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Habitat use patterns of newly settled spotted seatrout in estuaries of the north-western Gulf of Mexico

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Abstract This study examined habitat use patterns of newly settled spotted seatrout *Cynoscion nebulosus* (Cuvier) across several Gulf of Mexico estuaries. Intensive sampling using an epibenthic sled was conducted in three Texas bays and among three potential habitat types. A long-term data set (1982 to 1997) from the National Marine Fisheries Service was also used to examine *C. nebulosus* habitat use patterns in both marsh and seagrass-dominated bay systems for broad regional comparisons along the north-western Gulf of Mexico. Vegetated habitat types such as seagrass and marsh supported the highest densities and use was dependent upon availability of particular vegetated habitat types. In laboratory mesocosm experiments, both wild-caught and hatchery-reared *C. nebulosus*, showed strong selection for structured and vegetated habitat types. These field and laboratory results suggest that seagrass meadows and marshes may be functioning as important habitat for *C. nebulosus* in Gulf of Mexico, and other habitat types such as oyster reef need further evaluation.

KEYWORDS: hatchery-reared fish, mesocosm, salt marsh, sciaenid, seagrass.

Introduction

Estuaries are productive ecosystems that support diverse communities, and numerous ecologically and economically important fish species use estuarine habitats during critical phases of their life cycle (Weinstein 1979; Minello 1999). Primary functions of these areas include refuges from predation and promotion of rapid growth from abundant food supplies leading to subsequent recruitment to adult populations (Heck & Thoman 1981; Kneib 1993; Beck *et al*. 2001). Generally, estuarine fishes are not randomly distributed and the underlying mechanisms for this pattern can be complex. Specific distribution patterns may be caused by behavioural responses of fish to specific habitat types. New recruits may increase their relative fitness by selecting habitats that maximise growth rates and minimise encounters with predators (Heck & Crowder 1991; Sogard 1992; Stunz *et al*. 2002). For example, some fish selectively settle in seagrass (Bell & Westoby 1986), marshes (Minello 1999), coral reefs (Sale *et al*. 1994) and rocky reefs (Levin & Hay 1996), and these selection patterns can influence distributions and abundance of fishes (Bell *et al*. 1987; Levin *et al*. 1997; Levin & Stunz 2005). The value of vegetated habitat is well-documented, but few studies have

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simultaneously focused on the relative value of seagrass, salt marsh and non-vegetated bottom in terms of habitat use (Rozas & Minello 1998; Minello 1999). Given the decline of both salt marsh (Penland & Ramsey 1990) and seagrass meadows (Short & Wyllie-Echeverria 1996), a comparative evaluation of habitat types is needed for many species.

Spotted seatrout, *Cynoscion nebulosus* (Cuvier), is one of the most sought after recreational fish in southeast USA. In the Gulf of Mexico, 3.3 million anglers spent 23 million days fishing in 2003 and the most commonly captured species was *C. nebulosus* (Van Voorhees & Pritchard 2004). While Texas has traditionally supported an abundant *C. nebulosus* stock, results from the Texas Parks and Wildlife Department's (TPWD) long-term monitoring programme has raised some management concerns over decreasing availability of *C. nebulosus* in some regions (particularly South Texas) that has resulted in stricter regulations (Green & Campbell 2005). Moreover, in an effort to supplement natural recruitment of recreational fish stocks, the State of Texas has been carrying out a marine stock enhancement programme in Texas estuaries (Scharf 2000). Currently, approximately 1 million *C. nebulosus* fingerlings (about 40 mm total length) are released annually into Texas estuaries. Recruitment and maintenance of sustainable populations rely on estuarine nursery habitat availability and use, but there are considerable gaps in knowledge concerning specific spatial patterns of habitat use for both wild-caught and hatchery-reared *C. nebulosus*. Studies generating habitat use information have the potential to enhance the success of management and enhancement programmes.

In Texas, *C. nebulosus* spawns from April to October, with two peaks, one in June and another in September (Rooker *et al.* 1998; Powell 2003). Spawning sites are typically in deeper water and channels adjacent to shallow flats and seagrass beds (Pearson 1929). Newly settled juveniles are found in seagrass meadows, salt marshes and non-vegetated bottom (Baltz *et al.* 1993; Rooker *et al.* 1998), but there are considerable differences in habitat availability in estuaries along the Gulf of Mexico. For example, in a south-western progression, estuarine habitats change from marsh to seagrass-dominated systems, but the extent to which *C. nebulosus* adapt their habitat use patterns in response to changes in availability of certain habitat types is unknown. Previous habitat selection studies have also predicted distributions of fishes based on experimental mesocosms (Fraser & Sise 1980; Heck & Crowder 1991; Baltz *et al.* 1993). *Sciaenops ocellatus* (Linnaeus), a sciaenid similar to *C. nebulosus,* selects specific vegetated habitat types (Baltz *et al.* 1998; Rooker *et al.* 1998; Stunz *et al.* 2002), but it is unknown if other sciaenids exhibit similar behaviours. Despite these generalities concerning *C. nebulosus* recruitment, few studies have examined specific habitat use preferences of juveniles when given a choice of habitat types.

