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THE DISTRIBUTION AND ABUNDANCE OF THE BAY ANCHOVY, *ANCHOA MITCHILLI*, IN A SOUTHEAST TEXAS MARSH LAKE SYSTEM

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ABSTRACT A one-year distribution and abundance study on the bay anchovy, *Anchoa mitchilli*, was conducted in a southeast Texas marsh-lake system from March 1990 through February 1991. Day and night collections were conducted in backwaters, lake shores, and lake centers by seining and trawling. Bay anchovies were the second most abundant fish species collected, and exhibited seasonal, diel and habitat variations in abundance and distribution. Across the study area, seasonal abundance peaks occurred in May and August following migration into the marsh and seasonal recruitment. However, within each habitat type, peaks of abundance varied in time of occurrence. Within habitats, significant differences in the mean number of anchovies occurred such that backwaters in the daytime had the greatest number followed by backwaters at night, lake shores in the daytime, and lake shores at night. Lake center collections showed no significant diel pattern. The presence of vegetation was associated with reduced anchovy numbers; however, when present, anchovies were significantly more abundant in the daytime than at night.

Introduction

Anchoa mitchilli (Valenciennes) is the most abundant species of fish in the estuarine waters of the northern Gulf of Mexico (Robinette 1983) and comprises the greatest biomass in estuaries along the Atlantic and Gulf coast states (Christmas and Waller 1973; Perret 1971; Gunter 1963). However, most of what is known about the distribution and abundance of *Anchoa mitchilli* is from off shore, near shore and estuarine studies, with little attention to marshland habitats.

Monaco et al. (1989), Robinette (1983), and Morton (1989) have summarized information on the distribution and abundance of *A. mitchilli* within large estuaries. Abundance is seasonal, and in the Gulf of Mexico varies from Spring through early winter (Robinette 1983; Ross et al. 1987; Modde and Ross 1983). In East Galveston Bay, peak abundance occurs from April to June (Arnold et al. 1960) with Galveston Bay showing an abundance of adults and juveniles from May to November (Monaco et al. 1989). In Sabine Lake, adult and juvenile *A. mitchilli* are found from March through October, with juveniles present into November (Monaco et al. 1989).

The abundance and distribution patterns of *A. mitchilli* result in part from fall and spring migrations to and from deeper waters in bays and on the continental shelf (Christmas and Waller 1973; Hildebrand 1963; Swingle and Bland 1974; Vouglitois 1987). Migration of anchovies in and out of the marsh system west of Sabine Lake is well documented (Hartman et al. 1987; Stelly 1980).

Their great abundance and small size make anchovies a key element in estuarine food webs (Hildebrand 1963; Christmas and Waller 1973; Darnell 1961; Robinette 1983). Bay anchovies are selective planktivores which link the zooplankton community with larger predatory species (Johnson et al. 1990). From spring through fall, the bay anchovy provides more than half the energy intake of predatory fish in Chesapeake Bay (Baird and Ulanowicz 1989, as cited by Houde and Zastrow 1991).

Because of their great abundance and key position in food webs, additional information on the distribution and abundance of *A. mitchilli* is needed to better understand their significance in estuarine systems. This is especially true for the associated marshes and lakes where little information exists on their distribution and abundance. This study presents information on the distribution and abundance of *A. mitchilli* in the marsh-lake system lying west of Sabine Lake in Southeast Texas. Specifically, this study examines the temporal and spatial distribution and abundance of the bay anchovy by studying three habitat types common in marshes.

Methods

Study Area

The study area was located in southern Jefferson County, Texas, west of the south end of Sabine Lake and included Keith Lake, Sea Rim State Park, and the McFaddin

National Wildlife Refuge (Figure 1). The brackish marsh-lake system consists of nine lakes and backwaters connected by meandering streams and man-made cuts. Three habitat types that could be adequately sampled were identified. The habitat types were backwaters, lake shores and lake centers. Backwater habitats were connected to tidal creeks or lakes by restricted openings or were sheltered from the main body of a lake by a small peninsula of land or an island which lay close to shore. A key point was that backwaters were protected in some way from the wave action which occurred on the more open lakes. Lake shores lay along the edges of lakes, and lake centers were at least 100 m or more from shore. Backwater stations were the shallowest ($\bar{x}$=48.73 cm, S.D.=15.79), followed by lake shore stations ($\bar{x}$=58.1 cm, S.D.=16.1), and lake center stations ($\bar{x}$=124.9 cm, S.D.=26.5).

