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Seasonal movements of western gray whales *Eschrichtius robustus* between the feeding areas on the northeast coast of Sakhalin Island (Russia) in 2002 - 2006

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Abstract

The study area covered the northeastern part of Sakhalin Island, Russia. Photo-identification of the Korean-Okhotsk gray whale *Eschrichtius robustus* was conducted in summer-fall 2002-2006. The feeding areas included the nearshore area seaward of Piltun spit (Piltun area) and an area offshore of Chayvo Bay (Offshore area). The photo-identification study was mostly concentrated in these two areas but took advantage of opportunistic sightings outside these regions. In 2005 gray whales were observed in two new areas: an area adjacent to Levenshtern Cape (Northern Area) and Elizabeth area in Severny Bay. No sightings were recorded in these areas in the following years. In 2006 more focus was placed on the nearshore region seaward of Chayvo spit where whales were sighted for the first time at depths 12-15m. During the 5 years of observation in Offshore area, utilization by gray whales varied. Significant numbers of whales were observed in the Offshore area in 2002 and 2003. Abundance of gray whale was recorded much lower in 2004 and 2005. From 2002-2006, 63 whales were identified in both the Offshore and Piltun areas both in the same year and in different years.

Introduction

There are currently two distinct gray whales (*Eschrichtius robustus*) populations: the eastern (California-Chukchi or Eastern North Pacific) and western (Korean-Okhotsk or Western North Pacific). The current state of both gray whale populations and their distribution range are covered in an exhaustive review (Swartz et al. 2006). The eastern gray whale population numbers were far more than the western population. There is a small-scale whaling of eastern gray whales by aboriginal peoples in the northeastern Russia (Krupnick 1984). The western gray whale population is currently of great concern. These populations are considered to be critically endangered by the World Conservation Union (IUCN) (Brownell & Chun 1977; Hilton-Taylor 2000).

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Much of the gray whale life cycle takes place in the coastal waters of densely populated countries with a high risk of human impact on the environment (discharges of domestic and industrial wastes, intensive fishing and maritime traffic, development of oil and gas fields, large-scale mariculture and mass tourism). Western gray whales are likely exposed to anthropogenic activity during all three stages of their life cycle: (1) during whale reproduction in the southern part of their range, the location of which is currently unknown; (2) during prolonged north-south migrations, the route which is currently unknown; and (3) in their known feeding areas off the northeast coast of Sakhalin Island, Russia. Over the last few years four female whales have been killed in fishing nets in Japan (Brownell et al. 2007).

Oil and gas development is in proximity to gray whale feeding areas along the northeastern coast of Sakhalin Island, especially during the summer migration period and could negatively impact western gray whales (Meier et al. 2007; Yazvenko et al. 2007). Data are required to monitor the status and design appropriate measures to minimize potential effects on the western gray whale population. Photographic identification (herein referred to as Photo-ID) is a key tool in effective monitoring studies and provides data for development of mitigation strategies and monitoring their effectiveness. Photo-ID work has proven to be a useful tool for studying this endangered populations of animals while minimizing the impact on individuals (Tyurneva et al. 2007).

