Exxon Valdez Oil Spill
Restoration Project Final Report

Introduced Predator Removal From Islands

Restoration Project 95041
Final Report

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Study History: Project 94041 was first funded in FY94 as Introduced Predator Removal From Islands.

Abstract: In order to restore black oystercatchers (*Haematopus bachmani*) and pigeon guillemots (*Cepphus columba*), 2 species injured by the *T/V Exxon Valdez* oil spill, the introduced predator, arctic fox (*Alopex lagopus*), was removed from 2 islands near the western edge of the trajectory of the oil. In 1994, most of the foxes were removed from Simeonof Island (33 animals) and all foxes were eliminated from Chernabura Island (3 animals). The remaining 5 foxes were removed from Simeonof by July 1995. Surveys indicated that although adequate nesting habitat was available at Simeonof and Chernabura, oystercatcher and guillemot population densities were much lower than at nearby fox-free islands. Elimination of foxes is expected to dramatically increase populations of these injured species as well as other native birds.

Key Words: arctic fox, black oystercatcher, Chernabura I., habitat restoration, introduced predator removal, pigeon guillemot, Simeonof I., Shumagin Is.

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EXECUTIVE SUMMARY

Introduction

Few options have been presented for direct restoration of marine birds injured by the *T/V Exxon Valdez* oil spill. Removal of introduced predators is one way to enhance injured species; therefore, a project was begun in 1994 to remove introduced arctic foxes (*Alopex lagopus*) from 2 islands near the western edge of the area affected by the oil spill. These islands, Simeonof and Chernabura, contain nesting habitat for 2 spill-injured species: black oystercatcher (*Haematopus bachmani*) and pigeon guillemot (*Cepphus columba*), but breeding populations have been substantially reduced by fox predation.

Objectives

The object of the project was to enhance populations of black oystercatchers and pigeon guillemots at Simeonof and Chernabura islands by eliminating introduced arctic foxes. Oystercatchers and guillemots were surveyed to record their response to fox removal.

Methods

Study Area.--Simeonof (4,000 ha) and Chernabura (3,000 ha) islands lie in the outer Shumagin Island group south of the Alaska Peninsula. These islands had no native terrestrial mammals except river otters (*Lutra canadensis*), so the introduction of foxes for commercial fur farming in the late 1800's and early 1900's resulted in large-scale declines in native birds. Fortunately, foxes did not persist on some of the small islands near Simeonof and Chernabura, so substantial populations of oystercatchers and guillemots remain in the vicinity to provide founder sources after fox removal.

Fox Removal.--Leg-hold traps were deployed on fox trails and beaches around the peripheries of Simeonof and Chernabura at a density of about 3.4 traps km^{-1} of coastline. In 1994, trapping occurred from 24 May to 24 June on Simeonof and from 24 June to 14 July on Chernabura. Foxes found in traps were killed immediately. In 1995, both islands were rechecked in late May for signs that foxes remained. Chernabura was found to be fox-free, but fresh tracks were found on Simeonof. Trappers again visited Simeonof in May and June 1995, and 5 additional foxes were killed. Rechecks thereafter in late June and July 1995 indicated no foxes remained.

Oystercatcher and Guillemot Surveys.--An inflatable boat was used to circumnavigate Simeonof, Chernabura, and several fox-free "control" islands nearby in order to count oystercatchers and guillemots. Locations of oystercatchers were delineated and later checked on foot to determine the number of breeding pairs and non-breeders. We could not determine the number of breeding pairs of guillemots because they nested in crevices hidden from our view, so we made four replicate counts of birds within 100 m of shore at most sites. The peak count was used as a population index.

Oystercatcher and Guillemot Habitat Surveys.--To compare densities of oystercatchers and guillemots among islands, we determined the amount of breeding habitat for the two species at each site. Oystercatchers nest on open beaches, so we measured the length of all beaches and expressed nesting density as pairs km^{-1} of beach. Guillemots are known to nest in log and boulder piles and in cliff crevices. We estimated the surface area of potential habitat, and density was expressed as guillemots ha^{-1} of habitat.

Results

Fox Removal.--We removed 38 foxes from Simeonof and 3 foxes from Chernabura. No foxes remained on either island when we left in July 1995.

Black Oystercatcher Densities.--Although oystercatchers were observed on Simeonof and Chernabura, foxes apparently kept them from nesting successfully in 1994, but by 1995 at least a few pairs were already nesting successfully. Densities of pairs were 5-21 times higher on fox-free islands nearby, suggesting a predicted range of potential expansion at Simeonof and Chernabura.

Pigeon Guillemot Densities.--Some guillemots nested on Simeonof and Chernabura while foxes were still present. Nevertheless, densities of birds were 4-50 times higher on nearby fox-free islands.

Discussion

Foxes apparently have reduced oystercatcher and guillemot populations on Simeonof and Chernabura islands, but both islands have substantial amounts of breeding habitat for these injured species of birds. Following the removal of foxes from these islands in 1994 and 1995, oystercatcher and guillemot populations will increase rapidly.

Conclusions

Foxes were removed from Simeonof and Chernabura islands, as planned. Surveys of oystercatchers and guillemots and their habitats show that conditions are favorable for population increases of these injured species.

INTRODUCTION

Among the species of birds injured by the T/V *Exxon Valdez* oil spill were black oystercatchers (*Haematopus bachmani*) and pigeon guillemots (*Cepphus columba*) (Piatt et al. 1990, Andres 1993, Oakley and Kuletz, unpubl. ms.). Few options have been presented for direct restoration of injured populations, but removal of introduced arctic foxes (*Alopex lagopus*) is one method of substantially enhancing oystercatchers, guillemots, and other seabird populations (Bailey 1993, Byrd et al. 1994). The Shumagin Islands, near the western edge of the oil's trajectory, provided an opportunity to employ this restoration method. Fox-free islands in the Shumagins have substantial populations of oystercatchers and guillemots (Bailey 1978, Day 1977, Bailey and McCargo 1984), but 2 islands in the group, Simeonof and Chernabura (Fig. 1), have introduced foxes and consequently reduced numbers of these injured species.

In 1994, the *Exxon Valdez* Oil Spill Trustee Council approved funding for a restoration project at Simeonof and Chernabura islands. During that summer, fox removal began, and remaining foxes were removed in 1995. Oystercatcher and guillemot populations were surveyed on these islands and nearby fox-free control sites to evaluate their potential for recovery.

OBJECTIVES

The purpose of this project was to enhance populations of black oystercatchers and pigeon guillemots at Simeonof and Chernabura islands by eliminating introduced arctic foxes and to document the response of birds to fox removal.

METHODS

Study Area

The outer Shumagin Islands (i.e. southeast of Nagai Island) include five islands over 2,500 ha and 12 smaller islands and islets (Fig. 1). Most of the islands are in the Alaska Maritime National Wildlife Refuge. These islands originally had no terrestrial mammals except river otter (*Lutra canadensis*). Foxes were introduced for fur farming in the late 1800's and early 1900's to all of these islands except the very small ones. Although most fox farming ended prior to WWII, the introduced animals persisted on all five relatively large islands in the outer Shumagins (Bailey 1993). From evidence elsewhere in southwestern Alaska (Murie 1959, Jones and Byrd 1979), and from comparisons of islands with and without foxes in the Shumagins (Moe and Day 1977, Bailey 1978, Sowl 1982, Bailey and McCargo 1984, E.P. Bailey unpubl. data), it is apparent that foxes have substantially reduced oystercatcher and guillemot populations as well as other seabirds.

In addition to fox introductions, ground squirrels (*Spermaophilus undulatus*) were introduced for fox food, and cattle were introduced to Simeonof and Chernabura islands (Bailey 1994). Cattle were removed from both islands in 1983, but ground squirrels remain.

Like the other outer Shumagins, 4,000-ha Simeonof Island and 3,000-ha Chernabura have no native trees; the tallest plants are shrubs: alder (*Alnus sinuata*) and willows (*Salix spp.*). Besides scattered clumps of shrubs, primary plant communities are coastal grass-umbel, subalpine meadows on lower mountain slopes, and crowberry (*Empetrum nigrum*) and other heaths at higher locations (Bailey 1994).

Fox Removal

Trapping was conducted by a crew of up to 6 people on Simeonof Island from 24 May to 24 June, 1994, and on Chernabura Island from 24 June to 14 July, 1994. In 1995, up to 10 people rechecked the islands for fox sign and reset traps on 19-20 May . Methods similar to those employed at other southwestern Alaskan sites were used (Bailey 1993). Specifically, leg-hold traps were deployed on fox trails and beaches around the periphery of an island and in heavily-used interior areas as quickly as possible after personnel arrived (most readily-accessible areas had trap lines deployed within 10 days). Trapping density was about 3.4 traps km^{-1} coastline on both Simeonof and Chernabura islands. Traps were rechecked as often as possible, usually at least every 3 days. Foxes found in traps were immediately killed.

Oystercatcher and Guillemot Surveys

In order to evaluate the response of oystercatchers and guillemots to removal of introduced foxes, birds were counted on Simeonof and Chernabura and on nearby fox-free islands (Bird, Herendeen, and Atkins) which will serve as "controls" (Fig. 1).

