Exxon Valdez Oil Spill State/Federal
Natural Resource Damage Assessment
Final Report

Technical Report: Marine Mammals Study Number 6

Mortality of Sea Otter Weanlings in Eastern and Western Prince William Sound, Alaska, During the Winter of 1990-91

Marine Mammal Study 6-18
Final Report

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Study History: Marine Mammal Study 6 (MM6), titled *Assessment of the Magnitude, Extent, and Duration of Oil Spill Impacts on Sea Otter Populations in Alaska*, was initiated in 1989 as part of the Natural Resource Damage Assessment (NRDA). Final results are presented in a series of 19 reports that address the various project components. The work reported herein was conducted by Drs. C. Monnett and L.M. Rotterman as part of a Cooperative Agreement between the Prince William Sound Science Center and the U.S. Fish and Wildlife Service. A draft of this report was included in the November 1991 NRDA Draft Preliminary Status Report for MM6; portions of the material in this report were initially reported in a December 1990 Draft Report on MM6 submitted by Drs. Monnett and Rotterman.

Summary: Sixty-four dependent sea otters [Eastern Prince William Sound (EPWS): n = 24; Western Prince William Sound (WPWS), the oil spill area: n = 401 were captured, examined, instrumented with radio-transmitters, and monitored in Prince William Sound between September 1990 and July 15, 1991. This study was one of several interrelated studies aimed at assessing the impact of the T/V *Exxon Valdez* oil spill on sea otters in Prince William Sound, Alaska. Peak periods for birth, weaning, and mortality of young of the year may occur a month or more later in the oil spill area than in the eastern portion of Prince William Sound. While the absolute timing of instrumentation was similar for pups in EPWS and the oil spill area, pups in the oil spill area weighed significantly less at the time of capture than their counterparts in EPWS. Most pups in EPWS became independent of their mothers in October, whereas mother-pup separation typically occurred in November and December in the oil spill area. Most mortality in EPWS occurred during November and December of 1990, whereas most mortality in the oil spill area occurred during January 1991. Survival rates of weanlings over their first winter (analyses consider data until May 1, 1991) were significantly higher in EPWS (the control) than in the oil spill region. This result was the same regardless of whether missing animals were assumed to be dead (χ^2 = 4.64, 1 D.F., $p < 0.05$) or were eliminated from the analyses (χ^2 = 4.70, 1 D.F., p < 0 05).

Key Words: *Enhydra lutris*, *Exxon Valdez*, sea otter.

Citation: Rotterman, L.M., and C. Monnett. 1991. Mortality of sea otter weanlings in eastern and western Prince William Sound, Alaska, during the winter of 1990-91, *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Marine Mammal Study 6-18), U.S. Fish and Wildlife Service, Anchorage, Alaska.

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SUMMARY

Sixty-four dependent sea otters [Eastern Prince William Sound (EPWS): n = 24; Western Prince William Sound (WPWS), the oil spill area: n = 40] were captured, examined, instrumented with radio-transmitters, and monitored in Prince William Sound between September 1990 and July 15, 1991. This study was one of several interrelated studies aimed at assessing the impact of the T/V *Exxon Valdez* oil spill on sea otters in Prince William Sound, Alaska.

Peak periods for birth, weaning, and mortality of young of the year may occur a month or more later in the oil spill area than in the eastern portion of Prince William Sound. While the absolute timing of instrumentation was similar for pups in EPWS and the oil spill area, pups in the oil spill area weighed significantly less at the time of capture than their counterparts in EPWS. Most pups in EPWS became independent of their mothers in October, whereas mother-pup separation typically occurred in November and December in the oil spill area. Most mortality in EPWS occurred during November and December of 1990, whereas most mortality in the oil spill area occurred during January 1991. Survival rates of weanlings over their first winter (analyses consider data until May 1, 1991) were significantly higher in EPWS (the control) than in the oil spill region. This result was the same regardless of whether missing animals were assumed to be dead ($\chi^2 = 4.64$, 1 D.F., $p < 0.05$) or were eliminated from the analyses ($\chi^2 = 4.70$, 1 D.F., $p < 0.05$).

INTRODUCTION

On March 24, 1989, over 11 million gallons of crude oil were spilled in Prince William Sound, Alaska, due to the wreck of the T/V *Exxon Valdez*. The research discussed in this report was undertaken as part of Natural Resource Damage Assessment (NRDA) Study Marine Mammal Study 6, which was aimed at determining if the spill caused damage to the sea otter population(s) in the region, and, if so, the type, magnitude, and significance of the damage(s). The specific goal of this study was to test whether overwinter mortality rates were equivalent among weanling sea otters in eastern and western areas of Prince William Sound, the latter containing the oil spill zone. While this report focuses only on this question, this information is crucial to understanding: the overall extent of damage to the sea otter population(s); whether the affected sea otter population(s) are in a recovery phase; estimating the rate and pattern of recovery; and formulating restoration and response policies for sea otters throughout their range.

