USE OF BEACHED BIRD SURVEYS TO INVESTIGATE IMPACTS OF THE EXXON VALDEZ OIL SPILL ON BIRDS AND MAMMALS IN THE AREA OF PUALE BAY, ALASKA PENINSULA, ALASKA 1989 - 1992

By:

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Key Words: Alcids, Alaska Peninsula, Becharof, beached bird surveys, Exxon Valdez oil spill, marine mammals, passerines, Puale Bay, shorebirds, waterfowl

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ABSTRACT

INTRODUCTION

On 24 March 1989, the oil tanker Exxon Valdez ran aground on Bligh Reef in Prince William Sound, Alaska spilling 11 million gallons of crude oil, making this the largest oil spill in North American history. In the weeks that followed, currents and prevailing winds spread the oil through Prince William Sound, the western Gulf of Alaska, lower Cook Inlet and southwest to the Kodiak Archipelago and Alaska Peninsula through the Shelikof Strait. More than 1,920 km (1,200 mi) of coastline were oiled impacting shorelines over 750 km (470 mi) from Prince William Sound (Piatt et al. 1990). About one month after the spill occurred, oil impacts were first recorded in Alinchak Bay, the northernmost portion of the Alaska Peninsula/Becharof National Wildlife Refuge Complex. Oil impacts were subsequently documented as far south as Kupreanof Cape, including scattered impacts along the entire 1,170 km (725 mi) of refuge coastline (Dewhurst et al. 1990). Focus of this report is on Puale Bay within the Becharof Refuge portion of the Complex.

The marine area impacted from the oil spill hosts some of the densest populations of marine birds in North America, ~~rivaled only by some portions of the Bering sea, the Canadian Arctic and Newfoundland~~ (Sowls et al. 1978, Gould et al. 1982, Piatt et al. 1989). Millions of pelagic seabirds (murres, puffins, cormorants, gulls, kittiwakes) breed in the 320 colonies in the affected area (Sowls et al. 1978). Thousands of coastal water birds including loons, grebes and seaducks winter in the area (Forsell and Gould 1981). Marine mammals are also abundant with numerous haul-outs and pupping areas (Forsell and Gould 1981, Irons et al. 1984, Loughlin 1987).

~~During~~ 1989, carcasses of over 36,000 birds, 1,011 sea otters (Enhydra lutris), and small numbers of other marine and terrestrial ~~mammals were~~ recovered and cataloged (Piatt et al. 1990, Exxon Valdez Oil Spill Trustees 1992). Total avian mortality was estimated at 375,000-435,000 birds (Ecological Consulting Inc. 1991). These numbers were based on the results of a massive interagency effort between the U. S. Federal Government, the State of Alaska, private citizens and Exxon and its contractor "VECO" to walk beaches and collect animal carcasses in the impacted areas. On Becharof Refuge, specifically at Puale Bay, the U. S. Fish & Wildlife Service (FWS) initiated a program of beached bird surveys conducted via seasonal field camps, which was continued annually through the summer of 1992. The primary purpose of the Puale Bay field camp was to conduct population and productivity monitoring of breeding seabirds in nearby colonies, under a wildlife damage assessment study indirectly funded through mitigation by Exxon (Dewhurst 1991, Dewhurst and Moore 1992, McCarthy and Dewhurst 1992). The beached bird surveys were a secondary purpose of the field camp, but the emphasis of this report.

In 1989, when the beached bird survey transects were first established, the primary purpose was to assess the immediate impacts of the oil spill; i.e. animal mortalities and quantities of oil on the beaches. As the years progressed, visible oil impacts and mortalities declined, shifting the surveys' emphasis to documenting non-oil related ("natural") mortality and

The summer climate at Puale Bay was primarily foggy, windy and rainy, with infrequent sunny days and generally free from snow at sea level from early May to late September (Dewhurst 1991). Severe storm conditions occurred predominately during September with extremes of 40+ knot winds and seas 4-6 m (13-20 ft). Average summer daytime temperatures were 4-14°C (40-60°F).

Survey Staffing and Logistics

The field camp was located immediately south of Teresa Creek, nestled behind the grassy dunes, with the same location used during the entire study (1989-1992). The field research crew generally consisted of 3-5 volunteers with a paid biological technician as camp leader. Field camp facilities and equipment consisted of 2-3 weatherports, an outhouse, inflatable boats with outboard motors and associated safety equipment, a 4-wheeler ATC with utility trailer, a single-side-band radio, kerosene heaters and a portable generator. Special brown bear safety equipment included: 12-gauge riot shotguns, 375 H&H rifles, hazing devices (cracker shells, flares, rubber slugs), bear-proof steel barrels for food storage, barrel incinerator for trash burning, and an electric fence which surrounded ~~the~~ boats and 4-wheeler. Field equipment was transported between King Salmon the Puale Bay using a combination of fixed-wing aircraft and helicopters. Radio contact with the Refuge Complex office in King Salmon was maintained daily and resupplies were usually every 2 weeks using fixed-wing aircraft. ~~The~~ field seasons were as follows: 14 June-26 September 1989, 17 June-21 September 1990, 21 June-26 September 1991, and 13 June-23 September 1992.

Carcass Collection and Documentation

In 1989, all bird, sea otter and small terrestrial mammal (weasel, fox, river otter) carcasses found on the beaches of Puale Bay were collected and stored in bear-proof steel barrels, as per written camp guidelines (Appendix I). Carcasses of larger marine mammals (seals, sea lions, whales) and terrestrial mammals (bears, wolves, caribou) were not collected. When pinneped or whale carcasses were found, the carcasses were examined externally and measurements were taken as per standardized marine mammal forms (Appendix I). When the quantities of carcasses started to accumulate, the field camp contacted Exxon/VECO chartered motor vessels to meet the field crew on the beach for transfer of carcasses. The carcasses were then generally transported to a processing ship, where they were identified (if not already done), cataloged and transported to the FWS "bird morgue" on Kodiak Island. Carcass identification was based on guidelines in Ainley et al. (1980). Ultimately all carcasses were transferred to freezer vans in Seward(?) for storage until government litigation against Exxon was settled. As of October 1992, carcasses were finally being released to interested museums and universities for research and educational uses. This carcass collection process continued until late August 1989(???????????), when Exxon canceled contracts with the collector boats. During ~~September 1989~~, carcasses were identified on-site, cataloged, marked with spray paint and tossed far above the high tide line to avoid duplicate reporting.

During 1990, only very fresh oiled and non-oiled bird carcasses and all sea otter carcasses were collected as per written guidelines (Appendix I). Carcasses were bagged individually and stored in the camp's propane freezer (if the carcass was small) or a bear-proof steel barrel, until pick-up by

aircraft could be arranged. Pick-up generally coincided with resupply flights. Carcasses were then transferred to freezers in the Refuge Complex Office in King Salmon. If requested, these carcasses were then flown via commercial airlines to the Regional FWS Office in Anchorage for examination and long term storage. All other bird and small mammal carcasses were identified on-site, cataloged, marked with spray paint and tossed far above the high tide line to avoid duplicate reporting. Pinneped and whale carcasses were treated the same as during 1989.

During 1991 and 1992, no carcasses were collected from Puale Bay beaches. Bird and mammal carcasses were all identified and cataloged on-site in a similar manner as during 1989 and 1990. Smaller quantities of carcasses eliminated the need to mark them with spray paint.

Beached ~~Bird~~ Surveys

Walkable portions of the Puale Bay shoreline were divided into 6 survey sections (Fig.2) separated using anadromous fish streams and sections of rugged, rocky terrain as boundaries (Table 1). One beached bird survey transect was designated to correspond with each shoreline section, so that transect numbers corresponded to section numbers (eg. Transect 1 is in Section 1). Transects were parallel to the water line using the section boundaries as starting and end points. Transects did not have fixed widths, but were variable due to changing beach conditions and the number of observers. Beaches were ideally walked between low and high tides, on an incoming tide. When possible, 2 or more observers were used to comb the transect walking 3-5 m (10-15 ft) apart, surveying the low tide line in one direction and returning along the high tide line. If a transect was only surveyed in one direction, the observers split, with one walking high and one walking low.

Table 1

During a beached ~~bird~~ survey, all live birds and mammals sighted on the beach, on or in the water, in the air, and in the dunes or rocks bordering the beach were identified, counted and recorded in field notebooks (~~Appendix II~~). Animal carcasses were treated as described in the preceding Methods Section. Also identified and noted were any mammal tracks seen in the sand. Upon returning to camp, this data was recorded onto data forms (~~Appendix I~~).

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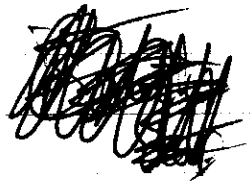
In 1989 and 1990, beached ~~bird~~ surveys also documented in detail, the location, quantities and description of oil impacts observed along the transect (Dewhurst et al. 1990). Exxon/Veco was also conducting extensive clean-up efforts during 1989-1991 along the Puale Bay beaches concentrating on Sections 3, 4, 6 and 1 (Hood 1990, 1991, 1992). Nature also aided in the clean-up process by the wind and surf burying the oil on the beaches (Dewhurst et al. 1990). Subsequently, in following years oil impacts were much less visible reducing records of oil impacts to notes made on the main data sheets of general quantities and condition, if any was observed.

Survey replicates of the transects were not evenly distributed during the study period, due to logistical problems? Sections 1 and 2 were the only accessible on foot from the field camp. Inflatable boats had to be used to access Sections 3-6. Consequently, Sections 1 and 2 were surveyed more frequently than the others. Section 1, the closest to camp, was surveyed 3-7x/week, depending on weather and scheduling with other research projects. Section 2 was surveyed about once a week, if possible, and sections 3, 4 and 5

- Literature Review?
  i.e. see R+D., pg. 2, Re. Hansen (1981) Ptacek et al. (1990)
  → i.e. immediate effects, long term effects / Death - mortality causes,

① Introduction
→ Revise
~~→ find missing pages.~~
→ # pages!



② Methodology.
→ 12th page?

③ Results + Discussion: (Separate Results from Discussion)
→ pg. 1 - how was mean, blkd, standardized
→ "highest" measured. OR highest #.?
→ Figure 2 - move to page after Results.
→ Hansen 1981 - find
→ Reworked / edit; get rid of bullets

④ Discussion: need to read literature / incorporate w/ Results / Discussion.

Objs:
⑥ Compare band / measured mortality 1989 to 1990 - 1992 ✓
⑦ variation in live band + measured pops. ✓
⇒ ⑧ Quantifiable / to determine if there was a relationship between the live band + band count data of selected sp. ← Remove.

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⑨ Compare sp. composition of band counts recovered during 1989, from Prince Bay w/ those from the rest of the Refuge Complex coast + the entire oil spill area. ← date?

about once a month.

Data Analysis

~~Analysis of this~~ study's data was primarily using Lotus 1-2-3 spreadsheets and displayed using Lotus Freelance graphics. Data was sorted by species, bird groups (shorebirds, seabirds...), survey sections, months, and years. Carcass data was graphed using actual raw data totals, but live bird and mammal sightings data was converted to ratios of species/km to eliminate biases due to unequal survey replication. Mammal tracks data was converted by species to a percentage present (surveys with tracks observed/total surveys). Variation between years (1990-1992) of live bird data was examined statistically by species????? using a two-tailed Analysis of Variance test. For all comparisons between transects, data from Transects 3 and 4 was combined because often they were not separated in the field records.

To determine if there was a relationship between bird species abundance (observed live) and bird carcasses found, a mortality index was created by dividing carcasses/km by live birds/km of beach surveyed. Mortality indices were only calculated for species of which carcasses were found. For 1990-1992, mortality indices were calculated using both carcass and live bird data from those individual years. However for 1989, records of live birds observed were incomplete and not usable. Therefore, live bird from 1992 was substituted for the 1989 mortality index calculations under the assumption that it represented the closest to pre-spill conditions ~~as were achievable~~ from post-spill data.

RESULTS ~~AND DISCUSSION~~

Carcass Recovery

Birds.-- As would be expected, in 1989, ~~the year of the oil spill~~, there were far more seabird carcasses found on the beaches of Puale Bay than in the following three years (Figure ~~1~~ 2). During the period the field camp was in place in 1989, puffins accounted for ~~the~~ majority of carcasses collected. There were also many murres, black-legged kittiwakes (Rissa brevirostris) and shearwaters found. By 1990, the number of carcasses was drastically reduced, with ~~the~~ black-legged kittiwakes, murres and puffins being among the highest. In 1991, there was a jump in sooty shearwater (Puffinus griseus) carcass numbers, and ~~the~~ black-legged kittiwakes were still high in relation to other species. Carcass numbers were low in 1992, with ~~the~~ murres, ~~and~~ puffins, and glaucous-winged gulls (Larus glaucescens) in the majority. Overall, puffins and murres seem to account for ~~the~~ most mortalities, with shearwaters and black-legged kittiwakes also contributing ~~highly~~ to carcass numbers.

Both Hansen (1981) and Piatt et al. (1990) name alcids ~~which includes the murres, puffins and guillemots~~ as being among the most sensitive seabirds to oil pollution. ~~This corresponds with the above findings~~. Although the pigeon guillemots (Cepphus columba) did not figure highly in the carcass numbers of Puale Bay, ~~it should be noted~~ that pigeon guillemot carcasses were only found in 1989. Their low carcass numbers in relation to other alcids could be partly related to ~~their overall live numbers being much lower~~. ~~The~~ murres and

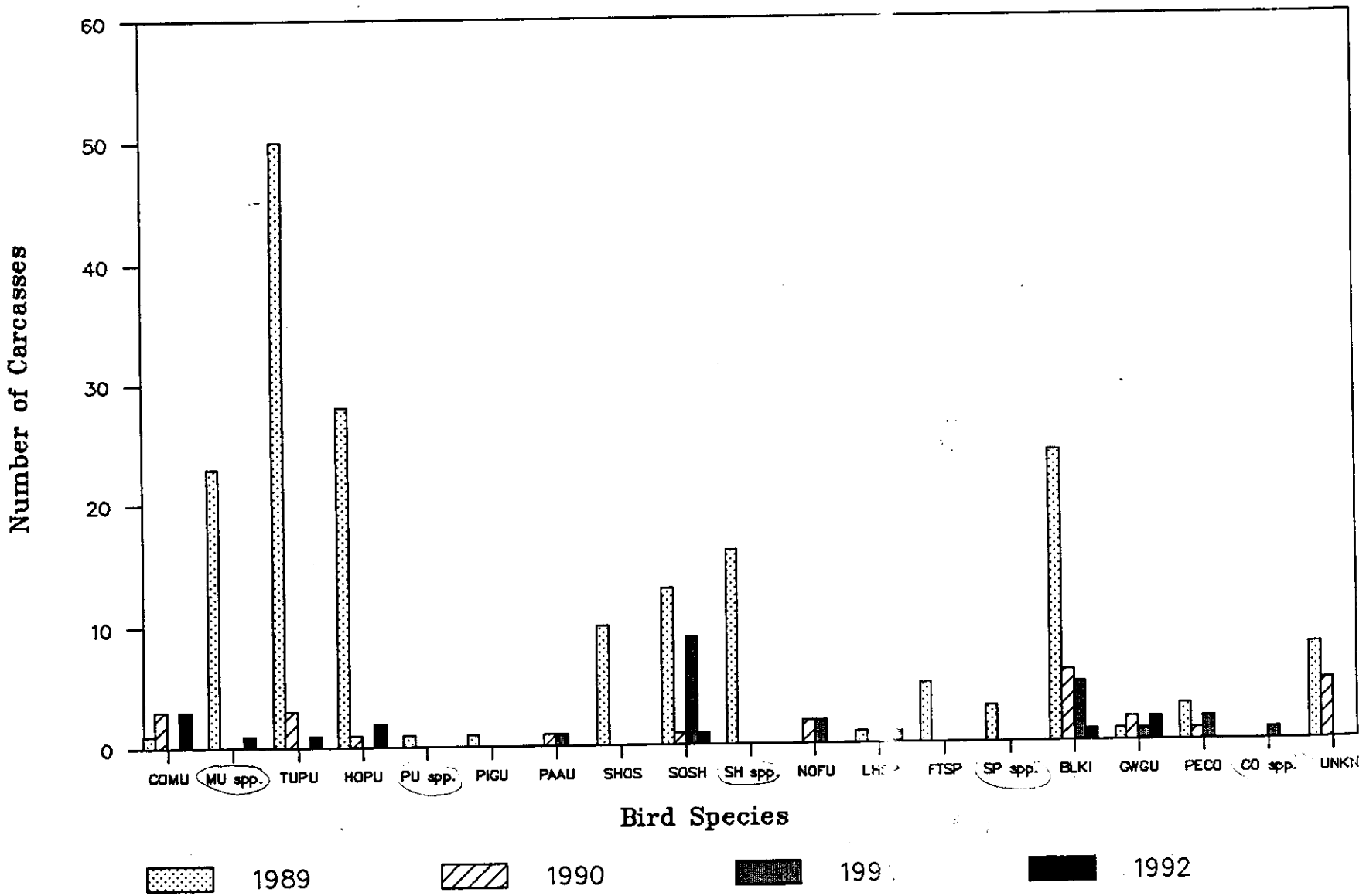

Figure #. Number of bird carcasses for each species found on all the beach survey sections of Puale Bay, Alaska Peninsula, Alaska from June–September of 1989–1992.

puffins breed on cliffs on Puale Bay, so their numbers would be expected to be higher.

