

**A comparison of light traps and zooplankton grabs for assessing invertebrate assemblages
in muskellunge nursery bays**

by

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Abstract

The near shore invertebrate assemblages of four bays along the St. Lawrence River were surveyed as an extension of a juvenile muskellunge survival study to better understand the potential prey base. Zooplankton and macroinvertebrates were collected using light trap and zooplankton grab sampling methods. Since larval muskellunge are visual predators and are dependent on invertebrate consumption prior to their complete conversion to piscivory during ontogeny, there is a need to understand the potential prey community composition. Two gears were compared to determine the optimal approach to represent invertebrate community structure within critical Muskellunge nursery habitats in bays. The light traps were set at night simultaneously for thirty minutes at each of four bays. In the laboratory, samples were scanned under a dissection microscope for rare organisms and subsampled to a minimum of 200 organisms counted in milliliter increments. The zooplankton grabs were performed during daytime by taking three 2L samples sieved through 60 μ mesh within a 1 meter square plot, and were subsampled underneath a dissecting microscope in full milliliter increments to a minimum of 100 organisms. The two sampling methods produced similar species composition, but with very different community structure. The light traps had greater overall abundance and greater richness; however they likely selected for photopositive organisms. The zooplankton grabs do not discriminate among organisms in the water column, but may be missing organisms which exhibit patchy distributions or are diurnally benthic. The differences observed with each method highlight the importance of using multiple sampling methods, and indicated that a selection bias may exist for surveys that employ a single gear and time.

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Introduction

Crustacean zooplankton supply nutrients and energy for many aquatic organisms and support critical linkages in aquatic food webs as both herbivores and predators (Pennak, 1998). Although there are some which are carnivorous or omnivorous, most crustacean zooplankton filter phytoplankton out of the water, thus supplying upper trophic level organisms the plant-based nutrients (i.e. certain essential fatty acids) in a more accessible form (Fryer, 1957; Pennak, 1998). Zooplankton are the primary food source for many invertebrates and fish, although some fish only rely on them during the juvenile phase (Lynch, 1979; Romare et al., 1999)

Adult Muskellunge (*Esox masquinongy* Mitchell) are the largest predators on fish in freshwater systems such as the St. Lawrence River; however they depend on crustacean zooplankton as a crucial food source before converting to piscivory. Following yolk adsorption, Muskellunge fish larvae become visual predators on zooplankton, especially large cladoceran species (Scott and Crossman, 1998). This is when the larvae must begin to hunt their own food, and therefore need to be



Image: A larval Muskellunge which feeds primarily on large Cladoceran zooplankton. (Photo: J.Farrell)

in an area where an adequate prey base is available. Although they only feed on plankton for a few weeks of their life, their success during this period can be a major factor of their survival into adulthood (Scott and Crossman, 1998).

As part of an ongoing Muskellunge study, the littoral invertebrate assemblages of four bays along the St. Lawrence River were compared to better understand the larval prey base. Muskellunge eggs were raised at the facilities of the Thousand Islands Biological Station and were released during this period of planktivory. The four sites were chosen for their optimal littoral habitat and their distribution along the St. Lawrence River, however the composition of the zooplankton communities were never sampled before the fish were released. Because the Muskellunge were released during the period of planktivory, knowing the zooplankton composition of each bay could help explain any patterns of success or failure between the sites.

To assess invertebrate communities, many scientists commonly use large, active gears such as plankton tow nets and grab samples. Littoral habitats preclude the use of active tows, so these methods are not an effective way to sample the community (Anderson et al., 1998). An alternative technique is a passive light trap, which attracts organisms to the trap via a directed light source. This method can be used without plants and sediments disrupting the procedure, making it a more suitable option for shallow habitats. Active and passive gear types, represented by zooplankton grabs and light traps, were compared to determine if either are optimal in representing the invertebrate community structure.