Specifically, this study (1) examines habitat use patterns of newly settled *C. nebulosus* in three south Texas bays, (2) assesses habitat use of *C. nebulosus* in estuaries with limited seagrass habitat using long-term data sets from the northwestern Gulf of Mexico and (3) examines *C. nebulosus* habitat selection preferences for both wild-caught and hatchery-reared fish using experimental mesocosms.

Materials and methods

Habitat selection in south Texas bays

Cynoscion nebulosus were collected from Aransas Bay, Corpus Christi Bay and the Upper Laguna Madre (Fig. 1). Aransas Bay is a bar-built estuary along the Texas Gulf Coast lying between Corpus Christi and San Antonio bays. *Halodule wrightii* (Ashers) and *Thalassia testudinum* (Banks) are dominant seagrasses within the estuary. *Spartina alterniflora* (Loisel) forms intertidal salt marsh habitat that lines the bay's perimeter. The northern reaches of Aransas Bay have extensive marsh complexes and aerial coverage of marshes declines progressively southward. Corpus Christi Bay is a bar-built estuary south of the Aransas Estuary. *Halodule wrightii* is the dominant seagrass in the estuary. *Spartina alterniflora* intertidal salt marshes are common in many areas but are much less extensive than Aransas Bay. By contrast to Aransas and Corpus Christi bays, the Laguna Madre is a bar-built hypersaline lagoon, extending from Corpus Christi Bay, Texas to Rio Soto la Marina, Mexico. The Laguna Madre is a negative estuary because of evaporation losses exceeding freshwater inflows. The estuary contains four species of seagrasses: *H. wrightii; T. testudinum; Ruppia maritima* (L.)*; and Syringodium filiforme* (Kuetz). The Upper Laguna Madre differs from the other bay systems in this study as it is a seagrass-dominated system with very little intertidal emergent marsh vegetation. All three estuaries support abundant populations of *C. nebulosus* but are characterised by differences in vegetated habitat availability.

Juvenile *C. nebulosus* were sampled in seagrass, non-vegetated bottom and marsh edge (when available). Seagrass habitats sampled were in meadows dominated by *H. wrightii*. Non-vegetated bottom habitat sampled was mud and sand bottom >1 m from the marsh edge

