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North Pacific right whales (*Eubalaena japonica*) recorded in the northeastern Pacific Ocean in 2013

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The North Pacific right whale (*Eubalaena japonica*) is among the most critically endangered marine mammals in the world (Brownell *et al.* 2001). Its population was drastically reduced by 19th and 20th century whaling and its recovery was additionally slowed by illegal Soviet whaling that occurred during the 1960s (Clapham *et al.* 2004, Ivashchenko and Clapham 2012). With a severe decrease in the population also came a restriction in range, from extensive distribution across the North Pacific, to a constricted presence of two different populations, one in the Sea of Okhotsk and along the Western Pacific, and the other in the eastern Bering Sea (Scarff 1986, Clapham *et al.* 2004, Josephson *et al.* 2008). The abundance estimates for the eastern population are around 30 animals (Wade *et al.* 2006, 2011*b*; Marques *et al.* 2011), while the western population is considered to be larger with current estimates of probably no more than 300 animals (Brownell *et al.* 2001).

Most baleen whales undertake seasonal migrations, spending summers feeding in high latitude, productive areas and winters in warmer, lower latitude breeding grounds (Kellogg 1929). North Pacific right whales spend their summers in the Bering Sea and, to a lesser extent, the Gulf of Alaska, the Aleutian archipelago, and off Kodiak (Scarff 1986, Brownell *et al.* 2001, Clapham *et al.* 2004, Mellinger *et al.* 2004, Shelden *et al.* 2005, Wade *et al.* 2011*a*). Most current research effort has been focused within the area in the Southeastern Bering Sea where North Pacific right whales have been sighted most frequently (Wade *et al.* 2006, Munger *et al.* 2008). Over the years, however, a small number of sightings of single right whales have been

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reported off Washington, southern California, Hawaii, and Baja California (Rowntree *et al.* 1980, Carretta *et al.* 1994, Rowlett *et al.* 1994, Gendron *et al.* 1999, Salden and Mickelsen 1999). Sightings in the Gulf of Alaska are very rare (Waite *et al.* 2003, Mellinger *et al.* 2004), but considering this was once a productive whaling ground (Josephson *et al.* 2008, Ivashchenko and Clapham 2012), this paucity is likely the result of little effort and may not be true indication of right whale occurrence in these oceanic waters (Shelden *et al.* 2005).

North Pacific right whales produce a variety of low frequency sounds, including: up-calls, down-calls, gunshots, screams, and moans (Clark 1983, Parks and Tyack 2005). The acoustic repertoire is shared among North Atlantic right whales (*E. glacialis*), southern right whales (*E. australis*) and North Pacific right whales (Clark 1983, McDonald and Moore 2002, Mellinger *et al.* 2004, Parks and Tyack 2005). These high amplitude, low frequency sounds propagate well over long distances, making these rare animals detectable over large ranges (Wiggins *et al.* 2004, Munger *et al.* 2011). Therefore passive acoustic monitoring is a cost-effective tool to monitor this small cetacean population (Marques *et al.* 2011) and study their potential range extension in remote areas.

High-frequency Acoustic Recording Packages, HARPs (Wiggins and Hildebrand 2007), were deployed at four locations in the northeastern Pacific Ocean during 2013, three in the Gulf of Alaska, and one off the coast of Washington State (Fig. 1). The HARPs recorded continuously at sample rates of 200 or 320 kHz (Table 1), but once the data were downloaded, they were decimated by a factor of 100 creating an effective bandwidth from 10 to 1,000 or 10 to 1,600 Hz, respectively, allowing sufficient bandwidth for analysis of right whale call presence. After decimation, data were processed into 5 s long-term spectral averages (LTSAs) with 1 Hz resolution (Wig-

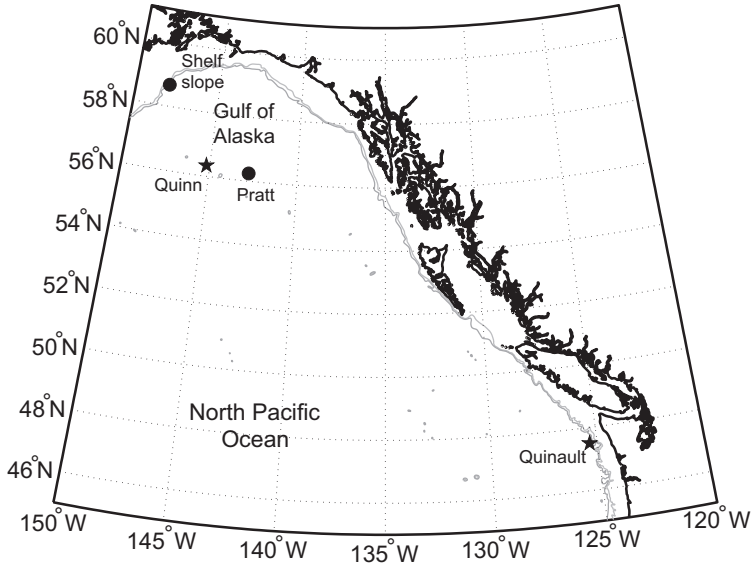

Figure 1. Map of the Northeast Pacific Ocean showing two HARP deployment locations where North Pacific right whales were recorded in 2013 (stars), and two locations where there was recording effort but no calls detected (circle). Gray lines mark 500 and 1,000 m bathymetry contours.

