Appendix E
Response to EcoMetrix Inc. Report
“Literature Review and Field Investigations of Round Whitefish Habitat along the North Shore of Lake Ontario”
Appendix E: Response to EcoMetrix Inc. Report “Literature Review and Field Investigations of Round Whitefish Habitat along the North Shore of Lake Ontario”

Prepared for The Regional Municipalities of York and Durham

September 2014
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Objective</td>
<td>iii</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1-1</td>
</tr>
<tr>
<td>2 Summary of Response</td>
<td>2-1</td>
</tr>
<tr>
<td>3 Literature Review - Round Whitefish and its Decline in Lake Ontario</td>
<td>3-1</td>
</tr>
<tr>
<td>4 Response to Statements in Torn of Ajax Part II Order Request Report</td>
<td>4-1</td>
</tr>
<tr>
<td>5 Response to Statements in the EcoMetrix Report</td>
<td>5-1</td>
</tr>
<tr>
<td>6 References</td>
<td>6-1</td>
</tr>
</tbody>
</table>

Attachment 1 – Literature Review of Recent Scientific Research on the Round Whitefish (*Prosopium cylindraceum*)

Attachment 2 – Independent Peer Reviewer Memorandum

Attachment 3 – Peer Review Comment/Response Log
Report Objective

The objective of this report is to provide a response to the issues and concerns in Table A regarding Round Whitefish that is documented in the Town of Ajax Part II Order request and the associated report entitled “Literature Review and Field Investigations of Round Whitefish Habitat along the North Shore of Lake Ontario” prepared by EcoMetrix Inc. in 2014 (referred to herein as EcoMetrix Report).
1 Introduction

The Schedule C Class Environmental Assessment (EA) titled “Addressing Outfall Capacity Limitations at the Duffin Creek Water Pollution Control Plant” was filed for public review in November of 2013. As part of the Environmental Study Report (ESR), fish species in general were identified as a ‘Valued Ecosystem Component’ (VEC). VECs were chosen to reflect a wide range of factors considered important to stakeholders as defined throughout the early stages of the Class EA. As the current project does not include direct alteration to the nearshore substrates in the form of infilling to the nearshore zone where sensitive life processes may occur; Round Whitefish was not specifically identified as a VEC, but rather included under the broader category of VECs to include fish, fish habitat and Species at Risk (SAR) fish.

As part of the Part II Order request from the Town of Ajax, EcoMetrix Inc. reviewed the ESR with particular focus on the consideration of project impacts on Round Whitefish habitat. The EcoMetrix Report describes the decline of Round Whitefish along the north-central waters of Lake Ontario and claimed that the potential effects of Cladophora growth on gravel and rubble substrate typically used as spawning habitat by Round Whitefish include:

- Avoidance of these habitats for spawning;
- Inability of whitefish eggs to settle into security, exposing them to predation; and
- Mortality of over-wintering eggs due to dissolved oxygen depletion within these substrates as the algal mass decays and decomposes (EcoMetrix Report, page 4.1).

EcoMetrix also claimed the following deficiencies in the ESR with respect to fish and fish habitat:

- Lack of information on fish habitat data and the current condition of the substrates within the study area;
- Lack of information of the current use of the habitat by Round Whitefish and other fish species and the potential for excessive algal growth to impact fish habitat; and
- Lack of current information on reproductive success of Round Whitefish in Lake Ontario specifically in the study area (EcoMetrix Report, page 5.1).

This report provides a response to the statements from the Town of Ajax Part II Order request and to the EcoMetrix Report. Below is the structure of the response.

- Literature Review – Round Whitefish and its decline in Lake Ontario
- Response to statements in the Town of Ajax Part II Order request prepared on their behalf by Gowlings
- Response to statements in the EcoMetrix Report
2 Summary of Response

The decline of Round Whitefish in Lake Ontario is an issue that is not confined to the Regional Study Area\(^1\) of this Outfall Class EA but is a broader issue across the north central waters of Lake Ontario. The three main spawning areas for Round Whitefish identified in the EcoMetrix Report (Figure 2.2) are outside the Regional Study Area for this Outfall Class EA.

The EcoMetrix Report (page 2.1) states that the cause of the Round Whitefish population decline in Lake Ontario is not known. LGL Limited conducted a literature review and found limited information on the distribution, movement and abundance of Round Whitefish, but did find a number of changes in Lake Ontario that could be influencing the decline including the introduction of invasive species (e.g. zebra mussels, round goby), and climate change.

The EcoMetrix Report (page 4.1) states a number of potential effects of *Cladophora* growth on gravel and rubble substrate typically used as spawning habitat by Round Whitefish (e.g. avoidance of these habitats for spawning). However, no references were provided in the EcoMetrix Report to back up this statement of potential effects. In addition, the review of current scientific literature conducted by LGL Limited (see Attachment 1) found a number of factors limiting the recruitment of Round Whitefish including invasive species and climate change, but no literature was found on the effects of *Cladophora* on Round Whitefish.

The statements made by EcoMetrix regarding the lack of information on fish species and fish habitat in the ESR for this Outfall Class EA are not accurate. A comprehensive dataset of available data on fish species, habitats and substrate was included in the ESR within the study. Fish species data were compiled from a wide variety of sources of documentation, including Ontario Hydro, Ministry of Natural Resources (MNR), and Toronto Regional Conservation Authority (TRCA) for the period 1976-2013. All of the fish species, including those that are resident and incidental to the area, as well as Round Whitefish are part of the list of fish species that are provided in the ESR. Substrate and lake bottom information were determined through, literature, bathymetry surveys, underwater camera footage, and sidescan sonar surveys.

Assessments of the current use of nearshore and offshore habitat by all fish species, including Round Whitefish, were included in the ESR. All members of the fish community (including Round Whitefish) were considered under the broader category of fish and fish habitat Valued Ecosystem Component (VEC). Round Whitefish had been selected as a VEC in other environmental assessments where there were direct impacts on habitat (e.g. infilling associated with the Darlington Nuclear Generating Station), potential thermal effects on nearshore spawning shoals (e.g. thermal impacts associated with industrial effluent such as the Darlington, Pickering, and Bruce Nuclear Generating Stations) or sensitive life processes (concerns surrounding entrainment of eggs and larvae). As the current project does not include direct alteration to the nearshore substrates in the form of infilling or release of effluent to the nearshore zone where sensitive life processes may occur; Round Whitefish was not specifically identified as a VEC, but rather included under the broader category of VECs that included all fish and fish habitat.

In Phase 2 of the Outfall Class EA, a short list of five alternatives were evaluated and an impact assessment of VECs was performed using technical, natural, social/cultural, and economic criteria. It was found that the preferred alternative, which includes modifying the existing outfall and optimizing the existing operations, would not negatively affect spawning grounds for Round Whitefish since:

- No construction is required (as opposed to the other short-listed alternatives such as tertiary treatment, extending the outfall, or a new outfall)
- Operation results in a slightly smaller phosphorus mixing zone compared to the baseline

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\(^1\) The area studied in the Outfall Class EA comprised of a Local Study Area (LSA) nested within a Regional Study Area (RSA) which are both described in the Environmental Study Report. The RSA was established to include the area within which there was potential for cumulative biophysical effects and extended to Frenchman’s Bay in the west and to Paradise Beach in the east. Please see Section 3.2 in the ESR for a figure of the Local and Regional Study Areas.
• Operation results in negligible change in the size of the un-ionized ammonia mixing zone relative to the size of the nearshore zone in the Regional Study Area, where
  – no fish habitat important to sensitive life stages was recorded within the mixing zone
  – mixing zone is used by fish on a transient basis

This report and the appended literature review were peer reviewed by Serge Metikosh, Senior Fish Habitat Biologist and Regulatory Advisor at Fish Habitat Solutions Inc. The peer review report and comment/response log are provided as Attachment 2 and Attachment 3 respectively.
Literature Review - Round Whitefish and its Decline in Lake Ontario

A literature review was conducted by LGL Limited to summarize the results of scientific research conducted on the Round Whitefish and outlines the information currently available through government documents and technical and industry reports regarding the life history of the species including such ecological factors as diet, habitat requirements, reproduction, predation, fluctuating water temperatures and competition. The literature review entitled “Literature Review of Recent Scientific Research on the Round Whitefish (Prosopium cylindraceum)” is Attachment 1 of this appendix.

The EcoMetrix Report states that the cause of the Round Whitefish population decline in Lake Ontario is not known (page 2.5). The literature review conducted by LGL Limited found information on the distribution, movement and abundance of Round Whitefish to be lacking, but it did point to a number of changes in Lake Ontario that could be influencing the decline including:

- Introduction of invasive species (e.g. zebra mussels, round goby) and associated impacts to food webs, competition for resources, composition of substrates, and predation pressures.
  - The shift in energy pathways from pelagic to benthic brought about by the establishment and proliferation of dreissenid mussels appear to be a major driver for the ecological changes that are occurring.
- Climate change, and associated impacts to lake level fluctuations and warming water temperatures, have the potential to influence the quality of nearshore water with respect to its suitability for fall spawning, cold water species.

The results of the literature review revealed that Round Whitefish, one of the least studied coregonine species, are declining in Lake Ontario. Understanding the decline of Round Whitefish in Lake Ontario cannot be uncoupled from ecological changes that are occurring in Lake Ontario. No single cause for the decline of Round Whitefish could be identified, however, it is likely that declines are in response to lake-wide changes.

The EcoMetrix Report (page 4.1) states that the potential effects of Cladophora growth on gravel and rubble substrate typically used as spawning habitat by Round Whitefish include:

- Avoidance of these habitats for spawning;
- Inability of whitefish eggs to settle into security, exposing them to predation; and
- Mortality of over-wintering eggs due to dissolved oxygen depletion within these substrates as the algal mass decays and decomposes (EcoMetrix Report, page 4.1).

No references were provided in the EcoMetrix Report to back up this statement of potential effects. Similarly, LGL has found that peer reviewed literature is not currently available to describe effects of filamentous algae, if any, on Round Whitefish spawning. No references in the literature reviewed suggest that extensive growth of Cladophora affects Round Whitefish spawning habitat, and no references in the literature reviewed indicate that the loss of spawning habitat is responsible for the decline in Round Whitefish populations.

The available literature demonstrates that the inter-relationships of the various levels of the food chain are complex and, that the presence of algae or excessive algae itself does not necessarily result in avoidance behaviour by Round Whitefish, or an increased risk of predation as EcoMetrix has suggested in its 2014 literature review. Further, specific to Round Whitefish, declines in recruitment of this species have been noted in other areas of the Great Lakes and Lake Ontario where Cladophora is not prevalent, as documented in LGL’s 2014 “Literature Review of Recent Scientific Research on the Round Whitefish (Prosopium cylindraceum)” accompanying this report.
4 Response to Statements in Town of Ajax Part II Order Request Report

This section is intended to provide responses to comments included in the Review of the Part II Order Request of the Corporation of the Town of Ajax, prepared on their behalf by Gowlings, regarding the Schedule C Class EA to Address Outfall Capacity Limitations at the Duffin Creek Water Pollution Control Plant Document, submitted February 18, 2014.

Section 6.2 subsection (b) (page 41) of that document provides comments by EcoMetrix Inc. regarding perceived deficiencies within the ESR and supporting reports relating to fish and fish habitat. The following provides responses to the perceived deficiencies in the ESR which pertain to fish and fish habitat.

Comment 1: there is no assessment at all of the effect excessive Cladophora growth has on fish or fish habitat;

A more detailed assessment on the effects of excessive Cladophora growth on fish or fish habitat was not included for three reasons:

1. A review of recent literature showed there were other significant factors responsible for stimulating excessive algal growth in the Ajax-Pickering nearshore and that the Duffin Creek WPCP plays a limited role.

2. A review of recent literature showed that Cladophora is a Great Lakes wide phenomenon and is not limited to the Ajax-Pickering waterfront.

3. There was no change from the baseline condition in the amount of phosphorus, indicated as the limiting nutrient for Cladophora growth by a majority of studies (Higgins et al. 2008), allowed to be discharged to the open waters of Lake Ontario through the Duffin Creek WPCP outfall since the Regions had agreed during the Stage 3 Expansion project to a mass loading limit of 311 kg/d in the effluent. This mass loading limit is in effect now and will remain in effect should flows to the WPCP be permitted to increase.

As Cladophora growth appears to be result of lake-wide phenomena and baseline phosphorus loadings applied during the Outfall Class EA process will not be changed by the implementation of the preferred alternative, no effects on Cladophora growth are expected. Therefore the assessment of the effects of Cladophora on fish or fish habitat was not warranted. Despite this, the Regions included a discussion of the factors governing Cladophora growth in Section 5 of the ESR, as well as in Appendix C of the ESR; the Natural Sciences Report.

Furthermore, as described above, the results of the literature review did not yield pertinent information that would change the outcome of the Outfall Class EA.

Comment 2: there is a lack of information and data on fish species, habitat and the current conditions of the lake bottom within the nearshore;

A substantial amount of data was included in the ESR on fish species, fish habitat, and current conditions of the nearshore lake bottom as follows:

1. Fish Species – The ESR provides an overview of the historical fish community (Section 2.4.2.4, Appendix C - Natural Sciences Report). Appendix C of the ESR also presents the data compiled from 1976-2013 for fish species documented for the Lake Ontario from a wide variety of sources including records from Ontario Hydro, the Ministry of Natural Resources (MNR), and the Toronto and Region Conservation Authority (TRCA) in order to provide the most comprehensive listing of fish community and species that would be present within the Local and Regional Study Areas within Lake Ontario. As well, consultation with the MNR’s Lake Ontario Management Unit (LOMU) was conducted to characterize the fishery in Lake Ontario using the most current data available, throughout the Outfall Class EA.

2. Fish Habitat and Lake Bottom Conditions - The ESR (Section 2.4.3, Appendix C - Natural Sciences Report) discusses habitat use in both the nearshore and offshore respectively. The current condition of fish habitat along the nearshore based on bathymetry and sidescan sonar imagery is also described in Appendix C of the ESR.
ESR (Section 3.2). Substrate and lake bottom conditions in the nearshore and offshore were obtained through direct surveys using bathymetric, underwater camera, and sidescan sonar surveys along two transects extending 3 km offshore. Generally, substrates were observed visually and represented on sidescan sonar imagery to be comprised of sand and cobble with intermittent boulders from the shoreline to water depths of approximately 3 m (at a distance from shore of approximately 100 m). Throughout the remainder of the nearshore zone, substrates consisted mostly of boulder and exposed bedrock. Substrates were comprised largely of shale in the offshore zone. This description generally pertains to both the east and west transects with little variation in substrate and structure found, particularly in the offshore zone. The sidescan sonar imagery collected in this Outfall Class EA was supplemented with substrate data from the University of Waterloo study which used a sonar transducer to collect and characterize substrate as hard and soft in a portion of the Regional Study Area.

Also, the EcoMetrix Report (Sections 5.2 and 5.3) stated that information from the following two references were not presented in Natural Sciences Report (Appendix C of the ESR):


Information from Golder (2007) was directly referenced in the ESR, Appendix C (Natural Sciences Report) and used in the following ways:

- Fish data was included in the species tables
- Description of aquatic environment in the Regional Study Area as it relates to substrates and currents
- Description of aquatic communities in the Regional Study Area in terms of: dreissenid mussels; filamentous algae; benthic invertebrates; and aquatic plants

To address the Town of Ajax’s Part II Order Request potential concern of Cladophora impacts on Round Whitefish, LGL conducted a review of scientific research conducted on Round Whitefish. The letter referenced as EcoMetrix (2009) was included as an appendix of the larger 2010 OPG document (OPG, 2010. Impact of PNGS Thermal Discharge during the Winter of 2010 on Potential Round Whitefish Spawning. Document# P-REP-07250-00001). As part of the literature review on Round Whitefish, LGL Ltd reviewed the 2010 OPG document including EcoMetrix (2009) and the following information was referenced:

- Suitability of substrate for Round Whitefish and a description of the substrate in terms of algae, mussels
- Catch size and relative distribution of Round Whitefish
- Comparison of habitat suitability in the area of Pickering NGS compared to reference sites

Taking into account the nature of the expected effects associated with the preferred alternative, the available information on the conditions of the lake bottom within the area affected was adequate for the assessment.