Carcass Distribution

~~Bird Distribution~~.--

Birds

The majority of the carcasses found on Puale Bay were in Section 1 (Figure ~~RD-3~~ 3). Once a carcass has washed ashore it may be buried, scavenged or decomposed before it is discovered (Piatt et al. 1990). Therefore, beaches walked more frequently are likely to have fewer lost carcasses. More replicates were done on Transect 1 than on any other transect, so this could account in part for why Section 1 had more carcasses. Another possible factor could have been the direction of currents and wind patterns in Puale Bay. They may be such that any debris (including carcasses) drifting into the bay will be directed toward the western shores, which would also explain why more wood and human garbage debris could be observed on the western shore beaches (Sections 1-4, but especially 1), than the eastern ones (Sections 5 and 6). Sections 3 and 4 combined had the next largest number of carcasses for the oil spill year, but it was still well below that of Section 1.

In all sections, the carcass numbers for 1989 were higher than they were in 1990, 1991 or 1992 (Figure ~~RD-4~~ 8). Due to the fact that the Puale Bay area contains ~~one of the Peninsula's major breeding areas for many seabirds (Figure ??map showing major colony sites??)~~, it is logical to assume that some of the carcasses found in Puale Bay were local. However, Piatt et al. (1990) felt, based on their drift experiments, that most carcasses found on Alaska Peninsula and Kodiak Island beaches before 1 August 1989 were killed near the Barren Islands and southwestern Kenai Peninsula in April. They also believed that few birds were killed by oil after May because carcass recoveries diminished greatly in June and July. This ~~was certainly~~ reflected in the ~~Puale~~ Bay data; there were not many carcasses found in June and July (Figure ~~RD-5~~). ~~But~~ June could also have been low due to the fact that the field camp always went out then and was therefore only in place for one or two weeks at the end of the month. ~~But~~ In May 1989, before any camp was established, clean-up efforts resulted in 366 bird carcasses (more than double the number collected in September) being collected off Puale Bay beaches. Some were old (dryed and decaying), which could mean they came from elsewhere. However, many were fresh, suggesting they were from the local colony. Oil first reached Puale Bay on 29 April, 1989 (Hood 1989), and rafts of murres had been observed in the waters around Puale Bay as early as 10 and 11 April, 1989 (Refuge files, King Salmon, Ak., 1989). Therefore, there must have been local murre mortalities, and they would likely have contributed to the May carcasses collected, of which 89% were murres.

Piatt et al. (1990) also noted that in August and September, carcass recoveries increased again. Some of these recoveries were old and decomposed, while others were mainly species that had been little affected by oil in April and May, but were later dying of starvation. These species included shearwaters, storm-petrels, Larus gulls, black-legged kittiwakes and puffins. Most of the puffins were recently fledged. In Puale Bay, far more carcasses were found in August and September (especially September), than had been found in June and July. Puffins made up the majority of these carcasses, many of which were immature birds, and the ~~common cause of~~ death was found to be starvation. This all compares with their findings.

Citation is in 1981 how can this be is spill is 1989?

A possible explanation for the high mortality of puffins due to starvation could be that the oil spill caused a local reduction in major food sources for these birds (Hansen 1981). Because the spill occurred in March, before the puffins arrived back on their breeding grounds within the affected area, they avoided most of the direct kill from the oil (Piatt et al. 1990), which would explain the lack of puffin carcasses in the spring. Most of the oil had been dissipated or been removed by the time they arrived. However, if their food source was damaged by the spill, it could have resulted in starvation of these birds and their young later in the year, causing the fall influx of puffin carcassses.

By 1991 and 1992, more carcasses were being found in August than any other month.

Mammals. (Put w/ Bird carcass Recovery)

Not many mammal carcasses washed ashore on Puale Bay beaches in any of the four years studied. There was only one more carcass found in 1989 than in later years; three in 1989, and two in each of the following years (Table 3). So the oil spill does not appear to have had a great mortality effect on the mammals in the area. Of the carcasses that were found, most were sea otters (Enhydra lutris) (6 in all), with 1 Steller sea lion (Eumetopias jubatus), 1 porcupine (Erethizon dorsatum) and 1 harbour seal (Phoca vitulina) also being found.

Mammal Distribution.-- Why is This Here and Not w/ Mammal Carcass collection P. No mention of distribution

Sea otters were particularly vulnerable to the oil spill and the populations believed to have been most affected were in the Prince William Sound and along the Kenai Peninsula. It was estimated that 3,500 to 5,500 sea otters died as a result of acute exposure to the oil in 1989 for the entire affected area. And in 1990 and 1991, blood sample analyses and abnormal patterns of mortality in sea otters suggests a possible chronic effect of the spill (Exxon Valdez Oil Spill Trustees 1992). Not many mammal carcasses were found at Puale Bay during the beached bird surveys, however most of what was found were sea otters. It is possible that the three 1989 otters were direct kills from the initial exposure to the oil, and that the otters found in 1991 and 1992 may have died of chronic oil effects. The low numbers of carcasses in Puale Bay, as compared to elsewhere, may be a reflection of probable lower populations in that area than in the Prince William Sound and Kenai Peninsula areas. Also, otters carcasses probably would not be likely to drift as far as bird carcasses before sinking, resulting in fewer carcasses arriving in Puale Bay from higher populated areas up the coast.

No harbour seals were found in Puale Bay until 1992, and there were no outward signs of oiling on it. Only 19 seal carcasses were recovered overall from the spill in 1989, but seals will sink when they die. Through examination of the carcasses that were retrieved and studies of population numbers in oiled and unoiled areas before and after the spill, there are indications of seal mortalities due to the oil (Exxon Valdez Oil Spill Trustees 1992). It is difficult to determine if the Puale Bay harbour seal population suffered due to the oil spill or not though, with so little data.

Live Annual Observations

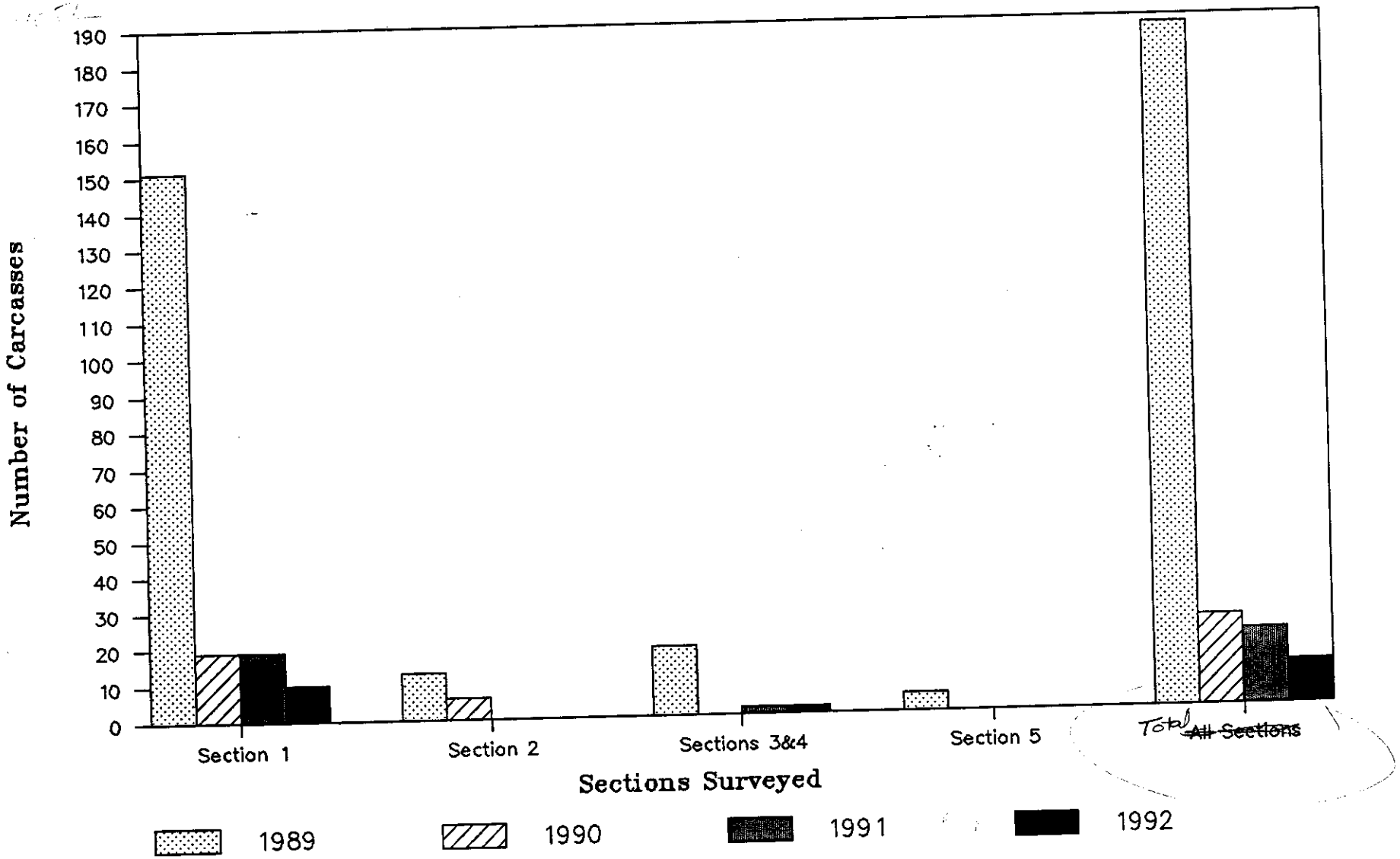

Figure #4 Number of carcasses for all species totalled for each beach survey section and all the sections of Puale Bay, Alaska Peninsula, Alaska collectively. Note that no carcasses were found on section 6 in any year, so it has not been included in this graph.

Fig 3

R&D

CARC Rec

Table 3. Mammal carcasses found on beach surveys of Puale Bay, Alaska Peninsula, Alaska from June-September of 1989-1992.

Year	Section	Quantity	Species
1989	1	2	Sea Otter
	2	1	Sea Otter
1990	1	1	Stellar Sea Lion
	1	1	Porcupine
1991	2	1	Sea Otter
	2	1	Sea Otter
1992	1	1	Sea Otter
	1	1	Harbour Seal

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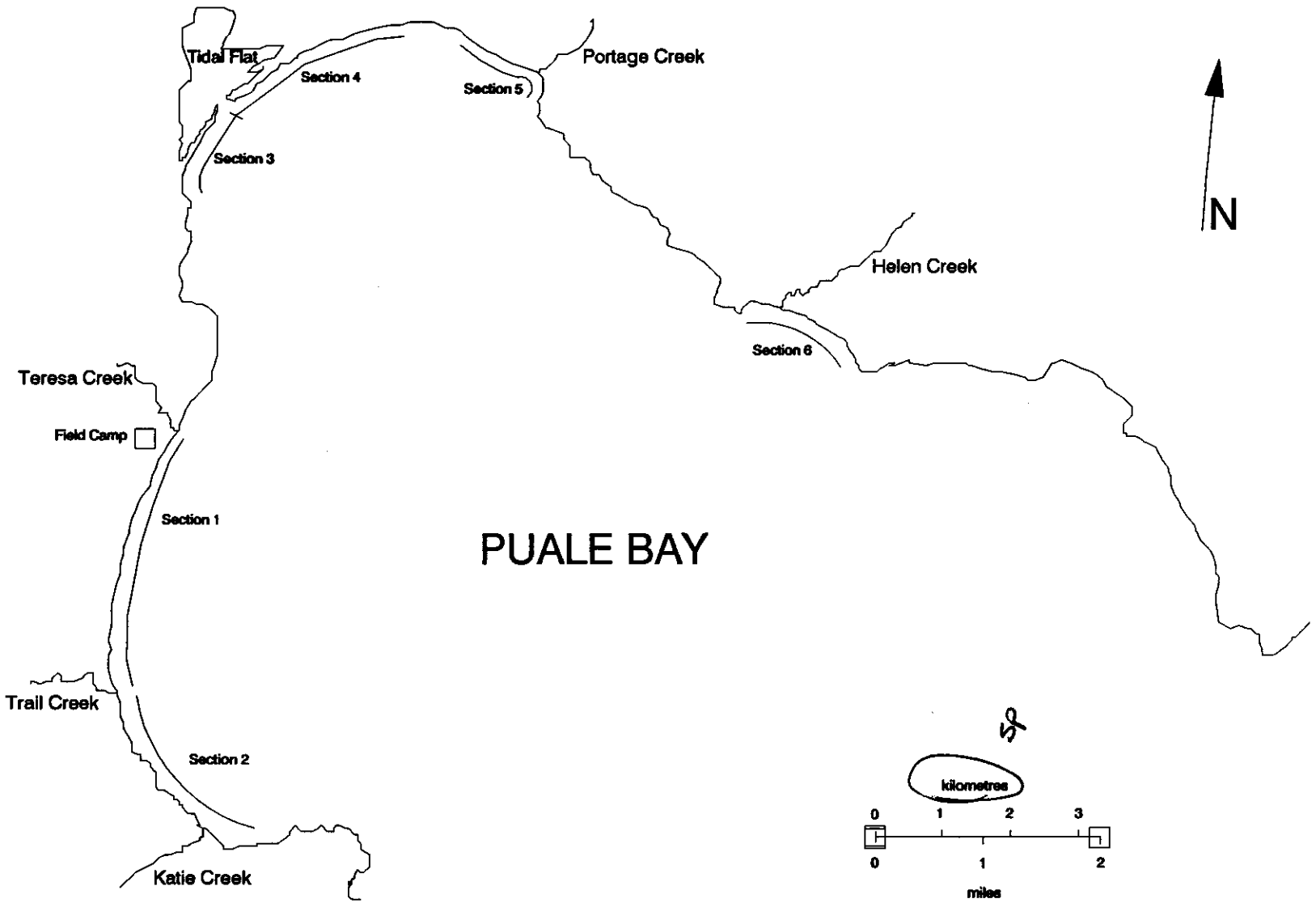

Figure #. Beach walk survey sections on Puale Bay, Alaska Peninsula, Alaska.