Stations exhibited wide variations in substrate composition. Backwater stations had the greatest amount of variation in substrate composition, which included mud, silt, and detritus in various combinations. Wave action along lake shore stations prevented silt deposition, resulting in a band of firmly compacted clay 1 to 5 m wide extending out from the shore. Beyond this band, the sediment consisted of a soft silt 6 to 30 cm deep.

Starting in May and extending to October, the aquatic plant *Ruppia maritima* covered 50% or more of stations 4 and 6, and occurred sparsely in stations 3, 5 and 10. By June, *R. maritima* occupied the entire water column of stations 4 and 6 and covered nearly 100% of both stations as well as the surrounding area. The primary difference between stations was that station 6 was very densely covered while station 4 was less densely covered. Otherwise, the coverage

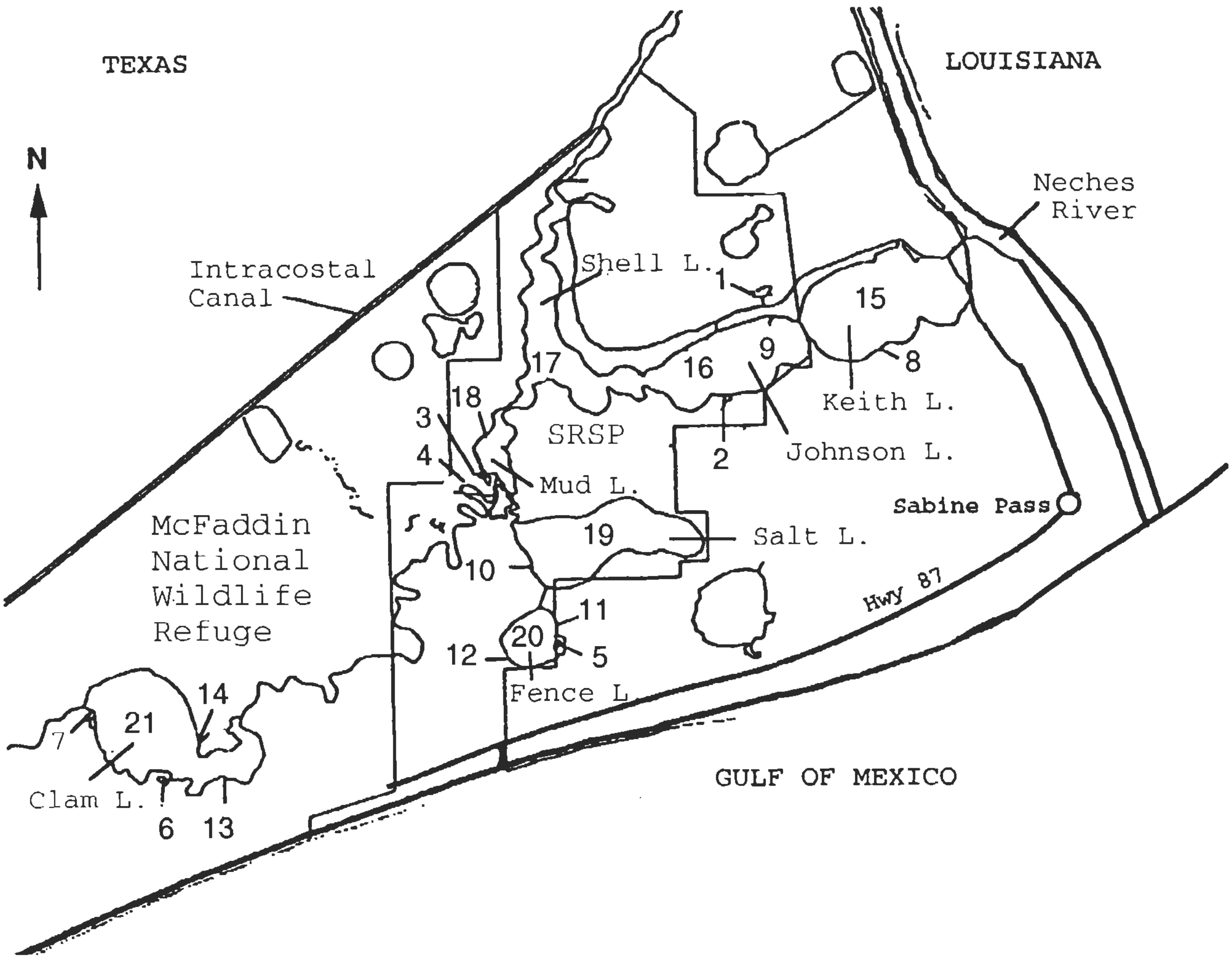

Figure 1. Study area along the Louisiana-Texas Border, Jefferson County, Texas. Incoming tides enter and leave at the east end of Keith Lake and Salt Bayou. Numbers 1-21 represent stations discussed in the text. SRSP stands for Sea Rim State Park which lies between the two sets of vertical and horizontal straight lines representing the park boundary.

