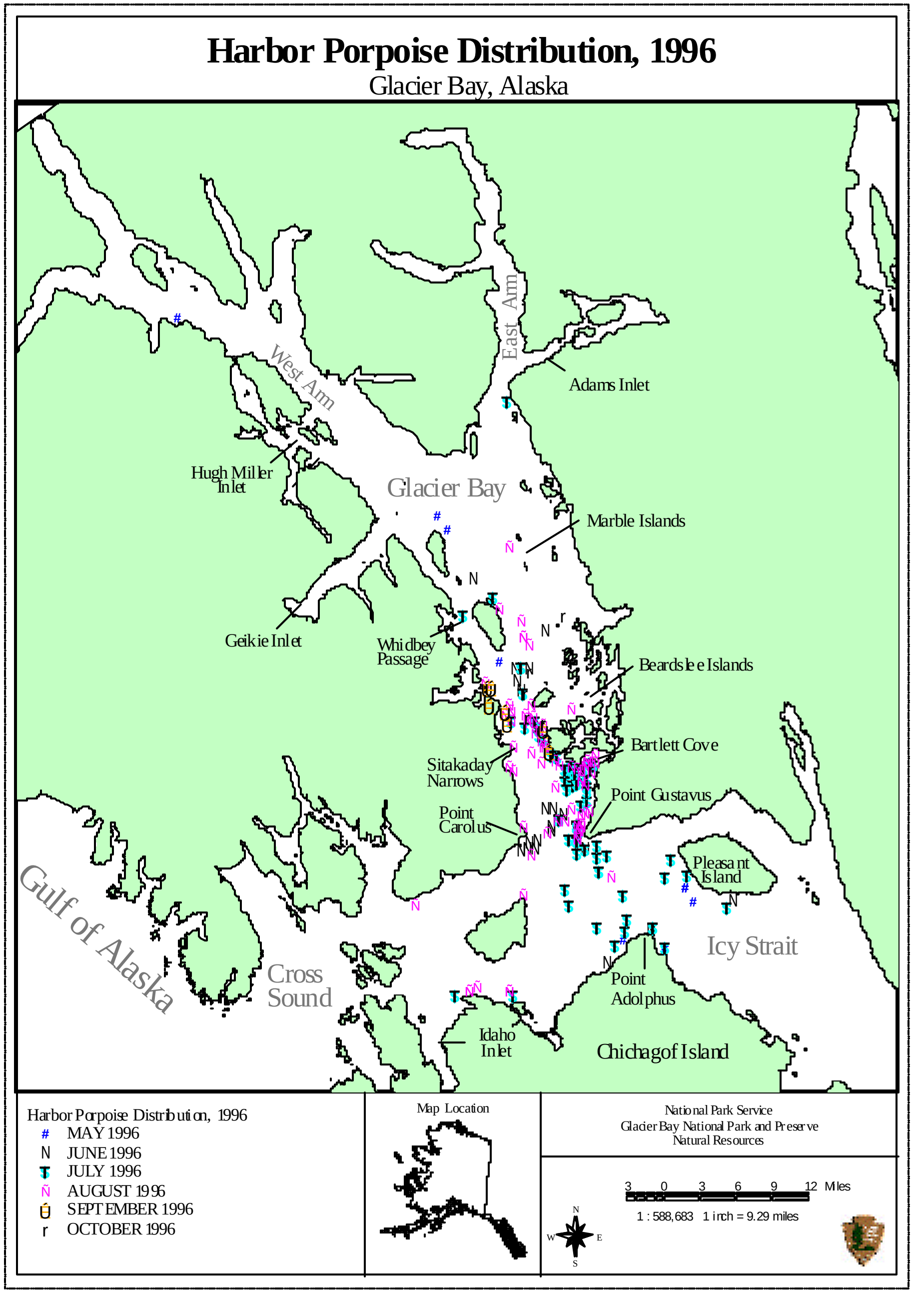

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