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ADDITIONAL STUDIES OF THE EFFECTS OF SALT MARSH IMPOUNDMENTS ON MOSQUITO POPULATIONS

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ABSTRACT

Research was conducted during the summer and fall of 1974 in three adjacent areas in Carteret County, N. C., to determine the effectiveness of an impoundment for mosquito control. A comparison was made between a natural marsh, a partially completed impoundment, and a completed mosquito control impoundment.

Potential mosquito producing sites in both the natural marsh and the partially completed impoundment were comparable in vegetative cover. Neither area produced salt marsh mosquitoes, probably due to opposite reasons. The natural marsh was inundated by tides too often; in the partially completed impoundment, the dikes eliminated normal tidal flooding.

Within the impounded marsh, Juncus roemerianus Scheele (black needlerush) remained in several large stands. However, in vast areas, only the stumps of the Juncus remained. Most of these and other marginal areas had been invaded by Typha spp. (cattail). Numerous patches of Spartina patens (Aiton) and Distichlis spicata (L.) were still thriving around the perimeter of the dike and on high ground within the interior. Bacopa monnieri (L.) Pennell, an emergent plant species, had also invaded the shallow areas near the perimeter.

Only two larvae of the salt marsh species Aedes sollicitans (Walker), were recovered within the impoundment. They were recovered following a heavy rain from a deep hole left by a fallen tree. Anopheles mosquito larvae were collected in small numbers from areas containing thick mats of vegetation (Spartina patens, D. spicata and B. monnieri) and flooded with less than six inches of water. During the hot summer months, the water level dropped 6 inches due to evaporation. This loss of water caused most mosquito breeding sites to become unproductive. Areas in deeper water, or where the vegetation was submerged, were not mosquito producers.

Salinity within the impoundment was 0 parts per thousand throughout the entire research period.

Light trap data indicated that adult mosquito populations were greatest during late spring and early summer in the nearby Davis community. Aedes sollicitans and Culex species were most abundant with Anopheles bradleyi (King) and Aedes taeniorhynchus (Wiedemann) following, respectively, in abundance.

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SUMMARY AND CONCLUSIONS

Production of mosquito larvae was determined over a 19 week period (June-October) in 1974 at three adjacent sites near Otway, Carteret County, North Carolina. These were (1) a natural marsh, (2) an impounded marsh and (3) a partially constructed impoundment. Very few mosquito larvae were found in any of the areas. Small numbers of Anopheles larvae were recovered in the impoundment.

The natural marsh adjacent to the impoundment was flooded too frequently to be a source of Aedes salt marsh mosquitoes. The impounded area continually lost water and the water was fresh (0 ppt salinity throughout the study) and could not support Aedes salt marsh mosquitoes. Emergent and floating vegetation was increasing in the impoundment and appeared to be suitable for some Anopheles mosquito production. The partially completed impoundment was largely mud flat and unsuitable for mosquito production.

The impoundment was an excellent wildlife retreat with abundant bass fish and visiting ducks. Osprey nests were present but declining drastically in numbers due to the lack of nesting sites as a result of trees rotting off at the waterline and falling.

Water was not being pumped into the impoundment to maintain the proper level and salinity. No efforts were being made to maintain a desirable habitat for wildlife.

From this study, it is not possible to say whether or not this impoundment has been successful in reducing the mosquito abundance in the area. This is principally due to the low numbers of mosquitoes produced on the unimpounded or check area during the period of the study.

With the lack of any management practices on the impoundment, it is concluded that the wildlife benefits are likely to decline in the future.

If impoundments are to be built for the purpose of mosquito control and side benefits to fish and wildlife, greater attention should be given to their construction and management. Retention of ownership by a private landowner after investment of public funds for impoundment construction encourages construction wherever a landowner is cooperative rather than where serious mosquito production occurs. Further, it leaves no public control over the proper post-construction management of the impoundment and no public access to enjoy the enriched wildlife habitat.

RECOMMENDATIONS

1. If an impoundment is used for source reduction of salt marsh mosquitoes, proper and long term management should include:

   a. Maintenance of water levels through pumping at a minimum depth of 12 inches over all marsh within the dikes. Proper water depth will help to prevent dense mats of vegetation at the surface, will allow greater wave action, and will permit easy access for surface-feeding minnows, all factors that limit or prevent mosquito production.

   b. Fish and wildlife should be stocked and or encouraged to make use of the available habitat. Nesting sites such as those for ospreys, which are created by large dying trees, should be maintained by placing pilings at their bases to prevent their falling or even replaced completely by tall poles.

2. The existence of salt marsh impoundments which have been partially constructed and abandoned due to political or environmental pressures should be corrected:

   a. Dikes should be completed and the interior flooded to serve the original function in mosquito source reduction and to create better habitats for waterfowl and wildlife, or

   b. Existing dikes which prevent or impede the normal flow of tides and subsequent nutrient exchange should be removed if mosquito source reduction and other fish and wildlife benefits do not justify the necessary changes to the environment.

3. If federal, state, or local taxes are used to finance the impoundment of salt marshes:

   a. The state and local governments should finance and enforce the proper management of the impoundment to insure maximum mosquito control and wildlife enhancement.

   b. The resulting fish and wildlife habitat created by impoundment should be included in the state game lands or sanctuaries.

INTRODUCTION

The effects of impoundments on the production of salt marsh Aedes mosquitoes in North Carolina were documented in the University of North Carolina Water Resources Research Institute Report No. 92 by R. N. LaSalle and K. L. Knight ("Effects of Salt Marsh Impoundments on Mosquito Populations"). A review of the literature and discussion of the problem was included. That report included several impoundments, in Carteret and Pamlico Counties, which were predominately expanses of Juncus roemerianus (black needlerush). These studies have been extended by an examination of a more varied marsh habitat in Carteret County. The study site (Otway Impoundment) included an impounded area, a partially constructed impoundment and an adjacent unimpounded marsh. The results are presented in this report.

PROCEDURE

This research was conducted at the Otway Impoundment (also known locally as Huntley's Impoundment) in Carteret County, North Carolina (Fig. 1-3). The impounded salt marsh is located approximately 2 miles south of Otway, 3 miles northwest of Harkers Island, and 4 miles northeast of Beaufort. The impoundment is immediately bordered to the north by a large expanse of unimpounded salt marsh, to the west by North River and to the south by a partially constructed salt marsh impoundment. Construction of the 17 acre impoundment was completed in 1966. The impounded area consists of several acres of Juncus marsh, several small groves of pine woods, and large expanses of open water.

A sixteen acre area, primarily salt marsh, adjoins the southern dike of the impoundment and was intended to be a second impoundment. Approximately 65 percent of the diking was constructed in 1966 but the remainder was never completed. Except for an open channel approximately 25-30 feet in width, the marsh was enclosed in dikes running from high ground to high ground. The existing inlet permits slight flooding of the enclosed marsh but normal high tides are never accomplished.

The primary objective of this study was to compare the size and species composition of the mosquito populations occuring in the natural salt marsh, the completed impoundment, and in the partially completed impoundment. A standard larval-pupal monitoring procedure was established and collections were made at weekly intervals from June 17 to October 21, 1974.

The three research areas were surveyed on foot to locate mosquito larvae and potential mosquito breeding sites. Selected sites were numbered and marked with stakes four feet in height. The maximum breeding area and the vegetative cover was determined at each site. At each weekly visit, the mean depth of water at each site was determined and the necessary data for a

mosquito breeding index were collected, (see LaSalle and Knight, WRRI Report No. 92).

Salinity at various sites in each study area was determined weekly using a refractometer measuring parts per thousand of salt. A rain gauge was stationed at the impoundment and precipitation data were collected weekly. A water-level gauge measuring in inches was located within the impoundment and the water level measured weekly.

Two water-depth transits extending from the dike into the impoundment were established. Each month a line was stretched between the end stakes and the water depths determined at 3 feet intervals.

The number of mosquito larvae and pupae at each site was determined using a sampling procedure standardized by Belkin (1954). Larvae were grouped according to size, first and second instars in one group with third and fourth instars in a second and their numbers recorded in the field. Representative samples of the larvae and pupae collected at each site were brought into the laboratory. The larvae were killed in boiling water and preserved in 70% alcohol. The larger specimens were mounted on slides for identification. Pupae were placed in rearing chambers for emergence and identification.

A standard New Jersey light trap, operated at Davis in Carteret County, has been used to monitor adult mosquitoes each season since 1970. Though not located in the immediate area of the impoundment, the collections from this trap were used as an indicator of the adult mosquitoes in the general area.

RESULTS

A summary of the physical and vegetative data for the three study areas is shown in Table 1, with more detailed data on each site in Appendix Tables 1-12.

The natural marsh was dominated by Juncus roemerianus, Spartina patens, and Distichlis spicata. Although no tide gauge was placed in the area, 20-25 floodings per month would be a conservative estimate. The seven sampling sites regularly visited throughout the research period failed to produce mosquito larvae. Additional weekly searches through approximately four acres of this natural marsh also failed to reveal any productive mosquito breeding sites.

The partially completed impoundment also proved to be free of mosquito larvae. There were many sites throughout the area which had vegetation commonly associated with mosquito production (Fig. 5). The lack of mosquito larvae was due to the continual absence of surface water (Table 1). The dikes across the low marsh on either side of the area prevented normal tidal action. Only one site near the marsh edge was flooded by high tides and this occured only four times during the research period.

