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FLORIDA'S SALT-MARSH MANAGEMENT ISSUES: 1991–98[1]

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ABSTRACT. During the 1990s, Florida has continued to make important strides in managing salt marshes for both mosquito control and natural resource enhancement. The political mechanism for this progress continues to be interagency cooperation through the Florida Coordinating Council on Mosquito Control and its Subcommittee on Managed Marshes (SOMM). Continuing management experience and research has helped refine the most environmentally acceptable source reduction methods, which typically are Rotational Impoundment Management or Open Marsh Water Management. The development of regional marsh management plans for salt marshes within the Indian River Lagoon by the SOMM has helped direct the implementation of the best management practices for these marshes. Controversy occasionally occurs concerning what management technique is most appropriate for individual marshes. The most common disagreement is over the benefits of maintaining an impoundment in an "open" vs. "closed" condition, with the "closed" condition, allowing for summer mosquito control flooding or winter waterfowl management. New federal initiatives influencing salt-marsh management have included the Indian River Lagoon–National Estuary Program and the Pesticide Environmental Stewardship Program. A new Florida initiative is the Florida Department of Environmental Protection's Ecosystem Management Program with continuing involvement by the Surface Water Improvement and Management program. A developing mitigation banking program has the potential to benefit marsh management but mosquito control interests may suffer if not handled properly. Larvicides remain as an important salt-marsh integrated pest management tool with the greatest acreage being treated with temephos, followed by *Bacillus thuringiensis israelensis* and methoprene. However, over the past 14 years, use of biorational larvicides has increased greatly.

KEY WORDS Wetlands, estuary, source reduction, salt-marsh management, mitigation banking

INTRODUCTION

Many in the mosquito control community typically consider salt-marsh management to be the implementation of mosquito control source reduction techniques in these environmentally sensitive habitats. However, we believe that the definition is considerably more broad, and can include the use of larvicides to control salt-marsh mosquito populations, the management of salt-marsh habitats for wildlife utilization, and even the use of salt marshes for storm water retention before upland runoff enters the adjacent estuary. Carlson et al. (1991) described how the scientific and political considerations of salt-marsh management issues had been addressed in Florida from the late 1970s to the early 1990s. This included the mid-1980s legislative creation of the Florida Coordinating Council on Mosquito Control (FCCMC) and its Subcommittee on Managed Marshes (SOMM), (see Table 1 for acronyms). Also during that decade, considerable research documented the impacts and benefits on the ecosystem of different source reduction techniques. This research led to the widespread implementation of Rotational Impoundment Management (RIM) in salt-marsh impoundments along the Indian River Lagoon (IRL) and Open Marsh Water Management (OMWM) utilizing rotary ditching in disturbed estuarine habitats. Since then, additional progress has been made in managing Florida's salt marshes. During the process, full recognition has been afforded to the need to control the salt-marsh mosquitoes *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Walker), while at the same time maintaining the ecological integrity of these biologically productive habitats and minimizing the impacts to nontarget organisms. This paper reviews Florida's continuing efforts over the past 8 years to address these sometimes conflicting goals.

THE SUBCOMMITTEE ON MANAGED MARSHES

The SOMM continues to play a central advisory role in assuring that salt-marsh source reduction projects, whether being implemented by private or government entities, take into account both mosquito control and natural resource interests. The SOMM meets quarterly at different locations around Florida, with the meetings typically including a field trip to relevant sites, followed by a business meeting. Most of the salt-marsh projects reviewed by the SOMM during the 1990s have been ones where either RIM or OMWM have been proposed for implementation.

Rotational Impoundment Management

Rotational Impoundment Management is the most commonly employed management technique in impoundments and involves the installation of culverts with flapgated risers through impoundment dikes to seasonally reconnect the impounded marsh

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Table 1. Acronyms used in manuscript.

