Exxon Valdez Oil Spill
Restoration Project Final Report

Trends in Sea Otter Population Abundance in Western Prince William Sound: Progress toward Recovery Following the 1989 *Exxon Valdez* Oil Spill

Restoration Project 10100750-Amendment
Final Report

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STUDY HISTORY: Sea otter populations in western Prince William Sound (WPWS) were injured as a result of the 1989 *Exxon Valdez* oil spill (EVOS) (Ballachey et al. 1994). The U.S. Geological Survey, Alaska Science Center conducted aerial surveys of sea otters in Prince William Sound from 1993-2011. Analysis of surveys conducted through 2000 describes significant increases in abundance in much of the spill area (Bodkin et al. 2002), but that in areas most severely influenced by the spill, no increases were evident and abundance remained at about half the pre-spill level (Dean et al. 2000). Subsequent to 2000, aerial surveys were conducted under EVOS Projects –0423, –0620, –0808 and most recently under Project 1007050 Amendment, and are reported herein.

ABSTRACT: Sea otters in western Prince William Sound (WPWS) and elsewhere in the Gulf of Alaska suffered wide-spread mortality as a result of oiling following the 1989 T/V *Exxon Valdez* oil spill. Following the spill, extensive efforts have been directed toward identifying and understanding long term consequences of the spill and the process of recovery. We conducted annual aerial surveys of sea otter abundance from 1993-2011 (except for 2001, 2006, and 2010) in WPWS. We observed an increasing trend in population abundance at the scale of WPWS through 2000 at an average annual rate of 4%. However, at northern Knight Island where oiling was heaviest and sea otter mortality highest, no increase in abundance was evident by 2000. We continued to see a significant increase in abundance at the scale of WPWS between 2001 and 2011, with an average annual rate of increase from 1993-2011 of 2.6%. We estimated the 2011 population size of WPWS to be 2,896 (se = 392). The modeled population size in 2011 (3,427), based on linear regression, is nearly 1,400 more than the first post-spill estimate in 1993. Surveys since 2003 have also identified a significant increasing trend at the heavily oiled site in northern Knight Island, averaging about +23% annually and resulting in a 2011 estimated population size of 148 (se = 25). The 2011 estimate for northern Knight Island is approximately 10% less than the pre-spill estimate of 165. We interpret the trends in sea otter abundance in western Prince William Sound and at Knight Island as strong evidence of a trajectory toward recovery of spill-affected sea otter populations in WPWS.

KEY WORDS: population estimates, sea otters, trends, Prince William Sound.

PROJECT DATA: Data gathered include numbers, locations and behaviors of adult and dependent pup sea otters in Western Prince William Sound, Alaska between the shoreline and the 100 m depth contour. Data are obtained by a single observer from a single engine aircraft along predetermined transects from an altitude of 97m. Incorporated into the data collection is a procedure for estimating the detection probability of sea otters observed along transects during the survey. Additional data are collected on the numbers and locations of other marine mammals. These data are available in Microsoft Excel or Access data sets. Data are housed at:

US Geological Survey, Alaska Science Center, 4210 University Dr., Anchorage, Alaska 99508, Contact: Dan Esler (desler@usgs.gov).

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Introduction

Sea otter populations in western Prince William Sound (WPWS) were injured as a result of the 1989 *Exxon Valdez* oil spill (EVOS) (Ballachey et al. 1994). Effects included both acute mortality, resulting from contact with spilled oil in the days and months following the spill, and chronic effects, resulting from sub-lethal initial exposure or protracted exposure to lingering oil, or indirect effects, e.g., reduced prey populations or other ecosystem disturbances (Peterson 2000, Peterson et al. 2003). Estimates of sea otter mortality due to acute effects of the oil spill in WPWS ranged from 750 to 2,650 individuals (Garrott et al. 1993, Garshelis 1997). The disparity among acute mortality estimates largely reflects the lack of accurate pre-spill estimates of sea otter population size. Using population models, Udevitz et al. (1996) predicted recovery of the WPWS sea otter population in 10 to 23 years, with maximum annual growth rates from 0.10-0.14.

