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DISTRIBUTION AND ABUNDANCE OF WESTERN GRAY WHALES IN THE WATERS OFF NORTHEAST SAKHALIN ISLAND, RUSSIA, 2004-2009

V.A. Vladimirov¹, S.P. Starodymov¹, M.S. Kornienko² and J. E. Muir³

1 – All-Russian Research Institute for Fisheries and Oceanography (VNIRO) – 17 V. Krasnosel'skaya ul., Moscow, 107140, Russia (contact e-mail: marmam@vniro.ru).

2 – Institute of Marine Biology, Far East Division of the Russian Academy of Sciences – 17, ul. Palchevskogo, Vladivostok, Russia (contact e-mail: kornbear@mail.ru).

3 – LGL Limited, environmental research associates – 9768 Second Street, Sidney, BC, Canada (contact e-mail: jmuir@lgl.com)

ABSTRACT

Data from systematic shore- and vessel-based distribution surveys conducted offshore northeast Sakhalin in the summer-to-fall seasons of 2004-2009 indicate the presence of two primary gray whale feeding areas. The first, nearshore Piltun feeding area is located adjacent to Piltun Bay and extends from Ekhaba Bay in the north to Chayvo Bay in the south over a coastline stretch of about 120-km length; whales predominantly feed in this area at a distance <5 km from shore and in water depths <20 m. The second, deeper Offshore feeding area is located at a distance of about 35-50 km from shore to the southeast of Chayvo Bay; the water depth in this area is about 35-60 m.

The observations show significant variation in whale densities between years within the Piltun and Offshore feeding areas. Whale densities in the Piltun area began to decrease in 2006, with lowest densities observed in 2008. This decrease reversed in 2009, when the maximum number of whales in this area seen during one survey day was 55% higher than in 2008 and comparable to 2007 levels. Increased use of the Offshore feeding area was observed from 2005-2008, with the highest number of whales (since 2001) being recorded in 2008. In 2009, the maximum number of whales observed on one survey day in the Offshore feeding area decreased compared to 2008. This partly may be explained by the low number of Offshore area surveys that were carried out in 2009 due to bad weather conditions, as well as by the fact that considerable numbers of whales were observed to the northeast of the Offshore area transect lines outside the survey grid. In general, results from the 2009 distribution surveys, combined with results from 2009 photo-ID surveys, indicate that the western gray whale population is in stable condition.

Introduction

The western gray whale population (*Eschrichtius robustus*) has historically been low in numbers and was driven to near-extinction by commercial whaling in the early to mid-20th century. Recent estimates indicate that the current population may consist of somewhere between 130 (Cooke et al., 2008) to 140-150 individuals (Yakovlev and Tyurneva, 2008; Tyurneva et al., 2009, 2010). The eastern population of gray whales on the other hand has recovered after commercial whaling decimated its numbers in the 19th and 20th centuries. Current population estimates of Eastern gray whales range from 18,000-30,000 individuals (Rugh et al., 2005). Historic and present locations of gray whale sightings in Russian waters include areas of the Sakhalin shelf, the far northern reaches of the Sea of Okhotsk, and the coastline of the Kamchatka Peninsula (Fig. 1). Little is known about the winter breeding area of western gray whales, but significant work has been done to monitor the distribution of this population of whales within their known summer-autumn feeding area off northeastern Sakhalin Island. In

1997, Exxon Neftegas Limited and Sakhalin Energy implemented a comprehensive western gray whale monitoring program jointly funded by the Sakhalin-1 and Sakhalin-II developments. To date, results from the program have shown that individuals belonging to the western gray whale population are encountered feeding on the northeast Sakhalin shelf and off the southeast coast of Kamchatka during the ice-free season (Vladimirov et al., 2009, 2010; Tyurneva et al., 2009, 2010).

Scientific studies as part of the program also have identified the presence of two western gray whale feeding areas on the Sakhalin shelf, where the whales are concentrated during their feeding season from late May/early June to October (Vladimirov et al., 2008, 2009, 2010; Tyurneva et al., 2008, 2009, 2010). The first area is the Piltun near-shore feeding area, which extends over a distance of about 120 km along the Island's coast from Ekhaba Bay in the north to Chayvo Bay in the south (Fig. 3). Whales in this region are observed primarily in shallow waters <20 m depth, i.e., within 5 km from shore. The second area is the Offshore feeding area, located approximately 45 km to the south/southeast of the Piltun area. The Offshore area is situated at a distance of about 30-50 km from the coast offshore Chayvo and Nyisky Bays, in water depths ranging from 35-65 m. Systematic survey data collected from 2004 to 2009 display inter-annual variability in gray whale abundance and distribution in the two feeding areas. Data from the 2009 surveys are presented in this paper and compared to observations from previous years.

Methodology

Vessel-based Surveys: Vessel-based surveys were conducted onboard the *Akademik Oparin* research vessel from July 6 to September 17, 2009 by specialists from the Institute of Marine Biology (IBM), DVO RAN (Vladivostok). The 2009 transect lines in the Piltun and Offshore feeding areas, along with the Arkutun-Dagi license area, were the same as in previous years, with the addition of a transect network in the Piltun-Astokh license area (Fig. 2). The survey area encompassed all known gray whale feeding grounds in eastern Sakhalin waters. A total of 13 dedicated surveys were planned during the 2009 vessel-based program in all transect areas combined; however, owing to extremely bad summer and fall weather, only four of the planned surveys could be completed (two in the Offshore feeding area, one in the Arkutun-Dagi license area, and one in the Piltun-Astokh license area). Five more surveys (one in the Piltun feeding area, two in the Offshore area, one in the Arkutun-Dagi license area, and one in the Piltun-Astokh license area) were begun but not completed due to deteriorating weather conditions.

