Interim Report to Marine Scotland Science

Report on the analysis of humpback whale (*Megaptera novaeangliae*) acoustic presence on the west coast of Scotland

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Introduction

After 200 hundred years of intense human exploitation, humpback whales (*Megaptera novaeangliae*) appear to be making a promising comeback in parts of their range (Stevick et al. 2003). Although slower than in other areas, humpback whale sightings have also increased in Scottish waters, including both the east and west coast, in recent years. It is currently unclear whether this is due to an increase in number of animals frequenting Scotland's seas, or as a result of increased shore-based sightings effort. Several non-governmental organisations, including the Sea Watch Foundation, Hebridean Whale and Dolphin Trust (HWDT) and Whale and Dolphin Conservation (WDC), collate sightings of cetaceans. In some cases, such as the shore-watch site at Tiumpan Head on Lewis, run by WDC volunteers, these data have revealed a consistent number of sightings of these large baleen whales in recent years. Humpback whales, like all cetaceans, are a European Protected Species under the EU Habitats Directive, and EU member states are required to maintain populations of these species at Favourable Conservation Status (FCS). A recent study showed that there is a considerable risk of entanglement of humpback whales in static fishing gear (especially creel pots) in Scottish waters (Ryan et al. 2016), indicating the importance of accurate species monitoring in this region.

Despite increasing sightings in recent years, the temporal distribution and abundance of humpback whales in Scottish waters are still poorly understood. As for most other cetacean species, winter data in particular is currently missing, because visual survey methods are limited by weather and light conditions. Therefore, alternative methods, such as long-term passive acoustic monitoring (PAM) collecting data during times of year that are typically not covered by visual survey effort, may significantly improve efforts to understand the distribution and abundance of this species in Scottish waters (Charif & Clark 2009).

Humpback whales are known to vocalise across their range, most prominently in their tropical breeding grounds where in the early 1970s their songs were first described (Payne & McVay 1971). In addition, recent work on humpback whale song in several of their northern latitude habitats provides evidence for widespread occurrence of song on feeding grounds and outside the traditional breeding season (Vu et al. 2012, Magnúsdóttir et al. 2014), as well as on migration (Charif et al. 2001). They are thus an ideal species to be monitored acoustically and PAM could be employed as a relatively low cost approach to better understand their distribution and occurrence around Scotland.

The EU INTERREG VA 'COMPASS' project, which started in October 2017, involves a network of passive acoustic recorders to monitor protected areas and species across Scottish, Northern Irish and northern Republic of Ireland waters over the next four years. Preliminary analysis by SAMS has shown that humpback whales can be detected using PAM off western Scotland. In

this, and following reports, we will explore humpback whale vocal presence across the COMPASS acoustic array and develop methodology to automatically detect humpback whale song and non-song vocalisations in long-term recordings. Detection results will be summarised by season, diel period and recording location to explore humpback whale acoustic behaviour and the utility of using PAM for improving humpback whale monitoring in Scottish waters.

Methods

Acoustic Data Collection

The COMPASS project comprises 12 different recording sites covering the inshore water of the Scottish west coast and Northern Ireland. Acoustic recorders were deployed at depths ranging from 50 to 110 m (Figure 1). Acoustic broadband recorders (Soundtrap, Ocean Instruments, Ltd) were typically moored 3-5 m above the sea floor and programmed to record at a sample rate of 96 kHz, with a 20/40 minutes on/off duty cycle. Broadband recordings analysed for this preliminary report were made during March and April 2018. Initial analysis focused on three sites: Tolsta, Stoer Head and Stanton Banks (Figure 1), where humpback whale song presence had been determined during an initial scoping study.

