

Seasonality and distribution of baleen whales in the Chiloe-Corcovado region, Chile, using passive acoustic monitoring

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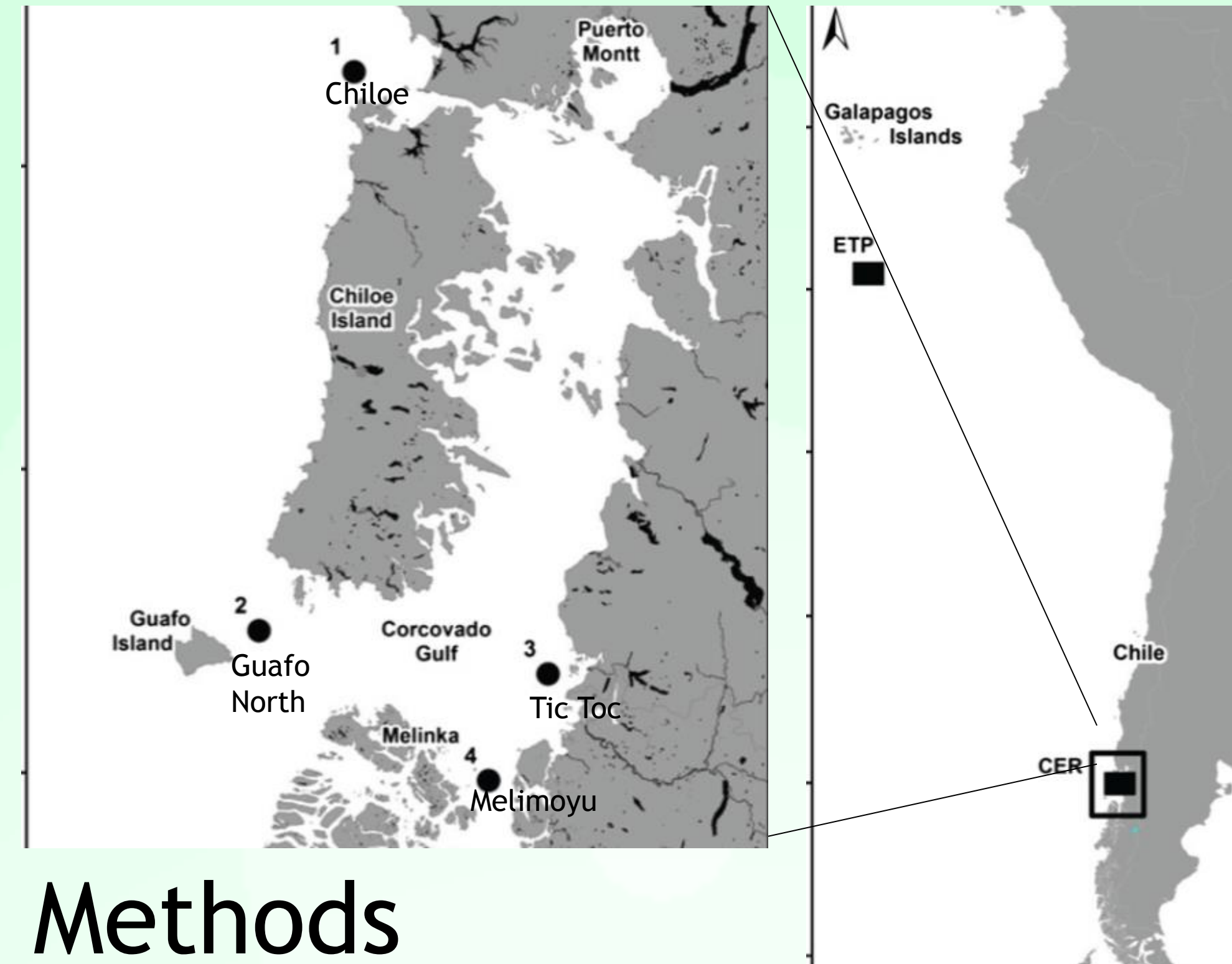
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Introduction

