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ABUNDANCE PATTERNS OF JUVENILE BLUE CRABS (*CALLINECTES SAPIDUS*) IN NURSERY HABITATS OF TWO TEXAS BAYS

J. L. Thomas, R. J. Zimmerman and T. J. Minello

ABSTRACT

In Christmas Bay, Texas, monthly densities of juvenile blue crabs, smaller than 40 mm carapace width, were highest in seagrass (2.8 to 50.6·m^{-2}), intermediate in salt marsh (1.3 to 22.1·m^{-2}) and lowest on bare sand (0.6 to 5.6·m^{-2}). In West Bay, Texas, where seagrasses were absent, crab densities were intermediate in salt marsh (2.2 to 13.0·m^{-2}) to low on bare mud (0.1 to 1.7·m^{-2}). The lowest seasonal abundances occurred in the early spring after juvenile crabs overwintered on subtidal sand and mud. The highest abundances and smallest mean sizes occurred in the late summer and fall corresponding to seasonal recruitment. Crabs were larger in mean size in salt marsh than in seagrass or nonvegetated habitats. Although seagrasses are often the preferred nursery of *Callinectes sapidus,* seagrasses occur infrequently in the NW Gulf and salt marshes are used as an additional nursery. Features that increase utilization of salt marshes in the NW Gulf compared to other regions are reticulated marsh geomorphology, low tidal amplitude and long periods of tidal inundation.

Blue crabs (*Callinectes sapidus* Rathbun) historically support one of the largest commercial fisheries in the Gulf of Mexico (Rees, 1963), and the northwestern Gulf contributes most to the landings (Perry, 1984). Moreover, in recent years landings in Texas have increased, rising from fourth (Hammerschmidt, 1982) to second (Murray, 1989) in volume of all fisheries. Information on blue crabs in the NW Gulf comes from a few studies on life history, seasonality and fisheries (Daugherty, 1952; More, 1969; Hammerschmidt, 1982; Perry, 1984). Daugherty (1952) and More (1969) report spawning near the coast where salinities are greater than 20‰. Peaks occur in March–April and again in July–August. More (1969) added that megalopae from the summer spawn are present in coastal passes from July through September, and megalopae from the late summer and fall are in passes from October through March. Crabs reach commercial size about a year after hatching (More, 1969). Investigations into feeding, predators and habitat utilization of blue crab populations in the NW Gulf are lacking.

Faunal distribution studies have shown that vegetated habitats (i.e., seagrass and salt marsh habitats) tend to be used as nurseries by estuarine-dependent species such as *Callinectes sapidus,* more than habitats without vegetation (Briggs and O'Connor, 1971; Adams, 1976; Hooks et al., 1976; Heck and Wetstone, 1977; Heck, 1979; Heck and Orth, 1980b; Stoner, 1980; Penry, 1982; Lewis and Stoner, 1983; Virnstein et al., 1983; Boesch and Turner, 1984; Heck and Thoman, 1984; Orth et al., 1984; Zimmerman et al., 1984; Zimmerman and Minello, 1984b; Orth and van Montfrans, 1987). In Galveston Bay, Zimmerman and Minello (1984a) demonstrated that juveniles of blue crabs, brown shrimp and some fishes were significantly more abundant on flooded salt marsh surfaces than in subtidal areas without vegetation. In the lower Chesapeake Bay, similarly high numbers of juvenile blue crabs used submerged seagrasses more than marsh creeks (Orth and van Monfrans, 1987) and marsh surfaces were essentially not utilized (Orth, pers. comm.). However, in Great Bay, New Jersey, small crabs were equally low in abundances in marsh creeks, eelgrass beds and algal beds (Wilson et al., in press). Such differences in distributions may be related to variations in tides, current structure, substrates, and geomorphology that affect recruitment and the food and refuge quality of nursery habitat.

The comparative value of food and protection to blue crabs between seagrass and salt marsh habitats is poorly understood. However, numerous studies have shown that protection is derived from seagrass structure (Nelson, 1979; Heck and Orth, 1980a; Coen et al., 1981; Heck and Thoman, 1984; Orth et al., 1984; Wilson et al., 1987). Minello and Zimmerman (1983), have also shown that simulated structure of salt marsh plants can reduce predation. Our results from recent predation and feeding experiments with blue crabs comparing seagrass, salt marsh, and bare sand indicate significant differences among habitats. Salt marsh and seagrass were similar in protective qualities but differed in food qualities (unpubl.). Such differences may account for habitat-related distributions. Yet, no published information exists on utilization of nursery habitats by juvenile blue crabs in the NW Gulf.

