Northeast Gulf Science

Volume 5
Number 2 *Number 2*

Article 2

7-1982

A Comparison of the Fish Populations and Habitat in Open and Closed Salt Marsh Impoundments in East-Central Florida

R. Grant Gilmore
Harbor Branch Foundation, Inc.

Douglas W. Cooke
Harbor Branch Foundation, Inc.

Christopher J. Donohoe
Harbor Branch Foundation, Inc.

DOI: 10.18785/negs.0502.02

Northeast Gulf Science Vol. 5, No. 2, p. 25-37

A COMPARISON OF THE FISH POPULATIONS AND HABITAT IN OPEN AND CLOSED SALT MARSH IMPOUNDMENTS IN EAST—CENTRAL FLORIDA

R. Grant Gilmore, Douglas W. Cooke and Christopher J. Donohoe
Harbor Branch Foundation, Inc.
R.R. 1, Box 196
Fort Pierce, FL 33450

ABSTRACT: Historical and recent biological surveys including aerial and ground level photographs reveal gross changes in vegetation and fish habitat associated with impoundment and flooding of salt marshes bordering the Indian River lagoon in east-central Florida. These studies show a depauperate ichthyofauna and floral association in impoundments excluded from estuarine tidal influence.

Monthly collections of fishes made during 1979 and 1980 are used to compare two marsh impoundments: one closed to tidal influence from the Indian River lagoon and the other reopened to tidal influence through a single 80 cm diameter culvert. The closed impoundment was found to contain a depauperate ichthyofauna consisting of 12 species collected under stressed environmental conditions. Water temperatures ranged from 14 to 34°C, salinities fluctuated widely from 2.0 to 200 ppt and dissolved oxygen was measured as low as 1.2 and as high as 14.2 ppm. The open impoundment contained a far richer ichthyofauna with 41 fish species captured at temperatures of 13.5 to 30°C, salinities of 25 to 38 ppt and dissolved oxygen levels of 2.2 to 7.5 ppm. The open impoundment also demonstrated extensive regrowth of marsh vegetation.

From 1955 to 1968 salt marshes bordering the Indian River lagoon in east-central Florida were impounded for mosquito control (Fig. 1). These marshes were principal breeding sites for the mosquitoes *Aedes taeniorhynchus* and *A. sollicitans*. These species oviposit on the soil surface and hatching is delayed until the marsh is flooded, either by tides or rainfall. Diking and flooding prevents access to breeding substrate for oviposition and effectively reduces mosquito populations (Provost, 1967).

Prior to impoundment of one of the marshes investigated, a study was made of 16 fishes occurring there during annual tidal inundations (Table 1; September-October, 1956; Harrington and Harrington, 1961). The marsh was impounded in 1966 (Fig. 2; now Impoundment No. 12, Indian River County, Bidlingmayer and McCoy, 1978). Thirty months later (September-October, 1968) a second study was conducted to determine the effects of impoundments on the marsh ichthyofauna (Harrington and Harrington, in press). These observations demonstrated an overall reduction in fish species, from 16 to 5, as a result of marsh impoundment. The latter study also revealed a change in feeding strategies for the remaining resident species. Carnivorous and omnivorous species that were found to feed on a variety of organisms prior to marsh impoundment converted to a herbivorous diet in impounded waters.

The Indian River County Mosquito Control District discontinued management of Impoundment No. 12 in 1978. Estuarine waters were no longer pumped into the impoundment and water levels were allowed to fluctuate in response to rainfall and evaporation. This impoundment was chosen for study based on both abundance of background data and change in management strategy of the marsh.

Impoundment No. 23, in St. Lucie Co. (Fig. 1), was also managed by pumping estuarine waters into it during mosquito breeding seasons. However, observa-

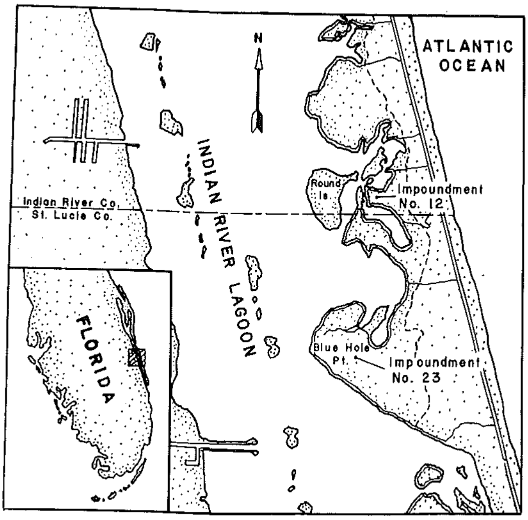

Figure 1. Location of marsh impoundment study sites in east-central Florida.

tions during October 1977 revealed that Impoundment No. 23 had been permanently reopened to tidal water movements through a single culvert 80 cm in diameter. This impoundment was chosen for comparison with Impoundment No. 12 because of this significant change in impoundment hydrography.

It is the purpose of this presentation to qualitatively delineate impounded marsh ichthyofaunas at the two sites. Comparisons can then be made between pre- and post- impoundment ichthyofaunas (Impoundment No. 12, Indian River Co.) and those of an unmanaged impoundment that has been reopened to tidal estuarine influence (Impoundment No. 23, St. Lucie Co.).

METHODS

Techniques utilized to capture fishes in Impoundment No. 12 were intended to duplicate as nearly as possible those of Harrington and Harrington (1961). Therefore, heart traps of the same design and dimensions as those used by them were constructed and set at the same locations over approximately the same time periods. Unbaited heart traps were set between 0930 and 1100 hr and were retrieved 24 hr later. This was done at monthly intervals from January to December 1979. Seine hauls were made, where possible, using a 3.1 x 1.9 m seine (3.2 mm mesh). Most fishes captured in the seine were returned to the water after a subsample was taken for size range determination and future reference. All fishes captured in the traps were preserved. A 5.5 m diameter (12 mm mesh) cast net was used to capture juvenile tarpon.

