Seasonal Abundance, Age Structure, Gonadosomatic Index, and Gonad Histology of Yellow Bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana

A Thesis

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Cynthia Nichole Fox
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CERTIFICATE

This is to certify that the thesis entitled "Seasonal Abundance, Age Structure, Gonadosomatic Index, and Gonad Histology of Yellow Bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana" submitted for the award of Master of Science to Nicholls State University is a record of authentic, original research conducted by Miss Cynthia Nichole Fox under our supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles.

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ABSTRACT

The Barataria Estuary is composed of interconnected lakes, bayous, canals, cypress-tupelo swamps, hardwood forests and freshwater, intermediate, brackish and salt marsh. The main riverine conduit source of the upper reaches of the estuary is Bayou Chevreuil, which drains much of the area into Lac des Allemands. Historically, the upper Barataria Estuary (UBE) received an annual flood pulse from the Mississippi River until the construction of flood protection levees. Since levee construction, water level in the upper estuary is a function of precipitation. The lack of a natural annual flood pulse has altered the hydrology of the upper Barataria Estuary.

The yellow bass *Morone mississippiensis* is a common, yet lesser known species of the Mississippi River drainage basin. Yellow bass abundance in the upper Barataria Estuary follows a seasonal migration pattern. The purpose of this study was to gather basic life history data to better understand the ecological niche of yellow bass in the Barataria Estuary, Louisiana. The goal of this study was to assess a yellow bass population in the upper estuary by examining relative seasonal abundance, age, gonadosomatic index (GSI), and gonad histology.

To quantify seasonal abundance, yellow bass were collected weekly to biweekly from six sites in Lac des Allemands and Bayou Chevreuil using gill nets from 14 November 2008 to 17 November 2009. Catch per unit effort (CPUE) was calculated for each site for each date as a measure of relative abundance. Mean CPUE values for each sample date were used to describe the relative abundance of yellow bass in the upper Barataria Estuary. Dissolved oxygen

(mg/L), salinity (ppt), temperature (°C), and specific conductance (μS) were measured at each site and water level (m) and photoperiod (hrs) data were obtained from USGS and US Naval Observatory, respectively, to determine if environmental variables affected yellow bass abundance. CPUE was highest from February-April, indicating yellow bass use the UBE seasonally. Yellow bass abundance peaked as temperature reached approximately 18-22°C. Hypoxic conditions (DO < 2.0 mg/L) were not recorded during this study; therefore it is unknown how yellow bass abundance would be affected by low oxygen levels.

Total length (TL; mm), weight (WT; g), and GSI were measured for all fish collected (N = 1,061). Age was estimated using saggital otoliths that were sectioned with a low-speed saw (Buehler, St. Louis). Gonad samples (N = 200), from fish collected throughout the year, were placed in 10% neutral buffered formalin for histological analysis. Yellow bass age ranged from 1 to 4 years, although no 3 year old fish were identified. The population was dominated by the 2 year old age class. GSI decreased as temperature reached 18-22°C, indicating spawning had occurred. Spawning activity was confirmed histologically based on the presence of post-ovulatory follicle complexes (POCs) in female gonads collected from January 2009 to April 2009. As of May 2009, gonads of both males and females, except for one female collected on 23 June 2009, were in the "regressing" and "regenerating" stages and consisted of residual spermatozoa and follicles, respectively, along with several early development stage spermatogonia and oocytes.

Results of this study indicate that yellow bass in the UBE mature by age 2 and spawn from early February through late April. The increase in yellow bass abundance in early spring was directly related to spawning activity and not to water quality or flood pulse.

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INTRODUCTION

First described by Jordan and Eigenmann (1887), the yellow bass *Morone mississippiensis* is a member of the family Moronidae with striped bass *M. saxatilis*, white bass *M. chrysops*, and white perch *M. americana*. The specific epithet is derived from the name Mississippi. Yellow bass are found in the Mississippi River and its drainage basin from Minnesota to Louisiana and western Iowa to eastern Tennessee (Figure 1; Douglas 1974; Lee et al. 1980; Page and Burr 1991). Moronids are referred to as temperate basses, to be separated from black bass species such as the largemouth bass *Micropterus salmoides* which is a member of the sunfish family Centrachidae. Temperate basses include freshwater (*M. mississippiensis* and *M. chrysops*), anadromous (*M. saxatilis*), and euryhaline (*M. americana*) species (Mettee et al. 1996; Etnier and Starnes 2001).

Until recently, *Morone* spp. were listed in the family Percichthyidae and grouped with many species from throughout North and South America, Europe, Australia, Africa, and Asia (Page and Burr 1991; Etnier and Starnes 2001). In 1984, Johnson removed *Morone* spp., *Dicentrarchus* spp., *Lateolabrax* and *Coreoperca* spp. from Percichthyidae and placed them into Moronidae. Throughout the 1800s and early 1900s scientists debated the validity of the genus *Morone*, proving and debating its separation from Percichthyidae many times (reviewed in Whitehead and Wheeler 1966). The genus *Morone* was first proposed by Mitchill (1814).

Yellow bass are moderately deep bodied fish with a terminal mouth, light olive to yellowish color, 5-7 dark lateral stripes, which are usually broken and off

Figure 1. Distribution of yellow bass in the United States. The bold outline delineates the Mississippi River drainage basin. The dark shaded region indicates the native range for yellow bass (Adapted from Lee et al. 1980 and Page and Burr 1991).

set above the front of the anal fin, and often have yellow eyes (Figure 2; Smith 1979; Hubbs et al. 1991; Mettee et al. 1996; Ross 2001). The second and third anal spines are nearly equal in length (Hubbs et al. 1991). The dorsal, caudal and anal fins are dark, and the pectoral and pelvic fins are usually clear or white (Page and Burr 1991; Ross 2001). The yellow bass can be separated from other members of the *Morone* family by the lack of a tooth patch on their tongue and the membrane that connects the two dorsal fins (Cook 1959; Hubbs et al. 1991). The reported maximum size of adult yellow bass is 275 mm total length (TL) and 0.5 kg in weight (Burgess 1978; Boschung and Mayden 2004). According to Lee et al. (1980) and Pflieger (1997), the maximum lifespan of yellow bass is six years; however, yellow bass up to age eight have been collected in Clear Lake, Iowa (Carlander 1997).

Yellow bass are a schooling species most commonly found in backwater pools and oxbows of the river systems they inhabit (Driscoll and Miranda 1999; Etnier and Starnes 2001). Harlan and Speaker (1956), Cook (1959), and Becker (1983) listed the yellow bass as a game fish because of its feisty nature and wide range of lure acceptance. Yellow bass meat is firm, white, flaky and is often considered superior to white bass meat (Becker 1983). Several states encourage the harvest of yellow bass to reduce angling pressure on other fish populations residing in the same areas, yet many anglers tend to disregard them while trying to land the larger white and striped basses (Pflieger 1997; Ross 2001).

In Tennessee and Wisconsin male and female yellow bass matured at ages two and three, respectively (Priegel 1975; Carlander 1997). Males from Clear

Figure 2. Female yellow bass (TL=263 mm) collected 23 January 2009 from the upper Barataria Estuary, Louisiana (photograph by Cynthia Fox).

Lake, Iowa matured at age two, but females matured at age four (Carlander 1997). Throughout their range, yellow bass spawn in large streams over gravel substrate during April and May (Bulkley 1970; Mettee et al. 1996), but the spawning season can extend into June in the northernmost reaches of the yellow bass range (Becker 1983). Yellow bass typically migrate upstream to spawn in waterways that flow into the lakes where they reside. Similar to white crappie *Pomoxis annularis*, lake sturgeon *Acipenser fulvescens*, and channel catfish *Ictalurus punctatus*, male yellow bass migrate upstream to the spawning grounds prior to females (Becker 1983; Ross 2001; Boschung and Mayden 2004).

Spawning activity in fish can be triggered by endogenous and exogenous cues. Photoperiod and temperature are frequently the strongest environmental cues that induce physiological and behavioral responses in fish. The hypothalamus receives melatonin released from the pineal gland which stimulates the pituitary gland to release gonadotropins (Jameson 1988). Common gonadotropins in fish are called gonadotropin hormones (GtH) I and II (Lin et al. 2004). These hormones function similarly to the follicle-stimulating hormone (FSH) and the luteinizing hormone (LH) in mammals (Jameson 1988; Patiño and Sullivan 2002; Lin et al. 2004). Gonadotropins travel to the gonads and stimulate the release of estrogen or testosterone (Jameson 1988). In females, estrogen then travels to the liver where it initiates the production of vitellogenin (Vtg; Specker and Sullivan 1994). Vtg is then transported by the bloodstream back to the ovary where it is taken up by growing oocytes (Mommsen and Walsh 1988) in preparation for maturation and spawning.

Yellow bass spawning in Iowa begins when water temperature reaches approximately 18°C (Bulkley 1970) with the most intense spawning occurring between 20-22°C (Becker 1983). Spawning occurs among one female and one to several males (Burnham 1909; Mettee et al. 1996). As described by Burnham (1909), yellow bass females lie on their side and release eggs towards the male who remains right-side up and fertilizes the eggs as they are released. Female yellow bass do not release their entire egg complement in one spawning attempt, because all of the eggs do not mature at the same time (Burnham 1909; Bulkley 1970) leading to their as asynchronous batch spawners (Grier 2009). Yellow bass eggs are semi-adhesive and hatch within 4-6 days of fertilization at 21°C (Ross 2001). The yolk sac contents are absorbed within 4 days and the fry begin exogenous feeding and aggregate in schools according to fish size (Burnham 1909).

Yellow bass are one of many species found in the Barataria Estuary (Lantz 1970). Throughout their range, yellow bass initiate a pre-spawn migration to preferred spawning habitats as temperatures approach 18°C (Bulkley 1970). Similarly, gizzard shad migrate to the upper reaches of the Barataria Estuary to spawn when temperatures reach 17-22°C, resulting in a much higher gizzard shad abundance than during other times of the year (Fontenot et al. *in press*). As with gizzard shad, yellow bass abundance in the UBE may be seasonal and related to spawning activity. Few yellow bass have been collected from the Barataria Estuary(Fontenot 2006; Davis 2006; Dyer 2007) and their ecological role within the UBE has not been described.

Figure 3. The Barataria Estuary (shaded region) in southeast Louisiana.

The Barataria Estuary is bordered by Bayou Lafourche to the west and the Mississippi River to the east (Figure 3), and is composed of interconnected lakes, bayous, canals, cypress-tupelo swamps, bottomland hardwood forests, freshwater marsh, intermediate marsh, brackish marsh, and salt marsh (Braud et al. 2006). The main riverine conduit source of the upper reaches of the estuary is Bayou Chevreuil, which drains much of the area into Lac des Allemands (Figure 4). For several hundred years the Barataria Estuary was inundated by an annual spring-time Mississippi River flood pulse. However, flood protection levee construction has cut off the upper estuary from the Mississippi River (Sklar and Conner 1979; Inoue et al. 2008). As a result, the water level in the upper estuary is a function of local precipitation and wind direction (Hopkins and Day 1987; Inoue et al. 2008). The lack of annual floodplain inundation may negatively impact spawning of many riverine fish species (Bayley 1995), such as bowfin (Davis 2006). However, the lack of a flood pulse does not appear to affect gizzard shad spawning activity (Jackson 2009; Fontenot et al. *in press*).

Low oxygen levels can negatively affect aquatic species (Suthers and Gee 1986; Kramer 1987; Fontenot et al. 2001; Killgore and Hoover 2001). Based on oxygen level, bodies of water can be classified as normoxic (DO > 2.0 mg/L), hypoxic (DO ≤ 2.0 mg/L), or anoxic (DO = ≤ 0.02 mg/L; Estay 2008). Hypoxic conditions in the UBE can range from a few days to several weeks (Estay 2008) and can affect blue crab abundance (Dantin et al. *in press*). Hypoxic conditions are typical of the high water period in active large river floodplains representing a normal component of the yearly flood pulse cycle (Junk et al. 1989; Bayley

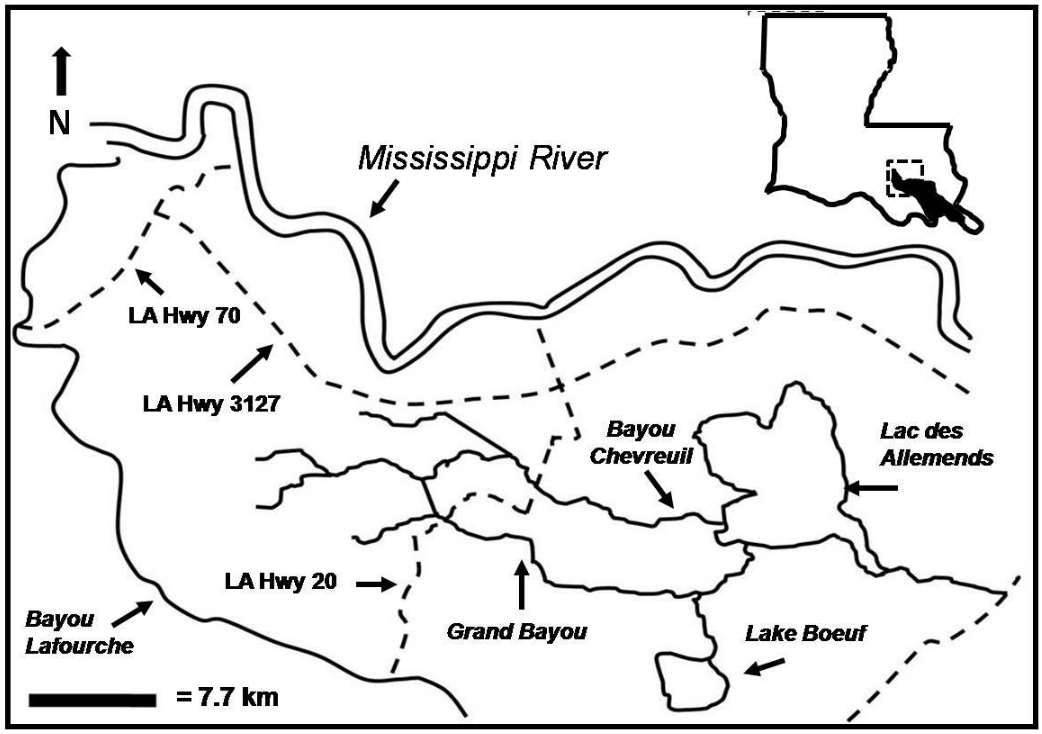

Figure 4. Major waterways (solid lines) and roadways (dashed lines) of the upper Barataria Estuary, Louisiana.

1995). However, hypoxic conditions in the UBE are most likely related to rain events (Estay 2008), and are not predictable. The unpredictable occurrence of hypoxic conditions without being coupled to a seasonal flood pulse in the UBE may disrupt the distribution and abundance of the fishes in the system.

The gonadosomatic index measures the cyclic changes in gonad weight in relation to total fish weight, and can be used to determine spawning periods (Nieland and Wilson 1993; Jons and Miranda 1997; Smith 2008). An increase in GSI suggests an approaching spawning season, and a decrease suggests spawning has occurred. Gonad histology is the microscopic examination of gonads and is used to classify individuals into specific reproductive stages. Combining GSI with histological analysis enhances the ability to determine if fish are spawning in the immediate area.

Using histology, both male and female fish can be separated into one of six reproductive stages (Brown-Peterson et al. 2007). Individuals can be classified as “immature” (not capable of spawning), “developing” (gonads developing but not capable of spawning), “spawning capable” (capacity to spawn this season), “actively spawning” (active or recent spawning), “regressing” (post-spawning), or “regenerating” (post-spawning and recovering; Brown-Peterson et al. 2007). Histology has been used to assess gonad development and to describe the reproductive cycle of fish (Blazer 2002; Lowerre-Barbieri et al. 2003). In addition to GSI, Smith (2008) used gonad histology to more accurately describe the reproductive cycle of spotted gar by identifying gonad development through time.

Fish age can be estimated using hard structures such as otoliths, scales, spines or fin rays (Welch et al. 1993; Soupir et al. 1997) according to species specific characteristics. In striped bass and white bass, otoliths have been more accurate than scales for age determination (Soupir et al. 1997; Secor et al. 1995; Welch et al. 1993). Basic life history characteristics of fishes such as annual growth rates, difference in growth rates between the sexes, age of maturity, and year class strength require age data. In some fish species, a large percentage of the population will consist of one or two year classes (Jennings et al. 2001) as seen in Atlantic herring *Clupea harengus* and Atlantic cod *Gadus morhua* (Hjort 1914). Also, monitoring changes in population age structure allows for assessment of how environmental or management changes affect the population.

Few studies have been published on yellow bass life history south of Tennessee (Schoffman 1958; Darnell 1961; Van Den Avyle and Higginbotham 1983; Driscoll and Miranda 1999). Most information pertaining to yellow bass in the southeast has either been related to diet ecology or the commercial hybridization of yellow bass with white and striped bass (Darnell 1961; Wolters and DeMay 1996; Bosworth et al. 1998; Driscoll and Miranda 1999). In Louisiana, yellow bass have been captured for hybridization and trophic level studies (Darnell 1961; Wolters and DeMay 1996); however their life history characteristics have not been documented.

The goal of this study was to describe the seasonal abundance and life history characteristics of the yellow bass population in the upper Barataria Estuary. The specific objectives of this study were to:

1. Quantify seasonal abundance of yellow bass,
2. Determine sex specific age and growth rates,
3. Determine sex specific gonadosomatic index,
4. Use histological techniques to describe seasonal gonad development, and to confirm spawning, and
5. Determine the relationships between dissolved oxygen (DO; mg/L), salinity (ppt), specific conductance (µS), temperature (°C), water level (m), and photoperiod (hours of daylight) and yellow bass abundance.

METHODS

Field Sampling

To describe the yellow bass population in the upper Barataria Estuary, yellow bass were collected from three sites in Lac des Allemands (Figure 5) and three sites in Bayou Chevreuil (Figure 5) from 14 November 2008 to 17 November 2009, using monofilament gill nets. Sampling occurred biweekly from mid-April through January and weekly from February through mid-April. Three separate individual 22 m long, 1.8 m deep, 25.4 mm and 35 mm bar mesh nets, and a single 22 m dual mesh net (first section: 11 m long, 1.8 m deep, 25.4 mm bar mesh; second section: 11 m long, 1.8 m deep, 51 mm bar mesh) were deployed for approximately three hours at each site. Nets in the bayou were set at a 45º angle from the shore pointing downstream, and nets set in the lake were set parallel to the western shore. At each sample site dissolved oxygen (DO, mg/L), specific conductance (µS), temperature (ºC), and salinity (ppt) were measured 0.3 m below the surface of the water using a handheld oxygen-conductivity-salinity-temperature meter (Yellow Springs Instruments, Yellow Springs, Ohio). Water level (m) data was obtained from the USGS monitoring site #07380401 in the St. James Canal (Figure 5). To compare photoperiod among known spawning periods for yellow bass, photoperiod data for the 15^{th} of each month from January 2009 through July 2009 were obtained from the United States Naval Observatory (http://aa.usno.navy.mil/) for Thibodaux, Louisiana, Dyersburg, Tennessee, Clear Lake City, Iowa, and Madison, Wisconsin.

All yellow bass were kept on ice in separate labeled containers for each

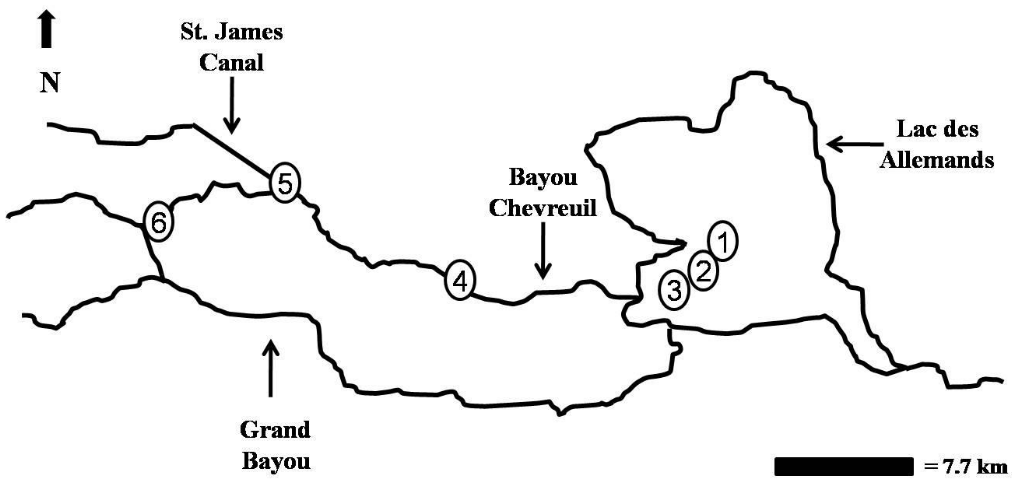

Figure 5. Location of the six study sites located in Lac des Allemands (sites 1-3) and Bayou Chevreuil (sites 4-6). GPS coordinates for each site are: Site 1: 29°54’22.7”N, 90°35’11.1”W; Site 2: 29°54’08.0”N, 90°35’37.7”W; Site 3: 29°53’44.9”N, 90°35’52.7”W; Site 4: 29°53’36.9”N, 90°40’50.5”W; Site 5: 29°55’46.9”N, 90°44’51.0”W; Site 6: 29°55’21.3”N, 90°47’06.5”W. Bar = 7.7 km.

net and transported to the Bayousphere Research Laboratory at Nicholls State University for processing. All other species collected were recorded and released on site. Catch per unit effort (CPUE) was calculated for each net by dividing the number of yellow bass caught in the net by the number of hours the net was deployed (# fish/# hours). The mean CPUE for each net type within each habitat was calculated. Although net mesh sizes were different, the same net combinations were used at each site, therefore the mean CPUE for all nets at each site was combined for an overall site CPUE. Only one yellow bass (TL = 215 mm, weight =152 g) was collected in the 51 mm bar mesh, so that net size was not included in any analyses.

