Composition and Abundance of Stream Macroinvertebrates as a Determinant of Water Quality Up and Down Stream of the Imperial Dam, Saranac River, New York

Erika A. Hartmann and Timothy B.Mihuc (**Faculty**)

Lake Champlain Research Institute and
Center for Earth and Environmental Science
SUNY Plattsburgh, Plattsburgh, New York 12901

ABSTRACT

The removal of the Imperial Dam in Plattsburgh, New York is a subject being currently discussed by parties including city officials, Trout Unlimited and the New York Department of Environmental Conservation. One concern is the impact on water quality and stream benthos below the impoundment which may impact the fishery. This project investigated the hypothesis that the composition and abundance of aquatic stream invertebrates do not differ as a result of the change in water quality above and below the Imperial Dam on the Saranac River. Using a Hess sampler, stream invertebrates were collected, as well as associated physical characteristics (water depth, velocity, substrate size) from two different sites located up and down stream of the Imperial Dam. Aquatic stream invertebrates were identified to Genus or Family and the data were analyzed using various community diversity indices. Results show distinct community differences between the two sites with increased filter feeder abundance at the impounded reach and higher mayfly diversity and abundance at the open river reach. While impoundment has impacted aquatic biota in the Saranac River at Imperial Dam, recovery of the benthos to open river conditions is likely to occur rapidly from upstream colonization sources upon restoration of open river conditions at Imperial Dam.

Key Words: Saranac River, impoundment, macroinvertebrate impacts .

INTRODUCTION

The majority of U.S. dams will pass their anticipated life expectancy in 2020 (Stanley and Doyle, 2003). Over 500 U.S. dams have already been removed from U.S. rivers and the topic of removal is still controversial (Stanley and Doyle, 2003). Great concern over maintaining fresh water supplies helped spur an increase in dam erection during the latter half of the 20th century (Stanley and Doyle, 2003). The WCD (World Commission on Dams) reported over 45,000 impoundments existed worldwide by 1999. Dams alter flow regimes, sediment distribution and temperature all which affect the streams invertebrates (Ligon et al., 1995). Discussion on dam removal in the U.S. can cause large debates and have increased in number during the past 20 years (Stanley and Doyle, 2003). Dam removal is unavoidable considering the intended life expectancy of many dams will be expired in 2020 (Stanley and Doyle, 2003). Stanley and Doyle (2003) classify dam removal as a disturbance with both benefits and consequences.

ECOLOGICAL EFFECTS FROM DAMS

Dams block flow which raised water heights, flood surrounding area and slows moving water (Stanley and Doyle, 2003). Sediment normally suspended in streams is deposited in the reservoir created by the impoundments and accumulates through out the life of the dam (Stanley and Doyle, 2003). Dams alter river sediment regimes, especially downstream through the reduction of large sediment (Ligon et al.,

1995). Dams can also reduce inundated floodplain through the control of water which provide key habitat for common invertebrates eaten by fish (Ligon et al., 1995). Sediment deposition and increase surface area of reservoirs increase water temperatures. Increased temperatures decrease dissolved oxygen which can stress aquatic taxa and cause a shift in river community composition (Schmidt-Nielsen, 1997). Dams decrease the variation in minimum and maximum temperatures, which affect composition of riverine species. Downstream of a dam a river tends to lower and its channel deepens due to loss of sediment previously deposited in the upstream reservoir (Ligon et al., 1995). The fine sediment and particulates in the reservoir can result in increased particulate drift downstream of the dam (Poff et al., 1997). These effects alter the habitat and may decrease or increase suitable habitat availability, in turn, for aquatic organisms (Poff et al., 1997). Sediment eroded from downstream banks may be carried further downstream where it is deposited, smothering eggs and invertebrates (Kearns, 2004). Dams can also change the rate of water level fluctuation causing further stress to organisms (Kearns, 2004). Adverse water conditions can affect fish and invertebrate reproductive success and juvenile growth (Kearns, 2004).

