Sound Production and Spawning by Black Drum (*Pogonias cromis*) in Southwest Florida

JAMES LOCASCIO, ERNST PEEBLES, and DAVID MANN

[1]*College of Marine Science, University of South Florida, 140 Seventh Ave. South, St. Petersburg, Florida 33701 USA,*

ABSTRACT

Many fishes produce sound associated with courtship and spawning. Sound production can therefore be used as a proxy for spawning activity and Long-Term Acoustic Recording Systems (LARS) are useful for documenting this activity on daily and seasonal time frames at high resolution. We used the LARS to investigate patterns of sound production in spawning aggregations of black drum (*Pogonias cromis*) during 2004 – 2006 in southwest Florida. Our purposes were to document trends in black drum sound production on daily and seasonal time scales and to investigate the temporal and quantitative relationships between egg production and sound production. Sound production was strongly diel, beginning near dusk and lasting for several hours. Sound production occurred from October through April and peaked in February-March, consistent with prior descriptions of the spawning season for this species based on the gonado-somatic index (GSI). To investigate the relationship between sound production and egg production, surface plankton tows were conducted hourly between 1600 – 0400 on two consecutive nights while continuous underwater acoustic recordings were made. This was done five times between January and April, 2006. Neither the timing nor quantity of sound production was correlated with egg production on a nightly basis. These results indicate that patterns in sound production are not useful for predicting patterns in egg production by black drum on a daily scale but do provide accurate characterization of spawning behavior on a seasonal basis. Sampling on consecutive nights also allowed us to estimate egg development and mortality rates, and female spawning stock biomass.

KEY WORDS: Black drum, sound production, egg production, spawning aggregation

Producción de Sonido y la Freza de la Corvina Negra (*Pogonias cromis)* en el Suroeste de la Florida

Muchos peces producen sonidos asociados con el cortejo y la freza. La producción de sonido puede usarse para estudiar la actividad de freza y los Sistemas de Grabación Acústica de Periodos Largos (LARS) son útiles para documentar esta actividad diariamente o estacionalmente a una alta resolución. Usamos el LARS para investigar los patrones de producción de sonido en agregaciones de freza de la corvina negra (*Pogonias cromis*) durante 2004-2006 en el Suroeste de la Florida. Nuestro propósito fue documentar las tendencias de producción de sonido de corvina negra diaria y estaciónalmente, e investigar las relaciones temporales y cuantitativas entre la producción de huevos y la producción de sonido. La producción de sonido fue altamente regular, comenzando en el anochecer y durando varias horas. La producción de sonido ocurrió desde octubre hasta abril con la época pico en febrero-marzo, lo cual fue consistente con descripciones anteriores de la época de freza para esta especie basada en el índice gonado-somático (IGS). Para investigar la relación entre la producción de sonido y de huevos, se hicieron tomas de arrastre de plancton superficial entre las horas 1600 y 0400 en dos noches consecutivas al mismo tiempo que grabaciones acústicas fueron hechas. Estos se hizo cinco veces durante enero y abril, 2006. Ni la sincronización ni la cantidad de producción de sonido estuvieron correlacionadas con la producción de huevos durante la noche. Estos resultados indican que los patrones de producción de sonido no ayudan a predecir los patrones de producción de huevos de la corvina negra en una escala diaria pero pueden caracterizar exactamente el comportamiento de freza en una escala estacional. El muestreo en noches consecutivas permitió estimar el desarrollo de los huevos, las tasas de mortalidad, y la biomasa de hembras en freza.

PALABRAS CLAVES: Corvina negra, producción de sonido, producción de huevos, agregaciones de freza

INTRODUCTION

Many species of Sciaenids, a family of fish well-known for their sound producing abilities, inhabit the waters surrounding Cape Coral, Florida. Sounds can be produced by fishes in particular behavioral contexts (Fish and Mowbry 1970, Winn 1964,). In Sciaenids (drums) the functional significance of sound production is mainly associated with reproductive behavior and sounds are species specific (Winn 1964). Sound production in these fishes is typically performed by males via rapid flexure of the sonic muscle against a gas filled swim-bladder – hence the common name, drum.

Drums are broadcast spawners forming large aggregations during the night in which the males and females release gametes into the water column where fertilization occurs. To efficiently form a sizable spawning aggregation a directional stimulus must be employed. In turbid coastal waters visual communication is limited to very short distances (< 5 m). Sound however propagates very efficiently underwater, traveling at 1500m/sec (5x faster than in air) with low attenuation. Hydrophone surveys can therefore be used to document when and where spawning of soniferous fishes is taking place (Mok and Gilmore 1983, Saucier *et al*. 1992, Saucier and Baltz 1993, Mann and Lobel 1995, Luczkovich *et al*. 1999, Zelick *et al*. 1999; Gilmore 2003, Locascio and Mann 2005).

