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Sea Lampreys: Still A Concern

A report to the Ministry of the Environment as to the problems still being imposed by the invasive Sea lamprey species

Sea lampreys are an invasive and harmful species, that has drastically diminished the number of Lake trout, and other freshwater fish species in the Great Lakes of North America. When the Sea lamprey (*Petromyzon marinus*) was introduced into Lake Ontario in 1890, the results were devastating, not only for the ecological balance within the Great Lakes, but for economical reasons as well.

Fig.# 1: Feeding Sea lampreys
(Photo by: NOAA, Great Lakes Environmental Research Laboratory)

Sea lampreys are primitive vertebrates which parasitize other fish namely the common Lake trout (*Salvelinus namaycush*). The fishing industry depends heavily upon Lake trout for business, as prior to the Sea lamprey invasion, the fishing industry brought in close to 2,000 metric tons of Lake trout per season. However,

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sixty years after the Sea lamprey invasion, the fishing industry had brought in no more than 100 metric tons per season. Not only were lake trout affected by this parasitic invader, but so too were many other freshwater species like Burbot (*Lota lota*), Rainbow trout (*Onychorynchus mykiss*), and Whitefish (*Coregonus clupeaformis*); also species of fish relied upon in the fishing industry (Sorensen, 1991). As you may have come to understand, Sea lampreys have impacted the once stable freshwater ecosystem of the Great Lakes for more than a century now, and may continue to influence the ecosystem and economy, unless the proper actions are taken.

Sea Lampreys, perfectly adapted to their 'new' environment

The Sea lamprey is a parasitic, anadromous organism, which resembles the common eel. Sea lampreys are among the few surviving jawless vertebrates from which the rest of the vertebrate species are believed to have descended. Their evolutionary history dates as far back as 300 million years ago ('Sea Lamprey', 2003). Cartilaginous species, like the Sea lamprey and its relative, *Myxine glutinosa* (Hagfish), are of evolutionary descent from the now extinct *Ostracoderms genus*, meaning 'jawless fish' (Jablonski, 1997). Sea lampreys are indigenous to Europe and the North Atlantic Ocean (Chambers, 1997), but had to adapt slightly when they became 'land-locked' in the 1800's. The Great Lakes are freshwater lakes having excellent visibility, and very low salt concentrations. Since Sea lampreys are anadromous (a salt-water species that migrates to freshwater systems to spawn and then die), they were already well suited to life in freshwater. However, the excellent visibility of the Great Lakes influenced the development of more precise eyesight, while the low salt concentrations altered the structure of the kidneys. These adaptations allow the Sea lampreys to catch prey more easily and live longer in the absence of salt. Dorsal 'nostrils' developed

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among Sea lampreys in the Great Lakes as well, although it is uncertain how this structure may benefit the species (Janvier, 1991). So despite these changes, it seems as though Sea lampreys were already accustomed to fresh water when they became 'land-locked' in the late 1800's, and the above alterations may have helped the Sea lamprey population explode.

Sea lampreys do not begin as parasites, but rather transform into a parasitic creature after three to ten yeas of remaining in a larval stage, embedded in a sandy/gravel bottom of a slow moving freshwater stream. These larval Sea lampreys (*ammocetes*) lack their characteristic suction cup-like oral disk and eyes. During metamorphosis, eyes, an oral disk laced with many horny teeth, and alterations in the kidney structure develop among the Sea lampreys. Their sharp teeth are capable of piercing through the skin of any host fish, while an anticoagulant in the Sea lamprey's saliva prevents blood clotting. This allows the parasite to remain attached to the host until sources have been depleted, or until the spawning season arrives in April ('Sea Lampreys', 2003). It is estimated that one adult Sea Lamprey will feed off and kill 7 to 18 kilograms of fish in its parasitic stage. Fortunately, the parasitic stage of an adult Sea lamprey lasts only one year. After a year in the parasitic stage, the Sea Lamprey detaches from its host, and searches for a suitable spawning site. The spawning season for the Sea lamprey lies between April and July ('Anadromous Fish', 2003), where a female Sea lamprey can lay up to 60,000 eggs (Fetterlof, 2003). Soon after breeding, the Sea Lamprey travels down stream and dies (Sorensen, 1991).

Problems imposed by the Sea lamprey

The success of the Sea lamprey in the Great Lakes can be attributed to many factors. One such factor is the lack of an effective predator, and another is that Sea Lampreys probably have as many kilometres of tributaries and hectares of larval

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habitat as the native range of the Sea lamprey along the Atlantic coast ('Sea lampreys', 2003). Also, the Sea lampreys were already supremely adapted to life in freshwater, and food sources have been abundant. With these conditions in hand, the Sea Lamprey population grew at an incredible rate, and impacted the ecological and economical balance within the Great Lakes in many ways.