Since 1993 we have conducted aerial surveys of sea otter populations in WPWS annually to track the progress of sea otter recovery, except in 2001, 2006, and 2011. Results of sea otter population surveys through 2000 demonstrated a significant increase of nearly 600 animals in WPWS, resulting in a statistically significant average annual increase of 4% per year since 1993 (Bodkin et al. 2002). This increase at the scale of WPWS was considered indicative of progress toward recovery, although the average annual rate of increase was about half the long-term growth rate experienced in PWS earlier in the 20th century (Bodkin et al. 2002). Additionally, Dean et al. (2000) and Bodkin et al. (2002) describe a situation at northern Knight Island in WPWS where there was no evidence of increase in sea otter abundance by 2000, more than a decade after the spill, and abundance was less than half of the population size prior to the spill.

Recovery of the PWS ecosystem from the *Exxon Valdez* oil spill may not be considered complete until individual animals are no longer exposed to lingering oil from the spill, and when populations reach pre-spill levels of abundance (Exxon Valdez Oil Spill Restoration Plan, EVOS Trustee Council 2006). The results of aerial surveys of sea otters in WPWS provide a means to evaluate progress toward recovery goals and were summarized in detail by Bodkin et al. 2011. Our objective in this report is to update the results and interpretation of aerial surveys to estimate sea otter abundance in WPWS conducted through 2011. Here, we present those abundance estimates derived from the aerial surveys and evaluate the trends in abundance evident in the time series of data from 1993-2011.

Study area

Our survey efforts were focused on WPWS, the site of previous EVOS sea otter studies (Burn 1994, Bodkin et al. 2002, Dean et al. 2000, Dean et al. 2002, Ballachey et al. 2003). We surveyed sea otter population sizes at two geographical scales: 1) a regional scale defined as WPWS, and 2) an intensive scale within WPWS which included one oiled and one unoiled area. The WPWS study area included all oiled areas of Prince William Sound as well as areas contiguous to oiled areas (Figure 1). The intensive survey area included an oiled area identified as the shorelines of the northern Knight Island archipelago (Figure 2). Oiling in 1989 was heaviest here, and population levels of sea otters are generally lower here than in other areas of PWS that were not oiled (Bodkin and Udevitz 1999, Dean et al. 2002). The northern Knight Island survey area consisted of 168.1 km^2, including 93.9 km^2 of low density and 74.2 km^2 of high density stratum. The intensive survey area also included an unoiled area along the northwestern shore of Montague Island between (Figure 2). The Montague Island survey area consisted of 90 km^2, including 20.6 km^2 of low density and 20.6 km^2 of high density stratum.