The Chiloe-Corcovado area is a unique coastal habitat that boasts an abundant and diverse assortment of marine life^{3,5}. We used passive acoustic monitoring (PAM) to study the seasonal patterns of occurrence of vocalizations of several baleen whale species in this area. Our primary focus was the Chilean or Southeast Pacific (SEP) population of blue whales, which is acoustically and morphologically distinct from Antarctic and pygmy blue whale populations^{1,2,3,6, 7,9}. SEP blue whales produce low-frequency, high-intensity calls that are composed of 3-4 parts and are sometimes punctuated with higher-frequency components (Fig 1a and b)^{1,2,3,4}. There are two established variants of this call (SEP 1 and 2; Fig 1a and b), and we also found two new variants consisting of two (SEP3; Fig 1c) or one (SEP4; Fig 1d) low-frequency pulsed sound(s). In addition, we found a down sweep call that we believe is also produced by SEP blue whales, based on recent recordings made with DTAGs in this area (Fig 1e). Further, we logged occurrences of calls of Antarctic blue, humpback and possibly minke whales (Fig 1e, f, g), as well as several unidentified species. These data provide insights into potential seasonal and movement patterns of baleen whales in the Chiloe-Corcovado region.

Figure 2: Map of acoustic recorder locations within the Chiloe-Corcovado region (from Buchan et al. 2014)²



Methods

Six Marine Autonomous Recording Units (MARUs, Cornell University) were deployed at four sites within the Chiloe-Corcovado area, recording sounds continuously at a 2000 Hz sample rate for six-month periods between January 2012 to April 2013 (Fig 2). The recordings were subsampled, resulting in the analysis of every sixth hour, for a total of 3,586 hours. Sound types were categorized visually using RavenPro software, resulting in 102,360 sound selections. Calls from three likely mysticete species were identified, and the rest were put into a broad 'unidentified' category. Seasonal trends were determined for each group by dividing the year into four seasons. Spatial variation was analyzed by comparing call rates at the four locations (Figs 3 and 4). Blue whale sounds were further examined by comparing the mean sound production rate of four major SEP call types and Antarctic 'z' calls in different seasons at the Chiloe site (Fig 5).

Results & Discussion

Southeastern Pacific (SEP) blue whale sounds dominated at all sites and in all seasons with over 17 calls per hour on average (note different y axes in Figs 3 and 4). SEP call production rates suggest that these whales probably migrate into the area during the summer, peak in abundance in the fall (call rate 1.4x the mean), begin to leave in the winter, and are rare in the spring (call rate 0.14x the mean, although recordings were only made at Melimoyu in the spring). SEP whales appear to be more prevalent offshore, where call rates were 1.75x the mean. Of the four SEP call types, SEP2 and SEP3 were most frequent, occurring 2.4x and 2.3x more often than overall mean call rate, respectively.

Antarctic blue whale calls tended to occur most often in summer (call rate = 1.79 calls/hour) compared to fall (rate = 0.18 calls/hour) and winter (0.02 calls/hour). Since Antarctic blue whales tend to feed in the summer in Antarctica⁸, this is likely a product of whales passing through the area.

Humpback whale calls were much less abundant than blue whale calls, and although they occurred in all four seasons in Melimoyu, and in 2-3 seasons at the other sites, most calls occurred at Guafo North in fall, where call rate was 8x the mean. This trend may reflect southern hemisphere humpback whales beginning to migrate north to winter breeding grounds in the fall^{7,8}.

Calls tentatively attributed to minke whales also occurred in all four seasons in Melimoyu, and in 2-3 seasons at the other sites. In the summer, the majority of calls occurred offshore at Chiloe (3x summer average), whereas in the fall the majority occurred in coastal Melimoyu waters (3x fall average). Overall, winter call rates were 0.4x lower than the species average.

Unidentified animals called 2x more often in offshore waters than average and most calls occurred in the fall (1.7x the mean call rate).

