AQUATIC ECOLOGICAL PARAMETERS ASSOCIATED WITH SALT MARSH MOSQUITO DITCH SYSTEMS

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Abstract: Water quality and aquatic fauna associated with ditching systems dug in 1968 and in 1972 in an irregularly flooded marsh were studied. Salinity, pH, temperature, dissolved oxygen, were determined monthly. Dissolved oxygen was lowest at the upper ends of the ditches. Organic matter seemed to have been built up at the upper ends of the ditches due to inadequate tidal flushing. Mats of submersed vegetation hindered tidal flow which reduced the flushing effectiveness of the tides. Water quality differences between the upper and lower portions of the ditches seemed to be physical rather than biological. Organisms collected were typical estuarine species. There were no significant benefits from the ditches other than to control mosquitoes.

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As early as 1888 work was initiated to reclaim considerable acreages of the fresher tidal lands for agricultural purposes. These early reclamaation attempts were primarily involved with the construction of systems of dikes and ditches for salt hay for livestock.

Alteration of the marshes to control mosquitoes was first begun in 1912 along the New Jersey coast and by 1938 similar mosquito control activities had begun in other states. Bourne and Cottam (1950) reported that sportsmen and conservationists began objecting to the practices of altering the marshes to control mosquitoes. Their objections were based on the contentions that these mosquito control systems released water polluting gases that killed the spawn of game fishes; that the ditches drained the ponds where waterfowl fed; and that the drainage ditches were death traps for young waterfowl.

Nelson (1934) reported that excessive silt destroyed oyster beds following ditching through marshes for mosquito control. He stated that the mud and silt suffocated the oysters, as well as certain lethal quantities of hydrogen sulfide gas.

The control of mosquitoes may be accomplished by using one or a combination of several methods. Provost (1967) reported that *Aedes* mosquito reproduction can be prevented in several ways, which includes (a) landfilling of the marsh to a level above spring high tides, (b) dewatering of the marsh to prevent oviposition or larval growth, (c) keeping the marsh flooded to prevent oviposition, and (d) assuring that no water stands over the surface of the marsh for more than two or three days while permitting free access to larvivorous fishes such as *Gambusia affinis* to all ramaining standing waters.

A mosquito control method that involves alteration of the marsh will undoubtly upset the natural ecology of the system in order to destroy breeding habitat for mosquitoes. Along the Mississippi Gulf Coast, Hancock County, in particular, ditches have been dug to reduce the mosquito breeding habitat in the coastal marshes. These ditches are about 3.7 m wide and 1.8 m to 2.4 m deep and may range in length from 30 m to over 1.6 km. This study was concerned with the water quality and the aquatic organisms associated with these ditches rather than the effectiveness of the ditches in controlling mosquitoes.

MATERIALS AND METHODS

Description of the study area

The study area is located in Hancock County, which is the most westerly county of coastal Mississippi. This marsh complex is part of the Coastal Plain Region and is considered an estuary of the Pearl River. Eleuterius (1973) described this complex as a saline marsh similar to the Pascagoula Estuary and other saline marshes along the Mississippi coast. The dominant vegetation of the Pearl River Estuary is needle rush (*Juncus roemerianus*). Other important marsh species include wire grass (*Spartina patens*), saltmarsh bulrush (*Scirpus robustus*), bay cane (*Spartina cynosuroides*) and saltgrass (*Distichlis spicata*). Man-made channels and lagoon levees are vegetated with sea myrtle (*Baccharis halimifolia*), marsh elder (*Iva frutescens*) and phragmites (*Phragmites communis*).

A map of the study area appears in Fig. 1. The 2 areas being studied for comparative purposes are: (1) a ditching system in irregularly flooded marsh dug in 1968, (2) a ditching system in irregularly flooded marsh dug in 1972. Salinities in the study area vary from freshwater to 15 ppt. The ditch system consists of the main mosquito ditch which was initially excavated to 3.7 m wide and 1.8-2.4 m deep. Lateral ditches, 1.8 m wide and 0.6 m deep, were constructed perpendicular to the main ditches. The length of a lateral ditch is approximately 9 m.

