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THE USE OF WEIRS IN COASTAL MARSH MANAGEMENT IN LOUISIANA

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Along the Louisiana coast, ponds and lakes subject to severe tidal action usually support very little aquatic vegetation. Also, marshes subject to tidal action and drastic salinity changes usually support undesirable plant types. Consequently, these areas are of little value to waterfowl or fur-bearing animals. As more canals are dug and stream channels deepened each year for navigation pipelines and drainage, the problem of tidal action and salt water intrusion becomes more severe.

Since the Louisiana coast is a major waterfowl wintering area and a highly potential fur-bearer producing area, marsh management is of extreme importance.

The ideal management technique should be capable of accomplishing several effects. It should reduce water level fluctuation, stabilize water salinity, minimize water turbidity and reduce the rate of tidal exchange. But mainly, the technique should encourage the growth of desirable plants in the marsh, and at the same time encourage the growth of aquatic vegetation in the ponds and lakes.

An ideal condition in coastal marsh management for both furbearing animals and waterfowl is the production of three-cornered grass (*Scirpus olneyi*) in the marshes and widgeongrass (*Ruppia maratima*) in marsh ponds and lakes. The roots of three-cornered grass are a favorite food of muskrats and blue and snow geese The foliage and seeds of widgeongrass are very desirable for practically all species of ducks. Also, the seeds of three-cornered grass and of different annual plants, that grow in a mixture with three-cornered grass, are widely used by ducks.

The use of impoundments has been very successful in southwestern Louisiana for waterfowl management (Chabreck, 1960). However, because of the fluid nature of the subsoil, most marsh areas in the Delta and Sub-delta marsh types as described by O'Neil (1949) will not support continuous levees. Consequently, in such areas impoundments can not be constructed.

The placement of earthen dams in all drainage systems of a marsh area has been widely used along the Louisiana coast as a management procedure for obtaining both effects. However, the value of this method is doubtful. A similar method, the construction of Wakefield-type weirs in the drainage systems, is gaining popularity with landowners. The weirs, although installed at a higher initial cost, require less maintenance when properly constructed.

Weirs are constructed with sheet piling by placing a continuous bulkhead across a drainage outlet. The crest of the weir is set at an elevation several inches below marsh level to provide drainage, yet holding a basin of permanent water behind the structure.

Small weirs were constructed throughout the Louisiana coast during the early 1940's, when muskrat populations were at a peak. The weirs were constructed by trappers and used to prevent marsh drainage so as to provide access to trapping grounds by boat. However, these weirs were poorly constructed and seldom lasted over one year.

During the early 1950's several marsh owners became alarmed at the deteriorating conditions and began large-scaled development project using weirs. These weirs were constructed on large drainage systems and with methods and materials necessary to assure little maintenance.

Although much work of this type has been done, no detailed studies have been conducted to determine the effectiveness of the weirs. As the need for marsh management increases, the need for this information will become more and more important. In May, 1958, a study was begun on Marsh Island Wildlife Refuge in Iberia Parish, Louisiana, following the completion of three large weirs.

The purpose of this study was to determine and compare the vegetative composition of the marsh and of lakes and ponds behind weirs with comparable, unaffected areas as a control and to evaluate the water conditions associated with both areas.

DESCRIPTION OF THE STUDY AREA

Two separate study areas were used. The first area included portions of the 85,000-acre Marsh Island Wildlife Refuge, which is owned by the Louisiana Wild Life and Fisheries Commission. Nineteen weirs have been constructed on the refuge, but only five were used for this study.

Marsh Island is bordered on the north by Vermilion and Cote Blanc Bays and on the south by the Gulf of Mexico. Water from the Atchafalaya River enters the Gulf only 15 miles east of the refuge and during the study greatly affected salinities. Salinities varied from 650 to 7,800 parts per million, producing fresh to brackish marsh conditions.