Laboratory Processing

Total length (TL; mm) and weight (g) were measured for each fish. Sex was determined macroscopically by examination of gonads, which were removed and weighed (g) separately. Gonadosomatic index was calculated by dividing total gonad weight by total fish weight. For the months of December through July the testes or ovaries from a minimum of 25 male and 25 female yellow bass were preserved in 10% neutral buffered formalin for histological analysis.

Age Determination and Gonad Histology

For age determination, saggital otoliths were removed and stored dry in labeled vials until processed. Up to 30 fish from each month were aged (N=325). The right otolith for each fish was sectioned using an isomet low speed saw (Buehler, St. Louis). A 1,270 µm transverse section was cut across the nucleus of the otolith and mounted onto microscope slides using thermoplastic cement.

After mounting, otolith sections were ground with 600 grit wet/dry sandpaper until smooth then polished with 800 grit wet/dry sandpaper for approximately twenty seconds. Two readers independently viewed otolith sections coated with immersion oil using a dissecting microscope (Olympus SZX12) at varying magnifications. Lengths of the fish were not known by the readers and any discrepancies were discussed among the readers until an age was agreed on.

Histological methods followed the methods of Brown-Peterson et al. (2007). Samples from the center of the gonads were cut (approximately 5 mm thick), placed in labeled tissue cassettes, stored in 75% ethanol for up to five days and sent to McNeese State University, Lake Charles, Louisiana for processing. The tissues were dehydrated in ascending grades of alcohol, cleared in xylene and infiltrated with paraffin (Table 1). Post-infiltration, the tissues were embedded and 10μm sections were made using a microtome. Slides were stained using hematoxylin and eosin and coverslipped (Table 2). Each slide was viewed using a compound light microscope (Nikon Eclipse E600) at 20, 40, 100, or 200X magnification. A modification of the Brown-Peterson et al. (2007) reproductive classification system (Table 3) was used to provide descriptions specific to male (Table 4) and female (Table 5) yellow bass gonad histology. For histological analyses of both sexes, the “spawning capable” and “actively spawning” stages were combined (Smith 2008). In females, these stages occur intermittently until a female finishes spawning for that year. In males, the two stages are histologically indistinguishable and can only be separated by the observation of free flowing milt before dissection.

Table 1. Tissue processing procedure for histological preparation of yellow bass gonad samples.

Station	Treatment	Time
1	75% Alcohol	Up to 5 days
2	75% Alcohol	30 min
3	80% Alcohol	30 min
4	80% Alcohol	30 min
5	95% Alcohol	30 min
6	95% Alcohol	30 min
7	100% Alcohol	30 min
8	100% Alcohol	30 min
9	Xylene in Vacuum	30 min
10	Xylene in Vacuum	30 min
11	Paraffin in Vacuum	30 min
12	Paraffin in Vacuum	30 min
13	Imbed with Paraffin	2-3 min
14	Microtome	Variable
15	Warm Water Bath	5 min
16	Stretching Block	Overnight

Table 2. Staining procedure for histological preparation of yellow bass gonad samples. Acid water – 3% glacial acetic acid in water, Ammonia water – 3% ammonium hydroxide in water. A – Agitation, D – Dip, W – Wash, S – Soak.

Station	Reagent	Action	Time/Number
1	Xylene	A	3-6 min
2	Xylene	A	3-6 min
3	100% Alcohol	D	20-30
4	100% Alcohol	D	20-30
5	95% Alcohol	D	20-30
6	95% Alcohol	D	20-30
7	Water	W	3-5 min
8	Hematoxylin	S	2 min
9	Water	W	3 min
10	Acid Water	D	1
11	Water	W	3 min
12	Ammonia Water	D	3
13	Water	W	3 min
14	70% Alcohol	D	20-30
15	Eosin	S	2 min
16	95% Alcohol	D	20
17	95% Alcohol	D	20
18	100% Alcohol	D	20-30
19	Xylene	D	20
		Coverslip	1 min
		Set	Overnight

Table 3. Reproductive classification system for male and female fishes according to histological characteristics of gonads (modified from Brown-Peterson et al. 2007). Female "regressing" stage was modified to include vitellogenic and cortical alveolar oocytes. PGO – primary growth oocytes, CAO – cortical alveolar oocytes, VTGO – vitellogenic oocytes, POF – post-ovulatory follicles, GVM – germinal vesicle migration, GVBD – germinal vesicle breakdown, SG – spermatogonia, CY – spermatocysts, SC – spermatocytes, ST – spermatids, SZ – spermatozoa, GE – germinal epithelia.

Stage	Male	Female
Immature	Small testes, only primary SG, no lumens in lobules.	Only oogonia and PGO present. Usually no atresia.
Developing	Initiation of spermatogenesis and formation of CY. Secondary SG, primary SG, secondary SC, ST, and SZ can be present in CY. No SZ in lumens of lobules or sperm ducts. GE continuous.	PGO, CAO, early VTGO, and mid VTGO may be present. No POF. Some atresia can be present.
Spawning Capable	SZ in lumens of lobules and/or sperm ducts. All stages of spermatogenesis (SG, SC, and ST) can be present. CY throughout testis. GE continuous or discontinuous. Histologically undistinguishable from "actively spawning" phase.	VTGO predominant. Some atresia and old POF may be present. Less-developed oocytes often present.
Actively Spawning	SZ in lumens of lobules and/or sperm ducts. All stages of spermatogenesis (SG, SC, and ST) can be present. CY throughout testis. GE continuous or discontinuous. Histologically undistinguishable from "spawning capable" phase.	Ovulating (spawning) or approximately 12 hours prior to or after spawning as indicated by either GVM, GVBD/hydrated oocytes, or POF < 12 hours old. Atresia of late VTGO or hydrated oocytes may be present.
Regressing	Residual SZ in lumens of lobules and sperm ducts. Widely scattered CY near periphery containing ST. SG proliferation and GE regeneration common in periphery of testis.	Atresia present (any stage). Majority of VTGO undergoing early atresia. Less-developed oocytes often present. VTGO or CAO can be present. POF may be present.
Regenerating	No CY. Lumens of lobules small or nonexistent. Proliferation of primary, occasionally secondary, SG throughout testis. Residual SZ may be present in lumens of lobules and sperm ducts.	Only oogonia and PGO present. Muscle bundles, enlarged blood vessels, thick ovarian wall and/or late atresia may be present.

Table 4. Description of reproductive classification system for male yellow bass according to histological characteristics of gonads (as modified from Brown-Peterson et al. 2007). SG – spermatogonia, CY – spermatocysts, ST – spermatids, SZ – spermatozoa, GE – germinal epithelium.

Stage	Description
Immature	Only primary SG present. No lumens.
Developing	Continuous GE throughout testis. Spermatogenesis begins giving rise to the formation of CY. CY are clusters of cells in the same stage of spermatogenesis. CY may contain secondary SG, primary SC, secondary SC, ST and SZ. As SG develop into SZ, each stage of cells become smaller, increase in number, and stain darker purple. SZ can be separated from ST by the appearance of a bright pink tail on SZ. No SZ will be in lumen.
Spawning Capable	SZ released and scattered throughout lumens and sperm ducts. Some CY present throughout testis. CY may contain all stages of spermatogenesis (SG, SC, and ST). GE can be continuous or discontinuous. Histologically undistinguishable from "actively spawning" stage. However, if milt does not flow from vent with gentle squeeze, fish can be classified into this stage.
Actively Spawning	SZ released and scattered throughout lumens and sperm ducts. Some CY present and may contain SG, SC, and ST. GE may be continuous or discontinuous. Histologically undistinguishable from "spawning capable" stage. However, if milt flows from vent with gentle squeeze, fish can be classified into this stage.
Regressing	Residual SZ present in lumens. Some CY containing ST scattered near periphery. Primary SG begins forming at periphery as GE regeneration also begins.
Regenerating	No CY present. Lumens are small and difficult to see. Primary SG dominant with some secondary SG present. Residual SZ may be present.

Table 5. Description of reproductive classification system for female yellow bass according to histological characteristics of gonads (as modified from Brown-Peterson et al. 2007). PG – primary growth oocytes, CA – cortical alveolar oocytes, Vtg – vitellogenic oocytes, POC – post-ovulatory follicle complex, OM – oocyte maturation, GVM – germinal vesicle migration, FOM – final oocyte maturation, MA – macrophage aggregates.

Stage	Description
Immature	Only PG present. Usually no atresia. Thin ovarian wall.
Developing	PG present and stained dark purple. CA larger than PG and stained light purple. Cortical alveoli are small dark purple spheres that form a circle inside the CA. Primary Vtg are similar to CA (in size) but contain small dark pink granules and white yolk oil droplets. Granules line outer edge of oocyte while droplets surround nucleus. Atresia may be present appearing as "empty holes," indicating previous location of fatty tissue. Some secondary Vtg may be present.
Spawning Capable	Tertiary Vtg prominent. Secondary and primary Vtg common, CA present. Secondary Vtg are larger and contain more yolk than early Vtg with a dark pink vitelline envelope. Thin layer of thecal cells surrounds all Vtg oocytes, but may be difficult to distinguish between oocytes. Ovarian wall will start thinning. Old (> 24 h) small POCs present and appear grainy and folded.
Actively Spawning	OM present with lipid and yolk coalescence occurring with GVM. Tertiary Vtg prominent and larger than Secondary Vtg. Some FMOs can be present with fused yolk that is stained pink and looks smooth or layered. Vitelline envelope will be thick and dark pink. Some new (<24 h) POCs, atresia and PGs may be present.
Regressing	Atresia dominant. Some FMOs, POCs, and PGs scattered throughout ovary. MA present appearing yellowish- brown. Some Vtg and CA oocytes present.
Regenerating	Only PGs present. Blood vessels enlarged. Some late stage atresia and MA may be present. Thick ovarian wall.

Statistical Analyses

Analysis of variance was used to determine if DO, temperature, specific conductance, or CPUE differed among sites. Multiple regression analysis was used to determine the relationships among CPUE and DO temperature, salinity, and specific conductance. Analysis of variance was used to compare age specific size difference between the sexes. Analysis of variance was used to compare CPUE and sex specific GSI among months and was followed by Tukey's *post hoc* analysis. All statistical inference were based on alpha = 0.05.

RESULTS

A total of 1,061 yellow bass were collected from 14 November 2008 to 17 November 2009 from the upper Barataria Estuary and the male:female ratio was 2.63:1 (male N = 769; female N = 292). Males made up more than 70% of the catch for February, March and April (Figure 6). In addition to yellow bass, twenty-three other species were collected, including seven marine species (Table 6). Yellow bass CPUE increased during the winter, peaked in early spring, and declined and remained low throughout the summer and the fall, with the exception of a small increase on 22 July 2009. The greatest peak in abundance occurred on 10 March 2009 (Appendix I) after water temperature reached 18 - 22°C (Figure 7). Yellow bass abundance was greatest ($P = 0.0003$) during their spawning season (February through April; Figure 8) compared to months they are not spawning; however, mean CPUE did not differ among the six sites ($P = 0.6711$).

Site specific dissolved oxygen measurements ranged from 0.7 to 14.3 mg/L (Appendix II) with an average of 7.8 ± 1.4 mg/L (mean ± SE). Mean dissolved oxygen levels did not differ among the six sites ($P = 0.9985$; Figure 9). Site specific temperature measurements ranged from 10.4 to 33.8°C (Appendix II) with an average of 22.4 ± 6.3°C. Temperatures fluctuated seasonally with the highest mean temperature (32.1°C) occurring in June and the lowest (11.1°C) occurring in January (Figure 7) with no difference among the sites ($P = 0.9687$). Site specific salinity measurements ranged from 0.1 to 0.3 ppt (Appendix II) and averaged 0.14 ± 0.03 ppt. Salinity remained fairly constant among all six sites

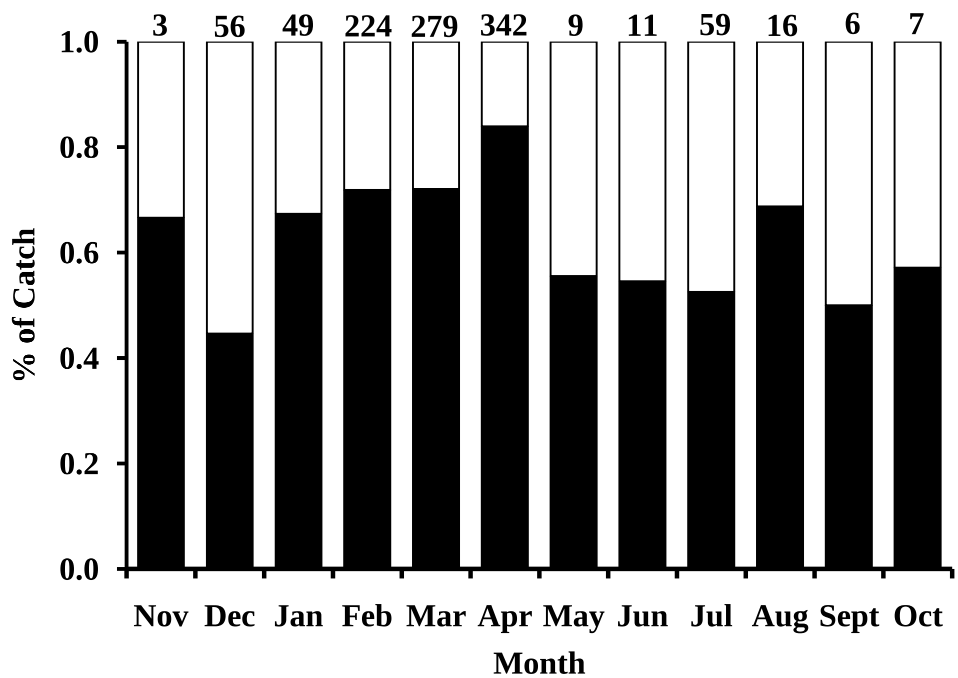

Figure 6. Percent of monthly catch of male (N = 769; dark bar) and female (N = 292; open bar) yellow bass collected 14 November 2008 to 17 November 2009, from the upper Barataria Estuary. Numbers above columns indicate the total number of fish collected each month.

Table 6. Total number of each species collected in the upper Barataria Estuary from 14 November 2008 – 17 November 2009. Species marked with an asterisk are considered marine organisms.

Species	Common Name	Number
Morone mississippiensis	Yellow Bass	1061
Dorosoma cepedianum	Gizzard Shad	1052
Lepisosteus oculatus	Spotted Gar	472
Mugil cephalus	Striped Mullet*	424
Ictalurus punctatus	Channel Catfish	392
Callinectes sapidus	Blue Crab*	74
Elops saurus	Ladyfish*	55
Amia calva	Bowfin	41
Lempomis macrochirus	Bluegill	39
Micropterus salmoides	Largemouth Bass	39
Ictalurus furcatus	Blue Catfish	33
Leiostomus xanthurus	Spot*	31
Alosa chrysochloris	Skipjack Herring	28
Cyprinus carpio	Common Carp	22
Pomoxis nigromaculatus	Black Crappie	21
Lepomis microlophus	Redear Sunfish	20
Micropogonias undulatus	Atlantic Croaker*	13
Notemigonus crysoleucas	Golden Shiner	9
Pomoxis annularis	White Crappie	9
Morone chrysops	White Bass	8
Sciaenops occellatus	Red Drum*	8
Erimyzon sucetta	Lake Chubsucker	3
Brevoortia patronus	Gulf Menhaden*	1
Lepisosteus osseus	Longnose Gar	1
Total		**3851**

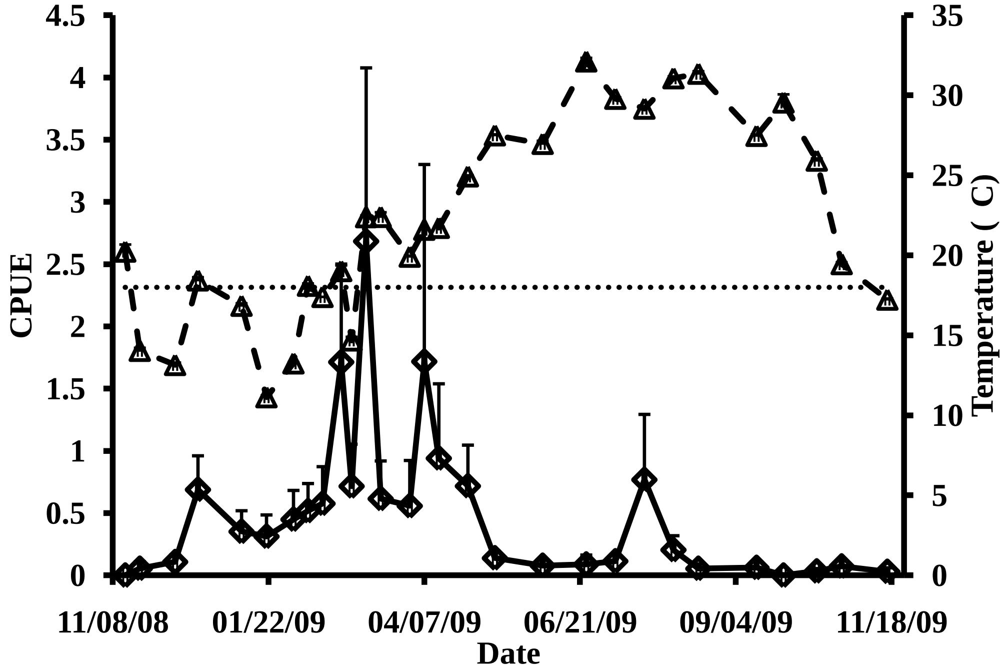

Figure 7. Mean (± SE) yellow bass CPUE (◊) and temperature (Δ) in the upper Barataria Estuary, 14 November 2008 to 17 November 2009. Dotted line at 18°C indicates the temperature that spawning is reported to occur (Bulkley 1970).

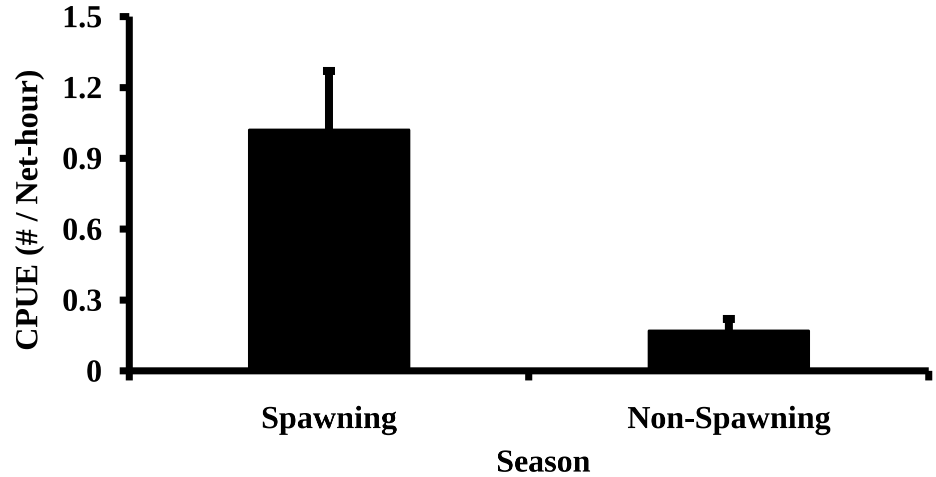

Figure 8. Mean (± SE) yellow bass CPUE collected during the spawning (February to April) and the non-spawning season (May to January; $P = 0.0003$) in the upper Barataria Estuary from November 2008 and November 2009.