In the case of the completed impoundment, the passage of eight years has produced vegetative changes that even the most casual observer would notice. The large stands of existing Juncus appear to be 90 percent dead or dying, with a high percentage of such stands having been replaced by Typha (cattail) (Fig. 6). In these areas only the basal portions of the Juncus stems remain. Spartina patens and Distichlis spicata are abundant around the inside perimeter of the dike and on natural elevations of marsh sod (Fig. 7) throughout the impoundment. Bacopa monnieri (Fig. 8), was also very abundant in the shallow areas of the impoundment near the dike.

Data on mosquito populations within the Otway Impoundment are shown in Table 2. A total of 449 specimens were taken throughout the study period. Field counts indicate that 65 percent of the larvae were first or second instars and 33 percent were third or fourth instars. Only seven pupae (1.5%) were taken. Eighty percent of the specimens were anopheline mosquitoes (primarily Anopheles bradleyi). Sites 1-14, located in the northwestern corner of the marsh were consistently breeding mosquitoes during June and July. These sites were dominated either by Spartina patens, Distichlis spicata or Bacopa monnieri. Breeding continued until evaporation lowered the water level (Figs. 9-11) leaving the sites free of standing water. Only 3 mosquito larvae were found in these 14 sites past August 6, 1974. Sites 15-33 were located throughout the dead pine woods area (Fig. 12). These sites consisted of deep natural depressions or stump holes formed by falling trees. Mosquito breeding occured in only 3 of these sites, following a 3.5 inch rainfall (Fig. 13) the last week in June. Except for this occasion, these sites were free of standing water until the middle of October.

Data on the adult mosquito populations were obtained at the Davis light trap and are shown in Figures 14 and 15. Mosquito populations were greatest during the late spring and early summer reaching a peak of 1755 adults captured during the month of May. Data indicate that in the Davis community, Aedes sollicitans was the most abundant mosquito species present, with Culex spp., Anopheles bradleyi and Aedes taeniorhynchus following, respectively, in abundance.

DISCUSSION

The three study areas at Otway are extremely difficult to compare. The natural unimpounded marsh is flooded frequently and is therefore not a producer of mosquitoes. The area inside the partially completed impoundment does not flood often enough to obtain or to maintain the necessary standing water for mosquito production. Within the impoundment, mosquito production was greater in areas where floating surface vegetation occurred in dense mats and the water was 4 to 6 inches deep. Mosquitoes were not found in areas where water was deeper and wave action vigorous. These findings are in agreement with the data reported by LaSalle and Knight (WRRI Report No. 92) from other impoundments in Carteret and Pamlico Counties.

The field data on larval development indicate that few reached maturity. This probably is a result of the very large minnow and bass populations.

Salinity data throughout the study show the impoundment to be consistantly fresh. On no occasion did we record any degree of salinity within the impoundment. Mr. George Huntley, former owner of the property, recalled that the water level within the impoundment had not been increased by pumping from the tidal basin within the past three years.

Data from this study, and other impoundments, indicate that had the water level been maintained at a level greater than 12 inches, the mosquito breeding found in sites 1-14 probably would not have occurred.

From a fish and wildlife standpoint, the Otway Impoundment is a paradise. The impoundment was stocked with fresh water bass. Fishing with artificial lures was fantastic. On several occasions before the property changed ownership in 1972, one of the authors averaged a catch of 30 to 40 (3/4 - 1 lb) bass per hour. Individual bass weighing 4 to 5 pounds were not uncommon.

Waterfowl used the impoundment heavily. The numbers and variety of shore birds utilizing the area make it a bird watcher's haven. At the time of construction, one osprey nest was located within the impoundment. The population increased until 1972, when there were 13 active pairs of ospreys nesting within the impoundment boundary. In 1974, only 4 active pairs remained. This decline in the osprey population is a direct result of the loss of nesting sites. Large pine trees which died as a result of impoundment were favored nesting sites but within the past year, most have fallen because of decay in the area of the water surface.

