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FIVE-YEAR PERFORMANCE REPORT

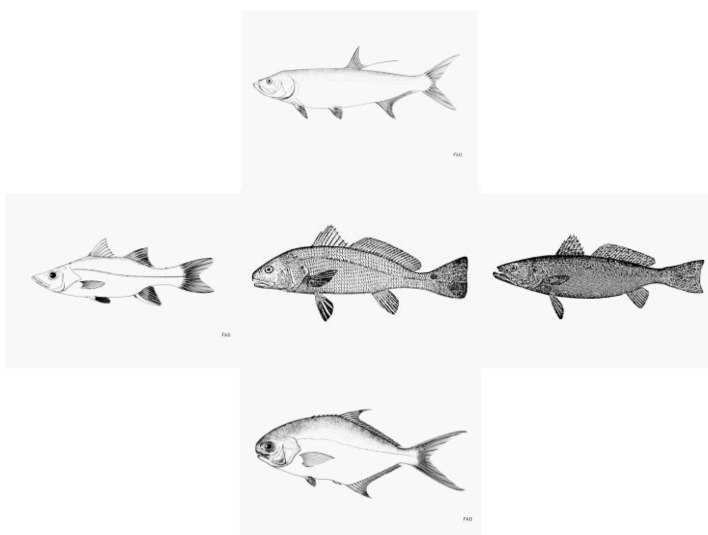
TO THE

U.S. DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE

FROM THE

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
FLORIDA FISH AND WILDLIFE RESEARCH INSTITUTE

INVESTIGATIONS INTO NEARSHORE AND ESTUARINE GAMEFISH BEHAVIOR, ECOLOGY, AND LIFE HISTORY IN FLORIDA



GRANT F-59

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GRANT NUMBER:	**F-59**
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GRANT DATES:	**JULY 1, 2003 THROUGH JUNE 30, 2008**
PRINCIPAL INVESTIGATORS:	**LUIZ R. BARBIERI and JAMES A. COLVOCORESSES**
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Study IX - Spatial and temporal reproductive dynamics of spotted seatrout in Tampa Bay and adjacent waters

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Introduction

Spotted seatrout (*Cynoscion nebulosus*) support one of the largest and most popular inshore sport fisheries along the southeastern US and in Florida. However, in the mid-1980's and 1990's there was concern that they were greatly overfished. Spawning potential ratios (SPRs) for Florida in 1992 were estimated to be between 12-14%, well-below the 20% recommended by the Atlantic States Marine Fisheries Commission's (ASMFC) management plan (Muller 1993) and the 35% goal set by the then Florida Marine Fishery Commission (since merged into the Florida Fish and Wildlife Conservation Commission, or FWC) . Recent management measures apparently have improved the stock's status, with the latest modification to the regulations occurring in July of 2000, and with the total length measure defined in 2006. Current recreational regulations are as follows: FL is broken down into two recreational management regions (the North Region includes state waters on the Gulf coast north and west of a line near the Pinellas/Pasco counties border, and on Florida's east coast north of the Volusia/Flagler counties border; the South Region includes all other state waters) and the bag limit is 4 fish in the South region and 5 fish in the North region; and closed seasons are November and December in the South region and during the month of February for the North region. The most recent estimates of spotted seatrout transitional spawning potential ratios indicate that all regions are above the Commission's management objective of 35% (Murphy *et al.* 2006).

However, the current trend in Florida coastal population growth will impact fish that spawn close to shore both through increased fishing pressure and spawning habitat degradation. Spotted seatrout are an excellent species to monitor to better assess these effects. As outlined in the Sustainable Fisheries Act of 1996, it is critical to identify essential fish habitat which is defined as, ―those waters and substrate necessary for fish for spawning, feeding or growth to maturity." Spotted seatrout have been reported to spawn within estuarine waters (Brown-Peterson *et al.* 1988; Mok and Gilmore 1983; Saucier and Baltz 1992) and primarily in their natal estuary (Holt and Holt 2002). In Texas, estuarine spawning has been reported to occur over grassbeds near shallow (2-m) channels (Brown-Peterson *et al.* 1988), with similar spawning habitat being documented for trout in the Indian River Lagoon (Mok and Gilmore 1983). In South Carolina, Saucier *et al.* (1992) reported estuarine spawning near bulkheads adjacent to the Charleston ship channel and in Georgia estuarine spawning was found near oyster beds and within the intercoastal waterway (Lowerre-Barbieri *et al.* 1999). However, in Louisiana spotted seatrout were found to spawn within the estuary in dredged or natural channels, as well as in passes between the barrier islands (Saucer and Baltz 1993).

Spotted seatrout apparently are capable of spawning within a wide range of environmental parameters. Their normal spawning temperature ranges from roughly 22 to 34^0 C, although spawning activity has been reported in temperatures as low as 19^0 C. Spawning has also been reported over a large salinity range, from 7 to 37 ppt (Brown-Peterson 2002), with optimal salinity ranges apparently related to the hydrographic conditions of a specific area (Holt and Holt 2002). Salinity affects the buoyancy of eggs and a sudden decrease in salinity may reduce spotted seatrout fecundity as well as survival of eggs and larvae (Brown-Peterson 2002).

Hedgecock‘s ―sweepstakes hypothesis” (1994) suggests year classes are produced by only a small fraction of the population, i.e. those fish which spawn within the appropriate spatial and temporal window for larval survival. Recent spatially-explicit reproductive studies appear to uphold this theory. It has now been proposed that recruitment may be affected as much by the spatial distribution of spawning activity as by the spawning biomass of a stock (Begg and Marteinsdottir 2002). In a past study to determine reproductive parameters of spotted seatrout conducted in Tampa Bay from 2000-2002, we found low-intensity spawning activity distributed over a fairly large geographic area (relative to the population distribution) and high-intensity spawning activity at one spatially-discrete ―hot spot” in a pass to the Gulf of Mexico. Given these results, we wanted to evaluate spotted seatrout reproductive activity throughout Tampa Bay and adjacent areas to better understand the spatial distribution of spawning activity and what might be the factors affecting spawning site selection. In addition, the high-intensity spawning site provided an ideal opportunity to study the temporal variability of spawning activity at this site (annual, seasonal and diel). Lastly, it has been suggested that natal homing may drive spawning site selection (Svedang *et al.* 2007). If this is the case, then pass spawners would be expected to demonstrate spawning-site fidelity and act as a separate subpopulation from those fish spawning in the estuary. Telemetry studies have the potential to address these issues (Robichaud and Rose 2003), and we were interested in applying this approach to evaluate site fidelity and individual spawning frequencies.

Methods

Passive acoustic survey

A total of six zones (upper, middle and lower Tampa Bay, Hillsborough Bay, passes and nearshore) were sampled in the Tampa Bay area from 2003 through 2005. Preliminary sampling was conducted from July through September 2003. Sampling in 2004 and 2005 was conducted from April through the first week of October, but only data through mid-September was included in our analysis as this is the end of the spawning season. In all three years the upper, middle and lower bay zones were sampled. In 2004 we also sampled Hillsborough Bay. In addition, passes along the west Florida coast from Clearwater to Sarasota were sampled: John‘s Pass, Blind Pass, Passagrille Pass, Bunces Pass (group 1); channels near Egmont Key, Southwest Pass, Passage Key Inlet, Longboat Key Pass (group 2); and New Pass and Big Sarasota Pass (group 3). In 2005, a nearshore zone was also sampled.