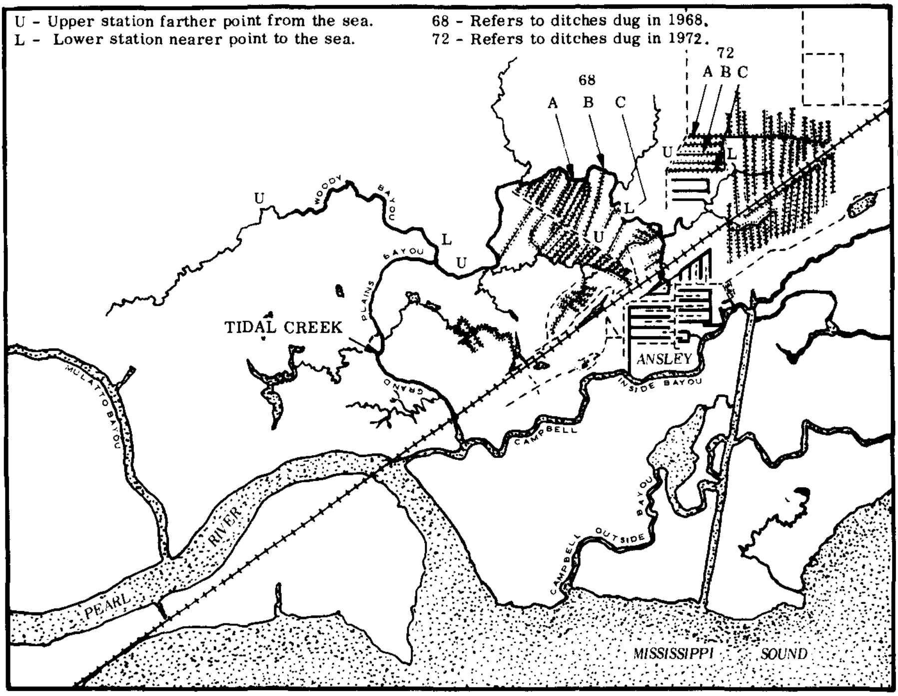

Fig. 1. Designated map of study area.

Water chemistry

Monthly samples were collected from the stations designated in Fig. 1. Prelimianry samples were collected during the month of March, 1976, to check field equipment and to identify sample stations. Routine sampling commenced in April, 1976 and continued through June, 1977. Salinity, pH, temperature, dissolved oxygen, and hydrogen sulphide were determined *in situ* at each station for both surface and bottom strata. Sub-surface or bottom water samples were collected using a horizontally fixed Kemmerer Water Sampler.

As indicated in Fig. 1, 3 ditches were studied in the 68 area and 3 ditches in the 72 area. At the upper and lower end of each ditch was a sampling station designated as U and L respectively. The upper station was farthest from tidal influence. Six stations from the 2 study areas were sampled each month. Since surface and bottom samples were taken, 24 samples were analyzed monthly for the parameters mentioned above.

Salinity was determined using a YSI Model 33 salinity-conductivity-temperature meter. A Markson Science Inc. Micro 50 pH meter was used to measure pH. Dissolved oxygen was measured using a YSI dissolved oxygen meter. Sulphides were measured colorimetrically using a Hach Hydrogen Sulphide Test Kit. Sampling times during the day were approximately the same at each station from one month to the next.

Trawl samples

Trawl samples from the mosquito ditches were taken using 1.8 m bobbinet trawl, hand drug through the lateral ditches. Trawling was done by hand to avoid disturbance by an outboard motor, which was prohibited. Samples were taken from the upper and lower ends of the 2 lateral ditches and the organisms from the 2 hauls consolidated in a plastic bag. The samples were placed in a cooler and transported to the laboratory where the organisms were separated as to species. Organisms were identified, counted, weighed and measured. Large homogenous samples were counted and their total weight recorded.

RESULTS

Water chemistry

Temperature (C) recorded during the study period from the 68 and 72 areas are shown on Fig. 2. Surface and bottom temperatures were either the same or 0.5C difference and