The other study area was in Terrebonne and Lafourche Parishes, immediately north of Lake Felicity, and included 14,000 acres in private ownership. In this area 20 weirs were examined with construction dates ranging from 1954 through 1958. Numerous bayous, canals and lakes connected the area with the Gulf of Mexico and water salinities ranged from 7,600 to 14,200 parts per million. In this area marsh conditions varied from brackish to saline.

In both study areas the marsh elevation averaged 1.1 feet above mean sea level. The mean daily tidal fluctuation was approximately one foot; however, high tides frequently inundated the marshes.

The poorly drained marsh types of both study areas was dominated by marshhay cordgrass (*Spartina patens*) and three-cornered grass. At well-drained sites the dominants were black rush (*Juncus roemerianus*) and marshhay cordgrass. As a result of wide ranging salinities on Marsh Island, several species of aquatics were found in lakes and ponds. Widgeongrass (*Ruppia maratima*) and coontail (*Ceratophyllum demersum*) were dominants. However, because of the high salinities in the Terrebonne-Lafourche Area, widgeongrass was the sole aquatic.

METHODS AND MATERIALS

Within the study areas a total of 90 ponds were sampled. Of these, 53 were behind weirs and 37 were unmanaged ponds sampled as controls. The ponds samples were selected from a map before the area was visited. All sampling was done in May and October during the height of the growing season.

At Marsh Island the study area was set up at the time the weirs were constructed and the lakes sampled then and at six-month intervals for the next four and one-half years. However, in the Terrebonne-Lafourche Area a number of weirs were present with ages ranging from one to five years. Ponds behind these weirs and in adjacent control areas were sampled only once.

In sampling, two parallel lines were run across each pond, and separated by a distance equal to about one-third the diameter of the pond. Each pond was sampled from a boat by simply dragging the bottom with a rake at a certain number of stations along the lines. The number of stations varied with the length of the line. Information recorded at each station included the plant species present and the estimated density of each. Water depths were recorded at every fifth station. In addition, the type bottom was recorded and a water sample taken for determining water salinity and turbidity. Salinity tests were made with a conductivity bridge and turbidity tests with a Jackson turbidometer. In all, 2,040 stations were checked behind the weirs and 1,410 in the control ponds.

The data from all ponds behind the weirs were grouped according to the year that the weirs were constructed. By doing this it was possible to determine the rate at which aquatic vegetation invaded ponds affected by weirs.

Line transects were used to sample marsh vegetation. Eight transects each 1,000 feet long and marked at 100-foot intervals were used. The lines totaling 4,000 feet long were sampled behind weirs and in control areas. A five-per cent sample was made of each line by using a five-foot rule for sampling at each 100-foot marker. Vegetative types and openings were tabulated as they occurred along each five-foot transect to the nearest one-tenth foot. The species composition of mixed types was estimated.

RESULTS AND DISCUSSION

In presenting the data on aquatic vegetation, percentage frequency was used, thus expressing the percentage of the sampling stations in which each species occurred. Although this method did not show density, it reflected the distribution, which was of primary importance during the study.

As a result of drastic salinities changes the tidal ponds on Marsh Island were low in aquatic vegetation production (Table 1). Five species were present, with several having great differences in salinity requirements. Increases and decreases in aquatic vegetation during each sampling period closely followed water salinity of the area at the time. This is clearly shown by comparing the occurrence of widgeongrass in Table 1 with the salinity in Table 2.

Throughout the Terrebonne-Lafourche Area the salinity of all ponds were high and well within the required range of widgeongrass. Consequently, this area offered the better test on the effects of weirs in the production of widgeongrass. The salinity of ponds sampled behind weirs averaged 10,468 p.p.m., while the control ponds averaged a very similar 11,052 p.p.m. In ponds behind weirs widgeongrass occurred at 41.2 per cent of the stations; while in the control ponds the occurrence was 11.4 per cent. The ponds behind weirs of different ages, as shown in Table 3, all had a higher occurrence of widgeongrass than did the controls. However, considerable variation existed among the weirs. There was no relationship between the age of weirs and the occurrence of widgeongrass. Ponds behind the newest weirs (1958) had the highest occurrence, 64.3 per cent, while the lowest, 18.5 per cent, was found behind medium-aged weirs (1956).

