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The Rehabilitation of the Tampa Bay Estuary, Florida, USA, as an Example of Successful Integrated Coastal Management

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The Tampa Bay Ecosystem is located in the state of Florida, USA. The 6739 km^2 ecosystem has undergone major changes due to coastal development, including dredging for maintenance and expansion of the 10th largest port in the USA. Approximately 44% of the historic emergent coastal wetlands and 81% of the historic submergent seagrass meadows had been lost through 1981. Declines in commercial and recreational fisheries harvests and coastal wildlife populations followed similar trends in declines. Beginning three decades ago, an informal Integrated Coastal Management (ICM) program initiated by citizen groups has progressed to a formal ICM program that has initiated restoration of the ecosystem and management through a unique multi-county umbrella organization, the Tampa Bay Estuary Program.

History

The Tampa Bay ecosystem includes 967 km^2 of primarily unvegetated estuarine waters with an average depth of 3.5 m , 72 km^2 emergent coastal wetlands and a 5700 km^2 watershed for a total area of 6739 km^2 (Fig. 1) (Lewis and Estevez, 1988; Tampa Bay National Estuary Program, 1996). Approximately 10% of the 967 km^2 of open water area (101 km^2) have shallow (<2 m) shelves vegetated with seagrasses (Johansson and Ries, 1997).

The primary emergent coastal vegetation consists of mangrove forests with three species of trees, *Rhizophora mangle* L. *Avicennia germinans* (L.) L. and *Laguncularia racemosa* Gaertn. f., with about 20% of the total area dominated by salt marshes consisting mostly of smooth cordgrass (*Spartina alterniflora* Loisel.) and needlerush (*Juncus roemerianus* Scheele) (Lewis and Estevez, 1988). Seagrass meadows are dominated by *Thalassia testudinum* Konig and *Halodule wrightii* Ascherson (Lewis *et al.*, 1985).

The watershed supports a population (ca. 1995) of 2 million within the cities of Tampa, St. Petersburg, Clearwater, Bradenton and surrounding suburban communities (Fig. 1). The first modern recognition of the bay's decline came from the US Public Health Service (Galtstoff, 1954), citing pollution from municipal discharges with nonexistent or inadequate treatment, industrial wastes from phosphate mines, citrus canneries, and other sources as major contributors. Galtstoff (1954) stated that 'Tampa Bay is grossly polluted, and bathing waters in Clearwater Harbor and St. Joseph Sound have been affected adversely'.

Problem Identification

The first suggestion that controls on eutrophication and dredging impacts were needed came in 1969. The Federal Water Pollution Control Administration (1969) recommended a water quality management plan and waste abatement program to control odour and other pollution symptoms in Hillsborough Bay, and a master plan for dredging and filling the bay. Also in the early 1970s, a citizens group called Save Our Bay began to push for a halt to uncontrolled dredging and sewage disposal in the bay. At the same time, the federal government was shifting more attention to environmental

