CALOOSAHATCHEE RIVER AND ESTUARY ECOLOGICAL INDICATORS AND RESTORATION TARGETS DRAFT SCIENTIFIC COMPENDIUM

Caloosahatchee Visioning

Introduction

The Conservancy of Southwest Florida is committed to protecting the southwest Florida environment and quality of life of its members. The Conservancy is a stakeholder in the Caloosahatchee Visioning process as the Caloosahatchee River and Estuary is a major ecosystem of our region and as restoration is needed to support the fragile aquatic communities that exist there, including several imperiled species. As the lifeblood of the area, restoration of the Caloosahatchee system is needed to ensure continued quality of life of residents and the tourism economy, as well.

This purpose of this compendium is to dovetail with the list of ecological indicators and literature listed in the August 2013 Caloosahatchee Visioning final report.[1] Both the Visioning report and this document draw from existing studies and available planning documents, exploring ecosystem indicators and relevant information to link the science to an improved management implementation.

While this document is not all inclusive, it does provide information on some key indicators and highlights management needs. This current draft compendium focuses on recommendations in the literature below that spoke about salinity and flow for these indicators. However, there are many other aspects and indicators that the Caloosahatchee Visioning process should include that are not discussed here, such as the interrelated and very important issue of water quality (e.g. pollutants, total suspended solids, color, dissolved oxygen, light penetration, existing and future total maximum daily loads and basin management action plans, etc).

However, this compendium does show that, indeed, the Caloosahatchee community has a current state of knowledge that is well-founded in regards to the Caloosahatchee and its resources, with very few if any remaining information gaps existing. As well, there are existing recommendations for improved management of the system that have already been extrapolated from these bodies of work to formulate necessary flow regimes.

As explored in the 2006 Caloosahatchee Estuary and Charlotte Harbor Conceptual Model,[2] as well as in many other works some of which are cited here, there are several factors that impact the ecosystem's resources. The impact of changing freshwater flow and its corresponding pollutant loading, has a domino effect on nearly all of the attributes we researched.

Overall, we found that the benefit of maintaining tape grass upriver (with a corresponding salinity of less than 10 ppt) and maintaining shoal grass (10-25 ppt) and oysters (14-28 ppt) further downstream, would also provide protection to the nursery function of the river and also support imperiled species needs throughout the river and estuary.

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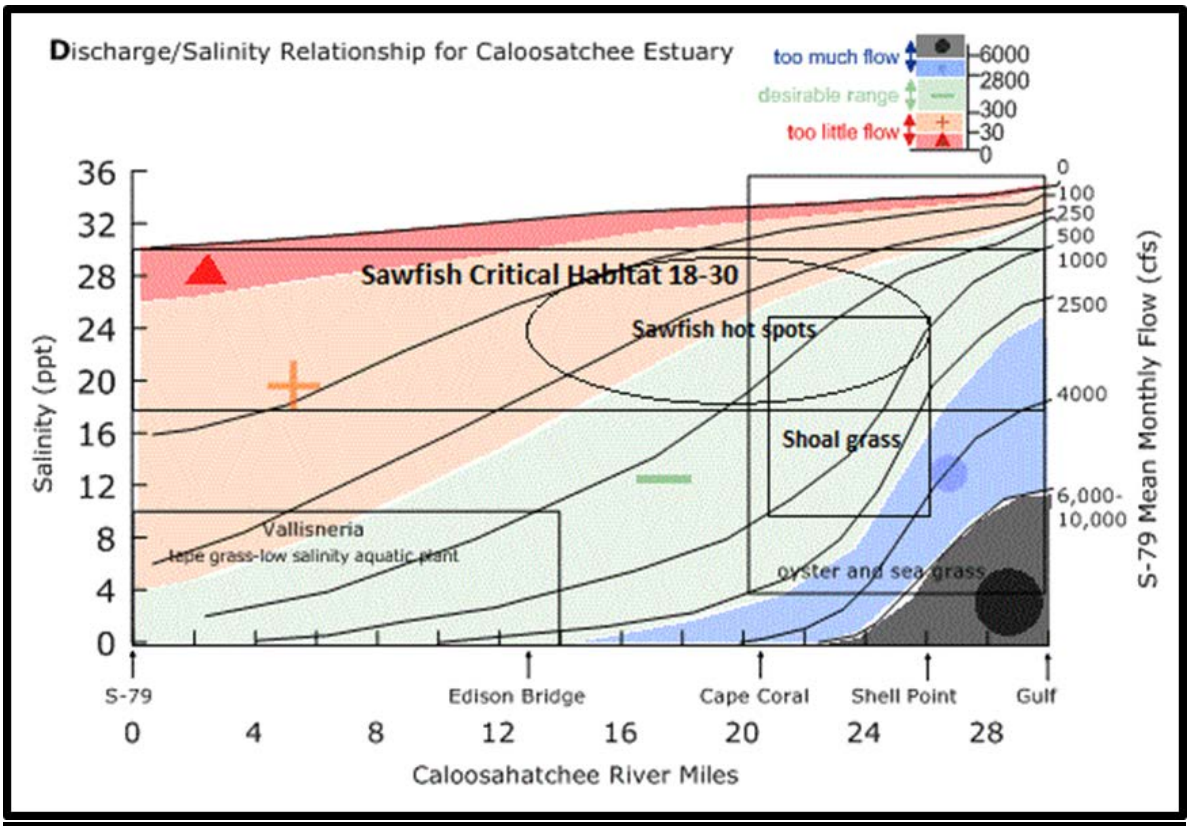
[1] South Florida Water Management District, August 23, 2013. Caloosahatchee River Visioning Process Stakeholder Assessment Findings and Process Design Draft Recommendation Final Report. Prepared by Consensus Building Institute.

