

Note

Marine Mammal and Sea Turtle Sightings During a Survey of the Endeavour Segment of the Juan de Fuca Ridge, British Columbia

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Marine mammals and sea turtles were documented as part of a monitoring and mitigation program during a seismic study offshore (~250 km) from Vancouver Island, British Columbia, during August–September 2009. Forty-one marine mammals in nine groups were sighted. Dall's Porpoise (*Phocoenoides dalli*) was the most frequently sighted species. A Sperm Whale (*Physeter macrocephalus*), a pod of Pacific White-sided Dolphins (*Lagenorhynchus obliquidens*), an unidentified toothed whale, a Northern Elephant Seal (*Mirounga angustirostris*), and a Leatherback Turtle (*Dermochelys coriacea*) were also observed. These data augment current knowledge on the occurrence of marine mammals and sea turtles in the offshore waters of British Columbia.

Key Words: Dall's Porpoise; *Phocoenoides dalli*; Leatherback Turtle; *Dermochelys coriacea*; Northern Elephant Seal; *Mirounga angustirostris*; Sperm Whale; *Physeter macrocephalus*; Pacific White-sided Dolphins; *Lagenorhynchus obliquidens*; seismic survey; marine mammal; Vancouver Island; British Columbia; Endeavour Hydrothermal Vent Marine Protected Area

Introduction

Limited information is available on the occurrence and distribution of marine mammals and sea turtles inhabiting the offshore waters of British Columbia. Although marine mammal surveys have taken place in deep offshore waters out to the edge of the exclusive economic zone approximately 200 nautical miles off the coast of Washington (e.g., Barlow and Forney 2007; Barlow 2016), surveys have generally not occurred that far offshore in Pacific waters of Canada. Surveys by Fisheries and Oceans Canada off British Columbia have typically occurred within 50 km of the shelf break and did not extend more than 150 km offshore (Ford *et al.* 2010); the most frequently sighted species were Humpback Whale (*Megaptera novaeangliae*), Fin Whale (*Balaenoptera physalus*), Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), and Dall's Porpoise (*Phocoenoides dalli*). In addition, systematic surveys have taken place in inshore coastal waters (e.g., Williams and Thomas 2007; Best *et al.* 2015). Opportunistic sightings in offshore waters have also been reported to the British Columbia Cetacean Sightings Network (BCCSN), but these records are not corrected for effort.

As part of the marine mammal monitoring and mitigation program for Lamont-Doherty Earth Observatory's Endeavour Tomography (ETOMO) experiment, biologists watched for marine mammals and sea turtles in and adjacent to the Endeavour Hydrothermal Vent Marine Protected Area (EHV MPA) during an academic seismic survey in August–September 2009. The EHV MPA is a unique ecosystem consisting of hydrothermal vents and associated fauna located ~250 km southwest of Vancouver Island, British Columbia. It covers ~93 km² and lies in water ~2250 m deep. The increased con-

centration of vent-derived material in the EHV MPA is likely enhancing the abundance of zooplankton there, leading, in turn, to increased productivity throughout the entire water column above the venting region (Tunnicliffe and Thomson 1999). However, it is uncertain whether this translates into higher densities of marine mammals and sea turtles above the vent fields (Gisiner *et al.* 2009; Soule *et al.* 2009).

This study was not designed as a systematic marine mammal and sea turtle survey, but rather as part of a program to reduce the possible effects of seismic survey operations on marine animals. Nonetheless, it allowed for determination of encounter rates and contributes to our understanding of the occurrence and distribution of cetaceans, pinnipeds, and turtles in deep, offshore waters of British Columbia.

