Indicator 1.2 - Submerged Aquatic Vegetation in Northern Estuaries

What is the desired restoration condition?

The desired restoration condition is to increase the spatial extent and improve the functionality of submerged aquatic vegetation in the northern estuaries including *Vallisneria americana* in the Caloosahatchee River and estuary and *Halodule wrightii, Halophila johnsonii* and *Syringodium sp.* in the St. Lucie Estuary and Southern Indian River Lagoon.

Why is the indicator important and why is it a good indicator of CERP restoration?

The ecological role of submerged aquatic vegetation in estuarine systems is well documented (Thayer et al. 1984, Day et al. 1989). Because of the many ecological functions attributed to submerged aquatic vegetation and their potential economic value (e.g., as fish habitat), submerged aquatic vegetation is often a focal point of restoration efforts (SJRWMD and SFWMD 2002). Submerged aquatic vegetation is also thought to be a sensitive barometer or indicator of anthropogenic impacts and is a prime candidate for inclusion in monitoring programs (Tomasko et al. 1996). Submerged aquatic vegetation meadows provide habitat for many benthic and pelagic organisms, stabilize sediments, and can form the basis of detrital food chains. *V. americana* is also a major dietary component of the West Indian Manatee and is often preferred over other submerged aquatic vegetation (Packard 1981).

V. americana (tape grass, wild celery) is a salt-tolerant freshwater angiosperm that often occurs in oligohaline reaches of estuaries in the northeastern and southeastern United States (Bourn 1932, Lowden 1982). Beds of *V. americana* can occur up to 30 kilometers (km) downstream of S-79 in the Caloosahatchee River but grow most luxuriantly upstream around Beautiful Island (Hoffracker 1994). Historical maps of distribution within the Caloosahatchee River indicate that this macrophyte was found in monospecific and in mixed stands with *Ruppia maritima* from the railroad trestle bridge on Beautiful Island downriver to the Mid-Point Memorial Bridge. Two additional mixed beds of *V. americana* and *Halodule wrightii* were also located immediately downriver of this bridge.

Submerged aquatic vegetation communities are sensitive to changes in salinity and water quality. Submerged aquatic vegetation species composition, abundance, and spatial distribution are affected by spatial and temporal salinity patterns and nutrient and light levels. Freshwater inflow quantity, timing, and distribution affect salinity, nutrients, and light. When conditions are favorable, *V. americana* exhibits a seasonal growth pattern, with the highest biomass achieved in the late summer, flowering in the late summer-early fall, and a winter decline (Bortone and Turpin 2000). Anecdotal, qualitative observations and quantitative data from monitoring indicate that the shoot density and canopy height vary inter-annually. In some years, growth may be extensive and quite lush in both wet and dry seasons, while in other years only sparse populations of small plants can be found.

In the upper Caloosahatchee Estuary, salinity fluctuations are currently very large and may cause great fluctuations in *V. americana* density. These salinity fluctuations are driven by seasonal changes in rainfall and by modifications to the Caloosahatchee River and its watershed. The density seems to decline as salinity rises above 10 parts per thousand (ppt) (Doering et al. 2002).

The salinity tolerance of *V. americana* has been used to identify freshwater flows that will maintain important grass beds and ensure the persistence of a low salinity region in the upper Caloosahatchee Estuary (SFWMD 2003). Approximately 300 cubic feet per second (cfs) minimum mean monthly inflow should be provided to the estuary through S-79 to protect *V. americana*. This flow should come from watershed runoff upstream of S-79, but could be supplemented as needed from other sources. At the other extreme, mean monthly flows should not exceed 2,800 cfs, because greater flows cause more than half the estuary to become a freshwater system and salinity near the mouth (Shell Point) drops to levels that threaten many of the species in this region.

Comprehensive Everglades Restoration Plan (CERP) projects are being designed to help improve timing, volume, and spatial distribution of freshwater inflows as well as water quality. Restoration of more natural freshwater inflows provided by retention in reservoirs, cleanup in stormwater treatment areas, storage in aquifer storage and recovery systems, and attenuation due to wetland rehydration as a result of CERP implementation should provide improvements in salinity and habitat conditions that will in turn promote the reestablishment of healthy submerged aquatic vegetation communities.

