Experiments to Determine Drift Patterns and Rates of Recovery of Sea Otter Carcasses following the *Exxon Valdez* Oil Spill

Marine Mammal Study 6

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Angela M. Doroff[a]

and

Anthony R. DeGange[b]

U.S. Fish and Wildlife Service
Alaska Fish and Wildlife Research Center
1011 East Tudor Road
Anchorage, AK 99503

[a] Present address: U.S. Fish and Wildlife Service; Marine Mammals Management; 4230 University Drive, Suite 310; Anchorage, AK 99508

[b] Present address: U.S. Fish and Wildlife Service; Division of Ecological Services; 1011 East Tudor Road, Anchorage, AK 99503

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ABSTRACT

Two experiments were conducted to evaluate efforts to recover sea otter (*Enhydra lutris*) carcasses following the *Exxon Valdez* oil spill. The first study was implemented during sea otter rescue and carcass recovery activities to assess the probability of carcass recovery. Twenty-five previously recovered sea otter carcasses were marked with flipper tags and released near northern Kodiak Island between 27 May and 3 June 1989. Five of the carcasses were recovered, for a recovery rate of 20%. A 95% confidence interval for a recovery estimate of 20% ranged from 7-41% or 2-10 of the 25 carcasses. In the second study, 30 radio-monitored floats designed to assess drift characteristics of floating sea otter carcasses were deployed in early summer 1990. During a 43-day monitoring period, 27 (90%) were known to have washed ashore, 25 in Prince William Sound (PWS) and two on the Gulf of Alaska coast of Montague Island. Final location of one float could not be precisely determined due to an intermittent, weak signal, but it was in the general location of Knight Island in western PWS. Contact was lost with two of the floats, despite extensive searches throughout PWS and the Kenai Peninsula.

These studies suggest that many more sea otters may have died from the spill than were recovered, and that some sea otters succumbing to oil exposure in PWS could have drifted outside of PWS and never been recovered. These studies do not address the following factors influencing the recoverability of sea otters dying as a result of the *Exxon Valdez* oil spill: 1) drift patterns of carcasses in heavy oil; 2) the proportion of sea otter carcasses sinking, 3) the persistence of floating and beach-cast sea otter carcasses, and 4) the behavior of oiled sea otters prior to death in nearshore and offshore areas.

INTRODUCTION

Following the *Exxon Valdez* oil spill of 24 March 1989, beach clean-up and wildlife rescue crews collected marine mammal and bird carcasses. Carcasses were labeled with the date, area recovered and species, and were stored in collection centers in Valdez, Seward, Homer or Kodiak. A total of 871 sea otter carcasses were collected throughout the oil spill area between 30 March and 15 September 1989 (Doroff et al., 1993). Of these, 493 were collected in Prince William Sound (PWS), 181 from the Kenai Peninsula, and 197 from the Kodiak Archipelago and Alaska Peninsula.

For the damage assessment process, estimates of the actual number of sea otters lost from the population were required. To help estimate the number of sea otters killed, we conducted two studies. One study assessed the recoverability of marked sea otter carcasses near northern Kodiak Island in late May and early June of 1989. This study was not a part of formal damage assessment studies on sea otters, but was implemented in the midst of sea otter rescue and carcass recovery activities. The second study assessed drift patterns and movement rates of simulated sea otter carcasses in Prince William Sound in the summer of 1990.

OBJECTIVES

1. To assess the recoverability of marked sea otter carcasses.

2. To determine if simulated sea otter carcasses (floats) deployed in Prince William Sound remained in or drifted out of the Sound.

METHODS

Carcass Recovery

Twenty-five frozen sea otter carcasses were taken from collection centers at Kodiak (n = 10) and Homer (n = 15) and were intact except one which was missing the head. Carcasses condition varied when originally frozen, from fresh to partially decomposed. Nine of the 25 had been oiled, and 18, 2 and 5 were adults, subadults and pups, respectively, and were tagged with white plastic tags (Temple Tag Co.) on the hind flipper prior to release.

Carcasses were released in waters of northern Kodiak, Raspberry and southern Afognak Islands, between the western end of Kupreanof Strait and Anton Larson Bay,

including Raspberry Strait. Release sites coincided with areas of sea otter concentrations (DeGange and Monson, unpublished data), which were considered affected by the *Exxon Valdez* spill. Ten thawed carcasses were released on 27 May 1989, nine frozen carcasses were released on 1 June 1989, with the remaining six carcasses thawed or partially thawed and released on 3 June 1989.

Beach cleaning crews and individuals searching for oiled wildlife were prevalent in the areas where the tagged carcasses were released but were not notified that marked carcasses were being released.

Drift Study

Floating, dead sea otters are generally found with head and tail submerged and only a portion of the rounded back exposed above the water surface. This shape was simulated by half of a 35-cm car tire with wood inserted centrally for flotation. The wood was bolted to the tire with threaded rod. A hole measuring approximately 1.9 cm in diameter was drilled in the tire above the wood block to allow trapped air to escape. This design allowed the float to be self-righting and have a relatively constant surface area exposed above water. Thirty of these floats were constructed with an average weight of 6.6 kg (range 6.1-7.0 kg). The sides of each float were painted fluorescent orange and each float was marked with a white stenciled identification

number. Radio transmitters (Advanced Telemetry Systems, Isanti, MN) weighed approximately 40 g and measured approximately 5 x 5 x 3.75 cm were bolted to each float. They had an external wire whip antenna and a battery life of 40 days. The radio signal could be received at 50 km from an altitude of 750 m. Floats remained low in the water, exposing approximately 2.5 cm of tread above the water surface where the radio transmitter was attached.

