AERIAL SURVEYS OF SEA OTTERS (*Enhydra lutris)* IN KACHEMAK BAY, ALASKA, 2008

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ABSTRACT

Previous to the 1960s Kachemak Bay had not yet been repopulated with sea otters *(Enhydra lutris)* after the commercial exploitation that lasted from the mid-1700s through the 1800s. In the late 1960s there were sporadic reports of single otters moving into the Bay. An estimate from limited aerial surveys in 1976 suggests there could have been up to 400 sea otters in the Bay and joint bird and otter boat surveys in 1994 estimated about 1000 animals. The first complete abundance survey was flown in 2002 and calculated 912 ± 368 sea otters. Five years later another complete survey was flown and found 3,724 ± 979 animals. A comprehensive marine habitat inventory of Kachemak Bay was undertaken in 2007 and 2008 as part of a feasibility study by the Army Corps of Engineers to assess the impact of constructing navigation improvements for Homer harbor. Information on current sea otter abundance and seasonal distribution in Kachemak Bay was needed as part of this study. To address the first question on population abundance of sea otters, five replicate aerial surveys were flown in Kachemak Bay over the course of one week in May 2008. Our estimate of the overall sea otter population of Kachemak Bay is 3,596 ± 802 animals. The estimated annual rate of increase in Kachemak Bay between 2002 and 2008 was 26% per year which exceeds the maximum productivity rate for this species. It is therefore likely that immigration from other areas has contributed to the observed population increase of sea otters in Kachemak Bay.

To address the question of sea otter distribution in Kachemak Bay, two additional surveys were flown in February and August 2008, respectively. The information from these surveys indicates that sea otters in Kachemak Bay have markedly different seasonal distributions although the north shore, waters adjacent to the Homer Spit, and the area around Yukon Island and Kasitsna Bay remain occupied at all times of the year. The southern fjords are important habitat for otters in the winter months when protection from large storms may be a priority. With the relative calm of the summer, otters are able to utilize more of the Bay especially areas east of Homer Spit where foraging opportunities abound. Information from our distribution surveys corresponds to data collected from 44 sea otters that have been radio-tracked in the Kachemak Bay area since August 2007. It is unclear if this population is at equilibrium or whether there is capacity for more growth so we recommend periodic aerial surveys to monitor the abundance and distribution of sea otters in Kachemak Bay. Possible mitigation measures may include limiting harbor construction activities to summer months when otters are more widely-distributed. Once the new harbor is complete, the additional vessel traffic would likely result in increased disturbance of sea otters, and increased risk of injury or mortality from boat. These potential impacts could be mitigated by regulating vessel speed in areas of known sea otter concentrations.

INTRODUCTION

Prior to the mid-1700s, sea otters *(Enhydra lutris)* occurred in large numbers in coastal areas of Japan, Russia (Kamchatka), the United States (Alaska, Washington, Oregon, and California), Canada (British Columbia), and Mexico (Lensink 1962, Kenyon 1969). Extensive commercial harvests of sea otters occurred from the mid-1700s through the 1800s which drastically reduced the population (Bancroft 1959, Lensink 1962, Kenyon 1969) and eliminated them from much of their range (Kenyon 1969, Riedman and Estes 1990). Sea otters were subsequently protected by the International Fur Seal Treaty in 1911. Sea otter populations were nearly eliminated from Cook Inlet in the early 1900s however, a remnant group was thought to remain in Kamishak Bay on the west side of lower Cook Inlet (Schneider 1976). In the absence of harvest pressure, the population expanded from the 11 remnant groups to re-colonize much of the former sea otter range.

Prior to the 1960s Kachemak Bay had not yet been repopulated with sea otters. In the late 1960s there were sporadic reports of single otters, usually old males, moving into the Bay (Schneider 1976). Sea otters had repopulated the outer Kenai Peninsula in the 1960s and Schneider believed it was these animals that were expanding into Kachemak Bay. In 1975 there was an increase in sightings in offshore areas west of the Homer Spit and reports from residents began to increase (Schneider 1976). In October 1975 Schneider conducted helicopter surveys along the coastline of Kachemak Bay and found 11 otters. From February to June of 1976 Schneider flew monthly surveys in a Grumman Goose in various areas of Kachemak Bay looking for sea otters and found as many as 49 otters. Most of the sightings were in the Seldovia area. Based on his observations, Schneider (1976) estimated there were 400 sea otters in the Bay but that it was a non-breeding population made up of males seeking new territory.

It was twenty years before another survey for sea otters was conducted in Kachemak Bay. From February to March of 1994 U.S. Fish and Wildlife crews used boats and planes to count marine birds and sea otters along the shoreline of Kachemak Bay (Agler et al. 1995). They counted 355 otters by aircraft and 151 by boat. From this they estimated the population of sea otters in Kachemak Bay to be 1,104 ± 592. They also observed mothers and pups which indicated reproduction was now occurring in the Bay.

In 2002 the first complete abundance survey for sea otters in Kachemak Bay was completed and estimated 912 ± 368 animals (USGS unpubl. data). Another complete abundance survey was flown in 2007 using the same observer and method (Bodkin and Udevitz 1999). This survey showed a large increase of sea otters since 2002; 3,724 ± 979 animals.

A comprehensive marine habitat inventory of Kachemak Bay was undertaken in 2007 and 2008 as part of a feasibility study by the Army Corps of Engineers to assess the impact of constructing navigation improvements for Homer harbor. Current sea otter seasonal distribution and abundance data from Kachemak Bay was needed as part of this study. Since the 2007 estimate represented such a big increase, another survey was needed to validate the population status in the Bay. In addition, as these surveys had been conducted during the summer months, there was a need for surveys to document seasonal distribution patterns of sea otters in Kachmak Bay.

Kachemak Bay is located near the western extent of the southcentral Alaska population stock (Gorbics and Bodkin 2001). The southcentral Alaska stock extends from Cape Yakataga to Cook Inlet and includes Prince William Sound, the Kenai Peninsula coast, and Kachemak Bay (USFWS 2008a). The most current Marine Mammal Protection Acts stock assessment report (USFWS 2008a) considers this population to be stable at this time.

If sea otters have indeed increased in Kachemak Bay as indicated by the 2007 survey, resource management conflicts can be expected, including disturbance, injury, and mortality of sea otters due to increased boat traffic. In order to address these management concerns, a comprehensive understanding of sea otter distribution and abundance in Kachemak Bay is needed. This report presents the results of an abundance survey for sea otters that was conducted in Kachemak Bay during May 2008 and distribution surveys that were conducted in February and August of 2008.

METHODS

Study area

The study area is located in Kachemak Bay (59.10°N, 152.00°W by 59.85°N, 150.90°W) on the west side of the Kenai Peninsula in lower Cook Inlet, Alaska (Figure 1). Kachemak Bay is 63 km long and 39 km wide at its entrance between Anchor Point and Point Pogibshi, with more than 515 km of shoreline. Homer Spit projects 7.2 km from the northern shore out into the Bay, dividing it into an inner and outer Bay. The inner Bay is east of the Homer Spit to the head of Kachemak Bay, and the outer Bay is west of Homer Spit to the mouth of Kachemak Bay. Much of the area in the region has been designated as wilderness and is part of the Kachemak Bay National Estuarine Research Reserve managed by the State of Alaska in cooperation with the National Oceanic and Atmospheric Administration. The Reserve manages 1,501 km^2 of the Bay and 2,658 km^2 of its watershed. The U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service also have the responsibility to manage lands and trust resources within these areas. Homer and Seldovia are the two main communities that reside on Kachemak Bay but numerous small settlements exist along the entire shoreline.