The black drum (*Pogonias cromis*) ranges from Massachusetts to Argentina and is the largest sciaenid occurring in waters of southwest Florida, predominantly inhabiting the neritic zone including bays and estuaries (Hoese and Moore 1998). A maximum age of 43 yr has been recorded for black drum in the northern Gulf of Mexico (Beckman *et al*. 1990) but Murphy and Taylor (1989) suggest a 50 - 60 year maximum age is possible.

Age at maturity has been reported as 4 - 5 year for males and 5 - 6 year for females (Murphy and Taylor 1989). Several investigations, based on histology and egg and larval distributions, have reported the spawning season in the Gulf of Mexico to occur from late fall through spring, peaking in February and March. Spawning locations have been reported within deeper areas of estuarine bays and in open coastal waters (Fitzhugh 1993). Mok and Gilmore (1983) investigated sound production and spawning in the Indian River Lagoon, Florida and documented a decline in black drum sound production with a decline in spawning activity.

The purpose of this study was to document the daily and seasonal patterns in sound production by black drum and to compare the timing and levels of sound production with the timing and quantity of egg production.

METHODS

Two Long Term Acoustic Recording Systems (LARS) were deployed at separate locations within residential canals of southwest Cape Coral and Punta Gorda Florida during portions of the winter and early spring in 2004 - 2005 to document sound production by black drum. Study sites were selected based on reports of unexplained sounds occurring during the evening within the homes of nearby residents (Figure 1). The LARS was programmed to record ten seconds of sound every ten minutes with 16-bit resolution and a sampling rate of 2,634 Hz. At each study site the LARS was chained to an anchor lowered to the bottom and secured to a dock by rope. The LARS remained stationary and positively buoyant 0.5 m above the bottom throughout the deployment period. Water depths at each site were approximately 6 m.

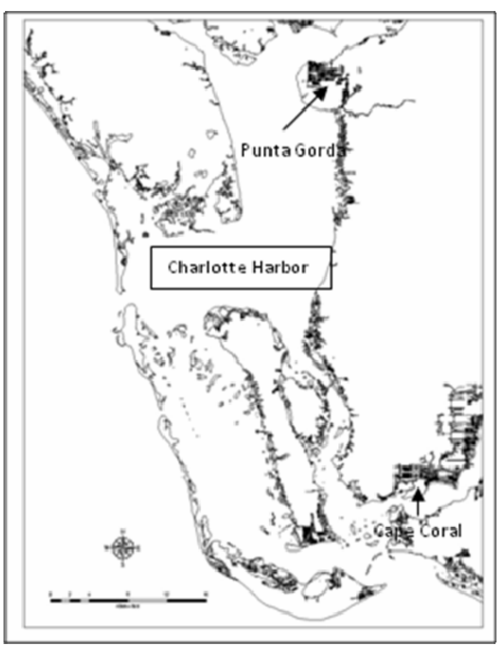

Figure 1. Map of Charlotte Harbor, Florida showing the location of the two study sites, Punta Gorda and Cape Coral.

The LARS is composed of a Persistor CF2 computer, Oceanographic Embedded Systems 16S2 analog to digital converter, and a custom signal conditioning circuit board that provides anti-aliasing filters. Ten second sound files were recorded to a SanDisk 512MB compact flash memory card. An HTI 96-min series hydrophone (sensitivity: -164 dBV/µPa) with an underwater connector was wired to the signal conditioning board, which also provided the power supply for the hydrophone. Four D-cell batteries were used as the power source.

LARS data were processed using Qlogger, a custom MATLAB (v6.5) program. Each ten second file was analyzed with a Fast Fourier Transform (FFT) to generate a power spectrum. The mean spectrum level sound pressure levels (SPL dB re 1 $\mu Pa^2/Hz$) in the 100 Hz band from 100-200 Hz were calculated from the FFT.

The resulting time series of average SPL for each 10 second recording period within the 100 - 200 Hz band were smoothed using a 5-point moving average. Time series of black drum sound production were compared to descriptions of the black drum spawning season by previous authors using the gonado-somatic index.