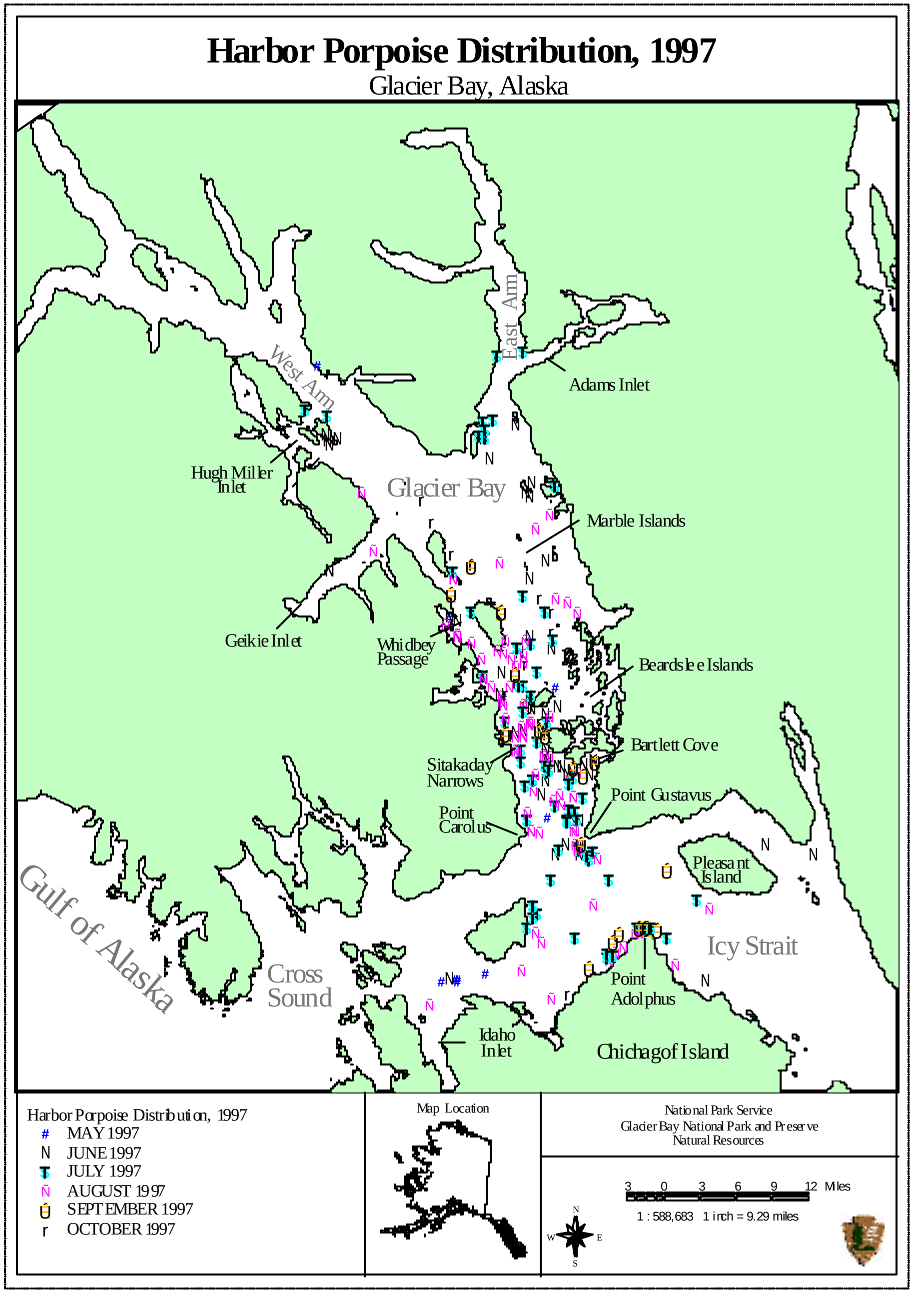

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