# Status of western gray whales off northeastern Sakhalin Island, Russia in 2011

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ABSTRACT

The western gray whale population is critically endangered and its continued ability to survive is of concern. The most recent population assessment, using a Bayesian individually-based stage- structured model, resulted in a median 1+ (non-calf) estimate of 130 individuals (90% Bayesian CI = 120-142). The collaborative Russia-U.S. research program on western gray whales summering off northeastern Sakhalin Island, Russia, has been ongoing since 1995 and has produced important data that has be used to determine the conservation status of this critically endangered population. This paper reviews findings from 2011 research activities and combines such with data from previous years, in some cases ranging back to an opportunistic survey in 1994. Photo-identification research conducted off Sakhalin Island in 2011 resulted in the identification of 83 whales, including twelve calves and two previously unidentified non-calves. Three new reproductive females were recorded in 2011, resulting in a minimum of 29 females now known to have produced calves at some point during the study. When 2011 data are combined with results from 1994-2010, a catalog of 200 photo-identified individuals has been compiled. In 2010 and 2011, a satellite tagging study on gray whales off northeastern Sakhalin Island collected photo-identification images. With data use permission from the International Whaling Commission, these photographs were processed and incorporated into our photo-identification catalog, bringing the total number of identified whales to 205.

KEYWORDS: WESTERN GRAY WHALE; RUSSIA; POPULATION BIOLOGY; BEHAVIOR; CONSERVATION

## INTRODUCTION

As with other species of baleen whales, gray whales annually migrate great distances from the breeding grounds in the subtropical waters to cold and productive northern regions. Two genetically separated populations of gray whales exist in the Eastern North Pacific region. The eastern (California-Chukchi) population is abundant (about 22,000 whales (Punt and Wade, 2010), breeds in the warm shallow lagoons off Baja California, and feeds in summer time in the Chukchi and Bering seas. The other population is the western (Korean-Okhotsk), which is extremely endangered numbering about 130 whales, including only 29 reproductive females producing calves once in about 2-3 years (Cooke, 2010).

Western gray whales travel for thousands of miles to feed on the abundant soft-bottom benthic communities in the western part of Bering and Okhotsk Seas. This feeding period is extremely important for these slow breeding whales, and any disturbance preventing, reducing or limiting feeding can potentially lead to stress in and compromise the health of these whales. The near-shore affinity of gray whales makes them particularly vulnerable to environmental fluctuations and anthropogenic activities. For the past decade, industrial development in the coastal waters of northeastern Sakhalin, namely oil and gas development and related exploration (including seismic surveys, offshore platform installation, pipeline construction, dredging, vessel traffic) became a cause for concern, especially since the oil and gas fields overlap with the primary feeding ground of western gray whales (Blokhin and Burdin, 2001; Gailey *et al.*, 2011). Many individual whales return annually to the same feeding sites off northeastern Sakhalin Island, indicating a site-specific dependence to this geographic area (Weller *et al*., 2007). This critically important habitat is especially vital for nursing females and their calves, as female energetic requirements are increased during lactation, and calves need to be ready to separate and begin to feed on their own.

The western gray whale population is critically endangered and its continued ability to survive is of concern (Weller *et al*., 2002a; Reilly *et al*., 2008). Hunted to such low numbers in the mid 20th century that some thought it to be extinct, the population remains highly depleted today (Weller *et al*., 2002a; Cooke *et al*., 2008). The International Whaling Commission (IWC) and the International Union for Conservation of Nature (IUCN) have each expressed serious concern about the status of this population and have called for urgent measures to be taken to help ensure its protection (see Reilly *et al*., 2008; IWC, 2004; Reeves *et al*., 2005).

Recent data obtained by a satellite tagged gray whale from Sakhalin Island (Mate *et al*. 2011), along with photo-identification matches (Weller *et al*., 2011), has shown that some whales migrate to Mexico to the well-known breeding grounds. But in November 2011, a female gray whale stranded in China in the Taiwan Strait area (Zhu, 2012). This record indicates some whales still inhabit the Asian coast, south from Korea. This novel information on gray mixing should stimulate further research on the gray whales coming to Russian waters during the summer because the number of the Korean-Okhotsk stock of gray whales may be even smaller than previously estimated (Weller *et al*., 2011).