OBJECTIVE

The specific objective of this study was <u>originally</u> defined in the corresponding statement of work as follows:

> To test the hypothesis that weanling survival at various age intervals is not different between oiled and unoiled areas at alpha = 0.20.

For reasons given in the methods section below, this objective was modified to the following:

> To test the hypothesis that weanling survival though their first winter (defined as to May 1, 1991) is not different between oiled and unoiled areas.

STUDY METHODOLOGY

Definitions

Terms are used in this report to make them consistent with usage in previous Natural Resource Damage Assessment reports and study plans. Thus, dependents or pups are individuals accompanied by their mothers. For the purposes of this report, individuals were classified as "weanlings" when they were no longer accompanied by their mothers. This term is used only to make it comparable to previous NRDA sea otter literature. We do not know the dates at which individual pups actually stopped nursing.

Status classifications are made based on consideration of data to May 1, 1991. Individuals classified as dead are known to be dead because their carcass or other remains were observed and, in some cases, recovered. "Missing" individuals are those whose radio signal cannot be detected by boat or aircraft radio searches within Prince William Sound or adjacent areas (see Monitoring section below). The classification of alive is based on visual observations of the individual.

Because we did not have data on location of radio-tagged individuals on a daily basis, the estimated weaning date is that date midway between the dates when the individual was last observed with its mother and when it was first observed to be independent. Similarly, estimated date of death is that date midway between the dates when the individual was last confirmed to be alive and when it was found dead.

Study Groups

Data from two groups of dependent sea otters captured in the fall of 1990 are compared: those captured in the western portion of Prince William Sound (referred to as **the oilspill region or area**) and those captured in eastern Prince William Sound (EPWS).

Capture

Sea otters were captured at night in tangle nets and during the daytime with dip nets using methods previously described (Monnett et al. 1991). In many cases, mother-pup pairs were captured together and the mother was held in a floating net-pen while the pup was instrumented. In other cases, pups were captured with hand-held dip nets and brought aboard a 25-foot Boston Whaler for instrumentation while the mother remained free-swimming.

It is important to note that, for the purposes of calculating "take" for Table 1 (take being defined under the 1972 Marine Mammal Protection Act of the United States), both the mother and the pup were counted in all pairs in which at least one of the pair was harassed or captured. However, all individuals that were "taken" were not captured or examined. In those cases in which only one member of the pair was caught using a gill net, the other member of the pair was immediately released, was not brought aboard, and was not examined.

Marking and Instrumentation

Following capture, otters were anesthesized, examined, tagged, instrumented with a transponder, and implanted with a radio-transmitter following established protocols (Monnett 1988; Monnett et al. 1991). Anesthetized sea otters were weighed to the nearest 0.5 pound on a hanging scale. Total body length (tip of nose to tip of tail) was measured to the nearest 0.5 inch. Samples collected included blood samples for hematology, blood chemistry and toxicology analyses, and subcutaneous fat samples for toxicology analyses (Table 2). Following completion of instrumentation, otters were usually released at the site at which they were captured, or, less typically, a short distance away, but still in the bay in which they were captured.

Individuals were not implanted if: a) its weight was less than 18 lbs; b) it was in very poor physical condition and the attending veterinarian believed that surgery would endanger its life; c) its mothers was inattentive prior to injection of the anesthetic; d) its initial temperature was greater than 102°F and could not be stabilized; e) it did not respond to the anesthetic; f) it was grossly malformed, and hence, not comparable with any other otters; or g) only one member of the female-pup pair was captured using a gill net. In actuality, nearly all pups that were examined and were above the minimum weight specified above, were instrumented. If only the pup was captured in a gill net, it was immediately released, was not brought aboard, and was not examined

Monitoring

Radio-instrumented sea otters were monitored by observers in aircraft and skiffs. Aircraft and skiffs were equipped with right- and left-mounted Yagi antennas and programmable, scanning FM receivers. Aircraft were flown at various heights depending upon whether observers were attempting to locate radio signals or make visual observation on individual sea otters. An attempt was made to find and visually examine each otter at least biweekly. All areas of Prince William Sound have been searched by aircraft for missing animals. Additionally, a radio search of the nearcoastal areas between Prince William Sound and Homer, Alaska (to the west) and to Controller Bay (to the southeast) was made by aircraft, specifically to search for missing individuals in this study. Data were recorded directly on topographical maps and in field notebooks for later entry into computer spreadsheets.

Comparison of Overwinter Mortality of Weanlings

Contingency chi-square analyses were used to compare the frequencies of weanling sea otters known to be alive, those known to be dead, and those that were missing as of May 1, 1991 in EPWS and oil-spill areas. Thus, a categorical statistical model was employed (rather than Kaplan- Meier survival estimation procedure as described in the corresponding study plan) because, given the nature of the study subjects and the short duration of the study, the biologically meaningful comparisons were the survival frequencies of weanlings to a specific life-history milestone: through the end of their first winter. Additionally, Fisher's exact test for 2 x 2 tables was also employed to compare the frequencies of sea otter weanlings in various outcome categories in the two geographical areas by first combining dead and missing otters, and secondly, by eliminating missing otters. The cutoff date of May 1, 1991 was used based on previous (Monnett 1988) information indicating that human causes of mortality, especially death associated with gillnet fisheries, may become important in EPWS shortly thereafter due to the initiation of fishing activity.