Zones were chosen based on geographic and logistical criteria. Zones within Tampa Bay, except Hillsborough Bay, were subdivided into eastern and western regions. Hillsborough Bay and the nearshore area were considered both zones and regions. Each region was subdivided into sampling units composed of 1-nautical mile square grids. At least 5% of each grid had to contain water deeper than 1.5 m to be included in the sampling design (n= 324). Grids were categorized as either ―open-water” or ―shoreline.” A shoreline grid had more than 5% of its area composed of either land or water that is adjacent to land with a depth less than 1.5 m. An open-water grid had 95% or more of its area covered by water deeper than 1.5 m that was not adjacent to land. This designation was necessary because regions varied in their number of shoreline and open-water grids and spotted seatrout are reported to spawn in shoreline areas. In order to compare regions, shoreline and open-water grids were sampled proportionally to the number present in each region. Passes were divided into groups, based on proximity and the ability to sample them within a given night. A minimum of six locations per pass were sampled in order to accurately reflect the associated sound profiles. Targeted locations within each pass included: the mouth of the pass, the middle of the pass, anywhere the pass split into different channels, as well as any structure (typically bridges) close to the pass. Hydrophone observations, recordings, and environmental data were taken as described below for other sites. The number of grids sampled per night was proportional to the size of the region. To ensure representative sampling of the grids, four stations were sampled per grid and station locations were distributed as evenly as possible over available bottom types.

Once at a sampling station within a grid, the boat‘s engine was turned off, position (GPS) and depth measurements were recorded, and a mobile hydrophone (HTI model 96, minimum sensitivity of

64dBV/µPa) was lowered one meter into the water. Recordings were begun after a two-minute period in the event the spotted seatrout calling ceased because of engine noise disturbance (Lowerre-Barbieri *et al.* 1999). During the two-minute waiting period, a YSI Model 600 QS was used to record middepth temperature (ºC), salinity (ppt), and dissolved oxygen (mg/L). Middepth measurements were taken because Tampa Bay is a well-mixed estuary with little difference in bottom and surface temperature and salinity (Goodwin 1989). At each station, time of day and bottom type were also noted and recorded. If sciaenid courtship calls were heard, then a recording was made.

Male spotted seatrout produce distinct courtship calls. Their calls can be distinguished from those of other soniferous fishes based on pulse duration, repetition rate, and dominant frequency range. The estimated number of spotted seatrout producing sound was categorized as (1) 1-2 individuals, (2) 3-5 individuals, (3) small aggregation (individuals still distinguishable, approximately up to 10-15), or (4) large aggregation (individuals not distinguishable), with the latter category used as the proxy for spawning as it is the most conservative estimate. Distance to the fish was subjectively categorized as “directly on top of,” “close-by,” or “in the distance” based on loudness.

Acoustic monitoring of a known spawning site

The pass spawning site has been acoustically monitored from 2004 through 2008. This pass has a relatively deep channel (maximum depth 8.5 m) bordered by sandbars that extend out in to the gulf approximately 1000 m on the north and south that are partially exposed at the greatest low tides. Currents within the pass reach speeds of 1m/s (1.9 kts/hr) during the strongest spring tides. Previous research indicated that spotted seatrout occur at this site almost exclusively to spawn, with virtually all females collected at this site having histological indicators of active or imminent spawning (97%, n=170). Acoustic dataloggers have been deployed at the pass, anchored approximately 0.5 m from the bottom. These dataloggers are programmed to record 10 seconds of the ambient sound every ten minutes.

Biotelemetry of fish at a known spawning site

Biotelemetry is commonly used to study fish behavior and physiological condition in natural systems as well as to monitor large-scale movements of individuals (Nielsen 1992) and has been used to determine movement patterns associated with spawning (e.g., Robichaud and Rose 2002). In this study we used telemetry to monitor movement patterns at the pass spawning site. Specifically, we wanted to test the following hypotheses: (1) do spotted seatrout exhibit fidelity to this spawning site; (2) does spawning frequency differ due to sex or size of the fish; and (3) are fish spawning at this site are drawn from the estuary and return to the estuary.

Before conducting this study, we needed to assess if the tag or method of tag attachment affected either the health of the fish or its ability to spawn. To assess these issues and to develop our surgical procedures for implantation, we conducted an in-captivity study in 2000 at the Fish and Wildlife Conservation Commission Stock Enhancement Research Facility. A total of 60 spotted seatrout (1:1 sex ratio; 250-350 mm TL) were held in two indoor circular (15,912L, 2m deep, 9.14m diameter) re-circulating tanks. One tank was dedicated to an implant group and the other to a control group due to the possibility that handling stress would preclude spawning. The implant group underwent surgery on 24 April 2000. Half the fish were culled after two months and the remaining fish after four months. To create spawning conditions, we used a modified photo-thermal schedule (Arnold *et al.* 1978).

Our in-captivity surgical protocol was as follows. Fish were individually captured and immediately anesthetized with clove oil (40mg/l). After a fish lost equilibrium (average time: 1 m 34 s) it was measured for total length (TL, ±1 mm), weighed (TW, ±0.1g) and placed on a surgery cradle. Fish were tagged with an external PDS dart tag (Hallprint) on the dorsal side just posterior to the second dorsal spine and then placed on their dorsums and the gills were intermittently flushed during surgery with oxygenated saltwater. Dummy tags manufactured by Vemco Ltd. to represent their V-8 series (8 mm diameter x 26 mm length, 4.5 – 5.0g weight in air) were implanted. Prior to making an incision the ventral side was rinsed with deionized water and cleaned with a sterile gauze pad. All surgical utensils and dummy tags were sterilized in 1% benzalkonium chloride and rinsed with deionized water. The incisions were made just off the midventral line with a curved scalpel, on average, 19.3 mm (mean) from the base of pelvic fins. Average incision length was 12.6 mm. Retractors were used to open the incision and pull the skin up to insert the dummy tag. The tag was placed directly below the incision to help keep sutures from piercing the intestinal viscera. The incision was closed with three single interrupted pattern coated vicryl absorbable sutures (4-0, P-S2 cutting edge, Ethicon). Coated vicryl was chosen because of its durability, knot strength, and reasonable absorption time (60-90 d). Recovery times were defined as the time between being returned to the tank and when the fish had righted itself.

Spotted seatrout appeared more negatively impacted by capture and handling stress than surgical implantation. Fish became agitated as we tried to capture them, swimming into the side of the tank, breaking dorsal spines and losing large numbers of scales. Although average surgery time was relatively fast (4 m 34 s), and fish quickly regained equilibrium after surgery (mean =57 s), most implanted fish showed signs of stress. They appeared mottled and remained on the bottom of the tank near ―structure" (the corrals) in the early stages of recovery. Five fish had problems regulating their buoyancy during the recovery period and had not regained it by the time observations had ended (up to three hours post surgery). These fish tended to be smaller (mean TL=283 mm, range: 255-315 mm) than those without buoyancy problems (mean TL =312, range: 272-348 mm). Increased mortality associated with the implanted fish (27%) compared to the control group (0%) appeared due to handling/capture stress. Two fish died after jumping out of the tank and another four fish died within four days of the first culling. Of these six fish, five of them were observed on the day of implantation to be extremely stressed and/or beaten up during the capture process.