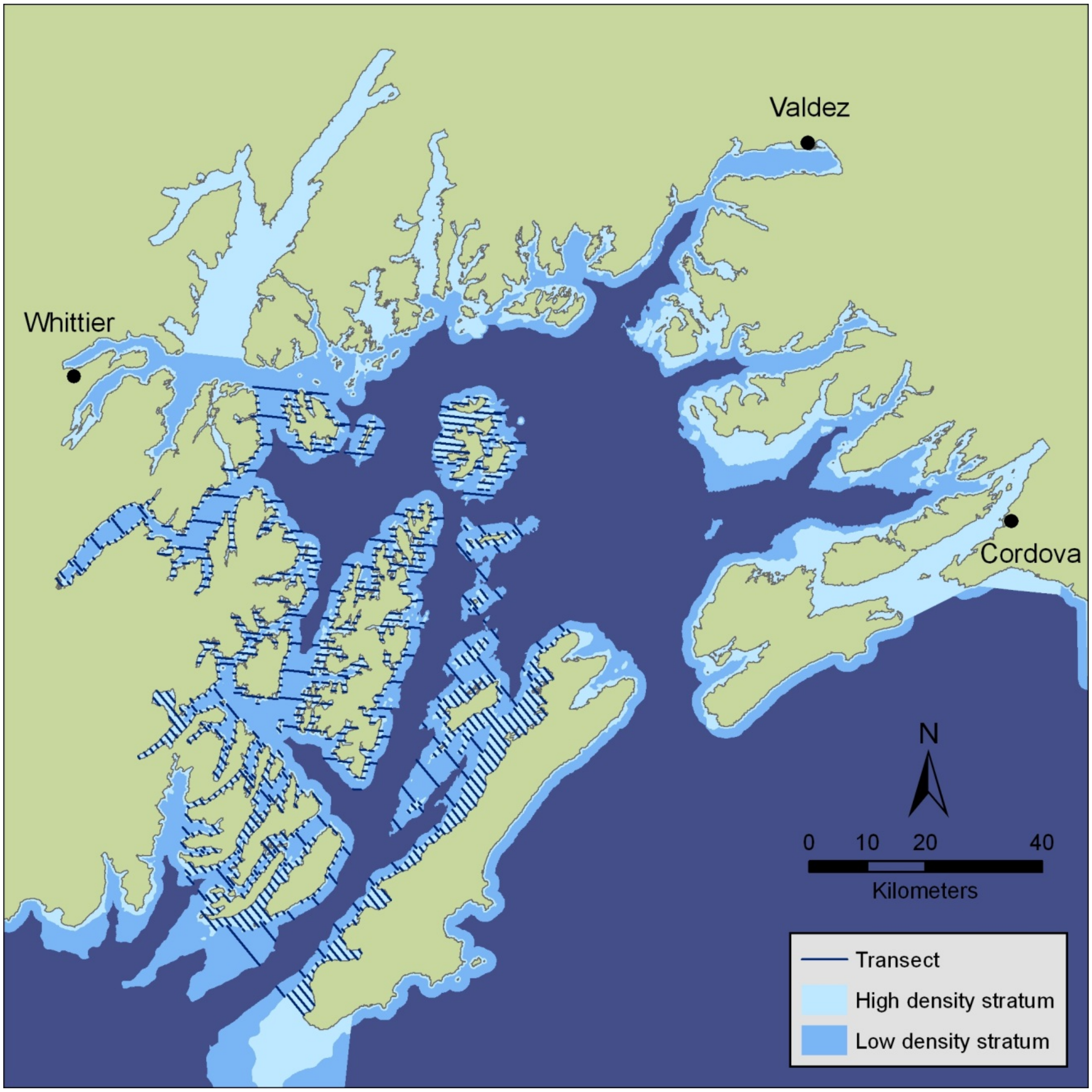

Figure 1. Prince William Sound, Alaska. The high density stratum (light blue) for sea otters is generally defined by water depths < 40 m and is sampled at a greater intensity than the low stratum (darker blue), which extends from the 40 m to the 200 m depth contour. Dark blue lines indicate the western Prince William Sound (WPWS) transects surveyed and collectively represent the survey area.

