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SEASONAL MIGRATION IN THE SOUTHERN HOGCHOKER, *TRINECTES MACULATUS FASCIATUS* (ACHIRIDAE)

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ABSTRACT Life history patterns often respond to local environmental conditions. The seasonal migration pattern of the northern hogchoker has been described, but the southern subspecies rarely has been studied. To document the migratory movements and the habitat characteristics of the southern hogchoker, long-term survey data and specimens collected during 1993 were examined. Moderate depth (5.8-6.4 m), low water clarity (0-1.2 m), moderate oxygen concentration (4-9 ppm), and sand-mud substrata generally defined hogchoker habitats. Hogchoker habitats only showed seasonal shifts in temperature and salinity characteristics. Hogchokers were only collected in low salinity (0-2 ppt) waters during the winter, but exhibited three abundance peaks in relation to bottom salinity during the summer samples at 0, 5, and 18 ppt. The survey data and the data from the 1993 specimens support the hypothesis that southern hogchokers are following a migration pattern similar to that described for the northern subspecies.

INTRODUCTION

The distribution of *Trinectes maculatus fasciatus*, the southern hogchoker, extends south from approximately South Carolina to the Yucatán peninsula. The range of the northern subspecies (*T. m. maculatus*) extends from the South Carolina coast north to Massachusetts (Hildebrand and Cable 1938, Gilbert and Kelso 1971). Hogchokers are small estuarine fish with a complicated migration pattern. Newly-hatched individuals begin moving into freshwater areas following summer estuarine spawning and begin migrating into low salinity areas the next spring. This downstream distance is extended progressively each year until maturity, when spawning occurs in the outer areas of the estuary. A return migration into freshwater occurs each fall for the winter period (Dovel et al. 1969).

Life history patterns may vary in response to local ecological conditions and the timing of environmental factors can often dictate differences in the evolution of these traits (Stearns 1976, Boyce 1979). The migratory movements and many life history factors of the northern hogchoker have been widely studied. However, the southern subspecies has only been the subject of a few studies along the Atlantic coast (Castagna 1955, Smith 1986).

The purpose of this study was to determine if the movement pattern documented in the northern subspecies is also present in a Gulf population of southern hogchokers. While individual collections have documented hogchokers in both freshwater streams and estuaries along the Mississippi coast, I also examined continuous survey data to clarify seasonal movement patterns. These survey data were also used to describe habitat characteristics of

T. m. fasciatus. Finer details of the migration pattern were investigated by examining the reproductive condition and age of hogchokers along the salinity gradient during 1993.

MATERIALS AND METHODS

Hogchoker distribution and habitat data were obtained from a fishery survey conducted since 1980 along the salinity gradient from the Back Bay of Biloxi offshore to Horn Island by personnel of the Gulf Coast Research Laboratory (GCRL), Ocean Springs, Mississippi. The survey samples consisted of standardized 10 minute tows with a 4.9 m flat otter trawl. Deeper trawls, at stations 83 and 84, required 30 minute tows with a 12.2 m flat otter trawl. Both trawls consisted of a 19.1 mm stretch mesh body with a 6.4 mm mesh cod end liner. Monthly collections were made at six sites along the salinity gradient and hogchokers were commonly caught at four of these sites: Bayou Bernard (36), Keesler Marina (34), Biloxi East Channel (37), and Bellefontain Buoy 8 (32) (Figure 1).

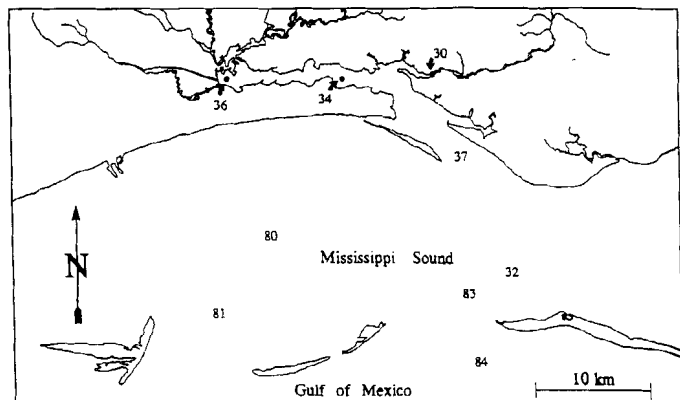


Figure 1. Distribution of sampling localities for the GCRL survey in the Back Bay of Biloxi, Mississippi.

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Hogchoker abundance, bottom temperature, bottom salinity, bottom oxygen concentration, water clarity (Secchi disk) and several habitat classifications (water body, bottom morphology, and substratum) were measured at each site. A factor analysis (SPSS_x-V2.1) of all environmental variables was performed to specifically describe hogchoker habitats. Although the assumptions were validated, this procedure was abandoned because even if all 11 variables were included, only 40% of the variance in hogchoker abundance could be explained. This variability is probably attributable to the complicated and interactive nature of the factors associated with the hogchoker's seasonal movements along the salinity gradient. Instead, frequency distributions of the number of hogchokers collected during the survey were examined for each variable. In examining the trends, the presence of 45 individuals was considered to be biologically meaningful. The data were examined in three sets: the entire sample, a summer sample (May through August), and a winter sample (October through March). When no differences occurred between the seasonal data sets, only the entire data set is presented.

