A Brief Review on Restoration Projects: On Lake Superior Coastal Wetlands in Ontario, Canada

By

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An Undergraduate Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Honors Bachelor of Science in Forestry

Faculty of Natural Resources Management

Lakehead University

April 20, 2020

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A CAUTION TO THE READER

ABSTRACT

In recent years, human beings have done much damage to the lakes and wetlands, resulting in some irreversible effects. It is, therefore, necessary to restore and protect the remaining wetlands. The most representative is the Great Lakes wetland ecosystem. The wetlands along the great lakes cover an area of more than 500,000 acres and span the great lakes basin. They play an essential role in the great lakes ecosystem and support many beneficial ecological functions. Among them, Lake Superior wetland is the principal research object. To successfully restore the wetland, this paper will adopt scientific methods to repair it. We will conduct field tests in four areas: eliminate sediment, ecological, hydrology and chemistry. Eliminate sediment remediation is the proper control of erosion of agricultural land, restoration of gully wetlands and effective management of beach, dune, ridge and marsh systems to control the coastal sediment problems that lead to wetland restoration. Ecological remediation is the restoration of wetland productivity by increasing the diversity and habitat of target organisms. Hydrologic remediation is a test to restore the essential hydrologic relationship through the preliminary study of the hydrologic relationship of constructed wetland and the fluctuation of the natural water level. A variety of chemical sediment remediation techniques can be used to rehabilitate existing contaminated sites, including tree planting, erosion control, riverbank reinforcement, buffer zones, reconstruction, diversion of surface drainage systems and drainage of wetland sewage.

CONTENTS

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, Professor Wang Jian, who has a genius attitude and substance. He professionally guided me to complete this graduation thesis and share his many years of research experience as a professor. Without the continuous help of his guidance this thesis would not have been possible.

INTRODUCTION

The disappearance of coastal wetlands has aroused great concern for the restoration and protection of wetland ecosystems. For decades, human activity and natural events have affected the degradation of the Great Lakes ecosystem. The changes in human settlements, land use and transportation of goods and raw materials directly affect the health of the ecosystem along the great lakes (Steinman, 2017). As observed, problems such as drainage, packing, pollutants and high rates of pollutants, deposition, the introduction of alien species, loss of hydrological links, increased flooding and damming affect the health of wetlands in different locations along the great lakes. In this way, Great Lakes Restoration Initiative is an unregulated agency committed to providing resources critical to the long-term goal of conserving and preserving wetlands along the great lakes (U.S. Forest Service, 2019). According to Brazner's (2016) research, Laurentian Great Lakes (LGL) in North America contains more than 2,000 coastal wetlands with an area of 215,000 hectares.

Great Lakes coastal wetlands remain a transitional position between terrestrial and aquatic environments. Lake Superior, one of the Great Lakes, is the world’s largest freshwater lake with surface area of coastal wetlands and is rich in natural and human history. The coastal wetlands in Lake Superior provide critical habitats for a variety of species of fish, birds, plants and animals. However, when humans join in, lots of coastal wetlands have decreased, and some have disappeared. Lake Superior is the least disturbed in the Great Lakes, but still been impacted. Human activities cause wetland degradation, such as ecosystem disturbed, non-native species, clearing, filling. The objective of this study is to review on Lake Superior Coastal Wetlands restoration project, such as the Black Bay Project in Canada and two unique coastal properties along Lake Superior by Superior Watershed Partnership and Land Conservancy (SWP) in the U.S.A.

The Nature Conservancy of Canada (NCC) is a private land conservation organization to protect the most critical natural areas. Since 1962, NCC and its partners have helped to protect more than 1.1 million hectares (2.8 million acres), coast to coast, with more than 74,400 hectares (184,000 acres) in Ontario (NCC 2018). On September 14, 2018, the Nature Conservancy of Canada (NCC) and its partners announced the creation of a new 3,170-hectare (7,835-acre) protected area in northwestern Ontario - Black Bay Project, which is the largest conservation project on the north shore of Lake Superior. It included 1,300 hectares (approximately 3,200 acres) of coastal wetlands. Furthermore, also in September 14, 2018, the Superior Watershed Partnership and Land Conservancy (SWP) declared the permanent protection for two unique coastal properties on Lake Superior over 3,100 ft (~945 m). The SWP is a local Great Lakes non-profit organization that protects the three Great Lakes, which is Superior, Michigan and Huron.

In addition to the conservation project at Lake Superior, LGL, one of the largest freshwater systems in the world, provides social and economic value to Canada and the United States. Decade (stricter,2017). The great lakes recovery initiative (GLRI), enacted in 2010, seeks to accelerate efforts to protect and conserve freshwater systems and life in the great lakes (Bay, 2018). Primarily, LGL constitutes an abundance of forests and wetlands, with a variety of designations on land and in water bodies. It is important to understand how the restoration program is applied to different areas of Lake Superior, Ontario. The aim of the literature review is to assess the applications of these projects and their practical impact on wetland and lake ecosystems. This paper briefly summarizes the characteristics of the Lake Superior restoration project and uses as a means to determine the methods used to restore the ecosystem and the amount of knowledge related to it (Annis et al., 2017). Through the review, I want to understand how conservation projects are tested and implemented in the district to enhance the understanding of conservation improvement projects.

Coastal Wetlands in Ontario

The loss of coastal wetlands has generated a great concern towards restoring and protecting wetland ecosystems. Over the decades, human actions and natural incidences have influenced the degradation of the Great Lakes ecosystems. Factors such as changes in human settlement, the transformation of land use and transportation of goods and raw materials have a direct effect on the wellbeing of coastland ecosystems in the Great Lakes

(Steinman, 2017). In a recent article, Poulton & Bell (2017) observe that issues such as drainage, filling, high rates of pollutants and contamination, sedimentation, the introduction of non-native species, loss of hydrological connectivity increased flooding and damming affect the wellbeing of coastal wetlands in different sites across the Great Lakes.

In this manner, GLRI is a non-regulatory body that works to provides resources that are essential in protecting preserving the long-term goals of coastal wetlands in the Great Lakes (U.S. Forest Service, 2019). Brazner (2016) shows that the Laurentian Great Lakes (LGL) of North America accommodate over two thousand coastal wetlands covering an area of 215,000 ha. Lake Superior is the largest Lake covering approximately 82,100 km2 (Brazner, 2016). The article argues that coastal wetlands in the lake export high margins of fish to nearby bays and food webs. This way, these regions host unique habitat species and have structures, functions and exhibit specific responses to the anthropogenic stressors caused by the hydrogeomorphic setting (Selheimer et al, 2011). Levels of human impact have a significant effect on the wellbeing of the ecosystems nearby the Lake. The aim to outlay a brief review of restoration projects on Lake Superior Coastal Wetlands in Ontario, Canada.

The Great Lakes

Apart from accounting as one of the largest freshwater systems in the world, LGL provides social and economic value to Canada and the U.S (Sterner, 2017). The Great Lakes Restoration Initiative (GLRI) was established in 2010 to accelerate efforts to protect and conserve freshwater systems and life in the Great Lakes. On the other hand, Bay (2016) describes LGL with abundant forests and wetlands that host a variety of species both on land and in the water bodies. It is essential to understand how the restoration projects have been applied in different parts of Lake Superior in Ontario.

Uzarski et al (2017) cover different case studies regarding the effect of restoring recreational projects in coastal wetlands. In particular, the article evaluates the application of the projects and the actual impact they have on the wetlands and the Lake's ecosystems. The paper suggests that offsetting plays an important role in conserving coastal wetlands as well as reduced the cost and resources used in recreational projects. Annis et al, 2017) analysed Lake Superior and restoration projects implemented in the lake. By outlining the recreational parks of Ontario as significant projects in the coastal wetlands, they identified the need for further investigation into understanding the features of coastal wetlands along the Great Lakes.

