OPERATIONAL AND SCIENTIFIC NOTES

OPEN MARSH WATER MANAGEMENT IN MASSACHUSETTS: ADAPTING THE TECHNIQUE TO LOCAL CONDITIONS AND ITS IMPACT ON MOSQUITO LARVAE DURING THE FIRST SEASON

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In recent years, mosquito abatement techniques known variously as quality ditching, source management, or open marsh water management (OMWM), have shown promise of reducing mosquito numbers on salt marshes while preserving habitats and species diversity (Provost, 1977). Pool habitats are created or maintained rather than destroyed, and the levels of insecticide use greatly reduced. Although these techniques have been successfully used in the Chesapeake Bay region (Ferrigno 1970, Whigham, et al. 1983, Saveikis et al., 1983), they have not yet been tested in New England. The physical and biological characteristics of New England salt marshes are different from those farther south and the success of OMWM as practiced in the mid-Atlantic states, cannot be readily extrapolated to New England. In Massachusetts, for example, the tidal range on salt marshes is between 7 and 11 ft, and icing can be severe in winter. North of Cape Cod, marsh biota tends to be predominantly boreal rather than temperate because the coastal waters are linked to the Gulf of Maine.

In 1982, the Essex County (Massachusetts) Mosquito Control Project, in collaboration with the Massachusetts Audubon Society and the Manomet Bird Observatory, began a five-year study to test OMWM on Essex County marshes. In trying to apply the standards and methods proposed by Ferrigno et al. (1975), we found that some were not practical on our local marshes. For example, many of the marshes that breed mosquitoes are small and not suited for construction of large ponds, since this method would eliminate relatively large areas of productive plant habitats. Also, the unavailability of a rotary ditcher to the Mosquito Control Project meant that alterations which generate large quantities of spoil such as meandering ditches, have to be minimized. Without a rotary ditcher, spoil cannot be broadcast, and has to be transported to the upland or thinly spread with a plow. Since both the characteristics of the marsh and the equipment available for alterations are different, we are trying to achieve the objectives of OMWM by using slightly different methods as described below.

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MODIFICATIONS TO OMWM METHODS. Reservoirs to provide refuges in mosquito breeding areas for larval eating fish are created by digging ditches, 3 ft deep and 1.5 ft wide, rather than by constructing ponds. Old upland perimeter ditches, because of their larger size and proximity to major breeding areas, are preferred for such reservoirs. If an old ditch is still open to tidal flow, the seaward end is blocked with a 10-ft or longer spoil plug level with the marsh surface. In our early trials, the dissolved oxygen near the bottom of the plugged ditches fell below 1 ppm on hot summer days. We hypothesize that low oxygen levels resulted from the resuspension, during the re-excavation, of anoxic sediments with a high oxygen demand. In the future, cleaned ditches will be left open to tidal flow for at least one month before they are plugged, thus allowing the sediments to settle and become oxygenated.

The reservoirs that provide refuges for larval predators are connected to major breeding areas by "radial" ditches 18 in deep and 1 ft wide. Existing ditches are used wherever possible and if these are deeper, spoil is used to fill them to the chosen depth. Following the pattern developed in New Jersey, these connecting ditches are straight, or in a loop to connect several pans. Meandering ditches at present are generally not considered because of the additional spoil they generate. Again, none of the radial ditches are connected to tidal channels, so water levels remain at the height of the marsh surface.

The construction of ponds has not been eliminated from the marsh management program, but it has been limited to areas where, in the opinion of the project foreman and marsh biologist, the previously described technique will not adequately reduce larval numbers. As an alternative, we are maintaining high water levels in depressions on the marsh surface by connecting them to deeper reservoirs in the hope that ponds will re-establish naturally.

FIELD TESTING METHODS IN ROWLEY, MA. The first marsh alterations using our modified OMWM method were done in June 1983 on two salt marshes on a tributary of the Parker River in Rowley, Massachusetts. Approximately 2.5 acres (1 hectare) were altered on a poorly drained marsh, and 5 acres (2 hectares) on another marsh which had functioning grid ditches. In order to maintain consistency with other experimental sites in this continuing study, the plots are respectively identified as Plot 3 and Plot 4A (Figs. 1 and 2). The first site (Fig. 1, Plot 3), was chosen as an example of a relatively undisturbed marsh, and the second (Fig. 2, Plot 4A), as one heavily impacted by the usual mosquito practices of grid ditching. The ditches on Plot 4A had been cleaned in 1976 and all breeding depressions within the experimental area regularly drained out after the spring tides.