The objectives of this survey were to compare the sampling ability of light traps and zooplankton grabs and to determine if the Muskellunge larvae had an adequate prey base within each bay. Many comparisons have been made for light traps in regards to juvenile fish capture (Hickford and Schiel, 1999; Tolimieri et al., 2000), however light trap effectiveness for catching zooplankton is not as commonly discussed. Because this gear is effective in catching zooplankton as well as fish, it is important to assess its ability to sample the invertebrate community. This study is also highly focused on the large Cladoceran species, whose presence and abundance will indicate an abundant food supply for the Muskellunge (Scott and Crossman, 1998).

Methods

Site Description

Four bays were chosen based on their littoral habitat and location along the St. Lawrence River used by Muskellunge for reproduction (Farrell and Werner, 1999). These bays include Rose Bay, Boscobel Bay, Affluence Bay, and Deer Island, all of which were located between Cape Vincent, NY and Alexandria Bay, NY. The nearshore habitat of the sites generally contained greater than 90% vegetation cover. *Chara spp* was the most abundant vegetation species throughout the sampling sites, but other prevalent species included *Vallisneria Americana*, *Potamogeton*

pusillus, *Potamogeton pectinatus*, and *Elodea Canadensis*. All sampling sites were less than one meter deep, with a 0.82 meter mean depth.

Field Collection

Invertebrates were collected using two methods: a light trap and a zooplankton grab. Zooplankton grabs were performed during the daytime in replicates of five: four nearshore samples and one around the middle of the sampled area. Collection sites were chosen randomly using a one meter square quadrat to determine the outer limits of the sample area. Zooplankton grabs were conducted by inverting a two liter pitcher to the lowest position possible and reverting the pitcher and returning it to the surface. At this point, the contents of the pitcher were filtered using a 60 μ sized mesh and stored in >70% ethanol. This was repeated three times for a total of six liters sampled. The habitat was surveyed at the same time and location of the zooplankton grabs. The habitat of each area was assessed based on the total percentage of coverage, depth, and the percentage of coverage for each vegetation species. All sites were sampled within two days to ensure the community had not changed significantly between collection periods.

The other method used to collect the zooplankton was a lighted funnel trap, which uses a light source as an attractant for aquatic organisms. The trap is cylindrical with darkened walls, and contains a funnel which leads organisms into the trap and makes it difficult for them to escape. The light is directed from the back to beyond the front of the trap. This light trap design was created by Dr. Bruce Smith of Ithaca College. The light traps were deployed around the new moon on the same night to decrease ambient moonlight, changes in weather, and temporal differences on



Image: Lighted funnel trap deployed in a bay. (Photo: B. Brown)

zooplankton behavior. Each trap was set in water less than one meter deep and was positioned in the middle of the water column. They were active for thirty minute sets and at that time the contents were emptied, rinsed, and stored in >70% ethanol.

Processing and Analysis

All of the samples were subsampled and specimens were identified and enumerated in the laboratory. Zooplankton grabs were diluted and subsampled in full milliliter increments until at least 100 organisms were counted. Light trap samples were initially sorted to identify and count any rare organisms (taxa of which representation by at least 100 individuals was uncertain before counting). The samples were then diluted and subsampled in full milliliter increments until at least 200 organisms were accounted for. All of the samples were sorted under a dissecting microscope and specimens were identified using books by Balcer et al. (1984) and Peckarsky et al. (1990). Cladoceran zooplankton and macroinvertebrates were identified to species when possible, and copepods were identified to order.

Statistical tests and visualizations were performed using Microsoft Excel and include species, order, and Cladocera richness, and basic descriptive statistics such as population means and proportions within each sample. Simpson's and Shannon-Weiner Diversity Indices, a Dominance Three calculation, and Two sample T tests. Multivariate Analysis of Variance (MANOVA) and Analysis of Variance (ANOVA) tests were performed to determine if each gear produced a similar composition throughout the bays. This tested each gear separately to find differences in community composition in each bay.

