Literature Report: Spiny Water Flea

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Bythothrephes longimanus more commonly known as the spiny water flea, is an invasive macroinvertebrate that was discovered in the Great Lakes in 1982. It has been presumed that they were transported to Canada via cargo ships and have been spreading ever since. More and more lakes are found to be invaded each year in Ontario and more studies are looking for factors that allow the spiny water flea to thrive and to disperse to other lakes. **The increasing dispersal of the spiny water flea by human transport and other natural factors is having a negative affect on native zooplankton communities by decreasing biodiversity and species richness, therefore disrupting lake food chains which will inevitably destroy our lakes.** Considering spiny water fleas tend to be found in deep, cool, large lakes, understanding their impacts and how to mitigate their dispersal is critical to preserving the health of Kushog Lake which has these specifications.

*Boudreau, S. A., & Yan, N. D. (2003, November). The differing crustacean zooplankton communities of Canadian Shield lakes with and without the nonindigenous zooplanktivore Bythotrephes longimanus. *Canadian Journal of Fisheries & Aquatic Sciences, 60*(11), 1307-1313. doi:10.1139/F03-111

Harp Lake in Ontario was being monitored before the invasion of the spiny water flea. It was noted that after the spiny water flea had invaded, zooplankton richness suffered as well as the abundance of other species. This could signal changes in other lakes in Ontario of zooplankton communities. This study sought to compare the zooplankton of invaded and non-invaded Canadian Shield lakes; hypothesizing that there would be differences in zooplankton between the two types of lakes seen similarly in the Harp Lake case. Selecting 30 lakes, 17 invaded and 13 non-invaded reference lakes, they ensured some variables remained similar (i.e. lake area, maximum depth, total phosphorus concentrations, pH and alkalinity) between the two sets and sampled the water of each lake for zooplankton. Observing 32 crustacean zooplankton species in all the lakes, significant differences were discovered. It was found that zooplankton species richness was 30% higher in the uninvaded reference lakes, biomass was also higher in the reference lakes which is significant as this result was lower than previous studies of zooplankton in Canadian Shield Lakes; likely caused by methodological differences. It was also noted that Cladoceran is the most vulnerable to spiny water flea invasions, as they may be a favoured food source. Although this study does not absolutely prove that the spiny water flea affects zooplankton in invaded lakes, it strongly suggests that zooplankton suffers from spiny water flea invasion.

*Kim, N., Yan, N. D., & Arts, M. T. (2014, March). Eicosapentaenoic acid limitation decreases weight and fecundity of the invading predator Bythotrephes longimanus. *Journal of Plankton Research, 36*(2), 567-577

It is now known that the spiny water flea negatively affects zooplankton in Canadian Shield lakes and others. It is also known that the n-3 fatty acid eicosapentaenoic acid (EPA) is highly retained by the spiny water flea but it's effects on populations are unknown. This study hypothesizes that the availability of EPA affects the spiny water flea's success and impacts. Several laboratory experiments were carried out testing the effects of EPA on Daphnia and the spiny water flea by controlling its availability and monitoring its affects compared to controls. The results stated that adult spiny water fleas that fed on EPA-enriched daphniid prey were much heavier than those feeding on non-EPA enriched daphniids. Their growth in turn may affect their fecundity. This finding is important as limiting EPA may be able to deter spiny water flea population growth. Using this knowledge, we can then search for ways to limit the invasion of the spiny water flea therefore mitigating its negative effects on Canadian Shield Lakes in Ontario,

Branstrator, D.K., Shannon, L.J., Brown, M.E., & Kitson, M.T. (2013). Effects of chemical and physical conditions on hatching success of Bythotrephes longimanus resting eggs. *Limnology and Oceanography*, 58 (6), 2171. doi: http://dx.doi.org.eztest.ocls.ca/10.4319/lo.2013.58.6.2171

This study attempts to fill an information gap they say is necessary to prevent species invasive by anthropogenic factors. There is an abundance of information on the resilience of the dormant stages of crustacean zooplankton, but there is not a lot of information on the survival thresholds of these stages. In this particular study, they have examined the survival thresholds of the spiny water flea during its dormant stages. Generally, it has been reported that the spiny water flea prefers well-oxygenated, cool and low-salinity conditions. Using this knowledge coupled with the known major cause of dispersion to be human caused, strategies can be recommended to mitigate the proliferation of the spiny water flea (i.e. decontamination of equipment, drying or rinsing with hot water). By conducting dose-response experiments, this study sought to determine the lethal thresholds of spiny water flea resting eggs to chlorination, heat, freezing, desiccation and salinity to better create management strategies. The results showed that salinity and chlorination had no effect, heat presented some threshold in different samples and in differing desiccation and freezing exposures hatching was prevented. Above all, the most influential factor proved to be desiccation. Knowing that desiccation has the greatest effect in preventing the hatching of spiny water flea eggs, it can be recommended for stewardship purposes that all anthropogenic introduced objects (i.e. equipment and recreational crafts) should be dried to prevent the dispersion of the spiny water flea.

