Dredged Material Disposal Impact on Habitat Quality and Gamefish Populations of the Apalachicola River

Charles L. Mesing, *Florida Game and Fresh Water Fish Commission, P.O. Box 38, Midway, FL 32343*

Lothian A. Ager, *Florida Game and Fresh Water Fish Commission, P.O. Box 38, Midway, FL 32343*

Abstract: Within-bank disposal of dredged material has detrimentally impacted natural habitats and gamefish of the Apalachicola River. Between 1947 and 1980 40 km of natural bank habitat has been altered by disposal of dredged material resulting from navigational maintenance activities by the U.S. Army Corps of Engineers. Gamefish catch per unit of effort (CPUE) values from natural bank habitats were significantly greater ($P < .05$) than those from "new," "recent," and "old" disposal sites. Gamefish CPUE values measured on "new," "recent," and "old" disposal sites were 75%, 66%, and 50% less than gamefish CPUE values on natural bank habitats.

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The U.S. Army Corps of Engineers (COE) has been authorized since 1875 to maintain a navigable channel (3 m × 46 m) in the 171 km Apalachicola River (Leitman et al. 1984). Since that time, the COE has dredged the main channel, oxbows, tributaries, and sloughs and disposed of dredged material on the floodplain and within the natural river banks. Deposition of dredged material on forested floodplain sites has resulted in the loss of valuable wildlife habitat in the lower Apalachicola River (Eichholz et al. 1979). Subsequently, floodplain disposal was restricted to few areas and the number and use of within-bank disposal sites increased (Leitman et al. 1984). The COE's concept of within-bank disposal involved the placement of dredged material on point bars within the natural levee of the river. During annual high flow periods this dredged material would be redistributed downstream rejuvenating the use of the point bar as a disposal site. This disposal method was assumed to be the least environmentally damaging to the Apalachicola River. In 1980, nearly 150 within-bank disposal sites were permitted throughout the river based upon channel dredging requirements and the location of natural point bars. Required dredging locations exceeded the number of point bars, resulting in selection of natural gently sloped river bank habitat above and below these bars for dredged material disposal. No site preparation was provided. Length and width of within-bank disposal sites varied with dredging requirements. Although some effort is made to keep disposal material within the river bank, it often encroaches on the natural levee and frequently exceeds the height of the natural river bank. All existing vegetation and snags at the site are buried by this disposal practice.

Baseline fish and aquatic invertebrate population studies on the Apalachicola River were conducted by Brown (1964) from 1954 to 1963 and Cox (1975) from 1967 to 1974. Although not specifically designed to evaluate the impact of dredging and disposal, both studies reported concern over the loss of productive fish habitat by navigational maintenance activities. Long-term consequences of continued maintenance dredging and disposal in the middle and lower Apalachicola River by the COE had received very little attention and concern from the state of Florida prior to 1980. Although emphasis on within-bank disposal of dredged material increased in 1973, no scientific investigation was designed to assess and quantify its impact on aquatic habitat and fish populations until 1981. The Florida Game and Fresh Water Fish Commission was contracted in 1982 by the COE to evaluate short-term environmental impacts of within-bank dredged material disposal on fish populations in the Apalachicola River.

The objectives of the study reported in this paper were to quantify the loss of natural habitat and predict short-term (<1 year) and long-term (≥ 5 years) impacts of dredged material disposal on gamefish populations associated with present and potential disposal areas. This paper represents a portion of a larger study to evaluate the impacts of dredging and disposal practices on natural habitats, fish populations, macro-invertebrates, and water quality of the Apalachicola River and its tributaries.

Methods

Study Area

The Apalachicola River is part of the Apalachicola-Chattahoochee-Flint (A–C–F) River basin that drains 210,448 ha. It is formed by the confluence of the Flint and Chattahoochee rivers in Lake Seminole and originates as a tailwater discharge from Jim Woodruff Lock and Dam. This is the largest river in Florida in terms of discharge with a mean annual flow of 690 m^3/second (Leitman et al. 1984). The river is 171 km in length and can be divided into 3 physiographic segments. The upper river extends from Navigation Mile (NM) 106.3 (Jim Woodruff Lock and Dam) downstream through steep bluffs on the east to NM 78.0. The middle river begins at Blountstown (NM 78.0) and meanders through gently sloping lowlands to the River Styx below the city of Wewahitchka (NM 35.0). The lower river section flows through a wide floodplain with numerous tributaries and distributaries before emptying into Apalachicola Bay.