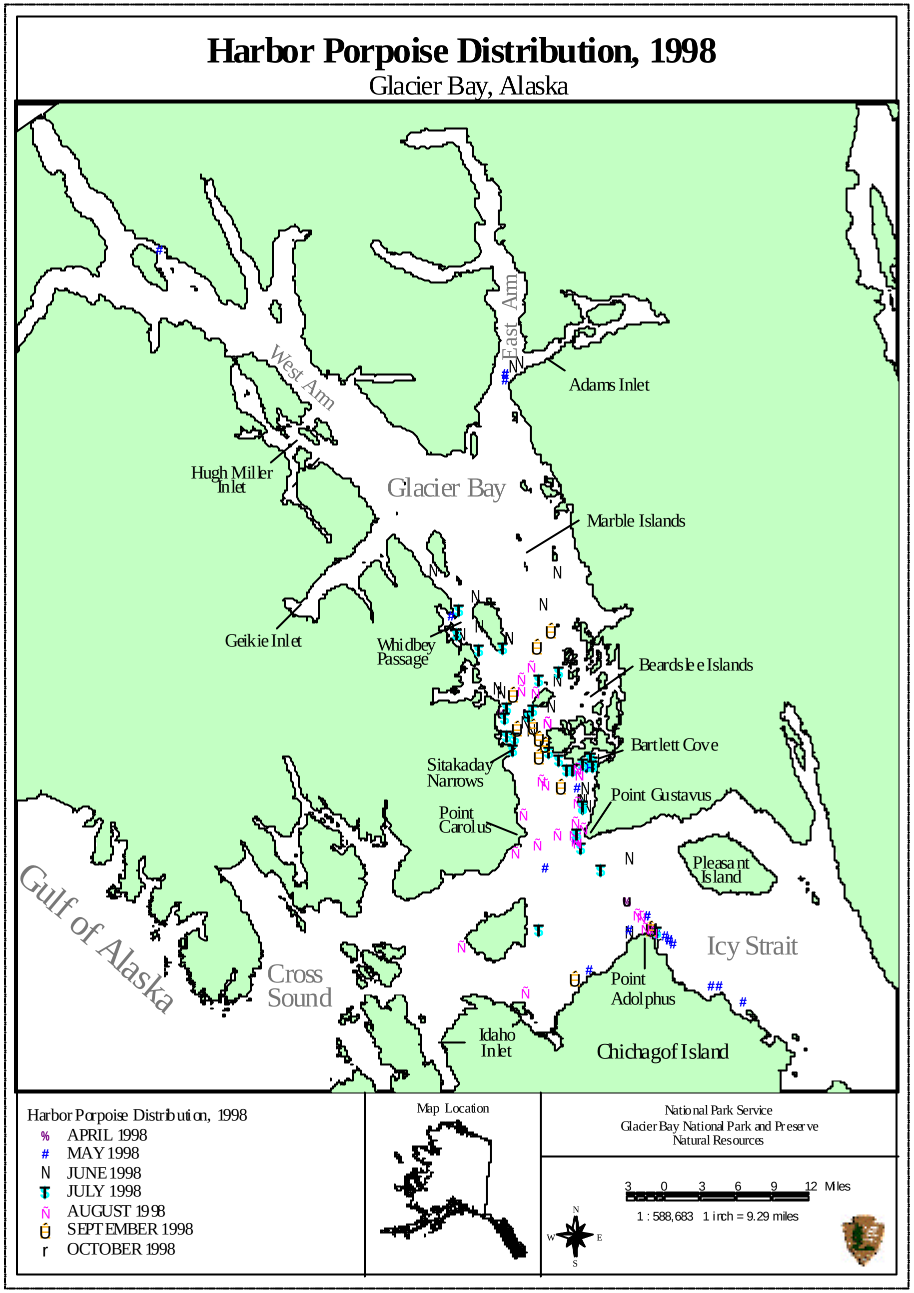

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