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INTRODUCTION

Blue whales produce nine regionally distinct patterned call sequences termed songs. It has been proposed that these songs can be used to characterize population structure (McDonald et al. 2006). The song recorded in the Northeast Pacific (NEP) is made up of two distinct units. Unit A consists of a series of low frequency pulses and unit B is a tonal signal with abundant harmonics and a fundamental frequency at 15 Hz (Figure 1). The Central Pacific (CP) blue whale song has only a single tonal song unit with a fundamental frequency of 19 Hz and few or no harmonics (Figure 1).

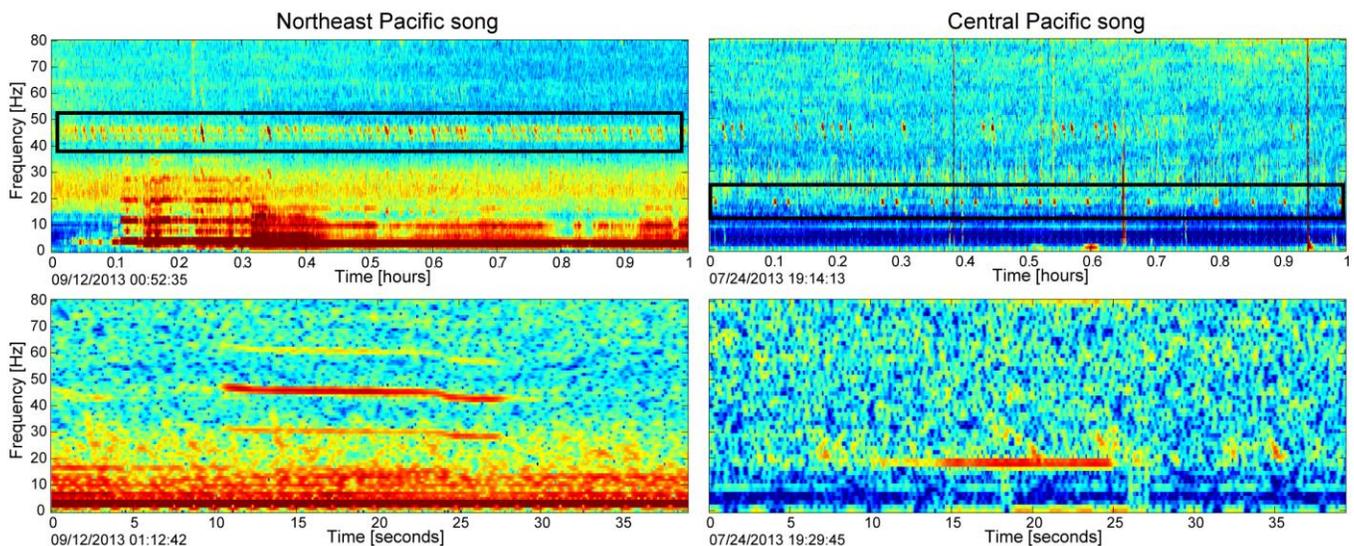


Figure 1. Long term spectral averages (top panels) and spectrograms (bottom panels) of Northeast Pacific (NEP) and Central Pacific (CP) blue whale song. Sequences of songs are highlighted in rectangles in the LTSA, and individual song units are visible on the spectrograms. The intensity of the signal is shown in color, with red indicating higher intensity sound.

METHODS AND RESULTS

Two different types of blue whale song were recorded at five sites in the Gulf of Alaska, distributed from the continental slope to deep water offshore, during 2013-2014 (Figure 2). Blue whale B calls, part of the NEP song, were detected manually at some of the coastal sites, and they were detected automatically at offshore sites and during some coastal deployments. The hourly presence of Central Pacific blue whale song was determined by manual scrutiny. Thus the data are presented either as percentage of hourly bins with calls or as the total call count, per week.

