A REVIEW OF CURRENT SALT MARSH MANAGEMENT ISSUES IN FLORIDA

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ABSTRACT. For the past decade, salt marsh management in Florida has been a central issue in attempts to reconcile mosquito control and natural resource interests. Progress has been made in trying to maintain effective mosquito control while protecting and enhancing salt marsh resources primarily due to: 1) efforts by the Florida Coordinating Council on Mosquito Control and its Subcommittee on Managed Marshes, which are committees comprised of agencies responsible for wetlands resources, those mandated to provide mosquito control, and research institutions; and 2) funding of research to investigate ecosystem effects of marsh management techniques. Research and management experience have demonstrated that Rotational Impoundment Management (RIM) and rotary ditching can provide ecologically sound source reduction benefits. Salt marsh ownership, management of state lands and mariculture remain controversial salt marsh management issues.

INTRODUCTION

Since the late 1970s, when there was considerable controversy among mosquito control and natural resource agencies about how to manage Florida's salt marshes, much progress has been made in maintaining effective mosquito control while protecting and enhancing salt marsh resources. This progress was primarily due to 2 factors: 1) cooperation among agencies responsible for wetlands resources and those mandated to provide mosquito control, and 2) funding of research to investigate the effects of different management techniques on a wide variety of marsh-estuary system components. By reviewing Florida's salt marsh management history, the past decade's scientific and political climate, and identifying unresolved issues, this paper familiarizes managers elsewhere with Florida's system for resolving salt marsh issues, thus providing them possible solutions to their problems.

SALT MARSH MANAGEMENT IN FLORIDA

Historical source reduction techniques: Mosquito control agencies were first created in the 1920s in east-central Florida to control the salt-marsh mosquitoes *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Walker). Over the past 60 years, several source reduction techniques such as ditching, diking and dewatering, marsh filling and impounding have been used in Florida's salt marshes. Each has mosquito control and environmental benefits and liabilities.

As early as the 1920s, ditching as a mosquito control dewatering technique was common. However, these projects called for evenly-spaced ditches regardless of marsh topography or mosquito producing locations. Silting frequently closed the ditches along the estuary edge, thus hindering their effectiveness. However, even when properly maintained, mosquito-producing sites located between ditches remained a problem. Pumping water out of mosquito-producing diked marshes was briefly attempted. It was not effective because it was impossible to dewater the area before mosquitoes emerged.

Obviously, marsh filling eliminated the mosquito problem by turning wetlands to uplands, but it was slow and costly. The environmental problems associated with dredge and fill projects included loss of wetland habitat and increased estuarine turbidity.

Impounding began in the mid-1950s. Impoundments were created by constructing earthen dikes around known mosquito-producing high marsh to control water levels. Flooding impoundments during the summer eliminates oviposition sites for salt-marsh mosquitoes that lay their eggs on soil, but will not oviposit upon standing water (Clements and Rogers 1964). Over 16,000 ha of salt marshes and mangrove swamps were impounded along the east-central Florida coast, making this the most widely used source reduction technique in the state.

Environmental aspects of impounding: Research and management experience has shown that impounding can have both negative as well as positive effects on natural resources. Impoundment dikes prohibit marsh access to aquatic organisms that must use the high marsh during a portion of their life cycle. These include several commercially and recreationally important fish species such as snook (*Centropomus undecimalis* (Bloch)), mullet (*Mugil* spp.), ladyfish (*Elops saurus* Linn.) and tarpon (*Megalops atlanticus* Valenciennes) (Harrington and Harrington 1982, Gilmore et al. 1982). Excessive or prolonged flooding of impoundments can stress or kill existing high marsh vegetation and significantly alter plant distribution and species composition. Vegetational shifts from the historically common herbaceous halophytes to

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barren flats or red mangrove (*Rhizophora mangle* Linn.) monocultures are of special concern. Prolonged flooding can also result in low dissolved oxygen concentrations and elevated hydrogen sulfide levels. These have been shown to have negative impacts upon the marsh aquatic communities (Fleming and Alexander 1961, Nickerson and Thibodeau 1985).