This report reviews summary findings from 2011 research activities on western gray whales off Sakhalin Island in the Russian Far East and integrates new information with data from previous years, in some cases ranging back to 1994. Discussion of the current status of the population and a review of threats to its continued survival, including potential impacts associated with large-scale oil and gas development activities on the summer feeding ground and entrapments in trap nets off Japan during migration, are provided herein.

## METHODS

The overall consistency in research design, data collection techniques and data analysis maintained in 2011 allowed inter-annual comparisons to be made. Additional information, collected during more limited surveys off Piltun in 1994 and 1995 (Brownell *et al.*, 1997; Weller *et al.*, 1999), is also presented here to better describe inter-annual trends and facilitate a long-term interpretation for some results. Data from these 1994 and 1995 studies include gray whale photographs obtained between 7-12 September 1994 during the filming of a wildlife documentary by H. Minakuchi (for description see Weller *et al*., 1999) and from 14-20 August 1995 during a pilot study to determine the feasibility of conducting boat- and shore-based research in the study area (Brownell *et al.,* 1997).

### *Study area*

The study area is located near Zaliv Pil'tun (referred to as Piltun Lagoon) on the northeastern shore of Sakhalin Island, Russia (Fig 1). The lagoon is approximately 80-90 km long and 15 km across at its widest point. A single channel connecting the inner lagoon with the Okhotsk Sea occurs at 52° 50' N and 143° 20' E, and has considerable biological influence on the surrounding marine environment. A lighthouse, near the lagoon channel, served as the base from which studies reported here were conducted. The nearshore marine environment of the study site is mostly sand substrate, characterized by a gradually sloping and broad continental shelf. Water depths within 5 km of shore are mostly less than 25 m deep. Despite the similarity of Piltun Lagoon to the coastal lagoons used during the winter by eastern gray whales off Baja California, Mexico, whales do not enter this lagoon.

### *Photo-identification surveys*

Gray whales have distinctive body markings, such as natural coloration and pigmentation patterns, as well as scars that are unique to an individual and can be used for individual recognition. Boat-based photo-identification surveys were conducted on all good weather days during the 2011 study period. Identical methodology was employed during each survey, with the primary objective of encountering and photographically identifying as many whales as possible. Previous photo-identification data gathered in the Piltun area between 1995 and 2010 used right-side dorsal flank markings for identification (Brownell *et al.*, 1997; Weller *et al.*, 1999, 2006a), and for the sake of intra- and inter-annual reliability, we continued this methodological approach. Attempts were made to photograph the right dorsal flank of each whale, followed by efforts to photograph the left dorsal flank and fluke. The majority of whales identified to date now have images of right and left flanks as well as ventral surface of flukes in the photo-identification catalog allowing for useful identification images to be collected from nearly any body region. The western gray whale photo-identification catalog complied by our Russia-U.S. research program is available on request to all interested parties (Weller *et al*., 2006a).

Photographic surveys involved slow travel in a 4.5 m outboard-powered inflatable boat. To photograph whales we used a Nikon D7000 digital camera with a 100-400 mm Nikon lens. Measures of environmental conditions, water depth, geographic position, and group size were recorded for each group photographed.

In 2010 and 2011, a satellite tagging study on gray whales off northeastern Sakhalin Island collected photo-identification images (see Mate *et al*., 2011). With data use permission from the International Whaling Commission, these photographs were processed and incorporated into our photo-identification catalog.

**RESULTS**

***Survey effort and photo-identification catalog***

Fourteen photo-identification surveys, with a total of 77.2 hrs spent at sea and 32.7 hrs spent in direct observation of 83 whale groups, were conducted between 28 June and 26 August in 2011 (Table 1). The most surveys in 2011 were conducted in July (10 surveys). One photo-ID survey was completed in June, and due to the poor weather conditions (heavy fog and high sea state), only three surveys were conducted in August. Between 1994 and 2011, 200 western gray whales have been identified during 384 boat-based surveys off northeastern Sakhalin Island (Table 1). Ninety-six of the whales in the photo-catalog were animals first identified as calves, while the remaining 104 whales were considered non-calves (i.e. adults or subadults). In combination with the additional photo-identification data from the aforementioned satellite tagging study (Mate *et al*., 2011), our western gray whale catalog contains a total of 205 identified individuals. However, not all of these 205 individuals are considered to be alive (see Cooke *et al*., 2008).

