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Sound production in sturgeon *Scaphirhynchus albus* and *S. platorynchus* (Acipenseridae)

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Synopsis

Sound production has been recently discovered in several species of *Acipenser*. Our work has focused on testing for sound production in species of sturgeon in the genus *Scaphirhynchus*. We discovered that pallid sturgeon *Scaphirhynchus albus* and shovelnose sturgeon, *S. albus* produce sounds during the breeding season. These signals may be used as part of efforts to localize populations of sturgeon in the field, including the Alabama sturgeon, *S. suttkusi*.

Introduction

Fishes in over 50 families are known to produce sounds (Myrberg 1981), which are used by biologists for locating breeding aggregations of some species (Luczkovich et al. 1999). Such a tool would be extremely useful for finding rare fishes, especially where other methods of monitoring are difficult.

Six species of Russian sturgeon in the genus *Acipenser* and *Huso* are known to produce sounds (*Acipenser baeri*, *A. gueldenstaedti*, *A. nudiventris*, *A. ruthenus*, *A. stellatus*, and *Huso huso*) but very little information is available regarding the structure of these signals, and almost nothing is known about their biological significance (Tolstoganova in litt.). Preliminary play back experiments suggest that sturgeon are attracted to their own sounds and that sturgeon sounds may travel fairly long distances (Tolstoganovain litt.). Such findings suggest that sounds may be used as monitoring tools for these imperiled fishes, but first the sounds must be adequately described. The sturgeon acoustics work to date has been uninvestigated in the genus *Scaphirhynchus*.

The objective of this research was to investigate sound production in the genus *Scaphirhynchus* (i.e., do sturgeon produce sounds during the breeding season?). Signals are described and potential contexts of sound production are discussed.

Methods

This research was conducted at the Natchitoches National Fish Hatchery, Natchitoches, Louisiana. A total of 63 recording trials were conducted 2–3 and 11–13 May 2001 and 66 trials were run 30 April, 1 May and 14–15 May 2002. Trials were conducted for 15–30 min from 7 am to 10 pm. Fishes available for this research included both sexes of pallid, *Scaphirhynchus albus* (n = 7, 2001 and 8, 2002) and shovelnose, *S. platorynchus* (n = 19, 2002) sturgeon. Fishes were collected in the Red River, LA during the breeding season (April–May) and held in 630 l fiberglass tanks (33 cm depth × 149 cm diameter). To insure reproductive readiness, fishes were injected with luteinizing hormone releasing hormone (LHRH) (males: 10 µg/kg body weight; females: 100 µg/kg body weight). The sound properties of these tanks is unknown.

Sounds were monitored using Benthos model AQ20 hydrophones with built-in preamplifiers. Sounds were recorded on a Sony ProII tape recorder, and later transferred to the computer for analysis using Canary (ver. 1.2, Cornell University). Recordings of ambient noise were made in each tank in the absence of fish in order to assess background noise. Statistical analyses (analysis of variance, Duncan's multiple range test) were conducted on data from individual signals using the SPSS software package (SPSS Inc., 1995, Chicago, IL). In the figures, clipping level specifies a value below which any amplitude value is ignored (decibels, dB); frame length is the number of digitized amplitude samples that are processed to create each spectrum; and filter bandwidth is the range of input frequencies around the central analysis frequency that are passed by each filter (Canary, ver. 1.2, Cornell University).

During sound trials, 1–3 fish or one fish of known identity (fishes were injected with PIT tags) were placed into a round fiberglass tank with a hydrophone. Average fork length of pallid sturgeon was 807 mm and of shovelnose sturgeon was 605 mm (2002 hatchery data, Jan Dean, pers. comm.). Trials were run with females, males and both sexes. Trials with single individuals were conducted for both sexes, but few sounds were recorded from single fish. All aeration and filtration were turned off for sound trials, which did not exceed 30 min. During trials, fishes were observed and all movements and potential contexts during sound production were recorded. Sounds contaminated by the fish hitting the tank or each other were not used for analysis.