STUDY RESULTS AND DISCUSSION

Study Population and Monitoring

Two hundred and fifty-two sea otters were captured or taken by harassment in Prince William Sound between September 3, 1990 and October 15, 1991 (Table 1). The locations of capture of instrumented sea otter pups are shown in Figure 1. In EPWS, pups were only captured in Simpson Bay because at the time of capture activities it was the only location having high enough densities of pups to permit efficient capture using gill nets, the water conditions rarely permitted dip-netting, and it had been decided aforehand to limit capture activities to Simpson Bay, Sheep Bay, and Port Gravina. Table 2 provides information on the capture location, sex, weight, and sample types collected on sea otter pups instrumented for this study. Distribution of the date of instrumentation in the two general areas is shown in Figure 2. Twenty-four dependent pups in EPWS [16 males (67%) and 8 females (33%)] and 40 pups in the oil spill area [25 males (60%) and 15 females (40%)] were instrumented with intraperitoneal radiotransmitters. Two individuals (one male and one female both from EPWS), whose deaths may have been related to capture/instrumentation activities, were excluded from all summaries and statistical comparisons (one was found dead with an infected incision, whereas the other individual died 2 weeks after instrumentation). A female pup in the oil spill area that was still with its mother on May 1, 1991 (and hence, was not a weanling) was included in the comparison of body weight at the time of capture, and in summaries of the date of instrumentation, but eliminated from other comparisons. Her dependency length is much greater than those previously observed in Prince William Sound. Most importantly, since previous work (Monnett 1988) has shown that the probability of dying greatly increases after mother-pup separation. it would not be appropriate to include her in comparisons of outcome. Some pups that were last seen alive with their mothers were either dead at the next observation or became missing. These pups were eliminated from the figure summarizing weaning date.

The sample size for this study differs markedly from that outlined in the study plan for this portion of the damage assessment research which called for the instrumentation of 100 pups split evenly between EPWS and the oil spill area. Too few radios were ordered to permit implantation of 100 pups.

Size at Capture, Timing of Weaning, and Peak Mortality

There is some indication that in 1990-1991, the peaks of pupping, weaning, and weanling mortality may have occurred at least a month or two later in the oil-spill area than in EPWS.

The timing of instrumentation was similar for pups in EPWS and the oil spill area (Figure 2). However, the mean body weight at capture of male and female dependent pups in the oil-spill area was significantly less than that of pups in EPWS [(**MALES**: oil spill area: $\bar{x} = 25.28$ lbs, S.E. = 0.72, N = 25; EPWS: $\bar{x} = 32.27$ lbs, S.E. = 0.83, n = 15, t = 5.57, 38 D.F., $p < 0.001$); **FEMALES**: oil spill area: $\bar{x} = 24.17$ lbs, S.E. = 0.97, N = 15; EPWS: $\bar{x} = 30.36$ lbs, S.E. - 1.03, n = 7, t = 3.53, 20 D.F., $p < 0.003$)]. These differences and preliminary unpublished data on the timing of pupping of instrumented adult females (Monnett and Rottermen, unpublished data), indicate that the peak in pupping in 1990 was later in the oil spill area than in EPWS. Thus, it is likely that the oil spill area pups were younger at the time of capture than their EPWS counterparts. Dates of weaning tended to be a month to two months later in the oil-spill area than in EPWS. At present it is not clear whether this later date of weaning is explained sufficiently by the temporal shift in pupping, whether dependency periods tended to be longer in the oil spill area, or both. Integration, at some future date, of the pupping data from the female study, and the data provided here may be useful in resolving this issue. However, most pups in EPWS became independent of their mothers in October, whereas mother-pup separation typically occurred in November and December in the oil spill area (Figure 2).

Since available data (Monnett and Rotterman, unpublished data) suggest that mortality of large pups is very low (i.e., while they are large but still with their mother), it is not surprising that with a shift in the peaks of weaning, the period of highest mortality is also later. More mortality in EPWS occurred during November and December of 1990, whereas most mortality in the oil spill area occurred during January 1991 (Figure 2).

Further effort needs to be focused on determining whether these apparent timing differences are persistent, whether the shifts in weaning and mortality dates are explained by a shift in the peak of pupping of the same magnitude, or whether they reflect longer dependency periods and/or differences in the length of survival after weaning. Integration of these data with data from the reproductive behavior of the instrumented adult females will be especially insightful in this regard.

Mortality Rate Comparisons

Contingency chi-square analyses indicated that survival rates of weanlings over their first winter (analyses consider data until May 1, 1991) were significantly higher in EPWS than in the western sound (the oil spill region) (Table 3). This result was the same regardless of whether missing animals were assumed to be dead ($\chi^2 = 4.64$, 1 D.F., $p < 0.05$) or were eliminated from the analyses ($\chi^2 = 4.70$, 1 D.F., $p < 0.05$). The results from comparisons employing Fisher's exact test gave the same conclusion. If missing pups are assumed to be dead, $p = 0.0496$. If missing pups are eliminated from the analyses, $p = 0.0454$.