Table 1. Annual survey effort, groups encountered, and whales identified in 1994-2011.

| Year | Sampling Period | Number of Surveys | Observation Hours | Groups Encountered | Whales Identified |
|---|---|---|---|---|---|
| 1994 | 09/07 - 09/12 | 1 | | | 9 |
| 1995 | 08/15 - 08/19 | 5 | 10.1 | 23 | 28 |
| 1997 | 07/09 - 09/08 | 22 | 33.4 | 114 | 47 |
| 1998 | 07/06 - 09/29 | 35 | 50.5 | 125 | 54 |
| 1999 | 06/29 - 10/13 | 56 | 122 | 434 | 69 |
| 2000 | 06/25 - 09/16 | 40 | 56.5 | 365 | 58 |
| 2001 | 06/25 - 09/25 | 49 | 101.8 | 448 | 72 |
| 2002 | 07/01 - 09/25 | 36 | 75.6 | 411 | 76 |
| 2003 | 07/15 - 09/13 | 22 | 41.7 | 219 | 75 |
| 2004 | 07/29 - 09/12 | 21 | 33.8 | 194 | 94 |
| 2005 | 07/04 - 09/09 | 20 | 40.9 | 160 | 93 |
| 2006 | 07/23 - 08/25 | 10 | 24.1 | 96 | 79 |
| 2007 | 07/26 - 09/09 | 20 | 32.2 | 187 | 83 |
| 2008 | 07/08 - 08/21 | 12 | 47.0 | 38 | 45 |
| 2009 | 06/24 – 08/26 | 17 | 67.0 | 126 | 82 |
| 2010 | 08/09-08/26 | 4 | 11.5 | 40 | 42 |
| 2011 | 06/28-08/26 | 14 | 32.7 | 83 | 83 |
| Overall | | 384 | 780.8 | 3063 | 200 [1] (205) [2] |

[1] The number of whales identified annually includes resightings of individuals from previous years, resulting in a total of 200 identified individuals. The number of whales identified does not correspond to the size of the population.

[2] The total number of identified individuals in the catalog is 205 when data collected during a separate satellite tagging study (see Mate et al., 2011) are included.

Eighty-three naturally marked individual whales, including 12 calves, were identified during 2011 (Table 2). Of the 71 non-calves identified in 2011, 69 whales (97.2%) had previous sightings in the Piltun area during 1994-2010 photographic efforts (Table 2). The mean pod size for all groups (n=83) encountered during 2011 was 2.2 ± 1.47 ranging from 1 to 8 individuals per pod. The majority of sightings were of single whales (39.8%) and groups of two (32.5%). Two groups were encountered with the largest group size of eight individuals. The first sighting of a large group occurred on 18$^{th}$ July. Eight adult whales, all known from previous years, were observed feeding together. The second group of eight whales was sighted on 28$^{th}$ July and consisted of individuals of different ages interacting with

each other: three mother-calf pairs, one calf from 2010 (now a yearling), and a non-calf individual new to the Sakhalin catalog.

Forty-two individual gray whales were observed only once throughout the season; twenty-four whales were sighted twice. The maximum number of resightings in 2011 was seven, recorded for a calf that was observed both with its mother and alone (after separation from the mother). Two individuals identified as calves in 2010 were also sighted this year. One of them was photographed three times throughout the 2011 season. Also, four calves of 2009 were encountered this year; all of them were observed off Sakhalin in 2010 as well.