➤ *It is important to note that all of these trends may be due to more or fewer animals being present and/or to more or less calling behavior in a given area or time of year. Visual groundtruthing is needed to tease apart these possibilities.*

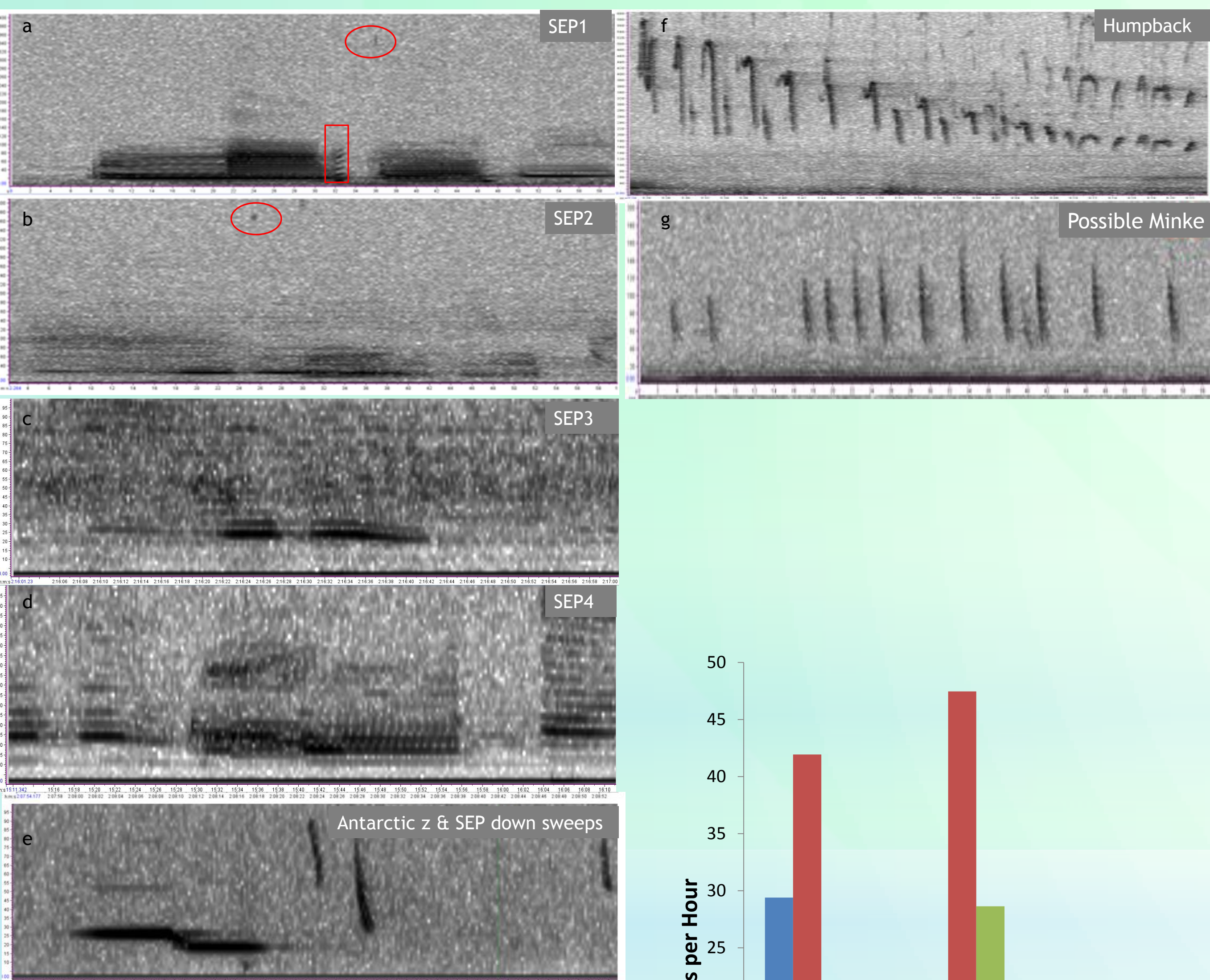


Figure 1: Spectrograms of identified baleen whale sounds. X-axes are one minute in length. Y-axes are presented as follows: a) SEP 1 - 650 Hz, note high-frequency