For oystercatchers, the objective was to census pairs; therefore, most surveys were conducted during the incubation period in June (Day 1977, Kenyon 1964) when pairs were territorial and most conspicuous. Coastlines were surveyed from an inflatable boat by 2-3 observers who recorded locations of all oystercatchers and guillemots seen (see below). All areas were surveyed 2-4 times in each year to reduce chances of missing birds. A "nesting pair" was defined by one of the following characteristics: courtship behavior, the presence of a nest or young, defensive behavior, or distraction displays. When birds exhibiting nesting behavior were noted during boat surveys, areas were checked on the ground at a later date to look for nests or other nesting evidence. In addition, the majority of beaches were surveyed on foot regardless of whether oystercatchers had been noted from the boat. Flocks of oystercatchers were also recorded.

Unlike oystercatchers, nesting pigeon guillemots are not conspicuous because they lay eggs in crevices. To estimate the number of birds associated with nesting colonies, guillemots were counted where they concentrated on the sea near colonies or on the surface of boulder piles or logs within which they nest. There is disagreement in the literature about the best approach

for monitoring guillemot populations (Drent 1965, Ainley and Boekelheide 1990, Sanger and Cody 1993, Vermeer *et al.* 1993), but we timed surveys during the incubation period when numbers are least variable (Vermeer *et al.* 1993). Guillemots were counted within approximately 100 m of the shoreline from an inflatable boat operated at slow speeds about 50 m from shore. Attendance of guillemots at nesting colonies is variable, with peak numbers of birds visible in the early morning. Morning fog and other severe weather conditions hampered counts in 1994, so most of the surveys for guillemots were made in the middle of the day resulting in relatively low numbers of birds observed. In 1995, weather permitted more strict adherence to recommended survey times, and numbers indeed were higher. Each island was surveyed 2-4 times each year.

Oystercatcher and Guillemot Habitat Surveys

Since the amount of nesting habitat for oystercatchers and guillemots varied among islands, we compared nesting densities. This necessitated estimating the amount of nesting habitat on each island.

Black oystercatchers nest in the open on beaches (Andres 1993). We delineated sections of beach with sand, boulder, and rock shelf substrates. The amount of available oystercatcher habitat was calculated by summing the lengths of all 3 types of beaches on an island.

The crevices used by pigeon guillemots for nest sites could occur in boulder beaches, talus-covered slopes, cracks in vertical cliffs, or in drift log piles (Drent 1965, Ewins 1993, Sanger and Cody 1993). This diversity in habitat types made it difficult to map all possible nesting areas for guillemots, but we attempted to delineate and estimate the surface area of each type of potential nesting habitat. In 1994, guillemots seen in nearshore waters were assigned to the nearest nesting habitat so that relative densities could be compared among types.

RESULTS

Fox Removal

At Simeonof, 33 foxes were killed in 1994, and 5 additional animals were removed in 1995. Fewer foxes were found on Chernabura, and only 3 animals were killed. No foxes remained on Chernabura in spring 1995, and Simeonof was fox-free by July 1995.

Black Oystercatcher Densities

Simeonof and Chernabura had relatively large numbers of black oystercatchers, but few were nesting in 1994 (Table 1, Appendix A). In fact, the densities of nesting pairs on these islands with foxes were only 0.1-0.2 pairs km^{-1} beach compared to densities ranging from 0.5 to 2.5 pairs km^{-1} beach on fox-free control areas. The proportion of non-breeders and failed-breeders in populations was much higher on Simeonof and Chernabura in 1994 than on the control sites (Table 1). Moreover, we found no oystercatcher nests on either Simeonof or

Chernabura in 1994 (although a pair giving a distraction display suggested that one nest may have been present on Chernabura), whereas nests were found on all the fox-free islands we searched. By 1995, successful nesting was beginning to occur again on Simeonof (2 nests) and Chernabura (3 nests), and the proportion of non-breeders declined at Chernabura between 1994 and 1995 (Table 1).

On islands with and without foxes, oystercatchers seemed to favor beaches with boulder habitat over those that had sand or rock shelf substrates (Table 2, Appendix B). As indicated, Simeonof and Chernabura have substantial amounts of favorable oystercatcher habitat.

Pigeon Guillemot Densities

The maximum densities of guillemots on fox-inhabited Simeonof and Chernabura islands were 2.3 and 12.3 birds ha^{-1} , respectively (Table 3, Appendix A). On the fox-free control islands, densities were much higher, ranging from 43.8 to 101.3 birds ha^{-1}. The density at Chernabura was much higher than at Simeonof, primarily due to the existence of a breeding colony at Chernabura in an area that appeared to be topographically inaccessible to foxes. Excluding this inaccessible portion, the density on Chernabura was similar to Simeonof.

Pigeon guillemots are known to use a wide variety of nest sites, the essential characteristic being a suitable crevice for the nest chamber (Ewins 1993). The primary types of pigeon guillemot nesting habitats at Simeonof and Chernabura were crevices among boulders or rocky benches on beaches (Table 4, Appendix C). These islands also contained log piles which provide potential nesting crevices, but which were not used by guillemots in 1994 or 1995.

DISCUSSION

Our results indicate that oystercatcher and guillemot breeding populations at Simeonof and Chernabura are below levels that would be expected based on the amount of available breeding habitat. Although few historical data are available for nesting densities of oystercatchers in the Shumagin Islands, the pattern at other areas is clear. If foxes are present, few if any oystercatchers are able to nest (Moe and Day 1977, Bailey 1978, E.P. Bailey unpubl. data).

As indicated above, estimated densities of oystercatcher breeding pairs on fox-free islands in the Shumagins ranged from approximately 0.5 to 2.5 pairs km^{-1} (Table 1). We had no information about habitat quality, although it must have varied among areas judging from differences in nesting densities. Nevertheless, if habitat quantity is used as a crude measure of predicted nesting populations of oystercatchers following fox removal, Simeonof (with 42 km of beaches) may eventually have 21-88 nesting pairs of oystercatchers, compared to zero nesting pairs in 1994 (Table 5). At Chernabura (31 km of beaches), the expected population would be 16-65 pairs, up from possibly one pair in 1994.

In contrast to oystercatchers, which are almost completely excluded from nesting on islands with foxes, pigeon guillemots are able to sustain reduced nesting populations because they nest in rock crevices, a proportion of which are inaccessible to foxes. In spite of this protection, foxes prey on guillemots (Murie 1959). Historical data on guillemots in the Shumagin Islands are opportunistic single counts which provide crude indices to population levels, and there is no data on nesting habitat. Strong conclusions would be inappropriate, but these data suggest fox-free islands have much higher densities of guillemots than those where foxes are present (Table 6). Furthermore, guillemots increased nearly 20-fold within 15 years after foxes were removed from an island in the western Aleutian Islands (Byrd et al. 1994). The magnitude of increase is dependent upon the quality and quantity of available habitat, so it is difficult to predict how many guillemots ultimately will nest at Simeonof and Chernabura following fox removal. Nevertheless, as indicated above (Table 3), fox-free islands near Simeonof and Chernabura had density indexes approximately 4-50 times higher than the islands with foxes. We predict Simeonof and Chernabura each eventually will have hundreds of nesting guillemots (Table 5).

CONCLUSION

It is apparent that the presence of introduced foxes is detrimental to breeding populations of oystercatchers and guillemots on islands and was probably the cause of low breeding populations of these birds on Simeonof and Chernabura islands. All foxes were removed from Simeonof and Chernabura islands in 1994 and 1995. This restoration project is likely to restore these injured species to higher population levels.

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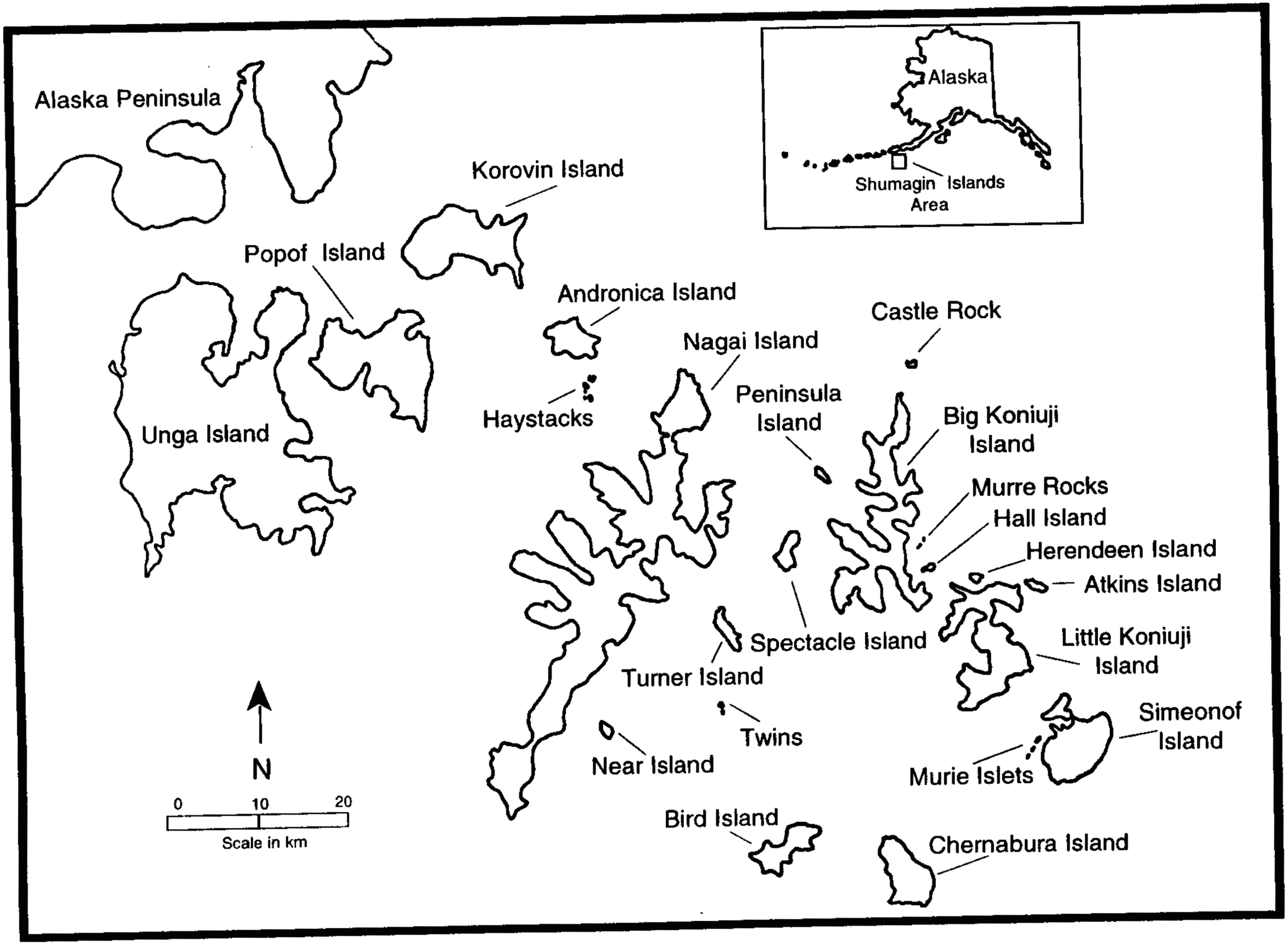