Impounding, however, is highly effective in controlling salt-marsh mosquitoes and can virtually eliminate the need for chemical control in impounded marshes (Carlson and O'Bryan 1988). Additionally, resident fish in impoundments can be more abundant than in native marshes (Schooley 1980[3]). They in turn can provide an abundant food source for wading birds and other predators. Also, marsh utilization by waterfowl and wading birds is often enhanced by impounding (Provost 1959, Trost 1964[4]).

PROGRESS IN SALT MARSH MANAGEMENT

Salt marsh research: In the early 1980s, two funding sources for salt marsh impoundment research emerged. They were the Florida Department of Environmental Regulation's Office of Coastal Management (Coastal Zone Management Program), (FDER/CZM), and the Florida Department of Health and Rehabilitative Services (FDHRS)—Office of Entomology Services. Research sponsored by these agencies investigated the effects of water management regimes on fish and macrocrustacean population dynamics, vegetation dynamics, above ground primary production, surface and pore water chemistry, soil chemistry and composition, zooplankton and mosquito production. Results from this research have provided valuable scientific data on which to base management decisions and stimulate innovations. Today, mosquito control agencies manage thousands of acres of salt marsh for multiple resource benefits.

Interagency cooperation: Also of great importance in improving salt marsh management was increased interaction and cooperation among regulatory agencies, mosquito control agencies and researchers. This was fostered by the creation of 2 committees, the Florida Coordinating Council on Mosquito Control (FCCMC) and its Subcommittee on Managed Marshes (SOMM).

The FCCMC was created in the Florida Statutes' mosquito control legislation (Chapter 388.46) in 1986. The FCCMC's role is to: foster efficient use of resources by minimizing duplication of effort, advise and assist arthropod control agencies in implementing best management practices, capitalize on outside research funding sources, establish research priorities regarding the environmental effects of arthropod control practices, and enhance interagency communication. This Council also serves as a mediator should disputes arise over the control of mosquitoes and other biting arthropods on publicly owned lands. Membership in the Council includes representatives from agencies concerned with mosquito control, natural resource protection, research and development, and private property owners (Table 1).

The SOMM, formed in 1983 under the auspices of the Governor's Office, was originally named the Technical Subcommittee on Mosquito Impoundments. The Technical Subcommittee's role was to improve interagency coordination on the complex and controversial issue of impoundment management. In 1986, with the legislative establishment of FCCMC, the Technical Subcommittee was renamed SOMM and became the FCCMC's first subcommittee (Carlson 1987). The legislatively defined role of SOMM is to provide technical review and guidance on salt marsh management plans.

The SOMM consists of representatives from various federal, state and local agencies and institutions (Table 1) (Carlson and Carroll 1985). It serves as an information source for salt marsh management. This role was highlighted in October 1988, when as part of a Coastal Zone Management Program grant, SOMM sponsored a "Workshop on Salt Marsh Management and Research." An abstract collection from this meeting has been published as Bulletin No. 1 (1989) of the Florida Anti-Mosquito Association.

The management plan process: In the mid-1980s, SOMM developed guidelines for impoundment and ditching management plans (Subcommittee on Managed Marshes 1989a,[5] 1989b[6]). These guidelines are used by mosquito

[3] Schooley, J. K. 1980. The structure and function of warm temperate estuarine fish communities. Ph.D. dissertation, University of Florida.

[4] Trost, C. H. 1964. Study of wildlife usage of salt marsh on the east coast of Florida before and after impoundment for mosquito and sandfly control. Florida State Board of Health, Entomological Research Center final report to U.S. Dept. of Interior, Fish and Wildlife Service. 180 pp.

[5] Subcommittee on Managed Marshes. 1989a. Information for permit applicants entering the impoundment management plan submittal process. Report to the Florida Coordinating Council on Mosquito Control. 13 pp.