The preferred alternative for the outfall will not involve in-water construction in the nearshore zone and will not change phosphorus loadings. There will be an increase in the size of the mixing zone for un-ionized ammonia to 5.7 ha from 4.1 ha; however, even with the increase in size, the mixing zone occupies a small portion of the surface area of the 1,800 ha nearshore zone. It is recognized that the shape of the mixing zone or the nearshore zone is irregular; however, for the purpose of visualization, 5.7 ha can be represented by a circle with a radius of about 135 m or a square of about 240 x 240 m. By contrast, 1,800 ha would occupy a circle with a radius of 2.3 km or a square about 4,200 m by 4,200 m.

**Comment 3: there is no assessment of the current use of habitat by Round Whitefish, a key local species, or other species and the potential for excessive Cladophora to impact fish habitat**

An assessment of the current use of nearshore and offshore habitat by all fish species, including Round Whitefish, was included in the ESR. Section 7 of the ESR, and the associated Appendix C (Natural Science Report) provides an
overview of fish species and habitat in the Local and Regional Study Areas, and a list of all fish species that are resident and incidental to the area (including Round Whitefish).

Appendix C of the ESR (Section 2.4.3) provides discussion on habitat use in both the nearshore and offshore respectively. The current condition of fish habitat along the nearshore based on bathymetry and sidescan sonar imagery is described in Section 3.2 (Appendix C of the ESR). Generally, substrates were observed to be comprised of sand and cobble with intermittent boulders from the shoreline to water depths of approximately 3 m (at a distance from shore of approximately 100 m). Throughout the remainder of the nearshore zone, substrates consisted mostly of boulder and exposed bedrock. Substrates were comprised largely of shale in the offshore zone.

Given that the aquatic component of the Local Study Area includes an exposed shoreline that provides little in the way of refuge for fish, and an offshore zone of exposed bedrock and shale, fish habitat in the Local Study Area is generally limited to providing a forage and passage function.

It is important to note that EcoMetrix’s focus on Round Whitefish was because Round Whitefish was selected as a VEC for the environmental impact assessments associated with the Pickering Nuclear Generating Station (PNGS) and the Darlington Nuclear Generating Station (DNGS). VECs are project specific; therefore, the use of Round Whitefish as a VEC for the PNGS and DNGS environmental assessments should not be taken to imply that Round Whitefish are a generic indicator of aquatic ecosystem health or that Round Whitefish are appropriate as VECs for all environmental assessments on the northshore of Lake Ontario.

**Comment 4: there is a lack of current information on the reproductive success of Round Whitefish in Lake Ontario, and within the area studied by the Regions;**

The Outfall Class EA considered the importance of all fish species and fish habitat from a community level in terms of habitat use and utilization of the Local and Regional Study Areas, rather than the reproductive success of any one species. Only Species at Risk (SAR) were considered on an individual level which is appropriate for a Class EA assessment. Round Whitefish is not categorized as a SAR under the *Endangered Species Act, 2007* and is considered Low Priority (Group 3) for assessment on the COSEWIC Candidate List.

Sufficient information on the fish and fish habitat in the area was collected to assess alternatives, and to select a preferred alternative. The preferred alternative selected (i.e. modification of the existing outfall diffuser) does not involve in water work in the nearshore area that would have physical effects on shoreline or littoral habitats, and phosphorus loadings will not change from baseline conditions. Additional information on the reproductive success of Round Whitefish would not have changed the outcome of the assessment.

The decline of Round Whitefish in Lake Ontario is a broader issue across the north central waters of Lake Ontario and not confined to the Regional Study Area of this Outfall Class EA. The three main spawning areas for Round Whitefish identified in the EcoMetrix Report (Figure 2.2) are outside the larger Regional Study Area for this Outfall Class EA.

**Comment 5: there is no assessment of the effect the mixing zone has or will have on important fish habitat and/or spawning areas.**

The modelling assessment for predicting mixing zones is provided in Section 6 of the ESR (modelling of baseline condition) and in Section 10.3 (modelling of alternatives). Section 10.5 describes the effect of the mixing zone on fish habitat and spawning areas which was consistent across all short-listed alternatives as follows:

- The pathway of effect considered is: Release of effluent at 630 MLD has potential to impair water quality → impairment of water quality can result in sub-lethal or lethal effects to fish and other biota → sub-lethal or lethal effects reduce abundance of biota.

The mixing zone at 630 MLD compared to the baseline condition will be larger for un-ionized ammonia (UIA) and slightly smaller for total phosphorus. UIA within the mixing zone is of concern to the natural environment because of its link to toxicity in fish and other biota. The baseline condition of the UIA mixing zone was considered small in comparison to the overall area of the nearshore zone. The UIA mixing zone is predicted to increase in size from a
baseline condition of 4.1 ha to 5.7 ha for the preferred alternative which represents a small area in comparison to the area available to biota in the nearshore zone of the Regional Study Area which is approximately 1,800 ha. The magnitude of impact as a result of this alternative is considered to be low for the following reasons:

a. The size of the mixing zone for UIA is small in relation to the size of the nearshore zone within the Regional Study Area;

b. The UIA mixing zone does not provide specialized habitat; and,

c. The UIA mixing zone is used by fish on a transient basis.

The phosphorus mixing zone for the preferred alternative is slightly smaller at 630 MLD due to the required operation of phosphorus removal treatment technologies at the Duffin Creek WPCP and that the mass loading of 311/kg/d remains unchanged.

Data collected for the Outfall Class EA indicate that the lake bed consists of sand and cobble with intermittent boulders. These features are neither unique nor in short supply within the area. Any effects within the mixing zone, should they occur, will be localized. The overall supply of similar habitats will not be changed substantially.
5 Response to Statements in the EcoMetrix Report

This section is intended to provide responses to inaccurate statements in Appendix 3 of the Part II Order Request of the Corporation of the Town of Ajax entitled “Literature Review and Field Investigations of Round Whitefish Habitat along the North Shore of Lake Ontario” prepared by EcoMetrix Inc. in 2014.

**Statement 1: Effects of Cladophora on Fish Habitat - Section 4.0 (Page 4-2) - None of the Outfall Class EA documents address the potential for significant adverse effects on Round Whitefish, which was identified by OPG, OMNR and OMOE as a VEC in the EAs associated with both the Pickering and Darlington NGS, which included the Outfall Class EA study area and the Ajax waterfront. Round Whitefish are not considered as a VEC in the draft Outfall Class EA.**

All members of the fish community (including Round Whitefish) were considered under the broader category of fish and fish habitat VEC. Various data sources were used to document fish species assemblages, SAR, and their status in the nearshore zone of the Regional Study Area including OPG’s “Pickering Nuclear Generating Station 2010 Impingement Monitoring Report”. The Natural Sciences Report in Appendix C of the ESR lists Round Whitefish in the summary of fish species documented in the Lake Ontario nearshore between 1976 to 2013 near the Duffins Creek Marsh, Frenchman’s Bay, the shoreline near the PNGS and the Regional Study Area.

Where Round Whitefish has been specifically identified as a VEC for previous EAs at nuclear generating stations, it was because of concerns regarding potential thermal effects on nearshore spawning shoals, concerns surrounding entrainment of eggs and larvae, as well as habitat loss from nearshore construction for the DNGS (Golder 2007, Golder and SENES 2009). Round Whitefish is also identified as a VEC in other nuclear power generation sites in the Great Lakes. The following excerpt from Ontario Power Generation (OPG) provides a summary of the monitoring program objectives used in Nuclear Generation Monitoring Programs:

“The primary focus of the historic aquatic monitoring program was to detect effects associated with cooling water withdrawal and discharge on local self-reproducing populations of native species that inhabit the coastal zone around Douglas Point (OPG 1999).”

This Outfall Class EA process has considered all members of the fish community, habitat, and SAR fish as VECs in the study so that impacts to fisheries as a whole can be assessed, rather than those specifically chosen by OPG as VECs for nuclear power generation sites.

The VEC concept was originally introduced in the early 1980s by Gordon Beanlands and Peter Duinker (Beanlands and Duinker 1983) and the use of VECs has become a standard practice in environmental assessment. The purpose of VECs is to focus the assessment on a relatively small number of species that are of greater local importance and to consider these species as indicators or “sentinels” of environmental impacts (Golder and SENES 2009). VECs are project specific and will often vary from one project to another. The use of Round Whitefish as a VEC for the PNGS and DNGS environment assessments should not be taken to imply that Round Whitefish are a generic indicator of aquatic ecosystem health or that Round Whitefish are appropriate as VECs for all environmental assessments on the northshore of Lake Ontario. Considering, that the preferred alternative will not involve in-water construction within the nearshore zone and will not result in an increase in phosphorus loadings or size of the phosphorus mixing zone, the decision not to use Round Whitefish as a VEC is justified and consistent with accepted environmental assessment methods.

**Statement 2: Alteration of Habitat as per the Department of Fisheries and Oceans (DFO) Fisheries Act – Section 4.1 (page 4-4) - Considering the changes to the nearshore habitat observed in 2013 (specifically from Pickering to near Newtonville at depths of 5 to 15 m) it appears that the spawning habitat of Round Whitefish may have already become permanently altered at a spatial scale, duration and intensity that the ability of the whitefish to use this area in order to carry out one or more of their life processes has been diminished.**
The issue of alteration of habitat for Round Whitefish is a broader issue that extends beyond the Regional Study Area of this Class EA to the north central waters of Lake Ontario, and not an issue directly related to the net effects of this Class EA. The three main spawning areas for Round Whitefish identified in the EcoMetrix Report (Figure 2.2) are outside the Regional Study Area for this Outfall Class EA.

The literature review (accompanying this report) found that there are a variety of possible factors that are responsible for the Round Whitefish decline in Lake Ontario, including the presence of invasive species and associated impacts to food webs, competition for resources, composition of substrates, and predation pressures. In addition, impacts of climate change as they relate to lake level fluctuations and warming water temperatures have the potential to influence the quality of nearshore waters with respect to its suitability for fall spawning, coldwater species.

**Statement 3:** The Ontario Ministry of Natural Resources Fish Community Objectives for Lake Ontario - Section 4.2 (page 4-4) - In a 2010 letter providing an opinion on environmental impacts resulting from the Darlington New Build proposal, the Lake Ontario Management Unit (LOMU) identified Round Whitefish as an important member of the native benthic fish community and as a VEC in the vicinity of both the Darlington and Pickering NGS (Todd 2010). Pickering NGS is adjacent to the Town’s waterfront and nearshore. The Regions’ draft ESR documents do not identify Round Whitefish in the same way and this should be considered a deficiency in the EA. The letter also stated that: “Of the species found in the vicinity of Darlington NGS, the Round Whitefish (Prosopium cylindraceum) is the most likely to suffer from negative impacts to its distribution and abundance” (Todd 2010).

As detailed in the response to Statement 1 above, all members of the fish community (including Round Whitefish) were considered under the broader category of fish and fish habitat VEC. Where Round Whitefish has been specifically identified as a VEC for previous EAs at nuclear generating stations, it was because of concerns regarding potential thermal effects on nearshore spawning shoals, concerns surrounding entrainment of eggs and larvae, as well as habitat loss from nearshore construction for the DNGS (Golder 2007, Golder and SENES 2009). The Round Whitefish is also identified as a VEC in other nuclear power generation sites in the Great Lakes. The following excerpt from OPG provides a summary of the monitoring program objectives used in Nuclear Generation Monitoring Programs:

“The primary focus of the historic aquatic monitoring program was to detect effects associated with cooling water withdrawal and discharge on local self-reproducing populations of native species that inhabit the coastal zone around Douglas Point (OPG 1999).”

This Outfall Class EA process has considered all members of the fish community, habitat, and SAR fish as VECs in the study so that impacts to fisheries as a whole can be assessed, rather than those specifically chosen by OPG as VECs for nuclear power generation sites.

**Statement 4:** Fish Community Objectives for Lake Ontario - Section 4.2 (page 4-5) - Fish Community Objectives for Lake Ontario published this year (2013) confirm that it is a goal of the Province of Ontario (together with New York State) to “protect, restore and sustain the diversity of the nearshore fish community, with an emphasis on self-sustaining native fisheries such as...Round Whitefish...” (Stewart et al, 2013). The relevant objective to Round Whitefish, which rely on the nearshore habitat for part of their life cycle, is to “maintain and restore native fish communities”.

The Regions agree that a key objective for the Ajax-Pickering nearshore is to protect, restore, and sustain the diversity of the nearshore fish community. Towards this end, the Regions continue to be proactive in meeting and exceeding effluent quality standards. As part of the Stage 3 Expansion project, additional phosphorus removal and ammonia removal treatment processes were constructed and the Regions committed to reducing the total allowable loading of phosphorus from 420 kg/day to 311 kg/day. The Duffin Creek WPCP now has one of the strictest effluent requirements of all WPCPs discharging to the open waters of Lake Ontario.

Furthermore, in the Outfall Class EA all members of the fish community (including Round Whitefish) were considered under the broader category of fish and fish habitat VEC and the preferred alternative will not negatively affect spawning grounds for the fish community for the following reasons:
• No construction is required (as opposed to the other short-listed alternatives such as tertiary treatment or a new outfall)

• Operation results in a slightly smaller phosphorus mixing zone compared to the baseline

• Operation results in negligible change in the size of the unionized ammonia mixing zone relative to the size of the Regional Study Area, where
  – no fish habitat important to sensitive life stages was recorded within the mixing zone
  – mixing zone is used by fish on a transient basis

**Statement 5: Lack of Information on Fish Species, Fish Habitat Data and Substrates within the Study Area - Section 5.1 (Page 5-1)**

Fish habitat utilization was not appropriately assessed for the offshore zone of the study area. The habitat utilization assessment that appears in the Natural Sciences Report for the ‘open water’ of Lake Ontario within the Regional Study Area (RSA) (Section 2.4.3) is for a substrate type that is not supported by substrate characterization data presented in other areas of the Report. Fish habitat utilization should be assessed for the open water or offshore zone of the RSA and the LSA using representative substrate characterization data for the fish species most likely to be present in these areas.

Available literature and studies on fish species, fish habitat data and substrates within the Local and Regional Study Areas (LSA and RSA) were utilized for this Outfall Class EA. Since there was limited literature available on fish habitat and substrates in the offshore zone of the Regional Study Area, additional field studies were performed in 2013 to collect substrate data in the offshore zone that had potential to be affected by the short-list of alternatives. Bottom sidescan sonar surveys revealed a smooth substrate in the offshore zone at depths greater than 15m, which was interpreted to be exposed shale (refer to Section 3.2 in the Appendix C of the ESR, Natural Sciences Report). As summarized in the report, variation in lakebed structure, such as the occurrence of shoals, drop offs, or macrophyte beds, with the potential to function as habitat for important life stages of fish (e.g. spawning), was not observed in the sonar surveys.

Given the offshore zone is characterized as exposed bedrock and shale, it was concluded that fish habitat in the Regional Study Area is generally limited to providing a forage and passage function.

In addition, the preferred alternative involving the installation of variable diffuser ports will not involve in-water work in the offshore and consequently will not have physical effects on lake-bottom habitats. Taking into account the nature of the expected effects associated with the preferred alternative, the additional information on utilization of offshore fish habitats would not change the outcome of the Outfall Class EA.

**Statement 6: Nearshore Zone - Section 5.1.2 (Page 5-2)**

LGL (2004) found the substrates within 300 m of the shoreline to be predominantly sand and boulder with some gravel. In 2013, the substrate along two transects on either side of the existing Outfall were found to consist mostly of boulder and bedrock between 5 and 10 m of depth. The data reported supports the presence of rocky substrates that may be used for spawning by coarse substrate spawning species but there is no assessment of habitat utilization for any fish species within the nearshore zone of the RSA or within the LSA.

Habitat utilization by Great Lakes Fish within the Regional Study Area and within the Local Study Area and supplementary tables of Fish Species Lists are provided in Appendix C (Natural Sciences Report) of the ESR. The Fish Species Lists provide listings of fish that may be present within the area. Habitat utilization, as described in Section 2.4.3, Appendix C of the ESR is governed seasonally by temperature and also by life stage.

Regarding substrates, the 2013 field study found that variation in lakebed structure, such as the occurrence of shoals, drop offs, or macrophyte beds, with the potential to function as habitat for important life stages of fish (e.g. spawning), was not observed in the sonar surveys.