To address reproductive condition, the specimens collected during the 1993 monthly survey trawls were examined. Two additional stations, 80 and 81, were sampled in the Mississippi Sound during June and July

1993 using 12.2 m trawls. A low salinity site (station 30), near the mouth of Old Fort Bayou, was also sampled in May and September 1993 with 3.2 mm mesh seines.

All *T. maculatus* were fixed in 10% seawater formalin. Each specimen was weighed (0.1 mg), measured (SL and TL, 0.01 mm) and then dissected to remove the gonads and otoliths. Gender was determined and reproductive condition of females was classified following Smith (1986) (Table 1). Gonadosomatic indices (GSI) (Nielson and Johnson 1983) were calculated for each specimen as the wet gonad weight divided by whole wet body weight multiplied by 100. The assumptions of a linear relationship and a 0 y-intercept for a gonad and body weight regression were validated before using the GSI. The average GSI values were compared between stations.

The otoliths were embedded in Ciba Geigy® media and sectioned with a Beuhler Isomet® Low Speed Saw into 1.0-2.0 mm increments. The sections were hand ground to a 0.20-0.50 mm thickness using 600 and 1500 grit sandpaper and then polished (Beuhler® Alpha Micropolish II). The otoliths were aged by three independent readers and only used if at least two of the three readings agreed. Symmetrical growth between otoliths and the annular formation of rings were validated in Peterson (in preparation). Age distributions were compared between stations along the salinity gradient.

TABLE 1

Female reproductive classifications based on external morphology of the ovaries, following Smith.

Category	Color	Shape	Tissue
Immature	pale	small, equilateral triangle; no posterior elongation	undifferentiated; no vascularization
Resting	light yellow	more robust; some posterior elongation (length = 2X height)	folicular development; no vascularization
Developing	deep yellow	more elongated posteriorly; becoming turgid and distended	appears granular from folicular development; slight vascularization
Ripe	dark yellow to orange	extended to the distal end of the coelomic cavity; very distended	appears granular with distinct eggs visible; highly vascularized
Spent	pale to yellow; often with a reddish hue	elongated but extremely flacid; appearing deflated	folicular material loose, with atretic eggs present; vascularization disrupted

RESULTS

A total of 936 collections were made from 1980-1993. The salinity gradient from Biloxi Bay out to Horn Island was stable, but there was substantial yearly variation in the absolute salinities (Figure 2).

Hogchoker abundance was not seasonally associated with changes in water depth, water clarity or oxygen concentrations. Hogchokers occupied depths from 2.4-6.7 m, with most captured in 5.8-6.4 m of water (Figure 3a). The available habitat range extended from 0.6 to 11.6 m. The water clarity of the sample area usually ranged from 0.0-2.4 m, with a few samples reported from 3.1-7.6 m. Hogchokers were mostly associated with habitats of 0.0-1.2 m of visibility (Figure 3b). The Back Bay of Biloxi had oxygen concentrations ranging from 4-12 ppm over the study area. The highest abundance of hogchokers were collected in habitats with 4-9 ppm oxygen (Figure 3c).

There were definite seasonal trends, as expected, in the temperature of habitats utilized by hogchokers. Throughout the sample period, temperatures ranged from 1-36°C. During summer months, hogchokers were most abundant in temperatures of 24-32°C; while during the winter peak abundance occurred between 12 and 19°C (Figure 4).

Hogchokers also did not exhibit seasonal shifts in the use of habitat types. They were usually in the Bay and Bayou, sometimes collected in the Sound, and only rarely in the Gulf (Figure 5a). They were also commonly collected in natural and dredged channels, but less so in open water without submerged vegetation (Figure 5b).

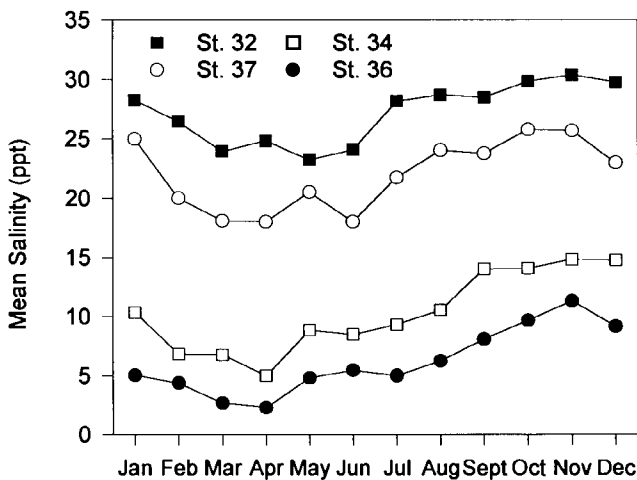


Figure 2. Monthly average salinity levels of four sampling stations in the Back Bay of Biloxi from a 14-year survey. 95% confidence intervals were large and, for clarity, are presented in Peterson (1994).