Table 1—Percentage Frequency of Aquatic Vegetation Behind Weirs * and in Control Areas, Marsh Island Refuge

BEHIND WEIRS

SPECIES	*May 1958*	*October 1958*	*May 1959*	*October 1959*	*May 1960*	*October 1960*	*May 1961*	*October 1961*	*May 1962*	*September 1962*
Widgeongrass (*Ruppia maratima*)	18.0	12.6	8.0	13.0	1.0	7.3	.3	4.7	..	..
Coontail (*Ceratophyllum demersum*)	...	.3	.6	.3	.9	1.4	4.6	..	..	..
Wild celery (*Valisneria spiralis*)	1.4	1.9	.9	1.1	1.4	1.1	2.7	1.0	1.0	.7
Dwarf spikerush (*Elocharis paruula*)	.9	...	..	...	..	..	..	.3	..	..
Pondweed (*Potamogeton foliosus*)	...	...	..	...	..	..	..	..	..	..
TOTAL	20.3	14.8	9.5	14.4	3.3	9.8	7.6	6.0	1.0	.7

CONTROL AREA

	May 1958	*October 1958*	*May 1959*	*October 1959*	*May 1960*	*October 1960*	*May 1961*	*October 1961*	*May 1962*	*September 1962*
Widgeongrass	18.0	2.6	8.3	2.9	..	1.7	..	.3	..	..
Coontail	...	...	..	...	..	..	..	..	..	..
Wild celery	.3	.3	1.0	.1	.7	.7	1.0	1.3	1.1	.7
Dwarf spikerush	.6	.6	.6	...	1.7	.9	.3	..	.4	.1
Pondweed	...	...	..	..	..	..	..	8.9	10.3	..
TOTAL	19.9	3.5	9.9	3.0	2.4	3.3	1.3	10.5	11.8	.8

* Weirs constructed in May, 1958.

Table 2—Water Salinity (P.P.M.) and Turbidity (P.P.M) Behind Weirs and in Control Areas, Marsh Island Refuge

	BEHIND WEIRS									
	May	*October*	*May*	*October*	*May*	*October*	*May*	*October*	*May*	*September*
Salinity	3624	1001	709	5469	1475	2707	954	6700	651	5721
Turbidity	<25	<25	33	<25	63	35	45	<25	69	27
	CONTROL AREAS									
	May 1958	*October 1958*	*May 1959*	*October 1959*	*May 1960*	*October 1960*	*May 1961*	*October 1961*	*May 1962*	*September 1962*
Salinity	3528	953	709	4929	1421	3157	977	6800	704	5779
Turbidity	<25	<25	54	30	66	38	<25	<25	51	28

TABLE 3

PERCENTAGE FREQUENCY OF WIDGEONGRASS AND WATER SALINITY (P.P.M.) IN PONDS BEHIND WEIRS AND CONTROL PONDS TERREBONNE-LAFOURCHE AREA, MAY, 1959

	PONDS BEHIND WEIRS					
	1954 Weirs	*1955 Weirs*	*1956 Weirs*	*1957 Weirs*	*1958 Weirs*	*Control Ponds*
Widgeongrass	29.8	50.0	18.5	40.0	64.3	11.4
Salinity	12,383	10,150	10,050	8,150	11,605	11,052

The study revealed that the weirs had little effect on water salinities in ponds in both study areas. Increases and decreases in salinities in the control areas was reflected with similar increases and decreases behind the weirs. In general salinities in ponds behind weirs were from five to ten per cent less than those not affected by weirs.

In coastal marshes subjected to waters from large rivers or other drainage systems carrying heavy silt loads, turbidity is frequently a limiting factor in the growth of aquatic vegetation. Sunlight is essential for plant growth and in turbid waters the light can not penetrate to a sufficient depth.