Potential for nearshore spawning of fish (including Round Whitefish) within the LSA and RSA were considered and documented in the Appendix C, Natural Sciences Report, of the ESR. As noted in the response to Statement 4 above, it was found that the preferred alternative, which includes modifying the existing outfall and optimizing the existing operations, would not negatively affect spawning grounds.
Statement 7: Lack of Information on the Current Use of Habitat by Round Whitefish and Impact on Habitat - Section 5.2 (Page 5-3) - Round Whitefish are not considered as a VEC in the Outfall Class EA.

Where Round Whitefish has been specifically identified as a VEC for previous EAs at nuclear generating stations, it was because of concerns regarding potential thermal effects on nearshore spawning shoals, concerns surrounding entrainment of eggs and larvae, as well as habitat loss from nearshore construction for the DNGS (Golder 2007, Golder and SENES 2009). The Round Whitefish is also identified as a VEC in other nuclear power generation sites in the Great Lakes.

The preferred alternative for the Outfall Class EA was not expected to have similar effects as nuclear generating stations making the selection of Round Whitefish as a VEC unnecessary.

VECs are project specific and will often vary from one project to another, as the environmental effects of each project can be different. Selection of Round Whitefish as a VEC for the PNGS and DNGS environmental assessments should not be taken to imply that Round Whitefish are a generic indicator of aquatic ecosystem health.

Statement 8: Lack of Information on Round Whitefish Reproductive Success - Section 5.3 (Page 5-3) - Another study that is not presented in the Natural Sciences Report is a Round Whitefish spawning investigation conducted by EcoMetrix in 2009. The results from this study were included in the Appendix of an OPG report titled ‘Impacts of PNGS Thermal Discharge during the Winter of 2010 on Potential Round Whitefish Spawning’. The study was conducted in the vicinity of the Pickering NGS, which included the existing outfall area and a portion of the Duffin Creek WPCP Outfall Class EA LSA, the Darlington NGS and reference locations.

The purpose of the environmental assessment was to assess the effects of the preferred alternative. The preferred alternative involving the installation of variable diffuser ports does not involve in-water work that would result in the physical disturbance of the nearshore area that would have physical effects on shoreline or littoral habitats. Moreover, phosphorus loadings will not change and the phosphorus mixing zone will be slightly smaller at 630 MLD compared to baseline. Information on fish and fish habitat in the Regional Study Area was adequate for the purpose of the assessment. Additional information on the reproductive success of Round Whitefish would not have changed the outcome of the assessment.

The 2010 OPG report with the appended 2009 EcoMetrix study was reviewed as part of the literature review on Round Whitefish accompanying this report. Based on the additional information reviewed, the conclusions made in the Outfall Class EA are still valid.

Statement 9: Additional Comments on the ESR - Section 5.4 – Comment on page ES-11 of the ESR, Table ES1 net effects for Natural - states that no important fish habitat was recorded in the mixing zone (i.e., nearshore area) and the habitat is only used by fish on a transient basis. This statement is not supported as fish distribution or habitat utilization was not assessed (from field studies or literature) in the nearshore area of the RSA or at all in the LSA. Substrate data for the nearshore area in the LSA clearly shows the presence of rocky substrates that could be used for spawning by coarse substrate spawning species. Round Whitefish and their spawning habitat has been documented within the nearshore area of both the LSA and RSA (EcoMetrix, 2009; Golder, 2007).

Page ES-11 of the ESR, Table ES1 states that “No important fish habitat was recorded in the mixing zone. Mixing zone is used by fish on a transient basis only.” This statement refers to the specific area within the mixing zone and is not intended to refer to the entire nearshore zone. As noted in the response to Statement 6, potential for nearshore spawning of fish (including Round Whitefish) within the LSA and RSA were considered and documented in the Appendix C, Natural Sciences Report of the ESR.

Data collected for the study indicate that the lake bed consists of sand and cobble with intermittent boulders. These features are neither unique nor in short supply within the area. Any effects within the mixing zone, should they occur, will be localized. The overall supply of similar habitats will not be changed substantially.
Statement 10: Additional Comments on the ESR - Section 5.4 – comment on Page 2-6, Section 2.2.3 of the ESR – Phosphorous and unionized ammonia are identified as the most sensitive parameters with potential impacts to algal blooms and fish toxicity, yet there is no assessment in the ESR or supporting documents of the potential for excessive Cladophora growth to impact fish or fish habitat.

The effects of excessive Cladophora growth on Round Whitefish habitat or habitat of other fish species have not been documented in the literature. However, the literature indicates that excessive growths of Cladophora are a result of changes in substratum, water clarity, and phosphorus availability associated with the establishment of dense dreissenid mussels (Higgins, et al. 2008), and that local point sources have a small influence on conditions that support Cladophora growth (Leon, et al. 2009).

Since phosphorus loadings will not be changed by implementation of the preferred alternative and the phosphorus mixing zone will be slightly smaller at 630 MLD than the baseline condition, assessment of the effects of excessive Cladophora growth on fish and fish habitat would not change the outcome of the assessment.

Statement 11: Additional Comments on the ESR - Section 5.4 – comment on Page 2-8, point 3 of the ESR – states that mixing zones should not impinge on important fish spawning areas – yet there was no assessment of fish distribution or habitat use within the nearshore area of the LSA (i.e., the mixing zone) and Round Whitefish and their spawning habitat has been documented in this area (Golder 2007; EcoMetrix, 2009).

As noted in the response to Statement 6, potential for nearshore spawning of fish (including Round Whitefish) within the LSA and RSA were considered and documented in Appendix C (Natural Sciences Report) of the ESR. The ESR provides an overview of the aquatic habitat found within the area of the mixing zone and provides a discussion of how fish utilize that zone based on a review of habitat associations. Known habitat associations (Lane et al. 1996a, 1996b and 1996c) were identified for the fish species documented to occur in the area. These associations were employed as indicators of habitat use and considered as noted in Appendix C, Natural Sciences Report (pages 9, 23, 25, and 48) of the ESR.

Gathering data on the physical features present at the site and evaluating them in terms of their suitability for use species likely to be present is an accepted means of habitat assessment. Depth cover and substrate are variables that are commonly used in the assessment. Habitat surveys determined that the lake bottom within the area of the mixing zone consisted of sand and cobble with intermittent boulders. This type of habitat was ubiquitous throughout the study area. None of the species that spawn at depths ranging from 5 to 15 m show high associations with sand and cobble substrates (Lane et al. 1996).

The research from the cited Golder 2007 study was referenced in Appendix C (Natural Sciences Report) of the ESR. Information from the EcoMetrix 2009 study was reviewed as part of the literature review by LGL accompanying this report. Of particular note is that the 2009 study draws the conclusion that the substrate at the Pickering Nuclear Generating Station site is of poorer quality for Round Whitefish spawning than other available habitat located considerably east of Duffins Creek (approximately 11 to 17 km) which is outside the RSA of this Outfall Class EA.

Statement 12: Additional Comments on the ESR - Section 5.4 – comment on Page 7-23 of the ESR, last paragraph – states that exposed shorelines provide little refuge for fish and the offshore zone consists of bedrock and shale therefore the habitat is limited to provide forage and passage functions. Some fish species rely on exposed rocky shorelines adjacent to deeper water for spawning habitat (e.g., lake trout [Salvelinus namaycush], lake whitefish [Coregonus clupeaformis] and Round Whitefish all of which are found along the north shore of Lake Ontario). In addition Round Whitefish and their spawning habitat have been documented in this area (Golder, 2007; EcoMetrix, 2009).

It is true that some fish species (i.e. lake trout) rely on exposed rocky shorelines adjacent to deeper water for spawning habitat. In Appendix C (Natural Sciences Report) of the ESR, the following was stated on page 23: “Within the regional study area subject to this report, Duffins Creek would provide a greater variety of habitat for spawning, such that fish species (e.g. lake trout) may also use the open water as a migratory corridor or staging area prior to spawning in the creek or associated marsh habitat.”
Since fish species use the open water as a migratory corridor, and the change in the size of the mixing zone in the open water was negligible compared to baseline conditions and compared to the overall size of the study area, the ESR documented that no net effects are anticipated on aquatic communities.

Statement 13: Additional Comments on the ESR - Section 5.4 – comment on Page 7-24, Section 7.4.1 of the ESR – the report states that the nearshore area does not provide specialized habitat for fish – this statement is not supported as no fish distribution or habitat utilization data or studies were presented in the Natural Sciences Report for the nearshore area. The results of 2013 side scan sonar show rocky substrates at 5 to 10 m of water depth and Round Whitefish have been recently documented in this area (EcoMetrix, 2009).

This section of the report refers to a very specific location of the nearshore (in the vicinity of the surveyed transects), it is not intended to suggest that no specialized habitat occurs in other areas of the nearshore area of Lake Ontario. The results of the 2013 side-scan sonar found that variation in lakebed structure, such as the occurrence of shoals, drop offs, or macrophyte beds, with the potential to function as habitat for important life stages of fish (e.g. spawning), was not observed in the sonar surveys. The ESR also provides an overview of the aquatic habitat found within this area of the mixing zone and provides a discussion of how fish utilize that zone based on a review of habitat associations. The following references were used for this purpose: Lane et al. 1996a, 1996b and 1996c.

Statement 14: Additional Comments on the ESR - Section 5.4 – comment on Page 7-25, Section 7.4.3.3 of the ESR – provides a very brief description of fish species found in the nearshore area although, the fish species listed are from an OPG impingement study that is not directly relevant as the sampling was not conducted in Lake Ontario but rather from the Pickering NGS screenhouse bins. The species list also contains an error it should be Rainbow Smelt (Osmerus mordax) not Rainbow Trout (Oncorhynchus mykiss). The appropriate study from Golder (2007) that should have been cited was the Analysis of Aquatic Habitat Effects study, which captured a total of 19 species. White sucker and Round Whitefish were the most common of the VEC species captured during that study (Golder, 2007). There was no fish distribution or habitat utilization data for the nearshore area while there was an assessment of habitat utilization based on habitat preferences from Lane et al, 1996 for the offshore or open water area where substrate data is limited.

The Natural Science Report (Appendix C of the ESR) provides details on all fish species found in the Regional Study Area. As indicated, data for fish species documented for the Lake Ontario nearshore was compiled from 1976-2013 from a wide variety of sources including records from Ontario Hydro, Ministry of Natural Resources, and Toronto Region Conservation Authority to provide the most comprehensive listing of fish community and species that would be present within the local and regional study area within Lake Ontario. The OPG impingement study was one of these data sources used. Specifically, the fish that are listed in the OPG impingement study were provided to the study team by OPG staff (B. Hester pers comm.) to be used for this purpose in the study, as an indication of potential fish species that may be found within this area.

The substrate and lake bottom conditions have been obtained through direct surveys using bathymetric, underwater camera, and more recent sidescan sonar surveys, which was also supplemented by data provided by the University of Waterloo.

For responses specific to habitat utilization, see responses to Statements 6 and 9 above.

Statement 15: Additional Comments on the ESR - Section 5.4 – comment on Page 10-20, Section 10.3.2 of the ESR – states that the model predicts that the mixing zone does not interfere with fish spawning or fish migration. This statement is not supported as habitat utilization was not assessed within the nearshore area (i.e., the mixing zone) and Round Whitefish and their habitat has been documented in this area (Golder, 2007; EcoMetrix, 2009).

Please see responses to Statements for 9 and 11 above which describe how habitat utilization was assessed within the mixing zone.

Statement 16: Additional Comments on the ESR - Section 5.4 – comment on Page 10-44 of the ESR – the report states that the substrate in the area of the diffuser is sand with algal mats. EcoMetrix 2013 sampling, which
included underwater photography and ponar grabs, along the Ajax waterfront and diffuser area at depths of 5 to 20 m determined the substrate to be sand and hard rocky material (gravel and cobble) covered with mussels and mats of Cladophora.

It is not clear if the EcoMetrix 2013 sampling was taken at the same location as the LGL 2013 survey since the locations of the underwater photography and ponar grabs from the EcoMetrix 2013 sampling are not included in the study. The LGL 2013 survey locations for the sidescan sonar and ponar grab samples are indicated in the Natural Sciences Report appended to the ESR (Figure 8 on page 43).

For the 2013 LGL survey, substrates were generally represented on sidescan sonar imagery to be comprised of sand and cobble with intermittent boulders from the shoreline to water depths of approximately 3m (at a distance from shore of approximately 100m). Throughout the remainder of the nearshore zone, substrates consisted mostly of boulder and exposed bedrock. Collection of lakebed samples with a petite ponar dredge in the nearshore zone confirmed the presence of exposed bedrock at water depths of 10-11m, as no sediments could be collected by the dredge.

Statement 17: Additional Comments on the ESR - Section 5.4 – comment on Page 13-1, Section 13.1.2 of the ESR – the report states that the operation of the preferred alternative will have no to negligible effects on the aquatic environment but the potential for excessive Cladophora growth to impact fish and fish habitat was not assessed.

Phosphorus is indicated as the limiting nutrient for Cladophora growth from a majority of studies (Higgins et al. 2008). The preferred alternative will not change phosphorus loadings from the baseline conditions, which will remain 311 kg/d to 630 MLD and operation of the alternative results in a slightly smaller phosphorus mixing zone compared to the baseline. As Cladophora growth appears to be the result of lake-wide phenomena, the preferred alternative is not expected to affect Cladophora growth. Therefore; the assessment of effects of Cladophora on fish or fish habitat does not appear warranted.

As noted in the response to Statement 10, adverse effects of excessive Cladophora on Round Whitefish habitat or habitat of other species have not been documented in the literature, and the assessment of the effects of excessive Cladophora growth on fish and fish habitat would not change the outcome of the assessment.

Statement 18: Additional Comments on the ESR - Section 5.4 – comment on Page 13-1 of the ESR, last paragraph – the report states that the habitat in the LSA and mixing zone does not provide important fish habitat and is only used by fish on a transient basis. This statement is not supported as fish distribution or habitat utilization was not assessed (from field studies or literature) in the nearshore area of the RSA or at all in the LSA. Substrate data for the nearshore area in the LSA clearly shows the presence of rocky substrates that could be used for spawning by coarse substrate spawning species. Round Whitefish and their spawning habitat has been documented within the nearshore area of both the LSA and RSA (EcoMetrix, 2009; Golder, 2007).

This statement is a repeat of Statement 9. Please see the response to Statement 9 above.

Statement 19: Additional Comments on the ESR - Section 5.4 – comment on Page 13-8 of the ESR, Table 13-3 Net Effects for Natural – see previous comment.

This statement is a repeat of Statement 9. Please see the response to Statement 9 above.

Statement 20: Additional Comments on the ESR - Section 5.4 – comment on Page 14-1 of the ESR – Independent peer review (Natural Environment – Fisheries and Aquatic expert) – the documents peer reviewed for fish and fish habitat did not contain recent data on substrate within the nearshore area (University of Waterloo 2007 and 2013 side scan sonar results) or the relevant study documenting fish species likely to be present in the nearshore zone from Golder, 2007.

Results of the University of Waterloo 2007 study are included in Appendix C (Natural Sciences Report) of the ESR (Figure 4 and Section 2.4.1.6). The Natural Sciences Report of the ESR was finalized November 2013; the 2013 University of Waterloo results were not available at the time of reporting. Also, follow up work was completed in
LGL’s 2013 field study to obtain more recent substrate data using sidescan sonar which was incorporated into Appendix C (Natural Sciences Report) of the ESR.

Regarding the cited Golder 2007 study, this research was referenced in the peer reviewed Natural Sciences Report (Appendix C of the ESR), and used in the following ways:

- Fish data from the study was included in the species tables.
- Description of the aquatic environment from the Golder 2007 study was included as it relates to substrates and currents.
- Description of aquatic communities from the Golder 2007 study was included in terms of: dreissenid mussels; filamentous algae; benthic invertebrates, and aquatic plants.

Statement 21: Additional Comments on the ESR - Section 5.4 – comment on Page 14-22 of the ESR – Independent peer reviewer (Natural Environment – Fisheries and Aquatic expert) recommended that Stage 2 focus on habitat data collection within the area likely to be affected by the project and that the habitat data should be compared to known habitat associations and preferences of fish most likely to be present in the area. It was also recommended that fish sampling be conducted at specific times of the year to confirm habitat use. This comment was not addressed and habitat use was not assessed for the nearshore area for any species likely to be present in the area.