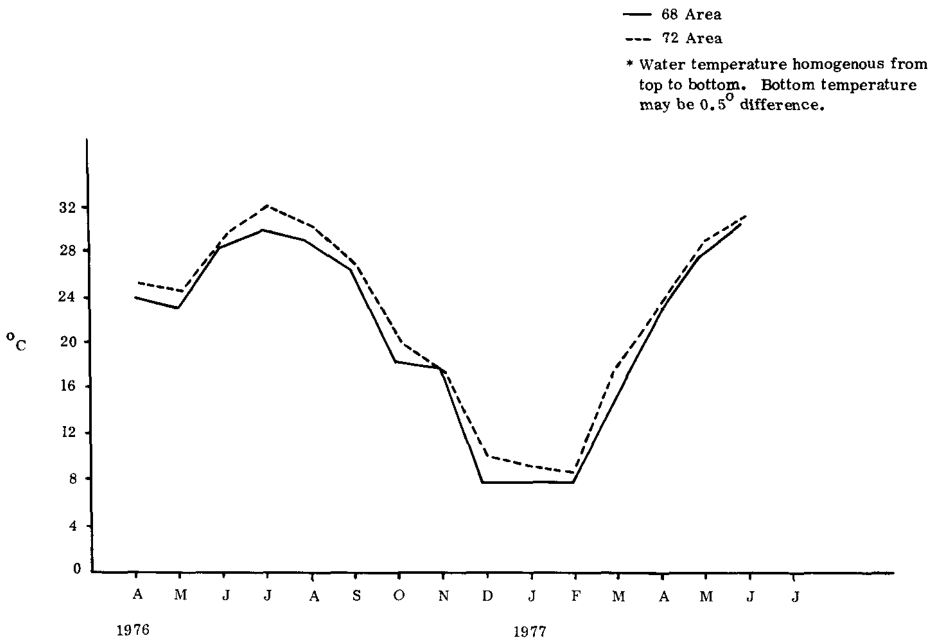

Fig. 2. Mean water temperature (°C) from the 68 Area and 72 Area between April, 1976 through June, 1977.

not distinguished on the figure. Salinities (ppt) recorded during the study period are shown on Figs. 3 and 4 for the 68 and 72 areas respectively. As illustrated, surface and bottom salinities were similar, the latter having only slightly higher salinities. Ranges and patterns of recorded temperature and salinity are typical of brackish marshes in Hancock County.

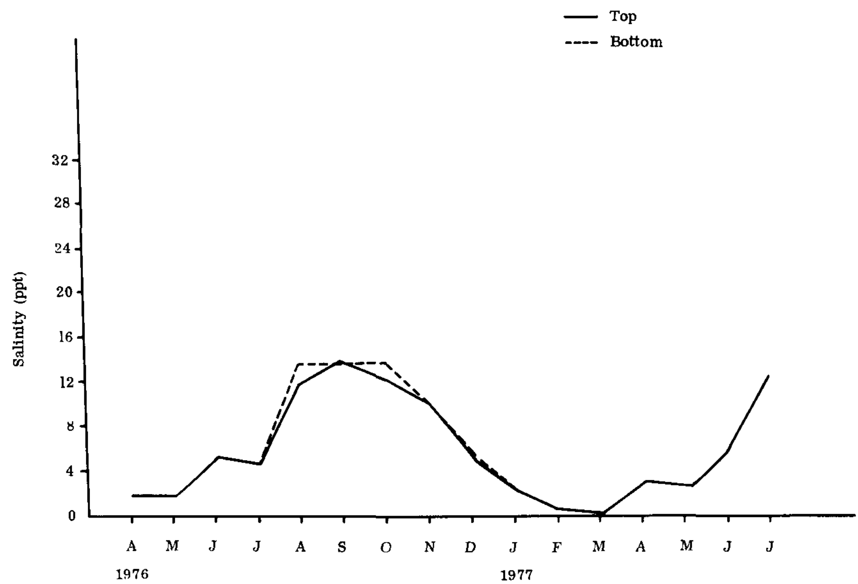

Fig. 3. Mean salinities (ppt) on the surface and bottom from the 68 Area between April, 1976 through July, 1977.

Monthly ranges of pH values taken from the 68 and 72 areas through the study period are shown on Table 1. Most pH values recorded were in the 6 - 7 range with very little pH differences occurring between the surface and the bottom.

Average hydrogen sulphide levels from the upper and lower portions of the ditches in the 68 and 72 areas are shown on Figs. 5 and 6 respectively. Except for bottom samples in April from the 72 area and April and June from the 63 area, all hydrogen sulphide levels were below .10 ppm. The highest readings were .17 ppm from the 72 area and .19 and .13 from the 68 area. As can be seen from Figs. 5 and 6, hydrogen sulphide levels and patterns were similar in both areas. Concentrations of hydrogen sulphide were lowest in both areas in the late summer - early fall months and highest in the spring months.

Mean oxygen levels appear in Figs. 7 and 8 for areas 68 and 72 respectively. Mean dissolved oxygen concentrations for the two areas appear in Table 2. There were indications that water quality deteriorated somewhat toward the upper ends of the 68 and 72 area mosquito ditches. Oxygen concentrations on the bottom of the upper poriton of the ditches fell below EPA levels (below 4 ppm) during the months of April through August, 1976, and were on the critical line in 1977. There seems to be little difference in oxygen levels between the 68 and 72 areas.