Harrington and Harrington (1961 and in press) had used rotenone fish toxins to capture fishes in Impoundment No. 12. However, because of the confined nature of the sample sites and lack of estuarine water exchange, fish toxins were not used in the current investigation at this site. However, a selective crystalline rotenone solution (Gilmore *et al.* 1981) was used on two occasions in Impoundment No. 23, at locations selected because of a relatively large volume of estuarine water exchange.

Impoundment No. 23 was sampled periodically from October 1977 to November 1979 and monthly, from January to December 1980. A variety of techniques was used because of water depth, bottom topography and estuarine influence. The same cast net was used in deeper locations. A 15 m x 4 m, 65 mm mesh gill net was set overnight on three occasions at strategic locations to capture large migratory species. A 15.4 x 1.85 m, 3.2 mm mesh seine was pulled over a 80 m transect through a 0.3 to 1 m deep canal from the culvert to a sand beach at the impoundment dike. Marsh vegetation, i.e., mangroves, *Batis maritima* and *Salicornia* spp. formed the margins of the seine corridor which was principally over a mud bottom. The maximum water depth at all locations sampled was 2 m. Heart traps were set on two occasions on shallow marsh flats (depths to 15 cm). Use of heart traps was curtailed as the species captured in the traps were more adequately sampled with other gear. A 25 m x 3 m, 25 to 6.4 mm mesh Fyke net was set in the impoundment to sample the culvert water plume at flood tide on three occasions.

Although the sampling methods differed between study sites, the limited habitat in Impoundment No. 12 did not require the diverse collecting apparatus used in Impoundment No. 23.

Salinity (AO optical salinometer), temperature and DO levels (Yellow Springs Instrument Co., Model 57 portable DO-Temperature meter) were recorded at all sample sites during monthly collections. These measurements were also made when traps were set and retrieved in Impoundment No. 12.

STATION DESCRIPTION

Impoundment No. 12

The pre-impoundment marsh vegetation at this site was mapped by Mr. W.L. Bidlingmayer during the late 1950's and further described by Harrington and Harrington (1961). The peripheral vegetation of the marsh consisted principally of red and black mangrove, *Rhizophora mangle* and *Avicennia germinans.* The major portion of the marsh was described as "an expansive 'parkland' of saltwort (*Batis maritima L.*) and glasswort (*Salicornia perennis* Mill.) interspersed with clumps of black mangrove" (Harrington and Harrington, 1961). Small depressions at various locations in the marsh contained water during the wet season and some throughout the year. From August to October (1956) salinities of these ponds varied from 7.5 to 39 ppt. The average minimum temperature was 27.0° C but maxima as high as 43° C were reached (Harrington and Harrington, 1961).

After the impoundment dike was completed in 1966 (Bidlingmayer and McCoy, 1978), the 50.4 ha (126 acre) impoundment was flooded with water pumped from the Indian River lagoon (Fig. 2A). The impoundment water level was maintained during the mosquito breeding season (April to October). During the nonbreeding season the impoundment water level was not controlled but allowed to drop through evaporation.

During periods when the impounded marsh was flooded, water levels were high enough (30 to 45 cm, Harrington and Harrington, in press) to cover black mangrove pneumatophores, thereby killing all black mangroves inside the impoundment dike. High water also extirpaed stands of *Batis* and *Salicornia* in the open marsh. The marsh was gradually colonized by the submerged aquatic grass, *Ruppia maritima*. During periods when the majority of the marsh was dry due to evaporation, *R. maritima* blades died back, although rhizomes continued to live below the soil surface. Immediate regrowth of *R. maritima* blades was evident after water levels increased through pumping or rainfall. Also abundant in the flooded impoundment were several species of blue-green "algae" (e.g., Cyanobacteria: *Microcoleus lyngbenaceous, Anabaena furtillissma, Spirulinia subsalsa, Anacystis dimidiata, A. montana*) and a chlorophyte (*Batophora oerstedi*). This annual dry-wet season vegetative cycle occurred only when the impoundment was managed for mosquiot control prior to 1979.

During 1979, the impoundment did not receive pumped estuarine waters and was allowed to dry through evaporation. *Ruppia maritima* was eventually extirpated through prolonged drought over much of the marsh but remained in the more permanent ponds along with various species of blue-green and green algae. From the late fall 1979 throughout 1980, regrowth of a few isolated red and black