was nearly uniform within the station. The *R. maritima* was replaced with filamentous algal mats in October and November. All vegetation died back by December.

Protocol

From March 1990 through February 1991, 242 collections were made in the study area. Twenty-one stations were established based on the three habitat types:

- back waters (stations 1-7)
- lake shores (stations 8-14), and
- lake centers (stations 15-21).

Stations were numbered east to west following the incoming tides. Lake shores and backwaters were marked with stakes 15 m from the bank. Lake centers were not staked. Stations were sampled monthly with night collections made every other month. Lake shores and backwaters were sampled by pulling a seine from the station markers to the bank. The seine was 6.1 m long, possessed 6.35 mm knitted mesh, and a 4.6 m opening maintained by tying a rope to the seine poles. Lake center stations were sampled with a 3.66 m trynet (25 mm stretch mesh) fitted with a 6.35 mm bar mesh cod-end liner. The trynet was pulled by boat for three minutes for a distance of approximately 430 m. This distance was originally estimated by timing how long it took to pull the net over 125 m marked off by stakes set out in a marsh lake.

All anchovies captured were hardened in 10% formalin for 24 hours, washed in water 24 hours, and preserved in 55% isopropyl alcohol. Specimens were returned to the laboratory and enumerated. Type and percent submerged vegetation within stations was visually estimated. Problems with scheduling, equipment failure, and weather caused the postponement or elimination of some collections listed in Griffith (1993).

RESULTS

During the 12-month collecting period, 49 fish and 14 invertebrate species were collected. Fish represented 67% of all specimens collected and invertebrates 33%. The four dominant taxa were *Brevoortia patronus* (24,321), *A. mitchilli* (13,266), *Menidia beryllina* (5,697), and *Micropogon undulatus* (5,183). A full breakdown of all species and their yearly totals can be found in Griffith (1993).

Bay anchovies comprised 23.3% of the total fish catch with a per catch average of 54.8 (N=242, S.D.=124.8). The temporal distribution and abundance of bay anchovies exhibited two peaks which were seen in all three habitats (Figure 2). Generally abundance increased from March through May, decreased in June, increased in July, and peaked a second time in August. After August, abundance steadily decreased until February. In lake shore and lake center stations, the first peak abundances of anchovies occurred in April, one month earlier than the in backwaters. The second peaks of abundance occurred in November in lake shores, July in lake centers, and August in backwaters. While anchovies were present in low numbers in lake shore and lake center stations in June, they were nearly absent in backwater stations. The anchovies that were present were mostly juveniles with only a few adults present. Within each habitat type there were no significant differences in the use of stations by bay anchovies (Oneway ANOVA; Backwaters: N=81, df=80, F=1.410, P=0.221; Lake shores: N=83, df=82, F=1.490, P=0.193; Lake Centers: N=78, df=77, F=1.130, P=0.355).

Differences in the diel distribution of anchovies occurred in backwaters and lake shores. In all cases, nighttime collections had lower means than daytime collections, while backwater stations always had the highest means (Table 1). A oneway ANOVA using as treatments day and night collections from backwaters and lake shores (N=164; df=3,160; SD=144.4; F=2.990; P=0.033) followed by a Tukey test showed significant differences between day and night collections in both habitats. The Tukey test revealed that each treatment value calculated (backwaters day-backwaters night = 59.50, backwaters night-lake shores day = 21.10, lake shores day-lake shores night = 4.69) exceeded the critical value (3.68), indicating significant differences in densities within each habitat for day and night collections. The relative abundance of anchovies/habitat/photoperiod was: backwater stations, daytime ($\bar{x}$=129.6) > backwater stations, night ($\bar{x}$=70.1) > shoreline stations, daytime ($\bar{x}$=49.0) > shoreline stations, night ($\bar{x}$=44.3). Lake center collections were not significantly different between day and night collections (N=78, day $\bar{x}$=21.68, night $\bar{x}$=12.00, df=51; t=1.570, P=0.120).