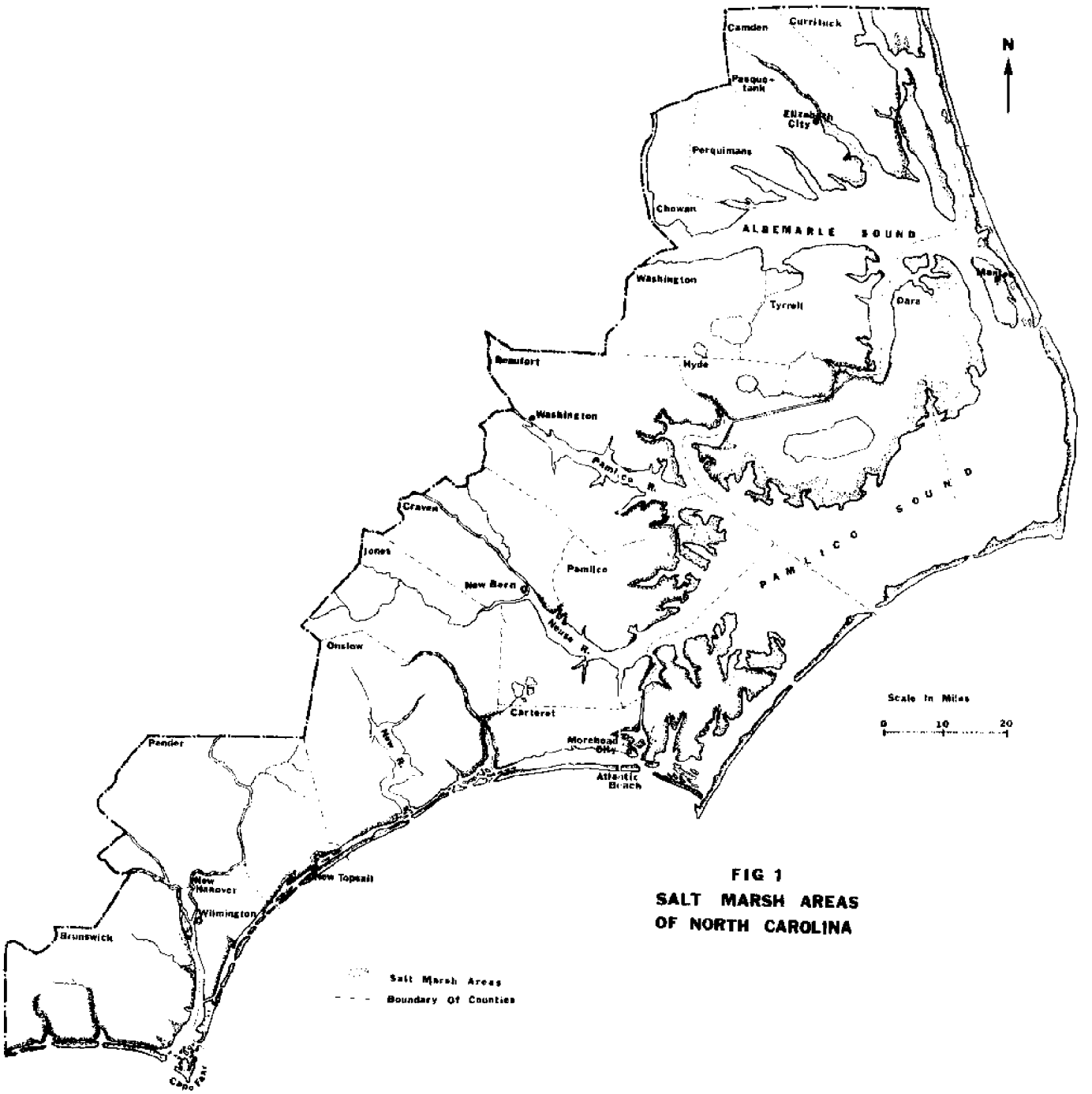


FIG 1
SALT MARSH AREAS
OF NORTH CAROLINA

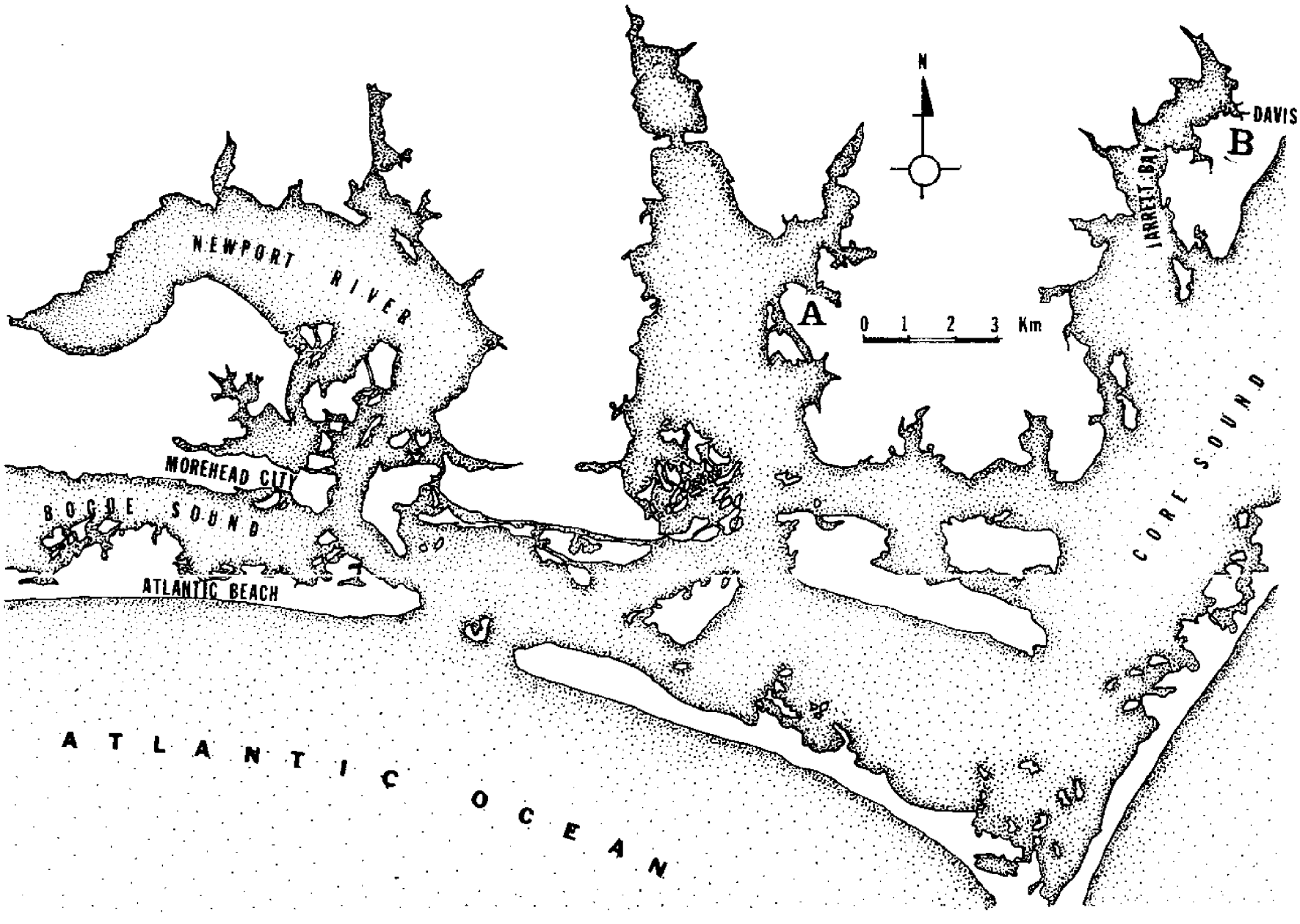


FIG 2. CARTERET COUNTY A - STUDY SITE B - LIGHT TRAP

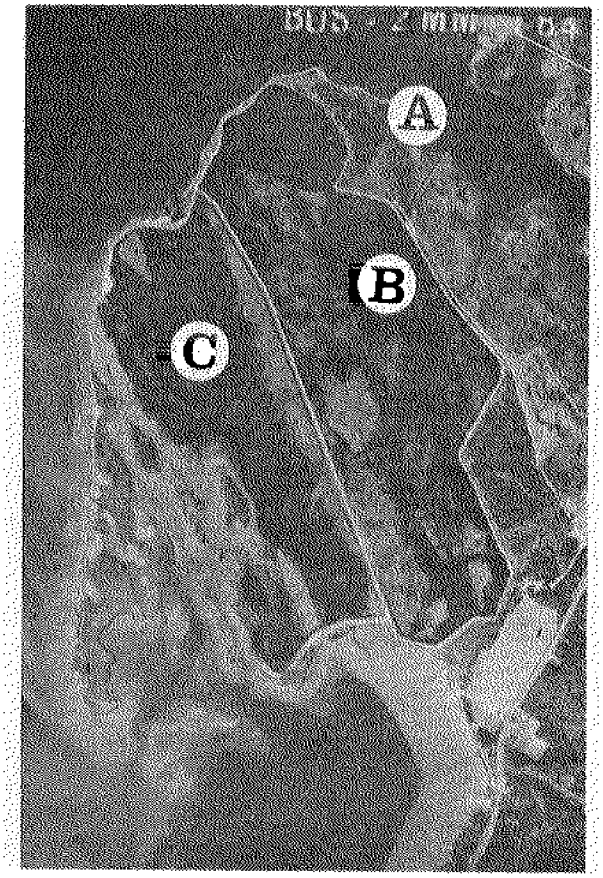


Fig. 3 AERIAL VIEW OF THE OTWAY IMPOUNDMENT, 1970. A = NATURAL MARSH, B = IMPOUNDMENT, C = PARTIALLY CONSTRUCTED IMPOUNDMENT. A COMPARISON OF THIS PHOTOGRAPH AND FIG. 4 SHOWS THAT MUCH OF THE AREA WITHIN THE IMPOUNDMENT WHICH WAS OPEN WATER IS NOW DOMINATED BY THE EMERGENT VEGETATION, TYPHA.

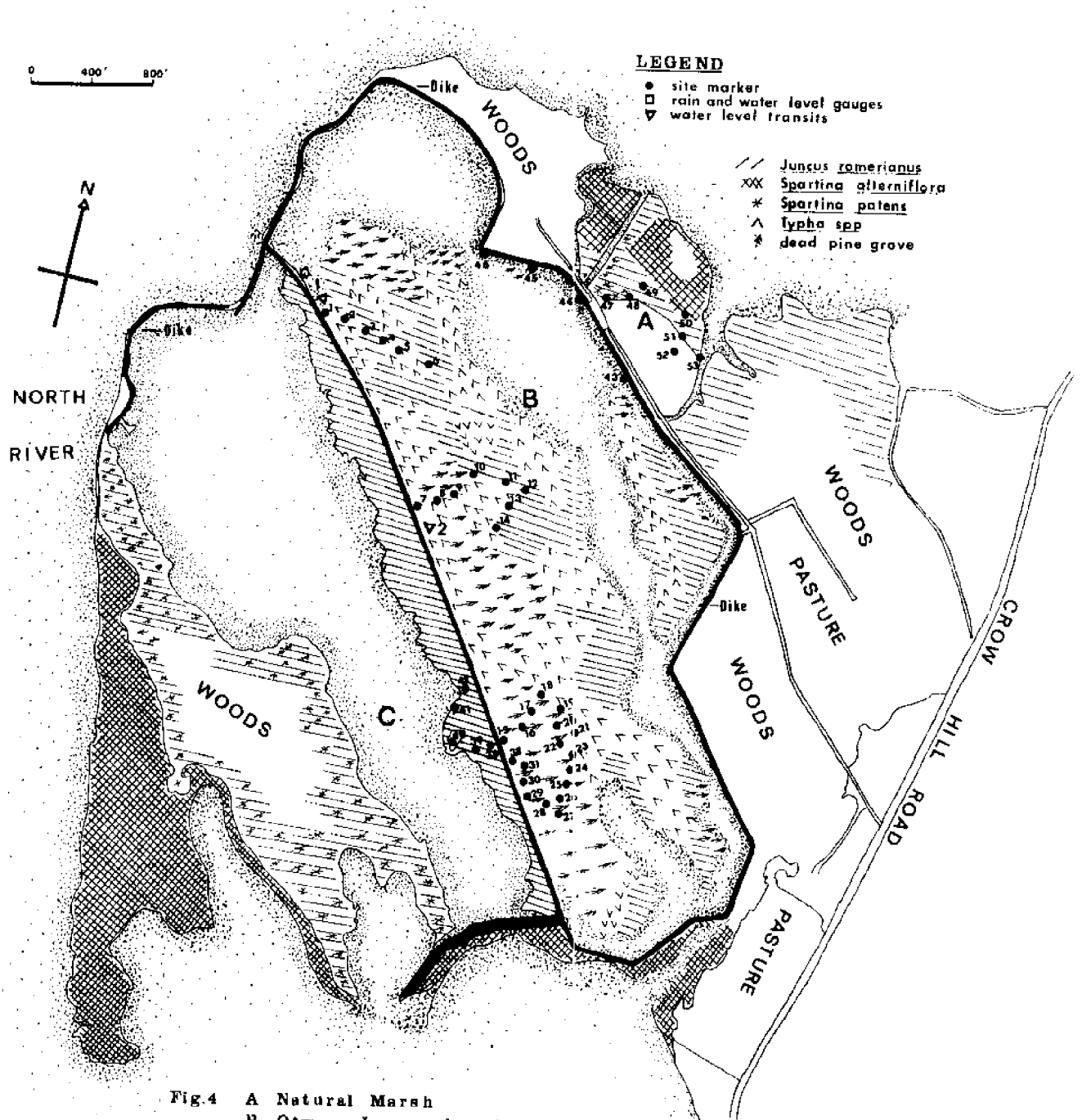


Fig.4 A Natural Marsh
B Otway Impoundment
C Partially Constructed Impoundment

FIG. 5 THIS SAMPLING SITE DOMINATED BY JUNCUS ROEMERIANUS AND DISTICHLIS SPICATA WAS TYPICAL OF THOSE SITES LOCATED WITHIN THE PARTIALLY CONSTRUCTED IMPOUNDMENT. THE EXISTING DIKES OBSTRUCTED THE TIDAL FLOW TO SUCH A DEGREE THAT ONLY THE OUTER EDGE OF THE MARSH FLOODED.