Table 2. Annual sighting trends and resighting percentages, 1994-2011.

| Year | Whales Identified | Number of Calves | New Non-Calves | % Non-Calves Previously Identified |
|---|---|---|---|---|
| 1994[1] | 9 | | | |
| 1995[1] | 28 | 2 | 20 | 23.1% |
| 1997 | 47 | 2 | 25 | 44.4% |
| 1998 | 54 | 8 | 5 | 89.1% |
| 1999 | 69 | 3 | 12 | 81.8% |
| 2000 | 58 | 3 | 3 | 94.5% |
| 2001 | 72 | 6 | 6 | 90.9% |
| 2002 | 76 | 9 | 3 | 95.5% |
| 2003 | 75 | 11 | 2 | 96.9% |
| 2004 | 94 | 8 | 3 | 96.5% |
| 2005 | 93 | 6 | 4 | 95.4% |
| 2006 | 79 | 4 | 3 | 96.0% |
| 2007 | 83 | 9 | 2 | 97.3% |
| 2008 | 45 | 3 | 0 | 100.0% |
| 2009 | 82 | 7 | 2 | 97.6% |
| 2010 | 42 | 3 | 1 | 97.4% |
| 2011 | 83 | 12 (15)[2] | 2 | 97.2% |

[1] Data from 1994 and 1995 were opportunistic and pilot in nature (respectively) and are thereby viewed as incomplete for some of the reported values.

[2] Total of 15 calves identified in 2011 when data collected during a separate satellite tagging study (see Mate *et al.*, 2011) are included.

***Mother-calf pairs***

Eleven mother-calf pairs and one already weaned calf were identified in 2011. This is the highest number of calves identified off northeastern Sakhalin among all years of our research. In addition, two more mother-calf pairs and another weaned calf were photographed by the satellite tagging team, summing up the total number of calves identified in 2011 to 15. All thirteen mothers have been sighted in the study area prior to 2011, however, three of them have never been observed in previous years with calves. Therefore, a total of 29 known reproductive females have been documented between 1995 and 2011. One of the females observed as a mother in 2011, also had a calf in 2009, and was first identified in 1998 as a calf herself. We presume that this is her second calf and her first calving interval was 2 years. All other nine females have had multiple offspring during the 1995-2011 study.

The first sighting of a mother-calf pair in 2011 occurred during our second photo-ID survey on 7 July. Eight different mother-calf pairs were identified in July, and three other pairs were sighted in August only. The calf that was already weaned prior to the first sighting was observed on 20 August in association with two mother-calf pairs.

Two mother-calf pairs and one weaned calf photographed during the satellite tagging study were sighted in August and September.

***Biopsy sampling***

Our second research objective during the 2011 survey was biopsy sampling of gray whales observed in the area. A total of 14 biopsy samples were obtained in 2011. Eight of these samples were from calves of this year; one sample was taken from a calf of 2010, and one from the calf of 2009.

**DISCUSSION**

A number of biological parameters in concert with a variety of human-related threats, as identified during the current long-term study and discussed below, raise concern about the ability of the western gray whale population to rebound from its highly depleted state and highlight the importance of continuing the long-term Russia-U.S. collaborative research and monitoring program.

***Population size***

The size of the western gray whale population is extremely small compared to most other baleen whale populations. Photo-identification studies off northeastern Sakhalin Island have identified a total of 200 individual whales during 384 surveys conducted between 1994 and 2011. Although the photo-catalog now contains 205 whales (combining satellite tagging data), not all of these individuals are assumed to be alive. The most current mark-recapture analysis conducted estimated the abundance for the population to be 99 (95% CI = 90-109) in 2003 (Bradford *et al*., 2008). A population assessment by Cooke *et al*. using a Bayesian individually-based stage-structured model fitted to the same photo-identification data as used in the mark-recapture studies, but also including data from 2004 through 2007 has recently been completed. Should current population and demographic trends continue, this assessment projected a median 1+ (non-calf) estimate of 130 (90% Bayesian CI = 120-142) in 2008 (Cooke *et al*., 2008).

***Reproduction and survival***

Although calves are being born annually, the limited number of known reproductive females in combination with relatively low calf survival is likely to be limiting potential population growth (Bradford *et al*., 2006; IISG, 2006; Cooke *et al*., 2008). In recent years, the calving interval in the western population appears to be shifting from a three-year interval to a two-year interval (Weller *et al*., 2009). If this change persists, the general increase in calf production will continue and, in turn, contribute to an increase (albeit slow) in the growth rate of the population.