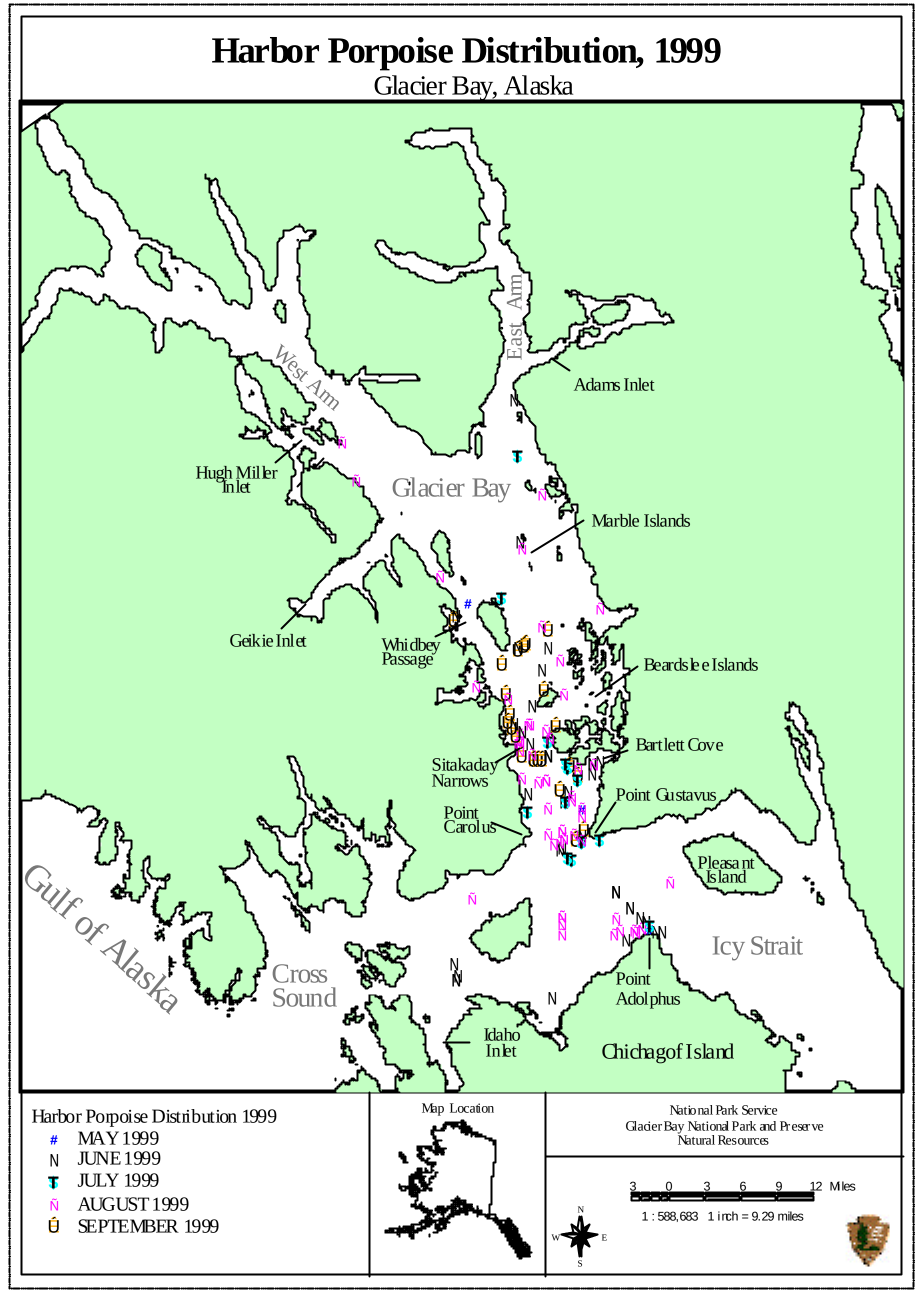

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