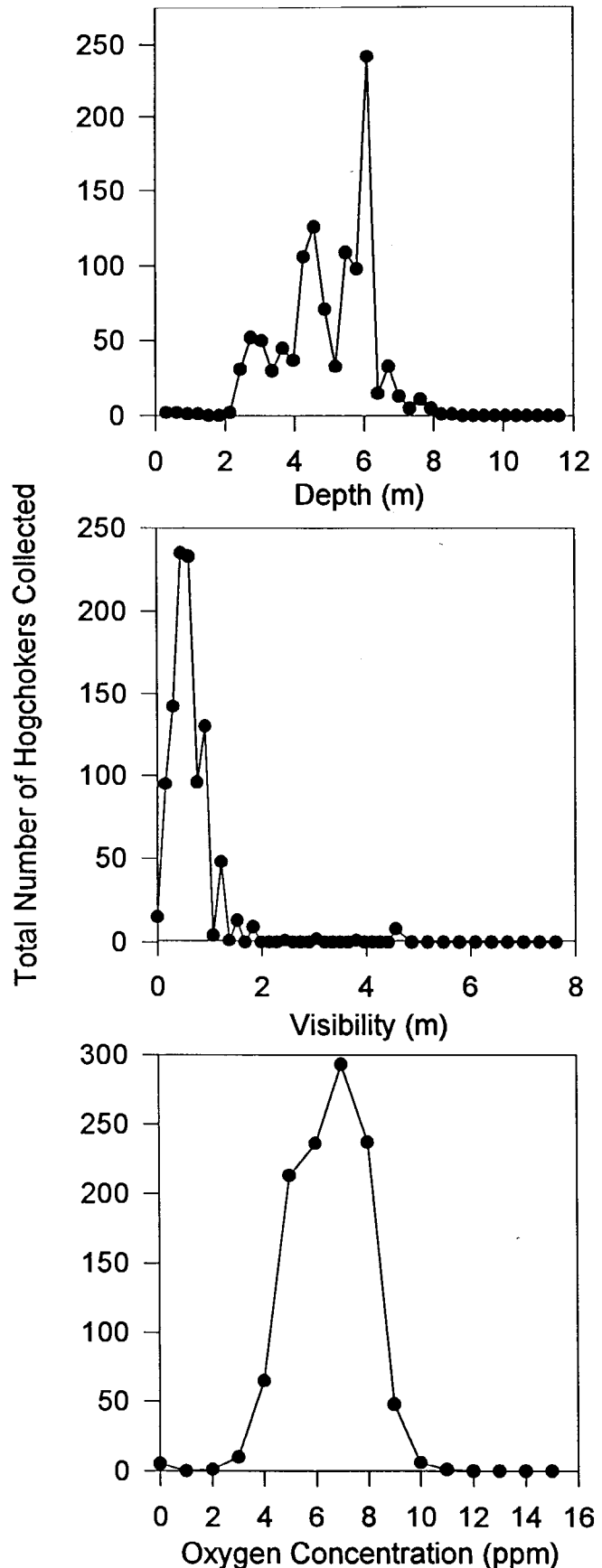


Figure 3. Hogchoker abundance distribution in relation to habitat depth, water clarity and bottom oxygen concentration.

In addition to these categories, only three others (sand beaches with submerged vegetation and marsh areas both with and without submerged vegetation) were sampled, a total of 11 times, throughout the sample period. Hogchokers were documented in each of these habitat types, but they were most abundant in habitats with mud bottoms (Figure 5c). However, during the study there were no sites classified as sand substrata, probably indicating an actual sand-mud combination along the salinity gradient.

Hogchokers were collected during all months, but they were most abundant from April to September (Figure 6a). Abundance also varied among years, with a peak from 1988-1989 (Figure 6b). This peak is followed by a sharp decline in collection abundance, with a subsequent increase in 1993.

Hogchokers did exhibit a seasonal shift in terms of habitat salinity. During the winter, hogchokers were most abundant in salinities of 0-2 ppt (Figure 7), with only rare occurrences in higher salinity areas. During the summer, three abundance peaks occurred, at approximately 0, 5, and 18 ppt. Hogchokers were documented throughout most of this salinity range during summer collections.