***Mother-calf pairs***

Thirteen mother-calf pairs were identified during the 2011 season. All thirteen mothers have been sighted in the study area prior to 2011, however, three of them have never been observed in previous years with calves. Therefore, a total of 29 known reproductive females have been documented between 1995 and 2011. The annual return of reproductive females while pregnant, resting and lactating indicates that the nearshore Sakhalin Island feeding area is of significant importance to the continued survival of this population. The behavior of these females indicates that this feeding ground is vital to population survival and growth.

***Threats to the population***

In addition to the biological difficulties (e.g., small population size, low number of reproductive females) that western gray whales face, the onset of large-scale oil and gas development programs off Sakhalin Island in the mid-1990s introduced new threats to the future survival of the population (Weller *et al*., 2002a; Reeves *et al.*, 2005; IISG, 2006). Sakhalin Island is a region rich with large reserves of offshore oil and gas that, until recently, have been unexploited. Industrial activities on the continental shelf of this region have steadily increased in the past ten years and are scheduled to expand at a rapid pace into the future. Oil and gas development activities that may negatively impact western gray whales include: (1) disturbance from underwater noise associated with seismic surveying (Weller *et al*., 2002b; 2006b, 2006c), pipeline dredging, ship and helicopter traffic and platform operations; (2) direct interactions between whales and an oil spill or other waterborne chemicals, ships, and possible entanglements in cables or lines; and (3) habitat changes related to seafloor modifications associated with dredging and sand pumping activities that may adversely impact gray whale prey (for reviews see Reeves *et al.*, 2005; IISG, 2006).

The number of individual whales photo-identified on the nearshore feeding ground in 2008 was very low in comparison to 2009 and previous years with a similar amount of spatial and temporal survey effort (see Table 1). Given the short nature and small number of surveys in 2010, a direct comparison with 2009 data was inappropriate;

nonetheless 42 whales identified during four surveys suggest 2010 was similar to previous years except 2008. In 2011, a high number of individual gray whales were encountered, which is comparable to the results of 2009-2010. While the low numbers observed in 2008 continues to be of concern, it is clear that results from 2009-2011 are more typical. It is possible that the observed pattern in 2008 was anomalous and was simply attributable to natural variation in behavior. It is also plausible, however, that the change reflected whales being displaced from the feeding area or, worse, indicates partial abandonment of what has traditionally been a critical feeding habitat (especially for mother-calf pairs) for the population. While natural variation in food resources and other biological factors are being investigated by industry-sponsored research groups, additional investigations need to be undertaken to examine the possible contributions of pile driving activities and a seismic survey that both occurred in close proximity to the nearshore feeding ground in summer 2008. Until more conclusive explanations can be drawn with regard to the low number of whales observed in 2008, the influence of industrial activities cannot be ruled out as contributing factors.

Another significant threat to the western gray whale population involves incidental catches in coastal net fisheries, particularly off Japan, within their migratory route (Weller *et al*., 2002a; Kato *et al*., 2005, 2006, 2007; Brownell *et al*., 2007; Weller *et al.,* 2008). In 2005, three female western gray whales (one mother-calf pair and one yearling) died in fishing nets on the Pacific coast of Japan during their northward migration. Unfortunately, in 2007 another young female western gray whale died after being entrapped in a trap net also on the Pacific coast of Japan (Anonymous, 2007a,b,c; Brownell *et al*., 2007; Kato *et al*., 2007; Weller *et al*., 2008). Projections from recent population assessments suggest that if this level of net-related mortality continues, there is a high probability the population will decline to extinction (Cooke *et al*., 2008). In addition, an analysis of anthropogenic scarring of western gray whales found that 18.7% ($n$ = 28) of 150 individuals identified between 1994 and 2005 were determined to have been previously entangled in fishing gear (Bradford *et al*., 2009), further highlighting the overall risks coastal fisheries pose to western gray whales. Finally, while nothing is known about net entrapments or entanglements in other regions (e.g., Korea and China) within the range of the population, it is likely that coastal net fisheries outside of Japan also contribute to some level of mortality.