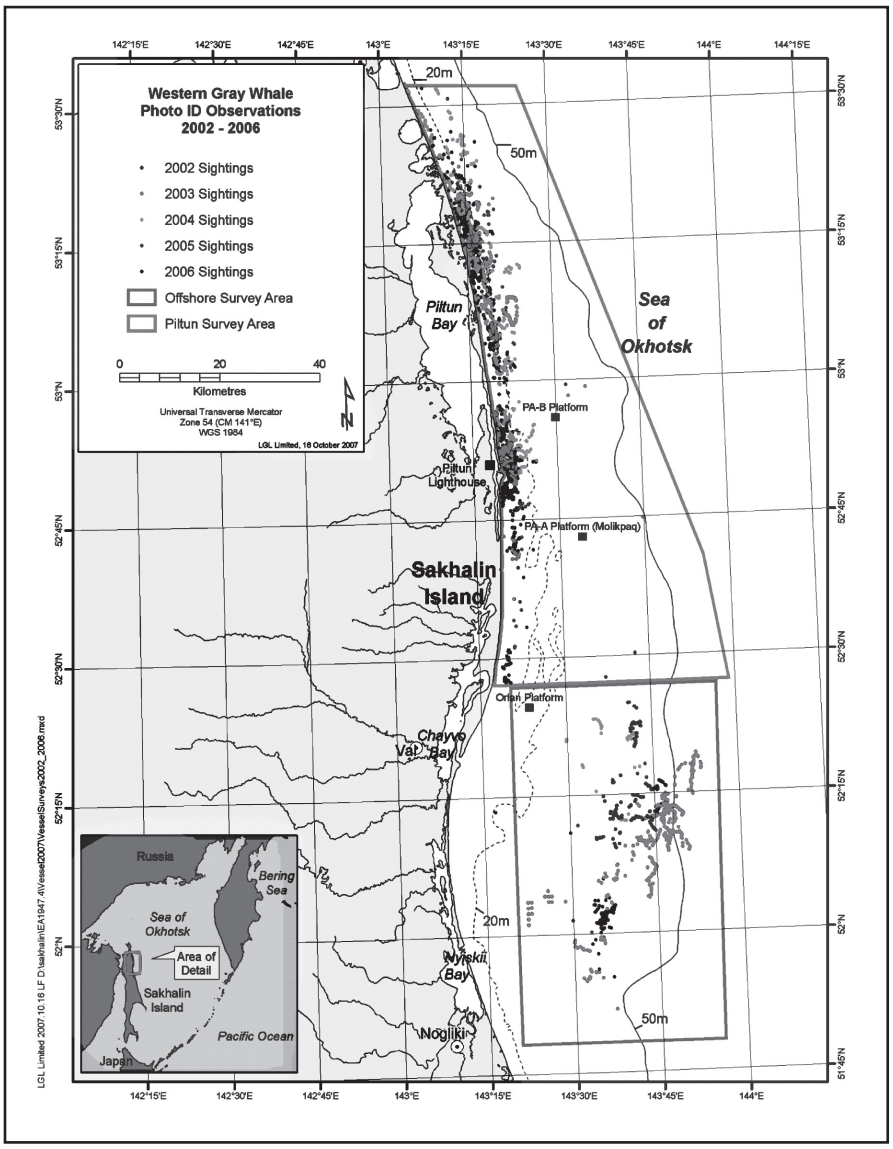
The discovery of a new primary gray whale feeding area, the Offshore area (Maminov &Yakovlev 2002) in September 2001, offered Institute of Marine Biology researchers an opportunity to study whales in detail in this area for the first time in 2002 and to determine whether there were movements of whales between the two feeding areas.

Materials and methods

Study area

The study area covers the entire northeast coast of Sakhalin Island (Sea of Okhotsk, Pacific Ocean), including the Piltun feeding area (52°40’ N to 53°30’ N) stretching along the shore of Piltun Bay at depths from 0 to 35m, and the Offshore feeding area located offshore of Chayvo Bay (51°50’ N. to 52°25’ N) at depths of 35-60m (Fig. 1).

Photo-ID effort was concentrated in these two feeding areas, but whales were also photographed opportunistically, if encountered outside of these regions.



Field photo-identification

The vessels "Nevelskoy", "Professor Bogorov" and "Akademik Oparin" were the base ships for photo-ID and other parts of the monitoring program, including vessel surveys of marine mammals, acoustic monitoring and prey studies.

Visual observations of marine mammals were conducted from the base vessel during daylight hours in all types of weather. Photo-ID was conducted from a 3.8 m long zodiac with a 45 HP four-stroke Mercury outboard motor. The zodiac was deployed

from the base vessel when gray whales were encountered. Photos were also taken opportunistically from the deck of the base vessel when other monitoring activities were being conducted (i.e. prey sampling, distribution surveys, acoustics).

A Nikon D1X or D2X digital camera with a fixed 300 mm f/4 telephoto lens or a Nikkor 80-400mm zoom lens with image stabilizer (VR) was used for photography. The photographs were recorded at a high resolution setting in large RGB JPEG format. Video footage was recorded using a Sony DSR TRV 730 (Digital 8) or Canon Optura 20 mini DV digital video camera.

Upon initial sighting of a whale, the driver slowed the zodiac to idling speed to assess initial conditions and whale behavior. Once established, the zodiac maneuvered safely to a vantage point to obtain ID photographs of the subject animal. The frame and video recording counter numbers in reference to the whales identified, the position, the depth, the temperature (at the sea surface) and salinity of the water, the distance to the whale, and the course according to compass readings, the time, behavior, number of whales in the area, direction of their movement, the presence of killer whales, and passing vessels, airplanes or helicopters in the observation area were recorded. The presence of feeding mud plumes was also recorded. The data was recorded during each mission and each photo session as the parameters changed.

