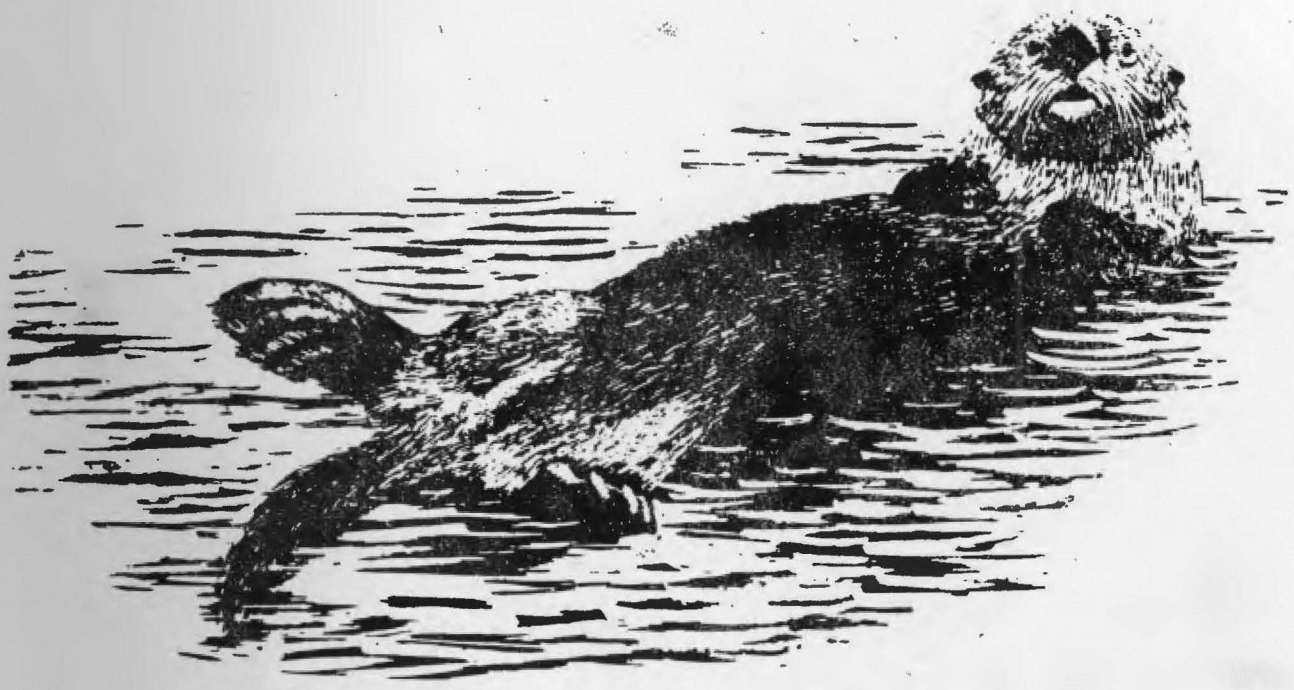
STUDIES OF SOUTHEASTERN ALASKA SEA OTTER POPULATIONS: DISTRIBUTION, ABUNDANCE, STRUCTURE, RANGE EXPANSION, AND POTENTIAL CONFLICTS WITH SHELLFISHERIES



U.S. Fish and Wildlife Service Cooperative Agreement
NO. 14-16-0009-954
Final Report
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99518-1599

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by
Kenneth W. Pitcher
15 August 1989

STATE OF ALASKA
Steve Cowper, Governor

DEPARTMENT OF FISH AND GAME
Don W. Collinsworth, Commissioner

DIVISION OF WILDLIFE CONSERVATION
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PREFACE

In September 1986 the U. S. Fish and Wildlife Service contracted with the Alaska Department of Fish and Game to conduct studies of reintroduced sea otter (*Enhydra lutris*) colonies in southeastern Alaska. It was recognized that these expanding populations probably had the potential to adversely impact certain shellfish populations that were being exploited in commercial and personal-use fisheries. Sea otters in southeastern Alaska were also the target of an unregulated harvest by Alaskan Natives, as provided for under the Marine Mammal Protection Act. There was an obvious need for information on sea otter distribution, abundance, population growth, and range expansion as well as information on shellfish populations and fisheries, locations of important shellfish harvest areas, and the impacts of sea otter predation on shellfish populations.

This report covers the findings of studies conducted by the Alaska Department of Fish and Game under this contract and is composed of two parts. Part I reports on the findings of surveys conducted in 1987 and 1988 of sea otter colonies throughout southeastern Alaska, including information on abundance, distribution, population growth, population productivity, and range expansion. Part II is a review and synthesis of historical harvest records of shellfisheries in southeastern Alaska that appeared to have the potential to be negatively impacted by sea otter predation. Important shellfish harvest areas are identified, and the relative commercial values of these fisheries are presented. An ongoing study designed to evaluate the impacts of predation by a colonizing population of sea otters on dungeness crab populations in the Cross Sound-Icy Strait area will be reported on at a later time.

STUDIES OF SOUTHEASTERN ALASKA SEA OTTER POPULATIONS: DISTRIBUTION, ABUNDANCE, POPULATION GROWTH, RANGE EXPANSION AND POPULATION PRODUCTIVITY

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Sea otters (*Enhydra lutris*) were presumably abundant in southeastern Alaska prior to exploitation by Russian and American hunters during the 18th and 19th centuries because the area was reported to have been an important hunting ground (Lensink 1962). Kenyon (1969) concluded that otters were essentially eliminated from the area before 1900. Several undocumented reports of sea otters in southeastern Alaska from 1940 through 1961 (Kenyon 1969) suggested that a few individuals may have survived, although Lensink (1962) did not consider these sightings valid.

Between 1965 and 1969, 402 sea otters were translocated from Amchitka Island (359) and Prince William Sound (43) to six sites in southeastern Alaska (Table 1) by the Alaska Department of Fish and Game (ADF&G) (Burris and McKnight 1973, Jameson et al. 1982). The rational for these transplants was to speed repopulation of historical sea otter habitat distant from areas with major concentrations.

Table 1. Numbers of sea otters translocated to southeastern Alaska (Burris and McKnight 1973).

Release Site	Year	Number of Sea Otters
Khaz Bay	1965	23
Khaz Bay	1966	20
Khaz Bay	1968	92
Khaz Bay	1969	58
Khaz Bay (total)		193
Yakobi Island	1968	30
Biorka Island	1968	48
Barrier Islands	1968	55
Maurelle Islands	1968	51
Cape Spencer	1968	25
Total Released		402

In 1975 personnel from ADF&G and the U.S. Fish and Wildlife Service (USF&WS) conducted skiff surveys of the transplant sites, areas where sea otters had been sighted, and areas that appeared to be good habitat to evaluate the outcome of the transplant. During the survey 477 otters, including 62 pups, were counted at six sites (Schneider 1975), indicating that the translocation program had probably succeeded in establishing viable sea otter colonies in southeastern Alaska.

In 1983 USF&WS and ADF&G conducted similar surveys of southeastern Alaska and documented growth of all groups and range expansion of the larger colonies. During this survey 1,124 sea otters, including 129 pups, were counted (Johnson et al. 1983); however, the survey was not completed because of weather and time limitations. Several months later an aerial survey, under nearly ideal weather conditions, was conducted along the outer coast north of Sitka; 1,062 otters were seen, compared with 698 during the previous skiff survey, indicating that substantial numbers had previously been missed (ADF&G unpublished data).

During March and April 1986, Simon-Jackson and Hodges (1986) conducted aerial surveys from the Necker-Biorka Islands area north to Icy Point. The total number of otters observed (986) was less than that seen during the more limited ADF&G aerial survey in 1983; however, significant numbers (229) were counted north of Cape Spencer and along the outer coast of Kruzof Island (106), where they had not been found during previous surveys.

The USF&WS, the agency responsible for sea otter management in Alaska, recognized several important management issues that appeared to be developing in southeastern Alaska (Simon-Jackson and Hodges 1986). These included the likely adverse impacts of sea otters on shellfisheries (with the possible prospect of zonal management of sea otters) and the unregulated harvest of otters by Alaskan Natives. Staff from the USF&WS realized that a rational resolution of these issues would require information on the distribution and population status of sea otters in southeastern Alaska as well as information on shellfish resources and harvests in the area. In September 1986 USF&WS contracted with ADF&G to collect and synthesize this information. This report presents information regarding otter abundance, distribution, population growth, and range expansion in southeastern Alaska collected under that contract.

METHODS

The ADF&G vessel Polaris was used to provide living accommodations and to transport personnel and equipment throughout the study area. Two Boston Whaler skiffs, 16 and 20 feet in length, were used to conduct the actual surveys. Each skiff was manned by an observer/recorder and an observer/skiff operator. Areas surveyed included sites known to contain sea otters from previous surveys and areas adjacent to those sites that contained habitat that appeared suitable for otters. The shorelines of islands and the mainland, offshore rocks, and kelp beds were searched from the skiffs. On the occasions when otters were seen offshore, transects were run with the skiffs. Binoculars were used as an aid in counting animals. When large numbers

of animals were encountered or when otters were scattered offshore, we attempted to place an observer on a nearby rock or island so that counts could be made with binoculars or a spotting scope. Most surveys were conducted between about 0800 and 1700 hours, when the proportion of animals resting on the surface is normally highest. On some occasions when weather conditions were good, surveys were extended until 2000 hours. The areas occupied by sea otters and adjoining areas were arbitrarily divided into count areas to facilitate data management and areal coverage during surveys. Data recorded included total number of sea otters, number of dependent pups, locations of sightings, activity of the otters observed, survey conditions, and date and time of sightings. Survey quality was subjectively classified as excellent, good, fair, poor, or bad based on impressions of visibility and thoroughness of coverage. Survey methodology was comparable to the skiff surveys conducted in 1975 and 1983 (Schneider 1975, Johnson et al. 1983).

Surveys were conducted in the Barrier Islands on 4, 5 and 25 June 1987, 22 July 1987, and 8-10 July 1988. The Maurelle Islands were surveyed on 7, 8, and 12 June 1987, 21 July 1987, 11-13 and 16 July 1988. The Coronation-Spanish-Kuiu Islands area was surveyed from 9-14 June 1987 and 14-19 July 1988. The outside coast from Palma Bay south to the Necker Islands was surveyed from 8-19 July 1987. The Cross Sound-Icy Strait area was surveyed from 8-11 July 1987 and then resurveyed from 11-13 May 1988. The Necker Islands and Sitka Sound were again surveyed from 20-23 July 1988.

The observed mean annual exponential rate of increase (r) for each of the colonies was estimated by linear regression of the natural logarithms (Caughley 1977) of area counts. When more than one count was made of a colony during a single year, the higher count was used.

RESULTS AND DISCUSSION

During the 1987 and 1988 surveys, a total of 4,521 sea otters (including the highest counts when replicate surveys were conducted) were counted in five areas of southeastern Alaska (Table 2). These apparently discrete groups of otters were found in the Barrier Islands, the Maurelle Islands, the Coronation-Spanish-Kuiu Islands area, the Necker Islands, and the area from Sitka Sound to Astrolabe Point (Figure 1). While all otters from Sitka Sound north essentially composed a single, continuous group, they have been subdivided in Table 2 for ease of presentation and historical comparisons.

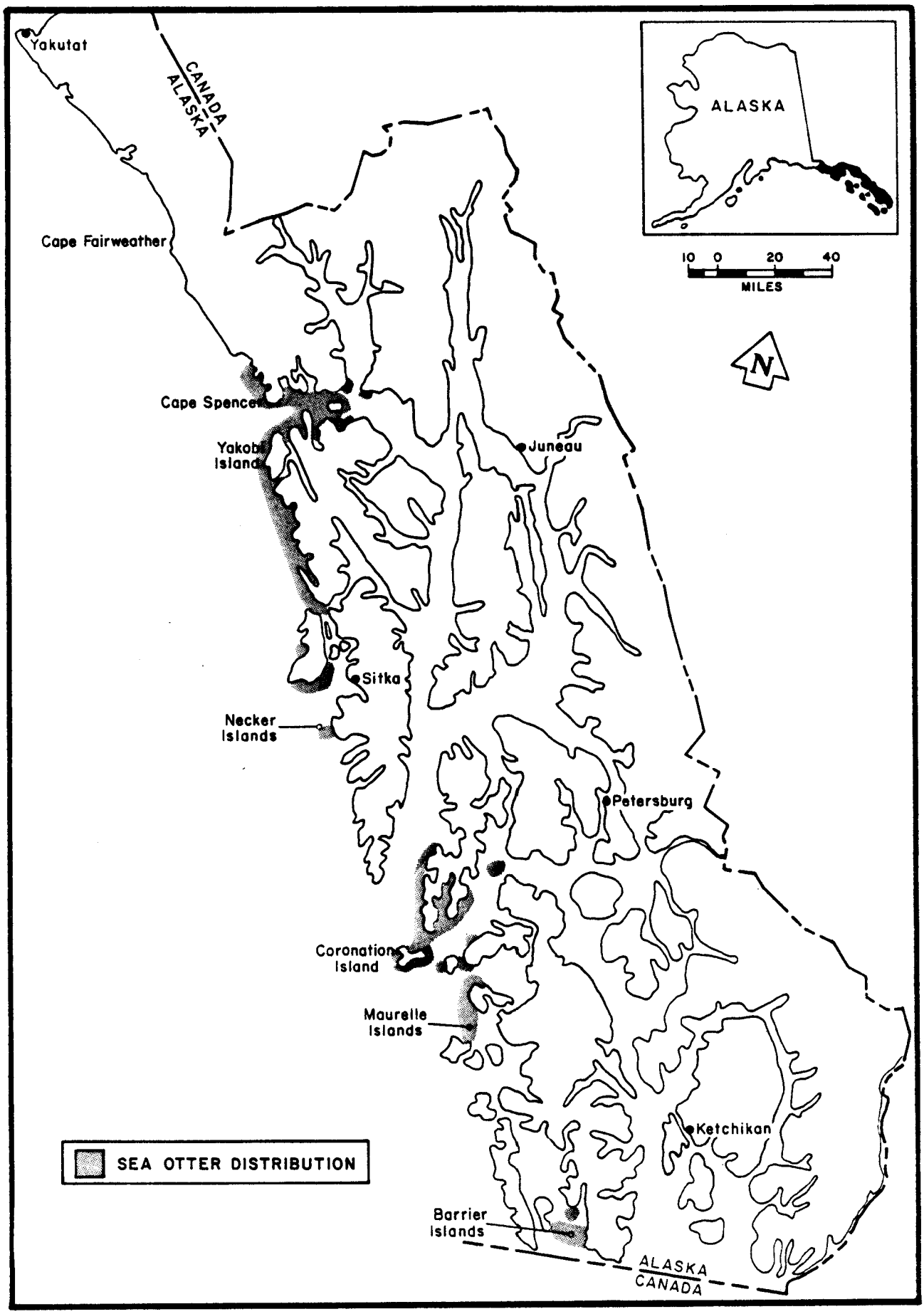

Figure 1. Distribution of sea otters in Southeastern Alaska, 1987 and 1988.

Table 2. Historical summary of major sea otter surveys in southeastern Alaska, 1975-1987.

Geographic Area	Total Otters 1988	1987	1986	1983(a)	1983(b)	1975
Barrier Is.	243	180	NS	NS	81	21
Maurelle Is.	861	520	NS	NS	159	47
Coronation I.	1,063	604	NS	NS	138	65
Necker Is.	106	47	8	NS	20	4
Sitka-Cross Sd.	NS	2,099	749	1,062	726	340
Cape Spencer-north	NS	149	229	NS	0	0
Total	2,273	3,599	986	1,062	1,124	477

1987-1988:this survey, 1986:Simon-Jackson and Hodges 1986, 1983(a):ADF&G unpublished data, 1983(b):Johnson et al. 1983, 1975:Schneider 1975

BARRIER ISLANDS: The Barrier Islands area was initially surveyed on 4 and 5 June 1987. The coastline of southern Prince of Wales Island was covered in addition to the Barrier Islands (Figure 2). A total of 147 sea otters was counted; all were in the Barrier Islands (Table 3). Counting conditions during this survey were fair-to-good. Southerly winds to 20 knots made visibility poor on some exposed shorelines. Under excellent conditions, on 25 June 1987, Bob Wood, Division of Wildlife Conservation area management biologist, flew an aerial survey in a Piper Supercub (PA 18) of the coastline of southern Long Island and southeastern Dall Island. He observed a single otter off the coast of Long Island, directly west of the Barrier Islands. The areas known to contain otters (count areas 1001-1004) were surveyed again by skiff on 22 July 1987, and 180 animals were counted. Conditions were better than those of the first survey; this factor probably accounted for the higher count. Seven more pups, that may not have been born during the first survey, were counted during the last survey contributing to the higher total.

Table 3. Summary of sea otter surveys conducted in the Barrier Islands area during 1987 and 1988.

Count Area	Date	Total Otters	Pups	Survey Quality
1001	5 June 1987	9	2	Fair
1002	5 June 1987	109	14	Fair
1003	5 June 1987	7	0	Fair

Table 3. (Continued)

1004	5 June 1987	22	0	Fair
1006	5 June 1987	0	0	Fair
1008	5 June 1987	0	0	Fair
1009	5 June 1987	0	0	Good
1011	5 June 1987	0	0	Good
1013	4 June 1987	0	0	Fair
1014	4 June 1987	0	0	Fair
1015	4 June 1987	0	0	Good
1017	4 June 1987	0	0	Good
1018	4 June 1987	0	0	Good
Total		147	16	
1020*	25 June 1987	1	0	Exc.
1021*	25 June 1987	0	0	Good
1022*	25 June 1987	0	0	Good
1023*	25 June 1987	0	0	Good
1024*	25 June 1987	0	0	Fair
Total		1	0	
1001	22 July 1987	2	0	Good
1002	22 July 1987	98	18	Good
1003	22 July 1987	7	2	Good
1004	22 July 1987	73	3	Good
1011	22 July 1987	0	0	Fair
Total		180	23	
1001	9 July 1988	8	1	Good
1002	9 July 1988	106	18	Fair
1003	9 July 1988	6	0	Fair
1004	9 July 1988	11	4	Fair
1006	9 July 1988	0	0	Good
1007	9 July 1988	0	0	Good
1009	9 July 1988	1	0	Good
1010	9 July 1988	0	0	Good
1011	9 July 1988	21	0	Fair
1012	8 July 1988	0	0	Good
1013	8 July 1988	0	0	Good
1014	8 July 1988	0	0	Good
1015	8 July 1988	0	0	Good
1016	8 July 1988	0	0	Good
1020	10 July 1988	0	0	Good
1022	10 July 1988	0	0	Good
1023	10 July 1988	0	0	Good
Total		153	23	

Table 3. (Continued)

1001	10 July 1988	7	1	Exc.
1002	10 July 1988	199	55	Good
1003	10 July 1988	23	5	Fair
1004	10 July 1988	8	4	Fair
1011	10 July 1988	6	0	Fair
Total		243	65	

*aerial survey

Distribution of otters in the Barrier Islands changed between the two surveys. Movement to the southeast occurred, resulting in an substantial increase in the numbers observed in count area 1004 (Table 3). Most females with pups were found in count area 1002 during both surveys. It appeared that much of count area 1004 was a male area that may have only been recently occupied. Few otters were observed in this area in 1983 (Johnson et al. 1983) and numbers observed increased considerably between the two 1987 surveys.

In 1988 the Barrier Islands and surrounding area were again surveyed (Figure 3). On 9 July 153 otters, including 23 pups, were seen while on 10 July, 243 sea otters, including 65 pups, were counted. The main difference between the two surveys was a large, compact group of 123 otters, including 39 pups, seen on 10 July in an area where only 53 otters with 6 pups had been observed the previous day. In addition, on 9 July a group of 9 sea otters was not included in the total because we were concerned that they might have been counted previously. As in 1987 most females and pups were found in count area 1002. It appeared that males from this colony continued to pioneer new habitat to the east, because otters were seen in count area 1011, along the southwestern Prince of Wales coast, for the first time in 1988.