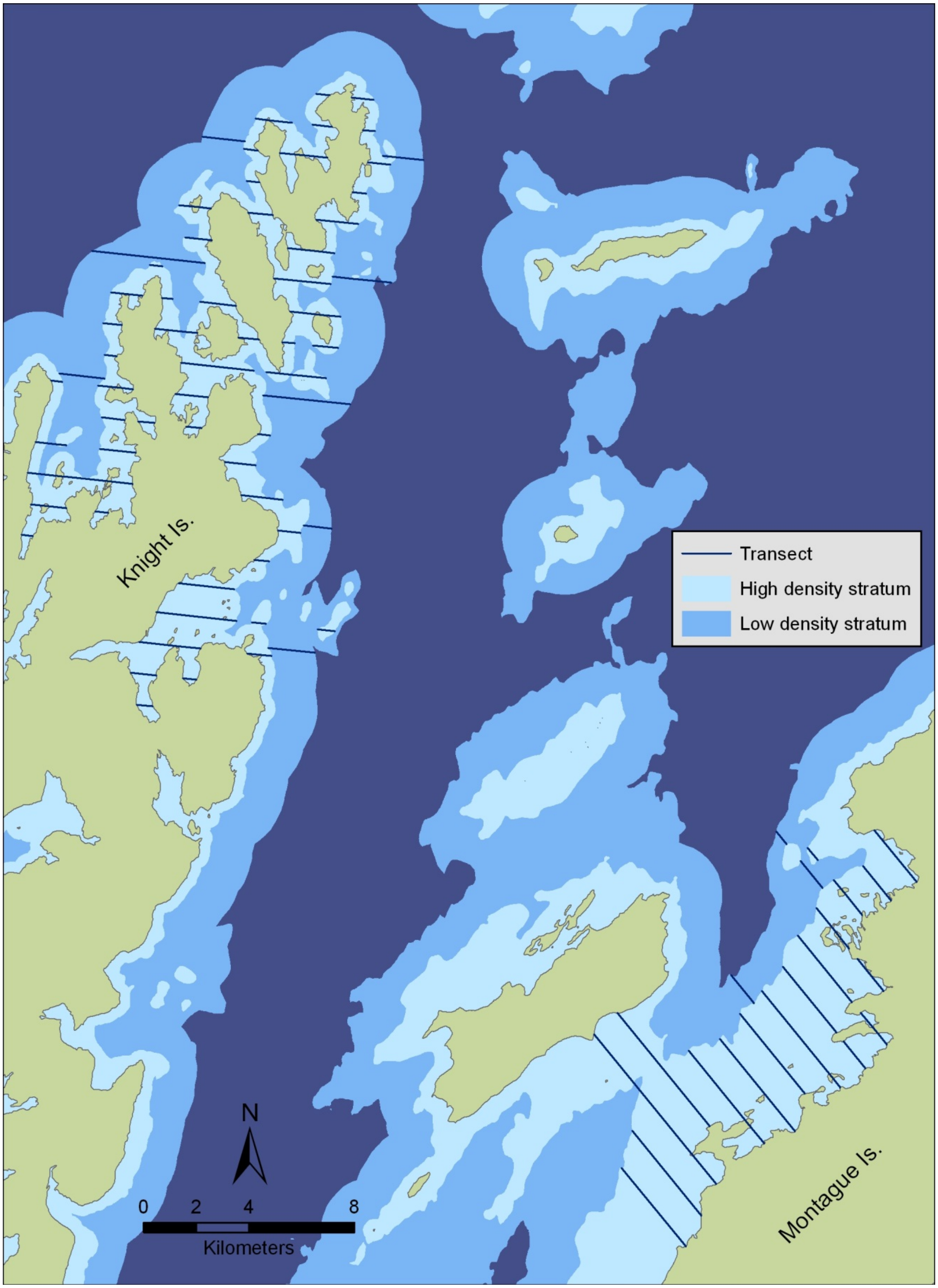

Figure 2. Northern Knight Island (oiled) and Montague Island (unoiled) intensive study areas in western Prince William Sound. High density stratum (light blue) is generally defined by water

depths < 40 m and are sampled at a higher intensity than in the low density stratum (darker blue) that extends from the 40 m to the 200 m depth contour. Dark blue lines delineate transects surveyed and collectively represent the survey area.

Methods

The aerial surveys of sea otters consist of two components: (1) strip transect counts and (2) intensive search units, which are fully described in Bodkin and Udevitz (1999). Sea otter habitat was sampled in two strata, high density and low density, distinguished by distance from shore and depth contour. Surveys are conducted during the months of June and July. Survey effort was allocated proportionally to expected sea otter abundance by adjusting the systematic spacing of transects within each stratum, with approximately 80% of the effort allocated to the high density stratum. Transects with a 400 meter strip width on one side of a fixed-wing aircraft were surveyed by a single observer at an air speed of 104 km/h (29 m/sec) and altitude of 91 m. The observer searched forward as far as conditions allowed and out laterally 400 m, indicated by marks on the aircraft struts, and recorded each otter group size and location on a transect map. A group was defined as one or more otters spaced less than three otter lengths apart. Intensive search units (ISU's) were used to estimate the proportion of sea otters not detected on strip transect counts, and result in correction factors which are used to adjust strip counts for animals not detected. ISU's were conducted at intervals to provide a sample distribution throughout the survey period, and were initiated by the sighting of a group. ISU’s consisted of five concentric circles flown within the 400 m strip perpendicular to the group on the transect that initiated the ISU. Groups of sea otters initiating each ISU are not included in calculating detection. Pups are included in the population estimate as independent sea otters.