component (circled in red) and low frequency component (boxed in red); b) SEP2 - 650 Hz, note high frequency component (circled in red); c) SEP3 - 100 Hz; d) SEP4 - 100 Hz; e) Antarctic blue "Z" call and possible SEP blue whale down sweeps - 100 Hz; f) humpback whale song - 400 Hz; g) possible minke whale down sweeps - 200 Hz.

Acknowledgments

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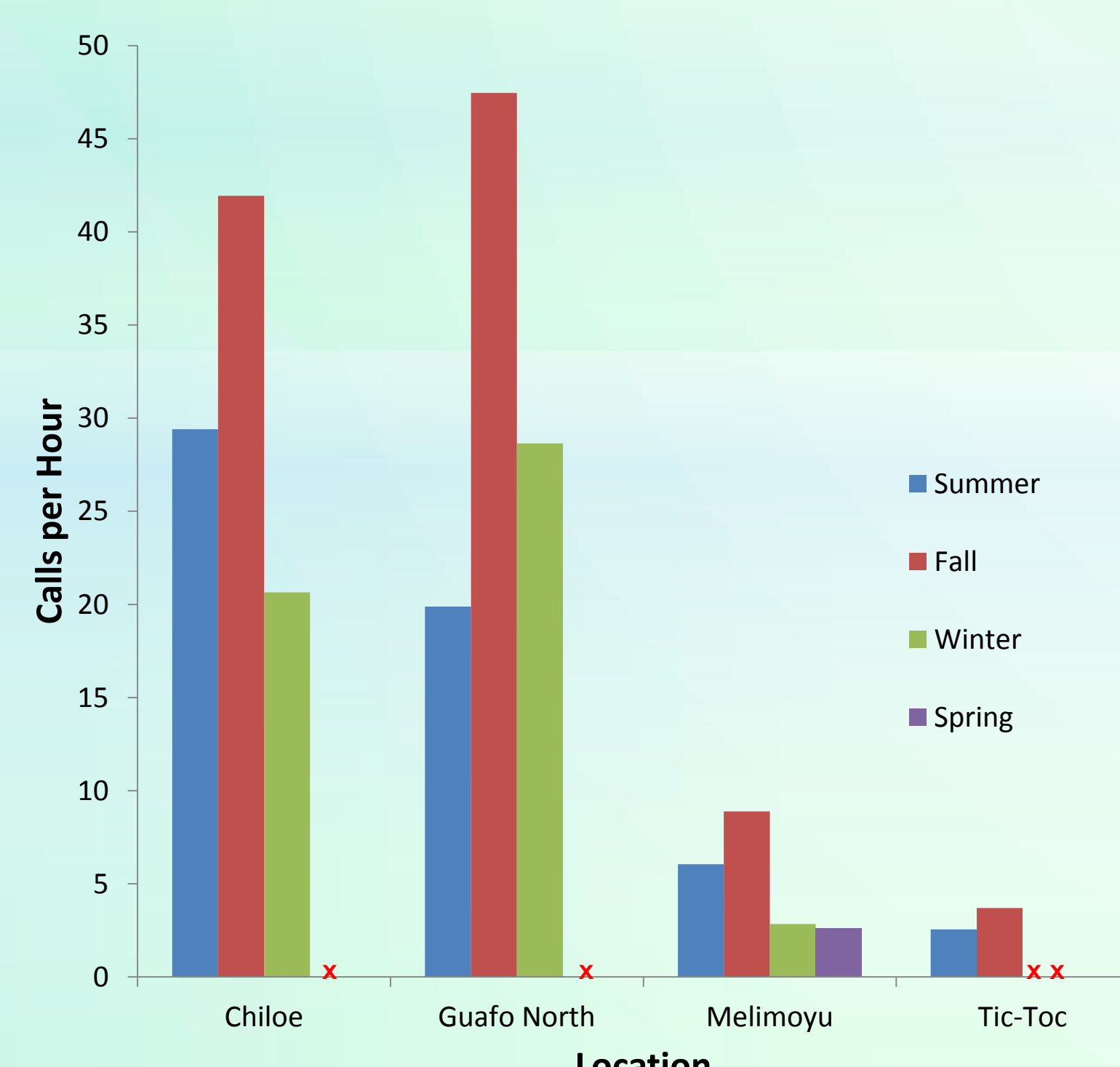