The purpose of this study is to report on distribution patterns of juvenile blue crabs among salt marsh, seagrass and nonvegetated habitats from the NW Gulf of Mexico. In the study, monthly abundance patterns of blue crabs have been examined by size and as a function of habitat type. The working hypothesis is that seagrass beds contain higher densities of juveniles than other habitats and that usage of salt marsh increases in the absence of seagrass.

Methods

Study Sites.—The study was conducted in Christmas Bay (95°10′W; 29°2′48″N) and West Bay (94°59′W; 29°12′N) southwest of Galveston, Texas, in the northwestern Gulf of Mexico (Fig. 1). The bays are separated by San Luis Pass, through which Gulf water and megalopae enter. The Christmas Bay (CB) site was characterized by contiguous salt marsh (*Spartina alterniflora*), seagrass (*Halodule wrightii*) and sand habitats. The inner margin of the *Halodule* seagrass bed was adjacent to intertidal *Spartina* marsh and the outer margin was adjacent to subtidal bare sand bottom. The mean width of the grassbed was 300 m and it became emergent only during seasonally low tides in the winter and early spring. The West Bay (WB) site (described by Zimmerman et al., 1984) consisted of a reticulated intertidal *S. alterniflora* marsh located adjacent to subtidal open water with barren muddy substrate. The site was located on the inland side of Galveston Island approximately 16 km east of the CB site (Fig. 1).

Sampling Techniques.—To sample crab densities, we employed drop sampler methodology of Zimmerman et al. (1984). This method provides quantitative measurements of faunal abundances that are comparable among a variety of shallow water habitats. In brief, a 1.8-m diam fiberglass cylinder enclosing 2.6 m^2 was dropped from a boom mounted on the bow of a skiff to entrap epibenthic and demersal fauna. Once in place, water was pumped from the sampler into a 1-mm square plankton net. Most of the fauna, consisting of fishes and decapod crustaceans, were captured with dip nets during the pump down process. Animals remaining in the drained sampler were picked up by hand. All samples were labelled, placed in 10% Formalin with seawater and rose bengal stain, and stored for laboratory sorting. In the laboratory, all fishes and decapod crustaceans were counted, measured and identified to species. Blue crabs were divided into 5-mm size classes for determinations of monthly mean density and size in each habitat. Crabs larger than 40-mm carapace width (cw) were not used in calculating mean size due to their infrequent occurrence. Above ground plant biomass and shoot density were measured in samples where seagrass was present with a 10-cm diam subsample and in the salt marsh with a 30-cm diam subsample. Temperature, salinity, dissolved oxygen, and water depth were also recorded with each sample. The record of water level changes influencing sites in both bays was taken from a permanent National Oceanic and Atmospheric Administration/National Ocean Service (NOAA/NOS, Rockville, Maryland 20852) tide station (No. 877-1450) in Galveston.

Sampling Design.—Samples were taken from July 1984 to June 1985 in monthly sets of eight replicates per habitat. Adjacent habitats were sampled on the same day. Accordingly, in West Bay (WB), eight drop samples were taken monthly from both the intertidal salt marsh surface and the adjacent subtidal bare mud. In Christmas Bay (CB), monthly sets consisted of salt marsh and the adjacent inner seagrass margin taken together, and the outer seagrass margin and adjacent bare sand taken together. Samples from adjacent habitats were normally separated by no more than 4 m. All collections were at high tide to insure maximum availability of each habitat to the fauna.