Although the range of this group of sea otters remains almost entirely restricted to the Barrier Islands, there has been progressive range expansion. In 1975 otters were found only in the western Barrier Islands (Schneider 1975). By 1983 the range included both the western and central islands (Johnson et al. 1983). In 1987 the entire Barrier Island group was being used, although densities in the western islands (count area 1001) had decreased substantially. In 1988 males were observed along the southwestern coast of Prince of Wales Island. Otters will likely continue to expand their range, probably initially along the southern Prince of Wales coast, the islands and reefs to the north of the Barrier Islands, and possibly along the southern coastlines of Long and Dall Islands.

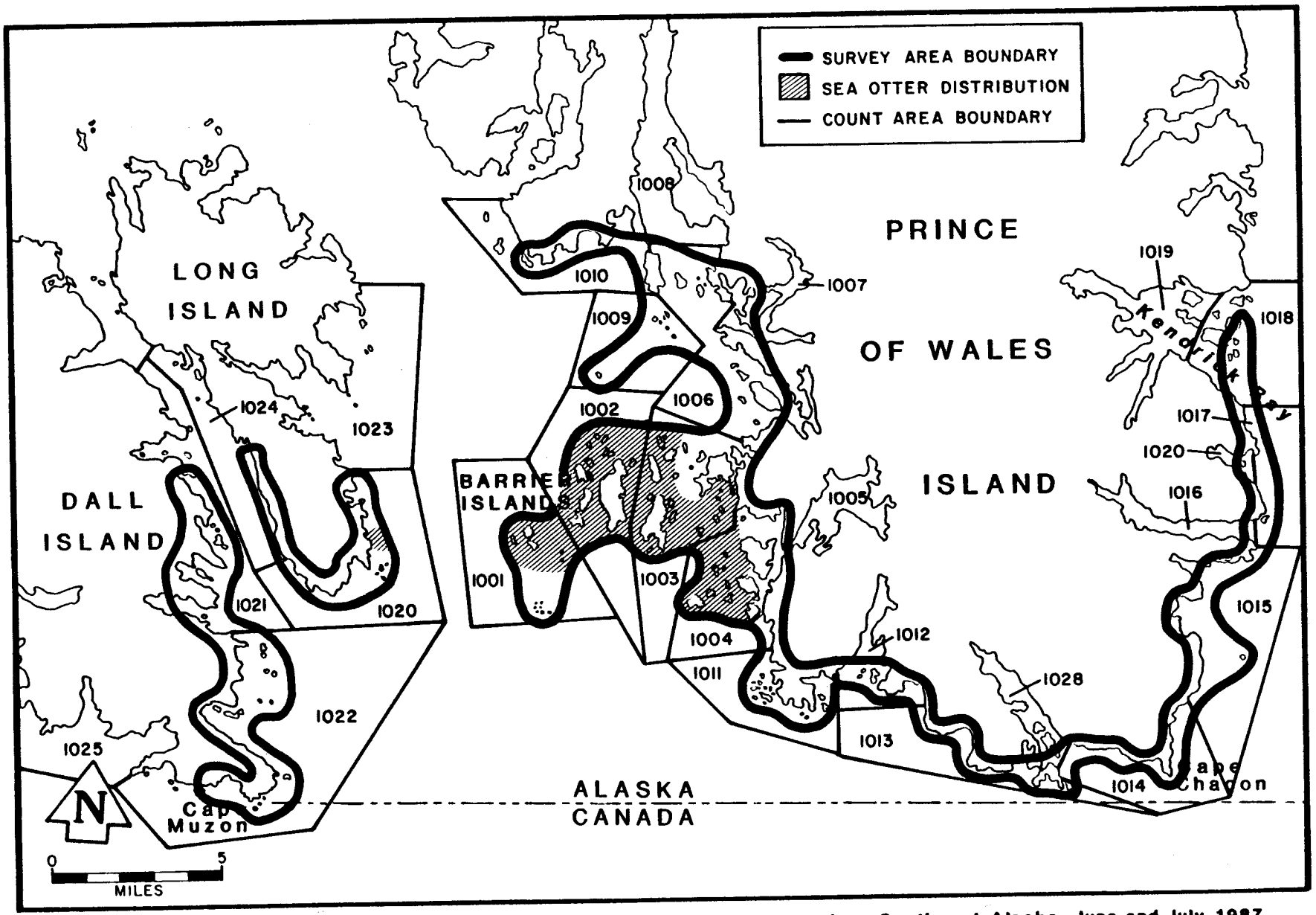

Figure 2. Area surveyed and sea otter distribution near the Barrier Islands in southern Southeast Alaska, June and July 1987.

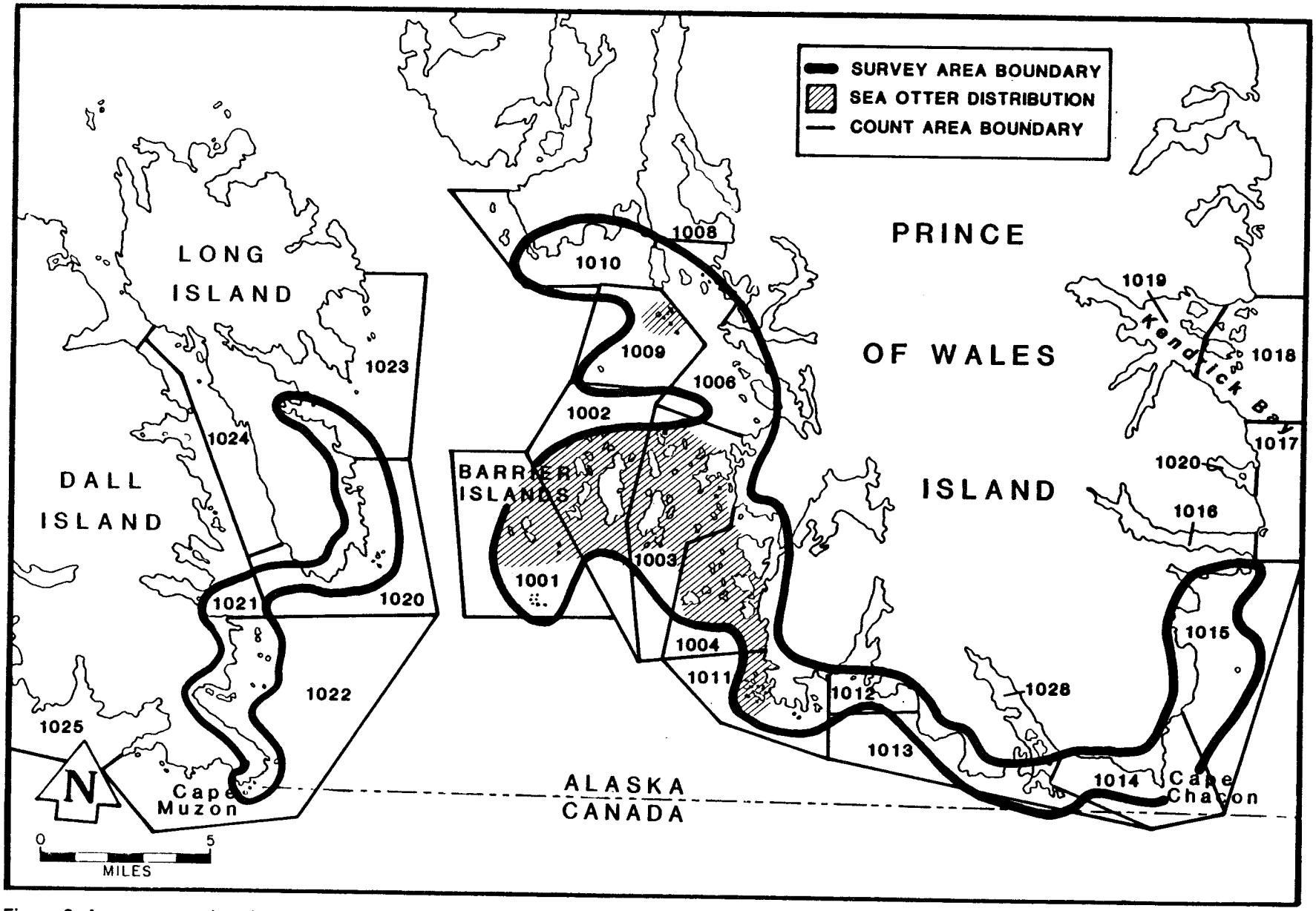

Figure 3. Area surveyed and sea otter distribution near the Barrier Islands in Southern Southeast Alaska, July 1988.

The Barrier Island group originated from the translocation of 55 otters to the area in 1968. Schneider (1975) reported that a few otters had been seen the month after release and thereafter a few sightings had been made by members of the public through 1974. During the 1975 survey 21 otters, including two pups, were seen, while in 1983 81 animals were counted. It appears that for several years after the translocation, group size was below the number actually stocked, probably the result of dispersal and transplant-associated mortality; however, from 1975 through 1988 this group increased rapidly. The exponential rate of increase (r) from 1975-88 was estimated to be 0.185.

The Barrier Islands colony has the best potential of any group of otters in southeastern Alaska for studies of population dynamics, population control and geographic containment. The group is distant (i.e., about 100 km from the Maurelle Islands) from other sea otter colonies and will likely remain isolated for a number of years. Group size is small enough that effective manipulations could be reasonably accomplished.

MAURELLE ISLANDS: The Maurelle Islands area was first surveyed on 7, 8, and 12 June 1987 (Figure 4). The count areas containing nearly all of the otters were completed on the first day; peripheral areas were surveyed on the other two days. During this survey, conditions ranged from good to poor. A large ocean swell reduced the effectiveness of the survey along the outside coastline. The Maurelle Islands area and outside coastline of Heceta Island, where otters had been seen during previous surveys, were covered as well as additional areas to both the north and south. Sea otters counted during this survey totaled 356 (Table 4). Much of the same area, including all locations where otters had been previously observed, was resurveyed on 20 and 21 July 1987, and 520 sea otters were counted. Minor problems with sun glare and brisk winds occurred in local areas. The higher count during the second survey was probably the result of three factors. Survey conditions during this survey were generally better than during the earlier survey. During the first survey many otters were observed scattered offshore suggesting that some were missed during the shoreline survey. In the second survey most otters appeared to be closely associated with the coastline; therefore, it was unlikely that many were missed offshore. Also during the second survey, 45 more pups were counted, suggesting that a number of pups had been born between surveys.

In 1988 two surveys of the Maurelle Islands group were again conducted, one on 11 and 12 July and the other on 13 July (Figure 5, Table 4). Conditions were good during both surveys, and area coverage was comparable to 1987. During

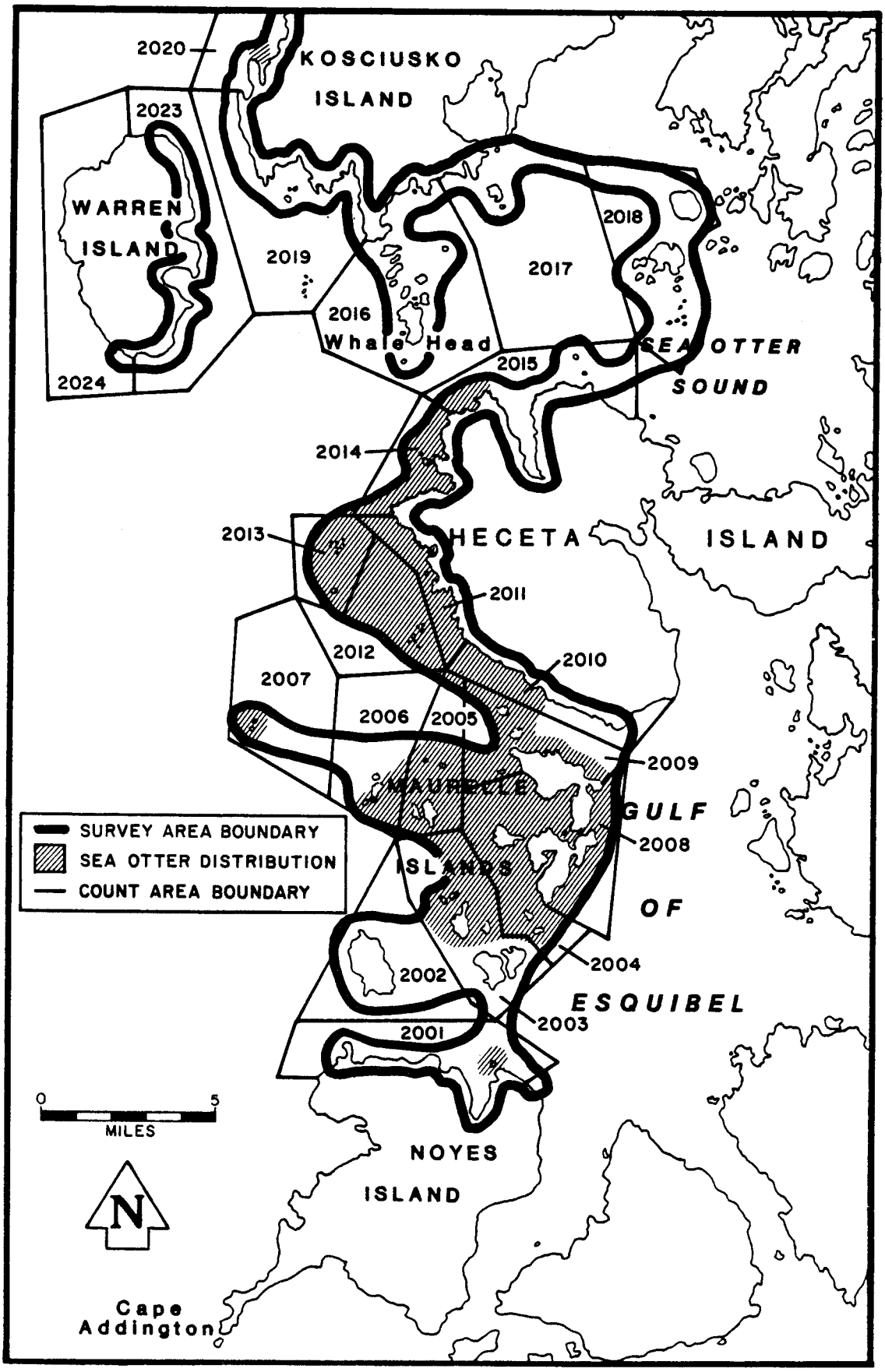

Figure 4. Area surveyed and sea otter distribution in the Maurelle Islands area during June and July 1987.

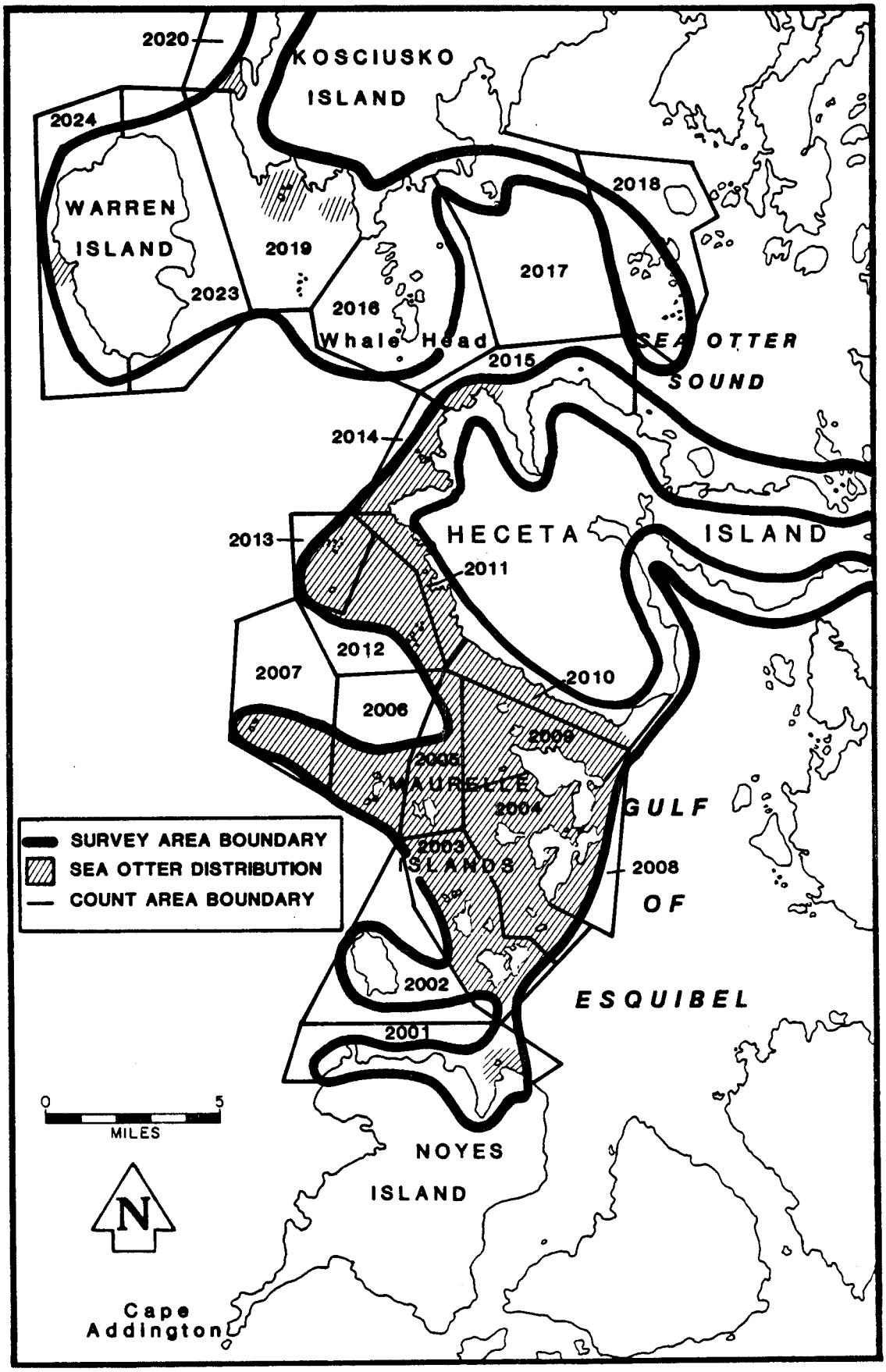

Figure 5. Area surveyed and sea otter distribution in the Maurelle Islands area during July 1988.

the first survey 746 otters were counted, including 171 pups; while during the second survey 860 animals were counted, including 135 pups. While a higher number of otters were counted during the second survey, 36 fewer pups were seen; therefore the minimum population size for this group was 896. The major difference between the two surveys was a higher count of a large group of males in count area 2019 during the second survey.

Table 4. Summary of sea otter surveys conducted in the Maurelle Islands area during 1987 and 1988.

