BIOLOGICAL SOURCES OF AMBIENT NOISE IN THE NORTH EAST ATLANTIC OCEAN

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Abstract: *The sound of snapping shrimp (family Alpheidae) is widely recognised to be the dominant source of underwater noise in many shallow (<60 m) tropical and sub-tropical waters. Research during the past few years has revealed the presence of a similar noise in the NE Atlantic. This paper reports on a clicking noise observed in waters as deep as 120 m during a cruise near the edge of the continental shelf in the Bay of Biscay. The source of this noise has not yet been confirmed, but snapping shrimp are a strong candidate which, if proven to be the source, would question several aspects of received wisdom, such as the mechanism for generation of the noise, and the distribution of snapping shrimp in waters deeper than 60 m. Recommendations are made as to how the investigation should proceed in order to identify the clicking noise source in this region.*

Keywords: *ambient noise, snapping shrimp*

1. INTRODUCTION

In 2001, a hydrophone was fixed off the coast of the Durlston Marine Reserve under 7 m of water [1] so that researchers and centre visitors could observe sounds within the local waters. Recordings made using the hydrophone revealed the presence of an audible clicking sound. It was observed that the frequency content of individual clicks generally appeared to be in excess of the maximum observable frequency of 20 kHz, and that the duration of these clicks was on the order of a few tens of milliseconds. Subjectively, the signal can be described as being not unlike the sound of food frying, and very similar to the noise observed in waters which have been colonised by snapping shrimp (family *Alpheidae*) [2], a type of crustacean animal well-known to colonise in tropical waters, and some sub-tropical waters.

There is no evidence in the literature that snapping shrimp exist in UK waters in any significant numbers. Johnson *et al*. [3] observed in 1947 that snapping shrimp are "not uncommon" on the mud bottom off Ram's Head near Plymouth, England and in the Mediterranean, but provided no acoustic evidence in conjunction with this claim. Contrary to the suggestion by Johnson *et al*., Hayward and Ryland's 1990 key to marine fauna for UK waters lists all *Alpheidae* as "scarce" or "very scarce" [4].

An investigation was begun by the authors in 2004 to determine the source of this noise, and to establish whether *Alpheidae* are in fact distributed sufficiently well in the English Channel to have an impact on the ambient acoustic environment of those waters. Unfortunately, shortly before the beginning of this investigation, the hydrophone at Durlston Marine Reserve was damaged beyond repair. The investigation has so far resulted in the observation and recording of clicking noises along the south coast of England in locations stretching from Chichester Harbour to Falmouth, in the Bay of Biscay, and in isolated locations along the west coast of France (see Fig. 1). The investigation has not yet resulted in the collection of a snapping shrimp specimen coincident with the observation of ambient clicking sounds. It should be noted that some third party observers have occasionally collected specimens of the snapping shrimp *Alpheus glaber* in the English Channel and the Irish Sea, and reported their findings in online marine life databases, such as the Marine Life Information Network [5]. However, no acoustic information accompanies any online information concerning findings of snapping shrimp in the NE Atlantic Ocean.

Finfer *et al*. [6] reported that a 4-element array had been deployed near Kimmeridge Bay (off the South of England) in waters where clicking was observed. The data acquired during that survey suggest strongly that the clicking sound in that location emanates from the bottom – which would be consistent with the hypothesis that snapping shrimp are responsible for the noise.

This paper will use the acoustic data gathered during a trawling survey in the Bay of Biscay to suggest the possibility that snapping shrimp can affect the ambient acoustic spectrum in deep, temperate waters.

2. BACKGROUND

Snapping shrimp are bottom-dwelling creatures, and have the habit of hiding in crevices and holes. They are easily identified, as they have one small utility claw, and one very large claw which is responsible for creating the snapping sound [7]. During one

study in the Bahamas, Johnson *et al.* [3] reported that it is not common to encounter large numbers of snapping shrimp on mud bottoms without some sheltering materials. Snapping noise has been reported to fall off at depths greater than about 60 m [8], but most studies have been made in tropical and subtropical waters, such as near Bermuda [9][3], Singapore [10], Southern California [11] , Hawaii [12], and the Great Barrier Reef [13]. *Alpheus glaber*, however, has been found in the NW Mediterranean in abundance (tens per hectacre) at 200 m depth [14], and in isolation off the Iberian peninsula at depths as great as 704 m [15]. While *Alpheus glaber* has the peculiar claw asymmetry associated with the snapping sound, there has not been a direct investigation to establish whether in fact this species of *Alpheus* is capable of producing a snapping sound.