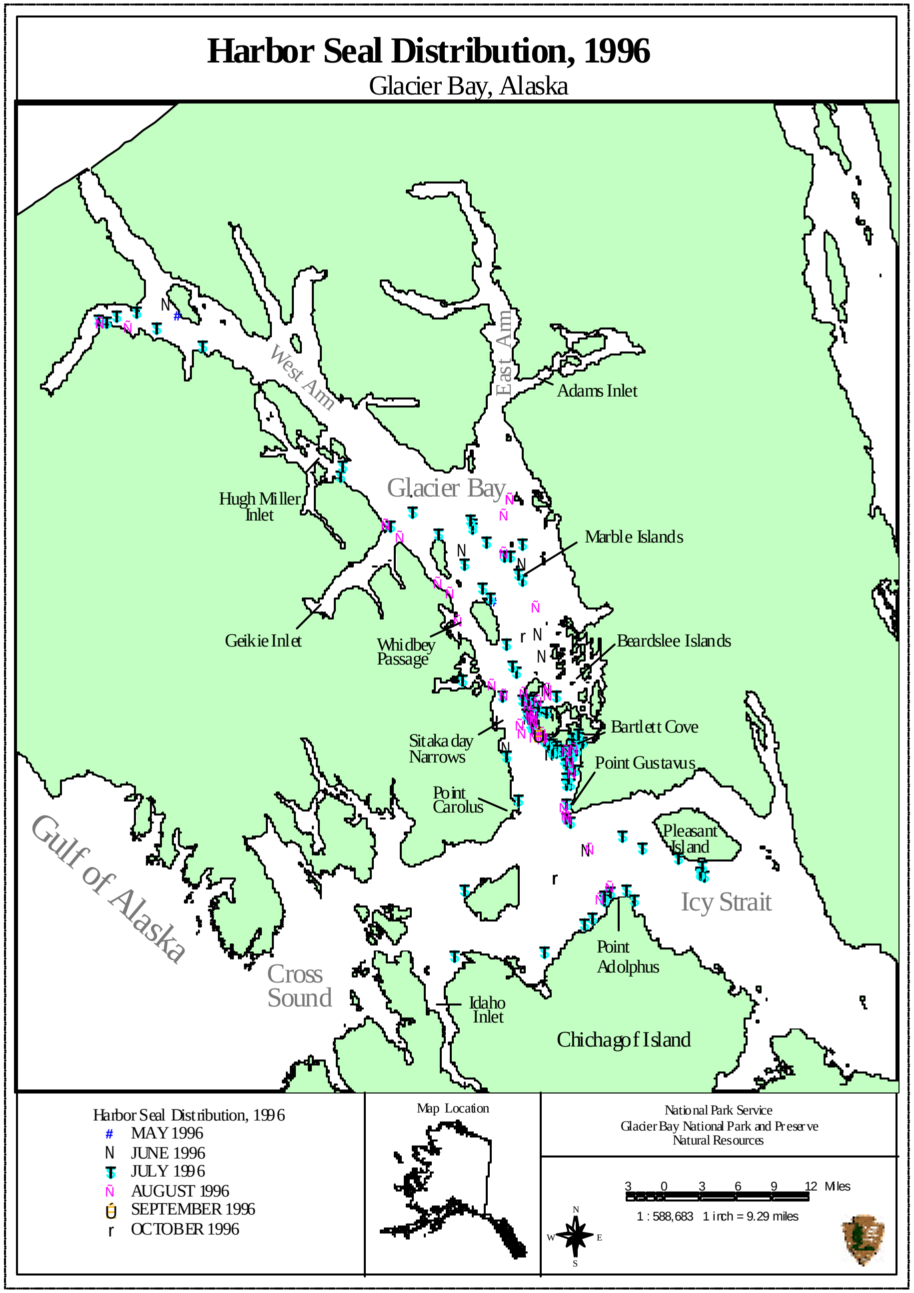

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