Count	Area	Date	Total Otters	Pups	Survey Quality
2001	7	June 1987	1	0	Fair
2002	7	June 1987	0	0	Poor
2003	7	June 1987	9	0	Exc.
2004	7	June 1987	76	*	Good
2005	7	June 1987	66	0	Good
2006	7	June 1987	16	1	Fair
2007	7	June 1987	0	0	Poor
2008	7	June 1987	0	0	Good
2009	7	June 1987	98	12	Fair
2010	7	June 1987	0	0	Fair
2011	7	June 1987	56	0	Good
2012	7	June 1987	7	0	Good
2013	7	June 1987	10	0	Poor
2014	7	June 1987	15	0	Good
2015	7	June 1987	1	0	Good
2016	8	June 1987	0	0	Fair
2017	8	June 1987	0	0	Poor
2018	8	June 1987	0	0	Poor
2019	8	June 1987	0	0	Fair
2020	8	June 1987	1	0	Exc.
2021	12	June 1987	0	0	Good
2022	12	June 1987	0	0	Good
2023	8	June 1987	0	0	Fair
Total			356	13	
2001	21	July 1987	0	0	Poor
2002	21	July 1987	0	0	Good
2003	21	July 1987	33	4	Good
2004	21	July 1987	106	4	Fair
2005	21	July 1987	29	4	Good
2006	21	July 1987	97	22	Good
2007	21	July 1987	1	0	Good
2008	21	July 1987	2	0	Good
2009	21	July 1987	63	17	Exc.
2010	21	July 1987	2	0	Fair
2011	21	July 1987	15	1	Fair

Table 4. (Continued)

2012	21 July 1987	5	0	Good
2013	21 July 1987	36	6	Good
2014	21 July 1987	131	*	Poor
2015	20 July 1987	0	0	Fair
2016	20 July 1987	0	0	Fair
2017	20 July 1987	0	0	Fair
2018	20 July 1987	0	0	Fair
2019	20 July 1987	0	0	Fair
2020	20 July 1987	0	0	Fair
Total		520	58	
2001	11 July 1988	1	0	Good
2002	11 July 1988	0	0	Good
2003	11 July 1988	23	3	Exc.
2004	11 July 1988	80	3	Good
2005	11 July 1988	19	6	Exc.
2006	11 July 1988	320	123	Exc.
2007	11 July 1988	41	0	Exc.
2008	11 July 1988	1	0	Good
2009	11 July 1988	39	13	Exc.
2010	11 July 1988	1	0	Fair
2011	11 July 1988	1	0	Exc.
2012	11 July 1988	44	12	Exc.
2013	11 July 1988	44	11	Exc.
2014	12 July 1988	15	0	Good
2015	12 July 1988	8	0	Good
2016	12 July 1988	0	0	Fair
2017	12 July 1988	0	0	Fair
2018	12 July 1988	0	0	Fair
2019	12 July 1988	107	0	Good
2020	12 July 1988	1	0	Good
2023	12 July 1988	0	0	Good
2024	12 July 1988	1	0	Good
Total		746	171	
2001	13 July 1988	1	0	Fair
2003	13 July 1988	19	4	Good
2004	13 July 1988	51	3	Exc.
2005	13 July 1988	28	8	Good
2006	13 July 1988	298	87	Exc.
2007	13 July 1988	92	1	Exc.
2008	13 July 1988	1	0	Fair
2009	13 July 1988	31	11	Good
2010	13 July 1988	1	0	Good
2011	13 July 1988	1	0	Good
2012	13 July 1988	85	15	Exc.
2013	13 July 1988	34	6	Fair
2014	13 July 1988	0	0	Good
2015	13 July 1988	46	0	Good
2019	13 July 1988	172	0	Good

Table 4. (Continued)

2020	16 July 1988	0	0	Fair
2021	16 July 1988	1	0	Fair
Total		861	135	

*Unable to classify pups

No striking changes in geographical distribution were noted between the two 1987 surveys, although considerable range expansion had occurred since the 1975 and 1983 surveys. In 1975 otters were restricted largely to the Twin and Wood Islands (count areas 2005 and 2006) (Schneider 1975). By 1983 they had occupied areas to the east and north (count areas 2004, 2005 and 2012) (Johnson et al. 1983). In 1987 distribution had been extended to both the north and south (Figure 4). In 1988 a large group of males had moved across the mouth of Davidson Inlet to the southwestern coast of Kosciusko Island (count area 2019). No obvious sexual segregation was noted in 1987; however, low proportions of pups in both northern and southern count areas (2014, 2004) suggested that they might be predominately male areas. In 1988 the newly inhabited southwestern coast of Kosciusko Island was the only obvious male area. During both years the Wood Islands-Epsilon Rock area (count area 2006) and the northern Anguilla Island area (count area 2009) had high proportions of females with pups. For the immediate future, range expansion appears most likely to the north, because habitat appears to be excellent in portions of Davidson Inlet, Sea Otter Sound, around Warren Island, and along the western coast of Kosciusko Island.

This colony originated from a transplant of 51 animals to the Maurelle Islands in 1968. The exponential rate of increase for this group between 1975 and 1988 was estimated at 0.215. The 1975 survey was conducted under fair to extremely poor conditions (Schneider 1975) therefore the estimate of r is probably high.

CORONATION, SPANISH, AND KUIU ISLANDS: This area was surveyed on 9, 12, and 14 June 1987 (Figure 6), and a total of 604 sea otters were counted (Table 5). Conditions were only fair for much of the counts, and stormy weather caused delays in completing the survey. Because visibility may have negatively affected the counts and movement of otters could have occurred during the delays, my confidence that the total count approximated population size was not as great as for most other areas. I do feel that information obtained on distribution was probably accurate. Count areas 3002 (Aats Bay), 3005 (Windy Bay), and 3016 (southwest Afleck Canal) all contained high proportions of females with pups. No distinct male areas were recognized.

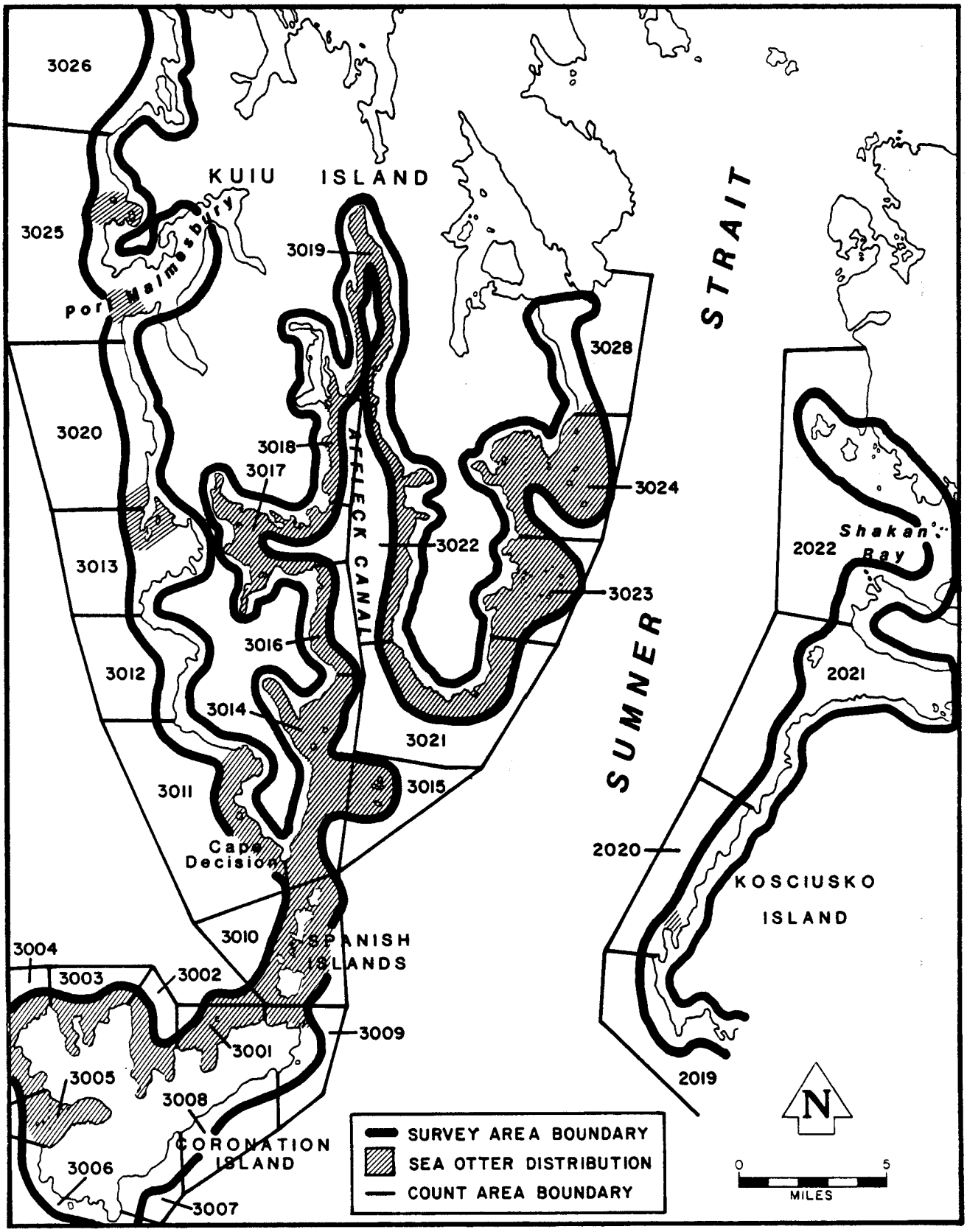

Figure 6. Area surveyed and sea otter distribution in the Coronation–Kuiu Islands area during June 1987.

In 1988 the area was surveyed between 15 and 19 July. A total of 1,063 otters was counted, including 234 pups (Table 5). This total included the highest of two counts for three count areas (3014, 3016, and 3017) (Table 5). Conditions in those areas were poor during the initial count; because the surveyors thought they might have missed significant numbers of animals, they repeated the counts the following day. Discounting the unlikely possibility that significant numbers of animals moved into those count areas overnight, this total should provide a minimum population estimate for the area. The 76% increase in numbers counted between 1987 and 1988 is probably mostly the result of superior counting conditions and more experienced surveyors as well as recruitment to the population.

Table 5. Summary of sea otter surveys conducted in the Coronation, Spanish, and Kuiu Islands area during 1987 and 1988.

Count Area	Date	Total Otters	Pups	Survey Quality
3001	9 June 1987	65	10	Exc.
3002	9 June 1987	43	14	Good
3003	9 June 1987	5	0	Exc.
3004	9 June 1987	6	1	Poor
3005	9 June 1987	76	23	Exc.
3006	9 June 1987	0	0	Fair
3007	9 June 1987	0	0	Fair
3008	9 June 1987	0	0	Fair
3009	9 June 1987	0	0	Fair
3010	9 June 1987	92	20	Good
3011	9 June 1987	6	0	Fair
3012	9 June 1987	0	0	Fair
3013	9 June 1987	24	6	Fair
3014	12 June 1987	99	10	Fair
3015	12 June 1987	9	3	Good
3016	12 June 1987	76	22	Fair
3017	12 June 1987	3	0	Fair
3018	12 June 1987	2	0	Good
3019	12 June 1987	10	0	Good
3020	9 June 1987	3	0	Poor
3021	12 June 1987	26	9	Fair
3022	12 June 1987	15	3	Poor
3023	12 June 1987	25	4	Exc.
3024	12 June 1987	15	3	Exc.
3025	14 June 1987	4	0	Good
3026	14 June 1987	0	0	Poor
3027	14 June 1987	0	0	Poor
3028	12 June 1987	0	0	Poor
Total		604	128	

Table 5. (Continued)

3001	14 July 1988	108	33	Good
3002	14 July 1988	27	7	Good
3003	14 July 1988	53	8	Exc.
3004	14 July 1988	5	1	Good
3005	14 July 1988	14	2	Good
3006	14 July 1988	1	0	Exc.
3007	14 July 1988	0	0	Good
3008	14 July 1988	1	0	Exc.
3009	14 July 1988	2	0	Exc.
3010	14 July 1988	140	32	Exc.
3011	15 July 1988	54	22	Good
3012	15 July 1988	0	0	Fair
3013	15 July 1988	22	6	Fair
3014	15 July 1988	133	9	Poor
3015	15 July 1988	40	15	Good
3016	15 July 1988	8	0	Poor
3017	15 July 1988	37	11	Poor
3018	15 July 1988	0	0	Fair
3019	15 July 1988	1	0	Fair
3020	15 July 1988	49	13	Good
3021	16 July 1988	62	19	Fair
3022	16 July 1988	16	6	Poor
3023	16 July 1988	114	34	Good
3024	16 July 1988	17	2	Fair
3025	15 July 1988	3	1	Poor
3026	19 July 1988	24	2(?)	Poor
3027	19 July 1988	0	0	Poor
3028	16 July 1988	0	0	Fair
3029	16 July 1988	0	0	Fair
3030	16 July 1988	23	0	Fair
Total		954	223	
3014	16 July 1988	185	10	Good
3016	16 July 1988	31	4	Fair
3017	16 July 1988	71	17	Good

Sea otters were not translocated to this area and probably originated from dispersals from the Maurelle Islands transplant, 25 miles to the southeast, and possibly from the Necker Islands, 70 miles to the north (Schneider 1975). The first sightings were in 1973, when Commercial Fisheries biologist Alan Davis reported regularly seeing a pod of about 30 animals near the southern Spanish Islands (count area 3010). During the 1975 survey, 65 sea otters were seen in the southern Spanish Islands and along the northeastern Coronation coastline (Schneider 1975). In 1983, 138 otters were counted throughout the Spanish Islands and along the northern and western Coronation shoreline (Johnson et al. 1983). The Kuiu Island coastline beyond Cape Decision was

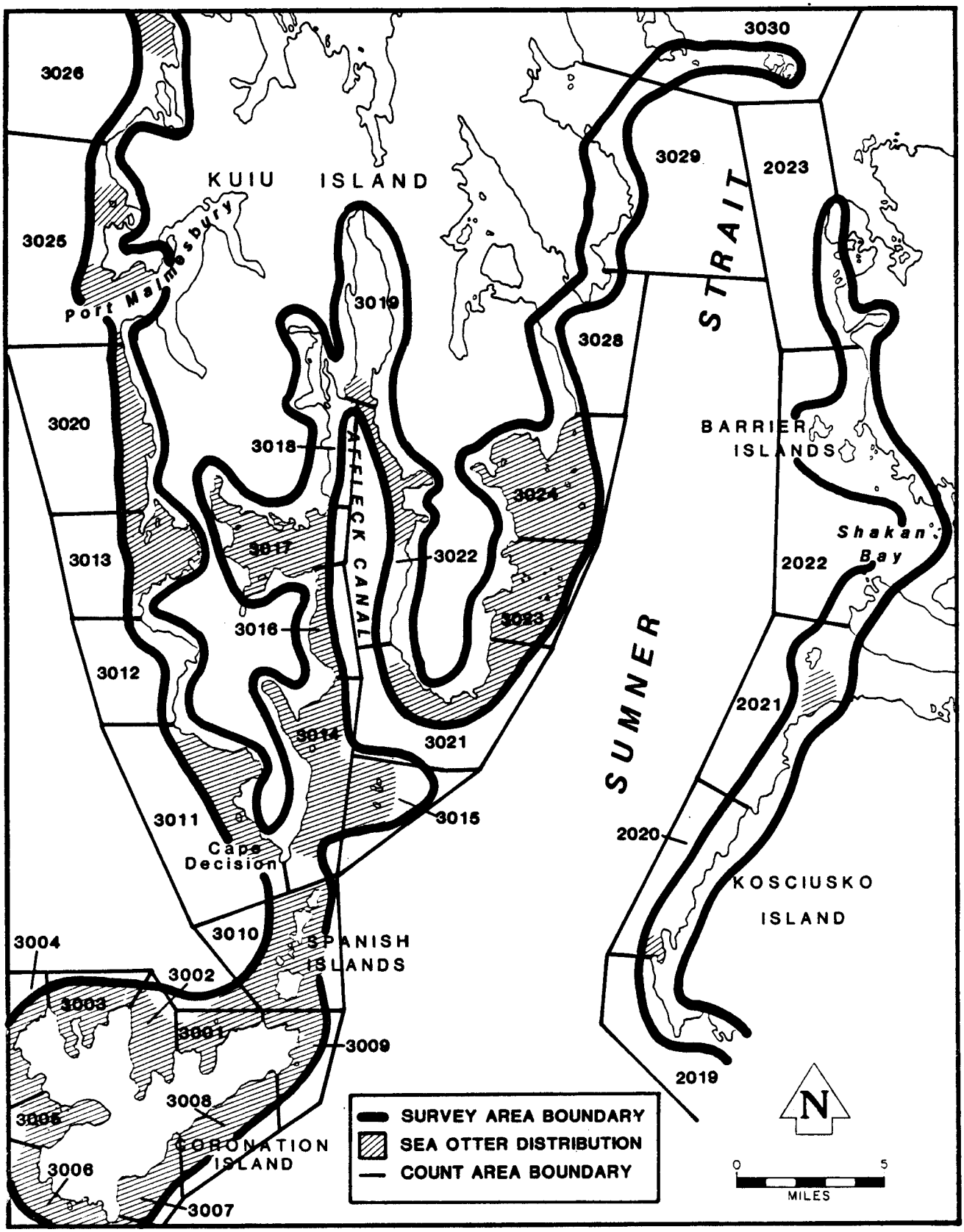

Figure 7. Area surveyed and sea otter distribution in the Coronation–Kuiu Islands area during July 1988.

not surveyed at this time. In 1987 distribution was similar around Coronation and the Spanish Islands (although densities had increased); however, sea otters were abundant along the southeastern shoreline of Kuiu Island in Sumner Strait and were found in several locations along the southwestern coast of Kuiu Island in lower Chatham Strait. Several changes in distribution were noted between 1987 and 1988. The numbers of otters in the Windy Bay area of Coronation Island (count area 3005) was reduced substantially in 1988. Increased numbers of animals were found along both the southwestern and southeastern coastlines of Kuiu Island and distribution had progressed northward. Twenty-three males was observed at Mariposa Reef near Point Baker on northwestern Prince of Wales Island.

Future range expansion will probably proceed up the coastlines of Kuiu Island and may cross Sumner Strait to the Shakan Bay area, which appears to be good habitat. If this occurs, this colony will eventually merge with the Maurelle Islands group. A drift gillnet fishery for salmon takes place in Sumner Strait off northern Prince of Wales Island. If otters become established in this area, entanglement with resulting mortality of otters such as is taking place off the Copper River Delta (Simon-Jackson 1986), will probably occur. Between 1975 and 1988 the exponential rate of increase was estimated at 0.205 for the Coronation, Spanish, and Kuiu islands group.

NECKER ISLANDS: Forty-seven sea otters were counted during surveys of this area on 17, 18, and 19 July 1987 (Figure 8, Table 6). Conditions were fair-to-poor because of brisk westerly winds and sun glare, and it was likely that some (possibly substantial numbers) animals were missed. In 1988 the Necker Island area was surveyed on 22 July (Figure 9), again under fair-to-poor conditions. A total of 106 otters, including 19 pups, were counted (Table 6). The range of this group has not expanded greatly since the 1975 and 1983 surveys, although some movement to the southeast of the earlier concentrations has occurred. Previously all otters were found in count area 4006, and during the 1987 survey about half were found in count area 4007. A group of 31 males was seen in count area 4005, the Biorka Island area, in 1988, the first time substantial numbers have been observed there. This area has never been thoroughly surveyed under good conditions, and it is possible that the colony is substantially larger that our surveys indicate. Considerable areas of unoccupied habitat remain in the Necker-Biorka Islands area; therefore, it is unlikely that large-scale range expansion will occur within the next several years. Animals from the large group north of Sitka Sound will probably eventually merge with this group, possibly within the next several years.

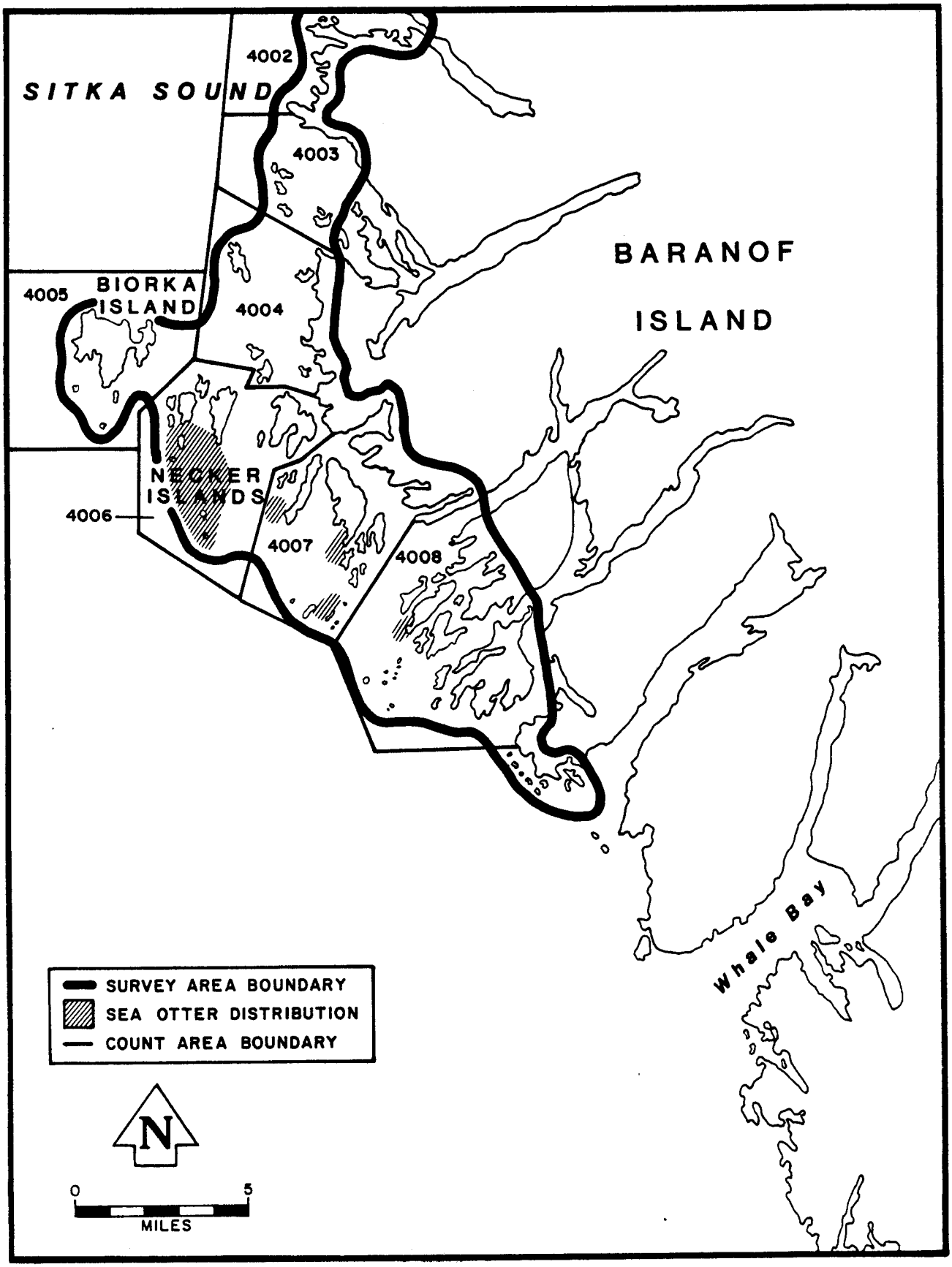

Figure 8. Area surveyed and sea otter distribution in the Necker Islands area during July 1987.