Live Annual Observations

Birds.-- Unfortunately, the quality of the live bird data collected in 1989 was incomplete and therefore not suitable for comparison with data from 1990-1992. Data from the latter three years was statistically tested by general bird group to determine if there was any significant difference in numbers of birds from year to year. Waterfowl, seabirds and passerines were all found to have significant differences between the years ($p < 0.001$, $p < 0.10$ and $p < 0.01$, respectively). Shorebirds and raptors, however, were found not to be significantly different between the years ($p > 0.50$ for both).

Although the live bird data was not a direct count of a population, but a record of repeated sightings, the assumption was made that the more abundant a species, the more frequently they would be seen. Based on this assumption, one correlates a high number of sightings to mean a high abundance. Studying the number of birds/km for each of the families within these groups showed that there were some families that did increase over the three years (Table RD-6.5). If the population of a family or species was detrimentally affected by the 1989 oil spill, it could be expected that in the years to follow, numbers might begin to increase, as the population tries to recover. Without any base data from before the spill, however, it cannot be concluded if a population was definitely damaged by the oil. Gaviidae, Corvidae, Hirundinidae, Accipitridae, and Falconidae all showed definite increases each year, while there was a slight increase in Podicipedidae, Procellariidae, Troglodytidae, Muscicapidae, and Fringillidae in 1992. Emberizidae numbers doubled in 1992 from what they were in 1990 and 1991. The only family to decrease in numbers from 1990 to 1991 and 1992 was Cinclidae, and that decrease was very slight. Anatidae, Phalacrocoracidae and Alcidae increased greatly from 1990 to 1991, but then dropped somewhat in 1992. Laridae, Charadriidae, Haematopodidae, Scolopacidae, Motacillidae and Alaudidae all had increases in 1991, but in 1992 dropped back near or equal to the numbers of 1990. It must also be kept in mind that due to the uneven numbers of replicates and the many different observers over the three years was likely to have created bias in the data. This may account for some of the high numbers in 1991, since there were more replicates completed then, and a particularly avid and meticulous birder in the crew who did many of them.

Scoters (especially white-winged scoters (Melanitta fusca)), harlequin ducks (Histrionicus histrionicus) and red-breasted mergansers (Mergus serrator) made up most of the waterfowl species found on beach walks in Puale Bay (Fig. RD-[illegible]). Glaucous-winged gulls and black-legged kittiwakes predominated the seabird and overall bird numbers, with there also having been a fair number of murres seen (Fig. RD-[illegible]). Shorebirds sighted were primarily semipalmated plovers (Charadrius semipalmatus), western (Calidris mauri), rock (Calidris ptilocnemis) and least sandpipers (Calidris minutilla) (Fig. RD-[illegible]). American (formerly "water") pipit (Anthus spinoletta) and savannah sparrow (Passerculus sandwichensis) were the most common passerines sighted, with many common ravens (Corvus corax), bank swallows (Riparia riparia) and lapland longspurs (Calcarius pictus) seen as well. The bald eagle (Haliaeetus leucocephalus) was the most abundant raptor found on beach walks, but peregrine falcons (Falco peregrinus) occasionally, too.

Bird Distribution.--

Of all the sections, Section 5 seemed to have the highest number of waterfowl, seabirds, passerines and birds overall per km, but the fewest raptors. The

Table 3. Results of ANOVA statistical testing of the live bird data from beached bird surveys conducted at Puale Bay, Alaska Peninsula, Alaska from June-September of 1989-1992. The null hypothesis (H_o) was tested for each general bird group and was as follows: There is no significant difference from one year to the next (1989-1992) of the live bird numbers for the species within the group.

Group	Calculated F-value	Tabular F-value	Probability Level	Conclusion
Waterfowl	9.11	8.10	$p < 0.001$	significantly different
Seabirds	3.49	3.07	$p < 0.10$	significantly different
Shorebirds	0.81	1.40	$p > 0.50$	not significantly different
Passerines	5.77	5.54	$p < 0.01$	significantly different
Raptors	0.59	1.40	$p > 0.50$	not significantly different

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Table 6

~~Table #~~. Number of live birds/km of beach walked in each family for all of Puale Bay, Alaska Peninsula, Alaska surveyed from June-September of 1990-1992.

Group	Family (Scientific Name)	Family (Common Name)	Year 1990	1991	1992
Waterfowl	Gaviidae	Loons	0.18	0.64	0.93
	Anatidae	Swans, Geese & Ducks	15.32	148.85	102.68
Seabirds	Podicipedidae	Grebes	0.08	0.06	0.39
	Procellariidae	Shearwaters & Petrels	0	0	0.01
	Phalacrocoracidae	Cormorants	1.66	7.31	5.86
	Laridae	Skuas, Jaegars, Gulls & Terns	112.28	438.26	104.89
	Alcidae	Auks & Puffins	5.54	50.68	28.88
Shorebirds	Charadriidae	Plovers	3.42	10.03	4.67
	Haematopodidae	Oystercatchers	0	0.15	0
	Scolopacidae	Sandpipers	10.53	23.97	10.46
Passerines	Corvidae	Jays, Crows, & Magpies	1.92	5.38	8.39
	Troglodytidae	Wrens	0	0	0.23
	Muscicapidae	Thrushes	0	0	0.23
	Cinclidae	Dippers	0.05	0	0
	Motacillidae	Pipits & Wagtails	5.14	16.45	8.72
	Emberizidae	Warblers & Sparrows	6.49	6.02	13.64
	Fringillidae	Finches	0.10	0.02	1.02
	Hirundinidae	Swallows	0.03	2.08	24.15
	Alaudidae	Larks	0	0.02	0
Raptors	Accipitridae	Hawks & Eagles	2.51	2.93	3.60
	Falconidae	Falcons	0.03	0.06	0.49

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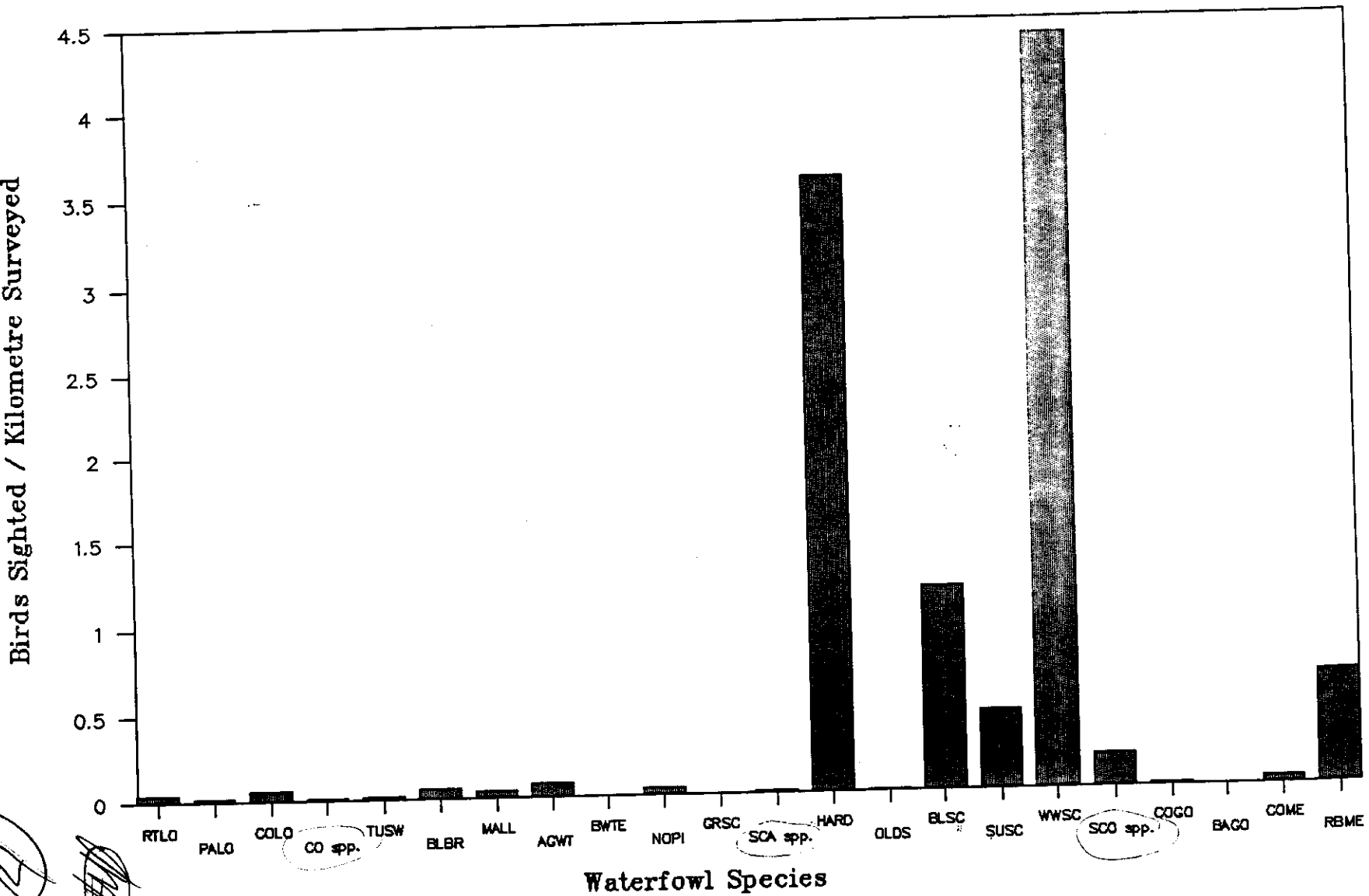

Figure #. **Number of live birds per kilometre of beach surveyed for the species of waterfowl seen on all six sections of Puale Bay, Alaska Peninsula, Alaska. Numbers are an average of the June–September 1990, 1991 and 1992 values.**

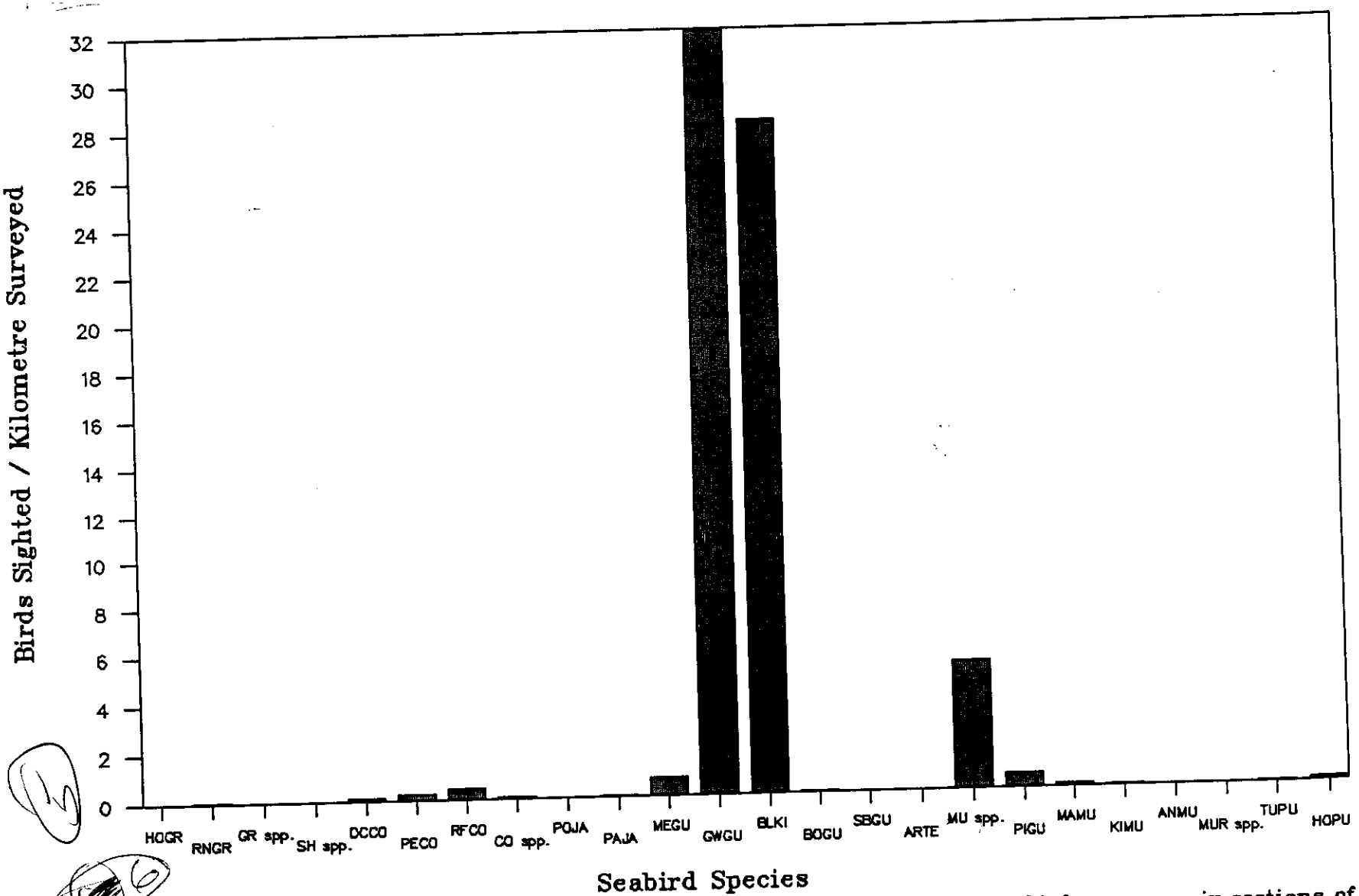

Figure 6. Number of live birds per kilometre of beach surveyed for the species of seabirds seen on six sections of Puale Bay, Alaska Peninsula, Alaska. Numbers are an average of the June–September 1990, 1991 and 1992 values.

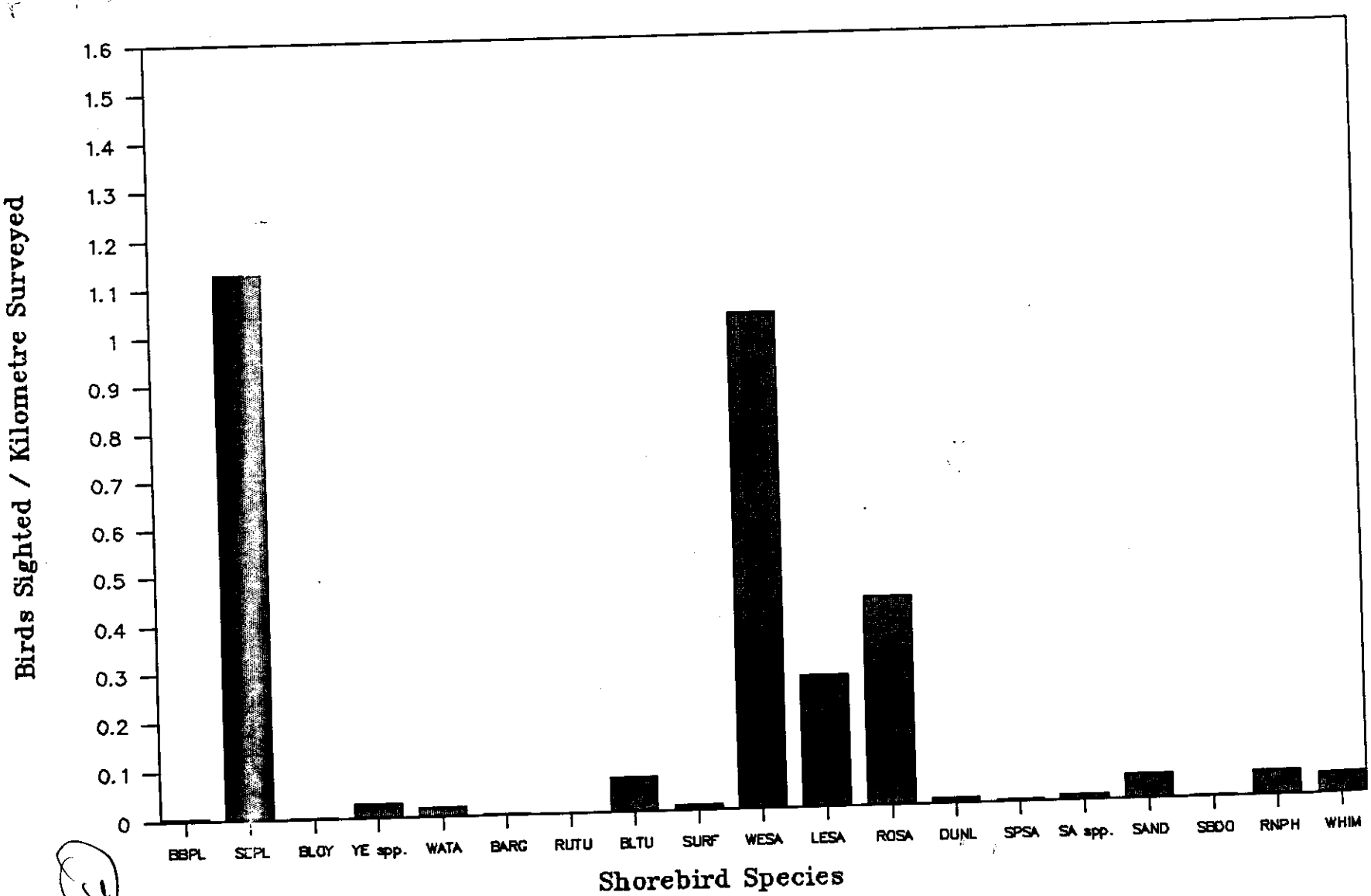

Figure #7 Number of live birds per kilometre of beach surveyed for the species of shorebirds seen on all six sections of Puale Bay, Alaska Peninsula, Alaska. Numbers are an average of the June–September 1990, 1991 and 1992 values.