Joleka, A., Arnott, S.E., & Beisner, B.E. (2013). Influence of light on the foraging impact of an introduced predatory cladoceran, Bythotrephes longimanus. *Freshwater Biology*, 58(9), 1946-1957. doi: 10.1111/fwb.12182

This study notes the importance of examining the influences that affect the foraging ability of invasive species to be able to better predict the impact the invader will have on its prey. In the case of the spiny water flea, they decided upon looking at the impact light has on its foraging abilities as its large eye makes it a visual predator. Dissolved organic carbon (DOC) and water clarity play a large role in predicting the amount of light present; with a trend occurring due to climate change and the reduction in acid composition, water clarity is decreasing and DOC increasing. Through a series of experiments, this study sought to compare the foraging ability of the spiny water flea in varying light environments. They hypothesized that the spiny water flea would be more successful in well-light ambient light conditions as opposed to light deprived conditions. The results indicated that the hypothesis proved to be true but only within certain taxa of zooplankton. Predictably, the spiny water flea was more successful at foraging in well light conditions; this mostly affected *cladocerans* which the spiny water flea tends to favour. This study further equips us with the knowledge that the spiny water flea is partially dependant on the light conditions in their foraging success which we can incorporate in management strategies of this invasive species.

Kelly, N.E., Yan, N.D., Walsend, B., & Hessen, D.O. (2013) Differential short- and long-term effects on an invertebrate predator on zooplankton communities in invaded and native lakes. *Diversity & Distributions*. 19 (4) 396-410.

This study also examined the effects that the spiny water flea had on the zooplankton communities by comparing Canadian lakes with Norwegian lakes. This study also aims to not only examine the short term but also the long term effects as these are more unknown. They recognize that the study of the long term effects of zooplankton communities are essential for the conservation and proper management of fresh-water resources considering they are the mediators between phytoplankton and higher trophic levels. Considering Canada's history of the spiny water flea started with their introduction to the Great Lakes during the 1980s, Norway has a longer history and is therefore good to use as a comparison when looking at the long term effects. By comparing lakes in Canada and Norway with similar geological, ecological and physio-chemical characteristics with differing lengths of time of exposure, the long term effects were studied Lakes in Norway are reported to have higher zooplankton biodiversity than Canada. Using statistical analysis on the incidence of the spiny water flea in Canadian and Norwegian lakes, it was found that the zooplankton communities in the Canadian lakes had a different composition compared to non-invaded lakes and this was not found to be true in the Norwegian lakes. This indicates that the presence of the spiny water flea alters the zooplankton communities in Canada but not in Norway. The importance of this long versus short term analysis tells us that the initial short term effects of the spiny water flea are drastic and consequential which we are currently seeing in Canadian lakes, but looking in the long term the zooplankton communities adapted to the presence of the spiny water flea as seen in the Norwegian lakes.

Kerfoot, W.C., Yousef, F., Hobmeier, M.M., Maki, R.P., Jarnagin, S.T., & Churchill, J.H. (2011). Temperature, recreational fishing and diapause egg connections: dispersal of spiny water fleas (Bythotrephes longimanus). *Biological Invasions*, 13 (11), 2513.

In considering the anthropogenic factors that are related to dispersing the spiny water flea, this study looks more specifically at recreational fishing by comparing lakes with similar conditions that only differ in the amount of recreational fishing on each lake. By sieving sediment samples from 83 lakes and looking for the presence of the spiny water flea in dispausing eggs as well as dissecting fish from nearshore beach environments, the abundance of the spiny water flea in the lakes was examined. When larger fish ingest dispausing spiny water flea eggs, they are able to survive in the gut of the fish and are later excreted. Dispersion of the spiny water flea is enabled by recreational fishing with the use of baitfish, dispausing eggs that are defecated into live wells and bait buckets as well as being attached to fishing lines and anchor ropes. This study argues that this is the main vector of transport among the other postulated anthropogenic factors in the spread of the spiny water flea. In the case that recreational fishing is causing the spiny water flea to disperse, they recommend simple measures to prevent this. Using this knowledge, management strategies can be formed to prevent the dispersion of the invasive spiny water flea that is caused by recreational fishing.

Olden, J.D., & Vander Zanden, M.J. (2008) A management framework for preventing the secondary spread of aquatic invasive species. *Canadian Journal of Fisheries and Aquatic Sciences*. 65 (7), 1512-1522. doi:10.1139/F08-099

This paper tries to bridge the gap between the research done on aquatic invasive species and putting management strategies into practice. Most strategies for invasive species are aimed at preventing the further spread of the species rather than offering solutions to already invaded areas. Suggested in this paper, the first step in the management of invasive species is to assess site vulnerability to invasiveness. Factors to look at are the ability for species to get to the location, can the site support a self-sustaining population and will there be undesired consequences? They suggest that since the most familiar defence against invasive species is prevention and the science is strong in predicting where species invasion will happen, it would be wise to focus prevention measures in areas highly susceptible to invasion before it occurs. Using the aforementioned steps in assessing site manageability may help gain the confidence of politicians who allocate funding and resources for management. In most cases, funding is allocated too late once concerns are raised about the consequences of invasive species. Not only does this strategy benefit the environment, it also appeals in the sense that it is cost-efficient and the best use of costly resources. Therefore, this paper is proponent of conservation planning as a way of managing and preventing the spread of aquatic invasive species.