Methods

The ETOMO experiment took place in and around the EHV MPA, located ~250 km southwest of Vancouver Island, British Columbia, within the area bounded by 47°–49°N and 127°30'–130°W (Figure 1). The seismic vessel *Marcus G. Langseth* left Astoria, Oregon, on 22 August 2009. During the study, a 36-airgun array with a total discharge volume of 6600 in³ (108 155 cm³) was towed behind the *Langseth*. The source array had an acoustic output (downward) of 259 dB re 1 μPa m_{zero-to-peak}. A brief (~0.1 s) pulse of sound was emitted every ~250–500 m along designated transect lines. Airgun operations occurred day and night on a daily basis starting on 26 August and concluding on 11 September. During seismic acquisition, the vessel traveled 7–9 km/h; when not towing gear (e.g., during transits to the study area), the *Langseth* cruised at 20–24 km/h. Water depth in the survey area was > 2000 m.

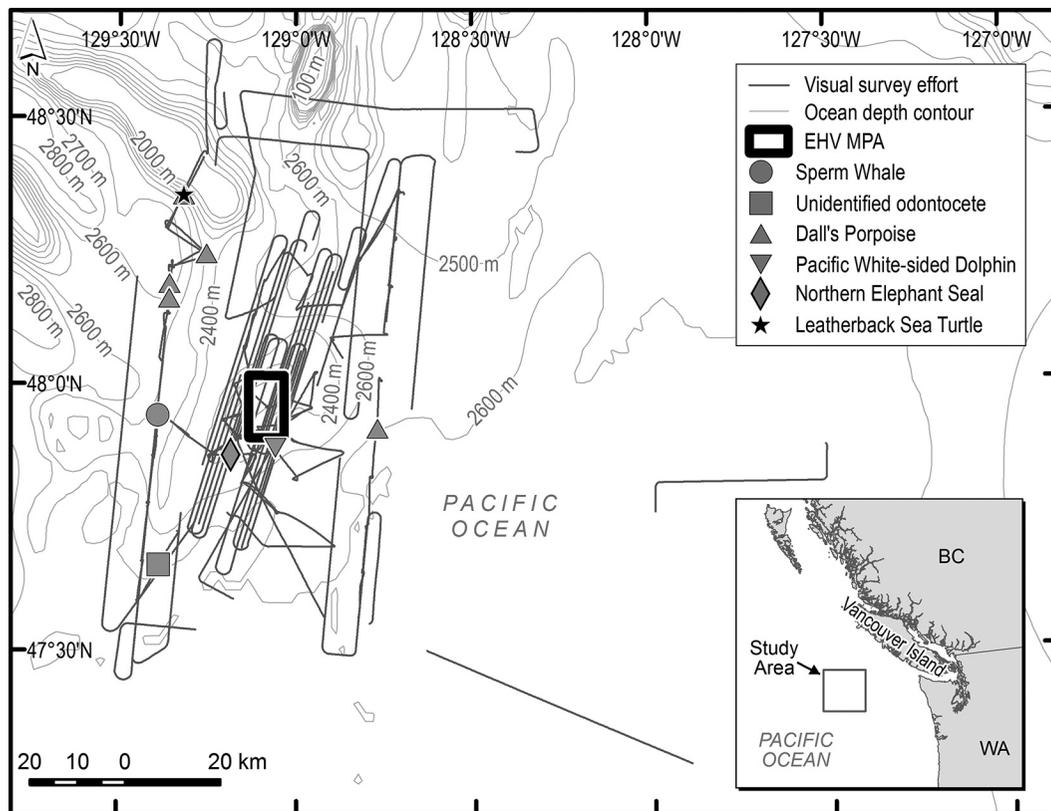


FIGURE 1. The Endeavour Tomography survey area showing observation effort and sightings of marine mammals and a sea turtle, 23 August to 18 September 2009. Note: EHV MPA = Endeavour Hydrothermal Vent Marine Protected Area.