Contact with a group of whales was maintained until all the individuals sighted had been photographed, if possible, or after approximately one hour, regardless of the number of aspects photographed, to avoid disturbance to the animal over an extended time period. Whales were photographed in sequence, from head to fluke on both the right and left sides, and the dorsal and ventral fluke surfaces. Priority was given to photographing the right and left sides of each whale, as fluking tendencies vary with individual behavior and foraging depth. Traditionally the right and left flanks have been considered for standard identification in photo-ID of gray whales. The surfaces of the flukes were considered as a supplemental view to aid in identification in an attempt to improve recognition accuracy.

Photo and video analysis

Standard photographic matching procedures for pattern-based matching of flanks and flukes were followed as described in the International Whaling Commission Special Issue No. 12 (Hammond et al. 1990). Identification numbers were not assigned on the basis of fluke photos that could not be matched to corresponding right or left side images of known whales.

Since 2005, I-Match software has been used for storage and processing of the 2002-2006 database. Digital photographs of whales were processed for subsequent

identification work and updating the gray whale database using the Adobe Photoshop and Adobe Illustrator software packages. The best photographs of each sighting were printed and compiled into a pre-catalogue portfolio.

Confident left to right side matches were established based on the following criteria: 1) the whale was photographed as a solitary individual; (2) two sequences were compared with flukes in common for a single sighting; and (3) as a final check to compare matches and assist with right to left matches, whale knuckle height, spacing and ratios were considered (S. Swartz and M.L. Jones pers. comm.). Whale body pigmentation was the primary feature used to distinguish individuals, with scars and barnacle patches supplementing the matching process.

All images were then compared with all of the "best" type-specimen photographs of existing whales from the 2002-2006 period to establish the recurrence of sightings of the same whales and to ensure that no duplicate individual whales were included in either the previous year's catalogues or the current pre-catalogue. Video data have only been used as an ancillary aid to assist in solving any discrepancies with whale sightings and questions about body condition.

Results

The frequency of encounters with identified individual whales during the entire survey period is important in determining how much movement of whales occurs between these two areas.

In 2002, photo and video imagery data were taken over a course of 13 days. A total of 21 encounters in Piltun area were recorded, including repeat encounters (sighting) of individual whales. A total of nine days, consisting of 51 encounters with gray whales were spent in the Offshore area. A total of 72 encounters with gray whales (field data with repeat encounters) were recorded during this time - 66 whales were identified (Table 1).

Table 1. Inter- and intra-year frequency of sightings of identified gray whales (IDW), 2002-2006.

Year	2002	2003	2004	2005	2006
Number of IDW sightings*	66	154	228	384	390
Number of IDW per year**	46	82	96	118	126
Average frequency of IDW sightings	1.43	1.88	2.38	3.25	3.1

* - including repeat encounters with individuals

** - these values include temporary whale sightings

According to our data from 2002, only one whale was documented in both the Piltun and Offshore feeding areas in the same season (Table 2, Fig. 2a).

Table 2. Gray whale movements between feeding areas, 2002-2006 (numbers in parentheses are counts of animals sighted only in this area and never seen in other surveyed areas)

Year	Number of whales identified in Piltun area	Number of whales identified in Offshore area	Number of whales identified in both Piltun and Offshore areas	Number of whales identified in Chayvo area	Number of whales identified in Chayvo /Piltun and Chayvo/ Offshore areas	Number of whales identified in northern areas	Number of whales identified in Chayvo /Piltun/ Offshore areas
2002	12(11)	35(34)	1				
2003	51(47)	35(31)	4				
2004	95(89)	7(1)	6				
2005	115 (112)	7 (2)	5			5 (1)	4
2006	105 (67)	33 (14)	16	28 (7)	19 / 1		2

Figure 2. Photo-identification sightings along the northeast coast of Sakhalin Island in September 2002-2006 (A-D).

From 7 August to 19 September 2003 there were 214 encounters with gray whales. Analysis resulted in the documentation of 154 sightings of 82 individual whales (Table 1). In the Piltun and Offshore feeding areas, 51 and 35 individual whales were observed, respectively (Table 2, Fig. 2b). Four individual whales were observed in both the Piltun and Offshore feeding areas.