The Terrebonne-Lafourche Area was not subjected to silt laden waters, and as a result, the turbidity readings in waters behind weirs and in the control areas was less than 25 p.p.m. However, Marsh Island was subjected to waters from the Atchafalaya River and the turbidity varied considerably from time to time (Table 2). The river was at flood stage during the spring and turbid waters were found during practically each May visit to the study area. However, by October the water had receded and the water was clear. The turbidity ranged from less than 25 to 165 p.p.m.

In general, water in ponds behind the weirs was less turbid than water in the control area, but like the salinity the difference was usually no more than from five to ten per cent.

In order to gain information on water levels, continuous water level recorders were installed on both sides of a weir on Marsh Island Refuge. The recorders were operated for two years and the results are shown in Table 4. The mean water level was slightly higher behind the weirs; however, the only great difference in water levels was the mean low tides. Behind the weirs the tide was permitted to drop to only 0.5 feet, the elevation of the weir's crest, but in the control area tides as low as a minus 2.1 feet elevation were recorded.

During low tides the bottoms of many uncontrolled marsh ponds become exposed and such tides may last three or four consecutive days. However, since water in ponds behind weirs can recede to only the elevation of the weir, very few become dry on low tides. In fact the study revealed that with a minus 1.0 tide the bottoms of only 2.4 per cent of the pond behind weirs would become exposed; but with the same tide, the bottoms of 84 per cent of the unmanaged ponds would become exposed.

Although not measured by this study, the sweeping action of tidal currents had a drastic effect on aquatic vegetation in certain areas. This was particularly noticeable in tidal waters subjected to heavy silt loads where turbidity was a limiting factor. Also, tidal action was believed to limit aquatic growth in ponds with unstable bottoms having heavy deposits of plant debris. Pond bottoms within the study area consisted of a soft organic ooze with varying amounts of plant debris. The debris consisted mainly of roots, stems and leaves of marsh grasses. Bottoms with dense debris produced few aquatics and bottoms with sparse debris usually had a much higher occurrence of aquatics. However, this occurred with exceptions.

TABLE 4—MEAN MONTHLY AND ANNUAL TIDES* BEHIND WEIRS AND IN CONTROL AREA, MARSH ISLAND, 1958-1959

	BEHIND WEIRS					CONTROL AREAS				
Month	*Mean High Tide*	*Mean Low Tide*	*Mean Water Level*	*Highest Individual Tide*	*Lowest Individual Tide*	*Mean High Tide*	*Mean Low Tide*	*Mean Water Level*	*Highest Individual Tide*	*Lowest Individual Tide*
January	.85	.67	.76	1.5	.5	.39	-.35	.02	1.5	-2.0
February	.91	.74	.83	1.4	.5	.56	-.26	.15	1.6	-1.8
March	.88	.71	.79	1.2	.5	.60	-.18	.21	1.3	-1.5
April	1.03	.83	.93	1.0	.5	.78	.09	.43	1.2	- .7
May	1.07	.82	.94	2.3	.5	1.13	.40	.76	2.4	- .7
June	1.04	.80	.92	1.5	.5	1.19	.18	.69	1.7	- .7
July	.74	.59	.66	1.3	.5	.83	-.06	.39	1.5	-1.0
August	.86	.68	.78	1.3	.5	.83	.11	.47	1.6	- .8
September	1.37	1.16	1.26	2.6	.6	1.26	.69	.97	2.6	- .2
October	1.11	.90	1.01	1.7	.5	1.06	.39	.72	1.8	- .5
November	1.03	.80	.91	1.4	.5	.85	.07	.46	1.5	-2.1
December	.76	.64	.70	1.1	.5	.37	-.62	-.12	1.4	-2.2
Mean Annual Tide	.97	.78	.87			.82	.04	.43		

* Data collected with continuous recorders. Tidal readings listed in feet.

Throughout the study marshhay cordgrass and three-cornered grass were dominants in the low, poorly drained marshes sampled. The vegetation transects on Marsh Island, Table 5, showed drastic changes from year to year in the vegetative composition. However, almost without exception the annual changes in the vegetative composition in marshes affected by weirs were very similar to those in the control areas.