The methodology for the vessel-based surveys remained the same throughout all years of monitoring and followed as closely as possible that which is recommended by the International Whaling Commission for vessel-based sighting surveys of cetaceans. The surveys were conducted from the bridge of the vessel simultaneously by two marine mammal observers. The azimuth of the whales determined using the vessel's gyrocompass, and the distance determined using range-finding Fujinon 7x50 binoculars, which were also used to identify the species and number of whales in a group.

Onshore Surveys: Onshore route surveys were conducted in a manner consistent with previous years' (2004-2008) methodology from 13 fixed observation points located on elevated shore areas spaced approximately 8-10 km apart. The surveys were synchronized between two groups of surveyors. The northern group conducted surveys in waters to the north of the Piltun Bay mouth, and the southern group conducted surveys in waters to the south of the Piltun Bay mouth (Fig. 2). The surveys were conducted by specialists from VNIRO, Moscow with the participation of biologists from other Far East scientific research institutes and universities. In total, the 2009 onshore survey period lasted 95 days (from June 25 to September 27). However,

due to extremely adverse weather conditions, only 15 complete synchronized whale surveys were carried out in the Piltun area. In addition, eleven asynchronous (all stations sampled in only one, i.e., northern or southern, section) were performed at one of the two sites (one at Odoptu-Piltun and ten at Astokh-Chayvo). In 30 other cases, surveys that had been initiated needed to be suspended due to worsening weather (reduced visibility or high seas).

The surveys were conducted by scanning the portion of the water area visible from the survey station in 10-degree sectors with Fujinon 7x50 range-finding binoculars with reticle scales to calculate distance. A built-in compass was used to determine the azimuth to the sighted animals, while their distance was inferred from the reticle scale in the binoculars. Four-wheel drive, high-clearance vehicles were used to get quickly from one survey station to the next. The field surveying methodology has been consistent since project initiation in 2004.

Data Analysis: Distance to the whales sighted during the vessel-based and onshore surveys was calculated using the methodology developed by Lerczak and Hobbs (1998) with a correction for refraction (Leaper and Gordon, 2001). The whale coordinates were calculated using an adaptation of the method developed by Yermolayev and Zoteyev (1988). Data were analyzed in order to estimate whale density throughout the survey area at a resolution of 1 km². Results from 2009 surveys were plotted on density maps and compared with results/maps from prior years (2004-2008).

Results and Discussion

General Results: Consistent with the 2004-2008 survey results, the 2009 distribution surveys indicated that there are two main feeding areas for western gray whales off northeast Sakhalin Island. The first is the nearshore Piltun feeding area and the second is the Offshore feeding area (Fig. 3).

Adverse weather conditions (i.e., high winds and seas, poor visibility) precluded researchers from attempting surveys on many days during the 2009 season, and disrupted ongoing surveys on other days. Nonetheless, important data were collected and observations were made in both feeding areas, which contribute to the longer term, inter-annual series of western gray whale distribution and abundance on the northeast Sakhalin shelf. There has been a high degree of inter-annual variability in whale distribution both within and between the feeding areas from 2004-2008, and data from 2009 are consistent with this result (Fig. 4). Onshore survey results show that the decline in gray whale abundance observed over 2006-2008 has reversed in 2009; the maximum number of whales recorded in 2009 rose over the previous year and returned to the 2007 level. Vessel-based surveys indicate that the whale distribution shifted northeast within and outside the known Offshore feeding area.

The following sections present a more detailed description of the 2009 results from distribution surveys in the Piltun and Offshore feeding areas. These 2009 data are compared with results from similar surveys conducted in 2004-2008. Our objective is to evaluate the current condition of the western gray whale population, based on an assessment of their distribution and relative abundance on inter-annual scales.

Piltun Area Results

2009 Data

The maximum number of whales recorded in 2009 during one single, synchronous onshore survey rose by 55% over the previous year, totaling 73 individuals in 2009 versus 47 in 2008, and was comparable to the 2007 level. Vessel-based surveys in 2009 also showed a substantial increase in the number of animals (33) sighted in this area compared

to 2008 (20). Average gray whale density over the entire Piltun feeding area was higher during the 2009 field season than in 2008. The highest whale densities in 2009 were found in the central (i.e., in the vicinity of stations 8 and 9) and southern parts of the area; the percentage of whales recorded between stations 7-13 in 2008 and 2009 was predominant and rather close (80.7% and 73.4%, respectively). Increases in whale densities in 2009 in the northern section of the Piltun area were observed primarily in the vicinity of stations 4-7 (22.2% of all whales were observed here in 2009 compared to 13.7% in 2008) near the ENL pile installation site located between stations 4-5. Slight increases in whale densities were observed in the vicinity of stations 1-3 in 2009 compared to the previous year.

Inter-annual Variations (2004-2009)

Onshore survey results show that the decline in average gray whale abundance in the Piltun area observed over 2006-2008 has reversed in 2009 (Fig. 4). Year-to-year analyses of Piltun Bay whale distributions demonstrate significant spatial and temporal variability. Abundances of whales in the Piltun area were at their peak in 2004-2005, when the whales mainly were concentrated in the northern reaches of the Piltun feeding area between stations 1-6, where up to 65-75% of the whales in the Piltun feeding area were sighted. Another smaller cluster of whales in the central part of the area, near the mouth of Piltun Bay, consisted of 15-20% of the whales. A much lower density of whales was distributed across the area's southern reaches, although minimal increases in this area were observed in 2005 (Vladimirov et al., 2005, 2006).