Figures 3 and 4 indicate the locations where the carcasses of instrumented weanlings were discovered. Table 2 indicates those sea otter weanlings on which a necropsy was performed after death.

Consideration of the status of the surviving weanlings as of July 15, 1991 does not alter the conclusions of this study. Between May 1 and July 15th, one individual in EPWS dropped out of the study due to radio failure and one additional weanling in the western sound died.

The data presented here address a focussed and narrow objective: to test the hypothesis that overwintering mortality is similar between EPWS and the oil-spill area over the winter of 1990-1991. We reject that null hypothesis. Weanlings in the oil spill area died at higher frequency than did their counterparts in EPWS.

LITERATURE CITED

Monnett, C. W. 1988. Patterns of movement, postnatal development and mortality of sea otters in Alaska. Ph.D. dissertation. University of Minnesota, Minneapolis, Minnesota.

Monnett, C., L. M. Rotterman, and D. B. Siniff. 1991. Sex-related patterns of postnatal development of sea otters in Prince William Sound, Alaska. J. Mamm. 72:37-41.

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Table 1. Summary of sea otters taken by capture or harassment as part of capture activities between September 1, 1990 and October 15, 1990. Use of the term taken corresponds to that given in the Marine Mammal Protection Act. If only one member of a female/pup pair was captured using a gill net, both are counted as being "taken" although neither would have been held, examined, or instrumented.

Area	Age/Sex Category	Number Taken	Number Implanted
EPWS	Adult Male	8	0
	Adult Female (indep)	37	4
	Mother-Pup Pairs	106 (53 prs.)	24 (pups)
	Unknown	2	0
	Area Total	153	28
WPWS	Adult Male	2	0
	Adult Female	1	0
	Mother-Pup Pairs	96 (46 prs.)	40 (pups)
	Unknown	0	0
	Area Total	99	40
	Total Number of Pups	99	64
	Grand Total	252	68

Table 2. Information and samples collected on sea otter pups instrumented in 1990 in Prince William Sound, Alaska. ID = identification number; Cap. Met. = method of capture; G = gillnet; D = dipnet; Clin. Blood = blood sample for clinical analyses; Necr. = necropsy; Y = yes; N = no.

ID	Capture Date	Cap. Met.	Capture Location	Weight (lb)	Clin. Blood	Toxicology Fat	Toxicology Blood	Necr.
90101	03 Sep	G	Simpson Bay	36.5	N	Y	Y	Y
90102	03 Sep	G	Simpson Bay	25.0	N	Y	Y	
90103	03 Sep	G	Simpson Bay	23.5	N	Y	Y	
90104	03 Sep	G	Simpson Bay	26.0	N	Y	Y	
90106	04 Sep	G	Simpson Bay	25.0	N	Y	Y	
90107	04 Sep	G	Simpson Bay	33.5	N	Y	Y	Y
90108	04 Sep	G	Simpson Bay	22.5	N	Y	Y	
90111	05 Sep	G	Simpson Bay	34.5	Y	Y	Y	
90114	08 Sep	G	Simpson Bay	30.0	Y	Y	Y	Y
90115	09 Sep	G	Simpson Bay	34.0	Y	Y	Y	
90118	09 Sep	G	Simpson Bay	35.0	Y	Y	N	
90120	13 Sep	D	Squirrel Island	28.5	Y	Y	Y	
90121	15 Sep	G	Drier Bay	30.0	Y	Y	Y	
90122	15 Sep	G	Drier Bay	25.0	Y	Y	Y	
90123	15 Sep	G	Drier Bay	25.5	Y	Y	Y	
90124	15 Sep	G	Drier Bay	31.0	Y	Y	Y	
90125	15 Sep	G	Johnson Bay	21.5	Y	Y	Y	
90127	21 Sep	G	Ewan Bay	21.0	Y	Y	Y	
90128	21 Sep	G	Ewan Bay	34.0	Y	Y	Y	
90129	21 Sep	G	Ewan Bay	26.0	Y	Y	Y	
90131	22 Sep	G	Ewan Lagoon	19.0	Y	Y	Y	
90132	22 Sep	G	Ewan Lagoon	20.5	Y	Y	Y	
90133	22 Sep	G	Ewan Lagoon	25.5	Y	Y	Y	
90134	22 Sep	G	Ewan Lagoon	22.5	Y	Y	Y	
90135	24 Sep	D	Stockdale Harbor	25.0	Y	Y	N	Y
90136	25 Sep	G	Stockdale Harbor	23.0	Y	Y	Y	
90137	25 Sep	D	Chalmers/Stockdale	31.0	Y	Y	Y	
90138	25 Sep	D	Chalmers/Stockdale	27.0	Y	Y	Y	
90139	25 Sep	D	Stockdale	25.0	Y	Y	Y	
90140	25 Sep	D	Port Chalmers	22.0	Y	Y	Y	
90141	26 Sep	G	Port Chalmers	27.0	Y	Y	Y	