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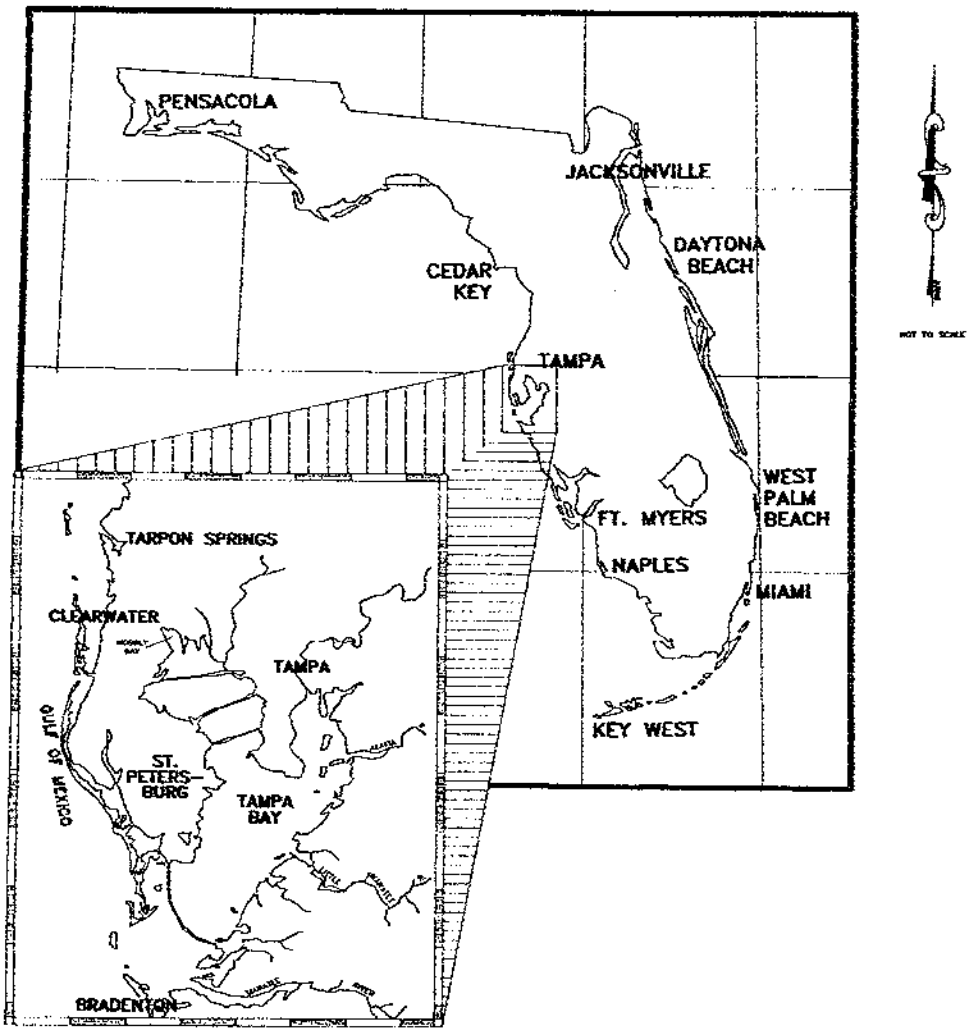

Fig. 1 Map of Florida showing the location of Tampa Bay.

needs with the establishment of the US Environmental Protection Agency (EPA) On of the major accomplishments of the EPA in its early years was providing federal grants to upgrade sewage treatment plants.

As a result of the federal report and of citizens call for action, one of those grants was awarded to the city of Tampa, which had for decades piped raw or barely treated sewage into Tampa Bay. The sewage was believed to be a major reason why many portions of the bay experienced continuous blue-green algae blooms and were badly polluted (Johansson and Lewis, 1992). This grant enabled Tampa to install an advanced wastewater treatment system (i.e., nutrient removal) at the plant in 1979, one of the first of its kind in the country. The technological improvements reduced the flow of nitrogen by an estimated 90% below untreated effluent levels, an achievement that is recognized today as a cornerstone in the bay's recovery. Subsequent state legislation, currently requires all sewage treatment facilities discharging to the bay to meet advanced treatment standards, with a total nitrogen concentration limit of 3 mg/l. The city of St. Petersburg chose another route to address its sewage disposal problems when it pioneered the first large-scale wastewater reuse program in the state, resulting in greatly reduced discharge of nitrogen to the bay.

In the late 1960s, the Environmental Protection Commission of Hillsborough County (EPC) was established. Over the years, EPC has provided a comprehensive record of long-term water quality trends in the bay, critical for tracking and documenting long-term water quality conditions and the bay's progressive re-

covery. EPC was one of the first agencies to identify sewage treatment problems in the bay, and its wetland protection rules are among the strictest in the state.

The estuary has been a major seaport for over 100 yr. Currently the port is rated as the tenth largest in the United States in overall tonnage (52 million tons/year). The largest exports are phosphate rock and fertilizer products, while the largest imports are petroleum and coal. The modifications of the estuary to facilitate coastal development, including port construction, have resulted in the excavation or filling of 44% of the emergent coastal wetlands (i.e. tidal marshes and mangrove forests originally estimated as covering 108 km^2) (Lewis, 1977).

Historical (pre-1930) seagrass meadows in Tampa Bay are believed to have covered 310 km^2 of the shallow bay bottom based upon historical maps and patterns of modern distribution. Interpretation of vertical aerial photographs from the 1950s and 1982 yielded about 165 and 88 km^2 of seagrass, respectively, suggesting a 72% loss from the earliest estimate and a 47% loss since 1900 (Lewis, 1977; Lewis *et al.*, 1985).