Results

Overall, each gear type collected significantly different community compositions according to the Simpson's Diversity Index (Table 1). This is not the case in the Shannon-Wiener Diversity Index, which did not detect such a difference. Figure 1 shows the composition of invertebrates in each bay by sampling technique. The composition of organisms between bays was similar according to the light traps. A MANOVA and ANOVA test of each gear was conducted using percent abundance data for the most abundant taxa within each sample. For light traps, the twelve most abundant species data was used. The degrees of freedom was 36 and the Pr (>F) value was 0.2847. The bays were not significantly different. Zooplankton grabs did collect

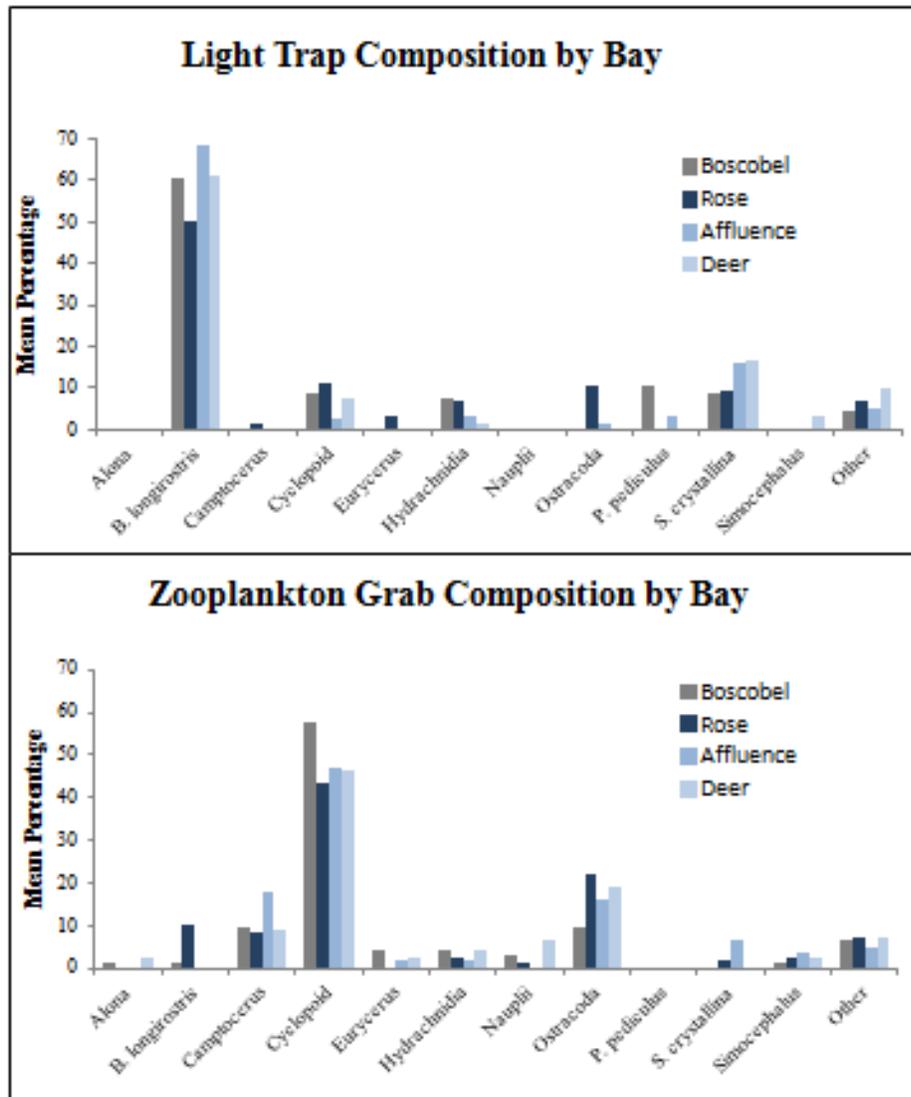


Figure 1: Invertebrate composition in each bay as collected by light traps and zooplankton grabs.