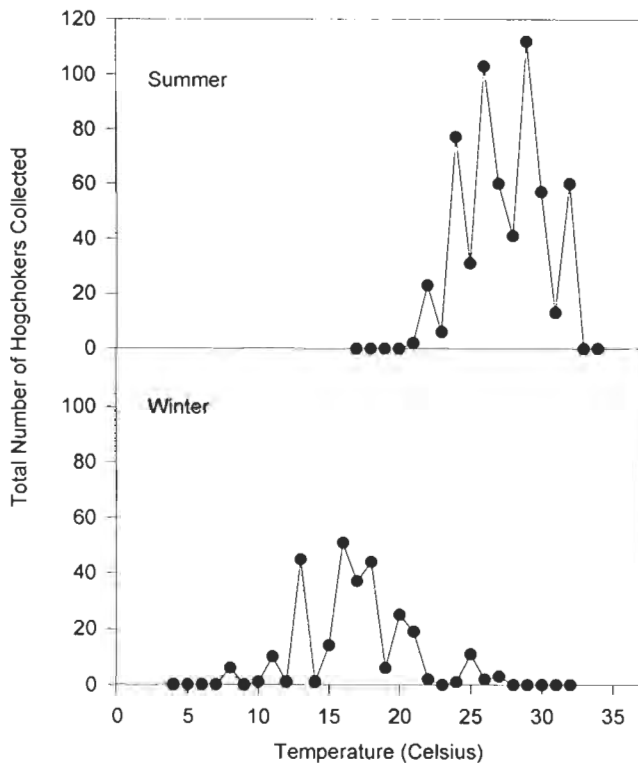


Figure 4. Hogchoker abundance distribution in relation to bottom temperature during summer and winter sample periods.

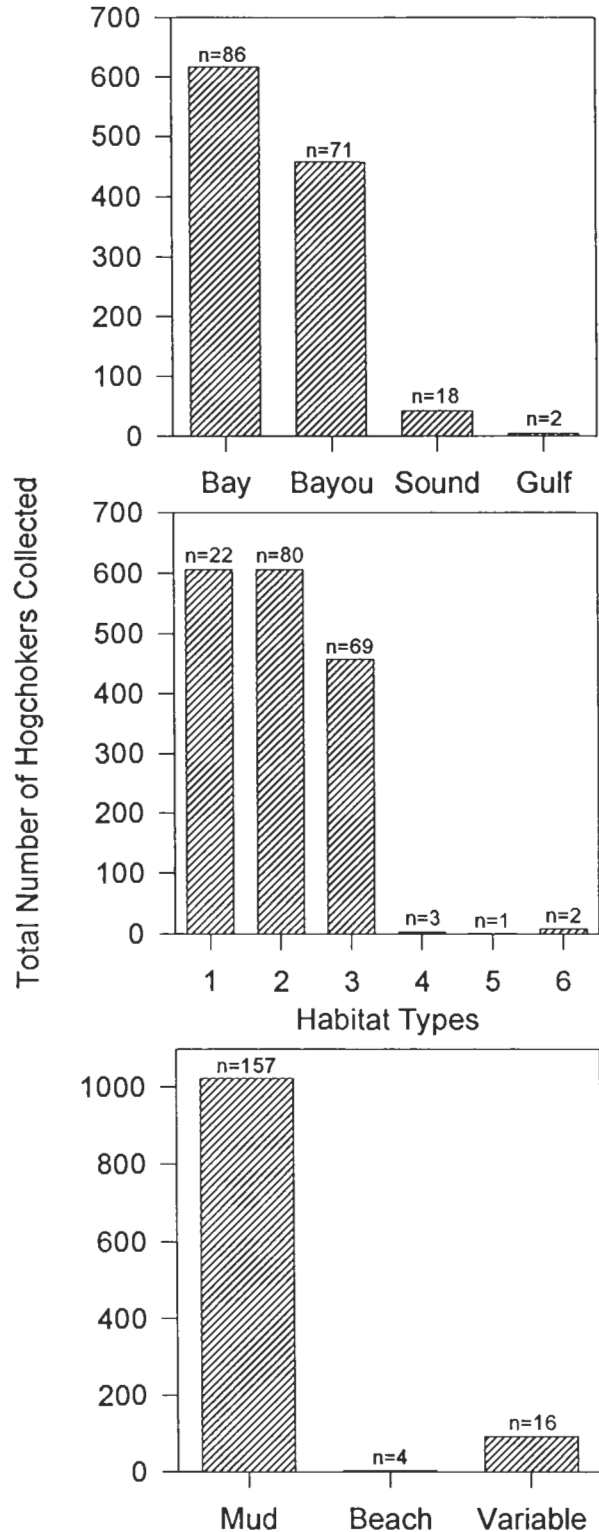


Figure 5. Distribution of hogchokers among categories of water body types, bottom morphology (Coding: 1-open water without submerged vegetation, 2-dredged channel, 3-natural channel, 4-sand beach without submerged vegetation, 5-marsh with submerged vegetation, 6-marsh without submerged vegetation), and substrata characteristics. Sample n's are the number of collections with hogchokers in each category.

In 1993, salinity generally increased along the gradient (Figure 8). Hogchokers were collected during April only at lower salinity stations. During June, most hogchokers were collected at the outer and higher salinity stations. Hogchokers were again only collected in low salinity areas in September. The salinity ranges during January-July 1993 were similar to the survey data means.

Immature individuals, males, and resting and developing females were collected in April. In June, only resting females were collected in low salinities, while ripe and developing females were collected at the Sound stations. Ripe females were only collected during June at the high salinity stations. Hogchokers, including a spent female, were only collected in July at a low salinity station in the bay. Only immature specimens were collected at the mouth of Old Fort Bayou during September (Figure 9).

The gonadosomatic indices were low (< 0.5) for all specimens collected in April and male GSI values never exceeded 0.5 in the 1993 samples. However, female GSI values increased to 5.0-6.1 at the outer stations during June, and then decreased in the next month (Figure 10).

