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THE WAKULLA SPRINGS WOODVILLE KARST PLAIN SYMPOSIUM – TRANSACTIONS OCTOBER 9, 1998

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FRESH WATER IMPACTS IN COASTAL ECOSYSTEMS

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ABSTRACT

Groundwater discharge contributes significant amounts of fresh water into coastal ecosystems in the Apalachee Bay region, helping to maintain estuarine conditions. These estuaries are currently in relatively good ecological health. As a result, the area supports diverse marine ecosystems, extensive marine sea grass beds and healthy populations of several endangered species. In particular, the Kemp's ridley sea turtle, Lepidochelys kempi, congregates in estuarine areas, feeding on large populations of blue crabs, Callinectes sapidus.

Groundwater discharge to estuaries is known to be extensive, but it is still poorly understood and nearly unmapped. As the aquifer develops elevated nutrient levels, it becomes a delivery system for excessive nutrient loading into coastal waters which can lead to major ecological degradation, particularly to sea grass ecosystems.

In addition, because of the diffuse and unmapped pattern of coastal groundwater seepage, it is virtually impossible to model and predict precisely any impacts to marine ecosystems resulting from major diversions of groundwater resources from their current status to human use. However, based on experience in Florida Bay, such impacts could be expected to be harmful and substantial.

Apalachee Bay, the coastal region adjacent to the Woodville Karst Plain, is the northern and western limit of the Florida Big Bend Coast, a little developed and nearly pristine coastal region stretching from approximately Crystal River in the south to Ocklockonee Bay in the north. Marine communities of the region are currently in relatively good ecological health. The Big Bend's diverse marine ecosystems include one of the largest coastal salt marshes in the US, dominated by the rush *Juncus roemerianus*; one of the most extensive marine seagrass beds in the world composed primarily of turtle grass *Thalassia testudinum*; and extensive limestone bottoms that support tropical coral reef associated species of fishes and invertebrates (FDEP, 1988; Iverson and Bittaker, 1986). Near the mouths of streams and in the vicinity of large coastal springs and groundwater seepage areas such as Spring Creek, estuarine conditions prevail, supporting large populations of commercially important blue crabs, *Callinectes sapidus*, stone crabs, *Menippe mercenaria*, and oysters, *Crassostrea virginiana*, as well as other estuarine species.

The economic value of the marine resources of the region exceeded $10 million, based on 1997 commercial fishery landings of pink shrimp, gag grouper, blue crabs, stone crabs, and oysters (FDEP, 1998). The value of the seagrasses and marshes as nursery habitat to these and other marine species is enormous, with published estimates ranging from approximately $6500/acre for sports fishing revenues in Florida to a value of $242-313 million per year for New England salt marshes (Bell, 1997; Stevens et al., 1995).

These diverse marine habitats currently support healthy and growing populations of several endangered marine species. The Kemp's ridley sea turtle, *Lepidochelys kempi,* congregates in estuarine areas, feeding on large populations of blue crabs, *Callinectes sapidus* (Rudloe et al., 1991). A growing population of the West Indian manatee, *Trichechus manatus*, forages in coastal seagrass beds in the summer and overwinters in Crystal River to the south (Powell and Rathbun, 1984). The present healthy populations of these well-publicized species are dependent on the presence of intact ecosystems with thousands of other more obscure species of marine plants and animals. Their future survival is equally dependent on the continued health of these ecosystems and their wealth of smaller species.

Perhaps because of its limited accessibility, this area has in the past been the subject of surprisingly little ecological investigation. Most notably, Livingston and his students (Hooks et al., 1976; Livingston, 1982; Hock and Orth, 1980) contributed greatly to our knowledge of the seagrass fauna in the 1970s and 1980s and some studies of the unusual *Juncus roemerianus* dominated salt marshes were done (Durako et al., 1985). At this time, however, the area is receiving more attention from researchers. The Florida Big Bend Coastal Research Workshop, held in 1997, highlighted a wide variety of marine investigations of the region, ranging from physical oceanography to geological processes to habitat investigation (Lindberg, 1997). In these studies, academic researchers have been joined by staff from the various state and federal agencies with management responsibilities in the area. This affords the opportunity for eventual development of long term, region-specific data sets that will be critical to the preservation of the area's resources.

Most of the coastal area is incorporated into a series of public preserves, including the St Marks National Wildlife Refuge, a series of state preserves, and the Lower Suwannee and Cedar Keys National Wildlife Refuges. State waters are included in the Big Bend Seagrasses Aquatic Preserve, a program designed to give extra legal protection to waters of exceptional ecological value. It might be assumed that these preserves would protect the marine resources of the region. However, like most marine ecosystems, they are highly vulnerable to decline due to pollution originating outside the immediate area and transported into the region by land drainage and coastal currents.

Maintaining the ecological integrity of these coastal areas is dependent on a number of factors. Among the most important is the preservation of the freshwater flow into the region, both to maintain the estuarine components of the system and to protect the seagrass meadows from developing periodic hypersaline conditions during summer when evaporation rates are high. Equally important is the protection of the grassbeds from the injection of excess nutrient loads that lead to algae blooms, reduced light penetration and the resultant decline and eventual disappearance of the grasses that are the foundation of the ecosystem.