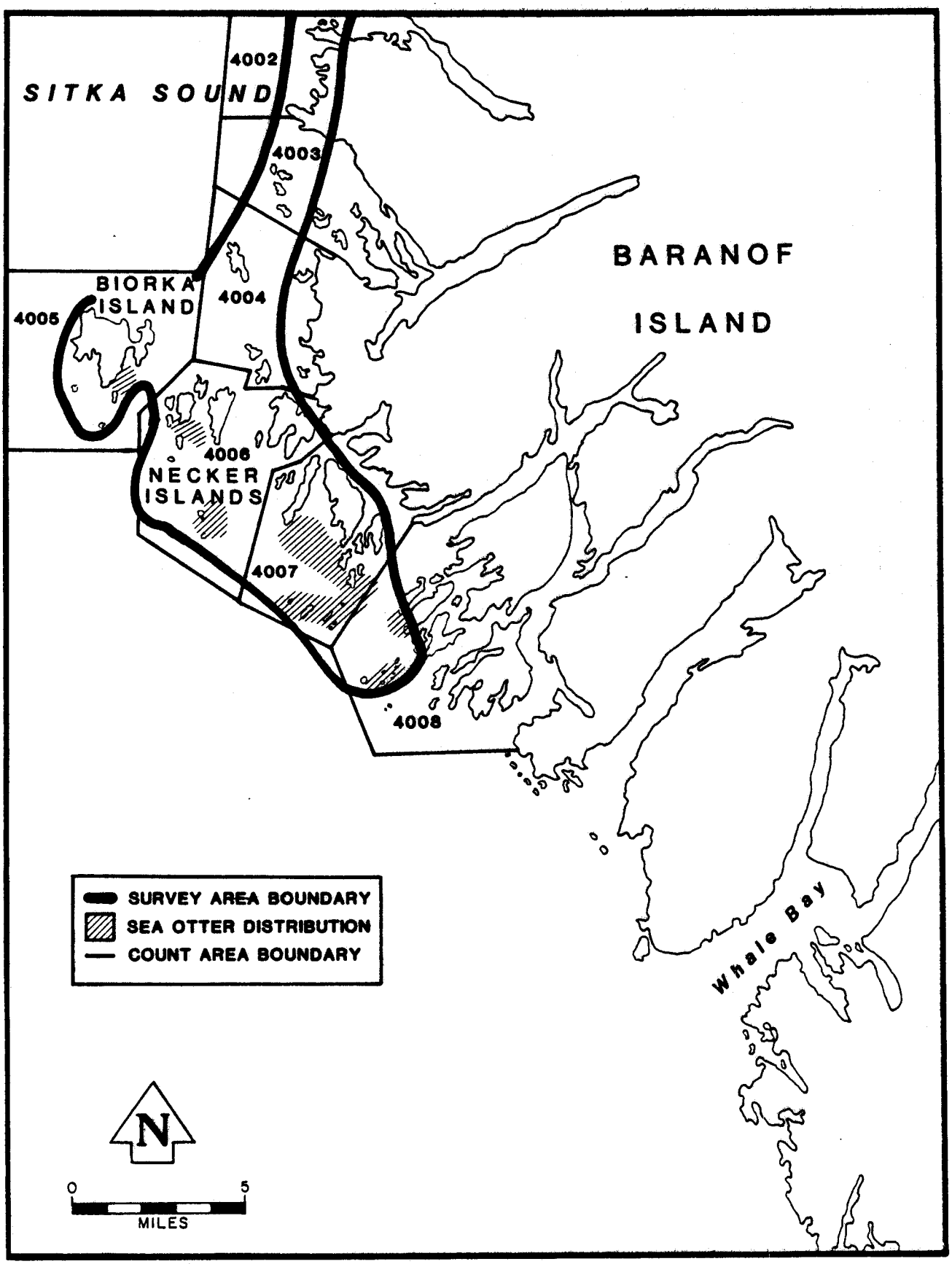

Figure 9. Area surveyed and sea otter distribution in the Necker Islands during July 1988.

In 1968, 48 sea otters were translocated to Biorka Island. Many of the original animals probably either died or dispersed, because only four otters were seen during the 1975 survey. Since that time the colony has grown rapidly, as demonstrated by the estimated exponential rate of increase from 1975 through 1988 of 0.233. The original survey, in 1975, was conducted in poor conditions (Schneider 1975) and it is likely that population size was substantially underestimated which would result in an overestimate of r.

Table 6. Summary of sea otter surveys conducted in the Necker Islands area during 1987 and 1988.

Count Area	Date	Total Otters	Pups	Survey Quality
4001	17 July 1987	0	0	Fair
4002	17 July 1987	0	0	Poor
4003	17 July 1987	0	0	Fair
4004	17 July 1987	0	0	Fair
4005	18 July 1987	0	0	Poor
4006	18 July 1987	25	2	Poor
4007	19 July 1987	21	7	Poor
4008	19 July 1987	1	0	Poor
Total		47	9	
4001	22 July 1988	0	0	Fair
4002	22 July 1988	0	0	Fair
4003	22 July 1988	0	0	Fair
4004	22 July 1988	0	0	Fair
4005	22 July 1988	31	0	Poor
4006	22 July 1988	5	0	Poor
4007	22 July 1988	66	19	Fair
4008	22 July 1988	4	0	Fair
Total		106	19	

NORTH OF SITKA: Surveys conducted during 1987 and 1988 indicated that sea otters were essentially continuously distributed along the outside coast from southern Kruzof Island to Astrolabe Point, north of Cape Spencer, and in portions of Cross Sound and Icy Strait (Figures 10-16). Areas with the patchiest distribution were the outside of Kruzof Island, portions of the Khaz Peninsula, and Cross Sound. During 1987 a count of 2,248 otters was obtained for this area (Table 7), which was 62% of the total obtained for all of southeastern Alaska during 1987.

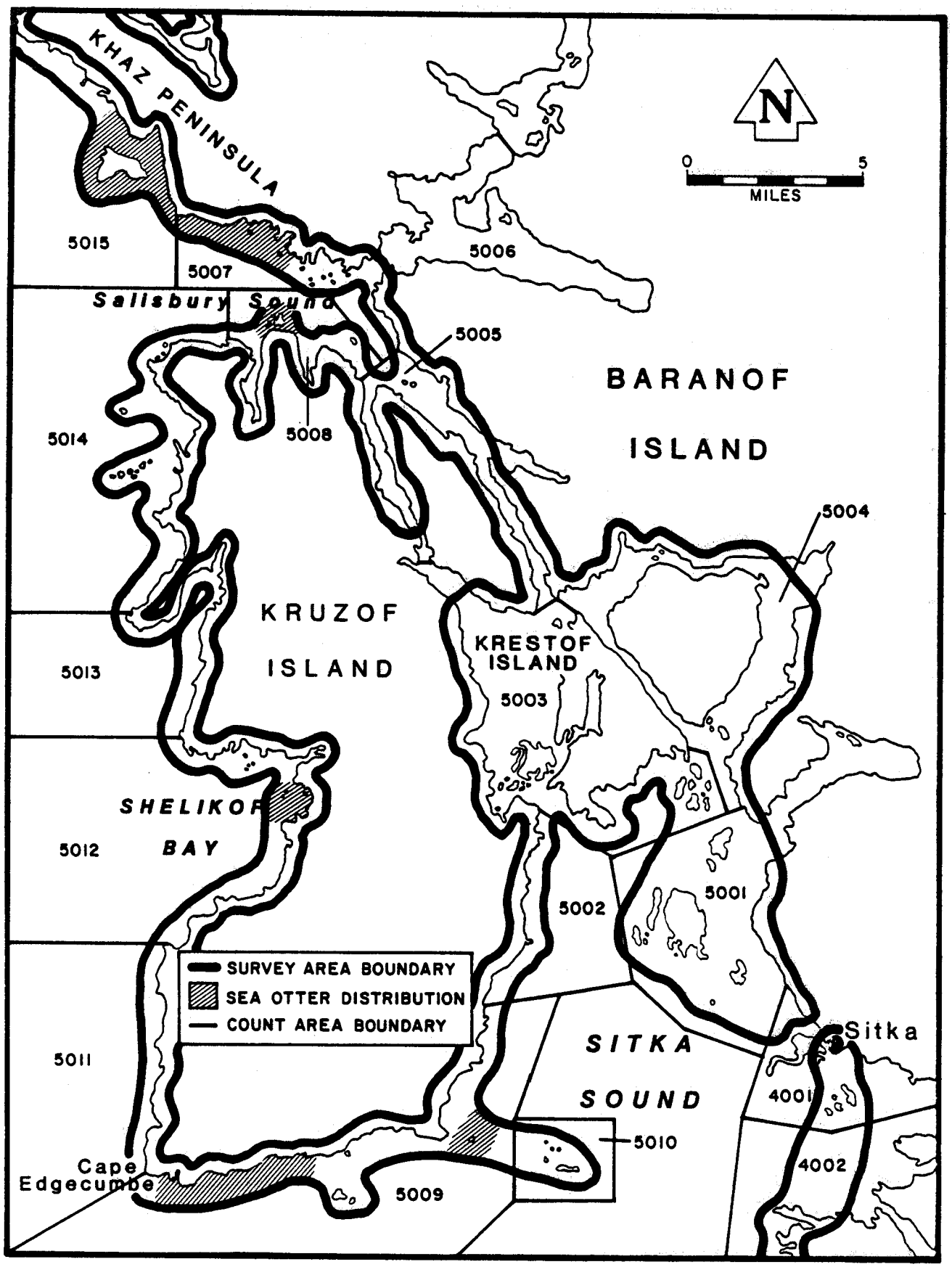

Figure 10. Area surveyed and sea otter distribution in the Kruzof Island area during July 1987.

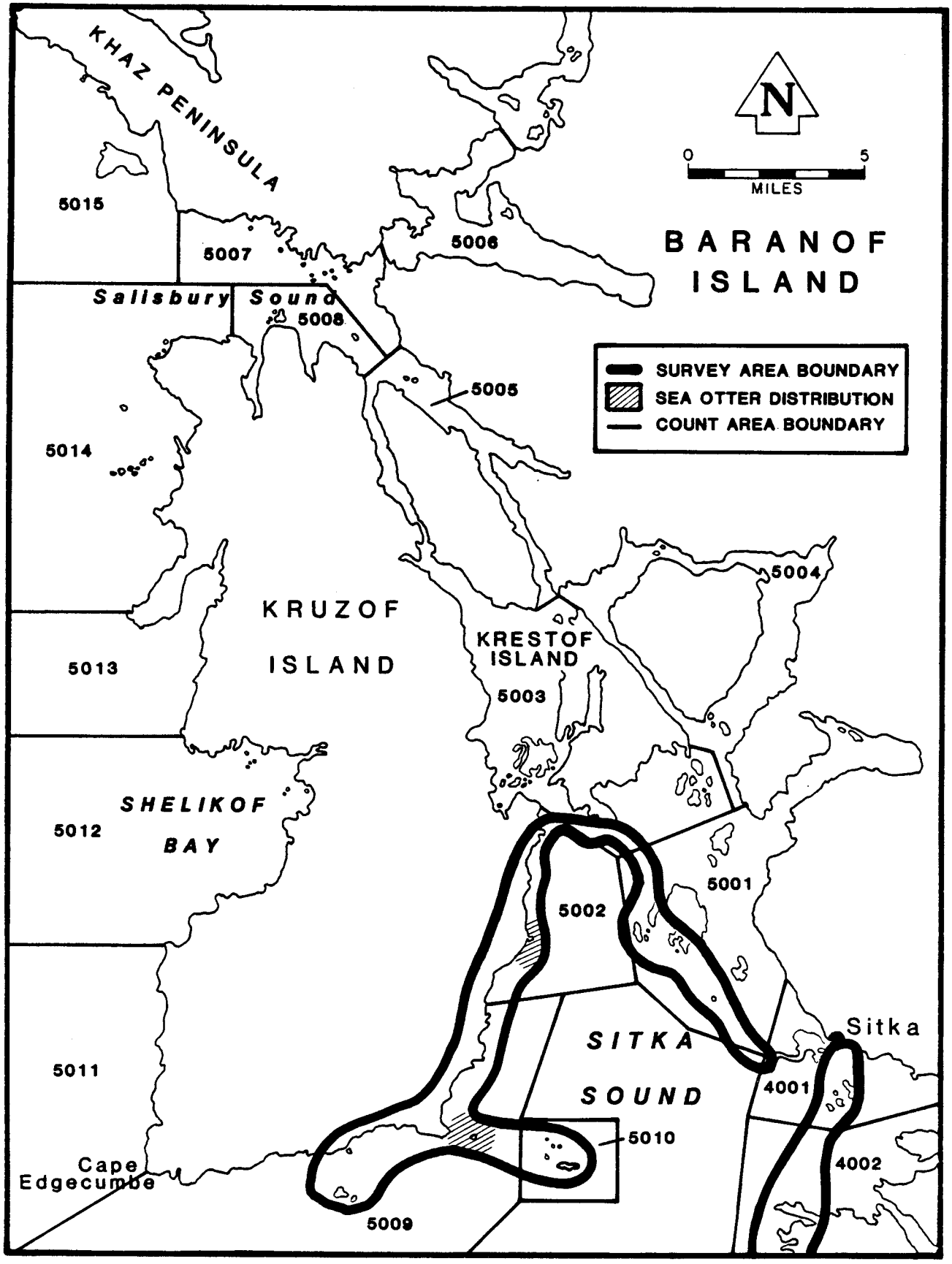

Figure 11. Area surveyed and sea otter distribution in the Sitka Sound area during July 1988.

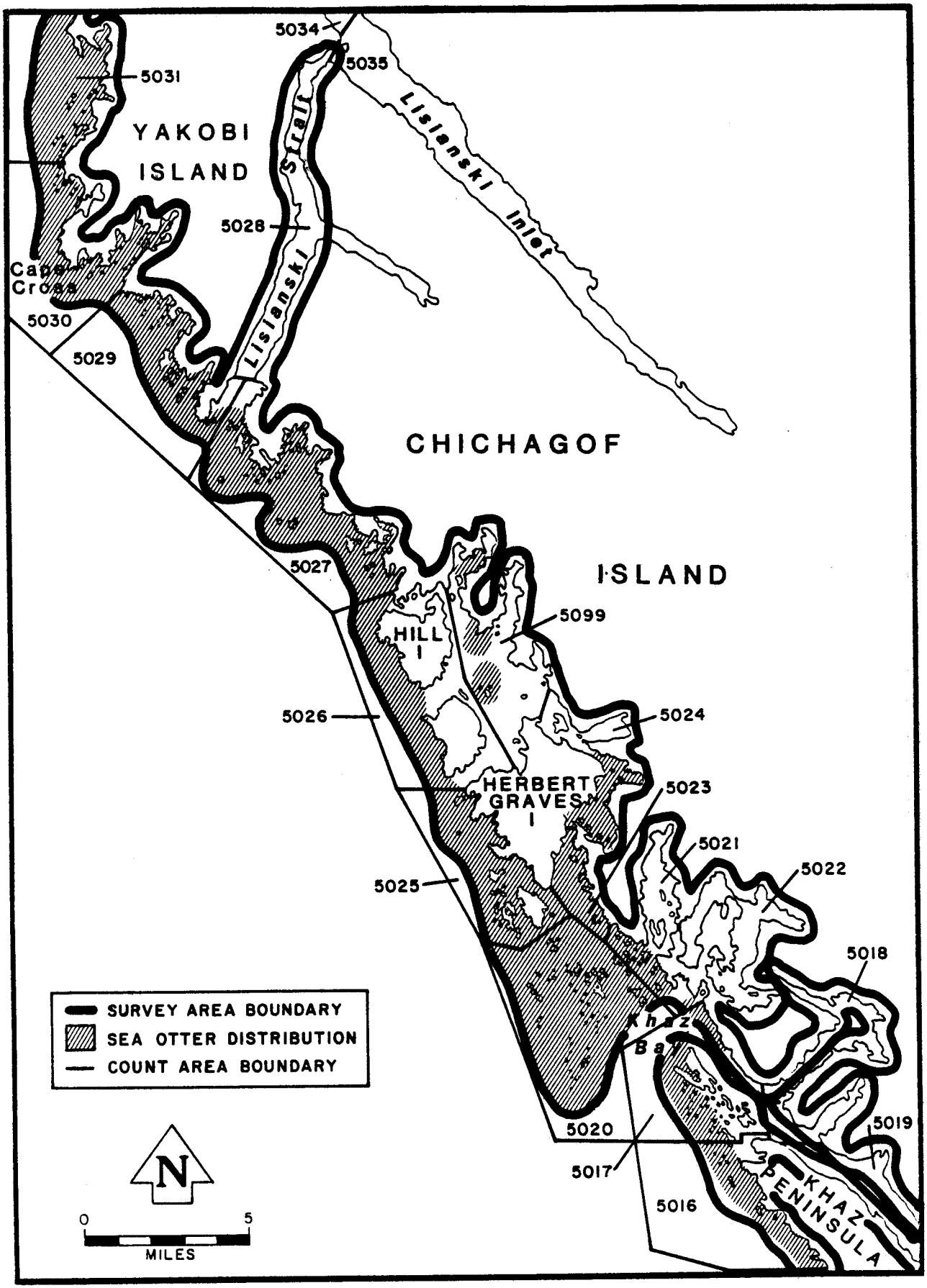

Figure 12. Area surveyed and sea otter distribution in the west Chichagof–Yakobi Islands area during July 1987.