Problem Resolution

An informal Integrated Coastal Management program, derived mainly from citizen action groups, began with the first Earth Day in 1969. Dredging of coastal wetlands to create waterfront housing was topped in 1975. Water quality targets were initially *technology based*, and later *water quality based*. This means that regulatory criteria to establish when violations occurred started by defining what types of sewage treatment (i.e., primary, secondary) should be applied (technology based). Later receiving water quality parameters were used (water quality based). Eventually, *resource based* criteria utilizing seagrass distribution became the standard (Lewis, 1991). Bay-wide seagrass mapping has been conducted by the South-west Florida Water Management District every 2 yr since 1988. Results from this study show that the trend of seagrass loss has been reversed. The 1994 cover was estimated at near 108 km^2, indicating an increase of almost 23% since 1982 (Figs. 2 and 3a–c). The seagrass expansion started in response to water quality improvements which occurred more than a two decades ago and which in turn followed a large reduction in nitrogen loading from primarily domestic and industrial point-sources (Johansson and Lewis, 1992). Although this nutrient reduction occurred almost two decades ago, the decline in macroalgae and microalgae blooms and an increase in water transparency did not become apparent for almost 5 yr.

The Tampa Bay National Estuary program has adopted goals to protect existing Tampa Bay seagrass meadows and to restore, over the long term, 5000 ha of additional seagrass primarily through the control of nitrogen loading to the bay. Tampa Bay seagrass meadows in areas popular to boaters are impacted by propeller scarring. Studies have been funded to determine the extent of propeller impacts and to evaluate management options for the protection of the impacted areas.

The programme to restore lost mangrove and tidal marsh wetlands began almost 30 yr ago with experimental work that firmly established the most appropriate and cost effective methodologies for restoring these habitats within damaged bay environments (see summaries in Lewis, 1990; Crewz and Lewis, 1991). The key criteria being the understanding of the bay's unique pattern of secondary succession in intertidal plant communities whereby smooth cordgrass colonizes recovery shallow intertidal areas formerly covered with mangroves and is later replaced by mangroves through competition (Lewis, 1982). In addition, the correct construction of tidal platforms at the correct tidal datum elevation for marshes and mangroves was found to be the most important criteria for successful construction of tidal wetlands (Crewz and Lewis, 1991). Data collection on the rate of natural colonization by fish of newly created tidal wetlands in Tampa Bay also indicated that fish populations essentially identical in both species composition and total numbers to control wetland sites recruited within 5 yr of their construction (Lewis, 1992; Whitman and Gilmore, 1993). These scientific studies when applied to the issue of restoration allowed bay managers to proceed quickly to designing large-scale restoration programs without delays to justify whether they would 'work' to restore functional habitats.

A bay-wide wetland and coastal upland restoration program has been developed and adopted for the bay (Lewis Environmental Services, Inc., and Coastal Environmental, Inc. 1996) and is being implemented with costs per hectare of USD$62 500 (excluding the cost of the land) using public agency staff and equipment to the largest extent possible. This is one-half of the normal commercial cost of such efforts. These costs are broken down into 18% for preconstruction activities (design, permitting) and 75% for construction and 7% for monitoring. These costs are slightly more than those reported by King and Bohlen (1994) in a national study, but may reflect variations in local costs. To date 0.45 km^2 of wetlands have been restored by the Surface Water Improvement and Management (SWIM) Program of the South-west Florida Water Management District.

Discussion

The struggle to protect and manage the natural resources of Tampa Bay has evolved in less than 30 yr from a grass-roots citizens effort to a complex, multilayered network involving three counties, a dozen cities, a variety of regional and federal agencies and numerous citizens and special interest groups. Tampa Bay's approach to Integrated Coastal Management (ICM) originated as a 'bottom up approach' with strong local