[2] Barnes, T. and Salvato, S., 2006. Caloosahatchee Estuary and Charlotte Harbor Conceptual Model.

The literature we reviewed provided a range of flow rates to support these resources. Appropriate flows would need to account for antecedent or existing conditions, as well as monitoring real world results of flows on salinity levels. The final rate of minimum and high flows should be adequately protective of the most sensitive ecological indicators and natural resources in this compendium.

To help begin the discussion, Figure 1A provides a visual description of the potential relationship of salinity and flow at various points along the Caloosahatchee River ecosystem. As part of the Visioning process, this graphic would need to be updated with the appropriate flows and also with additional natural resources (e.g. sawfish, shoal grass, etc.), to determine the restoration goals.

Figure 1A. Graphic showing Salinity Relationship along Caloosahatchee, modified from Chamberlain and Doering, 1997[3] with other critical natural resources added - *FOR DISCUSSION PURPOSES ONLY*



[3] Robert Sobczak, January 10, 2012. Discharge/Salinity Relationship for Caloosahatchee Estuary, Modified from Information Provided in Publications by Chamberlain and Doering, 1997. Retrieved from <http://www.gohydrology.org/2012_01_01_archive.html> on April 3, 2013.

Ecological targets should be determined first, based on the best available science and without regards to existing constraints or contingent on further scientific study. Our existing body of scientific information on the Caloosahatchee River and Estuary is voluminous and adequate for setting such targets.

Additionally, setting targets should not be constrained based on existing conditions: either physical or policy-wise. Just as recontouring the Kissimmee or raising the Tamiami Trail were once thought to be unrealistic, future restoration actions necessary to meet these targets may seem unrealistic to us now, but one day become viable.

We urge the South Florida Water Management District to immediately set the flow and water quality conditions necessary for restoration of these ecological resources based on the existing body of scientific work and available data, and then to turn to formulating a restoration plan to achieve these conditions. We look forward to continuing our involvement in the Caloosahatchee Visioning process and swiftly moving forward with the available science to identify restoration goals and implementation measures.