Standard monitoring and mitigation measures were implemented during the study, including ramp-up, power-down, and shut-down procedures (e.g., Nowacek *et al.* 2013; Wright and Cosentino 2015). Visual observations commenced 23 August and continued until 18 September. One or two experienced observers (out of a team of six) watched for marine mammals and sea turtles from approximately 0700 to 2030 from the *Langseth's* observation tower, ~20 m above sea level. Observers were on watch for shifts no longer than 4 h. The observers used 7 × 50 reticle binoculars, 25 × 150 big-eye binoculars, and the naked eye to look for marine mammals and sea turtles around the vessel. While on watch, observers kept written records of environmental conditions and vessel activities every 30 minutes. For each sighting, species, identification reliability, number of individuals, environmental conditions (glare, visibility, Beaufort wind force), date, time, and vessel position and activity were recorded on a datasheet.

Encounter rates (number of sightings per 1000 km surveyed and number of individuals per 1000 km) were determined for all species seen during periods without airgun activity. These “non-seismic” periods included only data collected before or more than 6 h after seismic

operations had ceased; the 6-h period was used to distinguish seismic periods from those periods where seismic surveys were sufficiently far in the past that it could be assumed that they had no residual effect on current animal behaviour or distribution. In addition, only data obtained during Beaufort wind force ≤ 5 and when the vessel travelled at speeds over 3.7 km/h were used to determine encounter rates.

Results

The ETOMO experiment included 330 h of observations covering ~2714 km; 121 h of observations (~1036 km) took place during periods when the seismic source was not operating, and the remaining effort occurred when airguns were operational. During non-seismic periods, nearly half of all observations (47%) were made by one observer; the remainder were made by two observers. Although the variable number of observers introduced a source of bias, we did not correct for it. Most observation effort (67%) occurred during Beaufort wind force ≤ 4.

A total of 41 marine mammals in nine groups were sighted; none were seen within the EHV MPA (Figure 1). Dall's Porpoise was the most frequently sighted spe-

cies (five groups totalling 28 individuals); a Sperm Whale (*Physeter macrocephalus*), a pod of ten Pacific White-sided Dolphins, one unidentified odontocete, and one Northern Elephant Seal (*Mirounga angustirostris*) were also observed. In addition, one Leatherback Sea Turtle (*Dermochelys coriacea*) was seen. Except for the pod of Pacific White-sided Dolphins, which was observed on 25 August before seismic operations commenced, all sightings were made during September after all airgun activity had ceased. Thus, all sightings occurred during non-seismic periods. The encounter rate was highest for Dall's Porpoise (5.0 groups/1000 km surveyed or 31.4 individuals/1000 km); the encounter rate for Pacific White-sided Dolphin was 16.5 individuals/1000 km. All other species were encountered at a rate of 1.7 groups/1000 km.

Discussion

Although the ETOMO experiment was designed to obtain information on the sub-seafloor structure of volcanic and hydrothermal features that form as a result of movements of the Earth's tectonic plates, useful information on the occurrence of marine mammals and a sea turtle in the area was also collected. Numerous sightings of Leatherback Turtles have been made throughout the waters of British Columbia, including offshore from Vancouver Island (McAlpine *et al.* 2004; Pacific Leatherback Turtle Recovery Team 2006; Spaven *et al.* 2009). Our sighting on 11 September is one of the farthest offshore observations — if not the farthest — reported for British Columbia. Most other reported sightings have occurred in August, followed by September (Spaven *et al.* 2009). Sightings of Leatherback Turtles have also been made off Washington in 1989 and 1990; most turtles occurred in continental slope waters, although some were found over the shelf (Green *et al.* 1992). During that study, all sightings were reported for June–September, with most in July.

There is a lack of information on the at-sea distribution of Northern Elephant Seals in British Columbia (Best *et al.* 2015). However, Elephant Seals are known to transit through the offshore waters of Vancouver Island, including our study area, as they move between southern rookeries and northern feeding areas (e.g., Le Boeuf *et al.* 2000; Ganong 2012; Robinson *et al.* 2012). Elephant Seals and Northern Fur Seals (*Callorhinus ursinus*) have been seen in the deep offshore waters of British Columbia and Washington (Bonnell *et al.* 1992; Ford 2014). Steller Sea Lions (*Eumetopias jubatus*) have been sighted in coastal waters of British Columbia (Ford 2014) and in shelf and slope waters of Washington (Bonnell *et al.* 1992).