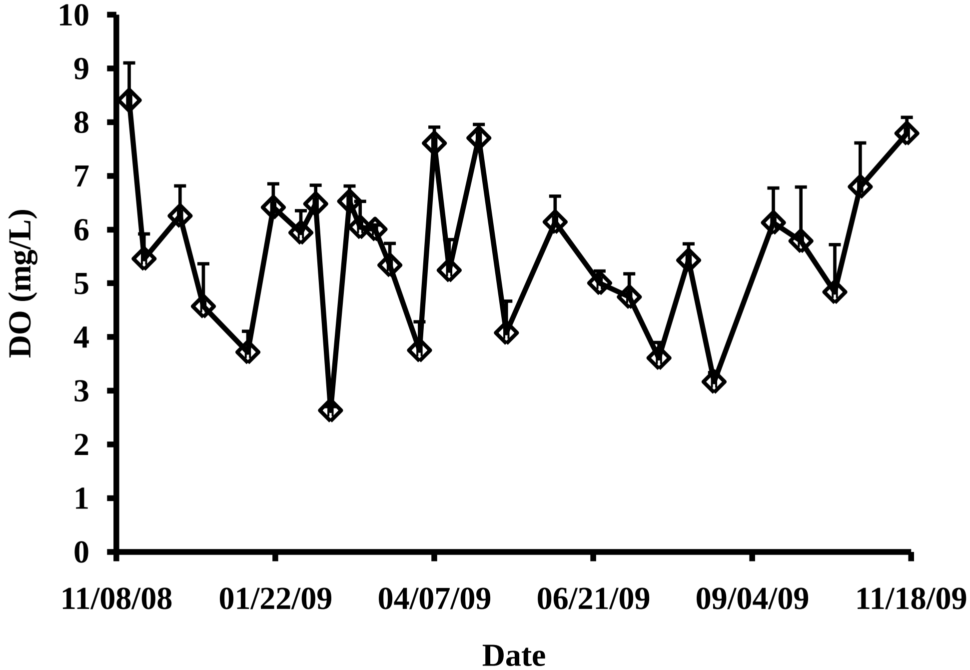

Figure 9. Mean (± SE) dissolved oxygen levels in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

(Figure 10). Site-specific specific conductance values ranged from 115 to 879.7 µS (Appendix II) with an average of 280.1 ± 73.8 µS. There was no difference among the mean specific conductance values of the six sites (P = 0.9975; Figure 11). Multiple regression analysis did not reveal a significant relationship between CPUE and DO, temperature, or specific conductance (Table 7). Daily individual water level measurements recorded by the USGS ranged from 1.36 to 2.38 m with an average of 1.81 ± 0.21 m. There was no evidence of a flood pulse and water level was not related to yellow bass abundance (Figure 12). Day length steadily increased for all four locations from January through June and was similar among locations in March (Figure 13); however, there was no correlation between CPUE and photoperiod (Figure 14). Peak yellow bass abundance occurred when photoperiod was at 12L:12D.

Yellow bass collected during this study ranged from 175 mm to 264 mm (Figure 15). Yellow bass weight ranged from 79.5 g to 347.5 g. Mean female length (P = <0.0001) and weight (P = <0.0001) were larger than mean male length and weight. There was no difference in the length-weight relationships (P = 0.1052) between male and female yellow bass, therefore length and weight data for the sexes were combined (Figure 16). The length-weight relationship for yellow bass in the upper Barataria Estuary is described by:

$$WT = 0.00001TL^{3.0354}$$

Fish age ranged from 1 to 4 years old but did not include any 3 year old individuals. This population of yellow bass was dominated by two year old fish (Figure 17). Because 95% of the fish aged were 2 years old, von Bertalanffy

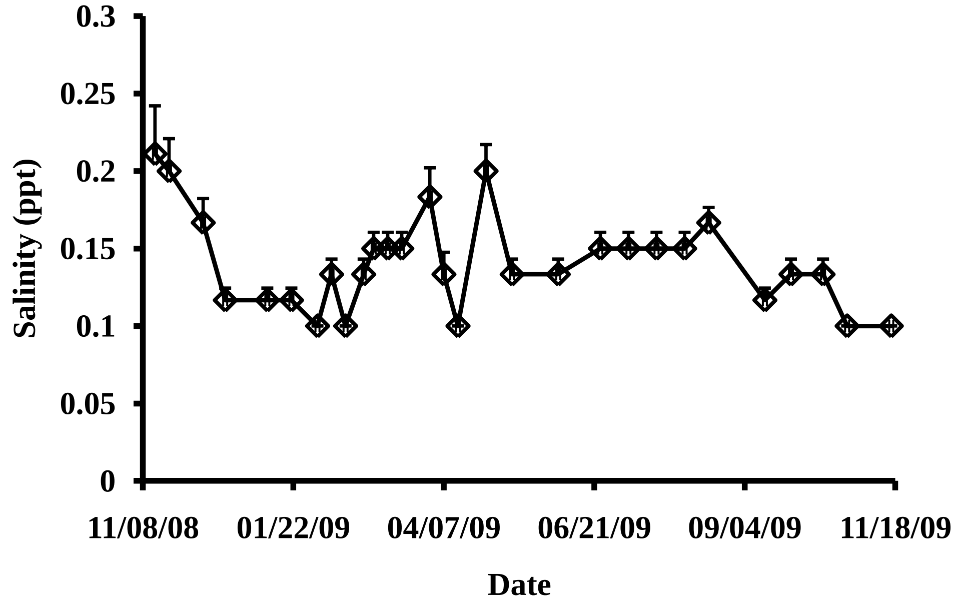

Figure 10. Mean (± SE) salinity in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

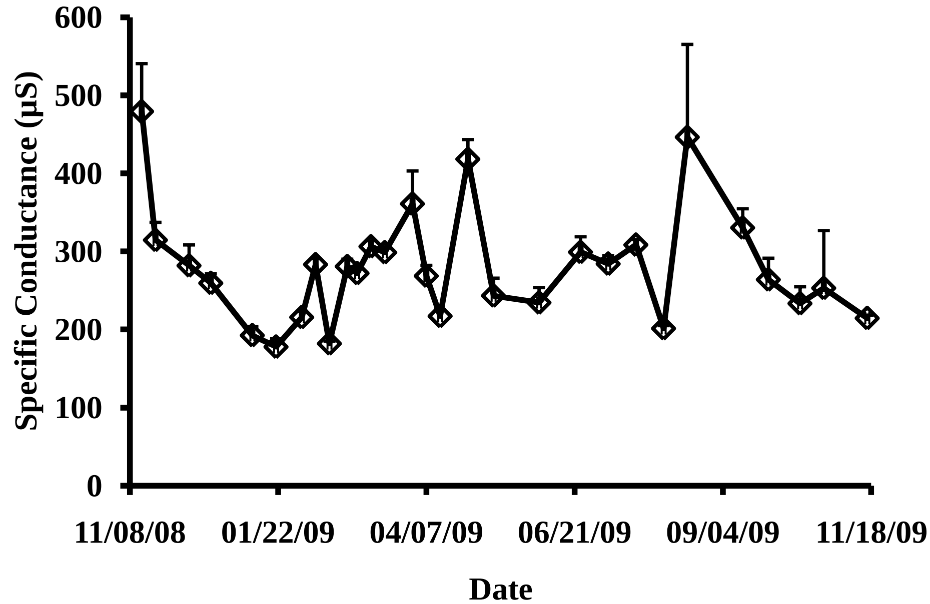

Figure 11. Mean (± SE) specific conductance in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

Table 7. Regression parameter estimates, standard errors, t-values, and P-values for multiple regression analysis comparing CPUE to dissolved oxygen (mg/L), temperature (°C), and specific conductance (µS).

Variable	Parameter Estimate	Standard Error	t-value	P-value
Dissolved Oxygen	0.00293	0.03393	0.09	0.9312
Temperature	-0.00551	0.01126	-0.49	0.6253
Specific Conductance	-0.00091	0.00075	-1.21	0.2283

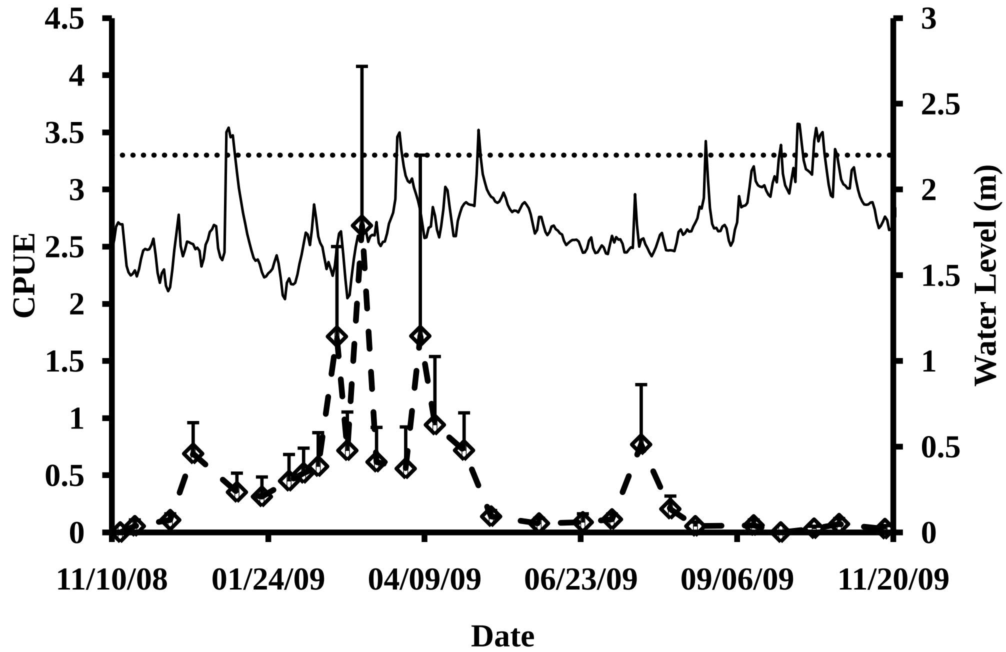

Figure 12. Mean (± SE) yellow bass CPUE (◊) and water level (solid line) in the upper Barataria Estuary, 14 November 2008 to 17 November 2009. The dotted line at 2.2 m indicates when the floodplain becomes inundated (Estay 2008).

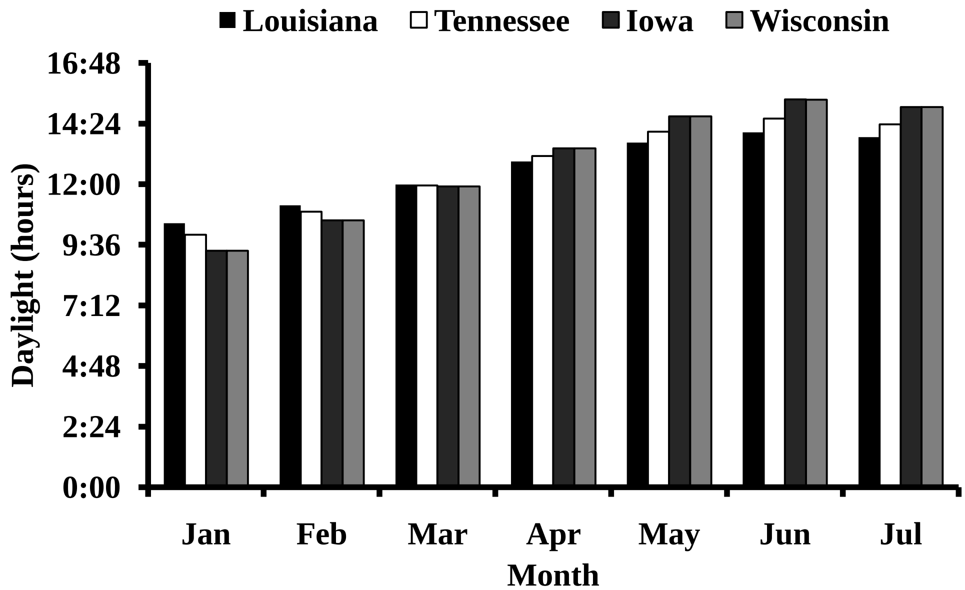

Figure 13. Photoperiod for the 15th of each month from January 2009 to June 2009 for Thibodaux, Louisiana, Dyersburg, Tennessee Clear Lake City, Iowa, and Madison, Wisconsin. Data obtained for the United States Naval Observatory (http://aa.usno.navy.mil/).

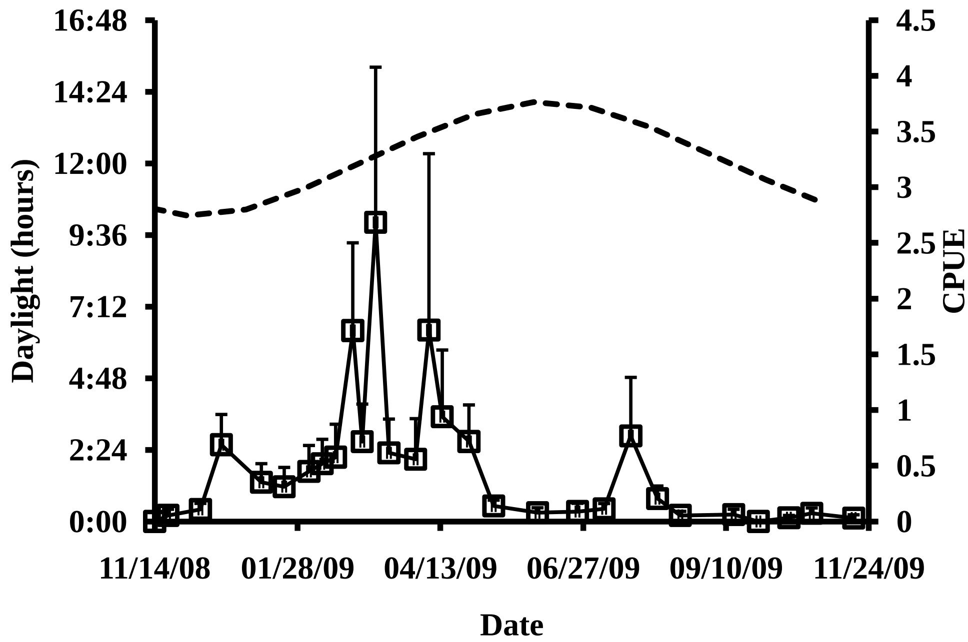

Figure 14. Photoperiod (dashed line) and mean (± SE) yellow bass CPUE (solid line) in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

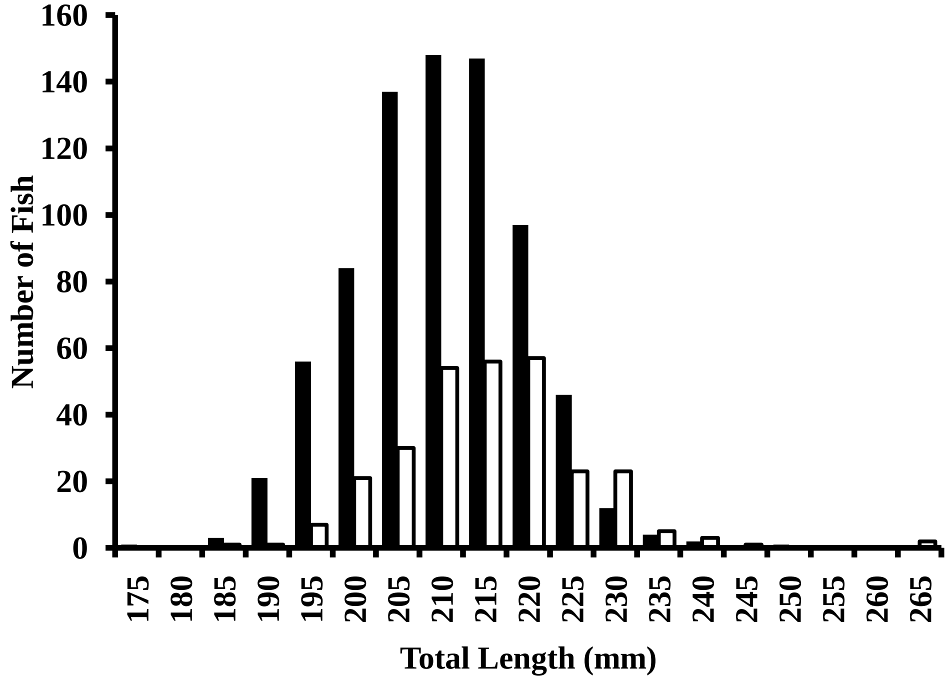

Figure 15. Total length frequency distributions of male (N = 769; dark bars) and female (N = 292; open bars) yellow bass collected 14 November 2008 to 17 November 2009 from the upper Barataria Estuary.

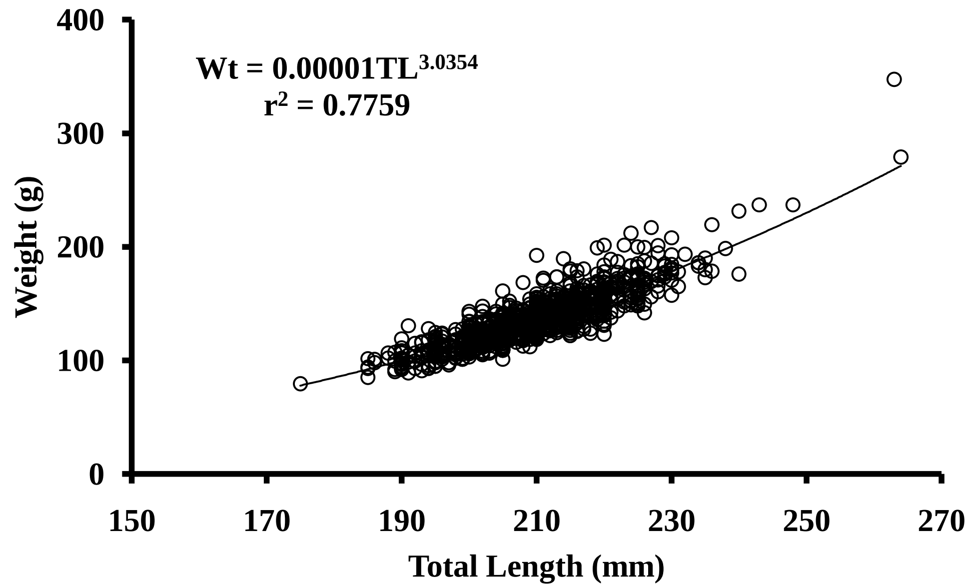

Figure 16. Length-weight relationship data for male and female yellow bass combined (P = 0.1052; N = 1061), collected from the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

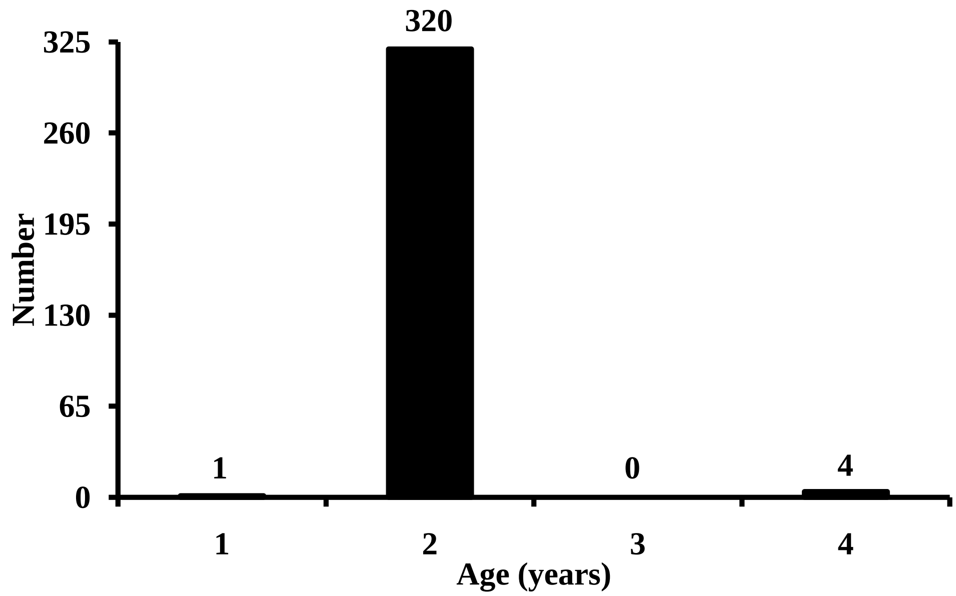

Figure 17. Age frequency of yellow bass collected from the upper Barataria Estuary, 14 November 2008 to 17 November 2009. Numbers above columns indicate the total number of fish in that age class.

growth parameters were not calculated.. Female yellow bass were larger than male yellow bass for ages 2 and 4 (Figure 18).

As with CPUE, yellow bass GSI increased during the winter, peaked in early spring, and declined and remained low throughout the summer and the fall. Peak GSI occurred on 03 February 2010, for both males and females (Figure 19). The peak in GSI occurred right before the largest peak in abundance (Figure 20). Individual male GSI ranged from 0.03 to 7.87% (Appendix III) with an average of 2.88 ± 1.90%. Individual female GSI ranged from 0.39 to 16.74% (Appendix III) and averaged 5.70 ± 4.34%. There was no difference in male GSI by month; however female GSI was highest from January through March (Figure 21).