To increase precision in estimates for the intensive oiled (northern Knight Island) and unoiled (Montague Island) areas, up to five replicate surveys were conducted using the same techniques described in Bodkin and Udevitz (1999). Replicate surveys were conducted during the same time period as the WPWS surveys (mid-summer; June-July). Rates of change in population estimates over time were calculated by regressing the log (N) of estimates over years. A single observer (JLB) conducted all surveys.

Results and Discussion

In WPWS we estimated the 2011 sea otter population size at 2,896 (se = 392). Although the 2011 estimate is less than the 2009 estimate, the increasing trend overall since the spill remains significant (Figure 3).

At northern Knight Island we continued to see an increase in abundance that began in 2004, with the 2011 estimate of 148 individuals (se=125). The 2011 estimate is 17 individuals less than the pre-spill estimate of 165 individuals in this same area at the time of the spill in 1989 (Dean et al. 2000). We interpret the 2011 estimate as consistent with a significant increase since 2003, with the population approaching a potential recovery endpoint as it attains a size approximating pre-spill abundance (Figure 4).

At Montague Island we estimated a 2011 population size of 662 (se = 224). There has been no significant trend in sea otter abundance at Montague over the years 1993-2011. There has been high annual variation in estimates from Montague Island, from about 300 to more than 600 individuals, but without significant trend. We interpret the high annual variation as potentially reflecting annual variation in the magnitude of commercial fishing activity during our survey period (Bodkin et al. 2011).

Conclusion

Our long-term data set of estimated sea otter abundance in the area of WPWS affected by the 1989 *Exxon Valdez* oil spill provide one means of evaluating progress toward recovery of affected populations. Because of uncertainty in pre-spill abundance and acute loss estimates, we recommend evaluating recovery on attainment of an asymptote in abundance over a three year period (Bodkin et al. 2011). Continued monitoring of the WPWS and Knight Island areas will provide defensible evaluations of the recovery status of sea otter populations affected by the *Exxon Valdez* oil spill.