To investigate the relationship between sound production and egg production, surface plankton tows (using a 333 micron mesh with flow meter) were conducted hourly between 1600 – 0400 on two consecutive nights while underwater acoustic recordings were made. This was done five times between January and April, 2006. Plankton samples were collected in an area of the canal system in Cape Coral, Florida which was bordered on four sides by seawall allowing only a small inlet for boat traffic. Plankton samples were preserved in 10% formalin immediately after collection and then transferred to 50% isopropyl alcohol forty eight hours later. Approximately 20% (by volume) of each plankton sample was subsampled to count the number of black drum eggs present. The first one hundred black drum eggs counted in each sample were also staged to estimate the developmental rate. A regression model on squared transformed data was used to back-calculate the time of spawning. Egg densities (expressed as # of eggs/cubic meter) at back calculated spawning times were grouped into 1 hour wide bins and plotted with sound production data to examine the temporal relationship between sound production and spawning. Maximum nightly sound pressure levels were also compared to nightly egg densities.

RESULTS

Sound production by black drum was strongly diel, beginning near dusk and lasting for several hours (Figure 2). Sound production occurred from October through April and peaked in February-March, consistent with prior descriptions of the spawning season for this species based on the gonado-somatic index (GSI) by Fitzhugh *et al.* (1993) (Figure 3). The time series of sound production shown in Figure 3 begins in early December, however several days of recordings in late October documented a small amount of black drum sound production.

The squared x model provided the best overall fit to data of egg development vs. time (Table 1). The fitted equation was used for back-calculating the time of spawning for various developmental stages of eggs collected throughout each night. The timing and amount of spawning was considerably more variable than the timing and amount of sound production (Figure 4).

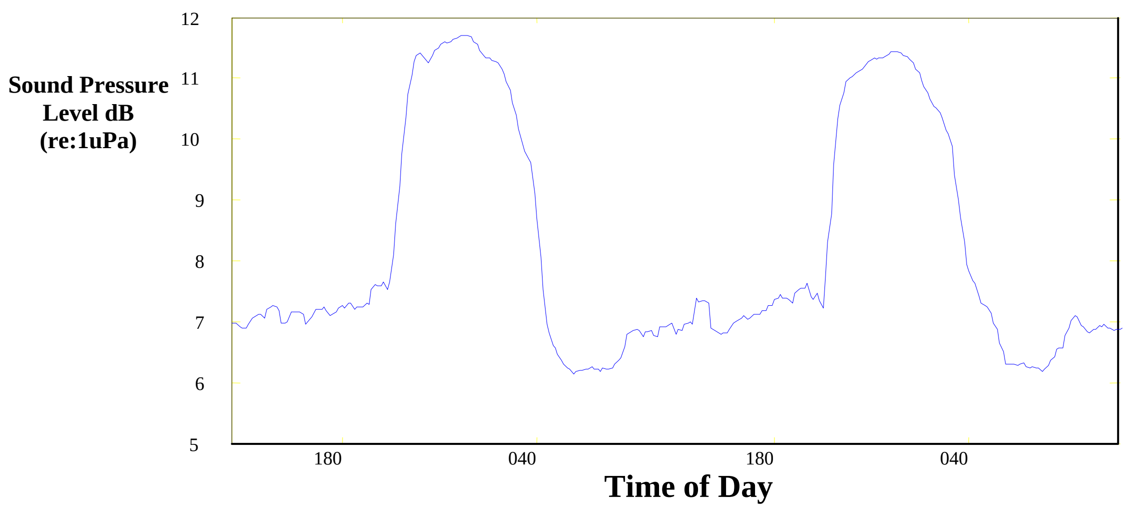

Figure 2. Diel periodicity of sound production by black drum. Sound pressure levels begin to increase near dusk and peak several hours later.