One hypothesis for the increased concentration of whales in the northern part of the area in 2004-2005 is related to changes in benthic food supply, namely, the increased frequency of occurrence of spawning concentrations of sand lance (*Ammodytes hexapterus*) in this region during those years (Fadeev, 2009). This benthic fish been identified as an additional food resource for gray whales (Zimushko and Lenskaya 1970). The sand lance is a temporary component of biota at depths between 20 and 40 m, where it breeds. The most distinct increase in frequency of occurrence and biomass of sand lance in the northern Piltun area was observed during 2004-2005 in water depths >20 m. The high numbers of sand lance in the northern Piltun area was concurrent with a decrease in the number of whales observed in the Offshore area, and an increase in the number of gray whales feeding at depths greater than 20 m in the northern Piltun area (Vladimirov et al. 2006; Yakovlev and Tyurneva 2006). Thus, the appearance of an additional, accessible food resource may have attracted feeding whales to the northern Piltun area, away from other feeding areas.

In 2006, as overall whale densities declined, whale densities in the northern Piltun area between survey stations 1-6 fell by almost half compared to 2004-2005 and comprised only about 35% of the whales present in the Piltun area. The decrease in whale densities in this region coincided with a decrease in availability of sand lance as a food resource. By 2007, the cluster of whales previously seen in the northernmost reaches of the Piltun area had decreased substantially (Fig. 4). Whale densities in the south also had decreased and only the cluster near the mouth of Piltun Bay remained (Vladimirov et al., 2007, 2008). The lowest average densities of gray whales in the entire Piltun area were observed in 2008 totaling only about 40% of their 2004-2005 levels. Also in 2008, whales almost completely disappeared from the northernmost reaches near stations 1 and 2; the only remaining substantial concentration of whales was observed in the central part of the Piltun area near the bay mouth, where about 60% of the total number of whales in the area were encountered (Vladimirov et al., 2009).

Observed whale numbers by station, averaged over each year from 2004-2009, confirm that the central part of the Piltun area near the mouth of the Bay, between survey stations 7-10, distinguishes itself from the remaining Piltun area through consistently stable gray whale

abundances (Fig. 5). Observations in the northern and southern sections of the Piltun area are highly variable in comparison.

Cow-Calf Pairs

Sixteen sightings of cow-calf pairs were made throughout the 2009 onshore survey period in the Piltun area, with a maximum of two pairs sighted on the same survey day (similar to the previous year). The last cow-calf pair was sighted on September 12; in comparison, the last pair in 2008 was observed on 21 September. The majority of cows and calves were sighted in the southern, nearshore part of the Piltun area between survey stations 8 and 13. Similarly, in 2008, almost all cow-calf pairs were observed between stations 9 and 13. All cows and calves were observed within the first kilometer of the nearshore zone in waters up to 10 m deep throughout the season, unlike previous years when cows and their calves gathered primarily in water depths of 10-15 m in September.

Offshore Feeding Area Results

2009 Data

Vessel-based surveys showed that in early September, the maximum observed number of gray whales in the Offshore feeding area declined by 58.7% (from 63 to 26 individuals), compared to the same period in 2008, with significant northeast shifts in distribution to areas outside the surveyed feeding area (Figs. 3 and 4). The decline in the observed number of gray whales may be partly attributable to two causes. First, due to adverse weather conditions, only two complete Offshore surveys could be performed in 2009. No surveys were completed in late September and early October when, in all prior years, the seasonal maximum number of gray whales occurred (e.g., 82 whales were observed in early October of 2008). Second, observations made during both the 2009 systematic and opportunistic Offshore surveys showed the presence of considerable numbers of whales to the northeast of the Offshore survey area, up to 55 km from shore, where whales have not been observed in previous years. Thus, additional whales outside the visible range of the transect lines during systematic surveys in 2009 may have been missed.

Inter-annual Variations (2001-2009)

Relative abundances and distributions of gray whales in the Offshore feeding area vary significantly from year to year. Data in this area were first collected using vessel-based surveys in 2001-2003. The maximum numbers of recorded whales in 2001, 2002 and 2003 were 83, 49, and 50 individuals, respectively (Vladimirov, 2004) (Fig. 6). Systematic vessel-based surveys conducted in 2004-2009 revealed substantial inter-annual variations. In 2004 the maximum number of whales counted during one complete Offshore survey was only 9 individuals; it increased to 25 individuals in 2005 and remained nearly constant at 26 individuals in 2006. Maximum whale numbers in the Offshore area further rose to 36 individuals in 2007 and more than doubled to 82 individuals in 2008, a level comparable to the previous peak figure recorded during the September 17, 2001 vessel-based survey (Vladimirov et al., 2005, 2006, 2007, 2008, 2009).

Inter-Annual Whale Relative Abundance Estimates (2004-2009)

The accuracy of gray whale relative abundance estimates in the entire northeast Sakhalin feeding range from vessel- and shore-based distribution surveys is limited by several factors: first, shore-based whale counts in the Piltun area only can be used for relative

abundance estimates when a complete survey has been performed, i.e., when the northern and southern distribution teams synchronously cover all northern and southern observation stations, respectively. Second, accurate estimates require that whale counts be made in both feeding areas, the Piltun area (shore-based) and Offshore area (vessel-based), either on the same day or within a time period short enough (preferably 1 day) to eliminate large errors caused by the dynamic exchange of whales between the two areas.

Data from synchronized and combined (Piltun and Offshore feeding areas) surveys from 2004-2009 (Table 1) indicate that relative abundances of whales in Sakhalin waters were relatively stable from 2004-2006, with 120-125 individuals counted over the three-year time span. From 2007-2009, relative abundances dropped from about 100 (2007 and 2008) to 77 individuals (2009). However, results from 2009, particularly in the Offshore area, are most likely an underestimate of actual whale numbers, since numerous gray whales were sighted to the east of the survey transects during both systematic and opportunistic surveys (Fig. 3). Further exacerbating the analyses, a very limited number of surveys were conducted in the Offshore area in 2009 and in less than ideal survey conditions that likely reduced detection of whales by the observers. In addition, at least 16 gray whales were observed within the Piltun-Astokh license area during the September 2 vessel survey. Although these whales may have moved there overnight from the Piltun feeding area, it is possible that some or all of these whales were in the license area on 1 September.