Acronym	Definition
AMCA	American Mosquito Control Association
BMP	Best Management Practices
CCMP	Comprehensive Conservation and Management Plan
EPA	U.S. Environmental Protection Agency
E-WRAP	Estuarine Wetland Rapid Assessment Procedure
FCCMC	Florida Coordinating Council on Mosquito Control
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FMCA	Florida Mosquito Control Association
IPM	Integrated Pest Management
IRL	Indian River Lagoon
MINWR	Merritt Island National Wildlife Refuge
NEP	National Estuary Program
OMWM	Open Marsh Water Management
PESP	Pesticide Environmental Stewardship Program
PINWR	Pelican Island National Wildlife Refuge
RIM	Rotational Impoundment Management
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SOMM	Subcommittee on Managed Marshes
SWIM	Surface Water Improvement and Management
USFWS	U.S. Fish and Wildlife Service

and estuary. Culverts are closed in the late spring and the marsh is minimally flooded by pumping during the summer months to prevent oviposition by salt-marsh mosquitoes. In the early fall, culverts are opened to the estuary enabling the annual fall high tides to enter the marsh. Rotational impoundment management is generally agreed to be the best compromise to allow the marsh to function in the most natural way while still allowing source reduction mosquito control with a minimum of pesticide use (Carlson et. al. 1991). Recent work by Taylor et. al. (1998) has demonstrated a quick response by transient fish in using culverts to enter and exit a previously isolated impoundment after it was reconnected to the estuary through culverts.

Open Marsh Water Management

During the 1990s, OMWM has been increasingly implemented in Florida, especially along the northern IRL in Volusia and Brevard counties (Fig. 1). Open marsh water management connects mosquito-producing areas on the marsh to deeper water habitats, thus facilitating circulation, interrupting mosquito oviposition and/or allowing larvivorous fish access to mosquito larvae (Carlson et al. 1991). Northern IRL OMWM projects have been implemented in breached impoundments, on high marsh islands, and on spoil islands, largely where old ditches were no longer functional (Stewart 1997).

Regional marsh management plans

By the late 1980s it became apparent to some that we risked managing virtually all marshes along the IRL in the same way. Given the fact that most marshes have been impacted in one fashion or another, and that reverting to pristine conditions is often not possible, identical management of all marshes may not be best; within given geographic areas, some variety was deemed most appropriate. Beginning in the early 1990s, the SOMM began considering the move toward block management. This involves the grouping of impoundments and marshes into geographically and ecologically meaningful management areas and applying different management techniques to various marshes of each group.

The members of the SOMM believed that without a comprehensive, lagoonwide management strategy, block management would not be widely applied because impoundment management continued to take place largely on an impoundment by impoundment basis. As a result, opportunities for improving environmental conditions in the lagoon are potentially being squandered. Areas are often not managed in the best possible way, and many adjoining areas are managed identically when there may be a legitimate need for alternative management there.

The first attempt to develop a block management approach was for the Sebastian Inlet Management Area in northern Indian River and southern Brevard counties on Florida's central east coast (Fig. 1). The management plan developed for this area encompasses 15 impoundments and advocates a variety of management strategies for different impoundments in the area. Proposed strategies include the use of RIM in some impoundments, management for wading bird habitat enhancement in others, and leaving some intertidal all year with the use of ecologically sound larvicides for mosquito control when needed. The St. Johns River Water Management District (SJRWMD), through the Surface Water Improvement and Management (SWIM) program funded the implementation of much of this management plan with the cooperation of the Indian River and Brevard County Mosquito Control Districts.

Given the success of implementing this Sebastian Inlet plan, in early 1993 the federally funded (National Oceanographic and Atmospheric Administration) Coastal Management Program (administered in Florida by the Deptartment of Community Affairs) provided funds to continue developing regional marsh management plans for the remainder of the IRL. The Indian River Lagoon–National Estuary Program (IRL-NEP) and the SJRWMD's SWIM program later funded completion of this project. The ensuing document, entitled *Regional*