Knowlton and Moulton [11] report that specimens of snapping shrimp kept in glass aquaria survive well as long as the water temperature remains between 14 and 24 ^{o}C. In 1947, Johnson et al. [3] stated that the 11 ^{o}C winter surface isothermal line seemed to mark the approximate northern and southern limits of the continuous range in which snapping shrimp live; but acknowledged that, at that time, the Northernmost border of the 11 ^{o}C isothermal region passes some 7^{o} latitude (almost 800 km) South of Plymouth, England [3] (Water temperatures off the south coast of England are known currently to approach 7 ^{o}C in February [16]).

Twenty-four hour (circadian) acoustic activity was monitored by other investigators to determine the degree to which ambient levels generated by snapping shrimp vary with time of day. Johnson *et al.* [3] noted only "a small diurnal variation in shrimp noise. At night the levels are 2 to 5 dB higher than in the daytime. In addition, there is a slight peak in the noise level shortly bef ore sunrise and after sunset." No such study has yet been conducted in the NE Atlantic. Johnson *et al.* [3] found no significant seasonal variation in shrimp noises. However, all long term observations in that study were at localities which, unlike the NE Atlantic, only undergo small seasonal variation in water temperature.

3. MEASUREMENTS IN THE BAY OF BISCAY

In October 2004, data were gathered from a 2-element towed array pulled by the vessel *Wando Lady*, a 65-foot wood-hulled power boat. The array was deployed on the evening of 6 October 2004 at 16h00m UTC, and the system continued to acquire data throughout the course of the night. No reference pressure was available for the hydrophone array, and as a result absolute pressure levels are not available for these data. Acoustic observations began near 17h00m, but no clicking sounds were observed on the array output signal until approximately 21h00m. The water depth at that point in the time was noted to be approximately 130 m.

A suitable threshold was used to facilitate click-counting. Click-rates are displayed below in Fig. 1, and are based on 30 second recordings taken during each 2 minute period throughout the course of the night. For plotting, rates were normalised by the maximum number of clicks in any one recording (68 clicks in 30 seconds). Some isolated click trains were noted after the noise subsided at approximately 01h24m, but those noises were identified to be sperm whale clicks, and so were removed from the for the set of data plotted here. Depth data was logged from the depth sounder to the geographic information systems (GIS) computer.

