

Article

Acoustic monitoring of swimming motions in the slipper lobster *Scyllarides acquinoctialis* (Lund, 1793)

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Abstract

Members of the Malacostraca employ an escape swimming mode called a tail-flip. In this maneuver the uropods and telson are rapidly brought forward until they contact the ventral surface of the abdomen. This movement is the result of stimulation of the ventral cord giant fiber. When swimming at or near the surface the slipper lobster *Scyllarides acquinoctialis* produces a distinct acoustic signature with an average acoustic pulse duration of 82 milliseconds and peak amplitude between 0.1 kHz and 6.0 kHz. The acoustic signature of members of the Malacostraca can be exploited to passively monitor swimming motions in the marine environment.

Keywords bioacoustics; passive acoustic monitoring; *Scyllarides acquinoctialis*; tail-flip.

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1 Introduction

The Slipper lobster, *Scyllarides acquinoctialis* (Lund, 1793) has been found to produce a distinct acoustic signature when using the tail-flip maneuver when swimming near the surface of the water (Fornshell, 2019). By expanding on this earlier work, a passive acoustic monitoring method is developed for studying near surface swimming behavior of slipper lobsters.

The tail-flip escape maneuver results when the muscles in the abdomen are caused to rapidly contract by stimulation of the ventral nerve cord giant fiber, bringing the uropods and telson forward until they touch the ventral surface of the thorax. Swimming motions involving the use of the tail-flip maneuver, are employed by many members of the Malacostraca to escape from predators (Webb, 1979; Cromarty et al., 1991; Spanier et al., 1991; Newland et al., 1992; Nauen and Shadwick, 1999, 2001; Heitler et al., 2000). Based on a limited initial data set (Five trials), Fornshell (2019) observed an average pulse rate of seven tail-flips per second (the range was 2.5 tail-flips/second to 16 tail-flips/second). The duration of the pulse was 62.5 milliseconds (Fornshell, 2019). Previous researchers have used video recording and/or ceni-photography to record the

movements of the animals (Spanier et al., 1991; Newland et al., 1992; Heitler et al., 2000).

2 Materials and Methods

In this study swimming sounds produced by *S. acquinocialis* were recorded using a Cermic ER M3 omnidirectional microphone and stored on the hard drive of a Dell laptop computer for further processing. The sensitivity of the microphone was -58 dB to +3 dB, the frequency range was 0.10 to 16 kHz and the signal to noise ratio was 60 dB. Fourteen separate trials were made in which recordings of the swimming sounds of slipper lobsters near the surface. The experimental measurements were made in a shallow tank 50 cm X 80 cm with water depths of 15 to 20 cm.

3 Results

Fourteen acoustic records of the swimming motions of *S. acquinocialis* were made. The duration of the swimming tail-flip was calculated and summarized in Table 1. The range of tail-flip durations was 32 milliseconds to 154 milliseconds. The average duration of the tail-flip was 82 milliseconds. A spectrogram of the background noise is shown in Fig. 1. An example of a spectrogram of the sounds produced by a lobster swimming near the surface is presented in Fig. 2. The loudest noise is represented in red with decreasing amplitudes represented by green, blue and violet. Only signals higher in intensity than the maximum background noise was produced by the swimming of the lobsters. When swimming at or near the surface the slipper lobster *S. acquinocialis* produces a distinct acoustic signature with a peak amplitude between 0.1 kHz and 6.0 kHz.

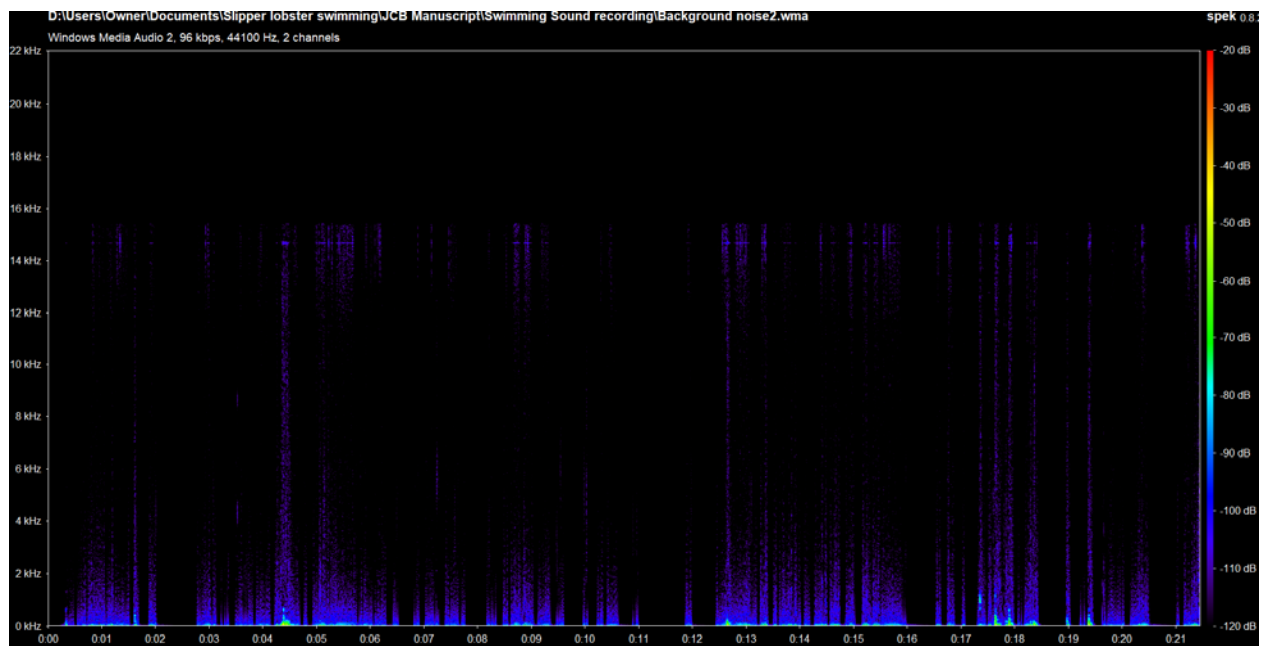


Fig. 1 Spectrogram made in the experimental tank without the presence of a lobster. This shows the background noise level. Only sound with greater intensities are produced by the swimming motions of the lobster.