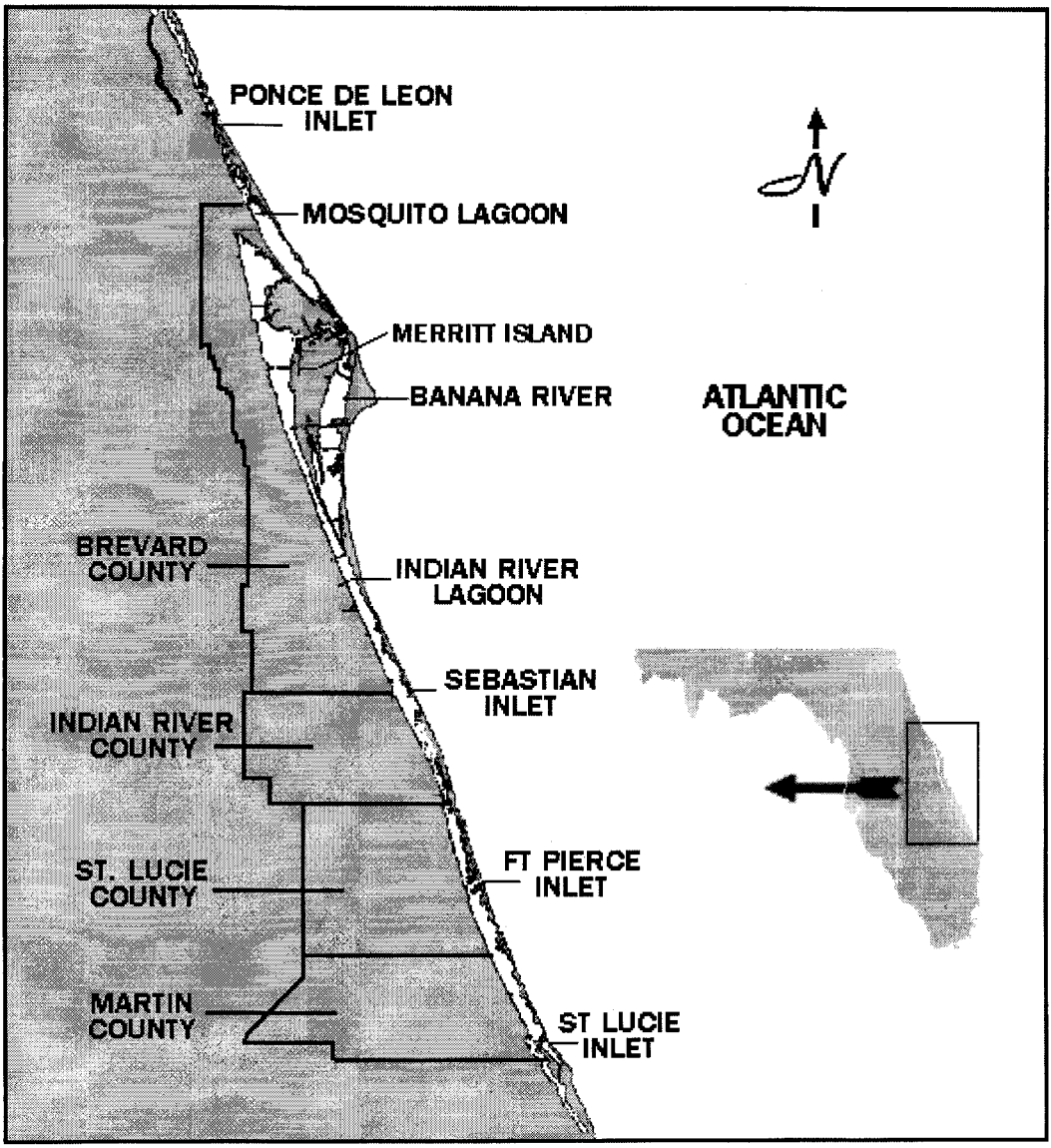

Fig. 1. East-central Florida's Indian River Lagoon

Marsh Management Strategies for the Indian River Lagoon (Rey et al., in press), is intended to provide guidance for natural resource managers seeking to implement best management practices (BMPs) in the lagoon's marshes. This document also became an integral part of the IRL-NEP's Comprehensive Conservation and Management Plan (CCMP). The SOMM meetings provided the forum for discussing, fine-tuning, reviewing, and ultimately adopting the resulting plan. In addition to receiving input for this document at 5 SOMM meetings over a 2-year period, presentations to numerous special interest groups (e.g., Audubon Society, Friends of the Sebastian River, Native Plant Society, Sierra Club), totaling several hundred individuals, were made to solicit their input. The document identifies the numerous management options available and discusses the benefits and liabilities of each. The document also defines and describes 10 management areas along the lagoon based upon shared geographical and ecological characteristics. This includes a discussion of the important attributes within each area (e.g., rookeries, inlets, large seagrass beds). And finally, the document develops specific management strategies in the 10 management areas. This document is serving as a planning tool for those involved in management of the IRL's marshes. This document is intended to be updated as scientific knowledge, marsh ownership, and conditions change. However, a document such as this is never

without some controversy. Even though it was unanimously adopted by the SOMM, concerns were later raised that in some areas, the plans did not adequately stress opening of impoundments, and placed too much emphasis on specific concerns such as water quality, mosquito control, waterfowl, endangered species, and storm-water management. However, it is important to point out that an ambitious multidisciplinary effort such as this can not be carried out in a vacuum, thus geographical and political considerations, as well as existing and projected anthropogenic impacts, must be taken into account in order to maintain momentum in establishment of lasting BMPs for the entire ecosytem.