To compliment abundance estimates from distribution surveys, the 2009 survey data were compared with photo-identification results for whales in northeast Sakhalin waters during the past season. According to photo-ID data, a total of 117 gray whales were identified on the northeast Sakhalin shelf during July-September 2009 (Tyurneva et al., 2010; Yakovlev et al., 2010). In the near-shore waters of the Piltun feeding area, 85 animals were sighted, while 39 were sighted within the Offshore area (a number of whales were counted in both surveys, due to their migrations from one area to the other). For comparison, in 2008, the total number of gray whales identified offshore eastern Sakhalin was 98 individuals, 62 of which were sighted in the Piltun area and 61 in the Offshore area (Tyurneva et al., 2009; Yakovlev et al. 2009). These results indicate that in 2009 the total number of gray whales in the eastern Sakhalin feeding habitat had increased from 2008 levels (from 98 to 117 individuals, i.e. by 19.4%), which contradicts results of the distribution surveys that falsely may indicate there were fewer whales.

The discrepancies between the numbers of recorded whales on the northeast Sakhalin shelf based on survey and photo ID data make it necessary to exercise caution when evaluating observed changes in the relative abundance estimates of gray whales in Sakhalin waters. Furthermore, it has become apparent that the annual and seasonal migrations observed in recent years between the eastern Sakhalin and eastern Kamchatka regions, which were also observed in 2009 (Tyurneva et al., 2010; Yakovlev et al., 2010), must be considered when assessing the presence of gray whales in eastern Sakhalin waters and their overall population numbers. Photo ID data taken offshore southeast Kamchatka since 2004 and particularly, since 2007 when the photo-ID effort in this region increased, indicate that whales from the Korean-Okhotsk population use the nearshore waters of eastern Kamchatka as foraging grounds, especially Olga Bay and Vestnik Bay.

Inter-annual variations in the intensity of use of the gray whale foraging grounds offshore Kamchatka and Sakhalin Island cannot yet be fully assessed and remain to be investigated as more data become available in the future. Changes in gray whale relative abundance and their distribution in the eastern Sakhalin feeding habitat may be associated with changes in the productivity of benthic communities in the near-shore shallow water areas of Sakhalin Island (Fadeev, 2007, 2008, 2009), particularly in the northern half of the

Piltun feeding area. These issues require additional, detailed investigation based on a comparative analysis of multiyear survey, photo ID, and benthic data.

In light of the photo ID data that in 2009 documented usage of the eastern Sakhalin feeding habitat by 117 whales (Tyurneva et al., 2010; Yakovlev et al. 2010), it is justifiable to conclude that the total number of animals annually using this habitat has remained relatively stable in recent years at about 100-120 individuals, although this has been accompanied by active migration between at least two existing feeding habitats in Far East seas (eastern Sakhalin and eastern Kamchatka).

C o n c l u s i o n s

Onshore survey results show that the decline in gray whale abundance in the Piltun area observed over 2006-2008 has reversed in 2009. Average whale densities over the entire Piltun feeding area were higher during the 2009 field season as compared to 2008 and were back to the 2007 level. As in 2008, the highest density of whales in 2009 was found in the central (i.e., in the vicinity of stations 8 and 9) and southern portions of the Piltun feeding area. The increase in whale densities in the northern part of the Piltun feeding area from 2008 to 2009 was observed mainly in the vicinity of stations 4 to 7, with only slight increases in the vicinity of stations 1 to 3. In summary, the 2009 surveys showed no evidence that Sakhalin-1 onshore construction, installation, and production in the central part of the Piltun Spit (between stations 4 and 5) have resulted in any negative impacts on gray whale distribution or abundance in adjacent waters. As was observed throughout the Piltun feeding area, gray whale densities near the Odoptu site, i.e., between survey stations 4 and 5, increased in 2009 compared to 2008.

The whale distribution in the Offshore area shifted northeast within and outside of the known feeding area, with a decline in gray whale numbers compared to the same period in 2008. This decline can be attributed to the small number of complete Offshore surveys (n=2) that were performed in 2009, due to adverse weather conditions, and the presence of high numbers of whales outside the delineated survey area where whales have not been observed in previous years. Thus, additional whales outside the visible range of the transect lines during systematic surveys in 2009 may have been missed.

The distribution and concentration of whales within the Piltun and Offshore feeding areas display both temporal and spatial variability. Inter-annual distribution trends at least in part appear to have coincided with natural variations in benthic food supply, e.g., high frequency of occurrence of sand lance in the northern Piltun are in 2004 and 2005.. Multivariate analyses of a comprehensive body of acoustic, benthic and behavioral data accumulated over the years are underway to better understand the factors that contribute to observed whale distribution and abundances.

While inter-annual variability in distribution data is apparent, a comparative analysis of survey and photo ID data confirms that the total abundance of the gray whale feeding group using the eastern Sakhalin feeding habitat remains relatively stable at about 100-120 individuals. Whale migrations have begun to occur in recent years between the traditional eastern Sakhalin and the new eastern Kamchatka feeding habitats. These migrations, which are still insufficiently studied, significantly complicate this assessment.

The field work and data analysis performed as part of the Western Gray Whale Monitoring Program provides valuable information on the status of this population and its feeding habitat. The surveys off the northeastern coast of Sakhalin Island will continue to be performed, contributing to the robust, long-term database that is already in existence.