Survey Methods

Abundance survey

The purpose of the abundance survey was to estimate the size of the sea otter population in Kachemak Bay by counting otters on specific transects and then correcting for those missed. Only those otters on transect are counted. The survey methodology followed Bodkin and Udevitz (1999), consisting of a stratified random sampling of parallel 400 m-wide strip transects, overlaying the study area and oriented perpendicular to the coastline. To allocate survey effort in proportion to expected sea otter abundance, we separated the survey area into high and low density strata. The entire inner Bay was designated high density stratum while for the outer Bay the high density stratum extended from shore to 400 m seaward or to the 40 m depth contour, whichever was greatest. In the outer Bay, the low density stratum boundary began at the seaward high density stratum boundaries and extended to 2 km offshore or to the 100 m depth contour, whichever was greater. Bays and inlets less than 6 km wide were sampled with high density strata regardless of water depth. The distance between adjacent transects was 4 km in the

high density stratum and 6 km in the low density stratum, thereby sampling approximately 10 and 7 percent of the high and low density strata, respectively.

The survey platform was a Piper PA18 Super Cub (a fixed-wing, single-engine aircraft with tandem seating) with a pilot and one observer. Five complete replicate surveys for Kachemak Bay were flown (7-10 May, and 13 May, 2008; Figures 2-6). There were two days of poor survey conditions between the fourth and fifth replicate surveys. Each survey consisted of a systematic random sample of all possible transects, with a different set of transects selected for each replicate.

All otter sightings were digitized into GIS format in real-time using a tablet PC connected to a Global Positioning System (GPS). A custom-written ArcPad software (ESRI, Redlands, California) application recorded the location, number of otters, and behavior of each otter group.

The survey methodology includes a survey-specific correction factor to account for otters that may be underwater and available for observation, as well as otters at the surface that may not be detected. This correction factor is calculated by conducting intensive search units (ISU) to estimate a correction factor for the proportion of sea otters that were missed by the observer on the strip transects. An ISU consisted of 5 concentric 400 m diameter circles flown within the survey strip. Each ISU is initiated by the sighting of a group (≥ 1 sea otter) only when the time since the previous ISU was > 1 minute. For each ISU, several variables are recorded: 1) whether animals were detected on the strip count or on the subsequent circles within the ISU, 2) location of the group within the ISU, and 3) the behavior of each animal (e.g. diving or non-diving). Sea otters in the initiating group and those that entered the survey area during the course of conducting an ISU are not included in the calculation of the correction factor. However, large groups of sea otters (defined as ≥20 sea otters) were observed until an accurate count or photo was obtained; these were recorded as complete counts.

Distribution survey

The purpose of the distribution survey was to count every otter in Kachemak Bay to provide a comprehensive picture of otter distribution across the Bay rather than a population estimate. The survey area was divided into two segments: 1) nearshore waters adjacent to the coastline; and 2) a series of parallel transects across the bay. The transects were located at equally-spaced interval to prevent double-counting of otters on adjacent transects, while ensuring complete coverage of the area. Unlike the abundance survey methods, no effort was made to correct for otters not detected by observers.

The survey platform was a Cessna 206 (a fixed-wing, single-engine aircraft with four seats; two in front and two in back) with a pilot, two observers, and a data recorder. All otter sightings were recorded using the same tablet PC, GPS, and ArcPad application as the abundance surveys.

Two distribution surveys were completed in 2008; 21-22 February (Figure 7) and 19 August (Figure 8). Due to reduced daylight in February the survey was divided over two days; one to fly the coastline and one to fly the transects across the Bay. In August both the coastline and transect were surveyed in one day.

Data Analysis

Abundance survey

To correct the estimates of sea otter abundance a correction factor is calculated from the ISUs that had 2 or more groups of sea otters. Bodkin and Udevitz (1999) suggest that at least 30 usable ISUs during a survey are needed to calculate a reasonable correction factor from a single replicate. Although 35 useable ISUs was flown during the Kachemak Bay survey a malfunction occurred in the ArcPad program and the data was not properly recorded. Therefore the correction factor used (3.1) was calculated as an average from previous surveys flown by VAG in Kodiak (Doroff et al. in prep) and Yakutat (Gill and Burn 2007). Complete counts were not considered in the calculation of the correction factor, nor was the correction factor applied to these large groups.

The variance in each replicate includes the variance associated with sea otter density between transects and the variance of the correction factor calculated from the ISUs (Bodkin & Udevitz 1999). Finally, we calculated an overall population estimate as the mean and the variance of the five replicate surveys. All resulted presented are ± standard error.

RESULTS

Abundance survey

The corrected population estimates ranged from 1,437 to 5,691 for the five replicate surveys in Kachemak Bay (Table 1). Estimates from the five replicates varied widely primarily due to the number of large groups observed and to the number of otters seen in low density strata. Both of these variables have a significant effect on the final corrected estimate. The mean estimate of the five replicate surveys was 3,596 ± 802.

The corrected population estimate for the first replicate survey was 3,422 ± 919 which is similar to the mean estimate and standard error of the five replicate surveys. The corrected population estimate for the second replicate was 2,344 ± 729. The third replicate survey had the highest corrected population size of 5,691 ± 1,247. The corrected estimate for the fourth replicate was 5,085 ± 1,363. The third and fourth replicates had the highest corrected estimates because of the presence of more sea otters in both high and low density strata. Additionally, several large groups ranging in size from 20-43 otters were observed during these replicates resulting in a higher corrected population estimate than the other replicates. The corrected estimate for the fifth replicate had the lowest corrected population size of 1,437 ± 593. This low estimate is due to the fact that no large groups were observed at all during this replicate and no otters were observed in the low density strata. Immediately after completing this replicate, the lead author noted that the distribution of otters differed markedly from the previous four replicates because of the number of single otters scattered and feeding. A pilot tracking radio-tagged sea otters on the same day in Kachemak Bay also noted that it was hard to find them because of their dispersal (J. DeCreft pers. comm.). It is presumed after the two-day storm that interrupted the survey, otters were taking advantage of the calm weather for intensive foraging. The scattering of otters across the Bay made it more likely to entirely miss animals on transect since it is easier to spot even a very small group than it is a single animal.

Distribution survey

The information from the two distribution surveys indicates that sea otters in Kachemak Bay have marked seasonal distributions. However, there do appear to be areas that are occupied at all times of the year; the Homer Spit, the north shore of both the inner and outer Bay, and the area around Yukon Island and Kasitsna Bay (Figure 9). Waters adjacent to the Spit are especially preferred in winter (Figure 7) while the entire inner Bay is heavily used in the summer (Figure 8). The protected waters of the southern fjords are densely occupied in the winter, especially around Seldovia, compared to the summer. As a comparison the distribution of sea otters during the five abundance surveys conducted in May were also mapped (Figure 10). Although this was not a distribution survey and only sea otters on transect were recorded it provides another snapshot of their distribution in Kachemak Bay albeit a coarser depiction. By May it appears that otters had already have moved out of the southern fjords and into their summer habitat to utilize the northern shore feeding areas.

The distribution of sea otters observed on the two distribution surveys and the five replicate abundance surveys corresponds to data collected from 44 radio-tagged sea otters that have been tracked from August 2007 to present within the Kachemak Bay area (USFWS unpubl. data).

DISCUSSION

The estimate of the overall sea otter population of Kachemak Bay is 3,596 ± 802 animals. The previous abundance survey was conducted in 2007 and estimated a similar number of sea otters; 3,724 ± 979 animals. The only other complete aerial survey of sea otters in Kachemak Bay was flown in 2002 when the population was estimated to number 912 ± 368 animals. All three abundance surveys (2002, 2007, and 2008) were flown using the same methodology. Additionally, the 2002 and 2007 surveys were flown by the same observer.

Other sources of information suggest that the sea otter population in Kachemak Bay has grown significantly since 2002. Over the past several years, the number of stranded sea otters recovered from Kachemak Bay has dramatically increased (USFWS unpubl. data). Larger numbers of stranded sea otters could be a result of either an increase in otter mortality, an increase in population size with a constant rate of mortality, or some combination of both factors. However, local residents and avid beachcombers in the area had never observed stranded sea otters prior to 2000. In 2006 a sea otter Unusual Mortality Event focusing on Kachemak Bay was declared because of large number of animals dying from one syndrome from 2002 to 2006 (Gill et al. in prep). It is clear from the increasing trend in otter numbers from 2002 to 2008 that this mortality event has had no negative impact on population growth.