The floats were deployed on 29 June and 12 July 1990 in western PWS, at sites where sea otters were known to occur based on boat survey information from July and August 1989 and March 1990 (Burn 1993) and where the water surface had been oiled. Three deployment sites (Applegate Rocks, Naked Island and Bay of Isles) were selected which were a distance of 200 m or more off-shore, and had a high abundance of sea otters as indicated in previous surveys. The intent of selecting areas at least 200 m offshore was to simulate the drift of characteristics of sea otters dying in offshore areas. Five floats were deployed haphazardly at each of the three sites by float plane on 29 June 1990; 14 days later, an additional five floats were deployed haphazardly at each of the sites.

Floats were monitored daily, as weather conditions permitted, during the 40-day operational period of the radio transmitter or until the float remained fixed on a beach. Location, date, time and water surface conditions were recorded each time a float was

relocated. We obtained digital data on wind speed and wind direction from a remote weather station located on Seal Island, PWS (National Weather Service, NOAA).

RESULTS

Carcass Recovery

Five adult sea otter carcasses (two from the first and three from the second release) of the 25 tagged carcasses were recovered between 31 May and 11 June 1989 by beach crews during clean up and monitoring efforts. Three of the recovered carcasses were intact, and two were partially scavenged. A 95% confidence interval for a recovery estimate of 20% ranged from 7-41% or 2-10 of the 25 carcasses.

Drift Study

The floats simulating sea otters were monitored over a 43-day period from 29 June to 9 August 1990. Weather conditions allowed relocation of floats by aircraft 22 days of this 43 day period.

Twenty-five of the 30 floats washed ashore in Prince William Sound and two

left the Sound and beached on the outside of Montague Island via Hinchinbrook Entrance during the monitoring period (Table 1). Of the remaining three floats whose fate was undetermined, two could not be found after 7 and 19 days, despite aerial searches in Prince William Sound and the Kenai Peninsula. Failure rate for this type of radio transmitter is generally < 3%, (L. Keuchle, Advanced Telemetry Systems, Isanti, MN, personal communication). It is possible that one or both of these floats drifted out of the Sound and went undetected. The third float was likely ashore but the location was not verified. We received an intermittent signal from the transmitter when tracking at a low tide and believe this float may have been lodged in the intertidal zone preventing the detection of a radio signal during high tides when the radio was covered with salt water.

Mean number of days for floats from the 29 June and the 12 July release to wash ashore were 16 (range 7-33 days, n = 13) and 13 (range 4-25 days, n = 14), respectively (Table 1). Of the 27 floats known to have washed ashore, 6 (22%) refloated and washed ashore elsewhere.

Thirteen movement rates were estimated from seven floats having two or more locations recorded on consecutive days (mean time between relocations = 24 hrs). Average rate of movement was 8 km/day (range 2-21). Corresponding wind direction was variable, ranging from NNW to SSE, and average wind speed for this period was

10.4 km/hr (range 0.32-26.7 km/hr). Six of the 13 floats travelled against the wind (i.e., heading within 45 degrees of the direction from which the wind originated) suggesting that current was the dominant factor in their movement. Three of the 13 floats travelled with the wind (i.e., wind originated >135 degrees from the direction of float movement) suggesting that wind or wind-generated surface current was the dominant factor in their movement. These three floats moved at an average rate of 1.6% of the wind speed. For the remaining four float movements, wind direction shifted over the 24 hour period and movements were erratic. Detailed vector analysis of float direction and movement rate was not possible because we lacked point specific data on water current, wind speed and wind direction for each relocation of the float.

The release site, approximate travel route and last location of all floats monitored are presented in Figures 1-6. Floats released at the same site at the same time exhibited very different movement patterns throughout the monitoring period. Similarly, floats released at the same site at different times exhibited dissimilar movement patterns.

DISCUSSION

The recoverability of sea otter carcasses on beaches following the *Exxon Valdez*

oil spill was likely influenced by the behavior of otters prior to death, the proportion of carcasses sinking, the persistence of carcasses on beaches, and by the drift pattern of floating carcasses. Whether a sea otter carcass sinks or floats may be influenced by cause of death. Drowned sea otters may have a greater tendency to sink, whereas otters which die acutely (e.g., if shot) generally float (A. Johnson, U.S. Fish and Wildlife Service, retired, Hecla, SD, personal communication). The extent to which oiled otters hauled out on beaches prior to dying is not known. Carcasses which have been frozen then thawed, such as those used in this study, tend to float low or sink when placed in water (G. Ford, Ecological Consulting, Inc., Portland, OR. personal communication). However, only two of the 25 otter carcasses (one thawed and the other frozen) were observed to have sunk or floated below the surface of the water when released. State of decomposition may also be a factor influencing buoyancy of a carcass. The extent to which recoverability was influenced in this study by sinking of carcasses is unknown.

Based on previous field observations, persistence of intact beached carcasses in Prince William Sound may be as short as three days. Carcasses are usually scavenged, and the length of time that a scavenged carcass remains on a beach can vary considerably. Bald eagles (*Haliaeetus leucocephalus*) are one of the major scavengers of otter carcasses (A. Johnson, U.S. Fish and Wildlife Service, Hecla, SD, personal communication). Dried, bleached bones can persist on a beach for several

months or longer. Although persistence of carcasses on beaches would have been a factor in recoverability following the oil spill, the extent of carcass persistence on beaches was not addressed.

Drift patterns of floats in this study showed no predictable patterns but did suggest that some of the carcasses may have exited Prince William Sound. We had speculated that carcasses exiting the Sound might have been picked up along the Kenai Peninsula. However, the two floats that did exit the Sound, unlike the oil from the spill, did so via Hinchinbrook Entrance and beached on the south side of Montague Island, which was not an area that was searched for carcasses following the oil spill.