ID	Capture Date	Cap. Met.	Capture Location	Weight (lb)	Clin. Blood	Toxicology Fat	Toxicology Blood	Necr.
90142	26 Sep	G	Port Chalmers	23.0	Y	Y	Y	
90143	30 Sep	D	Bay of Isles	22.0	Y	Y	Y	
90144	30 Sep	D	Bay of Isles	26.0	Y	Y	Y	
90146	01 Oct	D	Herring Bay	21.0	Y	Y	Y	
90147	01 Oct	D	Lower Herring Bay	29.0	Y	Y	Y	Y
90149	02 Oct	D	Drier Bay	23.0	Y	Y	Y	
90150	02 Oct	D	Drier Bay	19.0	Y	Y	Y	
90151	02 Oct	D	Drier Bay	20.5	Y	Y	Y	
90152	03 Oct	D	Jackpot Bay	26.0	Y	Y	Y	
90153	03 Oct	D	Jackpot Bay	29.0	Y	Y	Y	
90154	03 Oct	D	Jackpot Bay	24.0	Y	Y	Y	
90155	04 Oct	D	Ewan Bay	21.0	Y	Y	Y	
90156	05 Oct	D	Whale Bay	21.5	Y	Y	Y	Y
90157	05 Oct	D	Whale Bay	29.0	Y	Y	Y	
90158	06 Oct	D	Whale Bay	23.0	Y	Y	Y	Y
90159	06 Oct	D	POW Passage	20.5	Y	Y	Y	
90160	06 Oct	D	Little Bay	29.0	Y	Y	Y	
90161	06 Oct	D	Channel Island	24.0	Y	Y	N	
90162	08 Oct	D	Stockdale Harbor	25.0	Y	Y	Y	
90164	08 Oct	D	Port Chalmers	29.0	Y	Y	Y	
90165	10 Oct	G	Simpson Bay	31.0	Y	Y	Y	
90166	11 Oct	G	Simpson Bay	33.0	Y	Y	Y	
90167	11 Oct	G	Simpson Bay	31.5	Y	Y	Y	
90168	11 Oct	G	Simpson Bay	31.0	Y	Y	Y	
90172	11 Oct	D	Simpson Bay	35.0	N	Y	Y	Y
90173	11 Oct	D	Simpson Bay	35.0	N	Y	Y	
90174	13 Oct	G	Simpson Bay	31.0	Y	Y	Y	Y
90175	13 Oct	G	Simpson Bay	32.0	Y	Y	Y	
90176	13 Oct	G	Simpson Bay	32.0	Y	Y	Y	
90177	14 Oct	G	Simpson Bay	35.0	Y	Y	Y	
90178	14 Oct	G	Simpson Bay	32.5	Y	Y	Y	
90179	14 Oct	G	Simpson Bay	38.5	Y	Y	Y	
90180	14 Oct	G	Simpson Bay	26.0	Y	Y	Y	

Table 3. Status of radio-instrumented weanlings in Prince William Sound, Alaska, as of May 1, 1991. Two individuals whose death may have been related to capture/instrumentation activities were excluded from analyses, as was one pup that was still with its mother on May 1, 1991. Frequencies corresponding to the numbers in each category are given in parentheses.

Sex	Area	Total	Alive	Dead	Missing
Males	EPWS	15	5 (0.33)	8 (0.53)	2 (0.13)
	WPWS	25	2 (0.08)	17 (0.68)	6 (0.24)
Females	EPWS	7	3 (0.43)	2 (0.29)	2 (0.29)
	WPWS	14	3 (0.21)	9 (0.64)	2 (0.14)
Combined	EPWS	22	8 (0.36)	10 (0.45)	4 (0.18)
	WPWS	39	5 (0.13)	26 (0.67)	8 (0.21)

