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IMPLICATIONS OF CHINOOK SALMON PRESENCE ON WATER QUALITY STANDARDS IN A GREAT LAKES AREA OF CONCERN

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ABSTRACT. The Grand Calumet River watershed of southern Lake Michigan was surveyed to determine the occurrence of salmonid fishes during the predominant fall spawning run. Weekly core collections were performed at five core reaches and monthly synoptic collections at 14 additional reaches in the Grand Calumet River and Indiana Harbor Canal. Once temperatures were consistently below 19 °C, chinook salmon were present from mid-October until late November 1999. During this study, 465 chinook salmon and three rainbow trout (steelhead) were collected. Chinook salmon were found throughout the east and west branches of the Grand Calumet River. Chinook salmon were widely distributed and found throughout both branches to the mouths that form the Indiana Harbor Canal; however, we did not observe any successful reproduction. The presence of salmon in the Grand Calumet River could force changes in designated uses to a more conservative standard that are protective of coldwater fish, thus reducing pollutant inputs into the basin.

Keywords: Spatial distribution, Lake Michigan, fish management, stocking

The probability of salmonid fishes occurring in the Grand Calumet River watershed has been debated within state government, which resulted in the river not being designated a salmonid stream for Water Quality Criteria purposes (IDEM 1996). Chinook salmon (*Oncorhynchus tschawytscha*) is a non-indigenous species of Pacific salmon that was stocked into the Great Lakes as a species management control for alewives (*Alosa pseudoharengus*) and for a sport fishery (Dehring & Krueger 1986). The species has been collected throughout the Indiana tributaries of Southern Lake Michigan; however, few individuals have been observed in the Grand Calumet River (Simon et al. 1989; Simon & Stewart 1998; Simon & Moy 2000). The Grand Calumet River is located in a Great Lakes Area of Concern that has impairment of all 14 designated uses (IJC 1983; U.S. EPA 1985; Simon & Stewart 1998; Stewart et al. 1999; Simon et al. 2002). Spacek (1996) reported spawning salmonids and successful hatching in the West Branch of the Grand Calumet River about 1.6 km upstream from the junction with the East Branch of the Grand Calumet River. This observation would be the first reported spawning occurrence in southern Lake Michigan. Simon and Moy (2000) had previously considered this report unlikely.

Simon et al. (1989) found chinook salmon in the East Branch of the Grand Calumet River near the junction with the West Branch and found rainbow trout (*Oncorhynchus mykiss*) in the Indiana Harbor Canal between 1985–1988. Simon and Moy (2000) reported rainbow trout in the Gary Sanitary District's outfall in 1994. Rainbow trout were also observed there in 1998 and 1999 (Simon unpubl. data). No salmonids had previously been collected in the West Branch of the Grand Calumet River. Although few salmonid fishes have been collected over the last 15 years, attempts to find salmonid fishes between 1985 and 1998 were limited to periods when these species would be less likely to occur due to thermal limitations. The State of Indiana (1999) found no salmonids during a late spring survey of the East Branch of the Grand Calumet River although other thermally-sensitive lake species such as alewife were observed. Despite the information that salmo-