Lake Superior

The lake's basin has rare ecosystems in the LGL. The coastal wetlands of Ontario are disconnected from inland wetlands hydrologically through the connection of surface water from a great lake (Brazner, 2016). He provides an analysis of Lake Superior coastal wetlands to illustrate that the region yields a variety of young fish species to the adjacent bay. He also highlights the significance of biochemical signatures released in the region which is valuable in evaluating near shore and water body interaction (Brazner, 2016). As observed from the data collected from the article, it is clear that Lake Superior coastal wetlands are profoundly affected by the hydrogeormorphic components in the area (Brazner, 2016). In this way, development, invasive species, and climate change influence the integrity of the Lake. This exhibits the importance of developing recreation projects that seek to safeguard life in the ecosystem (Brazner, 2016). The article highlights the nature of the coastal wetlands and develops an emphasis on the importance of recreational initiatives that seek to flourish the region.

To define the integrity of coastal wetlands, Cooper et al. (2018) introduced biotic indicators as helpful tools in measuring the health of an ecosystem due to the structure of the neighbouring communities that express abiotic elements. In this way, the article suggests that biotic indicators are important and useful when applied to monitor programs covered in the Great Lakes (Cooper, 2018). The evaluation of Lake Superior seems to point out the causes of degradation in the Lake and the actual measures employed to ensures that restoration and protection are provided to the species in coastal wetlands.

Restoration Projects in Ontario, Canada

The Lake wide Action and Management Plan (LAMP) is an initiative by Lake Superior Partnership that seeks to implement an action plan for protecting and restoring coastal wetlands (Lake Superior Lakewide Action and Management Plan, 2019). The plan outlines the expectations of the action plan developed and led by USEPA and Environment and Climate Change Canada (Superior, 2019). It provides an illustration of Lake wide objectives, threats to the ecosystem, priorities for future scientific investigation and the actions and projects set to be implemented. Most significantly, the article provides data on Lake Superior stressors, threats, strategies, priorities and actual conditions to be achieved. The article illustrates the significance of Lake Superior by considering the indigenous communities as well as the parks and recreation centres that provide an array of recreational experiences such as hiking in the Pukaskwa National Park (Superior, 2019).

Pukaskwa National Park is located next to Pic River First Nation, along the shore of Lake Superior (Mirnadi, 2019). Pukaskwa coastal route encompasses white and Pukaskwa Rivers which have accessible paddle routes. The institution provides camping options to clients and easy and moderate trails where people can hike in less than thirty minutes (Mirnadi, 2019). Mirnadi (2019) provides an implicit look at the national park to highlight breath-taking recreation experiences offered to the community. The park's size and landscape provide a fit venue for hiking practices (Mirnadi, 2019). As observed, the recreation centre has created different hiking trails by considering the ability and experience of participants. Diversity promotes the community as a platform to visit different parts of the park. The government of Canada highlights Pukaskwa National Park as an endless adventure that features 135km of the Lake Superior coastline (Canada, 2019). The government websites provide pictures and a list of the activities covered in the graceful park. To outline, Pukaskwa has remote wilderness and backcountry hiking trails with a coastal paddling route. Apart from the day hike on a suspension bridge, the park offers geocaching activities that accommodate the whole family (Canada, 2019).

Alternatively, Lake Superior Provincial Park constitutes 40,000 acres of beautiful scenery and a total of eleven trails that run through the coastline (Parks, 2019). The Ontario Park Magazine invites people to visit the park and experiences four quality adventures. To begin with, short walks on the Agawa Rock Pictographs trail take around thirty minutes to complete. The stock contains great heritage; thereby, it promotes history and adventure through the walk (Parks, 2019). The park also encompasses the path to old rocks on the Noisy Bay trail which is four kilometres in length. The Nokomis trail goes through the stones of the Old woman River valley to a scenic look over 200-meter-high cliffs (Parks, 2019). The Towab trail in the park provides experienced hikers with hills that are parallel to the Agawa River (Parks, 2019). The International Joint Commission published an article highlighting the importance of building the Lake Superior Water Trail which creates a recreational corridor (Commission, 2017). In this, the commission seeks to promote the increase of Lake Superior users than can be stewards of the Lake. The national trail will not only increase paddling as a recreational manner of movement in the area but also promote the international water trail (Commission, 2017).

Social-economic Impact of Restoration Projects

The interaction between man and the environment influences the integrity of the environment. For instance, Gonzales et al. (2014) argue that there has been a dramatic decrease in the woodland caribou (a threatened species). The article introduces the use of translocation to reintroduce different populations expected to disappear if not cared for (Gonzales, 2015). However, it demonstrates different wildlife scenarios to clarify the importance of translocation in reducing the margin of wolf species to increase the densities of the woodland caribou (Gonzales, 2015). In this manner, the significance of developing a decision-making model that oversees the wellbeing of the coastal regions is imperative. The community should seek evidence-based approaches in ensuring that the effects of recreation projects do not harm the environment.

Boan et al. (2018) focuses on the decreasing margins of the woodland caribou in recreational centers in Ontario and argues that the public has provided a considerable level of attention towards the issue. The article points out that although there are wildlife management campaigns regarding the importance of these ecosystems, the margins of the endangered species continue to decline (Boan et al, 2018). In a publication by Deloitte, interviews with stakeholders from Ontario highlights the challenges experienced in the infrastructure, entrepreneurship, and transportation to different markets (Deloitte, 2018). The publication emphasizes the traditional nature of the businesses in Ontario and suggests younger talent as the way forward in developing creative manners to recreate the parks.

Lemelin et al (2010) argue that the Lake Superior National Marine Conservation Area (LSNMCA) fails to capitalize on potential tourism and recreational experiences. The article conducts a historical overview of the recreational activities developed in the area and states that current conservation practices fail to recognize the power of developing new opportunities or tourism in Ontario (Lemelin, 2010). It is important to note that tourism largely depends on mining and forestry. Thereby relevant stakeholders ought to evaluate the effect of new tourism practices that safeguard ecosystems and the surrounding communities (Lemelin, 2010). The publication emphasizes the importance of developing new strategies that seek to improve the wellbeing of tourist attraction sites in Canada. In particular, developing a new strategy will enhance the interaction of tourists visiting Lake Superior. As such, the evidence points out the importance of further research in developing recreational opportunities that have a minimal impact on society.

Further Research in Restoration Projects

The changing tides of human action and climate change emphasize the need to develop recreational opportunities that do not harm the environment. The importance of developing better recreational opportunities is to create healthy recreational spaces that have minimal effect on the environment. Under the circumstances, it is important to engage in further research and development in the recreational experience. Steinman (2017) argues that there is a minimal evaluation of the ecosystem services in the Great Lake basin. The lack of accurate data to determine the impact of the activities hinders the relevant bodies from making informed management decisions (Steinman, 2017). The article focuses on understanding the elements required to provide informed managerial decisions. The publication shows that credible resources are needed to promote the manners of data collection and analysis in the region. Most significantly, the article suggests that there is a need to accumulate intensive data to fill the data gaps available regarding the social issue (Steinman, 2017). Therefore, it is quite imperative to develop data collection methods that yield relevant information important in cultivating the environment.

The University of Michigan has promoted the use of ultra-detailed maps of the Great Lakes to develop better management decisions regarding recreational experiences (Michigan, 2015). As can be expected, the article argues that exceptionally detailed maps provide a more precise analysis of the region and can be able to identify areas that are most suitable to support recreational activities without endangering species in the ecosystem. Detailed maps are set to identify the location of different species which will make it easier for relocation strategies. The proposal of detailed maps quite allows the relevant bodies to outweigh traditional methods of conservation. The proposal is effective in bringing a new perspective in wildlife management across the coastal wetlands of Ontario. Better maps of the region will illustrate the movement of species as well as the emergence of invasive species that threaten the wellbeing of extant species in the region. This way, the proposition considers the importance of developing new opportunities and experiences as a means of improving the welfare of the ecosystem.

