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Joy H. Merino
National Marine Fisheries Service

Jacoby Carter
National Wetlands Research Center

Sergio L. Merino
IAP World Services

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Mesohaline Submerged Aquatic Vegetation Survey Along the U.S. Gulf of Mexico Coast, 2001 and 2002: A Salinity Gradient Approach

Joy H. Merino, Jacoby Carter, and Sergio L. Merino

Distribution of marine submerged aquatic vegetation (SAV; i.e., seagrass) in the northern Gulf of Mexico coast has been documented, but there are nonmarine submersed or SAV species occurring in estuarine salinities that have not been extensively reported. We sampled 276 SAV beds along the gulf coast in Florida, Alabama, Mississippi, Louisiana, and Texas in 2001 and 2002 in oligohaline to polyhaline (0 to 36 parts per thousand) waters to determine estuarine SAV species distribution and identify mesohaline SAV communities. A total of 20 SAV and algal species was identified and habitat characteristics such as salinity, water depth, pH, conductivity, turbidity, dissolved oxygen, and sediment composition were collected. Fourteen SAV species occurred two or more times in our samples. The most frequently occurring species was *Ruppia maritima* L. (n = 148), occurring in over half of SAV beds sampled. *Eleocharis* sp. (n = 47), characterized with an emergent rather than submerged growth form, was a common genus in the SAV beds sampled. A common marine species was *Halodule wrightii* Asch. (n = 36). Nonindigenous species *Myriophyllum spicatum* L. (n = 31) and *Hydrilla verticillata* (L. f.) Royle (n = 6) were present only in oligohaline water. Analyzing species occurrence and environmental characteristics using canonical correspondence and two-way indicator species analysis, we identify five species assemblages distinguished primarily by salinity and depth. Our survey increases awareness of nonmarine SAV as a natural resource in the gulf, and provides baseline data for future research.

Submerged aquatic vegetation (SAV) provides food for waterfowl (Baldassarre and Bolen, 1994) and habitat for fish and decapods (Minello et al., 2003). SAV also affects nutrient cycling, water flow, and hosts epiphytic algae communities (Hemminga and Duarte, 2000).

Although most coastal habitats are in decline (e.g., La Roe et al., 1995; Duarte et al., 2008), SAV receives less attention in science and media correspondence than other coastal habitats, such as coral reef and marsh (Duarte et al., 2008). The lack of attention to SAV is concurrent with a limited identification of the resource.

The distribution and occurrence of all SAV species is not widely reported across the northern Gulf of Mexico. Handley (1995) reported that over the last 50 yr in the northern gulf seagrasses, marine SAV restricted to areas where salinities average greater than 15 parts per thousand (ppt), have lost 20% to 100% of their habitat, and surveys of specific estuaries have been conducted to determine the status of SAV along the gulf coast [Adair et al., 1994; Barry Vittor and Associates, Inc. (BAVA), 2004]. Remote sensing by aerial photography has been the most common method for mapping SAV (McKenzie et al., 2001). It is often collected without regard to salinity (Duke and Kroczynki, 1992; Handley, 1995; BAVA, 2004; Handley et al., 2007) so the range of salinities included in estimation of the SAV resource are unreported. The method is less effective in the mesohaline environment (5 to 20 ppt) than in clearer saline and fresh waters (Iverson and Bittaker, 1986) due to the more patchy distribution of SAV than seagrasses, and higher turbidity of their habitat than seagrass habitats (Handley et al., 2007).

Shifts in SAV distribution or abundance can indicate ecological changes. Distribution of SAV in coastal communities is sensitive to changes in water quality (Dennison et al., 1993; Stankelis et al., 2003), but it has been underutilized as a biological indicator (Orth et al., 2006). Documenting the distribution of SAV is an important first step in consideration of human impacts to the SAV resource, such as in ecological impact statements prepared for National Environmental Protection Act compliance, and may prove useful in developing habitat change prediction models.

In a previous study, we (Carter et al., 2009) attempted to document the species composition and distribution of SAV occurring in mesohaline waters in gulf estuaries, and document environmental conditions where those SAV occur. The results were to be used in the development of an SAV climate change model. In 2000, we sampled areas with historical summer average salinities in the mesohaline range of interest, but found that

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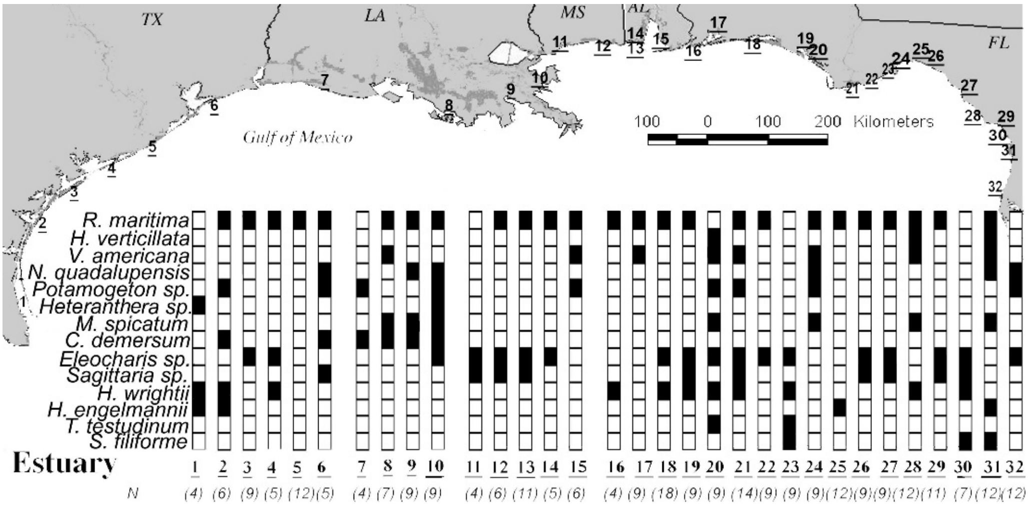

Fig. 1. Presence/absence of 14 submerged aquatic vegetation species in June and July of 2001 and 2002 are indicated by estuary along the U.S. Gulf of Mexico coast. Black boxes indicate presence. White boxes indicate that the species was not found at the beds sampled. N represents the total number of beds sampled at each estuary.

less than 2% (5 of 217) of sites were mesohaline, whereas 95% of sites had salinities above 20 ppt, and 73% of all SAV beds were composed of the seagrass *Halodule wrightii* Asch.

