New technologies for passive acoustic detection of fish sound production

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Introduction

Passive acoustic detection of fish sounds relies heavily on advances in recording and data processing technology. The recent explosion in fast, inexpensive personal computers and electronics has created tremendous growth potential in the field. This paper describes early efforts in developing passive acoustic detection systems for fishes and more recent efforts utilizing digital systems. The goals of each of these systems were to automatically detect and quantify sounds of interest in real-time, minimize false detections, and minimize the amount of data that needs to be stored to determine calling rates continuously over long periods of time.

First Generation Passive Acoustic Detection System

Most fish sounds are either simple pulsed broad-band sounds or tonal type sounds, where the pulse rates or dominant frequency are species-specific (e.g. Lobel and Mann, 1995; Mann and Lobel, 1998; reviewed in Zelick et al., 1999). Fish sounds do not typically exhibit complex frequency modulations seen in many marine mammal vocalizations. This makes it possible to describe most fish sounds with a few metrics, such as sound duration, peak frequency, and bandwidth. Timing between pulses can be recorded by storing the time of onset of each pulse. By recording these simple metrics, a system can be developed to automatically detect and process sounds of interest and greatly reduce the amount of data that would be acquired by simply recording continuously.

Early attempts at passive acoustic detection involved developing a largely analog system that would detect sounds that were above some background level and store the time of occurrence and sound duration (actual sound data were not stored) (Mann and Lobel, 1995) (Fig. 1). From these data, the rate of sound production of different species' sounds could be determined. This system was employed to measure sound production rates of individual damselfish over periods of months, and revealed a striking dawn chorus in sound production and a tight link between sound production and spawning cycles (Mann and Lobel, 1995).

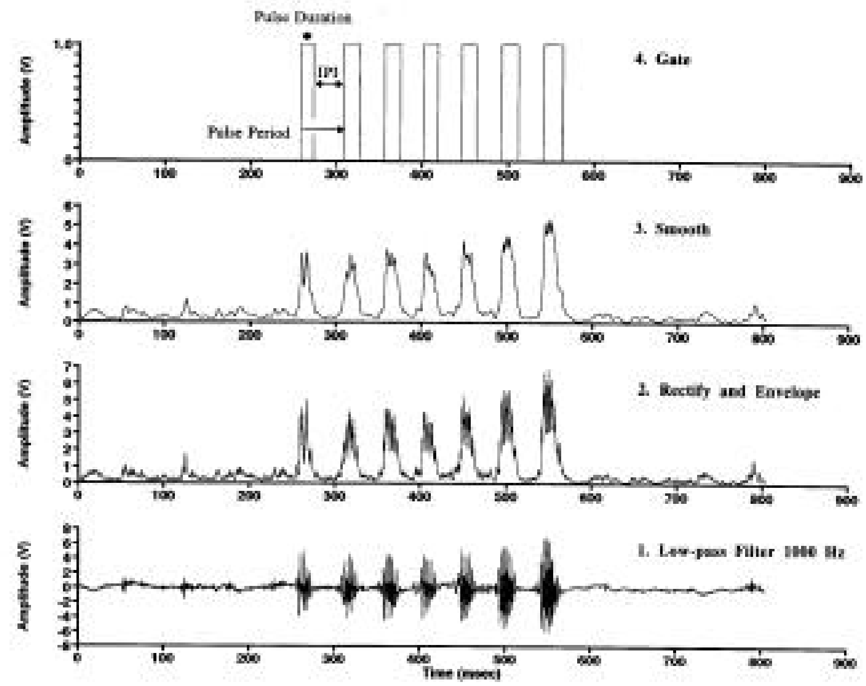

Figure 1. Signal processing scheme for the detection of damselfish (*Dascyllus albisella*) calls.

Real-Time Digital Signal Processing Systems

While the analog system was a robust detector, continued increases in data storage capacities and the emergence of inexpensive digital signal processing chips and the flexibility that these provide, prompted the development of a programmable digital system. This system is commercially produced by Tucker-Davis Technologies (Gainesville, FL) and consists of a battery-powered datalogger with two channels of A/D, 32 MB of RAM, and a graphical programming interface. The flexibility of the datalogger is that it can be used to process the signal in real-time including a wide array of filtering (FIR, IIR) techniques and adaptive thresholding. The datalogger can be programmed to store whatever data is desired by the researcher. To demonstrate its flexibility, a device was programmed to detect the sounds produced by the toadfish *Opsanus beta*, store the time of occurrence of the sound and record a 1000-point sound sample (Fig 2).

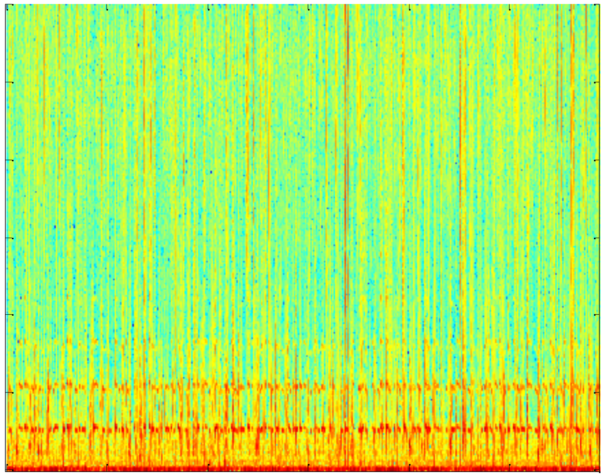

Figure 2. Spectrogram of a series of automatically-detected toadfish (*Opsanus beta*) calls plotted one after another. The dominant frequency of these calls is approximately 250 Hz.

The Future of Fisheries Bioacoustics

The primary tools for the fish bioacoustician will remain the PC and continuous digital recording systems for some time. To promote the emergence of fisheries bioacoustics requires more research into the sounds made by different fish species and the development of new technologies that utilize these data.

Ultimately fisheries bioacoustics should move the way of fisheries acoustics where the signal output is not the actual sound data, but the locations and intensity of fish spawning. A useful analogy is the development of SONAR systems for fish quantification. These systems do not deliver raw sound data to the researcher. They return processed data on fish location and abundance. One can envision the day when real-time fisheries bioacoustics systems will produce maps of the locations of sound-producing fishes that can provide managers with data on the temporal and spatial extent of spawning.

Acknowledgments

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References

Lobel, P.S. and D.A. Mann. 1995. Spawning sounds of the damselfish, Dascyllus albisella (Pomacentridae), and relationship to male size. Bioacoustics 6: 187-198.

Mann, D.A., and P.S. Lobel. 1995. Passive acoustic detection of sounds produced by the damselfish, Dascyllus albisella (Pomacentridae). Bioacoustics 6: 199-213.

Mann, D.A., and P.S. Lobel. 1998. Acoustic behavior of the damselfish Dascyllus albisella: behavioral and geographic variation. Environ. Biol. Fish. 51: 421-428.

Zelick, R., D.A. Mann, and A.N. Popper. 1999. Acoustic communication in fishes and frogs. In: Comparative Hearing: Fish and Amphibians. Springer, New York. pp. 363-411.