Conservation Strategy

The biodiversity conservation strategy for Lake Superior is a suggested manner of conserving and restoring the health of the lake and the ecosystems it encompasses. For the most part, the strategy is prepared by the Lake Superior Binational Program (Program, 2015). It aims at illustrating the actions necessary to restore and protect Lake Superior's habitat and species. The strategy focuses on a framework of coordinated and direct action that aims to restore the wellbeing of the Great Lake for future generations (Program, 2015). In this way, the article suggests six strategies that encompass the restoration and protection, as well as the management of the ecosystem in a manner that propels healthy and self-sustaining generations of the variety of species that exist in the region (Program, 2015). This article highlights the importance of moulding conservational techniques to suit the region. Through a detailed plan, this document provides a strategic approach in redefining conservational approaches in the region. The adaptation of the ecosystem based on climate changes is a commendable strategy. This venture ensures that species in the region will have diverse migration routes (Program, 2015).

The Biodiversity Conservational strategy has an objective to reduce the negative impacts of dams and restrictions by promoting linkage and hydrology between the lakes and the environment (Program, 2015). Similarly, the initiative is developed to address emerging issues and provide management solutions that will lead the recreation of coastal wetlands in Ontario and other regions that accommodate Lake Superior.

MATERIAL AND METHODS

The first method is to eliminate sediment restoration along coastal wetlands. Such as effective control of erosion problems and the restoration and management of beach and dune systems. Human activities in coastal wetlands threaten the restoration of local ecosystems. So, we must not only prevent sediment problems but also protect wetlands from erosion.

Another effective method is to use groin, which is often used to intercept longshore and beach drifting. But natural disasters often carry sediment to deep waters, bypassing the groin, and causing erosion of wetlands. Or the groin is flooded with sand. This method has been adopted in some regions, but due to too many variables, no conclusion has been reached.

The second method is ecological restoration, including: a) reducing / controlling non-target organisms; b) increasing target organisms; c) establishing and providing artificial habitats for target organisms. It can restore wetland systems by reducing or controlling non-native species. For example, there are many reeds around the wetlands of Lake Superior. We can spray glyphosate to control the growth of target species. However, this method also affects non-target species. We recommend artificial spraying in mixed forests, which can effectively control the target species and protect other species (Douglas 1999).

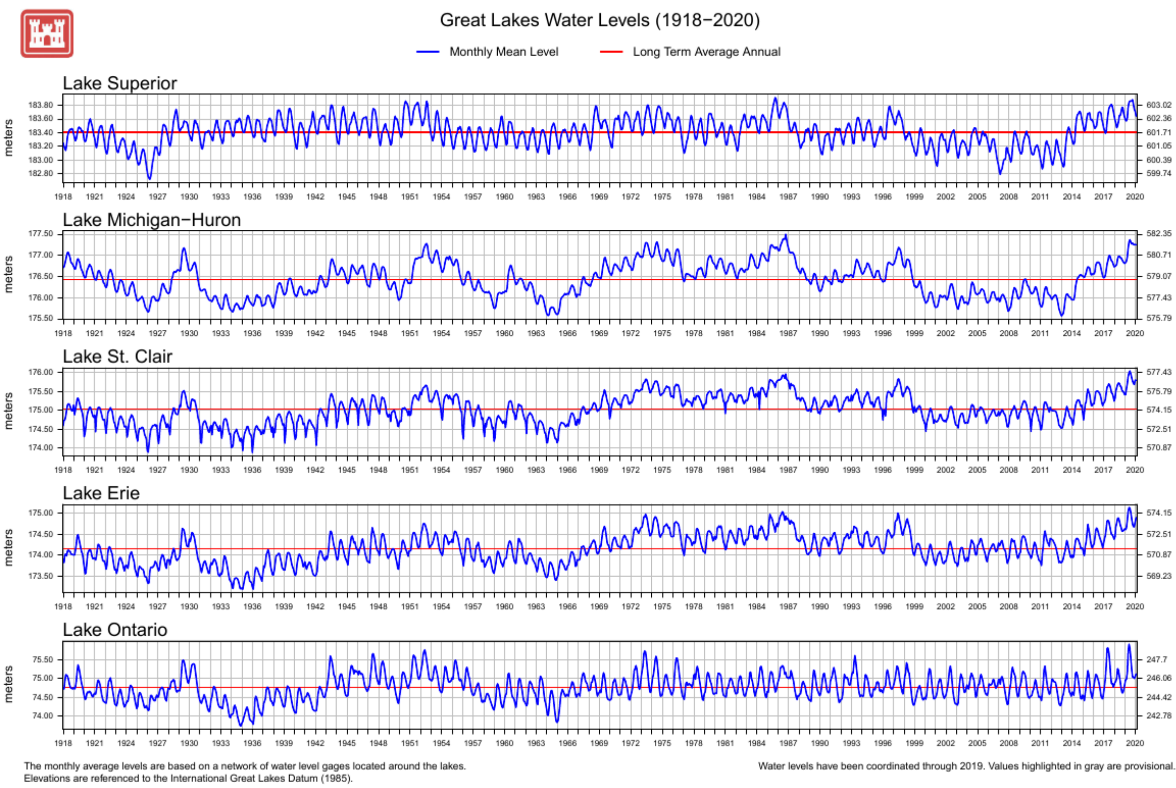

Figure 1. Great Lakes Water Levels (1918 - 2020).

Source: US Army Corps of Engineers

It is also feasible to control non-native animal species to restore wetlands. For example, Canada Goose (Branta canadensis L.), we can use the excreta of other species to these species to achieve wetland restoration. Another example is the school of fish. The most common method is to build dams. The disadvantage is reduced vegetation diversity. The growth of flora and fauna and habitats will also help wetland restoration.

We increase the number of target species by increasing their habitats and then stocking them.

The physical function of hydrology plays an essential role in the restoration of coastal wetlands. In the wetlands of Lake Superior, for example, there is often a 14-hour water grid. Surveys have found that coastal wetlands experience both high and low water levels each year, with water levels usually rising as temperatures rise. Historically, the highest and lowest water levels have been recorded at 1.19 meters in Lake Superior and 2.04 meters in Lake St. Clair (USACE 1999). Hydrology is one of the essential comprehensive factors affecting the vegetation composition and structure of marshes along the great lakes (Keddy and Reznicek 1986, Wilcox et al. 1993, Wilcox 1995).

Ditching and diking are the most common methods of controlling hydrology. Among the great lakes, levee control is minimal in Lake Ontario, where it is only 3% and highest in Lake St. Clair, where it is 33%. Usually constructed wetlands repair and protect vegetation by exposing sediment to an unnatural drop in water level (Douglas 1999). So I think that the use of hydrology to restore coastal wetlands can be divided into five levels: A) using reliable methods, such as ditching and diking. B) restore the connection between wetlands and lakes. C) avoid excessive water level drop and stabilize the water level of the wetland. D) restoration of wetland vegetation and wetland system. E) strict supervision and control of Great Lakes wetlands.

Aquadams can be used to build temporary DAMS that link natural water level fluctuations to the hydrology of constructed wetlands. The advantage is that it can be temporarily separated from the Lake and allow the seeds of the vegetation to regenerate naturally. The disadvantage is that it is costly and takes much labor to install. Although not widely tested, it has potential advantages (Douglas 1999). Another situation is that when the water level of the coastal wetland does not affect the hydrology, the water level can be lowered by linking. The general solution is to fill in and change the flow. But this solution can potentially affect the quality of the water and slow the growth of vegetation.