How is the interim goal for this indicator predicted?

A numerical model is currently being developed to estimate growth of *V. americana* under varying environmental conditions in the upper Caloosahatchee Estuary. The model consists of a system of three simultaneous finite-difference equations, one for each of three variables - total mass, number of shoots, and number of blades - solved by Euler numerical integration with a time step of one day. Primary inputs are water temperature, incident photosynthetically-active radiation (PAR), Secchi disk depth, water depth, and salinity. Information based on laboratory and field efforts is integrated in the model. It is assumed that neither nutrients nor epiphyte growth on leaves limits growth. Physical processes including waves, currents, and burial were not included in the model (Hunt and Doering in prep.). It was found in the development of the *Vallisneria* model by Hunt and Doering that to construct a numerical model, quantifiable information relating plant growth and survival to the variables of interest are needed. Owing to the highly variable and rapidly shifting physiochemical parameters in most estuaries, information included in model formulation should span a range of expected environmental conditions. Acute stress levels for environmental variables should be well represented.

It is envisioned that in the future, as models are completed, a series of watershed runoff, hydrodynamic salinity, and ecological models need to be used together in order to determine the changes in flow volumes, timing, and distribution that will occur as a result of CERP implementation. These models will need to be run at five-year increments to coincide with runs and output from the South Florida Water Management Model (SFWMM). This combined flow output will be input into the hydrodynamic salinity model that will be used to predict salinity ranges and locations at those time increments. The salinity output can then be used as one input into the *Vallisneria* model.

What are the predictions for five-year increments?

Predictions of potential submerged aquatic vegetation expansion have, to date, been made based on actual field monitoring during years when beneficial flows were provided, allowing for reestablishment of luxurious healthy grass beds (Figure 1.2.1).