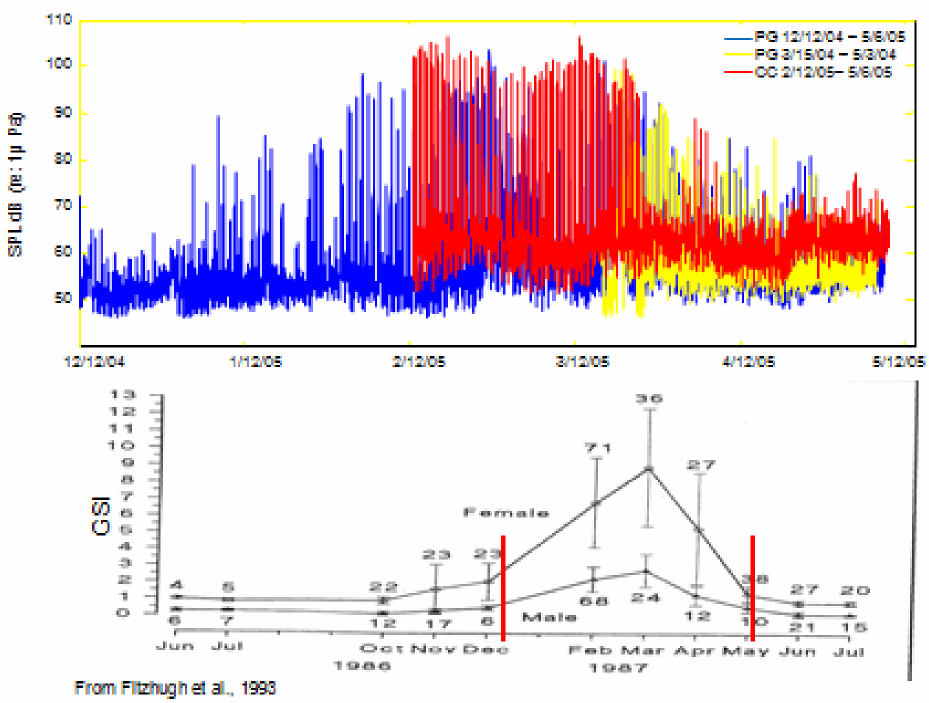

Figure 3. Seasonal patterns of sound production by black drum recorded in Punta Gorda and Cape Coral, Florida (top) showing and the relationship to the gonado-somatic data for this same species (bottom).

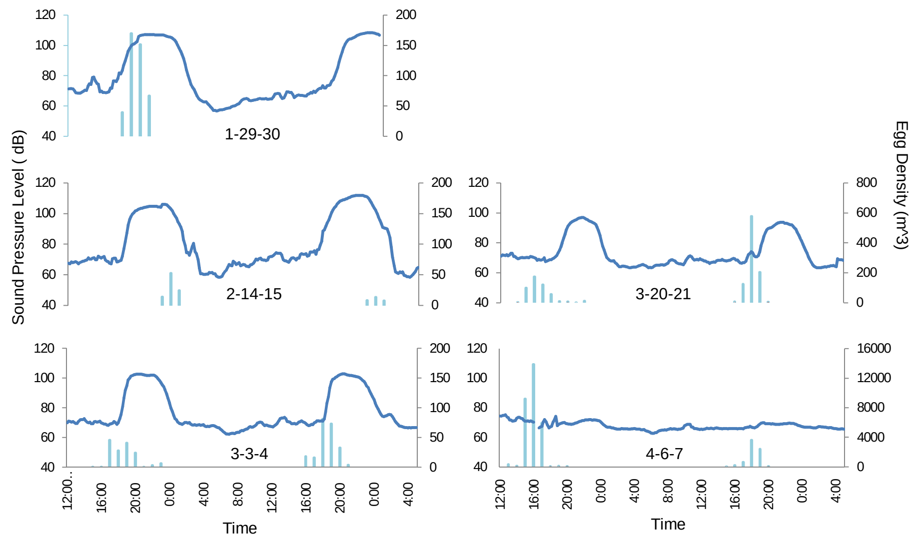

Figure 4. Nightly sound production by black drum (left y-axis) and densities of eggs at back-calculated spawning times (right y-axis).

Table 1. Fitted regression equations used to back-calculate time of spawning for eggs.

Date	Fitted Regression Equation	r^2
1/29/06	time2 = 19.2466 + 0.0542935*c1n1_c2n2_1_29_30^2	0.988
2/14/06	time2 = 23.2608 + 0.0607543*c1n1_c2n2_2_14_15^2	0.984
3/3/06	time2 = 18.2448 + 0.0523041*c1n1_c2n2_3_3_4^2	0.995
3/20/06	time2 = 16.522 + 0.0472593*c1n1_c2n2_3_20_21^2	0.979
4/6/06	time2 = 15.2549 + 0.0499481*c1n1_c2n2_4_6_7^2	0.996

DISCUSSION

These results indicate that patterns in sound production are not useful for predicting patterns in egg production by black drum on a daily scale at this site but do provide accurate characterization of spawning behavior on a seasonal basis. The study area was a small, mostly enclosed basin which allowed us to be reasonably sure that we were sampling eggs of the same population of fish whose sounds were recorded. It was not possible to estimate the total number of fishes in the basin at any time during the study, or the number of females spawning on a given night. Understanding how the relationship of sound production to egg production changes as a function of the number of individuals in the spawning aggregation changes would be useful to determine whether this is a general relationship for black drum.

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