Results

Both male and female pallid and shovelnose sturgeon produced sounds that were high enough in amplitude to be audible above the water when tank aeration and water filters were turned off. Sounds of four distinct types were characterized during trials and named according to our perception of what they sounded like: 'squeaks', 'chirps', 'knocks' and 'moans' (Table 1). Both male and female pallid and shovelnose sturgeon produced all sound types. Knocks were produced infrequently (25% pallid sounds, 8% shovelnose sounds), either singly or as series of pulses of short duration and low frequency without harmonics (Table 1, Figure 1). Squeaks were the most common sound type produced (51% pallid sounds, 54% shovelnose sounds), and consisted of one to three components of relatively short duration (Table 1, Figure 2). Squeaks were relatively high frequency and most had harmonics. Chirps also had harmonics but were produced less frequently than squeaks (17% pallid sounds, 37% shovelnose sounds) (Table 1, Figure 3). Chirps were higher in frequency and of shorter duration than squeaks, but were also often produced in series of one or more components. Moans were produced infrequently and consisted of a burst of low frequency, non-harmonic sound (8% pallid sounds, 1% shovelnose sounds) (Table 1, Figure 3).

For pallid sturgeon, all four sound types were statistically different in dominant frequency ($F = 35.1$, $p = 0.0001$) and duration ($F = 5.2$, $p = 0.003$). The number of harmonics for squeaks and chirps was also statistically different ($F = 13.8$, $p = 0.001$). For shovelnose sturgeon, squeaks and chirps were statistically different in dominant frequency ($F = 18.9$, $p = 0.0001$), duration ($F = 23.4$, $p = 0.0001$) and number of harmonics ($F = 31.3$, $p = 0.0001$). Paucity of data for knock and moan sound types from shovelnose sturgeon prohibits statistical comparisons.

Species differences were apparent in the squeak sound type for dominant frequency ($F = 11.6$,

Table 1. Characteristics of various sound types produced by shovelnose and pallid sturgeon.

Call type	Pallid			Shovelnose		
	Dom. freq. (kHz)	Duration (ms)	# harmonics	Dom. freq. (kHz)	Duration (ms)	# harmonics
Squeak	0.92 (0.31) (0.51–2.0) n = 27	211.1 (103.9) (95.3–485.3)	3.2 (0.89) (1–5)	1.3 (0.50) (0.51–2.78) n = 53	112.3 (66.1) (42.9–356.4)	3.9 (1.6) (1–9)
Chirp	2.0 (0.83) (1.0–3.2) n = 9	71.2 (30.5) (42.4–146.6)	2.0 (0.70) (1–3)	2.1 (.92) (0.94–4.2) n = 37	57.6 (21.8) (24.0–129.6)	2.3 (0.77) (1–4)
Knock	0.16 (0.004) (0.10–0.24) n = 13	196.6 (91.5) (47.2–314.9)	NA	0.09 (0.008) (0.09–0.11) n = 8	230.9 (72.8) (142.0–333.0)	NA
Moan	0.37 (0.003) (0.34–0.42) n = 4	210.8 (123.8) (108.0–381.0)	NA	0.26 n = 1	100.0	NA
Total		53			99	

Mean, standard deviation in parentheses, range and number of sounds analyzed on following line. NA = not applicable; not all sound types have harmonics.