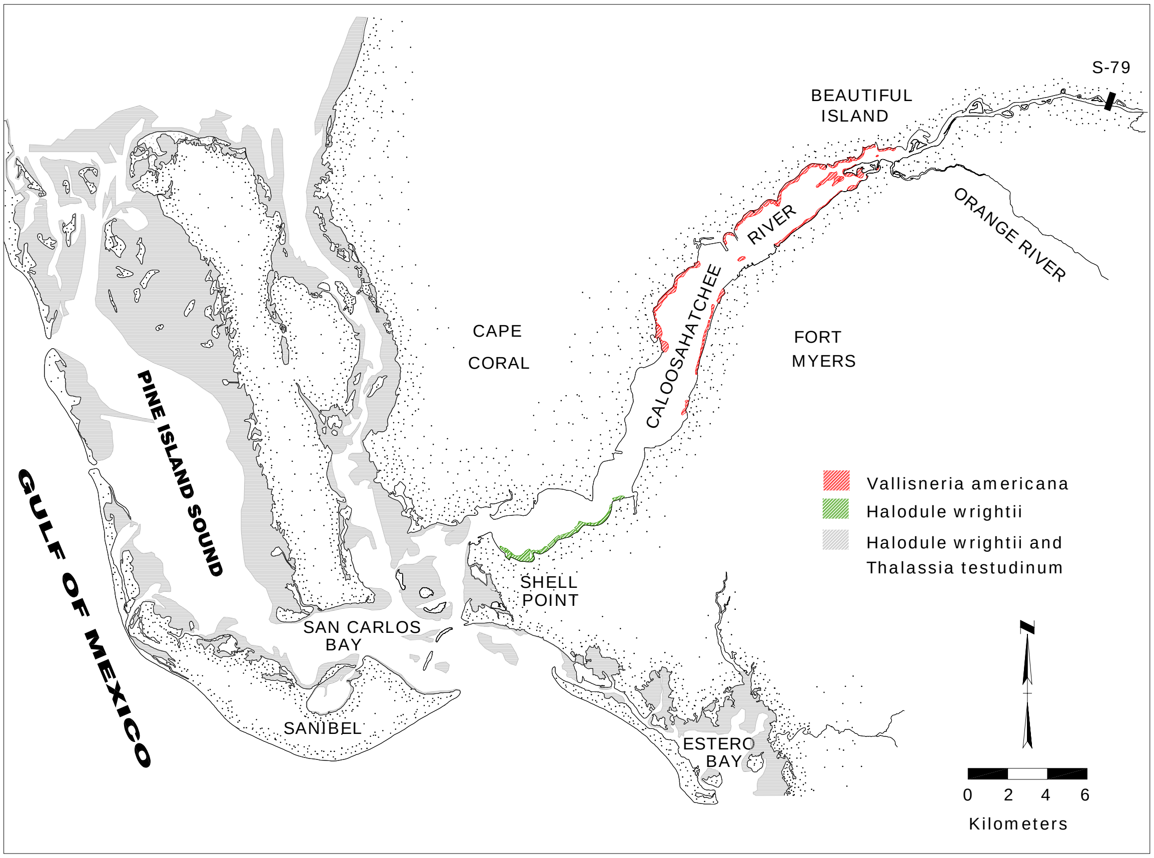

Figure 1.2.1. The general range of dominant submerged aquatic vegetation species in the Caloosahatchee Estuary and surrounding area when condition are good for maximum distribution (*V. americana* farthest upstream and *H. wrightii* near the downstream mouth at Shell Point).

How will we track whether the interim goals established for the indicator have been achieved?

The *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Researc*h (RECOVER 2004) includes monitoring to determine 1) spatial distribution and extent (coverage) of submerged aquatic vegetation and 2) percent cover and relative abundance of *V. americana* in the Caloosahatchee River and Estuary. Spatial distribution and extent (coverage) will be determined using aerial photographs or hydroacoustic monitoring. Percent cover and relative abundance of *V. americana* will be determined by field transect monitoring. Monitoring in St Lucie Estuary and Indian River Lagoon will also be conducted.

What additional work is needed to improve this interim goal?

The *Vallisneria* model needs to be completed. More work on salinity tolerance would help strengthen model calibration. Salinity tolerance is a very important environmental variable, but several field and lab studies designed to assess the salinity tolerances of *Vallisneria* have conflicting results and little information is available concerning factors that might modify salinity tolerance. Consideration should also be given to developing additional growth response relationships with the ability to regulate growth and the effect of environmental variables on different stages of plant development.

Development of submerged aquatic vegetation growth models for additional species in the outer St. Lucie Estuary and southern Indian River Lagoon should be pursued. *Halodule wrightii* and *Halophila johnsonii* near the mouth of the St. Lucie Estuary are expected to expand if salinity conditions improve (i.e., less variable, fewer occurrences of fresh or near fresh water in that area). A model for *Halodule* is being developed for the southern estuaries and could potentially be expanded to fit the needs of the St. Lucie Estuary. The other dominant seagrass that is expected to show improvements due to CERP implementation, especially projects that will decrease the size and frequency of large discharges from both Lake Okeechobee and the St. Lucie Estuary watershed is *Syringodium filiforme*. Additional mesocosm and species specific mapping as well as increased monitoring for this species south of the St. Lucie Inlet in the southern Indian River Lagoon would be needed in order to develop a predictive tool for *Syrigodium* expansion.

The watershed, hydrodynamic salinity, and the *Vallisneria* models need to be integrated. The watershed runoff model needs to be run at five-year intervals that will correspond to the SFWMM runs. Flows from the watershed can then be used in conjunction with S-79 flows supplied by the SFWMM in order to predict salinities at different locations in the river and estuary at five-year intervals. It is anticipated that data from the mass-based model will eventually be extrapolated to predict spatial coverage using geographic information system (GIS) applications. Ultimately, the submerged aquatic vegetation model/GIS applications will be linked to hydrodynamic water quality models to refine predictions.

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