SALT MARSH MOSQUITO CONTROL IN PORTSMOUTH, RHODE ISLAND

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ABSTRACT. The Portsmouth, Rhode Island Mosquito Control Program used granular *Bacillus thuringiensis* var. *israelensis* to successfully control salt marsh mosquitoes in a 9 acre salt marsh while monitoring for, planning and implementing small scale open marsh water management in the marsh. Single season larviciding costs were roughly 4% that of contracted open marsh water management in this marsh.

In 1985 and 1986 nearly two-thirds of mosquito-complaint calls recorded by the Portsmouth, Rhode Island Department of Public Works and Town Administrator's Office came from residents living in neighborhoods adjacent to the Island Park salt marsh. In 1986 a mosquito control plan was adopted which gave priority to mosquito control in this salt marsh. Following state mosquito abatement policy, larvicides were to be used for short-term control and open marsh water management (OMWM) for long-term control. However, the feasibility of small scale OMWM using a private contractor to do the ditching had yet to be established. The Island Park project reported herein provided considerable information in regard to the relative economic and environmental merits of larviciding versus contracted OMWM.

Responding to resident complaints, the town administrator initiated a mosquito control program in June 1985. From late June to the end of August, town mosquito-abatement workers, with aid from the Rhode Island Office of Mosquito Abatement, made 8 evaluation trips to the Island Park salt marsh. On 7 of the 8 trips, dipper counts of medium (6–25 larvae per dip) or high (25+ larvae per dip) levels were recorded at several locations. *Aedes cantator* (Coq.) and *Aedes sollicitans* (Walker) were collected. A New Jersey light trap was placed in an adjacent residential area, approximately one-fourth mile from the salt marsh. The timer-operated trap went on at 2000 h and off at midnight. Samples were collected weekly. This same trapping location and protocol was used in succeeding years (Table 1).

The light trap catch was influenced by other salt marshes. Directly adjacent to the Island Park salt marsh was a 4 acre (1.6 ha) salt marsh which had formed inside a rectangular sand embankment ca. 10–15 ft (3.0–4.6 m) high through which passed a single tidal channel. This marsh produced large numbers of salt marsh mosquitoes but could not be included in OMWM plans because the property owner did not want ditching in this area. Three additional, small salt marsh breeding sites were located within 1.5 miles (2.4 km) of the light trap.

In 1986 the marsh was divided into 3 sampling areas: North, East and South Island Park. Ten survey sites (Hruby and Montgomery 1986) were selected (4 each in North Island Park and East Island Park, and 2 in South Island Park). Samples were taken after the April and May moon tides, and then weekly between late May and early September. The mean number of immatures per dipper sample exceeded 5 per dip on 9 sampling trips to North Island Park, 8 to East Island Park and 3 to South Island Park.

Lack of experience in deciding placement of survey sites and changes in breeding patterns during the season necessitated adding 4 survey sites and dropping one of the original sites. Additional, random sampling throughout the marsh helped delineate the extent of the breeding.

Based on 1985 and 1986 data, OMWM permits were requested from the U.S. Army Corps of Engineers and Rhode Island Coastal Resources Management Council. Open marsh water management was to be used in East Island Park and North Island Park. A tidal ditch was requested in South Island Park, where the distance from breeding site to tidal pond was too short to allow for an OMWM system.

While monitoring the marsh and developing OMWM plans, ground larviciding with granular *Bacillus thuringiensis* var. *israelensis* at a rate of 8–10 lb/acre (9–11 kg/ha) was conducted when dip counts exceeded 3 or more larvae. From 1986 through 1988 an average of 8 such applications covering 6 or more acres (2.4 ha) per application occurred. Follow-up spot applications of Arosurf-MSF™ were used on small breeding areas missed in the first application. Declines from 1985 through 1987 in both complaint calls and light trap counts provided evidence that larviciding reduced mosquito populations. Fifty-three complaint calls were received in 1986 but only 6 in 1987. The decrease in *Ae. sollicitans* from 1985 to 1986 can be attributed primarily to larval control in Island Park. The additional

Table 1. Total and mean nightly catches of female *Aedes sollicitans* and *Ae. cantator* from 1985 to 1989 from a New Jersey light trap located 0.25 miles (0.4 km) from the Island Park salt marsh.