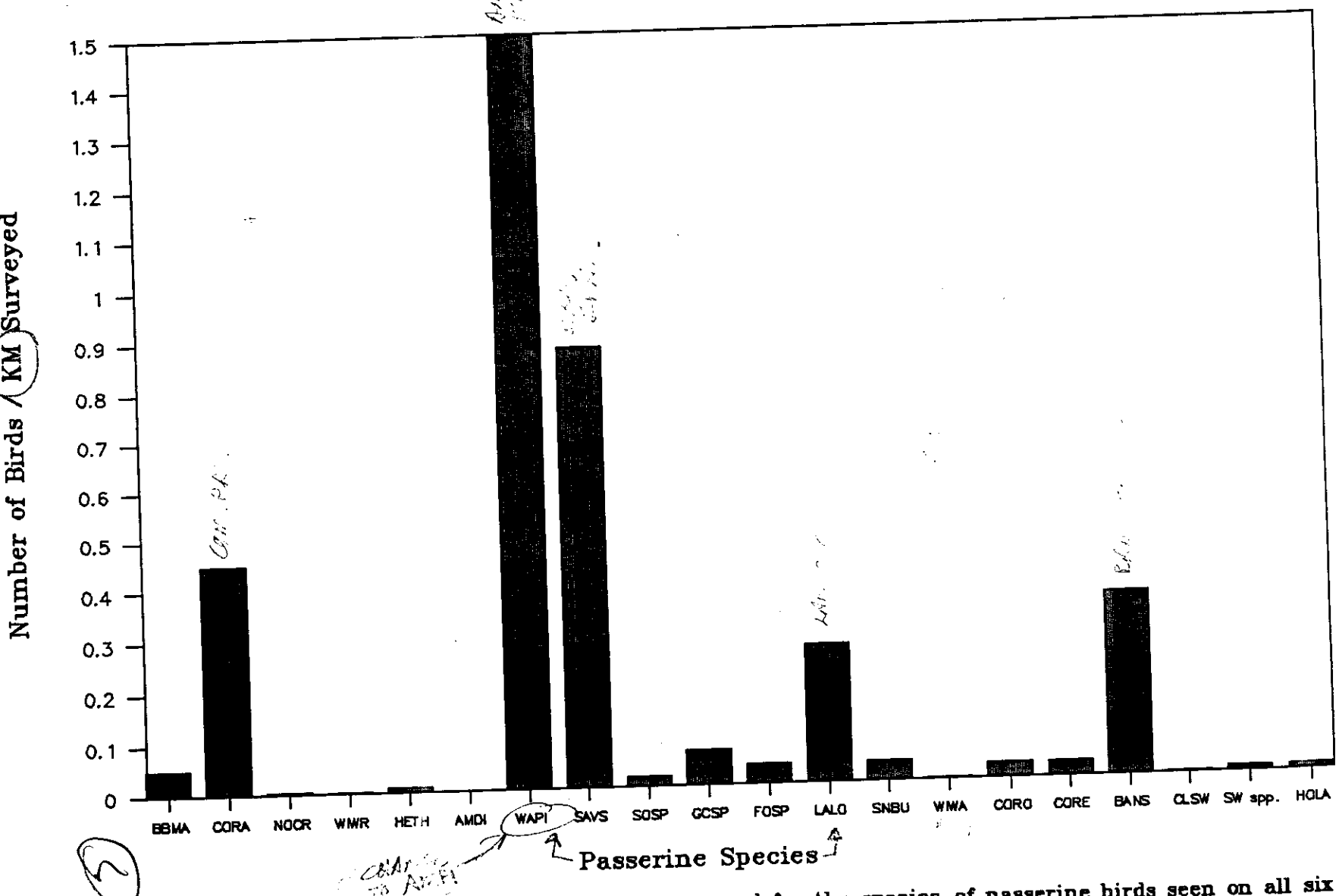

Figure 2. Number of live birds per kilometre of beach surveyed for the species of passerine birds seen on all six sections of Puale Bay, Alaska Peninsula, Alaska. Numbers are an average of the June–September 1990, 1991 and 1992 values.

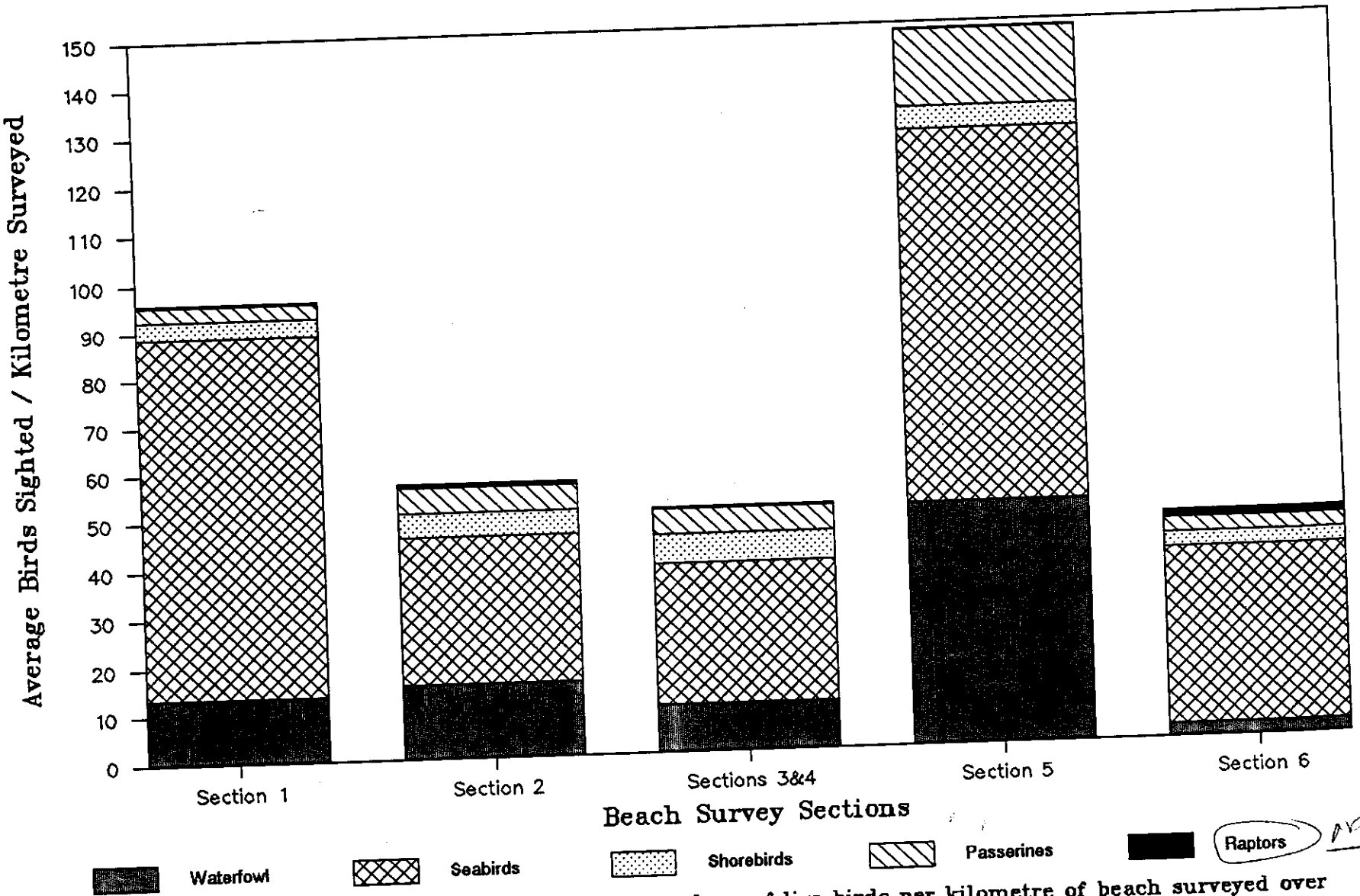

Figure 10. Totals for each bird group of the average numbers of live birds per kilometre of beach surveyed over the three years, June–September of 1990–1992, for each of the survey sections of Puale Bay, Alaska Peninsula, Alaska.

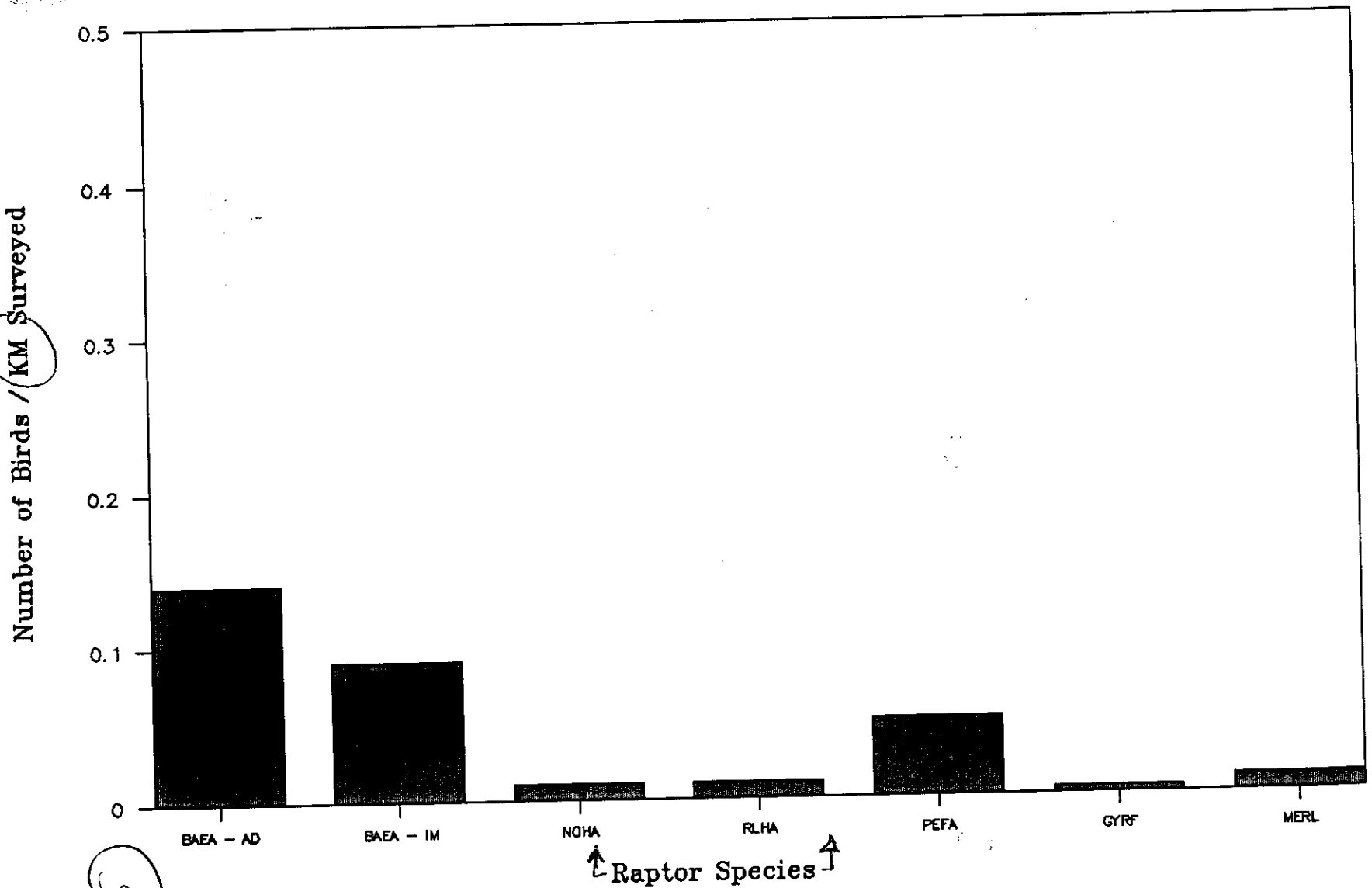

Figure #. Number of live birds per kilometre of beach surveyed for the species of raptors seen on all six sections of Puale Bay, Alaska Peninsula, Alaska. Numbers are an average of the June–September 1990, 1991 and 1992 values.

waterfowl and seabirds, which spend much of their time on the water, may have found that the northeast side of the bay around Section 5 to be a more sheltered area from wind and weather. Section 6 had the most raptors per km, and Sections 3 and 4 combined had the greatest number of shorebirds. The latter may have been partly due to the tidal flat or lagoon behind the dunes of the beach, which could be an attractive feeding ground at low tide for shorebirds. Section 1 had the second highest number of birds per km, most of which were seabirds, which is understandable due to its close proximity to the seabird colony. In fact, seabirds made up a large portion of the birds sighted on all sections.

Mammals.--

As with the birds, the sightings of live mammals was used as an indicator of general abundancies; species with higher numbers of sightings were assumed to be of greater abundance. If mammals were affected by the oil spill, it would seem logical that the marine mammals would be hardest hit because they would be in direct contact with the oil in the water. Scavenging land mammals such as brown bear (Ursus arctos ~~horribilis~~), red fox (Vulpes fulva) and wolf (Canis lupus), however, who would be attracted by the increase in carcasses washed ashore in 1989, would be expected to increase in numbers on the beaches. This was not always the case reflected in the data.