*Weisz, E.J., & Yan, N.D. (2010, March). Relative value of limnological, geographic, and human use variables as predictors of the presence of the Bythotrephes longimanus in Canadian Shield lakes. *Canadian Journal of Fisheries & Aquatic Sciences*, *679(3)*, 462-472. doi:10.1139/F09-197

Since it’s first discovery in the Great Lakes in 1982, the methods for the dispersion of the spiny water flea in Ontario is unclear. It is suggested that humans are the primary cause for dispersal and secondary causes such as hydrological transport in watersheds as well as lake size might contribute as well. Current models for dispersion are only representative of eutrophic and mesotrophic European lakes and not the oligotrophic Canadian Shield lakes we mainly find in Ontario. Previously, there had been no accurate studies done predicting the spread of the spiny water flea in Canadian Shield Lakes; a gap which this study sought to fill. Using probability based models and lakes that had varying water quality whilst examining human factors more closely, a more representative study was conducted. All of this data was compared to lakes known to be uninvaded by the spiny water flea. The results of the study found that with more sampling done, there was a greater detection of the spiny water flea. It was also noted that the size of the lakes did not affect the presence of the spiny water flea, although logistic regression models indicated that lake size was a good predictor of the spiny water flea presence. No trends were detected for the correlation between hydrological connections, but there were clusters of invaded lakes discovered. Human activity was revealed to be a key predictor of spiny water flea presence. The more human presence, particularly cottage proportion, the higher the spiny water flea presence. It is likely that cottagers unknowingly transported the spiny water flea from invaded lakes to uninvaded lakes supported by the fact that invaded lakes tended to be close together. Other lake parameters that were predictors for the presence of the spiny water flea were large, clear, deep and heavily developed lakes that had a higher pH, conductivity, alkalinity and calcium. It has been concluded that Canadian Shield lakes provide a good environment for the spiny water flea to thrive. Their dispersion can also be made possible by their transport within lake chains aside from the more impactful activities of humans. Considering not all lakes are invaded, this points to some limitations of the establishment of the spiny water flea. It is predicted that high DOC content, low food levels and declining calcium and phosphorus can hinder spiny water flea establishment. Considering the popularity and development of lakes in Ontario, it is predicted that the spread of the spiny water flea will continue in the future.

Yan, N., Leung, B., Lewis, M., & Peacor, S. (2011). The spread, establishment and impacts of the spiny water flea, Bythotrephes longimanus, in temperate North America: a synopsis of the special issue. *Biological Invasions*, 13 (11), 2423-2432, doi: 10.1007/s10530-011-0069-9

This paper looks at much of the research currently done on the spiny water flea and they note that from the plethora of information, strategies can be created to better manage the spread of this invasive species. From several studies, they note that the spiny water flea has a temperature threshold in which they can survive, they have the largest effect on daphniids, change the trophic status of lakes by reducing Cladocera populations and spring prey abundance is one of the greatest indicators in the size of the spiny water flea. In a broader view, there have been reports that invasion is actually slowing. There is currently no model or management strategy employed on the spiny water flea. They suggest risk assessment models can be constructed based off current information collected. Efforts are also best allocated in controlling the activities of recreational lake users. They summarize that the invasive of the spiny water flea is best understood by key drivers and management strategies need to be multi-faceted. They also point out that the lessons learned about the spiny water flea are also useful in understanding other zooplankton species.

Conclusion

The invasion of the spiny water flea has been a problem since they were first introduced to the Great Lakes in the 1980s via the ballast water of trans-oceanic vessels. They have spread to in-land lakes into Canada and the United States, including Kushog Lake. The main vector of dispersion is a result of human activities i.e. recreational boating and fishing. The spiny water flea has a negative effect on the biodiversity richness of the zooplankton communities in favourably cool, low-nutrient and deep freshwater lakes, which are incidentally characteristics of Kushog Lake. Although no management strategies have proven to be effective in mitigating the dispersal of the spiny water flea, current research indicates that desiccation and temperature are the most influential factors in controlling their establishment and spread. It has also been found that spiny water flea dispause eggs can survive in the guts of fish and therefore care should be taken when transporting fish from invaded to non-invaded lakes. Considering there has been extensive research on the effects of the spiny water flea already conducted, the next step in mitigating their consequential effects would to be create management strategies in preventing their dispersion and conducting vulnerability assessments to better allocate management resources.