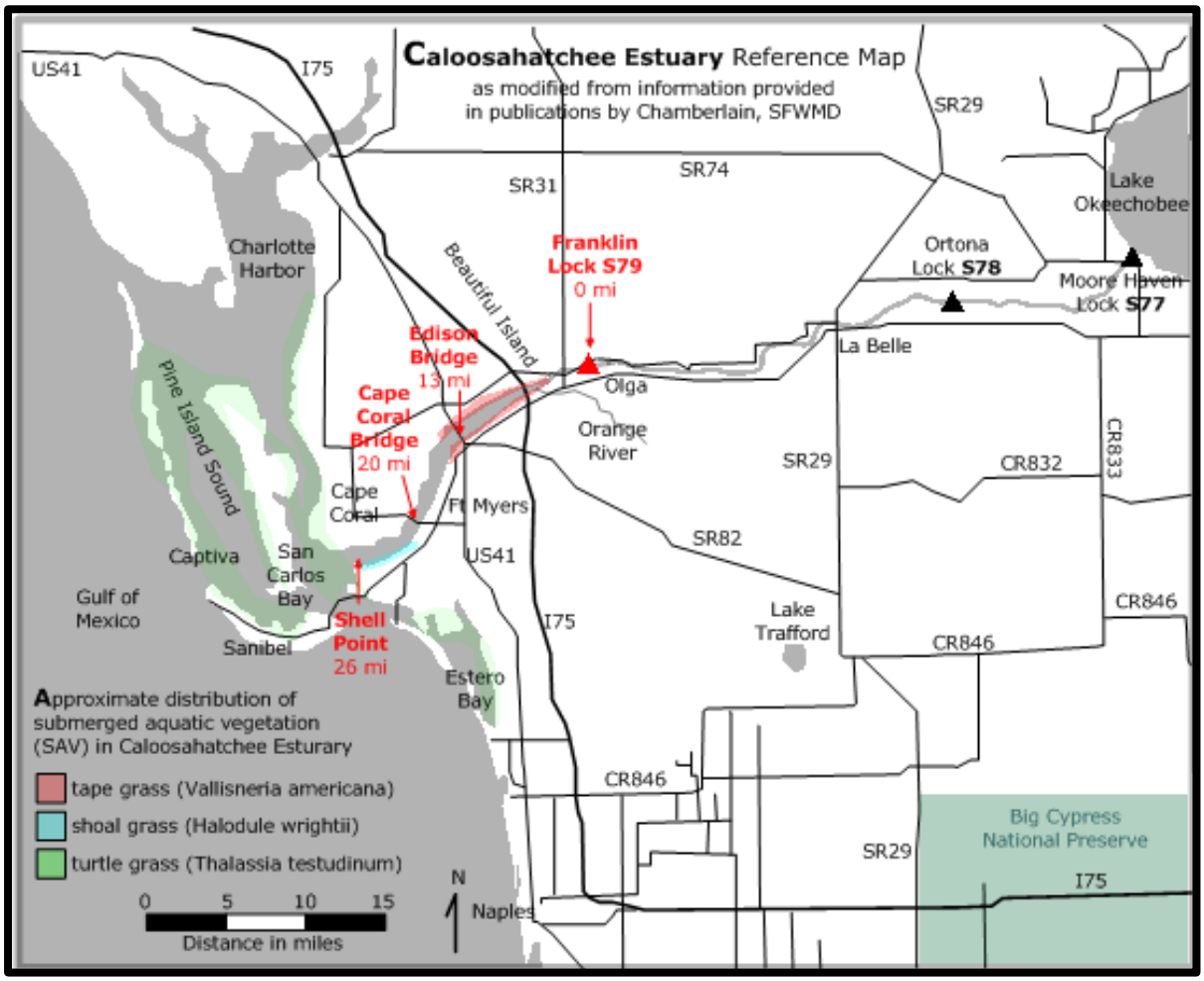
Submerged Aquatic Vegetation, including Seagrasses

- **Chamberlain, R. and Doering, P., 1998. Freshwater Inflow to the Caloosahatchee Estuary and the Resource-Based Method for Evaluation. Pages 81-90 in: S.F. Treat (ed.) Proceedings of the Charlotte Harbor Public Conference and Technical Symposium.**
    - "An important estuarine feature of [the area around the mouth of the Orange River] is the submerged aquatic grass, *Vallisneria americana* (tape grass)…. Distribution varies as controlling environmental factors (such as salinity and light penetration) change with the amount of freshwater input…." P. 83.
    - "The presence of *V. americana* is associated with a greater density of benthic invertebrates, and offers habitat, protection and foraging sites for many fish and invertebrates, including juvenile blue crabs…. During times of extended low to no inflow conditions, when salinity may be too high, this grass becomes very sparse and can disappear completely." Pg. 86.
    - "Excessive variation in salinity can maintain estuarine biota in a constant flux between those favoring higher salinity and those favoring lower salinity. At the extreme, appropriate salinity conditions do not last long enough for organisms to complete their life cycle and the estuary can become devoid of some self-sustaining populations and communities." Pg. 87.
    - "The proper quantity will be defined by determining the optimum range of freshwater inflow that protects key biota. Key species, or valued ecosystem components, sustain ecological structure and function by providing food, living space, refuge and foraging sites for other desirable species in the estuary. Oysters and submerged aquatic vegetation (SAV), such as the seagrass and tape grass described earlier, are considered key species…." Pg. 88.
    - RECOMMENDATION:
        - *V. americana* requires less than 10 ppt "to remain dense enough to provide habitat for other organisms"; in order to maintain this resource in appropriate quality and quantity to the Edison Bridge, "then a minimum discharge of about 500 cfs will be needed." P. 89.
        - Additionally, "if shoal grass and oysters can't tolerate salinity below about 4 ppt for an extended time, and it is desired to continue having them viably distributed up to the Cape Coral Bridge area, then the maximum monthly discharge should not exceed about 2,500 cfs." P. 89.
        - "Model output indicates the entire range of salinity is represented when discharge is around 500 cfs. In essence, this discharge provides a desirable

salinity somewhere for all organisms. A well-represented range of salinity probably occurs up to about 1000 cfs." P. 89.

- "When mean monthly discharges drop below about 250 cfs for extended priors of time, salinity climbs so high that is excludes the lower salinity ranges, which can adversely affect those plants and animals that exist in the upper estuary." P. 89.
- "During the other extreme, almost the entire estuary turns to freshwater when inflows exceed 4,500 cfs…. An extended period of depressed salinity throughout the system also can cause mortality of many bottom, non-mobile species."