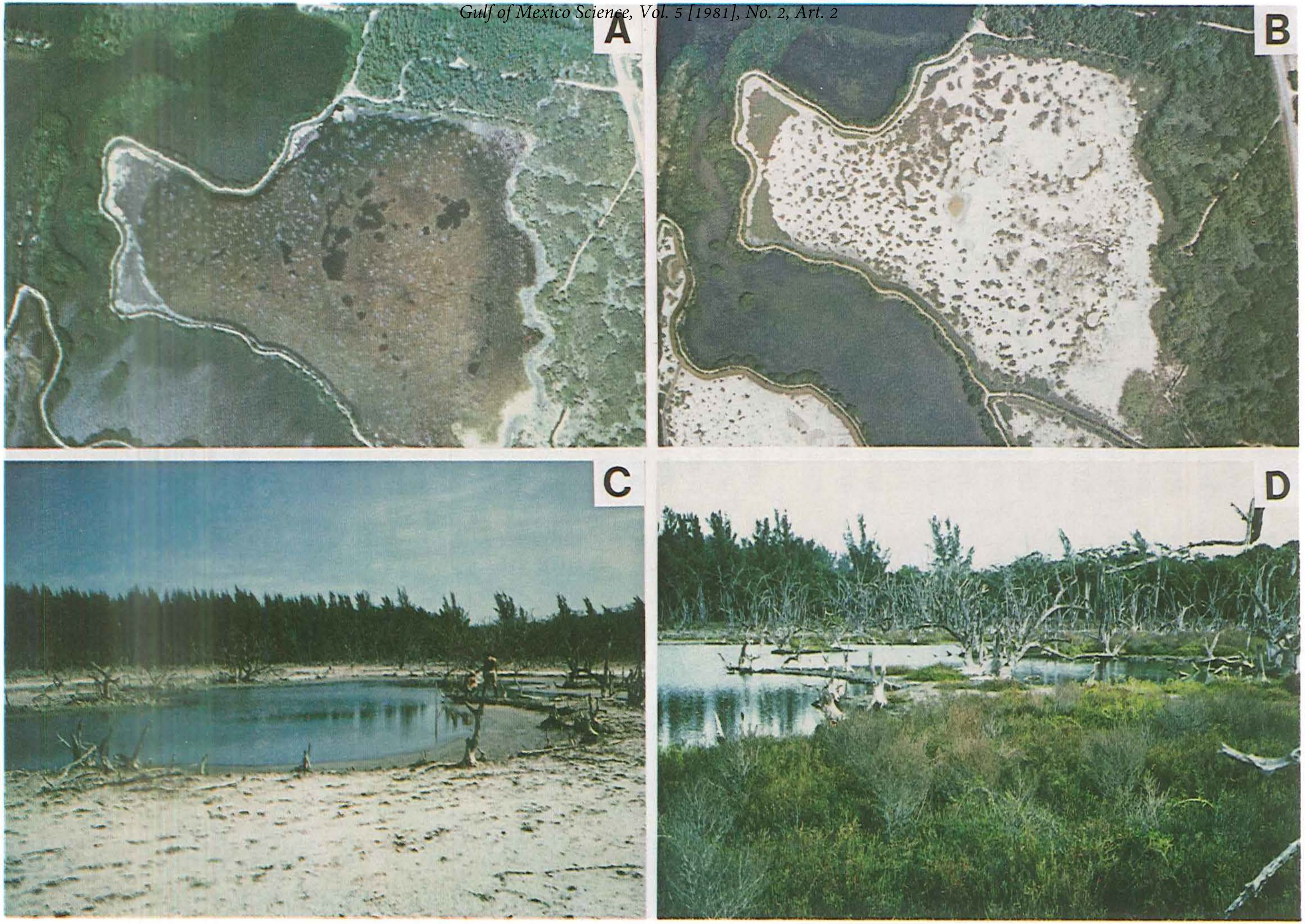

Figure 2. Vegetative changes and collection ponds (center and upland portions of marsh) in impoundment No. 12. (A) 1976 aerial photo of flooded marsh with dead mangroves and dark color due to growth of algae and *Ruppia maritima*. (B) 1981 aerial photo of the dry marsh with some regrowth of *Salicornia virginica*, *S. bigelovii* and *Batis maritima*. (C) Dry impoundment with hyper-saline pond, 13 April, 1979. (D) Regrowth of *Salicornia* spp. and *Batis maritima* at same pond, 16 December 1980.

mangroves from surviving stumps and reestablishment of saltwort and glasswort took place over much of the marsh (Fig. 2D).

During 1979, six ponds and a single location of higher elevation, which was only occasionally submerged, were isolated for study. Only three of these ponds contained water throughout the entire 1979 study period. Salinities, temperatures and dissolved oxygen levels varied between 2-125 ppt, 14-34°C, and 1.2-14.2 ppm, respectively, during 1979 (Fig. 3). As each ephemeral pond dried, hypersaline conditions were observed. One pond, which was not a major study pond, reached 200 ppt at which time the water's surface was coated with a thin layer of crystalline salt. Physical conditions changed abruptly when hurricane David passed over this impoundment on 3-4 September 1979, reflooding the impoundment and reducing salinities to 8.0 ppt. Subsequent visits to the study area

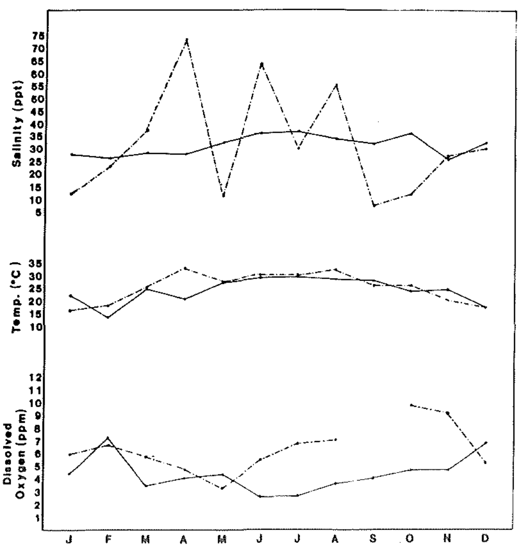

Figure 3. Comparison of annual variation in water temperature, salinity and dissolved oxygen in Impoundment No. 12 (.-.-.-, 1979) and Impoundment No. 23 (______, 1980). DO reading for Impoundment No. 12 were not taken during September and October due to meter failure.

during April 1981 revealed that all study ponds were virtually dry with remnant water salinities of 204 to 210 ppt.

Impoundment No. 23

This 159.2 hectare (398 acre) impoundment is located on a low geographical prominence extending into the Indian River, known as Blue Hole Point. The southern margin of Impoundment No. 12 is separated from the northern portion of Impoundment No. 23 by a dike.

The date of construction of Impoundment No. 23 is uncertain but probably took place during 1965 or 1966 (St. Lucie Co. Mosquito Control District, pers. comm.). The impoundment was managed by the same pumping scheme that was initially used for Impoundment No. 12. High water levels extirpated extensive stands of black mangrove, saltwort and glasswort and these were succeeded by submerged beds of *Ruppia*.