Although the marsh on Plot 3 had been ditched during the 1930's, the ditches were irregularly placed, clogged, and failed to drain the surface. By 1980, a system of shallow pans had become established naturally and the plot resembled nearby unditched marshes. The goal of the alterations on Plot 3 was to reduce mosquito larvae without destroying the pan habitat. This was accomplished by cleaning out the old ditches on either side and using them as reservoirs. Radial ditches were dug through the pan system connecting the two reservoirs (Fig. 1).

The ditches on Plot 4A required very little cleaning, and much of the work consisted of plugging the existing ditches at their seaward end (Figure 2). No new ditches were dug. The goal of the alterations on this marsh was to provide a refuge for fish in the deeper ditches while using the shallower ditches for access

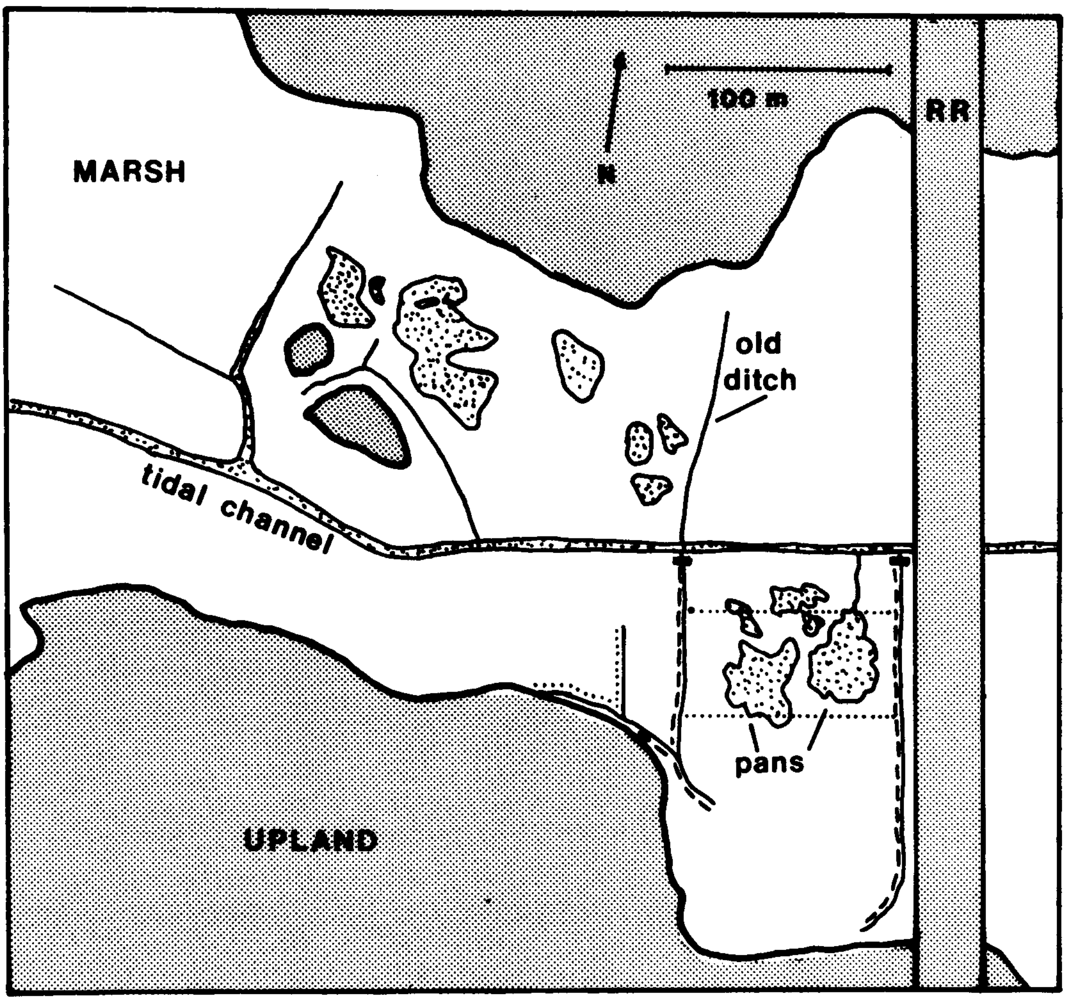

Fig. 1. Alterations done on Plot 3, a marsh recovering from the effects of ditching during the 1930's. Solid lines indicating existing ditches, dashed lines the ditches that were redug to a depth of 3′, and dotted lines those newly dug or redug to 18″. Solid blocks mark where ditches were blocked with spoil.