In this study, we conducted a survey to determine SAV community composition in mesohaline waters of the northern Gulf of Mexico using discrete salinity gradients. This information can be used as a baseline for future surveys to determine distribution trends in SAV species distribution in gulf estuaries, and to increase awareness of the mesohaline SAV resource.

Materials and Methods

We surveyed SAV in coastal estuaries along the gulf from Anclote Key, FL (28°10′N 82°49′W) to Laguna Madre, TX (26°20′N 97°19′W). Geomorphology of the gulf coast varies from sand beaches to mud marshes and was previously reviewed by Turner (2001). Tidal amplitudes in the gulf are less than 1 m (Turner, 2001) with a mean tidal range approximately 0.5 m in the northern gulf (Orlando et al., 1993). Several rivers and springs create the diversity of estuary size. Some estuaries have extensive barrier island systems such as Apalachicola Bay, FL. Others have no offshore barriers, such as the Big Bend, FL area (Mattson, 1999) where rivers, creeks, and marshes grade directly into the gulf. We selected 32 estuaries for survey using a stratified random design based on U.S. Geological Survey (USGS) hydrologic units (Seabar et al., 1987) to provide a sample of major estuaries across the northern gulf coast (Fig. 1). Because of time constraints, we could not sample all estuaries in the same year. Estuaries east of Louisiana were sampled in June and July of 2001, whereas Louisiana and Texas estuaries were sampled in June and July of 2002. Researchers were the same both years and used a work rotation schedule so survey methods and data collection were consistent. Three researchers were in the field at all times, one researcher changing each week.

We located the following salinity ranges in each estuary: 0 to 5 ppt, 6 to 10 ppt, 11 to 15 ppt, and > 16 ppt. These arbitrary salinity ranges reflected the full range of salinities within the estuaries, including our target mesohaline (5 to 20 ppt) environment. We initiated the survey at either the saline or fresh end of an estuary and continuously sampled salinities from the boat toward the opposite (fresh or saline) direction using a handheld salinity meter. This direction was dependent on the location of boat launches within an estuary. Except in unsafe weather conditions, such as lightning or high wind, surveys were conducted regardless of weather or tide. When water was too low for a standard boat, an airboat was used.

We attempted to locate a minimum of three SAV beds visually (in clear water) or by rake (in turbid water) within each salinity range for a maximum potential of 384 beds. We defined a bed as rooted vegetation within a square meter area having a minimum of 50% coverage. By recording within these arbitrary salinity ranges, we ensured that data would reflect our target mesohaline environment.

Sampled SAV beds were a minimum of 100 m apart. If more than three beds were found in each

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range, we sampled three SAV beds with representative size, species composition, health, and any other observable characteristics to other beds observed in the area. Locating SAV in clear water and determining three representative samples did not require the same effort as in turbid water. We searched the extent of each salinity range a minimum of 1 hr, excluding sample collection time. We would search an additional hour before determining that no SAV was present, or no other beds were present. The location of each sample was recorded with a handheld global positioning system. We recorded and identified the genera of all aquatic macrophytes (SAV and algae) present within the sampled bed. Plants were identified to species if possible, using the U.S. Department of Agriculture PLANTS database naming standards (USDA, 2006), Stutzenbaker (1999), and Godfrey and Wooten (1979). If no macrophytes were present in a salinity range, no data were recorded. We collected one sample of each species present for use as herbarium specimens. Samples were gathered by hand, rake, or sediment corer. USGS National Wetlands Research Center herbarium specimen collections were used to verify initial species identifications, with the exception that algal collections were identified by Dr. Fredricq, University of Louisiana, Lafayette, LA. Algal species were not used in analyses.

Environmental data were recorded for each bed [pH, salinity, temperature, turbidity, dissolved oxygen (DO), and depth] for future use in developing a model to predict the effect of global climate change in estuaries. We used a Yellow Springs Instruments-85 for salinity, conductivity, temperature, and DO; a Hanna Instruments (HI) 9025 for pH; and HI 93703 for turbidity. Depth was collected using a pipe or rake marked in 5-cm increments.

Species of SAV, which occurred in more than 2% of the 276 beds, were analyzed using two-way indicator species analysis (TWINSPAN) and canonical correspondence analysis (CCA, PC ORD version 4.2) with the default settings of the CCA program. We selected TWINSPAN to examine how species co-occurred, because only presence/absence data are needed. We used CCA to describe how species occurrence differed along the environments we encountered (e.g., depth gradients). Geographic locations (i.e., estuaries or site scores) were not used in the CCA, because we were not interested in how estuaries differed. Environmental variables were not averaged. Because of missing values in one or more of the variables, 229 sites were used in the CCA, whereas 249 were used in TWINSPAN. Using this analysis, we could examine how species align along the natural environmental gradients regardless of their geographic (estuary) location, and determine which environmental factors should be considered first in development of an SAV response model.