Tag retention of implanted dummy tags (100%) was better than that of dart tags (79%). Most fish (90%) which retained their dart tags had a red, irritated area at the base of the dart tag. Vicryl sutures held well, but caused inflammation at the suture sites, and had slower than expected absorption times (125 d).

The surgical procedure used in our 2005 field study was modified from that of the in-captivity study in the following ways: (1) Aqui-S was chosen over clove oil as an anesthetic (1.7 ml per 15 gallons water); (2) incisions were made on the midventral line to prevent cutting into male sonic muscles or developed ovaries; (3) a metal spatula was inserted into the incision and under the body wall to limit needle depth, ensuring body organs were not sewn into the stitches; and (4) use of the retractor was stopped because it sometimes tore the flesh.

In May of 2005, 32 spotted seatrout (13M:19F, 335-583 mm TL) were captured and implanted. Capture methods were designed to reduce stress. Fish were caught in a 400' x 8' knotless center bag haul seine with ¼" delta mesh, with a center bag measuring 8'x 8' x 8', which was immediately retrieved after deployment. The bag was kept in the water while by-catch were removed. Spotted seatrout were dipped out of the bag in a plastic sling. The sling had one closed end and PVC handles, allowing fish to swim into it and be contained in water while transferred to the aerated livewell of a mullet skiff. Each individual selected for surgery was removed from the live well by allowing it to swim into the sling and then transferring it to a 50 gallon cooler filled with the Aqui-S solution. Fish were implanted with Vemco V8sc-2L tags (139 dB output). These tags had a 190 d battery life and a 15-45 s random interpulse delay. They weighed 4.7 g in air and 2.8 g in water. Post-implantation, fish were again placed in the livewell. The time taken for the fish to regain equilibrium was recorded, as was time of release. All fish were kept for a minimum of 15 min. post-surgery.

The configuration of our receiver array was developed based on a defined area of coverage and the minimum range providing consistent reception at this site (70 m). This was critical as both relocation and lack of relocation data were used to test our hypotheses. The area of reception coverage was defined to correspond with the expected location of spawning, based on male aggregation sound production and the results of our previous capture-based study (Fig. 1). Using Arc View and an aerial photograph, receivers with 70 m range bubbles were arranged in a manner to cover the entire predetermined sampling site, ensuring that if an implanted fish occurred within the sampling area it would be within range of at least one receiver. The GPS coordinates of the hypothetical receivers were exported from ArcView and receivers were moored at the sampling site in the same manner as the initial test. A total of 14 Vemco VR-2 receivers were used to cover the study site. An additional estuarine gate was placed ≈ 400 m east of the study site and another receiver was placed ≈ 200 m west of the site. These receivers were used to estimate pathways fish could take to get to the spawning site (Fig. 1). Due to damage from a boater, there was not a working receiver at position #10 from 13 June through 12 July 2005.

Results and Discussion

Passive acoustic survey

The percentage of sites with large aggregation sound differed significantly by region (binomial regression, n=1,848, P =0.0069), grid type (P < 0.0001) and year (P=0.0103). Large aggregation sound was heard in all six regions that were sampled in all three years (regions E and F in the lower bay, regions C and D in the middle bay, and regions A and B in Old Tampa Bay; Figs. 2-4). However, the proportion of sample sites with large aggregation sound differed by region. The regions with the greatest percentage of sites with large aggregation sound were regions D, E, and F (ranging from 7-8% of sampled sites). But given reports that the majority of spawning occurs in the mid- to lower-Bay, the proportion of large aggregation sites in Old Tampa Bay was surprisingly high with 4% in A and 6% in B. The region with the lowest percentage of sample sites with large aggregations was region C, just off the city of St. Petersburg. Although region G (Hillsborough Bay) was only sampled in 2004, it had no large aggregation sites and is similarly close to a large metropolitan area, Tampa.

The percentage of spawning sites differed by proximity to shore and by year. Most large aggregation sites (89%) occurred in shoreline grids and the average depth associated with large aggregations sites was 3.1 m (range: 1.6 to 18.0 m; n=104). Only seven large aggregation sites were located in water depths greater than 6 m, indicating predominantly shallow water spawning sites as has been previously reported. The percentage of sampling sites with large aggregations was 7% (n=794) in 2004 and 4% in both 2003 (n=274) and 2005 (n=780). In 2003, only the second half of the spawning season was sampled. Potentially, not all spawning sites are used throughout the extended spawning season and this could have impacted the number observed. In 2005, sampling was conducted throughout the spawning season but spawning was severely impacted by a prolonged and intense red tide event. Red tide cell counts exceeding 100,000 c/L are considered lethal to fishes. Cell counts at this level were first detected within Tampa Bay on June 7 at one site. By June 28th cell counts at this level occurred consistently in the lower and middle bay and there were many reports of fish kills. Because the red tide organism, *Karenia brevis* cannot survive in salinities lower than 24 ppt, the Old Tampa Bay area (regions A and B) acted as refugia and this was the only area where spawning sites were located during the month of July 2005 (Fig. 5).

Although most of the passes throughout the Tampa Bay area were sampled in 2004, no other pass site had the intensity of the acoustic signal observed at our study site. There was only one other pass where a large aggregation was heard, and that was heard only on one date in comparison to the pass spawning site, where the acoustic signal was stronger and continued throughout the spawning season.

For a detailed analysis of the 2004 passive acoustic survey and environmental parameters associated with spawning sites see Waters *et al.* (2007) and Walters *et al.* (2009) (Appendix 1). Analysis of this data is on-going and will include using techniques from landscape ecology to better assess potential environmental drivers and anthropogenic affects on spotted seatrout spawning site selection.

Acoustic monitoring of a known spawning site

Acoustic monitoring of the pass spawning site began in 2004 and indicated that it was possible to monitor both the seasonal and diel periodicity of sound production as a proxy for spawning activity (Fig. 6). Assessing the beginning of the spawning season was difficult in 2004 due to equipment failure and patchy sound production. The first large aggregation sound was detected on March 7th for 2.7 h. Large aggregation sound was not heard again until a five-day period starting on March 18th, but average duration of sound over these dates was only 1.7 h. Periods of large aggregation sound were again detected in mid-April and the beginning of May but consistent, nightly large aggregation sound with a duration > 1 h/night did not begin until May 19th. Large aggregation sound occurred nightly after this date through mid-September. Aggregation level sound routinely began before or at sunset and was never detected during the day. Duration of aggregation sound on any given night was highly variable ranging from 0.2 to 12.3 h, with an average of 5.4 h per night during the period from 1 April through 12 September (n=98, some dates are not included due to equipment failure). Duration of aggregation level sound increased with both full and new moon lunar phases.

In 2005 no large aggregation sound was heard after 12 July, suggesting that the 2005 red tide greatly impacted spawning activity at this site. In 2005, large aggregation sound was first recorded on March 26th. As in 2004, there were several periods of large aggregation sound, interspersed with periods of a week or greater without large aggregation sound (Fig. 6). The gaps in sound production became smaller as the season progressed and relatively consistent large aggregation sound began on May 20th and continued thru June with only occasional gaps of 1-2 days. From 29 June throughout the rest of the spawning season, large aggregation sound was heard only on 10 July and 12 July for 2 h and 0.83 h, respectively. During the period of relatively consistent sound production in 2005 (1 April through 28 June), the average duration of large aggregation sound was 1.6 h (n=89) compared to 4.1 h in 2004 over the same time period (n=57). Maximum duration of large aggregation sound was 6.5 h, also lower than that observed in 2004, 8.8 h. This suggests that red tide may have affected the number of fish spawning at this site prior to the cessation of sound observed at the end of June. In 2005, from 1 April to 12 September, the average duration of large aggregation sound was 0.88 h (n=164), roughly 1/6 of that observed in 2004.

