AN APPROACH TO THE EVALUATION OF TEMPORARY VERSUS PERMANENT MEASURES IN SALT MARSH MOSQUITO CONTROL OPERATIONS[1]

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ABSTRACT. Three salt marsh water management projects for mosquito control were evaluated on the basis of mosquito production and costs of chemical and permanent control. Data showed that water management projects eliminated over 93% of the acreage from mosquito breeding and that these projects would save the project cost in 6.6 years to 15.0 years.

The effect of water management on mosquito populations is an important component in the overall evaluations of mosquito control practices. DeBord et al. (1975) examined the economics of mosquito control (utilizing light trap data), and found permanent control to be more costly than temporary control. These results have recently been questioned (Hansen et al. 1976 and Provost 1977). DeBord et al.'s use of light trap data may not be the most effective method of evaluating the control of mosquito populations in certain areas because of the movement of mosquito populations into treated areas and because of the extent of the adjacent areas that breed mosquitoes (Bidlingmayer 1969 and Downing 1976). Because of these difficulties, we employed a method (Gooley and Lesser 1976) that actually maps areas where larvicide has been applied.

Utilized for 4 years in Ocean County, this method allows evaluation of the immediate effects of water management projects on larval mosquito control and comparison with the control achieved in adjacent areas that had not been managed.

The three areas evaluated had been managed by the same method: identification of mosquito breeding sites, determination of the type of alteration applicable to the area (pond, pond radial or tidal ditch) and implementation of the plan by either a John Deere backhoe-bulldozer combination or an amphibious dragline.

AREA 1. Adjacent to the upland this 90.8 acres salt marsh area was a consistent breeder of mosquitoes. Certain sections had to receive five different larvicide treatments to control mosquito populations in 1974 (Table 1). Before the completion of the water management work in June 1975 a 26.6 acre section of the area had to be treated for larval control. After the work was completed, only a small section of less than 1 acre required larvicidal treatment in 1976 (Table 1).

Comparison of breeding in the managed areas with adjacent unmanaged areas showed that the areas not altered for mosquito control required treatment for 4 consecutive years.

AREA 2. Area 2 consisted of a salt marsh island of 89.1 acres that required multiple treatments per year (Table 1). During the 1975 mosquito breeding season, water management work was being done on the island and was completed in that November. After completion of the work, only one section (4.6 acres) has required a larviciding in 1977. Non-managed areas in adjacent marshes have required treatment from 1974 through 1977 (Table 1).

AREA 3. This is the largest of the three areas consisting of 195.4 acres of salt

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marsh adjacent to the upland. The water management work was completed in April of 1976. An area of 21.1 acres has been the only area requiring larviciding since the work was finished. Adjacent non-managed areas have required larviciding from 1974 through 1977 (Table 1).

In these three areas a total of 375.3 acres were altered by water management for mosquito control in 1975 and in the spring of 1976. Only 7% (26.6 acres) re-

Table 1. Acreage treated with a larvicide from 1974 to 1977 (TS = treatments/season, A = acreage, CA = cumulative acreage treated, NM = Non-Managed area, M = Managed Area.

		1974		1975		1976		1977	
Area	T/S	A	CA	A	CA	A	CA	A	CA
NM	1	4.6	4.6			7.3	7.3	5.5	5.5
(23.9A)	2	9.2	18.4	1.8	3.6	3.7	7.4	6.4	12.8
	3	6.4	19.2			2.8	8.4	5.5	16.5
	4	3.7	14.8	8.3	33.2			2.8	11.2
	5			2.8	14.0				
	6			8.3	49.8				
		23.9	57.0	21.2	100.6	13.8	23.1	20.2	46.0
1									
M	1	13.8	13.8	20.2	20.2	0.9	0.9		
(90.8A)	2	8.3	16.6	6.4	12.8				
	3	16.5	49.5						
	4	11.0	44.0						
	5	7.3	36.5						
		56.9	160.4	26.6	33.0	0.9	0.9	0.0	0.0
NM	1	15.6	15.6	4.6	4.6	12.9	12.9	5.5	5.5
(27.5A)	2	2.8	5.6	7.3	14.6	2.8	5.6		
	3	6.5	19.5						
	4			12.8	51.2			5.5	25.6
	5							6.4	27.5
		24.9	40.7	24.7	70.4	15.7	18.5	17.4	58.6
2									
M	1	26.6	26.6					4.6	4.6
(89.1A)	2	5.5	11.0						
	3	7.3	21.9	14.7	44.1				
	4	6.4	25.6	51.4	194.4				
	5	42.3	211.5	18.4	92.0				
	6			4.6	27.6				
		88.1	296.6	89.1	358.1	0.0	0.0	4.6	4.6
NM	1	27.5	27.5	51.4	51.4	34.9	34.9	78.0	78.0
(177.1A)	2			45.0	90.0	17.4	34.8	57.8	115.6
	3			16.5	49.5			7.3	21.9
	4			10.1	40.4			8.3	33.2
	5			4.6	23.0			4.6	23.0
		27.5	27.5	127.6	254.3	52.3	69.7	156.0	271.7
3									
M	1	66.1	66.1	34.0	34.0			21.1	21.1
(195.4A)	2	31.2	62.4	45.0	90.0				
	3	9.2	27.6	28.4	85.2				
	4	3.7	14.8	3.7	14.8				
		110.2	170.9	111.1	224.0	0.0	0.0	21.1	21.1

quired larviciding for mosquito control after water management work was completed (Table 1). This mapping and recording of larvicidal treatments allows a mosquito commission to evaluate its water management system and undertake additional alterations to eliminate mosquito breeding areas that might have been missed during the initial work.

