



# Study of associativity between the spatial distributions of gray whales and their prey species offshore north-east coast of Sakhalin Island



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## HIGHLIGHTS

- Spatial distributions of gray whales and their prey species are analyzed.
- Food factor is a key one in formation of the whale spatial distribution.
- Whales prefer shallow fields with high and evenly distributed Amphipoda biomass.

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## ABSTRACT

Among the most important ecological challenges of the modern age is maintaining the current level of biodiversity. The subject of this research is the gray whale (*Eschrichtius robustus*) that inhabits the northern parts of the Pacific Ocean. The gray whale of the Okhotsk–Korean or the Western Gray Whale (WGW) population is classified as critically endangered according to criteria of the International Union for Conservation of Nature (IUCN); current estimate of the total population numbers is approximately 150 individuals. The main feeding area where western gray whales spend their summer–fall period, constitutes a narrow (with depths no greater than 50 m) sea area that runs alongside the coastline over approximately 100 km, and is located in the north-eastern part of the Sakhalin Island. Unlike other cetaceans, the gray whale feed on benthic organisms — the primary components of their diet are bottom-dwelling crustaceans belonging to the groups of Amphipoda and Isopoda. Systematic research into the western gray whale, initiated by a group of oil companies working offshore Sakhalin, has been going on since 1997. We analyzed the associativity between the spatial distributions of the western gray whales and the biomass of the benthic organisms serving as their food source over the period of 2002–2011. The analysis was conducted using GIS technologies. Cartographic alignment of whale occurrence distribution and the abundance of food benthos demonstrate the high degree of their spatial associativity, thus indicating the important role of the food factor in the formation of the whale spatial distribution. Maximum values of cumulative yearly estimates of sighted gray whales are associated with the areas with the maximum density of benthos. The analysis of the associativity dynamics shows that most attractive for whales are shallow vast fields with high and relatively evenly distributed Amphipoda biomass.

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## 1. Introduction

Among the most important ecological challenges of the modern age is maintaining the current level of biodiversity (Adrianov, 2004). Many natural sites are characterized by a low degree of resilience against external impact, and require a strict approach

to ensure their preservation (Puzachenko, 1997). To that end, the issue of providing sufficient monitoring and protection to rare plant and animal species is extremely relevant.

The subject of this study is the gray whale (*Eschrichtius robustus*) that inhabits the northern parts of the Pacific Ocean (Fig. 1). The gray whale of the Okhotsk–Korean or the Western Gray Whale (WGW) population falls under Category V in the Red Book (Endangered Species List) of the Russian Federation, and is classified as critically endangered according to IUCN criteria (Baillie et al., 2004). Throughout history, their population numbered on the order of 1500 individuals (up to 10,000 according to some

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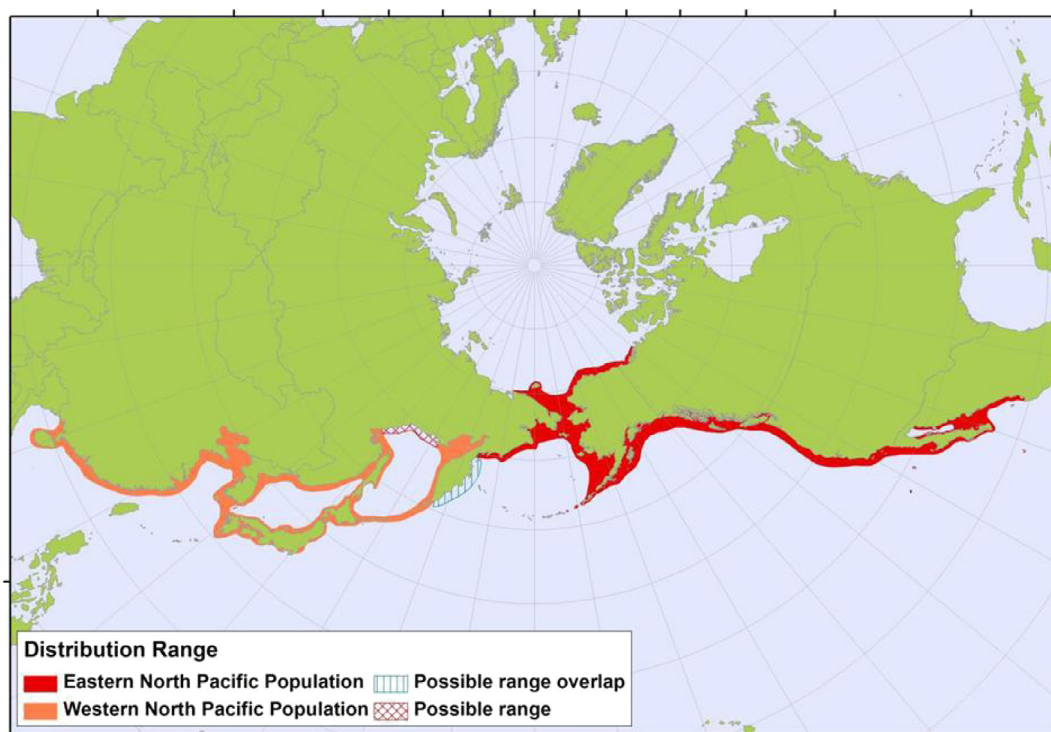