The annual rate of increase between the 2002 and the 2008 aerial abundance surveys was 26 % per year which exceeds maximum net productivity rate (R_{MAX}) for sea otters, which is estimated to be 20% (Estes 1990). Therefore, some portion of the observed population increase must be the result of immigration. The source of immigration could be movement of otters from the outer Kenai Peninsula coast and from across Cook Inlet in Kamishak Bay. The number of sea otters in Kamishak Bay is estimated to be 6,918 (USFWS 2008b) and the number in Cook Inlet and along the Kenai Peninsula (excluding Kachemak Bay) is 1,761 (USFWS 2008a). Schneider (1976) believed the source population for Kachemak Bay came from the outer Kenai coast and predicted a continued movement of animals into Kachemak Bay from the Peninsula. Also both Schneider (1976) and Agler et al. (1995) believed there was movement across Cook Inlet between Kachemak and Kamishak Bays. The distance between the two Bays (80 km directly west of Kachemak Bay across lower Cook Inlet) is not outside the swimming capability of a sea otter, particularly a female or young male, looking for new resources (Reidman and Estes 1990).

Schneider (1976) predicted Kachemak Bay would eventually support high densities of sea otters which he believed would make it a key area for this species because of its easy public access for wildlife viewing. A possible reason for the large increase of sea otters in Kachemak Bay since 2002 is a recent increase in the Tanner crab (*Chionoecetes bairdi*) population. Crab are a preferred prey item for sea otters (Bodkin et al. 2007) because of their high calorific value. The sport, personal use, and subsistence fishery (sport fishery) for Tanner crab in Kachemak Bay was closed from 2002 to 2008 because of a lack of legal-sized crab (Charles Trowbridge ADFG pers. comm.). However, beginning 15 July 2008 the Alaska Department of Fish and Game (ADFG) re-opened the sport fishery in Kachemak Bay and lower Cook Inlet because crab numbers had recovered enough to support a harvest. But tanner crab numbers have not recovered enough to reopen the commercial fishery which has been closed since 1994 in all fishing districts of the

Cook Inlet Management Area. The increase of this valuable prey resource since 2002 may have increased sea otter reproduction (see von Biela et al. in press) as well as driven immigration into the Bay. A continued increase in Tanner crab abundance may facilitate further sea otter population growth in Kachemak Bay.

It is not clear whether the population of sea otters in Kachemak Bay is at equilibrium or whether there is capacity for more growth. Based on density estimates from this survey there are 5.1 otters/km^2 in the Bay which is comparable to other populations in south central Alaska (USGS unpubl. data). Although the 2007 and 2008 estimates from Kachemak Bay are similar, the data are not sufficient enough to speculate that the population has reached carry capacity. Another survey in a few years is needed before this could be considered.

The seasonal distribution patterns of sea otters observed in Kachemak Bay indicate the north shore of both the inner and outer Bay are utilized year round. An extensive shallow shelf extending from this shore provides good foraging habitat for these typically shallow divers. The waters around the Spit are also used throughout the year, although more so in the winter. The protection the Spit provides in any wind direction may be crucial for resting animals throughout the year, especially mothers with pups in the summer months. The Spit is also a location where many sick and dying otters haul out (USFWS unpubl. data). The protected waters around Yukon Island and Kasitsna Bay are also used extensively year round, which tends to be an area that mothers and pups inhabit (USFWS unpubl. data). Schneider (1976) and Agler et al. (1995) also observed that the Yukon Island area, Seldovia, and the north shore were heavily utilized areas.

The southern fjords and sheltered bays are important habitat for otters in the winter months when protection from large storms is a priority. Both Schneider (1976) and Agler et al. (1995) commented on the preference for these areas during their respective winter surveys. With the relative calm of the summer, otters are able to utilize more of the Bay especially males (USFWS unpubl. data) in the mid-inner Bay where foraging opportunities abound. It is clear that weather conditions, foraging opportunities, and gender dictate where sea otters reside throughout the year and their seasonal habitat use should be taken into consideration with any activities in Kachemak Bay that may impact them.

Recommendations

This survey method provides a means of comparing population abundance over time and is readily repeatable over longer time intervals (e.g. every 5-10 years). There was considerable variability in the abundance estimates in the replicate surveys used to estimate abundance. Sea otters are highly mobile and large groups of animals can influence the variation among transects considerably. For example, the high estimates of 5,691 and 5,085 otters on the third and fourth replicates, respectively, were the result of large groups and otters in low density habitat. In contrast there were no large groups or otters observed in low-density habitat, resulting in the lowest estimate of 1,437. These numbers suggest that a single replicate using this survey method is unsuitable for estimating the sea otter population in Kachemak Bay. In order to estimate population size with acceptable accuracy and precision, multiple replicates should be conducted. We also suggest that for future surveys of Kachemak Bay all habitat be considered high density stratum since numbers were similar between the two strata during this survey. This should help

in decreasing the variability between replicates. Another opportunity to decrease variability between replicates would be to increase the percentage of habitat sampled. However, since the goal is to complete a replicate in one day, that may not be feasible.

We recommend periodic aerial surveys to monitor the abundance and distribution of sea otters in Kachemak Bay to establish a population trend. The development of new harbor facilities in Homer may affect sea otters in several ways. Possible mitigation measures to minimize disturbance may include limiting harbor construction activities to summer months when otters are more widely-distributed. Once the new harbor is complete, the additional vessel traffic would be result in increased disturbance of sea otters, and increased risk of injury or mortality from boat. These potential impacts could be mitigated by regulating vessel speed in areas of known sea otter concentrations.

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Table 1. Results for the five replicate aerial surveys of sea otters in Kachemak Bay, May 2008.

Replicate	Survey Stratum	Group Size[a]	Sea Otters Counted	Area Sampled (km^2)	Density (otters/km^2)	Stratum Area (km^2)	Uncorrected Population Size	Correction Factor	Corrected Population Size	Standard Error
1	High	Small	76	68.71	1.11	704.70	779	3.1	2,416	
	Low	Small	25	20.06	1.25	260.40	325	3.1	1,006	
	Total	**All**	**101**	**88.77**	**1.18**	**965.10**	**1,104**	**3.1**	**3,422**	**919**
2	High	Small	53	68.36	0.78	704.70	546	3.1	1,694	
		Large	50	68.36	0.73	704.70			515	
	Low	Small	3	18.02	0.17	260.40	43	3.1	134	
	Total	**All**	**106**	**86.38**	**0.56**	**965.10**		**3.1**	**2,344**	**729**
3	High	Small	114	68.09	1.67	704.70	1,180	3.1	3,658	
		Large	92	68.09	1.35	704.70				
	Low	Small	27	20.15	1.34	260.40	349	3.1	1,081	
	Total	**All**	**233**	**88.24**	**1.45**	**965.10**	**2,481**	**3.1**	**5,691**	**1,247**
4	High	Small	107	74.95	1.43	704.70	1,006	3.1	3,119	
		Large	70	74.95	0.93	704.70			658	
	Low	Small	24	20.19	1.19	260.40	310	3.1	960	
		Large	27	20.19	1.34	260.40			348	
	Total	**All**	**228**	**95.14**	**1.22**	**965.10**		**3.1**	**5,085**	**1,363**
5	High	Small	50	76.00	0.66	704.70	464	3.1	1,437	
	Low	Small	0	19.66	0.00	260.40	0	3.1	0	
	Total	**All**	**50**	**95.66**	**0.66**	**965.10**	**464**	**3.1**	**1,437**	**593**

[a] Small groups (<20) were used to generate the corrected population estimate and large groups (≥20) were treated as complete counts and added into the total estimate.