At the suggestion of the peer reviewer, known habitat associations (Lane et al. 1996a, 1996b and 1996c) were identified for the fish species documented to occur in the area. These associations were employed as indicators of habitat use and considered as noted in the Appendix C, Natural Sciences Report (pages 9, 23, 25, and 48) of the ESR.

As noted in the response to Statement 11, gathering data on the physical features present at the site and evaluating them in terms of their suitability for use species likely to be present is an accepted means of habitat assessment. As the preferred alternative does not require lakebed construction, and its operation results in negligible mixing zone changes, a seasonal fish sample program was not deemed necessary.
6 References


Attachment 1

Literature Review of Recent Scientific Research on the Round Whitefish (*Prosopium cylindraceum*)
Literature Review of Recent Scientific Research on the Round Whitefish (*Prosopium cylindraceum*)

In Response to the Town of Ajax Part II Order Request

*prepared for*

CH2M Hill Canada

*on behalf of*

The Regional Municipality of York
and
The Regional Municipality of Durham

*by*

LGL LIMITED
environmental research associates

September 2014
LGL Project TA8417
Literature Review of Recent Scientific Research on the Round Whitefish (*Prosopium cylindraceum*)

In Response to the Town of Ajax Part II Order Request

*prepared by:*

Arnel Fausto, M.Sc.
Senior Ecologist

Lynette Renzetti, B.Ed., B.Sc.
Planning Ecologist

LGL Limited
environmental research associates
445 Thompson Drive, Unit 2
Cambridge, Ontario N1T 2K7
Tel: 519-622-3300 Fax: 519-622-3310
e-mail: cambridge@lgl.com
url: www.lgl.com

September 2014
LGL Project TA8417
# Table of Contents

1.0  INTRODUCTION ......................................................................................................................................... 1  
2.0  ROUND WHITEFISH DISTRIBUTION ............................................................................................................ 1  
3.0  ROUND WHITEFISH LIFE HISTORY .............................................................................................................. 2  
4.0  STATE OF ROUND WHITEFISH RESEARCH IN CANADA ............................................................................... 5  
5.0  THE LAKE ONTARIO ECOSYSTEM ............................................................................................................... 5  
6.0  TRENDS IN ROUND WHITEFISH POPULATIONS .......................................................................................... 8  
7.0  FACTORS WITH POTENTIAL TO IMPACT ROUND WHITEFISH IN LAKE ONTARIO ......................... 9  
   7.1  INVASIVE SPECIES ............................................................................................................................................ 11  
   7.2  HABITAT QUALITY ........................................................................................................................................... 14  
   7.3  PREDATION .................................................................................................................................................... 15  
   7.4  FOOD AVAILABILITY ......................................................................................................................................... 17  
   7.5  NEARSHORE WATER TEMPERATURES .................................................................................................................. 19  
8.0  CONCLUSION ........................................................................................................................................... 21  
9.0  REFERENCES ............................................................................................................................................ 23
1.0 Introduction

A literature review has been conducted by LGL Limited to summarize the results of scientific research conducted on the Round Whitefish (*Prosopium cylindraceum*) and outline the information currently available through government documents, technical and industry reports regarding the life history of the species including ecological factors such as diet, habitat requirements, reproduction, predation, and competition. Efforts were made to focus on the Great Lakes ecosystem, in particular, Round Whitefish populations in Lake Ontario to address a claim in the Town of Ajax's Part II Order request that Round Whitefish populations are in decline due to the potential effects of heavy *Cladophora* growth on Round Whitefish spawning habitat including: avoidance of the habitat; increased egg exposure and predation; and increased mortality of overwintering eggs (Town of Ajax 2014). The purpose of this literature review is to confirm the presence of Round Whitefish in the nearshore area (with less that 15m water depth) of Lake Ontario and the status of the species in the Great Lakes, as well as document potential reasons for its decline.

2.0 Round Whitefish Distribution

The Round Whitefish ranges widely through northern North America and into northeastern Asia. In North America the species is documented in several northern U.S. States; and, in Canada from northern New Brunswick through to parts of Quebec and Ontario, and from northern Manitoba north-westward to the Territories and northern British Columbia (Scott and Crossman 1998). The northern range of the Round Whitefish in North America includes the Northwest Territories, Alaska and Yukon, and throughout all but the northeastern corner of the Nunavut mainland, and eastward (with some gaps in distribution), but generally encompassing the area between northwestern Manitoba, northern Quebec and Labrador (Stewart et al. 2007). The southern extent of its range includes southern Ontario south of Lake Nipigon, Quebec, New Brunswick, and several New England states. In the southern parts of their range, they inhabit shallower areas of deep lakes, and within the northern parts, they may be found in rivers and streams where they may also enter brackish waters (Stewart et al. 2007).

Round Whitefish is native to Ontario and with the exception of Lake Erie, the species’ distribution includes the Great Lakes and is considered to be a shallow water species in these environs; one that inhabits water less than 45m deep (Scott and Crossman 1998). Records for the species have been documented in the Brighton to Kingston area along the northeast shore of Lake Ontario, and along the northern shoreline in the vicinity of Darlington, Oshawa and Pickering.
3.0 Round Whitefish Life History

Round Whitefish is a coldwater, offshore benthic species that moves inshore to spawn in late autumn to early winter over gravel shoals of lakes and river mouths, or on occasion, in rivers (Scott and Crossman 1998, Richardson et al. 2001, Eakins 2014).

Habitat use by Round Whitefish has seldom been the focus of detailed studies, with the exception of depth distribution and spawning habitat (Stewart et al. 2007, Steinhart et al. 2007). The following provides an overview of known life history characteristics with emphasis on these features.

Round Whitefish spawn more than once following maturity and timing of spawning varies geographically in response to seasonal differences in water temperatures among water bodies. In Lake Ontario, Round Whitefish spawn in late fall (November-December) at temperatures of 2˚C to 4.5˚C, with hatching occurring in spring (April-May) (Patrick et al. 2013). The species typically spawns over a 10-14 day period in pairs or small groups rather than in large spawning aggregations (Normandeau 1969, Holmes et al. 2002). Normandeau (1969), Goodyear et al. (1982) and Haymes and Kolenosky (1984) have observed that although the species typically spawns in shallow water (less than 1m deep) it will use deeper inshore waters (5-10m) for this purpose as well. Spawning occurs at night, where eggs are broadcast over the shoals and hatch approximately 140 days later (March-May depending on location). Spawning substrate is almost always within gravel or rubble and must be clean (Normandeau 1969, Scott and Crossman 1998) in areas that are often exposed to wind, although spawning has also been observed over boulders and over sand and silt in northern locations (Stewart et al. 2007). Newly laid eggs are non-adhesive and sink to the bottom, and hatch as sac fry in March to May, where they remain and seek shelter within the substrate. Absorption of this yolk sac takes about 2 to 3 weeks.

Round Whitefish are considered to be a demersal fish species and generally inhabit a wide range of depths depending on season, age, and the presence of other fish species (Steinhart et al. 2007). Young-of-the-year Round Whitefish start their lives in shallow water, but tend to move to deeper and faster waters as they grow into juveniles in lacustrine and riverine populations respectively (Stewart et al. 2007). Adult Round Whitefish have been frequently reported in depths up to 45 m in large lakes (Scott and Crossman 1998), although they were most abundant in depths less than 36.6 m (20 fathoms) and rare at depths greater than 71.3 m (39 fathoms) (Stewart et al. 2007). Round Whitefish are captured mostly in shallower water, with January and February catches of Round Whitefish in Lake Huron are 10 times greater at the 5 m depth than at 12 m depth (Stewart et al, 2007).
Great Lakes populations typically mature at a younger age than populations near the northern extent of their distribution, with some maturing at ages 2 and 3, and all by age 6 (Mraz 1964, Haymes and Kolenosky 1984, Stewart et al. 2007). Individuals in northern populations appear to have longer lifespans than those in the south. Despite age differences within various geographic regions, southern populations mature at a larger size than northern populations because of their higher growth rates, with Great Lakes populations approaching their maximum size within the first 3 years of growth (Steinhart et al. 2007). The typical captured size at maturity within the Great Lakes is 380-400 mm (Mraz 1964, Steinhart et al. 2007), with fish as large as 500 mm TL considered a rarity.

Round Whitefish are described as opportunistic feeders, and consume a variety of zooplankton and benthic invertebrates. Benthic invertebrates consumed include caddisflies, chironomid larvae, craneflies, blackflies, and mayflies (Steinhart et al. 2007), as well as benthic molluscs, small crustaceans, fish eggs and fish (Stewart et al. 2007, NYSDEC 2014). The Round Whitefish’s ability to exploit a range of benthic prey species, as well as zooplankton and terrestrial drift is likely one of the key factors that enables it to inhabit oligotrophic lakes of low biological productivity in the northern parts of its range (Stewart et al. 2007).

Piscivorous fish are likely the key predators of Round Whitefish, and in northern waters, their eggs are eaten by suckers, burbot and members of their own species, while the fish themselves are preyed upon by lake trout, burbot and northern pike (Normandeau 1969, Stewart et al. 2007). Other researchers have suggested that rainbow smelt (Steinhart et al. 2007), yellow perch, smallmouth bass, and cisco (Normandeau 1969) may also be considered important predators of Round Whitefish, and their introductions can cause populations to decline (Steinhart et al. 2007, Stewart et al. 2007).

More recent research specific to Round Whitefish conducted in Lake Ontario in recent years has largely focused on thermal impacts to the species associated with the discharge of cooling water from nuclear generating facilities to Lake Ontario receiving waters. Round Whitefish has been selected as a Valued Ecosystem Component (VEC) in Ontario Power Generation (OPG) studies because of the potential for direct impacts to habitat (e.g. infilling associated with the Darlington Nuclear Generating Station) or sensitive life processes (i.e. thermal impacts associated with the release of cooling water at the Darlington, Pickering and Bruce Nuclear Generating Stations) and potential thermal effects on nearshore spawning shoals and concerns surrounding entrainment of eggs and larvae (SENES, 2011b). For this reason, research related to Round Whitefish has largely been facilitated by OPG in the area of the Pickering Nuclear Generating Station (PNGS) and Darlington Nuclear Generating Station (DNGS) on Lake Ontario, and the Bruce Nuclear Generating Station on the shores of Lake Huron. The focus of
Round Whitefish research conducted in the 1970s and 80s at the OPG sites was on the distribution and abundance of the species as well as the life history periods found near each of the generating stations (Holmes et al., 2002). More recent OPG investigations document use of habitat in vicinity of the facilities and investigate the effects of water temperature on egg hatch. Secondary information has also been documented through these efforts to include data on stomach contents, substrate conditions in spawning grounds, and effects of sedimentation on embryonic survival.

In support of an Environmental Assessment (EA) for refurbishments and continued operations at the PNGS, and at the DNGS in response to plans for lake infilling associated with the installation of new reactors, OPG conducted a fish community assessment at the DNGS in 2009, and spawning surveys were conducted in 2010 at both the DNGS and PNGS. Although the dominant species collected in 2009 was Round Whitefish, the dominant species collected in 2010 was White Sucker. The percent composition of the catch in 2010 and 2009 was similar with respect Round Whitefish, with values of 32% in 2009 and 31% in 2010 (OPG 2010). Round Whitefish ranged from three (3) to 23 years old, with 71.5% of these fish being 15 years of age or older and only 2.9% of these fish being under five years old. A few fish were noted to be over 20 years old. The researchers concluded that Round Whitefish appear to be getting larger, implying that the population near the Region of Durham is aging and may be declining as a result of low recruitment when compared to historical data (SENES, 2011a, OPG 2010). The presence of older Round Whitefish is regarded as more of a regional phenomenon rather than an observed localized effect (SENES, 2011).

Outside of Ontario, research has been conducted in New York State's Adirondack lakes to investigate Round Whitefish populations. The species has demonstrated declining numbers in these lakes over the past several decades, which has led to its classification as a State endangered species (Steinhart 2009). Possible reasons cited by for the decline in Round Whitefish populations in those lakes include: predation by invading Yellow Perch on whitefish eggs and fry; predation by Smallmouth Bass; competition with Lake Whitefish; overfishing; loss of spawning sites; siltation; and lake acidification (NYSDEC 2014). Some of these factors continue to pose a threat to remaining populations. Round Whitefish in New York State are now protected from harvest or possession. However in Canada, Round Whitefish has been given a low priority for assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for assessment and is not listed under federal Species at Risk Act or Ontario Endangered Species Act.
4.0 State of Round Whitefish Research in Canada

While common in Canada’s northern lakes and rivers, the Round Whitefish is one of the least studied in the subfamily Coregonines (Richardson et al. 2001, Steinhart et al. 2007). This is partly because of its slow growth and small average size, which limit its commercial value (Mraz 1964; MacKay and Power 1968). There is, however, a wide body of information based on research conducted for other closely related Coregonus spp. which may be used to draw some parallels. For example, studies on the related Lake Whitefish are much more prevalent due to its economic value as an important component of the Great Lakes fishery.

Round Whitefish and Lake Whitefish are members of a related Holarctic species complex and are sympatric in many large North American lakes (MacPherson et al. 2010). While there are distinguishing differences between the species, there are also many parallels in their life histories. While adult Lake Whitefish attain larger maximum body sizes, live longer and tend to use deeper waters (18-90m) (Cucin and Regier 1966), Round Whitefish are smaller and generally occupy more moderate depths (6-36m) (Holmes et al. 2002). Round Whitefish spawning begins at colder temperatures later in the fall, and over a more compressed timeframe than Lake Whitefish (Holmes et al. 2002). However, both species are benthivores feeding on amphipods, gastropods and aquatic insects, especially chironomid larvae and pupae (Pothoven and Nalepa 2006, Normandeau 1969), move inshore in autumn to spawn, and utilize the offshore waters of Lake Ontario. MacPherson et al. (2010) determined through a review of literature that while some Lake Whitefish populations in the Great Lakes (Lake Huron) remain abundant, populations in Lake Ontario have experienced dramatic declines in recent years. Less is known about the Round Whitefish on a population level, however production was always relatively low in the Great Lakes in comparison to Lake Whitefish. In some cases where parallels can be drawn between the two species, an effort has been made to identify relevant research in the sections below.

5.0 The Lake Ontario Ecosystem

To gain a greater understanding of the Round Whitefish populations in Lake Ontario, it is useful to examine the changes in its environment in relation to other fish and other aquatic fauna that has occurred over the past few decades. The changes that have occurred within the Lake Ontario ecosystem have been dramatic, and have significantly altered the food web and habitat that Round Whitefish depend upon, and these changes have also profoundly affected the fish community as a whole.

Although Lake Ontario is considered to be a large lake (17th largest in the world) it is the smallest of the Great Lakes and is under enormous pressure from influences of
major urban industrial centres on both sides of the U.S.–Canadian border. Influences include population growth, declining lake levels, introduction of non-native invasive species, the influence of the other Great Lakes (Lake Ontario receives 86% of its water from the upper Great Lakes and Lake Erie) and of water level regulation (Stewart et al. 2013). Since the late 1960s and early 1970s, the Lake Ontario ecosystem has been subject to numerous changes based on socio-political influences, management actions and unplanned events that have had a profound effect on the lake ecosystem (Mills et al. 2003, Mills et al. 2005).

Among the major events that have transpired include management actions to remediate anthropogenic impairments to the ecosystem, such as the agreements to reduce phosphorus loading to the lake, and actions to restore a more balanced fish community through annual releases of Pacific Salmon to control alewife and create a recreational fishery in 1968. In addition, treatment of streams with lampricide was initiated in the 1970s to kill larval sea lamprey, along with annual releases of hatchery reared lake trout for population restoration (Mills et al. 2003, Mills et al. 2005). However, one of the major pivotal events that have occurred in Lake Ontario ecosystem was during the early 1990s, where an unintentional establishment and proliferation of exotic species from Eurasia (e.g. Round Goby) gained entry to Great Lakes through transoceanic shipping. Altogether, these changes have led to dramatic changes to the Lake Ontario’s nutrient status, food web, and fishery over the past four decades. The status of the Lake Ontario benthic-macroinvertebrate community has changed dramatically since 1970. Aside from toxic contaminants, biological pollution associated with unexpected introductions has continued to impact Lake Ontario’s benthic food web. One of the most significant changes in the benthic macrofauna of Lake Ontario has been the establishment of two species of Dreissena mussels. The zebra mussel was first detected in the lake in 1989, and, by 1991, the quagga mussel (D. bugensis) was observed coexisting with the zebra mussel (Griffiths et al. 1991; Mills et al. 2003).