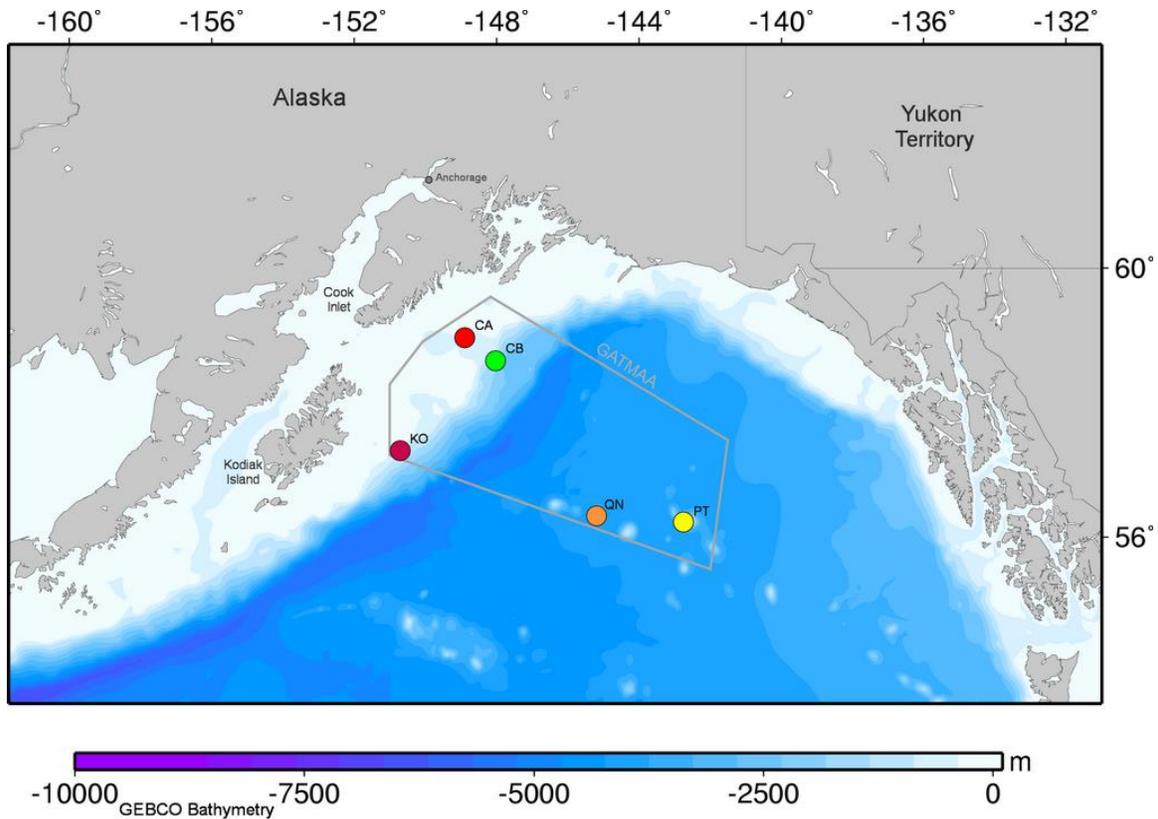


Figure 2. Locations of five High-frequency Acoustic Recording Packages (sites CA, CB, KO, PT, and QN) deployed in the Gulf of Alaska June 2013 through May 2014. Color is bathymetric depth.

Blue whale NEP song was detected from June 2013 through March 2014 at these five sites in the Gulf of Alaska. A peak in B call detections (proxy for NEP song) occurred in September – October 2013, with fewest calls detected at a coastal site CA and offshore site QN (Figure 3). Central Pacific song was detected at sites CB, PT, and QN from June to October 2013 with most detections occurring in July and August (Figure 4), indicating an earlier presence in the area than the NEP song.

In addition, the B unit of the NEP song recorded in the Gulf of Alaska was slightly different from the B unit recorded in Southern California. The Gulf of Alaska variant of unit B ended with a step-down change in frequency of the long tone, which is not apparent in Southern California songs (Figure 5).