significantly different compositions in each bay using the fifteen most abundant species. The MANOVA test had 36 degrees of freedom and a p ($>F$) value of 0.002. When an ANOVA test was conducted on this data, ten of the fifteen taxa were found to be significantly different between bays. Light traps were dominated by *Bosmina longirostris*, with a mean of 60% of the

| | T Statistic | T Critical |
|----------------|-------------|------------|
| Shannon-Wiener | -2.24 | 2.57 |
| Simpson's | 2.47 | 2.45 |
| Taxa Richness | 2.95 | 2.57 |

Table 1: Two Sample T-Test for significant differences between light traps and zooplankton grab diversity.

total composition of each sample (Figure 2).

Sida crystallina and Cyclopoid copepods were the next most abundant taxa, with a mean of 13% and 8% of the composition

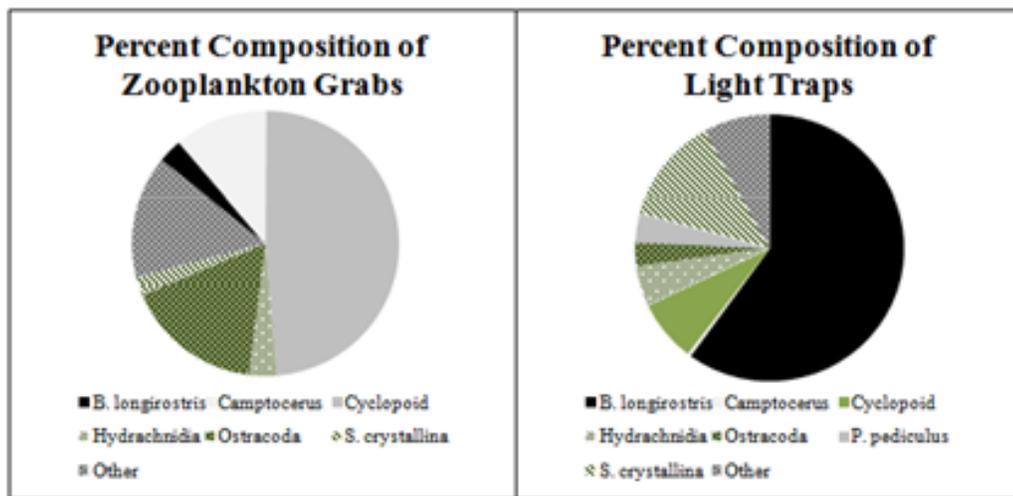


Figure 2: Invertebrate community composition mean percentages for light traps and zooplankton grabs.

| Metrics | Light Trap | | | | Zooplankton Grab | | | |
|--------------------|------------|----------|-----------|--------|------------------|----------|-----------|-------|
| | Rose | Boscobel | Affluence | Deer | Rose | Boscobel | Affluence | Deer |
| Shannon-Wiener | 1.50 | 1.18 | 0.99 | 1.24 | 1.58 | 1.32 | 1.50 | 1.66 |
| Simpsons | 0.38 | 0.45 | 0.57 | 0.47 | 0.30 | 0.44 | 0.29 | 0.30 |
| Dominance 3 | 76.69 | 86.90 | 90.48 | 86.14 | 82.40 | 83.18 | 84.14 | 78.05 |
| Mean Abundance | 17304 | 16665 | 71041 | 125423 | 1338 | 1156 | 1243 | 1311 |
| Taxa Richness | 15.50 | 12.00 | 14.25 | 16.25 | 11.50 | 10.75 | 9.75 | 12.75 |
| Order Richness | 6.75 | 6.00 | 7.00 | 7.00 | 2.75 | 3.25 | 3.00 | 3.25 |
| Cladocera Richness | 8.25 | 8.00 | 8.00 | 7.75 | 6.60 | 5.00 | 5.80 | 8.60 |
| % Cladocera | 51.90 | 61.76 | 69.34 | 65.72 | 50.62 | 27.26 | 53.48 | 41.59 |
| % Copepoda | 13.42 | 10.33 | 3.10 | 9.69 | 47.14 | 68.25 | 44.41 | 54.35 |