The presence of dense stands of *R. maritima* and filamentous algae from May-October in backwater stations 4 and 6 allowed two analyses to be made. The first analysis permitted the comparison of vegetated against unvegetated areas. This was done by comparing stations 4 and 6 to stations 1, 3 and 5 for the time period when vegetation was present. Stations 1, 3, and 5 were used as controls because their physicochemical structure was most like stations 4 and 6 (Griffith 1993). The analysis showed that heavily vegetated backwaters possessed significantly fewer anchovies ($\bar{x}$=54.0) per collection than unvegetated backwaters ($\bar{x}$=161.0) (N=59, DF=53, t=-2.210, P=0.032).

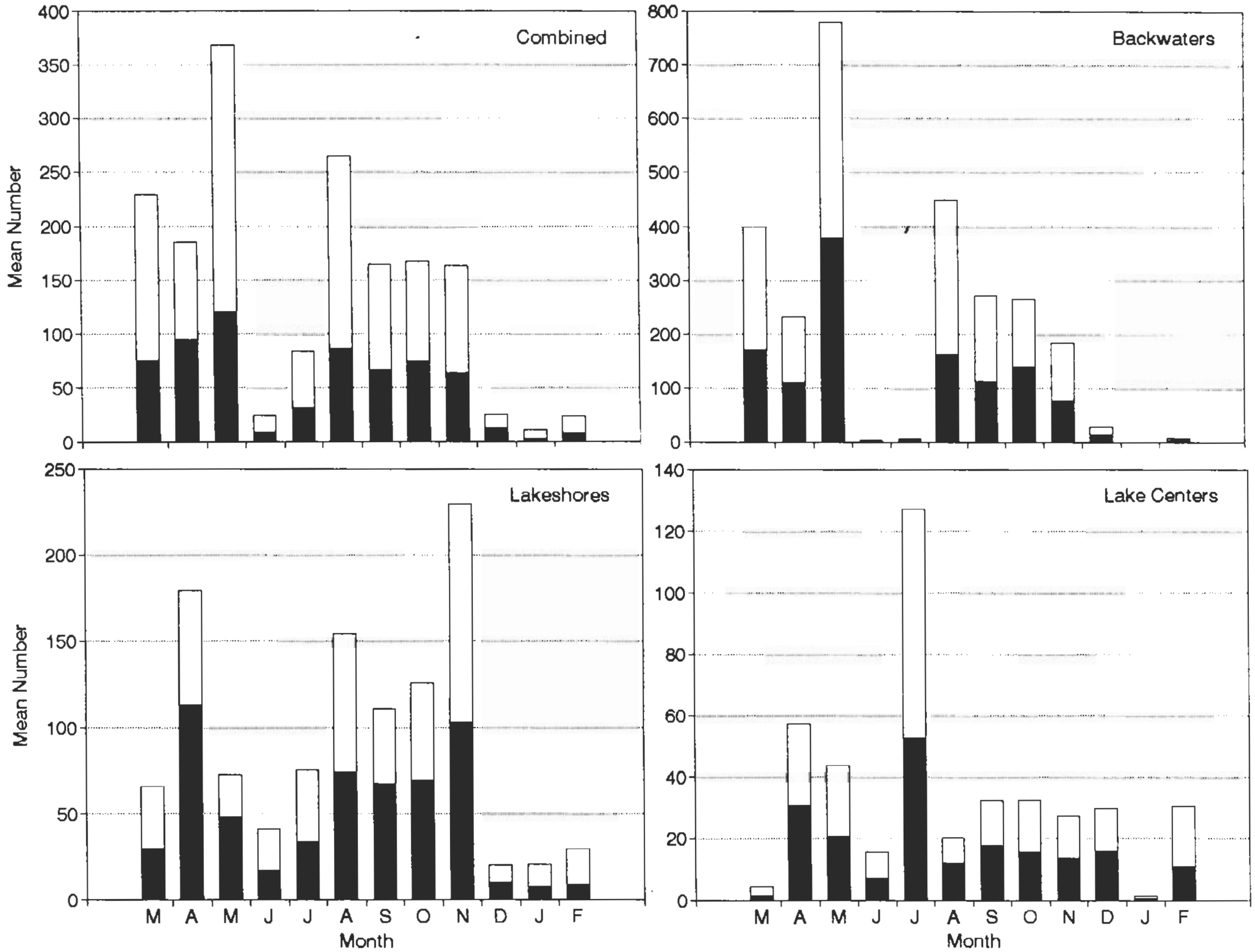

Figure 2. Mean number of anchovies collected per month in each habitat type and all habitat types combined. Solid bars represent the mean number of anchovies per month. Open bars represent the standard deviations.