[6] Subcommittee on Managed Marshes. 1989b. Guidelines for salt marsh ditching management plan evaluation. Report to the Florida Coordinating Council on Mosquito Control. 9 pp.

Table 1. Membership of the Florida Coordinating Council on Mosquito Control (FCCMC) and Subcommittee on Managed Marshes (SOMM).

Organization	FCCMC	SOMM
Agencies responsible for wetland resources		
Florida Dept. of Natural Resources	X	X
Florida Dept. of Environmental Regulation	X	X
Florida Game and Freshwater Fish Commission	X	X
Environmental Protection Agency	X	X
U.S. Fish and Wildlife Service	X	X
National Marine Fisheries Service		X
Research institutions		
Florida Medical Entomology Laboratory	X	X
Harbor Branch Oceanographic Institution, Inc.		X
U.S. Dept. of Agriculture	X	
Agencies responsible for mosquito control		
Florida Dept. of Health and Rehabilitative Services—Entomology Services	X	X
Local mosquito control agencies	X	X
Other		
Officer of the Governor	X	
Florida Dept. of Agriculture and Consumer Services	X	
Environmental groups (Florida Audubon Society, Florida Defenders of the Environment)	X	
Property owners	X	

control agencies and private firms when developing marsh management plans. They were revised and updated in 1989 to reflect research and management experience gained over the previous 5 years. They stress that management plans should be based on site-specific data and should emphasize mosquito control and natural resource enhancement and protection. Plans must demonstrate the potential for producing the desired environmental goals and must include sufficient monitoring to document the plan's success. The following are considered important management objectives: 1) effective mosquito control minimizing the use of insecticides, 2) optimal interchange of nutrients and organisms between the marsh and lagoon, 3) effective water circulation within the marsh, 4) water level controls that will enhance desirable marsh vegetation, and 5) protection or enhancement of water quality both within and outside the marsh.

These guidelines provide the framework for techniques currently used in Florida: 1) Rotational Impoundment Management (RIM), 2) rotary ditching in impounded marshes connected to the estuary by breaches or culverts, or 3) rotary ditching in unimpounded marshes, some of which follow Open Marsh Water Management (OMWM) guidelines as developed in New Jersey (Bruder 1980) and Delaware (Meredith et al. 1985).

CURRENT SALT MARSH MANAGEMENT TECHNIQUES

Rotational impoundment management (RIM): Rotational impoundment management entails installing culverts with flapgated risers through impoundment dikes to seasonally reconnect the impounded marsh and estuary. Culverts are closed in late spring and the marsh is flooded by pumping during the mosquito producing summer months. Risers are set at the minimum height necessary for mosquito control. This allows excess water generally from rain or upland runoff to spill over the risers into the estuary, thereby protecting vegetation from overflooding damage. In the early fall, culverts are opened enabling the annual fall high tides to enter the marsh. Culverts remain open through the spring, allowing flow between the marsh and estuary. Thus, RIM allows exchange of nutrients and organisms between the marsh and lagoon during the fall, winter and early spring; salt-marsh mosquito control during the late spring and summer (Carlson and O'Bryan 1988); and year-round maintenance of most marsh vegetation (O'Bryan et al. 1990).

Rotary ditching: In impounded or unimpounded marshes, shallow ditches can be used to connect known mosquito breeding sites with more permanent water (ponds or deep ditches) to facilitate drainage thus interrupting mosquito

oviposition or to allow larvivorous fish access to mosquito larvae. Rotary ditching was used initially in Florida to reintegrate impoundments to estuaries, either eliminating the need for summer flooding or allowing the impoundment to remain open to the estuary longer in the spring. It is being used by mosquito control agencies in Brevard (Rey et al. 1989) and Volusia counties (Duhring 1989) to reintegrate impoundments to the estuary.