FIG. 6 AT THE BEGINNING OF THE SAMPLING PERIOD, MUCH OF THE MARSH WAS OPEN WATER WITH SCATTERED EMERGENT VEGETATION. AS THE WATER LEVEL RECEDED, AREAS SUCH AS THIS WERE COMMON. FRESH WATER EMERGENT VEGETATION, BACOPA MONNIERI,, AND THE DEAD JUNCUS ROOTS DEMARK THE RECEDED WATER LEVEL. AREAS COVERED IN CATTAILS WERE ESSENTIALLY OPEN WATER AT THE START OF THE STUDY PERIOD. THESE AREAS SUPPORTED A POPULATION OF FRESH WATER BASS BUT AS THE WATER LEVEL DROPPED, THE FISH MIGRATED TO THE DEEPER WATER.

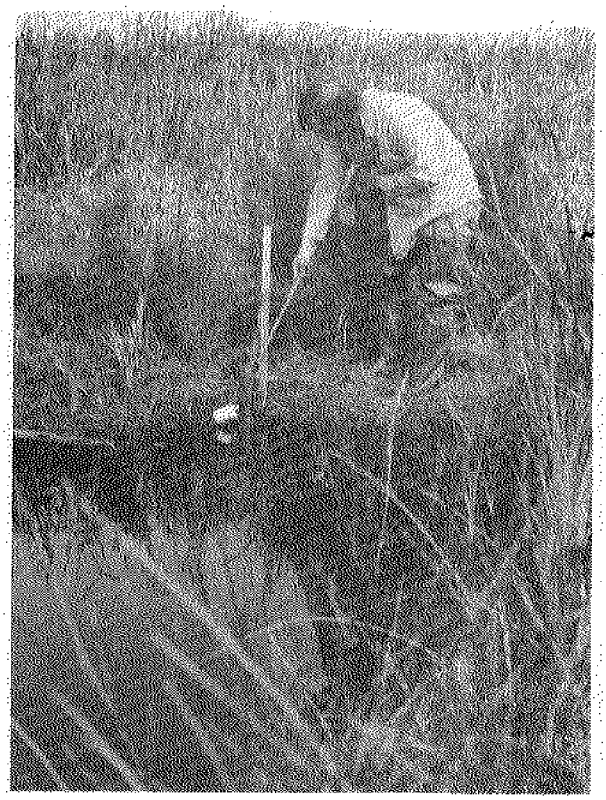


FIG. 7 SITE NO. 2 WAS LOCATED BESIDE A RIDGE INSIDE THE IMPOUNDMENT. THE VEGETATION CONSISTED OF B. MONNIERI AND D. SPICATA. DURING THE FIRST TWO MONTHS MOSQUITO BREEDING OCCURRED. THE WATER LEVEL DROPPED SIX INCHES LEAVING THE SITE COMPLETELY OUT OF WATER. WITH THIS DROP IN WATER LEVEL THERE WAS A DISCONTINUATION OF MOSQUITO BREEDING. THE NATURAL RIDGE IN THE STUDY PERIOD WAS SURROUNDED COMPLETELY BY OPEN WATER. DURING THE COURSE OF THE STUDY, CATTAILS EMERGED TO COMPLETELY COVER THE AREA.

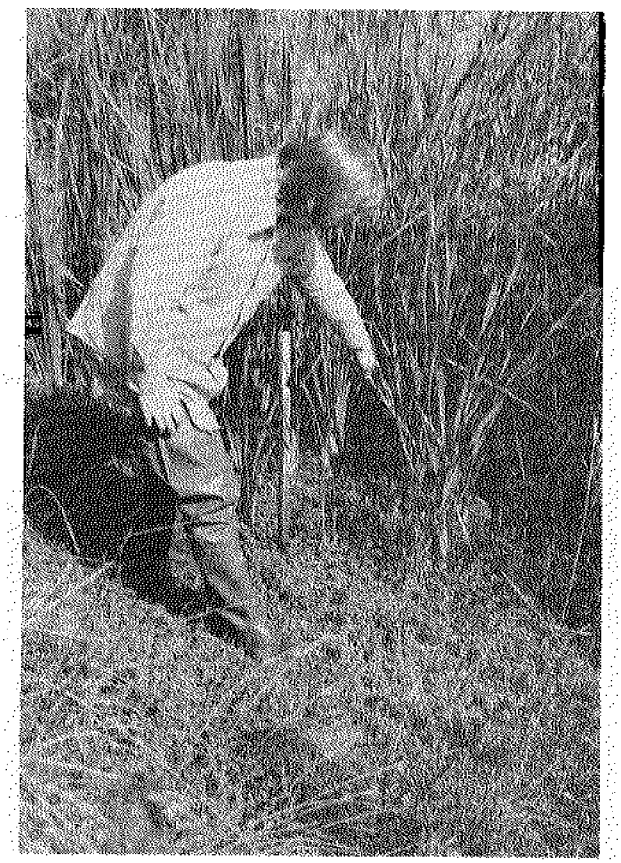


FIG. 8 SITE NO. 7 WAS LOCATED ALONG THE BASE OF THE IMPOUNDMENT DIKE. THE DOMINENT VEGETATION WAS BACOPA MONNIERI. AT THE START OF THE SAMPLING PERIOD, THE SITE WAS UNDER SIX INCHES OF WATER. THROUGHOUT THE SAMPLING PERIOD THE WATER LEVEL RECEDED FROM THE DIKE UNTIL THE VEGETATION WAS OUT OF WATER. AS THE WATER LEVEL RECEDED, THERE WAS A CORRESPONDING DROP IN THE LATTER PART OF THE SAMPLING PERIOD, PRODUCING NO LARVAE AFTER THE INITIAL SAMPLINGS.

TOTAL NO. LARVAE	62	MEAN WATER DEPTH	1.09 inches
BREEDING INDEX	.809	SALINITY (%)	0

Fig.9 Water Depth Gauge Readings in the Otway Impoundment, Carteret County, N.C. 1974.

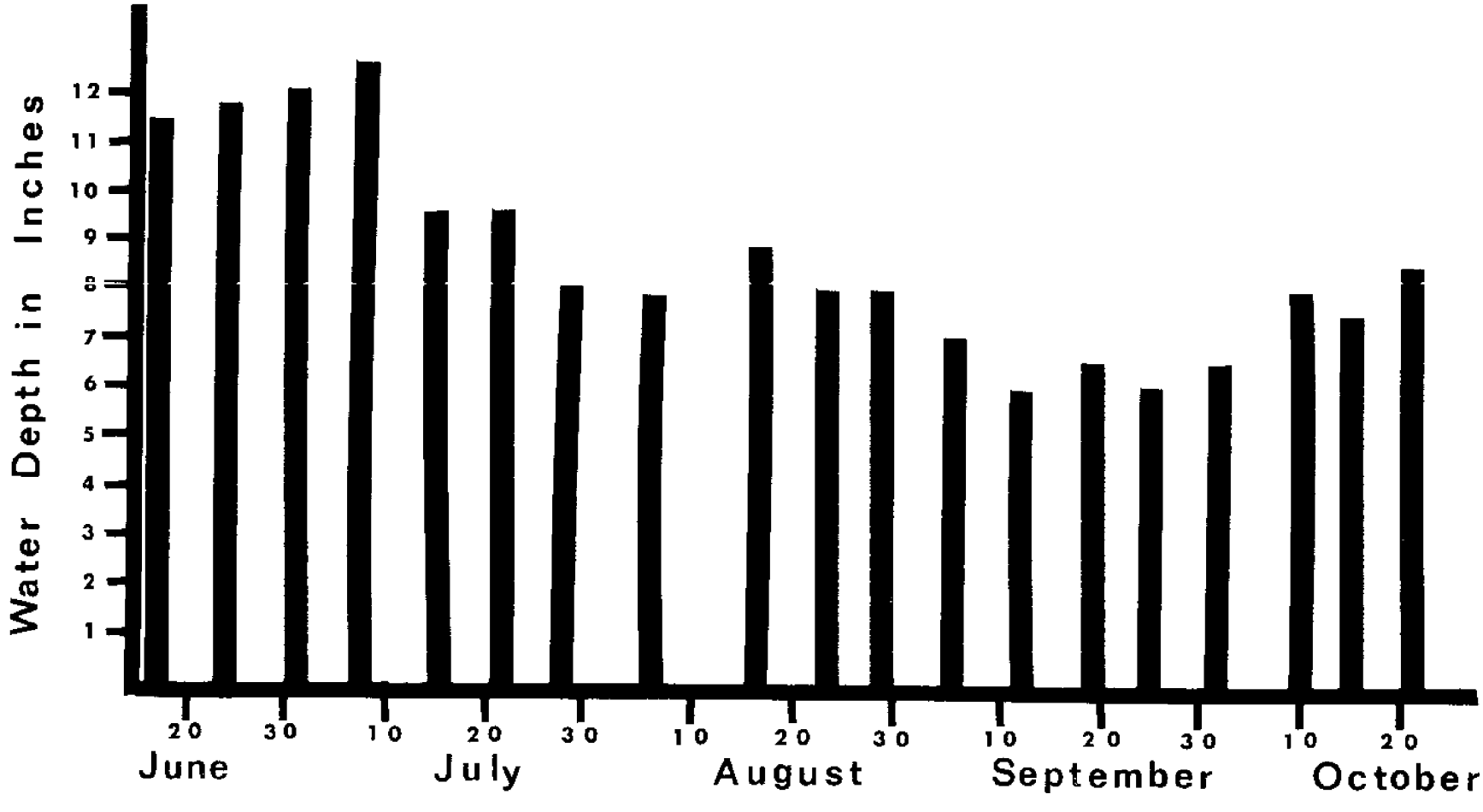


Fig.10 Water Depths Along Transit Number One Within The Otway Impoundment, Carteret County, N.C. 1974.