Aquatic invertebrates are excellent indicators of long and short term environmental conditions associated with impoundment (Mason et al. 2005). In studies done from 1963 to 1967, aquatic invertebrates below impoundments in the Ohio River showed colonization by pollution tolerant invertebrate species, Diptera and worms, indicators of poor to fair water quality (Mason et al. 2005). Studies done at 19 dams in Victoria and New South Wales demonstrated that dams can alter invertebrate communities (Marchant, 2001). Caddis flies (primarily the filter feeding Hydropsychidae) were found to be abundant downstream of the dam while mayflies were almost abundant (Marchant, 2001). Long term studies have shown the presence of mayflies to indicate good water quality and environmental health (Mason et al. 2005).

The purpose of this study was to assess benthic invertebrate communities in impounded and open river reaches of the Saranac River, NY to determine if biota have been impacted by impoundment at Imperial Dam.

STUDY SITE:

The Imperial Dam, located approximately 3.5 miles from the mouth of the Saranac River, was built in 1903 (Aprill, 2002). The removal of this dam has been an issue since the late 1990's (Aprill, 2002). Feasibility studies, sediment testing and temperature patterns of the Saranac River have been completed (Aprill, 2002; Mihuc, 2004). Temperature patterns showed the Imperial Dam to have a slightly higher temperature than all other 12 sites. The Imperial Dam also has increased minimum and decreased maximum daily temperature variations, dampening daily variability in the thermal regime, which can greatly affect stream invertebrates (Mihuc, 2004).

In this study, composition and abundance of stream invertebrates were determined from two sites, an open river site in Morrisonville, NY and at site 25 m directly below Imperial Dam. The null hypothesis of this study was that composition and abundance of stream invertebrates do not differ above and below Imperial Dam. Alternatively, comparison of the composition and abundance of aquatic stream invertebrates up and downstream of Imperial Dam may and provide evidence of change in water quality.

METHODS

The collection of aquatic stream invertebrates from two sites occurred September 12, 2005. The first site sampled was located approximately 25 meters downstream of the Imperial Dam. The second

site, Morrisonville, was located approximately 6 miles upstream of from the Imperial Dam and is considered open river. Using a Hess sampler, stream invertebrates were collected, as well as associated physical characteristics (water depth, velocity, substrate size) from two different sites located up and down stream of the Imperial Dam. Seven Hess samples and data collections were taken from each site. Seven additional sites were measured. Aquatic invertebrates were removed from the Hess sampler and preserved in 10 percent formalin. Contents of preserved samples were rinsed using tap water through 250 mm and 1 mm sieves. Aquatic stream invertebrates were separated from the organic and inorganic matter in each samples from each site, sorted, identified and enumerated. Most invertebrates were enumerated the Genus level, although some taxa were enumerated to Family. Various diversity indices, including Gleason's, Shannon-Weaver and Jaccard's coefficient of similarity, were used to analyze the data.

RESULTS

A total of 2098 steam invertebrates were collected from the Saranac at Imperial site. Of this, stream invertebrates fell into 24 taxa. Philopotamidae *Chimarra, Elmidae and* Hydrophychiidae *Hydrophsche,* were the most abundant taxa representing 72% of the total abundance present in the samples (Figure 1). Filter feeding caddisflies (Hydropsychidae, *Chimarra*, and others) accounted for 52% of the total abundance.