Figure 3: Mean SEP blue whale sound production rate in calls per hour at each of four locations (Chiloe, Guafo North, Melimoyu, & Tic-Toc) during four seasons: summer (December through February, blue), fall (March through May, red), winter (June through August, green), and spring (September through November, purple). Note that presumed SEP blue whale down sweep calls (Fig 1E) were combined with known SEP blue whale call types (SEP1-4, Fig 1A-D). Red x's mark seasons without recordings at a certain location.

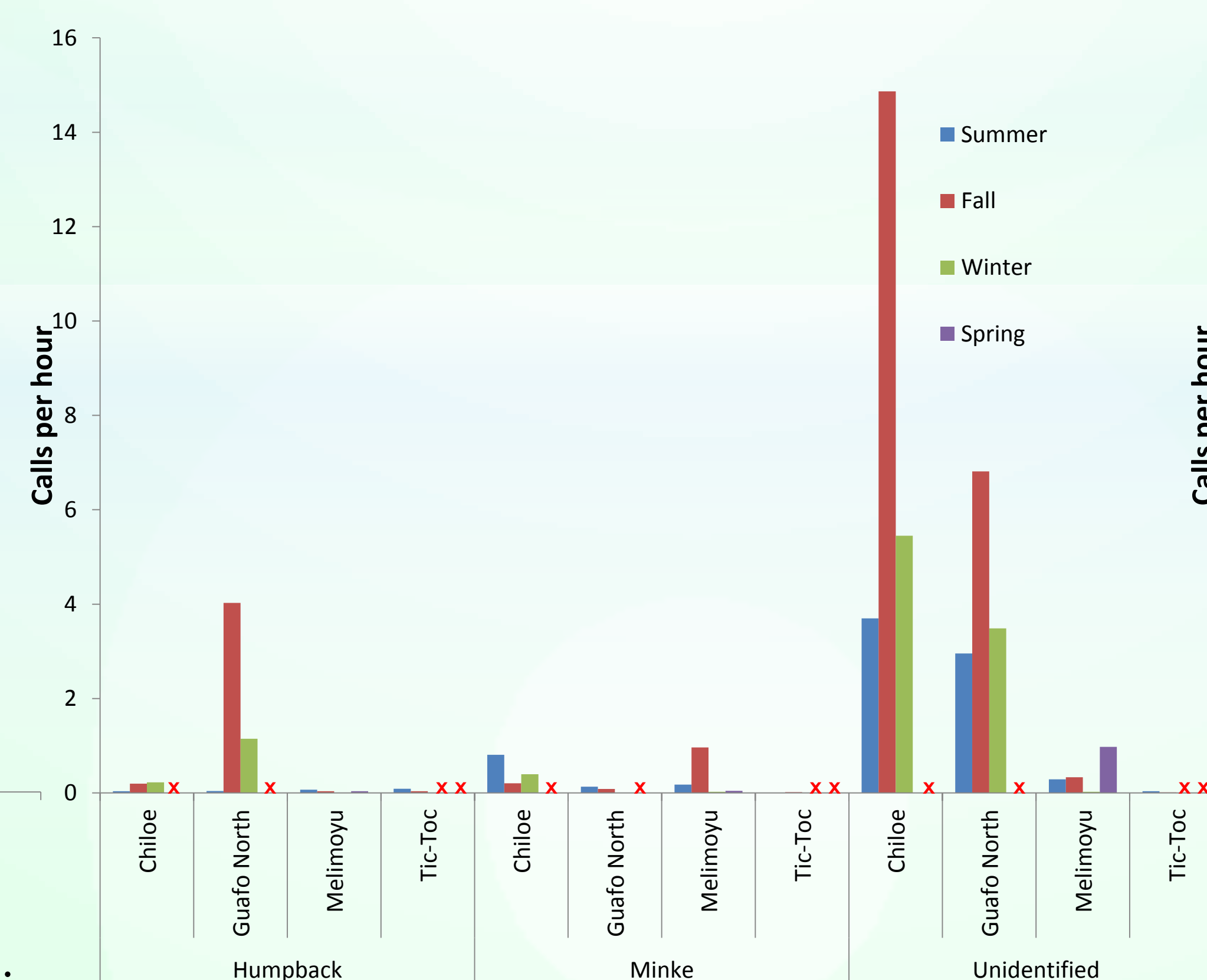


Figure 4: Mean sound production rate in calls per hour at four locations (Chiloe, Guafo North, Melimoyu, & Tic-Toc) during four seasons: summer (blue), fall (red), winter (green), and spring (purple) for humpback whale, possible minke whale, and unidentified whales. Red x's mark seasons without recordings at a certain location.