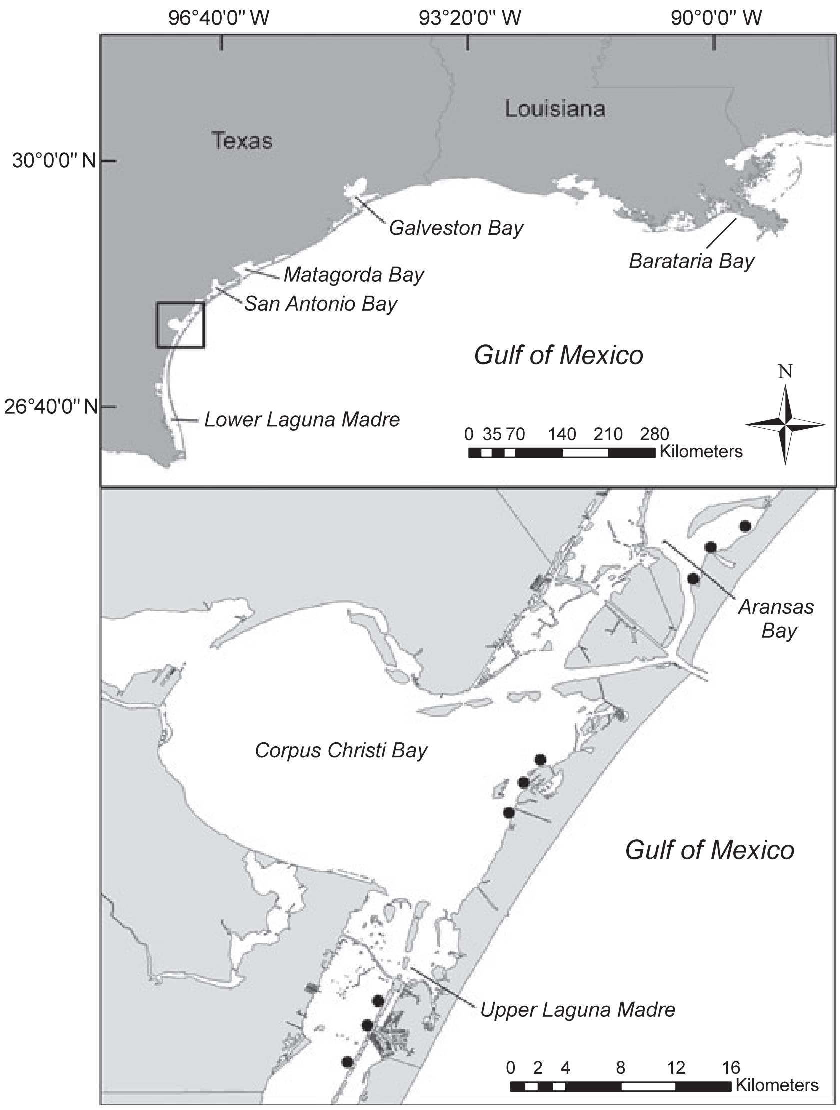

Figure 1. Map of bays in the northwestern Gulf of Mexico. Sampling sites for the south Texas bays are represented by filled circles.

open-water interface. Marsh edge is defined as open water immediately adjacent to salt marsh (*S. alterniflora*) vegetation (< 1 m towards open water). Each bay system included three sampling sites, and each site included all three habitat types when available (except Upper Laguna Madre did not contain marsh edge).

Samples were collected using triplicate epibenthic sled tows in each habitat type at each site every other week from April to October 2005, the peak spawning season for *C. nebulosus*. The sled is a fixed frame sampling device effective for sampling nekton in seagrass, non-vegetated bottom, and marsh edge habitat types (Stunz *et al.* 2002). The sled consists of a metal frame with a 0.6 m (L) × 0.75 m (H) opening that is fitted with a 1-mm mesh conical plankton net (Stunz *et al.* 2002). To collect a sample, the sled was placed on the bottom and a semicircular route was walked around the sampling location to avoid disturbance. The sled was then pulled in a straight line for 16.7 m covering 10 m^2 of habitat. Samples were rough sorted in the field, fixed in 10% formalin and transported to the laboratory. *Cynoscion nebulosus* were removed from each sample and measured to the nearest 0.1 mm standard length (SL). Salinity, water temperature (°C) and dissolved oxygen (mg L^{-1}) were taken at each sampling site.

Analysis was restricted to data from June 2005 to October 2005, when *C. nebulosus* occurred in the samples. Analysis of Variance (ANOVA) in the General Linear Model procedure in SAS 9.1 (SAS Institute, Inc., Cary, NC, USA) was used to test the null hypothesis that there was no difference in densities (number of fish m^{-2}) between habitat types. The experiment was designed with two main fixed treatment effects, bay (Aransas Bay, Corpus Christi Bay and Upper Laguna Madre) and habitat (marsh edge, seagrass and non-vegetated bottom), with date blocked to control for recruitment variability over time. The distribution of the residuals was analysed using the UNIVARIATE procedure in SAS and data were $\log_{10}(X + 1)$ transformed to ensure homogeneity of variance and normality of the residuals. Significant main effects were further examined using Tukey's HSD ($\alpha = 0.05$) (Day & Quinn 1989).

North-western Gulf of Mexico study

A long-term data set provided by NOAA Fisheries Galveston Laboratory was used to examine *C. nebulosus* habitat use from other Gulf of Mexico coast bays apart from Corpus Christi Bay and the Upper Laguna Madre, particularly those dominated by emergent marshes. The bays examined included Barataria Bay, Galveston Bay, Matagorda-Lavaca Bay, San Antonio Bay, Aransas Bay and the Lower Laguna Madre (Fig. 1). Dominant habitat types in the western Gulf of Mexico progress from marsh edge in northern latitudes to seagrass in southern latitudes. Only marsh edge and non-vegetated bottom were sampled in Barataria, Galveston and Matagorda bays. Marsh edge, seagrass and non-vegetated bottom were sampled in Aransas and San Antonio bays. Samples from the Lower Laguna Madre were only collected in seagrass and non-vegetated bottom. Marsh edge in Matagorda and San Antonio bays was primarily *S. alterniflora*, but this vegetation was at times mixed with *Distichilis spicata* (L.), *Juncus roemerianus* (Scheele), *Spartina patens* (Muhl) and *Scirpus maritimus* (L.).

Juvenile *C. nebulosus* were collected using boom-mounted drop sampling, described by Zimmerman *et al*. (1984). This gear uses an open-ended enclosure device that is dropped on a randomly selected section of habitats and pressed into the substrate. All fish were removed from the enclosure by dip nets and the water pumped out through a net. Any remaining organisms were collected by hand. Density of *C. nebulosus* was calculated by bay and habitat type and reported as mean density ± standard error.