Figure 2. Caloosahatchee Estuary Reference Map[4]



[4] Robert Sobczak, January 10, 2012. Caloosahatchee Estuary Reference Map, as Modified from Information Provided in Publications by Chamberlain, SFWMD. Retrieved from <http://www.gohydrology.org/2012_01_01_archive.html> on April 3, 2013.

- **Burns, et al., 2007. SAV and Faunal Relationships With Regard to Salinity and Seasonality. Mote Marine Laboratory Technical Report 1199 to the SFWMD.**
    - "In conjunction with agricultural and urban runoff into the watershed, freshwater releases are considered to be the main environmental stressors within the estuary responsible for seagrass loss and degraded water quality." P. 1.
    - Salinity is the main abiotic factor contributing to the preserve of tapegrass in the river and manatee grass in the estuary. P. 95.
- **University of Florida, Florida Museum of Natural History. Seagrass Species Profiles. Retrieved from <http:www.flmnh.ufl.edu/fish/southflorida/seagrass/Profiles.html> on November 17, 2013.**
    - Manatee grass (*Syringodium filiforme*) is found in salinities of 20-36 ppt.
    - Shoal grass (*Halodule wrightii*) is found in salinities of 10-25 ppt.

Water Column Communities

- **Tolley, S., et al., 2010. Responses to Turbidity, CDOM, Benthic Microalgae, Phytoplankton and Zooplankton to Variation in Season Freshwater Inflow to the Caloosahatchee Estuary. Florida Gulf Coast University.**
    - "High levels of freshwater inflow can decrease the abundance of both estuarine residents and marine species that utilized estuaries as nurseries." P. 1.
    - "A number of taxa exhibited marked seasonal changes in their centers of abundance, responding to reduced flows by moving upstream and relocating downstream during periods of higher inflow." These species move upstream as inflows decrease. P. 73.
    - "Lower flows can cause larger phytoplankton (diatoms) to grow in the upper zones… although this may benefit higher trophic levels (shorter food chains, higher nutritional value) it may also lead to reduced dissolved oxygen levels in bottom water as diatom biomass sinks and decomposes. Higher flows support growth farther down the estuary…are accompanied by an increase in cyanobacteria. This scenario may have negative food web implications (longer food chains, lowers nutritional value) and possible harmful algal bloom consequences." P. 91.
    - Appropriate flow will reduce habitat compression to S-79 lock which increases competition and predation-prey encounters, especially during the dry season (April, May). P. 93.
    - RECOMMENDATION:
        - "… the release of freshwater at S-79 during dry months (when these taxa are most likely to concentrate in the upper tidal river) would result in the

relocation of these taxa, downstream and away from this region prone to the development of low DO. Based on inflow relationships of hyperbenthic prey, it appears that releases of 1,000-1,200 cfs would achieve this result."[5] P. 92.

Oysters

- **Volety, A., 2007. Final Report: Caloosahatchee Estuary Oyster Monitoring and Research. Florida Gulf Coast University.**
    - The research objectives are to monitor eastern oysters (*Crassostrea virginica*) in the Caloosahatchee and to determine needs for beneficial freshwater inflow patterns for oyster restoration. P. 2.
    - "Temperature and salinity affect oyster growth, survival, reproduction, and general health….Oysters from an altered estuary having extreme salinities have significantly lower condition index compared to oysters from an un-altered estuary." Condition index can indicate oysters are stressed by either water quality or disease and have less energy for growth or reproduction. P. 4.
    - "Oysters in the Caloosahatchee estuary showed peak reproductive activity… between May and October…. [this is] a period that coincides with freshwater releases and or watershed runoff." P. 8
    - "….slower growth, poor spat production, and excessive valve closure occur at salinities below 14." P. 4
    - "higher salinities and temperatures favor parasite development and proliferation." P. 6.
    - "Results…indicate that 53 – 74% of the variation in salinity can be explained due to freshwater flows from S-79." P. 8.
    - RECOMMENDATION:
        - "Although oysters tolerate salinities between 0−42… growth is maximized at salinities of 14−28…." P. 4.
        - "Flows below 4000 CFS into the estuary from S-79 will result in salinity regime that will enable oysters to survive and grow." P. 8.
        - Limiting freshwater releases to < 4000 CFS during [summer-fall months] will limit flushing of oyster larvae to downstream locations and create favorable salinity regime for spat recruitment and survival.
- **Volety, A. "Oysters (*Crassostrea virginica*) as Sentinels of Ecosystem Health and Environmental Perturbation: A case study in the Caloosahatchee Estuary, Florida." Powerpoint presentation. Southwest Florida Coastal Watershed Workshop, Florida Gulf Coast University, Fort Myers, Florida. April 26, 2012.**

[5] The appropriate flow regime to address this potential problem may require further modeling. G. Tolley, personal communication, November 20, 2013.