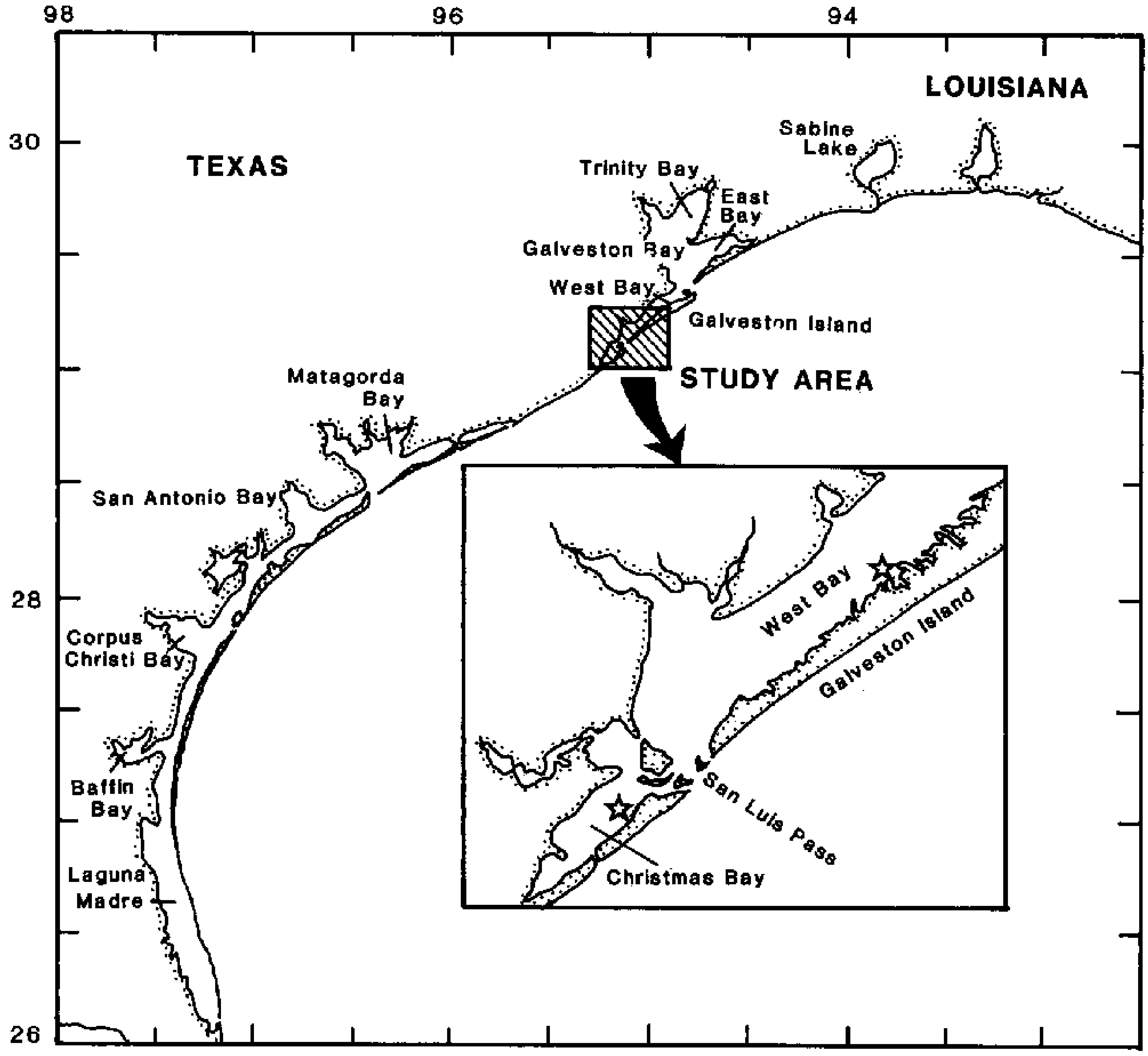

Figure 1. Study sites of blue crab nursery habitats in Christmas Bay and West Bay on the upper Texas coast in the northwestern Gulf of Mexico.

In some months not all habitats were sampled, due to problems of tidal elevation, weather or logistics. A full complement of twelve sets was obtained from CB inner seagrass and CB *Spartina*, but November was missing from CB outer seagrass and CB sand. In West Bay, the winter months were not sampled; therefore, only nine sets were available from WB *Spartina* and WB mud.

Analyses.—The data were analyzed using one way analysis of variances (ANOVA) and least significant difference (LSD) multiple range tests (Steele and Torrie, 1960) computed using SAS Institute, Inc. (1987) algorithms. Densities were log transformed due to a positive relationship between the standard deviation and the mean. For each month, differences in crab densities were tested at the 0.05 level among habitats sampled in that month, i.e., among CB *Spartina*, CB inner seagrass, CB outer seagrass, CB sand, WB *Spartina* and WB mud. Differences in crab sizes among habitats were tested similarly.

Results

Water depths at sites in both bays were generally less than 1 m. Mean diurnal tidal range for the area is 30 cm and the seasonal range is 1 m (Hicks et al., 1983). Seasonally high water occurred during the fall of 1984 and spring of 1985 and low water in the winter of 1985; Fig. 2, thus conforming to the usual pattern for the NW Gulf (Hicks et al., 1983). Mean monthly temperatures and salinities for the area normally range between 12.5 to 30.2°C and 19.7 to 28.8‰ (unpubl., Texas Parks and Wildlife Department, Austin, Texas). Temperatures and salinities during the study period approximated those ranges (Fig. 2).

Crab densities were significantly different between some habitats during every month except February (Table 1). Within Christmas Bay, the densities were significantly higher in inner seagrass than in the salt marsh for 7 of 12 months and