Fig. 1. Gray whale (*Eschrichtius robustus*) geographic range.

assessments Yablokov and Bogoslovskaya, 1984). Their migration routes strictly along the coastline and the fact that their habitat lies within the shallow coastal waters made them easy targets for whalers. As a result of an extensive and unregulated hunting, the population had shrunk so much that by the 1970 it was considered to be extinct (Bowen, 1974). However, further observations indicated that the population continued to exist as a small remnant group that spent its summer feeding season along the northeastern coastline of Sakhalin. Currently, the total population numbers is approximately 150 individuals (Tyurneva et al., 2012). Until recently, the western gray whale were assumed to be geographically isolated from the more numerous eastern population that inhabit the waters of the Bering and Chuckchee Seas, as well as the eastern coast of the Pacific Ocean—from Alaska to California (Swartz et al., 2006). Such isolation of WGWW was evidenced, in part, by genetic research results (LeDuc et al., 2002; Lang et al., 2011), although the latest data acquired using enhanced genetic analysis methods and satellite tagging, has spawned an alternative view. According to this view, the gray whales migrating to the feeding areas at the coasts of Sakhalin constitute what is merely a specific group existing within the larger eastern population (Ilyashenko, 2012; Mescherski et al., 2012).

Systematic research into the western gray whale, initiated by a group of oil companies working offshore Sakhalin, has been going on since 1997. Starting from 2002, a long-term comprehensive monitoring and survey program of the Okhotsk–Korean population of gray whales in the northeastern Sakhalin region is being in action, in preparation and realization of which the companies Exxon Neftegaz Limited and Sakhalin Energy take an important part. Offshore north-east Sakhalin researches are conducted in summer-fall feeding period and include whales abundance and spatial distribution registering, photo-identification, behavioral studies, studies of benthic fauna composition and abundance (benthos being the main component of whales diet). Over this time, a significant amount of data has been accumulated on the various biological aspects of this species: population numbers, size distribution and sex ratio, feeding and migration behavior,

reproductive rate, reaction to environmental factors, etc. (Weller et al., 1999, Bradford et al., 2006, Yazvenko et al., 2007, Bradford et al., 2008, Tyurneva et al., 2010, Weller et al., 2012, and others).

The main feeding area where western gray whales spend their summer-fall period, is quite compact in size. It constitutes a narrow (with depths no greater than 50 m) sea area that runs alongside the coastline over approximately 100 km, and is located in the northeastern part of the Sakhalin Island, in the vicinity of the Piltun Bay.

Unlike the majority of cetaceans, gray whale feed on benthos (Zenkovitch, 1937; Nerini, 1984). Also, the dietary requirements of animals as large as the gray whale are rather substantial: the daily ration of an adult individual is 1000–1200 kg (Highsmith and Coyle, 1992). The primary components of their diet are bottom-dwelling crustaceans belonging to the groups of amphipods (Amphipoda) and isopods (Isopoda). It is known (Highsmith and Coyle, 1992) that the life cycle parameters for amphipods depend on the water temperature, and that the northern Arctic waters are predominantly populated by long-lasting, slow-growing life forms with a low reproductive rate. It is suggested that the reduction in the eastern population of the gray whale, as noted in recent years, was caused by insufficient amounts of food related to a drop in abundance of amphipods within the Bering and Chuckchee Seas (Le Boeuf et al., 2000; Moore et al., 2001). Thus, from the standpoint of sustaining and restoring the whales numbers, the issue of maintaining a sufficient supply of food becomes especially important.

It should be noted that the nature and intensity of the trophic relationships depend not only on the biological properties of the interacting species, but also on environmental conditions, one of the most crucial factors of which is spatial heterogeneity. It is known that factors characterizing the spatial distribution of organisms can play a significant role in the “consumer-resource” system dynamics (Dolman and Sutherland, 1997, van der Meer and Ens, 1997, and others). Given a constant average concentration, local densities differ substantially, as a rule, which predetermines the outcome of any biological interactions for the system as a whole. Within the shelf area of northeastern Sakhalin, the spatial

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