We speculate, however, that the drift patterns and movement rates of the floats deployed in clean salt water in 1990 are not generally representative of those of sea otter carcasses in a heavy oil slick. A drift rate of 3% of the wind speed was used to model movement patterns of oil floating on the water surface (Tsahalis 1979, Galt and Payton 1990). In our limited analysis of float movements, only three floats moved with the wind, and at a drift rate of only 1.6% of wind speed. The effects of water currents were unknown. It seems likely that drift characteristics of bird and mammal carcasses constrained in heavy oil slicks were influenced by the drift pattern of the oil. Sea otter and marine bird carcasses were observed in heavy oil which had formed windrows in offshore areas in Prince William Sound (J. Bodkin, USFWS, Anchorage,

AK, and C. Monnett, Prince William Sound Science Center, Cordova, AK, personal communication). Galt and Payton (1990) estimated 25% of the spilled oil exited Prince William Sound and 10% traveled beyond Gore Point on the Kenai Peninsula. Although it seems likely that some sea otter carcasses also drifted out of the Sound with heavy oil, this could not be addressed by the present study, given dissimilarities between floats and actual carcasses, and differences in wind, current and water surface conditions (including presence or absence of oil) in spring 1989 vs. summer 1990.

We assume, our best estimate of proportion of carcasses recovered following the *Exxon Valdez* oil spill is generated from the tagged carcasses released near Kodiak Island. The applicability of our results to the overall recovery of sea otter carcasses following the *Exxon Valdez* oil spill is unknown. The timing and location of recovered sea otter carcasses, and the timing and location of live captures of oiled sea otters suggest that sea otters in Prince William Sound and along the Kenai Peninsula were more heavily affected by oil than those at Kodiak Island (Degange and Lensink 1990, Hill et al. 1990, Williams et al. 1990, Fish and Wildlife Service, unpubl. data). These areas differ oceanographically, topographically, and in the amount of time and resources devoted to searching for live, oiled sea otters and carcasses. Ford et al. (1991) report that only 16 contract boats were active in the Kodiak Archipelago and along the Alaska Peninsula compared to 40 for the Kenai Peninsula and 31 for Prince William Sound. Nevertheless, our results suggest that the number of sea otter that

died as a result of the *Exxon Valdez* oil spill may be much greater than the number of carcasses recovered.

Our results are generally consistent with the only other study that examined recovery of sea otter carcasses. Wendell et al. (1986) found that 4 of 12 (33%) sea otters incidentally taken in fishing nets set from boats in California, eventually came ashore and were found. Our results were also generally consistent with results from drift experiments with marine birds in which recovery varied from 0% - 59% (see review in Piatt et al. 1991). Piatt et al. (1990) suggest that as few as 3% of the marine birds killed as a result of the *Exxon Valdez* oil spill were recovered. Ford et al. (1991) using data collected from experiments conducted well after the oil spill, estimated that 8% of the seabird carcasses were recovered.

If we assume that our results are applicable to the entire oil spill area, then the acute loss estimate of sea otters associated with the oil spill would be 4,028[1] (range 2,028-11,280) sea otters (Doroff et al., 1993).

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[1] A total of 871 carcasses were recovered following the spill; however, 90 of these were judged pre-spill deaths. The estimate of 4028 is derived by assuming that 781 carcasses represent 20% of the total post-spill sea otter deaths, and adding 123, which is the number of otters that died in rehabilitation centers (4028 = 781/0.20 + 123).

CONCLUSIONS

In an area with intensive search effort, 20% of sea otter carcasses were found, which is somewhat lower than the recovery rate of a small sample of marked sea otter carcasses reported in California. Based on drift patterns of the floats, a wide search area would be necessary to recover carcasses where heavy oil did not influence drift. Lack of information on: 1) drift patterns of carcasses in heavy oil, 2) the proportion of sea otter carcasses sinking, 3) the persistence of floating and beach-cast sea otter carcasses, and 4) the behavior of oiled sea otters prior to death in nearshore and offshore areas, limited our ability to assess recovery rates of sea otter carcasses. To obtain basic data on the recovery rate and drift patterns of sea otter carcasses during oil spills, the methodologies employed in the carcass recovery and drift studies should be incorporated int future oil spill contingency plans.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Bishop, J. B. 1985. Summary report of gill and trammel net (set-net) observations in the vicinity of Morro Bay, California. Report prepared for the U.S. Marine Mammal Commission. National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA. 14pp.

Burn, D. M. 1993. Boat-based population surveys of sea otters (*Enhydra lutris*) in Prince William Sound, in response to the *Exxon Valdez* oil spill. NRDA Final Report, U.S. Fish and Wildlife Service, Anchorage, AK.

DeGange, A. R., and C. J. Lensink. 1990. Distribution, age, and sex composition of sea otter carcasses recovered during the response to the T/V Exxon Valdez oil spill. Pages 124-129 in K. Bayha and J. Kormendy, eds. Sea otter

symposium: proceedings of a symposium to evaluate the response effort on behalf of sea otters after the T/V EXXON VALDEZ oil spill into Prince William Sound, Alaska. U.S. Fish and Wildlife Service, Biol. Rep. 90(12), 485pp.

Doroff, A., A. R. DeGange, C. Lensink, B. E. Ballachey, J. L. Bodkin and D. Bruden. 1993. Recovery of sea otter carcasses following the *Exxon Valdez* oil spill. Pp. 285-288 *in*: Exxon Valdez Oil Spill Symposium, Program and Abstracts. 356pp.