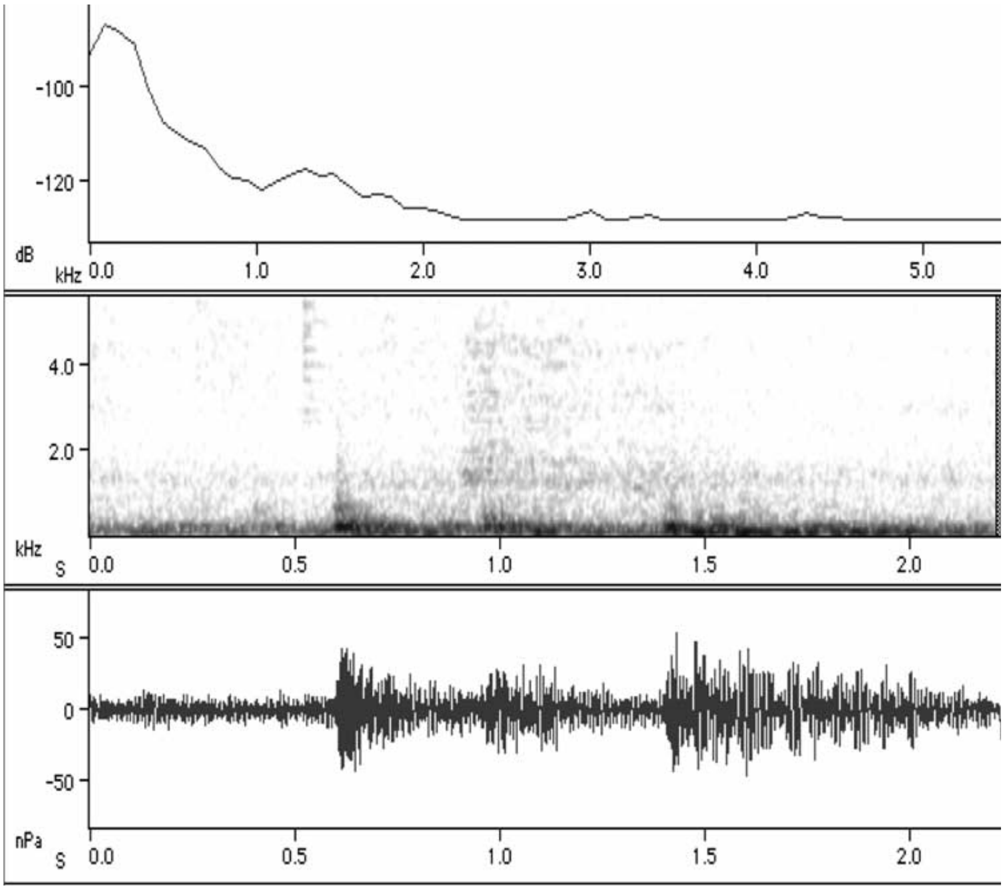

Figure 1. Representative power spectrum (top), spectrogram (middle), and wave form (bottom) from a series of three 'knocks' produced by a pallid sturgeon. Hanning window, −130 clipping level, frame length 256, filter bandwidth 350 Hz, FFT 256.

$p = 0.001$), duration ($F = 26.7$, $p = 0.0001$) and number of harmonics ($F = 4.1$, $p = 0.04$). No statistical differences between species were detected for the chirp sound type (dominant frequency $F = 0.005$, $p = 0.94$; duration $F = 2.4$, $p = 0.12$; number of harmonics $F = 1.1$, $p = 0.30$).

No apparent contexts were discernable when sturgeon produced sounds in this study. Fish typically swam around the sides of the tank or sat motionless. Isolated sexes both produced sounds, and single individuals produced fewer sounds than fish in groups.

Discussion

Sturgeon in the genus *Scaphirhynchus* produce sounds associated with the breeding season. Four distinct sound types were characterized on the basis of duration, frequency and presence of harmonics. Five signals types were described for *A. gueldenstaedi*, Russian sturgeon (Tolstoganovain litt.). The 'series of pulses' seems similar to the knocks produced by *Scaphirhynchus*, and the 'FM whistle' may be similar to squeaks recorded for *Scaphirhynchus*. One of the signals described for Russian sturgeon was produced very infrequently. It is possible that with more data we will recognize more signal diversity in *Scaphirhynchus*. Without more information, especially figures, it is difficult to compare the structure of *Acipenser* and *Scaphirhynchus* sounds at this time.

In our study, the signals of the two species differed in aspects of frequency, duration and number of harmonics. Shovelnose sturgeon are smaller in size than pallid sturgeon, and the higher frequency of the squeak call type may be due to this fact, as fishes with smaller body size may produce higher frequency signals (Myrberg et al. 1993). In our study, sturgeon produced sounds in groups of individuals, and it is not