Sightings - Brown bears were the most commonly seen mammals on Puale Bay beach~~walks~~ in all four years (Fig. ~~RP-12~~ 9). In 1989 and 1990, red fox was the second most common, but in 1991 and 1992 their sightings ~~became fewer~~. Both brown bear and barren ground caribou (Rangifer ~~arcticus~~) increased considerably from 1989 to 1991, but in 1992 ~~dropped back~~ again close to their 1990 numbers. Arctic ground squirrels (Citellus parryi) were the only land mammal seen more often in 1989 than in later years, and there were no actual sightings of them in later years. The most common marine mammals seen were harbour seals, which did decrease from 1989 to 1990, but increased over the next two years to nearly three times the sightings of 1989. If their numbers were decreased by the oil spill, they would seem to be recovering now. No sea otters were seen in 1989 or 1991, but there were minimal sightings in 1990 and 1992. ~~So either their numbers are not recovering well from the oil spill, or they may never have been in large numbers in the beach areas of Puale Bay to start with.~~

Tracks - Because the number of tracks per species per replicate was not always recorded along with the different species of tracks seen per replicate, it was necessary to convert the track data to a percentage (number of replicates on which tracks of a certain species were seen per the total number of replicates completed for that transect in that year). It is interesting to note that the results from the tracks for brown bear, red fox and barren ground caribou is opposite to that of the live sightings (Fig. ~~RP-13~~). Tracks of both brown bear and caribou were seen in the highest percentage in 1989, decreased considerably over the next two years, only to increase greatly in 1992. Red fox were lower in 1989 and increased steadily until 1992, except for 1991 when no red fox tracks were recorded. ~~In a personal communication with Jim McCarthy, a member of the 1991 field crew, he stated that red fox tracks were seen frequently and somehow must have just not been recorded. Which reinforces the point that there are some biases in this beached bird survey data due to the variety of people who have collected it over the years.~~

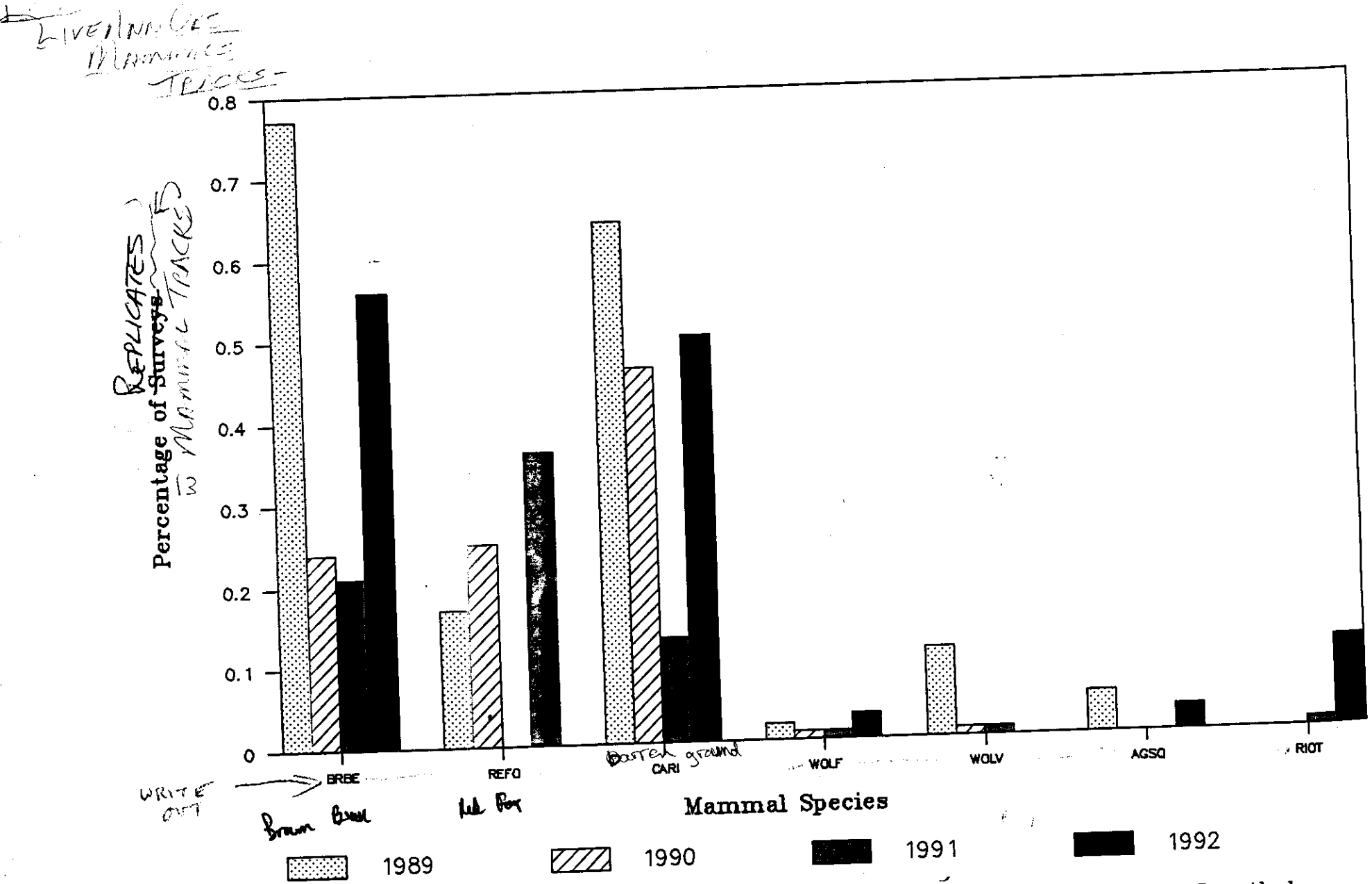

Figure #. Percentage by mammal species of beach surveys on which tracks were found on Puale Bay, Alaska Peninsula, Alaska from June–September of 1989–1992.

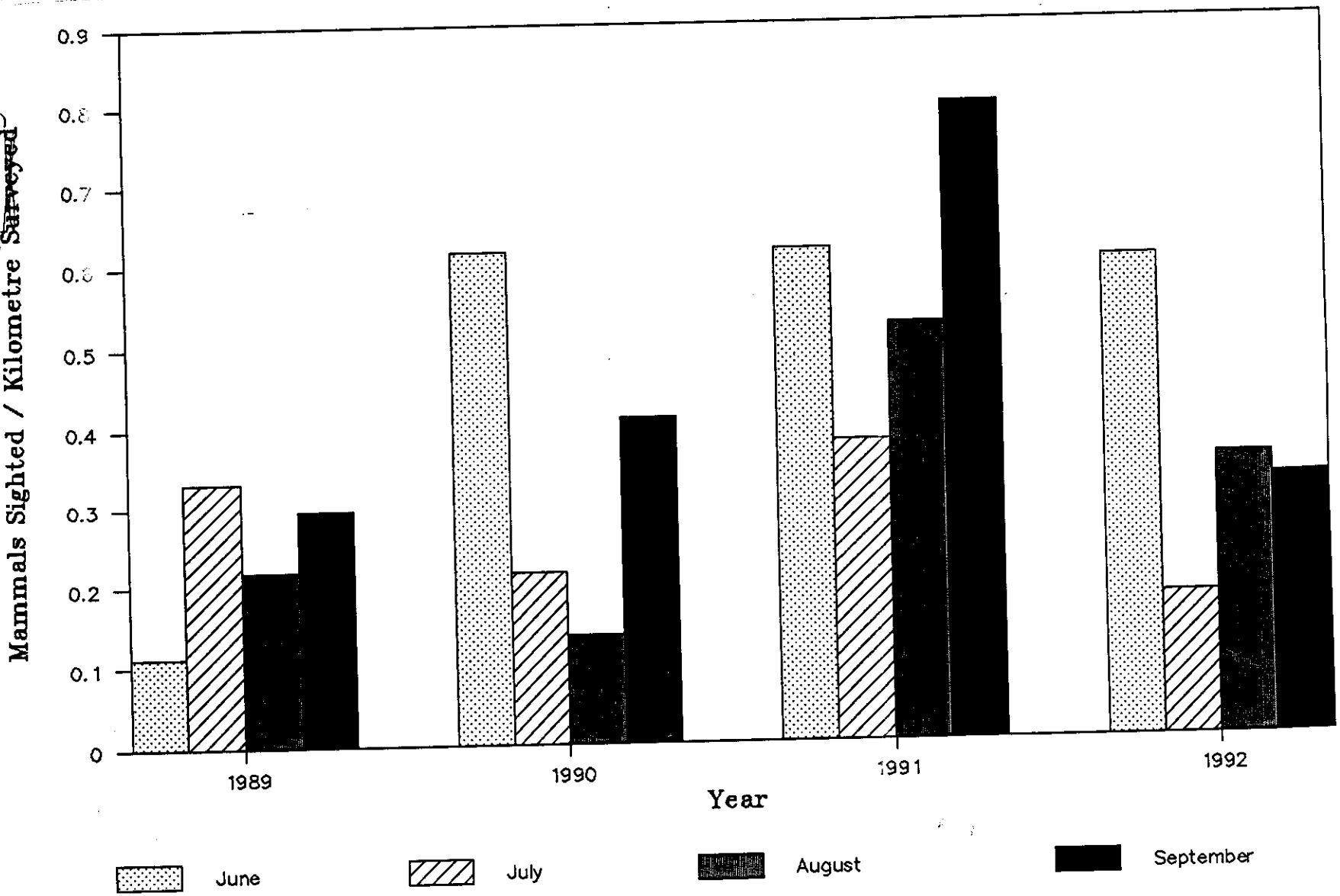

Figure 4. Number of mammals sighted per kilometre of beach surveyed for all sections of Puale Bay, Alaska Peninsula, Alaska for each month from June–September of 1989–1992.

observations of live birds and mammals. The objectives of this report were as follows:

A. To compare recorded bird and mammal mortality immediately after the oil spill (1989) to that of the following 3 years (1990-1992), in Puale Bay.

B. To examine variation in observed live bird and mammal populations of Puale Bay as recorded on beached bird surveys during 1990-1992.

C. To determine if there was a relationship between the live bird and bird carcass data of selected species using a mortality index.

D. To compare species composition of bird carcasses recovered during 1989, from Puale Bay with those from the rest of the Refuge Complex coast and the entire oil spill area.

change all Beached Bird surveys To Beach surveys due To beaches were searched for everything

METHODOLOGY

Study Area

Although shoreline and wildlife impacts have been documented along the entire coast of the Alaska Peninsula/Becharof Refuge Complex (Dewhurst et al. 1990), only the sandy beaches of Puale Bay (57°43'W, 155°33'N) were selected for study. Puale Bay is bounded by Cape Kekurnoi to the north and Cape Aklek to the south, and is 10 km (6.2 mi) across at its widest point. Surface substrates of the bay consist of 46% sandy beach, 36% bedrock/boulders, 10% cobble beach, and 8% mudflats (Dewhurst et al. 1990). Puale Bay is surrounded by mountains of the Aleutian Range, with a well-known sea level mountain pass at the head of the bay.

Change All genus sp To Lat. le

Treeless, ericaceous tundra forms the base carpet for Puale Bay upland vegetation with Sitka alder (Alnus crispa) lining the valley streams. Sandy beaches were predominately composed of beach ryegrass (Elymus mollis), seabeach sandwort (Honckenya peploides), beach pea (Lathymus maritimus), and seabeach senecio (Senecio pseudo-arnica). Commonly the beach was littered with washed-up algae consisting of bull kelp (Nereocystis leutkeana) and sugar wrack (Laminaria saccharina) with rockweed (Fucus distichus), sea sac (Halosaccion glandiforme) and filamentous green algae (Urospora spp.) growing on the intertidal rocks, making them very slippery.

Immediately north of Teresa Creek, the eroded mountain-sides form cliffs 170-300 m (560-1000 ft) high creating ideal colony habitat for ledge-nesting seabirds (Dewhurst 1991). Two similar, but larger cliff colonies were located south of Cape Aklek together with the Puale Bay colony provided breeding habitat for 37,000 common (Uria aalga) and thick-billed murres (U. lomvia), 1,300 black-legged kittiwakes (Rissa tridactyla), 200-650 red-faced (Phalacrocorax urile), pelagic (P. pelagicus) and double-crested (P. auritus) cormorants, 100-200 tufted (Fratercula cirrhuta) and horned (F. corniculata) puffins, and 300-400 glaucous-winged gulls (Larus glaucescens) (Dewhurst and Moore 1992, McCarthy and Dewhurst 1992).

Mammal Distribution.--

Sightings - Numbers of mammals sighted/km walked for Section 1 were about equal in all years except 1991, when there were twice as many (Fig. RD-15). In Section 2 the sightings/km were highest in 1989 and 1992. Sections 3 and 4 combined had no mammal sightings in 1990, but otherwise increased in 1991 and 1992 from 1989 numbers. Section 5 had no mammal sightings in the first two years, but had comparable numbers in 1991 and 1992 to those of other sections. The mammal sightings/km were especially high in 1990 for Section 6, but no mammals were seen there in 1992. When considering the data for Sections 6, 5, and even 3 and 4, it should be remembered that the number of replicates were much lower than for Sections 1 and 2, which can influence the end results despite efforts to compensate for this in the analysis. Section 6 is especially biased in this manner since it only was walked once or twice in any given year. The important thing to note is the lack of any distinct pattern that would suggest a difference in how the oil spill affected the mammals in the different sections. There was no distinct pattern with the monthly distribution of mammal sightings, either (Fig. RD-17). In general, the live mammal sightings do not appear to have been greatly influenced by the spill.

Tracks - Sections 3 and 4 combined had the highest percentages of replicates with tracks in 1989 and 1991, and were still comparitively high in 1990 and 1992 (Fig. RD-16). The highest percentage for all sections and years was in Section 6 in 1992, but that was based on only one replicate of Transect 6. And there were no tracks seen within Transect 6 in 1990 or 1991. Sections 2 and 1 had the highest percentages in 1990. September was the peak month for all years except 1989, when August was slightly higher (Fig. RD-18). Percentages for June were variable, but always lower than in other months. This may be due in part to the fact that surveying of the transects never started until mid to late June.

Comparison of Carcass Recovery to Observed Abundances

Annual Trends.--

Puffins had very high carcass numbers in relation to their live sightings in 1989 in Section 1 (Table RD-19A). This would suggest that many carcasses were drifting into Puale Bay from elsewhere. Considering the strong current of the Shelikof Strait, which passes by the mouth of the bay, they would likely have come from up the coast in the direction of the Barren Islands.

Murres had a low mortality index, indicating that their live observations was much higher than the number of carcasses found, (and that the carcasses could have been either local or drifted in from other colonies). This reflects the case during the survey period, but the pre-camp May carcass numbers for murres was very high and would probably have produced a high mortality index, suggesting that some of the carcasses were not from the local colony. Section 5 had no live murre sightings in 1989, but there were 3.64 carcasses/km. Murres would have been in rafts on the water near the local colony cliffs and may have drifted across the bay from there.

Distribution.--

CONCLUSIONS

RECOMMENDATIONS

ACKNOWLEDGEMENTS

Greatly appreciated were the conscientious efforts of the following Puale Bay field camp personnel listed by year:

1989 - Biological Technicians Tim Howard and Greg Thomson and Volunteers Allan Smith, Patrick Hickey, David Bassett, Doug Low, Tess Madigan, Carey Marzicola, Veronica Cassily;
1990 - Biological Technician Greg Thomson and Volunteers Bill Stahl, Gregor Yanega, Chris Simoniello, Lynn Schwartz, Patrick Opay;
1991 - Biological Technician Christine Berkman and Volunteers Toby Burke, Jim McCarthy, Carol Snetsinger, Mike Moore; and
1992 - Biological Technician Kevin Boden and Volunteers Jim McCarthy, Laurie Cleary, Nikki Benjamin, Nancy Cook, Dave Anderson, John Gerlach, Meredith Bridgers.