Ford, G. F., M. L. Bonnell, D. H. Varoujean, G. W. Page, E. E. Sharp, D. Heineman, and J. L. Casey. 1991. Assessment of direct seabird mortality in Prince William Sound and the Western Gulf of Alaska resulting from the Exxon Valdez oil spill. Final report to the Fish and Wildlife Service. Ecological Consulting, Inc., Portland, OR. 153pp.

Galt, J. A. and D. L. Payton. 1990. Movement of oil spilled from the T/V *Exxon Valdez*. Pp. 5-17 in: K. Bayha and J. Kormendy, eds. Sea otter symposium: proceedings of a symposium to evaluate the response effort on behalf of sea otters after the T/V EXXON VALDEZ oil spill into Prince William Sound, Alaska. U.S. Fish and Wildlife Service, Biol. Rep. 90(12), 485pp.

Hill, K., F. Weltz, T. Monahan, and R. Davis. 1990. Capture operations. Pages 59-81, in T. M. Williams and R. W. Davis, eds. Sea otter rehabilitation

program: Exxon Valdez oil spill. International Wildl. Research, 201pp.

Piatt, J. F., C. J. Lensink, M. Butler, M. Kendziorek, and D. Nysewander. 1990. Immediate impact of the Exxon Valdez oil spill on marine birds. Auk 92:387-397.

Piatt, J. F., H. R. Carter, and D. N. Nettleship. 1991. Effects of oil pollution on marine bird populations. Pages 125-141, in J. White, ed. The effects of oil on wildlife: research, rehabilitation, and general concerns. Proc. from the oil symposium, Herndon, VA, 16-18 Oct., 1990.

Tsahalis, D. T. 1972. Theoretical and experimental study of wind- and wave-induced drift. J. Phys. Oceanogr. 9:1243-1257.

Wendell, F. E., R. A. Hardy, and J. A. Ames. 1986. An assessment of the accidental take of sea otters, *Enhydra lutris*, in gill and trammel nets. Calif. Dept. Fish and Game, Mar. Res. Tech. Rep. No. 54. 31pp.

Williams, T. M., R. Wilson, P. Tuomi, and L. Hunter. 1990. Critical care and toxicological evaluation of sea otters exposed to crude oil. Pages 82-100, T. M. Williams and R. W. Davis, eds. Sea otter rehabilitation program: Exxon Valdez oil spill. International Wildl. Research, 201pp.

Table 1.– Fate of radio-tagged simulated sea otter carcasses deployed in Western Prince William Sound, Alaska on 29 June and 12 July 1990.

Release location	Release date	ID[a] number	Number relocations	Days to 1st beaching	Times beached & refloated	Final location or status[b]
Applegate Rocks	29 June	5243	9	-	-	Missing - 16 July
		5373	9	7	0	N Montague Is.
		5413	7	33	0	Green Is.
		5740	12	17	0	Seal Is.
		5013	11	18	0	Ingot Is.
	12 July	4122	6	11	0	Bay of Isles
		4293	7	11	0	NW Montague Is.
		5084	5	7	0	Bay of Isles
		5324	9	19	0	Main Bay
		5343	5	10	0	Bay of Isles
Bay of Isles	29 June	5035	6	-	-	Missing - 5 July
		5104	11	19	0	Busby Is.
		5273	12	7	2	Smith Is.
		5703	12	19	0	Eaglet Is.
		5823	13	17	2	SW Montague Is.
	12 July	5393	6	4	0	Green Is.
		5554	6	19	0	Smith Is.
		5632	8	25	0	SE Montague Is.
		5785	6	25	0	SE Montague Is.
		5863	8	11	0	Seal Is.
Naked Island	29 June	5133	12	13	0	Applegate Is.
		5192	13	17	2	Perry Is.
		5223	14	7	2	Storey Is.
		5613	13	17	2	Hidden Cove
		5852	12	13	0	Perry Is.
	12 July	4180	9	4	2	Chenega Is.
		4233	3	-	-	Knight Is. Pass.
		4563	4	5	0	Bay of Isles
		4911	7	5	2	SW Montague Is.
		5760	5	20	0	Bay of Isles

[a] Identification number derived from radio frequency of transmitter.

[b] All locations except SE Montague Island are within Prince William Sound.