- Goal is to retain a minimum of 200 acres of oysters.
- Need additional information on salinity tolerance for early life cycle period.
- RECOMMENDATION:
    - Oysters prefer 14-29 ppt.
    - Approximately 2,000 cfs is recommended.

Macro Invertebrates

- **Hunt, M. and Doering, P., 2013. Salinity Preferences and Nursery Habitat Considerations for Blue Crab (*Callinectes sapidus*), Bull Shark (*Carcharhinus leucas*), and Smalltooth Sawfish (*Pristis pectinata*) in the Caloosahatchee Estuary. South Florida Water Management District. Technical Publication WR-2013-001.**
    - The Caloosahatchee is a nursery area for blue crab, as well as many other important species. P. 12.
    - "Studies worldwide indicate that the oligohaline and mesohaline zones of estuaries (i.e., with salinities in the range 0–17) are utilized by larvae and juveniles of estuarine dependent species…. Areas with low salinities are considered critical to the life histories of many organisms… and offer habitat to a wide variety of adult and juvenile freshwater, estuarine, and marine fishes…." P. 5.
    - The blue crab occupies an assortment of coastal habitats for different parts of its life cycle, thus "maintenance of the entire estuarine system in a condition suitable for continued production is deemed important…." P. 6.
    - "Several studies have shown that tape grass beds serve as habitat for young blue crab…." P. 10.
    - RECOMMENDATION:
        - Highest catches of crabs was found to be in the salinity range of 0.5–5 range. P. 7.
        - Molting males can be found in salinity ranges of 11-15. P. 7.
        - "…freshwater inflows that provide year-round salinity conditions supporting sustainable tape grass beds in the upper Caloosahatchee Estuary (salinities in the range 0–10), would also benefit the blue crab by providing tape grass as nursery habitat." P. 10.

Dwarf Seahorses

- **Department of Commerce, 2012. Endangered and Threatened Wildlife; 90-Day Finding on a Petition to List the Dwarf Seahorse as Threatened or Endangered Under the Endangered Species Act. Federal Register, Vol. 77, No. 87, 26478-26486.**
    - The dwarf seahorse (*Hippocampus zosterae*) is proposed to be listed as protected under the Endangered Species Act.
    - Healthy seagrass shoot density is correlated with density of dwarf seahorse occurrence.[6] P. 26480.
    - RECOMMENDATION:
        - The seahorse prefers areas with dense and high seagrass canopies, in shallow waters less than 2m, and high salinity areas around 30 ppt.[7] P. 26480.

Smalltooth Sawfish

- **Simpfendorfer, et al., 2011 Environmental Influences on the Spatial Ecology of the Juvenile Smalltooth Sawfish (*Pristis pectinate*): Results from Acoustic Monitoring. PloS One, Vol. 6, No. 2, P. 1-12.**
    - The smalltooth sawfish is listed as endangered under the Endangered Species Act.
    - Changing water conditions "will affect populations by potentially changing their distributions" P. 1.
    - "During 2005, when flows were high, individuals were in the lower reaches of the river, while periods of little or no flow in 2007 corresponded to periods when individuals were far upriver. This suggests flow, in conjunction with physical factors such as depth, plays some role in individual location within the river, possibly through their influence on salinity." P. 7.
    - "The difference in movement direction between upriver and downriver locations was likely related to behavior that enabled individuals to locate or remain in their preferred salinity." P. 10.
    - "The extent of these movements is related to the magnitude of salinity change. When flow patterns are changed, individuals may move to areas with their preferred salinity, but habitats within these areas may be less (or more) suitable than those previously occupied. Within the Caloosahatchee River, increases in salinity that led to *P. pectinata* occurring upriver of the study area may be most problematic as the river