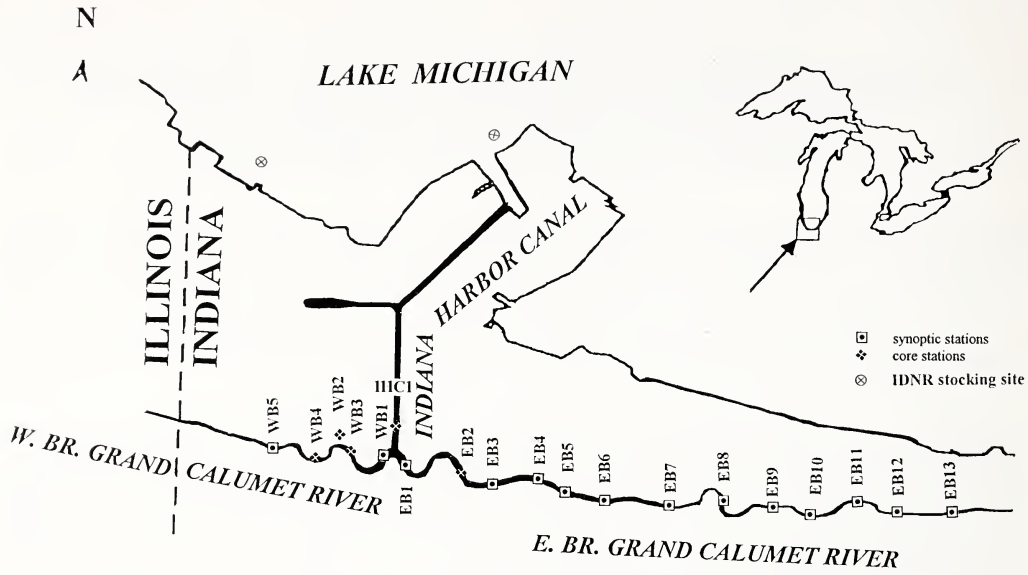

Figure 1.—Location of weekly monitoring reaches (♣) and monthly sampling reaches (⊙) in the Grand Calumet River and Indiana Harbor Canal during an investigation of salmonid fish species distribution performed between September and November 1999. Stocking sites in Lake Michigan are indicated by (⊗).

nids were sometimes present, the State of Indiana and the U.S. Environmental Protection Agency (EPA) granted a permit variance request to a major discharger in the East Branch of the Grand Calumet River. This variance, based on a recalculation of the cyanide standard without the salmonid data, allowed increased concentrations of cyanide to be placed into the river (Dennis Clark, Indiana Department of Environmental Management, pers. commun.).

The purpose of this study was to examine the water quality standard ramifications of salmonid presence in the West Branch of the Grand Calumet River and to authenticate salmonid occurrence and distribution in the remainder of the Indiana portion of the watershed. In addition, we wanted to verify the spawning and successful reproduction of chinook salmon in the East Chicago Sanitary District's discharge canal based on observations by Spacek (1996).

METHODS

Study area description.—The Grand Calumet River basin is a small watershed located in northwestern Indiana (Fig. 1) and encompasses about 17,500 ha contained almost entirely within Lake County, Indiana (U.S. EPA 1985). The Grand Calumet River is about 34 km long and has been designated an Area of Concern by the International Joint Commission (IJC 1989). The Grand Calumet River and Indiana Harbor Canal occupy a low-relief area in the glacial bed of geological Lake Chicago. The general flow is sluggish and westward in the East Branch of the Calumet River, east- or westward in the West Branch depending on Lake Michigan levels, and northward in the Indiana Harbor Canal, an artificial connection to Lake Michigan. Land-use disturbance in the area has been extensive with modification including ditching, channelization, flow modification, development of urban centers, and one of the most concentrated steel and petrochemical industrial complexes in the United States (U.S. EPA 1985). Severe sediment contamination has been documented in the Grand Calumet River and Indiana Harbor Canal, including polycyclic aromatic hydrocarbons (PAH), metals, and oil and grease (Hoke et al. 1993; Ingersoll et al. 2002; McDonald et al. 2002a, b). Surface waters were toxic and teratogenic based on an embryo-larval subchronic teratogenicity test, as a result of effluents emanating from point-source discharges (Simon 1989).

Community collection and reach selection.—Fish communities were sampled at select reaches that were based on previous water and sediment sampling stations above and below point-source discharges in the Grand Calumet River (Simon 1989; Simon et al. 1989; Simon et al. 2002). Five core reaches were evaluated weekly between 25 September and 23 November 1999 to quantify salmonid presence in the vicinity of the West Branch of the Grand Calumet River and Indiana Harbor Canal (Fig. 1). The five reaches sampled weekly were in each of the three tributary units of the Grand Calumet River and Indiana Harbor Canal. Reach WB2 is located in the West Branch of the Grand Calumet River (WBGCR) in the "earthen channel" outfall of the East Chicago Sanitary District; reach WB4 is located in the WBGCR west of Indianapolis Boulevard; reach WB3 is the WBGCR east of Indianapolis Boulevard, which is below the East Chicago Sanitary District's earthen channel outfall; reach IHC1 is located in the Indiana Harbor Canal between the railroad trestle bridge and Columbus Avenue; and reach EB2 is in the East Branch of the Grand Calumet River (EBGCR) west of Kennedy Avenue.