In other states, rotary ditching in OMWM systems has proven a successful source reduction technique both for mosquito control and improving natural resources (Resh and Balling 1983, Lesser and Shisler 1979, Meredith et al. 1983). Now in Florida, OMWM systems are also in use. An OMWM system completed in Hillsborough County included the creation of a permanent water minnow reservoir with associated rotary ditches (Murdoch 1989). Currently an in-depth study on the effects of rotary ditching in Charlotte Harbor is underway (Environmental Quality Laboratory 1989).

CURRENT AND FUTURE ISSUES

Salt marsh ownership: Despite the volumes of scientific data accumulated over the last decade, and the great strides made in interagency cooperation, implementation of better marsh management practices at many of Florida's impoundments has not occurred, largely due to their private ownership status. For instance, excluding the Merritt Island National Wildlife Refuge, 70% of the impoundments along the Indian River lagoon are privately owned. Most property owners are unwilling to allow physical management improvements to their property without some type of guaranteed benefit or financial return.

Not until a developer or governmental agency wants to alter or fill salt marsh wetlands can permitting agencies require long-term management improvements as partial mitigation for the resulting loss of marsh habitat. Over the past several years, mitigation has generally been in the form of improving marsh management through RIM. Increased public ownership of salt marshes could hasten implementation of beneficial management techniques. Public agencies are seriously considering increased purchases of Florida salt marshes.

Importance of retaining source reduction capabilities: Both regulatory and mosquito control agencies are interested in limiting the use of pesticides. Regulatory as well as mosquito control agencies are concerned about the potential impact of the chemicals on nontarget organisms. Mosquito control agencies also have concern about development of mosquito resistance to pesticides, about future application restrictions due to endangered species considerations, and about the shrinking arsenal of registered mosquitocides because of rising economic liabilities associated with pesticide reregistration. Experience shows that proper source reduction can significantly reduce pesticide use without compromising control.

Management of state lands: One of the most controversial salt marsh management topics in Florida has been mosquito control on state owned lands. Here too, interagency cooperation has produced acceptable compromises. In only 3 instances has the FCCMC been called on to mediate between a local mosquito control agency and the Department of Natural Resources (DNR), which has jurisdiction over state lands. Two of these disputes were over aerial adulticiding within state parks. The third dealt with implementation of RIM in a breached impoundment.

Guidelines and positions of DNR on mosquito control include: 1) aerial adulticiding is not supported, except as a last resort or in the event of a medical emergency, 2) existing impoundments should be managed to minimize environmental degradation and benefit marine resources, 3) rotary ditching is supported as part of a well designed OMWM system in impacted marshes; it is not supported in pristine marshes, and 4) only the use of species specific larvicides (*B.t.i.*) is supported; the use of methoprene is condoned (Irby 1989).

Management for endangered species: A RIM plan can be modified to manage for a selected group of species (e.g., waterfowl) or an individual species (e.g., wood storks, *Mycteria americana* Linn.). Several impoundment management plans of this type are in various stages of review and implementation. The most significant in terms of acreage is the RIM plan for the Sykes Creek area in Brevard County, FL. This is a cooperative project between the Brevard Mosquito Control District, the Canaveral Port Authority, the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service. It is by far the largest plan to come under SOMM review and thus has the greatest potential for large scale habitat improvement. The plan will improve management of approximately 800 ha of isolated wetlands and includes management variations to try and enhance habitat for the endangered wood stork (Banner 1989, Taylor 1989).

Mariculture: A new item of interest in impoundments is the possibility of their commercial use for mariculture. Currently one company is seeking approval to implement a pilot project for rearing clams. Should a site be secured and the necessary permits obtained, this project will

examine the biological impact and economic feasibility of such a venture. This type of pilot project is necessary because agencies such as the U.S. Fish and Wildlife Service are advocating a "go slow" policy for mariculture in impoundments by allowing only experiments and demonstration projects (Carroll 1989).