Trawl samples

Results of the trawl samples appear in Table 3. Organisms found in the two study areas are typical estuarine species. Of the 47 species collected in the trawl samples, 20 were considered freshwater and 27 brackish and marine species. A total of 8,364 specimens

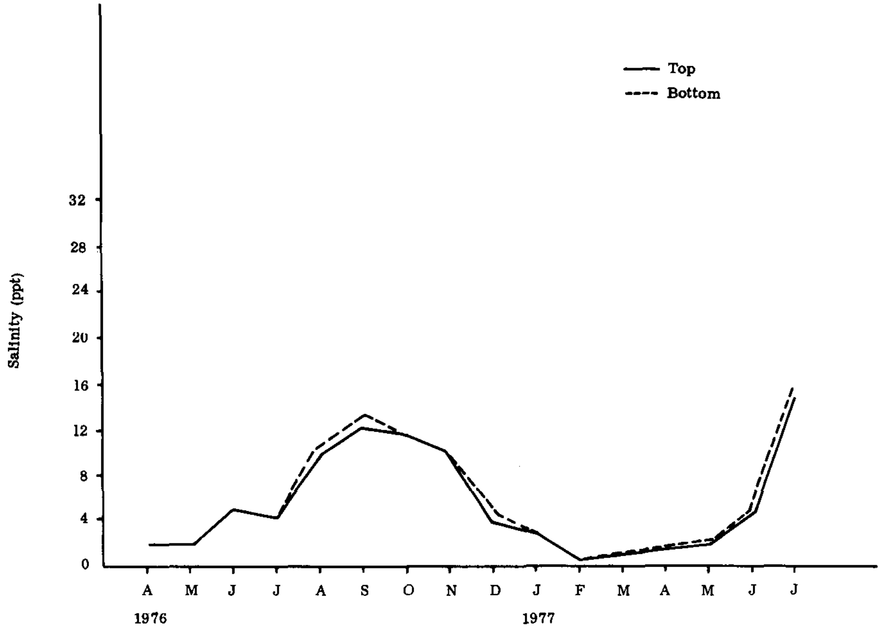

Fig. 4. Mean salinities (ppt) on the surface and bottom from the 72 Area between April, 1976 through July, 1977.

TABLE 1. Monthly range of pH values from May, 1976 through July, 1977 from the 68 and 72 study areas.

STUDY AREAS						
MONTHS	68 Area		72 Area		Range	
5/76 - 7/77	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
May	6.8 - 7.0	4.6 - 6.3	6.2 - 6.9	6.5 - 6.7	6.8 - 7.0	4.6 - 6.7
June	6.1 - 6.4	6.4 - 6.7	6.2	6.1 - 6.4	6.1 - 6.4	6.1 - 6.7
July	6.5 - 6.8	6.4	6.0 - 6.9	6.2 - 6.9	6.0 - 6.9	6.2 - 6.9
August	6.4 - 6.6	6.5 - 6.6	6.8	6.7 - 6.8	6.4 - 6.8	6.5 - 6.8
September	6.6	6.6 - 6.7	6.6 - 6.7	6.7	6.6 - 6.7	7.7 - 6.7
October	6.7 - 6.7	6.7 - 6.8	6.6 - 6.8	6.6 - 6.8	6.7 - 6.8	6.6 - 6.9
November	6.9	6.7	6.8 - 6.9	6.5 - 6.7	6.8 - 6.9	6.5 - 7.5
December	7.2 - 7.3	7.2	7.1 - 7.2	7.0 - 7.3	7.1 - 7.3	7.0 - 7.3
January	6.7 - 7.0	*	6.8 - 6.9	*	6.7 - 7.0	* *
February	6.4 - 6.7	6.5 - 6.6	6.2 - 6.2	6.3 - 6.5	6.2 - 6.7	6.3 - 6.5
march	6.6 - 6.8	*	6.9	*	6.5 - 6.9	* *
April	6.4 - 6.5	6.4 - 6.5	6.5 - 6.6	6.5 - 6.6	6.3 - 6.6	6.2 - 6.6
May	6.6	6.6	6.7 - 6.9	6.6 - 6.7	6.6 - 6.9	6.6 - 6.7
June	7.3 - 7.6	*	7.3 - 7.6	7.4 - 7.5	7.3 - 7.6	1.4 - 7.5
July	6.9 - 7.1	6.9 - 7.0	7.0 - 7.1	7.0	6.9 - 7.1	6.9 - 7.0