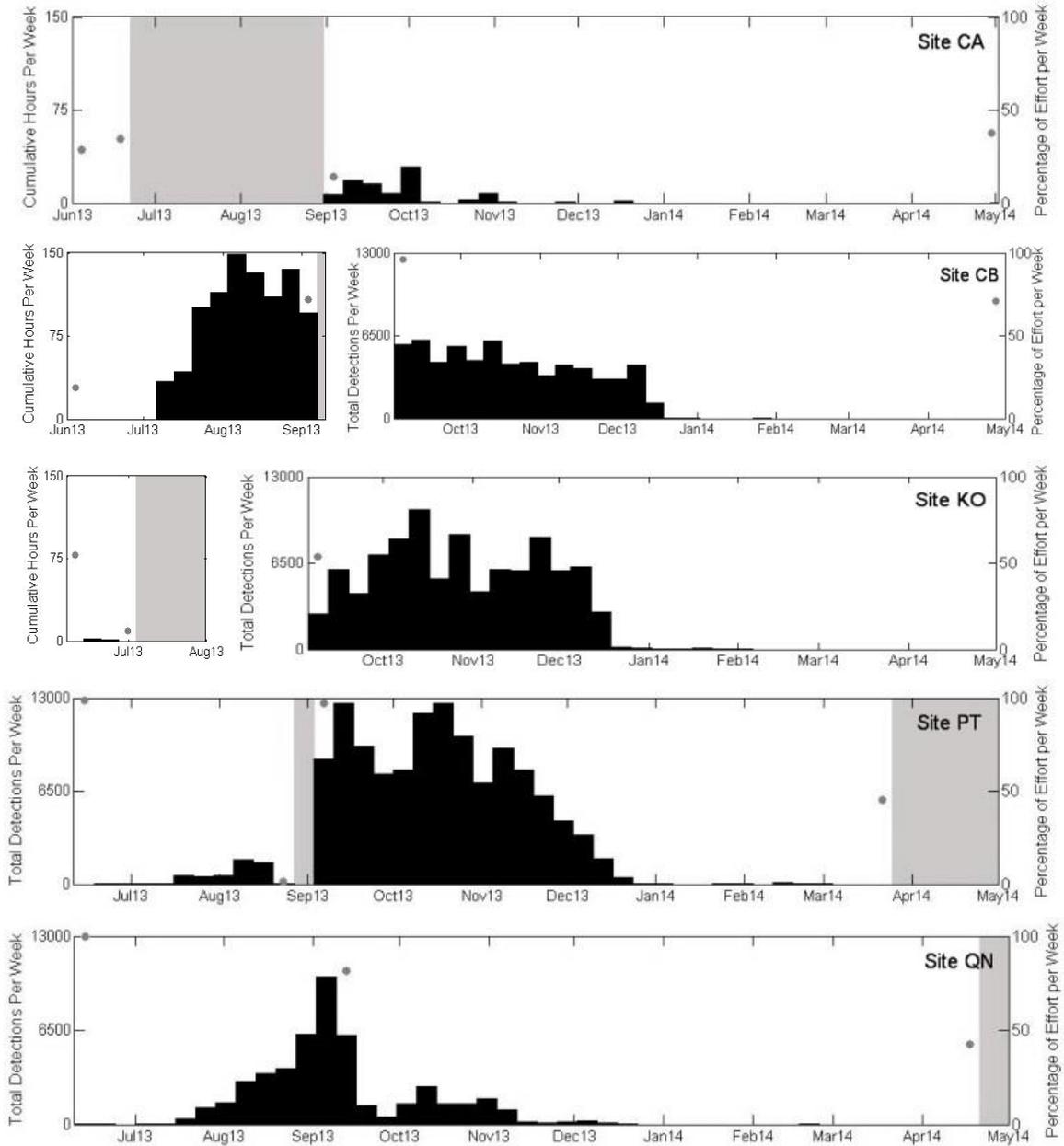


Figure 3. Weekly presence of NEP blue whale B calls between June 2013 and May 2014 at sites CA (top), CB (second from top), KO (middle), PT (second from bottom), and QN (bottom). Weekly detections shown for sites CA, CB (June 6 – September 5, 2013) and KO (June 6 – 27, 2013) were manually detected in hourly bins. Weekly detections for sites CB (September 5, 2013 – May 1, 2014), KO (September 8, 2013 – May 1, 2014), PT, and QN were detected using an automatic spectrogram correlation detector. Gray dots represent percent of effort per week in weeks with less than 100% recording effort, and gray shading represents periods with no recording effort. Where gray dots or shading are absent, full recording effort occurred for the entire week.

