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High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea

B.A. Bluhm[a,*], K.O. Coyle[a], B. Konar[a], R. Highsmith[b]

[a]School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 245 O'Neill Building, P.O. Box 757220, Fairbanks, AK 99775, USA
[b]National Institute for Undersea Science and Technology, University of Mississippi, MS 38677, USA

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Abstract

We describe gray whale (*Eschrichtius robustus*) distribution in the south-central Chukchi Sea in relation to environmental factors during two 5-day surveys in June and September of 2003. Whale counts per 10-min scan (an index of relative abundance) ranged from 0 to 41 in June and from 0 to 28 in September. CTD data showed an ocean front around 67.8°N with strong horizontal gradients in temperature, salinity, chlorophyll-*a* concentration and water-column stability. Highest whale abundance indices occurred in or near the front in both periods. Preliminary qualitative assessment of biological communities in the study area suggests that infaunal clams, echinoderms, euphausids, chaetognaths and Arctic cod were common, while ampeliscid amphipods, the previously abundant infauna (and likely prey) in the nearby Chirikov Basin feeding area, were not dominant. Euphausids may be a prey for gray whales in this area. We suggest that frontal systems may play an important role in eastern North Pacific gray whale foraging grounds. Further study is needed to fully describe the role of frontal systems in gray whale foraging grounds.
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1. Introduction

The eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) population migrates from the wintering grounds in Baja California north to the Bering and Chukchi Seas to exploit the rich northern foraging grounds during the summer (Marquette and Braham, 1982). The distribution of the summer foraging grounds is generally well-documented, ranging from the Siberian Koryak coast to the Chirikov Basin, near-shore sites of Chukotka and to the Alaskan Chukchi coast off Point Franklin and the Chukchi Sea shoals (Berzin, 1984; Moore et al., 2000; summary in Highsmith et al., 2006). Whale use of these grounds is temporally and spatially variable (Moore, 2000; Moore et al., 2003). Variability in the foraging ground use might be resulting from increases in the total gray whale stock over the past 150 years (Rice and Wolman, 1971; Le Boeuf et al., 2000; Witting, 2003), environmental conditions (Moore, 2000), and change of available food sources due to

*Corresponding author. Tel.: +1 907 474 6332; fax: +1 907 474 7204.
E-mail addresses: bluhm@ims.uaf.edu (B.A. Bluhm), coyle@ims.uaf.edu (K.O. Coyle), konar@ims.uaf.edu (B. Konar), ray@olemiss.edu (R. Highsmith).

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climate variability or top-down processes (Moore et al., 2001; Grebmeier et al., 2006a; Coyle et al., 2007).

During the 1980s, gray whales used the Chirikov Basin in the northern Bering Sea in dense aggregations (Highsmith and Coyle, 1990, 1992; Moore et al., 2000). During this period, ampeliscid amphipods occurred in high density in the Chirikov Basin (Grebmeier et al., 1989; Highsmith and Coyle, 1990) and were considered the major prey item of gray whales in this area (Yablokov and Bogoslovskaya, 1984). Indirect evidence for the abundance and importance of these amphipods as prey was given by Obst and Hunt (1990) who found these amphipods in stomachs of sea birds feeding in gray whale mud plumes. The biomass of these amphipods has since been reduced by as much as 50% relative to the 1980s (Moore et al., 2003; Coyle et al., 2007), and in 2002, gray whale relative abundance in the Chirikov Basin feeding area was as much as 17 times lower than in the 1980s (Moore et al., 2003). Concurrently, relatively high gray whale densities were recorded in the south-central Chukchi Sea near the Convention Line in 2002 (Moore et al., 2003). This area is occupied by the Bering Shelf Anadyr Water and the Alaska Coastal Water with a frontal boundary between them (Belkin et al., 2003; Coachman et al., 1975). In other areas, fronts are known to support elevated biomass of pelagic (Munk et al., 1995) and hyper-benthic communities (Dewicke et al., 2002) as well as bird and mammal aggregations (Hunt and Harrison, 1990; Mendes et al., 2002).

A considerable amount of survey effort was dedicated to gray whales in their Arctic summering grounds during the 1980s and early 1990s, concomitant with plans to develop oil and gas lease sales there (Moore and DeMaster, 1998; Moore, 2000; Moore et al., 2000; Clarke and Moore, 2002). After delisting of the eastern North Pacific gray whale stock (ENP) in 1994, and the decline in interest in oil and gas development in the northern Bering and Chukchi Seas, less effort has been spent surveying this species in the summering areas. Analysis of gray whale habitat selection in Alaskan waters using published ice charts and water transport data showed that gray whales preferred coastal/shoal and shelf/trough habitat and open water/light ice cover (Moore and DeMaster, 1998; Moore, 2000; Moore et al., 2000). Shelf habitat was selected during low-moderate transport through Bering Strait, while coastal and shoal areas were used more in high transport situations (Moore, 2000).

This study surveyed an area in the south-central Chukchi Sea in the summer and fall of 2003, an area previously noted for high gray whale densities. Our primary objective was to describe gray whale distribution in relation to specific environmental factors including salinity, temperature, chlorophyll-*a* concentration and water-column stability. Results are discussed in the context of prey availability and productivity near an oceanographic front.

2. Materials and methods

2.1. Field sampling

The study area was located in the south-central Chukchi Sea (box in Fig. 1) between 67.38°N and 68.35°N and between 167.39°W and 168.98°W. Water depths were between 40 and 60 m. The western and eastern boundaries of the survey area were determined by the international convention line (Fig. 1) and decreasing numbers of whale sightings, respectively. Northern and southern boundaries were determined by the estimated location of an oceanographic front based on preliminary data from the westernmost CTD transect, and by available ship time.

Gray whale counts were conducted during June 24–27 and September 20–24, 2003 to assess a relative index of abundance of whales relative to environmental conditions. Counts were made from a moving ship along a transect grid (black dots in Fig. 2) with a haphazardly chosen starting point. The height of the observation platform was 8 m above sea level. Every 10 min, one of two observers conducted a 180° visual scan from the vessel bridge using Fujinon 7 × 50 binoculars. Observers switched shifts every hour. A third person noted whale numbers, sea state according to the Beaufort scale, and occurrence of fog and glare. Travel speed varied between 6 and 10 knots, depending on other cruise activities. Whale surveys were interrupted by other station activities, dark hours or dense fog. In 42 areas where a whale was observed to first surface, we approached the whale to visually assess whether a mud plume was present behind it.

Conductivity, temperature, depth (CTD) and chlorophyll fluorescence vertical profiles were taken with a Seabird model 911 Plus CTD (see Fig. 4 for CTD locations). For chlorophyll-*a* analysis, water samples collected with Niskin bottles from a CTD rosette were filtered onto GF/F filters and frozen. For chlorophyll-*a* determination, filters were

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