*Sample not taken due to low tides

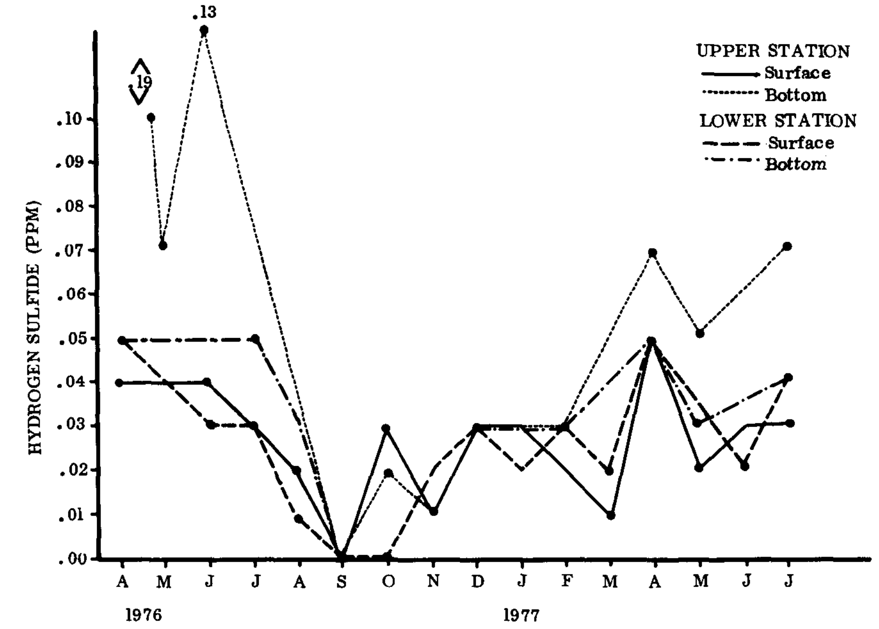

Fig. 5. Mean hydrogen sulfide levels (ppm) of the upper and lower portions of the 68 Area ditches on the surface and bottom during the study period.

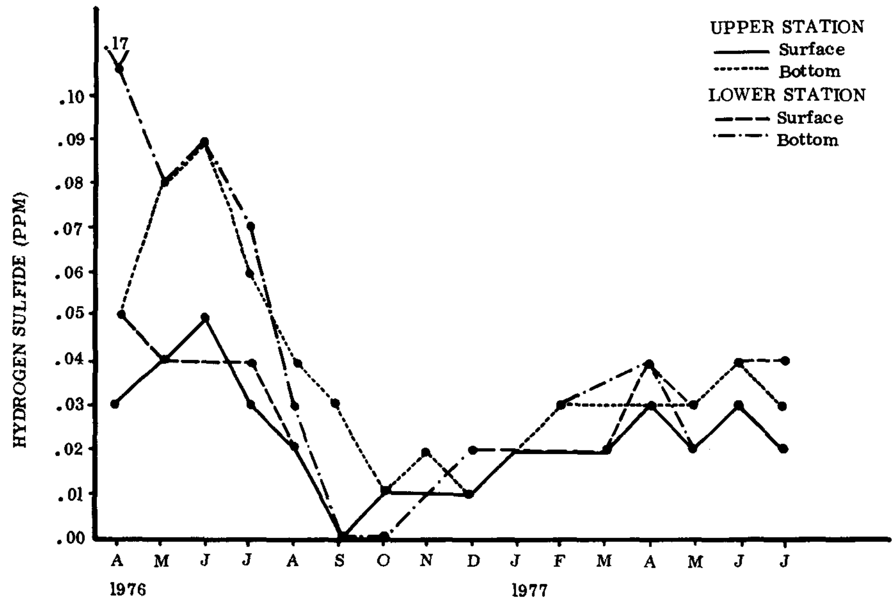

Fig. 6. Mean hydrogen sulfide levels (ppm) of the upper and lower portions of the 72 Area ditches on the surface and bottom during the study period.