Laboratory mesocosm study

Wild-caught, newly settled *C. nebulosus* were collected from seagrass meadows of the Upper Laguna Madre and Corpus Christi Bay for the laboratory mesocosm experiments. For behavioural comparison, hatchery-reared *C. nebulosus* were also obtained from the Texas Parks and Wildlife Perry R. Bass Hatchery in Palacios, Texas. These fish were reared from captive-induced ova. Eggs were collected and hatched in large holding tanks, and larvae were transferred to grow out ponds until they reached a size of about 25 mm SL. Both hatchery-reared and wild-caught fish were held for several days before the experimental trials.

Experimental mesocosms were constructed in 38-L glass aquariums (50.5 × 29 × 25.5 cm). Washed beach sand was placed in the bottom of each tank, followed by extruded plastic Vexar® mesh (5 × 5 mm) (Conwed Global Netting Solutions, Minneapolis, MN, USA) and an additional 2 cm of washed beach sand. Plastic mesh was used to secure and keep marsh edge culms erect by threading stems through the mesh. Each tank was filled with an equal volume of seawater (25–30 ‰). Temperature and oxygen levels were maintained between 24–28 °C and 6.0–6.8 mg L^{-1} O_2, respectively.

Four habitats were simulated in experimental mesocosms: seagrass, salt marsh, non-vegetated bottom and oyster reef. Mesocosms were divided in half and one habitat type was constructed in each section. Six possible habitat pair-wise combinations with two replicates per combination were simulated for each experimental trial until six trials were completed for each possible habitat comparison. The non-vegetated bottom consisted of washed beach sand. Seagrass habitat used in the experiments was obtained from cores of *H. wrightii* collected from the Upper Laguna Madre. Salt marsh habitat was simulated by cutting *S. alterniflora* from Corpus Christi Bay marshes and sun-drying the culms. They were then inserted into the plastic mesh to simulate marsh densities found in Corpus Christi Bay. Oyster reef was created using sun-dried oyster shells.

Three *C. nebulosus* were placed in the middle of each mesocosm and acclimated for 12 h. Preliminary observations indicated that the location of all fish could be detected by visual inspection and this assessment did not disturb or alter fish behaviour. The location of each fish was visually noted every 30 min over a 5-h period with the first observation occurring 30 min after the acclimation period (10 observations total). This procedure was performed separately for two different size classes of wild-caught fish (mean = 23.33 mm ± 1.08; mean = 65.77 mm ± 1.60) to test for ontogenetic differences in habitat selection and one size class of hatchery-reared fish (mean = 24.59 mm ± 0.24). Hatchery fish were replaced with new individuals for every trial. However, due to a limited supply of wild-caught juvenile *C. nebulosus*, fish were randomly selected from a pool of experimental animals for each trial. For each replicate, mesocosm percent occurrence was calculated for *C. nebulosus* based on 30 observations (3 fish per mesocosm × 10 observations). Data were arcsine transformed to normalise the distribution of percentage data, and a paired Student's *t*-test ($\alpha = 0.05$) was used to determine differences in habitat selection patterns.

Results

Habitat selection in south Texas bays

Juvenile *C. nebulosus* first appeared in Aransas Bay samples in June 2005 and remained throughout the sampling period to October 2005. Fish were captured in Corpus Christi Bay from July through September 2005 and were only collected from the Upper Laguna Madre during October 2005. The highest mean densities (0.037 m^{-2}) occurred during September 2005 in Aransas and Corpus Christi bays. *Cynoscion nebulosus* from the Upper Laguna Madre were only observed during October 2005 at a mean density of 0.028 m^{-2}. Mean standard lengths (± SE) in Aransas and Corpus Christi bays were 34.7 mm ± 3.09 and 26.2 mm ± 2.91 respectively. The highest mean standard length (± SE) among bays was in the Upper Laguna Madre, 44.5 ± 3.05 mm, but only five fish were collected during the study.

Cynoscion nebulosus were collected from all three habitat types in Aransas and Corpus Christ bays (Fig. 2a), but there was a significant habitat effect (Table 1). Higher densities were found in seagrass meadows than marsh and non-vegetated bottom (Fig. 2a). Only four of 61 fish were collected outside of seagrass in either non-vegetated bottom or marsh edge. Marsh was limited in the Upper Laguna Madre, and thus only seagrass meadows and non-vegetated habitats were sampled in this bay system. *Cynoscion nebulosus* was only caught from seagrass beds in the Upper Laguna Madre (Fig. 2b).

North-western Gulf of Mexico study

Juvenile *C. nebulosus* were collected from 2172 drop samples and were present from March through November (1982 through 1997), except in Galveston Bay where a small number were caught during winter sampling (9 of 1394 drop samples; 0.6%). The highest densities were found in Barataria (0.423 fish m^{-2}) and Aransas bays (0.368 fish m^{-2}) (Fig. 3). Bay-specific patterns of habitat use were observed with the overall pattern selecting for vegetated habitats.