The Lake Ontario fishery has been in a state of flux since European colonization. Historically, the offshore waters of Lake Ontario supported a large number of Lake Trout, Atlantic Salmon and Burbot as top predators; with Lake Whitefish, Lake Cisco, and Slimy Sculpin abundant in shallow water and offshore waters; whereas deeper offshore waters were dominated by four species of deepwater Cisco and Deepwater Sculpin (Stewart et al. 2013). Warmer nearshore areas supported Yellow Perch, Walleye, Northern Pike, American Eel and Lake Sturgeon with Emerald Shiners and Spottail Shiners as important prey fish. By the 1970s native fish communities of Lake Ontario had substantially decreased (Lake Sturgeon, Atlantic Salmon, Deepwater Sculpin, Burbot and Lake Trout), while invasive species (Alewife, White Perch, Rainbow Smelt) had increased in number. This change was largely attributed to habitat loss and
degradation, over-fishing, and the impact of invasive species such as Alewife, Rainbow Smelt and Sea Lamprey (Stewart et al. 2013).

Prior to the documented population collapses of many native species that comprised the historical fish community in the 1970s (Christie 1972), pessimism prevailed among Great Lakes scientists and managers as depreciation of the fish communities and degradation of water quality proceeded unabated in the 1950s and 1960s. By 1970, native lake trout populations were extirpated, the few remaining salmonids were riddled with sea lamprey wounds, cultural eutrophication resulted in excessive algal growth and low water clarity, proliferation of alewife led to intense zooplanktivory and a predominance of small cladocerans and cyclopoid copepods, and only a remnant population of Lake Whitefish persisted (Mills et al., 2003).

Currently, the Lake Ontario fish community is a mix of native and non-native species and continues to change in response to a variety of pressures including invasive species (such as zebra and quagga mussels) and introduced fish species (Stewart et al. 2013). Mills et al. (2005) summarize that since the 1970s negative effects of exploitation of native fishes, eutrophication, sea lamprey and alewife have been largely ameliorated; however the new establishment of non-native species continues to hamper goals to restore the lake’s historical fish communities. For example, following the invasion of dreissenid mussels and their impact on increased water clarity may have caused Lake Trout to shift to deeper waters during particular life stages, the implications of which are not well understood (O’Gorman et al. 2000). Indirect impacts of invasive species such as that described by O’Gorman et al. are far reaching.

Reductions in phosphorus in the open waters of Lake Ontario were well documented from lakewide surveillance and long term sampling programs undertaken by Environment Canada and Fisheries and Oceans Canada. From these reductions, comparisons of phytoplankton data collected in 1970 and 1990 indicated that a considerable change in phytoplankton composition has occurred, with predominant eutrophic diatoms replaced by oligotrophic species in very low numbers (Mills et al. 2003, Mills et al. 2005). This “oligotrophication” of Lake Ontario is also supported by other structural changes in the size distribution of phytoplankton. Changes in the nutrient status of Lake Ontario since the 1970s were expected to impact the zooplankton community through changes in abundance, biomass and production, and community composition. The response of the zooplankton community to declines in phosphorus levels occurred primarily in abundance, biomass, and productivity.

Fishery managers recognized the numerous stresses on the fish community and instituted new measures to set the stage for the recovery process. Historically, whitefish were an important component of the Lake Ontario commercial fishery and an abundant
species in the cold-water fish community of the eastern region of the lake. By the mid-1960s, these stocks and the fishery they supported collapsed; with only small populations persisted into the late 1960s and 1970s. Rehabilitation of lake trout in the late 1970s contributed to reductions in the alewife and rainbow smelt populations that may have indirectly impacted whitefish. Although oligotrophication was part of the recovery process for Lake Ontario, Mills et al. (2003, 2005) points out that by 2000, the food web was altered greatly with the reductions in sea lamprey predation, with the exotic alewife now supporting a recreational fishery for Pacific Salmon, and the invasion of *Dreissena* mussels creating new trophic interactions. Stewart et al. (2013) proposed that the fish production potential of Lake Ontario is further influenced by:

- climate change;
- change in structure of food webs (including interactions between phosphorus, phytoplankton, zooplankton, and benthic communities);
- impacts of invasive species on feeding relationships;
- impacts of water level regulation on fish spawning and nursery habitats, survival of stocked and naturally produced fish; and,
- recreational and commercial fish harvest.

There is general consensus in the literature that there is a high degree of uncertainty in our understanding of these factors, their interconnectedness, and how the resulting ecological changes might affect different elements of the lake’s food web. Ecological processes involving benthic and pelagic food web pathways and their linkages to fish will continue to challenge researchers in terms of scientific understanding and desire to manage large lake ecosystems, with expectations continually being hampered by ecological surprises resulting from forces such as climate warming and exotic species invasions. What researchers can agree on is that our understanding of how these many factors influence Lake Ontario’s capacity to produce fish, including Round Whitefish, is not well understood (Stewart et al. 2013).

In light of these changes, researchers have learned from lessons over the last three decades that the Lake Ontario food web has taken new and unpredicted ecological paths (Mills et al. 2003). It is also evident that managers of the Lake Ontario fishery will be challenged in the coming decades as the ecosystem changes, and will need to rely on more tools such as ecological modelling and risk assessment to gain insights into the possible outcomes and consequences of management decisions.

### 6.0 Trends in Round Whitefish Populations

The Lake Ontario Management Unit (LOMU) conducts regular gillnetting surveys in the northeastern basin of Lake Ontario in the Brighton-Kingston area. Historically, Round
Whitefish are known to have occurred in abundance along the north shore of Lake Ontario between Brighton to the east and Toronto to the west. It is unknown as to why they are present in this area of the lake (SENES 2011b). Offshore benthic species (Lake Trout, Lake Whitefish, Round Whitefish and Burbot) have been observed in declining numbers by the LOMU in those areas in recent years. In the case of Round Whitefish, the mean catch per gillnet in the Brighton area exhibited a decline from 1.19 (from 1992-2000) to 0.04 (from 2010-2012) (OMNR 2012, OMNR 2013, OMNR 2014). Similar results were observed for other benthic fish species in the north-eastern basin of the lake, over the same time period. According to SENES (2011b), the reasons for the apparent decline in Round Whitefish are not fully understood, such that a Round Whitefish Action Plan to better understand the current status of Round Whitefish and the effects that may be contributing to its population decline has been proposed by OPG, with support from DFO, MNR, Environment Canada (EC) and Canadian Nuclear Safety Commission (CNSC).

COSEWIC is a committee of experts that assesses and determines the national status of wild Canadian species, subspecies, varieties or other designable units that are suspected of being at risk of extinction or extirpation. COSEWIC develops the prioritized COSEWIC Candidate List of wildlife species needing assessment, manages the production of wildlife species status reports, and holds meetings at which wildlife species are assessed and assigned to risk categories. According to recent lists published by COSEWIC, the Round Whitefish has been given a low priority for assessment. Based on the 2005 Wildlife Species Report prepared by the Canadian Endangered Species Conservation Council (CESCC) National General Status Working Group, the Round Whitefish in Ontario is listed as Secure, which indicates that this species is not classified in any of the categories: Extirpated, Extinct, At Risk, May Be At Risk, Sensitive, Accidental or Exotic. The Secure list includes some species that show a trend of decline in numbers in Canada but remain relatively widespread or abundant (CESCC 2006). Also note that Round Whitefish is not listed under federal Species at Risk Act or Ontario Endangered Species Act.

7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario

As noted in the preceding sections, detailed information on the distribution, movements and abundance of Round Whitefish throughout the year is generally lacking, as is data pertaining to the growth, survival or recruitment processes important to Round Whitefish (Holmes et al. 2002). Most of the recent data and information are from technical reports prepared in support of monitoring programs at the PNGS, DNGS and BNGS sites on Lakes Ontario and Huron, designed to meet objectives specific to concerns relating to operation of nuclear generation facilities. Overall, the information available makes it difficult to draw sound conclusions with regard to what factors may be influencing the
number of Round Whitefish caught in the LOMU gillnetting surveys in north-eastern Lake Ontario.

Notwithstanding the lack of detailed life history information on Round Whitefish populations, the decline of Round Whitefish in Lake Ontario cannot be disassociated with the ecological changes that are happening in Lake Ontario ecosystem over the past several decades, including the presence of invasive species and associated impacts to food webs, competition for resources, composition of substrates, and predation pressures. In addition, impacts of climate change as they relate to lake level fluctuations and warming water temperatures have the potential to influence the quality of nearshore waters with respect to its suitability for this fall spawning, coldwater species. Factors with particular relevance to Round Whitefish include:

- invasive species
- habitat quality
- predation
- food availability and
- nearshore water temperatures

The following subsections summarize how these changes have influenced the Lake Ontario ecosystem and their potential effects on Round Whitefish populations along the north shore of Lake Ontario.
7.1 Invasive Species

Aquatic invasive species are entering Canadian waters at an unprecedented rate; each decade, some 15 exotic (non-native) species establish themselves in our coastal or inland waters (DFO 2014). Fisheries and Oceans Canada defines an invasive species (nuisance of pest species) as “non-indigenous species, the introduction of which into an ecosystem may cause harm to the economy, environment, human health, recreation, or public welfare” (DFO 2014). In the absence of their natural predators, the most aggressive of these species spread rapidly. Biological invasions have become an increasing concern in recent decades, particularly in the Great Lakes where a large number of exotic species have invaded primarily through ship ballast water as ships travel through the St. Lawrence Seaway. As a result, significant changes to the biodiversity of the Great Lakes have been realized, many of which scientists are still in the process of understanding the implications of these changes. According to Mills et al. (2003), it is not surprising that lessons learned over the past 30 years in Lake Ontario that environmental pollutants like invasive species is likely irreversible, as once established, exotic species rarely disappear although their role in the food web may change significantly.

In addition to the more immediate impacts realized shortly after an invasive species is introduced as a result of direct competition for resources, secondary impacts such as changes to food webs and water quality can take longer to become apparent. An example used by Fisheries and Oceans Canada (DFO 2014) is the following:

"For example, the filter feeding activity of zebra mussels rapidly increased water clarity in the lower Great Lakes. Over a much longer period, the increased light penetration (due to clearer water) produced significant growth and spread of aquatic vegetation and increased the frequency and severity of toxic algal blooms."

In the case of Lake Ontario, the Great Lakes Fishery Commission (Stewart et al. 2013) describes the link between lake nutrient levels, the presence of invasive dreissenid mussels, increased light penetration and abundant growth of aquatic plans and benthic algae in the nearshore as follows:

"Improved wastewater treatment programs have enhanced Lake Ontario’s water quality, and phosphorus levels have been declining in the offshore zone. Currently, the nutrient and algae levels in offshore Lake Ontario are characteristic of an oligotrophic (low productivity) system. Invasive dreissenid (zebra and quagga) mussels are efficient filter-feeders, removing large amounts of phytoplankton from the water column and re-directing this energy source away from zooplankton and fish. Dreissenid mussels feeding
on phytoplankton also results in increased water transparency/light penetration, and may also increase dissolved phosphorus levels in the nearshore zone. This may explain the observed increase in growth of aquatic plants and benthic algae in the nearshore zone, causing fouled shorelines or clogged water intakes in some areas."

Mills et al. (2005) suggest that impacts of dreissenids are far reaching to include an increase in macroinvertebrate activity, increased light penetration, establishment of benthic-feeding Round Gobies, and increased levels of benthic algae. The group attributes these events to greater light penetration and the redirection of energy production from the pelagic to benthic habitats. To illustrate the profound effects of these events on fish populations, a summary of the major stressors and responses from the fish community is provided in Table 1.

**Table 1: Summary of Stressors and Responses of Exotic Species Introductions in Lake Ontario 1970-2000 (Source: Mills et al. 2003)**

<table>
<thead>
<tr>
<th>Exotic or Introduced Species</th>
<th>Stressors</th>
<th>Ecosystem Responses</th>
<th>Fish Community Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dreissenid mussels</td>
<td>- Physical habitat alteration - Removal of phytoplankton from the water column - Redirection of energy production to benthic habitat</td>
<td>- Increased water clarity - Decreased population of <em>Diporeia</em> - Decreased crustacean zooplankton population - Decreased native fingernail clam population - Increase of amphipod population - change in overall trophic status to favour oligotrophy as a function of filter</td>
<td>- Shift in fish community to favour visual predators. - Shift in distribution of some fish species to deeper water (alewife, rainbow smelt) and other parts of the lake (walleye, yellow perch) - Shift in dietary food source from <em>Diporeia</em> to other zooplankton, leading to reduced fitness of some fish populations</td>
</tr>
<tr>
<td>Species</td>
<td>Effects</td>
<td>Feeding Efficiency</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Alewife</td>
<td>- Increased predation on zooplankton</td>
<td>- Increased salmonid fishery due to availability of abundant food source.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Availability as prey for large piscivores</td>
<td>- decreased recruitment of Lake Trout fry due to predation, and fry mortality from early mortality syndrome (EMS).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Altered zooplankton community towards smaller species</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Increase in numbers of top predators such as Lake Trout and Chinook Salmon</td>
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<td></td>
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<tr>
<td>Sea Lamprey</td>
<td>- Predation on large fish</td>
<td>- Reduced numbers of Lake Trout in favour of stocked non-native salmonids</td>
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</tr>
<tr>
<td></td>
<td>- Decreased population of top predator species such as Lake Trout, Burbot, and Chinook Salmon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td>- Predation on small fish</td>
<td>- Establishment of Chinook Salmon as dominant fish predator in Lake Ontario in relation to former native salmonid species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Decreased population of Alewife and other small fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand Mud Snail</td>
<td>- Competition with native gastropods</td>
<td>- Changes in food web composition</td>
<td></td>
</tr>
<tr>
<td>\textit{(Potamopyrgus antipodarum)}</td>
<td>- Decreased population of gastropod snails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Crested Cormorant</td>
<td>- Predation of small fish</td>
<td>- Low levels of abundance and poor year classes of Yellow Perch and Smallmouth Bass during periods of heavy cormorant predation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Decreased populations of Yellow Perch ad Smallmouth Bass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round Goby</td>
<td>- Benthic prey and energy vector between \textit{Dreissena} spp and other fish species</td>
<td>- Potential predation effects on young fish and eggs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Competitor with native fish for food sources, possible prey for some larger fish species</td>
<td>- Change in fish community due to competition</td>
<td></td>
</tr>
</tbody>
</table>
From examination of Table 1, linkages between ecosystem responses to the stressor and the fish community become apparent, with parallels to the Round Whitefish population in Lake Ontario. While the mechanism remains unclear, the reduction in the population of Diporeia has been linked to the introduction of dreissenid mussels (Mills et all 2003). With Diporeia being an important food source for the Round Whitefish, it stands to reason that the introduction of Zebra and Quagga Mussels has also negatively impacted the Round Whitefish population. Lake Whitefish have resorted to eating the mussels, but have shown a decline in growth and condition (Pothoven et al.2001). Further discussion on this issue is provided in Section 7.4. As a fish species which also consumes zooplankton, it is also presumed that increased competition from non-native fish species such as alewife and Round Goby, and competition for habitat are factors which could also adversely affect Round Whitefish populations.

Although researchers generally agree that new establishment of non-native species, continues to hamper goals to restore Lake Ontario’s historical fish communities by causing irreversible ecological effects (Mills et al. 2005), new exotic species invasions continue to occur and be reported, such as Eurasian Ruffe, Spiny Water Flea, and Rudd (OFAH/OMNR Invading Species Awareness Program 2012). In addition, there are other invasions that are less understood, including the Viral Hemorrhagic Septicemia virus on Lake Ontario fish populations (Stewart et al. 2013).