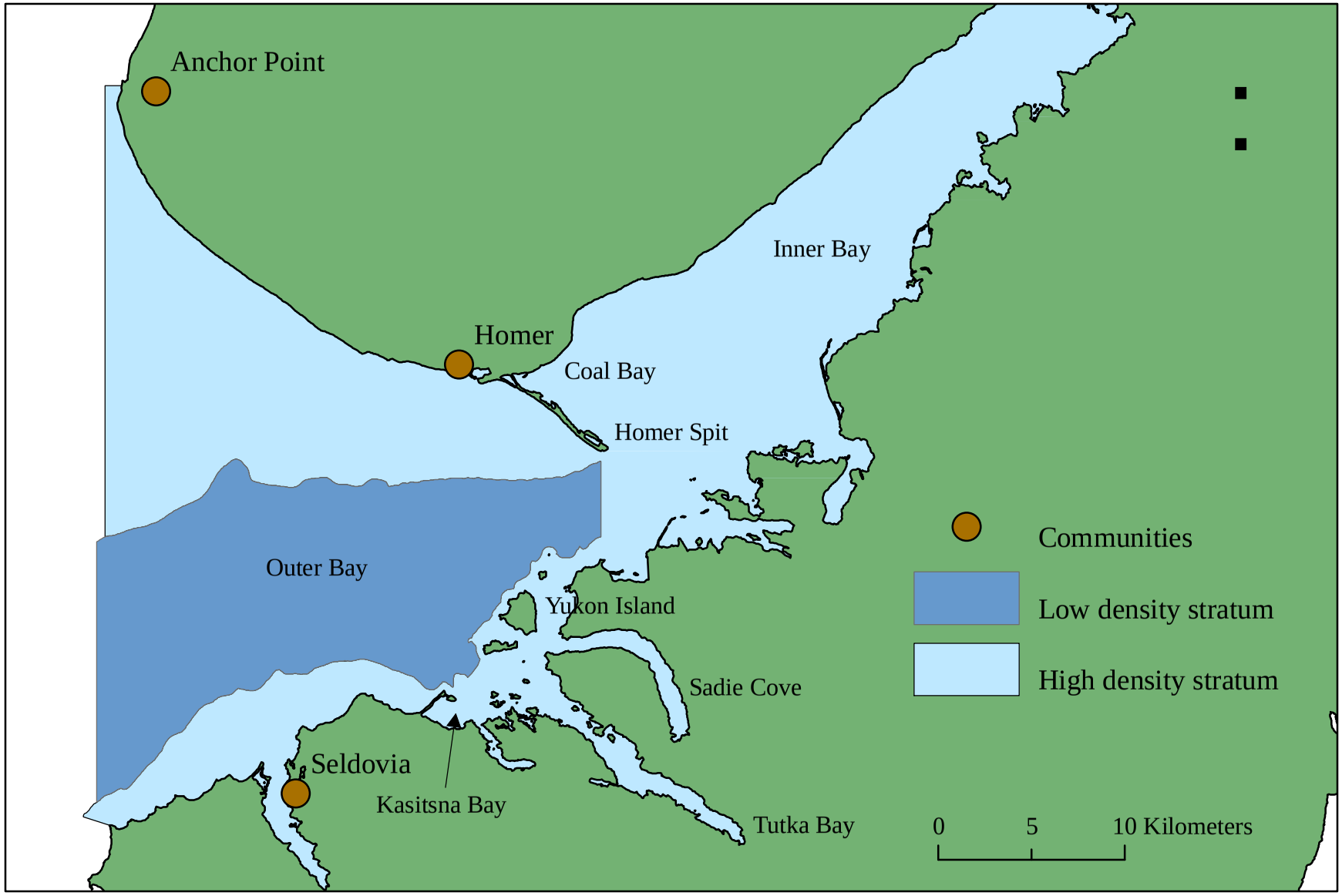

Figure 1. Study area of the 2008 sea otter aerial surveys in Kachemak Bay

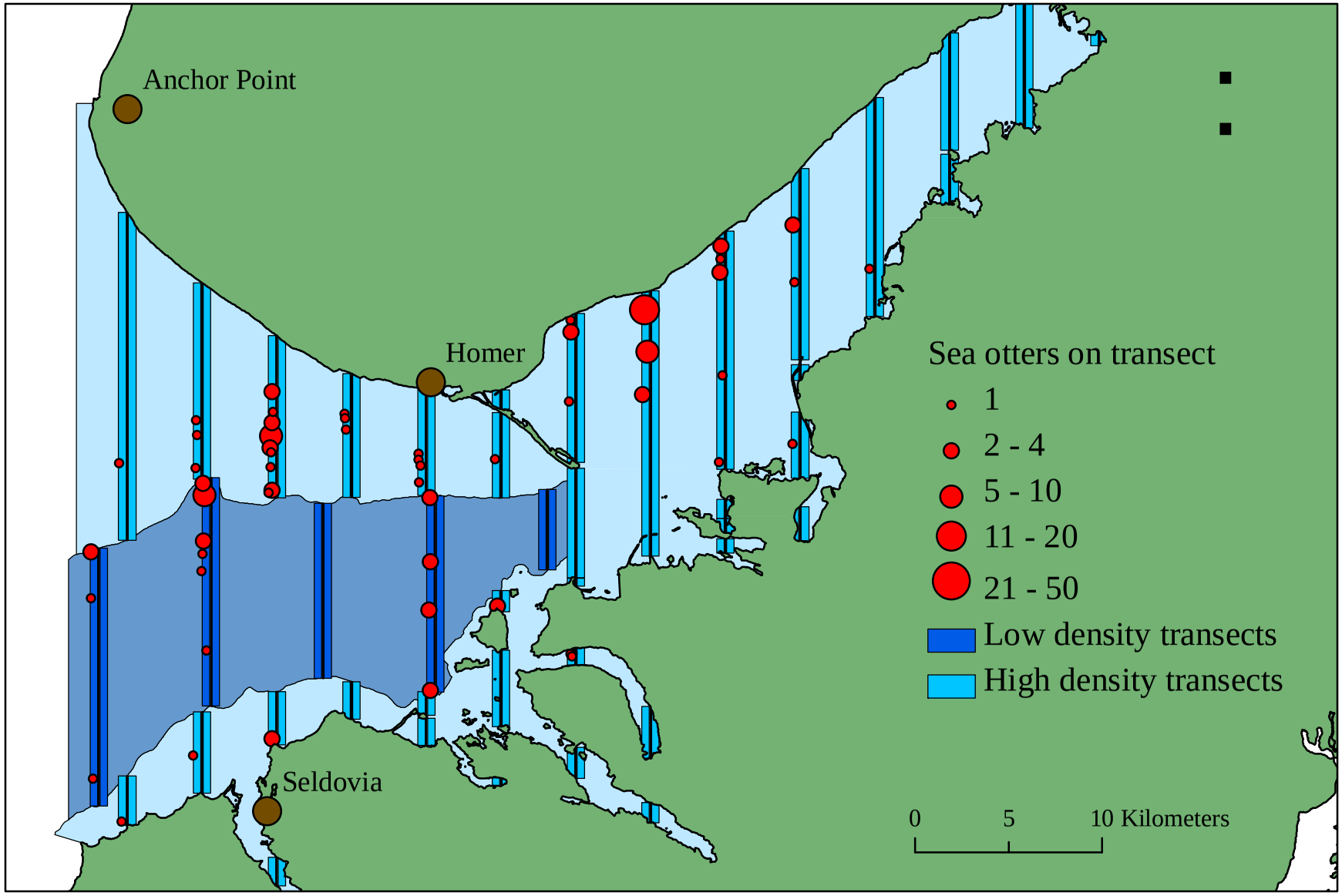

Figure 2. Survey transects and sea otter sightings for the first replicate of the aerial survey of Kachemak Bay conducted 7 May 2008