Figure 1. Map of the Shumagin Islands, Alaska, showing the locations of study areas.

Table 1. Black oystercatcher populations at Simeonof and Chernabura Islands, Alaska, compared to nearby fox-free islands.

	Foxes Present		Foxes Absent		
Variable	Simeonof	Chernabura	Atkins	Herendeen	Bird
Habitat	42.0[a]	31.1	10.1	2.4	13.0
1994					
Pairs	4.0	3.0	5.0	6.0	18.0
Others[b]	26.0	19.0	3.0	5.0	29.0
Total	34.0	25.0	13.0	17.0	65.0
Percent of birds not paired	76.6	76.0	23.1	29.4	44.6
Pairs/ km	0.1	0.1	0.5	2.5	1.4
Total/ km	0.8	0.8	1.3	7.1	5.0
1995					
Pairs	5.0	5.0	5.0	5.0	14.0
Others[b]	31.0	9.0	4.0	8.0	28.0
Total	41.0	19.0	14.0	18.0	56.0
Percent of birds not paired	75.6				
Pairs/ km	0.1	0.2	0.5	2.1	1.1
Total/ km	1.4	0.6	1.4	7.5	4.3

[a]Estimated nesting habitat in km.
[b]Oystercatchers observed as singles or in flocks.

Table 2. Densities of black oystercatcher pairs in different nesting habitats on selected islands in the Shumagin Islands, Alaska, in 1994 and 1995.

Location	Beach Habitat Type[a]		
	Sand	Boulder	Rock/Rock shelf
Foxes Present			
Simeonof			
Habitat	8.3[b]	29.6	4.1
1994 Density	0.1[c]	0.1	0.0
1995 Density	0.0	0.2	0.0
Chernabura			
Habitat	2.6	21.5	7.0
1994 Density	0.1	0.4	0.0
1995 Density	0.0	0.1	0.4
Foxes Absent			
Atkins			
Habitat	---[d]	3.2	6.9
1994 Density		1.4	0.2
1995 Density		0.3	0.4
Heredeen			
Habitat	---	1.3	1.1
1994 Density		3.8	0.3
1995 Density		1.2	0.0
Bird			
Habitat	1.6	9.8	1.6
1994 Density	0.0	1.1	0.4
1995 Density	0.0	1.3	0.6

[a]See Appendix B for definitions.
[b]Km of beach.
[c]Pairs per km of beach habitat.
[d]Dash indicates habitat is absent.

Table 3. Pigeon guillemot populations at Simeonof and Chernabura islands, Alaska, compared to nearby fox-free islands.

	Fox Present		Fox Absent		
Variable	Simeonof	Chernabura	Atkins	Herendeen	Bird
Habitat	3.1[a]	5.6	2.3	2.1	9.4[b]
Maximum					
1994	6	42	41	33	186
1995	7	69	233	92	529
Mean					
1994	4	28	14	19	138
1995	4	46	194	59	476
Maximum[c] Density	2.3	12.3	101.3	43.8	56.3
Mean[c] Density	1.3	8.2	84.4	28.1	50.6

[a]Hectares.

[b]Potential habitat area for Bird I. was revised in 1995 from 17.9 ha to 9.4 ha, based on a more thorough survey.

[c]Guillemots ha^{-1} based on 1995 data.

Table 4. Density of pigeon guillemots in different habitat types on selected islands in the Shumagin Islands, Alaska, in 1994.

Location	Habitat Types			
	Boulder	Cliff	Talus	Logs
Foxes Present				
Simeonof	2.7(2.57)[b]	--[c]	--	0.0(0.53)
Chernabura	8.3(5.02)	--	--	0.0(0.61)
Foxes Absent				
Atkins	44.2(0.27)	--	13.3(2.03)	--
Herendeen	30.8(0.29)	26.4(0.98)	14.0(0.85)	--
Bird	25.9(5.91)	58.7(1.96)	--	0.0(1.57)

[a]Boulder habitats include boulders and rock outcrops near sea level with crevices large enough for guillemot nest sites; cliff habitats were vertical rock walls with nest crevices; talus refers to boulder piles on sea slopes; and log habitat was piles of drift logs providing potential nesting crevices.

[b]Guillemots ha^{-1} with habitat area in parentheses.

[c]Dash indicates the habitat was absent.

Table 5. Predicted population of black oystercatchers and pigeon guillemots at Simeonof and Chernabura Islands, Alaska, following removal of introduced arctic foxes.

Species	Density at Fox-free Sites	Restored Island	Amount of Habitat	1994-1995 Population	Predicted Population
Black oystercatcher	0.5-2.1 pair km^{-1}	Simeonof	42.0 km[a]	4-5 pairs	21-88 pairs
		Chernabura	31.1 km	3-5 pairs	16-65 pairs
Pigeon guillemot	43.8-101.3 bird ha^{-1}	Simeonof	3.1 ha[b]	6-7 birds	136-314 birds
		Chernabura	5.6 ha	42-69 birds	245-567 birds

[a]Length of beach habitat.

[b]Area of habitat containing nesting crevices.

Table 6. Comparison of pigeon guillemot densities on selected islands with and without foxes in the Shumagin Islands, Alaska.

Island	Coastline (km)	Estimated number of birds	Density (birds km^{-1} coast)[a]	Survey date	Source
Foxes Absent					
Hall/Murre Rocks	3	1250	417	2 Jul 1976	Moe and Day 1977
Peninsula	5	60	12	24 Jul 1976	Moe and Day 1977
Gull (near Unga)	<1[b]	20	100	9 Jun 1973	Sowl 1982
Henderson	1	20	20	9 Jun 1973	Sowl 1982
Near	6	400	67	10 Jul 1977	Bailey 1978
Haystacks	1	6	6	7 Jul 1977	Bailey 1978
Castle	3	50	17	6 Jul 1976	Moe and Day 1977
Twins	2	20	10	15 Jul 1977	Bailey 1978
Murie Islets	3	161	54	8 Jun 1994	K. Schmidt unpubl.
Andronica	16	230	14	10 Jun 1973	Sowl 1982
Turner	13	30	2	14 Jul 1977	Bailey 1978
Spectacle	12	80	7	17 Jul 1977	Bailey 1978
Popof	55	40	1	10 Jun 1973	Sowl 1982
Mean density[c]			56		
Foxes Present					
Big Koniuji	90	40	<1	-- Jul 1976	Moe and Day 1977
Simeonof	42	12	<1	-- Jun 1994	this report
Chernabura	33	43	1	7 Jul 1994	this report
Mean density			<1		

[a]Rounded to nearest integer.
[b]0.2 km of coastline.
[c]Island is sample unit for calculating means.

Appendix A. Counts of pigeon guillemots on Simeonof, Chernabura, and nearby fox-free islands in the Shumagin Islands, Alaska, in 1994 and 1995. The appendix provides tables summarizing all boat-based counts along with survey conditions.

Table A-1. Counts of pigeon guillemots at Simeonof Island, Alaska, in 1994 and 1995.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
1994	1	06/1-2[b]	11:40-18:00	1	1	0
					2	0
					3	0
					4	2
					5	0
					6	0
					7	0
					8	2
					Total	4
	2	06/3	11:00-17:00	1	1	0
					2	0
					3	1
					4	0
					5	0
					6	2
					7	3
					8	0
					Total	6
	3	06/4	13:00-20:30	1	1	0
					2	0
					3	0
					4	1
					5	2
					6	0
					7	2
					8	0
					Total	5
	4	06/6-8	14:30-19:17	1-2	1	0
					2	0
					3	0
					4	0
					5	0
					6	0
					7	0
					8	0
					Total	0
					1994 Maximum	6
					1994 Minimum	0
					1994 Mean	4
					SD	3
					n	4

Table A-1. Continued.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
1995	1	06/23	06:40-09:10	1	1	0
					2	0
					3	0
					4	0
					5	0
					6	0
					7	0
					8	0
					Total	0
	2	06/24	06:30-09:25	1	1	0
					2	0
					3	3
					4	2
					5	0
					6	0
					7	2
					8	0
					Total	7
	3	06/25	06:30-09:20	1	1	0
					2	0
					3	1
					4	3
					5	0
					6	0
					7	3
					8	0
					Total	7
	4	07/15	06:15-09:51	1-2	1	0
					2	1
					3	1
					4	0
					5	0
					6	0
					7	1
					8	0
					Total	3
	5	07/16-17	06:25-09:55	1	1	0
					2	0
					3	0
					4	3

Table A-1. Continued.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
					5	0
					6	1
					7	0
					8	0
					Total	4
					1995 Maximum	7
					1995 Minimum	0
					1995 Mean	4
					SD	3
					n	5

[a]Condition codes: 1 = winds <15 knots, seas ≤ 2 ft, 2 = winds 15-20 knots or seas 2-4 ft, 3 = winds > 20 knots or seas > 4 ft.