Disagreements over marsh management goals

Since the late 1970s, when mosquito control and environmental resource agencies were in serious disagreement over how to manage salt-marsh impoundments, SOMM meetings have served as an avenue where these disagreements have been discussed and in many cases, compromises reached. This controversy first manifested itself with mosquito control's need to close and flood impoundments during the summer months. As mentioned above, RIM and OMWM evolved as the 2 compromise techniques that most marsh managers could agree upon as viable methods that allowed for many management interests to co-exist. However, as management possibilities have increased, new areas of controversy have occurred, particularly in regard to the management of coastal wetlands for avian habitat enhancement.

Waterfowl management: Some controversy has continued concerning managing large impoundment acreages for waterfowl at the expense of fisheries, or other management goals that presumably require the maximum interconnectedness of the marsh and estuary. Currently, the most prevalent controversy is the desirability of closing and flooding some impoundments during winter to benefit migratory waterfowl. This winter closure diminishes the period that the marsh can be connected to the estuary. The vast majority of marsh acreage managed for waterfowl in Florida exists on federal wildlife refuges, in particular the Merritt Island National Wildlife Refuge (MINWR) in Titusville (Fig. 1), managed by the U.S. Fish and Wildlife Service (USFWS). One of the mandates of the MINWR is waterfowl management and the USFWS is not likely to abandon this mission, particularly in view of the importance of this area to the migratory patterns of many waterfowl species. Compromise efforts are now being focused on temporal and spatial alternation of management in different impoundments so that in each area of the refuge some connection to the IRL is always maintained.

Wading bird management: Over the past decade, increased interest in managing some impounded wetlands to enhance habitat quality and feeding opportunities for wading birds has persisted along east-central Florida. In Indian River County (Fig. 1), impoundment management for wading birds has been accomplished through a cooperative venture with the USFWS employing a winter flooding–spring drawdown strategy that alternates annually between 2 impoundments within the Pelican Island National Wildlife Refuge (O'Bryan and Carlson 1995). This winter flooding does decrease the period of the year in which an impoundment is connected to the lagoon. However, given the proximity of the Pelican Island rookery to these impoundments and the importance of enhancing avian feeding opportunities in the refuge, wading bird management with the associated winter closure has been deemed appropriate at these impoundments.

An interesting complication of this management practice has been the fact that elevated fecal coliform levels have occurred in waters adjacent to one of these impoundments, at the location of a clam aquaculture venture. The contention by the Florida Department of Environmental Protection (FDEP) has been that fecal coliform bacteria generated by the birds utilizing this impoundment exit the impoundment through nearby culverts and contaminate the clam beds. Although one study did not substantiate this claim (O'Bryan and Carlson 1997), 2 culverts connecting the impoundment and estuary near the clam beds have been closed because of continuing public health concerns. However, to date, the source of the coliform contamination has not been determined.

In St. Lucie County (Fig. 1), wading bird management has been successfully pursued through summer drawdowns of numerous RIM-managed impoundments on a rotating basis (Swain and Rosier 1992, Sewell et al. 1997). The management goal of providing maximum connection between the impoundment and estuary is considered very consistent with this summer drawdown approach and at the same time enhances wading bird feeding opportunities. With this management technique, no controversy has occurred between those interested in maximizing the marsh–estuary connection and those interested in improving wading bird habitat.

The 2nd and 3rd Workshops on Salt Marsh Management and Research

During the 1990s, SOMM sponsored 2 workshops, the 2nd and 3rd Workshops on Salt Marsh Management and Research, designed to bring interested individuals up-to-date on salt-marsh management activities and salt-marsh–related research in the state. Abstracts of presentations for the 2nd Workshop (held in 1992) were published as Bulletin 2 of the Florida Mosquito Control Association (FMCA) (Carlson et al. 1992). Presentation abstracts from the 3rd Workshop (held in 1996) were published as FMCA Bulletin 3 (Carlson et al. 1997). Both publications provide valuable summa-

ries of topics as diverse as the early history of mangrove swamps and salt-marsh management in Florida (Beidler 1992, Harden 1997), regulatory agency perspectives on salt-marsh management (Julianna 1992, Tilton 1992), the potential of impoundment management for wading bird enhancement (O'Bryan and Carlson 1992, Swain and Rosier 1992), and the effects of predicted sea-level rise on salt-marsh management (Parkinson et al. 1997).