The last method is chemical repair, which is complicated modern technology. Use more effective techniques (such as multiple sediment remediation techniques) to reduce pollutants and sediments to repair the water quality of coastal wetlands (Douglas 1999). Chemical remediation methods include controlling erosion, rebuilding forests and rebuilding wetland drainage systems.

Although this technology can reduce pollutants in coastal wetlands, many sediments are accumulated over many years, and it is not very easy to eliminate them, and industrial contaminants such as pesticides will be on it. This results in the contamination of suitable sediments, but there is a chance that natural repairs will occur (Douglas 1999).

Another type of chemical repair is phytoremediation, which is an experiment on plants. However, Lake Superior is a coastal area; this method is mainly for land applications.

Removal techniques are more productive and more widely used than phytoremediation (Douglas 1999). Mechanical dredges and hydraulic dredges are two major categories of this technology. Bioremediation is carried out through dehydration, which is extremely efficient and easy to use.

RESULTS

Figure 1 shows the water level change of Lake Superior from 1860 to 2000. Due to the human influence on Lake Superior throughout the year, the water level fluctuates greatly, about 0.8m. As shown in the figure, 1926 and 1985 were the lowest and highest water levels with a water level difference of 1.19m.

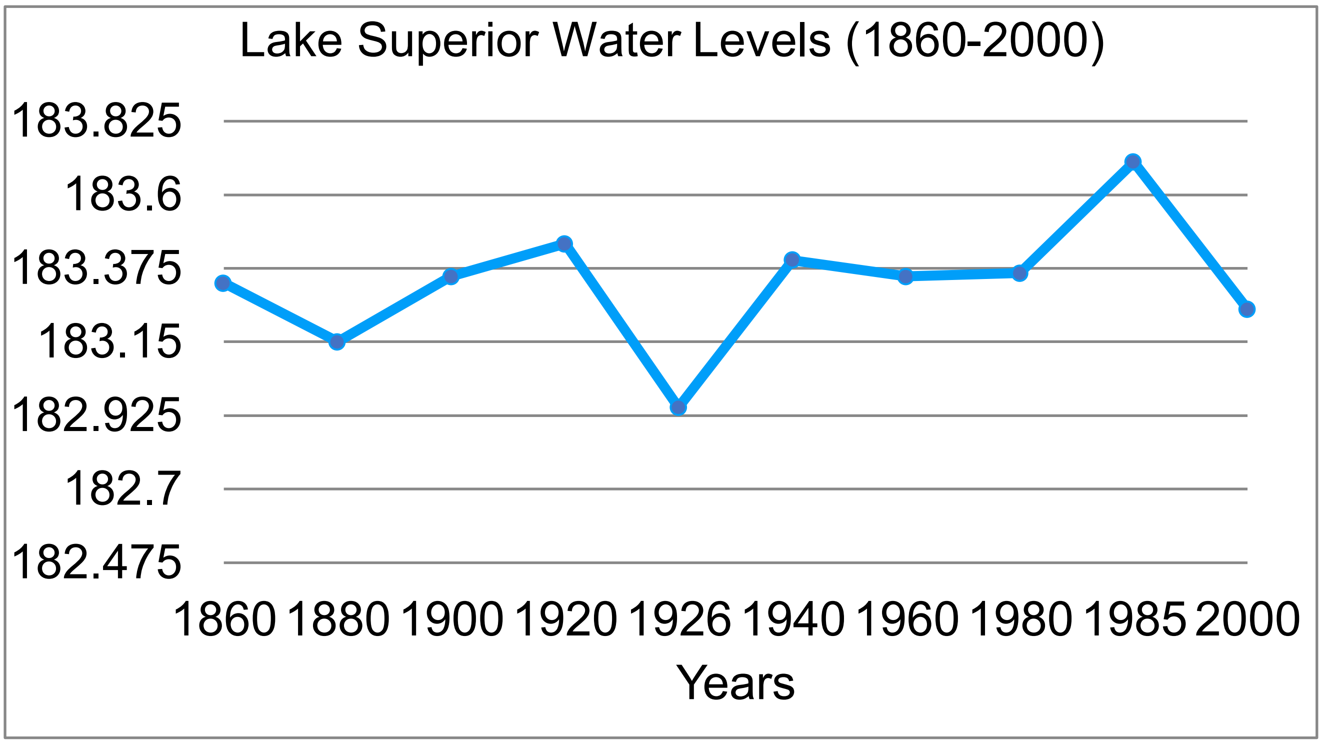

Figure 2. Lake Superior Water Levels (1860-2000)

Source: US Army Corps of Engineers

Figure 3 shows the water level change of Lake Superior between 2000 and 2015. The water level in 2000 was 601.5 ft. In 2005 it was only 0.5 ft higher than in 2000. By 2010 the water level had dropped to about 600.75 ft. The year with the highest water level in 2015 reached 602.255 ft, which is about 1.5 ft from the lowest value.

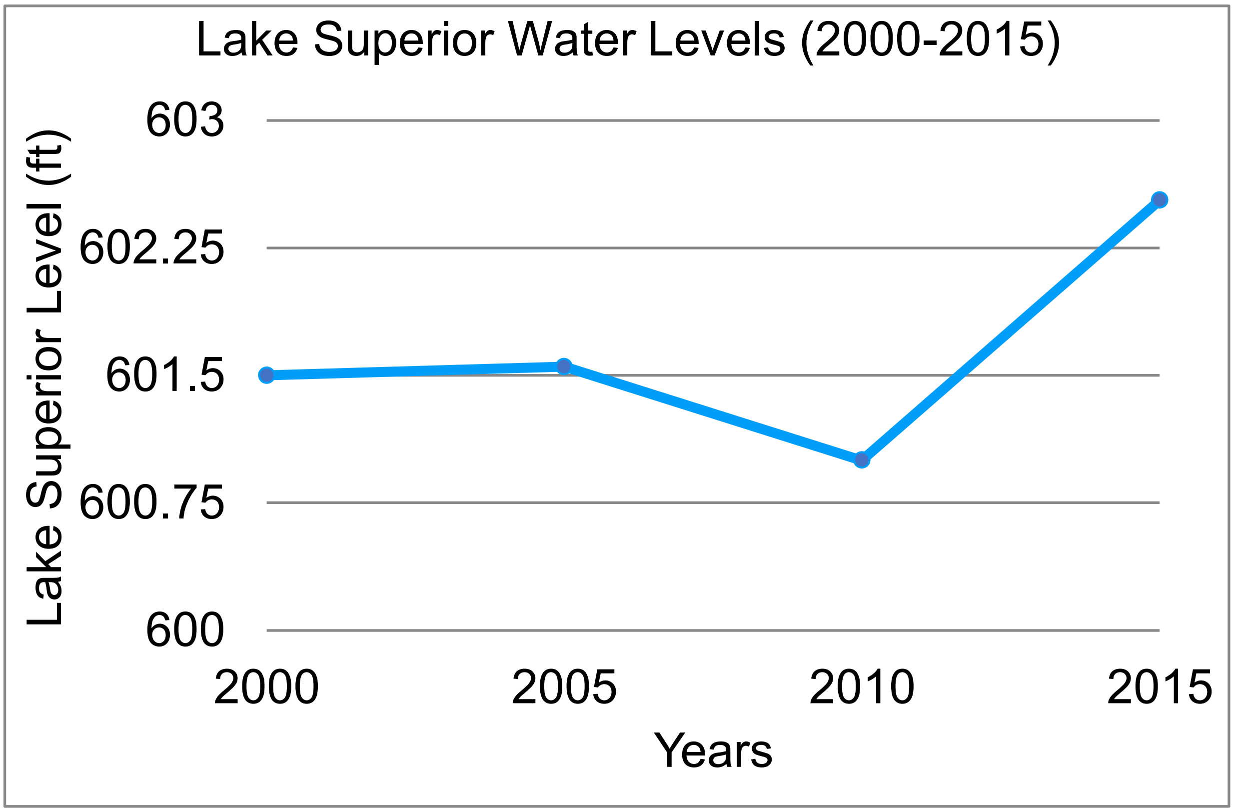

Figure 3. Lake Superior Water Levels (2000-2015)