A total of 200 yellow bass (100 male and 100 female) gonads collected from December through July were examined using histology. No "immature" males or females were identified. Although the only 1 year old male collected was not examined histologically. The majority of males (N = 71) were classified as "spawning capable/actively spawning" (Figure 23) and were collected from December through April (Figure 22). Ten males were classified as "regressing" (Figure 24) and eighteen were classified as "regenerating" (Figure 25) and were collected from April through July (Figure 22). Only one male, collected in December (Figure 22), was classified as "developing" (Figure 26). Similar to males, most of females were classified as "spawning capable" (N = 34) or "actively spawning" (N = 25). "Spawning capable" females (Figure 28) were collected December through April (Figure 27). Most of the "actively spawning" females (Figure 29) were collected February through April; however one

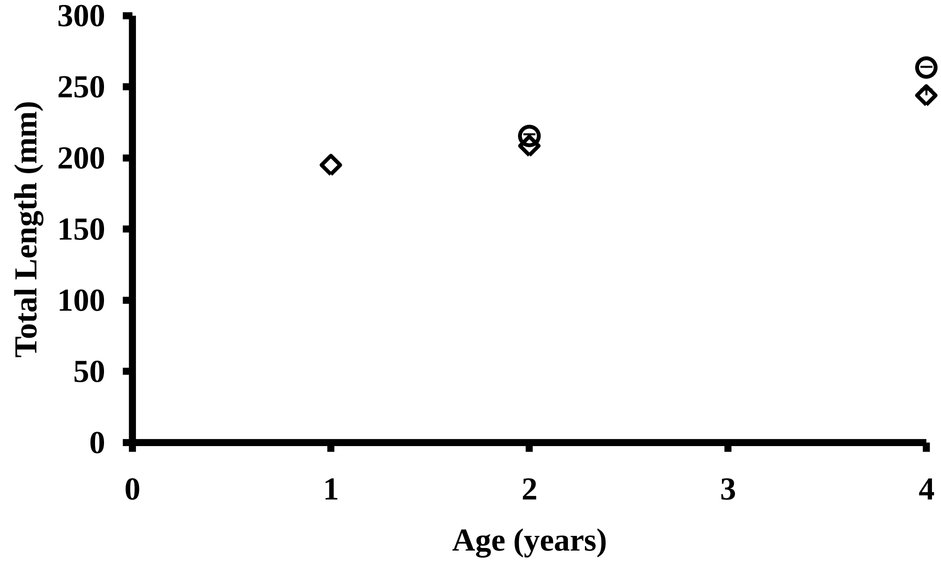

Figure 18. Mean (± SE) total length at age for male (□) and female (◊) yellow bass collected from the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

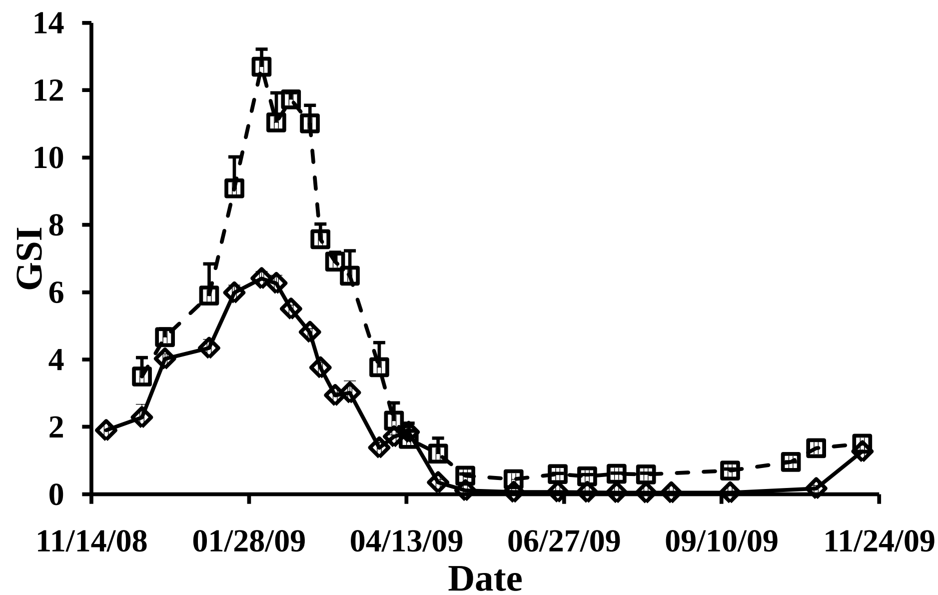

Figure 19. Mean (± SE) GSI for male (solid line) and female (dashed line) yellow bass collected from the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

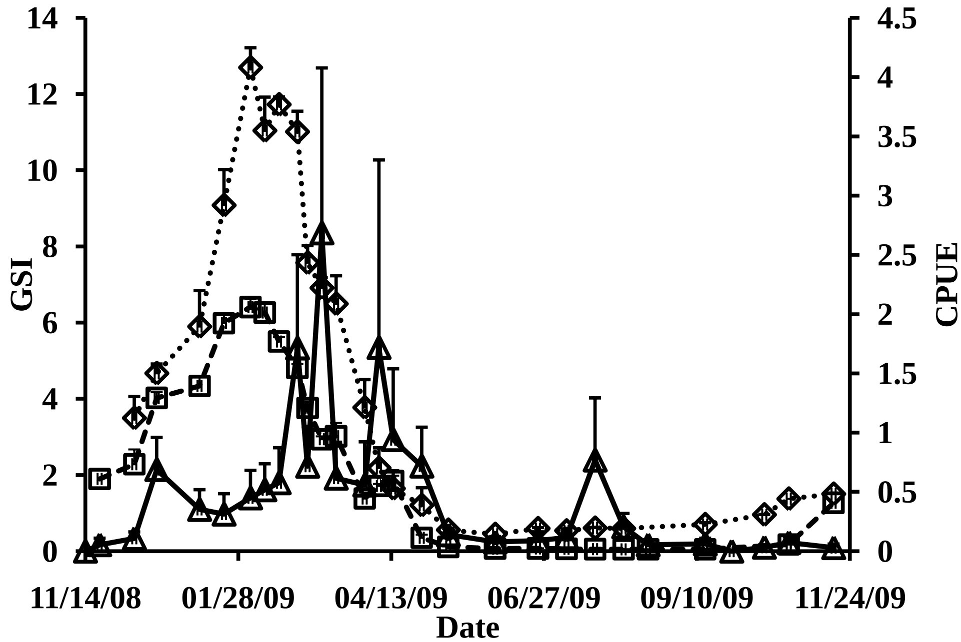

Figure 20. Mean (± SE) male GSI (open square with dashed line), female GSI (open diamond with dotted line) and mean (± SE) CPUE for yellow bass collected from the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

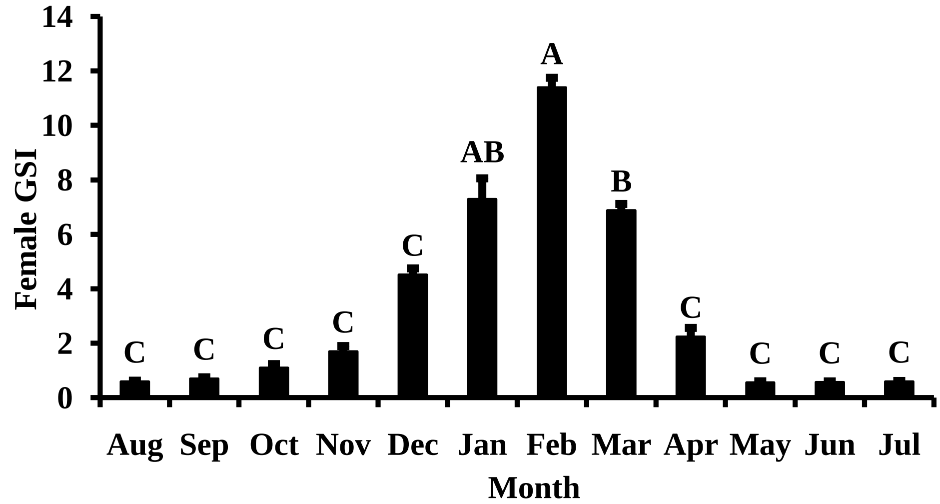

Figure 21. Mean (± SE) monthly female yellow bass GSI. Means marked with a similar letter are not different.

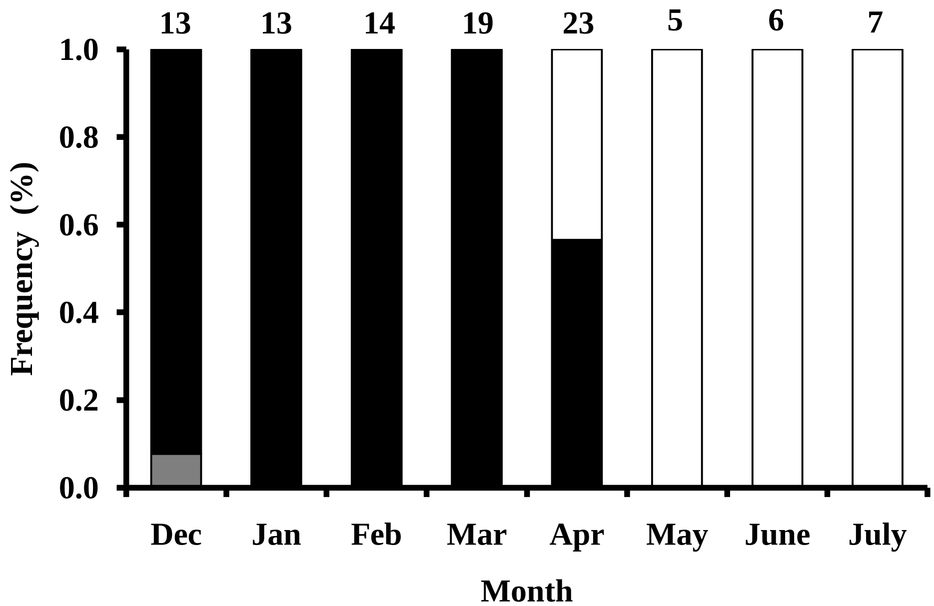

Figure 22. Percent of "developing" (grey bar), "spawning capable/actively spawning" (black bar) and "regressing/regenerating" (open bar) gonad developmental stages of male yellow bass collected 14 November 2008 to 17 November 2009, from the upper Barataria Estuary. Numbers above columns indicate the total number of fish examined each month.

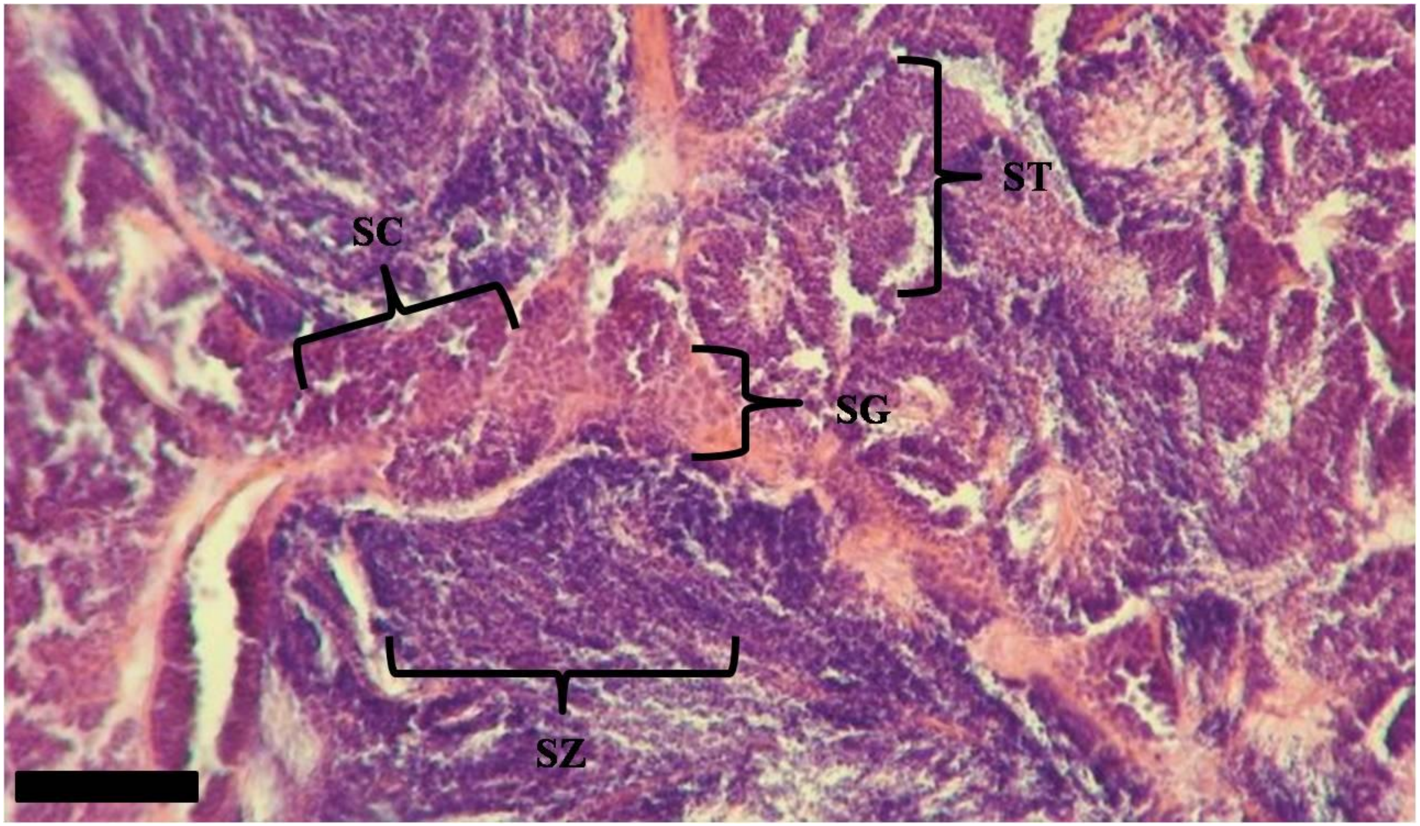

Figure 23. Histological section of a "spawning capable/actively spawning" yellow bass (TL = 209 mm) testis with spermatozoa throughout lumens and sperm ducts collected on 17 February 2009, from the upper Barataria Estuary. Bar = 5 µm. SG – spermatogonia; SC – spermatocytes; ST – spermatids; SZ – spermatozoa.

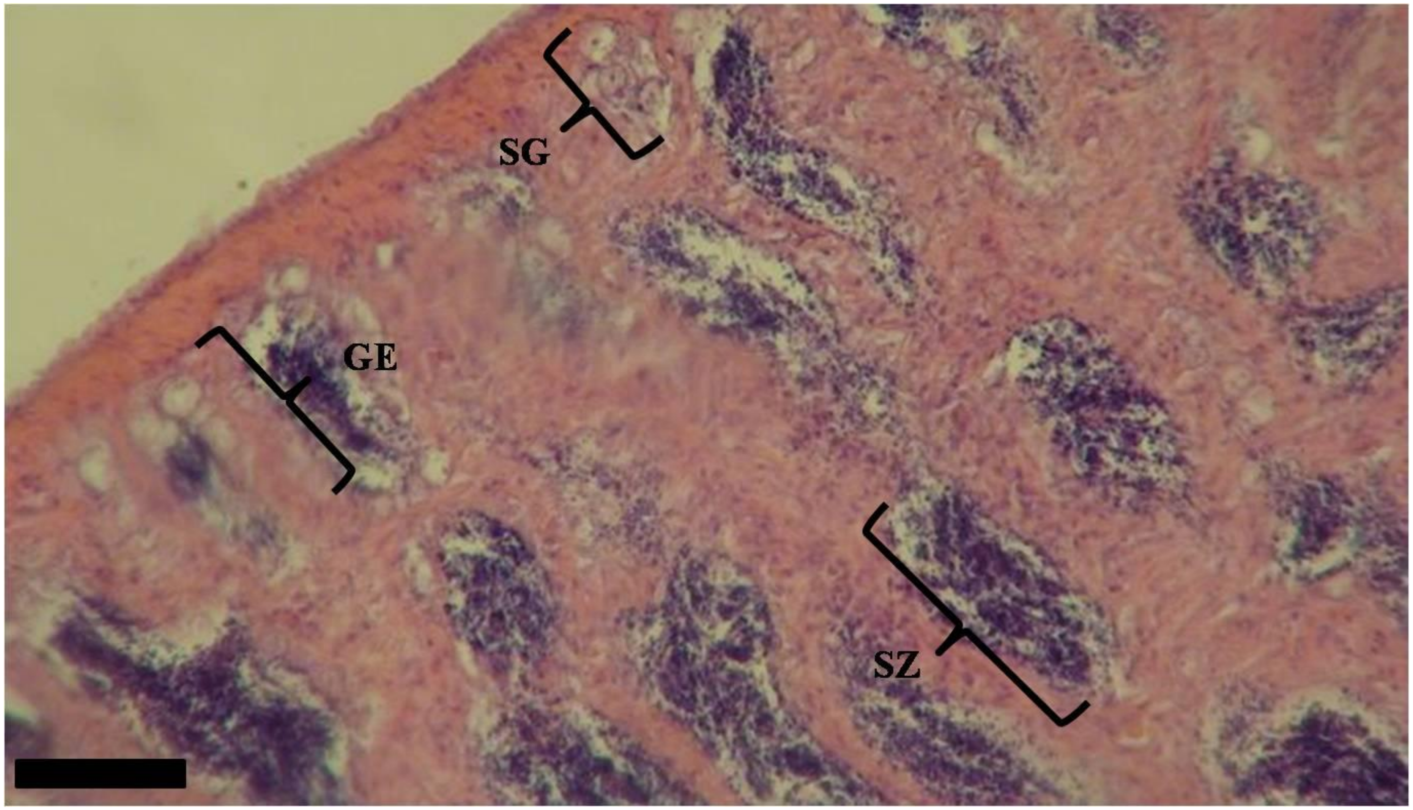

Figure 24. Histological section of a “regressing” yellow bass (TL = 205 mm) testis with germinal epithelia and spermatogonia proliferation at the periphery of testis collected 15 April 2009, in the upper Barataria Estuary. Bar = 5 µm. GE – germinal epithelia; SG – spermatogonia; SZ – spermatozoa.

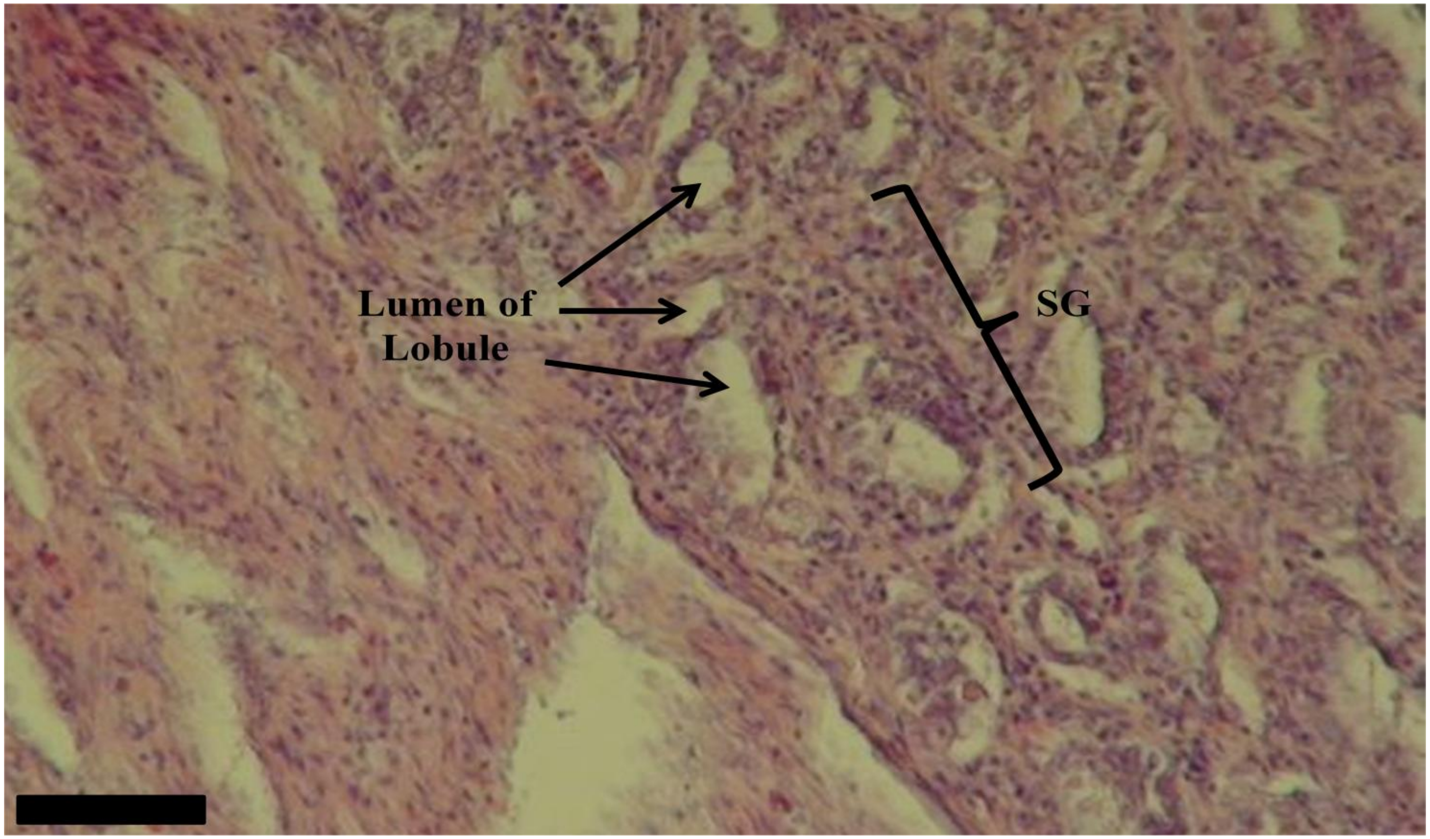

Figure 25. Histological section of a "regenerating" yellow bass (TL = 200) testis with empty lumens and spermatogonia throughout collected 03 June 2009, from the upper Barataria Estuary. Bar = 5 µm. SG – spermatogonia.