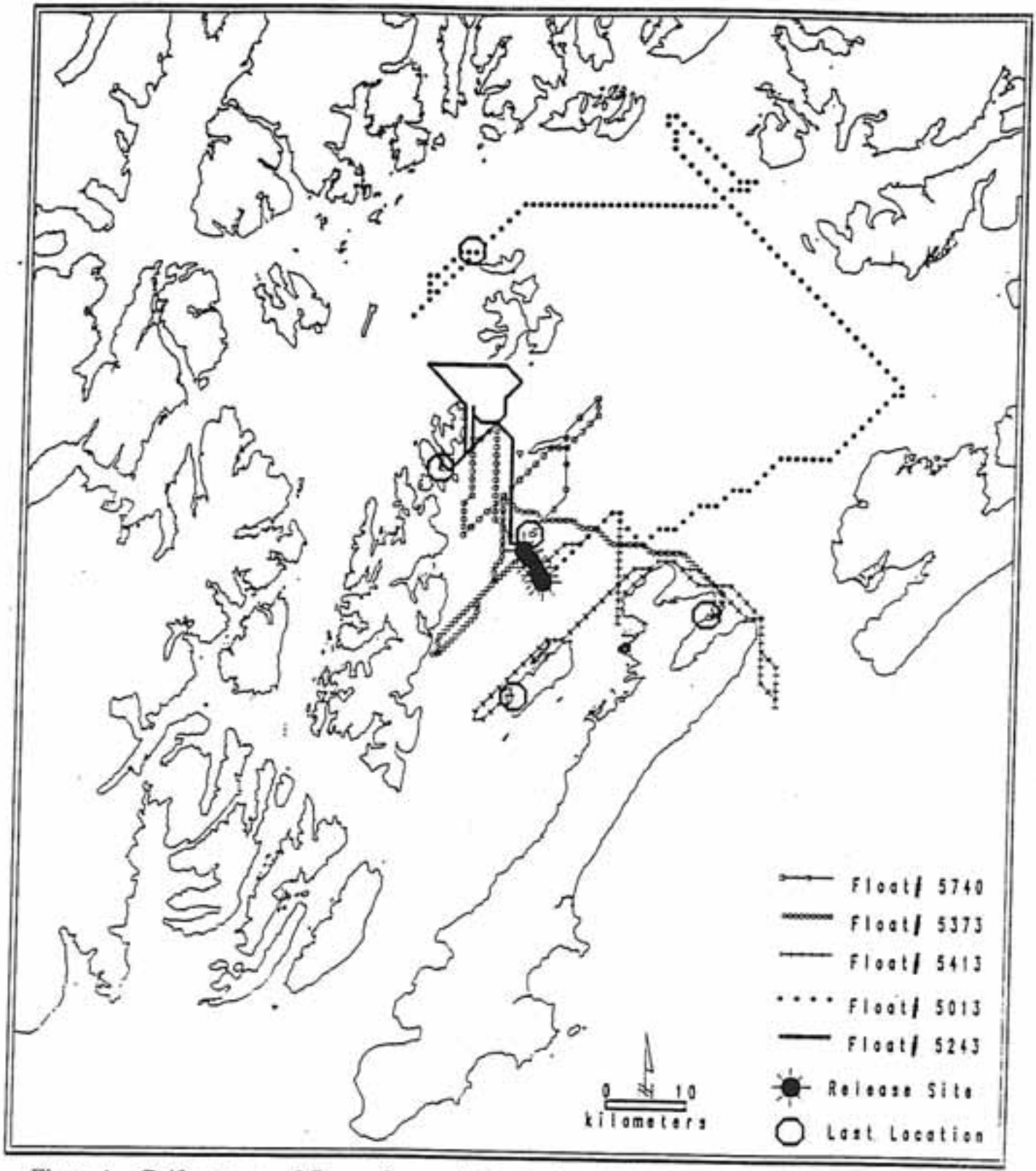

Figure 1. Drift patterns of five radio-tagged floats released 29 June 1990 near Applegate Rocks, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.