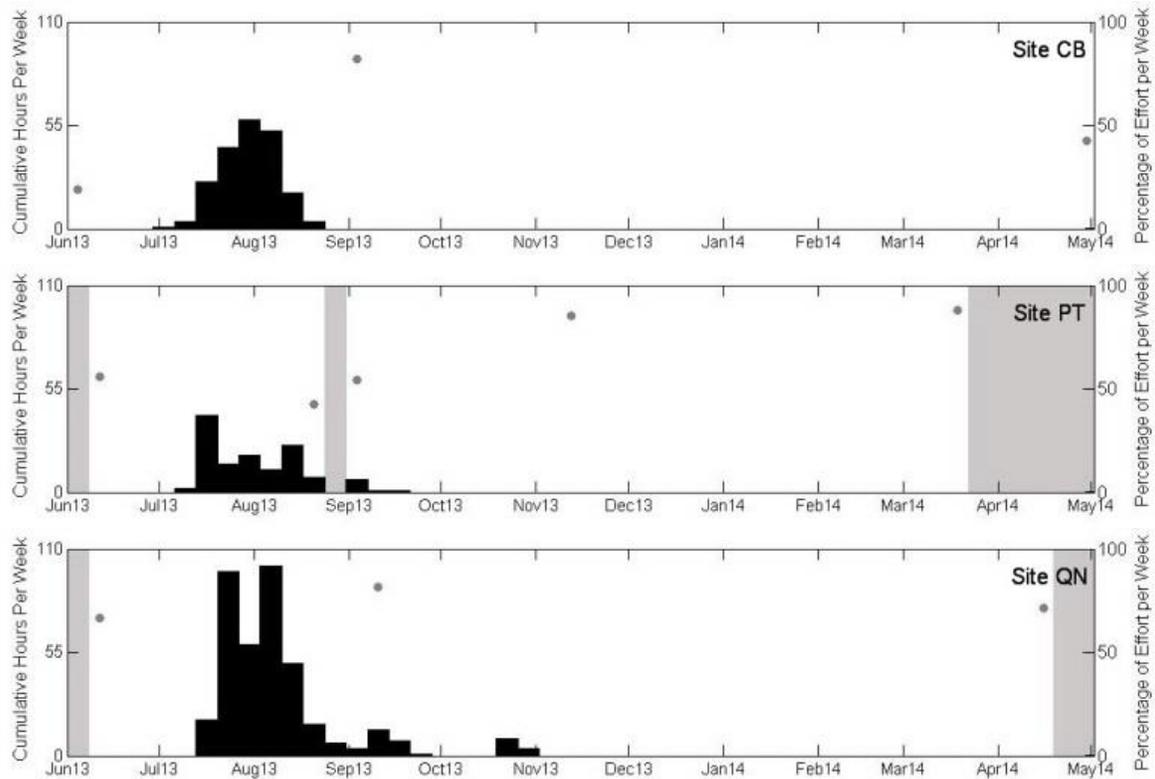


Figure 4. Weekly presence of Central Pacific tonal blue whale calls between June 2013 and May 2014 at sites CB (top), PT (middle), and QN (bottom). Effort markings are described in Figure 3.

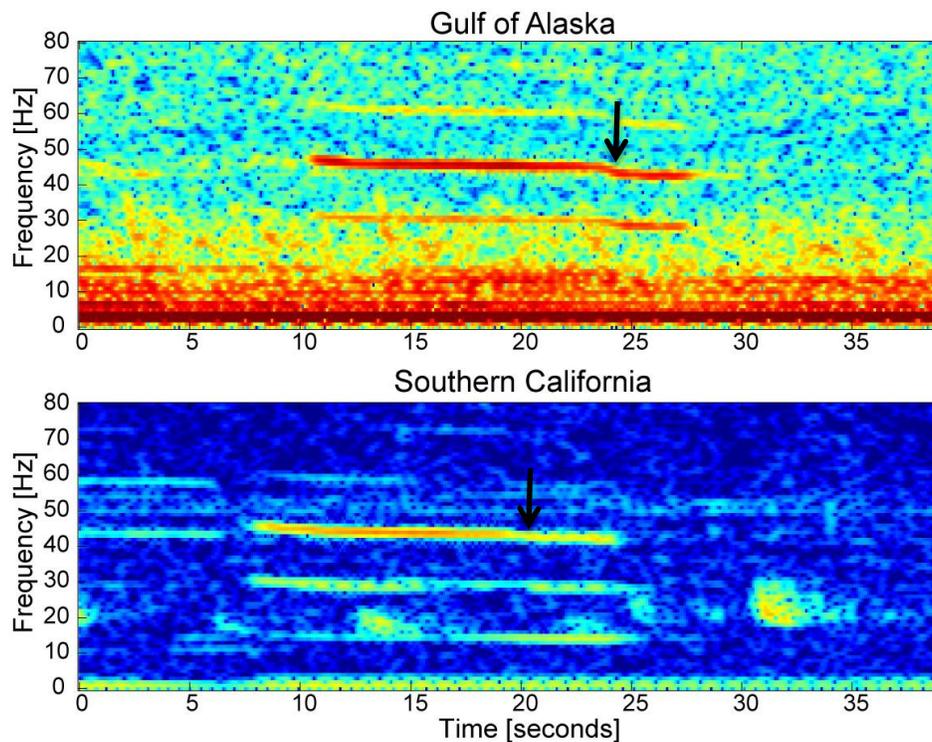


Figure 5. Spectrograms of NEP blue whale song variants from the Gulf of Alaska (top) and Southern California (bottom), with arrows pointing to a difference in frequency of the last segment in unit B.

DISCUSSION

Our data show higher proportion of the NEP song further west than has been reported previously, e.g. by Stafford (2003). The population surveys and estimates (Barlow and Forney 2007) indicate that the NEP population may be expanding its range. These higher proportions of the NEP song recorded farther west in the Gulf of Alaska more recently than the data from 1999-2001 may be the result of this expansion. Such an expansion would indicate that recent passive acoustic records may not be a reliable indicator of past distribution of the NEP population. This suggests that it may not be possible to assign 20th century whaling takes to a particular stock using modern passive acoustic monitoring data.

The variation in the NEP song in the Gulf of Alaska relative to the song off California has not yet been investigated in detail. However, if these variants are found to persist over different spatial and temporal scales, they may potentially be used to indicate finer scale population variability.

REFERENCES

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- Stafford, KM. (2003). Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science* 19: 682–693.
- Barlow, J, & Forney, KA. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *Fishery Bulletin* 105: 509–526.