The main food of choice for the Sea Lamprey is and always has been Lake trout. Although early declines in the abundance of Lake trout in the 1940's are suspected to have been caused by over-fishing, Sea Lampreys are also believed to have been another fundamental cause for the decline. With the near elimination of the Lake trout species in the 1940's, populations of Rainbow smelt and Alewives grew rapidly due to the absence of their main predator ('Sea Lampreys', 2003). The increase in the population of Alewives and Smelt caused a drastic reduction in the population of deep water Cisco and Sculpin. Alewives also prey heavily upon zooplankton. Since zooplankton prey heavily on phytoplankton, the populations of phytoplankton flourished in the absence of their main predator. As a result, water clarity diminished drastically with the increase in phytoplankton, and many species of fish faced near extinction. The above problems impacted the ecological balance within the Great Lakes with the introduction of the Sea lamprey. However, the economy suffered too.

The introduction of the Sea lampreys has had a very negative effect upon the fishing and tourism industry. Many fishermen were unemployed due to the absence of Lake trout in the Great Lakes. Recreational fishing diminished in the Great Lakes as well, due to the lack of trout and various other species. Furthermore, massive die offs of the Alewives, which flourished in the absence of the Lake trout, fouled the beaches of Lake Michigan and Lake Ontario, further impacting the economy by diminishing tourism to these areas ('Sea Lamprey', 2003).

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Predictions for the future are difficult

Predicting the future of Sea lamprey populations has been a difficult and arduous task. Roger Bergstedt and James Seelye, scientists at the Great Lakes Science Centre, demonstrated in a study conducted in 1990 that Sea lampreys do not have a homing mechanism like other aquatic organisms. Most fish return to the native stream where they were born to spawn and then die, but not Sea lampreys. I have created the following table as a synopsis of the information they gathered over a two-year study, spanning from August 1990 to April 1992.

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Table #1: Evidence for the lack of homing by Sea lampreys (Bergestedt, Seelye, 1995)

Focus on Population	Population Size
Estimated population of Sea lampreys migrating to Lake Huron in August 1990 from Devil River	3382
Sea lampreys caught and tagged in August 1990 migrating to Lake Huron from Devil River	555
Estimated number (percentage) of tagged Sea lampreys expected to return to Devil River in April 1992, assuming the use of a homing mechanism	372 (67%)*
Total number (percentage) of tagged Sea lampreys which returned to Devil River in April 1992	0 (0%)*
Total number of untagged Sea lampreys migrating to Devil River to spawn in April 1992	45
Number (percentage) of tagged Sea lampreys captured in Lake Michigan tributaries in April, 1992	1 (0.18%)*
Number (percentage) of tagged Sea lampreys captured in Lake Huron tributaries in April, 1992	41 (7.4%)*

* Note: The percentages (%) shown in various cells of this table are percentages of Sea Lampreys when compared to the total population of tagged Sea Lampreys released from Devil River in 1990 (cell #2).

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As seen in Table #1: *Evidence for the lack of homing by Sea lampreys*, the number of tagged Sea lampreys that were expected to return to Devil River during the spring mating run in 1992 was 372 out of 555. This value took into consideration equal mortality rates among the total number of Sea lampreys tagged and those not tagged, and was expected if Sea Lampreys utilise a homing mechanism in the selection of a spawning site. However, the actual number of recovered and tagged Sea lampreys that returned to Devil River in the mating run of April 1992 was zero, meaning that no tagged Sea Lampreys released from Devil River returned to spawn. Tagged Sea lampreys were only found in Great Lake tributaries such as Deer Creek, Manistique, and St. Mary's River (Bergstedt and Seelye, 1995). The fact that no tagged Sea lampreys returned to Devil River in the mating run of 1992 is a strong indication that Sea lampreys do not use a homing mechanism in the selection of a spawning stream, but rather an innate and thus far unspecific method of mating stream selection. To control and monitor any species population necessitates a strong understanding of their mating patterns. Since observable patterns have not yet been recognised among Sea lamprey populations, estimating future populations has become very difficult. However, it was estimated in 1995 that approximately 620,000 Sea lampreys existed in all of the Great Lakes (Fetterlof, 2003). What current and future populations are projected to be is uncertain. However, control techniques have only been improved since 1995, and it is not expected that Sea lamprey populations have grown much larger ('Sea Lamprey', 2003).

The evidence for the lack of homing by Sea lampreys is useful in many ways. This information indicates that Sea lampreys do not rely on a homing mechanism like many other aquatic organisms do. Instead, it seems as though other, innate conditions influence a Sea lamprey when it comes to choosing a spawn site. Should we find this innate sense of attraction, it may be used to lure Sea lampreys into traps, or even used as a lampricide.

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An invasive species necessitates inventive courses of action

Sea lampreys are an effective invasive species, having survived for 110 years now in a relatively new environment. Past methods of control, for the most part, have thus far rendered unsuccessful. The first methods of control involved using electric wires and physical barriers, which prevented Sea lampreys from invading new territory. However, the physical barriers disrupted the breeding cycles of many other species of fish, and the electric wires were suited unreliable and extremely unsafe. Chemically induced poisoning of Sea lamprey populations has worked well, as it is estimated that Sea Lamprey populations are now 10% of what they used to be in the 1940's. however, prices of the only effective lampricide agent, 3-trifluorometyl-4-nitrophenol (TFM), are currently running at seven million dollars a year, and are expected to rise an additional 75% within a few yeas (Sorensen, 1991).