TABLE 1. Estuaries surveyed for submerged aquatic vegetation in June and July of 2001 and 2002 are listed in order from west to east.

Location on Figure 1	Estuary name
1	Laguna Atascosa, Texas
2	Nueces estuary, Texas
3	St. Charles Bay, Texas
4	Lavaca River, Texas
5	Cedar Lake Creek, Texas
6	East Bay/Oyster Bayou, Texas
7	Mermentau River, Louisiana
8	Bayou du Large, Louisiana
9	Barataria Bay, Louisiana
10	Breton Sound, Louisiana
11	Bay St. Louis, Mississippi
12	Biloxi Bay, Mississippi
13	Pascagoula River, Alabama
14	Grand Bay, Alabama
15	Mobile Bay, Alabama
16	Perdido Bay, Florida
17	Escambia Bay, Florida
18	Choctawhatchee Bay, Florida
19	West Bay, Florida
20	St. Andrew Bay, Florida
21	Apalachicola Bay, Florida
22	Carrabelle River, Florida
23	Ochlockonee River, Florida
24	St. Marks River, Florida
25	Aucilla River, Florida
26	Ecofina River, Florida
27	Steinhatchee River, Florida
28	Suwannee River, Florida
29	Waccasassa River, Florida
30	Withlocoochee River, Florida
31	Chassahowitzka River, Florida
32	Anclote River, Florida

The CCA is a direct gradient analysis that pairs a matrix of sample units and species with a matrix of sample units and environmental variables (ter Braak, 1986; McCune and Grace, 2002). Species positions relative to environmental axes illustrate relationships between species and environmental variables (McCune and Grace, 2002). In a CCA plot, the length of an environmental line indicates its importance relative to other environmental variables, and the direction of the line indicates how well the variable is correlated with the species. Angles between lines indicate correlations between environmental variables. For example, a 180° angle between variables indicates that they are negatively correlated to each other. The location

TABLE 2. Mean and range of environmental variables [temperature, dissolved oxygen (DO), salinity, depth, pH, and turbidity] sampled at submerged aquatic vegetation beds by species along the U.S. Gulf of Mexico.

	Temperature (°C)	DO (gl^{-1})	Salinity (ppt)	Depth (cm)	pH	Turbidity (NTU)	
Species	Mean (range)	Mean (range)	Mean (range)	Mean (range)	Mean (range)	Mean (range)	n
Ruppia maritima	28.6 (22.8–37.7)	6.1 (0.8–14.5)	8.2 (0–26.7)	51.5 (10–120)	7.4 (3.9–8.8)	23.9 (0.2–380)	148
Hydrilla verticillata	27.2 (23.5–3.7)	4.3 (1.8–6.9)	4.6 (0–20.7)	85.0 (45–120)	7.9 (6.3–8.0)	1.9 (0.4–4.0)	6
Vallisneria americana	27.6 (23.2–32.6)	5.5 (2.8–11.1)	1.0 (0.2–4.7)	67.2 (35–100)	7.5 (6.5–8.8)	8.3 (0.4–22.7)	19
Najas guadalupensis	26.2 (22.8–30.3)	4.7 (1.8–11.2)	5.1 (0.9–13.6)	46.7 (15–80)	7.4 (6.9–7.6)	12.8 (1.3–65.6)	12
Potamogeton sp.	27.2 (22.8–30.8)	6.5 (3.1–11.2)	2.0 (0.2–5.4)	55.4 (10–100)	7.5 (6.4–8.8)	19.9 (0.4–81)	14
Heteranthera sp.	31.0 (27.9–34.0)	9.3 (7.7–10.8)	1.3 (0.2–2.3)	70.0 (60–80)	8.0 (7.8–8.2)	61.0 (40.9–81)	2
Myriophyllum spicatum	29.1 (22.8–32.6)	7.1 (3.7–14.3)	4.2 (0–20.7)	60.8 (20–120)	7.7 (6.4–8.8)	19.2 (0.4–81)	31
Ceratophyllum demersum	28.1 (22.8–32.4)	5.1 (1.4–8.1)	3.4 (0.2–7)	49.6 (10–90)	7.4 (6.4–8.1)	26.4 (4.0–65.6)	11
Eloecharis sp.	29.1 (22.5–38.8)	4.7 (0.8–14.3)	5.8 (0.2–23.8)	26.8 (5–80)	7.1 (5.3–9.1)	15.7 (0.4–58.8)	47
Sagitaria sp.	28.9 (22.9–33)	5.5 (2.8–14.5)	2.6 (0.5–11.6)	21.2 (5–70)	7.3 (6.1–7.8)	12.6 (1.1–36.4)	17
Halodule wrightii	29.5 (27.2–31.9)	5.5 (2.3–9.3)	16.2 (0.7–36)	68.7 (30–120)	7.9 (7.2–8.4)	7.2 (0.8–22.4)	35
Halophila engelmannii	28.2 (25.5–29.2)	4.7 (2.3–6.3)	17.6 (2.0–36)	84.6 (50–120)	7.9 (7.5–8.4)	6.2 (1–22.4)	11
Thalassia testudinum	29.4 (28.8–29.9)	5.5 (4.1–7.0)	13.3 (10.1–16.4)	115 (110–120)	7.7 (7.6–7.8)	4.1 (2.3–5.8)	2
Syringodium filiforme	28.4 (27.6–28.9)	5.2 (4.0–7.4)	12.4 (3.9–16.9)	80 (50–120)	7.43 (7.3–7.6)	11.6 (4.2–15.7)	3