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Table 1. Maximum instant total numbers of gray whales in the northeastern Sakhalin feeding range based on the survey data and numbers of photo-identified individuals, 2004-2009

Year	Survey results*					Number of gray whales based on the photo-ID data**
	Piltun area		Offshore area		Total	
	Shore-based survey		Vessel-based survey			
	date	number	date	number		
2 0 0 4	Aug 22	122	Aug 22	0	122	95
2 0 0 5	Sep 6	114	Sep 6	6	120	117
2 0 0 6	Oct 6	99	Oct 7	26	125	121
2 0 0 7	Aug 31	73	Sep 1	28	101	125
2 0 0 8	Oct 1	16	Oct 3	82	98	98
2 0 0 9	Sep 1	51	Sep 1	26	77	117

* - based on the data of two surveys carried out in both feeding areas in the closest dates and provided the maximum total numbers.

** - data from Tyurneva et al., 2010.

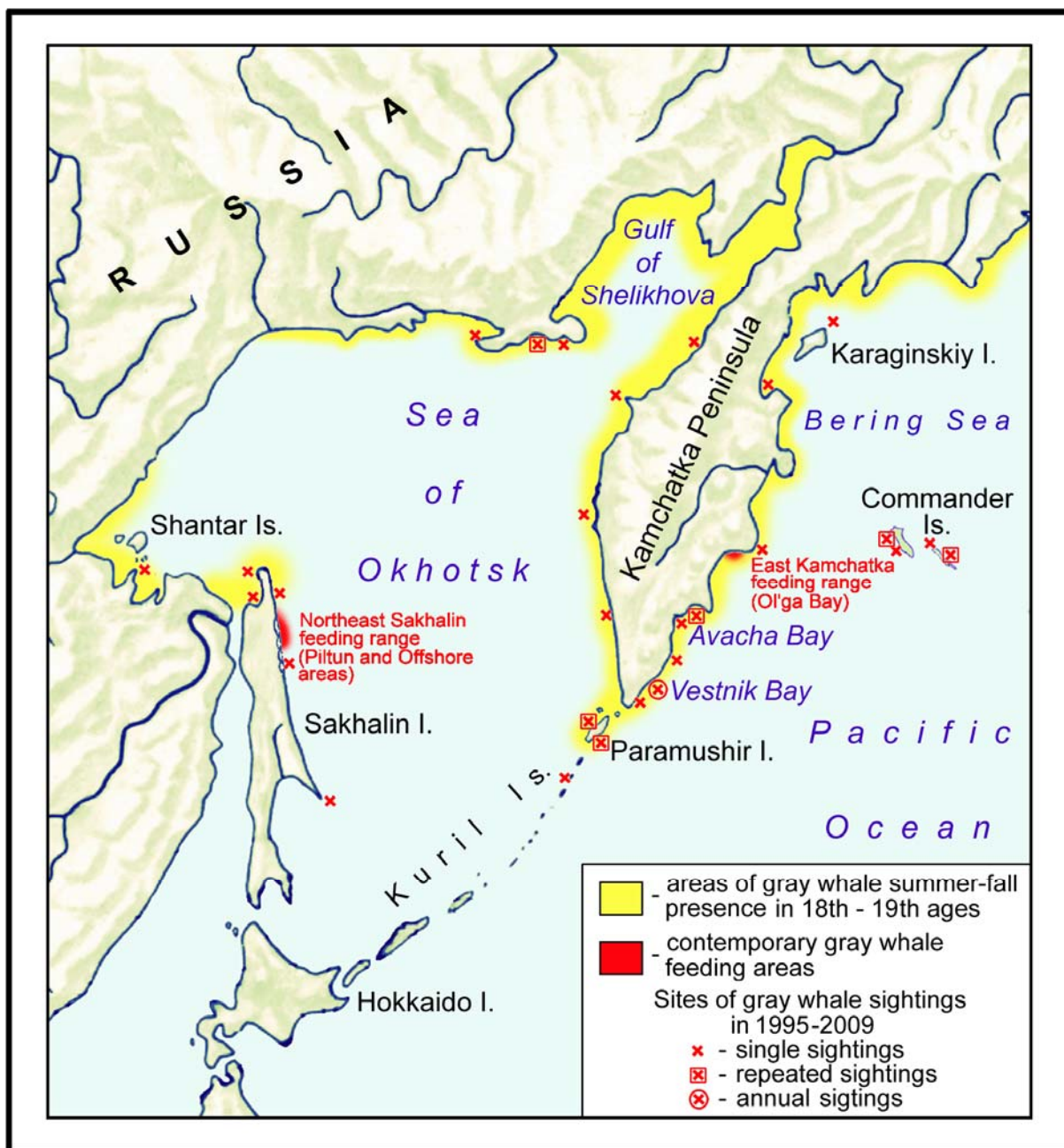


Figure 1. Former and contemporary distribution of gray whales in the Sea of Okhotsk and the southwestern part of the Bering Sea.