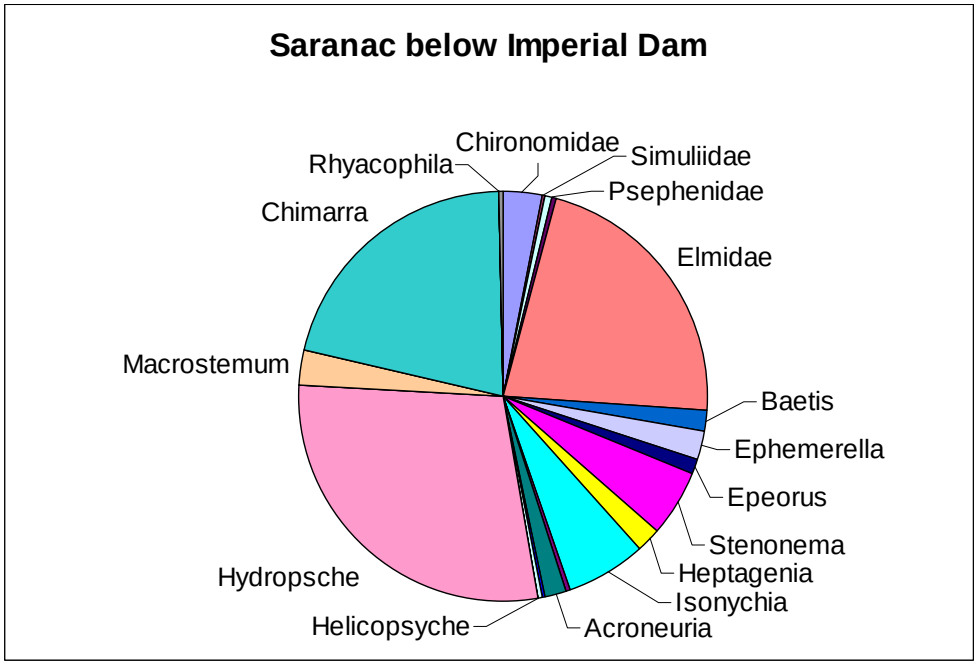

Figure 1. The composition of stream invertebrate collected from seven Hess samples from the Saranac River 25 meters below the Imperial Dam. Philopotamidae *Chimarra*, Elmidae and Hydrophychiidae *Hydropsyche* comprise 21%, 22% and 29%, respectively.

At the Morrisonville site, 1394 individuals were collected in the seven samples which were sorted into 27 taxa. Ephemerellidae *Ephemerella* was the most abundant genus (23%), followed by other genera in the Order Ephemeroptera (Figure 2). Although not in large abundance, six Phyralidae *Petrophila* were collected from the Morrisonville site. Filter feeding caddisflies accounted for only 23% of the total abundance in the open river site, representing a decline by 50% in filter feeders versus the impounded

site. Genera with the highest percentages fall into three families: Heptageniidae, Ephemerellidae and Baetidae

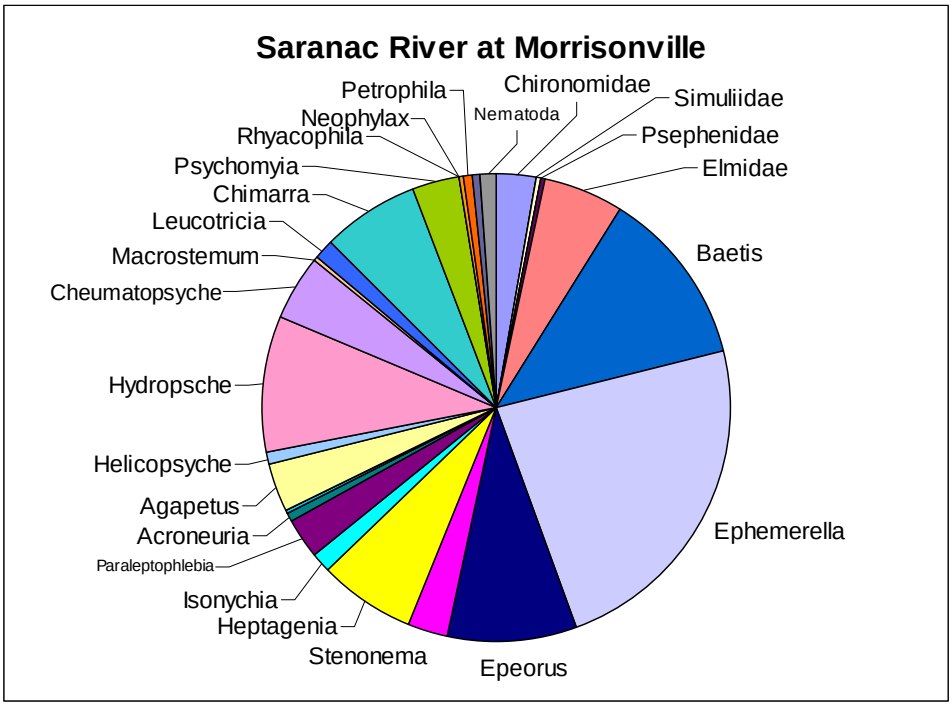

Figure 2. The composition of stream invertebrate collected from seven Hess samples from the Saranac River, 6 miles upstream from the Imperial Dam.