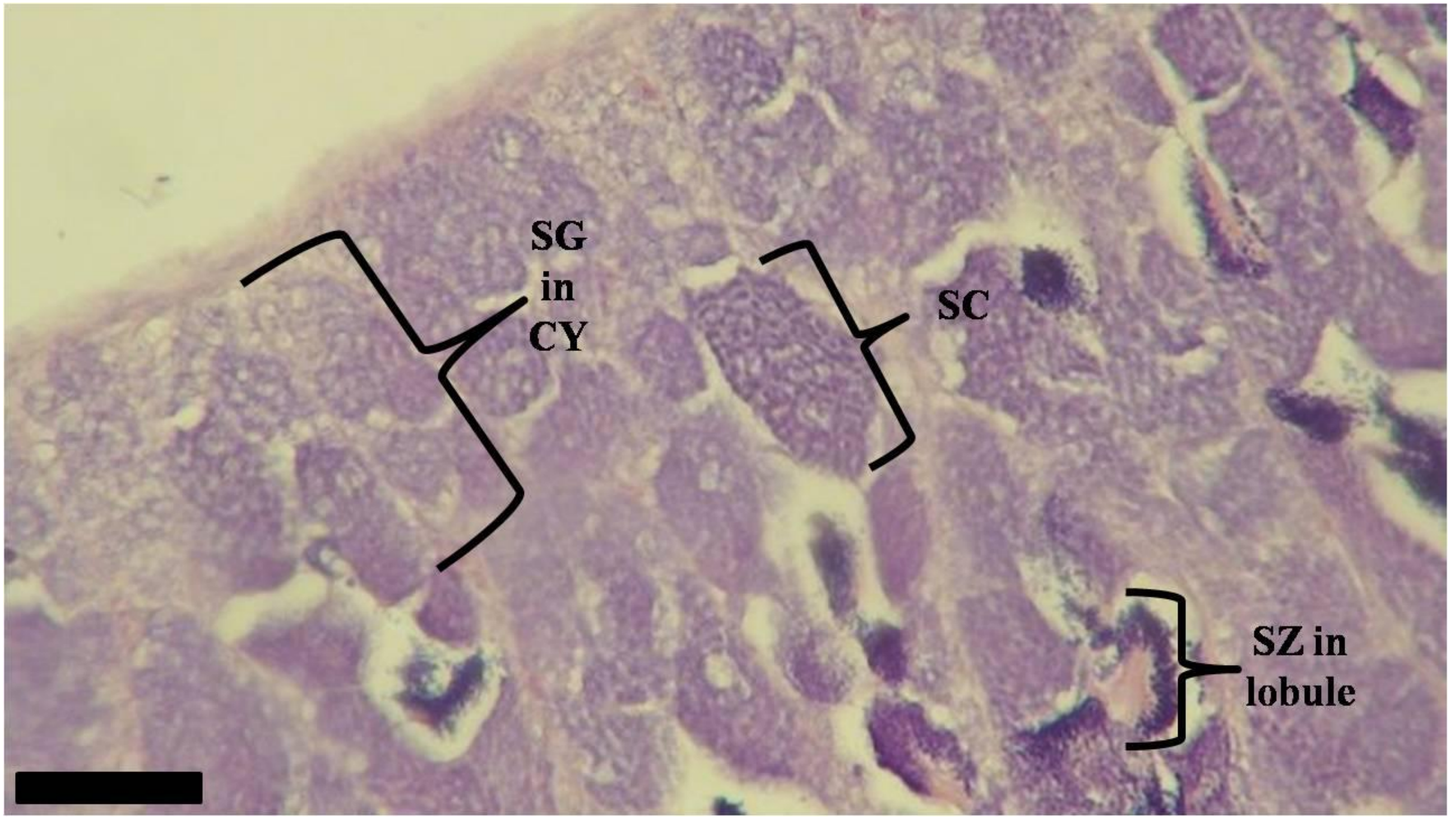

Figure 26. Histological section of a "developing" yellow bass (TL = 195 mm) testis with spermatogonia proliferation in spermatocysts at the periphery of the testis collected 08 December 2008, from the upper Barataria Estuary. Bar = 5µm. SG – spermatogonia; CY – spermatocyst; SC – spermatocytes; SZ – spermatozoa.

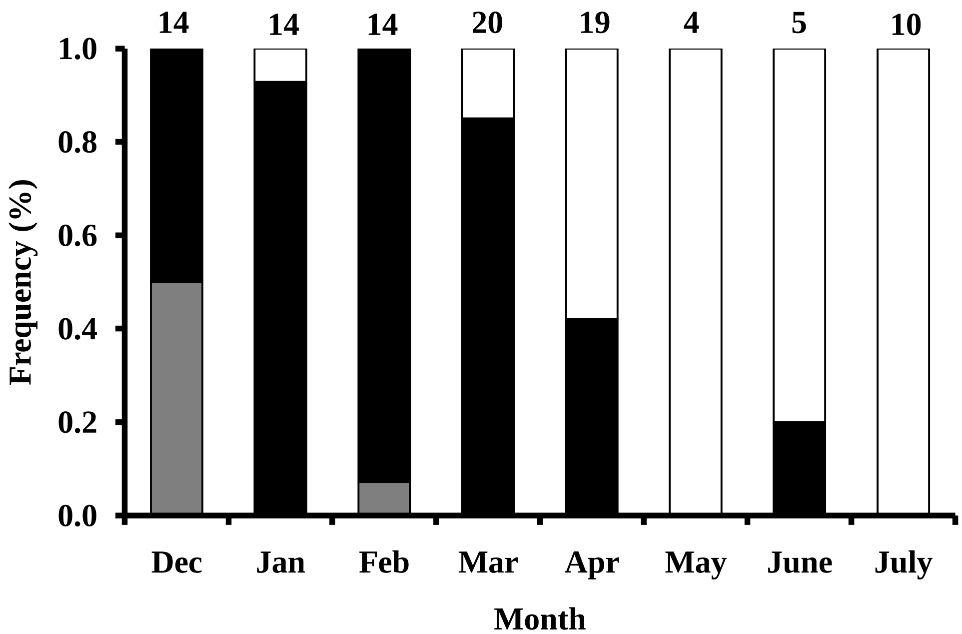

Figure 27. Percent of "developing" (grey bar), "spawning capable/actively spawning" (black bar) and "regressing/regenerating" (open bar) gonad developmental stages of female yellow bass collected 14 November 2008 to 17 November 2009, from the upper Barataria Estuary. Numbers above columns indicate the total number of fish examined each month.

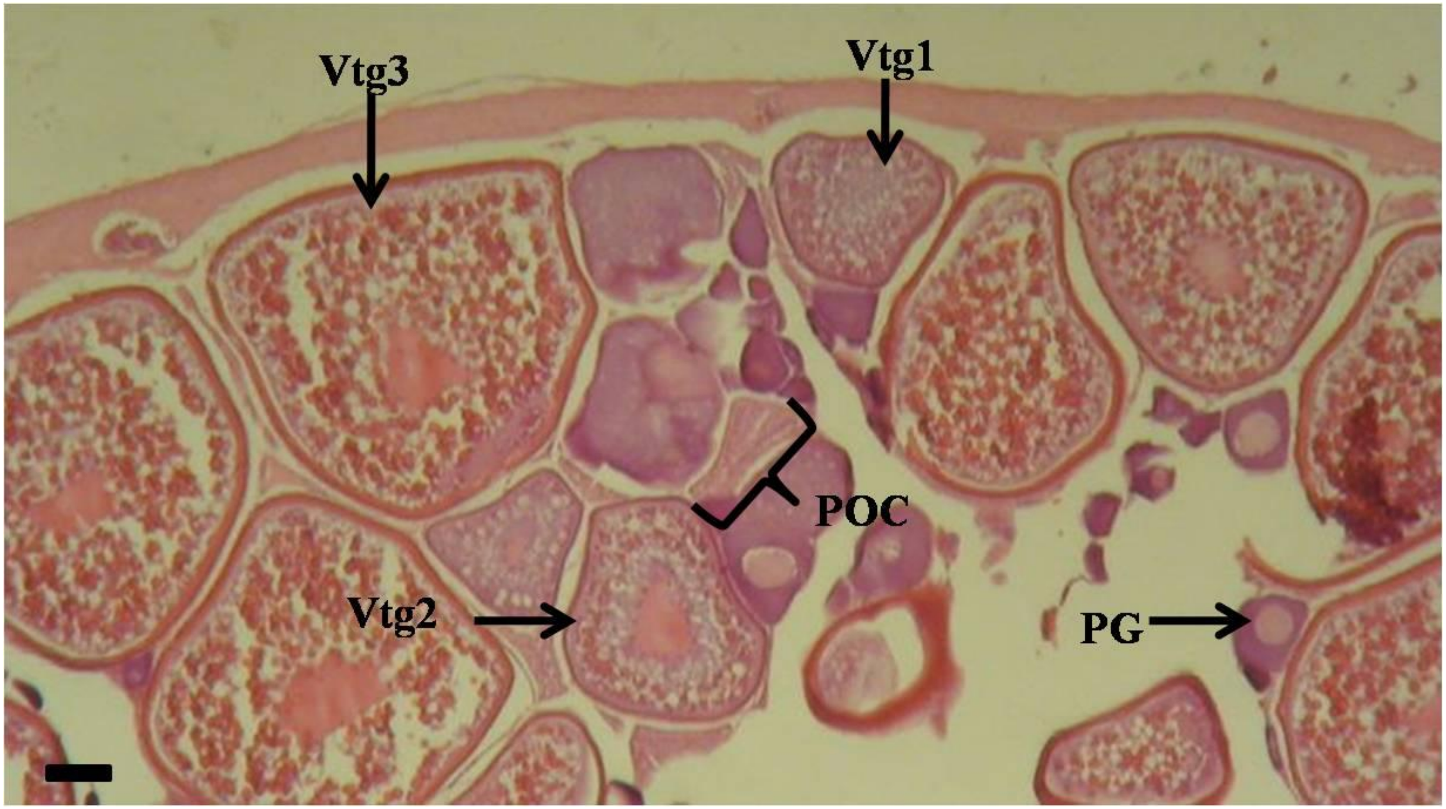

Figure 28. Histological section of a "spawning capable" yellow bass (TL = 218 mm) ovary with a >24 hour post-ovulatory follicle complex (Brown-Peterson et al. 2007) collected 04 March 2009, from the upper Barataria Estuary. Bar = 10 µm. PG – primary growth oocyte; Vtg1 – primary vitellogenic oocyte; Vtg2 – secondary vitellogenic oocyte; Vtg3 – tertiary vitellogenic oocyte; POC – post-ovulatory follicle complex.

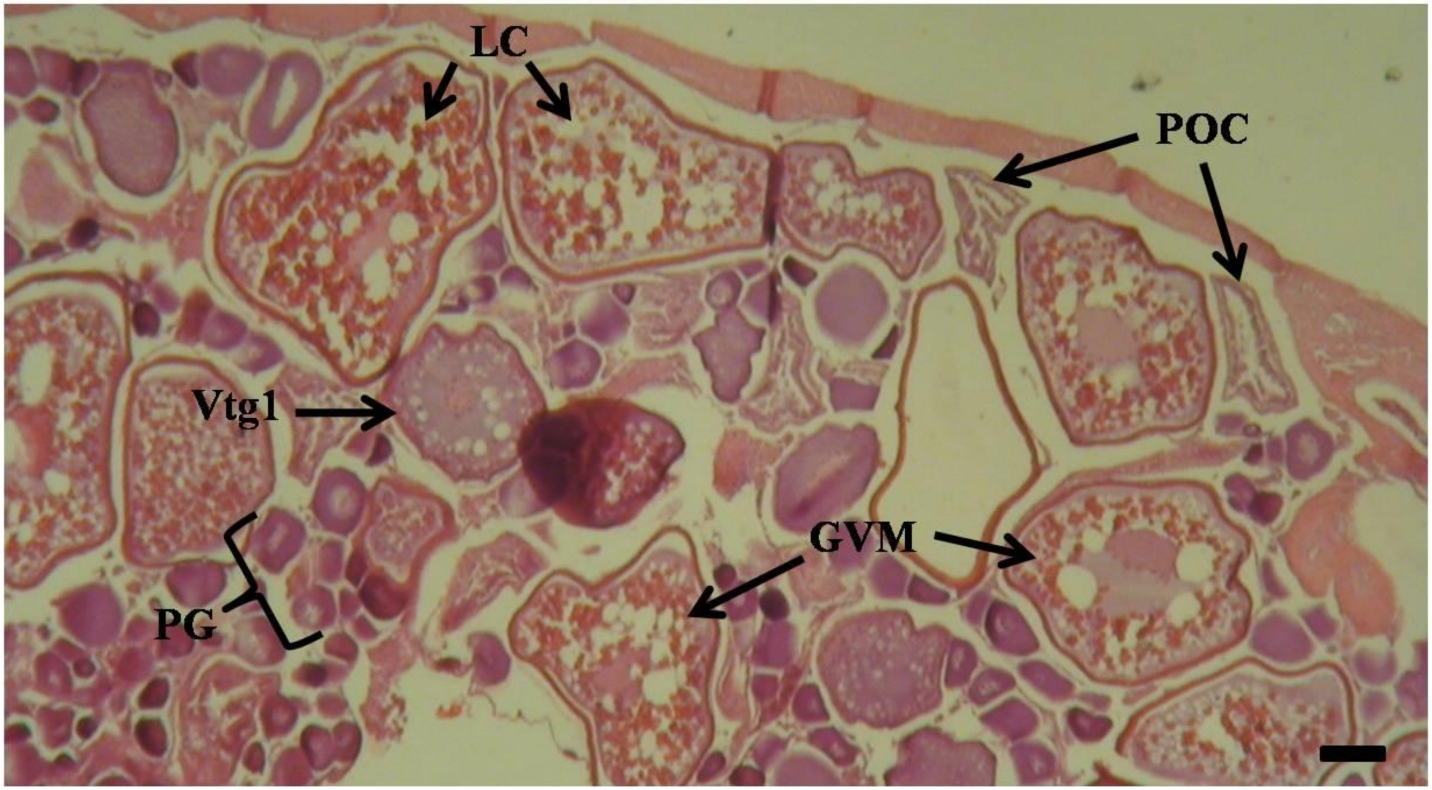

Figure 29. Histological section of an "actively spawning" yellow bass (TL = 235 mm) ovary with oocytes undergoing lipid coalescence and germinal vesicle migration collected on 10 Apr 2009, from the upper Barataria Estuary. Bar = 10 µm. PG – primary growth oocyte; Vtg1 – primary vitellogenic oocyte; GVM – germinal vesicle migration; LC – lipid coalescence; POC – post-ovulatory follicle complex.

“actively spawning” female was collected in January and in June (Figure 27). Twelve females, collected from January through May (Figure 27), were classified as “regressing,” (Figure 30) and twenty-one females, collected from April through July (Figure 27), were classified as “regenerating” (Figure 31). “Developing” (Figure 32) females were collected in December (N = 7) and February (N = 1; Figure 27).

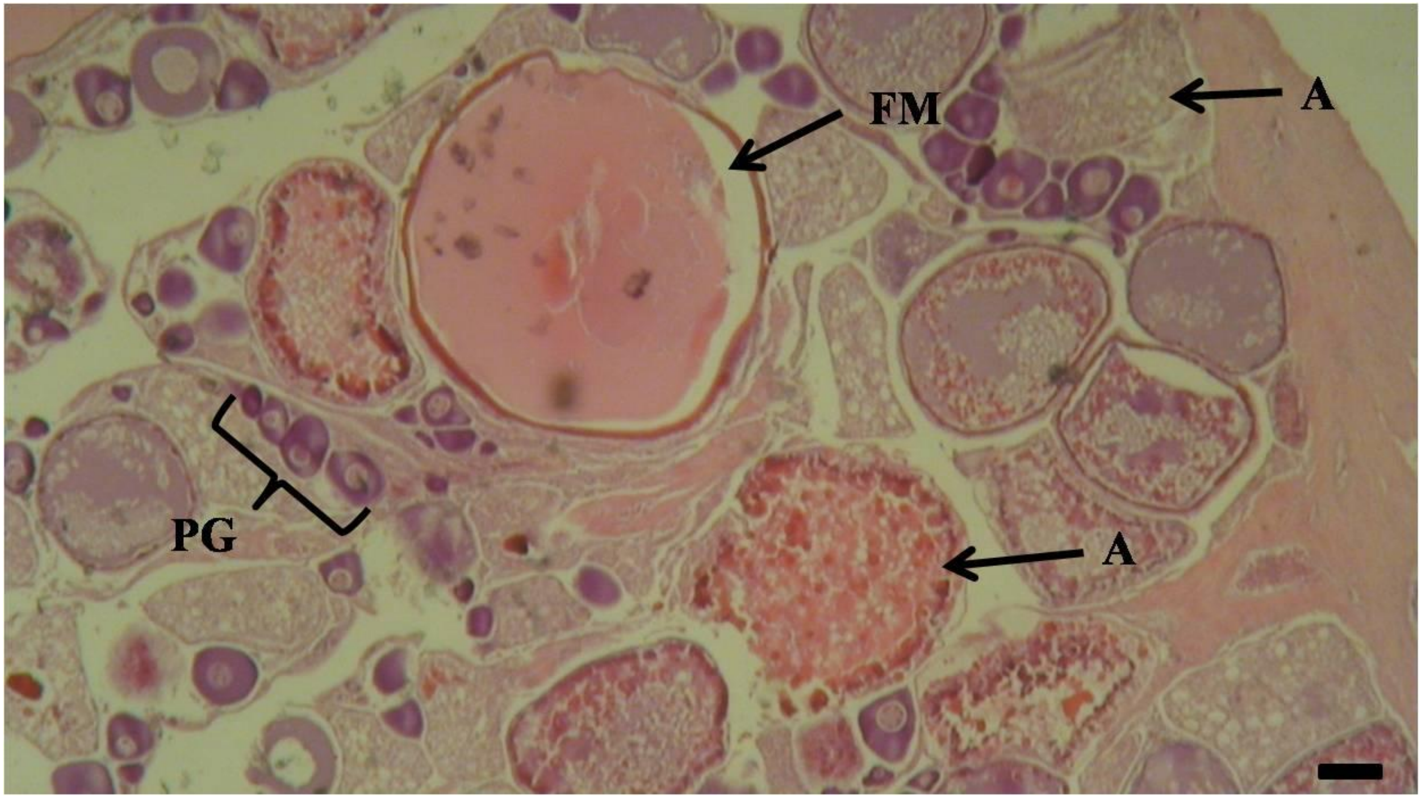

Figure 30. Histological section of a "regressing" yellow bass (TL = 230 mm) ovary with mostly atretic oocytes collected on 18 March 2009, from the upper Barataria Estuary. Bar = 10 µm. PG – primary growth oocytes; FMO – final maturation oocytes; A – atretic oocytes.