[b]Because of sea conditions it sometimes took more than 1 day to complete a replicate.

Table A-2. Counts of pigeon guillemots at Chernabura Island, Alaska, in 1994 and 1995.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
1994	1	07/5-7[b]	13:00-18:00	2-3	1	0
					2	0
					3	0
					4	1
					5	1
					6	11
					Total	13
	2	07/7-9	12:00-14:30	1	1	0
					2	0
					3	0
					4	0
					5	0
					6	22
					Total	22
	3	07/10	11:05-14:50	2	1	0
					2	0
					3	0
					4	2
					5	0
					6	40
					Total	42
	4	07/11	14:30-18:30	2-3	1	0
					2	0
					3	0
					4	0
					5	0
					6	34
					Total	34
					1994 Maximum	42
					1994 Minimum	13
					1994 Mean	28
					SD	13
					n	4
1995	1	06/10-11	06:00-10:15	1	1	0
					2	0
					3	0
					4	2
					5	0

Table A-2. Continued.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of *Guillemots*
					6	67
					Total	69
	2	06/12	06:00-09:55	1	1	0
					2	0
					3	0
					4	3
					5	5
					6	22
					Total	30
	3	06/13-15	06:15-08:15	2-3	1	0
					2	0
					3	0
					4	2
					5	0
					6	46
					Total	48
	4	06/16	06:30-09:45	2-3	1	0
					2	0
					3	0
					4	0
					5	0
					6	21
					Total	21
	5	07/27	07:25-08:45	2	1	0
					2	0
					3	0
					4	4
					5	2
					6	58
					Total	64
					1995 Maximum	69
					1995 Minimum	21
					1995 Mean	46
					SD	21
					n	5

[a]Condition codes: 1 = winds <15 knots, seas ≤ 2 ft, 2 = winds 15-20 knots or seas 2-4 ft, 3 = winds > 20 knots or seas > 4 ft.

[b]Because of sea conditions it sometimes took more than 1 day to complete a replicate.

Table A-3. Counts of pigeon guillemots at Atkins Island, Alaska, in 1994 and 1995.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
1994	1	06/15	19:02-20:39	1	1	3
					2	0
					Total	3
	2	06/17	16:30-19:15	1	1	2
					2	0
					Total	2
	3	06/20	14:10-16:27	1	1	8
					2	3
					Total	11
	4	06/22	15:00-15:50	1	1	28
					2	13
					Total	41
					1994 Maximum	41
					1994 Minimum	2
					1994 Mean	14
					SD	18
					n	4
1995	1	06/14	06:30-07:45	2-3	1	83
					2	150
					Total	233
	2	06/21	08:36-10:01	1	1	117
					2	61
					Total	178
	3	07/13	09:45-11:00	1	1	102
					2	101
					Total	203
	4	07/14	07:13-08:20	1-2	1	79
					2	81
					Total	160
					1995 Maximum	233
					1995 Minimum	160
					1995 Mean	194
					SD	32
					n	4

[a]Condition codes: 1 = winds <15 knots, seas ≤2 ft, 2 = winds 15-20 knots or seas 2-4 ft, 3 = winds >20 knots or seas >4 ft.

Table A-4. Counts of pigeon guillemots at Herendeen Island, Alaska, in 1994 and 1995.

Year	Replicate	Date	Time	Conditions[a]	Segment	Number of Guillemots
1994	1	06/15	15:40-18:40	1	1	2
					2	2
					3	1
					Total	5
	2	06/17	12:30-14:30	1	1	26
					2	7
					3	0
					Total	33
	3	06/18	15:50-16:55	1	1	2
					2	0
					3	3
					Total	5
	4	06/22	14:20-15:40	1	1	14
					2	13
					3	4
					Total	31
					1994 Maximum	33
					1994 Minimum	5
					1994 Mean	19
					SD	16
					n	4
1995	1	06/14	06:35-07:25	1-2	1	31
					2	55
					3	6
					Total	92
	2	06/18	06:22-07:10	2-3	1	17
					2	32
					3	0
					Total	49
	3	07/20	08:00-08:46	1-2	1	14
					2	24
					3	24
					Total	62
	4	07/21	07:44-08:22	1	1	16
					2	28
					3	0
					Total	44

Table A-4. Continued.

Year	Replicate	Date	Time	Conditions	Segment	Number of Guillemots
	5	07/13	08:51-09:30	1	1	17
					2	34
					3	13
					Total	64
	6	07/14	08:40-09:15	1-2	1	9
					2	22
					3	9
					Total	40
					1995 Maximum	92
					1995 Minimum	40
					1995 Mean	59
					SD	19
					n	6

[a]Condition codes: 1 = winds <15 knots, seas ≤ 2 ft, 2 = winds 15-20 knots or seas 2-4 ft, 3 = winds > 20 knots or seas > 4 ft.

Table A-5. Counts of pigeon guillemots at Bird Island, Alaska, in 1994 and 1995.

Year	Replicate	Date(s)	Time	Conditions[a]	Segment	Number of Guillemots
1994	1	07/13	11:00-18:00	1	1	47
					2	37
					3	33
					4	20
					5	12
					6	37
					Total	186
	2	07/13[b]	18:00-22:00	1	1	1
					2	10
					3	7
					4	20
					5	7
					6	45
					Total	90
					1994 Maximum	186
					1994 Minimum	90
					1994 Mean	138
					SD	68
					n	2
1995	1	06/13	08:00-10:30	2-3	1	48
					2	19
					3	22
					4	110
					5	54
					6	137
					Total	390
	2	06/15	07:05-10:00	2	1	57
					2	23
					3	29
					4	99
					5	64
					6	257
					Total	529
	3	06/16	06:45-08:20	2	1	69
					2	29
					3	26
					4	81
					5	63
					6	190
					Total	458

Table A-5. Continued.

Year	Replicate	Date(s)	Time	Conditions[a]	Segment	Number of Guillemots
	4	07/27	07:20-09:25	1-2	1	57
					2	53
					3	41
					4	97
					5	60
					6	219
					Total	527
					1994 Maximum	529
					1994 Minimum	390
					1994 Mean	476
					SD	66
					n	4

[a]Condition codes: 1 = Wind <15 knots, seas ≤ 2 ft, 2 = wind 15 - 20 knots or seas 2 - 4 ft, 3 = wind > 20 knots or seas > 4 ft.

[b]Because of sea conditions it sometimes took more than 1 day to complete a replicate.

Appendix B. Maps showing the distribution of black oystercatcher habitat on Simeonof, Chernabura, and nearby fox-free islands in the Shumagin Islands, Alaska, in 1994 and 1995. Habitats were described as follows:

Sand: Beaches with sand or pebbles

Boulder: Boulder-strewn beaches

Rockshelf: Beaches with contiguous rock substrates

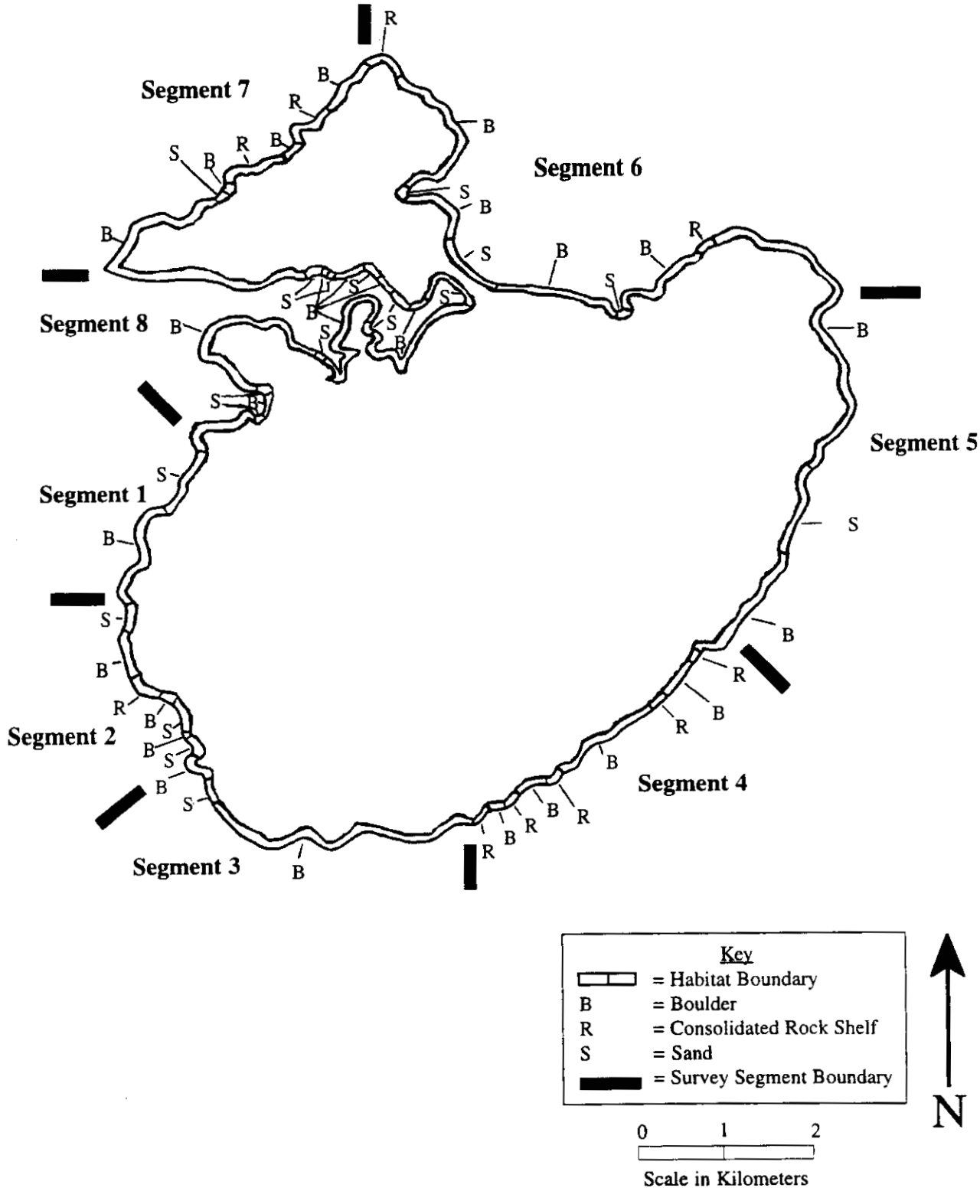

Figure B-1. Delineation of habitat types and survey segments for black oystercatchers at Simeonof Island, Shumagin Islands, Alaska, 1995.

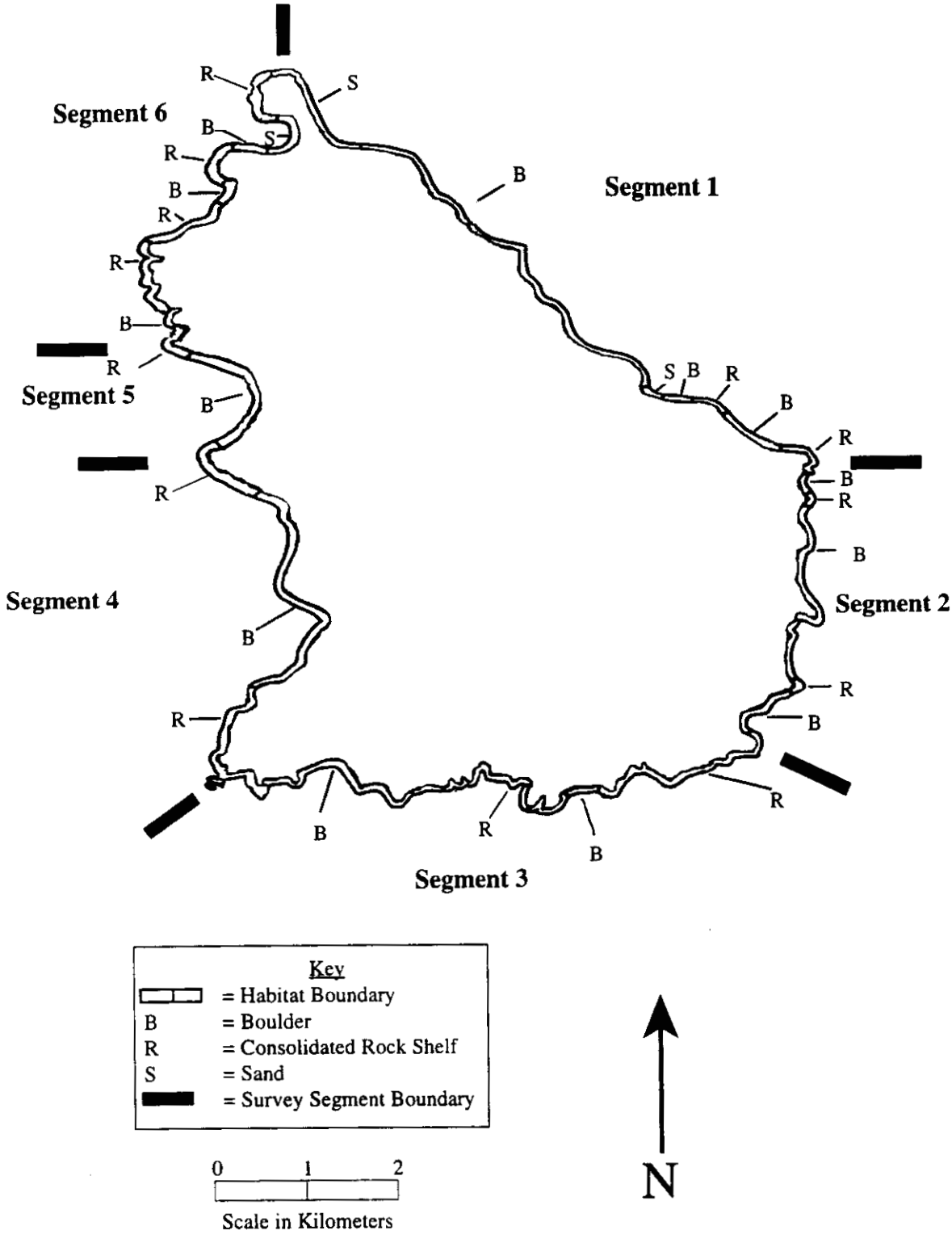

Figure B-2. Delineation of habitat types and survey segments for black oystercatchers at Chernabura Island, Shumagin Islands, Alaska, 1995.

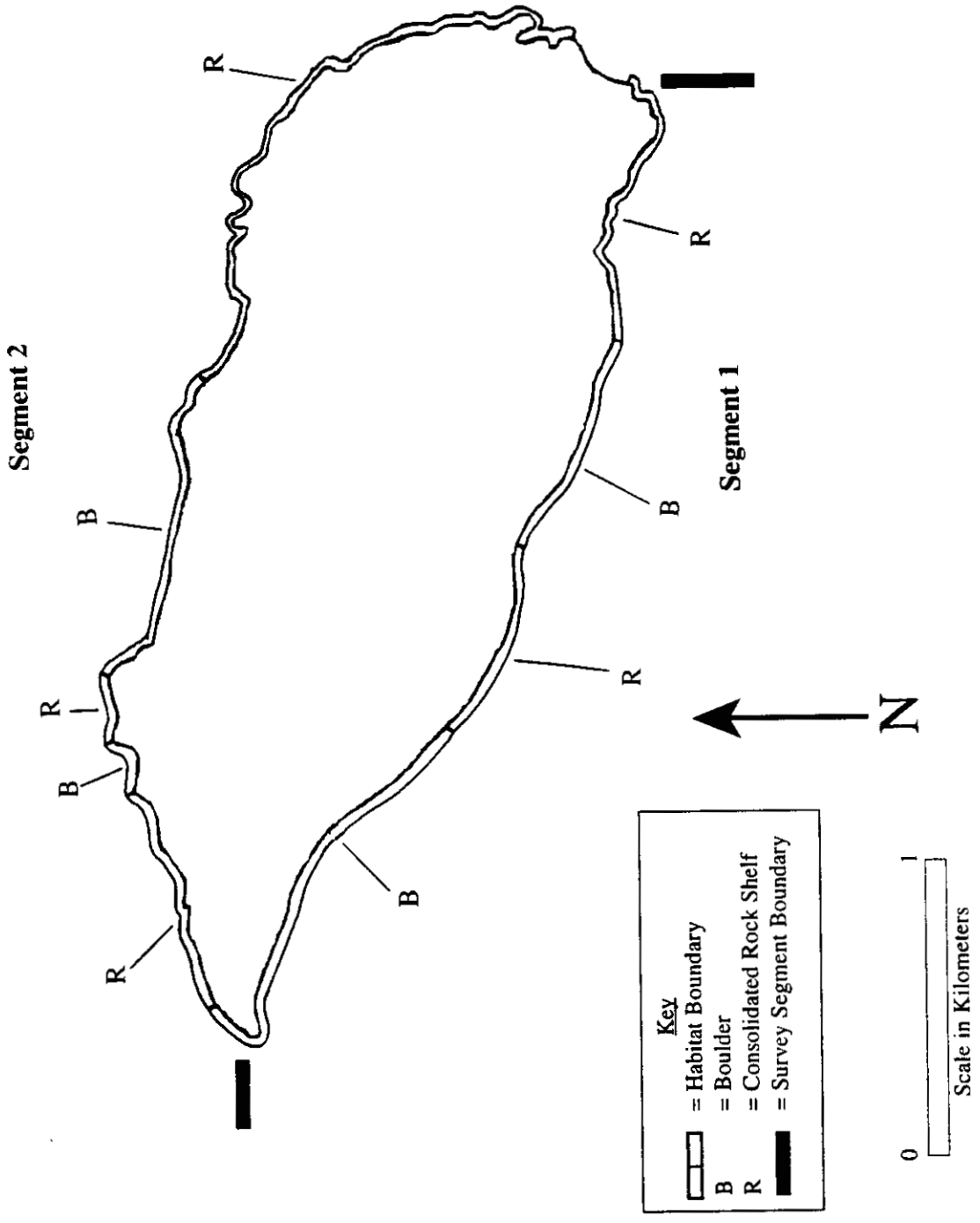

Figure B-3. Delineation of habitat types and survey segments for black oystercatchers at Atkins Island, Shumagin Islands, Alaska, 1995.

