DOES THE AMOUNT OF HUMAN DEVELOPMENT IN A LACUSTRINE ENVIRONMENT HAVE A SIGNIFICANT EFFECT ON ITS FISH POPULATIONS?

Jon L. Zande

University of Michigan Biological Station, 9133 E. State Street, Pellston, MI 49769

Abstract.—A priori analysis of Burt Lake suggests that it is much more developed than neighboring Douglas Lake, leading to questions as to how this increased human development may affect fish populations. Previous studies have tended to show variation in chemistry between Douglas Lake and Burt Lake in Cheboygan County, MI, and our study intended to figure out if these differences affected these lakes' fish populations. Minnow traps and seining methods were applied over a two-week period, and water chemistry and benthic samples were also taken multiple times and averaged. Results showed that richness was higher overall in Burt Lake than Douglas Lake, with marly areas in each lake proving richer than sandy areas. Vegetated benthos appeared to boost the Shannon Diversity Index of fishes when looking at minnow trap collection data, but when observing seining collection data, the Index was again elevated in the presence of a marly benthos.
Keywords.—Human development, pollution, fish populations, Burt Lake, Douglas Lake

Introduction.— Human development has been known to have substantial effects on the health and structures of lacustrine ecosystems, particularly on fish populations (Wilkinson, 2005). As fish serve as important economical and recreational resources, their regulation demands careful study. Species richness and total fish abundance are highest in undeveloped, warm water environments. In contrast, sites adjacent to human development have yielded fewer fish and fish species. (Brazner, 1997). Species richness and total abundance proved greater in natural, undeveloped near-shore depth zones (Bryan and Scarnecchia, 1992). One reason for this is that human shoreline development leads to loss of refuge, which in turn results in decreased resource heterogeneity for fishes, and a decrease in habitat complexity (Scheuerell and Schindler 2004).

Burt Lake (69.3km^2) and Douglas Lake (13.7km^2) in Cheboygan County, Michigan have both seen shoreline development from post-colonization human populations, largely due to logging and agricultural activities in the nineteenth century. Both industries have all but vanished since the earlier part of the twentieth century, but the recreational usages of the lakes remain. Though Burt Lake is considered to be largely populated with commercial and private residences (DNR Report), it is beginning to see a decline in new development and establishment of conservation movements such as "Restore the Shore" (Tip of the Mitt Watershed Council, 2006). In contrast, Douglas Lake has benefitted from decades of preservation and the establishment of vegetative fish refuges (Thomas, 1968). The amount of human development on Douglas Lake has been far less profound than that of Burt Lake, thanks in part to the preservation efforts of the University of Michigan Biological Station (Michigan DNR, 2008).

Trophic Status Indices have on average been lower for Burt Lake (~32) than Douglas Lake (~38), indicating slightly higher levels of limiting nutrients in Douglas Lake than Burt Lake (TOMWC, 2006). While limiting nutrients such as nitrogen and phosphorous might be slightly higher in Douglas Lake, previous research has shown that silica and nitrate levels increase as water moves through Carp Creek—the connecting waterway from Douglas Lake to Burt Lake

(Schultz, 1985). Additionally, chloride and ammonia levels remained constant between lakes. Agricultural activity in the surrounding areas has been absent for more than eighty years, lessening the possibility of high levels of nitrogen runoff (Gates, 1926). This suggests that typical human development effects such as agricultural runoff and septic system leakage may not be the sole cause of chemical mediated fish population variation.

Records of the Douglas Lake fish population diagram the rise in game fish population during the course of the twentieth century, noting that while the pumpkinseed (*Lepomis gibbosus*), bluegill (*L. marochirus*), longear sunfish (*L. megalotis*), smallmouth bass (*Micropterus dolomieui*) all increased in number, the yellow perch (*Perca flavescens*) and the rock bass (*Ambloplites rupestris*), exhibited the greatest increases in population (Thomas et al., 1968). Burt Lake boasts similar game populations, largely due to heavy stocking in the early twentieth century. Here, the walleye (*Sander vitreus*), white sucker (*Catostomus commersonii*), and small mouth bass (*Micropterus dolomieu*), joined as *A. rupestris* and *P. flavescens* as the more prominent species (Hanchin, Clark, Lockwood, & Wallinski, 2005).

We set out to answer the question as to whether the differing levels of human development on Burt Lake and Douglas Lake affects fish population differently. Given the previous information, we would expect there to be greater impact on fish population from the higher level of development of Burt Lake that would manifest itself by showing less diversity, less richness, and overall fewer fish due to the decreased nutrient levels.