After Impoundment No. 23 was reopened to tidal water movements (October 1977) through a single 80 cm diameter culvert, extensive vegetative regrowth occurred with the succession of black and red mangroves, saltwort and glasswort (Fig. 4). The short term restoration of marsh floral diversity is demonstrated by the rapid regrowth of plant species indigenous to the unimpounded marsh.

Salinity, temperature and dissolved oxygen levels for 1980 collecting periods ranged from 25-38 ppt, 13.5-30°C and 2.2-7.5 ppm, respectively (Fig. 3).

At one time a 2+ m deep cove extended into the marsh from the open estuary, but was bisected by the impoundment dike (Fig. 4A). This cove still provided a passage for larger organisms invading the central portion of the marsh within the impoundment and may account for the movement of larger fish species (e.g., tarpon, 260-720 mm SL) into our study site adjacent to the cove.

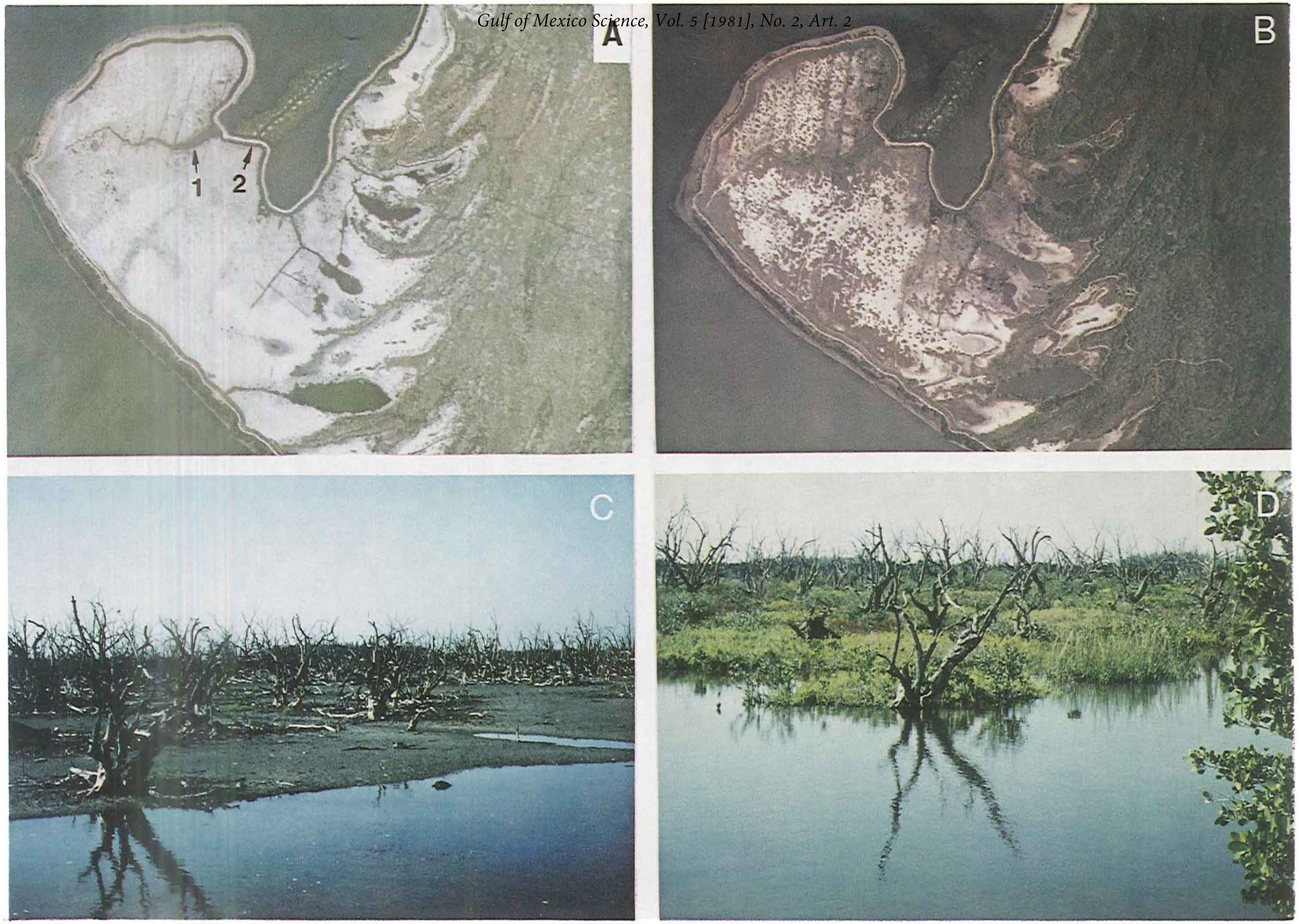

Figure 4. Vegetative change and collection locations in Impoundment No. 23. (A) Aerial photo of dewatered marsh, 19 April, 1976, 1=cut blocked by impoundment dike, 2=culvert site. (B) Aerial photo of marsh with vegetative regrowth, 24 April, 1981. (C) Impoundment scene on 21 January, 1977 with dead mangroves (condition prior to re-establishment of tidal connection). (D) Same scene on 14 October, 1980 showing vegetation regrowth following re-establishment of tidal influence.

IMPOUNDMENT FISH POPULATIONS

Impoundment No. 12

Our fish collections made in this impoundment during 1979 demonstrated that at least 11 species were present at the beginning of the survey (January-April, Fig. 5). Arid conditions from January through June produced hypersaline conditions in all ponds (39-125 ppt; Fig. 3), and only three ponds consistently contained water. Prior to the evaporative dewatering of the impoundment, the bay anchovy, *Anchoa mitchilli,* gulf killifish, *Fundulus grandis,* marsh killifish, *F. confluentus,* tidewater silverside, *Menidia peninsulae* and the gobies, *Microgobius gulosus, Gobiosoma robustum* and *G. bosci* were present. These species were probably introduced into the marsh when water levels were maintained by pumping estuarine waters into the impoundment prior to 1979. After salinities reached 66-150 ppt during April these species were no longer collected.