(former range – from Krupnik, 1984 and Reeves et al., 2008;
contemporary sightings reported by A.Andreev, V.Fomin, A.Grachev, S.Kornev, E.Mamaev,
E.Sobolevskiy, V.Vertyankin, Yu.Yakovlev, S.Zagrebel'nyy and others)

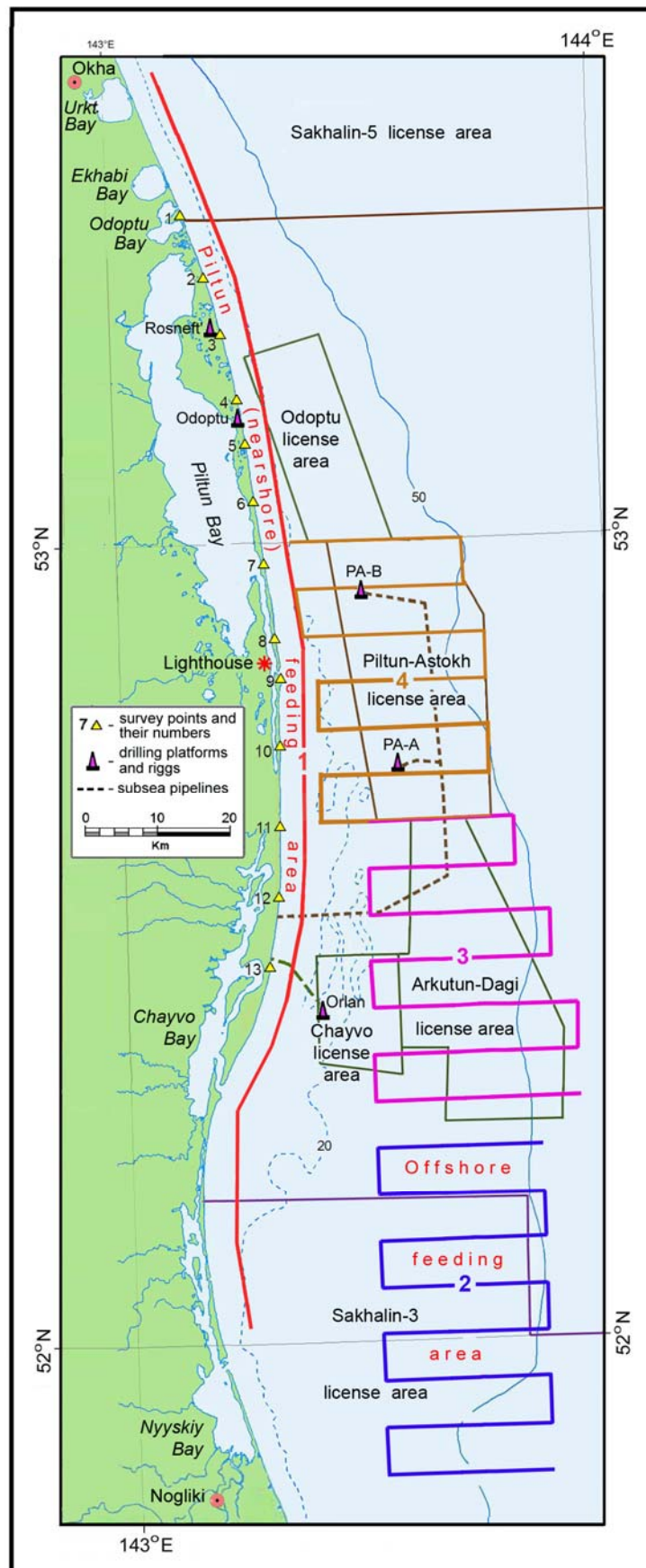


Figure 2. Location of survey stations for shore-based surveys of gray whales in the Piltun feeding area and systematic vessel-based gray whale survey transects in the whole area in 2009: (1) Piltun feeding area, (2) Offshore feeding area, (3) Arkutun-Dagi license area, and (4) Piltun-Astokh license area