In the high, well drained marsh types sampled marshhay cordgrass and black rush were dominants. This remained unchanged throughout the study in marshes affected by weirs and in the control areas.

Although high salinities existed, general observations in the marshes of the Terrebonne-Lafourche Area revealed that many brackish water plants were present. In much of the deep, poorly drained marsh three-cornered grass occurred in fairly dense stands. Individual stands often covered as much as 1,000 acres. However, no drastic differences were noted in the vegetative composition of marsh affected by weirs and unaffected marsh nearby. Although the marsh supported large stands of three-cornered grass, it also supported many acres of low quality vegetation. Much of the marsh supporting low quality vegetation, both behind weirs and in unaffected areas, was potentially capable of supporting three-cornered grass. The salinity of both areas was very similar and ranged between 9,500 and 10,200 parts per million.

Three-cornered grass grows best with water levels fluctuating between two inches above and two inches below marsh level (O'Neil, 1949). Since the weirs tend to stabilize water levels, conditions should remain favorable for three-cornered grass behind weirs even during drought years.

TABLE 5—VEGETATIVE COMPOSITION OF MARSH BEHIND WEIRS AND IN CONTROL AREAS, MARSH ISLAND REFUGE

	BEHIND WEIRS				
Species	*1958*	*1959*	*1960*	*1961*	*1962*
Marshhay cord grass *(Spartina patens)*	63.3	39.7	49.9	80.6	58.9
Three-cornered grass *(Scirpus olneyi)*	33.9	55.7	49.5	19.4	22.1
Switchgrass *(Panicum virgatum)*	...	...	...	...	...
Blackrush *(Juncus roemerianus)*	2.8	.1	...	...	...
Saltgrass *(Distichlis spicata)*	...	4.5	.6	...	...
Spikerush *(Eleocharis sp.)*	...	...	...	...	17.6
Leafy three square *(Scirpus robustus)*	...	...	...	...	.7
Cyperus *(Cyperus sp.)*	...	...	...	...	.7

	CONTROL AREAS				
Species	*1958*	*1959*	*1960*	*1961*	*1962*
Marshhay cord grass	67.1	52.7	53.6	72.9	46.5
Three-cornered grass	29.4	47.3	29.4	15.5	15.1
Blackrush	2.5	...	.6	1.5	1.6
Saltgrass	.1	...	...	...	...
Spikerush	.9	...	10.3	9.7	32.0
Cyperus	...	...	6.1	.4	4.8

Tides with extremely high salinities are infrequent in most marsh areas in Louisiana. Nevertheless, when such tides occur severe damage can result. Occasionally, tides invade the marshes with salinities of 25,000 p.p.m. during drought periods. O'Neil (1949) stated that at such times water levels in the marsh are low and are replaced with the highly saline water. As a result, brackish water plants are reduced considerably or eliminated. However, with weirs in the drainage systems the water can recede to only a certain level. Then with high, saline tides the basin behind the weir acts as a "mixing bowl" and in many instances will prevent damage to these species.

Aside from their effects on vegetation, weirs have other aspects which merit consideration. Most of these factors are associated mostly with water level stabilization and are frequently a marsh owner's primary aim when constructing a weir.

Access provided by stabilized water levels very often justifies the construction of weirs. Low tides make many marsh areas inaccessible by boat throughout much of the winter. However, with weirs in the drainage systems hunters and trappers can usually travel freely under all conditions.

Stabilized water levels greatly improve conditions for marsh wildlife. Fur-bearing animals such as muskrat (*Ondatra zibethica*), nutria (*Myocastor coypus*) and mink (*Mustela vison*) must occasionally move from certain marsh areas during summer droughts. However, water behind weirs can recede to only a certain level during such periods. Also, waterfowl benefit from the permanent water afforded by weirs. The area of suitable feeding and resting sites is greatly increased.

Many observations on Marsh Island Refuge have shown that ponds and lakes affected by weirs served as ideal nursery ground for shrimp (*Peneidea*). Not only was the mean water depth increased, but the ponds held permanent water throughout the growing season.