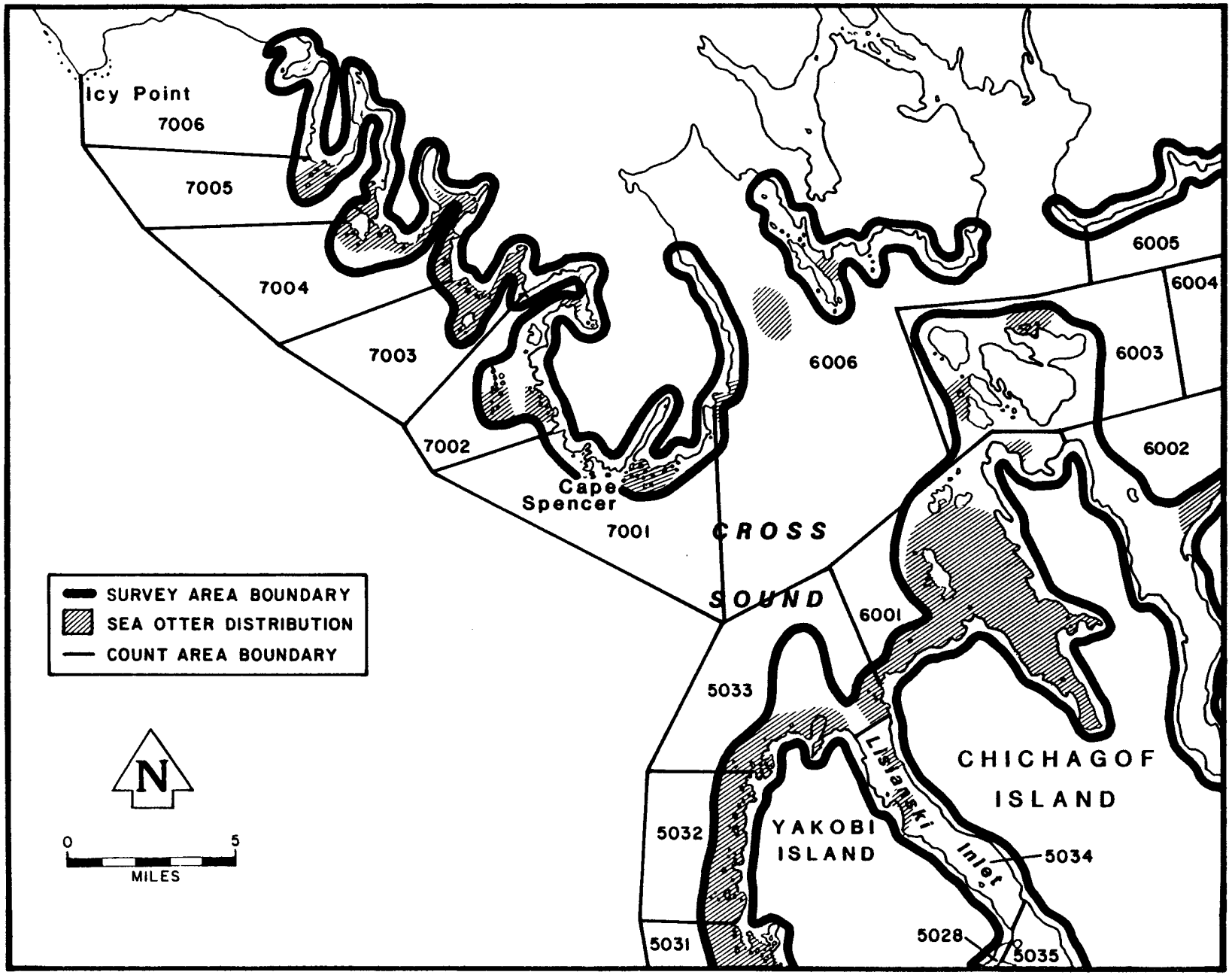

Figure 13. Area surveyed and sea otter distribution in the Cross Sound–Cape Spencer area during July 1987.

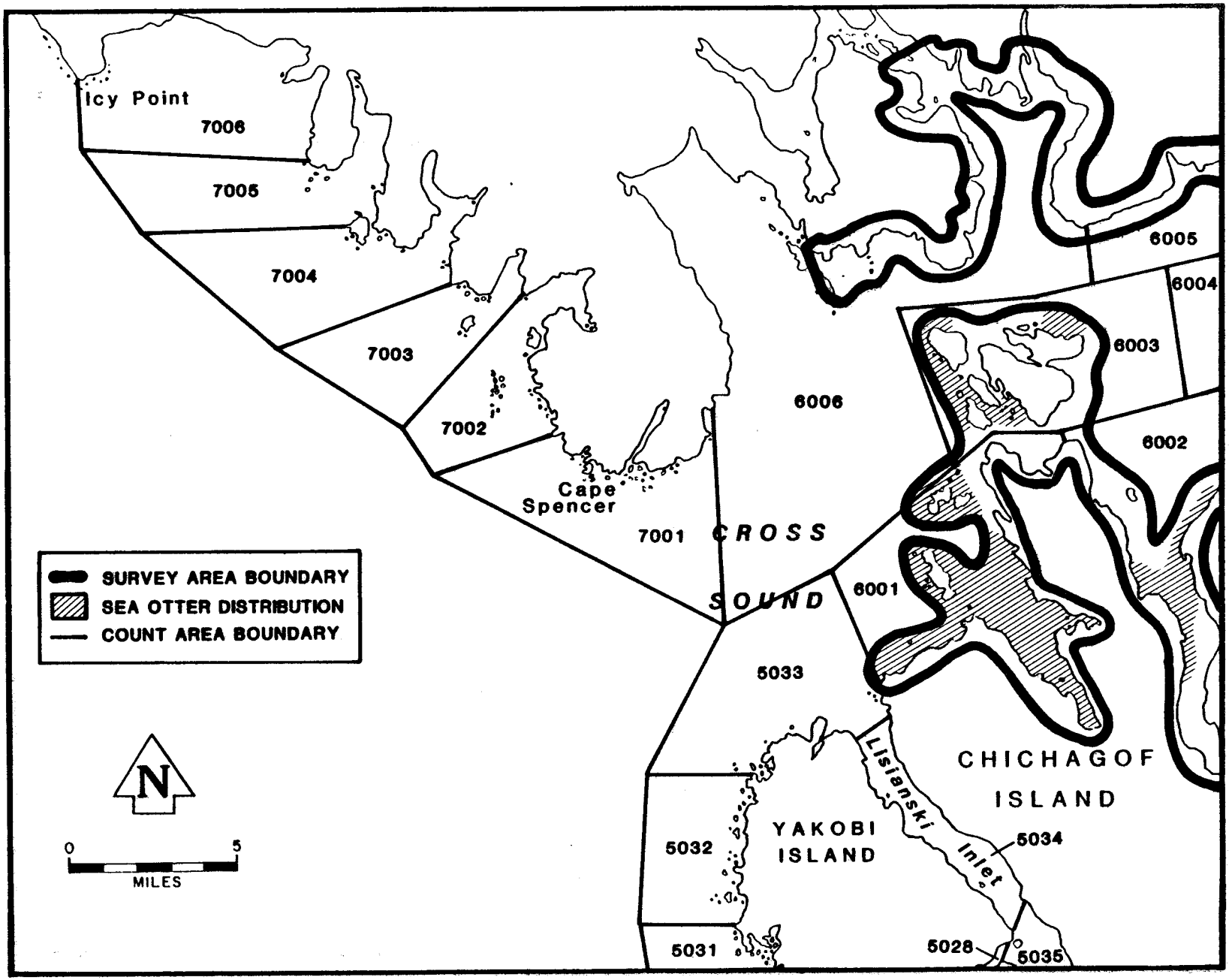

Figure 14. Area surveyed and sea otter distribution in the Cross Sound area during May 1988.

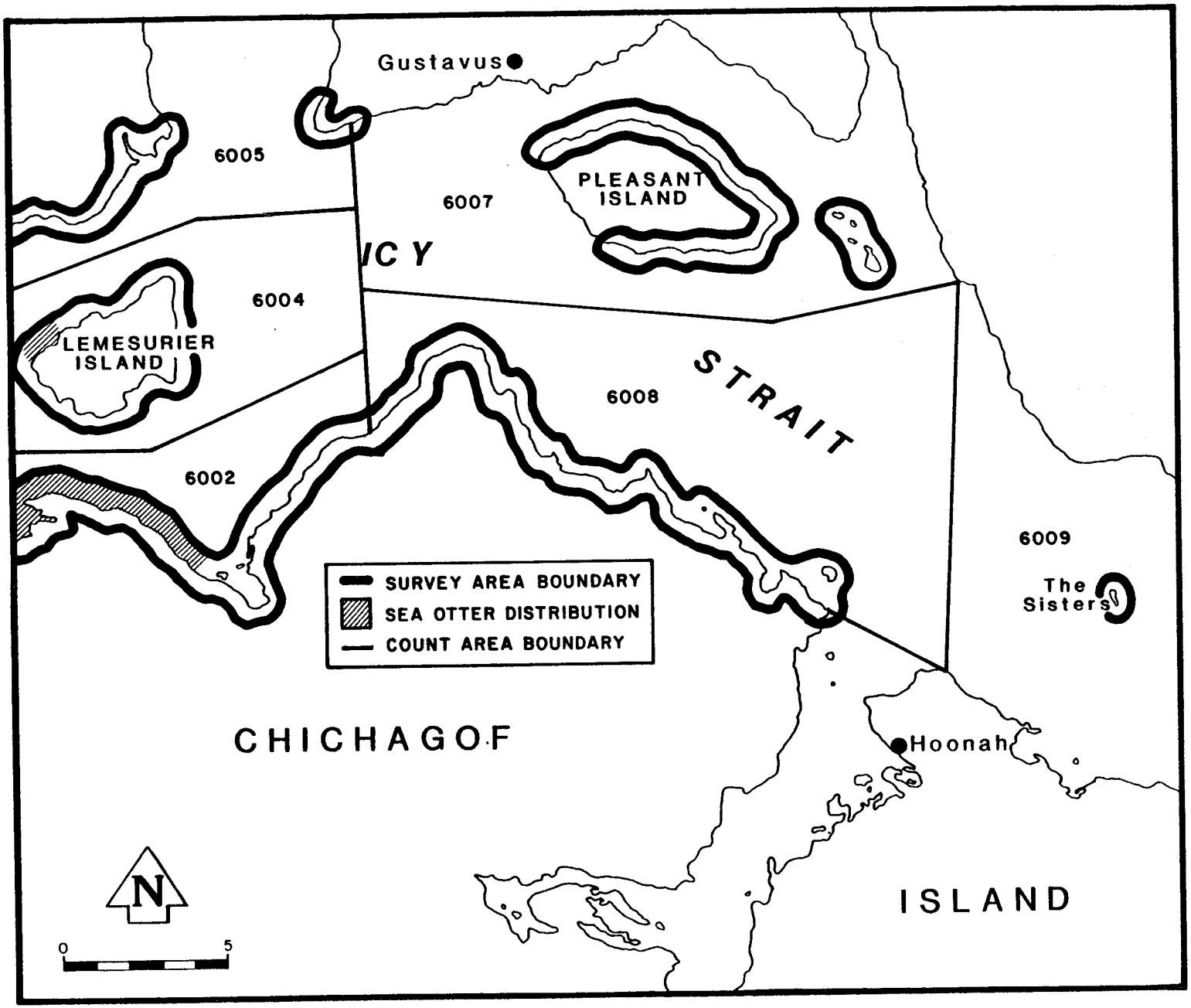

Figure 15. Area surveyed and sea otter distribution in the Icy Strait area during July 1987.

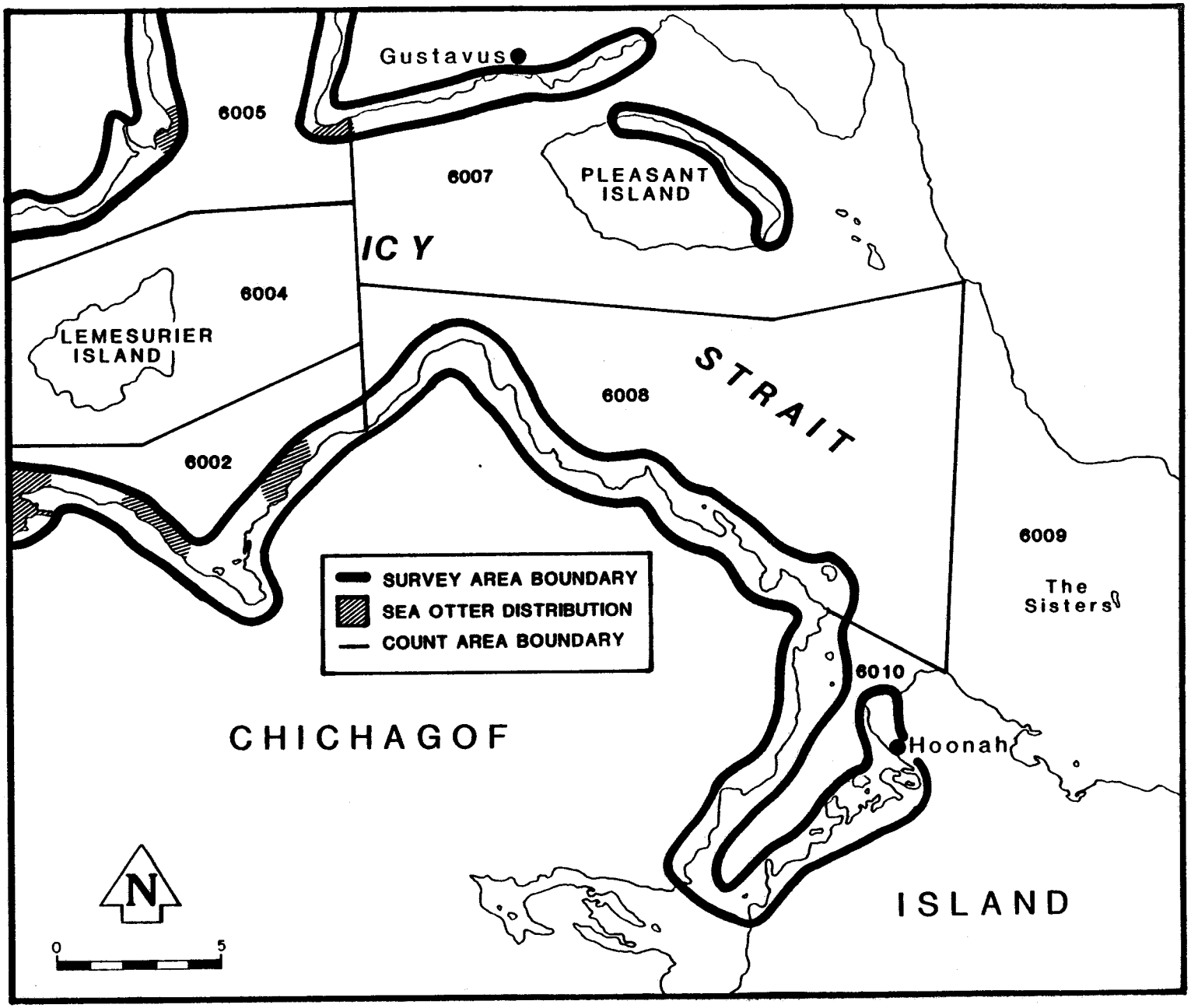

Figure 16. Area surveyed and sea otter distribution in the Icy Strait area during May 1988.

In the area from Cape Spencer north to Astrolabe Point (Figure 13), 149 sea otters were counted under good-to-excellent survey conditions. This was less than the 229 reported by Simon-Jackson and Hodges (1986) during April 1986. Our count may substantially underestimate the total number of animals in the area because numerous sea otters were noted scattered offshore, suggesting that our shoreline survey missed animals. Otters were first observed in the Cape Spencer area by National Park Service personnel in 1983; with substantial numbers seen in 1984 (Vequist 1987). Pups were first observed in the area in 1985 (Vequist 1987). Sea otters had extended their distribution about 5 miles to the northwest in the 15 months since the Simon-Jackson and Hodges (1986) survey. Nearly all pups seen were in the Cape Spencer-Graves Rocks area (count areas 7001 and 7002), suggesting that otters to the north in areas 7003, 7004, and 7005 were largely males. Range expansion in this area will likely be to the northwest along the coast towards Lituya Bay and Yakutat Bay. Intertidal and shallow subtidal habitats along this coast shift from rocky to sandy and undoubtedly contain a different prey base. This area apparently supported a substantial otter population prior to exploitation, because Lensink (1962) reported that Yakutat was a major sea otter trading post and Vequist (1987) stated that numerous otters were harvested in the Lituya Bay area.

Table 7. Summary of sea otter surveys conducted along the outer coast of southeastern Alaska north of Sitka during July 1987.

Count Area	Date	Total Otters	Pups	Quality
	Kruzof-Chichagof-Yakobi Islands			
5001	17 July 1987	0	0	Good
5002	16 July 1987	0	0	Good
5003	16 July 1987	0	0	Good
5004	15 July 1987	0	0	Good
5005	15 July 1987	0	0	Good
5007	15 July 1987	33	6	Good
5008	15 July 1987	3	0	Fair
5009	16 July 1987	161	0	Fair
5010	16 July 1987	0	0	Good
5011*	19 July 1987	0	0	Bad
5012*	19 July 1987	16	?	Bad
5013*	19 July 1987	0	0	Bad
5014*	19 July 1987	0	0	Bad
5015	15 July 1987	30	10	Fair
5016	15 July 1987	78	*	Good
5017	15 July 1987	109	37	Fair
5018	13 July 1987	1	0	Fair
5019	13 July 1987	0	0	Fair
5020	12 July 1987	620	*	Exc.
5021	13 July 1987	3	0	Poor

Table 7. (Continued)

5022	13 July 1987	0	0	Poor
5023	13 July 1987	38	*	Poor
5024	13 July 1987	2	0	Fair
5025	12 July 1987	90	25	Exc.
5026	12 July 1987	77	22	Good
5027	12 July 1987	180	27	Exc.
5028	10 July 1987	0	0	Good
5029	10 July 1987	92	15	Good
5030	10 July 1987	57	12	Good
5031	10 July 1987	112	21	Good
5032	10 July 1987	30	8	Good
5033	10 July 1987	84	16	Exc.
5034	10 July 1987	2	0	Fair
5035	10 July 1987	0	0	Poor
5099	13 July 1987	4	0	Fair
Subtotal		1,822	199	
	Sitka Sound			
5001	20 July 1988	0	0	Poor
5002**	23 July 1988	87	0	Fair
5003	21 July 1988	0	0	Poor
5009**	23 July 1988	188	0	Fair
5010	20 July 1988	0	0	Fair
Subtotal		275	0	
	Cross Sound-Icy Strait			
6001	11 July 1987	192	22	Good
6002	11 July 1987	75	9	Good
6003	9 July 1987	2	0	Good
6004	11 July 1987	1	0	Exc.
6005	11 July 1987	0	0	Good
6006	9 July 1987	7	0	Good
6007	8 July 1987	0	0	Poor
6008	8 July 1987	0	0	Poor
Subtotal		277	31	
	Cross Sound-Icy Strait			
6001	12 May 1988	166	26	Good
6002	11 May 1988	90	0	Good
6003	12 May 1988	17	3	Good
6004	13 May 1988	2	0	Good
6005	13 May 1988	3	0	Good
6007	13 May 1988	0	0	Fair
6008	11 May 1988	0	0	Good
6010	10 May 1988	0	0	Fair
Subtotal		278	29	

Table 7. (Continued)

	Cape Spencer North			
7001	9 July 1987	30	4	Good
7002	9 July 1987	36	9	Exc.
7003	9 July 1987	53	1	Good
7004	9 July 1987	28	1	Good
7005	9 July 1987	2	0	Exc.
7006	9 July 1987	0	0	Fair
Subtotal		149	15	

*Unable to classify pups
**Aerial survey

A total of 277 sea otters were counted during July 1987 under good conditions in the Cross Sound-Icy Strait area; major concentrations were in the Port Althorp and Idaho Inlet-Mud Bay areas (count areas 6001 and 6002) (Figures 13 and 15). During May 1988 this area, except for count area 6006, was resurveyed and 278 otters were counted. Distribution was similar during both years, although otters were more extensively distributed in Idaho Inlet and Mud Bay (count area 6002) in 1988. The Idaho Inlet-Mud Bay area may be primarily a male area because no pups were seen in 1988; however, a few were present in 1987. Johnson et al. (1983) first found otters along the northern tip of Yakobi Island and along the northeastern Chichagof coast in 1983, while in 1986 Simon-Jackson and Hodges (1986) found numerous otters in the Port Althorp area. Vequist (1987) reported occasionally seeing up to 12 otters at Pt. Carolus and Pt. Gustavus. These areas were surveyed; however no otters were seen in 1987 and only two were observed in 1988. The Cross Sound-Icy Strait animals obviously originated from the long-established Surge Bay group. It will be important to monitor range expansion of this group, because the degree sea otters will colonize the inside waters of southeastern Alaska is not clear, and this has important implications for future sea otter-shellfish interactions, particularly in regard to dungeness crabs. Kenyon (1969) found no record that sea otters ever occurred in the inland waters of southeastern Alaska and assumed that they were distributed only along the outer coast. Sea otter bones were reported to be widespread in middens at Native village sites near Angoon located in the inside waters of Chatham Strait (Vequist 1987 citing de Laguna 1960). This does not necessarily mean that otters occurred in that area but raises the possibility. Sea otters are well established throughout the inside waters of Prince William Sound, a somewhat comparable situation to southeastern Alaska.