Source: Roy 2016

Table 1 shows essential fish names and habitats in Lake Superior. This includes non-native fish. I selected several fishes in Figure 1 to illustrate the impact of the human or natural environment on them in recent years, including lake herring, lake whitefish, lake sturgeon and brook trout. The main prey of Lake Superior is lake herring, which provides food support for lake trout. However, in the mid-1960s, the number of lake herrings drastically decreased due to overfishing, peaking in 1990, a reduction of 80% (Great Lakes Fishery Commissioners 2003). Currently, Lake Superior 's regulatory agencies rely on natural reproduction to maintain the number of lake herrings and prohibit large-scale fishing. Lake Whitefish in Lake Superior provides a large amount of production for local fisheries every year and contributes to the economy. In recent years, it has been found that the population of Lake Whitefish has decreased, which was initially thought to be caused by sea lamprey. It was later discovered that it was caused by large-scale commercial fishing. Lake sturgeon is the only indigenous fish with the longest life span in Lake Superior. In the late 1880s, commercial fishing by humans and pollution from local sawmills led to a decrease in the population of lake sturgeon. In the late 1920s, some tributaries of Lake Superior built hydroelectric dams, further destroying the habitat of lake sturgeon (Great Lakes Fishery Commissioners 2003). Brook trout is a large trout living in the coastal area near Lake Superior. From 1880 to the end of the 1920s, the population of brook trout went from decline to extinction. They can only be found in some tributaries. This is due to overfishing and habitat destruction.

Table 1. Important fish species in Lake Superior

Common name	Scientific Name	Habitat
Lake herring	*Coregonus artily*	Offshore
Bloater	*Coregonus hoyi*	Offshore
Rainbow smlet	*Osmerus mordax*	Nearshore
Kiyi	Coregonus kiyi	Offshore
Lake whitefish	Coregonus clupeaformis	Nearshore
Brook trout	Salvelinus fontinalis	Tributaries
Ninepin stickleback	Pungitus pungitus	Nearshore
Pygmy whitefish	Prosopium coulteri	Nearshore
Slimy sculpin	Cottus cognatus	Nearshore
Lake sturgeon	Acipenser fulvescens	Nearshore
Deepwater sculpin	Myoxocephalus thompsoni	Offshore
Longnose sucker	Catostomus catostomus	Nearshore
White sucker	Catostomus commersoni	Nearshore
Coho salmon	Oncorhynchus kisutch	Offshore
Chinook salmon	Oncorhynchus tshawytscha	Offshore

Source: Horns et al. 2003

Table 2 shows the size of the fish around the shores of Lake Superior. From the table, we can see that some fish species are larger than 400 mm, such as *Salvelinus namaycush namaycush, Salvelinus namaycush siscowet*, and *Lota lota*, which indicates that the local wetland ecological environment is conducive to fish growth.

Table 2. Fish size scales on Lake Superior

Scientific name	Adults (size mm)
Salvelinus namaycush namaycush	>400
Salvelinus namaycush siscowet	>400
Coregonus artedi	>250
Coregonus hoyi	>225
Coregonus kiyi	>200
Coregonus zenithicus	>250
Coregonus clupeaformis	>415
Lota lota	>400
Cottus cognatus	>70
Cottus ricei	>72
Myoxocephalus thompsoni	>88

Source: Owen, Daniel and Jason 2012

Figure 3 shows the water quality levels of the Great Lakes. According to Figure 3, (100-80) is excellent, (79-45) is good, and (44-0) is poor. We can see the superb water quality around Lake Superior, most of which are green. This aspect shows that the wetland along the shore of Lake Superior has a good environment, and the restoration has played a role. Animals and plants need good water to grow and survive well, so this area is very suitable for species reproduction.

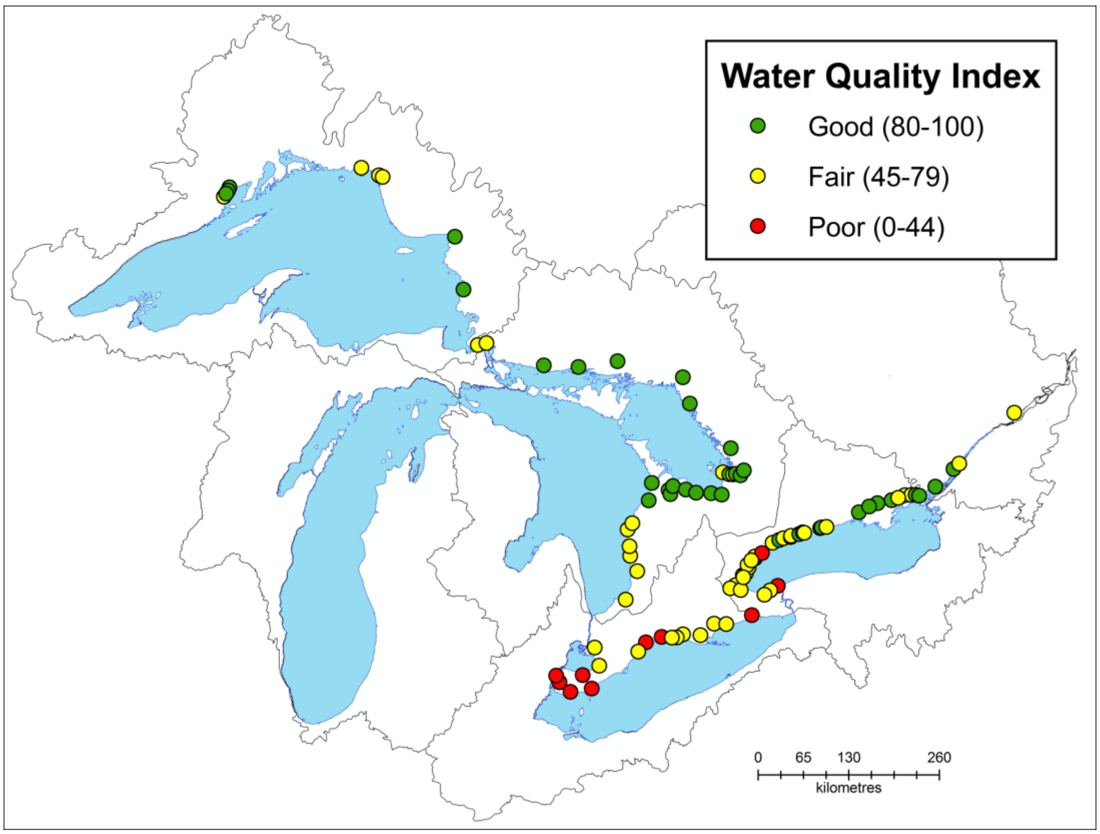

Figure 4. Water quality index for the Great Lakes.

Source: government of Ontario 2016

Figures 5 to 10 are the fish diving depths we have selected for several types of Lake Superior, divided into day and night. It can be seen that the same species can appear at different depths. A small number of them appear in the interval of 15-30 m, mainly concentrated in the middle area of 31-60 m and 61-90 m, while the interval of 91-120 m more fish appears during the day.