Table 1. Location and deployment periods for each of the four sites monitored for North Pacific right whale call presence.

Site name	Latitude (N)	Longitude (W)	Depth (m)	Deployment period	Sample rate (kHz)
Quinault Canyon	47°30.032′	125°21.215′	1,390	14 September 2012–30 June 2013 17 July–30 November 2013	200
Quinn Seamount	56°20.363′	145°11.235′	930	10 June 2013–11 September 2013	320
Pratt Seamount	56°14.575′	142°45.409′	990	11 June–20 August 2013	200
Shelf slope	58°40.312′	148°1.313′	880	6 June–5 September 2013	200

gins and Hildebrand 2007). These LTSAs were visually inspected for presence of right whale up-calls. If a suspected up-call was detected in the LTSA, the data were scrutinized in more detail using a spectrogram to confirm presence of call and thus reduce the false negative rate to 0. If an up-call was detected, an adjacent week of data before and after the call was analyzed more carefully using spectrograms (Washington data) or LTSAs (Gulf of Alaska data) for presence of additional right whale calls. Hourly presence of calls was logged using MATLAB-based custom software *Triton* for each call type found. Presence of calls was plotted against sunrise and sunset times at the deployment location, to qualitatively evaluate diel patterns in calling behavior. Also, start and end frequencies and durations of a subsample of seven high quality right whale down-calls from different days were measured from spectrograms (1 Hz frequency and 0.1 s temporal resolutions, Hann window) and we report their means and standard deviations.

We detected two right whale up-calls (Fig. 2) at the Quinault Canyon site (Table 1) off Washington State (Fig. 1) on 29 June 2013 during two different hours. Even though passive acoustic monitoring was conducted at this site in two previous years (2011 and 2012), these were the first right whale calls detected at this location. Coincidentally, two individual North Pacific right whales were sighted on two different occasions off British Columbia, Canada, in 2013,[2] one in June and the other in October. These were the first such sightings in this area in over 60 yr. No other potential right whale call types were recorded at this site.

Right whale up-calls were also detected at Quinn Seamount in the Gulf of Alaska during two days: 21 June and 3 August 2013, for a total of three hours of presence (Fig. 1, 2). More commonly detected at this site was a down-call, which occurred during 50 h between 27 July and 5 September 2013 (Fig 3). Almost all right whale down-calls at this site were detected during nighttime, while up-calls occurred during daytime, indicating possible difference in the behavioral context between the two call types. Down-calls occurred on one of the days with up-calls, but unlike previ-

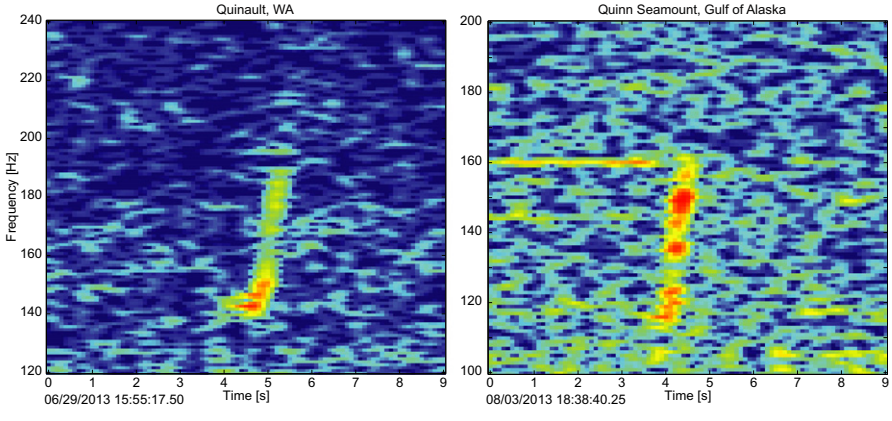

Figure 2. Spectrograms of North Pacific right whale up-calls recorded at Quinault (left), and Quinn Seamount (right) in 2013 (FFT with 1 Hz frequency resolution, Hann window and 90 % overlap).

[2]Personal communication from John K. B. Ford, Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road Nanaimo, BC V9T 6N7, Canada, July 2014.