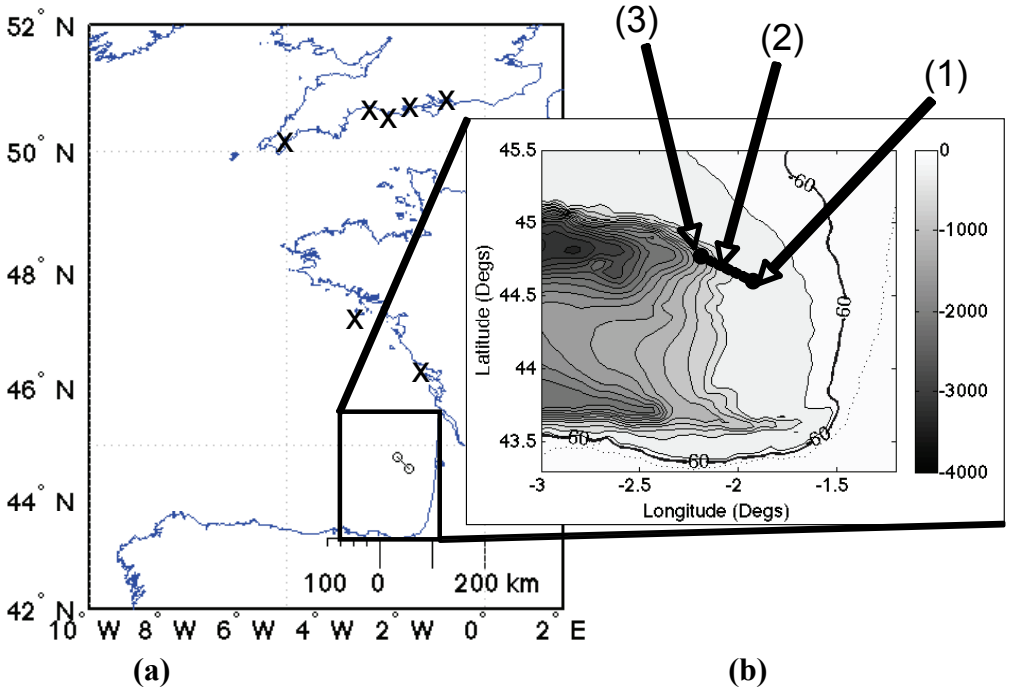

Fig. 1 ***(a)*** *A map of the region of interest [16], stretching from England south to the upper coast of Spain. Sites at which clicking has been observed by this group (reference) have been indicated by 'X'. The course followed by the boat during observations has been drawn in a black line, with the start end and end points indicated by 'o'* ***(b)*** *A bathymetric chart of the Bay of Biscay [17]. The cruise described in this paper took place along the course indicated by the bold dotted line in the centre of the chart (N 44.59° W 1.92° to N 44.78° W 2.21°). The number labels correspond to the following events* ***(1)*** *Point at which the clicking sound was first observed;* ***(2)*** *Last point at which clicking sound was observed;* ***(3)*** *Point at which the array was retracted as a result of rough seas. The 60 m depth contour has been shown, as it represents the previously accepted limit for snapping shrimp. The shore is represented by the light dotted line.*

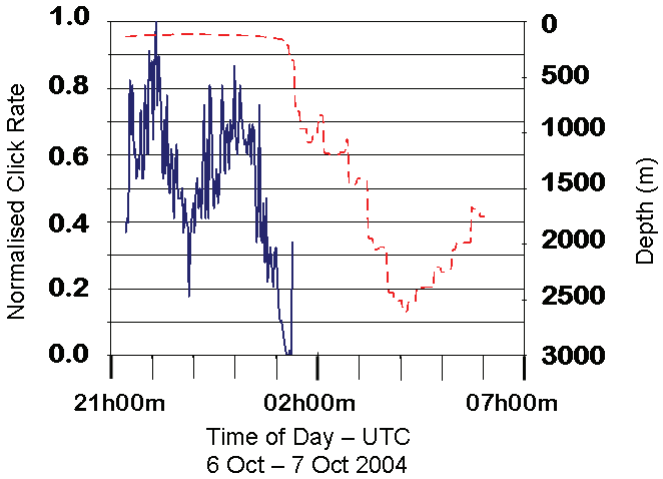

Fig. 2 Observation of clicking in the Bay of Biscay on the night of 6 October 2004. Click rate is plotted as a solid line, while the corresponding depth data is plotted as a dotted line.

The data presented in Fig. 2 show that the clicking subsided completely as the research vessel approached the edge of the continental shelf at approximately 01h30m. As this phenomenon was not observed using a vertical array, it is not possible to say whether indeed the clicking sound source was on the seafloor. To the best knowledge of the authors, these data represent the first reported instance of ambient clicking in waters deeper than 60 m.

4. ANALYSIS

While snapping shrimp have been found in abundance at depths of 200 m, there is no evidence in the literature of ambient clicking (caused by shrimp or any other source) in waters deeper than about 60 m. The bathymetric data shown in Fig. 1 (b) show that the course along which clicking was observed never came within 25 km of the nearest 60 meter depth contour.

It continues to remain unclear whether the noise observed in the bay of Biscay and the previously reported noise observed in the English Channel are of the some source. A significant step towards understanding whether or not the source of the sound is indeed biological could be made by performing a cathemeral study, and comparing the trends observed to those recorded by Johnson *et al*. [3]. Further conclusivity could be reached by performing a biogeographic survey such as the one carried out by Abello *et al.* in the NW Mediterranean [15]. A thorough study would require an acoustic study of circadian behaviour, a biogeographic survey, and a vertical acoustic array measurement to all be performed in the same region of water over the course of a single season.

It is interesting to consider whether this clicking ambient noise in the English Channel and the Bay of Biscay has been present but unreported for the last several decades, or whether the naturally generated portion of the ambient acoustic spectrum in the North East Atlantic is undergoing a significant change. A change in the ambient acoustic spectrum could in fact be a result of changes in the undersea climate. Unless a researcher is able to obtain and restore historic audio recordings [18] or intensive documentation of the ambient noise in this region of the world [19], it will remain difficult to evaluate whether the biologically-generated component of the ambient spectrum has changed during the time which has expired since the beginning of the sonar era. It would behove the community to begin documenting the ambient spectrum to allow future investigators to perform similar work.

5. CONCLUSIONS

This paper has reported on the recording of an ambient clicking noise near the edge of the Bay of Biscay. The noise is similar in nature to a clicking noise which was previously reported to be observable in the English Channel. It is suggested that the source of this noise is snapping shrimp, though further evidence is required to confirm this hypothesis. The recommendation is made here that an acoustic study of circadian behaviour, a biogeographic survey, and a vertical acoustic array measurement all be performed in the same region of water over the course of a single season. Further, the need has been stated for both the study of archived recordings, and the development of a database for the future study of ambient noise for this region.

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