### 7.2 Habitat Quality

Round Whitefish in the Great Lakes are identified by Lane et al. (1996) as having a high affinity for small cobble and gravel as spawning substrate based on results from Haymes et al. (1984) for spawning Round Whitefish in Lake Ontario. Steinhart et al. (2007) notes the requirement that the gravel and rubble must be clean to be utilized for spawning, and often in shallow water. However since the arrival of dreissenid mussels in the Great Lakes, the condition of the substrates have changed over time as dreissenid mussels have colonized much of the hard substrate in nearshore areas. Although the widespread colonization of dreissenid mussels and consequent fouling of spawning shoals have been linked to reduction in Lake Trout spawning success where they co-exist in the Great Lakes (Marsden and Chotkowski 2001), it is possible that Round Whitefish could also exhibit similar reductions, as it is reported that Round Whitefish sometimes use the same spawning areas as Lake Trout (Steinhart et al. 2007, Normandeau 1969). However, there has been no evidence that this reduction is occurring, based on limited studies completed by OPG in 2010.

The 2010 study of Round Whitefish during the spawning season conducted by OPG in the vicinity of the DNGS demonstrated a wide variation in catch per unit effort (CPUE); from 1.1 to 18.2 fish per 24h period (SENES 2010, SENES 2011a). The group also
documented the substrate condition in the areas surveyed. Many of the sites surveyed included large areas of mussel beds (SENES 2010). The site described as most densely covered with mussels and attached algae (site D, SENES 2010) was documented as having a moderate CPUE (8.4 fish/24h). Although studies report the capture of gravid Round Whitefish females at all sites, where many sites were heavily colonized by dreissenid mussels, no correlation between site substrate and fish abundance could be established. These results suggest that spawning adults are using these sites for spawning. However, the authors point out that the presence of gravid fish in spawning condition does not necessarily imply that successful spawning is occurring. No information was found in the reports regarding the recovery of eggs in these areas or success of hatch. It is interesting to note that more than 70% adult Round Whitefish captured by OPG were older than 15 years (SENES 2011). Consequently, the low number of fish aged younger than 5 years implies that recruitment is not occurring, but it is not clear if this is due to spawning failure. Although correspondence from OPG to the Canadian Nuclear Safety Commission (CNSC) suggested that further larval Round Whitefish studies would be undertaken in 2011, this information was not available during the writing of this report. An information request was sent to OPG by the Region of Durham in September 2014, and a response has not been received.

In the case of the PNGS, located to the west of the Duffin Creek WPCP, substrates in the area were reported in the 2010 OPG report to have a higher proportion of sand and sediments than nearshore reference sites located at Thickson Point and Bonnie Brae Point. The report draws the conclusion that substrates in the area of the PNGS represent habitat of lower quality with the lowest usage documented of the nearshore habitats studied for Round Whitefish (as represented by catch per unit effort) in the survey.

Data on sediment accumulation was also collected as part of the early OPG studies and summarized in Holmes et al. (2002) to indicate that sedimentation had a strong negative influence on the survival of Round Whitefish embryos over the winter (Griffiths et al. 1995).

7.3 Predation

While a review of available research related to the food web of Round Whitefish and their role as predator/prey did not reveal data pertaining to predation of Round Whitefish specific to Lake Ontario, this aspect was the subject of many other studies.

Stewart et al. (2007) summarizes the work performed in a variety of North American lake ecosystems with regard to diet and role of the species. Predation of Round Whitefish has been documented to include predation of eggs by White Sucker, Yellow
Perch, Burbot, Brown Bullhead (Normandeau, 1969), and crayfish. Round Whitefish are also documented to have been eaten by Burbot (Bendock and Burr 1984), Northern Pike (Rawson 1951), Lake Trout (Bendock 1980) and Smallmouth Bass (Steinhart et al. 2007). Normandeau (1969) also noted heavy predation on newly hatched fry, with observations of over 200 fry in the stomachs of Atlantic salmon in Newfound Lake, New Hampshire. Predation by Smallmouth Bass, Yellow Perch and Rainbow Smelt were cited as one of the primary reasons for the decline of Round Whitefish observed in the Adirondack lakes (Steinhart et al. 2007).

Because of their relatively small size, it is likely that there are many other species that prey on Round Whitefish opportunistically, but their efforts are not specifically targeting Round Whitefish. Accordingly, the decline of Round Whitefish may also be a function of top down predation by large fish predators. Riley (2008) attributes decreasing abundance of some species such as Alewife, Rainbow Smelt, and Deepwater Sculpin in Lake Huron to the effects of fish predation, as these species constitute a major part of the diets of important fish predators such as Chinook Salmon, Lake Trout, and Burbot. Declines in Rainbow Smelt and Alewife abundance in Lake Huron in the 1990s coincides with increased abundance of Chinook Salmon, and Sea Lamprey control efforts may have also resulted in the increased abundance of predators. With the overwhelming desire of stakeholders in Lake Ontario to promote a recreational fishery of naturalized and exotic salmonids, considered a driving force in Lake Ontario fish management (Mills et al. 2003), there can be little doubt that the top-down effect of caused by the burgeoning salmonid fishery that is supplemented through fish stocking, as well as recovering Lake Trout populations exert a considerable influence on Round Whitefish populations.

Egg predation by Round Goby, an invasive species in Lake Ontario found in increasing numbers, is documented as an interstitial predator of eggs (Fitzsimons et al. 2006). Round Goby has been documented in catches of Round Whitefish collected by OPG in the Pickering and Darlington areas (SENES 2010, OPG 2010). Round Goby predation on Round Whitefish eggs is likely and could result in decreasing recruitment success. Mills et al. (2003) notes that Round Goby will likely play a special role in the coming decades as both a benthic prey and an energy vector between Dreissena mussels and other fish species in the benthic food web of Lake Ontario. Round Goby has proliferated widely through the Great Lakes. Riley (2008) notes that the establishment of Round Goby in Lake Huron is likely to have affected the abundance of deepwater demersal fish species. Populations of Mottled Sculpin, Logperch, and Johnny Darters have declined dramatically in areas colonized by Round Goby.
7.4 Food Availability

Information on the diet of Round Whitefish larvae is sparse and generally based on an analysis of stomach contents of larvae collected during surveys at the DNGS site in 1993 and 1994 (Pope 1995). Pope’s findings are summarized by Holmes et al. (2002) to state that the majority of prey items found in the larval fish were chironomids, with unidentified copepods comprising the next largest group.

Stewart et al. (2007) describes the diet and food web relationships of Round Whitefish, and highlighted the dietary differences and predators in relation to life history stage and habitat. A generalized food web, showing the direction of energy flow is provided in Figure 1. Although the generalized food web shown in Figure 1 was developed from Round Whitefish populations in the Northwest Territories (Stewart et al. 2007), review of literature from other sources (Scott and Crossman 1998, Steinhart et al 2007) indicate that the food web is also applicable to the Lake Ontario populations, with minor changes associated with the species of fish predators (i.e introduced salmonids and exotic species) that have recently been documented in Lake Ontario.

Figure 1 Generalized Food Web for Round Whitefish (Source: Stewart et al. 2007)
It is apparent in Figure 1 that both adult and juvenile Round Whitefish are dependent on benthic macroinvertebrates, including gastropods, molluscs and insect larvae in their diet (Stewart et al. 2007, Steinhart et al. 2007), such that changes in abundance, availability and species composition of these food sources will also affect Round Whitefish populations in the Great Lakes. In benthic studies conducted within the Great Lakes, it has been determined that benthic communities have undergone changes in composition and abundance in recent years in response to invasive species. For example, a study conducted by McNickle et al. (2006) used benthos data from Lake Huron to illustrate that shallow water benthos communities tend to be more homogeneous (dominated by zebra mussels and isopods) since the invasion of dreissenid mussels (2002-03) than was the case historically (1980-81). Owens and Dittman (2003) also documented the collapse of Diporeia (a small, shrimp-like crustacean), formerly the most abundant macroinvertebrate in the benthic community, along with sharp declines in the abundance of Oligochaeta and Sphaeriidae. These declines coincided with the establishment and rapid expansion of Dreissena bugensis, the Quagga Mussel, and to a lesser degree Dreissena polymorpha, the Zebra Mussel. The group suggested that the collapse of populations of two native benthivores (Slimy Sculpin and Lake Whitefish) in eastern Lake Ontario was perhaps due in part to the removal of a major food source (Diporeia).

The linkage between the decline of the Diporea and the subsequent increase in dreissenid mussels has been linked to the demise of Lake Whitefish populations in eastern Lake Ontario (Owens et al. 2005), and as such, it is plausible that a similar effect is also occurring in Round Whitefish populations. Lozano et al. (2001) observed a decline in Diporeia as a result of interspecific competition with dreissenid mussels. According to Lozano et al. (2001), the decline of Diporeia was attributed to a redirection of energy from open water to habitats occupied by Dreissena. With their high ability to spread and colonize both soft and hard substrates and high ability to filter large volumes of water for food, food particles such as algae and diatoms that would have normally settled to the bottom and became available to Diporeia was diverted to Dreissena and converted into dreissenid tissue and biodeposits. This diversion had the effect of depriving Diporea and other deepwater macroinvertebrates of food settling in the water column (Lozano et al. 2001). In a more recent paper from Lozano (2011), a toxin/pathogen associated with dreissenid pseudofeces, along with the redirection of the food source may be responsible for the lake wide decline of Diporeia. Lozano et al. (2001) postulated that a decline in macroinvertebrate densities, especially populations of an important food item such as Diporeia in Lake Ontario sediments at depths of 12–88 m may have had a detrimental impact on the benthic food web. Owens et al. (2005) stated that they do not expect Lake Whitefish populations to recover unless the Diporeia population either recovers or is replaced by another suitable prey. While Lake Whitefish are considered to be mainly benthivores, a more recent study have noted predation on
Round Goby (Pothoven and Madenjian 2013) by Lake Whitefish, but this shift in diet has not resulted in an improvement in their overall condition.

Because of the similarities in diet, the significance of food availability with respect Lake Whitefish populations has important parallels that can be made towards Round Whitefish populations. Owens and Dittman (2003) suggest that with the disappearance of Diporeia, the diet of Lake Whitefish and Slimy Sculpin shifted to other prey. Changes in Lake Whitefish diet following shifts in the benthic community have been well documented in Lake Michigan and Ontario (Hoyle 2005, Pothoven 2005). Pothoven and Nalepa (2006) found that young Lake Whitefish eating shelled prey or other macroinvertebrates had less energy than those utilizing zooplankton. Diporeia has much higher lipid content than many other macroinvertebrates, including dreissenids (Owens et al. 2005). As the alternative food sources were apparently insufficient to sustain these two benthivores at their former levels of abundance, a collapse in the population ensued (Owens and Dittman 2003). It is reasonable to conclude that Lake Whitefish and Round Whitefish are sympatric demersal species that are known to prey on small amphipods and that the loss of a food source such as Diporeia can have a similar negative effect on Round Whitefish populations. According to Owens et al. (2005), Diporeia populations in Lake Ontario had disappeared or nearly disappeared from a wide area off of Prince Edward County and Bay of Quinte by 1995. Since the Diporeia decline is known to have led to the collapse of Lake Whitefish population in this region of Lake Ontario, it is also reasonable to conclude that a similar collapse would have occurred within the resident Round Whitefish population.

7.5 Nearshore Water Temperatures

Literature sources have indicated that coldwater species could be negatively affected by increases in water temperature brought about by climate change, which will alter thermal habitat and distribution and growth of aquatic organisms (Casselman 2002). In the case of the Round Whitefish, it is reasonable to assume that increased competition from cool and warmwater species, changes in availability of food, reductions in the availability of habitat (Sharma et al. 2009) could also negatively affect Round Whitefish populations in the north shore of Lake Ontario. Climate change is also expected to exacerbate non-native species invasions as conditions in the nearshore become less suitable for existing species and may become more suitable for invasive species. Mills et al. (2005) postulates that the impacts (both positive and negative) of global warming on fish species will depend on species-specific thermal requirements and changes in thermal habitat. For example, increasing nearshore water temperatures in late fall and early winter may negatively affect fish survival and emergence, notably of lake trout and whitefish (Casselman 1995), while at the same time promoting stronger year-classes of warmwater species such as smallmouth bass (Casselman et al. 2002) and alewife.
Patrick et al. (2013) investigated the impact of fixed and variable increases in water temperature on the incubation and development of Round Whitefish eggs collected from Lake Ontario and Lake Whitefish eggs collected from Lake Huron, with the intention of refining thermal effect endpoints as they relate to exposure of the species to industrial plant discharges. The focus of their study was to determine how increased temperatures above the ambient temperatures of the Great Lakes affect the timing of the hatch for these species. The conclusion of the study was that both Lake Whitefish and Round Whitefish eggs exposed to increasingly higher temperatures hatched earlier (Patrick et al. 2013). This advanced hatching in response to increased water temperatures has been established for other species, including Yellow Perch (Griffiths 1978), Lake Trout (Casselman 1995), and Eurasian Perch (Sandström et al. 1995). The implication of this finding relates to the mismatched timing of hatch and availability of food, such that advanced hatch of Round Whitefish and Lake Whitefish may indirectly lead to mortality due changes in food supply (Patrick et al. 2013). For example, Hoyle et al. (2011) determined that the success of larval Lake Whitefish is related to the availability of spring prey, namely zooplankton. It is reasonable to assume that growth and recruitment of Round Whitefish embryos will be similarly affected. Although the importance of zooplankton in the diet of Round Whitefish larvae is not known, zooplankton is a major part of their adult diet and it is presumed that they are also consumed by larval fish. In the case of Round Whitefish, the availability of benthic invertebrates under increased water temperatures would need to be further explored to determine if impacts related to food availability at an earlier timing of hatch are apparent.

In literature reviewed by Holmes et al. (2002) observations and hypotheses regarding Round Whitefish age structure data at DNGS and PNGS sites conducted in 1987 argued that cold winters result in greater embryonic survival and larger year-classes of fish in Lake Ontario because the formation of ice cover over nearshore spawning shoals protected developing embryos from wind-induced turbidity and wave damage (Griffiths 1987). Generally, cold falls and severe winters have been documented to have a positive effect on year-class strength of fall spawning, coldwater species (Casselman 2002). For example, the resurgence of whitefish in Lake Ontario in the late 1970s and early 1980s likely resulted from an abnormally cold fall and winter in 1976-77 (Casselman 1996). Casselman (2002) reported an overall warming trend in Lake Ontario mean surface water temperature of 1.02 degrees Celsius (°C) over a 51 period from 1950 to 2000, which is likely to continue into the future. Past climate trends indicate that the average air temperature in Canada has increased 1.2°C in the last 58 years (Environment Canada, 2006). These studies indicate that water temperatures in the nearshore may play a role in the survivorship of Round Whitefish larvae either directly or indirectly. Chronic warming of nearshore waters will likely have detrimental effects on coldwater fish species, which includes Round Whitefish.
8.0 Conclusion

Based on LOMU catch records taken over the past few years, Round Whitefish are declining in Lake Ontario, with the apparent cause of the decline not fully understood (SENES 2011). Accordingly, a literature review was undertaken to review and interpret the available information in an effort to understand the possible causes of decline of Round Whitefish along the northshore of Lake Ontario. Round Whitefish is one of the least studied Coregonines, with more information available on other closely related species such as Lake Whitefish, where some parallels in their life history can be drawn. This literature review summarizes the results of scientific research conducted on the Round Whitefish currently available through government documents, technical and industry reports regarding the life history of the species including such ecological factors as diet, habitat requirements, reproduction, predation, and competition.

Lake Ontario has undergone a number of changes over the last few decades. Currently, the fish community is a mix of native and non-native species which continues to change in response to a variety of pressures. As a result, significant changes to the biodiversity of the Great Lakes have been realized, many of which scientists are still in the process of understanding. In Lake Ontario, this situation is worsened by its position as a receiver of water from the other Great Lakes, experiencing similar stresses. It is clear that understanding the decline of Round Whitefish in Lake Ontario cannot be uncoupled from what is happening to Lake Ontario within recent history. It is evident that multiple physical and biological stressors have caused profound changes in the Lake Ontario ecosystem (Mills et al. 2003, Mills et al 2005), which has led to significant and widespread changes in the fish community. It is apparent that the Lake Ontario food web and energy partitioning within the food web has become more complex, particularly in nearshore waters.