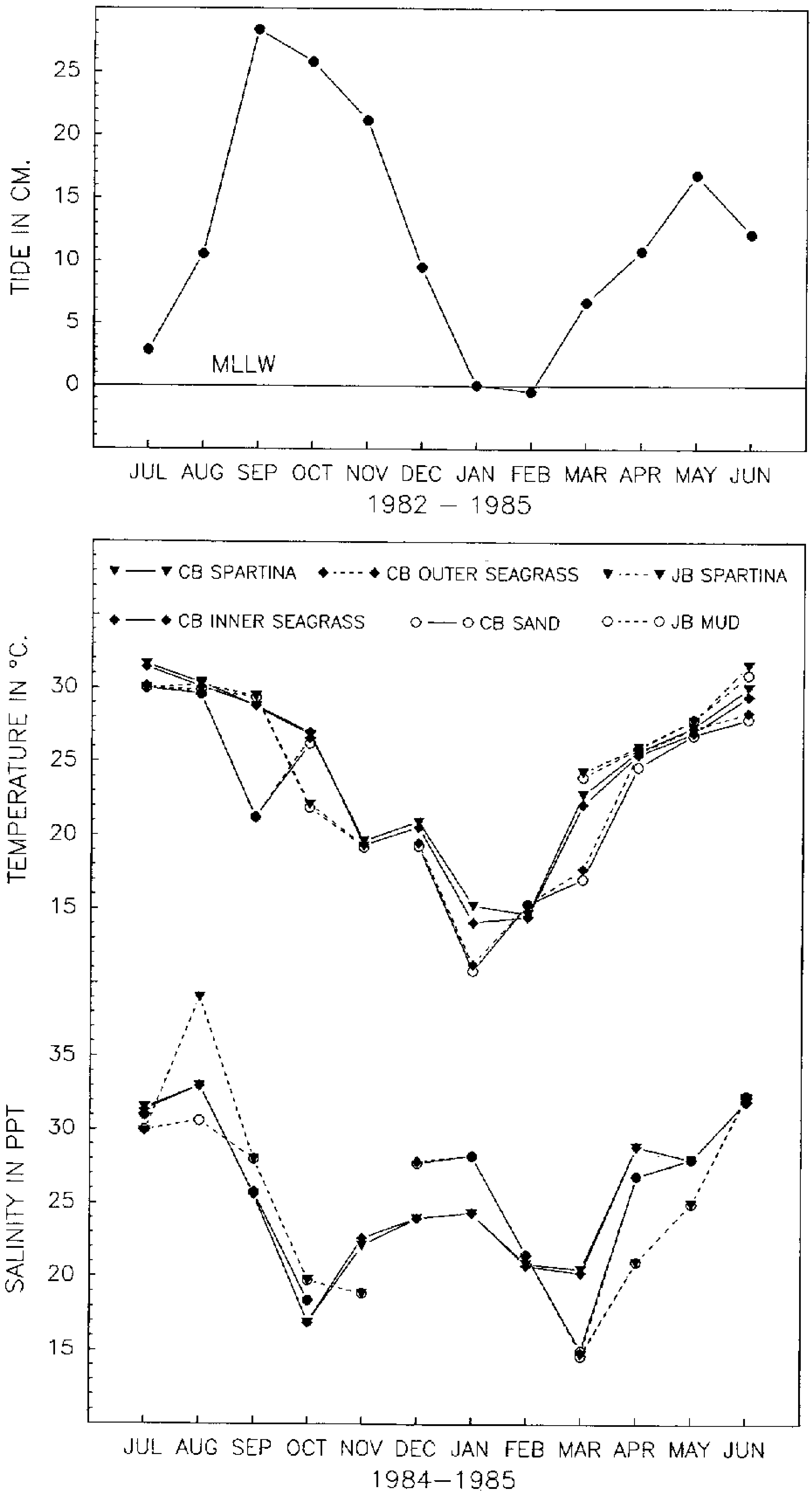

Figure 2. Seasonality in the physical environment of Christmas Bay and West Bay, Texas: average monthly tide levels (mean low low water) from NOAA/NOS station #877-1450 at Galveston, 1982 through 1985, and mean temperatures and salinities from monthly sampling, June 1984–July 1985.

Table 1. Distribution patterns of juvenile blue crabs (*C. sapidus*) in two northwestern Gulf of Mexico bays between salt marsh, seagrass and nonvegetated habitats

Month	High crab density			Low crab density		
	1	2	3	4	5	6
July	CB OSg	CB ISg	WB Sp	CB Sp	CB Sd	WB Md
August	CB OSg	CB ISg	WB Sp	CB Sp	WB Md	CB Sd
September	CB ISg	CB OSg	CB Sp	WB Sp	CB Sd	WB Md
October	CB ISg	CB Sp	CB OSg	WB Sp	CB Sd	WB Md
November	CB ISg	CB Sp	WB Sp	WB Md		
December	CB ISg	CB OSg	CB Sp	CB Sd		
January	CB OSg	CB ISg	CB Sd	CB Sp		
February	CB Sd	CB ISg	CB Sp	CB OSg		
March	CB ISg	CB OSg	CB Sp	WB Sp	CB Sd	WB Md
April	CB OSg	WB Sp	CB Sp	CB ISg	WB Md	CB Sd
May	CB OSg	CB ISg	WB Sp	CB Sp	CB Sd	WB Md
June	CB OSg	CB ISg	WB Sp	CB Sd	CB Sp	WB Md

CB ISg = Christmas Bay inner seagrass; CB OSg = Christmas Bay outer seagrass; CB Sd = Christmas Bay sand; WB Sp = West Bay *Spartina*; WB Md = West Bay mud. Underline denotes no significant difference between habitats (ANOVA, LSD multiple range procedure, $P < 0.05$, N = 8).

in outer seagrass than on sand for 10 of 11 months (Fig. 3; Table 1). Within West Bay, densities were always significantly higher in the salt marsh than on mud bottom (Fig. 3; Table 1).