Based on information from sightings in the offshore waters of Washington (e.g., Green *et al.* 1992; Barlow and Forney 2007; Becker *et al.* 2014; Barlow 2016),

Dall's Porpoises, Pacific White-sided Dolphins, Northern Right Whale Dolphins (*Lissodelphis borealis*), and Risso's Dolphins (*Grampus griseus*) were expected to be common in the ETOMO study area. Dall's Porpoise and Pacific White-sided Dolphin have been reported most often in this area, based on opportunistic sightings found in the BCCSN database¹, with more than 25 sightings each, followed by Fin and Humpback Whales with fewer than ten sightings each (BCCSN, unpublished data 1956–2015). The encounter rates (number per 1000 km) for Pacific White-sided Dolphin and Dall's Porpoise derived from the ETOMO study were greater than those for offshore areas of Washington, where 3.2–8.2 and 1.6–4.6/1000 km were found during summer and fall, respectively (Green *et al.* 1992).

In contrast to expectations based on surveys off Washington, only four sightings of Northern Right Whale Dolphins and no Risso's Dolphins were made in the ETOMO study area (BCCSN, unpublished data 1956–2015). Other opportunistic sightings in the ETOMO study area west of 127.5°W include two sightings each of Grey (*Eschrichtius robustus*), Sperm, Killer (*Orcinus orca*), and Short-finned Pilot (*Globicephala macrorhynchus*) Whales; and single sightings of Blue (*Balaenoptera musculus*) and Sei (*B. borealis*) Whales (BCCSN, unpublished data 1956–2015). Short-finned Pilot Whales and Pacific White-sided Dolphins have also been reported in offshore waters of Vancouver Island, including within the ETOMO study area (Stacey and Baird 1991; Baird and Stacey 1993; Ford 2014). Other species reported off the west coast of Vancouver Island within 150 km of shore include Cuvier's Beaked Whale (*Ziphius cavirostris*), Harbour Porpoise (*Phocoena phocoena*), and Risso's Dolphin (Ford *et al.* 2010; Ford 2014).

Our Sperm Whale sighting is one of the farthest offshore sightings made for this area (see Ford 2014); previous sightings occurred east of 128.2°W (BCCSN, unpublished data 1956–2015). Opportunistic sightings of Dall's Porpoise ($n = 6$), Pacific White-sided Dolphin ($n = 4$), Fin Whale ($n = 2$), and Humpback Whale ($n = 1$) have been made within the EHV MPA during June, July, and September (BCCSN, unpublished data 1956–2015). In addition, seismometers deployed near the hydrothermal vent fields from 2003 to 2006 detected Fin and Blue Whale calls every year (Soule *et al.* 2009). Fin and Blue Whale calls had previously been detected by bottom-mounted hydrophones deployed just south of the ETOMO study area (McDonald *et al.* 1995). No sightings were made within the EHV MPA during the ETOMO study, but only 220 km (65 km during non-seismic and 155 km during seismic operations) of the total 2714 km of survey effort occurred within the EHV MPA.

¹Data obtained from the BCCSN were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

As all sightings during the ETOMO study occurred during non-seismic periods, it is possible that marine mammals actively avoided the area around the operating source, thereby reducing encounter rates. Localized and short-term behavioural responses that include movement away from the sound source have been reported for some cetaceans during seismic surveys (e.g., Richardson *et al.* 1995; Gordon *et al.* 2004; Nowacek *et al.* 2007; Southall *et al.* 2007). Despite this limitation, our study allowed for the first effort-corrected sighting data to be collected >150 km off Vancouver Island and contributes to our understanding of marine mammal and sea turtle distribution and occurrence in offshore waters of British Columbia. Given the limited amount of data currently available, it is not possible to assess whether the EHV MPA is a concentration area for marine mammals; additional surveys would need to be undertaken in and around the area.

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