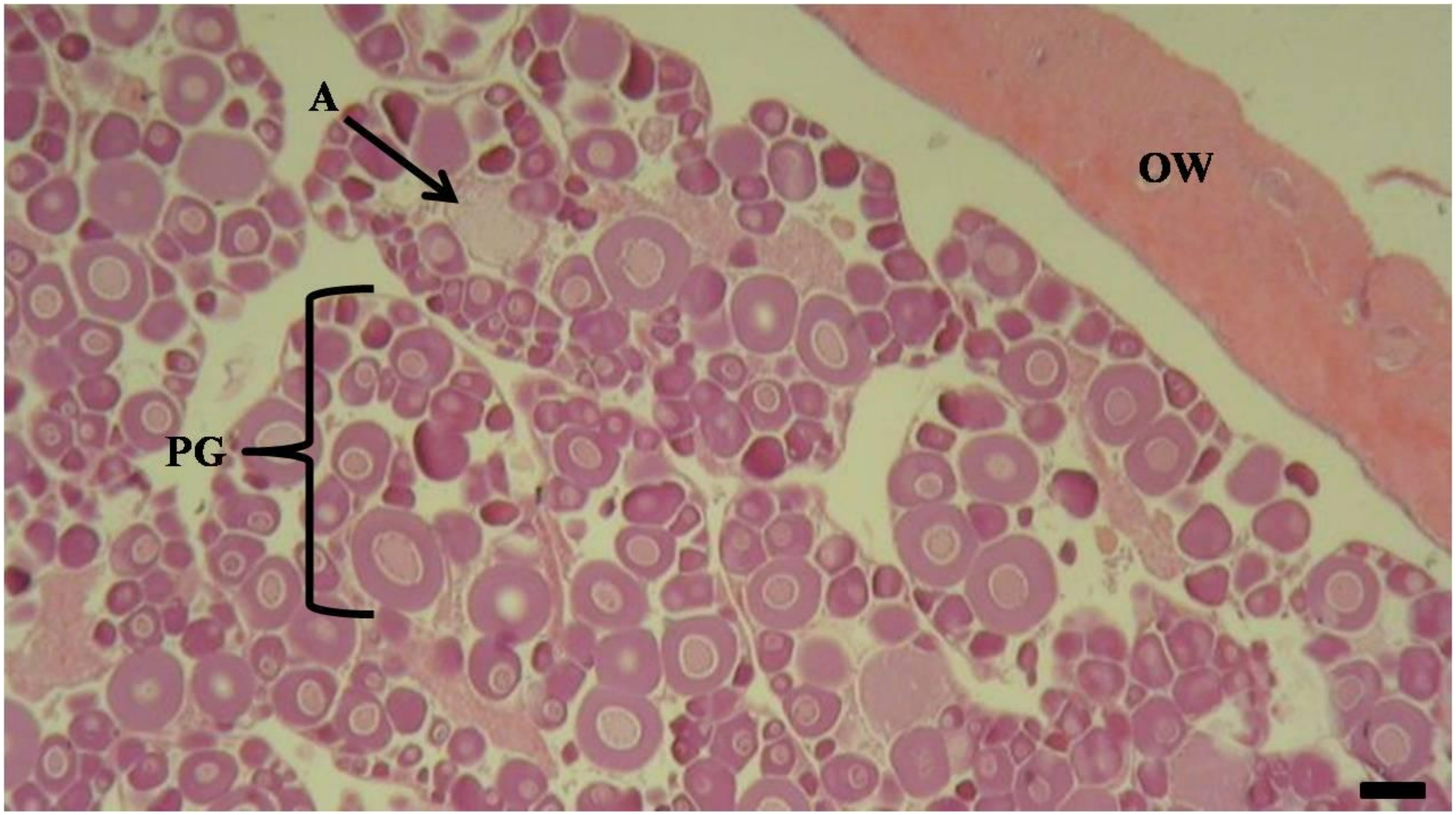

Figure 31. Histological section of a "regenerating" yellow bass (TL = 225 mm) ovary collected 15 April 2009, from the upper Barataria Estuary. Bar = 10 µm. PG – primary growth oocytes; A – atretic oocytes; OW – ovarian wall.

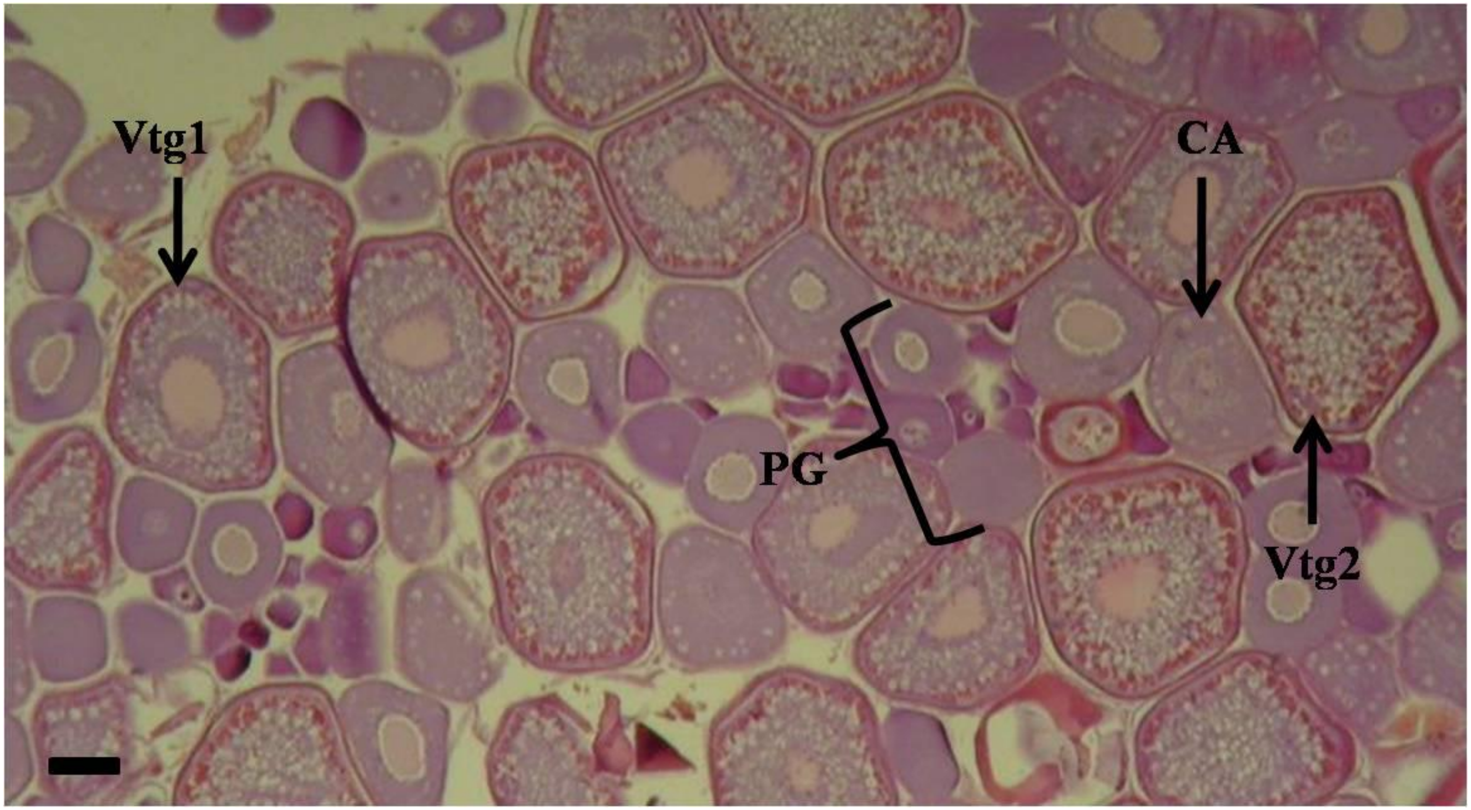

Figure 32. Histological section of a "developing" yellow bass (TL = 195 mm) ovary with many primary growth oocytes and primary vitellogenic oocytes present throughout, collected 19 December 2009, from the upper Barataria Estuary. Bar = 10 µm. PG – primary growth oocytes; CA – cortical alveolar oocytes; Vtg1 – primary vitellogenic oocytes; Vtg2 – secondary vitellogenic oocytes.

DISCUSSION

I have documented the occurrence and spawning of the yellow bass in the upper Barataria Estuary. The yellow bass occurs in the Mississippi River drainage basin and is common in natural lakes and oxbows of river systems (Harlan and Speaker 1956; Cook 1959; Becker 1983; Ross 2001). Yellow bass have been introduced into lakes and reservoirs in Alabama, Tennessee, Illinois, Wisconsin and Iowa (Harlan and Speaker 1956; Smith 1979; Becker 1983; Mettee et al. 1996; Etnier and Starnes 2001). Yellow bass populations can fluctuate in size and are often dominated by one or two large age classes that may be separated by several years (Harlan and Speaker 1956; Becker 1983). A dominant yellow bass year class may be large enough to negatively affect other fish species (Harlan and Speaker 1956; Cook 1959; Becker 1983; Lucas et al. 1994; Carlander 1997).

Like many other species, yellow bass abundance in spawning habitats fluctuates during the year due to movements into and out of spawning areas. Yellow bass were collected each month, but were most abundant in early spring due to movement into spawning areas. Similar seasonal fluctuations have been recorded for yellow bass in Iowa (Harlan and Speaker 1956), Illinois (Smith 1979), and Wisconsin (Becker 1983). Yellow bass were the most abundant species collected followed by gizzard shad and spotted gar, respectively. Because gill nets are size selective this is probably not a true representation of the fish community in the UBE. Previous studies in the UBE that used similar gill nets also recorded high species composition of gizzard shad (13.2%, Davis 2006;

71.5%, Fontenot 2006; 21.9% Smith 2008) and spotted gar (38%, Davis 2006; 11% Fontenot 2006; 59.7%, Smith 2008). However, these studies collected relatively few yellow bass (by % species composition1.3%, Davis 2006; 2.5% Fontenot 2006; 0.5%, Smith 2008) when compared to the 27.5% collected during this study. It appears that the yellow bass population in the UBE is subject to dominant year classes.

Spawning in fish can be affected by several different environmental factors. Temperature and photoperiod influence fish reproduction by stimulating sensory organs that induce the production of gonad hormones, which can induce physiological or behavioral responses (Junk 1999). Temperature and photoperiod cues ensure that fish will spawn at a specific time so that sufficient prey will be available to the larvae (Brander and Hurley 1992; Myers et al. 1993). For aquaculture purposes temperature and photoperiod have been manipulated to alter spawning times of Atlantic salmon *Salmo salar* (Taranger et al. 1998), rainbow trout *Oncorhynchus mykiss* (Bromage et al. 1984), and common carp (Davies et al. 1986). Gizzard shad in the UBE migrate into Bayou Chevreuil to spawn when temperatures reach 17 to 22ºC (Fontenot et al. *in press*). Throughout their range yellow bass spawn when water temperature reaches approximately 18ºC (Bulkley 1970; Becker 1983), similar to the results of this study.

Salinity is important to species whose larval and juvenile stages may require a different salinity than adults. Striped bass spend most of their adult lives in salt water but migrate into brackish and freshwater streams to spawn (Nichols 1966). Dantin et al. (*in press*) found that blue crabs use Bayou Chevreuil as nursery and maturation grounds before migrating to coastal saline waters to spawn. My sample sites are part of an estuary continuum that extends from the upper reaches of Bayou Chevreuil through Lac des Allemands, Lake Salvador, and Barataria Bay, to the Gulf of Mexico. Although salinity was representative of a fresh water system, salt water species were collected at some of my sampling sites. There is a possibility that under specific conditions transient peaks in salinity could extend into the bayous of the upper Barataria Estuary, as well as a gradual increase in ambient salinity. The effects of high salinities on the spawning activities of yellow bass have not been documented, but it would be likely to reduce acceptable yellow bass spawning habitat. Although yellow bass were not sampled in saline areas of the Barataria Estuary, spawning yellow bass were collected from fresh water regions of the estuary. Like other Moronids, yellow bass require fresh water for spawning habitat. If salt water intrusion continues to encroach the upper reaches of the Barataria Estuary, the area of acceptable yellow bass spawning habitat will be reduced.

The annual flood pulse of large rivers can also be an important spawning cue for species that rely on inundated floodplains for spawning or nursery habitat (Junk et al. 1989). The UBE no longer receives an annual flood pulse from the Mississippi River due to the construction of flood protection levees. The absence of a predictable annual spring flood pulse may negatively affect the spawning of many riverine species (Bayley 1995). Davis (2006) found that bowfin spawning in the UBE was negatively affected by the lack of a flood pulse; however, gizzard shad spawning did not appear to be negatively impacted (Jackson 2009; Fontenot et al. *in press*). Because there was no flood pulse associated with yellow bass spawning activity, it appears that the lack of a flood pulse did not negatively impact their spawning activity. However, long term effects of no flood pulse on yellow bass reproduction were not evaluated in this study.

Yellow bass abundance in the UBE appears to be related to spawning activity and not water quality. Neither hypoxic (DO < 2.0 mg/L) nor brackish (10-18 ppt) conditions were recorded during this study; however, it is unknown if hypoxic conditions would have affected yellow bass abundance. The floodplain did become inundated a few times during this study, but there were no changes in yellow bass abundance in relation to water level. The photoperiod associated with yellow bass spawning varies throughout the species' range with spawning occurring at shorter light periods at southern latitudes (Bulkley 1970; Becker 1983; Etnier and Starnes 2001). Yellow bass abundance increased as temperature reached 18-22ºC, which coincides with their spawning temperatures in other parts of their range (Bulkley 1970; Becker 1983). Therefore, yellow bass spawning activity appears to be more strongly affected by temperature than photoperiod.

Fish of the same species may grow and mature at different rates depending on local environmental conditions. For example, length at age of white bass in Texas was affected by latitude and longitude, total dissolved solids, water temperature and length of growing season (Wilde and Muoneke 2001). Gizzard shad collected in Missouri (Michaletz 1994) were smaller than gizzard shad collected in Alabama (Clayton and Maceina 2002) and Louisiana (Fontenot et al. *in press*). Burgess (1978) reported the maximum size of yellow bass to be 275 mm, but Priegel (1975) reported yellow bass in Lake Poygon, Wisconsin to reach 300 mm. Yellow bass collected in this study ranged from 175 – 264 mm with the majority (81%) between 195 and 225 mm, which is similar to the size range reported for yellow bass in Clear Lake, Iowa (Bulkley 1970) and Lake Poygon, Wisconsin (Priegel 1975). Yellow bass typically form size-based schools (Burnham 1909; Ross 2001), which suggests that schooling yellow bass are the same year class. Because the majority of yellow bass collected during this study were within a 30 mm size range, it is likely that the yellow bass were members of a dominant year class.

The lifespan of yellow bass is approximately six years (Lee et al. 1980; Becker 1983; Pflieger 1997); however, maximum age varies throughout their range. In Reelfoot Lake, Tennessee the maximum yellow bass age was 5 (Schoffman 1958), and maximum age of yellow bass in Clear Lake, Iowa was 8 years (Carlander 1997). The maximum age for yellow bass in this study was 4 years, but the majority were age 2. Females were larger than males at ages 2 and 4. This is typical for many fishes such as bowfin (Davis 2006), gizzard shad (Fontenot et al. *in press*), striped bass (Nichols 1966), red drum (Turner et al. 2002), American eel *Anguilla anguilla* (Poole and Reynolds 1995), and scalloped hammerhead sharks *Sphyrna lewini* (Klimley 1987). Because larger females have larger ovaries and larger energy reserves when compared to smaller females, larger females may produce more and larger eggs than smaller individuals (Bagenal 1978; Moyle and Cech 1982).

According to Becker (1983), yellow bass spawning occurs in tributary streams and lakes during May and June in Wisconsin. In Clear Lake, Iowa and Reelfoot Lake, Tennessee yellow bass spawn in April and May (Bulkley 1970; Etnier and Starnes 2001). The yellow bass spawning period appears to occur earlier in the UBE than in more northern latitudes. Fish populations in lower latitudes often begin spawning earlier in the year than do populations of the same species in more northern latitudes as seen in gizzard shad (Fontenot 2006) and spotted gar (Smith 2008). Temporal changes in GSI has been used to provide rough estimations of spawning periods for spotted seatrout *Cynoscion nebulosus* (Brown-Peterson et al. 2002), black drum *Pogonias cromis* (Nieland and Wilson 1993), gizzard shad (Fontenot et al. *in press*), and spotted gar (Smith 2008). Yellow bass GSI peaked in early February and decreased through late April suggesting that the yellow bass spawning period in the UBE occurred from mid February through the end of April. Peak yellow bass abundance occurred in early March as GSI began to decrease, and remained high through April.

Histological examination of gonads can provide a more accurate estimate of fish spawning periods than GSI (Brown-Peterson et al. 2002, 2007). Although histology of striped bass (Berlinsky and Specker 1991), white bass (Berlinsky et al. 1995), and white perch (Jackson and Sullivan 1995) gonads has received attention in earlier studies, to date there are no published data on yellow bass gonad histology. According to Becker (1983), Etnier and Starnes (2001), and Ross (2001), yellow bass spawning period and activity correspond to that of the white bass; however, too few white bass were collected during this study for comparison. Unlike white bass, yellow bass are asynchronous batch spawners because all stages of oogenesis can be found in reproductive female (Blazer 2002; Grier 2009). All two year old yellow bass that were histologically examined in this study were mature. Yellow bass in Wisconsin matured at age 3 and yellow bass in Tennessee matured by age 2 (Carlander 1997). In populations of migratory fish, immature fish do not typically inhabit the same areas as mature adults particularly during spawning periods (Berlinsky and Specker 1991; Lucas et al. 2001; Olney et al. 2001), which may explain why only one 1 year old yellow bass was collected.

"Developing" females were collected in December and February indicating that the yellow bass were maturing and preparing for a spawning season. Maturing or developing fish commonly occur and have been found before and during the spawning season of striped bass (Berlinsky and Specker 1991), white bass (Berlinsky et al. 1995), spotted gar (Smith 2008), and American shad *Alosa sapidissima* (Olney et al. 2001). The majority (58%) of females examined were in the "spawning capable/actively spawning" stages and were collected from December to April. Similar results were found in white bass collected in November and March in South Carolina (Berlinsky et al. 1995). The presence of a single POC verified that spawning activity had occurred on 23 January 2009, but POCs became more common after 10 February 09. In asynchronous batch spawners "spawning capable" and "actively spawning" female ovaries may contain POCs, with "spawning capable" females having > 24 hr old POCs and "actively spawning" females having < 24 hr old POCs (Brown-

Peterson et al. 2007). Beginning in April, “regressing” and “regenerating” females made up 50% of the ovaries examined and the percentage of females in these stages continued to increase through May, June, and July. The observance of the “regressing” and “regenerating” stages indicated that females finished spawning and were preparing for the next spawning season. During the “regressing” stage females undergo atresia to reabsorb remaining eggs and begin generating primary growth oocytes in the “regenerating” stage (Brown-Peterson et al. 2007). These data, in combination with GSI values, indicate that yellow bass spawning occurred mid February through the end of April.

Histological analysis of gonads is more commonly applied to females rather than males (Berlinsky and Specker 1991; Nieland and Wilson 1993; Berlinsky et al. 1995; Brown-Peterson et al. 2002). As with the females, the majority of the male yellow bass gonads were staged as “spawning capable/actively spawning,” and all were collected from December through April. Beginning in April, male yellow bass entered the “regressing” and “regenerating” stages indicating they had finished spawning and were preparing for the next spawning season. The occurrence of these stages suggests that male yellow bass are not capable of spawning year round. In combination with GSI values, these data complement female histology data that yellow bass spawning occurred from February through the end of April.

In summary, yellow bass in the UBE follow a seasonal migration pattern that appears to be influenced by increasing water temperatures rather than a seasonal flood pulse. Yellow bass abundance does not appear to be related to other water quality parameters; however, it is unknown how low dissolved oxygen levels would have affected yellow bass abundance. Yellow bass were most abundant in the UBE from February 2009 through April 2009, suggesting a spawning aggregation. The yellow bass population in the upper Barataria Estuary was dominated by one strong year class (age 2). Female yellow bass were larger than male yellow bass at ages 2 and 4. GSI values indicated that yellow bass spawned in Bayou Chevreuil from mid February through late April when water temperatures were approximately 18-22ºC. The presence of POCs in ovaries indicated that yellow bass spawned in early spring in the upper Barataria Estuary. This study provides basic life history information about a lesser known species of the Mississippi River drainage basin as well as information about the general ecology of the upper reaches of the Barataria Estuary.

RECOMMENDATIONS

A long term study of the population structure of yellow bass and other fishes in the upper Barataria Estuary would provide important information on dominant year classes of yellow bass and their effect on other fish species. I also recommend a long term study of the water quality of the upper Barataria Estuary and how it affects seasonally abundant species.

A multiple year study of larval fish abundance in Bayou Chevreuil would facilitate a better understanding of which species use the area to spawn and how the altered hydrology affects fish reproduction in the upper Barataria Estuary. Specifically sampling should occur throughout the water column and on floodplain, near the banks, and in the main channel.

For future yellow bass studies, I recommend sampling throughout Lac des Allemands, and the other lakes and bayous in the upper and lower Barataria Estuary to find where yellow bass are located during the non-spawning season. A telemetry project would be most beneficial for yellow bass throughout the Barataria Estuary in identifying their yearly seasonal movement patterns. I also suggest sampling for yellow bass during both day and night to determine yellow bass activity throughout a 24 hour period.