Materials and Methods.—Fish sampling, water chemistry, and substratum analysis was conducted over a two week period in July, 2008 at Burt Lake and Douglas Lake in Cheboygan County, MI. Four sampling sites were established in total: two at Burt Lake and two at Douglas Lake. King's Point in Burt Lake and Grapevine Point in Douglas Lake both consisted largely of a un-vegetated benthos with wild grass and woody debris occupying the shoreline. Maple Bay in Burt Lake and Hook Point in Douglas Lake consisted of patches of soft-stemmed bulrush *(Schoenoplectus validus)*, and muskgrass (*Chara spp.*). King's Point and Hook Point were both marly, while Maple Bay and Grapevine Point were predominantly sandy.

Fish Sampling

A dual-anchored 20m nylon transect line consisting of 5 wire-mesh minnow traps 4m apart was set at each location. Bait consisted of 3-6 pellets of dry dog food inserted into each trap. After 24-48 hours, trap contents were collected, identified, and released onsite. Seining was also conducted a total of nine times at each site using a 4.57m seine, and fish were identified and measured for length onsite. Unidentifiable or unique fish were taken back to the lab to be keyed out and stored.

Water Chemistry

Nutrient levels from each lake were collected twice using Nalgene^{TM} acid wash bottles, and sent to the UMBS Lakeside Lab for analysis. Dissolved oxygen (mg/L) was taken using a HACH DO meter (n=3 in Burt Lake, n=1 in Douglas Lake), conductivity (mS) was measured with a YSI conductivity meter (n=2 in Burt and Douglas), pH using a Fischer Scientific Accumet AP61 Portable Lab pH meter (n=1 in Burt, n=2 at Douglas), and air temperature (n=7 in Burt Lake, n=5 in Douglas Lake) and water temperature (n=6 in Burt and Douglas) using a generic alcohol thermometer. Each of these measurements occurred at 1m depth and within 5m of the minnow transect. Measurements were usually taken multiple times over the experimental period and averaged for accuracy purposes.

Substrate Analysis
A 2.54cm diameter $1m^2$ PVC quadrat was used to analyze substrate at three, 10m intervallic points along each 20m minnow transect. Macrophyte presence and percent coverage were then analyzed, and the Modified Wentworth Classification Scheme was used to analyze granule size.

Statistical Analysis

Results.—Using the Shannon Diversity Index…
Using the Habitat Diversity Index

King and Grapevine (patchy, vegetated benthos) average higher richness than Maple and Hook, respectively

Seining: marly benthos hosts higher diversity index
Minnow Traps: Vegetative qualities hosts higher diversity index
DISCUSSION: Outlier, caught school of fish

King and Maple average higher diversity and richness than Grapevine and Hook

Highest CPUE's at King and Grapevine

Marly spots showed higher richness than sandy spots

BUT Marly spot at Burt Lake and Sandy spot at Douglas lake showed higher diversity

Average CPUE was higher in Douglas Lake than in Burt Lake

	Burt Lake Avg.	Douglas Lake Avg.
Air Temp (˚C)	21.7	20.2
Water Temp (˚C)	23.8	23.5
Dissolved Oxygen (mgC/L)	5.91	4.89
Conductivity (mS)	322.3	237.0
Average pH	8.28	8.68
Cl^- (mg/L)	9.85	
NO_3^{2-} (ugN/L)	35	
NH_4^+ (ugN/L)	19.7	
Total N (ugN/L)	0.82	
PO_4^{3-} (ugN/L)	1.5	
Total P (ugN/L)	8.55	
Alkalinity ($mgCaCO_3/L$)	302.8	
Planktonic Chlorophyll	2.37	
Benthic Chlorophyll	3.2	

Kings Point (BL)
1: sandy/marly with small rocks, 20% covered by tree, 5% covered by other woody debris, turbid, no vegetation, zebra mussels
3: sandy/marly with small rocks, 10% covered by bulrush, 30% covered by chara
5: larger-grained, dark sand, no vegetation

Maple Bay (BL)
1: sand with small rocks, 20 stems soft bulrush, shells, 1% Chara stuff
3: sandy, NO shells, 8 stems soft bulrush, 25% Chara stuff
5: marly/clay, 40% covered by gunky algae, 5% covered by grass stuff, lots of algae

Grapevine Point (DL)
1: sandy with some small rocks, 5% Chara, 20% Potemogeton, 20% black leaf litter, lots of sticks
3: sandy with some shells, 40% black leaf litter, large sticks, Najas flexilis
5: sandy/marly, woody debris, 5% Potemogeton, some shells

Hook Point (DL)
1: sandy marl, no vegetation
3: sandy marl, no vegetation, lots of zebra mussels
5: sandy marl, 3 soft bulrush stems, green gunky stuff, small Najas flexilis

Discussion.—We wanted to discover if there was a significant change in the diversity and abundance of fishes in Douglas Lake and Burt Lake that could possibly be attributed to the environmental affects of human development.

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