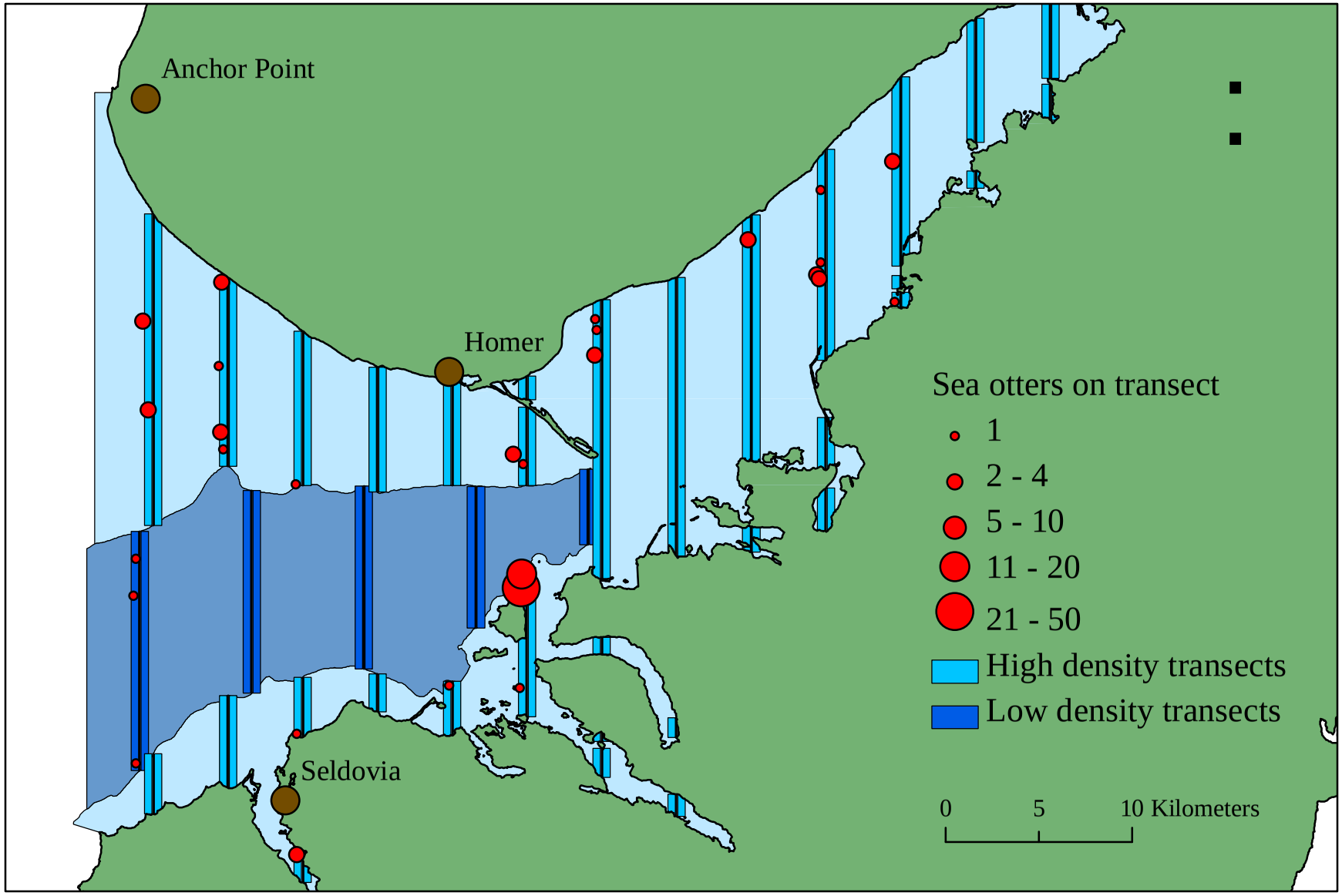

Figure 3. Survey transects and sea otter sightings for the second replicate of the aerial survey of Kachemak Bay conducted 8 May 2008

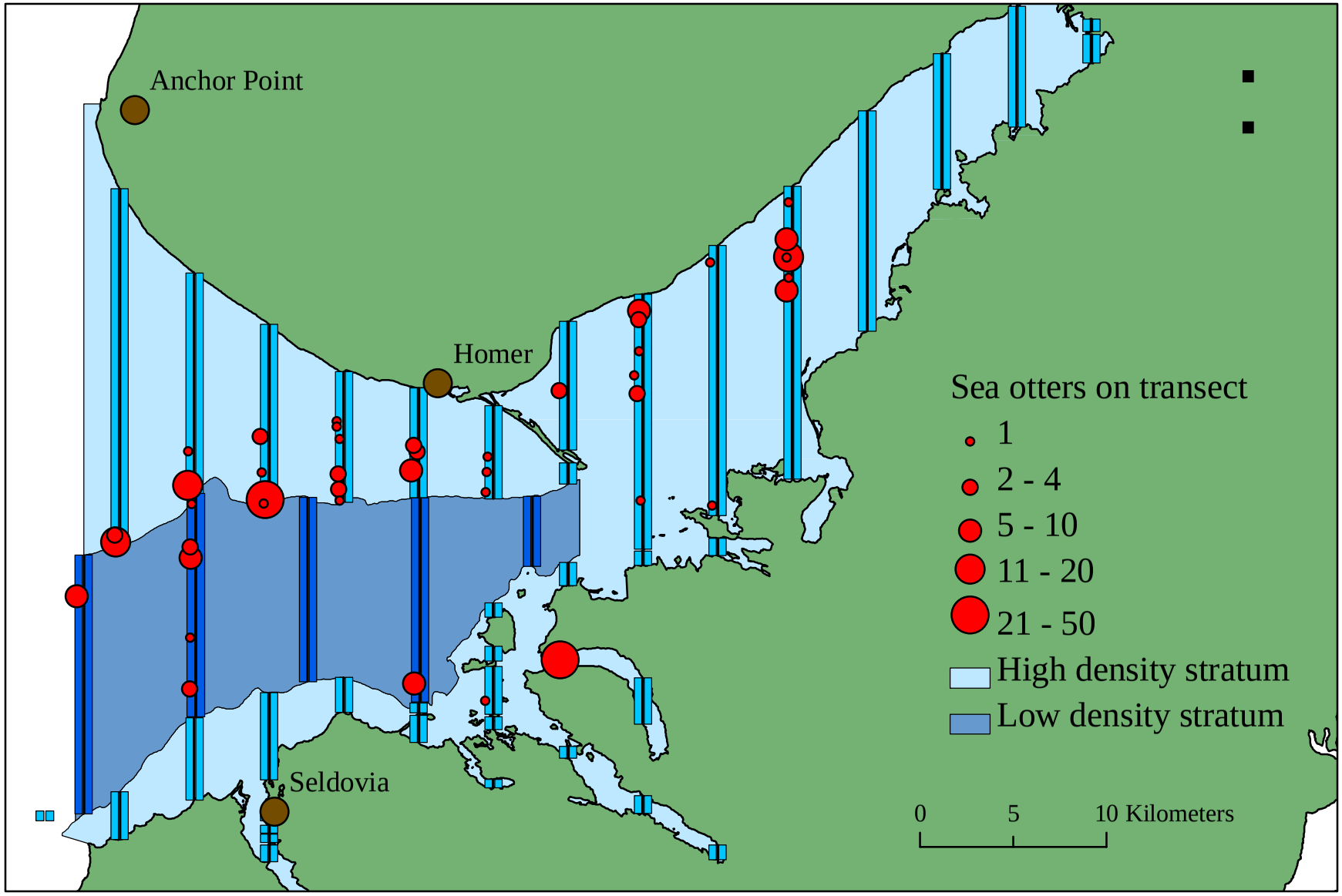

Figure 4. Survey transects and sea otter sightings for the third replicate of the aerial survey of Kachemak Bay conducted 9 May 2008