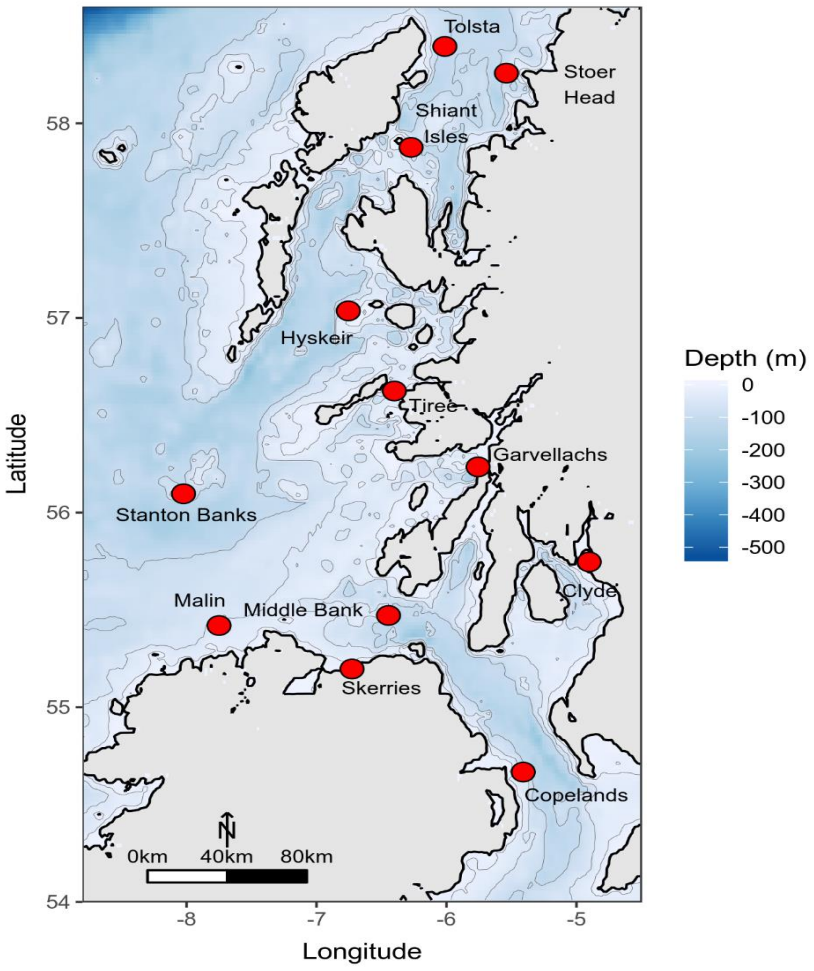


Figure 1: Map of the study area on the west coast of Scotland and locations of PAM moorings.

Data Analysis

During the current initial stage of analysis, humpback whale song was detected by visually and aurally reviewing spectrograms (Fast Fourier Transform (FFT) size: 2048 points, 85% overlap, Hanning window) of recorded sound files (decimated to a sample rate of 2 kHz using PAMGuard (Gillespie et al. 2008)) using the Matlab (MATLAB 2014a) based sound analysis and visualisation software XBAT (Figueroa & Robbins 2008).

Preliminary Results & Discussion

Humpback whale song was detected on Tolsta, Stoer Head and Stanton Banks starting early March 2018. Overall, during the months of March and April 2018, humpback whale song was detected for a total of 16 (out of 45), 12 (out of 38), 33 (out of 50) days at Tolsta, Stoer Head and Stanton Banks, respectively (Table 1). Figure 2 shows a representative spectrogram of typical humpback whale song detected during this study.

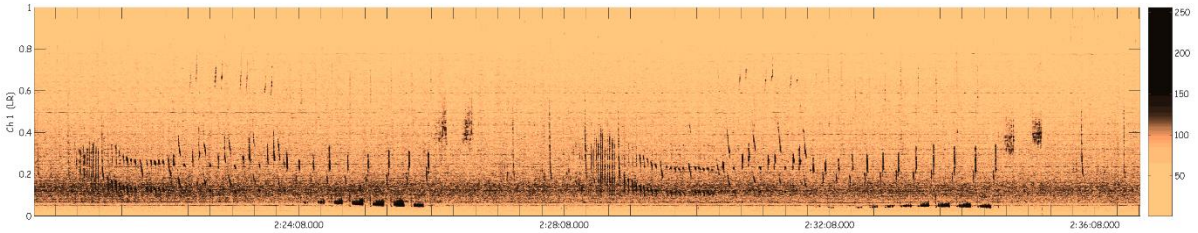
These detections confirm the feasibility of detecting humpback whale song and using PAM to establish the spatio-temporal distribution of the species in Scottish waters. In addition to several days (notably 12th & 13th, and the end of March) with very clear detection of humpback whale song (i.e. high signal-to-noise ratio), detections at Stanton Banks also included various faint and/or partial song phrases. The substantial acoustic presence of vessels at Tolstra and Stoer Head may have caused masking, preventing identification of fainter vocalisations if present, and only whales in relatively close proximity to the recorders were identified. Alternatively, or in addition, the faint song detection on Stanton Banks could suggest a more offshore distribution of humpback whale singers at this location at the southern end of the Outer Hebrides.

Data analysed from the other COMPASS monitoring locations on the inside of the Inner Hebrides, also allow for investigation into the movement of humpback whales along western Scotland. An understanding of whale temporal presence and mobility pattern may aid in understanding, and mitigating, entanglement risks.

Table 1: Temporal overview of acoustic humpback whale detections at the three COMPASS monitoring locations off western Scotland. Black filling indicates humpback whale presence, grey shading presents absence of, or non-analysed data. Total number of days in which whales were detected are provided at the bottom, with the total number of effort days between brackets.

	Tolsta	***Stoer Head***	***Stanton Banks***		***Tolstra***	***Stoer Head***	***Stanton Banks***
March				April			
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
11				11			
12				12			
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
21				21			
22				22			
23				23			
24				24			
25				25			
26				26			
27				27			
28				28			
29				29			
30				30			
31							
TOTAL	14 (26)	11 (27)	21 (31)	**TOTAL**	2 (19)	1 (11)	12 (19)

Figure 2: Spectogram example of humpback whale song as detected over ~17 minutes at Tolstra on the 13th March.



Future work

For the full report this preliminary analysis will be expanded to include all monitoring stations and cover all available PAM data collected by the COMPASS project so far (November 2017-March 2019). Using this preliminary data set, an acoustic data template detector, based on spectrogram cross-correlation, will be developed and tested in XBAT to automate and facilitate future analyses of large, long-term data sets. Acoustic monitoring results will also be compared to available visual data from Seawatch and WDC shore-watches, the HWDT volunteer sightings database and dedicated HWDT sightings data.

Acknowledgements

We thank the MSS and AFBI shipboard crews and data management teams for their help with data collection. We also thank the whole COMPASS project and SAMS CetRens team for their support and enthusiasm so far.

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