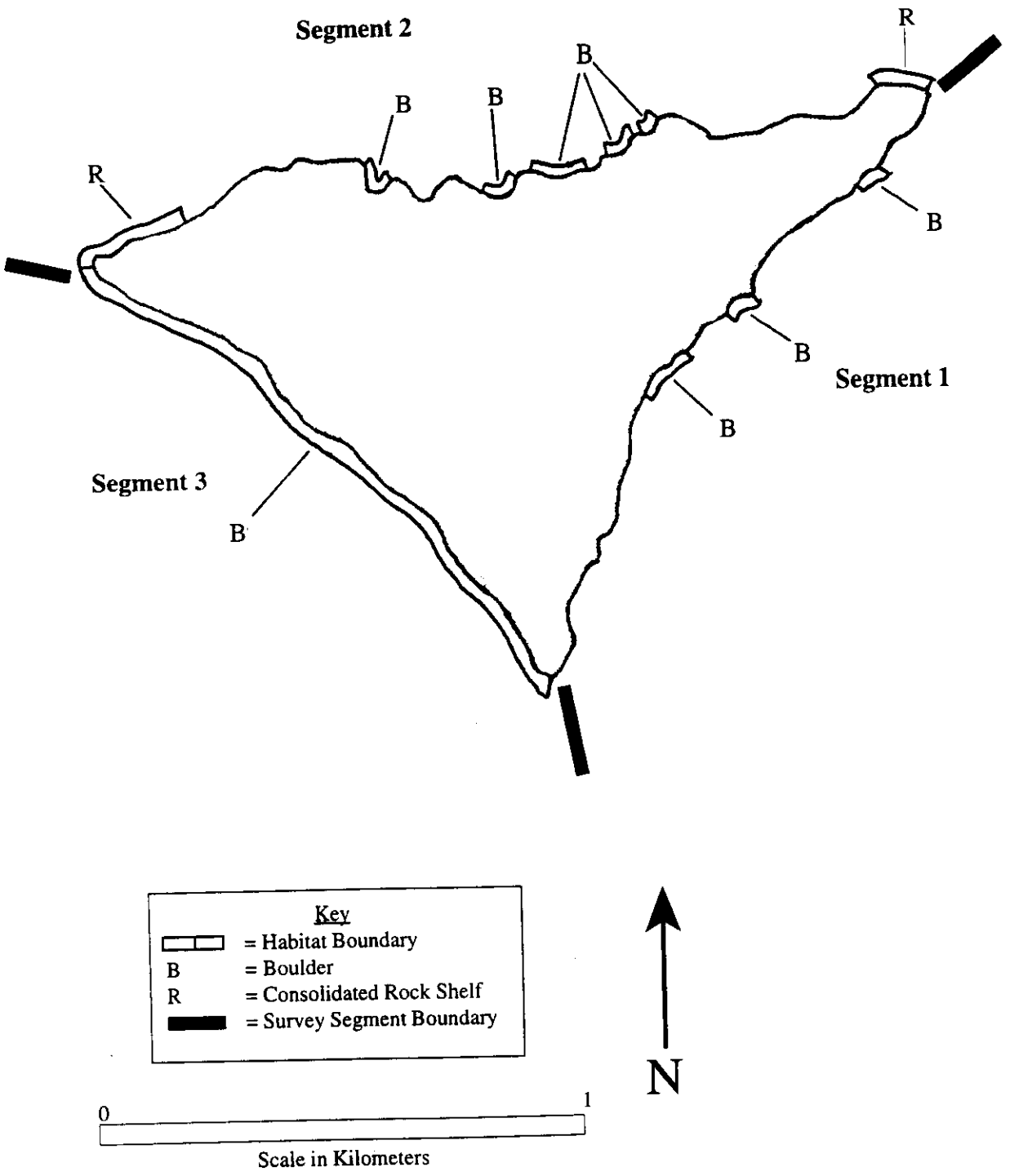

Figure B-4. Delineation of habitat types and survey segments for black oystercatchers at Herendeen Island, Shumagin Islands, Alaska, 1995.

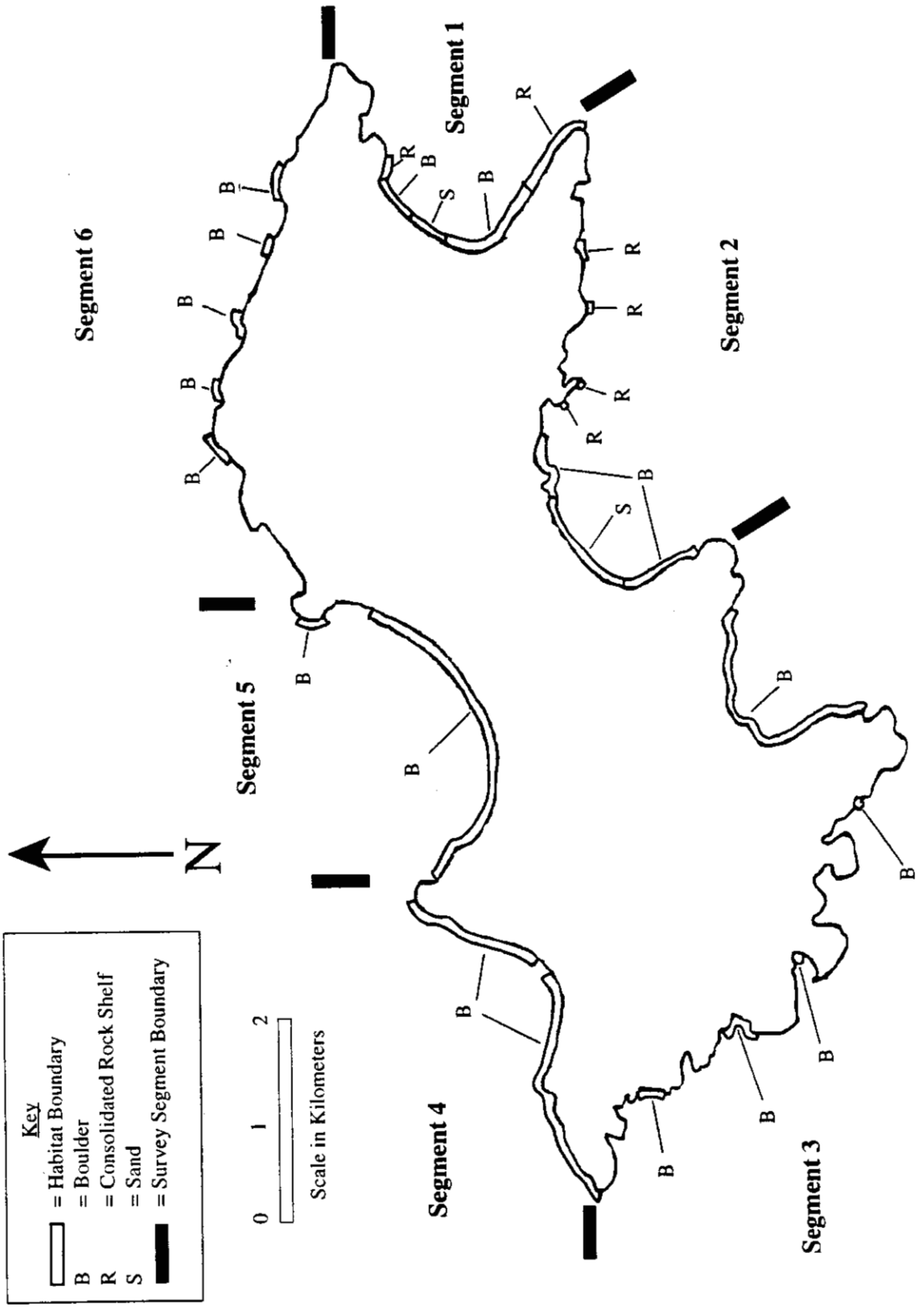

Figure B-5. Delineation of habitat types and survey segments for black oystercatchers at Bird Island, Shumagin Islands, Alaska, 1995.