Although sound production in 2006 occurred throughout the spawning season, it was less than in 2004, indicating that spawning had not recovered to pre-red tide levels (Fig. 7). Large aggregation sound was first detected on 10 April 2006 and was fairly consistent starting on 15 April, with occasional one to two day gaps. However during the period of 1 April through 12 September, average duration of large aggregation sound was only 3.7 h (n=165) compared to the 5.4 average seen in 2004. In addition, maximum duration was 8.5 h and the peaks in duration seen in August of 2004 were not realized in August of 2006. Data from 2007 is still being analyzed and recordings from 2008 are being reviewed for sound level. Analysis of this dataset is on going, as is work on a manuscript to be published in a peer-reviewed journal.

Biotelemetry of fish at a known spawning site

Implanted fish showed site fidelity to the spawning site and adjacent areas. Thirty of thirty-one fish were relocated (based on data from all VR2s, including the estuarine gate and the additional receiver in the channel) over the period of 10 May through 12 July (Fig. 8). The number of fish relocated on any given date varied from 1 to 17 and increased numbers of fish were relocated on dates associated or close to the time of the full moon. Most fish returned to the site over multiple dates, ranging from 1 to 49 times.

Fish were not resident at the spawning site. Although some fish were detected within the spawning site array (all VR2s except those at the estuarine gate, #s 17 & 18) within all hourly increments of the 24 h day (Table 1), individual fish were never relocated over the entire time period on any given date. Instead, most fish moved into the array from the estuary in the afternoon, moved down towards the point, often had a gap in reception, and then were relocated moving back towards the estuary and out of the spawning site by midnight. This general pattern was seen for both males and females. However, timing and location differed both by individual and by date for the same individual. As an example, 10 fish were relocated in the spawning site on 22 May 2005. On average, they were first detected at 15:03 h, but the initiation of individual spawning runs varied (range: 12:47 to 17:49 h). Most fish were detected as far west as receiver number 4 (range: 1 to 6). Eight of these fish had a gap in reception, which averaged approximately 4 h (range 2 to 9 h). Most fish were heard last at site 6 before the gap and picked up again at site 6 after the gap, suggesting fish may move out of the monitored site and into the shallow swash around the Gulf side of the key to spawn. Nine of the fish had returned to the estuary and were last heard in the spawning site before midnight (range: 20:26 to 23:24 h). However, one fish did not leave the spawning site until 4:46 h. This general movement pattern was considered indicative of a spawning run, and on this date average duration of spawning runs was 7:35 h and ranged from 4:49 to 15:09 h.

Although no fish were relocated after 12 July, apparently due to red tide, a total of 236 runs were identified between 10 May and 11 July for 26 of the implanted fish. Six fish never demonstrated spawning run behavior, although they were relocated at the estuarine gate and occasionally on the edge of the spawning site array. Males averaged 15.3 runs (n=13) compared to only 2.0 runs for females (n=19). Larger fish did not demonstrate a greater number of spawning runs.

Analysis of this dataset is on-going, as is work on a manuscript to be published in a peer-reviewed journal.

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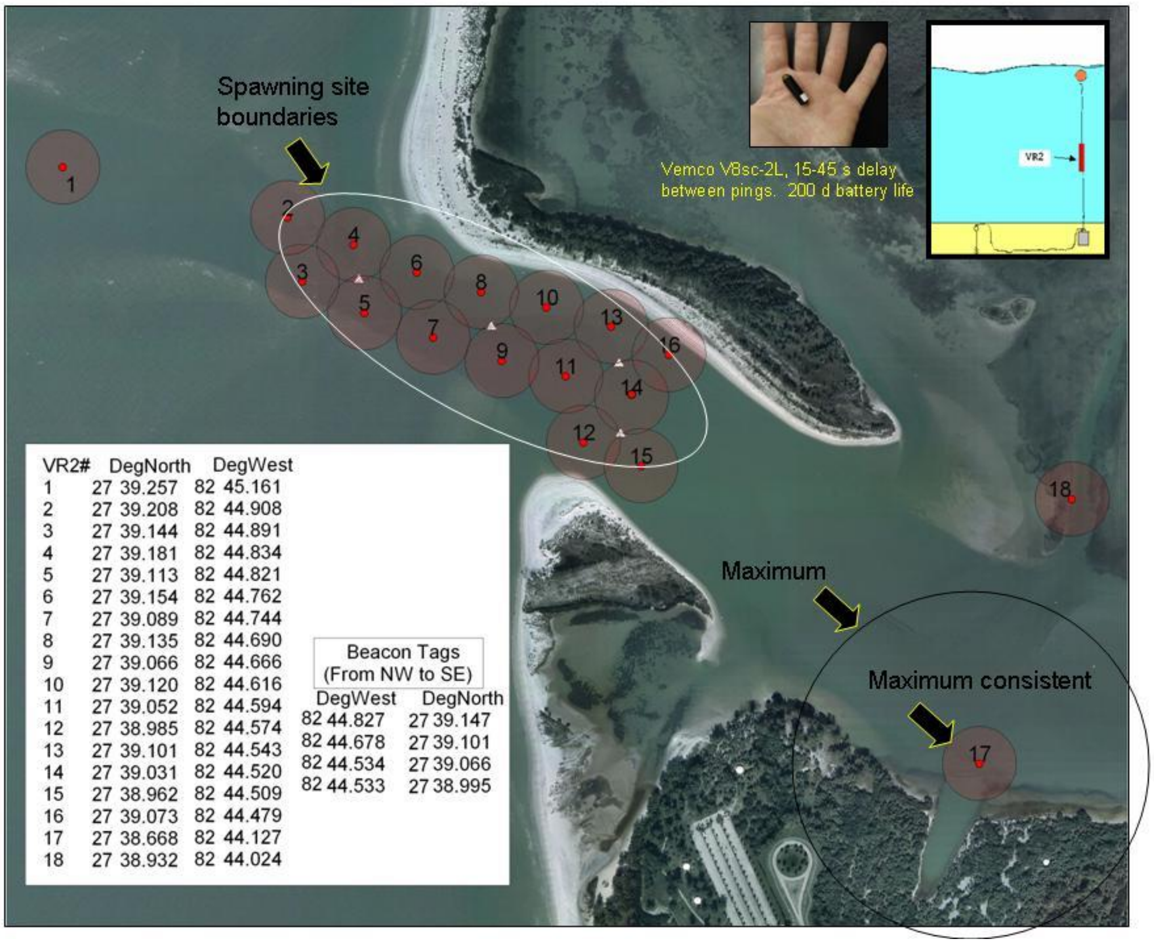

Figure 1. The spatial configuration of our telemetry array at the pass spawning site. The white oval indicates the assumed boundaries of the spawning site. Each red dot represents an acoustic receiver (Vemco VR2) site, which was numbered to more easily evaluate relocation data. Each receiver is surrounded by a 70 m minimum range bubble although maximum range could be as great as 200 m.