In comparison, the Imperial site contained more Hydropsychidae, Philoptamidae and Elmidae than the Morrisonville site. The Morrisonville site showed higher abundance in invertebrates from the families of Heptageniidae, Ephemerellidae and Baetidae (Figure 3).

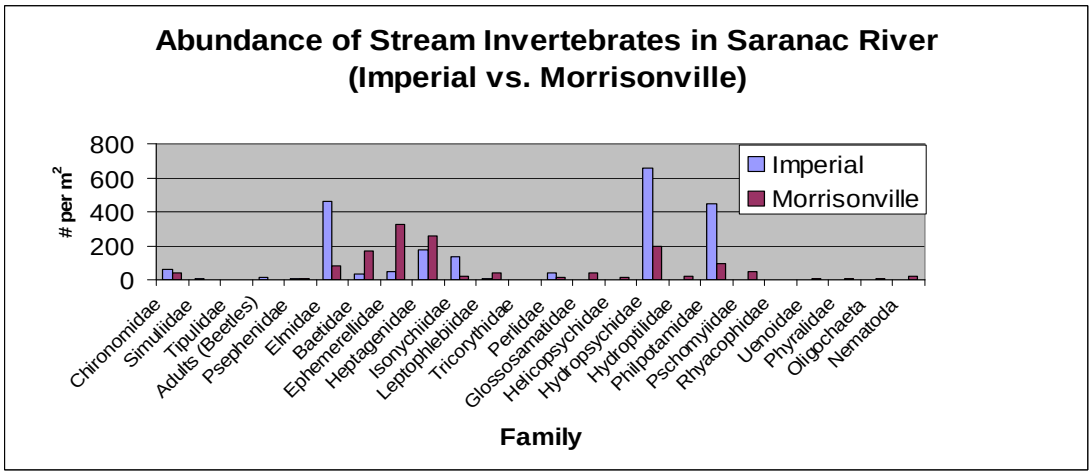

Figure 3. Comparison of the abundance of stream invertebrates shows the abundance of the family Hydropsychidae to be greater in the Imperial site than in the Morrisonville Site.

Substrate size, depth and velocity were measured and recorded for each Hess sample location at both the Imperial and Morrisonville Site. Although not significant, there is a trend for substrate size and steam depth to be greater at the Morrisonville site and velocity to be greater at the Imperial Site (Figure 4).

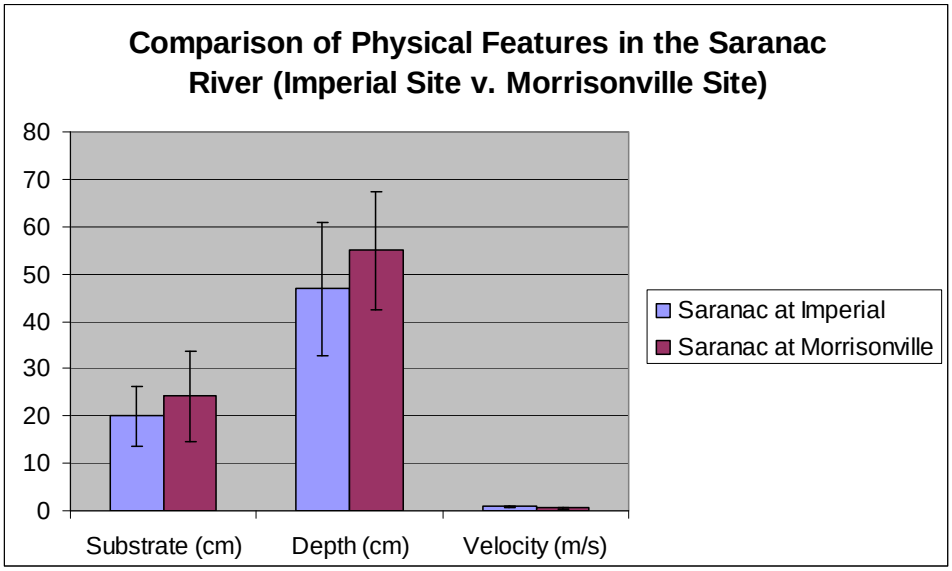

Figure 4: Comparison of substrate size, depth and velocity at the Imperial and Morrisonville sites. Error bars represent standard deviation.