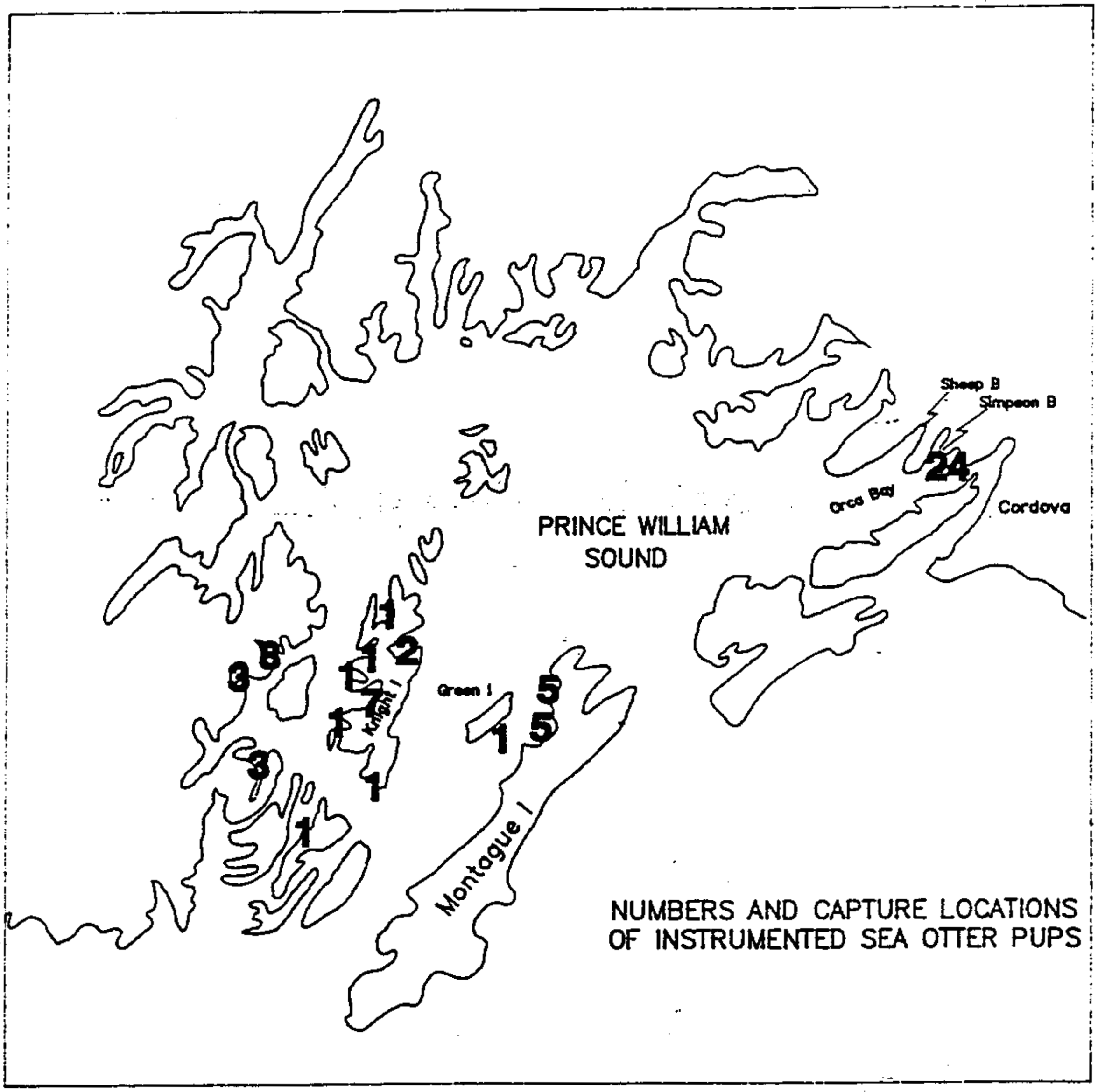

Figure 1. Capture locations of sea otter pups instrumented with implanted radio-transmitters during the fall, 1990, in Prince William Sound, Alaska. The numbers represent the number of individuals instrumented at each location.