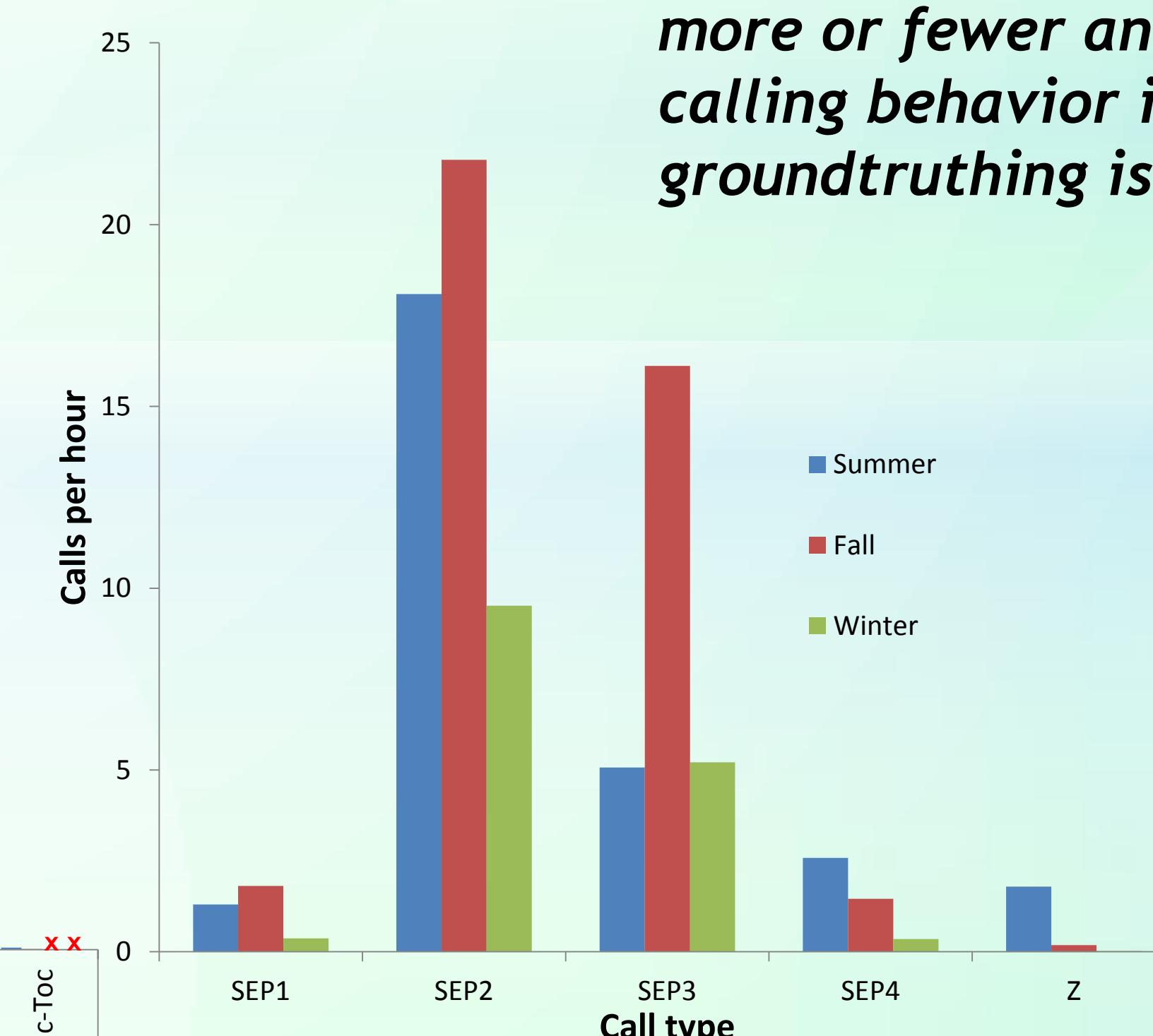


Figure 5: Mean sound production rate in calls per hour of the four major call types of South East Pacific blue whales (SEP1, SEP2, SEP3, & SEP4) and Antarctic "Z" calls during fall (blue), summer (red), and winter (green) at Chiloe in 2012. No recordings were made in the spring at this site.

- References
- Buchan, S.J., Rendell, L.E., Huckle-Gaete, R. 2009. Preliminary recordings of blue whale (*Balaenoptera musculus*) vocalizations in the Gulf of Corcovado, northern Patagonia, Chile. *Marine Mammal Science* 26:451-9.
 - Buchan, S.J., Stafford, K.M., Huckle-Gaete, R. 2014. Seasonal occurrence of southeast Pacific blue whale songs in southern Chile and the eastern Tropical Pacific. *Marine Mammal Science*, doi: 10.1111/mms.1217.
 - Buchan, S.J., Huckle-Gaete, R., Rendell, L., Stafford, K.M. 2012. A new song recorded in the Corcovado Gulf, southern Chile, and an acoustic link to the Eastern Tropical Pacific. *Endangered Species Research* 23: 241-252.
 - Cummings, W.C., Thompson, P.O. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. *The Journal of the Acoustical Society of America* 16: 1193-1198.