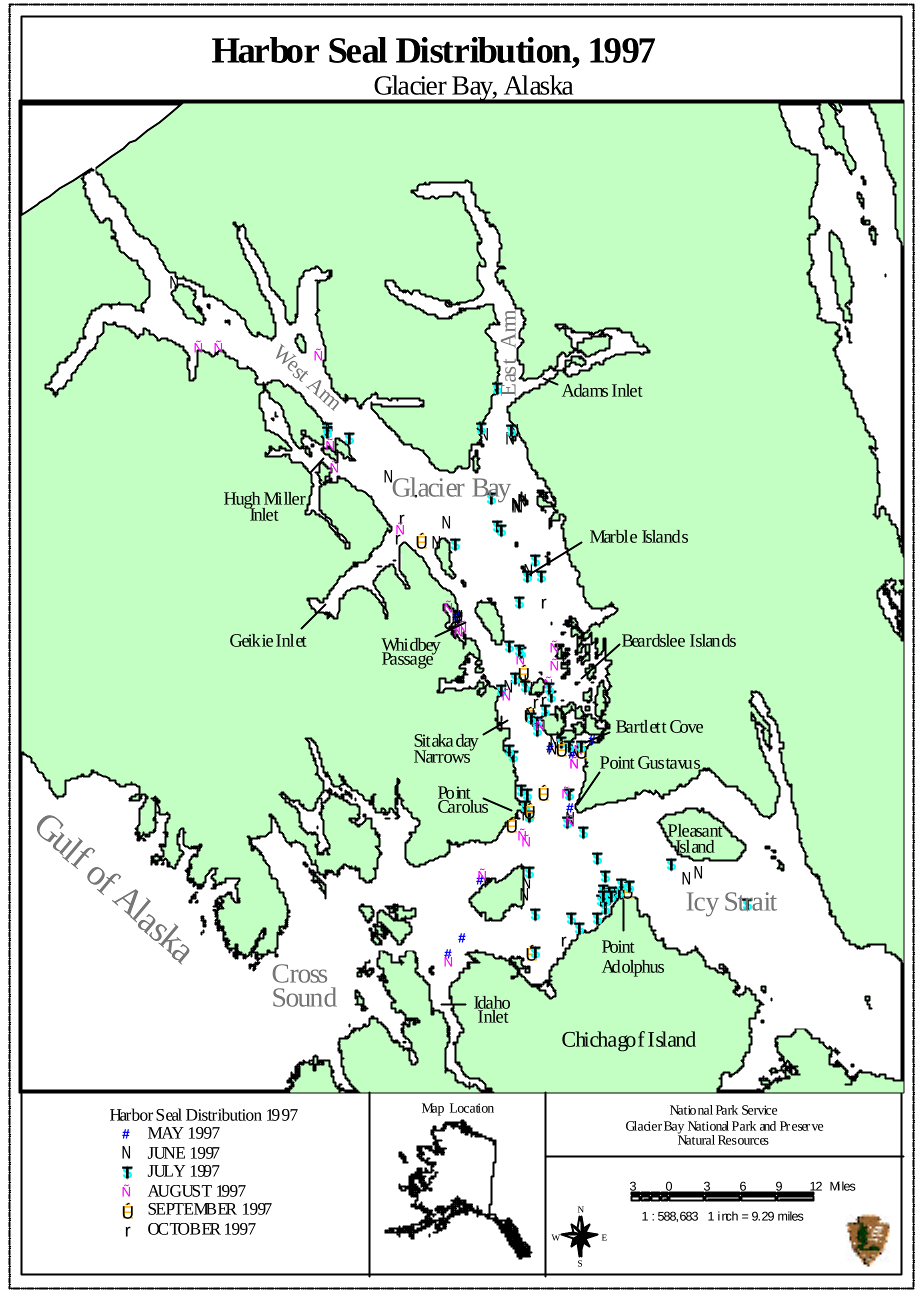

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