Habitat Mapping

An aquatic habitat map of the river banks was compiled from field observations conducted during low water periods. Linear shoreline distance for each habitat was calculated to the nearest 30 m from aerial photographs (1 cm = 60 m) of the river using a Dietzel map measurer.

Fish Sampling

Electrofishing sites for each habitat were randomly selected in each river section in proportion to the amount of each habitat. Samples were conducted during low water periods (May–December) from 1982 through 1984. A 4.9-m aluminum boat with 2 91-cm-diameter anodes and a gas powered Smith-Root generator was used to produce pulsed D.C. current (7–8 amperes) at 60 pulses per second. Two men collected all fish in 5 to 15 minute samples.

All fish collected were weighed and measured at the collecting sites except for individuals not readily identifiable. These specimens were preserved in formalin (10%) and identified, measured, and weighed at the laboratory. All species were categorized into 4 groups—gamefish, foodfish, foragefish, roughfish—according to Ager et al. 1983.

Dredged Material Disposal Sites

Location and frequency of use of approved dredged material disposal sites for the Apalachicola River was provided by the COE (Leitman et al. 1984). The number of years since disposal for each site ranged from 0 to 7. Because records were only available since 1977, disposal sites sampled by electrofishing in 1982, 1983, and 1984 without a known disposal history were considered as ≥5, ≥6, or ≥7 years old. Presumably, the oldest within-bank disposal sites should date only to 1973. However, because records of the COE activities were not available prior to 1973, some within-bank disposal sites may have been older than 10 years.

Preliminary observations suggested grouping sand habitat electrofishing samples by years-since-last-disposal to increase sample size and because of uncertainty over age of older sites. Data from individual sand habitat electrofishing samples were grouped and classified into 1 of 3 categories: "new" (<1 year since disposal), "recent" (1–4 years since disposal), and "old" (5–10 years since disposal) disposal sites.

Data Analysis

Daytime electrofishing samples from middle and lower river sand habitats were pooled and categorized ("new," "recent," or "old"). Data from upper river sites were deleted because of the paucity of "new" disposal sites and the influence of Lake Seminole which contributed fish to all upper river habitats (Ager et al. 1983). For our study objectives, only gamefish and total fish catch per unit effort (CPUE) values were analyzed because detrimental impacts to the gamefish community would directly affect the fishery of the Apalachicola River. Differences in total fish and gamefish numbers and weights between disposal sites and natural steep and gently sloping habitats were tested using Sidak's multiplicative inequality (SAS Inst. Inc. 1982) to adjust the alpha level such that the group of comparisons was valid at the 5% level. Relative changes in the structure of fish communities from "new" disposal sites to "recent" and "old" disposal sites were assessed by comparing CPUE values and percent composition of gamefish.

Results

Habitat Mapping

A total of 347.42 km of river shoreline was delineated into 6 habitat types (Table 1). Rock habitat existed only in the upper river while the submersed vegetation habitat type occurred only in the lower river. Steep natural banks, >45°; shallow natural banks, <45°; dike fields; and sandbars were found in each of the 3 river sections.

Results of the habitat mapping indicated 24% (82.99 km) of the shoreline was sand habitat representing an increase of approximately 40 km since 1947 (COE 1986). The lower river had the smallest percentage (9%) of sand habitat and the largest percentage of natural habitat. The middle river section contained the largest percentage (33.9%) of sand habitat.

A total of 348 electrofishing samples was conducted on the Apalachicola River during the study (Table 1). Of the 75 sand habitat daytime electrofishing sites sampled in the middle and lower river sections, 20 were classified as "new," 32 as "recent," and 23 as "old" disposal sites (Table 2).

Table 1. Estimated linear kilometers of shoreline habitat for the Apalachicola River by river section and habitat type, 1982–1984.

	Steep bank	Shallow bank	Dike field	Sand	Rock	Submersed vegetation	Total
Upper River (NM[a] 106.3–NM 78.0)							
Shoreline length (km)	46.03	8.22	1.05	24.12	7.19	0.00	91.44
Percent of shoreline	50.3	8.9	6.4	26.3	7.8	0.00	
Electrofishing samples (*N*)	23	3	43	38	18	0	125
Middle River (NM 78.0–NM 35.0)							
Shoreline length (km)	75.89	17.46	.055	48.25	0.00	0.00	142.15
Percent of shoreline	53.3	12.2	0.3	33.9	0.00	0.00	
Electrofishing samples (*N*)	13	10	4	64	0	0	91
Lower River (NM 35.0–NM 0.0)							
Shoreline length (km)	22.85	68.07	1.50	10.62	0.00	10.78	113.83
Percent of shoreline	20.0	59.8	1.3	9.3	0.00	9.4	
Electrofishing samples (*N*)	5	35	29	36	0	27	132
Total							
Length of habitat (km)	144.77	93.76	7.92	82.99	7.19	10.78	347.42
Percent of habitat	41.7	27.0	2.3	23.9	2.1	3.1	
Electrofishing samples (*N*)	41	48	76	138	18	27	348

[a]NM = Nautical mile.