By May the only species surviving at the collection sites were *Cyprinodon variegatus, Gambusia affinis, Poecilia latipinna and Megalops atlantica* and most of these were limited to ponds where salinities did not go above 80 ppt. Juvenile *Megalops atlantica* (110-169 mm SL) were present in the impoundment during the entire year; however, they were only observed in an isolated deep pond (2.8 m depth) where salinities did not exceed 21 ppt. When all of the remainder of the marsh was hypersaline during April, salinities in this pond remained 15 ppt. As both estuarine and impoundment waters were hypersaline during April we suspect that subterranean freshwater supplies were invading this pond.

Of the four remaining species, *C. variegatus* demonstrated the greatest salinity tolerance, swimming "normally" at salinities of 147 ppt (36°C), but dying at salinities of 150-157 ppt (33-36°C) during April 1979. However, additional observations of *C. variegatus* made on 13 April 1981 revealed that this species continued swimming actively at a salinity of 167 ppt. This is the highest salinity record published for this species. Harrington and Harrington (1961) recorded the highest water temperature for *C. variegatus* (43°C), at this same marsh site prior to impoundment. Our data showed *Gambusia affinis* survived salinities of 80 ppt (34°C) while *P. latipinna* did not. However, *P. latipinna* was observed to survive a salinity of 70 ppt (34°C). Prior to these observations the highest recorded salinities for *G. affinis* and *P. latipinna* in Florida waters were 30 ppt and 44.1 ppt, respectively (Tabb and Manning, 1961; Roessler, 1970). From 18 April to 9 May (21 days) the salinity in one pond fell from 80 to 2 ppt due to periodic rainfall. The populations of *C. variegatus* and *G. affinis* inhabiting this pond survived these rapid changes.

Prior to the September collections, hurricane David passed over the impoundment and water levels increased by 41.6 cm. The impoundment was completely flooded, and salinities dropped to 8 ppt across the entire impoundment. *Cyprinodon variegatus, G. affinis* and *P. latipinna* populations increased and spread through the impoundment (Fig. 5).

A single juvenile snook, *Centropomus undecimalis* (17 mm SL) was collected during the November visit. As local populations of adult snook spawn in nearshore Atlantic waters and no snook were captured in previous collections, this specimen was most likely introduced to the impoundment, perhaps during the passage of hurricane David or possibly by biological means (e.g., avian transport). This specimen brought the total fish species collected in Impoundment No. 12 during 1979 to 12 species (Table 1, Fig. 5).

Impoundment No. 23

Monthly collections were made in this impoundment from January to December 1980, 27 months after it had been reopened to estuarine tidal influence. The most obvious effect of reopening this impounded marsh was an increase in species richness due to the seasonal invasion of ephemeral migrants from the Indian River lagoon. The principal portion of this invasion took place during the wet season, June through December, with peak abundance from September to November during maximum tidal flooding of the marsh (Fig. 6). This fish invasion coincides with salt marsh mosquito breeding activity. The most abundant nonresident species was