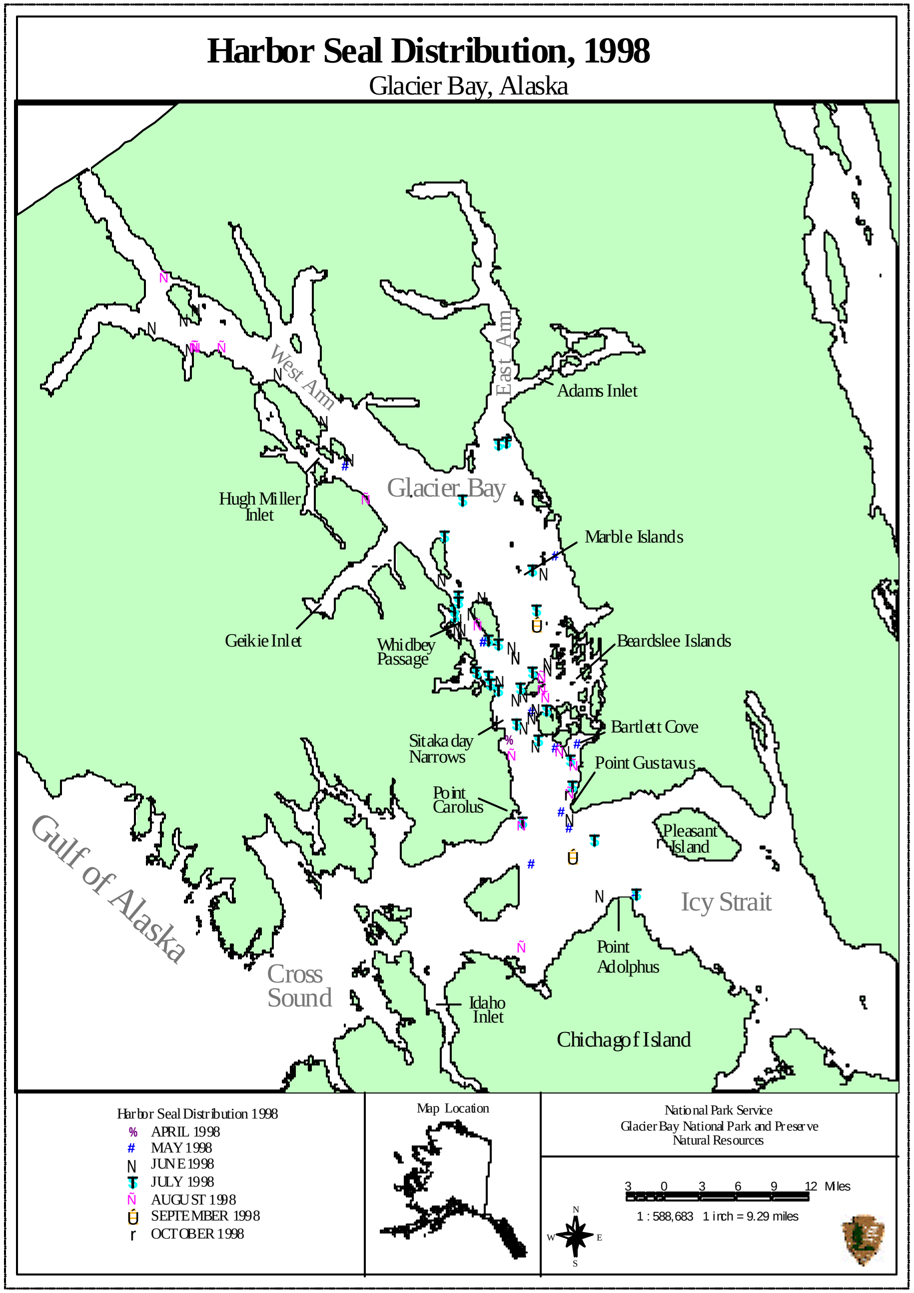

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