Although there are historical data on gray whales sightings in waters off Japan, South Korea and China, and also documented net entrapments near Japan, the wintering grounds for western population remain unclear (Weller *et al.* 2008). Some western gray whales are seen near Kamchatka, and both intra-annual and intra-seasonal exchange of individuals between feeding grounds off Sakhalin and Kamchatka are documented (Tyurneva *et al*. 2010). In 2010, a satellite tagging project was initiated off northeastern Sakhalin (Mate *et al*., 2011) [1]. A male gray whale, which was observed as a calf in 1997 and sighted in most years of study in the Piltun area, was tagged and tracked during October 2010–February 2011. This individual traveled over 7500 km from Sakhalin feeding grounds to the Oregon coast (USA). Five more whales observed on the feeding grounds off Sakhalin in different years were confirmed with photographic matches to the whales from a eastern North Pacific catalog (Weller *et al*. 2011). This highlights that the range and potential threats this population may face may be on a larger scale than previously anticipated.

Such a wide range in distribution makes whales vulnerable to other unknown threats to the western gray whale population including continued mortality from an undetermined level of suspected poaching in the central portion of the range (Brownell and Kasuya, 1999; Baker *et al*., 2002), as well as a potential increase in the likelihood of disturbance, exposure to pollution, and probability of ship strikes due to substantial nearshore industrialization and shipping congestion throughout the migratory corridor(s).

***Genetics***

Previous genetic research on the western gray whale population has documented clear genetic differentiation from the eastern population on the basis of mitochondrial DNA haplotype frequencies (LeDuc *et al*., 2002). Given the small size of the western population and its isolation from the eastern population, the potential for continued loss of genetic diversity due to genetic drift or removal of individuals with rare alleles is of concern (Lang *et al*., 2004; 2005). The limited number of females in the population may hinder reproductive output and in turn slow population recovery. The male bias observed for calves indicates lower recruitment of females into the adult population. This pattern further perpetuates the problem of a limited number of females being available to reproduce. Although, the recent genetics results of comparing microsatellite markers show some degree of movements between western and eastern populations, it supports their recognition as two separate populations (Lang *et al*., 2010).

**CONCLUSIONS**

Based on the results reported here, it is clear that the western gray whale population is precariously balanced between survival and extinction. In addition to the variety of biological factors that may be limiting population

growth, large-scale oil and gas development programs that may alter the prey base or introduce disturbance to feeding whales, as well as entrapment and entanglement in fishing gear, especially in trap nets off Japan, are of serious concern with regard to the future survival of the population.

Given the continued uncertainty regarding the ability of the western gray whale population to increase from its depleted state, impacts from oil and gas development activities off the northeastern Sakhalin Island coast need to be closely monitored and stringently mitigated to reduce disturbance to the lowest possible level. In addition, net entrapments of western gray whales off Japan and possibly elsewhere can lead the population to extinction (IISG, 2006; Cooke *et al*., 2008; Brownell *et al*., 2007; Weller *et al*., 2008). Thus, human related mortality during migration and in the (yet to be determined) wintering area(s) must be addressed and mitigated to the lowest possible level. Where scientific knowledge is lacking, the precautionary principle should be applied as the best measure of protection. With this in mind, the photo-identification and genetic biopsy research conducted since 1995, and reviewed here, must be continued to further monitor survival of individuals, describe the overall population trend and to recommend further conservation and protection measures.

In conclusion, protection of the Sakhalin Island feeding habitat, including the coastal lagoon systems that appear integrally related to the high benthic biomass used by the whales in the nearshore area, is clearly paramount to successful conservation of the western gray whale population. The unique method of benthic feeding by these whales makes them an "umbrella" species (Hooker and Gerber, 2004), whereby protection of their habitat provides protection for the biological diversity of the entire northeastern Sakhalin Island shelf. Thus, the feeding habitat of the western gray whale needs to be considered a "hot spot" for conservation planning now and in the future and every effort should be taken to protect its biological integrity. In continuation of this research and looking for the development of additional western gray whale conservation measures, the next step should be intensifying research of gray whales off Kamchatka.