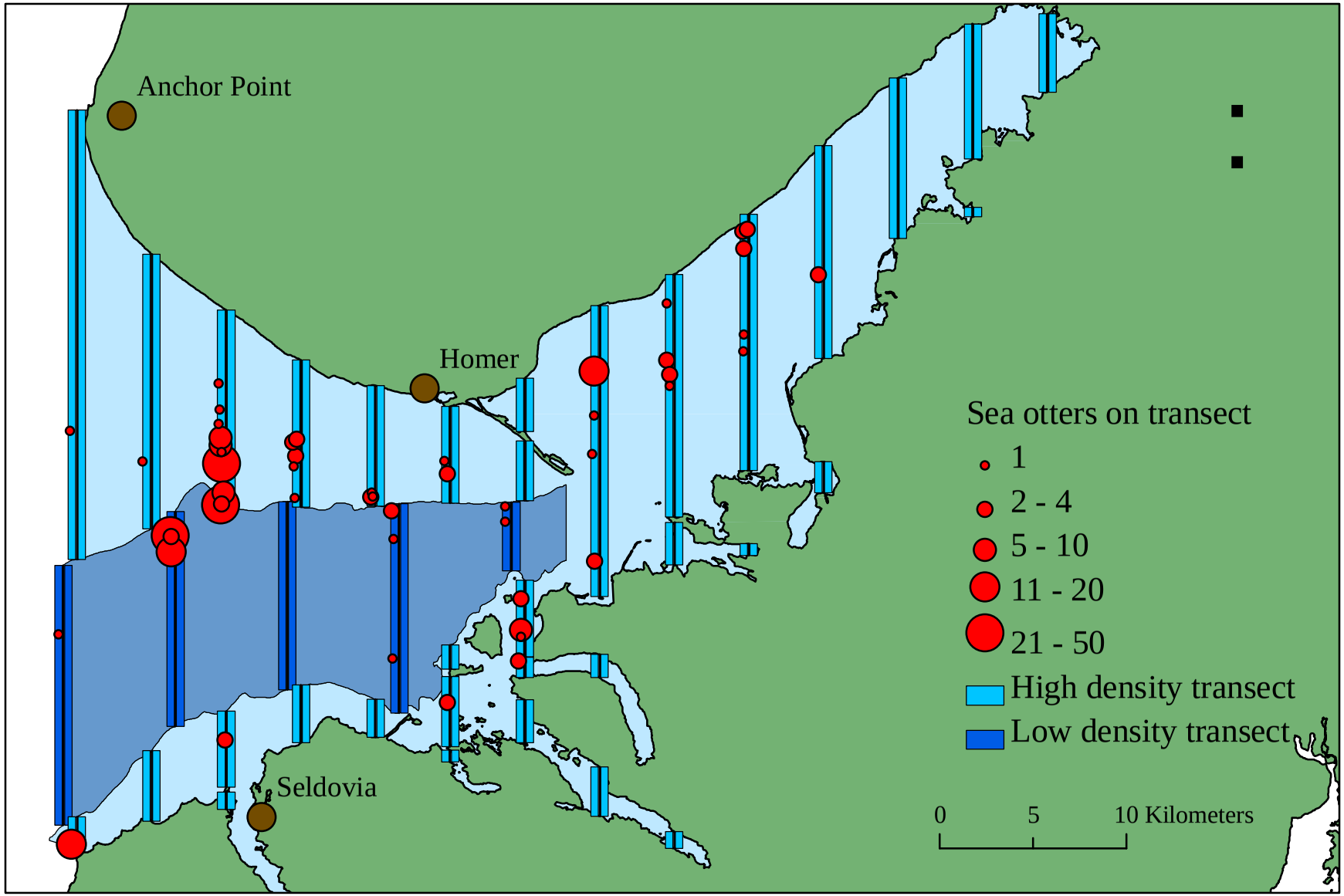

Figure 5. Survey transects and sea otter sightings for the fourth replicate of the aerial survey of Kachemak Bay conducted 10 May 2008

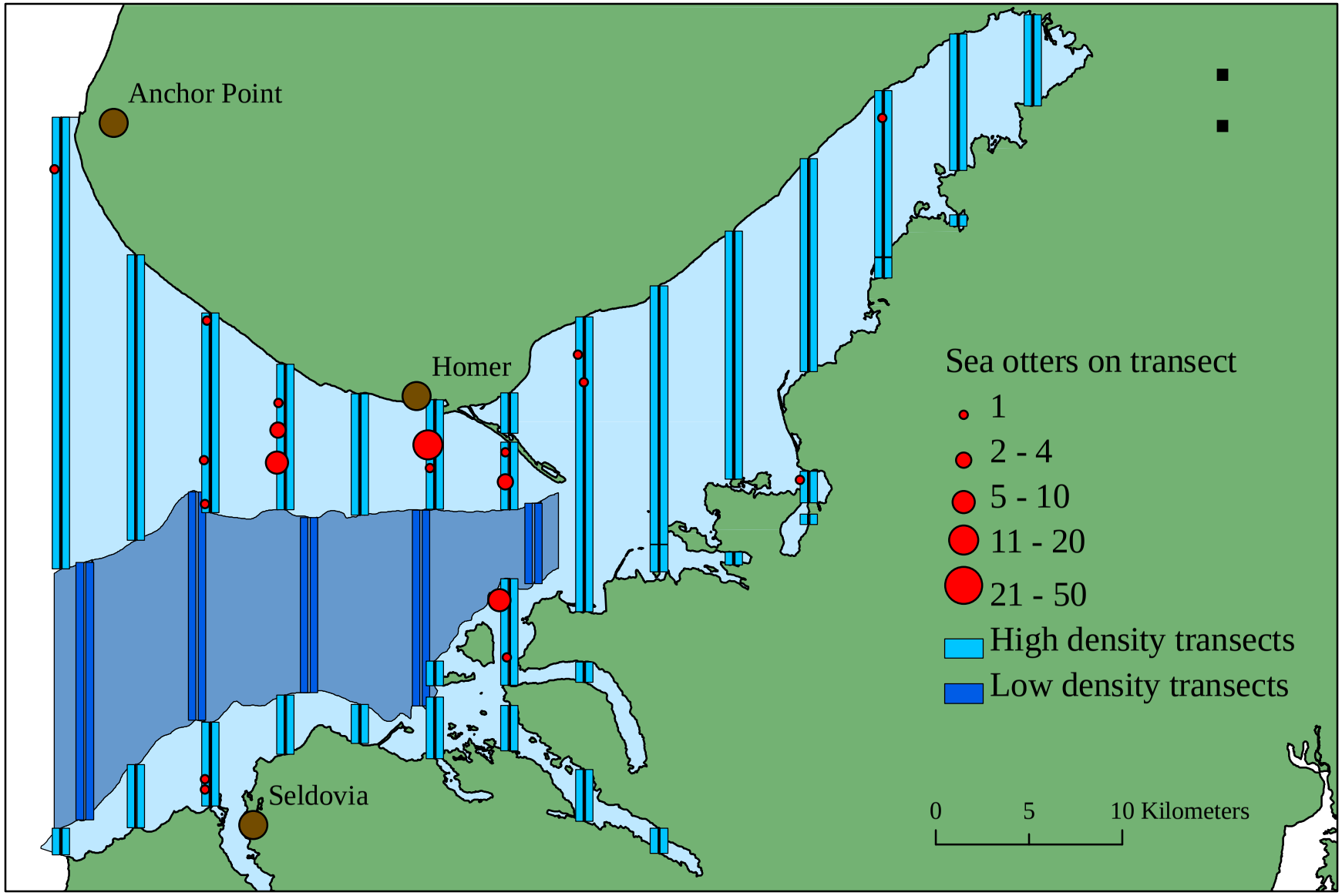

Figure 6. Survey transects and sea otter sightings for the fifth replicate of the aerial survey of Kachemak Bay conducted 13 May 2008