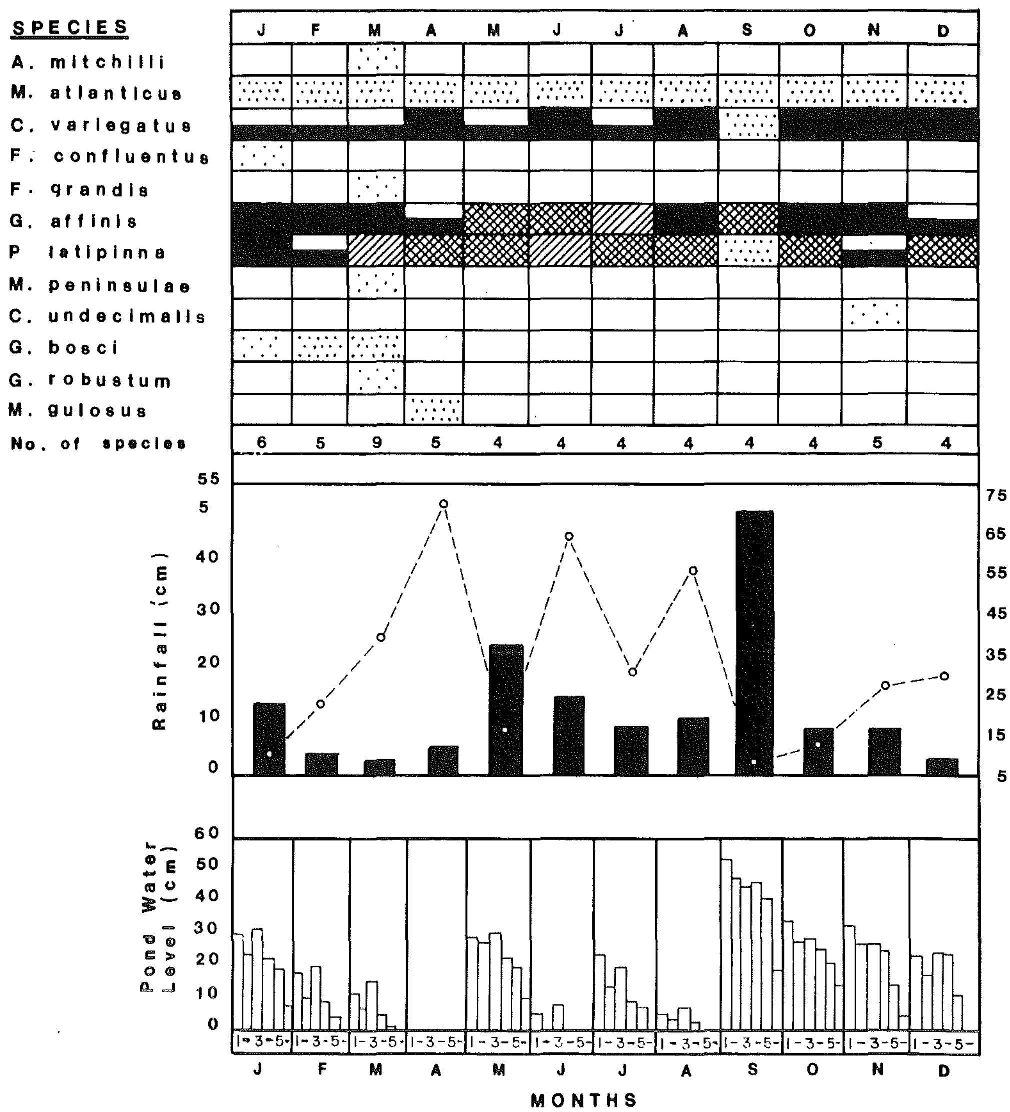

Figure 5. Monthly distribution of fishes in Impoundment No. 12 during 1979 [:·:·:] =1, [....] =2-5, [////] =6-15, [▩] =16-50, [▬] =51-100, [■] =100+, rainfall (data from Florida Medical Entomology Laboratory and Indian River Co. Mosquito Control District) and pond water levels. Some water remained in two ponds during April but was not measured as the permanent calibrated stake was completely exposed.

DOI: 10.18785/negs.0502.02

the Irish pompano, *Diapterus auratus,* followed by the mullets, *Mugil cephalus* and *M. curema,* and the snook, *Centropomus undecimalis.* The largest collections of juvenile snook were made from July to November with greatest abundance in September and October. As many as 59 juvenile snook were captured during a single sweep of the seine (covering 640 m^2). Mullet populations (including adults, but mainly prejuveniles and juveniles of *Mugil cephalus* and *M. curema*) were present through most of the year with several peaks in abundance. *Mugil cephalus* was generally more abundant from October through February while *M. curema* was more abundant during the warmer months, April through

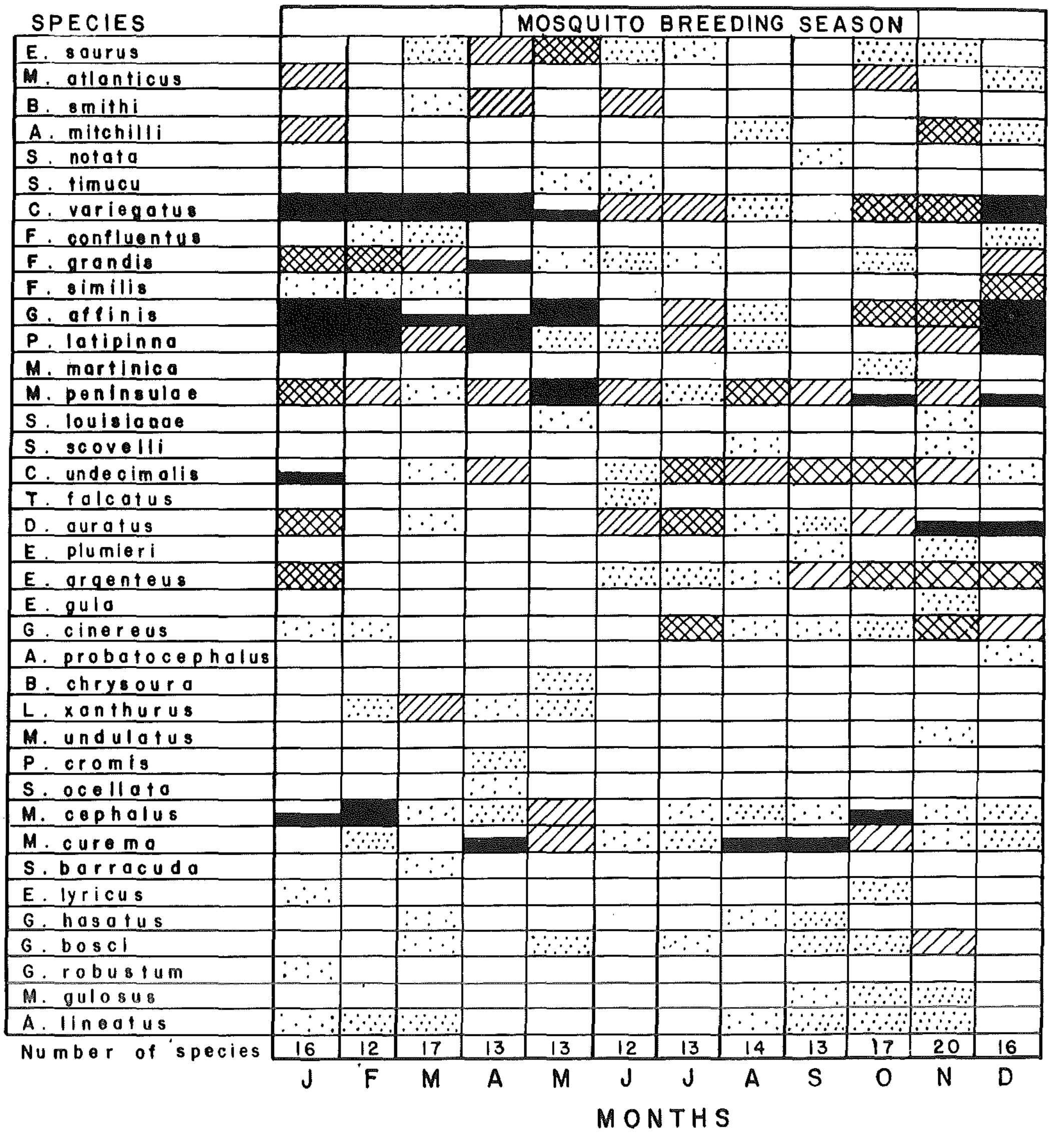

Figure 6. Monthly numerical distribution of fishes in Impoundment No. 23. Capture of *Megalops atlanticus* was limited to three sets of a gill net made during January, October and December, 1980. Numerical codes follow Fig. 5.