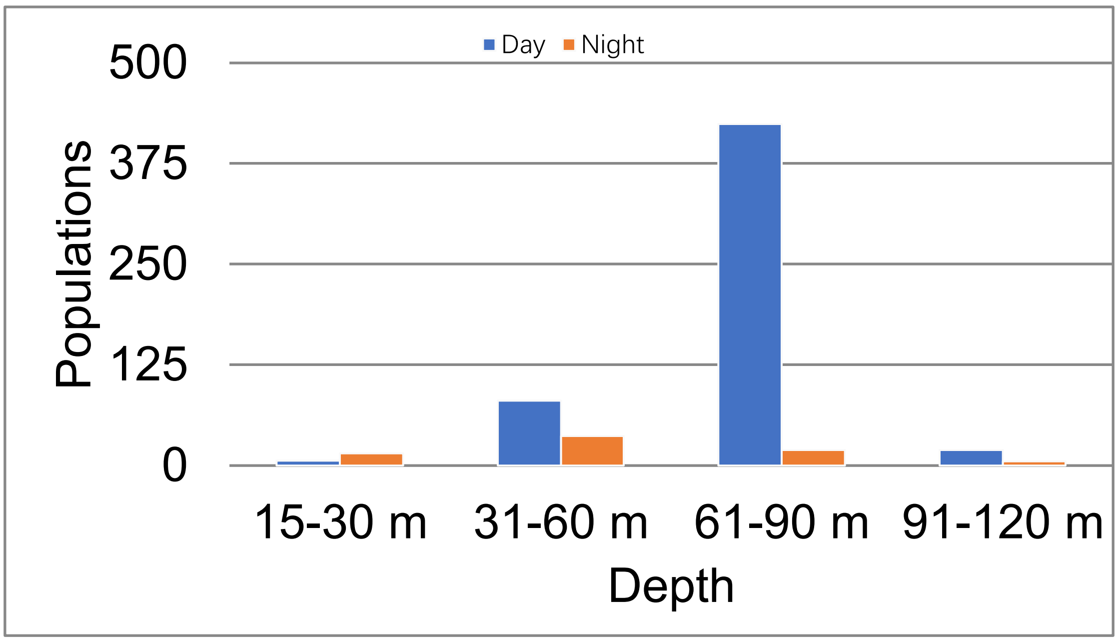

Figure 5. Number of *Coregonus artedi* captured in Lake Superior

Source: Owen 2012

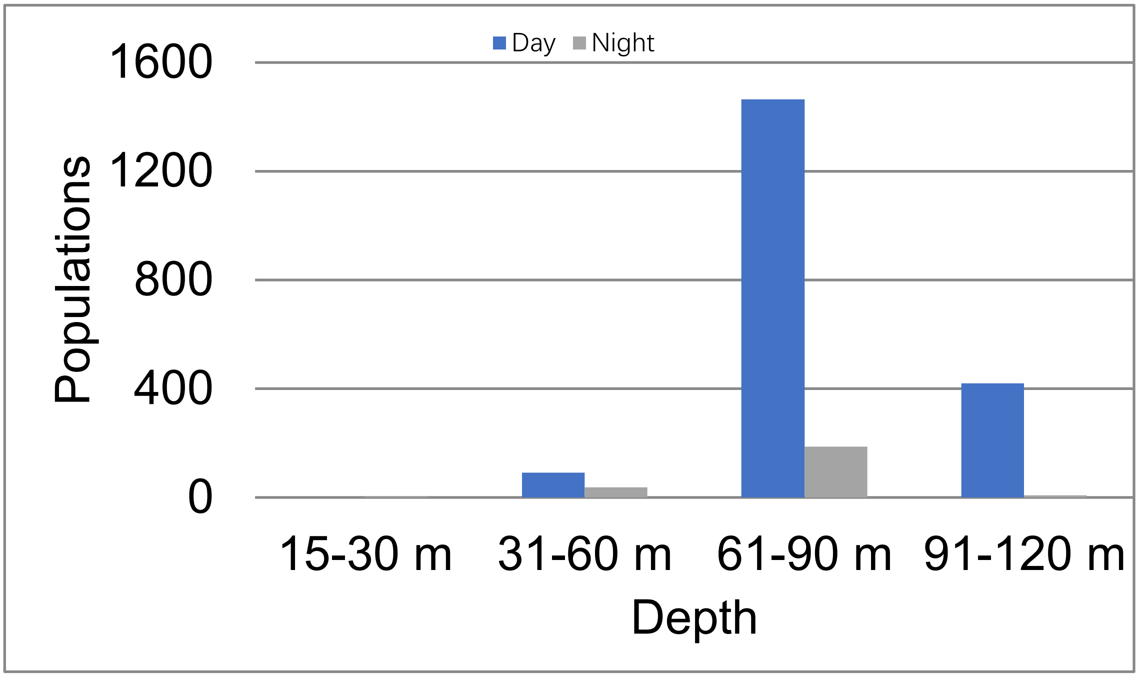

Figure 6. Number of *Coregonus hoyi* captured in Lake Superior

Source: Owen 2012

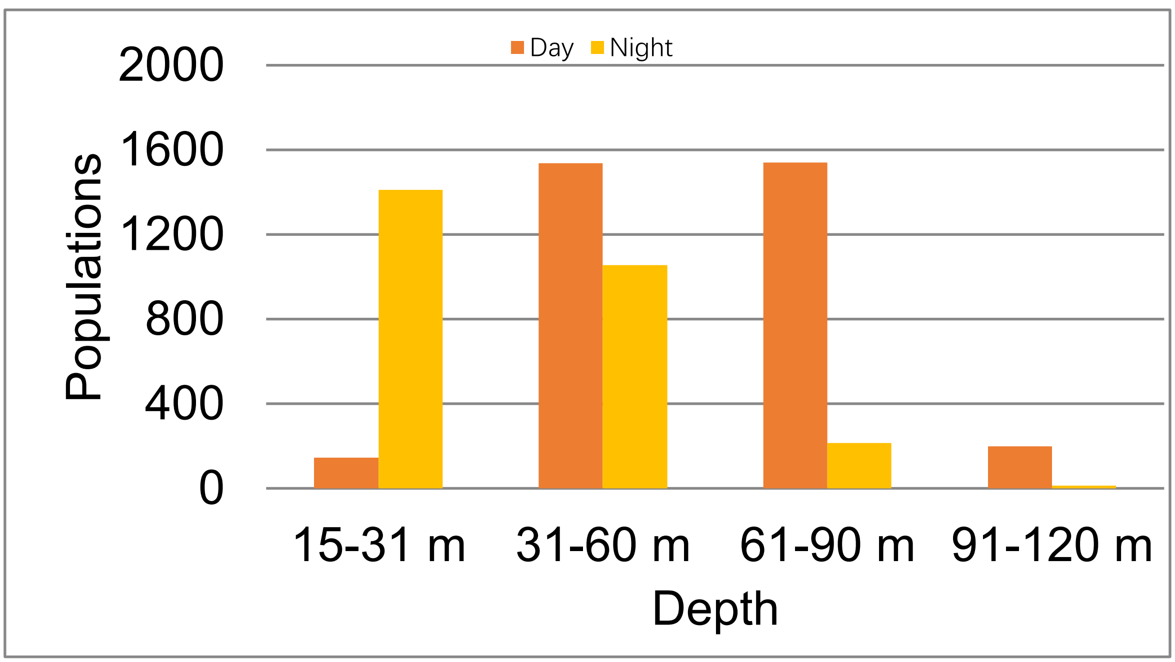

Figure 7. Number of *Coregonus clubpeaformis* captured in Lake Superior

Source: Owen 2012

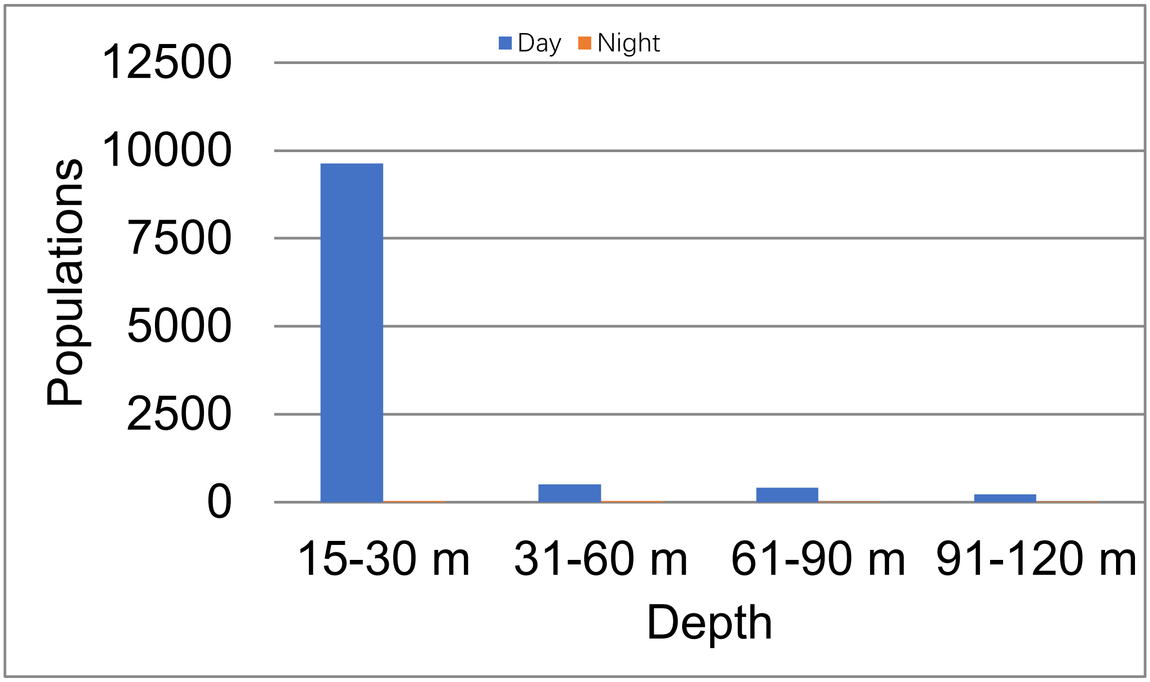

Figure 8. Number of Osmerus *mordax* captured in Lake Superior

Source: Owen 2012

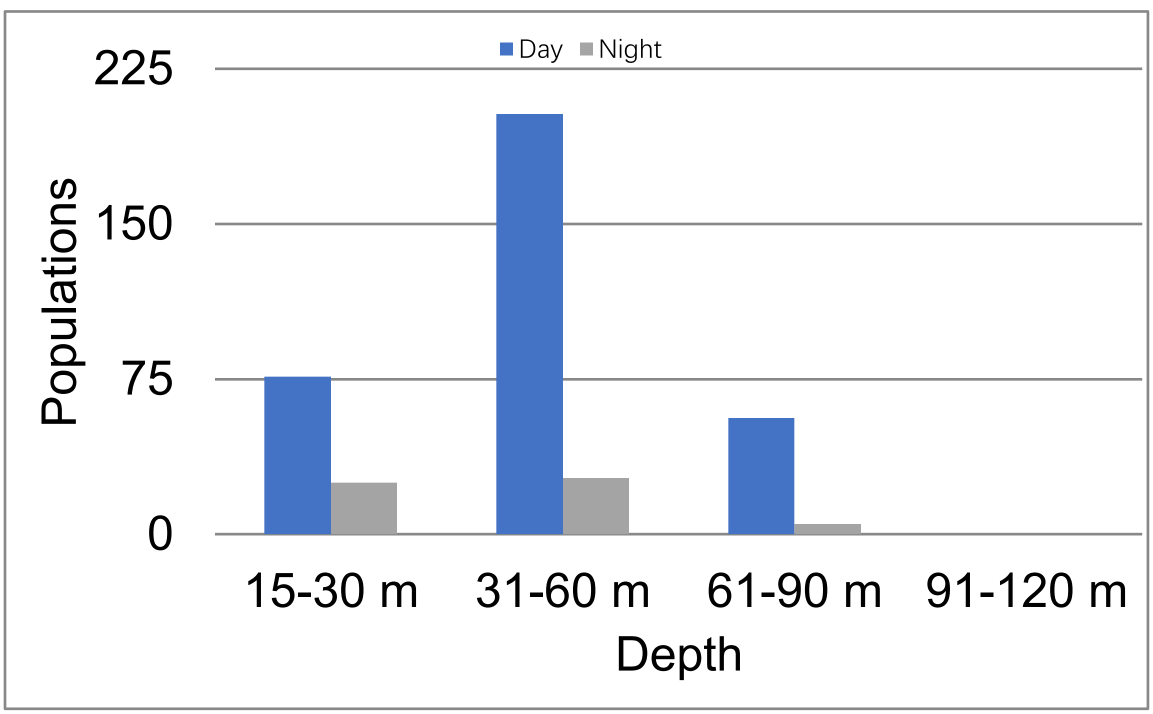