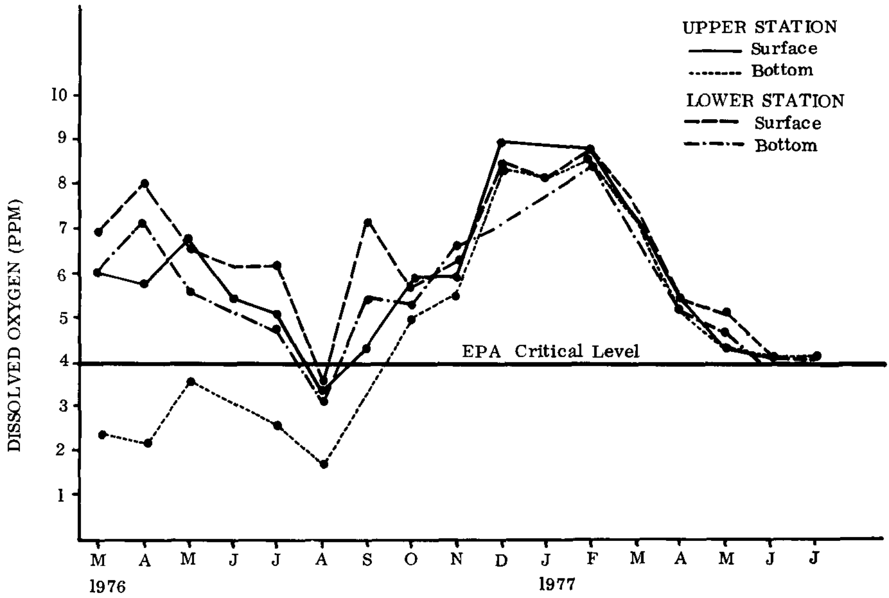

Fig. 7. Mean dissolved oxygen levels (ppm) of the upper and lower portions of the 68 Area ditches on the surface and bottom during the study period.

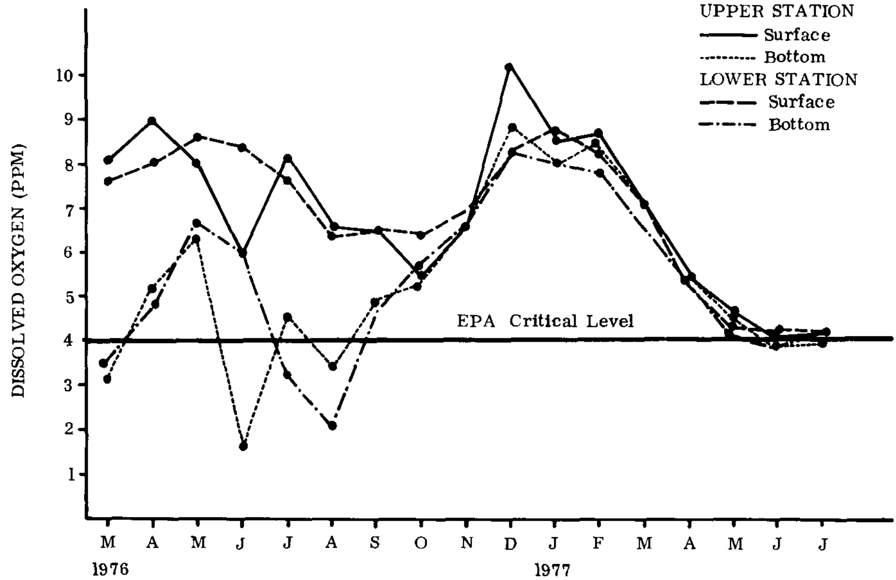

Fig. 8. Mean dissolved oxygen levels (ppm) of the upper and lower portions of the 72 Area ditches on the surface and bottom during the study ara.

TABLE 2. Monthly mean dissolved oxygen concentrations (ppm) from April, 1976 through July, 1977 from the 68 and 72 study areas.

MONTHS 4/76 - 7/77	68 Area TOP	68 Area BOTTOM	72 Area TOP	72 Area BOTTOM	Mean ± S.D. TOP	Mean ± S.D. BOTTOM
April	6.9	4.7	8.5	4.9	7.6 ± .7	6.2 ± 1.6
May	6.6	5.2	8.3	6.6	6.6 ± 1.3	5.7 ± .9
June	5.8	4.2	7.2	3.8	6.6 ± .5	5.3 ± 1.5
July	5.6	3.7	7.9	4.0	6.1 ± 1.4	4.3 ± .8
August	3.4	2.5	6.5	2.8	5.5 ± 1.4	4.4 ± 2.0
September	5.8	4.4	6.5	4.8	6.8 ± .8	4.8 ± 1.1
October	5.8	5.2	6.0	5.5	6.1 ± .3	5.6 ± .3
November	6.1	6.0	6.8	6.6	6.8 ± .5	6.6 ± .5
December	8.8	7.8	9.2	8.6	8.4 ± .8	7.9 ± .7
January	8.6	*	9.9	*	9.6 ± 1.5	6.5 ± 2.4
February	8.8	8.5	9.0	9.2	9.8 ± 1.3	9.2 ± .8
March	7.3	*	7.1	*	7.2 ± . 3	6.6 ± .4
April	5.4	5.3	6.9	5.6	6.1 ± .8	5.5 ± .4
May	4.7	4.3	4.5	4.4	4.8 ± .6	4.6 ± .3
June	4.0	*	4.2	4.6	4.3 ± .3	4.3 ± .3
July	4.0	4.1	4.0	4.1	4.2 ± .3	4.2 ± .2