Appendix C. Maps showing the distribution of pigeon guillemot nesting habitat on Simeonof, Chernabura, and nearby fox-free islands in the Shumagin Islands, Alaska, in 1994 and 1995. Habitats were described as follows:

Boulder: Boulders or contiguous rocky substrates with crevices large enough for guillemot nests

Cliff: Sea cliffs with crevices for guillemot nests

Log Pile: Piles of logs so densely packed enough to provide guillemot nest crevices

Talus: Boulder piles on sea-facing slopes

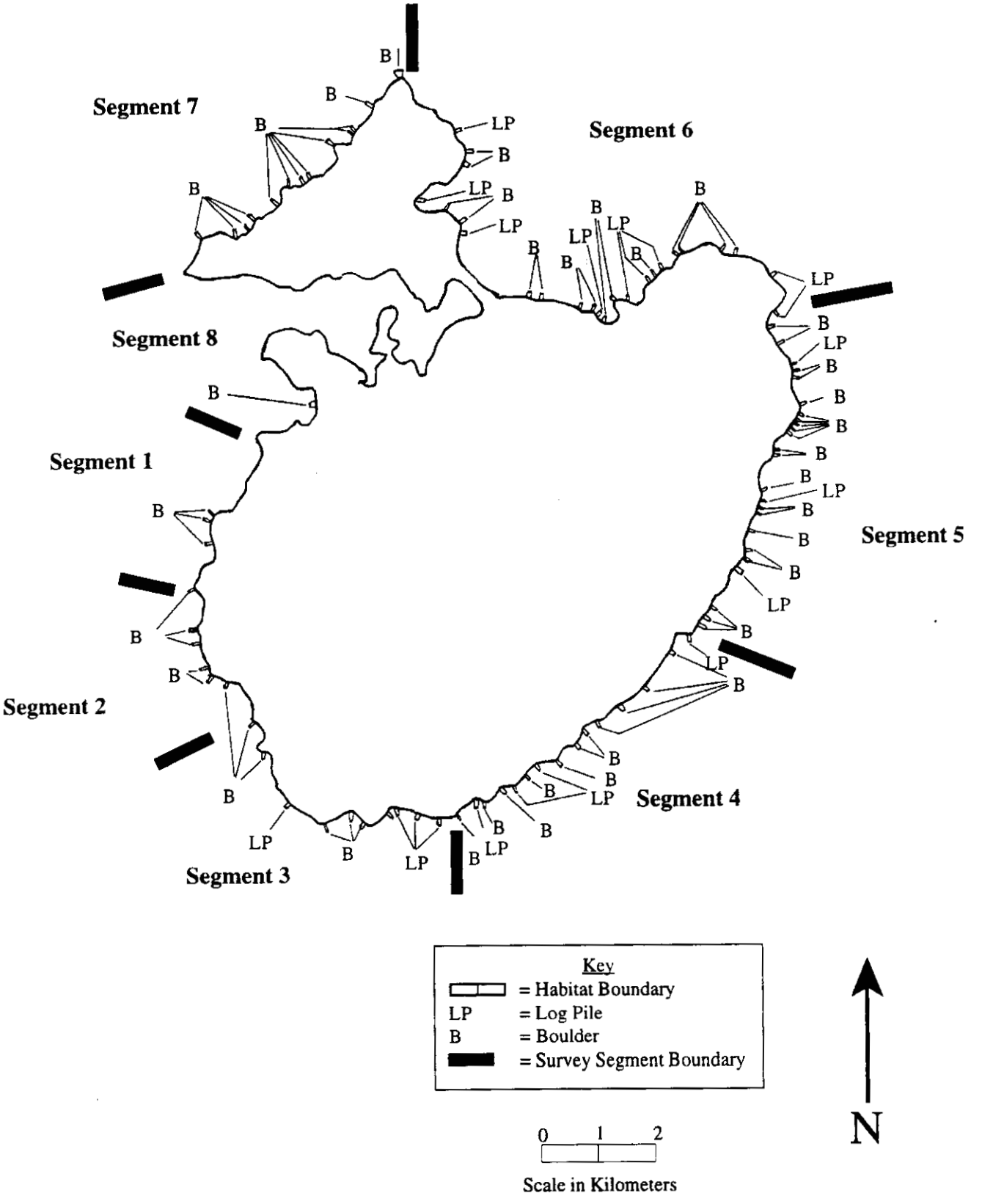

Figure C-1. Delineation of habitat types and survey segments for pigeon guillemots at Simeonof Island, Shumagin Islands, Alaska, 1995.

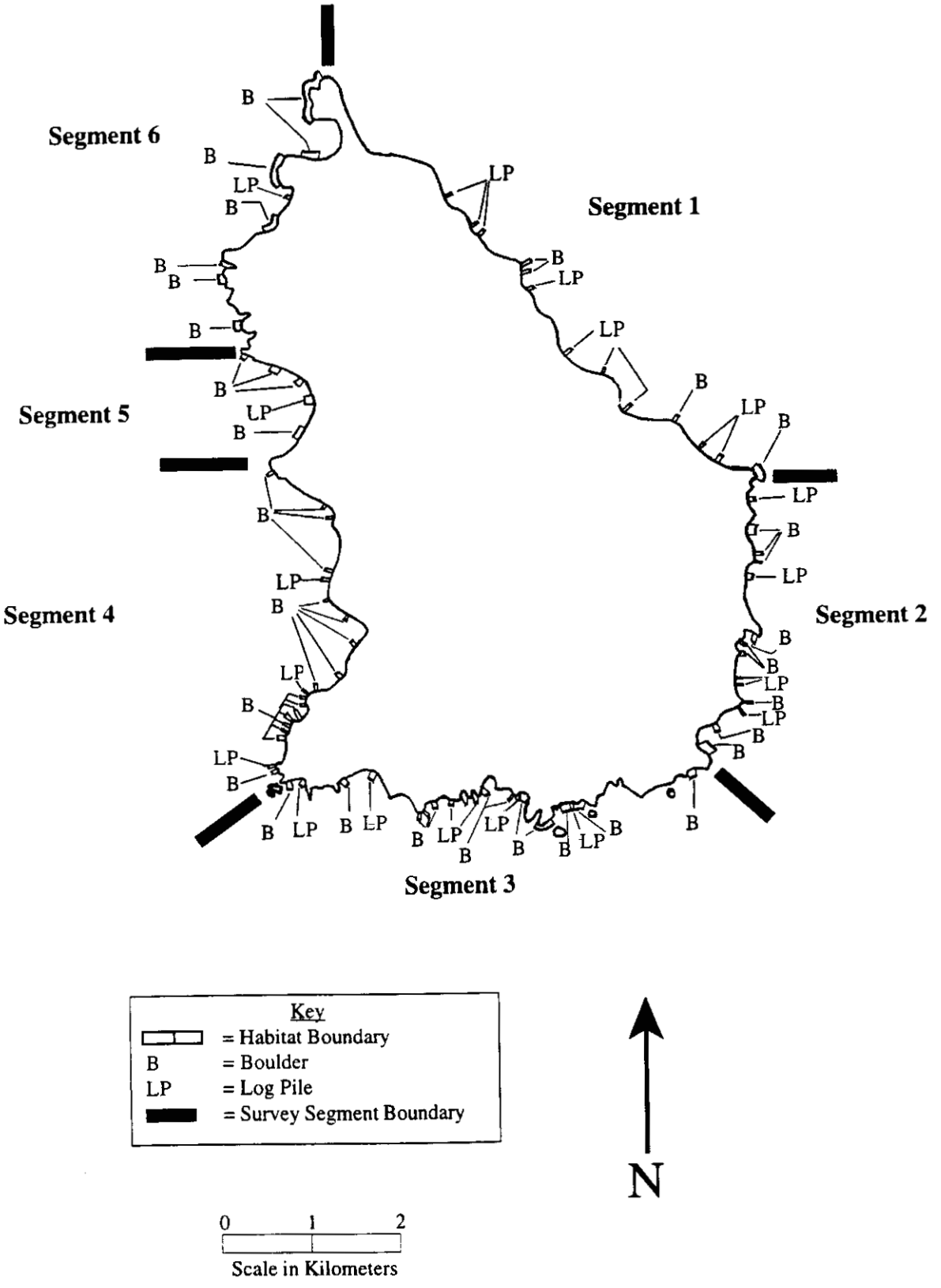

Figure C-2. Delineation of habitat types and survey segments for pigeon guillemots at Chernabura Island, Shumagin Islands, Alaska, 1995.