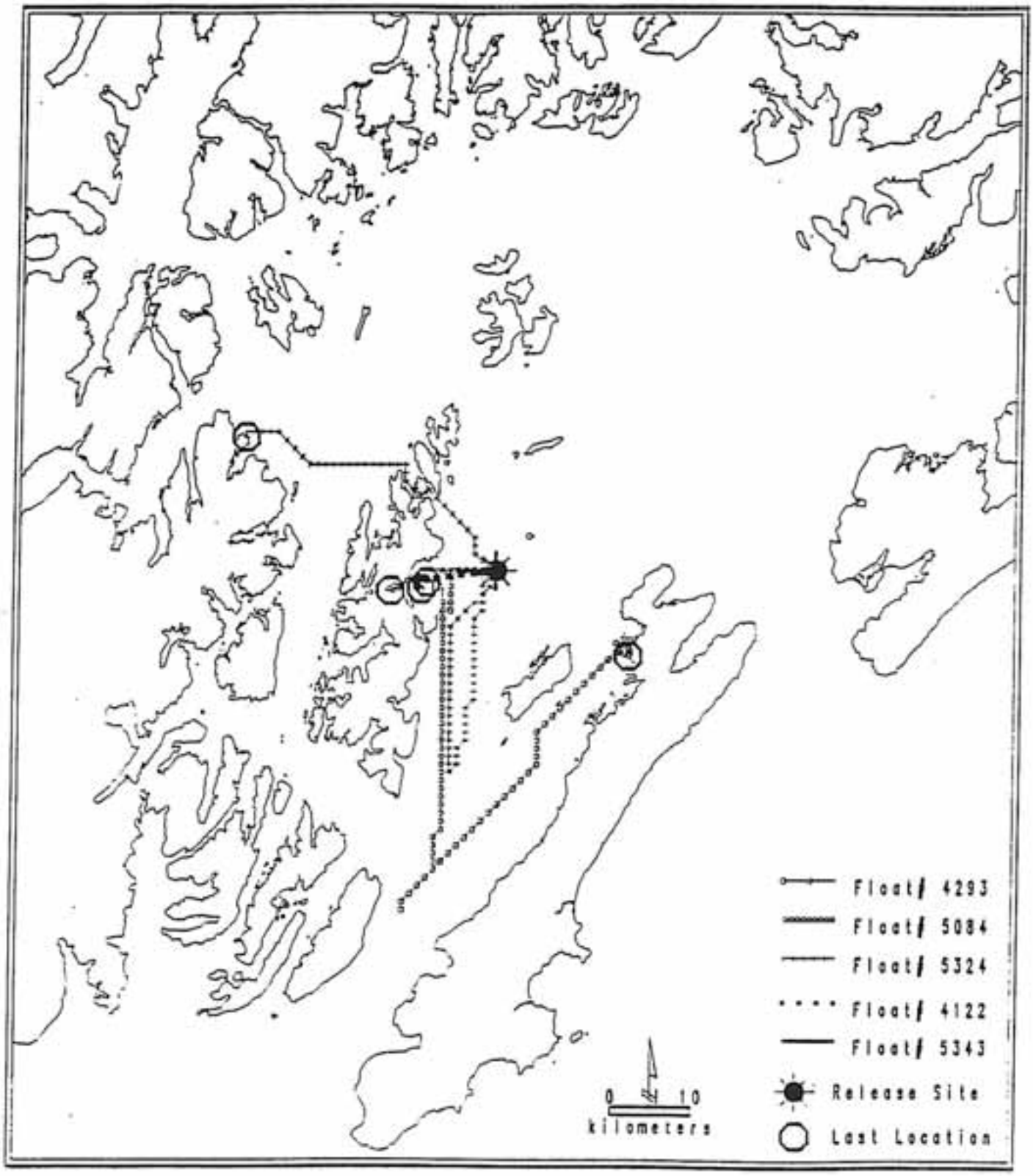

Figure 2. Drift patterns of five radio-tagged floats released 12 July 1990 near Applegate Rocks, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.

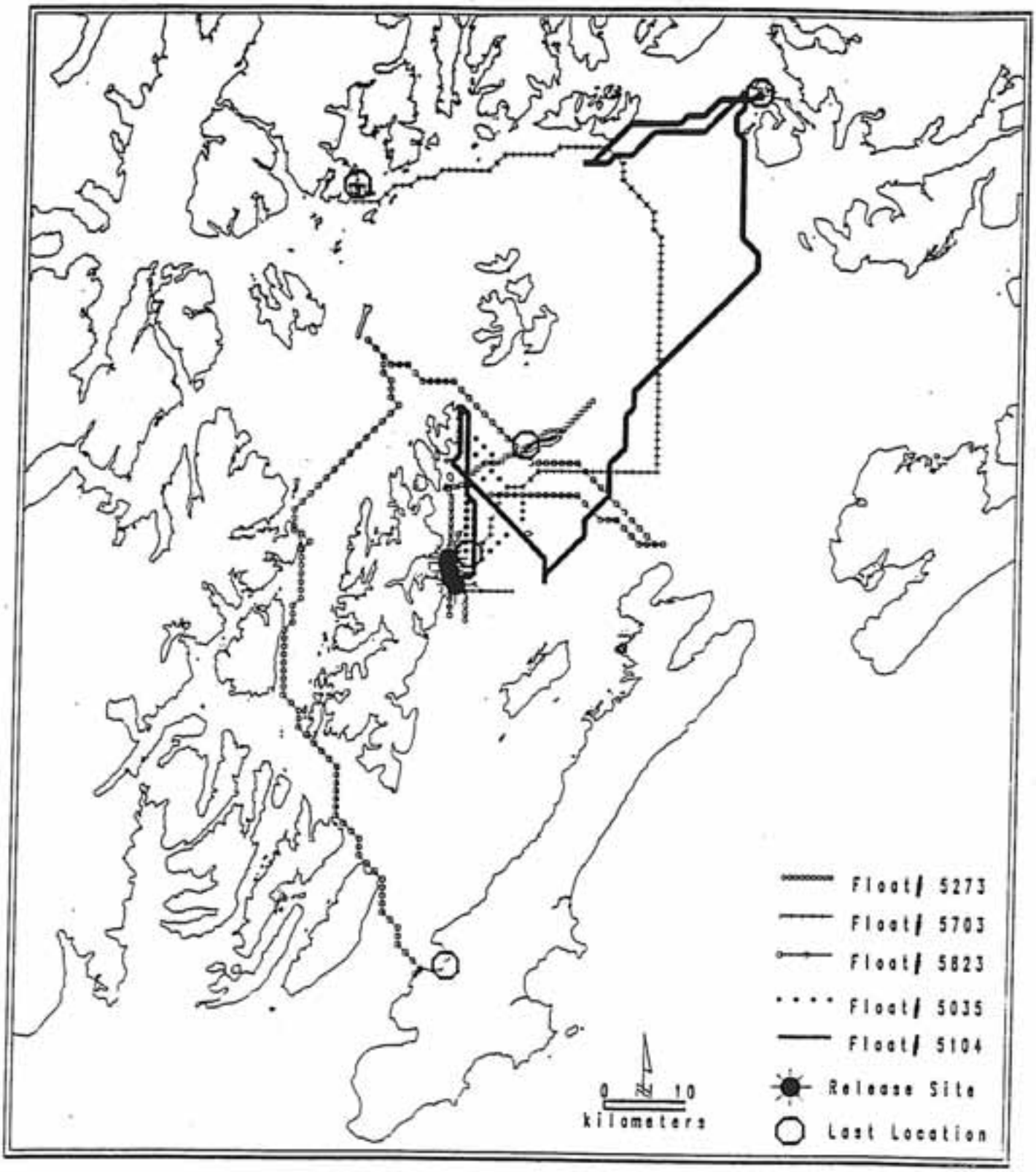

Figure 3. Drift patterns of five radio-tagged floats released 29 June 1990 near Bay of Isles, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.

