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DIVERSITY OF FISH SPAWNING SOUNDS AND THE APPLICATION OF PASSIVE ACOUSTIC MONITORING

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INTRODUCTION

Marine bioacoustics is a multidisciplinary field with practical applications to economically important global fisheries issues. One application of bioacoustics uses passive acoustic technology to record temporal and spatial patterns of fish reproduction by detecting sounds associated with spawning (Mann and Lobel 1995). The applicability of this tool depends upon whether specific species produce reliably identifiable sounds during courtship and spawning (Lobel 2001a). Monitoring courtship and spawning sounds can be used to define important breeding habitats (a priority in planning marine protected areas) and to understand the relationships between fish reproduction and the fate of larvae in ocean currents. Mating is the crucial biological event to monitor in order to understand the life history tactics of fishes, especially coastal marine species with a pelagic larval phase. Mating is also a critical endpoint measurement in pollution impact studies. Measuring a decrease in reproduction may be an early indication of subtle adverse affects of pollution. It is well known that many fishes produce sounds associated with courtship. However, which fishes produce specific sounds during spawning is not as well known.

A strong case for the value of bioacoustic monitoring is made by the discoveries that two of the world's most valuable fishes, cod and haddock, produce distinct courtship and spawning sounds (Nordeide and Kjellsby 1999, Hawkins and Amorim 2000). This paper documents the spawning sounds of four coral reef fishes and illustrates different types of acoustic patterns.

EXAMPLES OF SPAWNING SOUNDS

Methods are reported by Lobel (2001a) and spawning behaviours with sounds are described in references cited below for each species.

Ostracion meleagris (Family Ostraciidae) produces a clear tonal sound with one harmonic (Figure 1a, Lobel 1996).

Dascyllus albisella (Family Pomacentridae) produces a spawning sound composed of a simple series of one to four pulses (Figure 1b). This spawning sound differs from its courtship sound only by having fewer pulses (Lobel and Mann 1995). A spawning sound was not found in another pomacentrid (*Abudefduf sordidus*) or in related freshwater cichlids (Lobel 1998, 2001b, Lobel and Kerr 1999), even though these other fishes produce courtship sounds similar to *D. albisella.*

Hypoplectrus nigricans (Family Serranidae) produces a distinct two-part spawning sound (Figure 1c). A short downward frequency

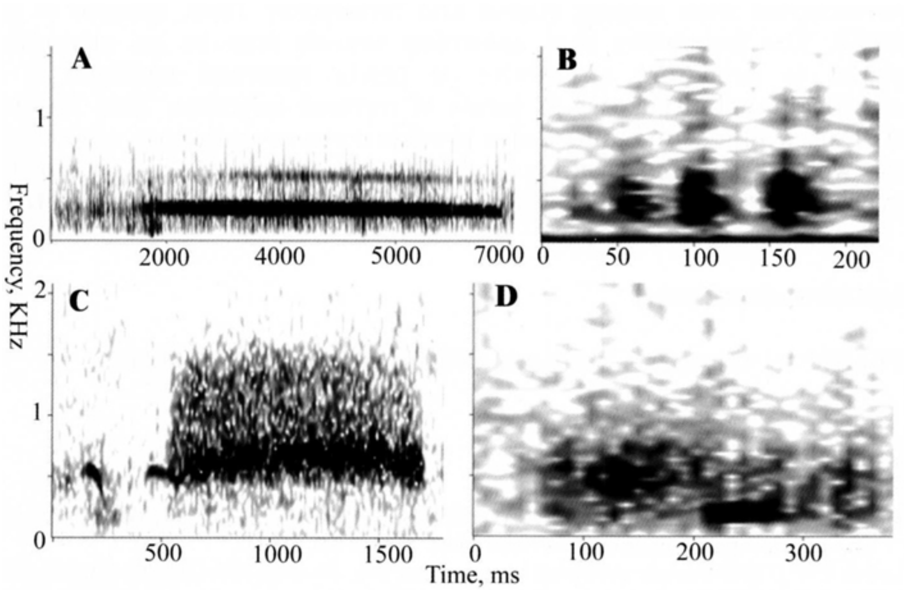

Figure 1. Sonograms produced using the hamming window function and an FFT size of 2048 points (Canary software). Frequency scale is the same in all graphs, but time scale differs in each. a) *Ostracion meleagris*, duration 6213 ms, dominant frequency, DF 258 Hz, b) *Dascyllus albisella*, 3 pulses, duration 130 ms, DF 328 Hz, c) *Hypoplectrus nigricans*, duration 1581 ms, DF 656 Hz, d) *Scarus iserti*, duration 329 ms, DF (two peaks) 492 & 211 Hz. Size range of these fishes is about 10-20 cm SL.

sweep is followed by a short silence and then followed by a broadband sound, which is made as the fish disperse gametes (Lobel 1992). This sound may be a combination of swimbladder sound and hydrodynamic noise from rapid fin fluttering.

Scarus iserti (Family Scaridae) spawns in aggregations of about 20 to 40 individuals. These fish gather in groups over the reef surface and then suddenly and with great speed, rush upwards a few meters, turn rapidly while releasing gametes and dart back to the reef shelter (Lobel 1992). This spawning sound is hydrodynamic noise produced by the fish's swimming movements (Figure 1d).

DISCUSSION

Why do some fishes make spawning sounds? By the time mating has started, mate selection has already taken place. Such sounds may have originated as a mere by-product of movements associated with swimming and gamete extrusion. Furthermore, these sounds are in the low-frequency range that has been shown to be highly attractive to predators, e.g. sharks (Myrberg et al. 1972). Spawning fishes may be less responsive to predatory threats once they are completely preoccupied with mating (Lobel and Neudecker 1985, Sancho et al. 2000). The possibility that spawning sounds may be an attracting signal to predators on adults or newly spawned embryos is a significant potential cost in terms of natural selection. This implies that spawning sounds must also provide some evolutionary advantage as well. Spawning sounds may have evolved to behaviourally synchronise gamete release in order to maximise external fertilisation.

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USING PASSIVE ACOUSTICS TO MONITOR ESTUARINE FISH POPULATIONS

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INTRODUCTION

The goal of this study was to develop a passive acoustic survey protocol to identify spawning habitats of sciaenid fishes. Based on comparisons of captive fish and field recordings of species-specific courtship sounds, we have identified the spawning areas of red drum *Sciaenops ocellatus*, weakfish *Cynoscion regalis,* spotted seatrout *Cynoscion nebulosus*, and silver perch *Bairdiella chrysoura* (Family Sciaenidae) in Pamlico Sound (NC).

CAPTIVE FISH RECORDINGS

Individuals in each species were caught using hook-and-line and recorded in captivity. Sonograms, average power spectra, and oscillograms were used to characterise recordings following Sprague et al. (2000).