EFFECTS OF SAND DREDGING ON CHANNEL MORPHOLOGY, INVERTEBRATE COMMUNITIES AND FISH COMMUNITIES IN URBAN DEKALB COUNTY STREAMS

Chris Decker[1], Jennifer Keyes[1], C. Rhett Jackson[2], Jay Shelton[3] and Ben Jackson[4]

AUTHORS: [1]Graduate student, [2]Assistant Professor, [3]Associate Professor, and [4]Professor, Warnell School of Forest Resources, University of Georgia, Athens, Georgia 30602.
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Abstract. We are sampling physical and biological channel characteristics to assess the effects of dredging sand from two urban streams in DeKalb County. We are comparing physical and biological metrics upstream and downstream of existing operations. In addition, we are studying metrics prior to and after future dredging at another site. Dredging has been found to be deleterious to aquatic habitat conditions in some streams. However, it is possible that dredging may benefit streams that have been subjected to large increases in sediment loading.

INTRODUCTION

We are investigating the effects of sand dredging on channel morphology and biotic communities in DeKalb county urban streams, specifically Peachtree Creek and South River. A comparison will be made between pre-dredging and post-dredging conditions in the South River and conditions upstream and downstream of two existing dredges on Peachtree Creek. This study is being conducted partly to fulfill a permit requirement, as well as to evaluate the hypothesis that sand dredging may benefit the ecology of urban streams with high sediment loads.

Our study focuses on two active dredging sites and on one site slated for near future dredging. The active sites are located on Peachtree Creek, a tributary of the Chattahoochee River. The proposed site for future dredging is on the South River, a tributary of the Ocmulgee River. Both of these stream basins are heavily urbanized. The Peachtree Creek headwater areas are nearly "built-out" and feature a mix of industrial, commercial, and residential development as well as a high density of interstate highways. Current conditions in Peachtree Creek result from a long history of agricultural, residential and commercial development in the basin. After World War Two, the Peachtree Creek watershed changed from a primarily rural watershed to an intensely developed suburb of Atlanta. Most of the urbanization occurred in the time period from 1950 to 1965 (James et al., 1971). Redevelopment and infilling continues today, but most of the sediment deposited in Peachtree Creek likely was delivered twenty to 160 years ago. Land use in the South River watershed includes closed landfills (including Superfund sites), industries, Hartsfield International Airport, the Atlanta zoo, dense residential development, and interstate highways.

The extensive development of the Peachtree Creek and South River watersheds causes problems of flooding, sedimentation, and channel erosion which concern creek-side residents and the Dekalb County government. Rapid urbanization of the landscape has lead to significant increases in flood peaks, because the natural drainage mechanisms have been altered and the constructed drainage facilities overloaded (James et al., 1971). In addition, sediment deposits delivered to the creek over years of anthropogenic disturbance altered channel substrate and form. The current and proposed dredging projects are an attempt to increase the capacity of Peachtree Creek and the South River to handle larger flows and to improve habitat conditions.

The dredges are wet pit operations that remove sand as a slurry directly from the stream channel. The water and coarse aggregate are separated from the sand in a trommel. The separated water is piped to a clarification pond to settle out suspended sediment before it is recycled back into the creek. Organic debris is left in the channel, but coarse material (gravel) and trash have been sent to a landfill. This practice may soon be modified to return the gravel to the channel. The dredges are constrained to operate within a 100 meter segment of channel in which they essentially remove all of the sand down to the bedrock and clay floor of the channel during the excavation. In Peachtree Creek the depth of the sand deposits are about two meters, while the sand deposits in the South River reach depths of four to five meters. The dredging operator "harvests" the sand like a crop, removing all of the sand within the dredge area and then ceasing operation until the stream brings in another crop.