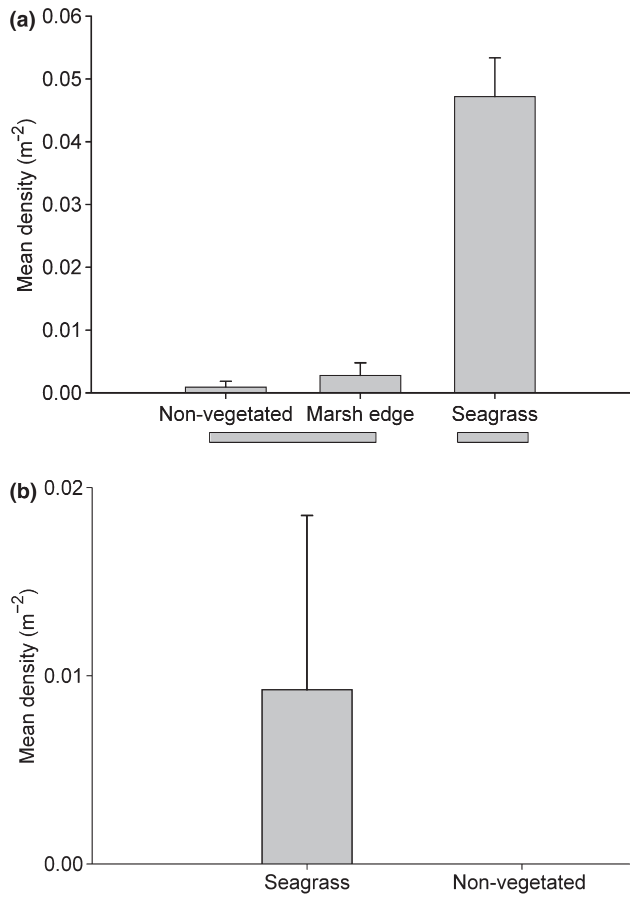

Figure 2. Mean density (± SE) of newly settled *C. nebulosus* collected with epibenthic sleds from (a) Aransas and Corpus Christi bays in non-vegetated bottom, marsh edge and seagrass; and (b) in the Upper Laguna Madre in seagrass and non-vegetated bottom. Horizontal bars below habitat types are from Tukey's *post-hoc* tests, and bars sharing horizontal bars are not significantly different ($\alpha = 0.05$).

Table 1. Analysis of Variance table for *C. nebulosus* habitat use (marsh edge, non-vegetated bottom and seagrass) patterns in Aransas and Corpus Christi bays

Source	d.f.	Sum of squares	Mean squares	*F* value	*P*
Bay	1	0.000002	0.000002	0.01	0.9145
Station	4	0.000359	0.000089	0.42	0.7927
Habitat	2	0.008279	0.004139	19.47	< 0.001
Bay × Habitat	2	0.000012	0.000006	0.03	0.9716
Event	5	0.002195	0.000439	2.07	0.0767
Residual	93	0.019771	0.000213		

Estuaries containing only marsh edge and non-vegetated bottom included Barataria, Galveston and Matagorda-Lavaca bays, and *C. nebulosus* were found in higher densities in marsh edge than non-vegetated bottom (Fig. 4a). San Antonio and Aransas bays

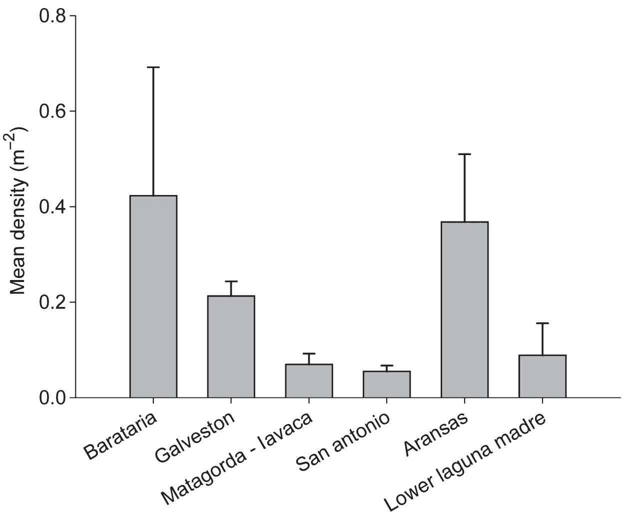

Figure 3. Mean density (±SE) of newly settled *C. nebulosus* collected with a drop sampler from Barataria Bay (n = 20), Galveston Bay (n = 1394), Matagorda-Lavaca Bay (n = 300), San Antonio Bay (n = 260), Aransas Bay (n = 100) and the Lower Laguna Madre (n = 98).

included all three habitat types. Densities in San Antonio Bay were higher in seagrass habitat than marsh edge and non-vegetated bottom (Fig. 4b). In Aransas Bay, the highest densities were found in marsh edge and seagrass habitat types (Fig. 4c).