*Sample not taken due to low tides

were collected from both areas during the study perod. The bay anchovy (*Anchoa mitchelli*), grass shrimp (*Paleomonetes* sp.) and bluegill (*Lepomis macrochirus*) were the 3 most numerous species, making up 19, 19 and 18% of total numbers respectively. Based upon the lateral ditch survey, there was no evidence that any of the commercially important species used the mosquito ditches as nursery areas. These lateral ditches actually provide better habitat than the main ditches for sport and commercially important species because of availability of more food and cover. Bay anchovies seemed to be the only estuarine species that used the mosquito ditches as nursery grounds. There were many species that spawned in the ditches. Members of the family Centrarchidae (sunfishes), particularly largemouth bass (*Micropterus salmoides*), bluegill and spotted sunfish (*Lepomis punctatus*) were the 3 most abundant species that utilized the ditches to spawn. These species were found throughout the year in the study area.

Aquatic life in the mosquito ditches is quite diverse. Based on the survey of the lateral ditches, sport and commercially important marine species are not prevalent in the mosquito ditches. Freshwater species such as largemouth bass and bluegill are prevalent, however, the ditches are not easily fished due to their narrow configuration. Also fishing is discouraged by the Mosquito Control Commission.

DISCUSSION

Indications are that water quality in the form of low dissolved oxygen deteriorates at the upper ends of the mosquito ditches much as that which occurs in dead end canals typical of development sites. The reason for this deteriorated condition can be seen by carefully evaluating the salinity measurements for the 2 study areas. The upper ends of the ditches were farther away from the effluence of the tides, thus exhibiting slightly lower

TABLE 3. Organisms collected by trawl for the 68 and 72 areas during the study period. Numbers in parenthesis represent the percentage that each species makes up of the total number of specimens sampled.

ORGANISMS	68	72	TOTAL
Astacidae - crawfishes *Procambarus* sp. (crawfish)	7	4	11 (*)
Anquillidae - Freshwater eels *Anquilla rostrata* (American eel)	0	2	2 (*)
Atherinida - silversides			
Labidesthes sicculus (Brook silversides)	278	22	300 (4)
Menidia audens (Mississippi silversides)	110	8	118 (1)
Blenniidae - Combtooth blennies			
Hypsoblennius ionthas (Freckled blenny)	1	1	2 (*)
Bothidae - Lefteye flounders			
Paralichths lethostigma (Southern flounder)	1	1	1 (*)
Centrarchidae - sunfishes			
Elassoma zonatum (Banded pygmy sunfish)	1	1	2 (*)
Lepomis sp. (sunfish)	5	196	201 (2)
Lepomis gulosus (warmouth)	45	53	98 (1)
Lepomis cyanellus (Green sunfish)	36	24	60 (*)
Lepomis humilis (Orangespotted sunfish)	29	0	29 (*)
Lepomis macrochirus (bluegill)	655	825	1480 (18)
Lepomis microlophus (Redear sunfish)	52	448	500 (6)
Lepomis punctatus (Spotted sunfish)	10	33	43 (*)
Micropterus salmoides (Largemouth bass)	110	148	258 (3)
Micropterus punctatus (Spotted bass)	101	33	134 (2)
Pomoxis annularis (White crappie)	0	1	1 (*)
Pomoxis nigromaculatus (Black crappie)	0	1	1 (*)
Clupeidae - herrings			
Brevoortia patronus (Largescale menhaden)	25	8	33 (*)
Cyprinidae - minnows and carps			
Hybopsis storeriana (Silver chub)	1	0	1 (*)
Cyprinodontidae - killifishes			
Cyprinodon variegatus (Sheepshead minnow)	6	2	8 (*)
Fundulus diapharus (Banded killifish)	254	16	270 (3)
Fundulus grandis (Gulf killifish)	11	4	15 (*)
Fundulus similis (Longnose killifish)	4	0	4 (*)
Engraulidae - anchovies			
Anchoa hepsetus (Striped anchovy)	17	5	22 (*)
Anchoa mitchilli (Bay anchovy)	1226	395	1621 (19)
Gobiidae - gobies			
Gobionellus shufeldi (Freshwater goby)	4	1	5 (*)
Gobionellus bosci (Naked goby)	0	1	1 (*)
Ictaluridae - freshwater catfishes			
Ictalurus punctatus (Channel catfish)	1	1	2 (*)
Lepiososteidae - gars			
Lepiososteus oculatus (Spotted gar)	7	3	10 (*)
Mugilidae - mullets			
Mugil cephalus (Stiped mullet)			
Poeciliidae - livebearers			
Gambusia affinis (mosquitofish)	840	508	1348 (16)
Heterandria formosa (Least killifish)	10	9	19 (*)

Table 3. (cont.)