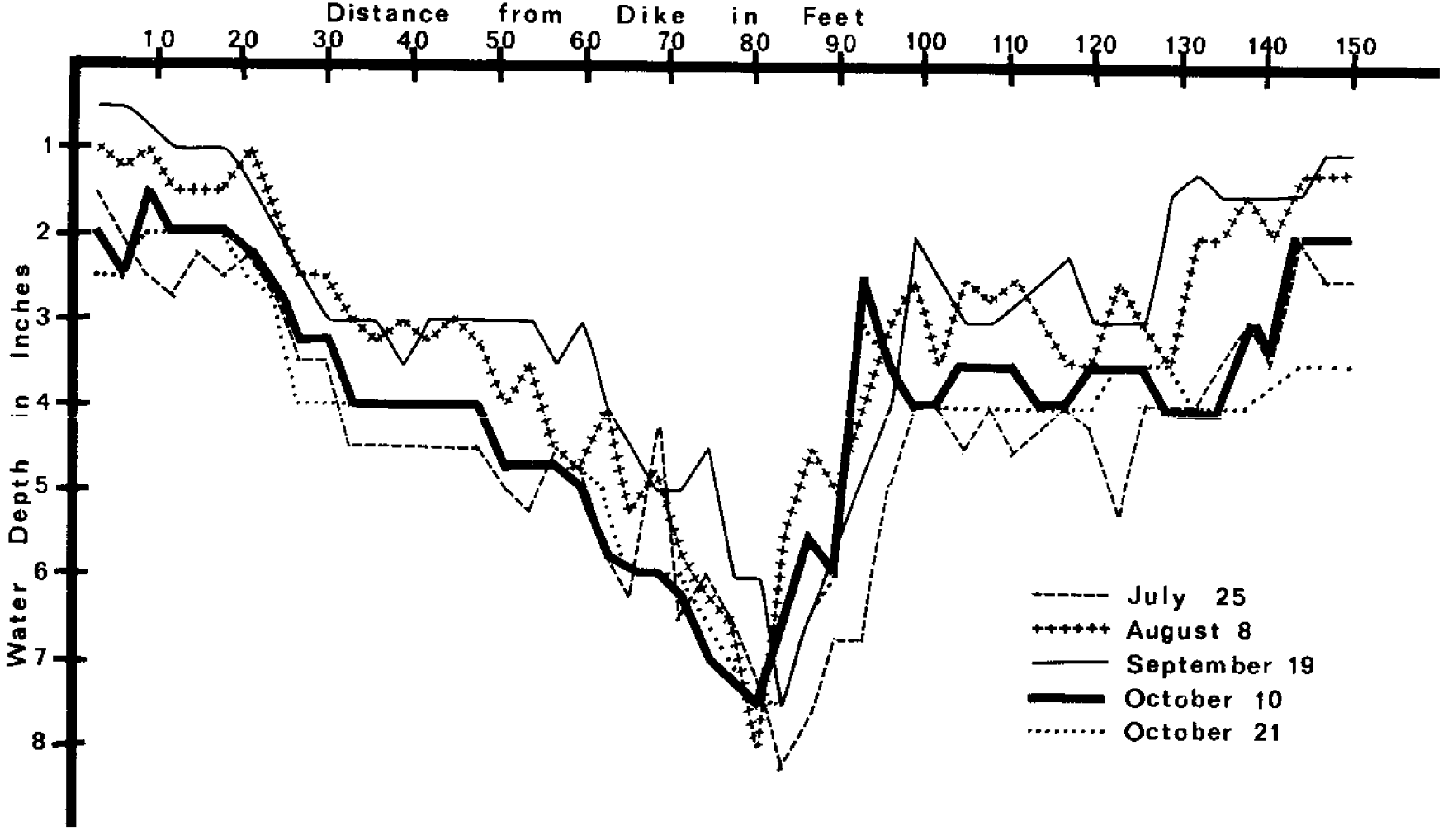


Fig.11 Water Depths Along Transit Number Two Within The Otway Impoundment, Carteret County, N.C. 1974.

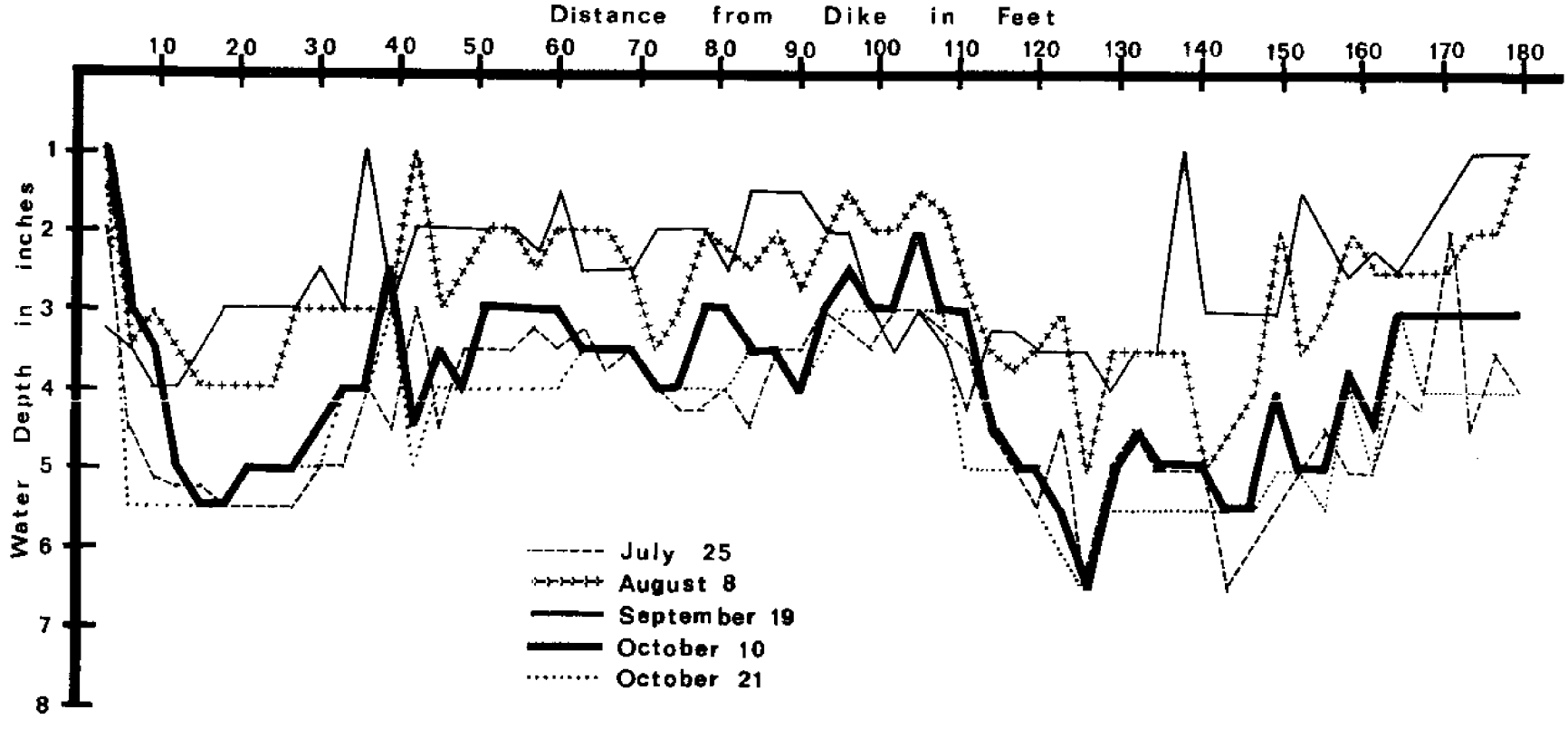
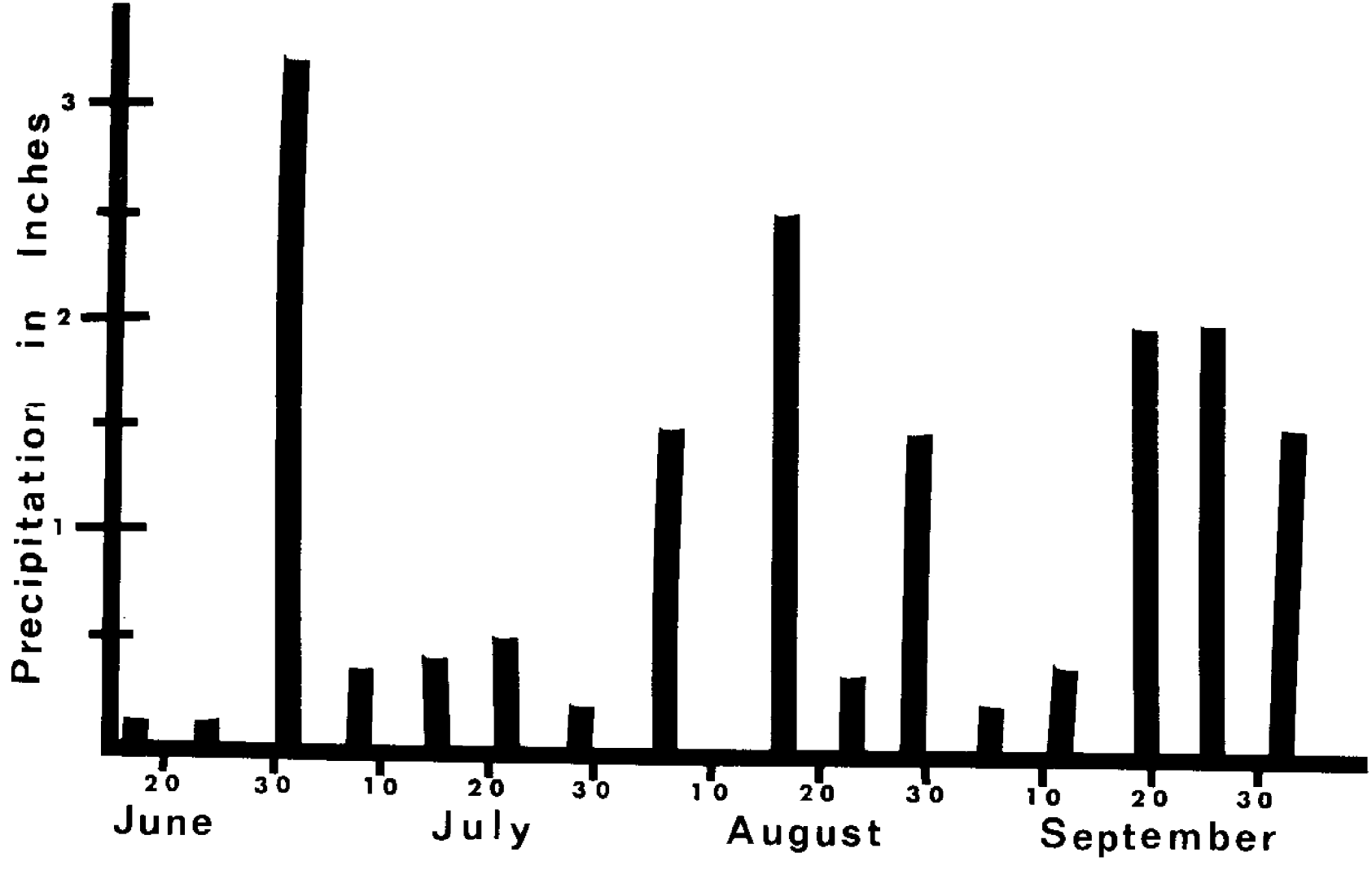