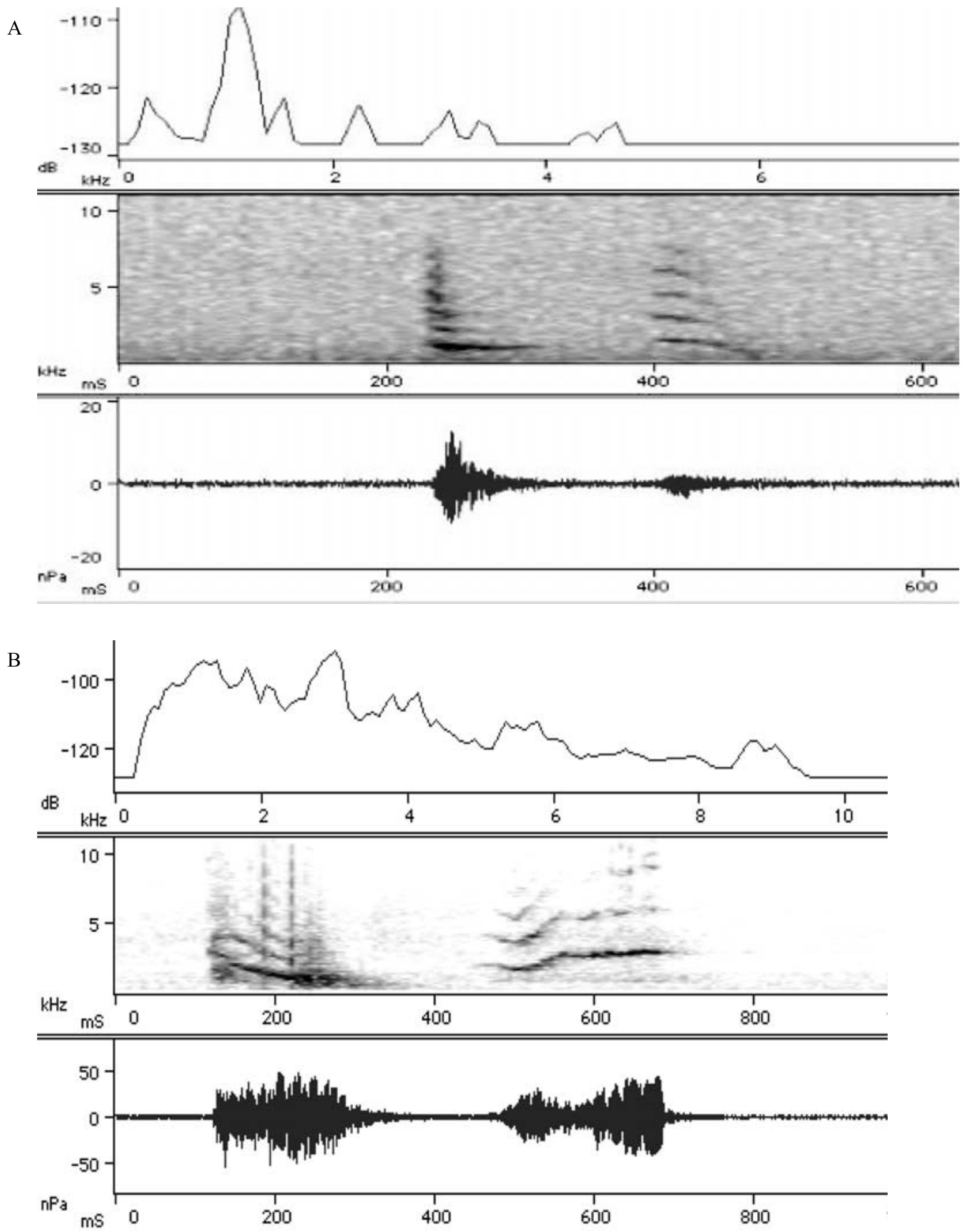

Figure 2. Representative power spectrum (top), spectrogram (middle), and wave form (bottom) from a 'squeak' produced by shovelnose sturgeon (A) and pallid sturgeon (B). A: Hanning window, −130 clipping level, frame length 296, filter bandwidth 350 Hz, FFT 256. B: Hanning window, −80 clipping level, frame length 256, filter bandwidth 700 Hz, FFT 256.