Between bays, crab densities were highest in seagrass habitats, followed by *Spartina,* then sand (Fig. 3). In all months except February either inner or outer seagrass ranked highest in crab densities among all habitats in either bay (Table 1). In 8 of 11 months, seagrass habitats were ranked first and second in density, and during 7 of those 8 months inner and outer seagrass densities were not significantly different from one another (Table 1). Although crab densities in CB sand were nearly always significantly lower than those in seagrass, they were often not significantly different from CB *Spartina* (6 of 11 months, Table 1). Only in February did CB sand rank highest in density. Crab densities in WB *Spartina* and CB *Spartina* were usually similar (7 of 9 months were not significantly different, Table 1) as were densities in WB mud and CB sand (5 of 8 months were not significantly different).

Mean crab sizes were usually largest in *Spartina* habitats, and generally similar between seagrass, sand and mud habitats (Fig. 4). Mean sizes were significantly smaller in CB inner seagrass than in CB *Spartina* from December through May (ANOVA, df = 5, $P < 0.05$). In West Bay, mean crab sizes were always smaller on mud bottom than in *Spartina* habitat (Fig. 4), and significantly smaller during 6 of 9 months (ANOVA, df = 3 to 5, $P < 0.05$).

The highest densities of crabs occurred in the summer and fall, and the lowest were in the winter (Fig. 3). Overall, mean size appeared to be inversely related to density (Pearson correlation coefficient = -0.41, $P < 0.001$, N = 64), with the smallest sizes occurring in the fall and the largest sizes in the late winter and early spring (Fig. 4). This seasonal pattern in density and size almost certainly reflects recruitment and non-recruitment periodicity during the year. Patterns of habitat related distributions (Table 1) were also generally related to high seagrass leaf biomass in the summer and fall and low biomass in the winter and early spring (Table 2). Blue crab densities were higher in CB seagrass during the recruitment