Acknowledgements

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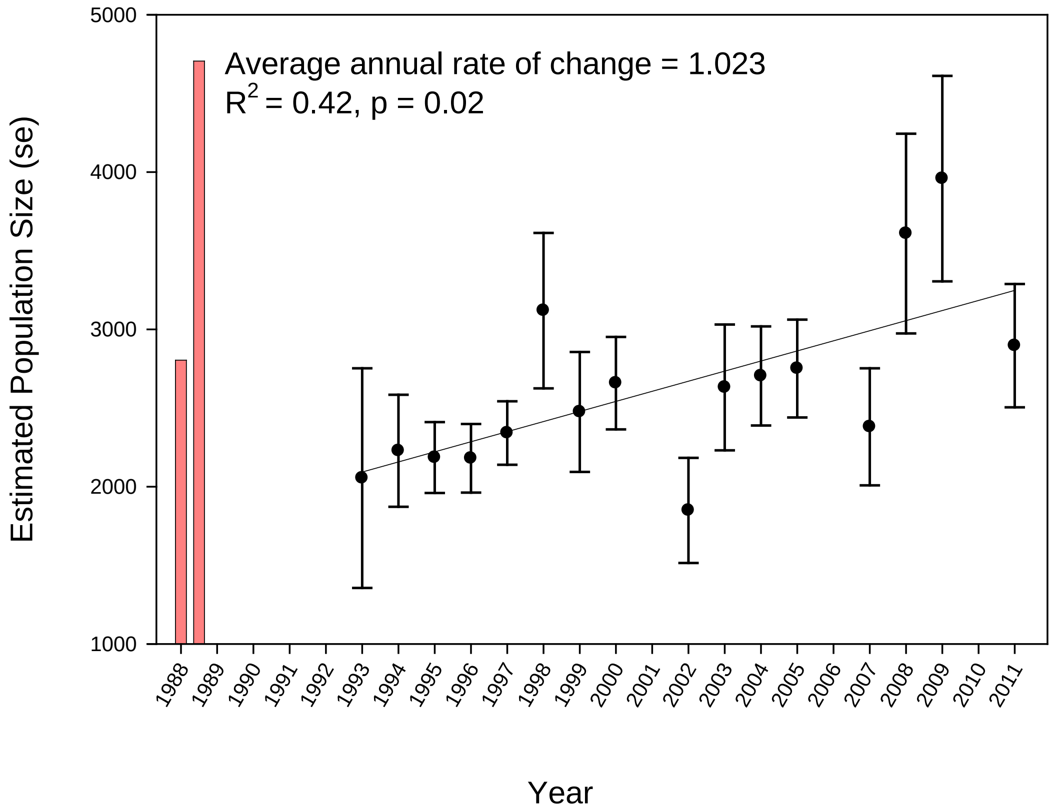

Figure 3. Trend in sea otter abundance estimates from Western Prince William Sound, Alaska, 1993-2011. Solid bars in 1988 represent potential pre-spill population sizes based on the range of published loss estimates (750; Garshelis 1997) and (2650; Garrott et al. 1993) added to the 1993 population estimate.

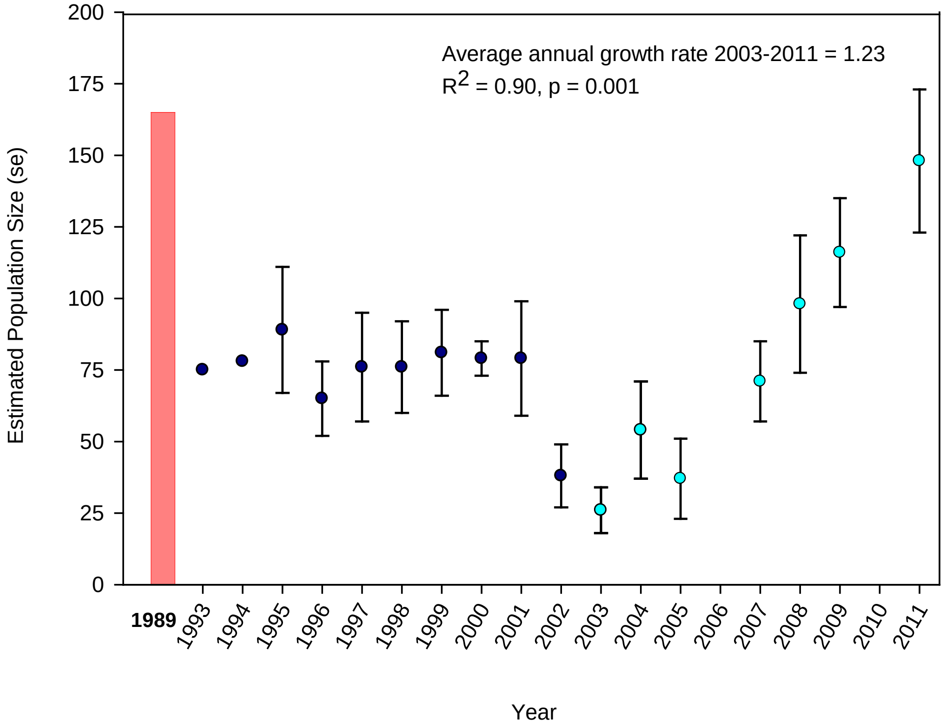

Figure 4. Trend in sea otter abundance estimates from northern Knight Island, Alaska, 1993-2011. Solid bar in 1989 represents minimum pre-spill population size based on the number of sea otters collected dead and alive in this same study area following the spill (165; Dean et al. 2000). Light blue symbols reflect period of significant increasing trend.