During the summer months in which hogchokers were collected, a trend of increasing age along the salinity gradient was exhibited (Figure 11). Young of the year fish were only collected at the low salinity sites and the oldest specimen, in its fifth summer, was collected at the outermost station. On the spawning grounds, considered to be stations 80 and 81 based on the reproductive data, the mean age of hogchokers was approximately 3 to 4 years.

DISCUSSION

The annual pattern of hogchoker abundance could be indicating population trends. If so, the Biloxi population of southern hogchokers increased in size from 1984 to 1989, followed by a sharp population decline in the following years and only in 1993 did an upward trend return. This could be the result of variation in annual recruitment and survival. To my knowledge, no major environmental phenomena occurred which could explain this pattern and annual salinity fluctuations do not correspond with the population trends. Further investigations of hogchoker population dynamics are needed to explain this annual variation.

Hogchoker habitats can be described as areas of moderate depth, low water clarity, moderate oxygen concentration, and mud-sand substrata. Temperature and

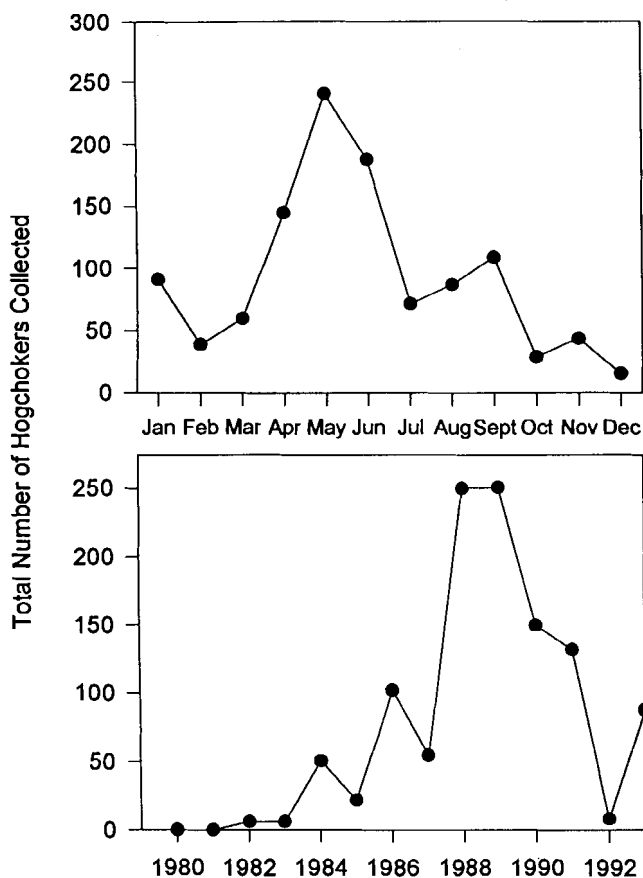


Figure 6. Total collection abundance of hogchokers during each month and year of the survey.

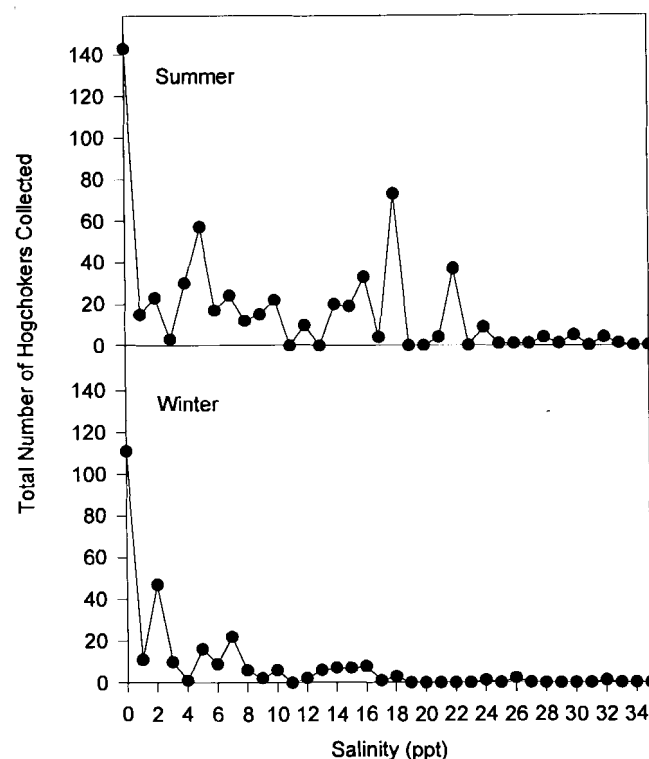


Figure 7. Distribution of hogchokers in relation to bottom salinity during summer and winter sample periods.

salinity were the only variables in which hogchokers showed a seasonal shift in resource use. These results correspond with Smith's (1986) suggestion that temperature initiates the migration while salinity is the directing factor. During winter months, hogchokers were most common in low salinity waters of 12-19°C. During the summer, there were three main hogchoker locations, all of 24-32°C. One area was at the freshwater interface, another at 5 ppt, and the final locality at 18 ppt.

