

Observations of the Sounds Produced by Swimming in the Spanish Lobster, *Scyllarides aequinoctialis* (Lund, 1793)

By

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ABSTRACT The objective of this research project was to study sound production by members of the Scyllaridae, slipper lobsters, specifically the Spanish Lobster *Scyllarides aequinoctialis* (Lund, 1793) when swimming at or near the surface. This is the first published record of swimming sounds produced by slipper lobsters. Analysis of recordings of swimming sounds produced by *S. aequinoctialis* in the laboratory indicates a peak of energy in the range of 100 Hz to 1.0 kHz with higher harmonics. The swimming sounds are co-incidental noise produced by slipper lobsters swimming near the surface. Such sounds may have significance for these animals.

Spiny lobsters and clawed lobsters produce sounds with a wide range of frequencies and amplitudes. Some of these sounds function as a means of communication with conspecifics. Others produce sounds to ward predators. Incidental sounds produced by feeding, walking or other biological processes may still be significant. Sensory organs that could detect particle motion at short ranges, millimeters to meters, are found on many decapod crustaceans.

Key Words: *Scyllarides aequinoctialis*; of *Scyllarides latus*; bio-acoustics; noise;

INTRODUCTION

The ability of spiny lobsters to produce sounds has been well established in the literature for over 134 years. The work of Parker [1] was the first to recognize the existence of two distinct groups of Palinuridae, spiny Lobsters, one producing sounds, the Stridentes, and the other lacking sound producing organs, the Silentes. George and Mann [2] reviewing the literature proposed a widely accepted evolutionary tree recognizing the two groups of spiny lobsters based on their sound production apparatus, termed Slip-stick, on the second antennae and carapace. The production of sounds in palinurid lobsters is a significant part of their anti-predator behavior [3]. Patek and Baio [4] greatly extended the work of Parker [1] and George and Mann [2] on Spiny lobster sound production. Reviewing the fossil record, Senter [5] concluded that stridulating insects first evolved in the Triassic and parallel evolution of stridulations occurred

multiple time in the Malacostraca. The existence of the primordia of sound producing organs on the phyllosoma larvae of some slipper lobster species indicates that the ability to produce sounds may have evolved at a very early stage in the evolution of the achelate lobsters [6].

There are no known examples of research establishing the ability to produce sound in the family Scyllaridae, slipper lobsters, however, Lavalli, and Spanier [7] offer anecdotal evidence, for sound production in *S. latus* Latreille, 1803, but state that there is no morphological evidence for sound producing organs like that in spiny lobsters. Spanier et al. and Spanier and Lavalli, [8 & 9], describe the swimming of the Mediterranean slipper lobster, *S. latus* in detail. They did not record any observations of sound production by swimming Nauen and Shadwick, [10] described the very similar swimming mechanics in the California spiny lobster *Panulirus interruptus* (Randall, 1840) providing more information on the actual energetics of the process, but again there is no mention of sound production in their study. In all of these descriptions of swimming achelate lobsters, the animals were not swimming at the surface as in our observations [9 & 10]. The objective of this research project was to study sound production by Scyllaridae, slipper lobsters, specifically *Scyllarides aequinoctialis* (Lund) when swimming at or near the surface.

MATERIALS AND METHODS

Live specimens of *S. aequinoctialis* were maintained in a 15 L aquarium at salinities between 34 ‰ and 36 ‰. Recordings of the sounds produced by were made in a shallow tank 50 cm X 80 cm with water depths of 15 to 20 cm. The recordings were made using a Cermic ER-M3 omnidirectional microphone with a diameter of 9.7 mm and length of 7.0 mm. 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. A spectrogram of the background noise is shown in figure 1. The loudest noise is represented by red color with decreasing amplitudes represented by green, blue and violet. Only signals higher in intensity than the maximum background noise were considered to be produced by the swimming of the lobsters. The lobsters were not forced to swim, consequently the recording times varied with more than ten seconds elapsing before the animals began to swim. Both spectrograms and direct recordings of the sounds were produced.