I also suggest further age and growth studies of the yellow bass population in the upper Barataria Estuary. Age has not been validated for this species. Age validation is a necessary step in providing a better understanding of most species, therefore age validation of yellow bass would benefit future research on the species.

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APPENDIX I

Appendix I. Collection date (day month year), sampling site and yellow bass CPUE (± SE) for all dates sampled in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

Date	Site	CPUE ± SE
14 Nov 2008	1	0
14 Nov 2008	2	0
14 Nov 2008	3	0
21 Nov 2008	1	0.2459 ± 0.2459
21 Nov 2008	2	0
21 Nov 2008	3	0
21 Nov 2008	4	0
21 Nov 2008	5	0
21 Nov 2008	6	0
08 Dec 2008	1	0.0731 ± 0.0731
08 Dec 2008	2	0.2704 ± 0.1569
08 Dec 2008	3	0.0738 ± 0.0738
08 Dec 2008	4	0
08 Dec 2008	5	0
08 Dec 2008	6	0.0701 ± 0.0701
19 Dec 2008	1	0.3171 ± 0.2221
19 Dec 2008	2	0.7206 ± 0.4468
19 Dec 2008	3	1.2528 ± 0.6724
19 Dec 2008	4	0
19 Dec 2008	5	0.8088 ± 0.3253
19 Dec 2008	6	0
9 Jan 2009	1	0.6811 ± 0.4286
09 Jan 2009	2	0.5379 ± 0.2484
09 Jan 2009	3	0.3648 ± 0.1832
09 Jan 2009	4	0
09 Jan 2009	5	0
09 Jan 2009	6	0
21 Jan 2009	1	0.219 ± 0.219
21 Jan 2009	2	0
21 Jan 2009	3	0.1818 ± 0.1818
21 Jan 2009	4	0
21 Jan 2009	5	0.1524 ± 0.0881
21 Jan 2009	6	0.8526 ± 0.7391
03 Feb 2009	1	0.1604 ± 0.1604
03 Feb 2009	2	0.0777 ± 0.07772
03 Feb 2009	3	0.0708 ± 0.0708
03 Feb 2009	4	0
03 Feb 2009	5	1.0696 ± 0.7923
03 Feb 2009	6	0.6433 ± 0.4286
10 Feb 2009	1	0.2308 ± 0.2308

Date	Site	CPUE ± SE
10 Feb 2009	2	0.2963 ± 0.2111
10 Feb 2009	3	0.0682 ± 0.0682
10 Feb 2009	4	0.2103 ± 0.2103
10 Feb 2009	5	0.3347 ± 0.1934
10 Feb 2009	6	1.19 ± 0.7446
17 Feb 2009	4	0.5652 ± 0.3266
17 Feb 2009	5	0
17 Feb 2009	6	0.7331 ± 0.4566
26 Feb 2009	1	1.2522 ± 0.8749
26 Feb 2009	2	0.2184 ± 0.2184
26 Feb 2009	3	0.4807 ± 0.2281
26 Feb 2009	4	0.149 ± 0.0861
26 Feb 2009	5	1.6351 ± 0.9878
26 Feb 2009	6	3.9777 ± 2.144
03 Mar 2009	1	1.7387 ± 0.6432
03 Mar 2009	2	0.5671 ± 0.307
03 Mar 2009	3	0.418 ± 0.1603
03 Mar 2009	4	0
03 Mar 2009	5	0.1957 ± 0.1957
03 Mar 2009	6	0.3042 ± 0.1791
10 Mar 2009	1	7.0788 ± 2.5196
10 Mar 2009	2	2.1225 ± 1.099
10 Mar 2009	3	1.0055 ± 0.4604
10 Mar 2009	4	0.9673 ± 0.6899
10 Mar 2009	5	0.6566 ± 0.3663
10 Mar 2009	6	0.2499 ± 0.0974
17 Mar 2009	1	1.3889 ± 0.665
17 Mar 2009	2	0.7799 ± 0.3568
17 Mar 2009	3	0.5359 ± 0.2661
17 Mar 2009	4	0.0664 ± 0.0664
17 Mar 2009	5	0
17 Mar 2009	6	0
31 Mar 2009	1	1.6696 ± 0.8985
31 Mar 2009	2	0.7065 ± 0.3628
31 Mar 2009	3	0
31 Mar 2009	4	0.0711 ± 0.0711
31 Mar 2009	5	0
31 Mar 2009	6	0.0636 ± 0.0636
07 Apr 2009	1	7.2106 ± 2.4068
07 Apr 2009	2	0.4813 ± 0.4813
07 Apr 2009	3	0.0411 ± 0.0411
07 Apr 2009	4	0
07 Apr 2009	5	0
07 Apr 2009	6	0
14 Apr 2009	1	2.8527 ± 1.1566

Date	Site	CPUE ± SE
14 Apr 2009	2	0.758 ± 0.4509
14 Apr 2009	3	0.5441 ± 0.3304
14 Apr 2009	4	0.0798 ± 0.0798
14 Apr 2009	5	0
14 Apr 2009	6	0
28 Apr 2009	1	1.719 ± 0.7435
28 Apr 2009	2	0.0974 ± 0.0974
28 Apr 2009	3	0.2675 ± 0.1732
28 Apr 2009	4	0.2479 ± 0.2479
28 Apr 2009	5	0.283 ± 0.1634
28 Apr 2009	6	0.6149 ± 0.2463
11 May 2009	1	0
11 May 2009	2	0.1403 ± 0.0811
11 May 2009	3	0.1872 ± 0.1189
11 May 2009	4	0.2284 ± 0.2284
11 May 2009	5	0.0685 ± 0.0685
11 May 2009	6	0
03 Jun 2009	1	0
03 Jun 2009	2	0
03 Jun 2009	3	0
03 Jun 2009	4	0.0688 ± 0.0688
03 Jun 2009	5	0.2072 ± 0.1306
03 Jun 2009	6	0.0781 ± 0.0781
24 Jun 2009	1	0
24 Jun 2009	2	0
24 Jun 2009	3	0
24 Jun 2009	4	0
24 Jun 2009	5	0.3395 ± 0.2623
24 Jun 2009	6	0.0605 ± 0.0605
08 Jul 2009	1	0.075 ± 0.075
08 Jul 2009	2	0
08 Jul 2009	3	0
08 Jul 2009	4	0.0777 ± 0.0777
08 Jul 2009	5	0.2243 ± 0.144
08 Jul 2009	6	0.137 ± 0.137
22 Jul 2009	1	0
22 Jul 2009	2	0.0714 ± 0.0714
22 Jul 2009	3	0
22 Jul 2009	4	2.361 ± 1.0886
22 Jul 2009	5	1.0268 ± 0.653
22 Jul 2009	6	0
05 Aug 2009	1	0.1721 ± 0.1025
05 Aug 2009	2	0.0638 ± 0.0638
05 Aug 2009	3	0.056 ± 0.056
05 Aug 2009	4	0

Date	Site	CPUE ± SE
05 Aug 2009	5	0.5629 ± 0.1974
05 Aug 2009	6	0.0664 ± 0.0664
17 Aug 2009	1	0
17 Aug 2009	2	0
17 Aug 2009	3	0.0893 ± 0.0893
17 Aug 2009	4	0.1558 ± 0.09
17 Aug 2009	5	0
17 Aug 2009	6	0
14 Sep 2009	1	0
14 Sep 2009	2	0
14 Sep 2009	3	0
14 Sep 2009	4	0.2836 ± 0.0095
14 Sep 2009	5	0
14 Sep 2009	6	0.0607 ± 0.0607
27 Sep 2009	1	0
27 Sep 2009	2	0
27 Sep 2009	3	0
27 Sep 2009	4	0
27 Sep 2009	5	0
27 Sep 2009	6	0
13 Oct 2009	1	0.0773 ± 0.0773
13 Oct 2009	2	0
13 Oct 2009	3	0.0714 ± 0.0714
13 Oct 2009	4	0
13 Oct 2009	5	0
13 Oct 2009	6	0
25 Oct 2009	1	0
25 Oct 2009	2	0.2035 ± 0.1317
25 Oct 2009	3	0.1255 ± 0.1255
25 Oct 2009	4	0
25 Oct 2009	5	0
25 Oct 2009	6	0
17 Nov 2009	1	0
17 Nov 2009	2	0.1345 ± 0.1345
17 Nov 2009	3	0
17 Nov 2009	4	0
17 Nov 2009	5	0
17 Nov 2009	6	0

APPENDIX II

Appendix II. Collection date (day month year), sampling site, dissolved oxygen (DO; mg/L), temperature (ºC), salinity (ppt), and specific conductance (µS) for all dates sampled in the upper Barataria Estuary, 14 November 2008 to 17 November 2009. ND = no data.

Date	Site	DO (mg/L)	Temperature (°C)	Salinity (ppt)	Specific Conductance (µS)
14 Nov 2008	1	9.58	20.8	0.3	658
14 Nov 2008	2	8.29	21.5	0.3	639
14 Nov 2008	3	10.06	20.9	0.2	481
14 Nov 2008	4	9.83	19.2	0.1	247.1
14 Nov 2008	5	5.78	18.4	0.1	253.3
14 Nov 2008	6	4.22	18.1	0.1	258.7
21 Nov 2008	1	7.79	13.3	0.3	438.2
21 Nov 2008	2	7.52	13.2	0.3	424.4
21 Nov 2008	3	7.65	13.2	0.3	405.1
21 Nov 2008	4	3.78	15.5	0.1	203.1
21 Nov 2008	5	3.02	14.3	0.1	206.3
21 Nov 2008	6	2.99	14.7	0.1	210.6
8 Dec 2008	1	8.5	12.6	0.3	550
8 Dec 2008	2	8.57	12.9	0.2	316.9
8 Dec 2008	3	9.62	12.7	0.2	197.6
8 Dec 2008	4	3.9	14.5	0.1	212
8 Dec 2008	5	3.74	13.5	0.1	209.6
8 Dec 2008	6	3.21	12.7	0.1	205.5
19 Dec 2008	1	7.73	16.7	0.2	376.1
19 Dec 2008	2	8.7	18.1	0.1	270.1
19 Dec 2008	3	8.64	18.9	0.1	263.7
19 Dec 2008	4	0.71	18.2	0.1	225.6
19 Dec 2008	5	0.94	19.6	0.1	208.8
19 Dec 2008	6	0.71	19.1	0.1	212.4
9 Jan 2009	1	5.28	17.5	0.1	238.8
9 Jan 2009	2	5.09	17.6	0.1	198.9
9 Jan 2009	3	6.22	17.4	0.2	276.8
9 Jan 2009	4	1.43	16.5	0.1	182.4
9 Jan 2009	5	2.26	15.8	0.1	129.8
9 Jan 2009	6	2.03	16.3	0.1	128.4
21 Jan 2009	1	9.05	11.6	0.2	273.3
21 Jan 2009	2	8.25	10.7	0.1	209.3
21 Jan 2009	3	8.16	10.4	0.1	146.7
21 Jan 2009	4	4.11	11.5	0.1	158
21 Jan 2009	5	4.7	11.1	0.1	139.3
21 Jan 2009	6	4.22	11.5	0.1	140.5

Date	Site	DO (mg/L)	Temperature (°C)	Salinity (ppt)	Specific Conductance (µS)
3 Feb 2009	1	7.83	12.8	0.1	261.4
3 Feb 2009	2	7.89	13.3	0.1	236.8
3 Feb 2009	3	7.99	13.5	0.1	255.6
3 Feb 2009	4	4	13.2	0.1	185.3
3 Feb 2009	5	4.04	13.8	0.1	181.1
3 Feb 2009	6	3.91	12.9	0.1	174.1
10 Feb 2009	1	7.05	18.8	0.2	320.8
10 Feb 2009	2	7.54	18.6	0.2	326.9
10 Feb 2009	3	7.38	18.5	0.1	303.3
10 Feb 2009	4	7.89	18.1	0.1	273.3
10 Feb 2009	5	3	17.7	0.1	231.5
10 Feb 2009	6	6.02	16.9	0.1	244.5
17 Feb 2009	4	2.8	17.4	0.1	196
17 Feb 2009	5	2.8	17.4	0.1	175.2
17 Feb 2009	6	2.3	17.4	0.1	174.8
26 Feb 2009	1	7.35	17	0.2	322.8
26 Feb 2009	2	7.3	17.5	0.2	341.7
26 Feb 2009	3	7.41	17.7	0.1	299.8
26 Feb 2009	4	6.35	20	0.1	256.4
26 Feb 2009	5	7.16	21.3	0.1	244.2
26 Feb 2009	6	3.6	20.6	0.1	220.9
3 Mar 2009	1	7.99	13.3	0.2	332.2
3 Mar 2009	2	8.81	13.9	0.2	262.8
3 Mar 2009	3	8.1	13.8	0.2	323.3
3 Mar 2009	4	4.54	16	0.1	243.9
3 Mar 2009	5	3.46	15.5	0.1	232.3
3 Mar 2009	6	3.38	15.6	0.1	237.7
10 Mar 2009	1	6.24	21.8	0.2	353.1
10 Mar 2009	2	6.38	23.2	0.2	326.3
10 Mar 2009	3	6.29	23	0.2	334.2
10 Mar 2009	4	5.76	22	0.1	299.1
10 Mar 2009	5	5.28	22.1	0.1	273.7
10 Mar 2009	6	6.09	22.2	0.1	251.9
17 Mar 2009	1	7.1	23.5	0.2	336.9
17 Mar 2009	2	7.02	23.5	0.2	334.5
17 Mar 2009	3	7.1	23.8	0.2	328.2
17 Mar 2009	4	5.26	22.5	0.1	272
17 Mar 2009	5	3.21	20.4	0.1	247.2
17 Mar 2009	6	2.34	20.7	0.1	273.8
31 Mar 2009	1	6.77	20	0.3	603
31 Mar 2009	2	7.38	19.7	0.3	660
31 Mar 2009	3	4.11	19.7	0.2	336.5

Date	Site	DO (mg/L)	Temperature (°C)	Salinity (ppt)	Specific Conductance (µS)
31 Mar 2009	4	1.58	20.2	0.1	245.8
31 Mar 2009	5	1.28	19.6	0.1	181.4
31 Mar 2009	6	1.4	20.3	0.1	139.6
7 Apr 2009	1	7.96	21.5	0.1	237
7 Apr 2009	2	8.61	21.5	0.2	332
7 Apr 2009	3	6.26	21.8	0.1	237
7 Apr 2009	4	ND	ND	ND	ND
7 Apr 2009	5	ND	ND	ND	ND
7 Apr 2009	6	ND	ND	ND	ND
14 Apr 2009	1	7.91	21.2	0.1	296
14 Apr 2009	2	8.4	21.5	0.1	227
14 Apr 2009	3	7.5	21.8	0.1	215
14 Apr 2009	4	3.3	22.1	0.1	202
14 Apr 2009	5	2.44	21.9	0.1	186
14 Apr 2009	6	1.91	21.8	0.1	177
28 Apr 2009	1	8.53	24.6	0.3	558
28 Apr 2009	2	8.39	24.8	0.3	572
28 Apr 2009	3	8.86	25	0.2	386
28 Apr 2009	4	5.21	25.2	0.1	239
28 Apr 2009	5	7.6	25.4	0.1	324
28 Apr 2009	6	7.65	24.6	0.2	431
11May 2009	1	6.53	27.9	0.2	403
11 May 2009	2	8.87	27.4	0.2	354
11 May 2009	3	4.33	27.6	0.1	266
11 May 2009	4	1.88	27.7	0.1	183
11 May 2009	5	1.64	27.2	0.1	139
11 May 2009	6	1.22	27.2	0.1	115
3 Jun 2009	1	7.77	27.5	0.2	368
3 Jun 2009	2	8.56	27.5	0.2	311
3 Jun 2009	3	8.71	27.7	0.1	284
3 Jun 2009	4	5.1	27.5	0.1	183
3 Jun 2009	5	3.52	26.4	0.1	135
3 Jun 2009	6	3.2	25.2	0.1	126
24 Jun 2009	1	5.56	31.1	0.2	413.8
24 Jun 2009	2	4.06	30.9	0.2	387
24 Jun 2009	3	6.85	31.5	0.2	375.2
24 Jun 2009	4	3.98	33	0.1	214.2
24 Jun 2009	5	4.04	32.4	0.1	197.8
24 Jun 2009	6	5.54	33.8	0.1	207.3
8 Jul 2009	1	6.6	30.1	0.2	343.2
8 Jul 2009	2	7.9	30.2	0.2	333
8 Jul 2009	3	5.56	29.6	0.2	317.5

Date	Site	DO (mg/L)	Temperature (°C)	Salinity (ppt)	Specific Conductance (μS)
8 Jul 2009	4	2.96	30.1	0.1	227.5
8 Jul 2009	5	3.07	29.6	0.1	267.8
8 Jul 2009	6	2.39	29.1	0.1	216.1
22 Jul 2009	1	2.8	29.1	0.2	342.3
22 Jul 2009	2	4.46	29.2	0.2	342.1
22 Jul 2009	3	4.64	29.4	0.2	316
22 Jul 2009	4	4.15	29.4	0.1	300.2
22 Jul 2009	5	4.73	29.3	0.1	303
22 Jul 2009	6	0.88	28.6	0.1	247.5
5 Aug 2009	1	3.39	31.5	0.2	ND
5 Aug 2009	2	4.32	31.6	0.2	ND
5 Aug 2009	3	4.4	31.6	0.2	ND
5 Aug 2009	4	6.21	30.5	0.1	190.1
5 Aug 2009	5	7.23	30.6	0.1	196.4
5 Aug 2009	6	7.03	30.6	0.1	217.7
17 Aug 2009	1	2.45	30.9	0.2	879.7
17 Aug 2009	2	3.55	30.9	0.2	870.5
17 Aug 2009	3	4.77	31.8	0.2	855.6
17 Aug 2009	4	3.06	32.7	0.2	ND
17 Aug 2009	5	2.4	30.6	0.1	199
17 Aug 2009	6	2.77	31.2	0.1	174.3
14 Sep 2009	1	9.07	27.8	0.1	436.1
14 Sep 2009	2	10.12	27.8	0.1	420.4
14 Sep 2009	3	7.02	27.8	0.1	413
14 Sep 2009	4	6.3	27.2	0.2	375.5
14 Sep 2009	5	2.13	27.4	0.1	186.4
14 Sep 2009	6	2.14	26.8	0.1	150.9
27 Sep 2009	1	11.13	32.3	0.2	453.5
27 Sep 2009	2	10.43	31.9	0.2	418.8
27 Sep 2009	3	10.23	31.7	0.1	270.6
27 Sep 2009	4	1.15	27.1	0.1	183.7
27 Sep 2009	5	0.84	27.1	0.1	137.1
27 Sep 2009	6	0.95	27.2	0.1	120.1
13 Oct 2009	1	11.55	26.3	0.2	362.4
13 Oct 2009	2	7.82	26.8	0.2	371.7
13 Oct 2009	3	7.14	26.5	0.1	243
13 Oct 2009	4	1.07	25.3	0.1	167.7
13 Oct 2009	5	0.7	25.2	0.1	128.1
13 Oct 2009	6	0.75	25.4	0.1	127.7
25 Oct 2009	1	14.3	19.8	0.1	216.1
25 Oct 2009	2	8.2	19.7	0.1	233.4
25 Oct 2009	3	7.78	19.9	0.1	198.1

Date	Site	DO (mg/L)	Temperature (°C)	Salinity (ppt)	Specific Conductance (μS)
25 Oct 2009	4	3.6	19.9	0.1	627.6
25 Oct 2009	5	3.24	18.7	0.1	123.7
25 Oct 2009	6	3.67	18.7	0.1	119.9
17 Oct 2009	1	9.11	17	0.1	231.4
17 Oct 2009	2	7.53	17.5	0.1	211.9
17 Oct 2009	3	6.74	17.2	0.1	200.3
17 Oct 2009	4	ND	ND	ND	ND
17 Oct 2009	5	ND	ND	ND	ND
17 Oct 2009	6	ND	ND	ND	ND

APPENDIX III

Appendix III. Collection date (day month year) sampling site, sex, number collected, total length (TL ± SE), total weight (Wt ± SE), and gonadosomatic index (GSI ± SE) for yellow bass collected in the upper Barataria Estuary, 14 November 2008 to 17 November 2009.