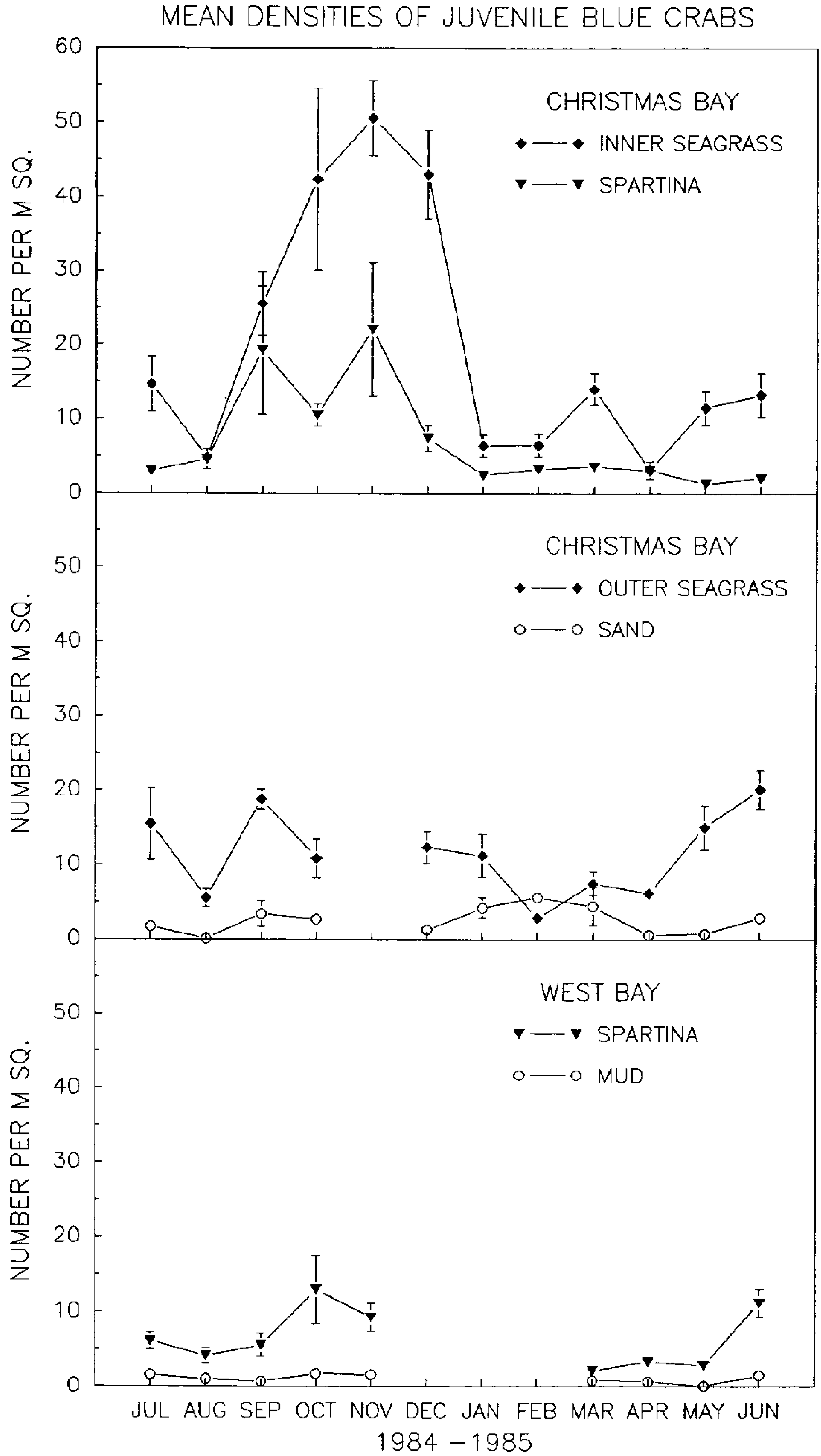

Figure 3. Mean monthly densities of juvenile blue crabs in Christmas Bay and West Bay, Texas—July 1984 to June 1985. Error bars = ±1 standard error.

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Figure 4. Mean monthly sizes of juvenile blue crabs in Christmas Bay and West Bay, Texas—July 1984 to June 1985. Error bars = ±1 standard error.

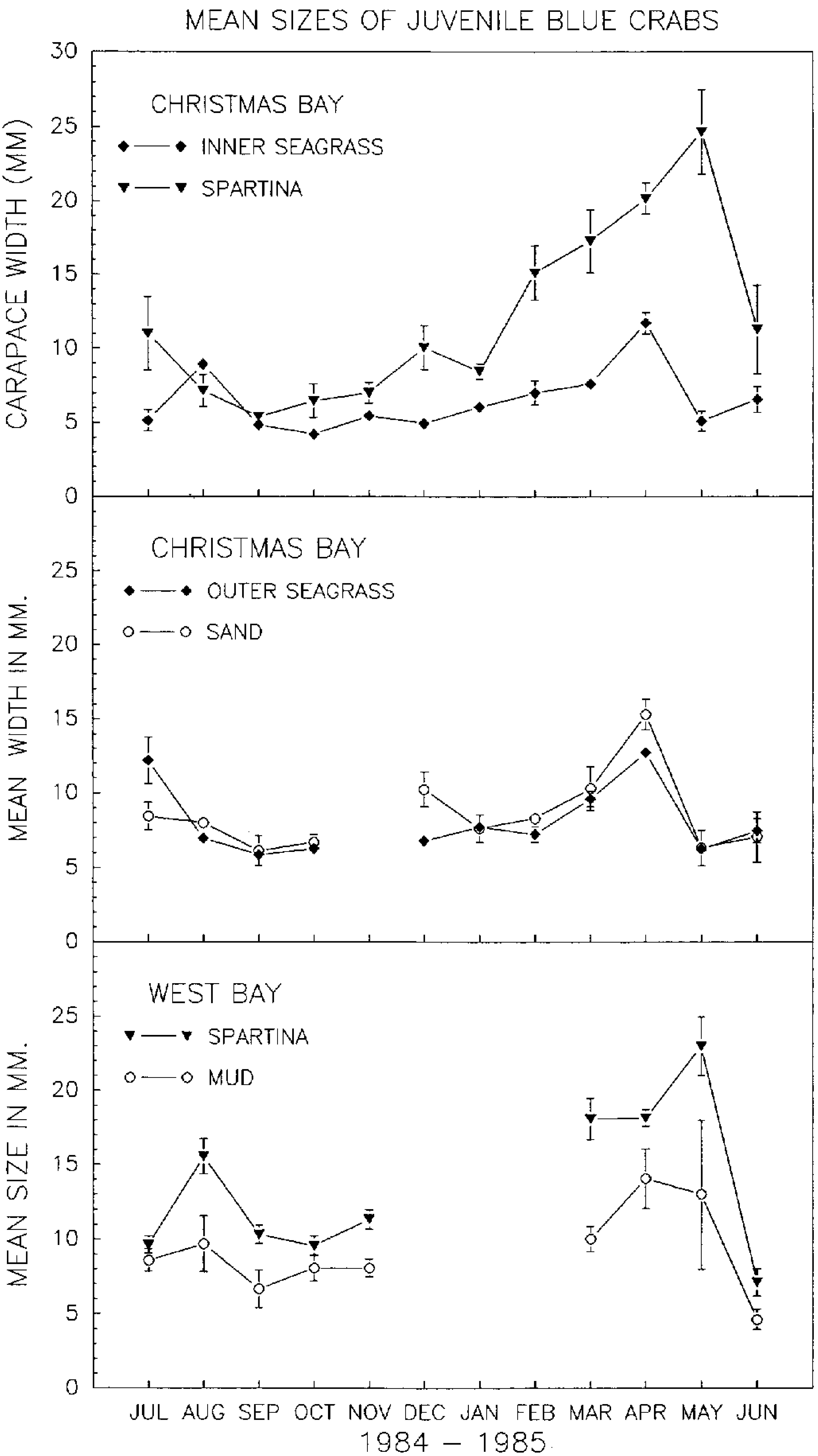
MEAN SIZES OF JUVENILE BLUE CRABS
CARAPACE WIDTH (MM)
CHRISTMAS BAY
INNER SEAGRASS
SPARTINA
MEAN WIDTH IN MM.
CHRISTMAS BAY
OUTER SEAGRASS
SAND
MEAN SIZE IN MM.
WEST BAY
SPARTINA
MUD
0
5
10
15
20
25
30
JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1984 – 1985