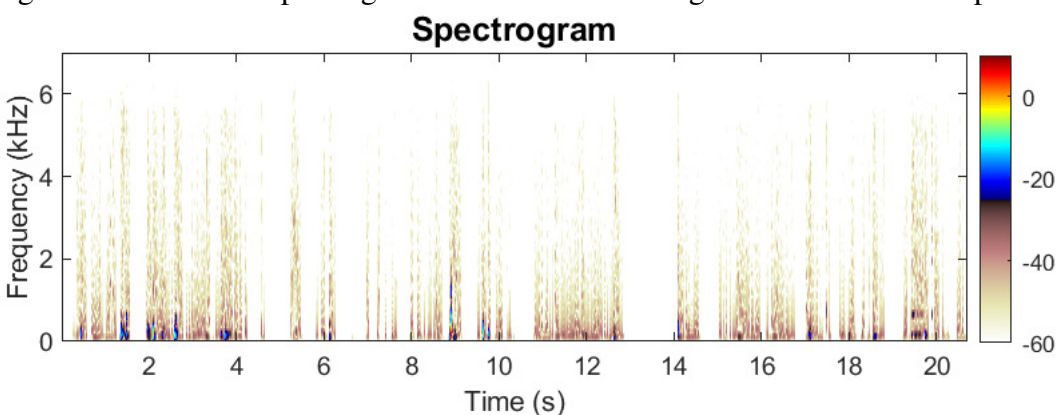


Figure 1. Background noise in the tank where all recording of the swimming animals were made. The residual noise may be due to small movements of the microphone.

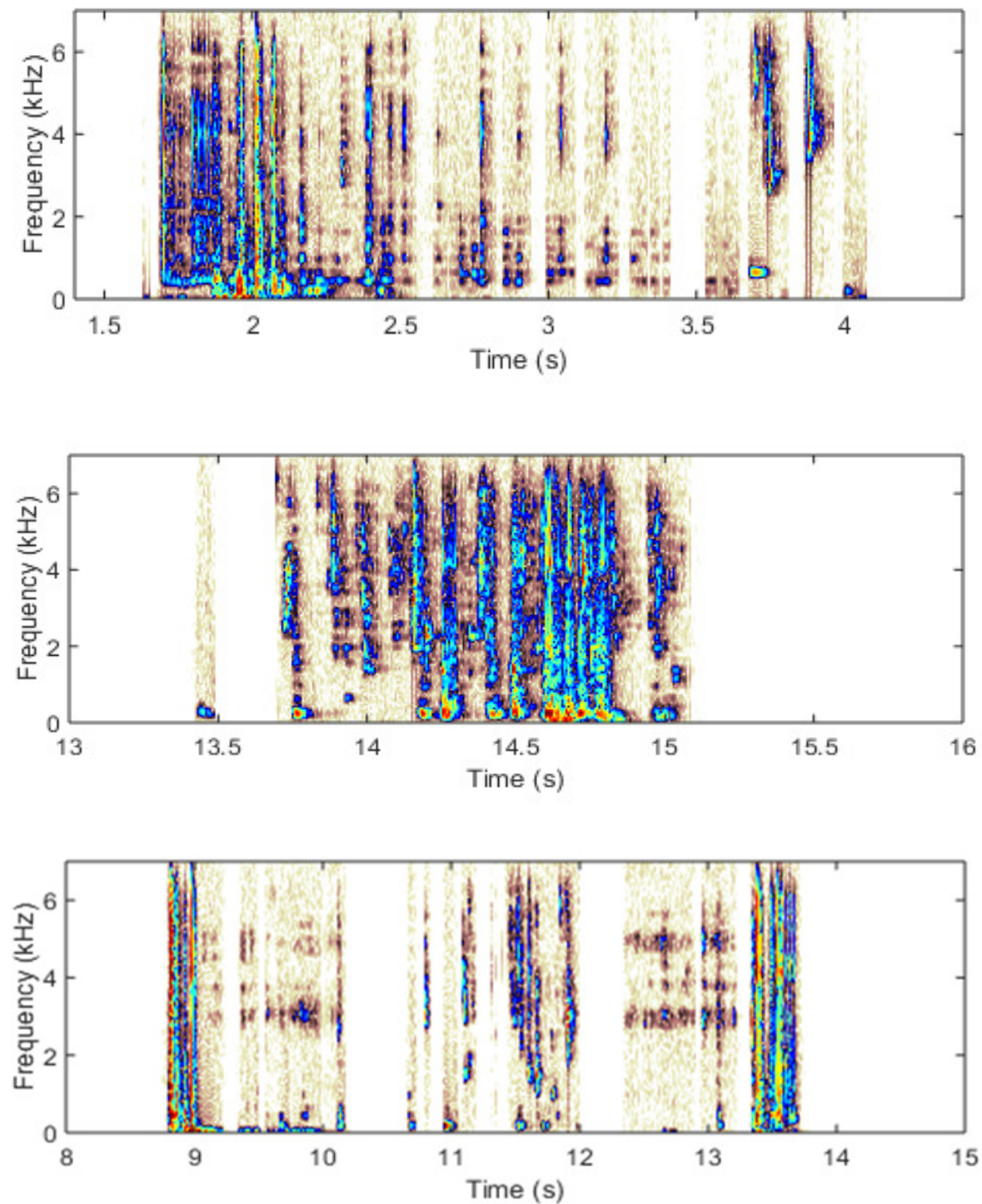


Figure 2. Three Spectrograms of sounds produced by *Scyllarides aequinoctialis* while swimming at the surface of a laboratory tank. The loudest sounds are produced by the impact of the uropods and telson on the water surface and the least intense by the pleopods. Only the period where the animals were actually swimming is shown.