Table 2: Statistical metrics of the abundance data from light traps and zooplankton grabs, including abundance and diversity statistics.

respectively. On average, these three species made up 85% of the community found in each bay using the light trap method. Zooplankton grabs were dominated by Cyclopoidea copepods, which consisted of 49% of each bay on average (Figure 2). Ostracoda and cladoceran *Camptocerus spp* zooplankton were also highly abundant in the samples, with mean values of 17% and 11% of the composition respectively. These three taxa made up 82% of every bay on average. Other notable taxa include *Alona spp*, *Eurycerus spp*, Hydrachnidia, *Polyphemus pediculus*, and *Simocephalus spp*, which consisted of at least 2% of the total composition for either gear type (Figure 2). In total, 36 taxa were identified between all the samples, with an average of 14.5 taxa in each light trap sample and 11.2 taxa in each zooplankton grab sample. Light traps had a mean of 8

Cladoceran species in each sample and zooplankton grabs had a mean of 6.5 Cladoceran species (Table 2).

Discussion

It is difficult to determine the true composition of the zooplankton in each bay due to the uncertainty of whether gear bias or community composition differences were the leading cause of the divergence of the assessed community. However, it is still possible to discuss the potential prey base for the Muskellunge based on the gear type. Because the large cladoceran species were not found to be in large abundances for any gear, a generalized discussion will commence. Water grab samples indicated dominance by copepods (Figure 2), which are considered a poor food source for larval muskellunge due to low capture rates (Farrell, personal communication). Copepods are capable of escaping predators in a large burst, with the possibility of “jumping” a distance ten times its body length in any direction in less than a second of detecting another organism’s presence (Buskey et al, 2002). Conversely, light trap samples were dominated by *Bosmina longirostris* (Figure 2), an acceptable but small prey, with a maximum size of about 0.6mm (Balcer et al., 1984). This is in agreement with previous surveys of zooplankton in the St. Lawrence River, in which *Bosmina* and Cyclopoid copepods were dominant and often contributed to a lower community diversity (Farrell et al., 2009). *Eurycerus spp*, *Polyphemus pediculus*, and *Simocephalus spp* are the zooplankton considered to be large Cladoceran species, which are the preferred prey item of Muskellunge larvae (Scott and Crossman 1998). Although these species as well as a few other large cladocerans are present in most bays, it is uncertain if their abundance is great enough to sustain the larval population without the support of less desirable prey, and additional research would be necessary. Other studies have demonstrated a connection between zooplankton abundance and fish stock biomass, with an increase in overall population biomass when larval prey is plentiful (Frederiksen et al., 2006). There is a history of successful Muskellunge juvenile stocking at each of these bays, therefore the zooplankton community must be able to support populations of the larval fish (Farrell and Werner, 1999).

Rose Bay and Boscobel Bay have also supported natural nurseries for Muskellunge, and homing behavior in adults may occur (Farrell and Werner, 1999). If this is the case, then these bays must contain a plankton community which can support a population of Muskellunge young.

The community interpretations diverge dramatically in their ability to assess the prey base, which made estimating the prey composition in each bay a difficult task. Each gear type is limited in its ability to accurately assess the community composition. Light traps were most likely biased towards photopositive and highly mobile species, due to the need for the organisms to be attracted to and swim into the trap as opposed to being captured or flowing past the funnel (Doherty, 1987). This was the only gear to show that there was no difference between the bays, which would support a significant bias in organism composition. They did, however, have a much higher abundance of organisms compared to the zooplankton grabs and were able to collect a sample over a period of time rather than just a single moment. Light traps are often deployed longer than thirty minutes, with the main limitations being the amount of time in which the sky is entirely dark and the manageability of the sample while processing it. This may allow organisms which are not in the immediate area time to travel into the trap. The light traps also attracted fish larvae (not identified further) and aquatic insects, which influenced the higher organism richness within the samples. However the low diversity rating from the Simpson's Diversity Index showed there was a lack of evenness within these samples.