Lake Ontario has experienced significant reductions in phosphorus, with a concomitant shift toward oligotrophy and a dramatic increase in water clarity resulting from both nutrient reduction and proliferation of filter-feeding Dreissena spp. As a result of increased clarity, light penetration has increased along much of the nearshore. The response to greater light penetration is reflected in a redirection of energy production from the pelagic to the benthic habitat. Researchers predict that benthic energy pathways will be favoured over pelagic energy pathways, particularly in nearshore and embayment habitats of Lake Ontario, and that the shift in the direction of energy flow will have dramatic ecological consequences for Lake Ontario. So far, researchers have documented many examples of increased water clarity and rising water temperatures favouring the colonization of bottom-dwelling organisms, promoting fish communities that make efficient use of the benthic habitat, and enhancing growth rate cycles of benthic algae and submersed aquatic vegetation. It is generally agreed that climate
change (global warming) and species invasions are the key drivers of coldwater fish population extirpation, and this effect has been predicted for Cisco (Coregonus artedii), a fish species that is closely related to the Round Whitefish (Sharma et al. 2011).

Given the scope of the works associated with the preferred alternative to address the limitations of the Duffin Creek WPCP outfall, no direct relationship was found in the literature review to support a pathway of effect between the project and the spawning of Round Whitefish in particular. Based on the literature review, no single cause for the decline of Round Whitefish could be identified; however, it is likely that declines are in response to lake-wide changes that have occurred over time, as similar declines have been observed in other offshore benthic fish species. There is currently no evidence in the literature to suggest that changes to the loss of spawning habitat are responsible for declines in Round Whitefish populations. There are also no references in the literature reviewed suggests that extensive growth of Cladophora affects Round Whitefish spawning habitat.
9.0 References


LGL Limited. 2013. Class Environmental assessment to Address Outfall Capacity Limitations at The Duffin Creek Water Pollution Control Plant – Natural Sciences Report. 99p.


New York State Department of Environmental Conservation (NYSDEC). 2014. Round Whitefish Fact Sheet, Bureau of Fisheries as viewed at: Round Whitefish Fact Sheet, Bureau of Fisheries webpage


Introduction

Stage 3 expansion of the Duffin Creek Water Pollution Control Plant (WPCP) was competed and brought on line in February 2012. With the completion of the expansion, the treatment capacity of the WPCP was increased to 630 million litres per day (MLD). Although the WPCP was able to treat flows up to 630 MLD, lake modelling studies indicated that near-field Ministry of Environment (OMOE) guidelines at the outfall would be exceeded when increased beyond 560 MLD. Nevertheless, the Ministry of Environment issued a Certificate of Approval (C of A) for the expanded plant on condition that the plant was not operated at a flow in excess of 540 MLD and that Regional Municipalities of York and Durham (the Regions) initiated measures to address the limitations of the existing outfall. To that end, the Regions undertook a multi-stage study to:

- identify potential solutions to limitations of the outfall,
- select a preferred alternative and assess the impacts, and
- assess the social and environmental impacts associated with implementation of the of the preferred alternatives

Results of the study were presented in the Class Environmental Assessment to Address Outfall Capacity Limitation at the Duffin Creek Water Pollution Control Plant (Report) (CH2M Hill 2014). Optimization of operations at Duffin Creek WPCP to meet the 311 kg daily load limit for Total Phosphorus and modification of the existing outfall structure by installing variable port openings on the diffuser was selected as the preferred alternative (CH2M Hill 2014). Assessment of impacts on the terrestrial and aquatic habitats inidcated that:

- terrestrial and aquatic environments would not be affected because no in-water or land-based construction was required
- the increase in size of the mixing zone for unionized ammonia was small in relation to the baseline
- fish and fish habitat would not be affected because there were no specialized habitats within the mixing zone and use of the mixing zone by fish was on a transient basis.

and concluded that the implementation of the preferred alternative would not result in adverse effects on the terrestrial and aquatic environment.
Upon review of the Report, the Town of Ajax submitted a request that the Minister of Environment issue a Part II Order, requiring the Regions to undertake a full individual environmental assessment of measures to address the outfall capacity limitations at the Duffin Creek Water Pollution Control Plant. As part of the Regions’ response to the Part II Order request, a literature review of the scientific literature on Round Whitefish (Prosopium cylindraceum) was conducted and a Technical Memorandum addressing the concerns raised about Round Whitefish in the Part II Order Request filed by the Town of Ajax was prepared. The Regions contracted Fish Habitat Solutions to review two documents entitled:

- Literature Review of Recent Scientific Research on the Round Whitefish (Prosopium cylindraceum) prepared for CH2M Hill Canada on behalf of The Regional Municipality of York and The Regional Municipality of Durham by LGL Limited
- Technical Memorandum: Outfall Class EA - Part II Order Request - Response to Issue and Concern on Round Whitefish prepared by CH2M Hill

prepared in support of their response to the Part II Order Request. Review comments are provided in the following.

**Review of Recent Scientific Research on the Round Whitefish (Prosopium cylindraceum)**

Mraz (1964) found Round Whitefish (RNWH) to be the least studied coregonine species. Little has changed since his paper was published in 1964. Apart from a small number of geographically localized studies focused on relatively small isolated lakes, or occasional studies in selected areas of the Great Lakes and in Alaska and the Northwest Territories, few investigations of the biology, behaviour, or habitat requirements of RNWF have been reported in the scientific literature. The literature review undertaken by LGL Limited (LGL) included most, if not all, the pertinent scientific literature on RNWH that is readily available.

The literature review includes a short discussion of the Lake Ontario ecosystem, largely summarized from Stewart et al. (2013), which provides context for the discussion of trends in RNWH populations and factors affecting Lake Ontario RNWH populations. In general, the literature review provides a good summary of the state of knowledge on RNWH. Some specific comments follow on:

- Section 3.0 Round Whitefish Life History
- Sections 5 The Lake Ontario Ecosystem,
- Section 6 Trends in Round Whitefish Population
- Section 7 Factors with Potential to Impact Round Whitefish and
- Section 8 Conclusion

**Section 3.0 Round Whitefish Life History**

The discussion of RNWH life history in this section is a bit sparse. Although the information provided covers the main aspects of the RNWH life history, additional information is available. Appendix 2 in Steinhart et al. (2007) provides a good review of a number of factors associated with the life history and ecology of RNWH. Additional information is available in Stewart, et al. (2007). Steinhart et al. (2007) are referenced in this Section, but only with respect to diet. Augmenting the current information on life history with the information provided in Steinhart et al. (2007) and (Stewart, et al. 2007) would make Section 3.0 more complete.

● Page 2
Section 5.0 The Lake Ontario Ecosystem

The Section summarizes the information on the Lake Ontario Food Web presented by Stewart et al. (2013). The section is useful because it sets the framework within which the Lake Ontario fish community functions. In particular, it points out that there are a number of factors at play, all of which have some degree of influence on Lake Ontario fish, and no single factor is likely responsible for the present state of Lake Ontario fish populations and communities. Additional information on changes to the Lake Ontario fish provided in Mills et al. (2003) and (Mills et al. 2005). Section 5.0 would be improved by including the information presented in the latter two publications.

Some of the discussion is carried through into Section 6.0 Trends in Round Whitefish Populations. Consideration might be given to moving the first paragraph of Section 6 to follow the discussion provided in Section 5. While this is not critical, doing so would likely improve flow and readability.

Section 6.0 Trends in Round Whitefish

The summary of the Lake Ontario fish community prior to European colonization provided by Stewart et al. (2013) describes the offshore shallow water and deep water fish communities. According to Stewart et al. (2013), Lake Whitefish, Lake Cisco, and Slimy Sculpin were abundant in shallow water offshore waters, whereas deeper offshore waters were dominated by four species of deepwater Cisco and Deepwater Sculpin. The first paragraph of Section 6 should be modified to reflect this. The list of fish species extirpated or reduced in abundance from 1970 should include Burbot and Lake Trout. This is consistent with Stewart et al. (2013).

Section 6 indicates that populations of RNWH, along with other offshore benthic species, appear to be declining. The statement is based on Ontario Ministry of Natural Resources catch data. However, the reference provided is not correct. The information in Section 6.0 was taken from the Lake Ontario Management Unit Annual Reports for the years 2011, 2012 or 2013 (OMNR 2012, OMNR 2013, OMNR 2014) not Stewart et al. (2013) as reported.

Section 6 indicates that Ontario Power Generation (OPG) undertook investigation of RNWH habitat use and effects of water temperature on RNWH hatching success, as well as stomach contents of RNWH, substrate conditions at RNWH spawning grounds, and effects of sedimentation on RNWH embryo development. However, this information does not appear to be reported in Section 6 or Section 3 dealing with life history. If this information is available it should be summarized and presented, ideally in Section 3.

The discussion of trends in RNWH populations should include the COSEWIC status of RHWH, as well as its latest status as reported by the Canadian Endangered Species Conservation Council (CESCC). Currently, RNWH have been given a low priority for assessment by COSEWIC and deemed in the 2005 Wildlife Species Report prepared by the CESCC National General Status Working Group lists RNWH in Ontario as secure (CESCC 2006).

Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario

Section 7.0 reviews several factors that could potentially affect RNWH in Lake Ontario. The authors conclude that categorically identifying a single factor responsible for the decline of RNWH is difficult. However, it is clear that the decline of RNWH cannot be divorced from the ecological changes that are happening to the Lake Ontario ecosystem this point needs to be stated clearly at the outset.

Five factors are discussed:

● Page 3
- invasive species
- habitat quality
- predation
- food availability and
- nearshore water temperatures

The discussion of factors summarizes the information presented in the available literature. However, a discussion of how those factors could contribute to the decline of RNWH is lacking. The section would benefit from including a discussion of how the information set out in the literature for each of the factors links back to RNWH populations along the northshore of Lake Ontario.

**Invasive species**
The effects of invasive species, particularly dreissenid mussel, on the Great Lake and Lake Ontario ecosystem cannot be overstated. The change in the Lake Ontario ecosystem has been profound and is likely irreversible (Mills (2003). It is not coincidental that changes in fish populations observed in the Great Lakes follow upon introduction of dreissenid mussels (Mills et al. 2003, Mills et al. 2005, Riley et al. 2008). The changes in Lake Ontario brought about by the invasive species and other stressors are described in detail by Mills et al. (2003).

The literature review acknowledges the role of dreissenid mussels and includes a paragraph taken from (Stewart et al. 2013). However, the effect of dreissenid mussels and other invasive species is dealt with superficially. The literature review would benefit from including a summary of the stressors affecting Lake Ontario and the response of the fish community to them as described by Mills et al. (2003, 2005). The summary of stressors and responses could then be used to draw parallels to RNWH. A summary discussing whether this is a likely factor affecting RNWH is needed. Although the absence of specific studies will likely prevent making direct linkages to RHWH explicitly, a number of implicit linkages could be made.

**Habitat Quality**
The literature review states that dreissenid mussels have colonized much of the hard substrate in Lake Ontario, including the small cobble and gravel which is used by RNWH for spawning. Little information about habitat preferences is provided. The authors indicate that no research on the use or preference of substrates by RNWH for spawning in Lake Ontario has been conducted. While this is true, a number of studies (Lane 1996)Steinhart et al. 2007, Stewart et al. 2007) do provide some general information on habitat suitability and life history. Information from these papers would augment the discussion of RNWH life history presented in Section 3.
Section 6 reports the results of studies undertaken by OPG in 2010 near the Darlington Nuclear Generating Station (DNGS) (SENES 2010, SENES 2011). Studies captured gravid female RNWH at all sites. Many of the sites were heavily colonized with dreissenid mussels; however, no correlation between site substrate and fish abundance could be established. The authors conclude that aggregation of fish suggests that sites are being used by RNWH for spawning. As the authors correctly point out, the presence of gravid fish does not necessarily imply spawning success. Egg survival and emergence data is necessary to demonstrate that successful spawning is occurring. Although an attachment to correspondence between OPG and the Canadian Nuclear Safety Commission (CNSC) (Sweetnam 2010) suggested that larval fish studies would be undertaken in 2011, the results of these studies are not reported in the literature review. Results from the DNGS studies would help to determine if RNWH eggs surveyed through to emergence. If the larval fish studies have been complete and results are available they should be included in the literature review.

More than 70% of adult fish captured were older than 15 years (SENES 2011). The low number of fish aged younger than 5 years implies that recruitment is not occurring. It is not clear whether this is a result of spawning failure. What is clear is that spawning habitat is present along the northshore of Lake Ontario and it is being utilized by RNWH.

**Predation**

All of the major predators of RNWH have been listed. There are likely other species that prey on RNWH opportunistically but their efforts are not specifically centred on RNWH.

The authors recognize the role of Round Goby as potential egg predators. Round Goby may also affect RNWH as they become a new vector for energy flow in the benthic food web of Lake Ontario (Mills et al, 2003). Establishing of Round Goby in Lake Huron likely affected the abundance of demersal fish in Lake Huron (Riley 2008). Is it likely that top down predators are affecting RNWH in Lake Ontario? A summary discussing how this factor links to RNWH is needed

**Food Availability**

The literature review summarizes the information on the diet of RNWH available in the scientific literature. Including a figure similar to the generalized food web described by Stewart, et al. (2007) but modified, if necessary, to reflect Lake Ontario, would provide interpretation of RNWH diet and main sources of energy. The figure would also provide a starting point for subsequent discussions of food availability and possible effects on Lake Ontario RNWH populations.

The discussion of the results reported by Lozano et al. (2001) is a bit oversimplified. Lozano et al. (2001) attributed the decline in *Diaporia* to a redirection in energy from open water to the *Dressenia* beds. Material that normally settled to the bottom and then became available to *Diaporia* was diverted by the filtering feeding *Dressenia* and converted to tissue and biodeposits. Since *Diaporia* are not known to feed on *Dressenia* fecal pellets, they were deprived of this energy source. A more recent publication (Lozano 2011) suggests that a toxin/pathogen with associated dresseniid pseudofeces, together with redirection in energy, may be responsible for the lake-wide decline of *Diaporia*. According to Lozano, et al. (2001), the detrimental effect on the food web resulted from the decline of benthic macroinvertebrates in the sediment. This is not as clearly stated as it could be in the current text of this section.
The significance of food availability as a factor that might be influencing RNWH needs to be discussed. Even though specific studies for RNWH have not been undertaken, Owens and Dittman (2003) suggest that with the disappearance of Diaporea the diet of Lake Whitefish (LKWH) and Slimy Sculpin (SLSC) shifted to other prey. For LKWH this included dreissinid mussels. However, the alternative food sources were apparently insufficient to sustain these two benthivores at their former levels of abundance and a collapse in the population ensued (Owens and Dittman 2003). Is it reasonable to conclude that since both LKWH and RNWH are sympatric demersal species that are known to prey on small molluscs that the loss of Diaporea could be expected to have some effect on RNWH? If so, this should be stated. The presence of adult RNWH in good condition in 2010 studies (SENES 2011) would suggest that food availability is not the main factor affecting adults. However, the virtual absence of RNWH younger than age 5 might indicate that food availability might be hampering development and maturation of young RNWH. Growth of larval LKWH in the Bay of Quinte was linked to prey abundance. Since diets of larval LKWH and RNWH are similar, is it possible that declines in the number of small copepods and cladocerans affected survival and recruitment of RNWH?

Nearshore Water Temperature
The literature review indicates that a warmer water temperature resulted in earlier hatching of incubating eggs. An early hatch could result in a mismatch between the timing of the hatch and the availability of food. Studies on LKWH by (Hoyle et al. 2011) indicated that availability of spring prey was an important factor in larval fish growth. It is reasonable to assume that growth and recruitment of RNWH embryos could be similarly affected. The importance of zooplankton in the diet of RNWH larvae is not known; however, zooplankton are part of the adult diet and it is likely that they are also consumed by larval fish. The literature also indicates that higher recruitment follows colder winters, suggesting that these species appear to benefit at colder temperatures. An overall warming trend of in mean Lake Ontario surface water temperature of 1.02°C over the 51 year period from 1950 to 2000 was reported by Casselman (Casselman 2002). Warming of nearshore waters is expected to continue. Chronic warming will likely have detrimental effects on coldwater fish species, including RNWH.

Section 8.0 Conclusions
The conclusions could be strengthened and refocused. The following points need to be brought out.