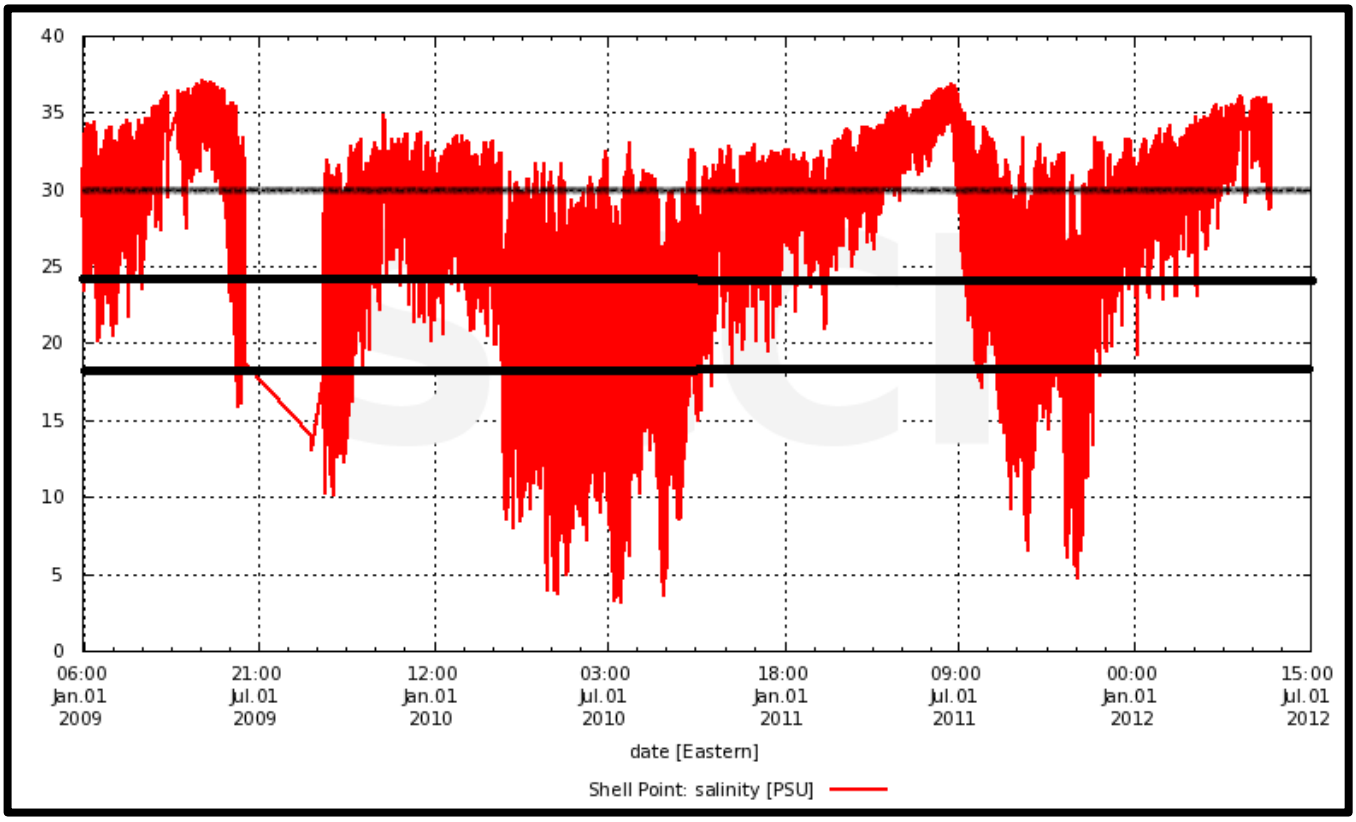
[6] Citing Sogard, et al., 1987.

[7] Citing Alford and Grist, 2005 and Bruckner, et al., 2005, and Vincent, 2004.

becomes quite narrow with few shallow habitats that this species appears to use as a refuge from predation." P. 10.

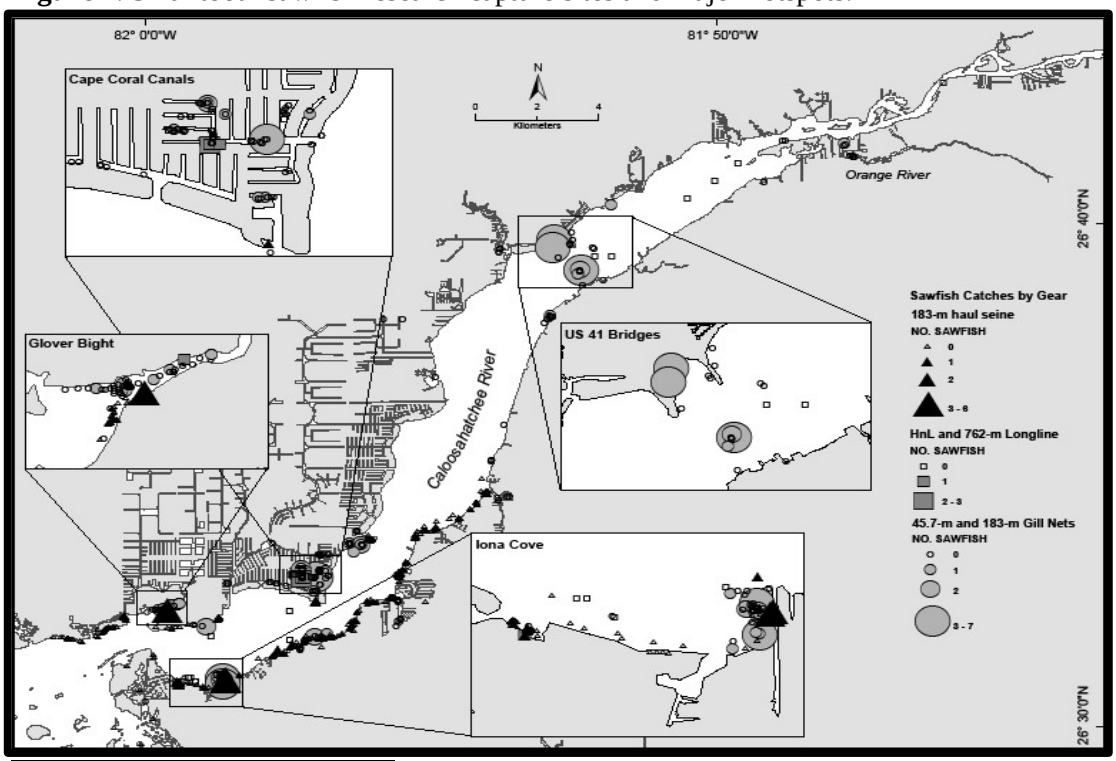
- "Similarly, water management practices that result in repeated large changes in flow over short periods of time will result in large amounts of movement between different habitats which will increase energy expenditure, and may expose individuals to greater risks of predation." P. 11.
- "Water management practices therefore need to be considered in relation to the recovery of the *P.pectinata* population." P. 11.
- RECOMMENDATION:
  - "Salinity electivity analysis demonstrated an affinity for salinities between 18 and at least 24 psu, suggesting movements are likely made in part to remain within this range." P. 1.