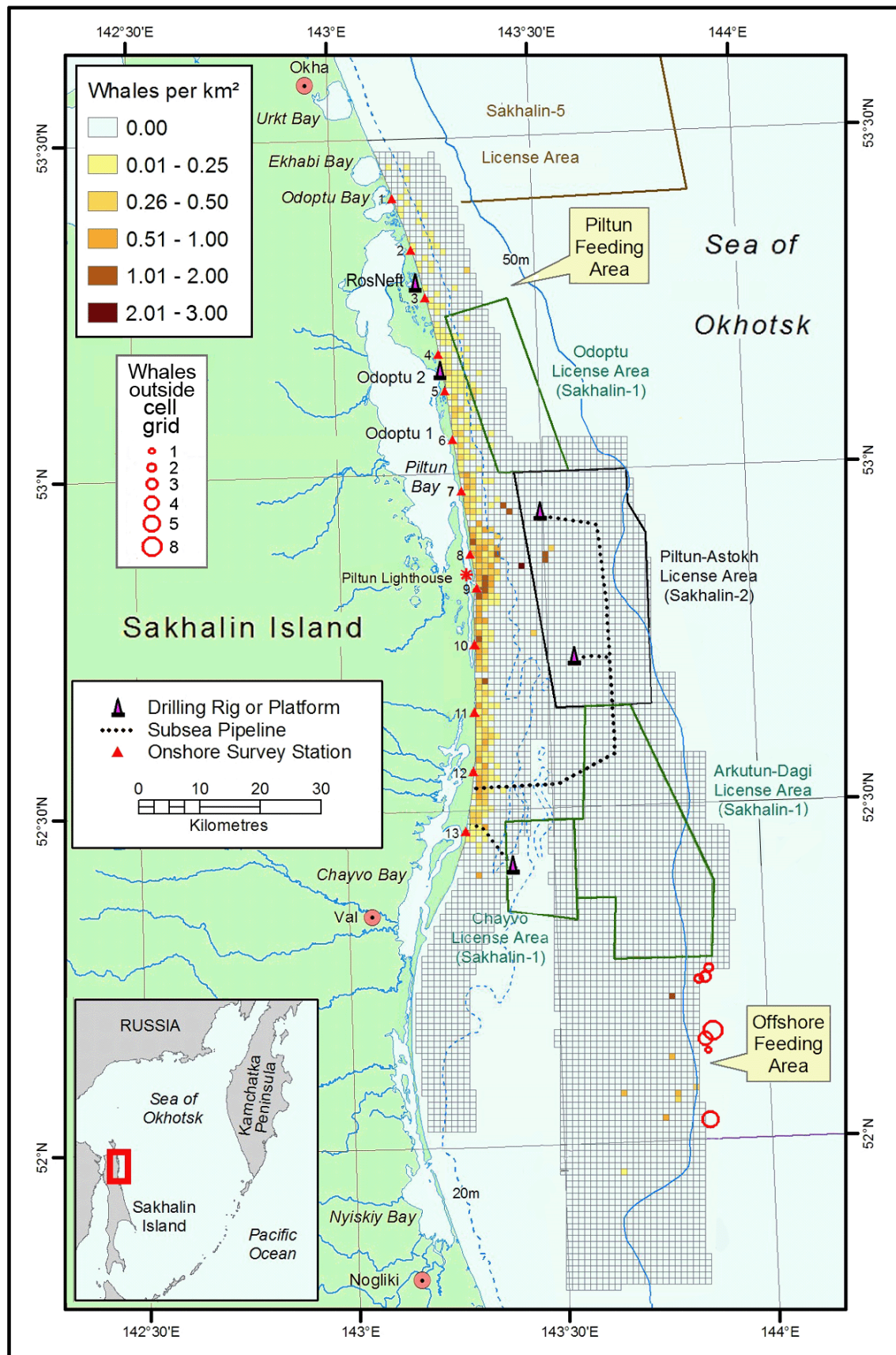


Figure 3. Gray whale distribution (average seasonal density per km²) in the Piltun and Offshore feeding areas in 2009 (from the combined shore-based and vessel-based survey data).

Whale sightings made beyond the ends of transects were excluded from the density analysis and are shown on the density maps as red circles whose size is proportional to the number of gray whales in the sighting.

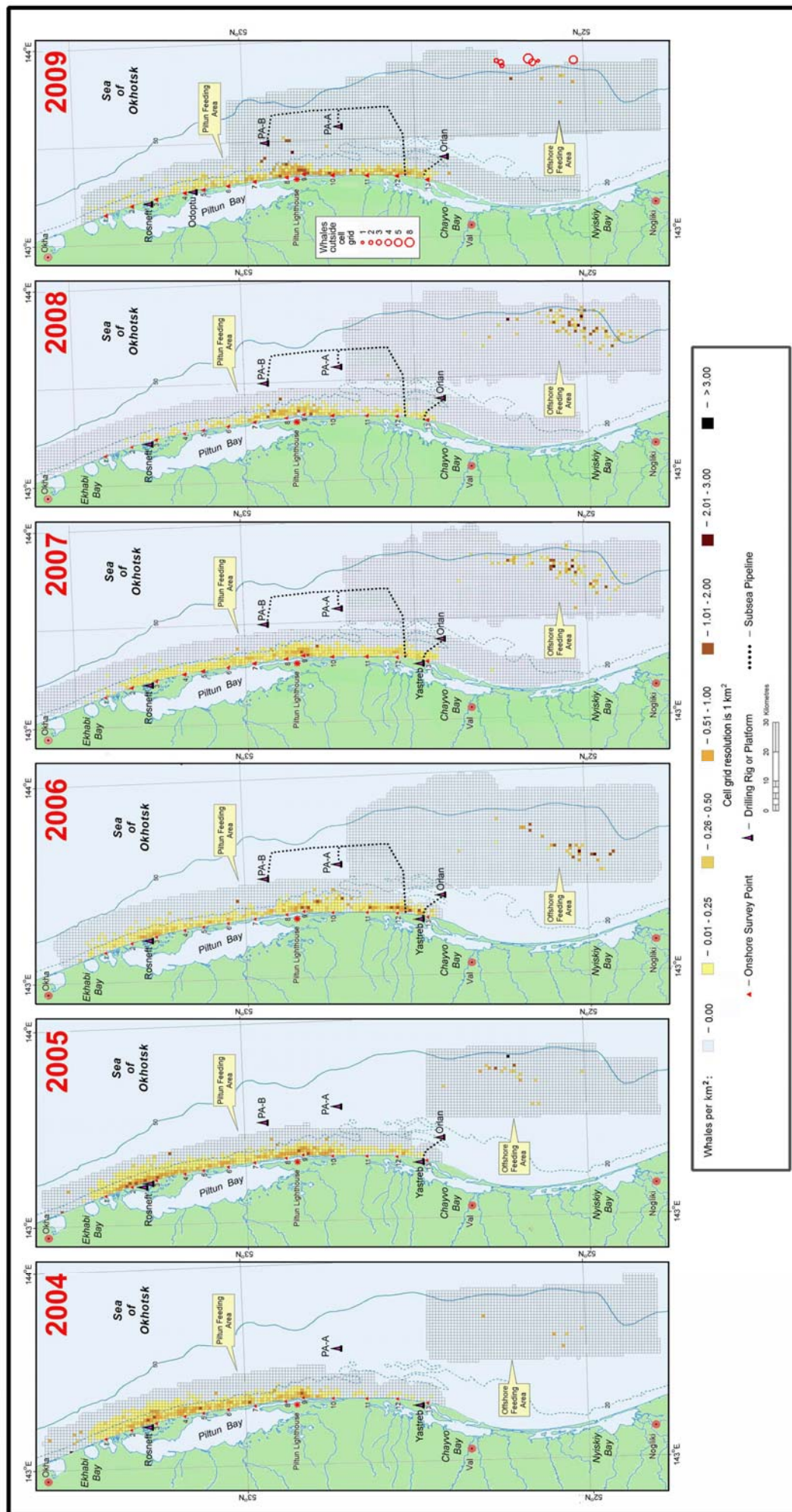
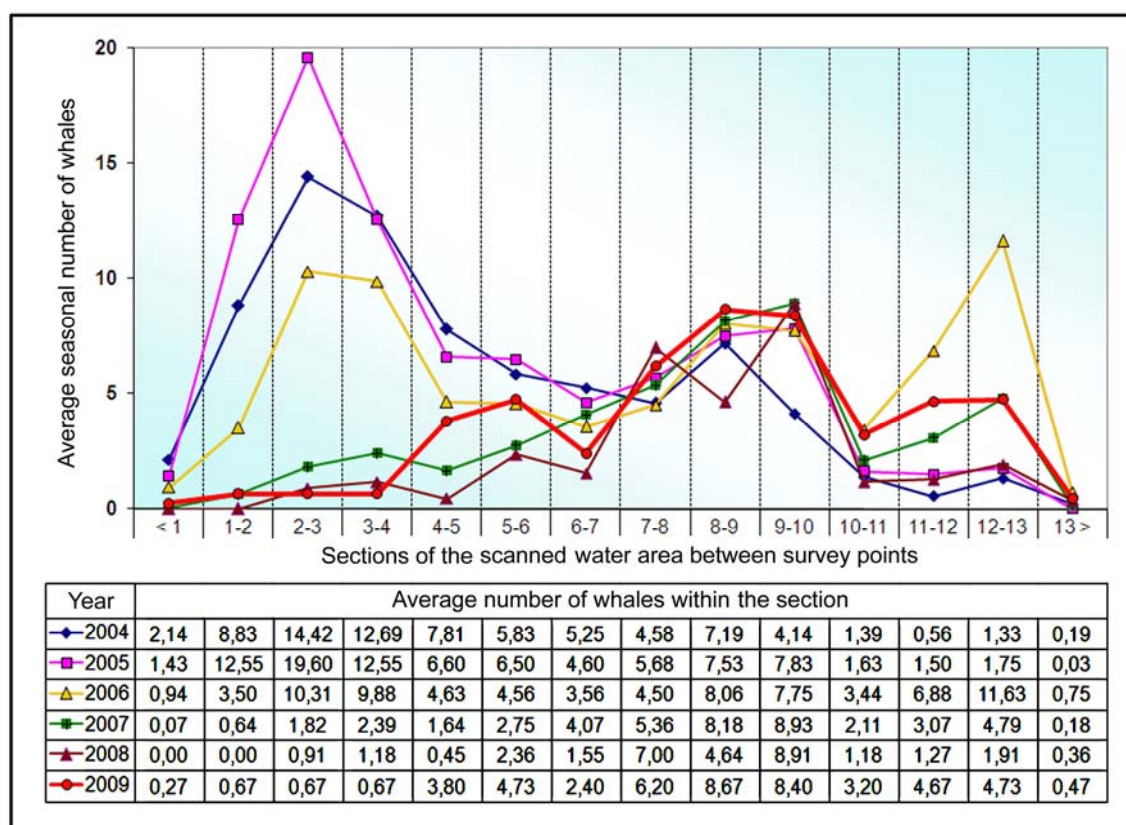