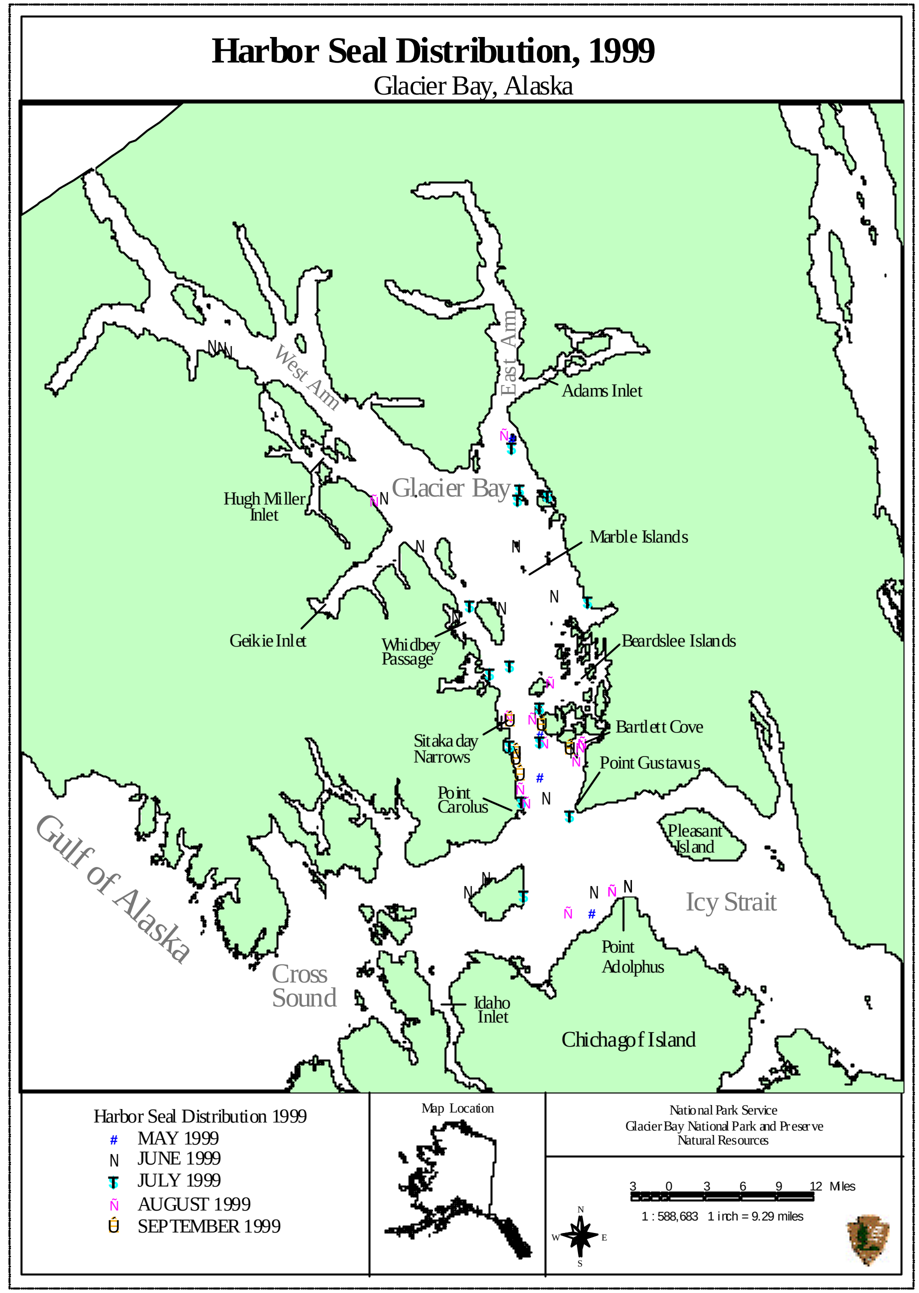

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