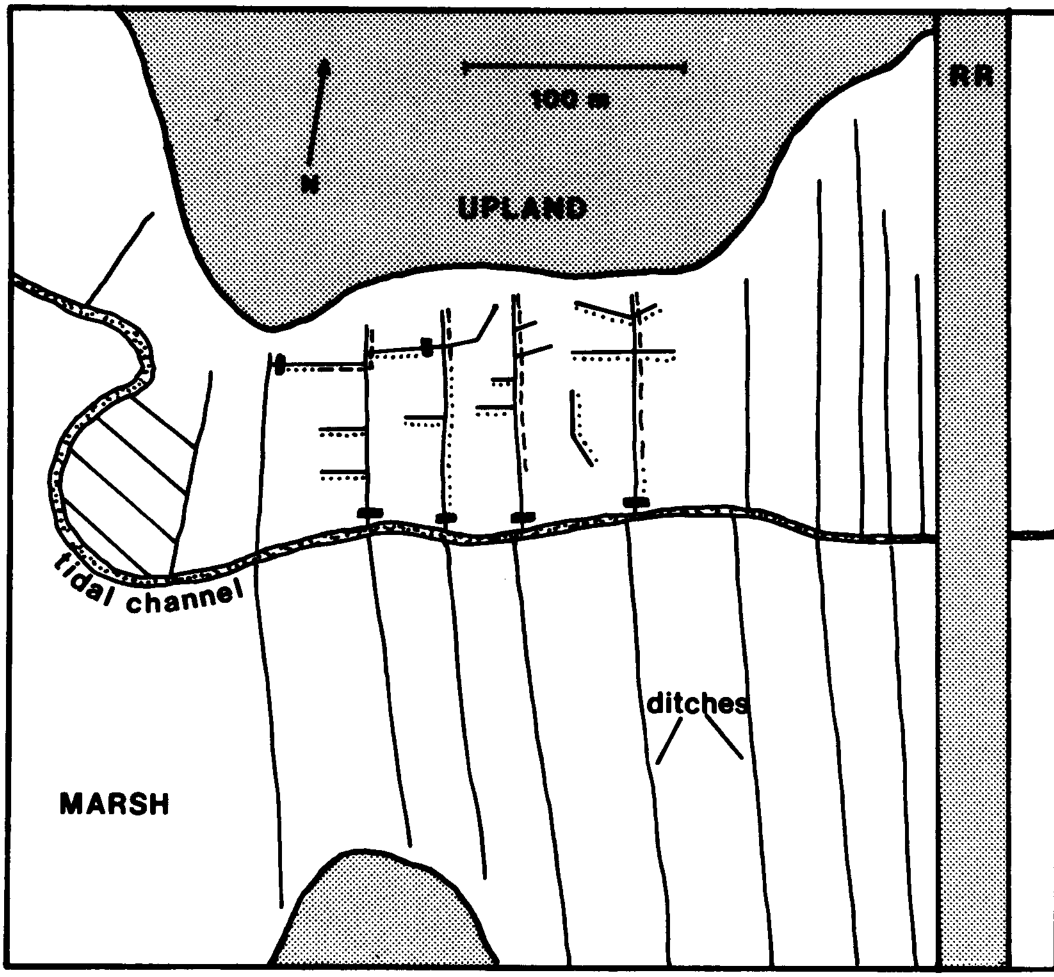

Fig. 2. Alterations on Plot 4A, a marsh redug in 1976 and currently well-drained by existing ditches. Solid lines indicate existing ditches, dashed lines those that were redug to a depth of 3′, and dotted lines those that were redug to 18″. Solid blocks mark where the ditches were blocked with spoil.

routes to breeding areas between the main ditches. Our hope is that pans will become established in the shallow depressions on the marsh surface, if we maintain high water levels in the ditches.