Dredging in Peachtree Creek began in June of 1997, and since that time about 45,000 U.S. tons of sediment have been extracted. This is approximately equivalent to removing about two meters of sand from 1240 meters of channel (the channel averages about 10 to 12 meters wide). The excavated sand is sold as aggregate, and the revenues fund the majority of the operation. Since 1997, sand dredging falls under a special category of permits called nationwide permits which are issued directly by the U.S Army Corps of Engineers. Prior to 1997, the Environmental Protection Division of the Georgia Department of Natural Resources permitted all instream mining under the Georgia Surface Mining Act of 1968 and the Corps of Engineers functioned only to regulate navigational dredging operations (Brooks, 1998). After reacquiring the permitting process, the Corps of Engineers sought a study to help evaluate the environmental impacts of sand dredging and thus required DeKalb County to initiate this investigation. This study may help set the standards for similar projects in the State of Georgia.

The economics of sand dredging usually require close proximity to urban areas because of high transportation costs. There are 66 active sand dredging facilities in Georgia. All of these sites occur in the Piedmont and are predominately located around metropolitan Atlanta. As little as 20 miles of transportation doubles the cost of aggregate (Bull and Scott, 1973). In addition, the demand for aggregates is greater in urban areas where there is active construction occurring.

ENVIRONMENTAL IMPACTS OF SAND DREDGING

Sand dredging operations can produce large quantities of suspended sediment, elevating turbidity levels and creating deposits in streams. There are several physical effects on streams caused by dredging activities: change in channel morphology, locally increased water velocity and scour, headcutting, streambed modification, enhanced fine particle deposits, remobilization of contaminants in the sediment, and increased turbidity (Brooks, 1998; Waters, 1995; Rivier and Seguier, 1985; Cordone et al, 1960). The presence and degree of all these effects are dependent upon local site conditions and dredging methodology. There are three types of instream mining. In Georgia, the most common form of instream mining is wet pit mining, in which draglines or dredges remove material from below the watertable or directly from a stream channel. This is the type of mining under investigation in Dekalb County. A second type is dry pit mining, in which heavy machinery is used to excavate pits on portions of the streambed exposed during low flows. A third type of instream mining is bar skimming, in which tops of sand or gravel bars are removed without excavating below the water table (Brooks, 1998; Mount, 1995; Knodolf 1994). Dry pit mining and bar scalping are viewed as less deleterious to the aquatic environment since they do not cause immediate turbidity impacts or direct egg mortality.

Results of previous studies of biotic impacts from sand dredging operations have been mixed. Bardarik et al. (1971) found no impact to fish and invertebrate communities from dredging activities in the Allegheny River, but Howard (1995) reported intense impacts to benthic organisms and severe violations of water quality standards as a result of instream dredging operations in a fifth-order stream in Southeastern Mississippi. In addition, Kanehl and Lyons (1992) and Nelson (1993) reported several general biological effects associated with dredging operations including decreased photosynthesis, declining fish and invertebrate community biomass, and reduced diversity among fish and invertebrates communities.

Increased levels of turbidity can have deleterious impacts on aquatic organisms depending on the life history of the organism and the amount of turbidity present. Turbidity affects both the density and metabolism of the plant populations present in stream channels (Aldridge, et al, 1987). A study by Clavel and Bouchard (1980), showed that the absorption of light energy by water is proportional to the concentration of suspended sediment. Plant development, which supports higher trophic levels through primary production, is greatly reduced or even completely inhibited by the presence of dredging works. Wallen (1951) studied the direct effect of sediment upon fishes. The observable behavioral reactions that appeared as a result of turbidity did not develop until concentrations neared 20,000 ppm and in one species reactions did not appear until the turbidity reached 100,000 ppm. Most individuals of all species studied endured exposures to more than 100,000 ppm for a week or longer. Mortality occurred at a concentration of 175,000 to 225,000 ppm. Casey (1959) conducted a study of bottom fauna prior to and after dredging. After dredging, the stream channel was inundated with silt and almost devoid of aquatic life for a quarter mile downstream. After one mile the stream still showed a 50% reduction in benthic fauna. There was no obvious or consistent evidence that any one type of organism was more tolerant of siltation than any other in this study.