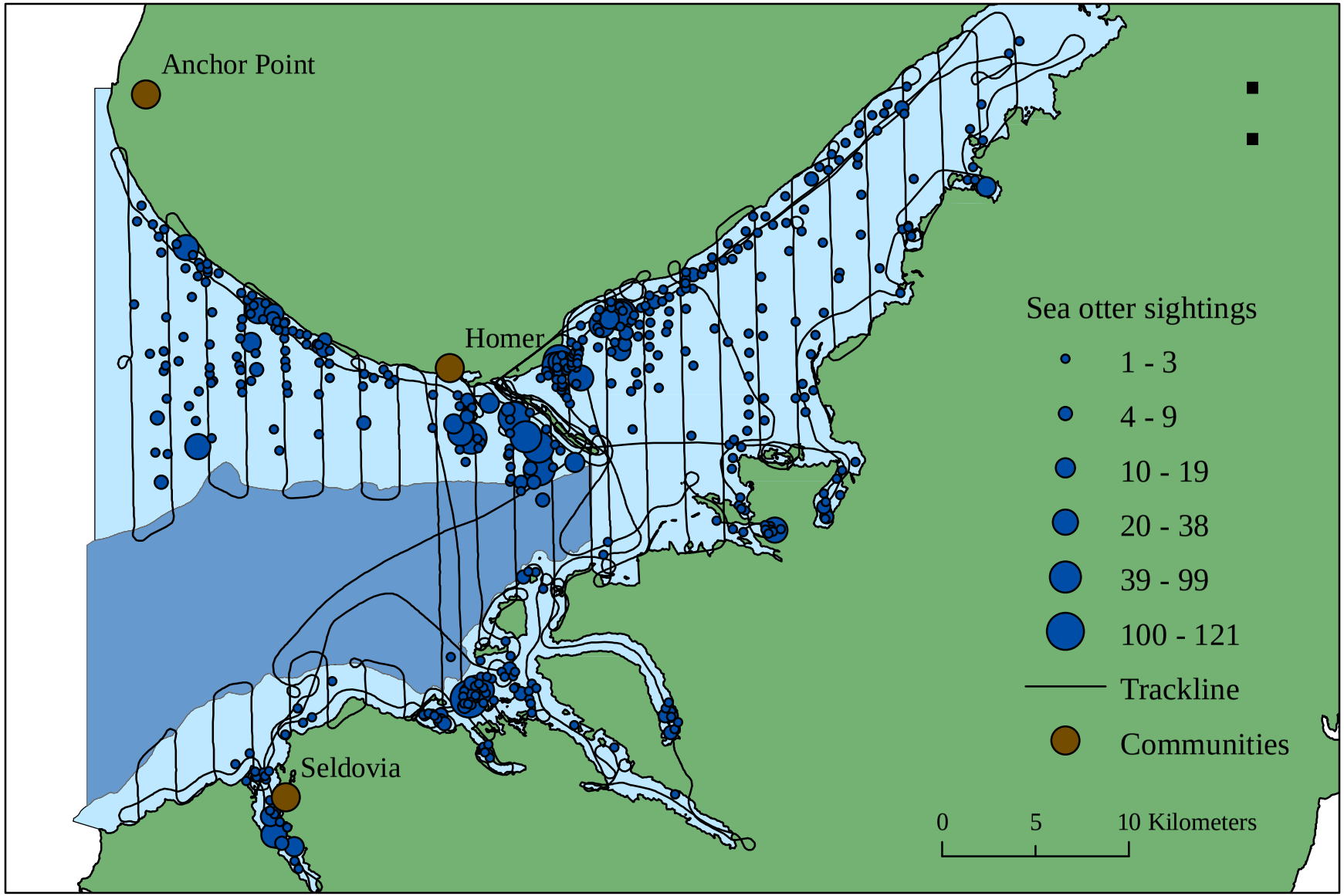

Figure 7. Trackline and sea otter sightings for the winter distribution survey, 21-22 February 2008

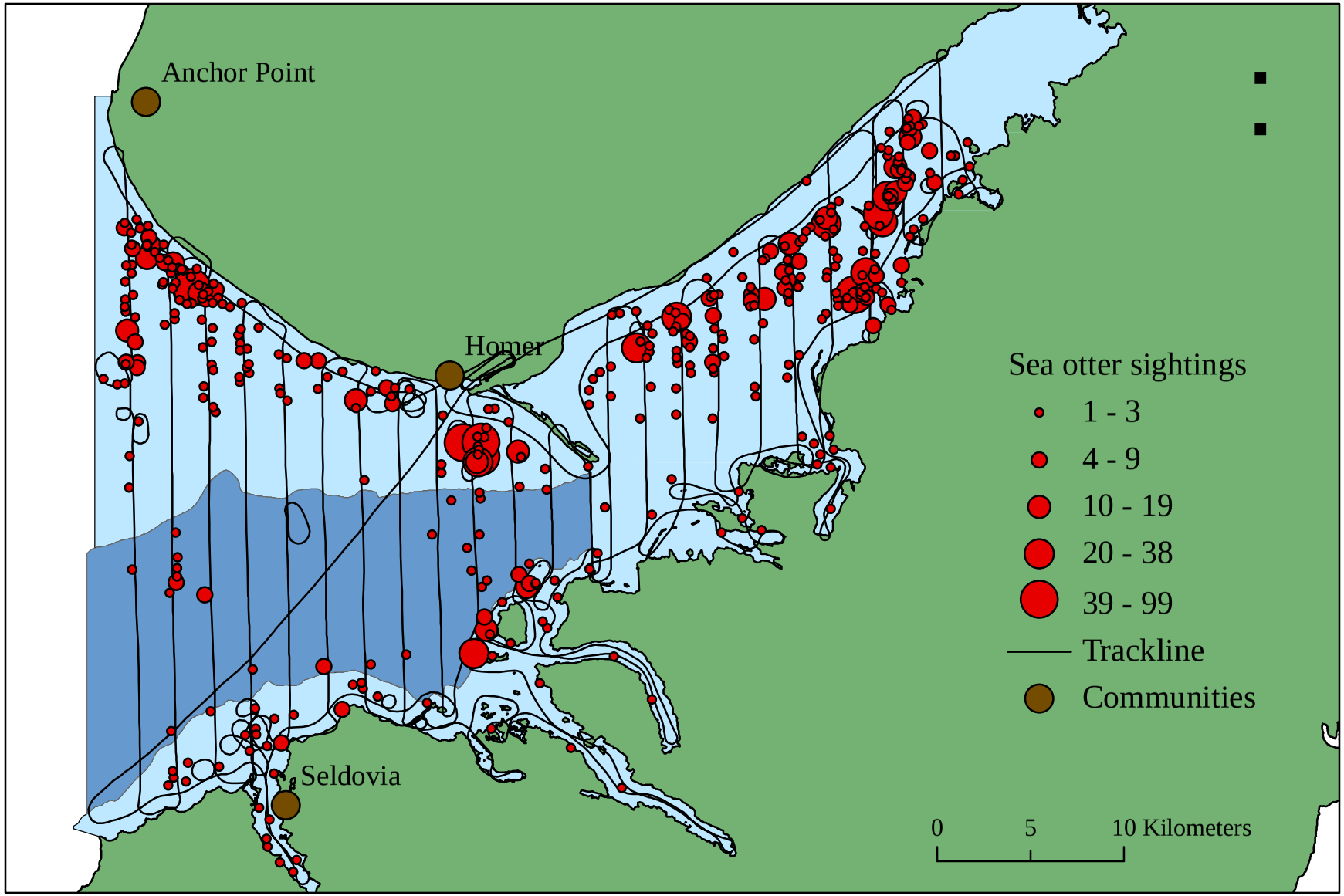

Figure 8. Trackline and sea otter sightings for the summer distribution survey, 19 August 2008