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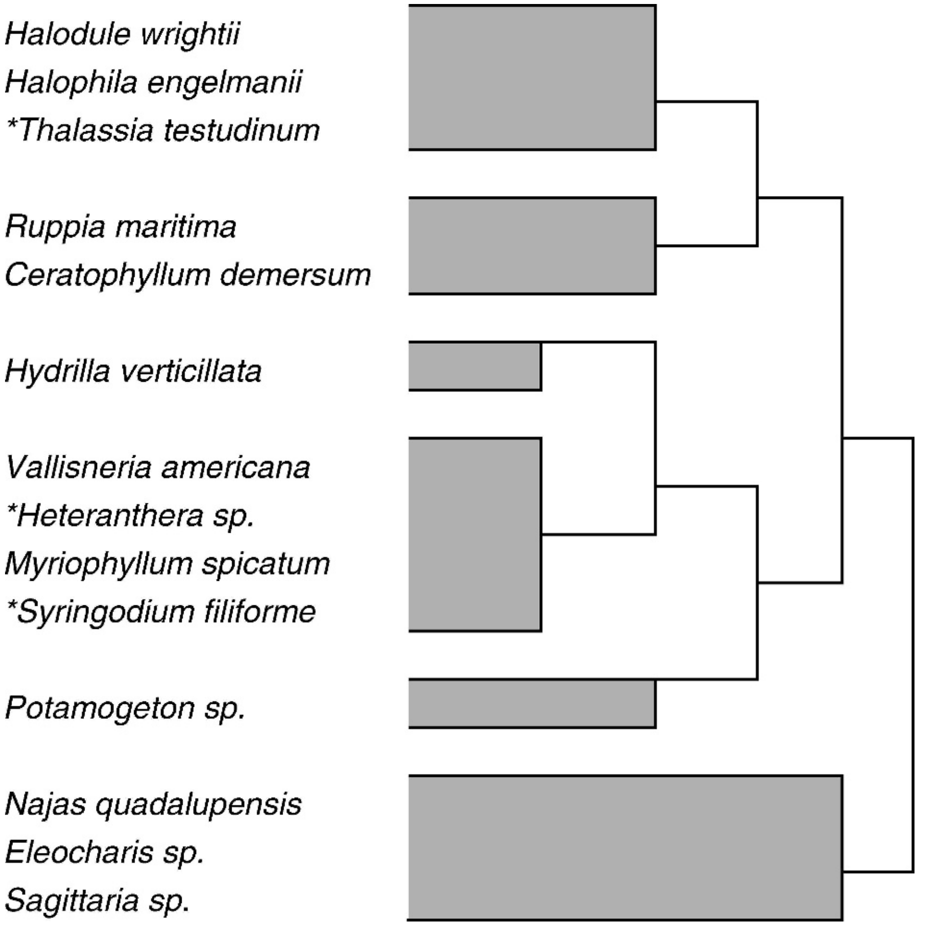

Fig. 2. Two-way indicator species analysis (TWINSPAN) on 11 submerged aquatic vegetation species at sites sampled along the U.S. Gulf of Mexico showing six species assemblages. Species with asterisks were present in less than 2% of sites.

of species relative to the lines indicated the environmental preference of each species.

Results

We sampled 276 SAV beds among 32 estuaries in 2001 and 2002 (Table 1). The number of estuaries and SAV beds sampled respectively by state were: Texas 6, 42; Louisiana 4, 30; Mississippi 2, 28; Alabama 3, 6; and Florida 17, 170. A total of 20 species was identified. The average species richness across estuaries was 3.5 species, ranging from seven species in Breton Sound, LA, St. Andrew Bay, FL, and Chassahowitzka River, FL to one species in Cedar Lake Creek, TX (Fig. 1). Fourteen nonalgal SAV species occurred two or more times in our samples. The most frequently occurring species was *Ruppia maritima* (n = 148), occurring in over half of SAV beds sampled and found in salinities ranging from 0.2 ppt to 26.7 ppt (mean = 8.3 ppt, Table 2). The next most common species were *Eleocharis* sp. (n = 47) and *H. wrightii* (n = 36). The nonindigenous species *Myriophyllum spicatum* (n = 31) and *Hydrilla verticillata* (n = 6) were also collected. *Vallisneria americana* (n = 19), *Sagittaria* sp. (n = 17), *Potamogeton* sp. (n = 14), *Najas guadalupensis* (n = 12), *Ceratophyllum demersum* (n = 11), *Halophila engelmannii* Asch. (n = 11), *Syringodium filiforme* (n = 3), *Heteranthera* sp. (n = 2), and *Thalassia testudinum* Banks & Sol. Ex Koenig (n = 2) were also found. *Thalassia testudinum*, *S. filiforme*, and *H. wrightii* were all found at mean salinities above 15.8 ppt, whereas remaining macrophytes were found at mean salinities below 5.8 ppt. Algal species identified were *Ulva lactuca* (n = 15), *Lyngbya* sp. (n = 11), *Enteromorpha*

TABLE 3. Axis summary statistics of canonical correspondence analysis (CCA) on 11 submerged aquatic vegetation species and six environmental variables in 226 samples along the U.S. Gulf of Mexico.

	Axis 1	Axis 2	Axis 3
Eigenvalue	0.418	0.225	0.092
Variance in species data			
% of variance explained	8.4	4.5	1.9
Cumulative % explained	8.4	12.9	14.8
Pearson correlation, spp-envt*	0.73	0.53	0.409
Kendall (rank) correlation, spp-envt	0.495	0.336	0.241
Correlations**			
Disolved oxygen (DO)	−0.049	0.234	−0.709
Temperature	0.173	−0.336	−0.198
Salinity	0.855	−0.421	−0.081
Depth	0.629	0.678	0.239
pH	0.362	0.252	0.35
Turbidity	−0.119	−0.009	−0.629

* Correlation between sample scores for an axis derived from the species.
** Correlations are ''intraset correlations'' of ter Braak (1986).

intestinalis (n = 9), *Acetabularia* sp. (n = 3), *Cladophora liniformis* (n = 4), and *Chara* sp. (n = 2).