It is interesting that on 15 August one gray whale was encountered in the Piltun area, observed again on 7 September in the Offshore area, and 12 days later again in the Piltun area.

It is important to note that our team spent limited time in the Piltun feeding area for parts of two feeding seasons in 2002 and 2003. As additional data are collected, it is likely that a significantly higher percentage of the whales observed in the Offshore area will have been sighted at some time in the Piltun area and vice versa.

In 2004, during the 24 days in which photo-ID was performed from the zodiac and the deck of the research vessel, only four days were spent in the Offshore area. Between 7 August and 1 October, there were 170 encounters (sightings) with 228 gray

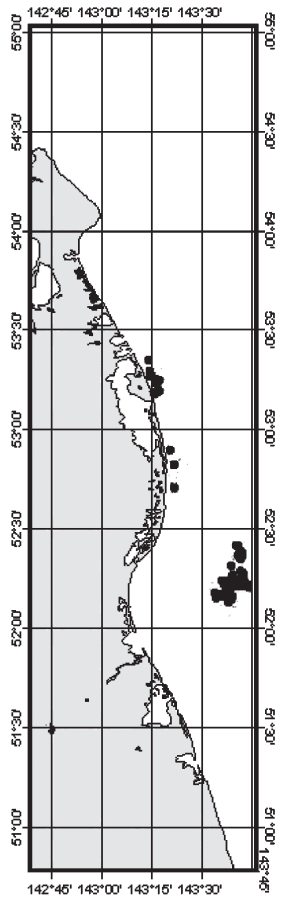


Figure 2. a

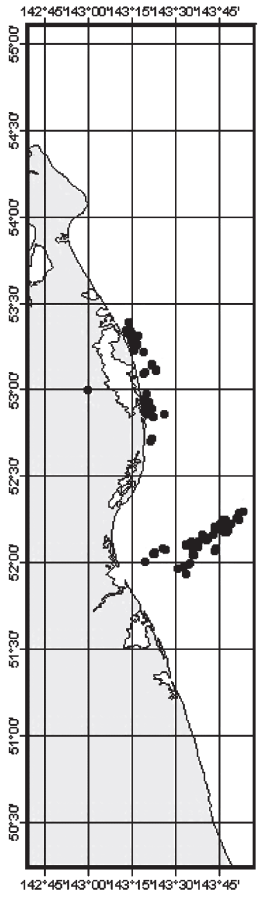


Figure 2. b

whales, including repeat sightings (Table 1, Fig. 2c). Of these whales, 220 were sighted in the Piltun area, while 8 were sighted in the Offshore area.

During the laboratory identification process, 95 and 7 individual gray whales were identified in the Piltun and Offshore feeding areas, respectively (Table 2). Six individuals sighted in the Offshore area were also observed in the Piltun area during the same season. Of the eight whales identified in the Offshore area in 2004, two whales were identified in two areas in the same year for the first time. The others had been described previously in 2002 and 2003 as only having been sighted in the Offshore area.

Between July and October 2005 there were 186 encounters (sightings) with 453 gray whales, of which 384 whales were identified, including repeat sightings (Tables 1, Fig. 2d). Of these, 370 whales were sighted in the Piltun area, 8 in the Offshore area, 4 in the area north of the city of Okha (North), and 2 beyond Cape Elizabeth, in Severny Bay (Fig. 2d). Small groups of gray whales were observed in the northern locations where they had never been seen in previous years.

During the laboratory identification process where repeated sightings were excluded, a total of 115 and 2 gray whales were identified in the Piltun and Offshore feeding areas, respectively, 4 in the North area, and 1 at the Cape Elizabeth site. Two animals sighted in the Offshore area were also seen in the Piltun area during the season, three from the North area were also recorded in the Piltun area during the season, and a