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
21 Nov 2008	1	M	1	195	106	1.9
08 Dec 2008	1	M	1	195	113.5	1.8
08 Dec 2008	2	F	2	207.5 ± 2.5	127 ± 2	3.9 ± 0.4
08 Dec 2008	2	M	2	197.5 ± 2.5	108.5 ± 0.5	2.5 ± 0.5
08 Dec 2008	3	F	1	208	131	1.9
08 Dec 2008	6	F	1	220	161	4.3
19 Dec 2008	1	F	3	214 ± 2.3	139.7 ± 1.7	3.8 ± 0.5
19 Dec 2008	1	M	1	202	128	5
19 Dec 2008	2	F	4	209.5 ± 2.5	148. ± 7.7	4.5 ± 0.2
19 Dec 2008	2	M	6	204.5 ± 2.	132.5 ± 9.1	3.8 ± 0.3
19 Dec 2008	3	F	10	211.3 ± 2.4	146.5 ± 9.2	4.4 ± 0.4
19 Dec 2008	3	M	9	205 ± 3.1	130.1 ± 5.2	3.8 ± 0.2
19 Dec 2008	5	F	10	219.6 ± 6.9	168.5 ± 16.5	5.3 ± 0.5
19 Dec 2008	5	M	6	217 ± 9.7	168.1 ± 22.5	4.3 ± 0.3
09 Jan 2009	1	F	4	208.5 ± 3.8	144.6 ± 19.1	6.1 ± 1.6
09 Jan 2009	1	M	7	202 ± 2.2	127 ± 2	4.4 ± 0.4
09 Jan 2009	2	F	5	210.4 ± 3.9	148.3 ± 15.3	5.7 ± 1.3
09 Jan 2009	2	M	3	203.7 ± 5.5	129.2 ± 7	5.1 ± 0.2
09 Jan 2009	3	M	5	199.6 ± 4.4	116.7 ± 6.2	3.8 ± 0.5

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
19 Jan 2009	6	F	1	221	189	8.672
19 Jan 2009	6	M	6	214.7 ± 3.3	166.7 ± 8.3	5.1 ± 0.5
21 Jan 2009	1	F	2	218.5 ± 4.5	162.8 ± 9.8	9.1 ± 1.6
21 Jan 2009	3	F	2	222 ± 2	170.3 ± 1.8	8.2 ± 3.6
21 Jan 2009	5	M	2	212 ± 1	150.8 ± 10.3	6.2 ± 0.1
21 Jan 2009	6	F	2	242.5 ± 20.5	258.8 ± 88.8	10.1 ± 0.9
21 Jan 2009	6	M	10	220.5 ± 1.9	164.25 ± 5.3	6.5 ± 0.1
03 Feb 2009	1	F	2	217 ± 13	163.5 ± 29.5	10.3 ± 0.6
03 Feb 2009	2	M	1	215	148	5.1
03 Feb 2009	3	F	1	206	130.5	15.4
03 Feb 2009	5	F	9	219.3 ± 2.6	177.4 ± 8.6	12.9 ± 0.5
03 Feb 2009	5	M	6	217.5 ± 2	159.4 ± 6.9	6.9 ± 0.2
03 Feb 2009	6	M	11	209.1 ± 3.5	132 ± 6.4	6.3 ± 0.3
10 Feb 2009	4	F	3	221 ± 11.5	181.2 ± 28.5	9.7 ± 0.9
10 Feb 2009	5	F	2	209.5 ± 4.5	169.5 ± 20	14.4 ± 1.4
10 Feb 2009	5	M	4	208.5 ± 4.8	145 ± 9.8	6.9 ± 0.4
10 Feb 2009	6	F	4	215.25 ± 8.3	156.6 ± 18.5	13.6 ± 1.1
10 Feb 2009	6	M	13	207.2 ± 1.6	136.3 ± 3.9	6.3 ± 0.3
10 Feb 2009	1	F	2	209.5 ± 9.5	144 ± 32	6.1 ± 2.6
10 Feb 2009	1	M	1	216	150	5.4
10 Feb 2009	2	F	3	222.7 ± 6.8	189.7 ± 14.9	10.9 ± 1.5
10 Feb 2009	2	M	1	210	138.5	4.6
10 Feb 2009	3	F	1	225	176	8.5
17 Feb 2009	4	F	2	212.5 ± 2.5	162 ± 18.5	11.5 ± 0.2
17 Feb 2009	4	M	6	195.7 ± 15.7	142.9 ± 8.4	5.239 ± 0.1
17 Feb 2009	6	F	2	228 ± 2	186 ± 1.5	11.9 ± 0.2

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
17 Feb 2009	6	M	15	210.9 ± 1.5	138.9 ± 2.8	5.6 ± 0.1
26 Feb 2009	1	F	1	215	178.5	15.6
26 Feb 2009	1	M	15	201.3 ± 2.6	121.7 ± 5.1	4.3 ± 0.3
26 Feb 2009	2	F	1	214	151	10.1
26 Feb 2009	2	M	2	208.5 ± 3.5	126 ± 13.5	4.7 ± 0.6
26 Feb 2009	3	F	4	212.5 ± 5.2	153.8 ± 6.3	9.8 ± 2.2
26 Feb 2009	3	M	3	196.7 ± 2.7	112.3 ± 10	4.7 ± 0.5
26 Feb 2009	4	M	2	212.5 ± 10.5	136 ± 12	4.7 ± 0.2
26 Feb 2009	5	F	12	214.6 ± 2.9	155.4 ± 6.1	11.7 ± 0.8
26 Feb 2009	5	M	14	209 ± 3	135.2 ± 5.4	4.8 ± 0.2
26 Feb 2009	6	F	14	214.8 ± 2.4	152.2 ± 5.8	10.5 ± 0.7
26 Feb 2009	6	M	67	213.2 ± 0.9	137.4 ± 1.9	5 ± 0.1
03 Mar 2009	1	F	1	203	123	6.9
03 Mar 2009	5	M	2	207.5 ± 2.5	124	4.1 ± 0.7
03 Mar 2009	6	M	5	208 ± 6.6	122.6 ± 11.2	4.2 ± 0.5
03 Mar 2009	1	M	23	201.6 ± 1.9	120 ± 3.5	3.7 ± 0.2
03 Mar 2009	2	F	5	210.8 ± 4.7	143.4 ± 9.6	7.3 ± 0.6
03 Mar 2009	2	M	3	213.3 ± 6.2	153.8 ± 10	4 ± 0.1
03 Mar 2009	3	F	4	203.5 ± 3.5	140.3 ± 8.4	8.1 ± 0.9
03 Mar 2009	3	M	1	209	126	2.7
10 Mar 2009	4	F	4	215.8 ± 5.1	145.4 ± 11.6	4.9 ± 0.2
10 Mar 2009	4	M	9	213.8 ± 2.6	132 ± 4.1	3.8 ± 0.2
10 Mar 2009	5	F	6	217.5 ± 4.1	150 ± 7.5	7.7 ± 1.4
10 Mar 2009	5	M	5	208.2 ± 2.8	124.8 ± 4.3	3.7 ± 0.3
10 Mar 2009	6	F	3	210.7 ± 5.4	132.3 ± 6.6	7.4 ± 0.9
10 Mar 2009	6	M	2	201.5 ± 2.5	106.8 ± 5.3	4 ± 1.43

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
10 Mar 2009	1	F	19	209.1 ± 2.6	139.8 ± 4.5	6.7 ± 0.4
10 Mar 2009	1	M	85	206.2 ± 1.5	123.4 ± 2.2	2.8 ± 0.1
10 Mar 2009	2	F	14	213.6 ± 2.4	148.3 ± 4.7	6.9 ± 0.5
10 Mar 2009	2	M	26	207.3 ± 1.9	124.9 ± 3.5	2.9 ± 0.2
10 Mar 2009	3	F	8	208.8 ± 3.7	145.9 ± 10.5	7.5 ± 0.7
10 Mar 2009	3	M	11	208.3 ± 2.3	131.5 ± 8.9	2.9 ± 0.2
17 Mar 2009	4	M	1	200	120.5	3.3
17 Mar 2009	1	F	4	211.3 ± 4.5	149.9 ± 9.1	5.8 ± 1.1
17 Mar 2009	1	M	18	208.9 ± 2.3	130.2 ± 4.5	2.6 ± 0.2
17 Mar 2009	2	F	5	211.4 ± 4.8	146.9 ± 9.7	7 ± 1.3
17 Mar 2009	2	M	6	201.7 ± 4.1	117.5 ± 6.1	4.5 ± 1.5
17 Mar 2009	3	F	4	211.3 ± 6.6	148.5 ± 12.6	6.7 ± 1.6
17 Mar 2009	3	M	3	204.7 ± 5.8	126.3 ± 10.9	2.1 ± 0.4
31 Mar 2009	4	M	1	225	166.5	1.4
31 Mar 2009	6	F	1	204	118	3
31 Mar 2009	1	F	12	211.6 ± 3	138.8 ± 6.2	4.6 ± 0.9
31 Mar 2009	1	M	14	203.4 ± 2	117.8 ± 3.2	1.2 ± 0.2
31 Mar 2009	2	F	3	211 ± 0.6	133.3 ± 3.6	0.9
31 Mar 2009	2	M	6	204 ± 1.5	121.7 ± 2.9	1.9 ± 0.3
07 Apr 2009	1	F	5	223.6 ± 3.1	161.5 ± 8.3	3.5 ± 0.6
07 Apr 2009	1	M	197	209 ± 0.7	134.6 ± 1.4	1.7± 0.1
07 Apr 2009	2	F	9	213.8 ± 3	150 ± 6.6	1.5 ± 0.7
07 Apr 2009	2	M	4	204 ± 6.1	125.1 ± 7.3	1.6 ± 0.2
07 Apr 2009	3	M	1	200	126.5	1.9
14 Apr 2009	4	M	1	215	135.5	1.4
14 Apr 2009	1	F	3	217 ± 5.7	145.3 ± 5.4	1.5 ± 0.9

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
14 Apr 2009	1	M	32	205.5 ± 1.6	125.2 ± 2.9	2 ± 0.2
14 Apr 2009	2	F	4	204.3 ± 3.6	130.1 ± 1.8	1.7 ± 0.8
14 Apr 2009	2	M	6	206.3 ± 5	123.2 ± 8.6	1.6 ± 0.4
14 Apr 2009	3	F	2	219 ± 1	151 ± 5.5	1.8 ± 1.2
14 Apr 2009	3	M	6	213.8 ± 3.1	131.2 ± 5	1.6 ± 0.4
28 Apr 2009	4	F	2	208 ± 3	135 ± 4	4.6 ± 3.9
28 Apr 2009	4	M	2	194.5 ± 19.5	126.5 ± 2.5	0.3 ± 0.2
28 Apr 2009	5	F	3	211 ± 3.2	132.8 ± 14.3	1.3 ± 0.2
28 Apr 2009	6	F	3	212 ± 6	142.3 ± 9	0.6 ± 0.1
28 Apr 2009	6	M	6	187 ± 13.5	115.8 ± 3	0.4 ± 0.2
28 Apr 2009	1	F	8	213 ± 2.1	141.5 ± 4.1	0.6 ± 0.1
28 Apr 2009	1	M	9	206.1 ± 2.6	124.4 ± 5.2	0.3 ± 0.1
28 Apr 2009	2	M	1	195	105	0.7
28 Apr 2009	3	F	1	215	147	0.5
28 Apr 2009	3	M	2	213 ± 3	148.5 ± 5.5	0.2
11 May 2009	4	F	1	217	130	0.6
11 May 2009	4	M	2	214 ± 1	143.3 ± 1.75	0.1
11 May 2009	5	M	1	216	146	0.2
11 May 2009	2	F	2	185 ± 25	148.8 ± 20.75	0.5 ± 0.1
11 May 2009	3	F	1	192	93	0.5
11 May 2009	3	M	2	209.5 ± 6.5	127 ± 19	0.1
03 Jun 2009	4	M	1	200	134.5	0.1
03 Jun 2009	5	M	3	212	141.5 ± 1.6	0.1
03 Jun 2009	6	F	1	216	155.5	0.4
24 Jun 2009	5	F	3	185.7 ± 20.8	132.3 ± 9.4	0.6
24 Jun 2009	5	M	2	175 ± 30	107.5 ± 1.5	0.1

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
24 Jun 2009	6	F	1	182	116.5	0.6
08 Jul 2009	4	F	1	211	133.5	0.4
08 Jul 2009	5	F	3	197.7 ± 13.8	152.5 ± 10.4	0.5 ± 0.1
08 Jul 2009	6	F	1	207	133	0.6
08 Jul 2009	6	M	1	170	149	0.1
08 Jul 2009	1	M	1	206	118	0.1
22 Jul 2009	4	F	12	212 ± 3	134.1 ± 4.9	0.6
22 Jul 2009	4	M	22	204.9 ± 4.3	129. ± 2.6	0.1
22 Jul 2009	5	F	10	213.1 ± 6.6	154 ± 6.3	0.6
22 Jul 2009	5	M	7	211.9 ± 4.2	144.4 ± 6.7	0.1
22 Jul 2009	2	F	1	219	149.5	0.6
05 Aug 2009	5	F	1	220	154.5	0.5
05 Aug 2009	5	M	7	212.9 ± 2	148.7 ± 2	0.1
05 Aug 2009	6	F	1	226	171	0.6
05 Aug 2009	1	F	1	228	165.5	0.7
05 Aug 2009	1	M	1	185	121.5	0.1
05 Aug 2009	2	F	1	211	137	0.7
05 Aug 2009	3	F	1	220	157	0.6
17 Aug 2009	4	M	2	215.5 ± 6.5	157.3 ± 29.8	0.1
17 Aug 2009	3	M	1	208	168.5	0.1
14 Sep 2009	4	F	2	218	147.3 ± 4.3	0.7 ± 0.1
14 Sep 2009	4	M	3	213.3 ± 2.2	144.3 ± 3.9	0.1
14 Sep 2009	6	F	1	220	168.5	0.7
13 Oct 2009	1	F	1	209	124.5	1
13 Oct 2009	3	F	1	205	119	0.9
26 Oct 2009	2	M	3	211.7 ± 3.3	137.7 ± 9.2	0.2 ± 0.1

Date	Site	Sex	N	TL ± SE	Wt ± SE	GSI ± SE
26 Oct 2009	3	F	1	220	156	1.4
26 Oct 2009	3	M	1	210	118.5	0.1
17 Nov 2009	2	F	1	214	150	1.5
17 Nov 2009	2	M	1	221	157.5	1.3

BIOGRAPHICAL SKETCH

Cynthia Nichole Fox was born on September 4, 1984, in Crossville, Tennessee. After graduating as Salutatorian from Hermitage Springs High School in Hermitage Springs, Tennessee, in 2003, Cynthia attended Tennessee Tech University. While at Tennessee Tech, Cynthia served as president of the Beta Beta Beta Honorary Biological Society for 3 years. Cynthia graduated cum laude from Tennessee Tech University in May of 2007 with a B.S. in Biology with a marine science concentration. In the fall of 2007, Cynthia was awarded an internship at Mote Marine Laboratory's Center for Shark Research and Aquarium, in Sarasota, Florida. During her internship at Mote, Cynthia assisted in several research projects including the endangered Smalltooth Sawfish Management and Outreach project. Cynthia then enrolled in the Marine and Environmental Biology graduate program at Nicholls State University, in Thibodaux, Louisiana. Cynthia conducted research on the life history and gonad histology of yellow bass in the upper Barataria Estuary. While at Nicholls State, Cynthia assisted in coastal restoration and clean-up, benthic invertebrate collection, and bird banding and recapture projects, and interned with Bayou Land RC&D and Bois d'Arc Gardens. After graduation in May 2010, Cynthia will either continue her education in a Ph.D. program or pursue a career as a biologist.

CURRICULUM VITAE

Cynthia Nichole Fox

Graduate Student
Nicholls State University

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EDUCATION

M.S. Marine and Environmental Biology. May 2010. Nicholls State University, Thibodaux, Louisiana, 70310. Thesis title: Seasonal abundance, age structure, gonadosomatic index, and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. GPA: 3.74. Hours earned: 36.00.

B.S. Biology with a concentration in Marine Science. May 2007. Graduated cum laude. Tennessee Tech University, Cookeville, Tennessee, 38505. GPA: 3.53. Hours earned: 121.00.

SELECTED COURSEWORK

Fish Culture
Freshwater Invertebrate Zoology
Animal Physiology
Marine Biology
Elasmobranch Biology
Marine Ichthyology
Biostatistics
Marine and Environmental Biology
Aquatic Toxicology
Population Dynamics

TEACHING EXPERIENCE

August 2008 – May 2009: Teaching Assistant, Nicholls State University, Department of Biological Sciences. Duties included assisting in three labs per week, preparing for labs, and proctoring and grading exams.

August 2009 – May 2010: Teaching Assistant, Nicholls State University, Department of Biological Sciences. Duties included teaching two labs per week, preparing for labs, preparing and grading quizzes and assignments. Topics included: scientific method, diffusion and osmosis, enzyme activity, localization of respiration and glycolysis, photosynthesis, genetic transformation, Mendelian genetics, animal development, population genetics, evolution and systematics.

RESEARCH EXPERIENCE

August 2008 – May 2010: Assessed seasonal abundance, age structure, GSI and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary by sampling gill nets, processing collected fish, and viewing polished sections of yellow bass otoliths.

September 2007 – December 2007: Assessed shark species diversity in several streams and estuaries of southern Florida. Also sampled for endangered smalltooth sawfish *Pristis pectinata* in southern Florida streams as part of an ongoing population and habitat survey.

EMPLOYMENT

August 2008 – May 2010: Graduate Teaching Assistant, Nicholls State University, Department of Biological Sciences. Taught introductory freshmen biology laboratories that examined basic biological processes.

August 2003 – May 2007: Undergraduate Laboratory Assistant, Tennessee Tech University, Department of Biological Sciences. Assisted in the separation of invertebrates from other organisms and debris in field samples for graduate student research. Trained new undergraduate workers from May 2006 – May 2007.

INTERNSHIPS

January 2010 – May 2010: Bois d'Arc Gardens, Schriever, Louisiana. Supervisors: Bud and Rusty McSparrin, Owners. Duties: assist with inventory collection, label rows, weed gardens, plant and transplant flowers, remove, wash, and bag flowers for sell, assist customers with purchases.

May 2009 – December 2009: Bayou Land RC&D, Thibodaux, Louisiana. Supervisor: Gary Fine, Researcher and Field Manager. Duties: assist in transplanting of plants and propagation of native plants for coastal restoration projects, water plants in greenhouses, use of farm machinery for maintenance of grounds around research plots.

September 2007 – November 2007: Mote Marine Laboratory Center for Shark Research and Aquarium, Sarasota Florida. Supervisors: Tonya Wiley, Research Biologist and Beau Yeiser, Field Technician. Duties: set and retrieved gill nets, long lines, and drum lines, handled live fish collected, recorded length(s), weight, and estimated age of collected fish, maintained and repaired all fishing gear, retrieved and cleaned acoustic receivers, assisted in the care and maintenance of live sharks collected for research and aquarium displays.

FIELD EXPERIENCE

Boat and trailer operation, gill net sampling, long line sampling, trawl net sampling, seine sampling, water quality monitoring (dissolved oxygen, salinity, temperature, specific conductance, Secchi disk depth, ammonia, nitrite), larval fish traps, fish identification, fish otolith removal, external fish tagging, telemetry, benthic sampling, bird banding, tractor and ATV operation, GPS (handheld).

LABORATORY EXPERIENCE

Fish otolith aging, gonad histology/staging, freshwater invertebrate identification, care and maintenance of live fish, water quality monitoring and maintenance, fish catalog photography. Software skills: Data management, Microsoft Word, Microsoft Excel, Microsoft Power Point, some experience with SAS and FAST.

MEMBERSHIPS AND SERVICES

Louisiana Chapter of the American Fisheries Society
Tennessee Tech University Beta Beta Beta Honorary Biological Society; President

SCIENTIFIC PRESENTATIONS

2009. **Fox, C.**, A. Ferrara, C. Kersten, and Q. Fontenot. Seasonal abundance, GSI, and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. American Fisheries Society Annual Meeting, Nashville, TN.

2009. Fontenot, Q., J. Davis, M. Dantin, J. Fontenot, S. Jackson, M. Estay, O. Smith, L. Pitre, **C. Fox**, T. Widgeon, C. Cortez, and A. Ferrara. Exploring the Fisheries of the upper Barataria Estuary Swamps. Undergraduates in Research Lecture Series, Nicholls State University, Thibodaux, LA.

2009. **Fox, C.**, A.M. Ferrara, C. Kersten, and Q.C. Fontenot. Seasonal abundance, GSI, and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. Nicholls State University, Calypseaux Expedition, Cocodrie, Louisiana.

2010. **Fox, C.**, A.M. Ferrara, and Q. Fontenot. Seasonal abundance, age structure, and growth rate of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. 31st Annual Meeting of the Louisiana Chapter of the American Fisheries Society, Baton Rouge, LA.

2010. **Fox, C.**, A.M. Ferrara, C. Kersten, and Q. Fontenot. Seasonal abundance, GSI, and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. 31st Annual Meeting of the Louisiana Chapter of the American Fisheries Society, Baton Rouge, LA (poster presentation).

2010. **Fox, C.** A.M. Ferrara, C. Kersten, and Q. Fontenot. Seasonal abundance, GSI, and gonad histology of yellow bass *Morone mississippiensis* in the upper Barataria Estuary, Louisiana. Nicholls State University, Research Week Competition, Thibodaux, Louisiana (poster presentation).