International personnel exchange program

To promote an objective of sharing salt-marsh management and research information, the FMCA has embarked on an International Personnel Exchange Program. Since 1994, several Florida mosquito control offices have participated in a personnel exchange program with Australia. To date, 5 Australians and 2 Floridians have made the trans-Pacific trip. Arriving in the host country, selected participants spend 2–3 months in a hands-on program, learning mosquito control techniques used in the country by actual participation. Also, by staying with host families, participants learn the cultural activities of the state and forge long-lasting friendships.

Some of the areas in which participants have learned new ideas and techniques and, in many cases have implemented them in their home country, have dealt with the following issues: larvicide application and calibration techniques, source reduction methods, political and environmental concerns, identifying and monitoring disease-bearing arthropods, and the increasingly difficult task of providing mosquito control to a public that continues to build closer and closer to mosquito-producing yet environmentally sensitive marshes. The programs of the 2 countries are dissimilar enough to allow learning of new ideas and techniques, yet the mosquito-producing habitats are similar enough to make those ideas applicable.

FLORIDA WHITE PAPER ON MOSQUITO CONTROL

At a meeting of the FCCMC during early 1994, a representative of the U.S. Environmental Protection Agency (EPA) made a request that the Florida mosquito control community develop a white paper to explain its practices. Early discussions stated that a goal of this project should be to identify ways in which pesticide use and risk can be reduced in the future. This goal of reduced pesticide use and risk is an objective of the EPA's Pesticide Environmental Stewardship Program (PESP) (discussed below), of which the American Mosquito Control Association (AMCA) is a partner and the FMCA is a participant. Each chapter of the Florida White Paper was individually approved by the FCCMC. The Florida White Paper includes several chapters dealing with salt-marsh management issues, stressing the importance of an integrated pest management (IPM) approach to properly accomplish the salt-marsh management goals of effective, economical, and environmentally compatible mosquito control with a minimum of pesticide use (Florida Coordinating Council on Mosquito Control 1998a). To bring the development of the White Paper to a conclusion, a conference entitled *Urban Growth and its Impact on Future Mosquito Control Problems and Opportunities* was held in May 1998. This meeting provided a forum where discussions occurred on many issues, including current issues facing Florida mosquito control, potential future problems and opportunities, and recommendations on how to solve those issues in the upcoming years. The recommendations, which include salt-marsh management issues, were reviewed and adopted by the FCCMC in August 1998 and have been published, along with abstracts of the speakers presentations, as an addendum to the White Paper (Florida Coordinating Council on Mosquito Control 1998b).

FEDERAL INITIATIVES INFLUENCING SALT-MARSH MANAGEMENT

Indian River Lagoon–National Estuary Program (IRL-NEP)

The National Estuary Program (NEP) was initiated by the Water Quality Act of 1987. The NEP identifies nationally significant estuaries that are threatened by pollution, development, or overuse, and promotes the preparation of comprehensive management plans to ensure their ecological integrity. The NEP's goals are to protect and improve water quality and enhance living resources. In 1991, the IRL, a 156-mi.-long lagoonal estuary along Florida's central-east coast, was designated an "estuary of national significance" by the EPA and the IRL-NEP was established. Over the 5-year life of this federally funded program, a CCMP (Indian River Lagoon National Estuary Program, 1996) was developed to help achieve NEP goals along the IRL. Concerning salt-marsh management, the CCMP identified the goal of restoring impounded marsh functions through implementing RIM or OMWM in isolated marshes. Also identified in the CCMP was the need to continue the public acquisition of salt marshes to help assure that optimal management techniques can be employed in wetlands that currently are privately owned. Other NEP programs in Florida during the 1990s included the Tampa Bay and Sarasota Bay NEPs. Although neither of the CCMPs developed from these initiatives specifically addressed salt-marsh management issues relating to mosquito control, the Tampa Bay plan does have salt-marsh management implications by inclusion of the development of a watershed strategy for coastal habitat restoration and protection that will attempt to restore the historic

balance of key emergent wetland plant communities (Greening and Lewis 1997).