Ruppia maritima was found three times more often than any other species (Table 2) and was present from turbid (mud bottom) waters to clear (sand and rock bottom) waters. *Ruppia maritima* was collected in 25 of the 32 estuaries sampled (Fig. 1). *Syringodium filiforme* and *T. testudinum* were collected only in eastern gulf estuaries, whereas *R. maritima*, *Potamogeton* L., and *Eleocharis* sp. were collected across the northern gulf.

The TWINSPAN identifies six species assemblages (Fig. 2). The iterations first divide *N. guadalupensis*, *Eleocharis* sp., and *Sagittaria* sp. from other species, then *Halodule wrightii*, *Halophila engelmannii*, *T. testudinum*, *R. maritima*, and *Ceratophyllum demersum* from those remaining. *Ruppia maritima* and *C. demersum* are grouped and *Potamogeton* sp. separates in the fifth division. The sixth and final division isolates *Hydrilla verticillata* (Fig. 2).

The CCA includes 11 species as the main matrix, and six environmental variables as the second matrix. In order of association, the variables most strongly associated with axis 1 are salinity, depth, and pH. Variables associated with axis 2 are depth and (negative) salinity, and those with axis 3 (negative) DO and (negative) turbidity (Table 3). However, the CCA only indicates that 14.8% of the variance in the data is explained by the three species composition axes.

Plots of CCA results show a clear separation of seagrass and other SAV species. *Ruppia maritima* is near the center of the environmental variables origin. The plotted results show salinity and depth as corresponding environmental variables more strongly associated with species distribution than other environmental variables analyzed (Fig. 3). *Hydrilla verticillata* and *R. maritima* occur midway along the salinity axis, indicating mesohaline environment; however, the analysis includes an outlying high salinity for *H. verticillata* (Fig. 4). We therefore provide further description of salinity and depth characteristics below.

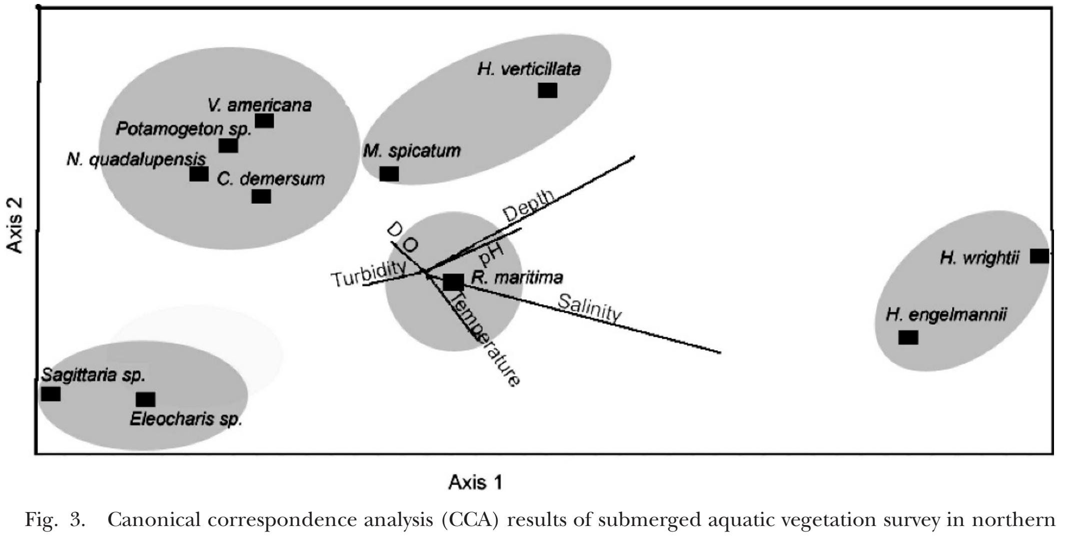

Fig. 3. Canonical correspondence analysis (CCA) results of submerged aquatic vegetation survey in northern Gulf of Mexico coast estuaries with final scores of 11 species overlain on a biplot of six environmental variables. Gray circles indicate five communities the authors interpret from the results.