A

B

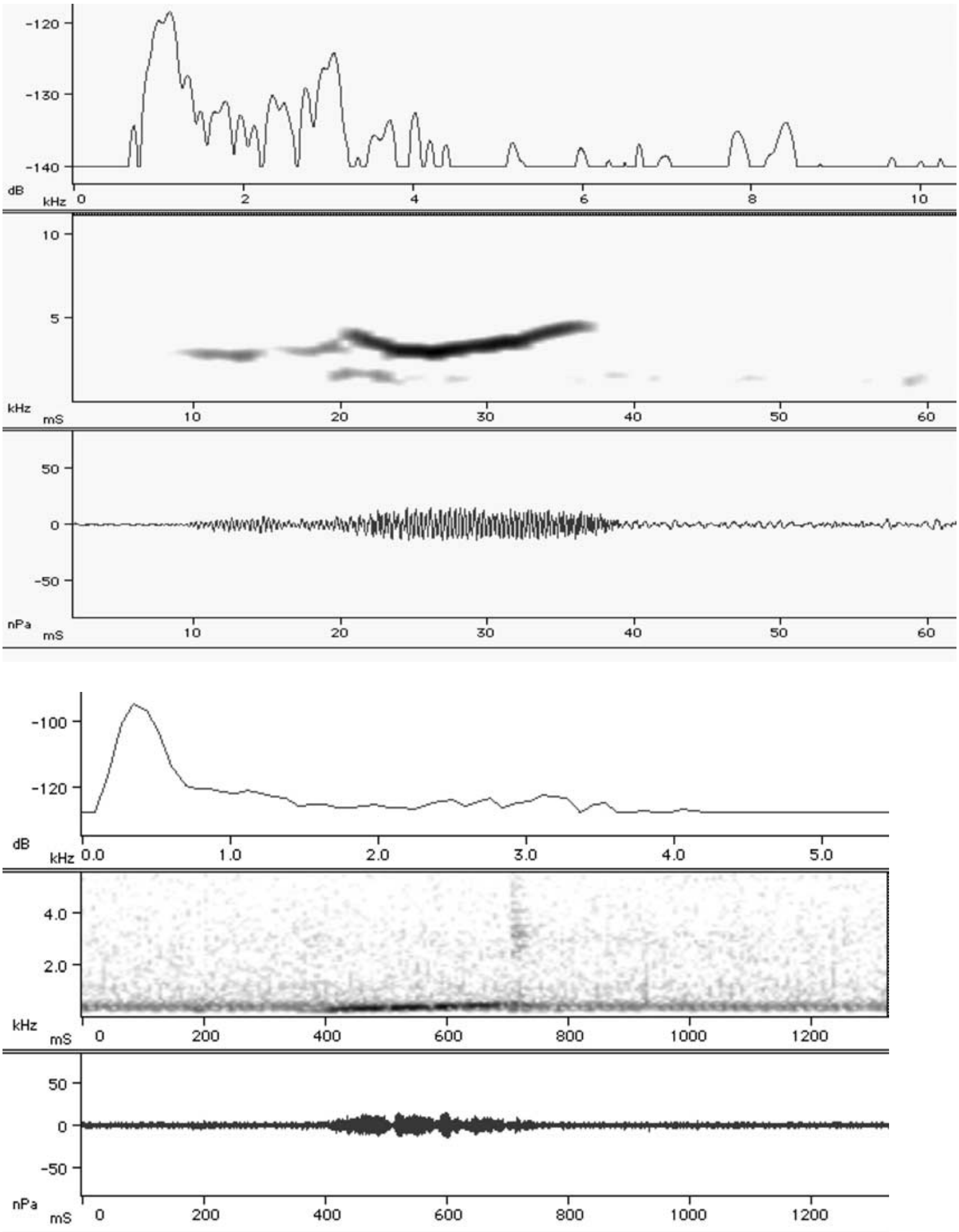

Figure 3. Representative power spectrum (top), spectrogram (middle), and wave form (bottom) from a 'chirp' produced by a shovelnose sturgeon (A) and 'moan' produced by a pallid sturgeon (B). A: Hanning window, −110 clipping level, frame length 64, filter bandwidth 1367 Hz, FFT 2048. B: Hanning window, −140 clipping level, frame length 256, filter bandwidth 350 Hz, FFT 256.

possible to remove body size from the analysis. It is not known how body size would effect signal duration or the number of harmonics, and these differences could be species-specific.

Currently, the context of sound production by sturgeon is unknown. Our recordings were made during the breeding season for fishes that were ready to spawn. It is possible that the low frequency knocks and moans produced by these fishes are used in aggregating individuals on the spawning grounds, as low frequency sounds travel longer distances than high frequency sounds. The squeaks and chirps, which are higher in frequency, may be used by these fishes in mate choice or individual recognition, activities that require closer proximity.

The mechanism of sound production in these taxa was not investigated in this study. Other fishes produce sounds by stridulating bones or by contracting muscles, often attached to the gas bladder (Demski et al. 1973, Hawkins 1993). The sounds produced by stridulation of bones typically consist of pulses of broadband noise of short duration (Demski et al. 1973). Sounds produced by contracting muscles associated with the gas bladder are usually harmonic (Demski et al. 1973), and this mechanism is consistent with the sounds produced by sturgeon.

During preliminary experiments where sturgeon sounds were played to groups of Russian sturgeon Tolstoganova (in litt.) found that individuals responded by moving towards the transducer. It may be possible not only to locate sturgeon in the field by listening to their sounds, but also attract them by broadcasting their sounds into the appropriate habitat. Tolstoganova (in litt.) also reported that sounds produced by sevruga during the breeding season were detected up to 500 m from the source. Given the amplitude and frequency of *Scaphirhynchus* sounds, it should be possible to locate the signals from many meters away, depending on the substrate and water depth. However, work is still needed to evaluate signal degradation for these species.

Bioacoustic monitoring is already being used for many species of fishes (Luczkovich et al. 1999) and it is quite possible that this technique will be useful for locating populations of *Scaphirhynchus*. This preliminary work provides the first descriptions of *Scaphirhynchus* sounds, information that hopefully will be useful in the conservation of these fishes.

Acknowledgements

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