A total of 1,822 sea otters was counted along the outer coasts of Yakobi, Chichagof, and Kruzof Islands during 1987 (Figures 10, 12, and 13). The largest concentration was in the outer Khaz Bay area (count area 5020), where about 1/3 (620) of the total was seen. Although no composition data were obtained there, it was obvious that many females with pups were in the Outer Rocks area. Survey conditions were generally very good from Khaz Bay north, while they were fair-to-poor south of Khaz Bay. Sitka Sound was resurveyed in 1988 (Figure 11). Survey conditions were fair-to-poor. The only area of obvious sexual segregation was at the southern limits of this group along southern Kruzof Island (count area 5009) where no pups were observed out of 161 sea otters in 1987 or 275 animals in 1988. This group of otters will probably spread throughout Sitka Sound, eventually merge with the Necker Islands group, and then colonize the outside coast of Baranof Island.

This large, continuous group of otters, extending from north of Cape Spencer to southern Kruzof Island, originated from transplants between 1965 and 1969 of 193 animals to Khaz Bay, 30 to southern Yakobi Island, and 25 to Cape Spencer. Initially, two colonies developed: one at Khaz Bay (count area 5020) and another at Surge Bay (count area 5031). At the time of the 1975 survey, these groups were localized, totaling 340 animals (Schneider 1975). By 1983 both distribution and abundance had increased substantially; total numbers probably exceeded 1,200 and the range extending from Cross Sound to the Khaz Peninsula (Johnson et al. 1983, ADF&G unpublished data). The observed exponential rate of increase between 1975 and 1987 for this group was 0.157. This was less than those found in the other groups where r averaged 0.21 during the same period. The difference may be accounted for by a harvest of unknown magnitude directed at this group under the Native exemption clause of the Marine Mammal Protection Act.

Dependent pups, obviously associated with a female, were recorded separately from older animals, in an attempt to evaluate productivity of the different groups. It was difficult to classify pups when large pods were encountered, particularly if the animals had been disturbed and were moving. In calculating pup percentages I deleted all sightings where it was impossible to classify pups. Percentages of pups ranged between 13% and 27% with an average of 18% (Table 8). The proportion of pups was lower in both 1975 and 1983 when pups comprised 13% (X^2=8.1, $P<0.01$) of the otters counted (Schneider 1975) and 11% (X^2=29.95, $P<0.001$) of the total (Johnson et al. 1983), respectively. These surveys were conducted one to two months earlier than the 1987 counts, so the results are not directly comparable. The progression of pupping in southeastern Alaska is not known; however, it is probably similar to the Aleutian Islands and Prince William Sound,

where births occur during all months of the year but peak during April, May, and June (Garshelis 1983, Schneider 1972). This probably explains the higher proportion of pups in the 1987 survey. Observed pup percentages are not a good indicator of annual productivity because pups born early in the year may be fairly large and not classified as pups and some pups will likely be born after the sampling period. However, samples taken during similar time periods may have comparative value between areas and over time.

Table 8. Percentages of pups counted during southeastern Alaska sea otter surveys, June and July 1987 and 1988.

Area	Adjusted Total*	No. Pups	%Pups
Barrier Islands (1987)	180	23	13
Barrier Islands (1988)	243	65	27
Maurelle Islands (1987)	390	58	15
Maurelle Islands (1988)	860	135	16
Coronation Island (1987)	604	128	21
Coronation Island (1988)	1,063	234	22
Necker Islands (1987)	47	9	19
Necker Islands (1988)	106	19	18
North Sitka (1987)	1,554	248	16
Total	5,047	919	18

*Total number of sea otters minus those sightings for which it was not possible to classify pups.

The surveys of these transplanted populations provided an opportunity to secure estimates of the rates of population growth from areas in which resources were not limiting. These measurements of intrinsic rates of increase, or r_m, (Caughley 1977) are useful for predicting population growth following transplants or expansion into unoccupied habitat and evaluating impacts of proposed harvest schemes. It appeared that it took a number of years for the southeastern Alaska populations to become established after the translocations. During the 1975 survey only slightly more sea otters were counted than were introduced during the late 1960's. Schneider (1975) proposed that this was the result of transplant-associated mortality, dispersal out of the area, and low productivity because of the sex and age structure of the translocated animals. From 1975 through 1987 these populations have grown rapidly (Table 9); observed annual rates of increase ranged between 0.157 and 0.233. Few data on rates of increase of sea otter populations are available. Lensink (1962) stated that sea otter populations could grow at an annual rate of 10-15%. The California sea otter population grew at about 4-5% per year between 1914 and the mid-1970's (Riedman 1987). Estes

(1981) stated that many small populations that had recently expanded into new habitat in Alaska grew at the rate of 10-16% per year. It appears that the southeastern Alaska populations have grown over the past 12 or 13 years at rates that exceed those previously reported.

Table 9. Annual observed rates of increase for sea otter colonies in southeastern Alaska.

Area	1975-1988
Barrier Islands	0.185
Maurelle Islands	0.215
Coronation Island	0.205
Necker Islands	0.233
North Sitka (1975-87)	0.157

These surveys were attempts at total counts of each sea otter colony. Obviously, not all animals were observed during any census attempt and the results varied depending on a number of factors. The counts should therefore be considered measures of relative abundance or population indicies, rather than estimates of absolute abundance. Factors that appeared to introduce variation in the counts included weather conditions; sea otters activity, movements, and behavior; distribution of otters relative to the shoreline; grouping of otters; and ability and experience of surveyors. Certain of these factors, such as weather conditions, ability and experience of surveyors, and even activity and behavior of otters, can be controlled to some extent by setting standards regarding acceptable conditions for surveys, timing of surveys, and qualifications of participants in those surveys. While these factors were considered during the surveys, there was still considerable variation within the range of acceptable standards. Other important factors, such as distribution and grouping of otters, could not be controlled for and undoubtedly added additional variability to the counts. During this project there was an opportunity to evaluate variability in the number of animals counted through replicate surveys (Table 10).

Overall, there were substantial differences between replicate counts of the same colonies. The four replicate counts that were conducted in the same year exceeded the original counts by an average of 37% (range = 15% to 63%). For three other colonies, the replicate counts were conducted in consecutive years and the second counts were, on the average, 68% higher than the first (range = 3% to 126%). Probably about 20% of the difference in the consecutive year counts can be attributed to recruitment.

For all replicate counts the second count was always highest, suggesting that experience gained counting a particular colony enabled the surveyors to be more effective when recounting. This occurred despite the survey teams switching count areas during the replicate count.

Table 10. Comparisons of replicate counts of southeastern Alaska sea otter colonies during 1987 and 1988.

Area (year)	Count	Percent Difference
Barrier I. (1987)	147	+22%
Barrier I. (1987)	180	
Barrier I. (1988)	153	+63%
Barrier I. (1988)	243	
Maurelle I. (1987)	356	+46%
Maurelle I. (1987)	520	
Maurelle I. (1988)	746	+15%
Maurelle I. (1988)	861	
Coronation (1987)	604	+76%
Coronation (1988)	1063	
Necker I. (1987)	47	+126%
Necker I. (1988)	106	
Ct Areas 6001-05 (1987)	270	+3%
Ct Areas 6001-05 (1988)	278	

It was disappointing to see the amount of variation between replicate counts. While the distributional data obtained during the surveys were likely quite good, the value of the estimates of population size, even as population indicies, was limited. When a series of such estimates over a number of years become available, they can be useful in evaluating general population trend and estimating average rate of increase; however the variability is so great that meaningful annual comparisons will be impossible, particularly if only single counts are made.

RECOMMENDATIONS

1. The Kruzof Island-Sitka Sound-Necker Islands area should be surveyed periodically. Southern Kruzof Island was the southern limit of distribution for the large group of sea otters north of Sitka. These otters can be expected to move into Sitka Sound in the near future and eventually merge with the Necker Islands colony. This is an important subsistence shellfishery area for Sitka residents, and conflicts are expected to develop after sea otters become abundant; therefore, the progression of colonization should be monitored.

2. The Barrier Islands colony, because of its size and isolation, provides an excellent opportunity for intensive studies of population dynamics, population manipulation, and geographic containment. If USF&WS has intentions of conducting such research, then the area should be resurveyed periodically in order to more completely document population growth prior to experimental manipulation.

3. The dungeness crab fishery is one of the most important commercial and subsistence shellfisheries in southeastern Alaska (Doerr and Sigman 1986). Between 1960 and 1986 the average annual commercial harvest was about 1.1 million pounds. This fishery, as well as major dungeness crab concentrations, occurs nearly exclusively within the inside waters of southeastern Alaska. Currently most sea otters occur along the outside coast, although some animals were found in the Cross Sound-Icy Strait area and in Sumner and lower Chatham Straits. As it is unclear to what extent sea otters will eventually utilize the inside waters of southeastern Alaska and because of important fishery conflict implications, surveys should be periodically conducted to monitor colonization of these inside water sites.

4. The impacts of sea otter predation on dungeness crab populations have not been well documented. Strong circumstantial evidence indicated that sea otters dramatically reduced the abundance of dungeness crabs, particularly large crabs, in the Orca Inlet area near Cordova, Alaska (Garshelis et al. 1986, Donaldson 1986). Some residents of Elfin Cove, in northern southeastern Alaska, claim that otters have greatly reduced dungeness crab abundance in nearby Port Althorp. Because dungeness crabs are such a valuable shellfish resource in southeastern Alaska it is important to understand the relationships between dungeness crab and sea otter populations in order to develop rational management programs for each. A project, as detailed in part 3 of this report, was begun under this contract to evaluate the impacts of sea otter predation on

dungeness crabs. This project should be continued because the resulting findings would be invaluable for considerations of zonal management of sea otters in Alaska.

5. The Gulf of Alaska coast between Cape Suckling and Icy Point is the largest section of uninhabited and underpopulated habitat remaining in Alaska. According to historical sea otter skin trade records (Lensink 1962, Vequist 1987), this area once contained large sea otter numbers. Only small numbers of sea otters have been seen along this coast in recent years; Calkins and Schneider (1985) estimated that 100 animals occurred in the area. This is another important dungeness crab fishing area; the average annual harvest is 1.5 million pounds (Doerr and Sigman 1986). It is expected that this coastline will eventually be naturally repopulated from expanding colonies to both the north and south. A comprehensive survey of this area should be conducted within the next few years.

6. Thought should be given to developing new techniques for either estimating total population size or obtaining reliable indicies of abundance for sea otters. There was considerable variability in replicate counts conducted during this study. Studies of population dynamics would benefit from more accurate data. In addition, sea otter colonies in southeastern Alaska are becoming so large and widely distributed that the shoreline-skiff technique employed during past surveys is expensive, time consuming, and personnel intensive.

ACKNOWLEDGEMENTS

Successful completion of skiff surveys of a substantial proportion of the outer coast of southeastern Alaska was made possible by the excellent field skills and enthusiastic participation of a number of ADF&G employees. Participants in the surveys included Don Calkins, Loyal Johnson, Dennis McAllister, Karl Schneider, John Westlund, Bob Wood, and Butch Young. Charlie McLeod, skippering the RV Polaris, provided topnotch support for the surveys. Dennis McAllister was invaluable for organizing logistical support for the project. Karl Schneider was helpful in reviewing past information on sea otters in southeastern Alaska and for supervising the project. Sid Logan, Lloyd Lowry, Steve Peterson, and Karl Schneider all provided useful editorial comments on drafts of this report. Financing for this work was provided through Cooperative Agreement No. 14-16-0009-86-954 with the U.S. Fish and Wildlife Service.

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POTENTIAL CONFLICTS BETWEEN SEA OTTERS AND THE HUMAN UTILIZATION OF SHELLFISH IN SOUTHEASTERN ALASKA

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Sea otters (*Enhydra lutris*) were apparently abundant in southeastern Alaska prior to exploitation during the 18th and 19th centuries. Kenyon (1969) reported that they were essentially eliminated from the area before 1900. Sea otters have since become reestablished as the result of translocations from Amchitka Island and Prince William Sound in the late 1960's (Burris and McKnight 1973), and total numbers now exceed 4,500 (Part I this report). Sea otter colonies in southeastern Alaska, although largely limited to the outer coast, have been rapidly expanding both in numbers and range (Part I this report). It is expected that these populations will continue to grow and expand their ranges for a number of years, although it is not known to what degree they will colonize inland waters.

Sea otters prey primarily on benthic invertebrates (including molluscs, echinoderms, and crustaceans), although fish are also a significant food in some of the Aleutian Islands (Estes and VanBlaricom 1985). Otters are effective predators that limit the age structure, size and abundance of many of their prey. Compared with sea otters, most prey species are relatively immobile making them particularly vulnerable to predation (Estes and VanBlaricom 1985). In addition, the metabolic rate of sea otters is 2.5-3.0 times that of terrestrial mammals of similar size (Costa and Kooyman 1984), and they consume food equivalent to about 23% of their body weight daily (Costa 1982). It appears that some prey species are able to coexist with sea otters only by persisting as small individuals or by utilizing areas that hinder access by otters such as cracks and crevices (Lowry and Pearse 1973, Hines and Pearse 1981) or deep water.

After sea otters were reduced by human exploitation to a few small, remnant groups in the latter part of the 19th century, a number of species of shellfish, which formerly had been limited by otters, became abundant (Estes 1981). In the absence of sea otters, commercial, subsistence, and sport fisheries developed on these populations that contained many old and large individuals. Now with the recovery of sea otter populations, human utilization of some shellfish is being reduced or precluded by otters.

In California, availability for human harvest of abalones (*Haliotis spp.*), sea urchins (*Strongylocentrotus spp.*), and Pismo clams (*Tivela stultorum*) appears to have been sharply reduced by sea otter predation (Lowry and Pearse 1973, Hines and Pearse 1982, Estes and VanBlaricom 1985, Wendell et al. 1986). In Alaska, the impacts of otter predation on human utilization of shellfish populations have not been well documented and are largely anecdotal in nature. Conflicts appear to be increasing as sea otter colonies grow and expand into more populated areas. Reports from fishermen suggest that sea otters have substantially reduced abundance

of legal-size abalones along stretches of the outer coast of southeastern Alaska. Some clam beds appear to have been depleted of large individuals by otters in the northern Kodiak archipelago (A. DeGange, pers. comm.). Strong circumstantial evidence indicated that sea otter predation on dungeness crabs (*Cancer magister*) precluded human use in the Orca Inlet area of Prince William Sound (Garshelis and Garshelis 1984, Garshelis et al. 1986). Residents of Elfin Cove, in southeastern Alaska, indicated to me that reduced availability of dungeness crabs in nearby Port Althorp coincided with the arrival of sea otters in large numbers in that area. Johnson (1982) reported reduced availability of clams and dungeness crabs in portions of northeastern Prince William Sound after the arrival of sea otters.

Based on these reports, it is anticipated that additional conflicts between human utilization of shellfish and expanding sea otter colonies in southeastern Alaska will develop. It is the purpose of this report to identify and review both the magnitude and geographic distribution of the various shellfisheries in southeastern Alaska and to evaluate the potential impacts of sea otter predation on those fisheries. Areas particularly important for the harvest of various species of shellfish will be identified to aid in consideration of zonal management of sea otters and shellfisheries.

Shellfish species which are currently harvested commercially in southeastern Alaska include red king crab (*Paralithodes camtschatica*), blue king crab (*P. platypus*), brown king crab (*Lithodes aequispina*), tanner crab (*Chionoecetes bairdi*), dungeness crab, shrimp (*Pandalus spp., Pandalopsis dispar*), northern abalone (*H. kamtschatkana*), weathervane scallop (*Pactinopectin caurinus*), geoduck clam (*Panope generosa*), green sea urchin (*S. drobachiensis*), and red sea urchin (*S. franciscanus*). Preliminary harvesting has been directed at octopus (*Octopus dolfleini*), squid (*Loligo opalescens*), and sea cucumber (*Parastichopus californicus*), although established fisheries have not yet developed. Most of these species are also the target of subsistence or personal-use fisheries.

Red king crabs, blue king crabs, bairdi tanner crabs, dungeness crabs, sea urchins, geoduck clams, and abalones all occur in shallow water (<20 fathoms) during all or portions of their life cycles. This is well within the feeding range of sea otters (Kenyon 1969, Newby 1975). Dungeness crabs, sea urchins, and abalones have all been reported as major prey of sea otters (Hines and Pearse 1982, Estes and VanBlaricom 1985, Garshelis et al. 1986). King crabs and tanner crabs have been reported as sea otter prey (Kenyon 1969; Johnson 1988; Alaska Department of Fish & Game (ADF&G, unpubl. data), although not as a major component of the diet. They would appear to be energetically profitable

prey, similar to dungeness crabs (Garshelis et al. 1986), if readily available. Few feeding studies have been conducted in areas where these species occur, which perhaps explains their infrequent mention as sea otter prey. Brown king crabs and weathervane scallops are not known to be sea otter prey. They usually occur in deep water and are probably seldom available to otters. Shrimp, while abundant over much of the sea otters range, have never been reported as a commonly utilized prey. Geoduck clams (Rosenthal and Barilotti 1973), octopus (Kenyon 1969, Johnson 1988), squid (Faurot et al. 1986), and sea cucumbers (Johnson 1988) have all been recorded as sea otter prey but not as composing substantial portions of their diet.

Based on these observations, it appears that the only species of shellfish in southeastern Alaska that are exploited to a significant degree and have a high likelihood of being impacted by sea otter predation are sea urchins, abalones, dungeness crabs and, possibly, red and blue king crabs, tanner crabs, and geoduck clams. Discussions in the rest of this report will be largely limited to these species.

METHODS

Historical commercial shellfish harvest records maintained by Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, were reviewed to determine the magnitude and geographic distribution of harvests of the species of interest. It was felt that harvest data were a good indicator of relative abundance throughout southeastern Alaska for abalones, red king crabs, tanner crabs, and dungeness crabs because these species are apparently fully exploited. Both the geoduck clam and sea urchin fisheries are still in developmental phases, and harvest distribution reflects regulatory and marketing restraints rather than biological distribution. The major sources of background information on these fisheries were the annual ADF&G staff reports to the Board of Fisheries (Koeneman and Imamura 1986, 1987). Interviews were conducted with Timothy M. Koeneman, coordinator of the southeastern Alaska shellfish program, and Donald E. House, a fishery biologist involved with the sea urchin harvest program. Ex-vessel prices paid by processors to fishermen were obtained from Elaine Dinneford, a research analyst with the Commercial Fisheries Entry Commission.

To identify and rank areas according to their importance as shellfish producers, the total harvest of the selected species for the 10-year period from 1975 to 1984 was calculated for each of the 15 ADF&G statistical harvest districts that compose southeastern Alaska (Figures 1-3). An index to the value of the harvest for each statistical district was calculated by multiplying the total harvest of each species for the 10-year period by the average ex-vessel price during 1983 and 1984, the last two years when red king crab seasons were open. The totals for each species were then summed to provide a total value for each statistical area for those species that potentially could be impacted by sea otters. Reports produced by ADF&G, Division of Subsistence were reviewed to obtain information on subsistence or non-commercial harvests of shellfish in southeastern Alaska.

RESULTS AND DISCUSSION

Geoduck Clams

A fishery for this species is currently in the developmental stage. Geoduck beds occur sporadically in central and southern southeastern Alaska, primarily near the outer coast. Prior to 1985 a few geoducks were harvested for bait or test marketing; 1,632 lb were reported marketed between 1980 and 1984. Additionally, 3 state grants to private industry were used to explore for geoduck beds with commercial potential. Geoducks, like other filter feeding bivalve molluscs, concentrate the paralytic shellfish poisoning (PSP) toxin produced by planktonic dinoflagellates in their tissues. Before they can be marketed they must be processed and the viscera, where most of the toxin is confined, removed. Each delivered lot of processed geoducks must be certified free of PSP by the Alaska Department of Environmental Conservation prior to marketing. In addition, before a geoduck bed can be exploited, it must be surveyed by ADF&G to estimate biomass so that a harvest quota (2% of total biomass = annual harvest quota) can be established.