Created marsh: In a few instances in Florida, developers are proposing to "create" high marsh as mitigation for development, employing OMWM principles to eliminate mosquito-producing sites created by the project. When marsh creation is proposed, SOMM stresses that the project design should include provisions for dealing with mosquito problems in an ecologically sound manner.

In Indian River County, Grand Harbor, a project incorporating created and rehabilitated marsh having OMWM components is nearly complete. Grand Harbor created 18 ha of high marsh from upland citrus groves and is improving 28 ha of remnant impoundments at a cost of approximately $2.5 million. Grand Harbor exercised meticulous care in creating marshes properly sloped to diminish puddling, thereby minimizing mosquito production. The project design calls for careful filling of any mosquito-producing depressions that remain or connecting them to estuarine channels with small ditches (D. Carlson et al. 1989). This project is a good example of a developer and mosquito control working closely with permitting agencies to address mosquito control concerns, which if not confronted could diminish the value of the development.

Surface Water Improvement and Management Act (SWIM): In 1987, the Florida legislature passed the SWIM act. This act acknowledged that the water quality of many of Florida's water bodies has degraded, and instructed water management districts to design and implement plans and programs for the improvement and management of surface waters. The 2 SWIM issues most pertinent to salt marsh habitats are: 1) loss of emergent wetlands and their isolation from the lagoon, and 2) restoration of the natural functions of impounded marshes. Consequently, providing and improving habitat for native plants, fish and wildlife has high priority in the SWIM plans.

As a first step, the St. Johns River Water Management District (SJRWMD), which administers part of the SWIM funds for Florida, funded an impoundment inventory update (Rey and Kain 1989). This inventory is a valuable reference for marsh managers developing individual impoundment management plans, and will serve as a reference for developing long-range regional planning goals.

Additionally, SJRWMD has chosen FDHRS—Office of Entomology Services to coordinate future portions of the SWIM impoundment management program. Initially this coordination will proceed on 3 fronts by providing funds to: 1) keep the impoundment inventory current, 2) develop management plans for several impoundments, and 3) purchase and install water control structures for projects where permits are in-hand. Future phases of this contract will attempt to restore and properly manage the remaining closed impoundments.

Remaining research priorities: Despite its many advantages, source reduction, in particular RIM-managed impoundments, is not without some problems. Fish kills have been associated with poor impoundment water quality during the summer. Some kills have also occurred at the time of fall culvert openings if impoundment water levels greatly exceed estuarine levels, resulting in a sudden rush of poor quality water from the impoundment to the estuarine lagoon. Research and experience is providing information about how to modify this technique to minimize these negative effects. One technique, initially developed by Jack Salmela (Brevard Mosquito Control District), uses subcells to remove transient fish trapped within the impoundment during the initial pump-up in the spring (Scheidt 1989). A second technique, "bottom water release," is used by St. Lucie County to improve impounded water quality (P. Carlson et al. 1989). More research and management experience is necessary to perfect these modifications.

Additionally, other salt marsh management questions still remain. In the fall of 1989, SOMM assigned high priority to the following items: 1) the effects of summer impoundment flooding on upper marsh flat flora and fauna, 2) a study of techniques to reclaim high salt marsh from red mangrove monocultures created by some impoundments, and 3) the effects of rotary ditching within impoundments to increase the time that impoundments can be left open to the estuary.

SUMMARY AND CONCLUSIONS

Research and management experience over the past decade demonstrated that improved marsh management techniques such as RIM and rotary ditching can provide source reduction for mosquitoes while improving fish and wildlife habitat. These objectives are consistent with Florida's goal of conserving and enhancing its dwindling high marsh habitat. Meeting all of these objectives is increasingly difficult given the intense development, environmental and mosquito control pressures present in the state.

The Florida Coordinating Council on Mosquito Control and the Subcommittee on Man-

aged Marshes are excellent interagency forums to make certain all interests are adequately considered when reviewing salt marsh management plans. Continued interagency cooperation and salt marsh research are essential in ensuring that Florida will continue to make progress in wisely managing our salt marsh habitats.

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