REDUCTIONS IN MOSQUITO NUMBERS DURING THE FIRST SEASON. The number of mosquito larvae on Plots 3 and 4A were sampled during the first breeding season following experimental alterations done in June 1983. Areas immediately adjacent to the two altered plots were used as controls. On the marsh containing Plot 3, the control was a 1-ha plot with a similar system of pans and pools seaward of the altered plot. Ditches in this area had been filled by duck hunters in 1974 to re-establish a system of pools. On the marsh containing Plot 4A, the control was a 2-ha plot on the other side of the main tidal channel with a similar ditch pattern.

Ten 12-meter diameter permanent circles were established on each plot for sampling larvae by dipping (modification of the method of W. Meredith, personal communication). On each plot five sampling circles were randomly located tangent to ditch edges and five randomly located on the surface of the marsh with edges at least 8 m from any ditch. In the control for Plot 3, there were no ditches. For comparison with "ditch edge" sites, the sampling circles were located in areas where *Spartina patens* was visibly dominant, since this species was also dominant along the length of newly cut radials in the managed area. On the other hand, the dominant vegetation away from the radials in Plot 3 was the short-form of *Spartina alterniflora.* As controls for these locations on Plot 3, therefore, circles containing the short form of *S.*

alterniflora were randomly chosen in the unmodified marsh.

Within the sampling circles, 24 dips (3 dips at each of 8 randomly chosen "breeding areas") were attempted at weekly intervals between July 17 and August 24, 1983. Breeding areas were chosen as those sites most likely to breed mosquitoes over the summer based on a preliminary dip survey. As the sites dried out between spring tides, dip counts were sometimes impossible. The larvae and pupae were not identified, but observations made by the Essex County Mosquito Control Project over the last 25 years, indicate that the dominant marsh mosquito (>90%) during July and August is *Aedes sollicitans* (Walker).

Counts of mosquito young (numbers per dip) obtained in 1983, are summarized in Table 1. Because so many of the dips had "0" counts, the non-parametric Wilcoxon two-sample statistical test was used to test for significant differences between counts in control and altered plots. Samples were combined for each habitat type and the test was based on up to 120 dips per group. As shown in Table 1, the altered marshes had significantly lower numbers of larvae and pupae in all cases where good hatches were found in the control sites. For the second brood sampled, the reductions in mosquito larvae were 99% on the natural marsh and 100% on the ditched marsh. These reductions are even higher than those reported by Ferrigno et al. (1975) for OMWM in New Jersey, and are similar to those reported by Saveikis et al. (1983) for Delaware marshes. Preliminary analysis of data collected in 1984 indicates that similar reductions were again present during the second breeding season.

Table 1. Mean counts per dip of mosquito larvae and pupae. Twenty-four dips at each of 5 sites were attempted in each habitat per day. Times when the counts on the altered marsh were significantly different from the control plot are underlined (p <.05 using non-parametric Wilcoxon Test). "C" represents control plots, "OMWM" represents plots that were altered. An (*) indicates times when sampling sites were too dry for dips.

	Natural marsh				Ditched marsh			
	Ditch edge/ *S. patens*		Marsh top/ *S. alterniflora*		Ditch edge		Marsh top	
Date	C	OMWM	C	OMWM	C	OMWM	C	OMWM
July 17	4.4	0.1	0.07	0.04	0.8	0.0	2.9	0.01
July 21	2.6	0.5	0.06	0.04	1.7	0.04	1.9	0.1
July 27	0.7	0.02	0.0	0.0	0.2	0.0	0.7	0.0
August 3	*	*	*	*	*	*	*	*
August 10	17.2	0.5	0.5	0.0	0.0	0.0	1.1	0.0
August 16	23.6	0.2	0.3	0.02	0.0	*	10.1	0.0
August 24	*	*	*	*	*	*	*	*

Although we are not yet ready to make definite claims about the effectiveness of OMWM in Massachusetts, we are encouraged with the results obtained to date. The study will run through 1987, and when completed we should have a better understanding of the impacts of OMWM. Along with the data on larval numbers, we are collecting information on possible changes in bird numbers, invertebrates, fish and vegetation.

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