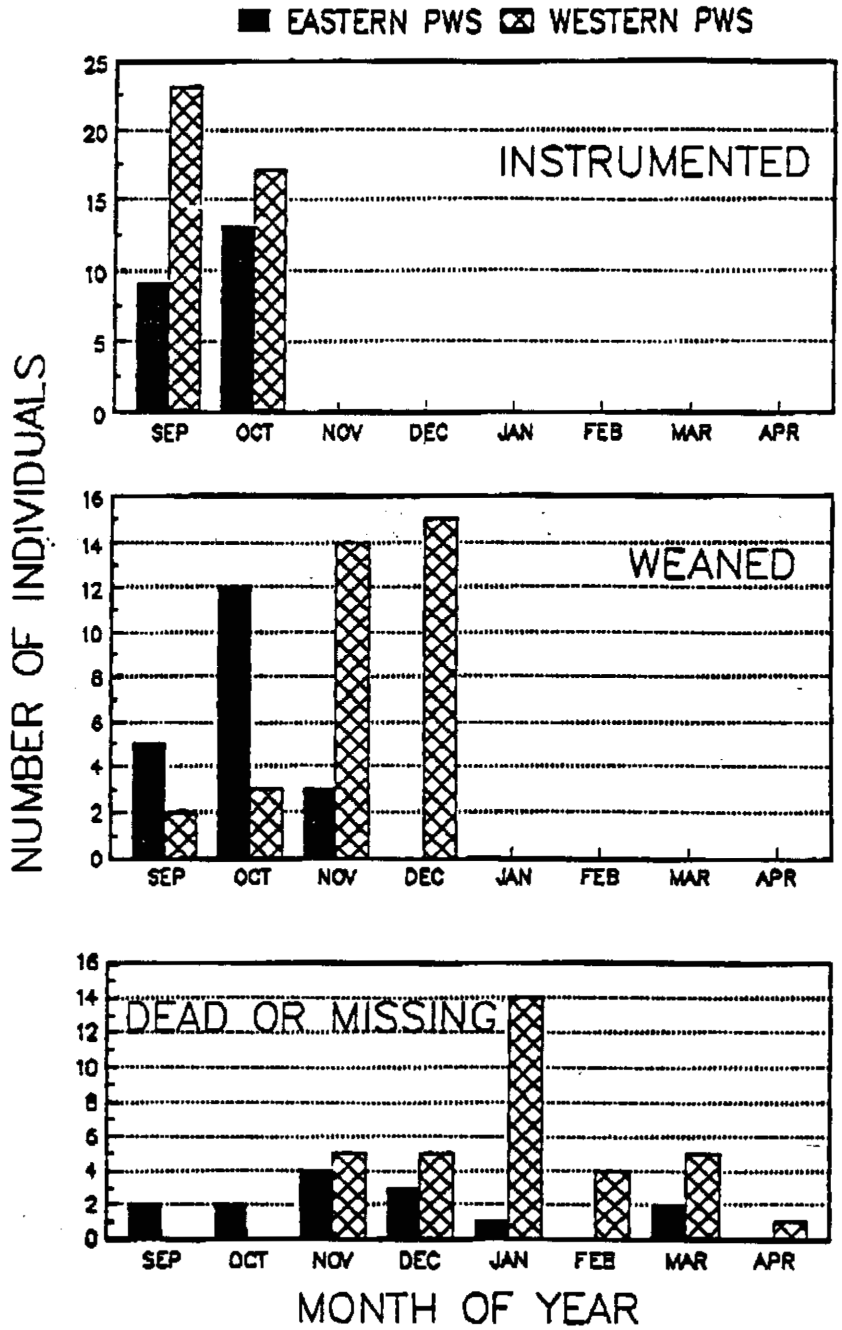

Figure 2. Summary of timing of instrumentation, weaning, and mortality of sea otters in Prince William Sound, 1990-1991.