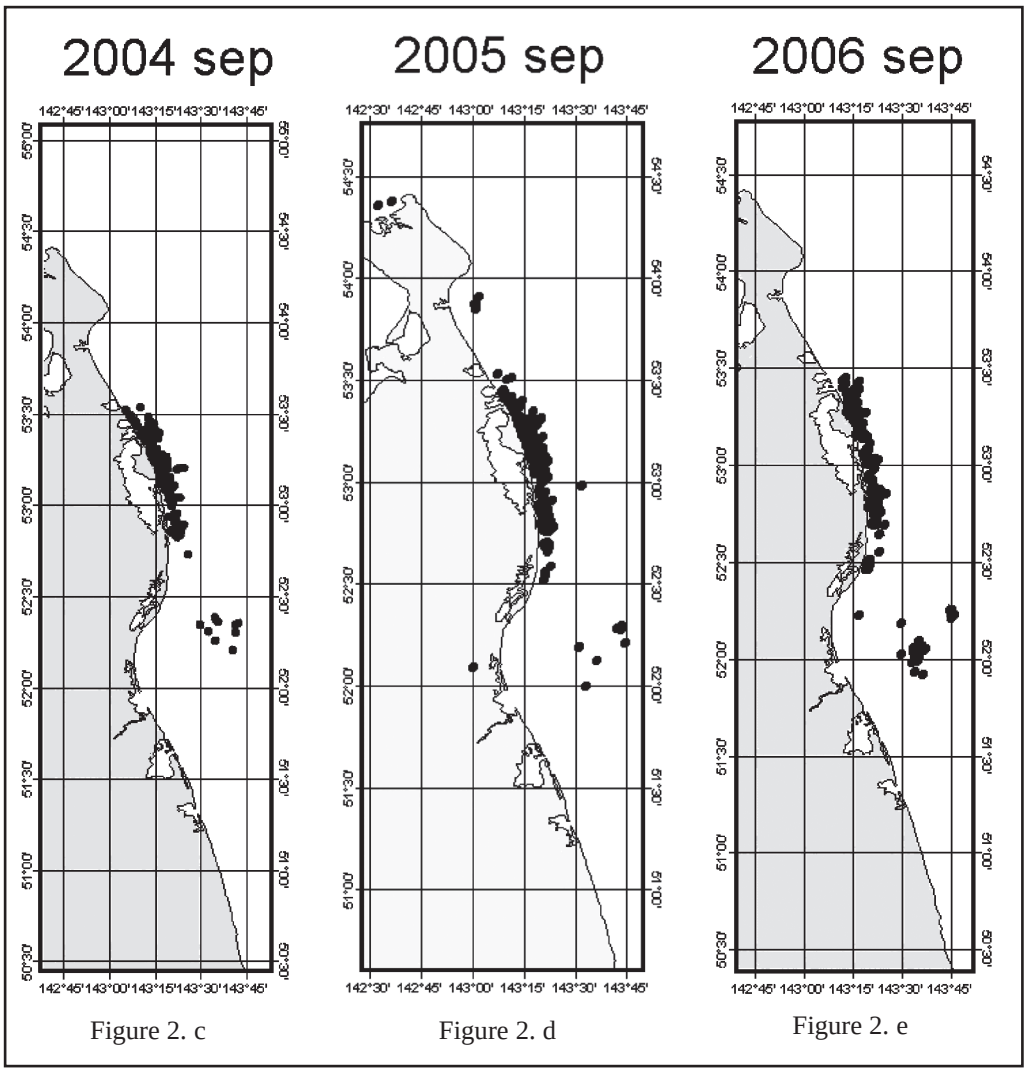


Figure 2. c Figure 2. d Figure 2. e

whale sighted beyond Cape Elizabeth was new to the catalogue and was sighted only once and only in that area (Table 2).

During the photo-ID surveys in the 2006 season (from 14 August to 9 October) in northeastern shelf of Sakhalin Island there were 390 sighting with identified gray whales recorded (Table 1, Fig 2e). In the Piltun area, 301 gray whale sightings were recorded during the same season of 105 individual whales, of which 67 were sighted in 2006 only in the Piltun area. A total of 56 gray whale sightings were recorded in the Offshore area of 33 individual whales, 16 of which were also observed in the Piltun area and one in the Chayvo Bay area. In the nearshore waters at depths 12-15m adjacent Chayvo Bay, 33 sightings were recorded of 28 individual whales. Seven of the identified

animals were sighted in this area only; 19 animals were also sighted in the Piltun area and one in the Offshore area. Two whales were sighted in all of the three areas during the same season (Table 2).