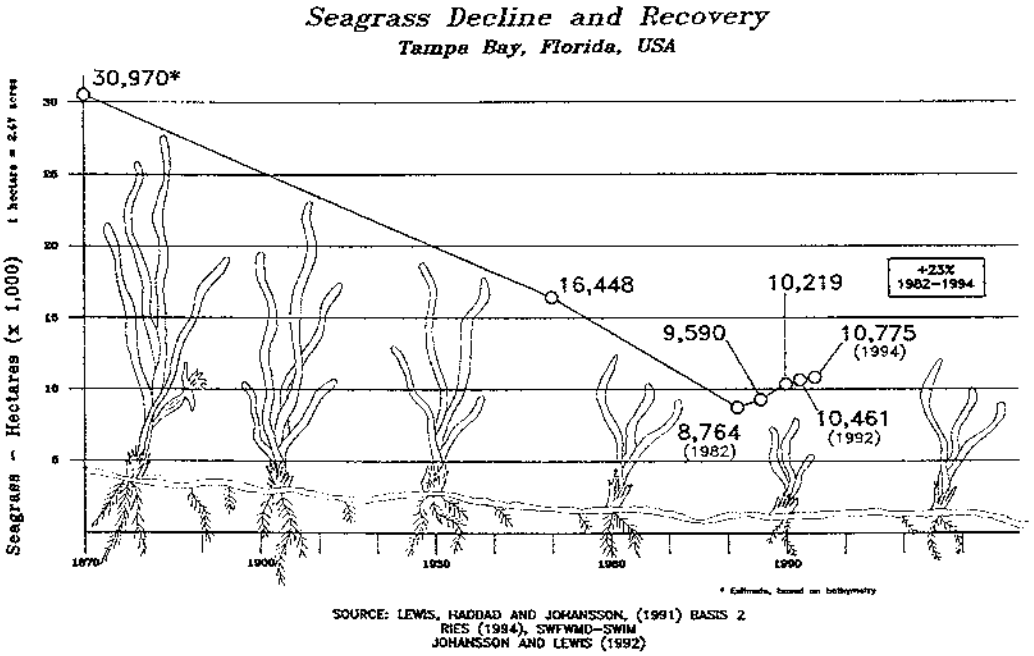

Fig. 2 Graph showing the measured areal extent of seagrass meadows in Tampa Bay over time.

citizen impetus. Citizen involvement and concern remain important driving factors through local government commitment to reach long-term goals for bay restoration developed with state and federal programs. A key lesson learnt here is that ICM programs are more likely to succeed if you start with strong local support rather than simply try to impose a program on a local community from some senior statewide agency (i.e., the top-down approach). This is also referred to as the 'community based' approach.

Following 6 yr of scientific research and community dialogue, the Tampa Bay National Estuary Program (TBNEP), a partnership that includes the EPA, Florida Department of Environmental Protection, South-west Florida Water Management District, Hillsborough, Pinellas and Manatee counties, the cities of St. Petersburg, Clearwater and Tampa, the Florida Game and Freshwater Fish Commission, US Army Corps of Engineers, Tampa Bay Regional Council, the Environmental Protection Commission of Hillsborough County, and the Florida Marine Research Institute, adopted a long-term strategy to protect and restore Tampa Bay's critical living resources. As noted before, this *resource based* strategy emphasizes using actual measured quantitative changes, such as areal extent of seagrass, or populations of birds, as the criteria for success or failure. Goals of the binding agreement to implement the strategy include the following:

Habitat:
- Recover an additional 5000 ha of seagrass baywide.
- Restore a minimum of 40 ha of tidal stream habitat every 5 yr while preserving existing marsh and mangrove habitat.
- Establish minimum seasonal freshwater flows to the bay and its tributaries to support fisheries habitat.

Water quality:
- Prevent increases, over 1992–1994 levels, of nitrogen entering the bay to encourage seagrass recovery.
- Implement actions to reduce toxic materials in impacted bay sediments.
- Implement actions to reduce bacterial contamination in areas which fail to meet health standards for swimming and fishing.

Fish and wildlife:
- Protect and enhance fish and wildlife populations and improve enforcement of environmental regulations.

Spill prevention and response:
- Install a vessel tracking system to reduce the chance of collisions and spills.

Dredging and dredged material management:
- Develop a long-term coordinated dredging and dredged material management plan for Tampa Bay.

Public education and involvement:
- Educate the public about bay issues and progress, and enlist them in bay protection.