The 1993 collections exhibited abundance trends similar to the survey data. Hogchokers were first collected in April only in low salinity areas, their GSI values were low and none of the specimens were mature. As summer progressed, the older maturing and mature fish began moving out into the estuary. The abundance peak in the

survey data at the freshwater interface were most likely immature individuals, and 2-3 year old maturing specimens probably represent the 5 ppt peak (Peterson in prep.). Peters and Boyd (1972) reported a similar summer distribution of juvenile hogchokers in a North Carolina population, with the highest abundance occurring at 25°C and 5-10 ppt. The final peak at 18 ppt represents the hogchoker spawning grounds. The only specimens seen in spawning condition, as well as the oldest individuals, were collected in this area. The distribution range then shortens as the fish move back to low salinity and freshwater habitats. This would explain why the winter survey samples produced only a single abundance peak in low salinity (0-2 ppt) areas.

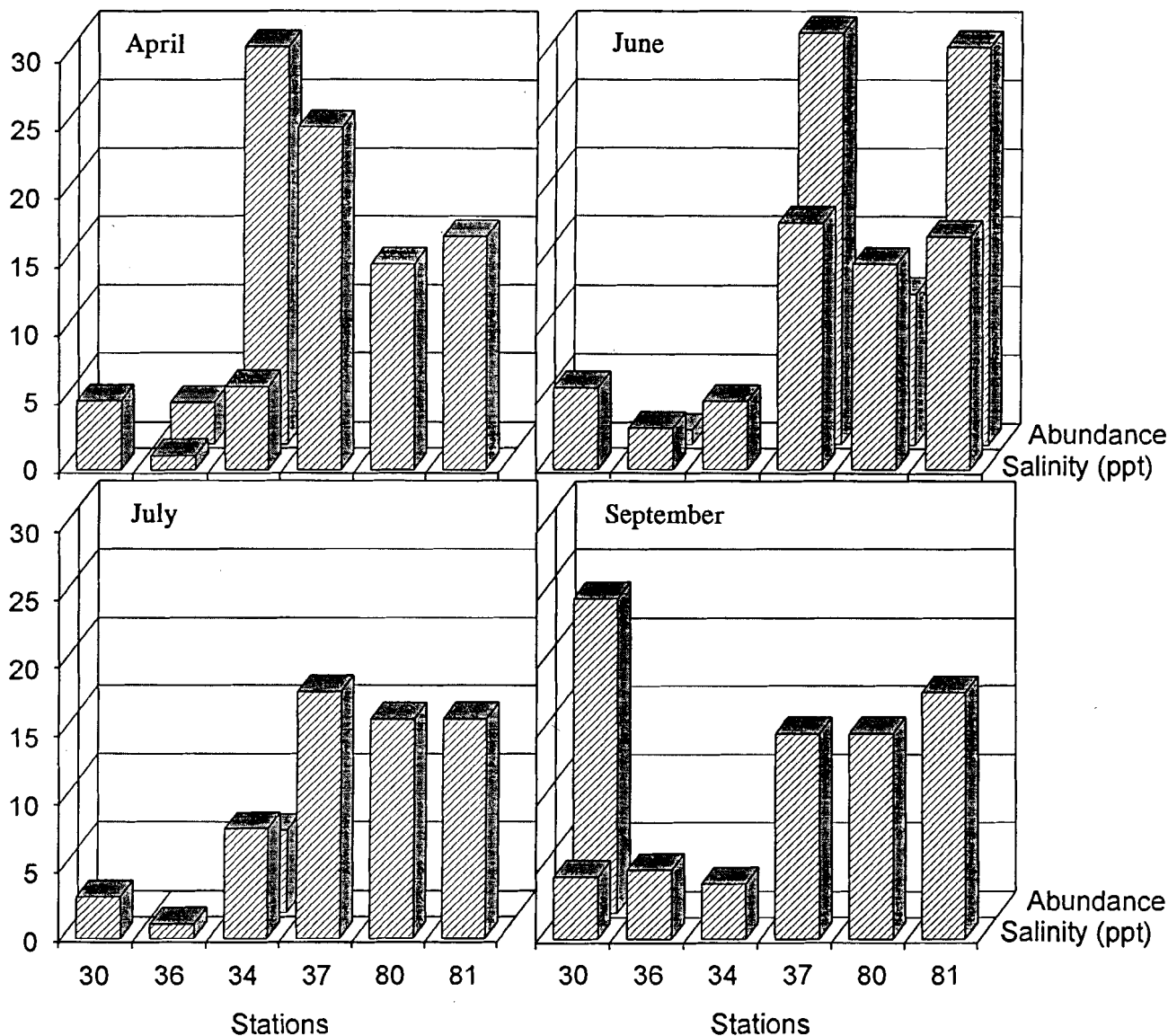


Figure 8. Habitat salinity and hogchoker abundance at each station along the salinity gradient during 1993.