FIG. 12 SITES 15-33 WERE LOCATED IN A DEAD PINE GROVE AT THE SOUTHEAST END OF THE IMPOUNDMENT. ALL OF THE SITES IN THE DEAD PINE GROVE WERE TREE STUMP HOLES RANGING IN DEPTH FROM 3 TO 6.5 INCHES. MOSQUITO LARVAE WERE FOUND IN THIS AREA FOLLOWING HEAVY RAINS. OSPREY NESTS, SUCH AS THE ONE SHOWN IN THE BACKGROUND, WERE ABUNDANT. NOW, MOST OF THE LARGE TREES SUITABLE FOR NESTING SITES HAVE FALLEN.

Fig.13 Rainfall Data at the Otway Impoundment, Carteret Co. 1974.



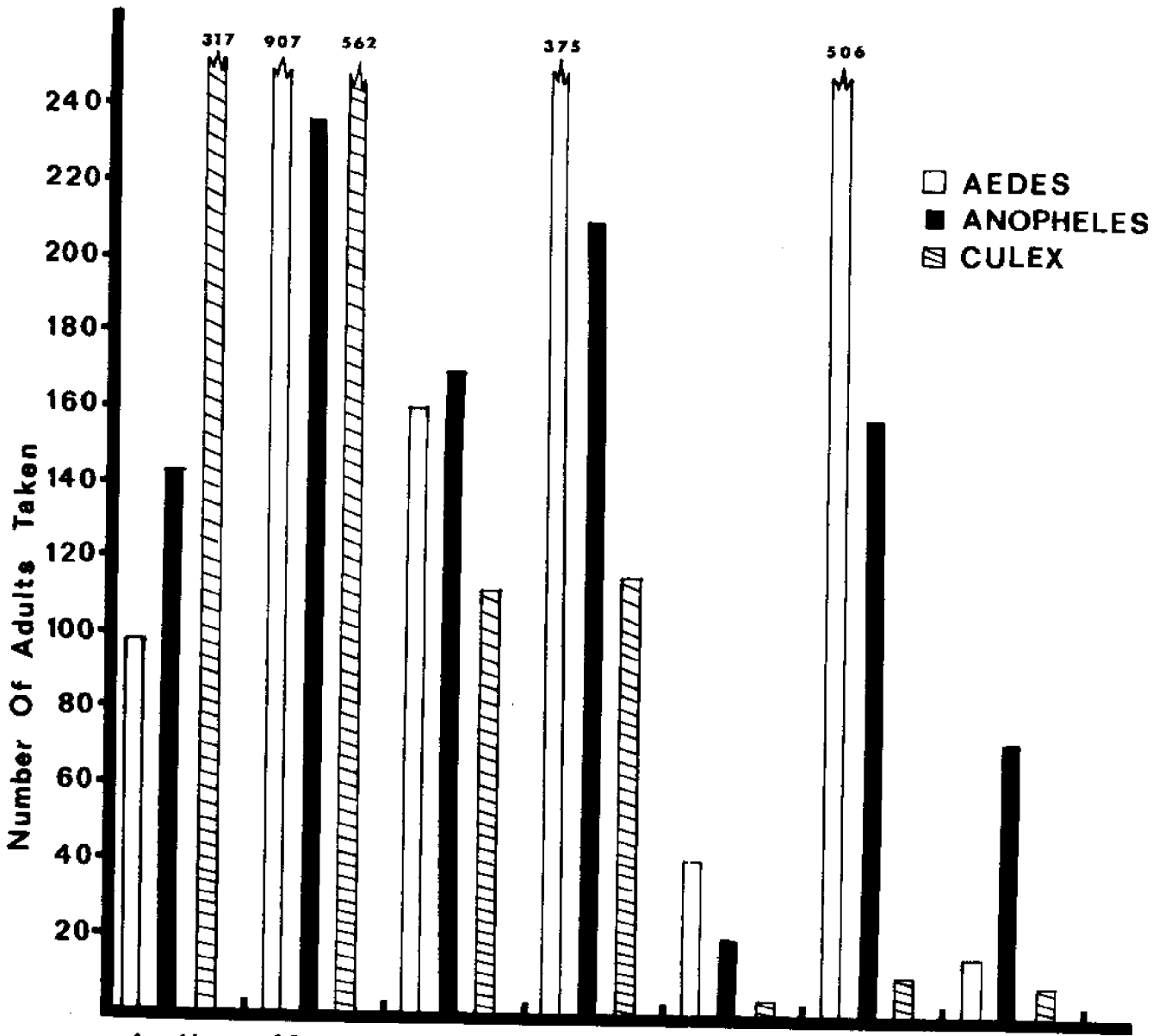


Fig.14 Total Number of Adults Taken per Month at the Davis, N.C. Light Trap

Fig.15 Average Number of Mosquitoes Taken Per Light Trap Night Per Collection at the Davis Light Trap, Carteret County, N.C. 1974.