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APPENDICES

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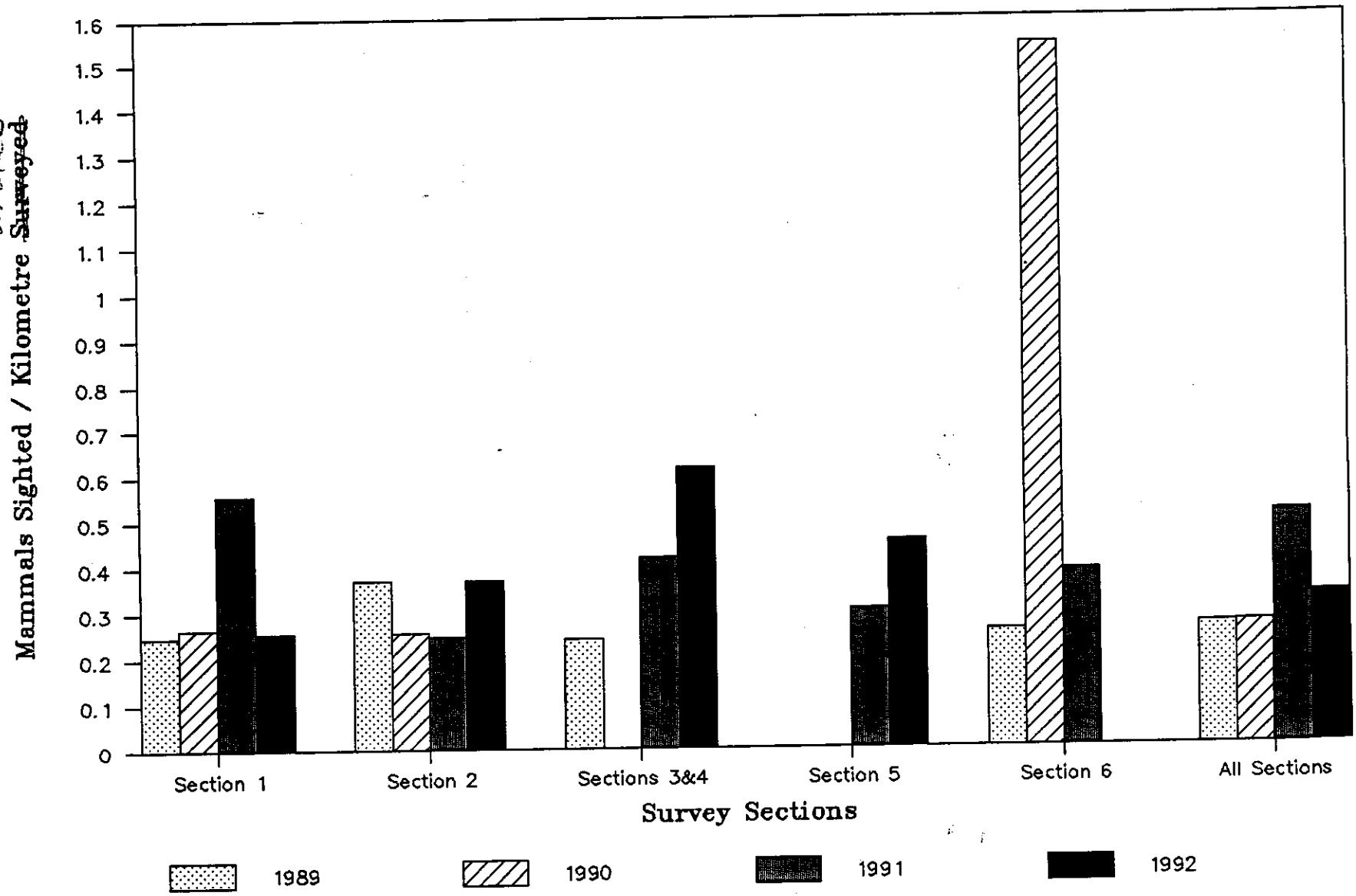

Figure #. Number of mammal sightings per kilometre of beach surveyed for each survey section on Puale Bay, Alaska Peninsula, Alaska from June–September of 1989–1992.

Table 2. Number of surveys conducted and total distance covered for each section in each year of the beached bird surveys on Puale Bay, Alaska Peninsula, Alaska from June-September of 1989-1992.

Section	Number of ~~Surveys~~ Replicates Done				Length of Transects ~~Section~~ (km)	Total Kilometres ~~Area~~ Distances Surveyed (km)			
	1989	1990	1991	1992		1989	1990	1991	1992
1	34	63	33	22	3.8	129.2	234.8	122.2	81.7
2	10	9	3	7	2.7	27.0	24.3	8.1	18.9
3	2	1	3	3	1.3	2.6	1.3	3.9	3.9
4	4	1	3	4	3.5	14.0	3.5	10.5	14.0
5	1	2	3	4	1.1	1.1	2.2	3.3	4.4
6	3	1	2	1	1.3	3.9	1.3	2.6	1.3
Total ~~All~~	?	?	?	?	13.7	177.8	267.4	150.6	124.2

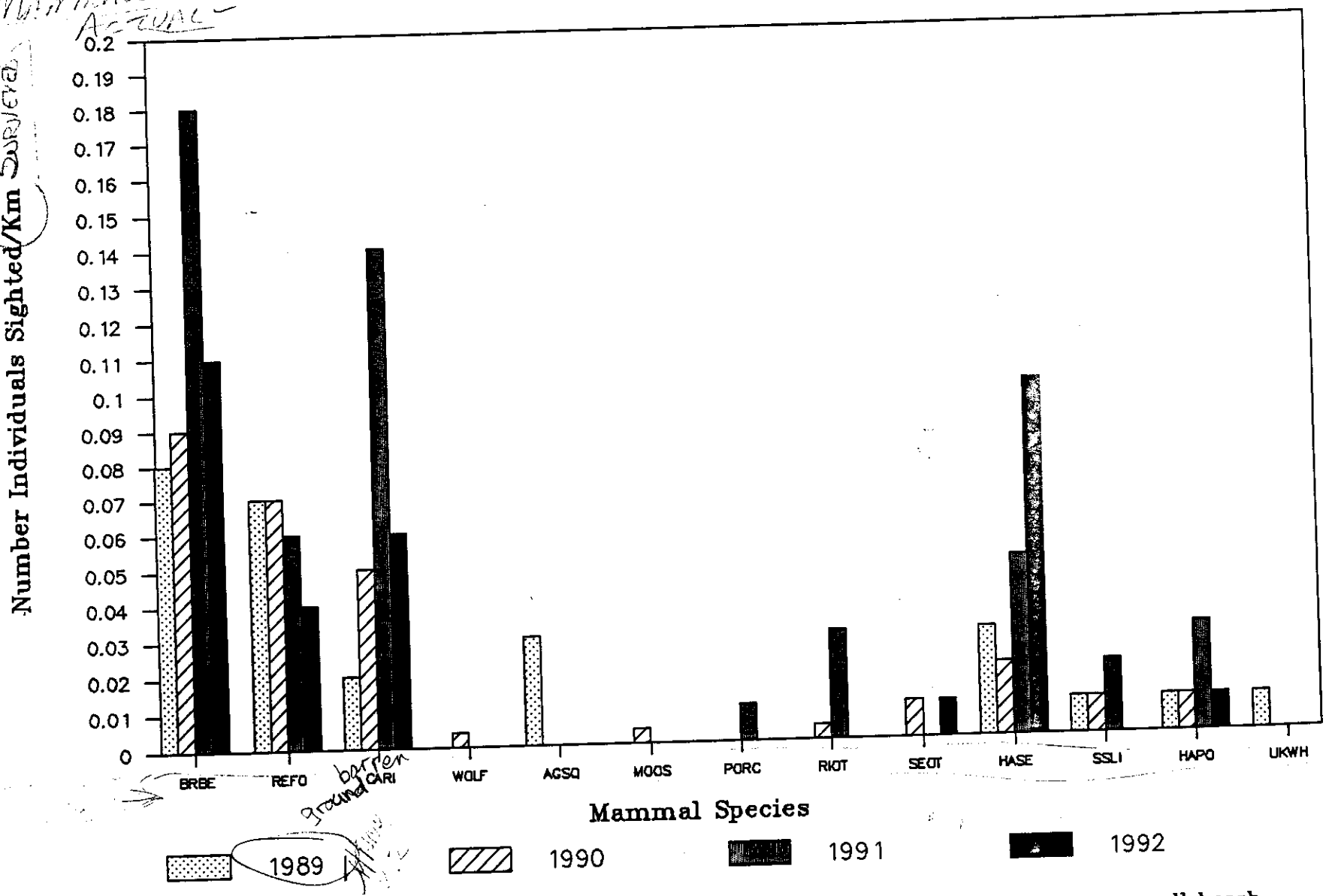

Figure #. Number of individuals sighted per kilometre of beach for all the mammal species seen on all beach survey sections of Puale Bay, Alaska Peninsula, Alaska from June–September of 1989–1992.

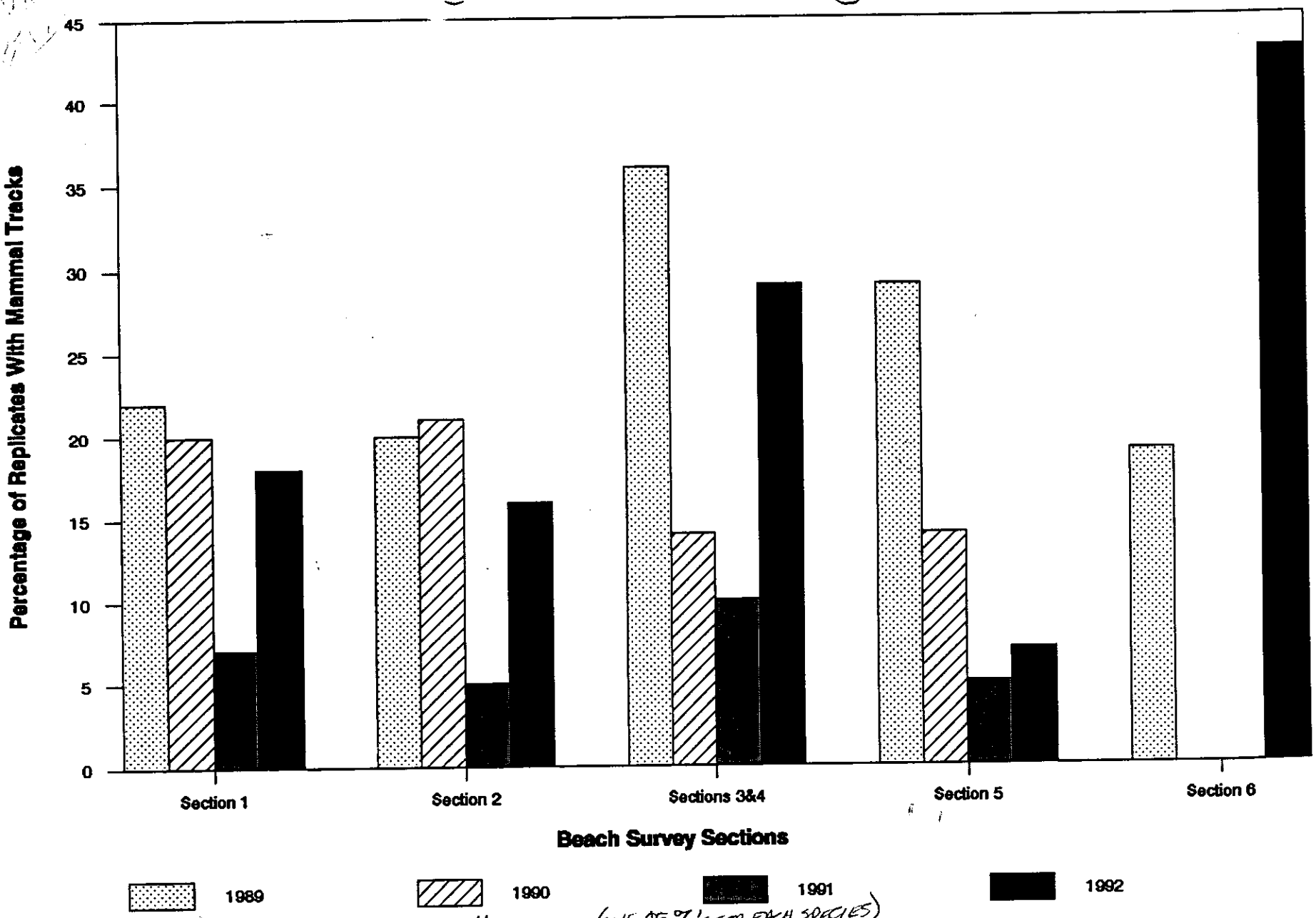

Figure #. Percentage of replicates on which all mammal tracks were seen in each of the beach survey sections on Puale Bay, Alaska Peninsula, Alaska from June-September of 1989-1992. (AVE. OF %'s FOR EACH SPECIES)

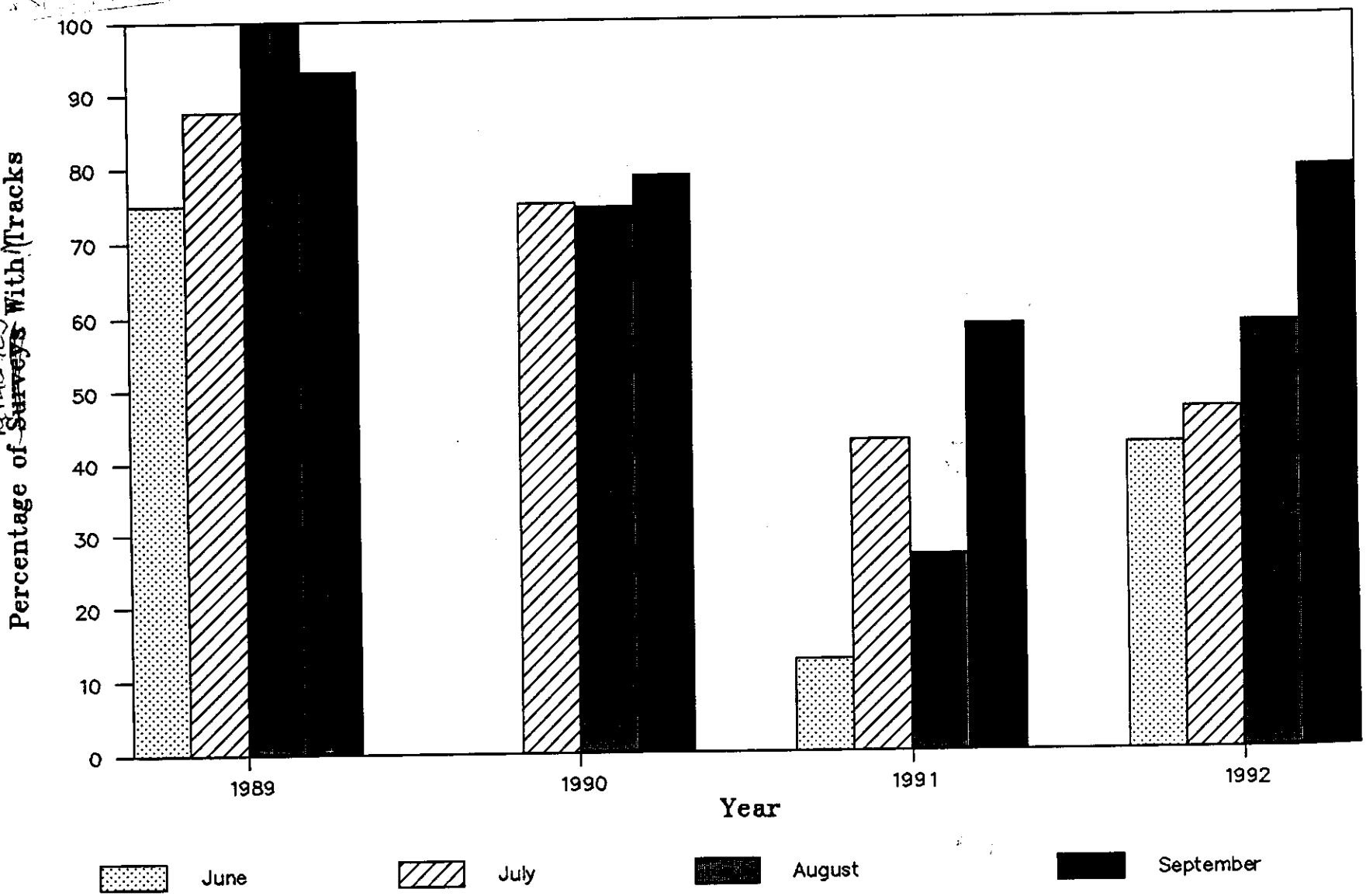

Figure #. **Average percentage for all sections of beach surveys with mammal tracks on Puale Bay, Alaska Peninsula, Alaska for each month from June–September of 1989–1992.**