Table 2. Mean catch per unit of effort, numbers, and weight (kg) of fish collected by daytime electrofishing on disposal sites and natural habitats in the lower and middle Apalachicola River (nautical mile 0.0–78.0), 1982–1984. Means with the same superscripted letter are not significantly different ($P < 0.05$) according to the Sidak's multiplicative inequality test for habitat comparisons.

		Gamefish		Total fish	
Habitat	*N*	Mean	SE	Mean	SE
	Mean Fish Per Minute				
Steep natural bank	16	3.7[a]	0.5	8.9[a]	1.0
Shallow natural bank	37	4.0[a]	0.4	10.3[a]	0.9
5–10 year since disposal (old)	23	1.7[b]	0.3	10.9[a]	1.8
1–4 years since disposal (recent)	32	1.4[b]	0.2	7.7[a]	0.8
0 years since disposal (new)	19	1.0[b]	0.3	7.0[a]	1.4
	Mean Total Weight (kg) Per Minute				
Steep natural bank	16	0.26[a]	0.06	0.81[a]	0.19
Shallow natural bank	37	0.19[a]	0.02	0.56[a,b]	0.06
5–10 years since disposal (old)	23	0.12[b]	0.03	0.54[b]	0.13
1–4 years since disposal (recent)	32	0.07[b]	0.01	0.33[b,c]	0.05
0 years since disposal (new)	19	0.05[b]	0.01	0.26[c]	0.05

Fish Communities Associated with Habitats

Mean catch rates for all fish from disposal sites and natural bank habitats ranged from 7.0 fish/min to 10.9 fish/min (Table 2). No significant differences ($P = 0.26$) in total fish/min values were detected between disposal sites and natural habitat sites.

Mean total fish weight per unit effort for disposal sites and natural banks ranged from 0.26 kg/min to 0.81 kg/min (Table 2). Total fish weight per unit effort for steep natural banks was significantly greater ($P < 0.05$) than for all disposal sites. Total weight from gently sloping natural banks was significantly greater ($P < 0.05$) than from "new" disposal sites, but not significantly different ($P > 0.05$) than "recent" and "old" disposal sites.

Catch rates for gamefish from natural bank habitats and disposal sites ranged from 1.0 fish/min to 4.0 fish/min (Table 2). Gamefish CPUE values (fish/minute and kg/minute) from natural bank habitats (gently sloping and steep) were significantly greater ($P < 0.05$) than from all disposal sites. No significant differences ($P > 0.05$) in gamefish per minute and weight per minute was detected between "new," "recent," and "old" disposal sites.

Gamefish comprised 39% and 42% of the total number and more than 30% of the weight of fish collected in electrofishing samples on natural bank habitats compared to 11% to 19% by number and 16% to 24% by weight for disposal sites (Figure 1). Forage species were the predominant fish group collected from all disposal sites, representing 75% to 79% by number in the samples, while only 51% to 57% of the fish collected from natural habitat sites belong to the forage fish group (Ager et al. 1983).