In many coastal areas, coastal groundwater discharge contributes a remarkable component of the total freshwater delivered to coastal ecosystems. Studies in South Carolina (Moore, 1996) indicate that groundwater contributes just under 50% of the amount provided by area rivers. Similar work in the Apalachee Bay region is reported by Burnett and his students (Cable et al., 1996 and elsewhere in this symposium). This extensive groundwater discharge currently contributes significant amounts of fresh water into coastal ecosystems in the Apalachee Bay region, helping to maintain both estuarine conditions and healthy seagrass communities. However, it is still poorly understood and nearly unmapped.

As the Floridian aquifer develops elevated nutrient levels from human activities such as improperly treated sewage, use of agricultural fertilizer and concentrated dairy and poultry farming, the most immediate damage is the degradation of the globally unique and beautiful spring ecosystems themselves. Such elevated nutrient loads have been reported in recent years from many of the freshwater springs in the aquifer. Staff from the Suwannee River Water Management District have found elevated nitrate levels in several major coastal springs, including Chassahowtzka, Homosassa, Weeki Wachee, and Rainbow as well as in many springs along the Suwannee River. Similar problems exist in Wakulla Springs. Some have reduced rates of flow as well (Ceryak and Rupert, 1997). Concurrent declines in water clarity, excessive levels of epiphytic algae and the explosive growth of exotic species of aquatic vegetation are now apparent in many of these springs relative to the mid 1970s when the last major survey of all the Florida springs was conducted (Rosenau et al., 1977). The major source of these elevated loads in the Suwannee River Valley appears to be agricultural development, (Ceryak, pers. comm.) while urbanization in the Tallahassee area and possibly forestry practices are candidates at Wakulla Springs.

Beyond impacts to the springs, polluted groundwater also becomes a delivery system for excessive nutrient loading into coastal waters. Eventually there is the potential for elevated nutrients in coastal ecosystems down stream, excessive plankton blooms and turbidity and the subsequent loss of those ecosystems as well. Seagrasses in particular are extremely vulnerable to such damage due to their dependence on high light levels and good water clarity. The potential vulnerability of coastal ecosystems to elevated nutrient loading in incoming freshwater is becoming apparent from studies conducted throughout the world. Coastal areas of chronic hypoxia, toxic algae blooms and resultant fish kills have been reported in increasing numbers in recent years. They are typically associated with elevated nutrient loading delivered via freshwater input. Fish kills resulting from nutrient loading and hypoxia now exceed those from any other single agent, including oil spills (Summers et al., 1997; Diaz and Rosenberg, 1995; Rosenberg and Diaz, 1993; Diaz et al., 1992).

The largest and best-studied example of this phenomenon in the Western Hemisphere occurs in coastal waters of the Gulf of Mexico west of the Mississippi River drainage. The river is currently carrying three times the levels of nitrates that it did in 1960, over 80% of which is from agricultural sources. Surface plankton blooms result and that in turn results in elevated organic levels on the sea floor as planktonic remains and fecal matter fall to the sea floor. Bacteria levels are then elevated, depleting oxygen from the bottom water. Benthic fish and invertebrates die en mass, further increasing the load of decaying organic matter. Eventually the sea floor may become coated with mats of sulfur oxidizing bacteria (Justic et al., 1996).

Blooms of toxic planktonic microalgae and resultant fish kills are also increasing concurrently with increasing nutrient loading, low oxygen and alterations in salinity regimes. In the Chesapeake Bay and in North Carolina, algae blooms have appeared in the last several years that are toxic to the point of being human health threats as well as sources of fish kills (Burkholder and Glasgow, 1997). Studies to improve methods of fertilizer application and reduce runoff are currently underway, particularly in the Mississippi River.

In addition to problems associated with eutrophication, the diversion of freshwater to human use and resultant declines in the volume of freshwater entering coastal ecosystems can also lead to environmental degradation. In particular, the reported severe declines of seagrass in Florida Bay, seaward of the Florida Everglades, are concurrent with and may be partly attributed to massive diversion of freshwater away from the coastal areas as well as altered hydroperiods due to human flood control activities (Smith and Robblee, 1994; Robblee et al., 1991). In the case of Florida Bay, other anthropogenic changes in the region, particularly development in the Keys, may also be involved as well as long term climate variables. At this time, an intensive research effort is underway to elucidate these factors (University of Miami, 1998). Research in the Waccasassa Bay area of the Florida Big Bend coast (Williams, 1997) suggests that the loss of coastal wetland forests, and particularly of coastal sabal palm, *Sabel palmetto*, is more immediately due to elevated salinity than it is to changes in levels of inundation experienced by the trees.

In short, the combination of eutrophication and/or diversion of freshwater, together with climatic variability typically leads to massive ecological damage and loss of the marine ecosystems whose freshwater supply is affected. In addition, because of the diffuse and unmapped pattern of coastal groundwater seepage, it is impossible at this time to model or predict exact impacts to the marine ecosystems of the Big Bend resulting from major diversions of groundwater resources of the Woodville Karst Plain from their current status to human use. However, based on experience in Florida Bay, Chesapeake Bay, North Carolina, the Mississippi coast, and many other coastal locations all over the world, such impacts may be expected to be substantial and devastating to the marine life of the Florida Big Bend and Apalachee Bay.

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