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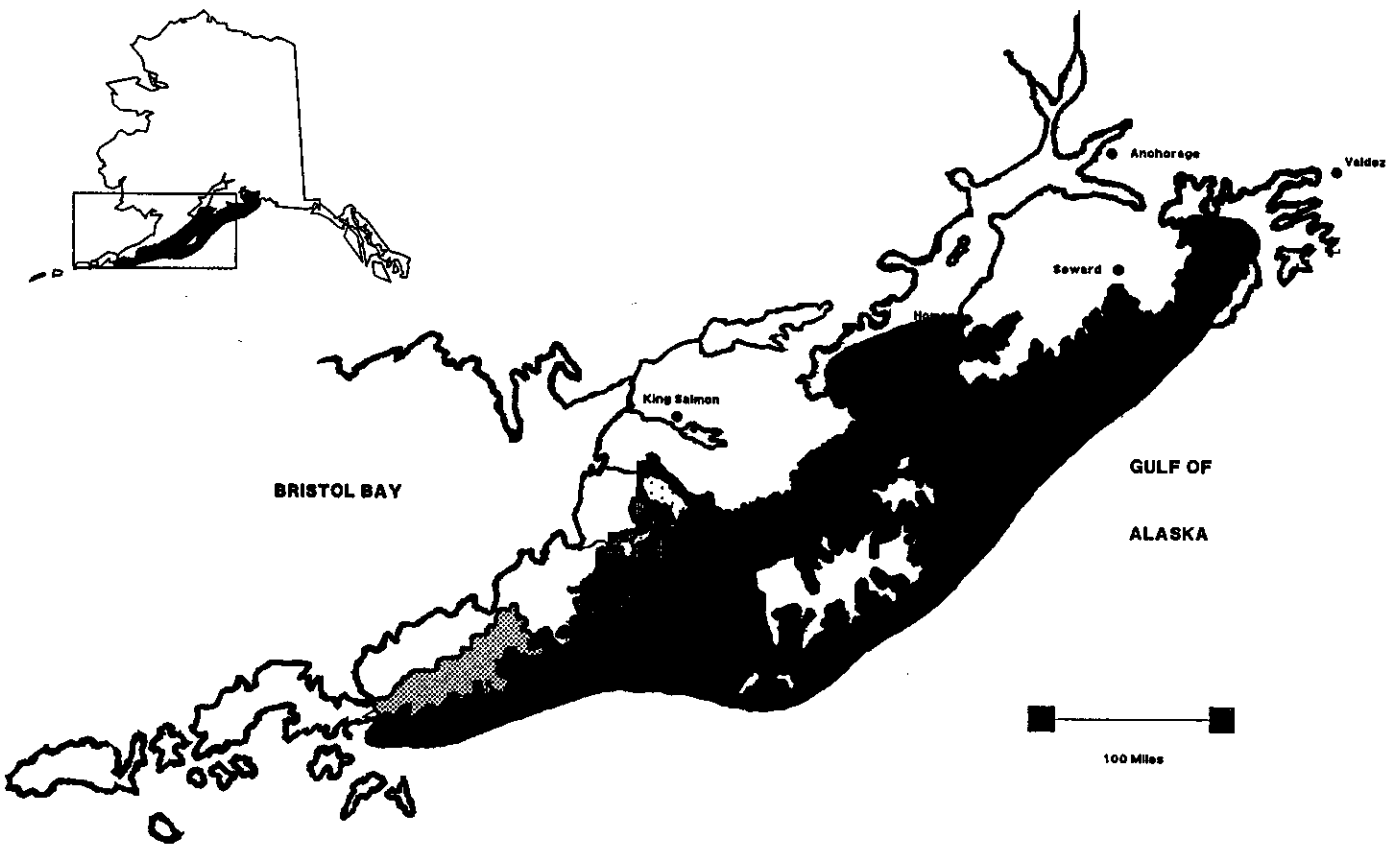
Table 2. Mortality Index comparing bird carcasses per kilometre of beach walked to live birds observed per kilometre for each survey section at Puale Bay, Alaska Peninsula, Alaska from June-September of 1989-1992. Live bird data from 1992 was used to represent the live bird numbers for 1989.

Section	Year	Species							
		MU spp.	TUPU	HOPU	PIGU	SH spp.	BLKI	GWGU	CO spp.
1	1989	0.01	7.8000	18.0000	0.01	21.0000	0.0104	NS	0.0215
	1990	0.2500	0.01/ 0	0 /NS	0 /0.02	NS	NS	NS	0 /0.44
	1991	0 /7.75[a]	0[b]	0 /0.02	0	0.07/ 0	NS	NS	0.02
	1992	NS	0.2000	1.0000	0 /1.22	1.0000	NS	NS	0 /0.94
2	1989	0.07/ 0	0	0 /0.32	0 /2.43	0.22/ 0	0.1	0 /25.40	0 /2.86
	1990	1.0000	0	0.0	0 /0.99	0	0 /0.86	0 /18.85	0.08
	1991	0	0 /0.25	0 /0.25	0 /5.31	0	0 /12.35	0 /14.81	0 /1.97
	1992	0	0	0 /0.32	0 /2.43	0	0 /1.11	0 /25.40	0 /2.86
3&4	1989	0.18/ 0	0	0.30/ 0	0 /0.06	0.24/ 0	0.18/ 0	0 /4.69	0 /0.34
	1990	0	0	0	0	0	0	0 /0.21	0
	1991	0 /3.82	0	0	0 /0.28	0	NS	0 /38.47	0.04
	1992	0.06/ 0	0	0.06/ 0	0 /0.06	0	0	0 /4.69	0 /0.34
5	1989	3.64/ 0	0	0 /2.73	0	0.91/ 0	0 /7.50	0 /14.55	0 /1.13
	1990	0	0	0	0	0	0 /9.09	0 /12.27	0 /0.45
	1991	0 /3.94	0 /3.94	0 /7.27	0 /5.76	0	0 /75.76	0 /39.39	0 /2.43
	1992	0	0	0 /2.73	0	0	0 /7.50	0 /14.55	0 /1.13
6	1989	0	0	0	0	0	0	0	0
	1990	0	0	0	0	0	0	0 /3.85	0
	1991	0	0 /0.77	0 /0.77	0 /2.31	0	0 /78.85	0 /19.23	0 /0.38
	1992	0	0	0	0 /3.85	0	0	0	0

Table 2. (continued)

Section	Year	Species							
		MU spp.	TUPU	HOPU	PIGU	SH spp.	BLKI	GWGU	CO spp.
All	1989	0.0140	8.781	1.0260	0.0049	27.3806	0.0257	0.0003	0.0149
	1990	0.2973	0.017/ 0	0.0089	0 /0.105	0.0047/ 0	0.0008	0.0002	0.0088
	1991	0 /6.740	0 /0.113	0 /0.206	0 /0.470	0.060/ 0	0.0004	0.0001	0.0160
	1992	0.0055	0.2500	0.1046	0 /1.224	1.0000	0.0009	0.0008	0 /1.145

[a] The ratio was written out, not calculated, when one of the values in the ratio was equal to zero.
[b] A zero denotes that both values in the ratio were equal to zero.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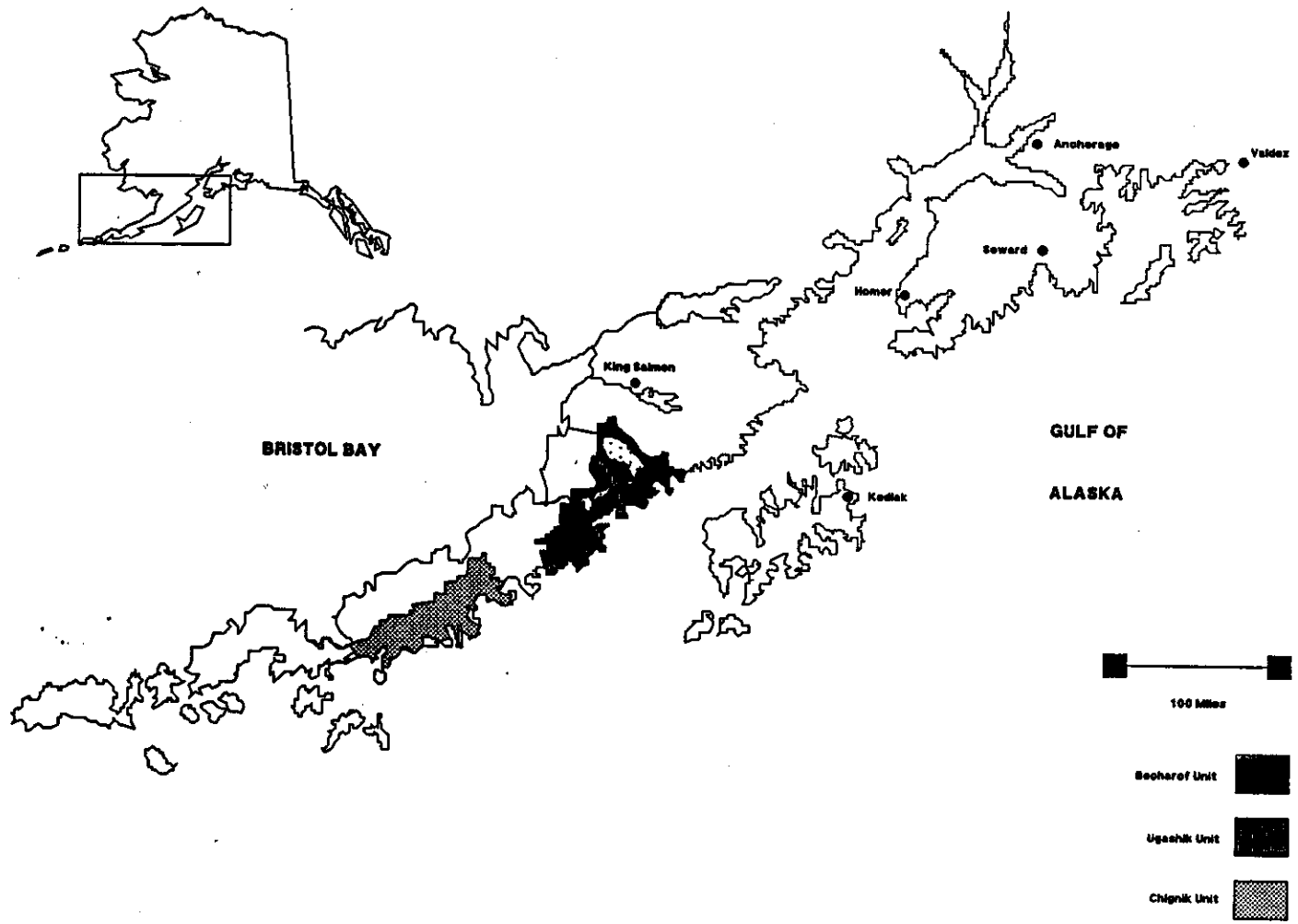
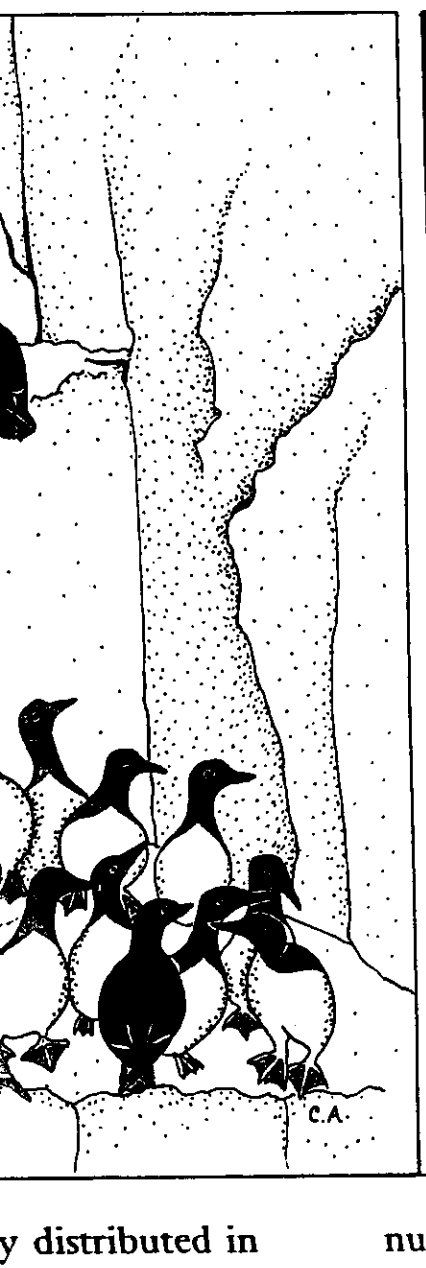
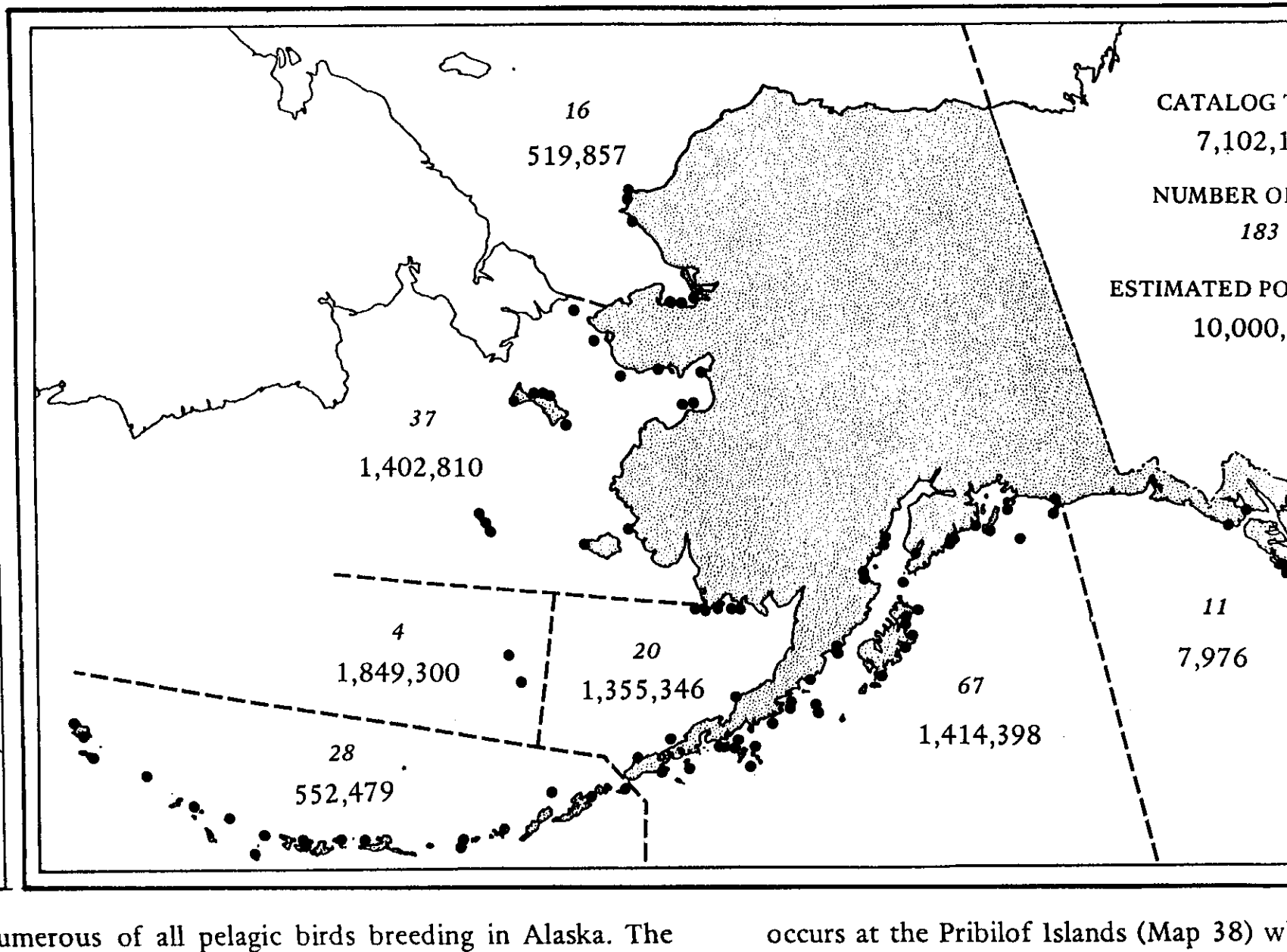
Valdez
Seward
King Salmon
BRISTOL BAY
GULF OF
ALASKA
100 Miles