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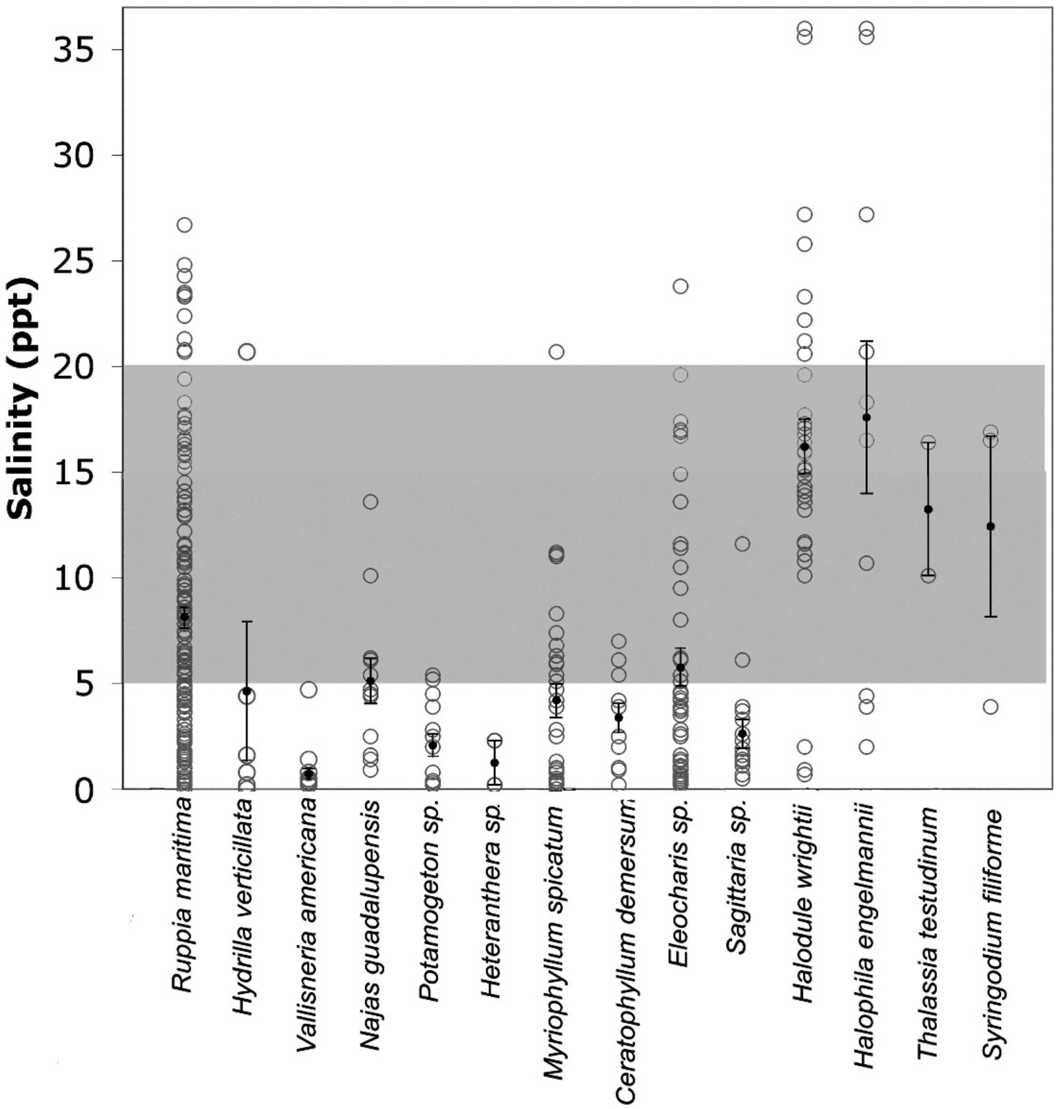

Fig. 4. Salinities at sites where submerged aquatic vegetation species were collected during a survey of the northern Gulf of Mexico coast estuaries. The gray bar represents mesohaline conditions (5 to 20 ppt). Open circles represent individual samples; closed circles represent mean, and bars represent 1 SE.

Submerged aquatic vegetation occurred across a range of salinities (Fig. 4). The mean salinity of sites where *R. maritima* occurred was 8 ppt. Seagrasses (*Halophila engelmannii*, *Halodule wrightii*, *S. filiforme*, and *T. testudinum*) occurred in more saline waters. With the exception of *Eleocharis* sp. (5.8 ppt), the mean salinity at which all other species occurred was equal to or below 5 ppt.

Species occurred at depths ranging from 5 cm to 120 cm (Table 2). *Ruppia maritima* occurred across the widest range of depths (10 cm to 120 cm) (Fig. 5). We noticed seagrasses and *Hhdrilla verticillata* on average occurred in waters deeper than other SAV. *Eleocharis* sp. and *Sagittaria* sp. L., emergent species that tolerate submergence, occurred at depths averaging around 20 cm. We observed *H. verticillata* mostly in low-salinity waters of three Florida estuaries. Another nonindigenous species, *M. spicatum*, was observed in our survey more frequently than *H. verticillata*. *Myriophyllum spicatum* was found in estuaries of Louisiana and Florida. The species co-occurred with *H. verticillata* in Florida estuaries.

Turbidity negatively corresponded with depth and pH (Table 3; Fig. 3) and ranged from 0.4 nephelometric turbidity units (NTU) to 280 NTU (Table 2; Fig. 6). *Ruppia maritima* was located in the most turbid sites, though *Heteran-*