Figure 9. Number of *Percopsis omiscomaycus* in Lake Superior

Source: Owen 2012

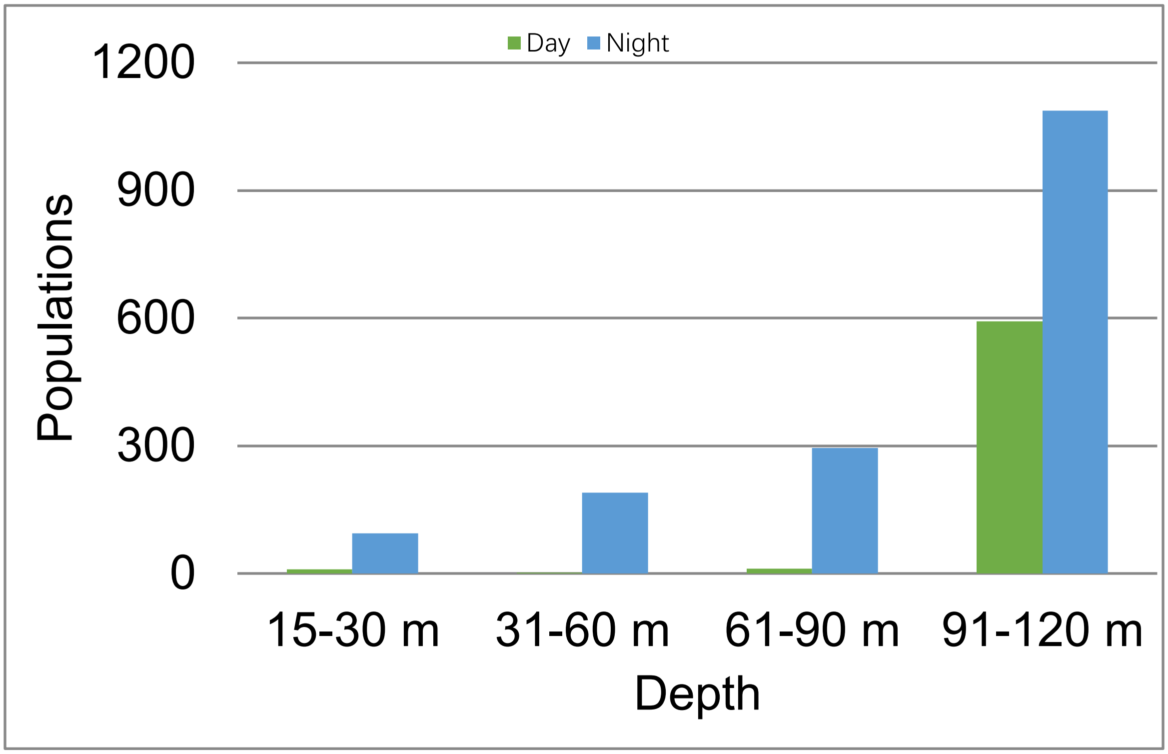

Figure 10. Number of *Cottus ricei* in Lake Superior

Source: Owen 2012

In Figure 5, we can see that *Coregonus artedi* mainly lives in the interval of 61-90 m. The number of activities during the day is 424, and the number of activities at night is 19. The number of activities of *Coregonus hoyi* in shallow water in Figure 6 is almost zero. Like Coregonus artedi, they are concentrated in the middle area.