The signatories to the agreement have agreed to collectively achieve these goals and to submit action plans detailing how they will meet their specific responsibilities. The agreement includes a specific time frame for accomplishing each of the goals for bay improvement, to be updated every 5 yr, and a strong baywide moni-

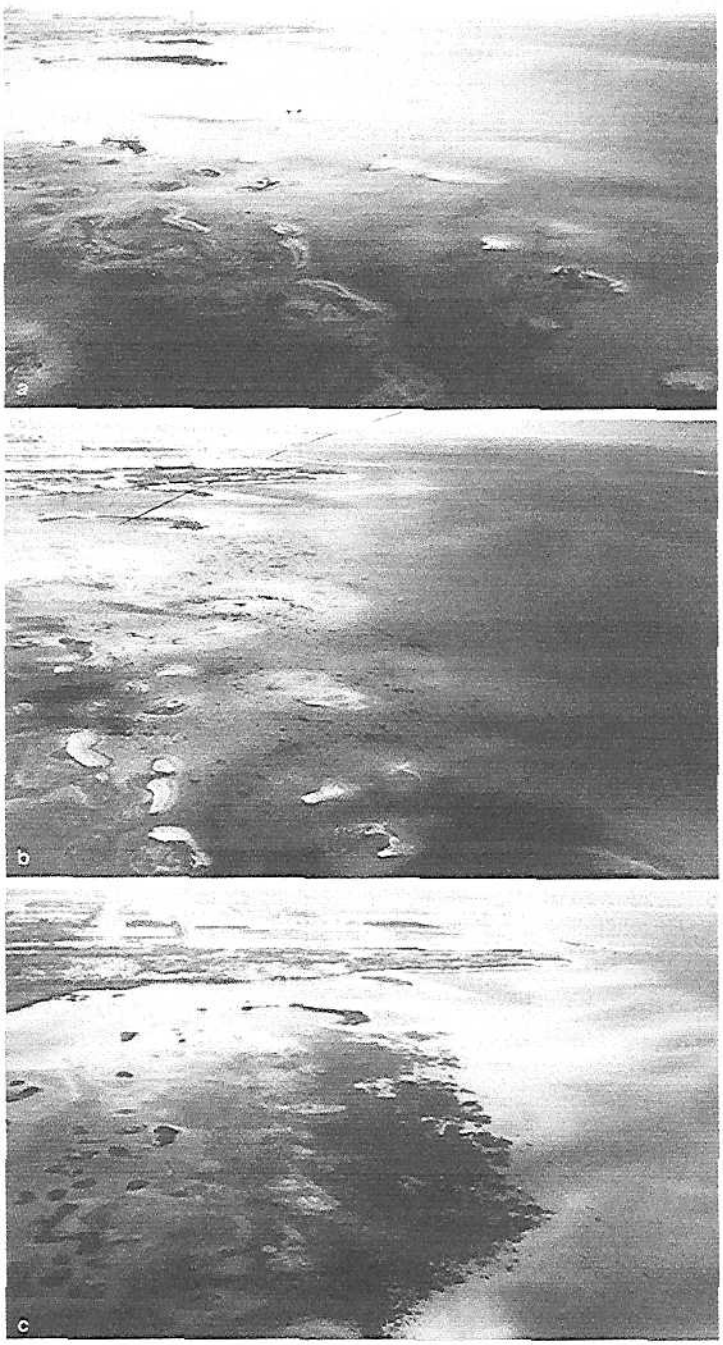

Fig. 3 (a) Oblique colour aerial photograph looking south along Tampa Bay's eastern shoreline showing large accumulations of macroalgae (dark signatures in foreground). Seagrasses are absent in this March 1986 photograph. (b) Same area as Fig. 3a, photograph taken in 1990. Some macroalgae in foreground but dark spots are newly colonized seagrass patches of shoalgrass, *Halodule wrightii*. (c) Same area as Fig. 3a, photograph taken in 1996. Shoalgrass meadows have coalesced to form the dark continuous seagrass meadow in the centre. Lighter signature to the left in the photograph are beds of the annual seagrass *Ruppia maritima*.

toring program to measure progress (or lack of) toward goals. The program leaders are the Tampa Bay Estuary Program, a local agency derived from the federally funded TBNEP.

Strong local direction and committment coupled with good science and significant support from state and federal programs has resulted in an ICM approach for Tampa Bay focused on agreed-upon measurable goals for bay restoration and the committment to attain them. Citizen watch-dogs are still present and are still needed to continue to monitor local agency responsiveness, but the future of the bay's natural and human resources appears bright.

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