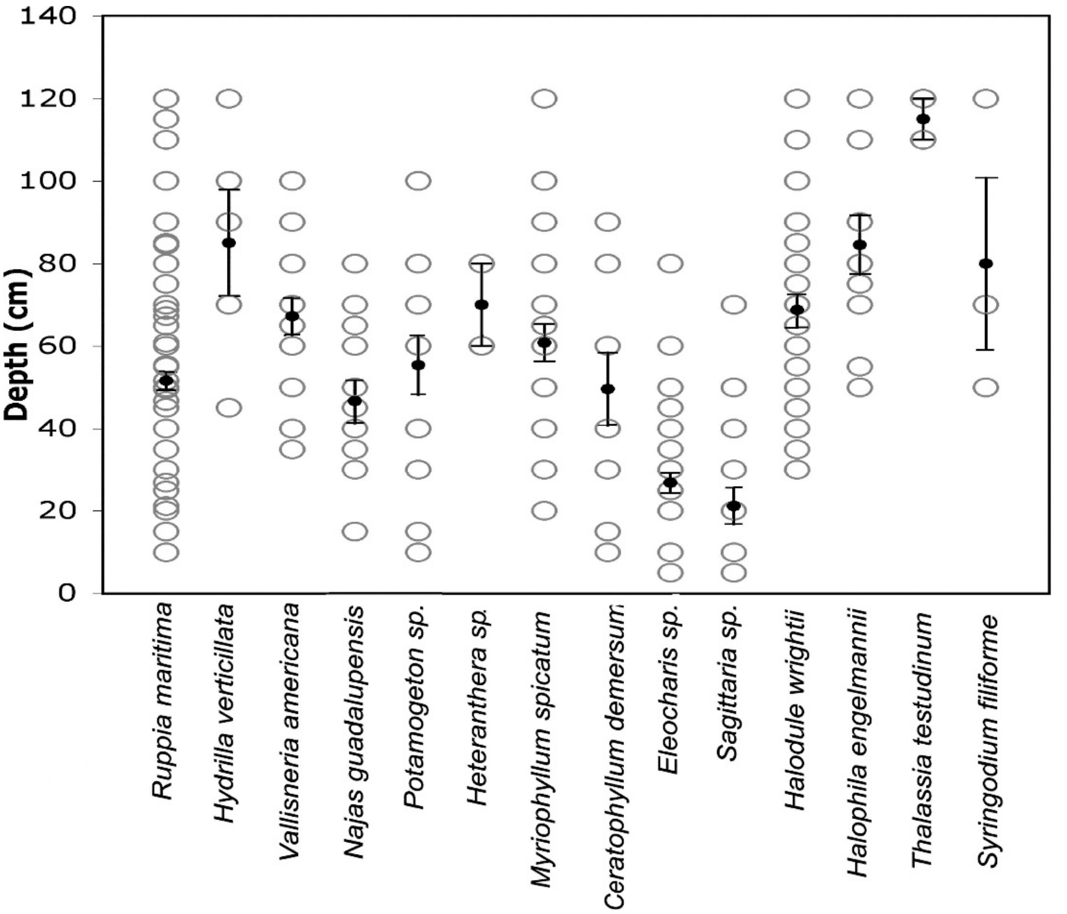

Fig. 5. Depth at sites where submerged aquatic vegetation species were found during a survey of the northern Gulf of Mexico coast estuaries. Open circles represent individual samples; closed circles represent mean, and bars represent 1 SE.

thra sp. occurrences had the highest mean turbidity (Fig. 6). The highest turbidities, greater than 100 NTU, were recorded in St. Charles Bay, TX; Cedar Lake Creek, TX; and Biloxi Bay, MS.

Discussion

Our survey included salinities from oligohaline to polyhaline as a method to document SAV occurrence along and within the shifting mesohaline zone. We documented the presence and distribution of nonseagrass SAV to gain recognition of this resource and its changing environment, and provide a supplement to existing SAV resource estimates (e.g., Handley et al., 2007). Subsequent collection of species abundance is needed to quantify the resource.

The CCA separates seagrass (marine SAV) from freshwater-tolerant SAV and then distinguishes by depth. Although the CCA did not explain 85% of the variance in species we sampled, our sampling was adequate to determine that salinity and depth are the primary variables discerning SAV species composition for SAV in the northern gulf, and salinity and depth are therefore the variables to incorporate in development of a future climate change model. The large variance shows that sampling was not adequate to determine environmental relationships among species.

Our goal was to identify mesohaline SAV communities and we found one predominant species, *R. maritima*. The location of *R. maritima* near the origin of the environmental variables in the CCA results from the frequent occurrence of the species across a wide range of environmental conditions. The species occurred from oligohaline to polyhaline waters and is known to occur in a wide range of salinities (Kantrud, 1991). The CCA weights species infrequently sampled (Faith et al., 1987; Minchin, 1987), and therefore balances those species with the ubiquitous *R.*

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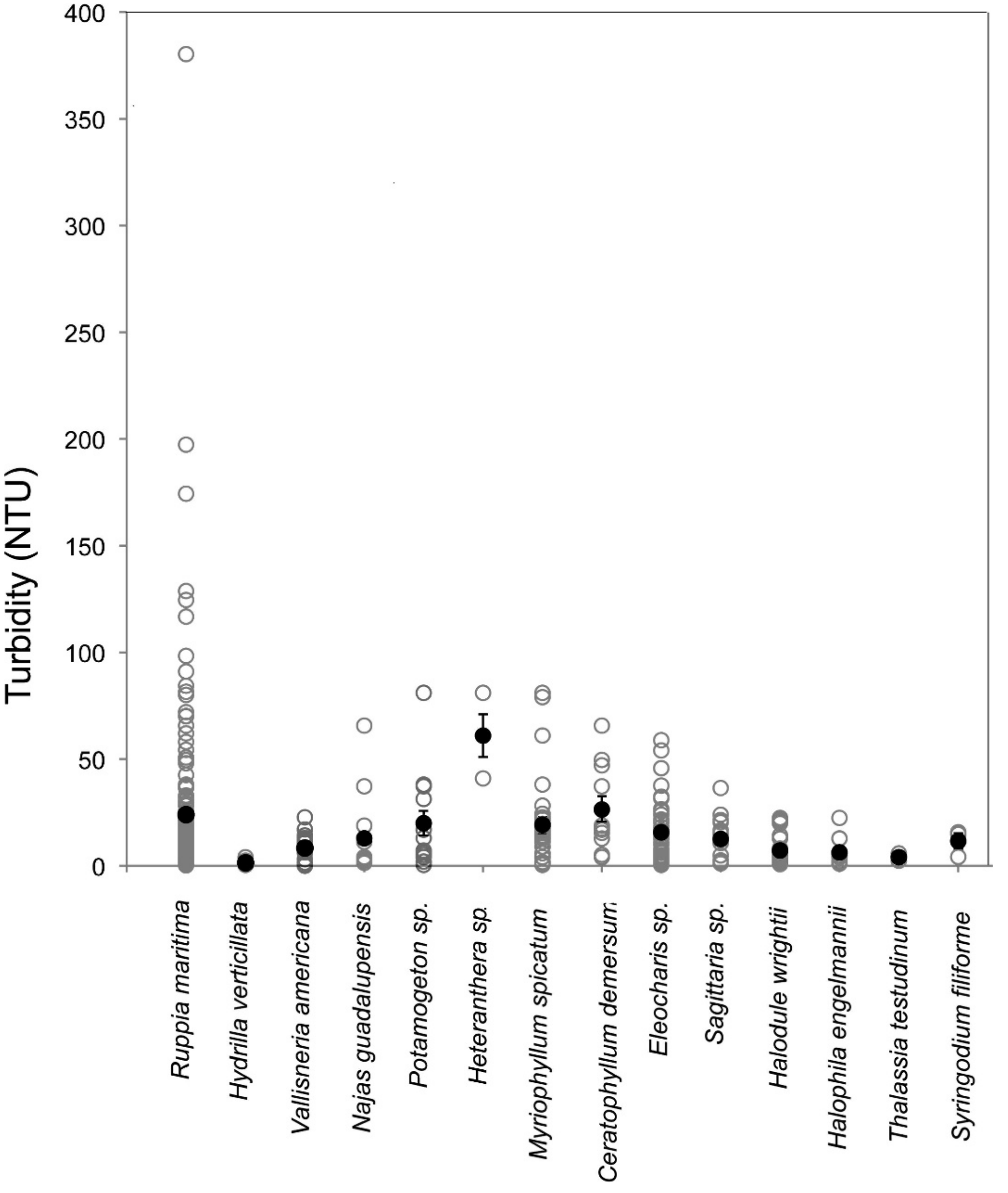