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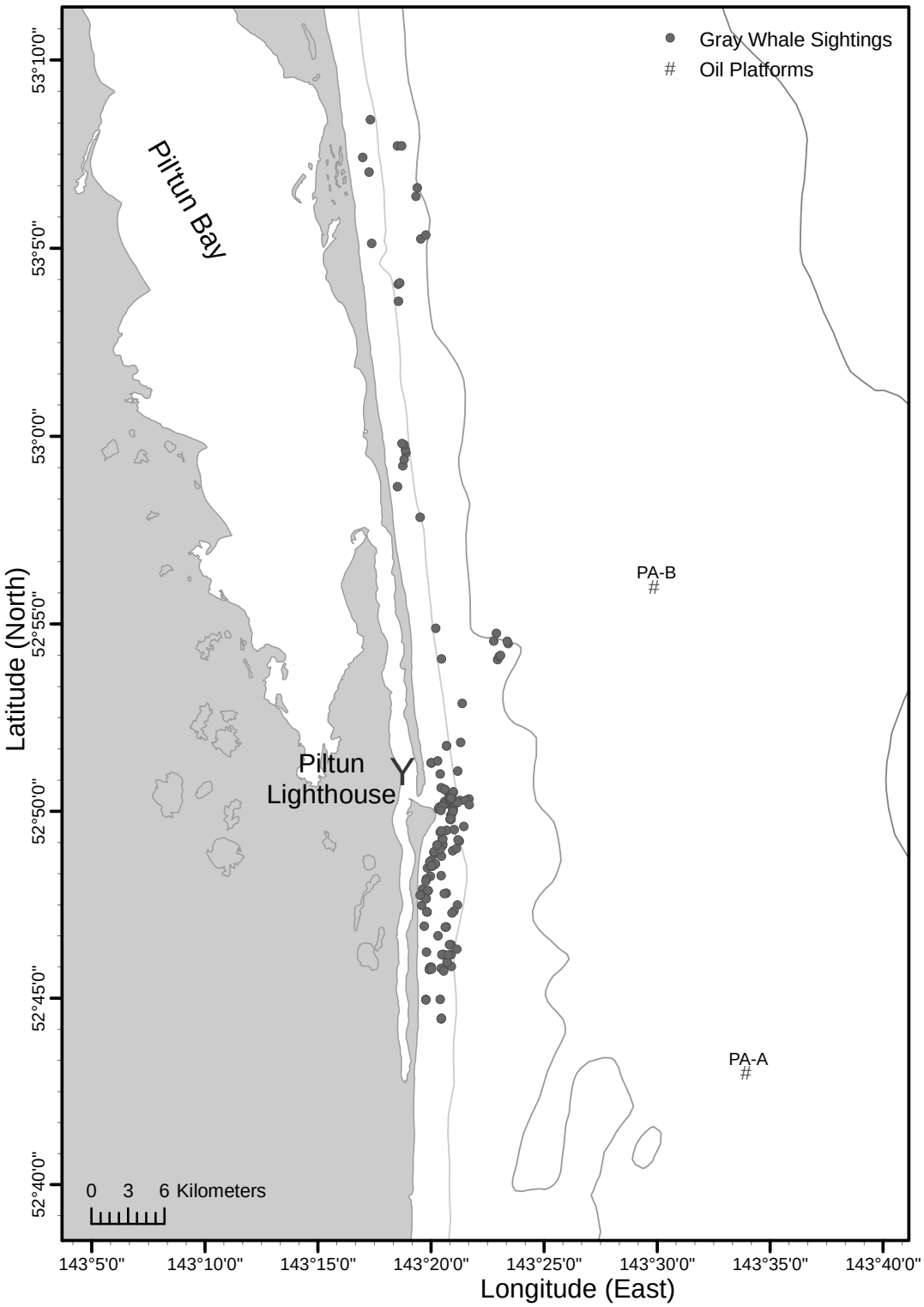


Fig.1 Gray whale sightings in the study area in 2011.