The weirs along the Louisiana coast have made ideal fishing places. The fish are probably attracted by the churning water as it pours over the structure. Also, small fish concentrate around the weirs for protection and the larger fish find them ideal feeding areas.

WEIR CONSTRUCTION

Most weirs constructed along the Louisiana cast are very similar, varying slightly with the method of construction. Draglines are used on all large weirs for handling material and driving piling. Round timber piling, wales and sheet piling are used, and all wooden material is pressure-treated with creosote.

Both interlocking steel sheet piling and wooden sheet piling are used. The steel piling are usually used on larger structures or in deep channels, and although more costly, they are much easier to install and not subject to fire damage or marine wood borers. Two types of wooden sheet piling are used. One type consists of 2 by 8's or 2 by 10's driven in two or three rows, with each row spliced over the seams of the previous row. The method used most successfully with this material is to nail several rows of piling together and drive them all at one time. The other type is 3 by 10 center-matched and involves the use of only a single row of sheet piling.

Drainage systems selected for weir construction should be carefully surveyed to determine the best site. The site selected should be in a straight reach with well defined banks. In general the water depth should not exceed six feet and width of the stream should be typical of adjacent portions.

A rule of thumb used in determining the length of sheet piling necessary is o multiply the depth of the deepest part of the channel by three. This will provide one-third of the sheet piling in the water and two-thirds in the ground.

The crest of the weir should always be set in reference to marsh level. Consequently, a level line should be run through the marsh to determine the mean elevation. The weir should be set at an elevation no less than six inches below the surrounding marsh. Weirs on small streams with large watersheds should be set even lower.

It should be remembered that water must drain from the area affected, and by setting the weir too high will only force water around the ends of the structure. Water erodes marsh soils very rapidly and in a short while will form a new channel around the ends of the structure.

Weirs are often constructed with splash boards to prevent water from eroding and deepening the bottom as it spills over the weir. With large watersheds the water may eventually erode the bottom to the depth of the sheet piling, thus permitting water to flow under the structure.

SUMMARY AND CONCLUSIONS

Weirs have been constructed in many marsh areas along the Louisiana coasts for the purpose of marsh management. The weirs are constructed in the drainage systems of selected marsh areas and offers the only suitable method of gaining control of water conditions in unstable marsh which will not support continuous levees.

Studies on weirs under various marsh conditions on Marsh Island Refuge and in Terrebonne and Lafourche Parishes have shown that the greatest production of aquatic vegetation through this type of management is achieved in marshes varying from brackish to saline. In fresh to brackish marshes with drastic salinity changes, the occurrence of aquatic vegetation was generally higher in ponds behind weirs than in adjacent control areas, but with frequent exceptions.

Weirs are constructed for the primary purpose of influencing vegetative growth in wetlands affected by the structures by altering salinity, turbidity, water levels and reducing tidal action.

The changes in salinities amounted to less than 10 per cent difference behind weirs as compared to the control areas. Although the weirs were constructed with idea of controlling salinities, they did not achieve this objective during the study.

Weirs should have their greatest effect on salinities during long droughts, when highly saline water is normally permitted to enter interior marshes. At such times brackish plants are severely affected.

Water turbidity on Marsh Island Refuge differed less than 10 per cent between ponds affected by weirs and in control ponds. Thus, the original objective of altering turbidity was not effectively accomplished. Because of high salinities in the Terrebonne-Lafourche Area, turbid water was practically non-existent.

The greatest effect through weirs was gained in water level stabilization. The mean difference occurring between water levels affected by weirs and those not affected was 0.44 feet. The greatest difference in water levels at one time was 2.7 feet. Areas not affected by weirs had uncontrolled tidal action, whereas the weirs reduced the flow of water and insured a minimum water level in ponds affected.

During the study no difference was found in marsh vegetation behind weirs and in control areas. However, the occurrence of aquatic vegetation was much higher behind weirs in areas not having a drastic salinity fluctuation.

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