Figure 4. Changes in gray whale distribution in the Pitun and Offshore feeding areas in 2004-2009. (based on data from combined onshore and vessel-based surveys (whale population seasonal density per km²))



re 5. Average gray whale seasonal numbers within survey sections in the Piltun feeding area, 2004-2009 (based on data from completed onshore surveys).

Fig

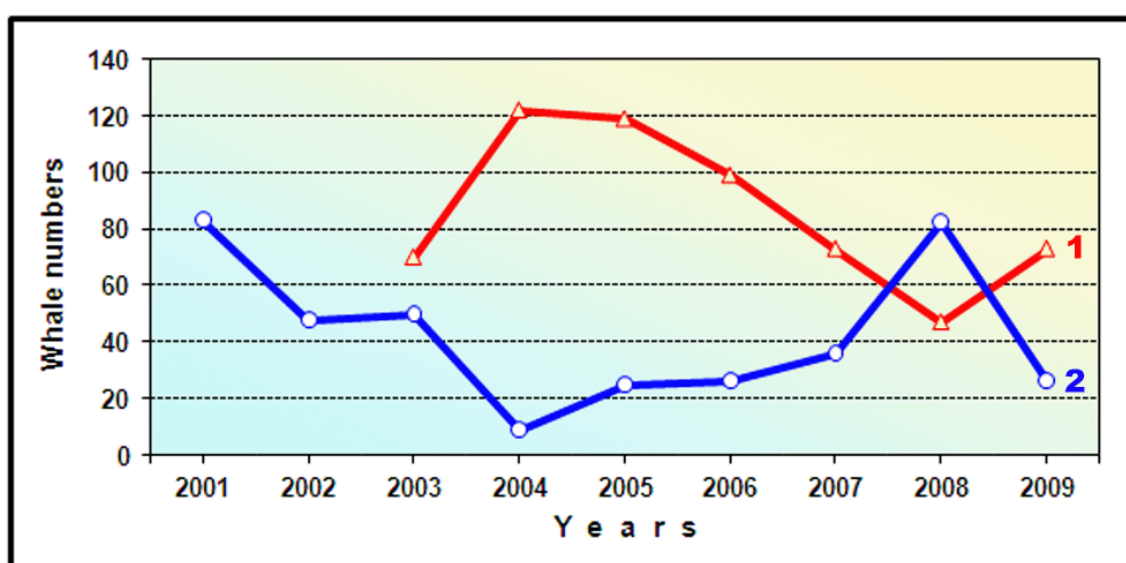


Figure 6. Recorded maximum gray whale numbers per year in the (1) Piltun and (2) Offshore feeding areas.