Mesocosm study

Wild-caught, newly settled *C. nebulosus* (23.33 mm ± 1.08) exhibited strong selection for complex structured habitats of seagrass (t = 2.59, d.f. = 22, P = 0.02) and oyster reef (t = 2.47, d.f. = 22, P = 0.02) over non-vegetated bottom in the experimental mesocosms (Fig. 5a). Hatchery-reared *C. nebulosus* (24.59 mm ± 0.24) similarly selected seagrass (t = 2.67, d.f. = 22, P = 0.01) and marsh edge (t = 5.56, d.f. = 22, P < 0.001) over non-vegetated bottom. In addition, hatchery-reared fish selected seagrass over oyster reef (t = 2.63, d.f. = 22, P = 0.02) (Fig. 5b). The larger size classes of wild-caught *C. nebulosus* exhibited limited habitat selection, only showing significant selection for oyster reef over non-vegetated bottom (t = 2.93, d.f. = 22, P = 0.01) (Fig. 5c).

Discussion

Habitat selection patterns of newly settled *C. nebulosus* were evaluated using both intensive field collections in marsh and seagrass-dominated South Texas estuaries

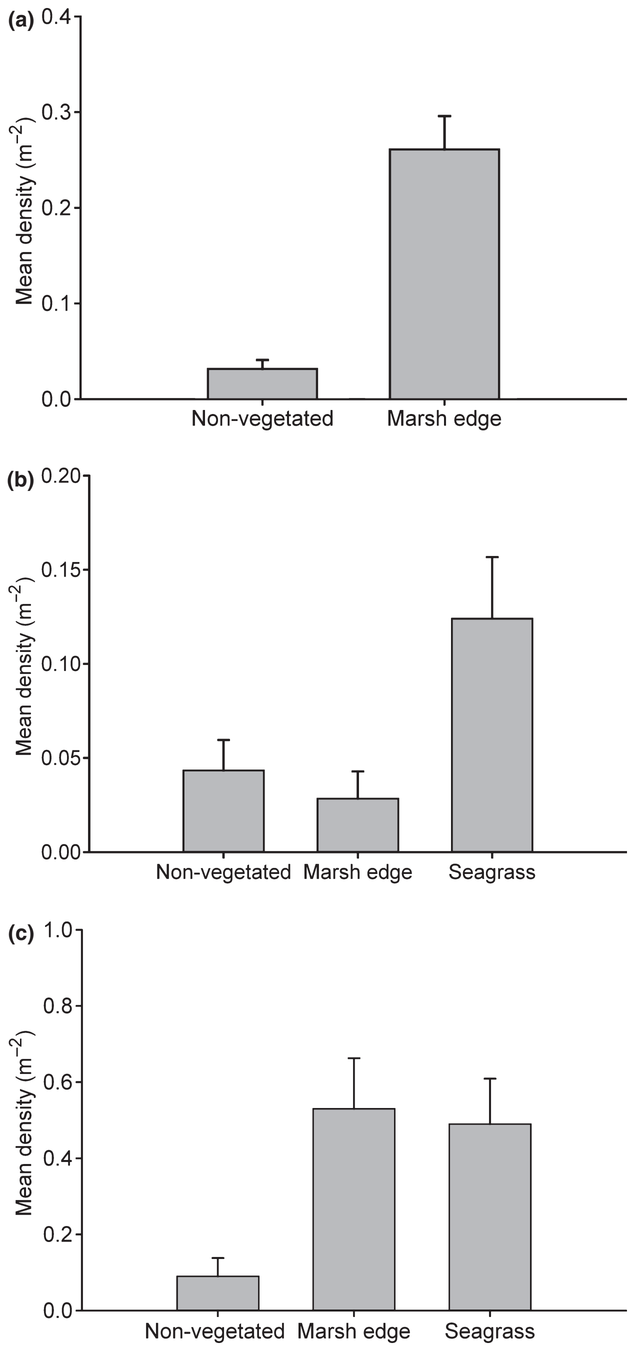

Figure 4. Mean density (±SE) of newly settled *C. nebulosus* collected with a drop sampler from (a) Barataria, Galveston and Matagorda-Lavaca bays in non-vegetated bottom and marsh edge, (b) San Antonio Bay in non-vegetated bottom, marsh edge and seagrass, and (c) Aransas Bay in non-vegetated bottom, marsh edge and seagrass.

and assessing a long-term dataset for bays along the north-western Gulf of Mexico, where marsh was the prominent habitat available. Overall, in both regions, newly settled *C. nebulosus* occurred at higher densities