Fig. 6. Turbidity of water at sites where submerged aquatic vegetation species were found during a survey of the northern Gulf of Mexico coast estuaries. Open circles represent individual samples; closed circles represent mean, and bars represent 1 SE.

maritima. We identify five species assemblages that are our interpretation of the CCA results (Fig. 3). These, however, differ from the species assemblages from TWINSPAN. Although these species assemblages differ, the commonalities are of interest. *Halodule wrightii*, *Halophila engelmannii*, and *T. testudinum* are clearly identified as marine SAV (seagrass) and *R. maritima* is clearly a mesohaline species in both analyses.

Ruppia maritima may have been ubiquitous as a result of frequent drought years reported by the U.S. Drought Monitor Archives (National Drought Mitigation Center et al., 2008). *Ruppia maritima* has been reported to colonize areas after natural disturbances. Johnson et al. (2003) reported the expansion of *R. maritima* into *Zostera marina* beds during an El Niño year in Southern California bays. After hurricanes in the gulf, *R.*

maritima has been reported to colonize seagrass beds (Franze, 2002; Byron and Heck, 2006). We reviewed the drought archives that provide a weekly report of drought conditions over broad geographic areas. The six reported conditions are: not dry, abnormally dry, moderate drought, severe drought, extreme drought, and exceptional drought (National Drought Mitigation Center et al., 2008). During our survey of 2001, central Florida experienced a severe drought that occurred near six of the 22 sites we sampled that year. The remaining sites were not experiencing dry conditions that year, and all six of those sites are natural spring-fed rivers that we believe were not influenced by the drought that year. However, nearly all 22 of these sites had extreme drought conditions the previous year. The sites we sampled in 2002 experienced dry to drought conditions that summer, but did not experience dry conditions in the previous year. From 1999 to 2009, there has been a drought approximately every 2 to 3 yr at each study site (National Drought Mitigation Center et al., 2008). Although these frequent drought conditions may have provided *R. maritima* the opportunity to proliferate, it does not appear to be a temporary condition and it may be that *R. maritima* was ubiquitous before the drought conditions. The naturally variable environmental conditions of the gulf estuaries may be only accessible to the broad tolerance range of *R. maritima*.

We did not observe any previously unreported invasive (e.g., harmful) species. *Hydrilla verticillata*, an invasive species management priority in the northern gulf [Environmental Protection Agency (EPA), 2000], is known to be abundant in oligohaline waters across the gulf (McCann et al., 1996; Owens et al., 2001; BAVA, 2004), but was not often found in the targeted mesohaline environment. The nonindigenous species *M. spicatum* was the fourth most frequently encountered SAV. Although it is not native, it is not ecologically harmful and can be beneficial for invertebrates (Chaplin and Valentine, 2009) and waterfowl (Goecker et al., 2006). These data are useful in long-term management planning and monitoring of invasive species (e.g., McCann et al., 1996; EPA, 2000; Madeira et al., 2000; Torres, 2003).

Our failure to find any particular species during our survey does not indicate that the species was not present within the estuary. The distribution of SAV in marine and oligohaline waters and interior marsh ponds are underrepresented in our survey. The inner marsh waterways and ponds, such as in the extensive marshes of Louisiana (Larrick and Chabreck, 1976), likely contain a significant presence of SAV in the northern gulf that remains underrepresented in natural resource estimates. Because of the inaccessible nature of interior marsh, such a survey would be a substantial undertaking but would increase our knowledge of a potentially underestimated SAV habitat. We encourage inclusion of nonmarine seagrass in descriptions of natural resources of the northern gulf estuaries, such as ecological impact statements prepared for National Environmental Protection Act compliance, so impacts on the entire SAV community can be considered.

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(JHM) U.S. Department of Commerce, NOAA, National Marine Fisheries Service, 646 Cajundome Boulevard, Lafayette, Louisiana 70506; (JC) Department of Interior, USGS National Wetlands Research Center, Lafayette, Louisiana; and (SLM) IAP World Services. Send reprint requests to JHM. Date accepted: October 6, 2009.

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