SEASONAL MIGRATION IN THE SOUTHERN HOGCHOKER

Dovel et al. (1969) reported that hogchoker spawning areas are in full seawater (30ppt). The data presented here suggest that southern hogchokers are spawning in lower salinity waters, approximately 15-18 ppt. This may not represent a true difference, but instead may be an artifact of environmental characteristics. The northern Gulf of Mexico does not have the higher salinity inshore areas as

those reported for the northern Atlantic coast. Moreover, the spawning area reported by Dovel et al. (1969) was determined by egg presence in plankton samples, not the presence of ripe hogchokers. Further studies of the northern subspecies, or hogchoker egg collections in the Gulf of Mexico, are required to verify this possible subspecies difference.

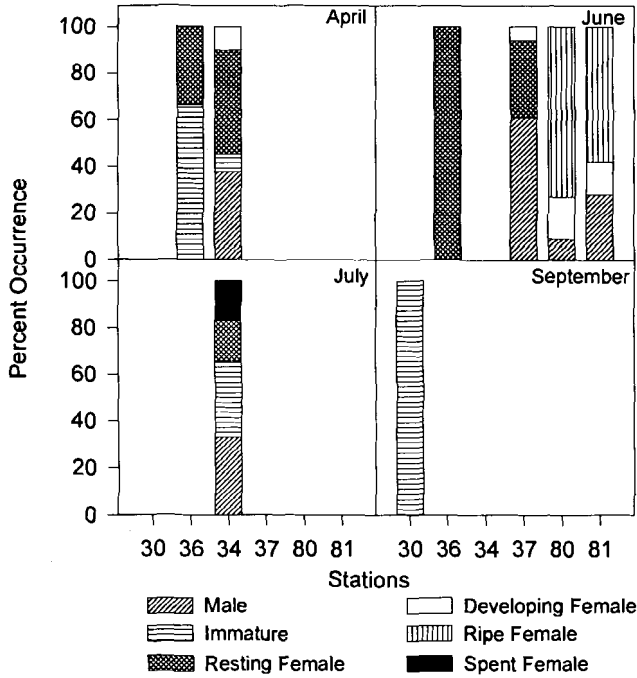


Figure 9. Percent occurrence of gender and female reproductive conditions of hogchokers collected at each station along the salinity gradient during 1993.

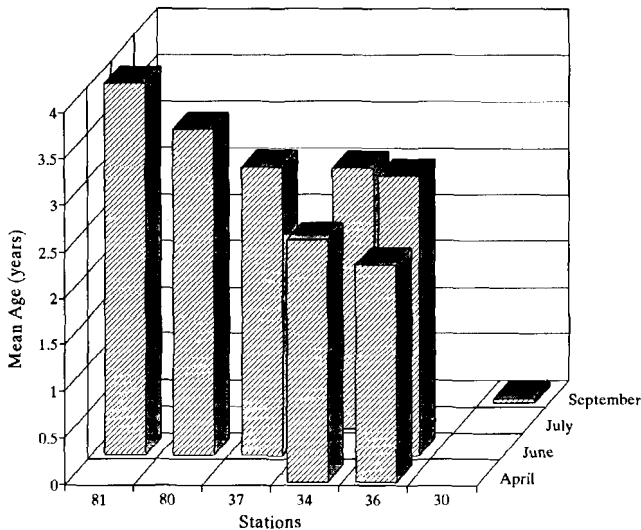


Figure 11. Mean age of hogchokers collected at each station along the salinity gradient during 1993.