In 1985 3 beds were surveyed near Noyes Island and 18,917 lb were landed. In 1986, 130,961 lb were harvested from these same beds; this amount was less than half of the annual quota. Ex-vessel price was $0.25/lb. Because of industry interest in harvesting areas nearer to transportation centers, beds along the outside coast of Gravina Island, near Ketchikan, were surveyed in 1987. An annual quota of 125,000 lb was established and harvesting began in 1988.

There is considerable commercial potential for expanded harvests of geoducks and other species of clams in southeastern Alaska. However first, an easily administered

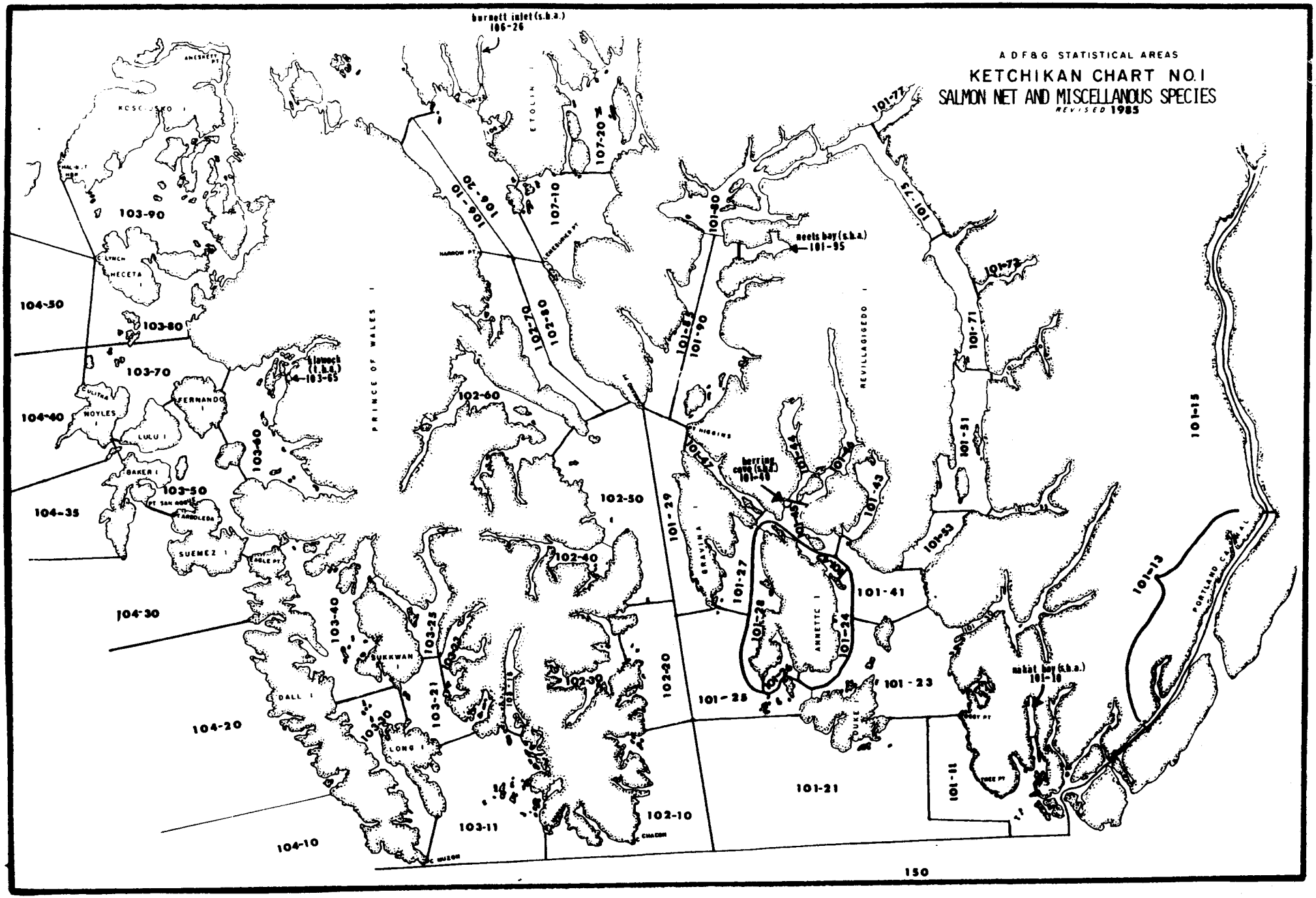

Figure 1. Alaska Department of Fish and Game commercial fisheries harvest statistical areas for Southern Southeastern Alaska.

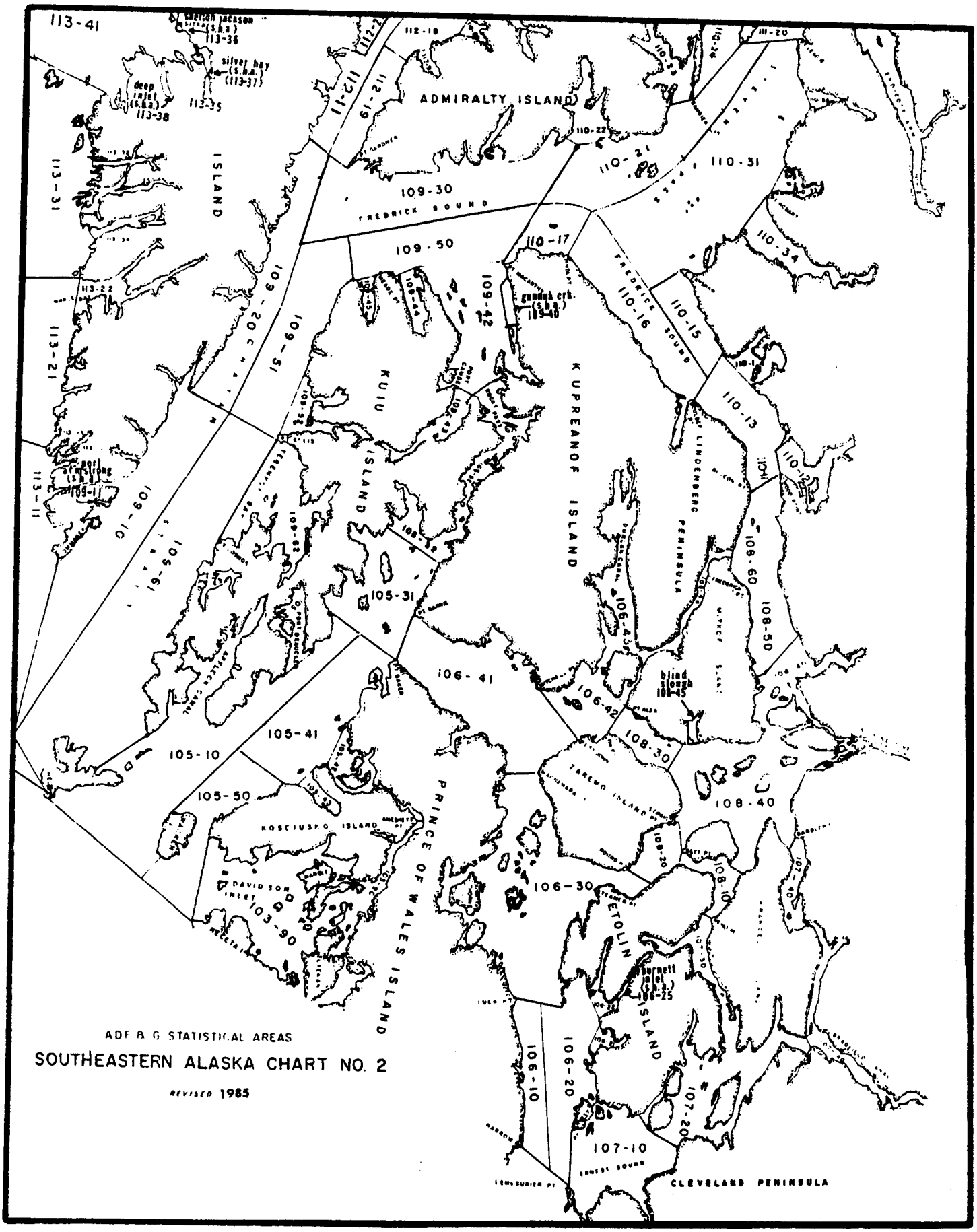

Figure 2. Alaska Department of Fish and Game commercial fisheries harvest statistical areas for Central Southeastern Alaska.

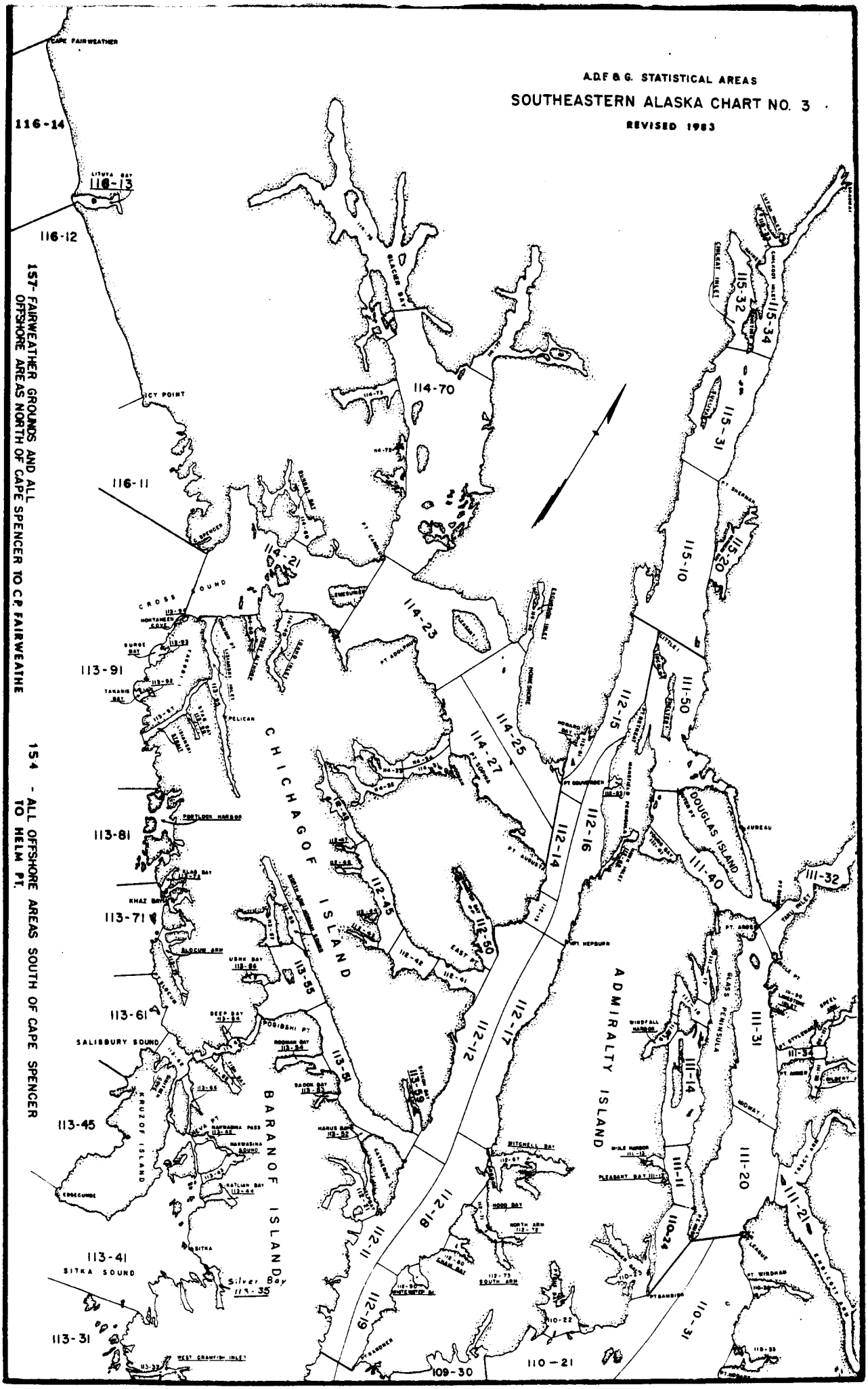

Figure 3. Alaska Department of Fish and Game commercial fisheries harvest statistical areas for Northern Southeastern Alaska.

and reliable test for PSP must be developed so that an unprocessed product can be marketed (T. Koeneman, pers. comm.).

Geoduck clams are harvested on a very limited scale by coastal residents for personal use. This harvest is conducted by SCUBA divers. Other species of clams are commonly harvested for personal use in southeastern Alaska (Gmelch and Gmelch 1985): butter clams (*Saxidomus giganteus*), Pacific littleneck clams (*Protothaca staminea*), razor clams (*Siliqua patula*), cockles (*Clinocardium nuttallii*), surf clams (*Spisula polynyma*) and horse clams (*Tresus capax*).

It is not known if sea otters will have any impact on geoduck populations. I am aware of only one reference to sea otters feeding on geoducks. Rosenthal and Barilotti (1973) reported finding discarded geoduck shells in sea otter middens off west Chichagof Island in southeastern Alaska. Geoducks are found at depths less than 90 ft; most of them at less than 40 ft, which is well within the diving range of sea otters. It may be that geoduck clams are buried too deeply in the bottom to be easily obtained by otters.

Other species of clams commonly occur in the sea otters diet (Rosenthal and Barilotti 1973, Hines and Loughlin 1980, Garshelis et al. 1986, Johnson 1988). In some instances, sea otters have apparently been responsible for reductions in abundance of clam populations and size of individuals (Johnson 1982, Estes and VanBlaricom 1985, Miller et al. 1975, Wendell et al. 1986).

Sea Urchins

From 1981 through 1983 small quantities (3,754 lb) of urchins were marketed to evaluate the feasibility of commercial harvesting and exportation of roe, primarily to Japan. There was interest in both red and green sea urchins. Apparently, red urchins, which are larger, are more abundant and widespread; however the green sea urchin is preferred in some markets. In 1984 the first significant harvest occurred; 40,000 lb were marketed. In 1985, 1986, and 1987 about 126,000, 282,000, and 653,000 lb were harvested, respectively, and sold for about $0.20/lb. Primary harvest areas have been the Ketchikan area and waters off northern and western Prince of Wales Island.

The fishery has been managed through collection of harvest data from the fish ticket program and by issuance of the miscellaneous shellfish registration-permit form. A season (1 October-31 January) and a size limitation (3.5-5.0 in) have been established. Because of very limited knowledge of the biology of these species in southeastern Alaska,

management has been restricted almost entirely to limiting harvests in specific areas to low levels and then requiring fishermen to move into other areas to prevent local depletion and to assist in the exploratory process. Very limited harvests of sea urchins for subsistence purposes occur (Mills 1982, Gmelch and Gmelch 1985).

It has been well documented in numerous studies that sea urchins are (1) a major prey of sea otters, (2) among the first prey utilized when otters move into an area, and (3) reduced both in size and abundance by otter predation (Lowry and Pearse 1973, Estes and Palmisano 1974, Duggins 1980, Estes and VanBlaricom 1985). Rosenthal and Barilotti (1973) found that red sea urchins composed 83% of identifiable food items in sea otter middens off west Chichagof Island in southeastern Alaska. Soon after Surge Bay and Deer Harbor in southeastern Alaska had been repopulated by sea otters, Duggins (1980) found low densities of urchins (all of which were small and concealed under rocks); however, the bottom was littered with broken urchin tests, evidence of their past abundance.

To quote Estes and VanBlaricom (1985): "There can be little doubt that presence of sea-otters is incompatible with red urchin fisheries." Anywhere that otter populations become established in southeastern Alaska, urchin densities and size will likely be reduced to such levels that human utilization will be precluded.

Abalone

Commercial harvests of this species, which began in the early 1960's, were small (<20,000 lb) and variable until 1978 when 181,000 lb were marketed. A combination of factors, including a reduced supply of abalones on the world market, acceptance of the northern abalone in the Japanese market, favorable exchange rates for the yen, and liberal harvest regulations, resulted in greatly increased harvests. From 1978 through 1980 the annual harvest of abalones in southeastern Alaska averaged about 262,000 lb. Since that time harvests have declined to much lower levels: about 76,000 lb, 54,000 and 63,000 lb in 1985, 1986 and 1987, respectively. With prices of about $3.10/lb the ex-vessel value of the fishery ranged between $167,000 and $235,000 for the past 3 years. The decline in harvest can be attributed to more restrictive regulations as well as reduced abundance of legal-sized abalones. The early, large harvests were probably taken from climax populations with many old and large individuals. Currently, it is primarily a recruit-based fishery probably complicated by low and sporadic recruitment. Southeastern Alaska is the extreme northern limit of the range of the species, and environmental conditions suitable for successful reproduction and survival may only occur sporadically.

Management strategies developed for the commercial fishery include a closed season during the spawning and settling season, a minimum legal size to retain some sexually mature individuals in the population, harvest quotas, and area closures.

Some residents of communities near the outside coast harvest abalones for subsistence purposes. Hydaburg, Craig, Klawock, Sitka, Ketchikan, Metlakatla, Elfin Cove, and Pelican are notable among the towns and villages with active abalone harvesters (Mills 1982). The amount of abalone actually consumed by these subsistence users is not great; however, it is a highly valued item often eaten on special occasions (Mills 1982). Most of the harvest occurs within close proximity to these towns, normally within 30 miles. The subsistence fishery is regulated by a minimum size limit (3 in; 3.5 inches in district 113) and a daily bag limit (50).

Northern abalones inhabit rocky areas with an ocean swell influence and are usually found at depths <50 ft. They are found primarily along the outer coast of southeastern Alaska, and 97% of the commercial harvest between 1975 and 1984 was taken from statistical areas 103, 104, and 113 (Table 1, Figures 1-3).

Table 1. Magnitude and ex-vessel value (based on $2.90/lb) of the commercial abalone harvest by district in southeastern Alaska, 1976-1985.

District	Lb	Value ($)	Rank
101	7,886	22,869	5
102	5,519	16,005	7
103	505,931	1,467,200	3
104	774,385	2,245,717	1
105	26,977	78,233	4
106	0	0	10
107	0	0	10
108	0	0	10
109	6,038	17,510	6
110	0	0	10
111	108	313	9
112	0	0	10
113	512,453	1,486,114	2
114	296	858	8
115	0	0	10
All Areas	1,839,593	5,334,820	

Sea otters are known to prey on abalones, particularly in California (Hall and Schaller 1964, Ebert 1968, Hines and Pearse 1982). Abalones have also been recorded as a prey of sea otters in southeastern Alaska (Rosenthal and Barilotti 1973). It is not possible to evaluate the impacts that expanding sea otter populations may have had on the commercial abalone fishery in southeastern Alaska because of (1) the newness of the fishery, (2) the large-scale exploitation that initially occurred, (3) annual variations in quotas, season lengths, and area closures, and (4) the large size of the harvest reporting areas. Estes and VanBlaricom (1985) concluded that in California there was little doubt but that sea otters had eliminated or hastened the decline of some abalone fisheries. It appears probable that significant abalone fisheries will not persist in areas of southeastern Alaska in which sea otters become established.

Dungeness Crab

Commercial harvests of this species in southeastern Alaska have averaged about 1.1 million lb annually since 1960, ranging between 124,000 lb and 4 million lb. Between 1976 and 1985 annual harvests averaged 1.3 million lb (Table 2). Based on the 1983-84 average price of $1.15/lb, the average annual ex-vessel value of this fishery between 1976 and 1985 was 1.59 million dollars. Historically, commercial demand for Alaskan dungeness crab has depended on the availability of crabs from California, Oregon, and Washington. During years when crabs were abundant in these states prices paid to Alaskan fisherman were not high enough to stimulate a large effort. During the late sixties and seventies when catches were high to the south, Alaskan dungeness crab stocks were not fully exploited. Currently all available fishing grounds in southeastern Alaska are fully utilized, and since 1981 annual harvests have averaged about 2.25 million lb. In 1987 the harvest was 3.2 million lb with an ex-vessel value of about 4 million dollars. Only males >6.5 inches in shoulder width can be legally harvested. Closed seasons occur during segments of the molting and mating seasons.