Figure 3. Sanibel Captiva Conservation Foundation custom graphic from RECON data, showing salinities at Shell Point. Black lines indicating 18, 24, and 30 ppt thresholds.



- **Poulakis, G., et al., 2010. Distribution, Habitat Use, and Movements of Juvenile Smalltooth Sawfish, *Pristis pectinata*, in the Charlotte Harbor Estuarine System, Florida. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. Final Report.**
    - Researchers tracked the distribution and movement patterns of juvenile smalltooth sawfish (< 3 yr old) in the tidal Caloosahatchee River. P. iv.
    - The distribution of sawfish was related to a 90-day lagged salinity, where by sawfish moved upriver when salinity increased and downriver as salinity decreased. P. v, 54. "These… movements were concurrent with changing flows suggesting that the fish were responding to changing environmental conditions (e.g., salinity)." P. 59.
    - There are several sawfish hot spot areas in the Caloosahatchee. The US41 bridge area hotspot was identified during the 2007 drought period. P. 12.
    - RECOMMENDATION:
        - "Environmental electivity preferences were examined and showed that sawfish had an affinity for water < 1 m deep, water > 30°C, moderate to high dissolved oxygen levels (> 6 mg l-1), and salinities between 18 and 30 psu…. Sawfish avoided water temperatures < 18°C, dissolved oxygen values < 6 mg l-1, and salinities > 30 psu." P. 15-16.

Figure 4. Smalltooth sawfish research capture sites and major hotspots.[8]



[8] From Poulakis, G., et al., 2010. Distribution, Habitat Use, and Movements of Juvenile Smalltooth Sawfish, *Pristis pectinata*, in the Charlotte Harbor Estuarine System, Florida.