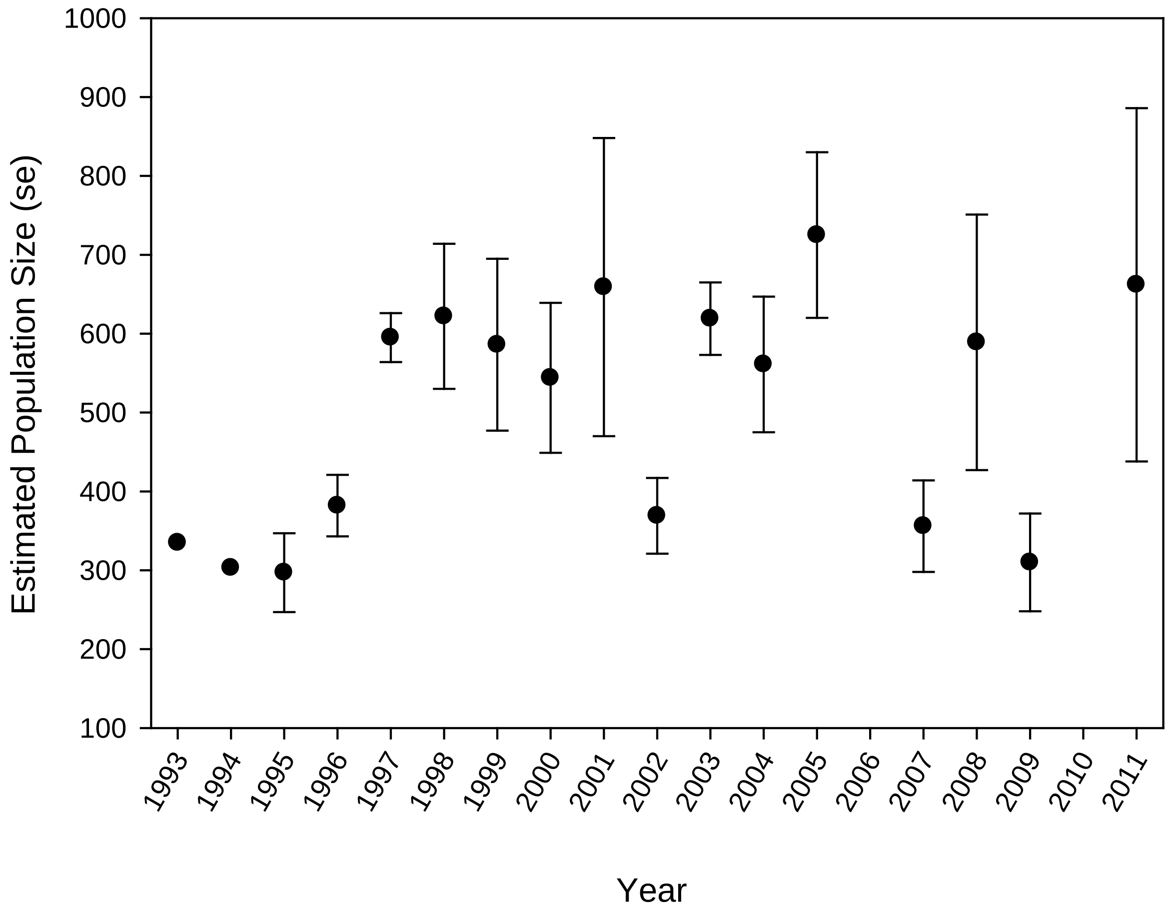

Figure 5. Sea otter abundance estimates from Montague, Alaska, 1993-2011. No estimates of precision available for 1993 and 1994.