In southeastern Alaska dungeness crabs are found and harvested primarily in bays with mud or sand bottoms, generally at depths less than 15 fathoms. Harvest of dungeness crabs occurs nearly exclusively within the inside waters of southeastern Alaska. Between 1976 and 1985 only 1% of the total commercial harvest came from outside waters (Districts 103, 104, and the outside portion of 113; Figures 1-3). Five of the 15 districts produced 73% of the harvest: districts 105 and 106, the Sumner Strait area; 108, the Wrangell-Stikine River area; 112, upper Chatham Strait; and 114, the Icy Strait-Cross Sound area.

Crabbing is one of the most common subsistence resource harvesting activities in southeastern Alaska (George et al. 1985), and dungeness crabs are the most commonly harvested species. An estimated 55% of the households in predominantly Native communities and 71% of the households in small, non-Native communities participated in subsistence crabbing. Residents of small communities may obtain up to 5% of their meat supply from crabs (Schroeder and Nelson 1983). Most subsistence crabbing occurs relatively close to communities, particularly in sheltered bays that can be reached in small boats. A partial catalog of subsistence dungeness crabbing sites for southeastern Alaska is presented in George et al. (1985). ADF&G regulations provide a subsistence priority around several communities through reduced commercial seasons and area closures to commercial crabbing.

Table 2. Magnitude and ex-vessel value ($1.15/lb) of the commercial dungeness crab harvest by district in southeastern Alaska, 1976-1985.

District	Lb	Value ($)	Rank
101	447,014	514,066	10
102	22,151	25,474	14
103	60,561	69,645	13
104	8,155	9,378	15
105	1,119,526	1,287,455	4
106	2,679,668	3,081,618	2
107	751,636	864,381	7
108	2,374,243	2,730,379	3
109	616,257	708,696	9
110	738,361	849,115	8
111	112,464	129,334	11
112	1,057,973	1,216,669	5
113	899,602	1,034,542	6
114	2,871,123	3,301,791	1
115	73,038	83,994	12
All Areas	13,831,772	15,906,538	

The only area for which dungeness crabs have been reported as an important prey of sea otters is Prince William Sound, Alaska (Garshelis et al. 1986, Johnson 1988). Except for southcentral Alaska, sea otters have not been abundant within the primary range of dungeness crabs in recent times. Most food habit studies have been conducted in California (south of Monterey Bay) and the Aleutian Islands where dungeness crabs are not abundant. As sea otter populations expand into areas supporting large dungeness crab stocks, they may be shown to be an important food item.

The only reasonably good information on the impacts of sea otter predation on dungeness crab populations comes from the Orca Inlet area of Prince William Sound near Cordova, Alaska. Observations in nearby Nelson Bay indicated that adult otters consumed an average of 14 crabs/day, while subadults took 10 crabs/day (Garshelis et al. 1986); over 50% of these crabs were of commercially harvestable size. Surveys indicated a substantial decline in the abundance of crabs after the arrival of large numbers of otters, and it was concluded that otter predation had a major impact on crab numbers (Garshelis et al. 1986). This large influx of sea otters into the Orca Inlet-Nelson Bay area was followed by a >80% decline in the density of dungeness crabs and a closure of crab fishing (Garshelis and Garshelis 1984). Based on this evidence, Estes and VanBlaricom (1985) concluded that there might be the potential for a substantial conflict between sea otters and the dungeness crab fishery along much of the west coast of North America.

Should sea otters move into the inside waters of southeastern Alaska where most of the dungeness crab fishery occurs, it is conceivable that a serious conflict could develop. Most of this fishery takes place in shallow waters (<15 fathoms), which is well within the sea otters feeding range. It is felt by shellfishery biologists that most of the dungeness crab population is present in shallow water, at least seasonally (T. Koeneman, pers. comm.), so they would be readily available as prey. Residents of Elfin Cove, in northern southeastern Alaska, indicated to me that dungeness crabs are no longer abundant in nearby Port Althorp since sea otters moved into the area. For the decade from 1976 to 1985 the dungeness fishery was second only to the tanner crab fishery as the most valuable shellfishery in southeastern Alaska. During recent years (1985-87) the dungeness fishery has been by far the most valuable, with a harvest twice that of tanner crabs.

Tanner Crab

Both the size and value of harvests for this species were the largest of any shellfishery in southeastern Alaska during the period 1976 to 1985 (Table 3). The average annual harvest and ex-vessel value was about 1.8 million lb and 1.9 million dollars (at $1.05/lb), respectively. During this period annual harvests have ranged between 1 and 2.5 million lb. This fishery did not develop in Southeastern until the early 1970's because of low prices due to preference for other species. Harvests peaked from the mid-1970's to 1982 with some years exceeding 2 million lb. Currently, it is thought that all significant stocks of tanner crabs in southeastern Alaska are being fully exploited.

Four districts (110, lower Stephens Passage; 111, Stephens Passage; 114, Cross Sound-Icy Strait; 115, Lynn Canal) produced 84% of the harvest between 1976 and 1985. In recent years there has been a trend of increasing harvests in districts 111 and 115 and decreasing harvests in district 114, the latter an apparent reflection of reduced crab availability. The Southeastern tanner crab harvest is nearly entirely restricted to inside waters. Only 1% of the harvest during the decade 1976-1985 occurred along the outer coast in districts 103, 104, and the outside portion of 113. The fishery occurs primarily in bays in northern and central southeastern Alaska at depths of 30 to 75 fathoms. Tanner crabs concentrate in shallow water seasonally from December through early summer (T. Koeneman, pers. comm.).

Table 3. Magnitude and ex-vessel value ($1.05/lb) of the commercial tanner crab harvest by district in southeastern Alaska, 1976-1985.

District	Lb	Value ($)	Rank
101	14,896	15,641	13
102	0	0	15
103	17,253	18,116	12
104	12,626	13,257	14
105	102,241	107,353	11
106	520,990	547,040	7
107	142,127	149,233	10
108	841,213	883,274	5
109	228,412	239,833	9
110	2,008,739	2,109,176	3
111	4,603,868	4,834,061	2
112	493,305	517,970	8
113	541,330	568,397	6
114	7,484,727	7,858,963	1
115	1,174,133	1,232,840	4
All Areas	18,185,860	19,095,153	

Management of this fishery currently involves an annual quota of 1 million lb and an open season from 15 January through 1 May. In 1987 the quota was reached and season closed on 17 February. Only male crabs with a shell width of 5.5 in or greater can be legally harvested. The fishery is primarily recruit dependent, and there is little annual carryover of legal-sized crabs.

Tanner crabs are harvested by subsistence users, although to a lesser extent than dungeness crabs (George et al. 1985). This is probably due to their more restricted geographic distribution and there tendency to inhabit deeper water and areas more exposed to inclement weather.

Tanner crabs have been reported as a food item of sea otters (Kenyon 1969; Johnson 1988; ADF&G unpubl. data) but have never been found to be a major prey. There is no evidence to indicate that tanner crab populations have been impacted by sea otter predation or that conflicts with fisheries have occurred. However, because (1) they concentrate seasonally in shallow water, (2) are known to be eaten by sea otters, and (3) appear to be an energetically profitable prey, there appears to be potential for conflicts to develop should the distribution of tanner crabs and sea otters overlap in southeastern Alaska.

Red King Crab

Blue king crabs are very limited in abundance and distribution in southeastern Alaska and are biologically similar to red king crabs. Therefore they are included with red king crabs in this report. The commercial fishery for these species, which developed during the 1960's, harvested an average of about 360,000 lb annually during the years 1976 to 1985 (Table 4). Since 1986 the fishery has been closed because of depressed stock levels. Based on the average price of $3.90/lb during 1983 and 1984, the average annual ex-vessel value of this fishery was about 1.3 million dollars, nearly the equivalent value of the much larger harvests of dungeness and tanner crabs.

Table 4. Magnitude and ex-vessel value ($3.60/lb) of the commercial red king crab harvest by district in southeastern Alaska, 1976-1985.

District	Lb	Value ($)	Rank
101	4,437	15,973	12
102	0	0	14
103	2,616	9,418	13
104	0	0	14
105	34,824	125,366	9
106	32,718	117,785	10
107	21,114	76,010	11
108	64,587	232,513	8
109	94,720	340,992	7
110	872,920	3,142,512	2
111	974,442	3,507,991	1
112	257,656	927,562	5
113	668,698	2,407,313	3
114	425,700	1,532,520	4
115	202,436	728,770	6
All Areas	3,656,868	13,164,725	

The commercial red king crab harvest occurs nearly exclusively in the northern portion of southeastern Alaska. Three districts (110, eastern Frederick Sound and lower Stephens Passage; 111, Stephens Passage and Seymour Canal; and the inside waters of 113, the Hoonah Sound area) were particularly important, producing 69% of the harvest during the years 1976 to 1985.

Guideline harvest levels for the fishery are based on ADF&G stock index surveys. The fishing season (1 September through 31 January) was established to afford protection during the congregation period, the major growth period, and the molt and mating seasons. Only male crabs with a carapace width of at least 7.0 in can be legally harvested.

King crabs are also harvested by subsistence users, primarily in northern southeastern Alaska, although to a lesser extent than dungeness crabs (George et al. 1985). Their distribution is more limited, and they often occur in deeper water, making them less accessible for most subsistence harvesters. King crab harvesting requires pots that are heavier, more expensive, and harder to handle than dungeness gear (Leghorn and Kookesh 1987). Maps showing some subsistence king crabbing areas are included in George et al. (1985).

Red king crabs are generally fished in protected bays and inlets at depths of less than 150 fathoms. They occur in shallow water within the diving range of sea otters from December through early summer (T. Koeneman, pers. comm.). Females and juvenile males probably occur in shallow water more frequently than adult males.

As with tanner crabs, king crabs have been reported as a prey of sea otters (Johnson 1988; Kenyon 1969; ADF&G unpubl. data) although not as composing a major portion of the diet. No reports are available indicating that sea otters have had an adverse impact on king crab populations. If eventually red king crab and sea otter distributions overlap in southeastern Alaska and should otters key in on shallow-water concentrations of king crabs as a seasonal food source, they could conceivably reduce abundance and compete with human utilization.

Geographic Distribution of Southeastern Alaska Commercial Shellfish Harvests

In order to identify those areas of southeastern Alaska that have the highest total economic value for the commercial harvest of those species of shellfish that are being fully exploited and are most likely to be impacted by sea otter predation, I summed the values of the abalone, dungeness crab, tanner crab, and red king crab harvests (Tables 1-4)

for the 15 districts (Table 5). Because the size of the districts vary substantially, I was concerned that the total value for each district might be a reflection of the size of the district rather than an indication of concentrations of shellfish resources. In order to evaluate this concern, rough estimates of area were made for each district and then each district was ranked according to total value/area (Table 5). Rank according to total value was then compared to rank according to total value/area of the district, using Spearman's Rank Correlation Coefficient. The two rankings were in substantial agreement ($r_s = 0.81$, $P < 0.01$). This supported the validity of using total value of the harvest as an indicator of the importance of the shellfish resources between districts. Three districts (110 , Stephens Passage; 111, eastern Frederick Sound; and 114, Cross Sound and Icy Strait) were particularly important; when combined they represented 51% of the total value. Districts 110 and 111 were the major king and tanner crab producers, while district 114 had the largest harvests of dungeness and tanner crab in the region.

Table 5. Total value by district of commercial harvest of selected shellfish species, 1976-1985.

District	Total value($)	Rank by value	Area (mi^2)	Value/ Area	Rank by Value/area
101	568,550	14	1,686	337	14
102	41,479	15	585	71	15
103	1,564,378	11	1,100	1,422	11
104	2,268,352	8	2,310	982	12
105	1,598,408	10	678	2,358	9
106	3,746,442	6	681	5,501	5
107	1,089,625	13	279	3,905	7
108	3,846,166	5	385	9,990	3
109	1,307,030	12	1,413	925	13
110	6,100,803	3	895	6,817	4
111	8,471,699	2	841	10,073	1
112	2,662,201	7	932	2,856	8
113	5,496,365	4	3,389	1,622	10
114	12,694,133	1	1,266	10,027	2
115	2,045,603	9	428	4,779	6
Totals	53,501,235		16,868	3,172	

The northern portion of southeastern Alaska (Districts 109-115) produced 71% of the total value, largely because most of the tanner and king crab as well as about half of the dungeness crab harvest occurred in that area. Conversely, the southern districts (101-108) produced 72% of the abalone harvest.

The distribution of commercially harvested abalones and dungeness, red king, and tanner crabs in relation to the exposed, outer coast of southeastern Alaska was striking (Table 6). Commercial abalone harvests occurred nearly exclusively along the outer coast, while the opposite was true for the three crab species which were harvested primarily in the more protected, inside waters. This is thought to accurately reflect the distribution of these species because they are being fully exploited in the southeastern Alaska fisheries (T. Koeneman, pers. comm.).

Currently, sea otter distribution (Figure 4) in southeastern Alaska is mostly limited to portions of the outer coastline, although some animals have moved into Sumner Strait and Cross Sound-Icy Strait area (Part I this report). It is expected (Johnson et al. 1983) that the outer coastline will eventually become continuously populated from Dixon Entrance to well north of Cape Spencer. The extent to which sea otters will populate the inside waters of southeastern Alaska is unclear. Kenyon (1969) found no record that otters ever occurred in the inland waters of southeastern Alaska and assumed that they were distributed only along the outer coast. Sea otter bones were reported as prevalent in middens at Native village sites near Angoon located in the inside waters of Chatham Strait (Vequist 1987 citing de Laguna 1960). The locations where these otters were harvested are unknown, but it is possible that they came from inside waters. Sea otters are distributed throughout the inside waters of Prince William Sound, a somewhat comparable situation to southeastern Alaska. There appear to be no physical or biological barriers to prevent otters from occupying inside waters.

Table 6. Proportion of commercial shellfish harvest which occurred along the outer coast (districts 103, 104 and outside portion of 113), 1976-1985.

Species	Outside harvest(lb)	Outside value($)	Total value($)	%Total value
Abalone	1,782,753	5,169,983	5,334,820	97
Dungeness Crab	471,010	541,662	15,906,538	1
Red King Crab	70,787	254,833	13,164,725	2
Tanner Crab	148,466	155,889	19,095,153	1
Totals	2,473,016	6,122,367	53,501,236	11

The future distribution of sea otters in southeastern Alaska has major implications regarding potential conflicts between sea otter and human utilization of shellfish. Abalones, which occur primarily along the outer coast in areas influenced by ocean swells, appear to be particularly

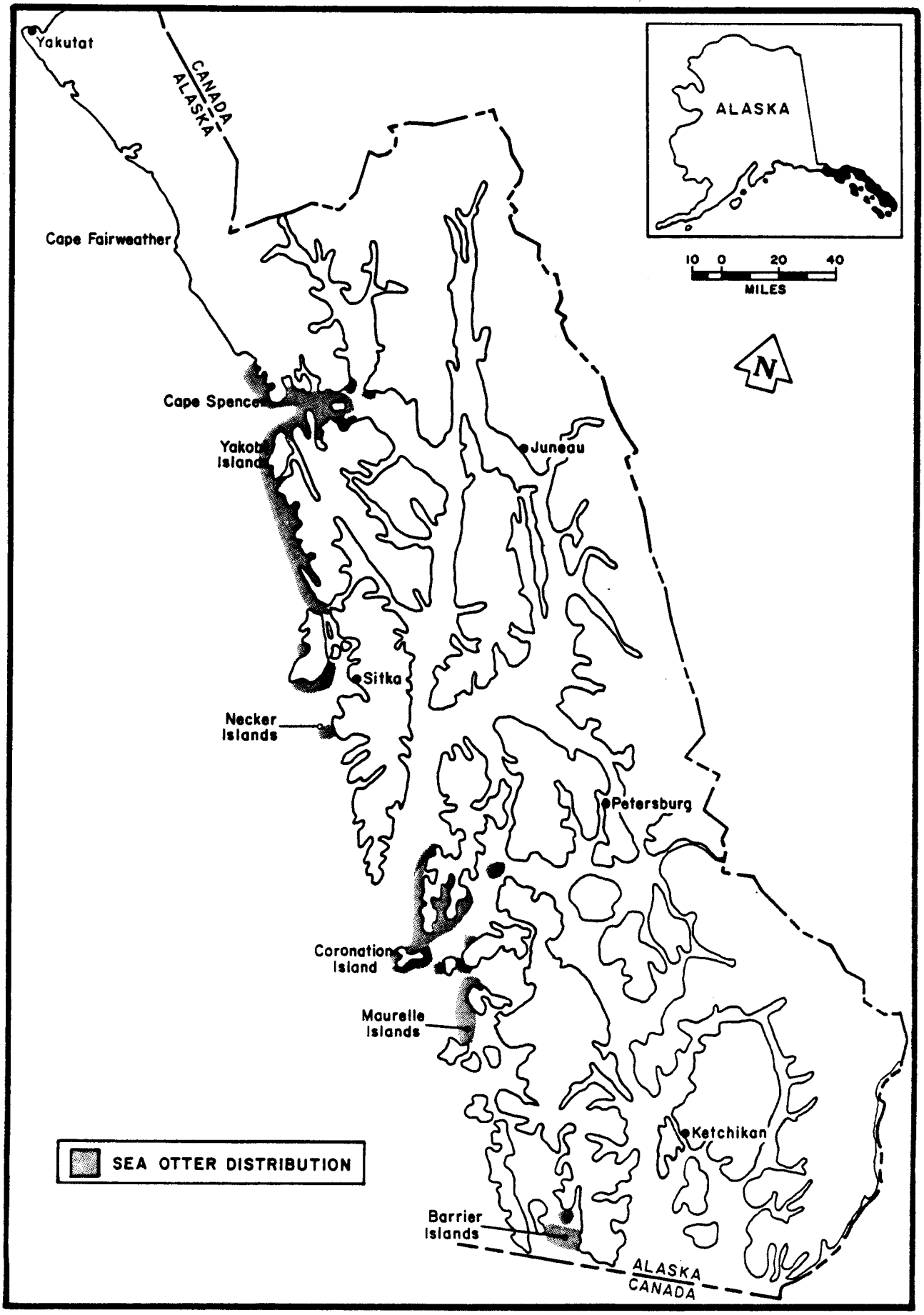

Figure 4. Distribution of sea otters in Southeastern Alaska, 1987 and 1988.

vulnerable to otter predation. Much of the harvest in recent years has come from areas that have not yet been fully populated by otters, including Dall, Lulu, Baker, and Sumez Islands, the Gulf of Esquibel, Sea Otter Sound, southeastern Sumner Strait, and southwestern Baranof Island. All of these areas are likely to eventually support substantial numbers of otters and abalone abundance will probably be reduced, perhaps, to the point that human utilization will become insignificant.

A fishery that is developing on red sea urchins will almost certainly be limited by sea otter predation. Red urchin distribution appears to favor areas influenced by ocean swells; most of these areas will probably be occupied by otters. Harvestable populations of green sea urchins, which favor more protected waters, may persist in some areas, depending on the extent of colonization of inland waters by sea otters.

Much of the range of geoduck clams, which also favor the outer coast, will likely be eventually occupied by sea otters. However the extent to which sea otters will prey upon and impact geoducks is unknown.

The dungeness crab fishery occurs nearly exclusively in inside waters where few otters now occur; however, 2 important dungeness fishing districts are areas in which sea otters appear to be colonizing inland waters. These are districts 105 in western Sumner Strait and 114 in the Cross Sound-Icy Strait area. Other major dungeness districts are 106, eastern Sumner Strait; 108, the Wrangell area; and 112, upper Chatham Strait. The latter two are well inland and will probably not have high otter densities for many years, if at all. It appears that otters have the capability, at least in some situations, to drastically reduce dungeness crab abundance. The potential appears to exist for serious sea otter-dungeness crab fishery conflicts to develop in southeastern Alaska.

The situation is much less clear for red king crabs and tanner crabs. Neither species has been documented as a major prey of sea otters, nor have fishery conflicts been reported. Both species occur seasonally in shallow water within the feeding range of otters and would appear to be suitable prey. Excepting district 114, the primary harvest areas (Tables 3 and 4) are well inland and likely will not have high otter densities for many years, if ever.

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