October.

Cyprinodontiform and atheriniform fishes present in this impoundment are considered typical marsh residents, i.e., the sheepshead minnow, *Cyprinodon variegatus,* marsh killifish, *Fundulus confluentus,* gulf killifish, *F. grandis,* mosquitofish, *Gambusia affinis,* sailfin molly, *Poecilia latipinna* and the tidewater silverside, *Menidia peninsulae.*

Table 1. Comparison of marsh and impoundment fish faunas. Natural marsh = unimpounded marsh during 1956 (Harrington and Harrington, 1961); Impoundment No. 12 1968 = collections of Harrington and Harrington, in press; Impoundment No. 12 1979 = fishes from our collections; reopened Impoundment No. 23 = fishes from our collections. (*Indicates species collected either before or after the January to December 1980 sampling period).

	Natural Marsh 1956	Impoundment No. 12 1968	Impoundment No. 12 1979	Impoundment No. 23
Anchoa mitchilli			x	x
Brevoortia smithi				x
Elops saurus	x			x
Megalops atlantica	x		x	x
Cyprinodon variegatus	x	x	x	x
Fundulus grandis	x		x	x
F. similis	x			x
F. confluentus	x	x	x	x
Lucania parva	x	x		
Rivulus marmoratus	x			
Floridichthys carpio				x*
Poecilia latipinna	x	x	x	x
Gambusia affinis	x	x	x	x
Menidia peninsulae	x		x	x
Membras martinica				x
Strongylura timucu				x
S. notata				x
Syngnathus scovelli				x
S. louisianae				x
Centropomus undecimalis	x		x	x
Trachinotus falcatus				x
Lagodon rhomboides				x*
Archosargus probatocephalus				x
Eucinostomus argenteus				x
E. gula				x
Diapterus auratus				x
Eugerres plumieri	x			x
Gerres cinereus				x
Leiostomus xanthurus				x
Sciaenops ocellata				x
Pogonias cromis				x
Bairdiella chrysoura				x
Micropogonias undulatus				x
Sphyraena barracuda				x
Mugil cephalus	x			x
M. curema				x
Dormitator maculatus	x			
Gobionellus smaragdus				x*
G. hastatus				x
Evorthodus lyricus	x			x
Microgobius gulosus			x	x
Gobiosoma robustum			x	x
G. bosci			x	x
Achirus lineatus				x

DOI: 10.18785/negs.0502.02

These species were most numerous in our collections during the cool dry season, November through May, with peak abundance at our sites for most species occurring in January and February. This seasonality correlates with a periodic seasonal tidal exposure of the majority of the marsh and low rainfall periods. Lower water levels cause cyprinodont and poeciliid populations to leave the higher flats and aggregate in deeper portions of the impoundment which were sampled most heavily by our techniques. *Gambusia affinis* was the most abundant fish in the marsh followed closely by *Cyprinodon variegatus.*

It is possible that several of the gobiids captured are marsh residents (e.g., *Gobionellus hastatus, Evorthodus lyricus, Gobiosoma bosci* and *Microgobius gulosus.*) However, other local studies have shown that *Gobiosoma robustum* prefers a seagrass bed or drift algal habitat (Kulczycki *et al.* 1981), indicating the salt marsh capture of this species may be extralimital. Most gobiid captures occurred during tidal inundations of the marsh from September to November.

Three additional fish species were captured in Impoundment No. 23 either before or after the Janaury to December 1980 collection period. The goldspotted killifish, *Floridichthys carpio,* and the emerald goby, *Gobionellus smaragdus*, were captured during earlier exploratory collections while a single pinfish, *Lagodon rhomboides,* was captured during May 1981.

A total of forty-one fish species were captured in this impoundment (38 during the January to December 1980 collecting period; Table 1, Fig. 6). Eighteen (44%) of these species occur in the local sport and commerical fisheries. The tarpon, snook, Irish pompano, white mullet, striped mullet, yellowfin mojarra, *Gerres cinereus,* and ladyfish, *Elops saurus,* were the most common fishery species occurring within the impoundment.

DISCUSSION

The placement of tidal barriers around "high marsh" margins (Provost, 1974) in the Indian River lagoon and associated estuarine systems (e.g., Banana River lagoon and Mosquito Lagoon) has effectively impounded 5337.2 hectares (converted from acreage given by Bidlingmayer and McCoy, 1978). The studies of Harrington and Harrington (1961 and in press) demonstrate that the impounding process significantly reduces the marsh ichthyofaunal richness, from 16 to 5 species, and radically changes feeding strategies from carnivorous and omnivorous to herbivorous. The portion of the marsh studied by the latter authors was revisited when it was no longer flooded for mosquito control and was found to be a marginal fish habitat containing 12 fish species. Several small bodies of water remaining in the impoundment were ephemeral and physical conditions in those that did not periodically dry up were beyond the tolerance levels of all but two fish species (i.e., *Cyprinodon variegatus* and *Gambusia affinis*).

The fact that we found 12 species in the impounded marsh while Harrington and Harrington (in press) found only five could be attributed to the number of samples taken and the length of the sampling period. The latter authors only sampled during the fall tidal inundations of the marsh while we sampled throughout the year. A similar time and sampling effort difference is seen between the Harrington and Harrington (1961) open marsh collections (with 16 species) and our open impoundment collections (with 41 species). In addition, our open impoundment collections utilized a wide variety of gear types not used by the Harringtons.