Pesticide Environmental Stewardship Program (PESP)

In 1994, the EPA, in association with the U.S. Department of Agriculture and the U.S. Food and Drug Administration, initiated a program entitled PESP. The PESP was created because of the nationwide need for an approach to pesticide application that strives to reduce pesticide use and risk while considering environmental stewardship. Consequently, environmentally sensitive salt-marsh management practices using an IPM approach (e.g., including source reduction and biorational larvicides) nicely fit the goals of the PESP. A key component of the PESP is the development of a public–private partnership so when an organization joins PESP, this partner (e.g., AMCA) must commit to stewardship as a key part of their pest management practices. Joining the PESP gives each participant the opportunity to demonstrate their commitment to environmental stewardship and upon joining, each is assigned a liaison who serves as that group's official EPA contact. An organization desiring to become a PESP partner must develop and implement a strategy document designed to meet PESP goals by using the safest, most effective, management practices available. The AMCA accomplished this with their *Partnership Strategy Document* where a commitment to an increased dedication to implementing source reduction techniques and the increased use of biorational larvicides were the stated salt-marsh management initiatives to meet PESP goals (Carlson 1997).

The AMCA, through its PESP Working Group, has developed a program whereby organizations under the AMCA's umbrella can apply to become a PESP partner under the AMCA's auspices. In order to achieve this designation, the applicant must strive to meet the goals and objectives of the AMCA's PESP strategy document, thus an integrated approach to mosquito management must be employed. Also, the applicant must develop its own strategy document, which must provide an overview of their current control practices and define ways in which the PESP goals of reduced pesticide use and risk will be accomplished. Along with several other state mosquito control associations, the FMCA has applied for, and been granted this status of PESP partner under the AMCA's auspices. The FMCA's strategy document has committed the FMCA to continuing to promote the implementation of environmentally acceptable salt-marsh source reduction techniques (e.g., RIM, OMWM) and the use of biorational larvicides in Florida's environmentally sensitive wetland habitats (Carlson 1998).

STATE INITIATIVES INFLUENCING SALT-MARSH MANAGEMENT

Surface Water Improvement and Management (SWIM) Act

A goal of Florida's 1987 SWIM act is to improve the management of Florida's surface waters. Now, with the termination of state funding for this program, the SWIM program is being supported and administered by regional water management districts. Along the IRL, the SJRWMD has taken an aggressive role in providing funding to purchase culverts with water control structures to allow the reconnection of impoundments to the lagoon. This is usually entered into as a partnership where the SJRWMD purchases the structures and the local mosquito control agency installs them, manages them, and maintains them. Since 1991, the SJRWMD has participated in the reconnection of 4,477 ha of impoundments. The area reconnected, or under contract for reconnection, is approximately 60% of the entire IRL impoundment area (approximately 20,000 ha; Brockmeyer et al. 1997). The South Florida Water Management District (SFWMD), which covers the southern portion of the IRL, has also provided funds for impoundment management improvements in St. Lucie and Martin counties.

Ecosystem management

Over the past several years, the FDEP has advocated an ecosystem management approach to Florida's environmentally sensitive habitats, an approach consistent with current salt-marsh management trends. The ecosystem management goals include improved stewardship of Florida's environment, the development of an environmental ethic and sustainable lifestyle among Floridians, and a sustainable, healthy environment and economy. The cornerstones of the program are place-based management (i.e., flexible management strategies, integrating management tools, creating grassroots support), cultural change (i.e., proactive responses to pollution prevention), common-sense regulation (i.e., flexible consensus-based problem solving), and improved foundations (i.e., developing a statewide resource atlas). The FDEP acknowledges that salt-marsh management is important within their ecosystem management initiative and that ecosystem benefits can be achieved by properly designed and implemented salt-marsh projects that include the input of numerous interested parties (Bess 1997).

Public acquisition of salt marshes

Almost a decade ago, Carlson et al. (1991) explained the importance of having salt marshes in public ownership in order to allow the implementation of optimal management practices and this

need remains true today. Although during the 1990s, many Florida counties, in collaboration with the state and regional water management districts, purchased numerous sizable tracts of coastal wetlands, vast areas still remain in private ownership. To correct this problem along the IRL, a proposal named the Indian River Lagoon Blueway has been submitted to the State's Conservation and Recreational Lands Program. This proposal, which includes the coordinated efforts more than 12 agencies, seeks to purchase approximately 3,300 ha of wetlands, shoreline uplands, and impounded marshes, all property deemed necessary to maintain the functional integrity of the IRL. If placed under public ownership, this land could be more appropriately managed than is now allowed by the current private owners and would significantly benefit salt-marsh management efforts along east-central Florida.