Table 2. Seasonal changes in seagrass leaf biomass (*Halodule wrightii*), in g dry wt·m^{-2}, from Christmas Bay Texas

Location	1984–1985											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Inner zone	24	96	—	22	18	15	5	—	4	5	5	33
Outer zone	—	17	18	—	—	10	4	4	—	—	—	37

Values were computed from 78.5 cm^2 core means (N = 4).

period from June to December which corresponded to favorable temperatures, high water levels and high seagrass leaf biomass. In January, the temperatures fell, seagrass leaves exfoliated, and crab recruitment apparently ended causing densities to remain low through May. High water levels increased the availability of marsh surface during the spring and fall and decreased availability during the winter (Fig. 2). Unlike seagrass leaf biomass, above ground biomass in the salt marsh did not change significantly during the year. In the salt marsh, crab abundances may have been more affected by water level and less by changes in plant structure than in the seagrass bed.

Discussion

The hypothesis that juvenile blue crabs prefer seagrass as nursery habitat was supported by crab densities that were nearly always higher in seagrasses than in other habitats. However, absence of seagrass neither increased nor diminished utilization of salt marsh habitat, i.e., crab densities in salt marshes of West Bay (without seagrass) and Christmas Bay (with seagrass) were similar. Although crab densities in salt marshes were unaffected by the presence of seagrasses, they were comparatively high being intermediate between those of seagrass and bare sand or mud bottom. This demonstrates that juvenile blue crabs are using salt marsh surfaces in the NW Gulf as a nursery.

A regional comparison of our results with studies of the lower Chesapeake Bay by Orth and van Montfrans (1987) and New Jersey by Wilson et al. (in press) provides insight into utilization of estuarine habitats by juvenile blue crabs. The Chesapeake Bay and New Jersey investigators used sampling methodology similar to ours to estimate crab densities in seagrass and marsh creek (nonvegetated) habitats. In the Chesapeake Bay and in Texas, crab densities were consistently higher in seagrass habitat when compared to nearby nonvegetated habitat. Highest densities of crabs in the seagrass bed during the 1-year study at Christmas Bay (50·m^{-2}) were within the range of highest densities in each of 4 years (15 to 90·m^{-2}) from Chesapeake seagrasses. Crab densities in nonvegetated habitats were also similar between the regions. Highest densities in Christmas Bay sand were 6·m^{-2} and in West Bay mud were 2·m^{-2}, as compared to 6 to 8·m^{-2} in Chesapeake Bay marsh creeks. In New Jersey, densities were equally low (0 to 3·m^{-2}) across vegetated or unvegetated habitats. It is important to note that the salt marsh surface in the Chesapeake Bay and New Jersey appeared to be virtually unused by comparison to Texas. For example, using a pit sampling technique, Orth and van Montfrans (personal communication), found very few crabs on the marsh surface at Chesapeake Bay sites. By contrast, relatively high densities of crabs occurred on salt marsh surfaces at Christmas Bay (22·m^{-2}) and West Bay (13·m^{-2}). Similar densities (17 to 20·m^{-2}), were found in a previous study of the same West Bay marsh by Zimmerman and Minello (1984a).