Impoundment No. 23, which had been reopened to estuarine influence, revealed marked species richness relative to Impoundment No. 12, due to the invasion of estuarine species during seasonal (late summer-fall) tidal inundations of the marsh. These marsh invaders were numerically dominated by four species of direct fishery value, i.e., Irish pompano, snook, white and striped mullet. The greatest group contribution to species richness was from gobiids (6 species), gerreids (5 species) and sciaenids (5 species).

Of the salt marsh residents, the species that occured in the lowest numbers was the marsh killifish, *Fundulus confluentus*. This species was captured on only four occasions (8 individuals) in both impoundments studied. Harrington and Harrington (1961) found *F. confluentus* to be a common member of the open marsh ichthyofauna. This species was present 30 months after the construction of Impoundment No. 12 but was considered uncommon (Harrington and Harrington, in press). We collected only one individual in Impoundment No. 12. *Fundulus confluentus* is known to breed in the marsh and produce eggs capable of withstanding atmospheric exposure between seasonal tidal inundations of the marsh (Harrington, 1959). The breeding strategy of *F. confluentus* is associated with tidal water fluctuations which do not occur in the impounded marsh. The decline in marsh populations of *F. confluentus* may relate to intertidal breeding strategies or to diet as this species is carnivorous, feeding most heavily on *Aedes* larva (54% volume, 42% frequency; Harrington and Harrington, 1961). The post-impoundment fish populations of Harrington and Harrington (in press) showed increased reliance on detritus and algae for food. It is, therefore, possible that available foods selected for herbivorous, omnivorous, or detritivorous species over carnivorous species.

A carnivorous species which was abundant in the unimpounded marsh was the rainwater killifish, *Lucania parva* (Harrington and Harrington, 1961). This species was "scarce" 30 months after marsh impoundment (Harrington and Harrington, in press). We did not collect *L. parva* in either Impoundment No. 12 or Impoundment No. 23. The same was true of *Rivulus marmoratus*, a species which was rare even in preimpoundment collections.

Larval tarpon that were so readily collected by Harrington and Harrington (1961) during the fall marsh tidal inundations, were never collected. However, large juvenile (or adult) tarpon (260-720 mm SL) were collected in January, October and December gill net sets in Impoundment No. 23. Gill nets were only set during these three months due to the high efficiency of these nets in capturing and killing tarpon in confined areas.

Many of the species captured in the open impoundment were only represented by juveniles. Primarily juveniles of tarpon, ladyfish, snook, yellowfin menhaden, permit, black drum, red drum, spot, croaker, silver perch, Irish pompano, yellowfin mojarra and great barracuda were found in the open impoundment. Both juveniles and adult anchovies, *Anchoa mitchilli*, needlefishes, *Strongylura timucu* and *S. notata*; silversides, *Membras martinica* and *Menidia peninsulae*; pipefishes, *Syngnathus louisianae* and *S. scovelli*; and the lined sole, *Achirus lineatus*, invaded the impoundment seasonally when it was tidally open to the Indian River lagoon. Therefore, it is evident that the marshes of the Indian River lagoon serve as a seasonal nursery ground for various species.

DOI: 10.18785/negs.0502.02

Our observations demonstrate that although a major loss of indigenous flora and fauna, and great physical and biological stress has been imposed upon the marsh habitat by impoundment construction, the marshes may be relatively quickly reinvaded by many of the same indigenous organisms. The placement of a single small access to estuarine waters (i.e., an 80 cm diameter culvert) has allowed much of the original ichthyofauna and vegetation to return to the marsh at least in a qualitative sense. Further research should quantify the organisms occurring in the impoundments and describe their dynamics. Marshes and impoundments under various mosquito management schemes should also be studied to determine strategies that would be most compatible with the biological activity of an unimpounded marsh.

ACKNOWLEDGMENTS

We thank Michael Clark and Philip Hastings for their aid in field collections. Mrs. Robert W. Harrington, Robert S. Jones and William L. Bidlingmayer made helpful comments on early versions of the manuscript. This constitutes contribution number 263 from the Harbor Branch Foundation, Inc.

LITERATURE CITED

Bidlingmayer, W.L. and E.D. McCoy. 1978. An inventory of the saltmarsh mosquito control impoundments in Florida. Unpublished Rept. to Fish and Wildlife Serv., U.S. Dept. of Interior. 103 pg., 173 maps, Appendices I-III.

Gilmore, R.G., P.A. Hastings, G.R. Kulczycki and B.L. Jennison. 1981. Crystalline rotenone as a selective fish toxin. Fla. Sci., 44(4): 193-203.

Harrington, R.W. 1959. Delayed hatching in stranded eggs of marsh killifish, *Fundulus confluentus*. Ecology 40: 430-437.

_________, and E.S. Harrington. 1961. Food selection among fishes invading a high subtropical salt marsh: from onset of flooding through the progress of a mosquito brood. Ecol. 42(4): 646-666.

_________. in press. Effects on fishes and their forage organisms of impounding a Florida salt marsh to prevent breeding by salt marsh mosquitos. Bull. Mar. Sci.

Kulczycki, G.R., R.W. Virnstein and W.G. Nelson. 1981. The relationship between fish abundance and algal biomass in a seagrass-drift algae community. Est. Coast. Shelf Sci. 1981(1): 341-347.

Provost, M.W. 1967. Managing impounded salt marsh for mosquito control and estuarine resource conservation. LSU Marsh and Estuary Symposium. pp. 163-171.

_________. 1974. Mean high water mark and use of tidelands in Florida. Fla. Sci., 36(1): 50-65.

Roessler, M.A. 1970. Checklist of fishes in Buttonwood Canal, Everglades National Park, Florida, and observations on the seasonal occurrence and life histories of selected species. Bull. Mar. Sci. 20(4): 860-893.

Tabb, D.C. and R.B. Manning. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf and Carib. 11(4): 552-649.

Wade, R.A. and C.R. Robins. 1973. The tarpon and its sport fishery: a review of our knowledge and outline of the problem. Intern. Game Fish. Conf., 15: 16-27.