MITIGATION BANKING

One topic that has the potential to significantly impact salt-marsh management and mosquito control in Florida is mitigation banking. Mitigation banking is a concept by which a person or firm can make environmental improvements to their property now, be awarded credits for those improvements, and then use or sell those credits, either now or in the future, to anyone (e.g., developer, governmental agency) who needs to mitigate for some environmental impacts elsewhere, and for which they do not have mitigation possibilities of their own. Mitigation banking was developed because over the past 20 years or so, on-site mitigation projects have frequently been small, disjointed projects that frequently did not provide significant ecosystem benefits. Also, many of these projects were not deemed ecologically successful. The figures of the FDEP demonstrate that in 1990, of the permitted mitigation for wetlands losses, an estimated 34% was never constructed, although the associated wetland losses occurred. Of those projects that were constructed, only 12% for freshwater wetlands and 45% for saltwater wetlands sites were successful. Mitigation banking has the potential to minimize mitigation failures and provide ecological benefits that were not being met by traditional mitigation (Ertman 1997). Only after the project has been deemed a success, will the full complement of credits be awarded to the initiator of the project (i.e., the mitigation banker).

The pre- and postbank assessment procedure will most likely be based on a functional analysis technique, such as the Estuarine Wetland Rapid Assessment Procedure (E-WRAP). This technique is a modification of WRAP originally developed by the SFWMD for use in freshwater wetland habitats and is being modified for estuarine situations. Functional assessments attempt to mathematically assess the condition of a salt marsh and determine what ecological lift will be provided by the proposed mitigation. Mitigation bank credits will be determined through an equation that incorporates the amount of lift achieved over the area affected. One serious E-WRAP concern raised by mosquito control interests is that the E-WRAP process awards maximum mitigation credit for changing an impoundment to its unimpounded condition. In situations where an existing impoundment can be improved for management under RIM (such as mangrove-dominated impoundments where an OMWM-type approach does not work well), mosquito control prefers this option to reverting the impounded marsh to its unimpounded condition. Eliminating the ability for flooding in a mangrove-dominated impoundment can necessitate the need for increased pesticide usage for mosquito control, both as use of larvicides in the salt marsh and adulticides in nearby areas. This resultant increase in the need for pesticide use is a condition contrary to the PESP goal of reducing pesticide use and risk in the future. It remains to be seen how this issue of mitigation banking will ultimately impact salt-marsh management and mosquito control in Florida. Consequently, all parties involved in salt-marsh mosquito control must remain involved and vigilant to make certain these important concerns are addressed.

LARVICIDES AS A SALT-MARSH MANAGEMENT TOOL

As was mentioned earlier in this paper, salt-marsh management along the IRL typically involves an IPM approach to mosquito control that includes source reduction as well as the use of larvicides. Florida Department of Agriculture and Consumer Services (FDACS) figures for 1994–95 show that of the 185,731 ha treated (which includes both wetland and nonwetland habitats), 42.5% was treated with biorational larvicides (*Bacillus thuringiensis israelensis* [*B.t.i.*] = 24.2%, methoprene = 18.3%). Treatments in 1994–95 with temephos totaled 48.3%. A historical perspective on larvicide use also provided by FDACS demonstrates that the use of temephos decreased from 5,323 kg of active ingredient (AI) in 1981 to 3,201 kg AI in 1995. Conversely, the use of methoprene increased from 114 kg AI in 1981 to 606 kg AI in 1995. The use of *B.t.i.* also increased over this period, from no use in 1981 to 674 kg AI in 1995 (Florida Coordinating Council on Mosquito Control 1998a). Certainly over this 14-year period, the trend in Florida has been consistent with PESP goals for an increased reliance on biorational larvicides.

SUMMARY AND CONCLUSIONS

During the 1990s, Florida has continued to make important progress in addressing the goals of environmentally sound coastal wetlands management

while controlling mosquitoes with a minimum of pesticide use. Much of this progress has been due to interagency cooperation, coordinated through the FCCMC and SOMM. This work has been consistent with the goals of the state's SWIM and Ecosystem Management programs and the federal PESP. Although environmentally acceptable salt-marsh management methods have been identified and widely implemented, the need for continuing research exists to address a multitude of remaining management-related questions.

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