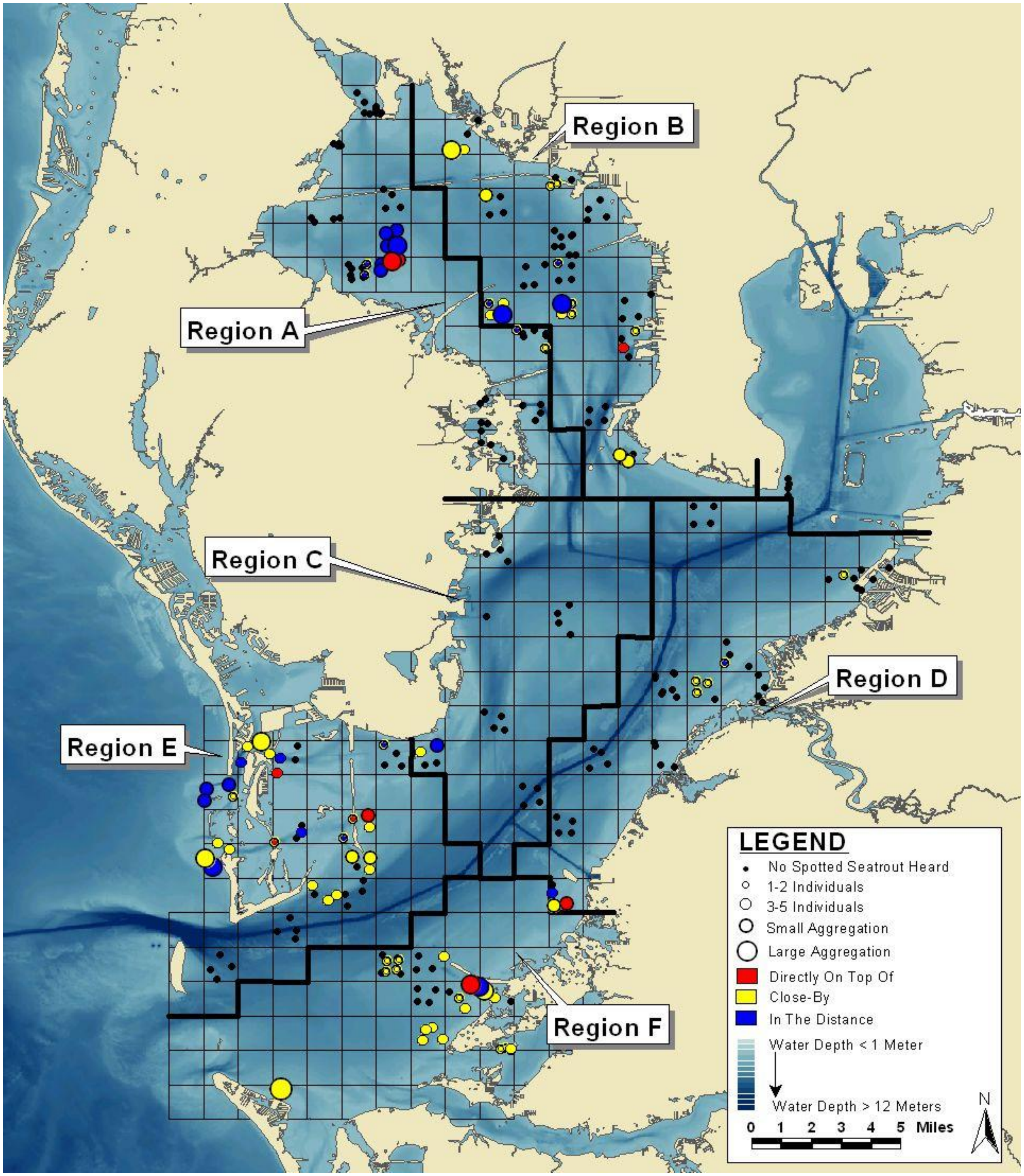

Figure 2. Passive acoustic survey results for 2003.