The difference in salt marsh utilization between the NW Gulf and the Chesapeake Bay or New Jersey may be due to differences in habitat geomorphology and tidal amplitude. Salt marshes in the Chesapeake Bay are often characterized by dendritic intertidal marsh creeks and daily tidal amplitudes on the order of 1 m or less. Periods of marsh inundation may be relatively short, rendering these habitats less accessible for exploitation by species such as *C. sapidus*. When these habitats are drained, blue crabs and other inhabitants are concentrated in deeper nonvegetated marsh creeks where predation pressure may be relatively high (Zimmerman and Minello, 1984a; Orth and van Montfrans, 1987). Salt marshes in the NW Gulf are more reticulated in morphology with stands of vegetation interspersed among many nonvegetated subtidal pools and creeks. This creates more edge for entry from subtidal areas into salt marsh. Tidal fluctuations in the Gulf are small, on the order of 30 cm daily. Inundation periods in northwestern Gulf marshes are also often relatively long because of high soil compaction and subsidence rates (Baumann, 1987). As a result, salt marshes along the upper Texas and Louisiana coast are potentially more accessible for exploitation and may have greater value as nursery habitat for blue crabs than those of the Atlantic coast.

Seasonal blue crab abundances in both the Chesapeake Bay and northwestern Gulf corresponded to recruitment pulses and changes in temperature, water depth and plant biomass. In both regions, highest crab densities occurred in the late summer and fall during primary recruitment periods. Chesapeake Bay crab abundances were lowest in marsh creeks in the winter (January–March) but relatively large numbers in the seagrass bed implied overwintering by juveniles (Orth and van Montfrans, 1987). In New Jersey (Wilson et al., in press), overwintering was suggested for both seagrass and marsh creeks. Lowest crab abundances within the Chesapeake Bay and New Jersey seagrass beds occurred prior to summer spawning. In Texas, crab abundances in seagrass beds were lowest in the winter. In contrast to the Chesapeake Bay, the low crab numbers from January through March in seagrasses corresponded to increases in crab numbers on nearby sand bottom. The distribution shift was possibly due to unfavorable winter conditions caused by seasonal low temperatures, low tides and an 85% reduction in leaf biomass in the seagrass habitat.

Such evidence suggests that juvenile blue crabs overwinter by burrowing into substrates on subtidal bottom but in shallow water. We have collected burrowed, torpid crabs from both inundated and exposed mud substrate during cold periods. We propose that overwintering in shallow estuarine waters (less than 1 m in depth) provides several benefits for juvenile blue crabs in the northwestern Gulf. Overwintering crabs escape predation by fishes and larger crabs that migrate to deeper waters. When temperatures rise in shallow waters, juveniles emerge ahead of other consumers to exploit high abundances of epifauna and infauna that develop in the winter (Flint, 1985). Subsequent rapid growth in the early spring may help crabs gain refuge in size against immigrating predators.

Juvenile crabs at the Texas sites were of a larger mean size on the salt marsh surface than in seagrasses or sand/mud bottom. Possible reasons for habitat-related size patterns include differential predation, differential recruitment of megalopae and inability of small crabs to move with tides in and out of salt marshes effectively. Because redistribution occurs with every tidal cycle, we hypothesize that the reasons may involve active selection. These may be influenced by nutritional requirements that change with size (Ryer, 1987), inability of larger crabs to forage as efficiently in high density vegetation (Orth, 1975) and refuge requirements that change with crab size (Heck and Orth, 1980a, Heck and Thoman, 1984; Orth et al., 1984). Whatever the reason(s), use of protection and food available in salt marshes depends greatly on the ability of crabs to adjust to tidal changes.

In conclusion, blue crab densities in subtidal seagrass and bare mud habitats in the NW Gulf of Mexico are comparable to those found on the Atlantic Coast. Seasonal patterns are also similar with the highest abundances of crabs in both regions occurring in the late summer and fall due to recruitment pulses. By contrast, differences between the regions occur in the use of salt marshes as nursery habitat. More marsh edge, low tidal amplitudes, and long periods of tidal inundation favor utilization of salt marshes by juvenile crabs in the NW Gulf, whereas those of the Atlantic appear hardly used at all. In addition, seagrasses are not extensive in the NW Gulf leaving salt marshes as the most likely vegetated nursery for blue crabs. However, intertidal salt marshes in the NW Gulf are largely unavailable during the winter because of seasonal low water. During this time, crab densities at the Texas sites increased on sand and mud bottoms indicating a shift in habitat use by overwintering juveniles. This estuarine overwintering may serve to maintain the juvenile population size for development into adults during the spring and summer.

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ADDRESS: *NOAA/National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory, 4700 Avenue U., Galveston, Texas, 77550.*