			Females collected			
			Total		Mean per night	
Year	Time period	No. days trap in operation	*sollicitans*	*cantator*	*sollicitans*	*cantator*
1985	June	17	37	24	2.2	1.4
	July–Sept.	74	502	35	6.8	0.5
1986	June	19	24	43	1.3	2.3
	July–Sept.	72	200	129	2.8	1.8
1987	June	20	45	57	2.3	2.9
	July–Sept.	71	55	71	0.8	0.3
1988	June	21	7	368	0.3	17.5
	July–Sept.	70	62	104	0.9	1.5
1989	June	21	44	98	2.1	4.7
	July–Sept.	70	21	43	0.3	0.6

decrease in 1987 was the result of increased effectiveness of timing of applications in Island Park but also reflects better control efforts in the embanked area and the 3 additional sites mentioned above. In 1985, the mean per night collection for July through August was 3 times higher than that of June, indicating a rising population during the course of the summer. However, for 1986 through 1988, no equivalent rise was seen.

Adult *Aedes cantator* populations did not decline as much when larviciding was initiated. Because *Ae. cantator* breeds in a wide variety of habitats, salt marsh mosquito control measures cannot reduce this species as effectively as *Ae. sollicitans*. This diversity of breeding habitat was most evident in 1988 when higher than normal rains, both in the spring and in July, resulted in the highest populations of *Ae. cantator* for the 5-year period while *Ae. sollicitans* remained under good control.

Open marsh water management permits were received from U.S. Army Corps of Engineers and Coastal Resources Management Council by late summer 1987. However, there were delays in securing permission from property owners. In addition, the bid process for hiring an outside contractor required several months. As a result, ditching had to be postponed until the winter of 1988–89.

A single contractor bid on the project. The $60,000 bid was accepted and work started in November 1988. The contractor operated 2-tracked, low-ground-pressure vehicles. The Bombadier had an enclosed, two-person cab with a backhoe mounted on the open flatbed rear and a bulldozer blade on the front. Ground pressure of the vehicle, with backhoe and blade, was roughly 2.5 psi (0.17 kg/cm^2). The Smalley 808 had an enclosed, single-person cab with 360° digging capability. Its ground pressure was 1.6 psi (0.11 kg/cm^2). Digging the 8,000 ft (2,440 m) of linear ditch and 17 reservoirs took 6 weeks.

Several operational problems occurred, including removal of spoil and machinery effects on the marsh. The backhoes dug out large squares of root mat which proved impossible to spread on the marsh. As a temporary measure, these mats were removed to the edges of the salt hay (*Spartina patens* and *Distichlis spicata*) portion of the marsh and placed in a series of piles 1–2 ft (0.3–0.6 m) high. Manual spreading along the *Phragmites*/marsh elder edge was envisioned, but intervention by Coastal Resources Management Council personnel resulted in the removal of the piled spoil to an upland site. Approximately 20–25% of the spoil from East Island Park remained as vegetative mat requiring extensive manual break up or removal. In North Island Park this proportion was reduced as the vegetative mats could be used to fill the numerous breeding depressions in this area.

The effect of several passages of machinery over the marsh was noticeable. *Spartina alterniflora* marsh overlays less stable substrata than the *Spartina patens*/*Distichlis spicata* marsh and was more easily churned up by the machine tracks. A larger problem was the inability of the machines to adequately spread spoil. The Smalley was slow and the Bombadier could not break up the vegetative mats. This prevented even spreading. Several passages of the Bombadier to attempt spreading resulted in break-up of the marsh surface, necessitating the removal of spoil to the salt hay edge.

The marsh was monitored in 1989 for mosquito production and vegetative growth. During the April and May moon tides, mosquito production was essentially nonexistent. Minor breeding occurred when higher than normal May rains filled the edging ditch (blocked by debris in one area) and puddles in areas left uneven by passage of machinery. On 2 occasions larvae were eliminated with spot applications of liquid *Bacillus thuringiensis* var. *israelensis* by backpack sprayer. However, 36 female *Ae. solli-*

citans were collected in the light trap in the week ending June 29. After this small outbreak, no weekly light trap counts exceeded 6 *Ae. sollicitans* for the remainder of the summer. Mean *Ae. cantator* trap collections were higher in June (4.7) than in 3 of the 4 previous years, but were negligible (0.6) for the remainder of the summer. Only one complaint call was received during the entire summer from the neighborhoods adjacent to the marsh.

Vegetative regrowth was strong. Glassworts (*Salicornia* spp.) now occupy extensive areas where short form *Spartina alterniflora* existed prior to ditching. However, in previous years on this same marsh, rapid growth of glassworts, followed by *Spartina alterniflora*, has occurred in the numerous tire tracks left by off-road vehicles. The same succession should occur in the tracks made by the low-ground-pressure machinery. *Phragmites* and marsh elder (*Iva frutescens*) are recovering along the edge of the salt hay portion of the marsh. Long-term monitoring will be required to determine the extent of vegetation changes caused by the ditching, but the initial regrowth patterns are encouraging.