TABLE 1

Yearly mean catch of *A. mitchilli* by habitat and time period (Day=L and Night=D), March 1990-February 1991.

Habitat	L/D Cycle	N	Mean	STDEV.	Min.	Max.
Backwaters	Day	40	129.6	235.8	0	1101
	Night	41	70.1	146.5	0	810
	24 hrs.	81	99.5	196.8	0	1101
Lake shores	Day	41	49.0	65.3	0	329
	Night	42	44.3	58.4	0	234
	24 hrs.	83	46.6	61.5	0	329
Lake Centers	Day	41	21.7	36.8	0	163
	Night	37	12.0	13.4	0	50
	24 hrs.	78	17.1	28.5	0	163
Combined	24 hrs.	242	54.8	124.8	0	1101

The second analysis compared vegetated areas at night against vegetated areas in the daytime. Because of skewedness, a Mann Whitney U-test was used to test the rank order of the data (Sokal and Rohlf 1981). The results showed that daytime collections of *A. mitchilli* (N=6, $\bar{x}$=99.0) were significantly higher than nighttime collections (N=6, $\bar{x}$=48.7, P=0.0127).

Discussion

Reproduction, habitat structure, diel period, season, and vegetation were all associated with anchovy abundance and distribution. Seasonal distributions and abundances of *A. mitchilli* in the study area were controlled in part by reproductive periods and seasonal migrations to and from the marsh. Peak abundances of adults and juveniles in the study area occurred during April-May and July-August, with periods of low abundance occurring in June-July and December-February, depending on the particular habitat. The periods of high and low abundance observed in the marsh lake system are similar to those observed by Herke (1971) and most likely resulted from reproductive periods which occurred two to three months prior to the peak abundances. Manaco et al. (1989) reported spawning, eggs, and larvae were common March through November in nearby Sabine Lake. Larval growth is rapid (Cowan and Houde 1990), and larval and juvenile stages may be completed in 2.5 months with some young-of-the-year maturing by late summer, although most over winter before maturing the following year (Houde and Zastrow 1991).

Stelly (1980) found a large net movement of bay anchovies out of the study area in November and December, while a smaller net movement out was detected in May and June accounting for some of the reduced numbers found in January-February and June-July, depending on the habitat type. Along the Gulf and Atlantic coasts, the bay anchovy migrates during winter to deeper waters and out to the inner continental shelf, returning to the estuaries in spring (Christmas and Waller 1973; Hildebrand 1963; Vouglitois 1987; Swingle and Bland 1974). While all the evidence indicates that the bay anchovy is migrating in and out of the study area, at least a small percentage of anchovies remain in the marsh year round.

Habitat and diel periodicity were also associated with anchovy distribution and abundance. Anchovies were more abundant in backwaters than lake shores and were more abundant in the daytime than at night in both habitats. Day and night time concentrations of *A. mitchilli* within lake center stations were not significantly different from each other. This would suggest that any diurnal migrations from backwater and lake shore stations were not solely to lake center stations, but to other areas within the marsh not sampled in this study.

Heavily vegetated backwaters possessed significantly fewer anchovies per collection than did unvegetated backwaters, indicating vegetation was a limiting factor. Herke (1971) found a similar pattern in his work on semi-impounded vegetated areas. Cornelius (1984) found *A. mitchilli* characteristic of unvegetated mud substrate, while others have captured *A. mitchilli* over, but not in, *Thalassia* seagrass beds (Scott Holt per. comm.). Castro and Cowen (1991) found no difference in the density of day and night collections of larval *A. mitchilli* in vegetated areas, suggesting that the presence of vegetation primarily affects juveniles and adults. *Anchoa mitchilli* is an opportunistic, selective zooplanktivore (Johnson et al. 1990) that may be less successful at foraging in dense vegetation. This hypothesis is supported by the fact that anchovies collected in vegetated areas have lower body weights than those collected from unvegetated areas (Herke 1971). However, *A. mitchilli* was significantly more abundant in vegetated areas in the daytime, suggesting that it may use dense stands of unbroken vegetation as a refuge from predators (Griffith 1993) and then move out to forage at night (Johnson et al. 1990).

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