The problem of economics associated with permanent control needs further attention (Rupp 1978). We would like to present some comparative costs associated with mosquito control for larviciding and for permanent control. To evaluate the costs, a uniform system has to be determined, such as costs/acre (Hansen et al. 1976).

LARVICIDING COSTS

Certain yearly costs are fixed no matter how many acres of marsh will breed within a given year. These costs are pilot salaries, contracted helicopter hours and inspector salaries. Costs that will vary with the amount of acreage treated are fuel and pesticide costs. The total of these costs was determined for the years 1974 through 1977 and a 50% administration cost was added. The total cost was then divided by the total acreage treated within a given time to yield a yearly cost/acre (Table 2). Data in Table 2 indicate that in years when mosquito populations are low (1976), fixed costs per treatment per acre are high.

WATER MANAGEMENT COSTS

The equipment utilized in these projects was a John Deere and an amphibious dragline. Records were kept as to the amount of time each piece of equipment was operated in water management projects and then a rental cost per day was assigned (John Deere = $100/day, dragline $200/day.) After total project costs were determined, a similar administration cost of 50% was added to the project. Individual project costs ranged from $99.12/acre to $309.76/acre (Table 3). These costs are higher than those reported by Hansen et al. (1976) and reflect the type of equipment since the cost data of Hansen et al. are based upon the more economically operated amphibious rotary ditcher.

Table 2. Comparison of the cost of larvicide treatment, acreage and *Aedes sollicitans* light trap population from 1974 through 1977.

Year	$/A	Acreage Treatment	$\overline{X}$ Light Trap[1]
1974	$ 6.60	27466	2.69
1975	5.98	35162	4.23
1976	23.63	6372	1.82
1977	6.76	28751	3.21

[1] William's Mean (5500 trap nights/yr).

Table 3. Costs for individual water management projects.

Area	Acreage	Total Costs	Costs/Acre
1	90.8	$ 9,000.00	$ 99.12
2	89.1	27,600.00	309.76
3	195.4	22,650.00	115.92

Kuenzler and Marshall (1973) stated that until ditching is clearly demonstrated to be effective and economically worthwhile there should be a moratorium on its employment. We do not accept this opinion which all our data, in addition to those of other recent studies (Hansen et al. 1976, Provost 1977) seem to deny. The evaluation of long term costs associated with permanent or temporary mosquito control methods is a problem. Such evaluation of various factors can lead to a "phenomenal amount of mathematical juggling" (Provost 1977) leading to producing erroneous results and conclusions. We feel that to avoid such juggling, it is best to compare costs for managed and non-managed areas without using light trap numbers in our calculations. We take it as axiomatic that treatment, be it chemical or water management, will not be undertaken unless there are mosquitoes in such numbers as to require control.

Since individual marshes vary in the breeding of mosquitoes because of environmental and year-to-year climatic or tidal conditions (Shisler 1978 and Downing 1978) the non-managed marshes adjacent to the managed marshes were used as control areas. Dividing the acreage of the project or non-managed area into the total acreage treated (managed or non-managed) that year (Table 1) yields average treatments/acre (AT/A) for that year. Assuming that the non-managed acreage will function similarly in mosquito production to the managed acreage before the alterations, then dividing the AT/A of the non-managed acreage into the AT/A of the managed acreage, yields an index that could be used to determine possible treatments/acre in following years. In areas 2 and 3, 2 years of data were available before initiation of the water management project. Therefore, an average of these two AT/A (1974 and 1975) would produce a more reliable index. The larviciding treatments per acre of marsh for the individual areas are shown in Table 4.

The cost/treatment/acre (Table 2) times the treatment/acre/year (Table 4) yields a cost/acre/year. Averaging yearly cost figures produces the average costs/acre/year (Table 5). Dividing such figures into the costs of the individual water management projects would determine the number of years required for the county mosquito control operation to recover its investment in the project. The estimates of from 6.6 to 15.0 years are higher than those of Provost (1977), Hansen et al. (1976) and Launay et al. (1978) because of equipment and mosquito breeding characteristics of the marsh.

What we have tried to present is an examination of the effect of water management on mosquito breeding and to relate these effects to the costs involved to determine if water management (permanent) for mosquito control is feasible. Water management, in this study, proved to be 93% effective in control of mosquito breeding areas and is economically attractive over a period of years in relation to the economics of chemical control of mosquitoes in salt marsh environment. Needless to say, such a management program, while still utilizing pesticide when necessary can reduce the amount of such materials applied in the sensitive salt marsh ecosystem.

Table 4. Average number of larviciding treatments per acre (AT/A) of marsh (underlined numbers are estimated treatments/acre, see text).

Area		1974	(index)	1975	(index)	1976	1977
	Non managed	2.38		4.21		0.97	1.92
1			(.74)				
	Managed	1.77		3.12		0.72	1.42
	Non managed	1.48		2.56		0.67	2.13
2					(1.38)[1]		
	Managed	3.33		4.02		0.92	2.94
	Non managed	0.16		1.44		0.39	1.53
3					(1.29)[1]		
	Managed	0.87		1.15		0.50	1.97

[1] Average of 1974 and 1975.

Table 5. Average savings per acre (SPA) per year after the water management project was completed and time required to repay the cost of the project.

Area	Costs/Acre	SPA	Yrs. to repay
1	$ 90.82	$ 15.09[1]	6.6
2	309.76	20.64[2]	15.0
3	115.92	12.57[2]	9.2

[1] Average of 1975, 1976 and 1977.
[2] Average of 1976 and 1977.

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