Macroinvertebrate and fish larvae were also caught in the light traps. Because macroinvertebrates are not relevant to the Muskellunge diet, their presence is considered an additional advantage to the light traps rather than a component of the larval fish diet (Scott and Crossman, 1998). Macroinvertebrate capture may make this a desirable sampling method for a broader range of studies. The same biases exist for macroinvertebrates in terms of phototactic and high mobility species having a greater abundance in the sample. Some of the most common macroinvertebrate taxa from this study include families Chironomidae, Ceratopogonidae, Dytiscidae, Corixidae, Culicidae, and Halipidae. Most macroinvertebrates were considered to be rare and were counted

before subsampling, however the midge (Chironomidae) and the mosquito (Culicidae) larvae were often considered to be common enough to be subsampled efficiently.

Grab collections do not attract organisms, however they may exclude benthic organisms which migrate up at night. Many zooplankton spend the daylight hours near or in the sediment and will emerge from the benthos at night to feed when visibility, and thus predation, is low (Pennak, 1998, Zaret and Suffern, 1976). Zooplankton grabs are also limited in assessing the composition of zooplankton over a large area. Some zooplankton exhibit a cluster pattern of abundance within a body of water, and because the grabs only sampled a few liters within a small area of the entire bay, it is very possible that some species could have been unintentionally avoided during sampling (Folt and Burns, 1999). Zooplankton grabs were better able to show that there was community diversity along the river, which makes them a better candidate for sampling zooplankton if only one gear must be used.

It is also important to note the weaknesses associated with each gear in terms of data analysis. Zooplankton grabs are easier to assess quantitatively than the light traps because of their specific volume of water sampled. Zooplankton grabs can be standardized by density captured per volume sampled, which can easily be compared to other studies and sampling methods. Light traps can only be assessed as a semi-quantitative or qualitative measurement. The organisms can be measured either as a total quantity sampled or by organisms captured per time unit sampled. This makes it difficult to compare to other gear types as there is no way to know how much of an area or volume was sampled. This data can be expressed in terms of sample abundance, since the most plentiful organisms in the traps should correlate to the most abundant organisms in the water, or in terms of presence and absence. Although it is still uncertain whether or not these calculations will accurately represent the community, it is the most logical way to make the data relatable to previous and future studies.

Conclusions and Further Implications

Because of the uncertainty surrounding the most accurate invertebrate composition within each bay, it is very difficult to determine the status of the Muskellunge larvae prey base. It can be determined that there is a presence of suitable prey for the fish, but the abundance of preferred prey may not be substantial enough to solely support the larvae. Small cladoceran prey may be able to supply extra nutrition to allow the fish to survive until they are large enough to convert to piscivory as their dietary preference. Each of these sites have supported Muskellunge larvae in the past, therefore the fish must be able to survive by feeding on the available prey.

It is also important to focus on the importance of using a variety of gear types when sampling any location. This ensures that the impact of gear bias can be significantly decreased and a more accurate portrayal of the community composition can be achieved. Although zooplankton grabs were better at demonstrating the community composition, it did have lower taxa richness and has the potential of missing many organisms. It is also important to standardize different methods to account for temporal changes in communities when they must be sampled at different times, as in the case of the light traps and the zooplankton grabs. In future studies, additional samples of zooplankton grabs should be taken immediately before the light traps are deployed in order to differentiate between changing community compositions and gear bias. In littoral habitats, it may also be beneficial to sample the upper portion of the sediment to account for burrowed zooplankton.

By having a better understanding of the lower trophic level organisms in a region, the success or failure of large organisms can be more accurately explained. Therefore, it is also important to have an accurate understanding of the community which is not influenced by gear bias to avoid performing actions which could be ineffective or harmful to the habitat.

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