 - Huckle-Gaete, R., Buchan, S. 2012. Passive acoustic monitoring of blue whales throughout the Chiloe ecoregion, Chile. A progress report to the Melimoyu Ecosystem Research Institute: 1-15.
 - McDonald, M.A., Mesnick, S.L., Hildebrand, J.A. 2006. Biogeographic characterization of the blue whale song worldwide: Using song to identify populations. *Journal of Cetacean Management and Research* 8: 55-65.
 - Stafford, K.M., Bohnenstiehl, D.R., Tolstoy, M., Chapp, E., Mellinger, D.K., Moore, S.E. 2004. Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans. *Deep-Sea Research I* 51: 1337-1346.
 - Stevick, P.T., Aguayo, A., Allen, J., Avila, I.C., Capella, C., Chater, K., Rosa, L.D., Engel, M.H., Felix, F., Florez-Gonzalez, L., Freitas, A., Haase, B., Llano, M., Lodi, L., Munoz, E., Olavarria, C., Secchi, E., Scheidat, M. 2004. Migrations of individually identified humpback whales between the Antarctic Peninsula and South America. *Journal of Cetacean Research Management* 6: 109-113.
 - Viddi, F.A., Huckle-Gaete, R., Torres-Florez, J.P., Ribeiro, S. 2010. Spatial and seasonal variability in cetacean distribution in the fjords of northern Patagonia, Chile. *Journal of Marine Science* 67: 959-970.