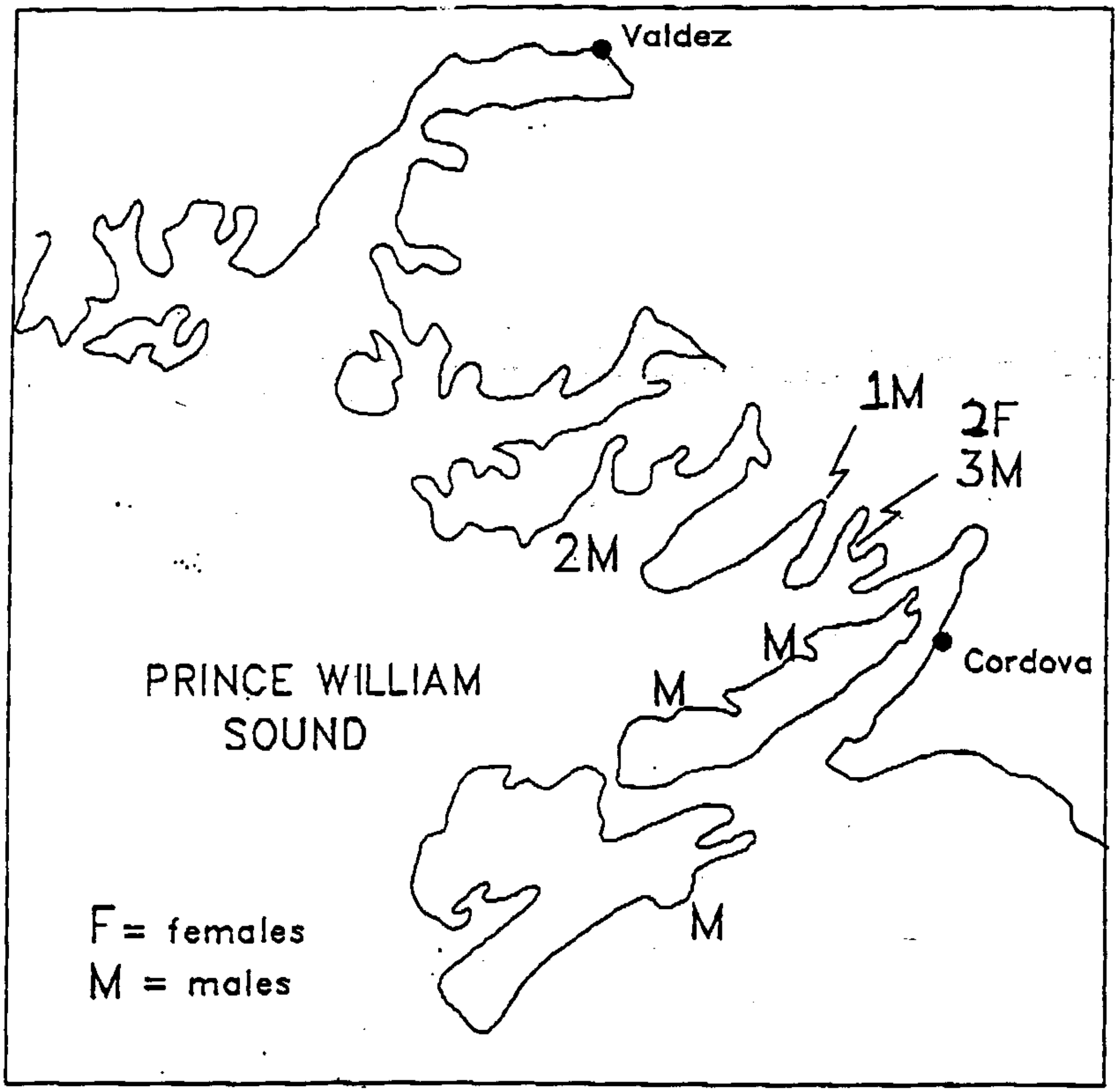

Figure 3. Locations at which remains of radio-instrumented weanling sea otters were recovered in Eastern Prince William Sound, Alaska, September 1990 - March 1991.

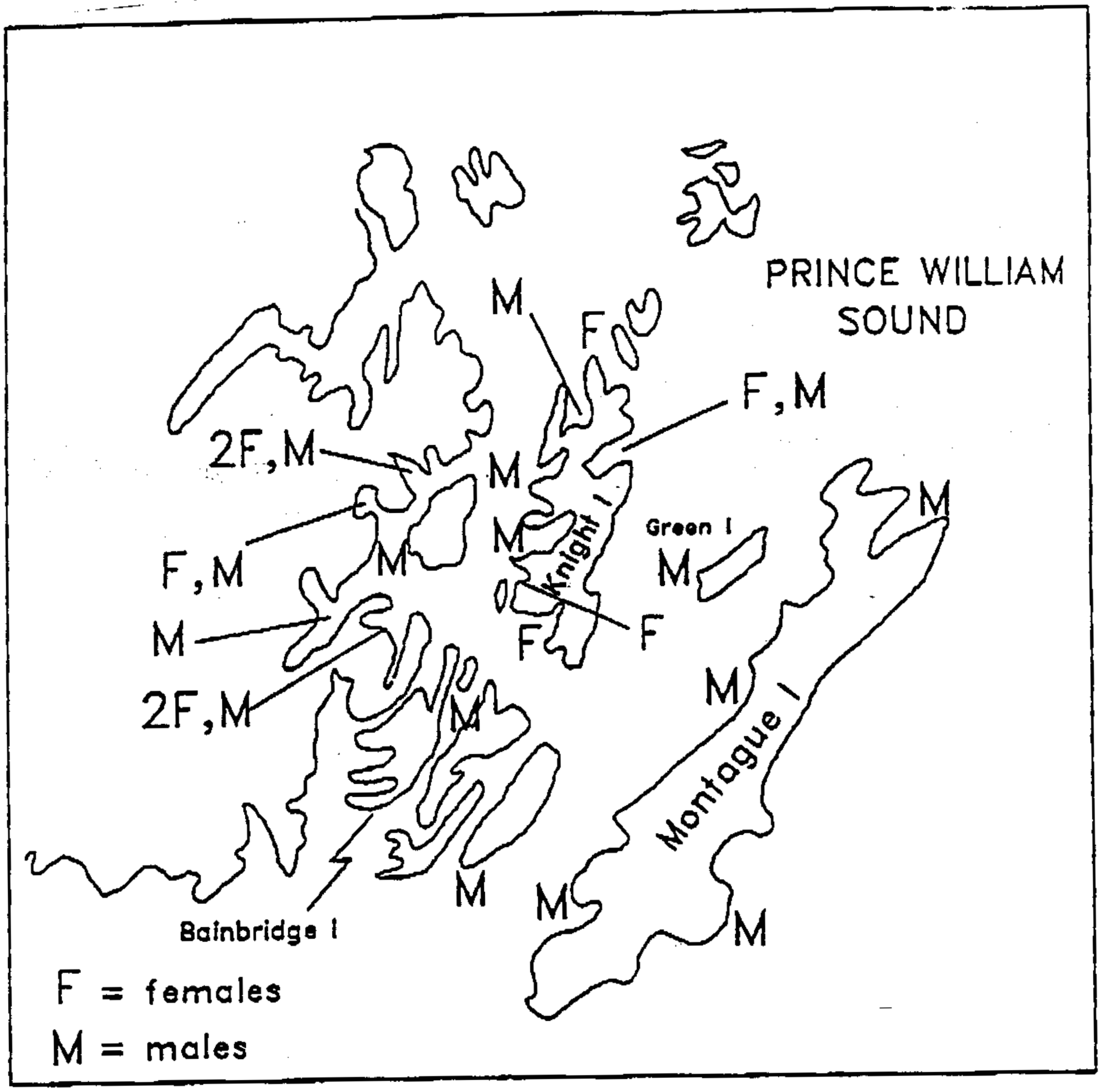

Figure 4. Locations at which remains of radio-instrumented weanling sea otters were recovered in Western Prince William Sound, Alaska, November 1990 - April 1991.