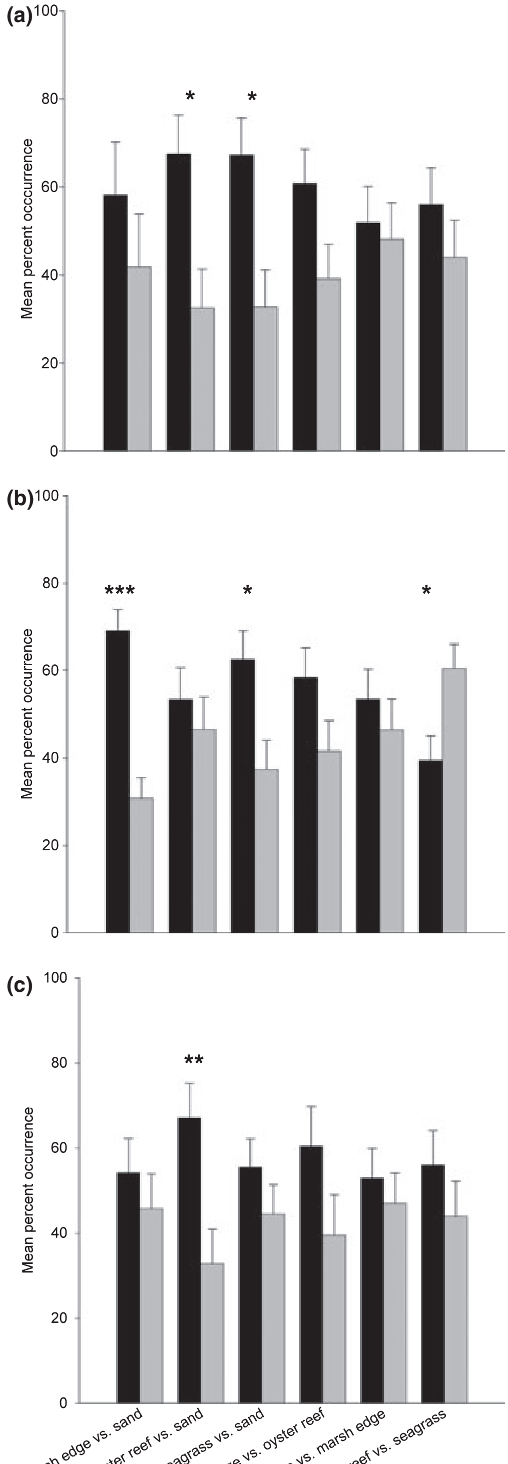

Figure 5. Mean percent occurrence (±SE) of *C. nebulosus* (a) newly settled wild-caught (23.33 mm ± 1.08); (b) hatchery-reared (24.59 mm ± 0.24); and (c) wild-caught (65.77 mm ± 1.60) in all possible pair wise comparisons. Significant results from paired Student's *t*-tests are indicated by ★ – $P < 0.05$, ★★ – $P < 0.01$, and ★★★ – $P < 0.001$.

in structurally complex vegetated habitats than over non-vegetated bottom. In laboratory mesoscom selection experiments, both wild-caught and hatchery-reared *C. nebulosus* showed strong selection for highly structured habitats.

In South Texas estuaries of Aransas Bay, Corpus Christi Bay and the Upper Laguna Madre, newly settled *C. nebulosus* first appeared in mid-summer to early autumn, mainly in seagrass meadows and rarely over marsh edge and non-vegetated bottom. Rooker *et al*. (1998) reported similar monthly trends of newly settled *C. nebulosus* in seagrass meadows from Aransas Bay and observed highest densities during August, September and October but did not compare alternate habitat types. The Laguna Madre is a negative estuary and the hyper-saline conditions prevent emergent marsh vegetation. Seagrasses are the predominant habitat type in the estuaries and the only habitat that supported young *C. nebulosus* in this region. These habitat types are important to numerous commercially and recreationally exploited fishes and invertebrates (Orth *et al*. 1984; Baltz *et al*. 1993). Seagrasses provide greater food abundance and higher survival rates for small nekton species, which may have equated to higher densities of nekton compared with non-vegetated areas (Heck & Crowder 1991; Minello 1999; Stunz *et al*. 2002). Relatively low densities of newly settled *C. nebulosus* were observed in the Laguna Madre. The shallow Laguna Madre (< 1 m average depth) is characterised by large continuous expanses of seagrass coverage in contrast to the fringing seagrass meadows along the marsh-lined shorelines of the deeper Aransas and Corpus Christi bays. While dispersion was not assessed during this study, these juvenile fish have the potential to spread over large spatial scales, thus decreasing overall density in the Laguna Madre. These results suggest seagrass is the most important habitat type for juvenile *C. nebulosus* in Aransas and Corpus Christi bays and the Laguna Madre.