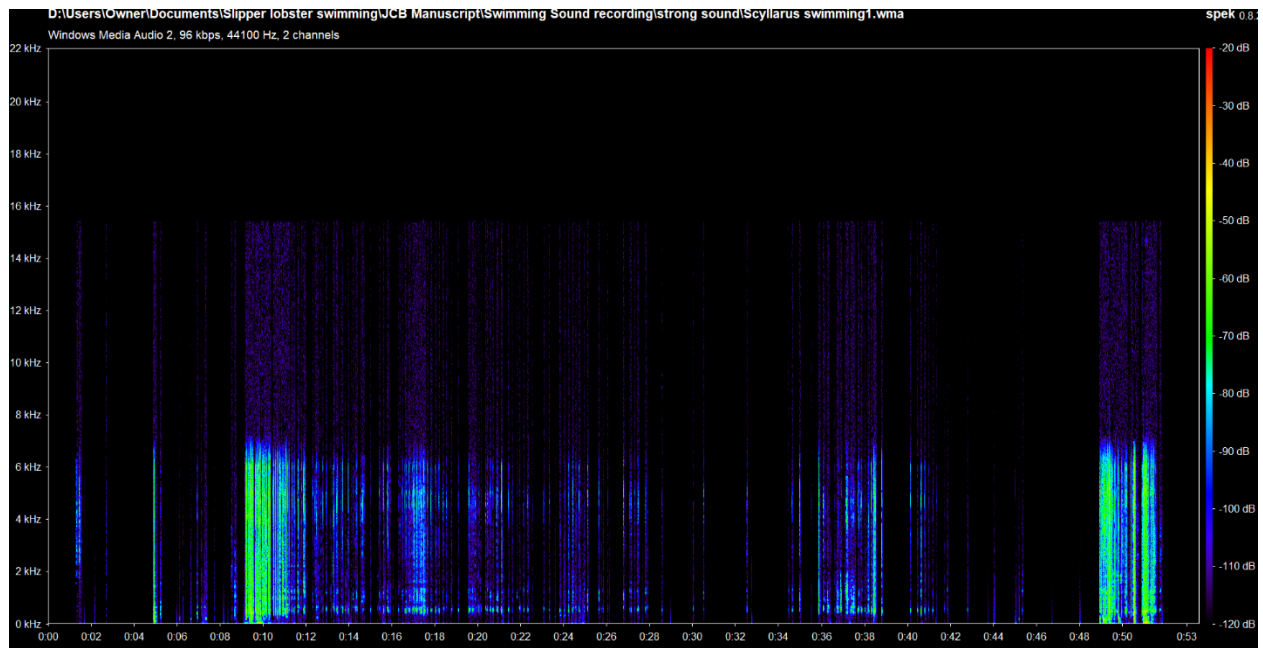


Fig. 2 An acoustic record of swimming by *S. acquinotialis*. During the period between 8.5 seconds and 10.5 seconds a maximum of 14 tail-flips were recorded. This corresponds to a period of 115 milliseconds per tail-flip.

Table 1 The results of fourteen acoustic measurements of tail-flip swimming by *S. acquinotialis*.

Trial	Average Tail-flip period (milliseconds)	Trial	Average Tail-flip period (milliseconds)
1	57	8	56
2	159	9	56
3	39	10	86
4	54	11	75
5	79	12	142
6	125	13	32
7	115	14	61

4 Discussion

The larger data set used in this study is believed to result in a more accurate measure of the acoustic signature of *S. acquinotialis* when swimming near the surface. A frequency ranges from 0.10 kHz to 6 kHz and an average pulse duration of 81 milliseconds (range 39 milliseconds to 159 milliseconds) is the result. More work on the near surface acoustic swimming signatures other members of the Malacostraca would be needed if a study were to be made in an ecosystem where other species were present.

The advantages of employing passive acoustic monitoring techniques to study swimming behavior in the Malacostraca are that it may be done in the natural environment without exposing the animals to the bright lighting conditions frequently used in video or ceni-photography. It also avoids any complicating effects resulting from attaching hardware to the animal. The use of passive acoustic monitoring has been employed to study marine mammals and fish by tracking sounds produced by the animals (Au, 2016; Picciulin, et al., 2019).

Cromarty et al. (1991) reported a tail-flip period of 50 millisecond to 100 milliseconds for the American Lobster, *Homarus americanus* H. Milne-Edwards, 1837. Newland et al. (1992) reported a tail-flip period for *Nephrops norvegicus* (Linnaeus, 1758) of 378 milliseconds. Nauen et al. (2001) reported a tail-flip period of 78 milliseconds to 129 milliseconds for *Panulirus interruptus*. These three studies used ceni-photographic methods for recording tail-flip period. The tail-flip periods acoustically recorded in Table 1. Acoustic records are found to be comparable. Passive acoustic monitoring is a viable technique for studying swimming behavior of slipper lobsters.

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