



FIN WHALE SONG PATTERNS SHIFT OVER TIME IN SVALBARD ISLANDS

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ABSTRACT

Climate change is leading to dramatic alterations in the Arctic marine environment, causing shifts in the distribution and migration patterns of species. Fin whales have been reported to show a poleward shift, persisting at higher latitudes also during the Polar Night. Male fin whales (*Balaenoptera physalus*) emit stereotyped songs formed by downsweep 20 Hz notes, during the reproductive period, in winter. The 20 Hz note sequences usually present regular inter-note intervals (INIs). Previous studies suggested that INI patterns may identify different acoustic stocks, or can change over seasons. Here, we analysed fin whale song structures over 5 years (from 2014 to 2020) in the western Svalbard coast. We report the presence of songs with different patterns over time. Results showed the presence of both unimodal and bimodal songs that coexist in the first season, while only unimodal songs were recorded from 2015, with different INIs. Song structure suggests both that fin whales switch INIs between singing seasons and the presence of specimens coming from different acoustic stocks. Further studies are needed to provide information on migration movements and possible song cultural transmission between specimens that share the same polar feeding area.

Keywords: Arctic Ocean, *Balaenoptera physalus*, Inter-Note-Interval, acoustic stocks

1. INTRODUCTION

Fin whales (*Balaenoptera physalus*) in the North Atlantic are known to move from temperate water breeding grounds during winter, towards high-latitude regions to feed on krill and pelagic fish during summer months. Recently, fin whale occurrence was recorded also during the Polar night (from October to March) in the Fram Strait and along the western coast of Svalbard Islands (Norway), with a year-to-year variability [1-4]. Fin whales worldwide emit stereotyped downsweep notes ranging from 25 to 15 Hz, lasting less than 1 s, and centered at 20 Hz [5-7]. During the reproductive period they can be arranged in songs, that have been suggested to represent a male acoustic display [8]. Within the songs, the 20 Hz note sequences usually show regular inter-note intervals (INIs), and other vocalizations can be emitted, such as the backbeat, constant low-frequency signals (about 0.8 s at 18-20 Hz), and a higher 130 Hz upsweep frequency note [9-10]. Here, we report the song patterns recorded across five singing seasons from 2014 to 2020 in the Svalbard Islands and discuss the song structure and INI patterns in the light of the known changes over seasons, shift over long periods of time, or presence of differing acoustic stocks.

2. MATERIAL AND METHODS

Data were collected in the Kongsfjorden (western Spitsbergen Island, Svalbard archipelago, Norway) (Fig. 1), with an underwater autonomous passive acoustic

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recorder (SM2, Wildlife Acoustics, US) deployed at about 75 m from the surface.

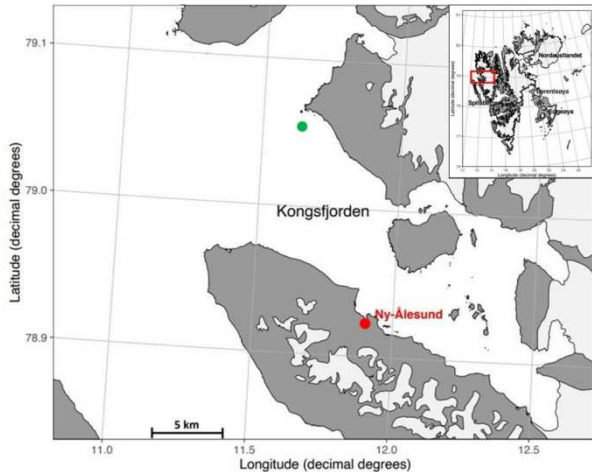


Figure 1. Recording site (green dot), and Ny-Alesund village position (red dot) within the fjord. Kongsfjorden location in Svalbard Islands is shown in the inset.

The calibrated hydrophone (sensitivity – 165 ± 5 dB re $1 \text{ V}/\mu\text{Pa}$ from 2 Hz to 30 kHz), was set at a sampling frequency of 48 kHz, with a duty cycle at 50%.