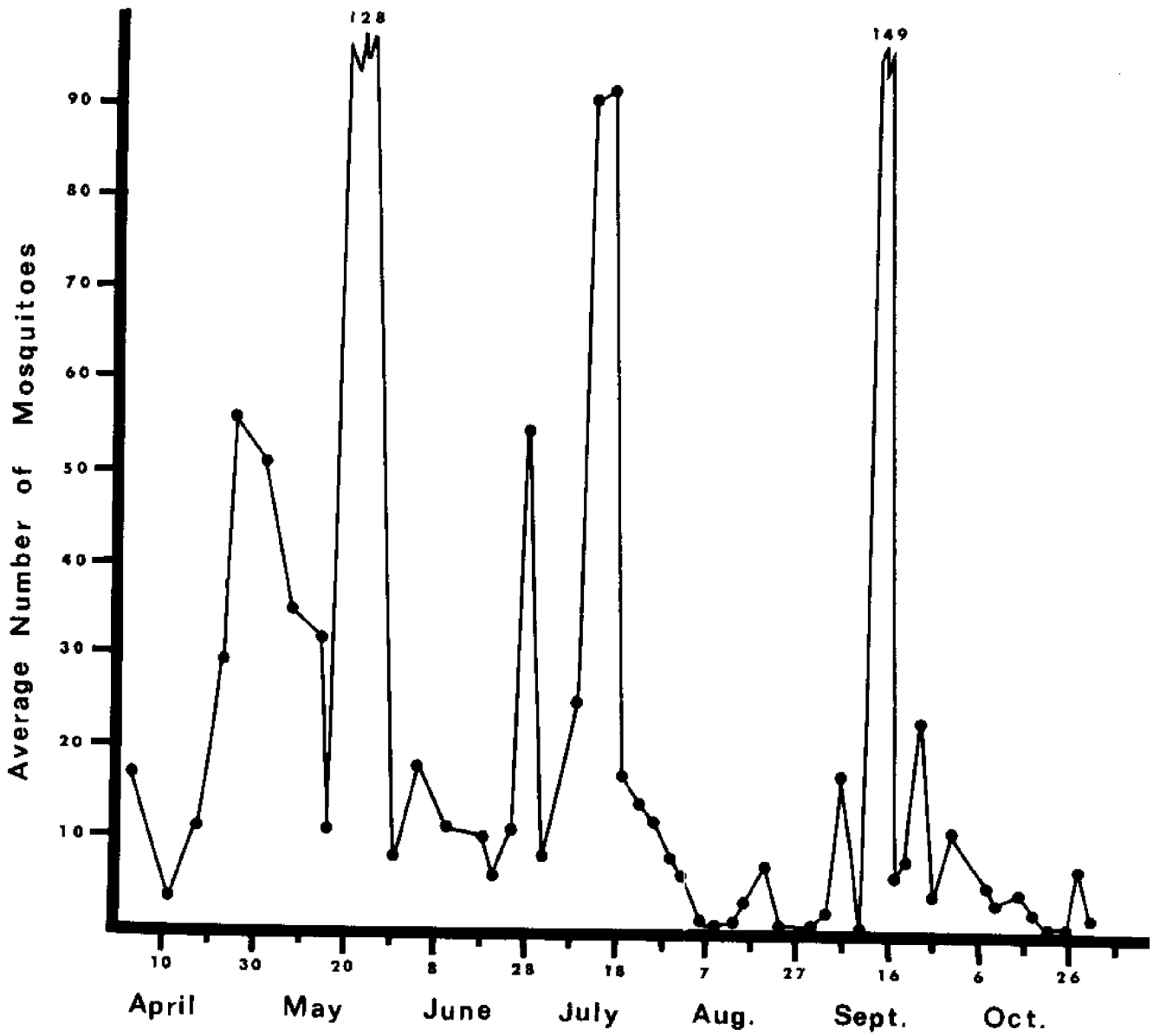


TABLE 1. SUMMARY OF PHYSICAL AND VEGETATIVE DATA FOR THE OTWAY IMPOUNDMENT AND ADJACENT STUDY AREAS, CARTERET COUNTY, NORTH CAROLINA, 1974.

	PHYSICAL DATA MEAN (RANGE)		
	NATURAL MARSH	IMPOUND-MENT	PARTIALLY CONSTRUCTED IMPOUNDMENT
Surface Area (ft.)	21.1	15.6	63
Site Water Depth (inch)	.07 (0-6.5)	1.09 (0-7.3)	0.2 (0-1)
Salinity (0/00)	19.1 (0-32)	0 (0)	6.4 (0-32)
	VEGETATIVE COVER (PERCENT)		
Juncus roemerianus	67.1	1.1	57.8
Spartina patens	29.1	49.9	20.0
Bacopa monnieri	0	22.8	0

TABLE 2 SUMMARY OF MOSQUITO ABUNDANCE FOR 37 LARVAL SAMPLING SITES IN THE OTWAY IMPOUNDMENT, CARTERET COUNTY, NORTH CAROLINA, 1974.

FIELD COUNTS	
Total No. Specimens collected	449
Total No. 1st and 2nd Instar larvae	292
Total No. 3rd and 4th Instar larvae	150
Total No. Pupae	7

LABORATORY IDENTIFICATIONS	
Anopheline species	71
Culicine species	18
Anopheles bradleyi	20
Anopheles atropos	2
Aedes sollicitans	2
Culex species	2

APPENDIX

Table 1. Mosquito Abundance for each site in the Natural Marsh, Otway, North Carolina, 1974 (Total of 10 dips per site)

Site No.	June		July					August				September				October			
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21
47	-	0	-	0	0	0	-	0	0	0	0	-	-	0	0	0	0	0	0
48	-	-	-	-	0	0	-	0	0	0	0	-	-	0	0	0	0	0	0
49	-	-	-	-	0	0	-	0	0	0	0	-	-	0	0	0	0	0	0
50	-	-	-	-	0	0	-	0	0	0	0	-	-	0	0	0	0	0	0
51	-	-	-	-	-	0	-	-	-	0	0	-	-	0	0	0	0	-	0
52	-	0	-	0	-	-	-	0	0	-	-	-	-	-	-	-	-	-	0
53	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	-	0

NOTE: Negative (-) sign indicates that the site was dry at the time of sampling.

Table 2. Mosquito Abundance for each site in the Otway Impoundment, Otway, North Carolina, 1974. (Total of 10 dips per site)

Site No.	June		July					August				September				October			
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21
1	2	5	15	0	0	0	2	0	0	0	0	0	-	-	-	-	0	0	0
2	7	8	0	2	2	0	0	0	0	0	0	0	-	0	0	2	0	0	0
3	10	0	2	0	14	0	2	0	0	0	0	0	-	0	0	0	0	0	0
4	8	3	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-
5	5	0	1	2	1	0	8	0	1	0	0	0	-	0	0	0	0	0	0
6	17	4	1	0	14	7	4	5	0	0	0	0	-	0	-	-	0	0	0
7	14	1	2	9	28	0	0	8	0	0	0	-	-	-	-	-	0	-	-
8	9	4	2	9	0	0	2	5	0	0	0	-	-	-	-	-	-	-	-
9	0	0	0	0	6	0	-	-	0	-	-	-	-	-	-	-	0	-	-
10	11	4	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
11	7	0	0	0	0	4	-	-	-	-	-	-	-	-	-	-	-	-	-
12	55	13	10	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
13	13	0	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
14	36	-	3	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	0	-	-	-	-	-	-	-	-	-	-	0	-	-	0	-	0
16	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
18	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
19	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
20	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
21	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
22	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
23	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
24	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
25	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
26	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
27	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
28	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
29	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
30	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
31	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
32	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
33	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0
43	-	33	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
46	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Mosquito Abundance for each site in the Partially Constructed Impoundment, Otway, North Carolina, 1974 (Total of 10 dips per site)

Site No.	June		July					August				September				October			
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	0
42	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Physical Characteristics for larval sampling sites within the Natural Marsh, Otway, North Carolina, 1974.

Site	Surface Area ($ft.^2$)	Depth of Water (inches)		Salinity Range (%)	Breeding Index	
		Mean	Range		Mean	Range
47	12	.627	1.0 - 2.75	0 - 32	0.0	0.0 - 0.0
48	12	.767	0.0 - 3.0	0 - 32	0.0	0.0 - 0.0
49	42	1.82	0.0 - 7.0	22 - 32	0.0	0.0 - 0.0
50	54	1.17	0.0 - 6.5	22 - 32	0.0	0.0 - 0.0
51	12	.056	0.0 - 2.0	22 - 32	0.0	0.0 - 0.0
52	12	1.03	0.0 - 5.0	22 - 32	0.0	0.0 - 0.0
53	4	.030	0.0 - 1.5	22 - 32	0.0	0.0 - 0.0

Table 5. Physical Characteristics for larval sampling sites within the Otway Impoundment, Otway, North Carolina 1974.

Site Number	Surface Area ($ft.^2$)	Depth of Water (inches)		Salinity Range (%)	Breeding Index	
		Mean	Range		Mean	Range
1	12	2.09	2.0 - 6.5	0	.077	0.0 - 1.08
2	18	4.55	1.0 - 5.25	0	.076	0.0 - .378
3	12	3.89	1.75 - 7.25	0	.034	0.0 - .36
4	9	1.38	0.0 - 5.0	0	.019	0.0 - .288
5	4	3.62	2.0 - 7.0	0	.009	0.0 - .09
6	9	1.54	0.0 - 5.5	0	.151	0.0 - 1.22
7	36	1.09	0.0 - 6.0	0	.809	0.0 - 9.32
8	24	3.17	1.5 - 7.5	0	.166	0.0 - 1.51
9	6	1.45	0.0 - 7.5	0	.011	0.0 - .216
10	24	1.45	0.0 - 6.0	0	.092	0.0 - 1.44
11	12	1.27	0.0 - 3.25	0	.031	0.0 - .504
12	81	1.26	0.0 - 4.0	0	2.45	0.0 - 40.1
13	9	1.10	0.0 - 4.0	0	.04	0.0 - .756
14	36	1.04	0.0 - 4.0	0	.528	0.0 - 9.72
15	4	.561	0.0 - 6.5	0	0.0	010 - 0.0
16	6	.525	0.0 - 5.23	0	0.0	0.0 - 0.0
17	9	.535	0.0 - 5.5	0	.007	0.0 - .135
18	6	.877	0.0 - 5.5	0	0.0	0.0 - 0.0
19	1	.342	0.0 - 3.5	0	0.0	0.0 - 0.0
20	1	.376	0.0 - 4.0	0	0.0	0.0 - 0.0
21	2	.338	0.0 - 3.5	0	0.0	0.0 - 0.0
22	4	.372	0.0 - 4.0	0	0.0	0.0 - 0.0
23	6	.368	0.0 - 4.0	0	0.0	0.0 - 0.0
24	2	.458	0.0 - 5.0	0	0.0	0.0 - 0.0
25	24	.273	0.0 - 3.0	0	0.0	0.0 - 0.0
26	6	.295	0.0 - 3.0	0	0.0	0.0 - 0.0
27	2.5	.295	0.0 - 3.0	0	0.0	0.0 - 0.0
28	20	.373	0.0 - 4.5	0	0.0	0.0 - 0.0
29	20	.304	0.0 - 3.5	0	0.0	0.0 - 0.0
30	4	.326	0.0 - 4.0	0	0.0	0.0 - 0.0
31	1	.210	0.0 - 3.0	0	0.0	0.0 - 0.0
32	4	.317	0.0 - 3.5	0	0.0	0.0 - 0.0
33	20	.338	0.0 - 5.0	0	0.0	0.0 - 0.0
43	72	1.44	3.5 - 5.5	0	1.0	0.0 - 19.01
44	63	1.28	2.0 - 3.5	0	0.0	0.0 - 0.0
45	3	.732	1.0 - 4.0	0	0.0	0.0 - 0.0
46	64	.725	1.0 - 2.5	0	0.0	0.0 - 0.0