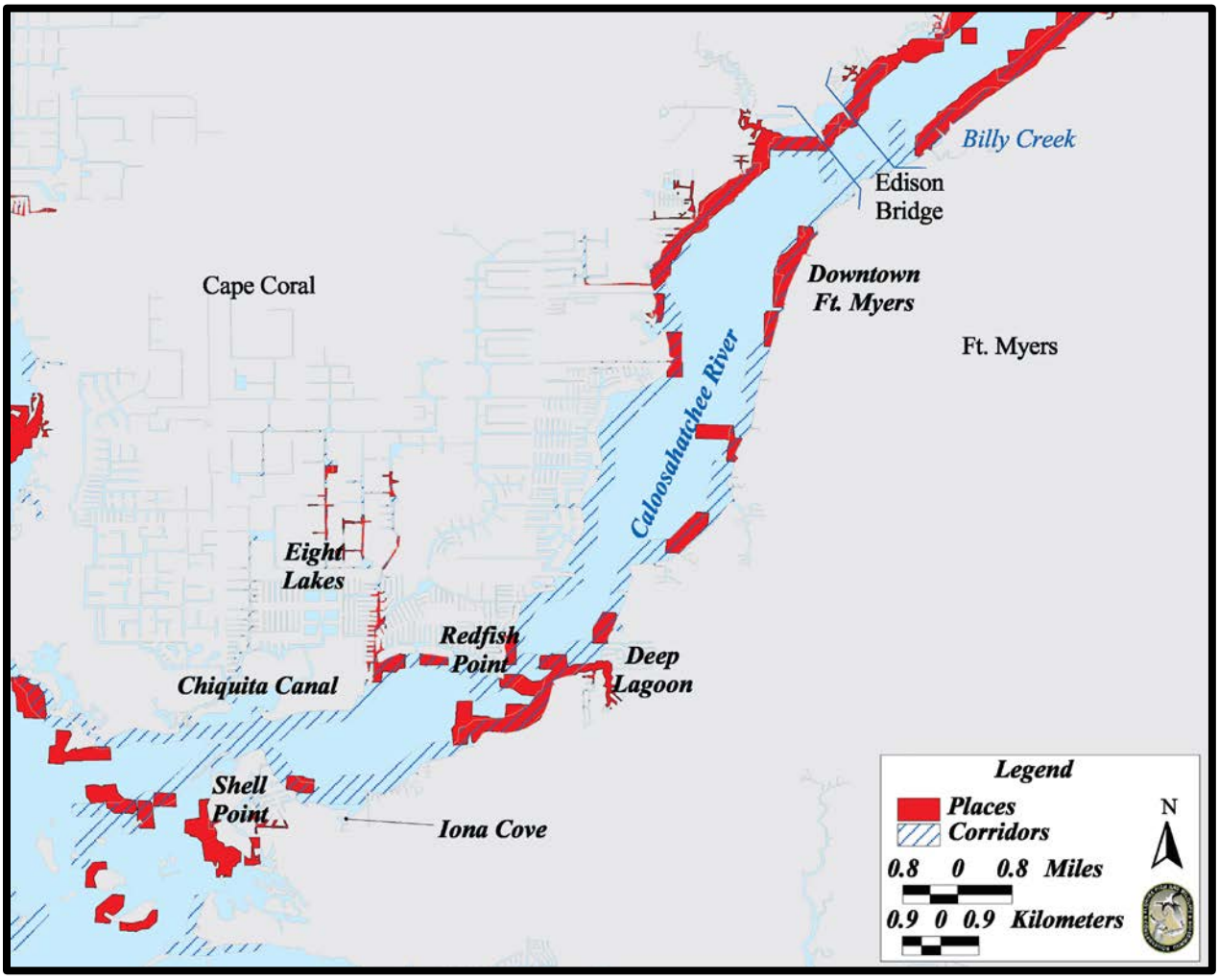
- National Marine Fisheries Service, 2009. Smalltooth Sawfish Recovery Plan. Prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service. Silver Spring, MD.
    - The Recovery Plan identifies alteration of freshwater flows as a threat/stress to the sawfish.
    - In order to ensure the long-term viability of the sawfish, the minimization of disrupting freshwater flow regimes (including timing, quality, and quantity) and a restoration of water quality is needed. This is particularly critical in nursery habitats such as the Caloosahatchee estuary. P. ix, I-21, IV-9, IV-22.
    - One of the criteria that must be met for recovery of the species is that: "Freshwater flow regimes (including timing, distribution, quality, and quantity)…are appropriate to ensure natural behavior (e.g., feeding, resting, and predator avoidance) by maintaining salinities within preferred physiological limits of juvenile smalltooth sawfish." P. III-4-5.

Manatees

- **McDonald, et al., 2006. A Regional Assessment of Florida Manatees and the Caloosahatchee River, Florida. Florida Fish and Wildlife Conservation Commission and FWRI Technical Report TR-10.**
    - The manatee is listed as endangered under the Endangered Species Act.
    - The study looked at habitat, manatee movements and abundance, and human uses (such as boating). P. 1.
    - Area of the Caloosahatchee River between Shell Point and Edison Bridge is an important travel corridor (between warm water areas and feeding areas). P. 1.
    - "Manatees feed on a variety of marine, freshwater, and terrestrial plans." Common forage species include shoal grass, manatee grass, turtle grass, tape grass, as well as wideon grass. P. 2.
    - "Manatees on Florida's west coast are frequently exposed to brevetoxin, a potential neurotoxin, during red tide events." P. 5. There have been a number of deadly events in the Caloosahatchee River and Estuary.
    - "Extreme quantities of fresh water followed by periods of drought have altered the estuarine ecosystem…. downstream turbidity has increased, resulting in decreases in light penetration and in SAV in the estuary." P. 11.
    - "Controlled releases or pulses of freshwater from Lake Okeechobee, upstream runoff, and prolonged periods of drought can severely, although temporarily, alter the salinity gradient…. Estevez (2000) reported that variations in salinity adversely affect seagrass biomass than more than actual salinity levels. Salinity fluctuations increase turbidity, reduce light penetration, and alter the pattern of SAV distribution." P. 15.

- "Sustained periods of salinity extremes could substantially reduce SAV…. Temporary elimination of SAV would force manatees to find food elsewhere…" P. 17.

Figure 5. Manatee places of importance and travel corridors along the Caloosahatchee.[9]



[9] From McDonald, et al., 2006. A Regional Assessment of Florida Manatee and the Caloosahatchee River, Florida. Florida Fish and Wildlife Conservation Commission and FWRI. Technical Report TR-10.