RESULTS

Scyllarides aequinoctialis generates sounds when swimming at the surface between 100 Hz and 6 kHz with peak energy in the 100 Hz to 1.0 kHz range in most cases (see figure 2). This noise appears to be incidental to their swimming movements and not as a form of conspecific communication or an attempt to ward off a predator as is the case of spiny lobsters and clawed lobsters [3].

The swimming motion is typical of that described for both slipper lobsters and spiny lobsters [8 & 9]. That is *S. aequinoctialis* swims backwards by rapidly flexing the abdomen an average of seven times per second and using the uropods and telson as a paddle to exert force on the water. This swimming pattern is an escape mechanism used by decapod crustaceans used to avoid predators [8-10]. If this occurs at the surface, then the uropods and telson is in fact slapping the water surface to produce at least part of the recorded noise. The pleopods are also believed to produce part of the noise as they rub against each other. There are no stridulations on either the antennae, pleopods or uropods and telson like those found in spiny lobsters [1-4].

When swimming, the average pulse rate is seven (7) pulses per sec. and the range is from 2.5 pulses/sec. to 16 pulses/sec. The duration of the pulse is approximately 62.5 msec (Fig. 1).

DISCUSSION

The acoustic signals emitted by crustaceans span a broad range of frequencies. Low frequency rumblings (20–60 Hz) are produced by the mantis shrimp, *Hemisquilla californiensis*, [11] and the American lobsters (*Homarus americanus*) (87-261 Hz) [12] while ultrasonic signals (20-55 kHz) are emitted by the European spiny lobster, *Palinurus elephas* [13]. *Palinurus elephas* was also found to produce audible rasps in the 2-75 kHz range (15 kHz peak frequency) using a stridulating organ (plectrum) and rigid file. These sounds and undefined rasps occur following human manipulation and appear to be associated with anti-predator responses elicited by the introduction of an octopus [3]. Such findings suggest that crustacean noises function to startle potential predators or serve as a conspecific warning mechanism [14 & 15].

Many crustaceans produce sound as a part of their natural behavior. Coquereau et al [16] recorded the sounds produced by 11 species of crustaceans found in the North Eastern Atlantic Ocean identifying thirty-four distinct sounds in their study. In this study sounds produced by movement, such as walking, feeding, mandible rubbing, swimming and other non-identified behaviors, were detected.

Farre [17] provided the earliest account of sound detection in the crustaceans. Providing an early account of the structure of the sensilla on the cuticle of crustaceans. Farre [17] produced figures based on light microscope observations of the statocyst structure as well. Sound perception in aquatic crustaceans is accomplished by detecting particle motion, but not the pressure component of the sound energy [18 & 19]. The Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758), for example, responds in a predictable way, postural responses, to close range (up to 90 mm) particle displacement vibrations with thresholds near 0.9µm in the frequency range of 20-189 Hz [20 & 21].

In insects, arachnids and crustaceans mechanoreceptor hairs serve as fluid flow sensors. These so-called filiform hairs in insects, trichobothria in arachnids and flow sensilla in crustaceans are among the most sensitive sensory organs in the animal world. All fluid flow sensors have a similar design and represent hair-like structures. Suspended in a cuticular socket, the hair shaft functions as a lever, which responds to fluid viscous forces in the surrounding medium. The movement of the inner end of the hair shaft during deflection triggers one or several sensory neurons that transmit signals indicating the velocity, direction and acceleration of the flow to the central nervous system. To induce appropriate behavior. There is considerable variability in the number location and size of the sensory hairs in the three groups of arthropods [19-28]. Derby [25] found that the American lobster, *H. americanus*, has mechanoreceptors called Peg sensilla. These organs are found on the dactylus and propodus, Type I (70 μm long) and widely distributed on all segments of the walking legs, Type II (30 μm long). These organs may have a single hair-like projection or several, four, emanating from the cuticular socket. These sensilla are usually dually innervated permitting bidirectional sensitivity to flow sensitivity to water currents, pressure waves or tactile stimuli. Scyllarid lobsters, *S. aequinoctialis*, *S. latus*, and *S. nodifer* have chemosensory setae and mechanoreceptor setae on the second antennae which may function in the detection of sound energy by means of particle motion [22, 24-28].

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