Table 6. Physical Characteristics for larval sampling sites within the Partially Completed Impoundment, Otway, North Carolina, 1974.

Site Number	Surface Area ($ft.^2$)	Depth of Water (inches)		Salinity Range (%)	Breeding Index	
		Mean	Range		Mean	Range
38	81	0	0	0	0	0.0 - 0.0
39	72	0	0	0	0	0.0 - 0.0
40	150	.101	0 - 1.0	0 - 32	0	0.0 - 0.0
41	6	0	0	0	0	0.0 - 0.0
42	6	0	0	0	0	0.0 - 0.0

Table 7. The Standing Water Level for each larval sampling site in the Natural Marsh, Otway, North Carolina, 1974 (Measured in inches).

Site	June		July					August				September				October				
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21	
47	-	1.0	-	1.0	1.0	2.0	-	1.5	1.0	2.0	2.5	-	-	2.7	1.0	1.0	1.5	1.0	2.0	
48	-	-	-	-	1.5	1.6	-	1.5	1.0	2.0	2.5	-	-	3.0	1.0	1.0	1.5	1.0	2.0	
49	-	-	-	-	5.0	6.0	-	6.0	6.0	6.0	7.0	-	-	7.0	5.5	6.0	7.0	6.5	7.0	
50	-	-	-	-	2.0	6.2	-	3.0	3.0	2.0	2.0	-	-	4.0	3.2	3.5	4.0	4.0	5.0	
51	-	-	-	-	-	2.0	-	-	-	1.5	1.0	-	-	2.0	1.5	.5	1.0	-	1.5	
52	-	5.0	-	5.0	-	-	-	1.0	1.0	-	-	-	-	-	-	-	-	-	1.0	
53	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	1.0	-	1.5	

NOTE: Negative (-) sign indicates that the site was dry at the time of sampling.

Table 8. The Standing Water Level for each larval sampling site in the Otway Impoundment, Otway, North Carolina, 1974.

Site No.	June		July					August				September				October			
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21
1	5.5	4.7	5.4	6.5	3.5	3.5	2.0	3.0	4.0	3.0	3.0	.5	-	-	-	-	2.5	2.0	3.5
2	1.0	3.1	3.0	2.0	1.5	3.6	5.2	5.0	5.5	5.5	5.5	3.0	-	1.0	1.0	1.0	4.0	3.0	5.0
3	5.5	4.0	7.0	4.7	7.2	6.0	7.0	3.0	5.0	5.0	5.0	4.0	-	2.0	2.0	1.7	3.0	3.0	3.0
4	1.0	1.0	3.0	2.2	-	5.0	1.5	2.5	4.0	4.0	4.0	2.0	-	-	-	-	-	-	-
5	5.5	4.0	7.0	7.0	6.0	4.5	3.5	3.5	4.5	4.5	4.5	2.0	-	2.5	2.5	2.0	2.0	2.0	3.0
6	5.5	3.1	5.0	3.0	5.0	4.0	3.0	2.0	3.0	2.5	2.5	1.0	-	1.5	1.5	-	3.0	2.5	4.0
7	5.5	4.0	6.0	5.0	3.0	1.0	1.0	1.5	2.0	2.0	2.0	-	-	-	-	-	-	-	-
8	7.5	5.0	7.0	4.0	5.0	4.0	2.0	2.5	3.0	2.0	2.0	-	-	-	-	-	1.5	-	-
9	7.5	3.1	6.0	4.0	4.0	2.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-
10	3.2	3.1	6.0	4.5	2.5	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
11	3.2	2.1	3.0	2.0	1.0	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-
12	3.2	3.1	4.0	4.0	2.5	3.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-
13	3.2	1.0	4.0	3.5	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	3.2	-	4.0	4.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	5.0	-	-	-	-	-	-	-	-	-	-	3.2	-	-	5.0	-	6.5
16	-	-	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	5.0
17	-	-	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	3.5
18	-	-	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2	-	3.5
19	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	-	1.5
20	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	2.0
21	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	2.0
22	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	1.0
23	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	2.0
24	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	1.0
25	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	1.0
26	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	2.0
27	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	2.0
28	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	4.5
29	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	3.5
30	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	4.0
31	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	1.5
32	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	-	3.5
33	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	3.0
43	-	5.0	5.5	5.0	4.0	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	3.5	3.2	3.5	2.5	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	4.0	4.0	4.0	1.5	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
46	2.0	2.0	2.5	2.0	1.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 9. The Standing Water Level for each larval sampling site in the Partially Constructed Impoundment, Otway, North Carolina, 1974 (Measured in inches)

Site	June		July					August				September				October			
	17	24	1	8	15	22	29	6	16	23	29	5	12	19	25	2	10	15	21
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	.25	-	1.0	-	-	1.0
41	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE: Negative (-) sign indicates that the site was dry at the time of sampling.

Table 10. Vegetative cover for larval sampling sites within the Natural Marsh, Otway, North Carolina, 1974.

Site Number	Plant Cover %			
	Juncus roemerianus	*Spartina patens*	*Distichlis spicata*	*Borrichia frutescens*
47	100	0	0	0
48	99	0	0	1
49	1	90	5	3
50	100	0	0	0
51	80	4	15	1
52	85	15	0	0
53	5	95	0	0

Table 11. Vegetative cover for larval sampling sites within the Otway Impoundment, Otway, North Carolina, 1974.

Site No.	Juncus roemerianus	Spartina patens	Distichlis spicata	Typha sp.	Fimbristylis spadicea	Pluchea foetida	Bacopa monnieri	Centella asiatica	Solidago tenuifolia
	Plant Cover %								
1	0	0	3	0	0	0	97	0	0
2	0	0	100	0	0	0	0	0	0
3	0	0	15	0	0	0	85	0	0
4	0	0	10	0	0	0	90	0	0
5	0	0	5	94	0	0	1	0	0
6	0	0	95	5	0	0	0	0	0
7	0	0	0	2	0	0	98	0	0
8	0	100	0	0	0	0	0	0	0
9	0	0	0	2	0	0	98	0	0
10	3	96	0	1	0	0	0	0	0
11	0	100	0	0	0	0	0	0	0
12	0	100	0	0	0	0	0	0	0
13	0	0	0	0	0	0	100	0	0
14	0	100	0	0	0	0	0	0	0
15	0	95	0	0	0	0	0	5	0
16	0	99	0	0	0	0	0	1	0
17	0	94	0	0	0	0	0	1	5
18	0	84	0	0	1	0	0	15	0
19	0	100	0	0	0	0	0	0	0
20	0	100	0	0	0	0	0	0	0
21	0	100	0	0	0	0	0	0	0
22	0	99	0	1	0	0	0	0	0
23	0	97	0	3	0	0	0	0	0
24	0	100	0	0	0	0	0	0	0
25	0	100	0	0	0	0	0	0	0
26	0	98	0	1	0	0	0	1	0
27	0	0	0	98	0	0	0	2	0
28	0	0	0	0	1	0	0	99	0
29	0	10	0	2	25	0	0	63	0
30	0	40	0	0	3	0	0	57	0
31	0	95	0	0	0	0	0	5	0
32	0	22	0	0	2	0	0	76	0
33	0	10	0	0	5	10	0	75	0
43	1	0	89	10	0	0	0	0	0
44	15	5	0	0	0	0	80	0	0
45	0	0	0	0	0	0	100	0	0
46	3	2	0	0	0	0	95	0	0

Table 12. Vegetative cover for larval sampling sites within the Partially Constructed Impoundment, Otway, North Carolina, 1974.

Site No.	Plant Cover %					
	Salicornica virginica	*Juncus roemerianus*	*Spartina patens*	*Distichlis spicata*	*Fimbristylis spadicea*	*Borrichia frutescens*
38	0	3	95	0	2	0
39	20	89	0	0	0	1
40	83	2	0	15	0	0
41	0	100	0	0	0	0
42	0	95	5	0	0	0