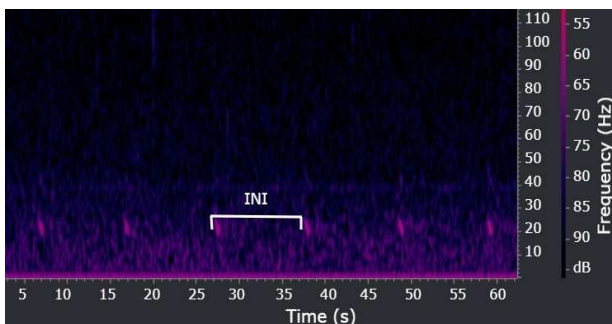


Figure 2. Spectrograms (Hamming window, FFT = 1024, overlap = 87.5%) showing fin whale songs and indicating the inter-Note-Interval (INI), measured from the beginning of a 20 Hz note to the beginning of the following note of the same type.

INIs were measured as the interval between the beginning of a note to the beginning of the following one in the spectrogram (Fig. 2). Inter-note intervals selected for analysis were measured between 20 Hz notes, and between 130 Hz notes only when songs did not contain the 20 Hz component. To limit the risk of non-independence of data, songs were selected in recordings at least 24 h apart from each other and at least 7 INIs, up to 20 INIs per song were measured.

3. RESULTS

Songs consisted of mainly 20 and 130 Hz notes simultaneously (30% of the total), but both notes were also found on their own. Backbeats were detected only in 2018–2019 and 2019–2020.

The INIs analysis revealed the occurrence of two kinds of patterns. Indeed, during the singing season of 2014–2015, both bimodal songs with INIs at 9 and 14 s, and unimodal songs with 15 s INIs occurred. However, while during this first season the 67% of songs were bimodal, in the following seasons only unimodal songs were recorded.

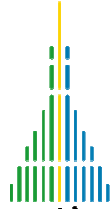
Furthermore, changes in the INIs occurred across all years. In 2015–2016, INIs were 15 s, and resulted significantly longer compared to the other years (Kruskal Wallis at 20 Hz $\chi^2 = 67.01$, p-value < 0.001; at 130 Hz $\chi^2 = 61.58$, p-value < 0.001). In 2016–2017, the INIs strongly decreased ranging from 7.5 to 12, while in 2018–2019 and 2019–2020, INIs slightly increased, remaining unvaried between 9 and 12 s.

4. DISCUSSION

The analysis of INI patterns collected in Svalbard waters from 2014 to 2020 showed that changes occurred over the years. Due to the lack of songs occurring during different seasons within the same year, no seasonal variations could be detected [11–12]. However, a shift from a both bimodal and unimodal pattern to unimodal only, a change between the INIs along the years, and variations in the song structure were recorded.

Song of fin whales can provide information about their geographic areas of origin, but the same population can also sing different song patterns [13].

Therefore, these results may suggest both that non-migrating fin whales could belong to the same acoustic stock that switch their INIs, or might come from different acoustic stocks.



The first hypothesis can be supported by data from the seasons 2016–2017, 2018–2019 and 2019–2020, when short INIs that cannot be attributable to fin whales in the Eastern North Atlantic in the concurrent period [14], occurred. However, songs with a 15s INI pattern recorded in 2014–2016, were concurrently collected in 2014–2017 in the Northwestern Mediterranean [15], and from an individual moving in southern Norway in February 2014 [10]. A migration route from Svalbard Islands to the Southern Portugal and Moroccan waters has already been detected [2] in November 2015 and 2019 through satellite tracks. The individuals recorded passed along Norway, Ireland, and coastal Portugal. Finally, the presence of backbeats in seasons 2018–2020 suggests the visiting of Svalbard by individuals from other acoustic stocks.

These outcomes leave the door open to both the explanations. This study is crucial since through INIs analysis, new information on fin whales overwintering in Svalbard can be achieved. Nevertheless, it is still not clear how fin whales interact with one another across populations, or how they change their song types within or between years.

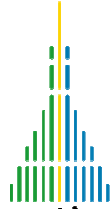
Changes over time in whales INIs and note frequencies are known worldwide [13]. However, the patterns have been suggested to change as a results of a moltitude of factors, from cultural transmission to environmental noise. Therefore further studies are needed to understand the species presence in a changing Arctic, and explaining the possible reasons of variations.

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