Analysis of the long-term dataset showed that the marsh-edge interface may function as a nursery area for newly settled *C. nebulosus* when seagrass coverage is sparse. Although seagrass meadows appear to be the most important nursery habitat for *C. nebulosus* compared with marsh and non-vegetated bottom, in some areas, geography influences the availability of this habitat type (Stunz *et al*. 2002). Compared with estuaries along the middle and lower Texas coast, many bay systems along the upper Texas and Louisiana coasts have minimal seagrass coverage. Nevertheless, these estuarine systems support large populations of *C. nebulosus*, suggesting use of other habitat types.

Systems such as Barataria, Galveston and Matagorda bays have many extensive marshes that may be used by juveniles. Salt marsh estuaries provide a variety of areas for juvenile fishes to exploit, and the ecotonal habitat between non-vegetated open water and marsh edge provides critical resources for juvenile fishes (Rackocinski *et al*. 1992; Baltz *et al*. 1993; Stunz *et al*. 2002). In a Louisiana salt marsh, 97.9% of all individuals sampled were associated with *S. alterniflora* marsh edge (i.e. captured within 1.25 m from the marsh; Baltz *et al*. 1993). A similar pattern was observed for another seagrass-dependent sciaenid *S. ocellatus* that occurred in high densities and selected for marsh habitat types when seagrass was not available (Stunz & Minello 2001; Stunz *et al*. 2002).

Similar patterns of habitat selection for structurally complex habitats were also observed in the laboratory mesocosms for both juvenile wild-caught and hatchery-reared *C. nebulosus*. Small-size classes of wild-caught and hatchery-reared *C. nebulosus* selected both seagrass and oyster reef over non-vegetated bottom. *Cynoscion nebulosus* along with several other sciaenids are known to exploit seagrasses during early life stages (Tolan *et al*. 1997; Rooker *et al*. 1998; Rozas & Minello 1998), and estuarine species commonly select structured habitats in the form of marshes, oyster reefs and seagrass meadows in an effort to reduce risk of predation and obtain food supplies (Heck & Thoman 1981; Wenner *et al*. 1996).

By contrast, larger wild-caught *C. nebulosus*, showed little habitat selection, only selecting oyster reef over non-vegetated bottom, suggesting that affinity for habitat may decrease with ontogeny. Tabb (1966) found that juvenile *C. nebulosus*, six to eight weeks old (25–80 mm) often form schools of five to 80 individuals that frequented a variety of habitats. Many fishes and crustaceans undergo ontogenetic shifts in their feeding behaviours during early growth and development (Grossman 1980; Thomas *et al*. 1990) and may change their predator avoidance behaviours (Reinert 1991) by settling in different habitats. In marsh-dominated systems, newly settled fishes may initially seek shelter within the marsh, eventually moving from the marsh edge to deeper, subtidal habitats (Baltz *et al*. 1993). Rozas and Minello (1998) examined nekton use of habitats adjacent to the Aransas National Wildlife Refuge (dominated by both marsh and seagrass). They collected significantly larger *C. nebulosus* in salt marsh habitat and concluded that recruits may initially settle in seagrass beds and later shift to marsh habitats as larger juveniles. Rooker *et al*. (1998) collected limited numbers of sciaenids >40 mm standard length in Aransas Bay and suggested these individuals migrate to other habitats because they are seasonal residents of seagrass and exhibit annual fluctuations in densities resulting from recruitment, migration and natural mortality.

Hatchery-reared *C. nebulosus* also selected for both seagrass and marsh edge over non-vegetated bottom, and seagrass over oyster reef. Previous studies on other sciaenids found hatchery-reared fish do not show strong habitat selection patterns (Stunz & Minello 2001; Stunz *et al*. 2001). The viability of hatchery-reared fishes is of major debate (Grimes 1998), and the hatchery experience was shown to compromise and deprive hatchery fish of necessary stimuli needed to develop predator avoidance tactics, such as habitat selection (Munro & Bell 1997; Olla *et al*. 1998; Stunz *et al*. 2001). However, results from this study suggest that juvenile hatchery-reared *C. nebulosus* select for complex habitat types, which may translate into greater chance of survival post-release. As the efficacy of stock enhancement programmes for *C. nebulosus* depend, in large part, on the mortality rate of young fish, these results may have important management implications, suggesting hatchery-reared fish should be released in complex habitat types.

Structured habitat types, particularly seagrass meadows and marshes, appear to be important nursery habitat for *C. nebulosus* along the northwestern Gulf of Mexico and their use is dependent upon availability. Laboratory mesoscoms showed that both wild-caught and hatchery-reared *C. nebulosus* select for structured habitats, including oyster reef. Given the availability of oyster reef in many areas, this habitat may also function as important nursery area and warrants further investigation.

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