Though OMWM represents an ecologically valid long-term solution to salt marsh mosquito control in Rhode Island, the economic validity of the project is more questionable. In Rhode Island, mosquito control is conducted on a town-by-town basis. Though regulation provides for the creation of multiple-town districts, no such districts have been formed. The resulting programs are very small-scale and have limited funds, eliminating the possibility of purchasing low-ground-pressure ditching machinery. The Town of Barrington, Rhode Island, solved this problem in the late 1970s by employing laborers to do manual ditching (Boyes and Capotosto 1980). Portsmouth rejected this option because regulations now require alterations to be done between mid-September and mid-April when manual labor is scarce and field conditions poor. In years prior to this restriction, Portsmouth had routinely hired summer help for ditch maintenance.

The limited demand for specialized low-ground-pressure machinery operates against contracted OMWM by generating higher overhead costs. Out-of-state firms must pay to get machinery on-site and to house workers temporarily during the project. Furthermore, since many of the larger mosquito abatement districts in New England have their own machinery, they cannot conduct large scale projects for private firms. Finally, the restriction on timing of ditching (September 15 to April 15) limits the time period in which a contractor can do salt marsh work. Either equipment must be left idle, in which case fixed monthly costs for nonworking months must be added to the bid price of seasonal work, or alternative types of work found. The latter may be preferable but involves purchasing additional equipment and learning additional skills, neither of which may be possible for a small company.

Costs specific to this project increased the overall cost of the ditching. Funding was with federal money distributed by a state agency. The requisite paperwork for both the town and the contractor added considerably to the adminstrative end of the project. The hired contractor owns a small, new company for which insurance rates, interest rates on short-term loans, and rentals of equipment too expensive to purchase are all higher than for an established public-sector control agency. If this contractor can get multiple jobs per winter, or be able to conduct freshwater water management work during the summer, costs should come down.

Regardless, the small side of many New England marshes, and the often smaller area requiring OMWM, argues against the economic soundness of OMWM. A marsh that can be traversed in 15 min and that can be treated with larvicide in a matter of hours may not warrant OMWM. Several years of work has proved that larviciding is effective in reducing mosquito populations. The cost of larviciding the Island Park salt marsh was approximately $250 per acre per year, or roughly 4% of the cost of ditching the 9 acres of marsh, without including preditching costs and postditching monitoring.

However, larviciding does present problems. First, larviciding is a continuing process which can fail, as evidenced by the outbreak of *Ae. cantator* in 1988. Second, larviciding requires an understanding of mosquito/salt marsh ecosystems not often found in public works departments. Exacerbating this problem is the relative decline in staff of some smaller public works departments in Rhode Island over the past several years. Directors are often loath to add another part-time task to an already overextended field staff, especially when significant amounts of time must be spent in learning the techniques involved. A final consequence of any chemical application is increased public scrutiny of mosquito control operations. In control programs with only 1 or 2 workers, responding to resident questions about control techniques can consume significant amounts of time, usually during the busiest control periods.

One consideration which has important consequences in Rhode Island is the degree to which state-level money is available for various types of mosquito control. The grant received by Portsmouth would not have been awarded solely for chemical control work. A newly started program of state grants (first grant awards scheduled for 1990) to local mosquito control districts reinforces this funding difference. Routine control operations are ineligible for grants whereas nonroutine control operations can receive substantial funding. As chemical control is regarded as a routine practice, while implementation of OMWM is not, the nonchemical orientation of future state aid is clear and will have a profound effect on the economic validity of control practices as perceived at the local level.

Future OMWM projects might benefit from flexible sampling, so as to accurately map the changing patterns of mosquito breeding, and from alterations which are designed to minimize spoil creation. Marsh slope and substrata composition should be carefully checked to aid in layout and grading of ditching. Rotary ditching machinery is much more effective at spreading spoil than is excavating machinery and should be used wherever possible. Unnecessary vehicular traffic on the marsh should be avoided. From a cost-benefit perspective, contracted OMWM in small salt marshes remains questionable. Cost reduction for ditching may be necessary to justify OMWM despite the numerous ecological factors favoring OMWM. Additional OMWM projects in Rhode Island will await Coastal Resources Management Council monitoring of the Portsmouth work and will probably depend on the availability of state monetary support for implementation.

The author wishes to thank P. Sellers, L. Bowerman, B. Mitchell and L. Tewksbury for their laboratory and field work. I also wish to acknowledge the assistance of J. Cookman, T. Hruby and W. G. Montgomery in the design and implementation phases of the work. Critical review of this article by W. M. King is deeply appreciated and special thanks go to machinery operator C. Lehman. Funding for this project was provided by a grant from the Rhode Island Small Cities Grant program. Publication of this work was provided by a grant from the Rhode Island Pesticide Relief Advisory Board.

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