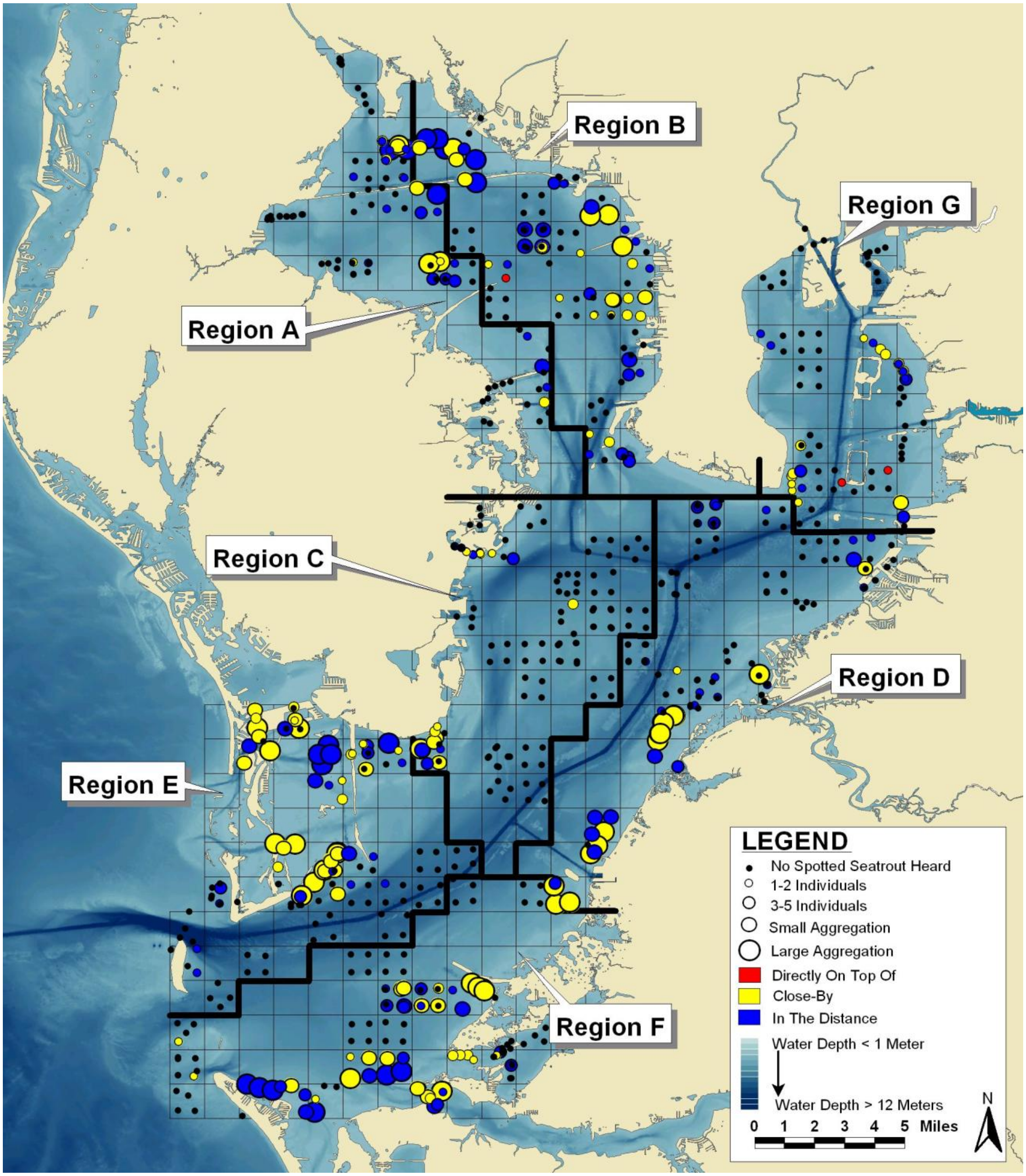

Figure 3. Passive acoustic survey results for 2004

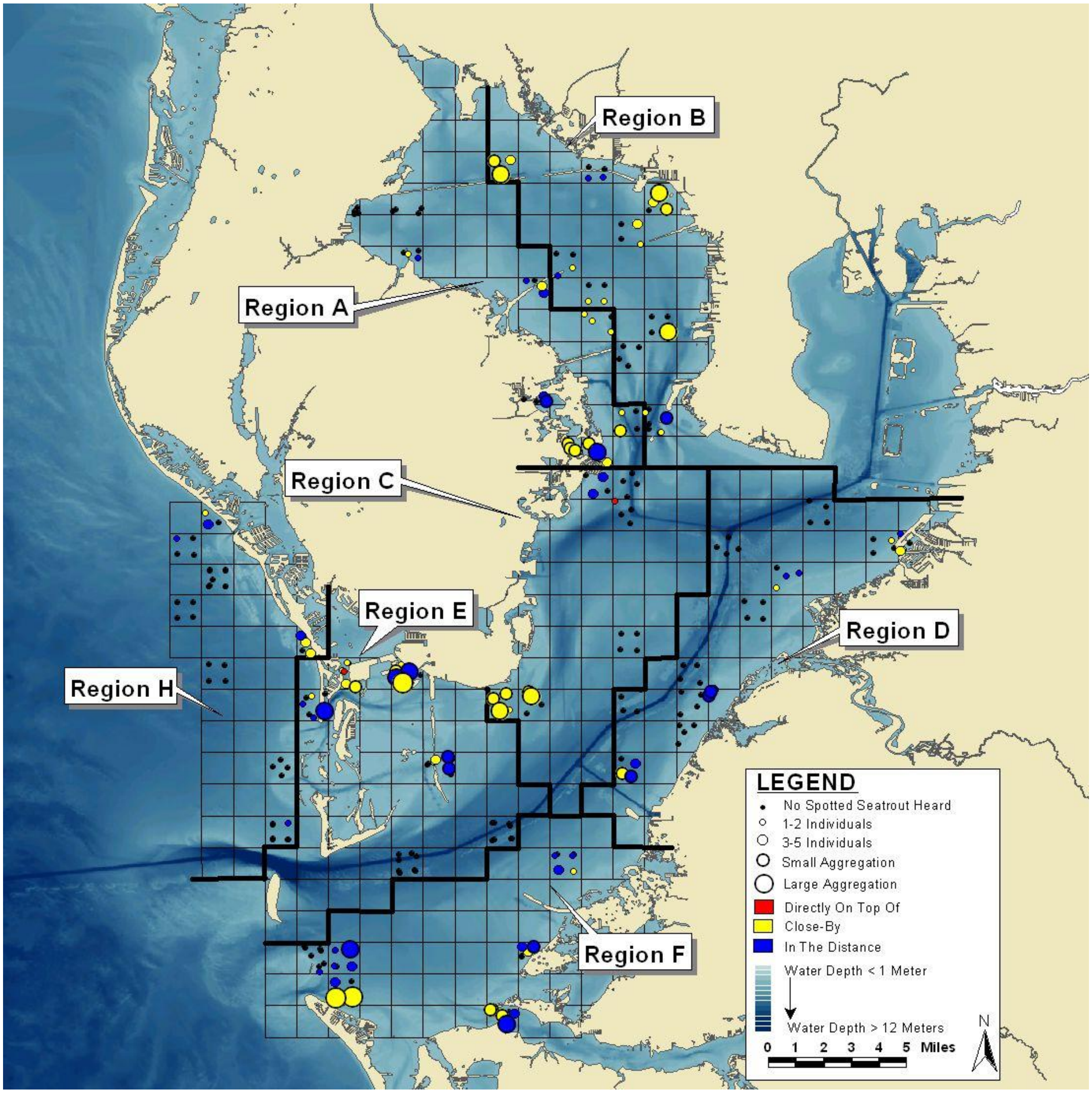

Figure 4. Passive acoustic survey results for 2005 prior to red tide (May through June)

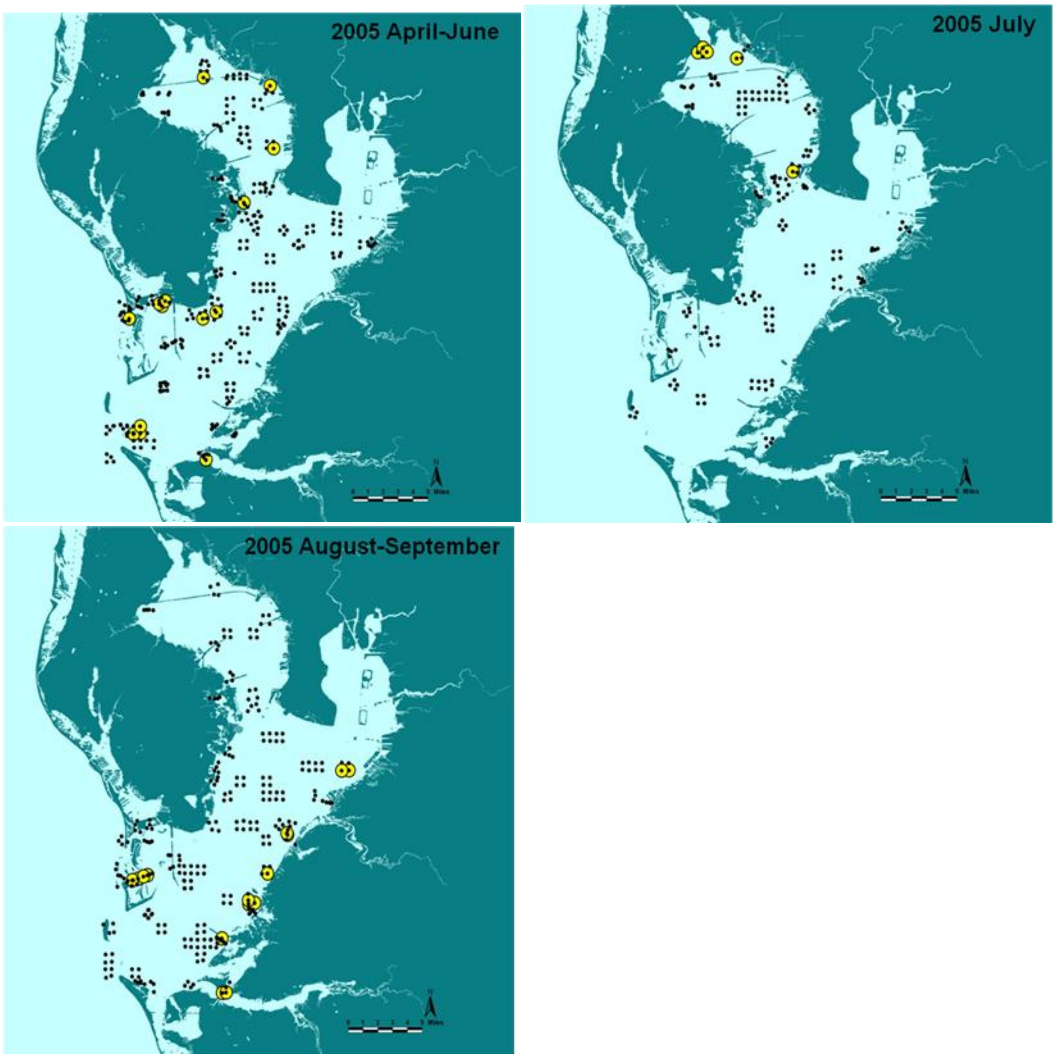

Figure 5. Spatial distribution of spotted seatrout spawning sites in 2005 associated with different intensities of the red tide bloom. Yellow dots indicate large aggregation sites. Black dots indicate sampled sites. Top left panel is data collected prior to major affects of red tide (May-June), top right panel is data from the most intense portion of the bloom (July) and the bottom left panel shows spawning sites after the bloom had weakened (August-September).