In addition to the five reaches sampled weekly, 14 additional synoptic sites were surveyed monthly for a total of 19 sites (Fig. 1). The WBGCR had five reaches that were distributed between Columbia Avenue and the junction with the East Branch at 1) east of Columbia Avenue (WB5), 2) west of Indianapolis Boulevard (WB4), 3) east of Indianapolis Boulevard (WB3), 4) the East Chicago Sanitary District earthen channel (WB2), and 5) the mouth of the West Branch (WB1). The EBGCR had 13 reaches distributed between Broadway Avenue to the junction with the WBGCR. These reaches included 1) the mouth of the East Branch (EB1), 2) west of Kennedy Avenue (EB2), 3) east of Kennedy Avenue (EB3), 4) west of Cline Avenue (EB4), 5) east of Cline Avenue (EB5), 6) east of Clark Road (EB6), 7) east of Bonji (EB7), 8) west of Bridge Street (EB8), 9) east of Bridge Street (EB9), 10) east of Buchanan Street (EB10), 11) west of Buchanan Street (EB11), 12) east of the triple train trestles of USX (EB12), and 13) west of Broadway Avenue (EB13). A single reach was sampled in the Indiana Harbor Canal during the synoptic and core surveys (IHC1).

Fish species composition and relative abundance (catch-per-unit-of-effort or CPUE is the number of fish/minute of electrofishing effort) data were gathered by performing electrofishing surveys at core and synoptic river reaches using a model 6A Smith-Root boat-mounted electrofisher. Electrofishing surveys included systematic sampling of representative habitats within reaches including the thalweg or deepest point in the cross-sectional profile, usually for distances of 500 m for a minimum of 900 seconds. Captured fish were placed in an onboard holding tank until a sampling event was completed. Data recorded for each survey event included species' identifications and weights, number of fish caught, examination for external disease and anomalies (DELTs), and sample and habitat conditions. Shallow depths in the earthen channel prohibited boat access and inhibited electrofishing after early October. A visual survey of species presence was performed in the earthen channel between 10 October and 23 November 1999 by walking the entire length of the earthen channel and recording the identity and number of observed fish. Water quality data was measured using a Hydrolab datasonde 4a, which measured dissolved oxygen, temperature, pH, specific conductance, oxidation-reduction potential, total dissolved solids, and salinity.

RESULTS AND DISCUSSION

The presence of salmonids in the Grand Calumet River watershed had previously been considered a result of transient individuals occasionally swimming into the river (Simon et al. 1989), while other reports considered their presence and spawning activity highly unlikely (Simon & Moy 2000). The previous absence of salmonids in the Grand Calumet River may actually have been a result of discharge temperatures associated with point sources than any other reason. The State of Indiana granted a variance request allowing increased cyanide discharge based on no records of trout or salmon in the East Branch of the Grand Calumet River. We collected 465 chinook salmon during this study, which negates the belief that these fish are only occasional or rare community components (Table 1). While only three rainbow trout were collected, we consider this the beginning of a fall run and anticipate that more trout would have been collected with continued sampling. Re-

ports of fall run rainbow trout in Trail Creek suggest that this species may be present until late February to mid-March (Brian Breidert, IDNR, pers. commun.). Chinook salmon occurred in the East and West Branches of the Grand Calumet River from the headwaters to the mouth of each branch. We observed only four salmonids in the Indiana Harbor Canal because of its greater depth reduced collection effectiveness; however, our expectation is that salmon use this waterway as the primary dispersal route between the river and Lake Michigan.