To effectively maintain Sea lamprey populations, a new method of control is needed. A relatively new and practical idea of Sea Lamprey population control utilises their sense of smell along with their use of pheromones for mating ('Sea Lamprey', 2003). Male and female Sea Lampreys are attracted to distinct pheromone, which only Sea lampreys produce. The principle Sea lamprey attractant is believed to be the amino acid *Isoleucine methlester*. Many unique steroids produced by Sea lampreys are also believed to be pheromone attractants. Isolating and artificially producing these pheromone and amino acids is a promising and theoretically attractive idea for the luring and capturing of male and female Sea lampreys. The Sea lamprey also relies heavily upon its sense of smell for the location of prey. Thus, isolating the Sea lamprey attractant that draws Sea Lampreys to fish, is another aspect of Sea lamprey luring that we may wish to utilise in the near future.

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These chemicals are expected to run at costs much lower than the present seven million dollars a year, and are expected to just as effective (Sorensen, 1991). It is advised that treatment with these chemicals begin immediately after safety approval, so that another mass explosion of Sea lampreys is avoided. Until mass fabrication of these attractants is made possible, treatment with TFM is suggested at regular use. Treatment with TFM should be used most heavily in shallow, low flowing streams with sandy / gravel bottoms, as larval Sea lampreys are most susceptible to TFM. It is predicted that with continuous treatment of streams with TFM, Sea lamprey populations remain low. Tourism and the fishing industry have finally been restored, and stocking of trout and Whitefish has stopped in many locations across the Great Lakes. Continue treating streams with TFM, and commence Sea lamprey luring with artificial pheromones, and we may one day eliminate Sea lampreys from our ecosystem.

The Sea lamprey is the major obstacle preventing the restoration of the Great Lakes to a balanced ecosystem with self-sustaining populations of endogenous fishes. Should the lamprey populations be greatly reduced or eliminated, it would benefit all those who fish these waters or who benefit from its industry (Sorensen, 1991).

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Teacher's Notes

Knowledge/Understanding

– The student demonstrates a high degree of understanding of how the invading species has adapted. He or she demonstrates knowledge of the changes in sea lampreys after they moved from salt water to fresh water habitats, and an understanding of how these changes were facilitated (e.g., "the excellent visibility of the Great Lakes influenced the development of more precise eyesight, while the low salt concentrations altered the structure of the kidneys. These adaptations allow the Sea lampreys to catch prey more easily and live longer in the absence of salt"; "Sea lampreys were already accustomed to fresh water when they became 'land-locked'").

Inquiry

– The student analyses the actual or potential problem with a high degree of effectiveness. He or she realizes that there are many aspects to the problem posed by the invading species (e.g., "the sea lamprey population grew at an incredible rate, and impacted the ecological and economical balance within the Great Lakes in many ways"). The discussion centres on the effects of the depletion of lake trout, "The main food of choice for the sea Lamprey".

– The student predicts the future impact of the invading species with a high degree of effectiveness. He or she identifies the challenges of making predictions (e.g., "Since observable [mating] patterns have not yet been recognised among Sea lamprey populations, estimating future populations has become very difficult"). However, the student uses research to suggest that the number of sea lampreys is not significantly increasing (e.g., "it was estimated in 1995 that approximately 620,000 sea lampreys existed in all of the Great Lakes … and it is not expected that Sea lamprey populations have grown much larger"; "it is estimated that Sea lamprey populations are now 10% of what they used to be in the 1940's").

Communication

- The student communicates information in graph/chart/table format with a high degree of clarity. He or she uses a "table as a synopsis" of "Evidence for the lack of homing by sea lampreys". The table effectively summarizes a large amount of information. The percentages included in the table are clearly explained in the note that follows it.
- The student communicates ideas and information with a high degree of clarity. The report is well organized and, in the main, clearly written. However, there are a few unclear expressions (e.g., "suited unreliable") and typographical errors (e.g., "*methlester*" for methylester, "trifluorometyl" for trifluoromethyl). The student uses and explains scientific terminology appropriately (e.g., "Sea lampreys are anadromous (a salt-water species that migrates to freshwater systems to spawn and then die)").

Making Connections

- The student recommends and justifies a highly effective course of action. He or she researches and discusses the advantages and disadvantages of past and current practices used to deal with sea lampreys. The student then recommends and justifies a course of action that involves the ongoing use of poisoning until chemicals that exploit the sea lamprey's "sense of smell along with their use of pheromones for mating" are available by "mass fabrication". The student advises "that treatment with these chemicals begin immediately after safety approval".

Comments

This work is representative of a solid level-4 performance. The student demonstrates a high degree of achievement of the expectations in all four categories of knowledge and skills.

Next Steps

In order to improve his or her performance, the student needs to:

- edit and proofread the report to eliminate unclear expressions and typographical errors.