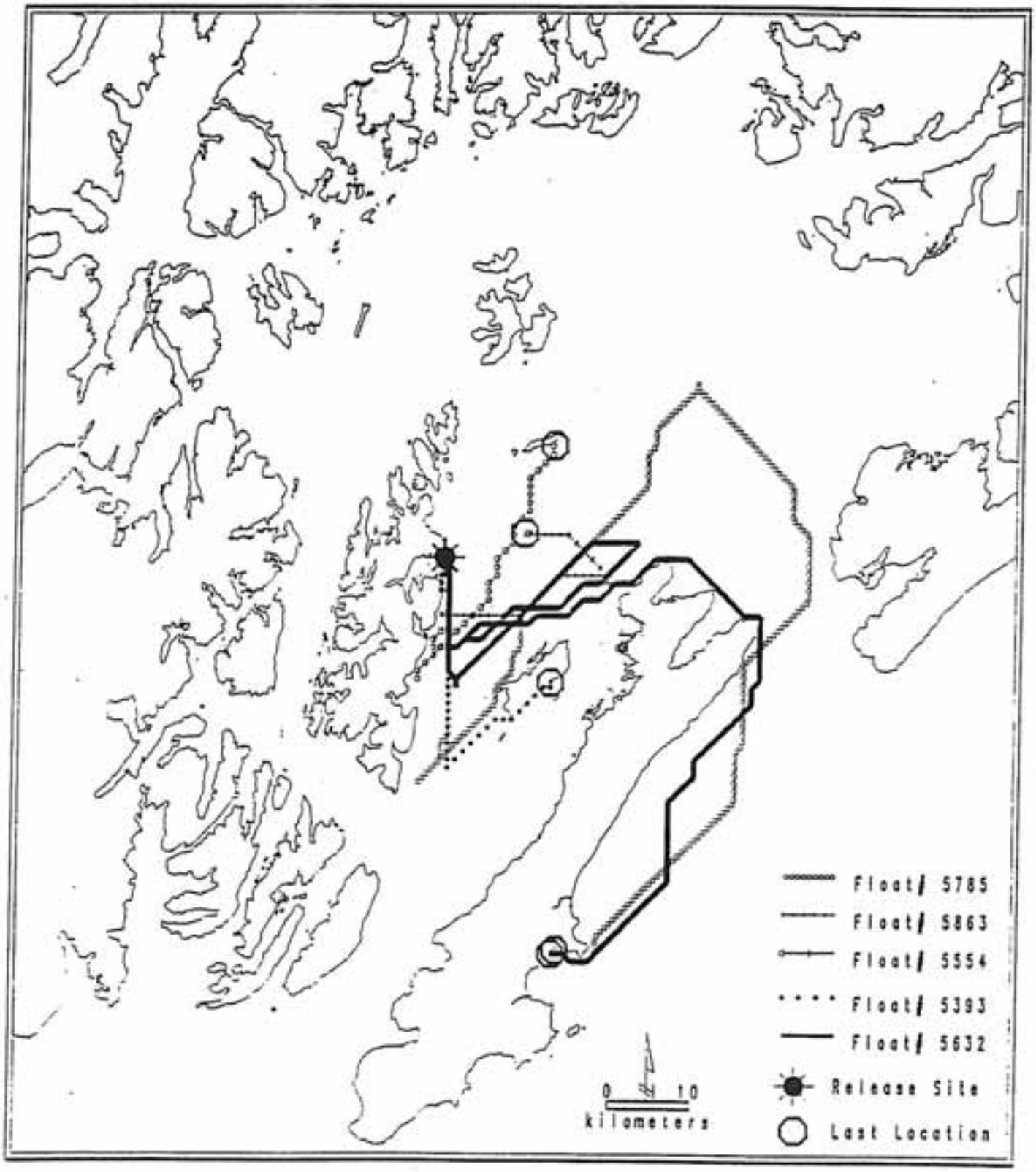

Figure 4. Drift patterns of five radio-tagged floats released 12 July 1990 near Bay of Isles, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.