Mollienesia latipinae (Sailfin molly)	3	0	3 (*)
Sciaenidae - drums			
Leiostomus xantharus (spot)	2	0	2 (*)
Micropogan undulatus (Atlantic croaker)	2	0	2 (*)
Soleidae - soles			
Trinectus maculatus (hogchocker)			
Syngnathidae - pipefishes and seahorses			
Syngnathus scovelli (Gulf pipfish)	13	13	26 (*)
Palaemonidae - grass shrimp			
Palaemonetes sp. (Grasss shrimp)	803	785	1588 (19)
Macrobrachium ohione (River shrimp)	2	16	18 (*)
Panaeidae - Salt water shrimps			
Panaeus aztecus (Brown shrimp)	7	16	23 (*)
Panaeus setiferus (White shrimp)	0	1	1 (*)
Portunidae			
Callinectes sapidus (Blue crab)	32	12	4
Xanthidae			
Panopeus herbstii (Mud crab)	0	2	2 (*)
Littorindae			
Littorina irrorata (Marsh periwinkle)	34	3	37 (*)
Phasmatidae - walking sticks			
Diapheroma fermorata (Walking stick)	2	0	2 (*)
Odonata - dragonflies and damselflies			
Anisoptera (Dragonfly nymphs)	4	0	4 (*)
TOTAL	4760 (57)	364 (43)	8364

*Less than 1%

salinities. Also the 72 area salinities are lower than the 68 area simply because that area is farther away from the influence of the tides. As a result, the mosquito ditches, especially the upper ends, do not receive the flushing action of the tides and thereby organic matter is not adequately distributed throughout the entire system. Instead, the organic material is pushed toward the upper portions of these ditches.

To further complicate the situation, there are several species of submersed aquatic vegetation such as *Ruppia maritima*, *Najas* sp., *Potomogeton* sp., *Cobomba* sp., and *Ceratophyllum* sp., that grow in dense mats in the mosquito ditches. The submersed vegetation is denser in the 68 area, however, submersed vegetation is common also in the 72 area. These mats of vegetation hinder tidal flushing and thereby influence water quality parameters in the upper portions of the diteches.

Another factor that affects water quality in the upper portions of the ditches is the sloughing of the sides of the ditches in the 68 area. Although the ditches dug in 1968 are only 10 years old, the edges have sloughed off and are no longer 1.8-2.4 m deep. The top of the mud layer is less than 1 m below the surface in many locations. The 72 area ditches are not noticeably being deteriorated, however, they are younger and farther away from tidal influence.

Indications are that water quality difference between the upper and lower portions of the ditches are largely attributed to physical causes rather than biological factors. Increased productivity and/or reduced flushing would further deteriorate water quality in the upper portions of the ditches.

The mosquito ditches do not appear to serve as a valuable nursery area for sport and commercial marine species. Indirect contribution may be affected through the food chain. Some of the organisms and detritus produced in the ditches find their way into open estuarine waters and would be expected to serve as food and/or nutrients for crustaceans and fishes having sport and commercial value.

There is a good population of largemouth bass and bluegill in the mosquito ditches. These ditches are narrow, however, and the surrounding bayous offer better fishing; the ditches therefore serve little value as a sport fishing area for largemouth bass and bluegill.

Based on the results of the investigation there are no substantial direct benefits derived from the ditches other than their intended use for mosquito control. There may be indirect benefits derived through the food chain. The ditches may serve as a nutrient trap, thus providing biologically insignificant benefits to the receiving estuary.

An obvious need is to determine the effectiveness of mosquito ditches in controlling mosquito populations. It is strongly recommended that other alternatives be investigated and evaluated to control mosquito populations.

CONCLUSION

1. Indications are that the effective life of mosquito ditches may be short.
2. Water quality deteriorates at the upper ends of the mosquito ditches.
3. These mosquito ditches do not serve as a significant nursery area for important sport and commercial marine species.
4. Other alternatives should be investigated and evaluated to control mosquito populations in coastal areas.

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