Table 1 reports the various diversity indices performed on the data collected from both the Imperial and Morrisonville sites. The Morrisonville site showed higher taxa richness, fewer total individuals, and higher biodiversity using both Gleason's and Shannon-Weaver indices. The community similarity coefficient, which represents percent similarity of invertebrate composition between two samples, indicates that benthic invertebrate communities are more dissimilar between the two sites than they are similar (Jacard's similarity coefficient of only 0.41, Table 1).

Table 1: Comparison of diversity indices for both Sites including Jaccard's Coefficient of Similarity.

	Saranac at Imperial	Saranac at Morrisonville
N	2098	1394
Log N	3.32	3.14
Sum of ni log ni	5283.97	2982.7
Taxa richness	24	27
N/richness	123.41	66.38
Gleason's index	5.11	6.67
Shannon-Weaver	2.66	3.33
Jaccard's Coefficient of Similarity = .41		

Figure 5 illustrates the increase in total mayfly abundance and simultaneous decline in filter feeders in the open river site vs the Imperial Dam site. Overall, total EPT (Ephemeroptera, Plecoptera, Trichoptera) abundance remained relatively similar between the two sites (>70%, Figure 5) suggesting the community shifts within EPT groups are more accurate indicators of habitat quality and impoundment effects than overall EPT abundance.

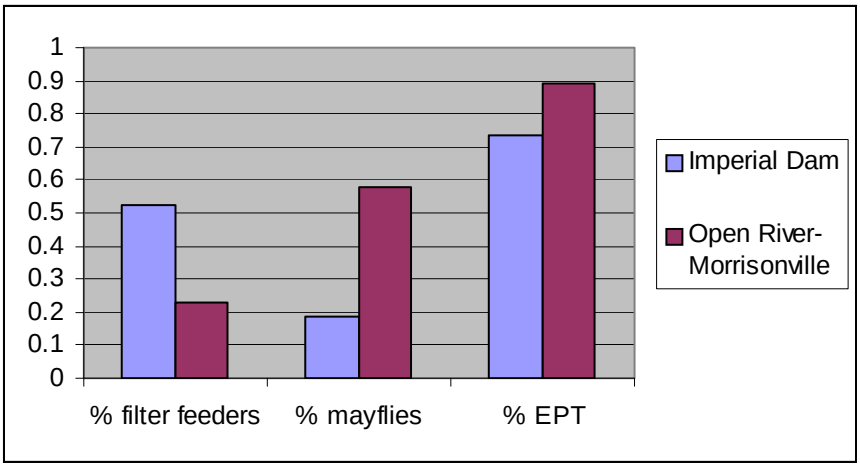

Figure 5: Comparison of percent filter feeders, mayflies and EPT (Ephemeroptera, Plecoptera, Trichoptera) between the study sites.

DISCUSSION

Our results suggest that benthic communities are, in fact, altered in the Saranac River as a result of impoundment at Imperial Dam. Decreases in biodiversity (taxa richness), coupled with shifts in abundance among the benthic community follow similar trends reported in numerous other impoundment studies. Our results show a 50% increase in abundance of filter feeding caddisflies below the Imperial dam, suggesting that habitat conditions for filter feeders (food resources and flow conditions) has improved as a result of impoundment. Also, numerous Ephemeroptera taxa increased in abundance at the open river Morrisonville site, suggesting that some mayflies may be intolerant of changes in habitat conditions below the impoundment. The presence of Lepidoptera in the open river site may be of interest from a habitat standpoint as well. Long term studies have shown the presence of mayflies (Ephemeroptera) to indicate good water quality and habitat conditions in rivers (Mason et al. 2005). Overall our results suggest that impoundment at Imperial Dam has altered benthic communities to the extent that riverine conditions are not similar to the pre-disturbance, or open river, condition. Given that the upstream colonization pool is intact at the Morrisonville site removal of Imperial dam may, in fact, allow restoration of conditions to the open river condition in the future.

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