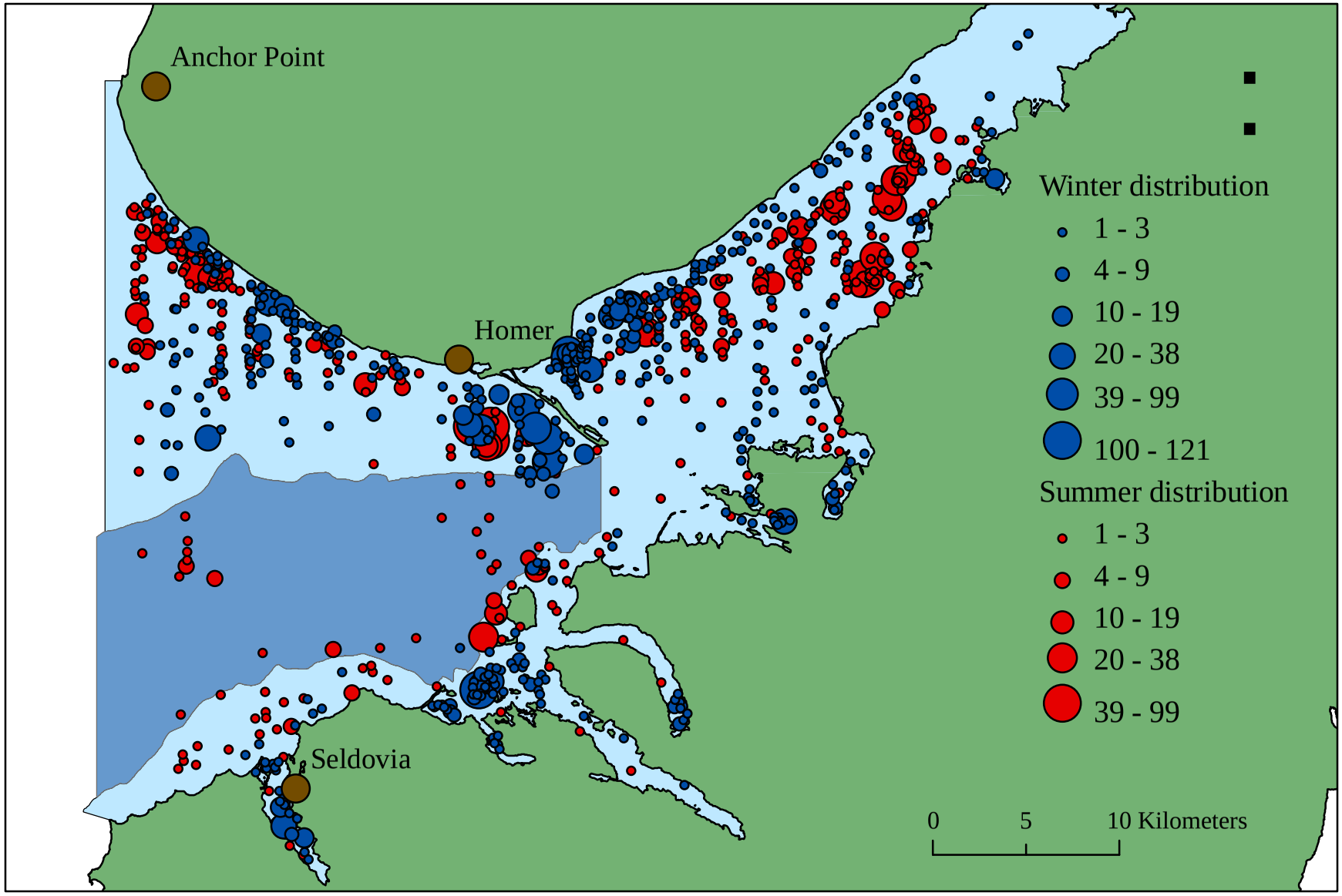

Figure 9. Winter and summer distribution of sea otters in Kachemak Bay, Alaska 2008

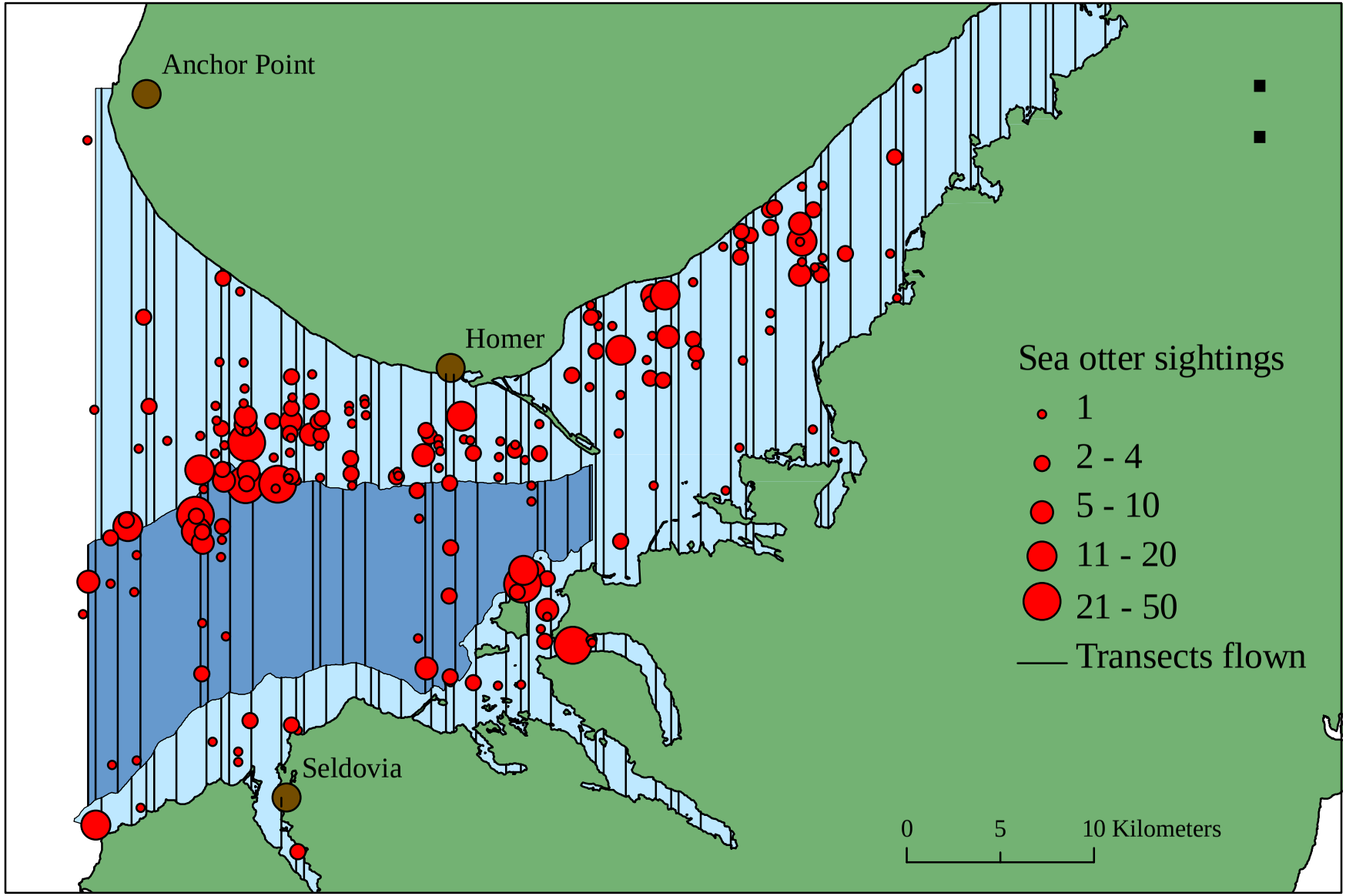

Figure 10. Distribution of sea otters in Kachemak Bay during the spring abundance survey, 7-13 May 2008