Water quality conditions, based on Indiana State Water Quality Standards, were within acceptable limits for salmonids. Dissolved oxygen ranged between 4.6–16.6 mg/L. Our results suggested that temperature limited salmonid entrance into the Grand Calumet River until mid-October, after which temperatures were consistently below 19.5 °C. The apparent reduction in surface water toxins from effluents since 1986 may be the result of more stringent National Pollutant Discharge and Elimination System (NPDES) permits (Ronald Kovach, U.S. Environmental Protection Agency, pers. commun.), which allow chinook salmon to survive in the watershed (Simon 1989). Dissolved oxygen concentrations prior to 1990 were generally below water quality standards (4.0 mg/L) for the Grand Calumet River watershed (STORET unpubl. data). The presence of large numbers of chinook salmon in the East Branch should result in further evaluation of the cyanide variance, possibly causing further modifications before reissuance (Dennis Clark, Indiana Department of Environmental Management, pers. commun.). However, since we found no evidence of reproduction, a compromise position may be to allow the inclusion of adult salmon data in the cyanide calculation but still remove juvenile and smolt toxicity data. No juvenile salmonids were found in over 15 years of effort in the entire Grand Calumet River watershed. In addition, sampling conducted by the Indiana Department of Environmental Management (Newhouse 1999) in the upper East Branch of the Grand Calumet River did not find any salmon; however, other coolwater species such as alewife were collected.

The presence of salmon in the Grand Calumet River could force changes in designated uses to a more conservative water quality standard that is protective of coldwater fish and would result in reduced pollutant inputs into the basin. Currently Grand Calumet River standards are those of a warmwater fishery. Documentation of the high numbers of salmon present should result in changes in the standards to those for a coldwater salmonid fishery.

Spacek (1996) reported reproduction and successful hatching of chinook salmon in the East Chicago Sanitary District's plant at an undisclosed time of the year. Although we attempted to document reproduction during this study, we observed only a single female in the plant's disinfection chamber between 2 October and 25 October 1999. Shallow depths (< 0.3 m) in the earthen channel due to drought conditions may account for this result. Large adult males were photographed swimming in the earthen channel, but no reproductive behavior was observed.

The Indiana Department of Natural Resources (IDNR) has stocked chinook salmon at Whiting and Inland Steel (Fig. 1) annually to supplement stockings further east. Inland Steel, located next to the Indiana Harbor Canal, is the primary stocking site, with a goal of 80,000 chinook salmon annually; and Whiting is the secondary site with a goal of 30,000 chinook salmon (John Kubisiak, IDNR, pers. commun.). These stocking goals have been met over the past several years, with the exception of 1997 when chinook salmon were not stocked at Whiting. Stockings at Inland Steel exceeded the goal and averaged 105,000 chinook annually during this time. None of the chinook salmon stocked by the IDNR at Whiting and Inland Steel between 1996 and 1998 were marked with fin clips, although a clipped adipose fin is the usual mark for Indiana. Several of the fish collected had their left pelvic fin clipped, but none had a clipped adipose fin. This suggests that not all of these fish were returning individuals from IDNR stockings. We suspect that the supplemental Indiana DNR stockings resulted in the successful return of chinook salmon in the Grand Calumet River watershed.

We evaluated the condition of chinook salmon encountered during this investigation. Generally, chinook salmon were in good condition; only one female had severe anal fin erosion. Since cobble and boulder substrates

Table 1.—Relative abundance, catch-per-unit-effort (CPUE-number of fish/per minute of electrofishing time), distribution, and chronological presence of chinook salmon at weekly and monthly survey reaches in the Grand Calumet River and Indiana Harbor Canal between 25 September and 23 November 1999. Dashed lines indicate that sampling was not conducted on that date. No CPUE was calculated for the East Chicago Sanitary District disinfection chamber because electrofishing surveys were not performed inside the wastewater treatment plant. Numbers in brackets refer to locations in Figure 1.