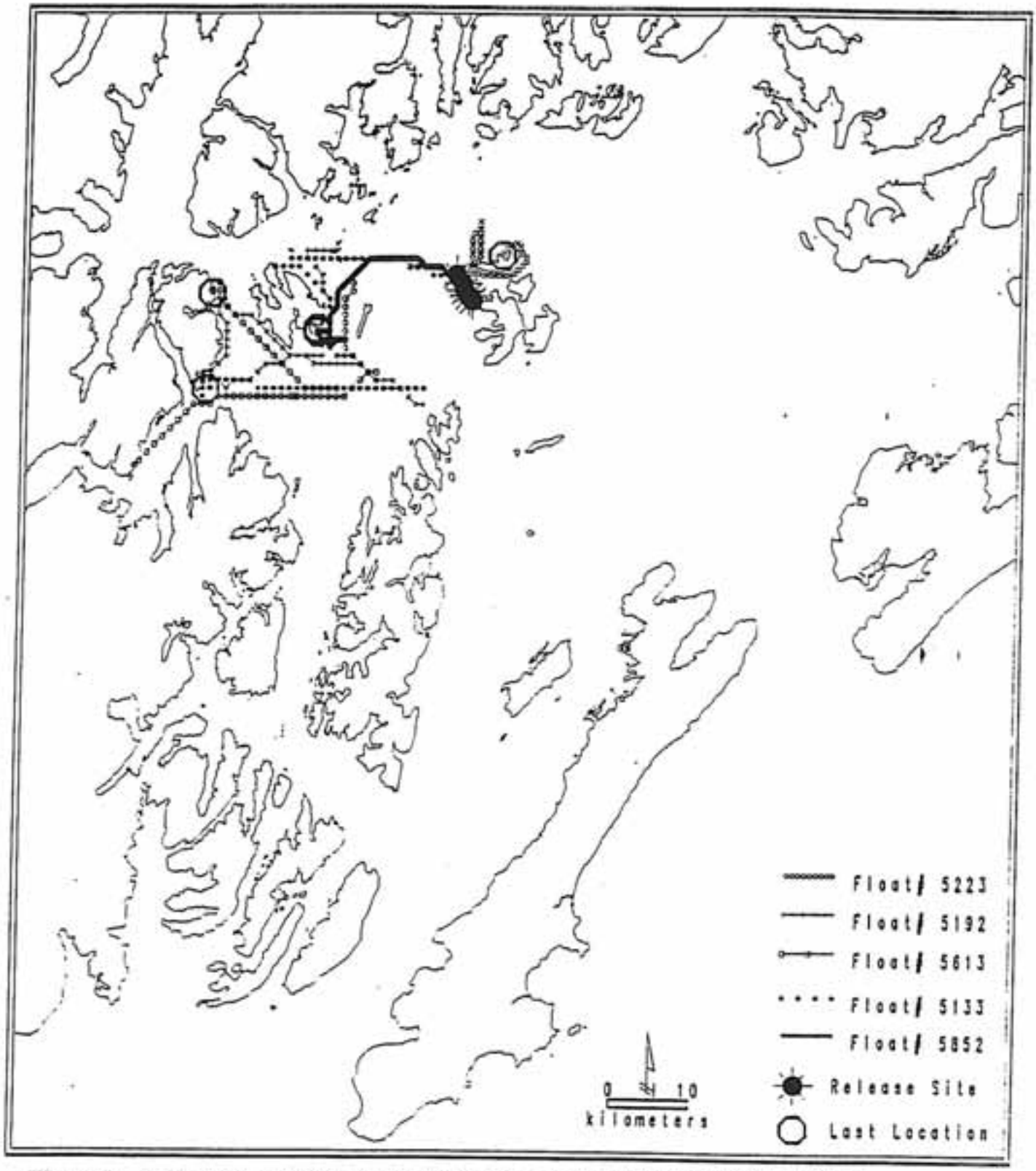

Figure 5. Drift patterns of five radio-tagged floats released 29 June 1990 near Naked Island, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.

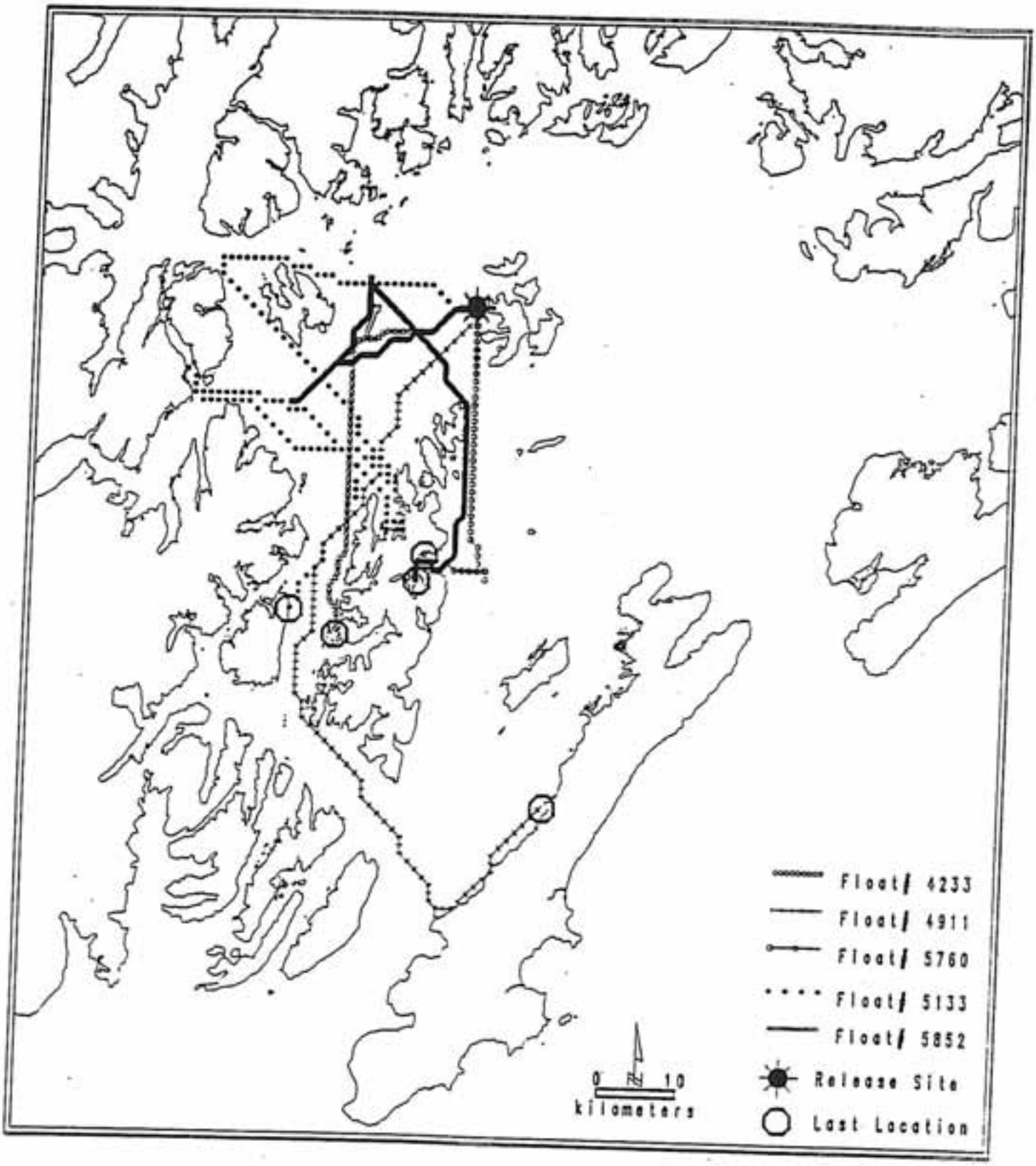

Figure 6. Drift patterns of five radio-tagged floats released 12 July 1990 near Naked Island, Prince William Sound, Alaska. The travel route between sequential relocations was synthesized by Network, a Geographic Information Systems program.