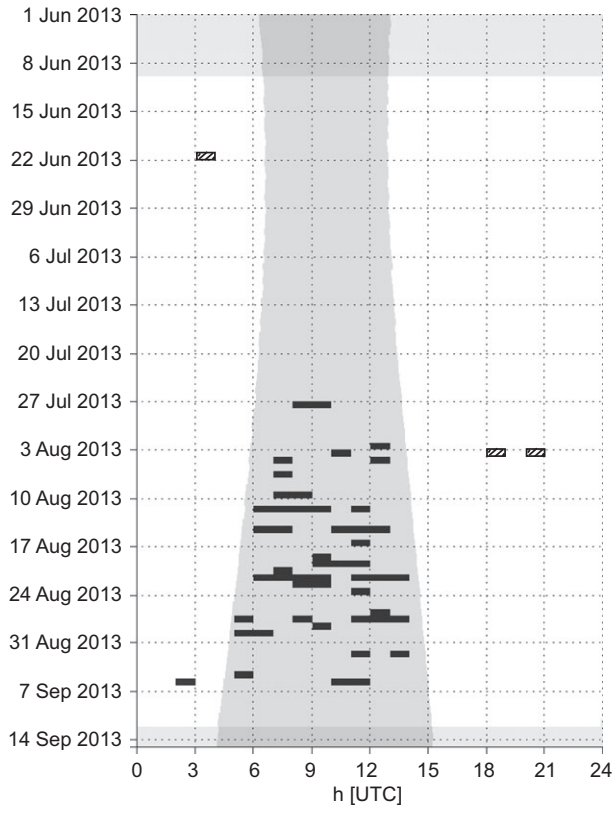

Figure 3. Hourly presence of the North Pacific right whale up- (hatched box) and down- (black box) calls at Quinn Seamount. Vertical gray shading represents nighttime at this site, and horizontal gray shading marks periods with no recording effort.

ously reported, they were overall the more common call type than the up-calls (McDonald and Moore 2002, Mellinger *et al.* 2004). Also, they were generally higher frequency (start and end frequency of 170 ± 8 and 135 ± 4 Hz, respectively) and longer duration (1.3 ± 0.6 s) than the down-calls reported for the eastern Bering Sea by McDonald and Moore (2002) and usually they contained harmonics. Despite these differences, we believe these are also right whale calls due to several factors. Firstly, these calls did not follow any regular temporal patterns as would be indicative for humpback whale (*Megaptera novaeangliae*) calls. In addition, no humpback whale songs or social sounds were detected at this site during this time (Payne and McVay 1971, Dunlop *et al.* 2008). In addition, no other baleen whale species found at this site, namely blue (*Balaenoptera musculus*) or fin whales (*B. physalus*), are likely to produce similar calls. Finally, sei whale (*B. borealis*) downsweeps are lower frequency than the calls recorded in this work (Rankin and Barlow 2007), yet the recorded down-calls are within the frequency and temporal characteristics of other right whale calls.

No right whale up-calls were detected at the nearby Pratt Seamount or at the Shelf slope site (Table 1) during the monitoring period in the summer of 2013. A disadvantage of using acoustic data is that you can only know the presence of a calling whale. If no calls are recorded, then either the whale is not present, or it is not calling.

So while we can confirm presence of right whales at the two sites with call detections, based on passive acoustic data alone, we cannot conclusively state right whales were absent from the other two sites.

The lack of detections at Pratt Seamount, which is relatively close (~150 km) to Quinn, may be the result of different monitoring areas for the deployed instruments. The HARP at Quinn was facing northeast of the seamount, while at Pratt it was on the west side of the seamount, thereby monitoring completely different parts of the Gulf of Alaska. In addition, many of the down-calls at Quinn had a relatively low signal-to-noise ratio, further indicating that the calling animal was not in the immediate vicinity of the HARP. Given its orientation, Quinn Seamount site was likely monitoring an area of high productivity offshore from the continental slope that may have the potential to provide a suitable foraging habitat for right whales (Gregr and Coyle 2009), which may explain the difference between these two sites.

Given the rarity of this species, and very few visual or acoustic sightings that have occurred outside the Bering Sea (Shelden *et al.* 2005), our detections are an important indicator that this population is using a larger, oceanic area of the North Pacific. Central Gulf of Alaska was once an important habitat for this species (Shelden *et al.* 2005, Ivashchenko and Clapham 2012) and more effort should be expended in this remote region to increase our understanding of habitat requirements and use by the North Pacific right whales, to facilitate efforts for their conservation. Recent mother-calf pair sightings in the eastern Bering Sea (Wade *et al.* 2006), and our extended range detections along with recent visual sightings may be indicators of an improving condition of this critically endangered species and may offer a sliver of hope for its eventual recovery.

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