Among the most directly affected organisms are filter-feeders such as fresh water mussels. In studies of saltwater mussels, the major effect of high turbidity and turbulence was to reduce the rate and/or efficiency of feeding (Moore, 1977). Freshwater mussel populations in Georgia streams have also been negatively impacted by large scale sedimentation (Edwards, 1996). Recent research has shown that juvenile mussels of many species occur only in riffle areas which can be scarce in streams that have been buried with sediment. The urban streams in our study area commonly have high turbidity even in the absence of dredging. Due to those higher levels, an increase in turbidity from dredging operations may not be as significant as it may be in streams with lower turbidity levels. A benefit of dredging may be to clear out excess sand caused by human disturbances, create more deep water habitat, expose less mobile substrate, and re-create riffle habitat.

STUDY DESIGN

The locations, types, and timing of dredging operations were chosen for economic and engineering reasons without scientific input. Ecosystem monitoring was therefore designed to best quantify and characterize dredging impacts under these circumstances. For these reasons, there is little baseline data on ecological conditions in Peachtree Creek. The small amount of baseline data is coincidental - the USGS sampled fish populations about two kilometers below the downstream dredge site about two months prior to dredging's commencement, and this sampling will be repeated over time to provide inferential data on the impacts of dredging. The study design on Peachtree Creek will focus on upstream/downstream comparison of conditions. Glide/pool/riffle habitat above the upstream dredge site will serve as one reference point. Similar habitat above the downstream dredge site will serve as a reference point for the downstream dredge, but this "reference" is about 5 kilometers downstream of the upstream dredge, so it is not a true reference. Conditions in the glide/pool/riffle habitat about 500 meters downstream of the lower dredge will be compared to these two reference locations. The channel downstream of the upper dredge is a regime channel that cannot be compared to the glide/pool/riffle channel upstream of the upper dredge.

The South River site is expected to commence operation in the fall of 1999. Prior to dredging, winter spring and summer sampling will be conducted in reaches upstream, a few hundred meters downstream, and two kilometers downstream. This sampling will provide baseline data for this dredge operation. Four quarters of sampling in the same locations will be conducted after dredging commences.

At each location, we will sample physical habitat conditions, invertebrate communities, and fish communities. Physical channel characterization will be based on a modified Hankin and Reeves (1988) channel survey methodology and will include the following: Wolman pebble counts, pool frequency and depth, habitat units (pools, riffles, glides, etc), woody debris, and flow width and depths. In addition, we will survey the longitudinal profile of thalweg and establish monumented cross sections so that changes in channel depths and cross-sections can be evaluated in the future. We also plan to measure basic water quality parameters (turbidity, conductance, pH, and dissolved oxygen) during high and low flows, with and without dredging in operation.

Bioassessment of the invertebrate community at the sampling sites will be conducted using the Georgia Bioassessment Protocol (GBP) (Georgia Environmental Protection Division, 1997). The GBP is a modification of the EPA Rapid Bioassessment Protocol III that addresses streams lacking productive riffle habitat. When riffle habitat is not present in a stream the GBP calls for the sampling of other productive habitats such as woody debris, undercut banks, roots, depositional areas, and leaf packs. This multi-habitat approach will help ensure a representative collection of the stream biotic community is obtained. The benthic macroinvertebrates will be sampled from all available habitats, kept separate, preserved in ethanol and returned to the lab for identification.

Fish populations will be surveyed by electroshocking. Individuals will be identified and total length will be determined. Fish sampling will be conducted by the methods used by the Georgia Department of Natural Resources Fisheries Division.

DISCUSSION

By creating areas of deeper water and less mobile substrate, we hypothesize that sand dredging will create habitat for fish and invertebrate species currently marginalized by habitat conditions in these urban streams. Dredging may therefore increase species diversity in these streams and provide a net benefit to the aquatic environment. Because of the already high turbidity in these streams, the negative impacts of additional turbidity caused by dredging may be minimal and outweighed by the positive changes in channel morphology.

Sampling will begin in the winter of 1999, and final post-dredging sampling in the South River should occur in the summer of 2000. The channel is expected to continue to respond to dredging for an indefinite period in the future. The baseline channel profiles and channel cross-sections measured in this study will help future researchers to evaluate the extent, magnitude, and timing of additional channel changes.

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