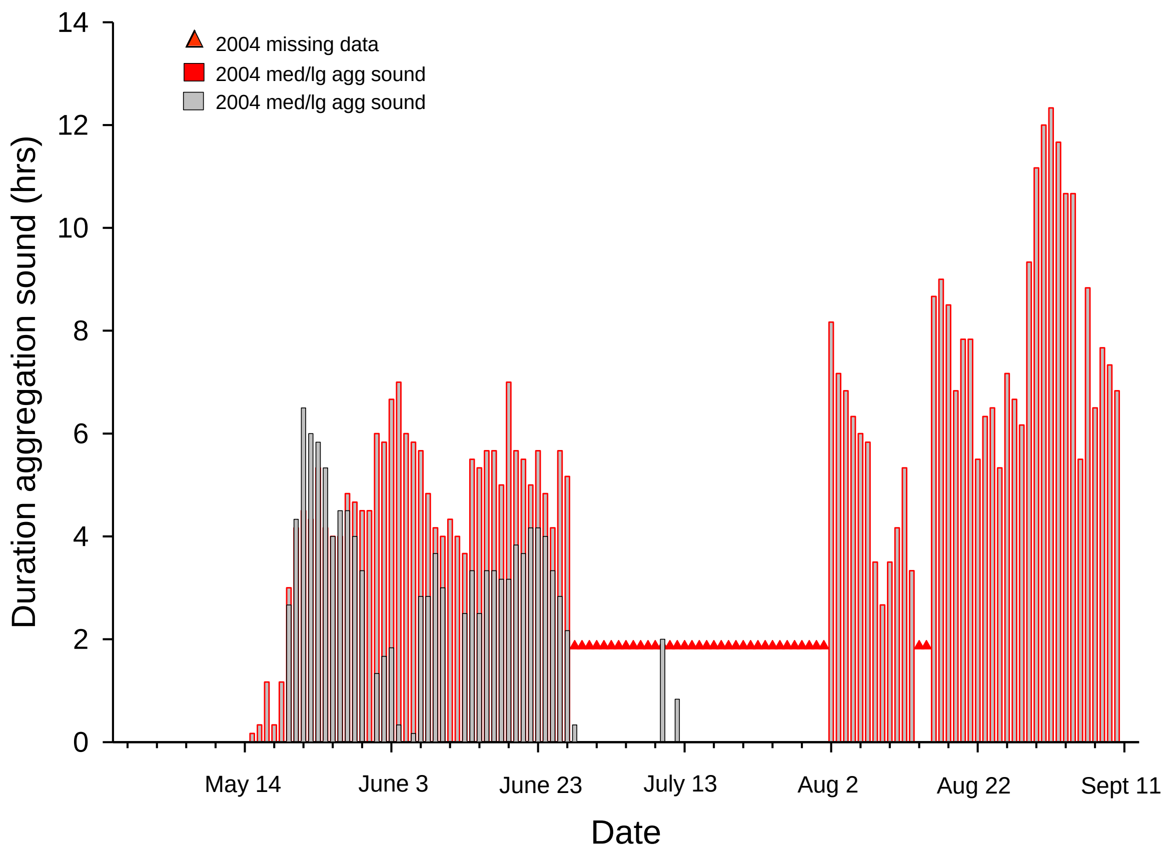

Figure 6. Daily duration of large aggregation level sound at the pass spawning site in 2004 (red) versus 2005 (gray). Data for some dates in 2004 is missing due to equipment failure. In 2005, spawning at this site was severely impacted by an intense and prolonged red tide bloom which entered the lower bay in late June.

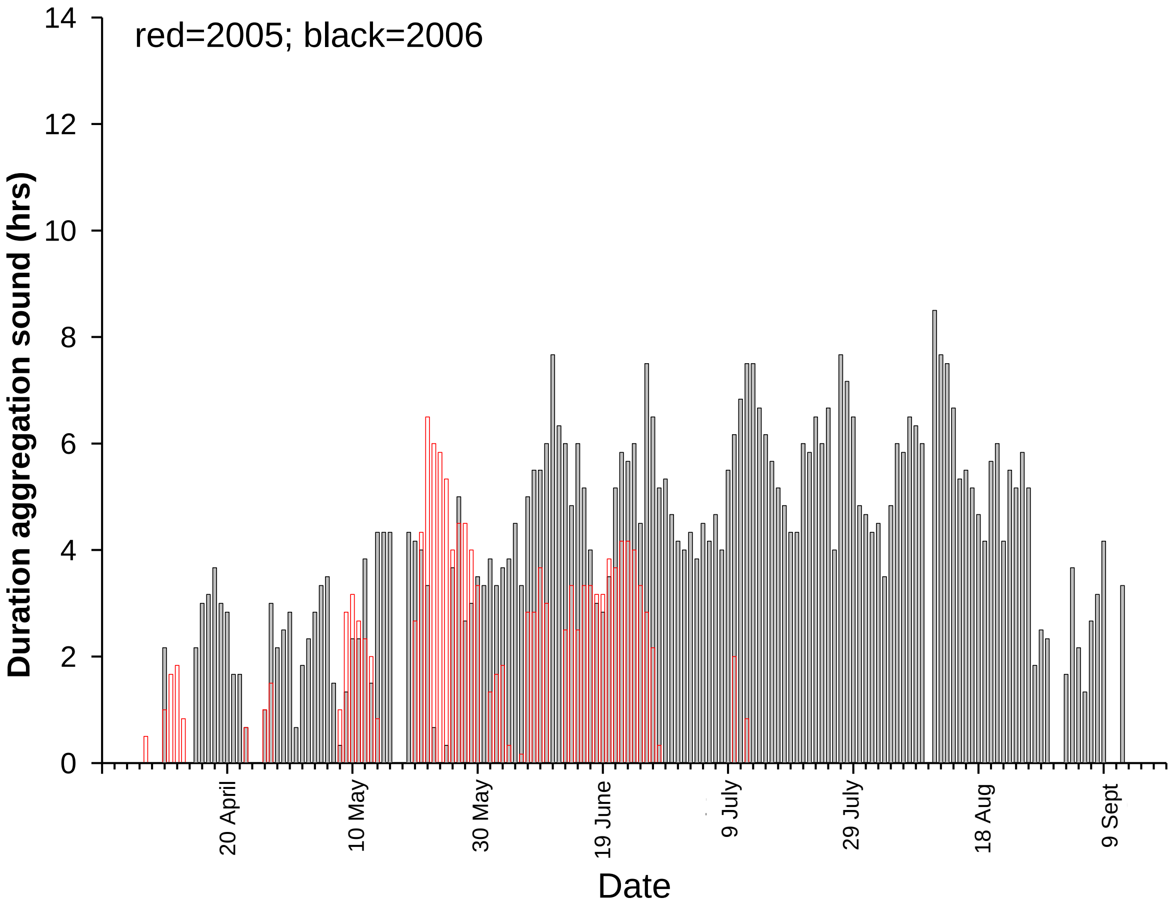

Figure 7. Daily duration of large aggregation level sound at the pass spawning site in 2005 (red) and 2006 (grey). In 2005, spawning at this site was severely impacted by an intense and prolonged red tide bloom.