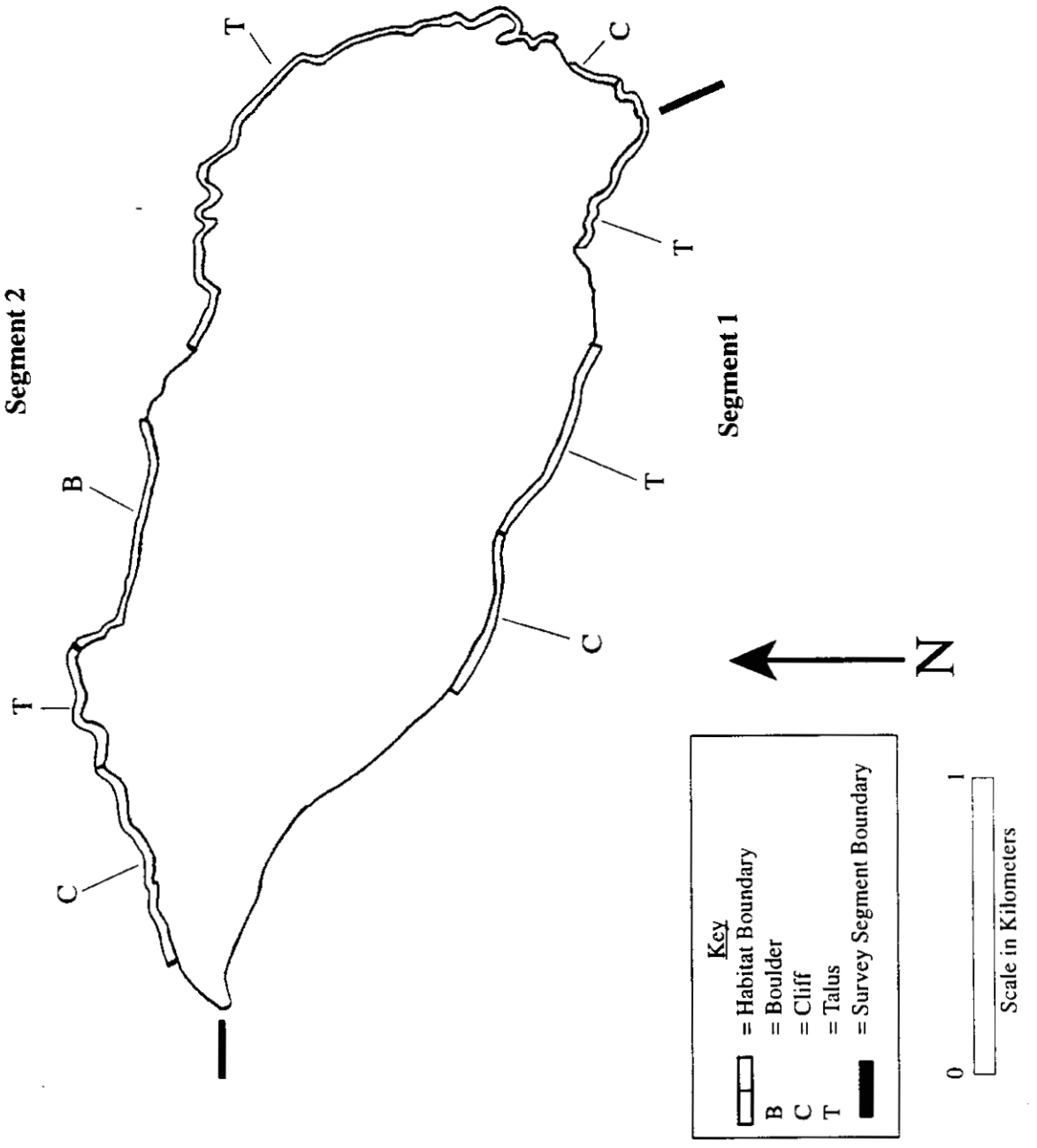

Figure C-3. Delineation of habitat types and survey segments for pigeon guillemots at Atkins Island, Shumagin Islands, Alaska, 1995.

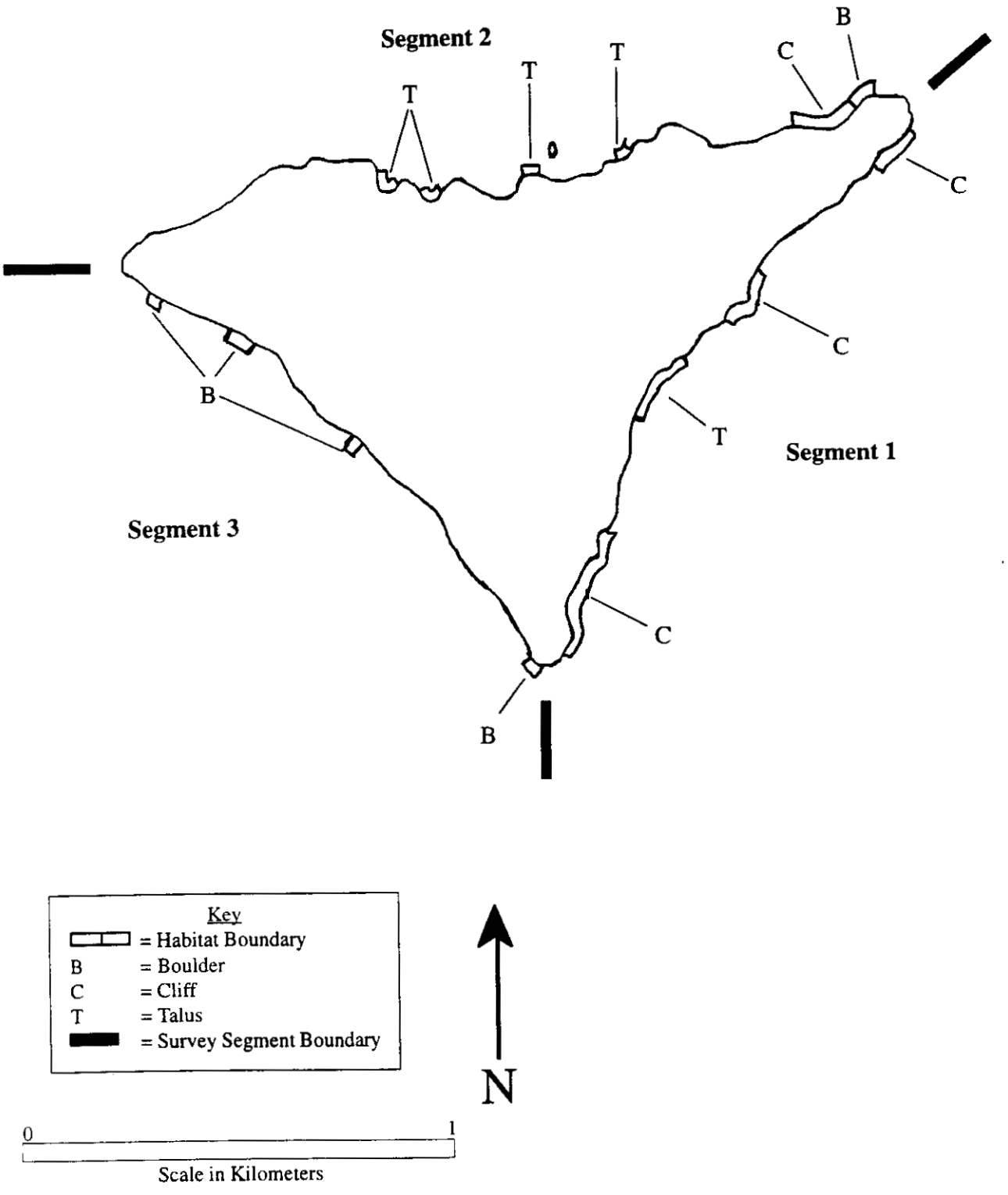

Figure C-4. Delineation of habitat types and survey segments for pigeon guillemots at Herendeen Island, Shumagin Islands, Alaska, 1995.

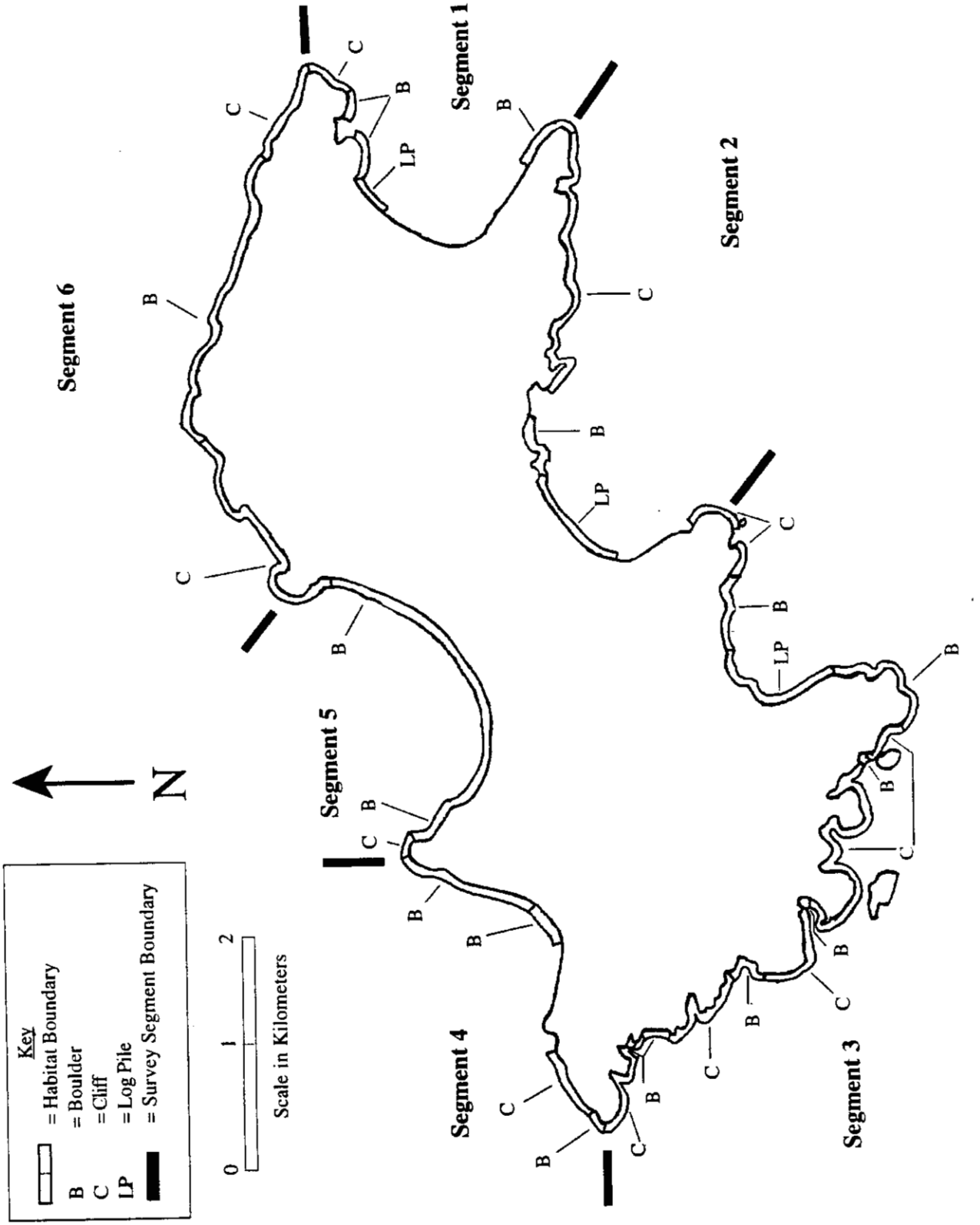

Figure C-5. Delineation of habitat types and survey segments for pigeon guillemots at Bird Island, Shumagin Islands, Alaska, 1995.