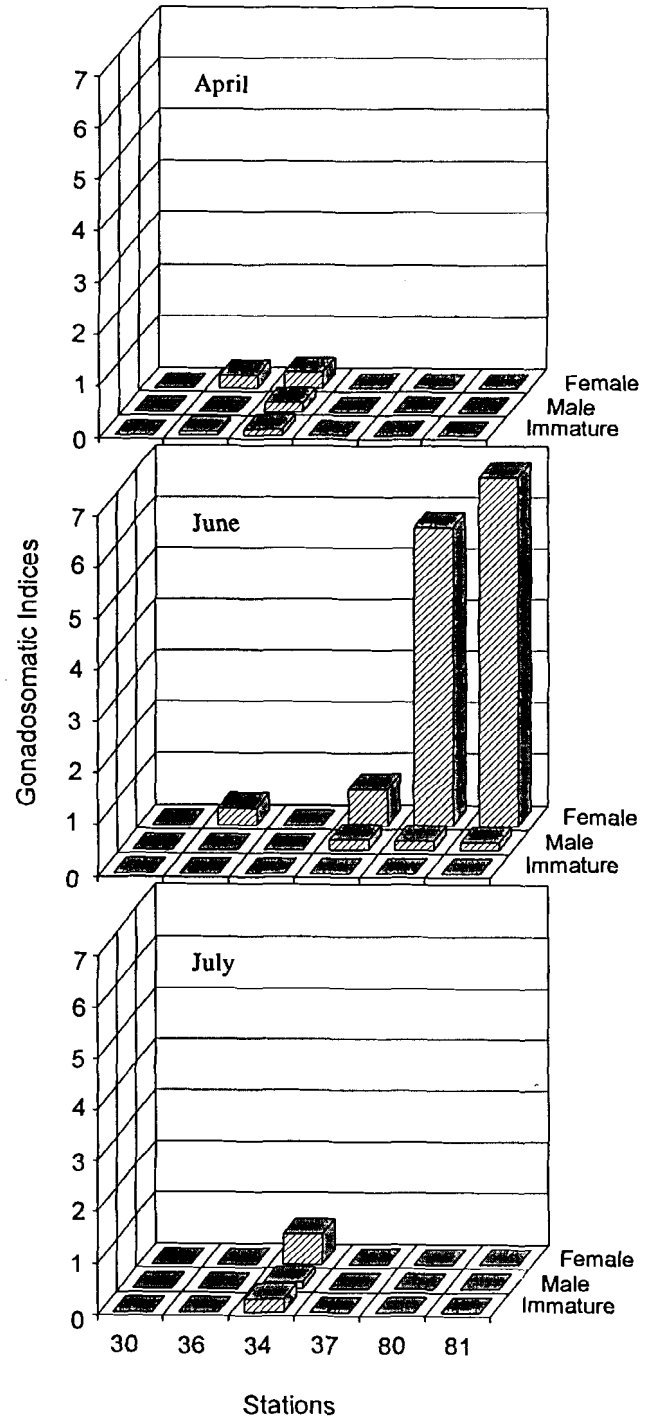


Figure 10. Mean gonadosomatic indices of hogchokers collected at each station along the salinity gradient during 1993.

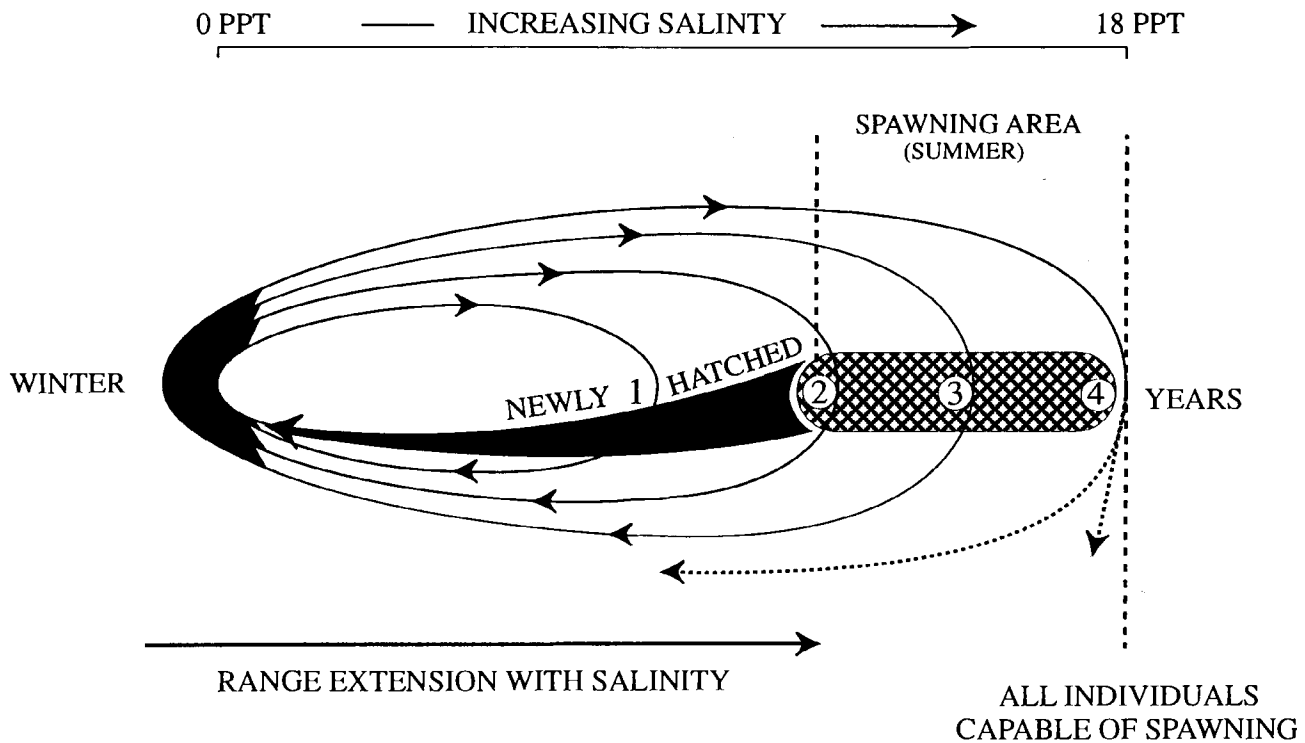


Figure 12. Proposed seasonal migration pattern of southern hogchokers, modified from Dovel et al. (1969).

The survey data and the 1993 movement patterns support the hypothesis that the Back Bay of Biloxi population of southern hogchokers uses a migration pattern similar to that described for the northern subspecies. A migration pattern, modified from Dovel et al. (1969), is presented as that followed by the southern subspecies (Figure 12). The conservation of this character between subspecies and over time agrees with McDowell's (1993) suggestion that diadromy is a stable process and not a transitional mechanism of evolving to a freshwater lifestyle.

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