Anchorage
Valdez
Seward
Homer
King Salmon
BRISTOL BAY
GULF OF
ALASKA
Kodiak
100 Miles
Becharof Unit
Ugashik Unit
Chignik Unit

Murres (*Uria* spp.)





y distributed in
eans. The Thick-
ic and subarctic
close association

numerous of all pelagic birds breeding in Alaska. The catalog lists 183 colonies of one or both species totaling more than 7 million birds. Population estimates are available for nearly all colonies. Diurnal and seasonal

occurs at the Pribilof Islands (Map 38) w
million Thick-billed Murres and 150,
Murres are found. Mainland colonies at Ca
(Map 039) and Cape Peirce (039 010)

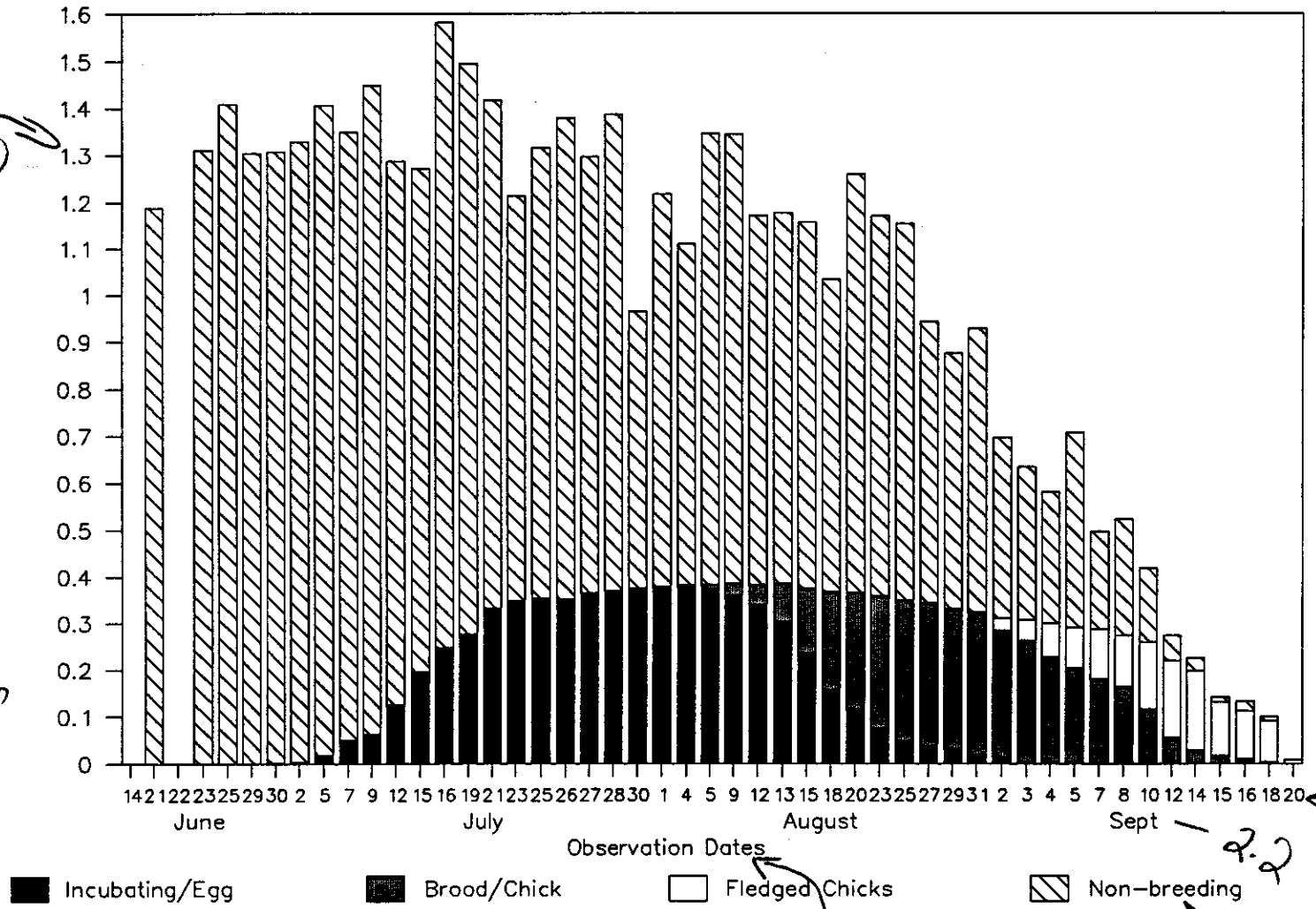


Fig . Composition of murre populations (common and thick-billed combined) observed June-September 1992 in the productivity plots at Puale Bay, Alaska Peninsula, Alaska. The stacked bars are additive with the top representing total counts per date.

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 SECLVBD .PIC      917  10-21-92 09:19a ° SECLVBD2.DRW    6,635  11-13-92 12:58p
 SECLVBD2.PIC    4,423  11-13-92 12:31p ° SECTSMAP.DRW    8,307  11-19-92 05:43p
 SHOREBRD.DRW    7,418  11-05-92 03:53p ° SHOREBRD.PIC    2,029  11-05-92 12:56p
 TABLES  .      42,763  11-30-92 12:57p ° WATERFWL.DRW    7,096  11-05-92 02:54p
 WATERFWL.PIC    2,107  11-05-92 12:42p °

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6 Look; 7 Other Directory; 8 Copy; 9 Find; N Name Search: 6


12-04-92  10:05a            Directory B:\*.*
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 ANOVA   .WK1   72,814  11-03-92 05:32p ° BBMETHOD.       21,387  11-23-92 04:45p
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 CARSECS2.DRW    6,664  11-05-92 05:45p ° CARSECS2.PIC    2,406  10-21-92 04:06p
 CARSECTS.DRW    5,106  10-26-92 11:52a ° CARSECTS.PIC    1,983  10-21-92 04:01p
 FAMILIES.DRW    9,048  10-23-92 04:40p ° FAMILIES.PIC    3,415  11-05-92 12:20p
 LIVBIRD2.WK1  102,605  11-13-92 12:32p ° LIVEBIRD.WK1   25,862  10-19-92 04:55p
 MAMMALS .WK1   36,545  12-02-92 10:06a ° MAMMALS1.PIC    4,109  10-22-92 11:17a
 MAMMALS2.DRW    6,442  11-13-92 02:45p ° MAMMALS2.PIC    3,786  11-13-92 02:18p
 MAMMALS3.PIC    5,637  10-22-92 12:56p ° MAMMALS4.DRW    9,165  11-06-92 03:24p
 MAMMALS4.PIC    5,379  11-06-92 11:12a ° MAMMALS5.DRW    4,960  11-13-92 04:47p
 MAMMALS5.PIC    4,068  11-13-92 04:27p ° MAMTRAK1.PIC    3,185  10-22-92 02:42p
 MAMTRAK2.DRW    5,286  12-02-92 10:41a ° MAMTRAK2.PIC    4,236  12-02-92 10:06a
 MAMTRAK3.PIC    3,544  10-22-92 03:17p  MAMTRAK4.DRW    5,755  11-06-92 03:53p

1 Retrieve; 2 Delete; 3 Move/Rename; 4 Print; 5 Short/Long Display;
6 Look; 7 Other Directory; 8 Copy; 9 Find; N Name Search: 6


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 RAPTORS .PIC    1,600  11-05-92 12:51p ° RAPTORS2.DRW    4,059  11-05-92 04:36p
 RAPTORS2.PIC      998  11-05-92 01:00p ° SEABIRDS.DRW    8,206  11-05-92 03:29p
 SEABIRDS.PIC    2,238  11-05-92 12:44p ° SECLVBD .DRW    5,108  10-28-92 11:13a
 SECLVBD .PIC      917  10-21-92 09:19a ° SECLVBD2.DRW    6,635  11-13-92 12:58p
 SECLVBD2.PIC    4,423  11-13-92 12:31p ° SECTSMAP.DRW    8,307  11-19-92 05:43p
 SHOREBRD.DRW    7,418  11-05-92 03:53p ° SHOREBRD.PIC    2,029  11-05-92 12:56p
 TABLES  .      42,763  11-30-92 12:57p ° WATERFWL.DRW    7,096  11-05-92 02:54p
 WATERFWL.PIC    2,107  11-05-92 12:42p °
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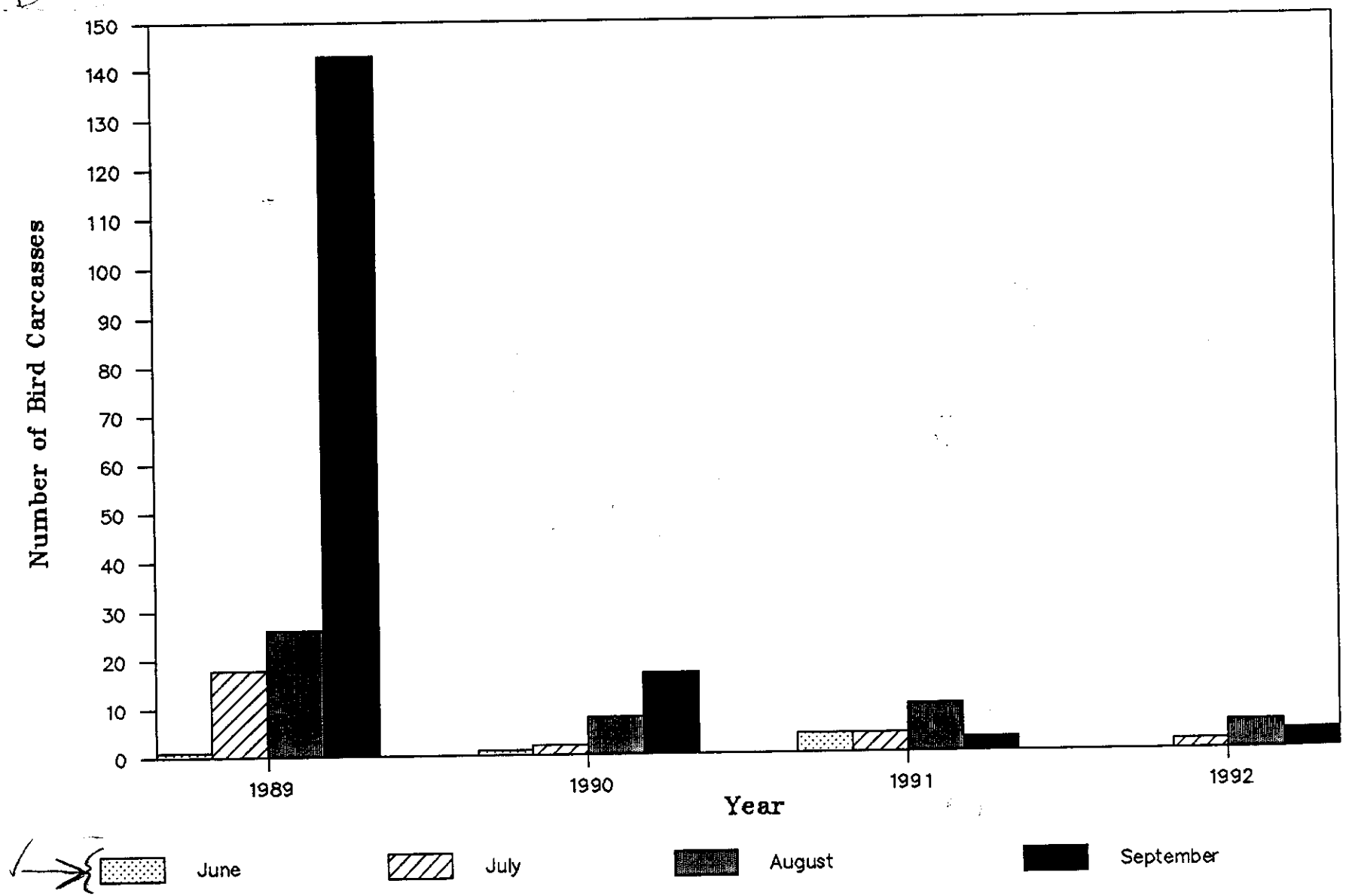


Figure #2 Number of bird carcasses found in all ~~the~~ beach survey sections in each month from June–September of 1989–1992.

all years except 1989, when August was slightly higher (Fig. RD-18). Percentages for June were variable, but always lower than in other months. This may be due in part to the fact that surveying of the transects never started until mid to late June.

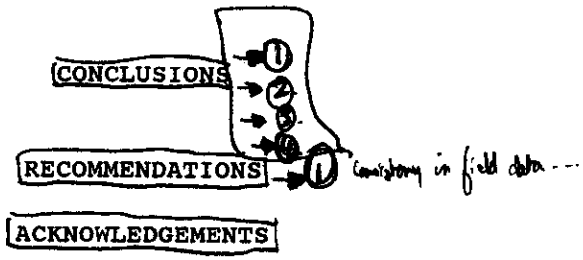
Comparison of Carcass Recovery to Observed Abundances

Annual Trends.--

Puffins had very high carcass numbers in relation to their live sightings in 1989 in Section 1 (Table RD-19A). This would suggest that many carcasses were drifting into Puale Bay from elsewhere. Considering the strong current of the Shelikof Strait, which passes by the mouth of the bay, they would likely have come from up the coast in the direction of the Barren Islands.

Murres had a low mortality index, indicating that their live observations was much higher than the number of carcasses found, and that the carcasses could have been either local or drifted in from other colonies. This reflects the case during the survey period, but the pre-camp May carcass numbers for murres was very high and would probably have produced a high mortality index, suggesting that some of the carcasses were not from the local colony. Section 5 had no live murre sightings in 1989, but there were 3.64 carcasses/km. Murres would have been in rafts on the water near the local colony cliffs and may have drifted across the bay from there.

Distribution.--



Greatly appreciated were the conscientious efforts of the following Puale Bay field camp personnel listed by year:

- **1989** - Biological Technicians Tim Howard and Greg Thomson and Volunteers Allan Smith, Patrick Hickey, David Bassett, Doug Low, Tess Madigan, Carey Marzicola, Veronica Cassily;
- **1990** - Biological Technician Greg Thomson and Volunteers Bill Stahl, Gregor Yanega, Chris Simoniello, Lynn Schwartz, Patrick Opay;
- **1991** - Biological Technician Christine Berkman and Volunteers Toby Burke, Jim McCarthy, Carol Snetsinger, Mike Moore; and
- **1992** - Biological Technician Kevin Boden and Volunteers Jim McCarthy, Laurie Cleary, Nikki Benjamin, Nancy Cook, Dave Anderson, John Gerlach, Meredith Bridgers.

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APPENDICES