	Sept-ember	October				November			
Reach	25	6	13	18	27	2	10	17	23
West Branch Grand Calumet River									
East Columbia Avenue [WB5]	—	—	—	—	25 (1.67)	19 (1.27)	8 (0.53)	2 (0.133)	2 (0.133)
West Indianapolis Boulevard [WB4]	0	0	0	3 (0.10)	11 (0.73)	9 (0.06)	8 (0.53)	2 (0.13)	2 (0.13)
East Indianapolis Boulevard [WB3]	0	0	0	1 (0.01)	4 (0.27)	7 (0.47)	7 (0.47)	3 (0.20)	4 (0.27)
East Chicago Sanitary District [WB2]	0	1	1	1	1	0	0	—	0
Earthen Channel [WB2]	0	0	0	0	1 (0.07)	1 (0.07)	0	—	0
West Branch mouth [WB1]	0	0	1	0	1 (0.07)	—	5 (0.33)	—	2 (0.13)
Indiana Harbor Canal									
South Columbia Boulevard [IHC1]	0	0	0	0	0	0	2 (0.13)	2 (0.13)	0
East Branch Grand Calumet River									
East Branch mouth [EB1]	0	—	—	1 (0.07)	1 (0.07)	—	5 (0.33)	—	3 (0.20)
West Kennedy Avenue [EB2]	0	0	0	2 (0.14)	2 (0.13)	8 (0.53)	9 (0.60)	1 (0.07)	2 (0.13)
East Kennedy Avenue [EB3]	—	—	—	—	3 (0.20)	—	9 (0.60)	—	2 (0.13)
West Cline Avenue [EB4]	—	—	—	—	3 (0.20)	—	6 (0.40)	1 (0.07)	1 (0.07)
East Cline Avenue [EB5]	—	—	—	—	3 (0.20)	—	3 (0.20)	1 (0.07)	0
East Clark Road [EB6]	—	—	—	—	1 (0.07)	—	10 (0.67)	—	1 (0.07)
East Bonji [EB7]	—	—	—	—	7 (0.47)	—	5 (0.33)	1 (0.07)	3 (0.20)
West Bridge Street [EB8]	—	—	—	—	3 (0.20)	—	15 (1.00)	0	9 (0.60)
East Bridge Street [EB9]	—	—	—	—	4 (0.27)	—	17 (1.13)	—	7 (0.47)
West Buchanan Street [EB10]	—	—	—	—	2 (0.13)	—	23 (1.53)	—	9 (0.60)
East Buchanan Street [EB11]	—	—	—	—	2 (0.13)	—	54 (3.60)	—	19 (1.27)
East Triple Trestle [EB12]	—	—	—	—	3 (0.20)	—	19 (1.27)	—	8 (0.53)
West Broadway Avenue [EB13]	—	—	—	—	15 (1.00)	—	21 (1.40)	—	7 (0.47)
Total by date:	0	1	2	8	92	44	226	13	79
Total at core reaches:	0	0	2	7	19	23	26	8	8

are non-existent in the Grand Calumet River, we speculate that this condition may have been caused by contact with PAH-laden sediments (Ingersoll et al. 2002; McDonald et al. 2002a, b), and about 95% of fish collected during this study were male. About 23% of all chinook salmon collected had either single or multiple lamprey scars. Comparison of the relative weight index for chinook salmon (Murphy et al. 1991) with the Grand Calumet River population shows that Grand Calumet River specimens did not deviate from acceptable condition of the reference index. The fish that were observed during our study ranged from 550–830 mm total length which, based on length-frequency data, suggests that they were between 2–4 years old (Carlander 1969). We suspect that since chinook salmon are known to swim around the entire shoreline of Lake Michigan and do not reside for significant periods of time in the Grand Calumet River nor feed in any appreciable amount during their spawning runs, it would be unlikely that any deviation in either contaminant burden or relative weight from other populations would be observed. However, increased risk to humans would include angler handling, exposure to contaminated water and sediment, and preparation differences (i.e., skin-on versus skin-off filets) of fish. Fish-consumption advisories exist on the entire Great Lakes shoreline in the AOC.

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