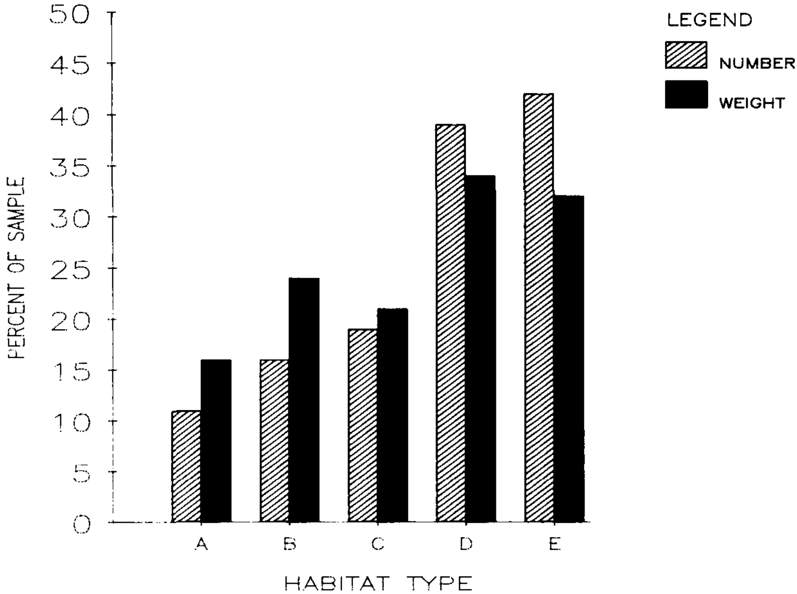

Figure 1. Gamefish numbers and weights (%) from naturally steep and gently sloping banks ("new," "recent," and "old" disposal sites) from the Apalachicola River. Habitat types: "new" disposal (A), "recent" disposal (B), "old" disposal (C), gently sloped natural bank habitat (D) and steep sloped natural bank habitat (E).

Discussion

Although the COE had anticipated only short-term effects of within-bank dredged material disposal, long-term environmental impacts on aquatic habitats and gamefish communities of the Apalachicola River were very evident. Sand habitat in the Apalachicola River has been increased from approximately 40 shoreline km in 1947 to approximately 80 shoreline km in 1980 as a result of the COE's disposal of dredged material (COE 1986). This represents a loss of 40 km of natural bank habitat. Habitat mapping in 1983 revealed an additional 2.99 shoreline km of sand habitat in the river. The natural gently sloping bank habitat has been most impacted by disposal material throughout the river.

Total fish catch rates did not differ between natural bank habitats and disposal sites primarily due to large numbers of small forage fish (*Notropis* spp.) collected from disposal sites. These forage species represented more than 75% of the total fish collected from disposal areas. Catch rates for *Notropis* spp. have increased since Cox and Auth (1973) sampled the Apalachicola River, possibly the result of increased spoil disposal habitat or difference in electrofishing efficiency. Ager et al. (1983) reported that sand was the least productive habitat in terms of gamefish per minute although many young-of-the-year *Morone* spp. and channel catfish (*Ictalurus punctatus*) utilized disposal sites or sandy habitats at night.

CPUE values for gamefish on "unspoiled" natural habitat were 4 times greater than from "new" disposal sites, 3 times greater than from "recent" disposal areas and more than doubled from "old" disposal sites in the middle and lower Apalachicola River. These differences in gamefish catch rate values between natural banks and disposal sites demonstrate a quantitative impact to the fishery as a loss to the gamefish community. Although the most severe impact (75% reduction in gamefish CPUE values) was measured between "new" disposal sites (1.0 fish/minute) and gently sloping natural habitats (4.0 fish/minute), a 50% reduction persisted 5 to 10 years after disposal.

Floodplain and within-bank disposal of dredged material has been used primarily because it is convenient and one of the least expensive disposal methods. Adverse environmental impacts on wetland areas, marshes, sloughs, and side channels have resulted from these methods of dredged material disposal (Brady 1976). Direct coverage of aquatic habitats buries aquatic organisms and sterilizes biologically productive areas (Schnick et al. 1982).

The merits of potential disposal sites for dredged material in coastal, estuarine areas have been discussed by Allen and Hardy (1980) and Morton (1977). Concern was expressed in both reviews for the direct covering of productive aquatic habitats and uncontrolled redistribution of disposal material to previously "unspoiled" areas such as backwaters and sloughs. In estuarine systems most aquatic disposal procedures have been designed to develop islands, but this does not have much potential for river systems (Schnick et al. 1982).

A majority of disposal sites in the Apalachicola River have been utilized frequently by the COE to accommodate increasing amounts of dredging necessary in the middle and lower river sections (Leitman et al. 1984). Recent predictions indicated 78 of 151 (52%) disposal sites in the Apalachicola River were anticipated to be disposed on every 1 to 2 years (Leitman et al. 1984). If dredging needs continue to increase, additional disposal sites will be requested by the COE to meet those needs. If additional unspoiled natural bank habitats are approved for disposal of dredged material, further reductions in gamefish will occur.

The impacts of current dredged material disposal practices of the COE measured in this study are too acute and long-term (50% less of gamefish at disposal sites) to permit additional within-bank disposal sites on natural bank habitat in the Apalachicola River. Disposal of dredged material on sandy habitats will have the least impact to the fishery. When disposal sites reach capacity, these sites could be rejuvenated by transporting accumulated material out of the river as opposed to using additional natural sites. The COE's historical practice of expanding within-bank disposal sites to gently sloping natural habitats above and below point bars has severely impacted and altered the gamefish populations associated with these once natural habitats in the Apalachicola River. The results of our investigation will assist state and federal agencies in developing policies to protect natural riverine habitats which remain in the Apalachicola River.

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