The *Coregonus clubpeaformis* in Figure 7 is mainly concentrated in shallow water and central areas. The number of activities is between 1054 and 1538, while in the area of 91-120 m, their number has decreased a lot, only 198 during the day and 14 at night.

Figure 8 shows the activity pattern of *Osmerus mordax*. We can see that in the 15-30 m area, his daytime activity is 9,626, which can be said to be very much. After observation, no matter what the depth, they are most active during the day and relatively quiet at night.

The range of activity of *Percopsis omiscomaycus* in Fig 9 is relatively average, mainly in the area of 15-90 m, but we cannot see them in the range of 91-120 m.

The active area of *Cottus ricei* in Figure 10 is precisely the opposite of *Percopsis omiscomaycus*. They rarely play in the diving zone, mainly in the 91-120 m section, and are active in the dark.

DISCUSSION

In this research, all restoration technologies are mainly ecological. To successfully maintain the restored ecosystem, we must reduce human damage to natural resources. With the rapid development of the world, we need more and more resources, and humans have begun to occupy wetland resources. Hunting and industrial pollution, for example, have damaged the habitats of species and led to a gradual decline in species near wetlands. Also, human beings have transformed wetlands into farmland to obtain more and more abundant crops. These are the reasons that cause many wetlands to disappear indirectly or directly.

In the study of Lake Superior wetland restoration, I found that many processes involve the management of secondary succession. However, many traces will be found after each succession, but these traces will change linearly with many complex factors. At the scale of the Great Lakes change, within the limits of nature, is the distance between vegetation loss during periods of high-water level and recovery during periods of low water level 20 or 30 years ((Douglas 1999)? The 20-30 years of humankind is a long process, so we need to take restoration actions as soon as possible.

Introducing non-native species may be the right choice. Considering the potential negative impacts on wetlands, we need a stable and sustainable window. We need to introduce new species for wetlands, which will strengthen the ecological environment of wetlands. Conversely, if the introduced species has a natural invasive component, it will not only damage the habitat of the local species but also cause irreversible damage to the wetland. Whether to use a permanent window or a temporary window requires further detailed research to conclude.

Besides, the success of rehabilitating wetlands along Lake Superior depends on the criteria used to measure success in the management plan. In the past, there were many cases with perfect plans, but they lost on a bad metric. This is sufficient proof that a good standard will play a decisive role. As a regulatory agency setting standards, they need to know that most wetland restoration requires a rigorous process and much time. Therefore, long-term success is the most critical.

CONCLUSION

Conservation of the environment is beneficial to current and future generations. Lake Superior is one of the largest freshwater bodies in the world. This way, the degradation of the species of the Great Lake's ecosystem causes harm to the sustenance of the region. Most significantly, recreational projects in Ontario provide the community with breathtaking natural scenery. People can visit Pukaskwa or Lake Superior National Parks to access recreation experiences with magnificent views and the flow of the Great Lake. Although institutions have directed measures in ensuring that the parks provide the best experiences, this article finds a gap in literature covering the conservational activities done in the coastal wetlands of the Great Lakes. To be specific, this article suggests that a better understanding of the region through research is required to broaden the knowledge defining the restoration and improvement of the projects on the coastal wetlands.

Restoration and protection of conservation projects on the Lake is a critical issue since it shapes the future of the region. Human activities and climate change are redundant issues that pose a significant threat to the wellbeing of restoration projects in the coastal wetlands. Both problems affect the health of different species in the wetlands, thus causing continuous degradation of the region. This shows that coastal wetlands are important. They protect wildlife food and habitat, against floods and soil erosion, while promoting water quality and recreation opportunities. It is important to deploy further research in understanding restoration projects in Ontario. With an evidence-based approach, the improvement of restoration projects will occur successfully.

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APPENDIX

Species	Scientific name	Species code	Size class, mm total length (TL) Small (juveniles)	Medium (sub-adults, adults)	Large (adults)
lean Lake Trout	*Salvelinus namaycush namaycush*	LLT	≤225	226–400	>400
siscowet	*Salvelinus namaycush siscowet*	SLT	≤225	226–400	>400
Cisco	*Coregonus artedi*	CIS	≤185	186–250	>250
Bloater	*Coregonus hoyi*	BTR	≤165	166–225	>225
Kiyi	*Coregonus kiyi*	KIY	≤130	131–200	>200
Shortjaw Cisco	*Coregonus zenithicus*	SJC	na	186–250	>250
Lake Whitefish	*Coregonus clupeaformis*	LWF	≤225	226–415	>415
Pygmy Whitefish	*Prosopium coulteri*	PWF	≤100	>100	
Rainbow Smelt	*Osmerus mordax*	RBS	≤100	>100	
Burbot	*Lota lota*	BUR	≤226	226–400	>400
Trout-Perch	*Percopsis omiscomaycus*	TRP	≤74	>74	
Ninespine Stickleback	*Pungitius pungitius*	NSS	≤53	>53	
Slimy Sculpin	*Cottus cognatus*	SLS	≤43	44–70	>70
Spoonhead Sculpin	*Cottus ricei*	SPS	≤45	46–72	>72
Deepwater Sculpin	*Myoxocephalus thompsoni*	DWS	≤47	48–88	>88

Source: Horns et al. 2003

Common Name	Scientific Name	Adult Habitat
Planktivores (diet predominantly zooplankton or phytoplankton)		
Lake herring	*Coregonus artedi*	Offshore, nearshore
Bloater	*Coregonus hoyi*	Offshore
Rainbow smelt*	*Osmerus mordax*	Nearshore
Benthivores (diet predominantly macroinvertebrates)		
Kiyi	*Coregonus kiyi*	Offshore
Lake whitefish	*Coregonus clupeaformis*	Nearshore
Brook trout	*Salvelinus fontinalis*	Tributaries, bays, coastal waters
Ninespine stickleback	*Pungitus pungitus*	Nearshore
Pygmy whitefish	*Prosopium coulteri*	Nearshore
Slimy sculpin	*Cottus cognatus*	Nearshore
Lake sturgeon	*Acipenser fulvescens*	Nearshore, tributaries
Deepwater sculpin	*Myoxocephalus thompsoni*	Offshore, nearshore
Longnose sucker	*Catostomus catostomus*	Nearshore, tributaries
White sucker	*Catostomus commersoni*	Nearshore, tributaries
Piscivores (diet predominantly fish)		
Coho salmon*	*Oncorhynchus kisutch*	Offshore, nearshore, tributaries
Chinook salmon*	*Oncorhynchus tshawytscha*	Offshore, nearshore, tributaries
Sea lamprey*	*Petromyzon marinus*	Offshore, tributaries
Pelagic lean lake trout	*Salvelinus namaycush*	Offshore, nearshore
Humper lake trout	*Salvelinus namaycush*	Offshore, nearshore
Siscowet lake trout	*Salvelinus namaycush siscowet*	Offshore, nearshore
Rainbow trout*	*Oncorhynchus mykiss*	Nearshore, tributaries
Brown trout*	*Salmo trutta*	Nearshore
Burbot	*Lota lota*	Offshore, nearshore, tributaries
Walleye	*Sander vitreus*	Tributaries, bays, coastal waters
Northern pike	*Esox lucius*	Tributaries, bays, coastal waters
Smallmouth bass	*Micropterus dolomieu*	Tributaries
Yellow perch	*Perca flavescens*	Tributaries, bays, coastal waters

*nonindigenous species

Source: Owen, Daniel and Jason 2012