During 2002 – 2005 years of photo-ID effort, use of the Offshore area by gray whales varied in intensity. In 2002 and 2003, there were significantly more animals in the area as compared to 2004 and 2005 (Table 2). In 2006, gray whales began appearing in the Offshore area at the end of August, during which five individuals were identified. By mid-September, the number of sightings increased and we were able to photograph and identify 17 animals. In 2006, none of the identified whales were seen in the more northerly areas where five individuals were recorded in 2005. A total of 147 whales were identified over the 2002-2006 seasons (Table 3).

Table 3. Numbers of whales identified, 2002-2006.

Year	Number of whales (annual total)	From 2002	From 2003	From 2004	From 2005	Number of new whales during a year	Number of whales from previous years, not encountered this year	Number of whales in the catalogue
A	B=C+D+E+F+H	C	D	E	F	H	I	G=B+I
2002	45(1)*					45(1)		45(1)*
2003	82	35				47	10(1)	92(1)*
2004	95(1)*	39	32(1)			24	21(1)	116(2)*
2005	117(1)*	41	39(1)	18		19	18(1)	135(2)*
2006	120(6)*	42	37	15	14	12(6)	27(1)	147(7)*

*- numbers in parentheses are counts of individuals with temporary identification numbers

Over this survey period 63 whales were sighted in both the Piltun and Offshore areas during one or over several years.

As we can see from the results given, repeat sightings of whales and photographing of whales over the course of a day, as well as sightings of the same whales over the course of a season, provide important data on the habitat use of the whales within their feeding areas and the dynamics of their visits to these areas.

Discussion

According to preliminary photo-identification results, 147 individual gray whales were identified during the 2002-2006 period (Tyurneva & Yakovlev., unpubished data).

Keeping sighting data current also maintains up-to-date site-fidelity records on known whales and whale groups which are important baseline information to compare if future geographical or temporal shifts occur in the whales feeding areas or feeding patterns (Yakovlev and Tyurneva 2005 a,b). The geographical shift of utilization of the Offshore feeding area in 2002, 2003 and 2006 to the Piltun feeding area in 2004 and 2005 demonstrates that continuous monitoring of the whales and their movements is needed to track these spatial patterns.

The results of analysis of the 2002-2006 data point to inter- and intra-year movements of gray whales, both within the Piltun and Offshore areas and between these areas, and, as discovered in 2005 and 2006, movements into areas farther north and south. Information about the whales' movement between areas over the course of a single season can only be provided by repeat sightings of individuals recognized during the same season. Single gray whale sightings in one area during a season with subsequent re-sightings of the same animal in the other areas in successive years have also been recorded.

If the western population of gray whales is truly isolated in geographic and genetic terms (LeDuc et al. 2002), significant changes in abundance in one region must be accompanied by proportional changes, albeit in the opposite direction, in the other region. Recent observations of foraging gray whales south of Piltun Bay and identification of individual gray whales in other areas of the Sea of Okhotsk indicate that seasonal changes in gray whale range call for additional studies (Tyurneva et al. 2007 b).

Seasonal changes in whale distribution have been described in numerous studies and are considered to be a response to seasonal variations in the habitats and movements of whale prey (Payne et al. 1986; Calambokidis and Quan 1997; Karczmarski et al. 1999). Eastern gray whales feeding along the west coast of Vancouver Island, Canada, rotate feeding areas and prey types within and between summer feeding seasons as a function of distribution and abundance of their prey (Dunham & Duffus 2001).

The distribution of feeding eastern gray whales along the west coast of North America is variable within and between years with whales utilizing areas from northern California to southeast Alaska from spring to fall involving significant interchange of individuals between areas with variable use of habitat within and between years (Calambokidis et al. 2002).

Recent research has indicated that eastern gray whales are not exclusively benthic foragers but are rather dynamic and selective foragers capable of utilizing a variety of prey types and foraging tactics, switching between prey species and techniques rapidly in order to take advantage of short-term availability of food resources (Dunham and Duffus 2001; Moore et al. 2003; Tyurneva et al. 2006).

Conclusion

Analysis of the inter- and intra-year frequency of sightings of identified whales in 2002-2006 is of particular interest. A better understanding and statistical substantiation of whale movements both within a single feeding area and between areas, as well as how the feeding areas are used, can be obtained only after accumulation of additional data in further studies and their comparison with benthos data, since use of a particular feeding area by gray whales within a single and between two feeding seasons may have to do with prey preferences.

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