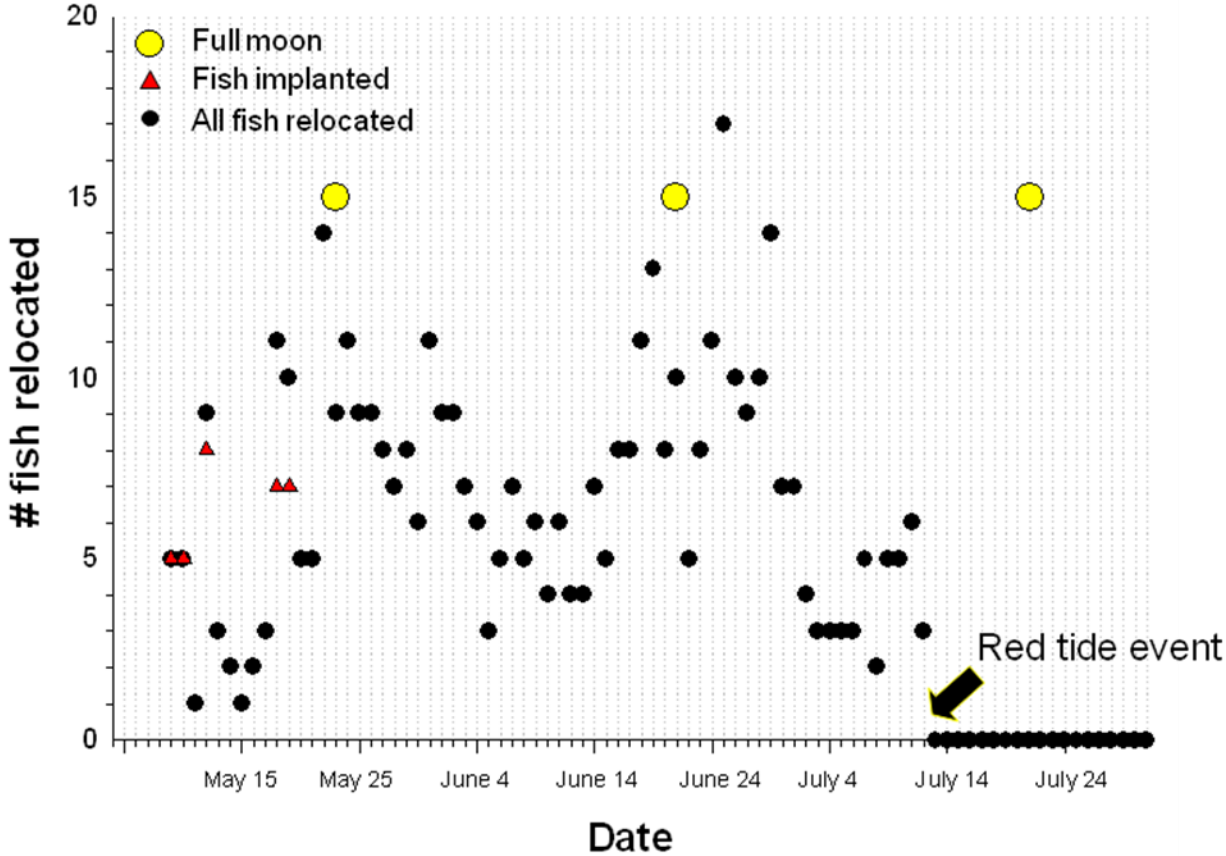

Figure 8. Number of implanted fish relocated by date on all VR2s. Red triangles indicate fish that were implanted on that date. Yellow circles represent the date of the full moon.

Table 1. Relocations of all fish at VR2s other than the estuarine gate (numbers 17 and 18) by hour.

Hour	**Percentage of relocations**
0	3.8
1	2.7
2	2.8
3	3.5
4	3.7
5	2.0
6	0.4
7	0.7
8	0.9
9	0.6
10	0.6
11	1.3
12	2.4
13	4.7
14	4.5
15	4.0
16	4.8
17	5.4
18	8.8
19	8.9
20	7.6
21	10.2
22	9.3
23	6.5

Appendix 1. Walters *et al.* grant publications.

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Preliminary results on seasonal and diel periodicities of a resident *Cynoscion nebulosus* spawning aggregation in Tampa Bay, Florida

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ABSTRACT

Diel and seasonal periodicities of a resident Tampa Bay spotted seatrout (*Cynoscion nebulosus)* spawning aggregation were determined using passive acoustics during the 2004 spawning season. This was possible because spotted seatrout males make courtship sounds or calls associated with spawning. Data were collected by two long-term acoustic recording systems (LARS) between February and early October 2004. The LARS recorded ten continuous seconds of sound every ten minutes. Sounds were categorized based on the estimated number of fish calling: 0, 1-2 males, 3-5 males, small aggregation, and large aggregation. Sounds from large aggregations were first recorded in mid-March and were detected daily from mid-May to mid-September (except during July, when the LARS was not functioning). Spotted seatrout typically begin spawning in mid to late March or early April in Tampa Bay, but the LARS data indicated that large aggregation sound did not occur daily until the month of May. Daily large-aggregation sounds ceased in mid-September, which is when previous studies have reported that the spawning season ends. Duration of aggregation sounds during the prime spawning season varied daily and seasonally, with peaks in sound coinciding with new and full lunar phases. Longer durations of aggregation sounds were recorded daily during the second half of the prime spawning season (August-September) than during the first half (May-June).

Appendix 1. (cont.)

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Using a Passive Acoustic Survey to Identify Spotted Seatrout Spawning Sites and Associated Habitat in Tampa Bay, Florida

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Abstract.—The spatial distribution of spawning activity can affect the reproductive success of certain fishes, and locating the key areas is critical to accurately assessing and managing their populations. We determined estuarine spawning locations for spotted seatrout Cynoscion nebulosus during the 2004 summer spawning season in Tampa Bay, Florida, using a passive acoustic survey. Sound production was evaluated at each of 754 randomly selected stations for the number of individuals calling and ranged from 1–2 individuals to large aggregations. Spawning was identified by large aggregation sounds and was detected at 8% of the selected stations. There was seasonal variability in spawning, as spawning areas were inconsistently used throughout the season. Spatially, spawning occurred in all regions of the bay except for the Hillsborough Bay region, most spawning taking place in lower Tampa Bay and the eastern portion of the middle bay. Spawning occurred most frequently near the shoreline in areas of relatively high dissolved oxygen and in association with submerged aquatic vegetation. The variability in spawning habitat, as exhibited by both the disproportionate distribution of spawning sites across Tampa Bay and the inconsistent use of spawning sites, may serve to increase the resilience of the stock. As management directives evolve to encompass habitatfocused strategies, surveys such as this one can supply data necessary for the creation of meaningful ecosystem-based management plans.