- RNWH are declining in Lake Ontario
- Literature review was undertaken to review and interpret the available information on RNWH in an effort to understand the possible causes of the RNWH along the northshore of Lake Ontario
- Round whitefish is one of the least studied coregonines
- Available information on the life history of the RNWH, including diet, habitat requirements, reproduction, predation, and competition was reviewed
- Understanding the decline of RNWH in Lake Ontario cannot be uncoupled from what is happening to Lake Ontario
- Multiple physical and biological stressors have caused profound changes in the Lake Ontario ecosystem (Mills et al. 2003, Mills et al 2005).
- Lake Ontario has experienced
  - significant reductions in phosphorus with a concomitant shift toward oligotrophy
  - a dramatic increase in water clarity resulting from both nutrient reduction and proliferation of filter-feeding Dreissena spp.
  - As a result of increased clarity, light penetration has increased
- The response to greater light penetration is reflected in a redirection of energy productions from the pelagic to the benthic habitat.
- Benthic energy pathways will be favoured over pelagic energy pathways, particularly in nearshore and embayment habitats of Lake Ontario.
  - Shift in the direction of energy flow will have dramatic ecological consequences for Lake Ontario.
    - favouring colonization of bottom-dwelling organisms,
    - promoting fish communities that make efficient use of the benthic habitat, and
    - enhancing growth rate cycles of benthic algae and submersed aquatic vegetation.
- No single cause for the decline of RNWH could be identified, however, it is likely that declines are in response to lake-wide changes.
- No evidence in the literature suggests that changes to the loss of spawning habitat are responsible for declines in RNWH.
- No references in the literature reviewed suggest that extensive growth of Cladophora affects RNWH spawning habitat.
- No references in the literature reviewed indicate that the loss of spawning habitat is responsible for declines in RNWH.

**Technical Memorandum: Outfall Class EA - Part II Order Request - Response to Issue and Concern on Round Whitefish prepared by CH2M Hill**

The Technical Memorandum entitled *Outfall Class EA - Part II Order Request - Response to Issue and Concern on Round Whitefish* (Tech Memo) was prepared by CH2M Hill to respond to issues identified in the Part II Order Request submitted by the Town of Ajax. In general, the responses provided in the Technical Memorandum are appropriate, are supported by the current scientific knowledge, and are consistent with environmental assessment practices. Additional comments on specific sections of the Tech Memo are provided where warranted.

**Section 1 Introduction**

The focus of attention on RHWH and assessment of effects on RNWH spawning habitat appears to have arisen from the assumption that RNWH are an accepted indicator of aquatic community health (Ecometrix 2014). RNWH were selected as a Valued Ecosystem Component (VEC) in the environmental assessment associated with the expansion of both Pickering Nuclear Generating Station (PNGS) and the Darlington Nuclear Generating Station (DNHS). Since the concept was originally introduced in the early 1980s by Gordon Beanlands and Peter Duinker (Beanlands and Duinker 1983) use of VECs has become a standard practice in environmental assessment. The purpose of VECs is to focus the assessment on a relatively small number of species that are of greater local importance and to consider these species as indicators or “sentinels” of environmental impacts (Golder and SENES 2009). RNWH were selected as VECs for the environmental assessment of the PNGS and DNGS specifically because of:

- potential thermal effects on nearshore spawning shoals
- concerns surrounding entrainment of eggs and larvae,
- and habitat loss with construction in the nearshore (DNHS).

(Golder 2007, Golder and SENES 2009).
VECs are project specific and will often vary from one project to another, as the environmental effects of each project can be different. Selection of RNWH as a VEC for the PNGS and DNGS environmental assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health.

Considering, that the project as currently proposed will not involve in-water construction within the nearshore zone and will not result in an increase in phosphorous loadings, the decision not to use RNWH as a VEC is justified and consistent with accepted enviromental assessment methods.

**Section 2 Summary and Conclusion**

There are references in the literature (Higgins, et al. 2008) that suggest that *Cladophora* provides habitat for a number of aquatic invertebrates, primarily *Gammarus* spp. and chironimids, as well as cladocerans, tricopterans, mollusks, and crayfish. As these organisms are part of the diet of many fish species, it could be argued that *Cladophora* has a beneficial effect on fish communities. Similarly, mats of filamentous algae such as *Cladophora* are highly associated with spawning habitat of Longnose Gar, Lake Chubbsucker, Golden Shiner, and Greenside Dace (Lane et al. 1996), and newly hatched pike preferred cover provided by *Cladophora* to that provided by more structured aquatic macrophytes (Engstrom-Ost and Mattila 2008). Survival rates of pike larvae in the presence of predation threats were also higher when filamentous algae were present (Engstrom-Ost and Mattila 2008). However, it is unreasonable to imply that such benefits make accumulations of *Cladophora* that reach nuisance levels acceptable or beneficial to fish and fish habitat.

**Section 3 Literature Review - Round Whitefish and its Decline in Lake Ontario**

See previous comments on habitat benefits of *Cladophora* (Section 2)

**Section 4 Response to Statements in Ajax Part II Order Report**

Comment 1: *there is no assessment at all of the effect excessive Cladophora growth has on fish or fish habitat*

The effects of the project on *Cladophora* growth was assessed. The assessment determined that local point sources were not major contributors to *Cladophora* growth and that Cladophora growth was primarily driven by factors operating on a lake-wide basis. Moreover, loadings of Phosphorous, the nutrient affecting growth of *Cladophora*, will not be changed by the project and will remain at the current level of 311 kg/d. As *Cladophora* growth appears to be result of lake wide phenomena and baseline phosphorous loading will not be changed by the implementation of the preferred alternative, no effects on *Cladophora* growth are expected. The assessment of effects of *Cladophora* on fish or fish habitat does not appear warranted.

Comment 2: *there is a lack of information and data on fish species, habitat and the current conditions of the lake bottom within the nearshore*

**Fish Habitat and Lake Bottom Conditions**

The preferred option for the outfall will not involve in-water construction in the nearshore zone and will not change phosphorous loadings. There will be an increase in the size of the mixing zone for un-ionized ammonia to 5.7 ha from 4.1 ha; however, even with the increase in size, the mixing zone occupies a small portion of the surface area of the 1800 has nearshore zone. For the purpose of visualization, 5.7 ha can be represented by a circle with a radius of about 135 m or a square of about 240 x 240 m. By contrast, 1800 ha would occupy a circle with a radius of 2.3 km or a square about 4200 m by 4200 m. It is recognized that the shape of neither the mixing zone nor the nearshore zone is a circle or a square.
Taking into account the nature of the expected effects associated with the preferred alternative, the available information on the conditions of the lake bottom within the area affected is adequate for the assessment.

**Comment 3: there is no assessment of the current use of habitat by Round Whitefish, a key local species, or other species and the potential for excessive Cladophora to impact fish habitat**

RNWH were selected as a VEC for the environmental impact assessment associated with the PNGS and DNGS. The use of RNWH as a VEC for the PNGS and DNGS environmental assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health or that RNWH are appropriate as VECs for all environmental assessments on the northshore of Lake Ontario.

**Comment 4: there is a lack of current information on the reproductive success of Round Whitefish in Lake Ontario, and within the area studied by the Regions**

The purpose of the environmental assessment was to assess the effects of the preferred alternative. The preferred alternative did not involve in water work in the nearshore area that would have physical effects on shoreline or littoral habitats, and Phosphorus loadings did not change from baseline conditions. Information on fish and fish habitat in the area was adequate for the purpose of the assessment. Additional information on the reproductive success of RNWH would not have changed the outcome of the assessment.

**Comment 5: there is no assessment of the effect the mixing zone has or will have on important fish habitat and/or spawning areas.**

Mixing zone for Phosphorus for the preferred alternative is reduced in size and the mass loading of 311/kg/d remains unchanged. Although the mixing zone for un-ionized ammonia has increased relative to existing conditions, the 5.7 ha mixing zone is still small in comparison the area of the nearshore zone within the Study Area. Data collected for the study indicate that the lake bed consists of sand and cobble with intermittent boulders. These features are neither unique nor in short supply within the area. Any effects within the mixing zone, should they occur, will be localized. The overall supply of similar habitats will not be changed substantially.

### Section 5 Response to Statements in Ecometrix Report

**Statement 1: Effects of Cladophora on Fish Habitat**

RNWH were specifically selected as a VEC for the environmental assessment of the PNGS and DNGS because of:

- potential thermal effects on nearshore spawning shoals
- concerns surrounding entrainment of eggs and larvae and,
- habitat loss with construction in the nearshore

(Golder 2007, Golder and SENES 2009). VECs are project specific and will often vary from one project to another. The use of RNWH a VEC for the PNGS and DNGS environment assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health or that RNWH are appropriate as VECs for all environmental assessments on the northshore of Lake Ontario.
Nuisance growths of Cladophora are a lake wide problem and appear to be driven by changes in substratum, water clarity, and P availability associated with the establishment of dense dreissenid mussels (Higgins, et al. 2008). Contributions of phosphorus from local point sources have a small influence on conditions supporting Cladophora growth (Leon, et al. 2009). The preferred alternative will not change phosphorous loadings, which will remain at the current level of 311 kg/d. As Cladophora growth appears to be the result of lake wide phenomena, and phosphorous loading will not be changed, the preferred alternative is not expected to affect Cladophora growth. The assessment of effects of Cladophora on fish or fish habitat does not appear warranted.

Statement 5: Lack of Information on Fish Species, Fish Habitat Data and Substrates within the Study Area - Section 5.1 (Page 5-1) - Fish habitat utilization was not appropriately assessed for the offshore zone of the study area.
The purpose of the environmental assessment was to assess the effects of the preferred alternative. The preferred alternative did not involve in water work in the offshore and consequently will not have physical effects on lake bottom habitats. Phosphorus loadings did not change and the mixing zone for for un-ionized ammonia will remain small. Taking into account the nature of the expected effects associated with the preferred alternative, the additional information on utilization of offshore fish habitats would not change the assessment.

Statement 7: Lack of Information on the Current Use of Habitat by Round Whitefish and Impact on Habitat - Section 5.2 (Page 5-3)
See previous comments on selection VECs

Statement 8: Lack of Information on Round Whitefish Reproductive Success
See previous comments on RNWH reproductive success

Statement 9: Additional Comments on the ESR - Section 5.4 – Comment on page ES-11 of the ESR, Table ES 1 net effects for Natural - states that no important fish habitat was recorded in the mixing zone
Using the term “no important habitat” may have been a poor choice of words. Data collected for the study indicate that the lake bed consists of sand and cobble with intermittent boulders. These features are neither unique nor in short supply within the area. Any effects within the mixing zone, should they occur, will be localized. The overall supply of similar habitats will not be changed substantially.

Statement 10: Additional Comments on the ESR - Section 5.4 – comment on Page 2-6, Section 2.2.3 of the ESR – Phosphorous and unionized ammonia are identified as the most sensitive parameters with potential impacts to algal blooms and fish toxicity, yet there is no assessment in the ESR or supporting documents of the potential for excessive Cladophora growth to impact fish or fish habitat.
Although Cladophora provides habitat to many benthic invertebrates and is used as spawning and nursery habitats, it is unreasonable to imply that such benefits make accumulations of Cladophora that reach nuisance levels acceptable or beneficial to fish and fish habitat.

Adverse effects of Cladophora on RNWH habitat or habitat of other species have not been documented in the literature. However, the literature indicates that nuisance growths of Cladophora are a result of changes in substratum, water clarity, and P availability associated with the establishment of dense dreissenid mussels (Higgins, et al. 2008), and local point sources have a small influence on conditions that support Cladophora growth (Leon, et al. 2009). Since phosphorous loading will not be changed by implementation of the preferred alternative, assessment of the effects of Cladophora growth on fish and fish habitat would not change the outcome of the assessment.
Gathering data on the physical features present at the site and evaluating them in terms of their suitability for use species likely to be present is an accepted means of habitat assessment. Depth cover and substrate are variables that are commonly used in the assessment. Habitat surveys determined that the lake bottom within the area of the mixing zone consisted of sand and cobble with intermittent boulders. This type of habitat was ubiquitous throughout the study area. None of the species that spawn at depths ranging from 5 to 15 m show high associations with sand and cobble substrates (Lane et al. 1996).

The study area consists of a Local Study Area (LSA) and a Regional Study Area (RSA) that are described in the Environmental Study Report (CH2M Hill 2014). The RSA was established to include the area within which there was potential for cumulative biophysical effects and extended to Frenchman’s Bay in the west and to Paradise Beach in the east. The location of known RNWH spawning habitat is outside of the area considered to be affected by the preferred alternative.

See previous responses related to effects of Cladophora growth and effect on fish and fish habitat (e.g., response to Statement 1 and Statement 10.

Summary

The review of current scientific literature on RNWH included most, if not all, of the available scientific literature on RNWH. The findings of the review should clearly state that

1. RNWH are declining in Lake Ontario
2. Round whitefish is one of the least studied coregonine species
3. Understanding the decline of RNWH in Lake Ontario cannot be uncoupled from ecological changes that are occurring in Lake Ontario
4. The shift in energy pathways from pelagic to benthic brought about by the establishment and proliferation of dreissenid mussels appear to be a major driver for the ecological changes that are occurring
5. No single cause for the decline of RNWH could be identified, however, it is likely that declines are in response to lake-wide changes
6. No references in the literature reviewed suggests that extensive growth of Cladophora affects RNWH spawning habitat
7. No references in the literature reviewed indicate that the loss of spawning habitat is responsible for declines in RNWH

Response to the use of RNWH as a VEC in the assessment and the effects of Cladophera growth on RNWH spawning habitat are recurrent themes in the Technical Memorandum. The responses provided in the CH2M Hill Technical Memorandum are appropriate, are supported by the current scientific knowledge, and are consistent with environmental assessment practices.
I trust that the preceding comments will be helpful to the Project Team. Please contact me at 403-281-3553 or by email (smetikosh@shaw.ca) if you have any questions or require additional details.

Serge Metikosh
Fish Habitat Solutions Inc.

References


CH2M Hill. 2014. *Class Environmental Assessment to Address Outfall Capacity Limitation at the Duffin Creek Water Pollution Control Plant*. Environmental Study Report, prepared for the Regional Municipalities of Durham and York Region.


Attachment 3
Peer Review Comment/Response Log
2  Section 3.0 Round Whitefish Life History
The discussion of RNWH life history in this section is a bit sparse. Although the information provided covers the main aspects of the RNWH life history, additional information is available. Appendix 2 in Steinhart et al. (2007) provides a good review of a number of factors associated with the life history and ecology of RNWH. Additional information is available in Stewart, et al. (2007). Steinhart et al. (2007) are referenced in this Section, but only with respect to diet. Augmenting the current information on life history with the information provided in Steinhart et al. (2007) and (Stewart, et al. 2007) would make Section 3.0 more complete.

Section 3.0 on RNWH life history has been expanded to include more details on spawning behavior, depth distribution, age, feeding behavior, and predation from Steinhart et al. (2007) and (Stewart, et al. 2007). In addition, studies from Ontario Power Generation (OPG) specific to Lake Ontario RNWH were also added to this section.

Additional information on life history has been added
New text refers to southern and northern part of RNWH range but the actual range is not identified
The northern and southern parts of the range should be defined as well as the location of the Great Lakes within the range Page 3 Para 1
Key predators of RNWH have nothing to do with whether RNWH are target harvest species. The two are independent statements and should not be in the same sentence
Relevance of Page 4 Para 1 to RNWH Life History is not clear
Page 4 Para 2: The points that relevant to RNWH life history are masked by a clutter of information that is not really necessary. The points that need to be clear are:
Although RNWH was the dominant species captured in 2009, the percent composition of the catch in 2010 and 2009 was similar (i.e. composition of RNWH in 2009 (32%) and 31%) in 2010 (OPG 2010)
Round Whitefish ranged from three (3) to 23 years old, with 71.5% of these fish being 15 years of age or older and only 2.9% under 5 years old
RNWH population near Durham Region is aging and declining because of low recruitment
Presence of older fish is a regional phenomenon.
Page 5 Para 1: - COSEWIC and CESCC are not the same thing
COEWIC is the Committee on the Status of Endangers Species In Canada
The Canadian Endangered Species Conservation Council (CESCC) was established under the Federal Species at Risk Act and consists of the Minister of the Environment, the Minister of Fisheries and Oceans, the Minister responsible for the Parks Canada Agency and Provincial Governments Ministers who are responsible for the conservation and management of a wildlife species.
The CESCC has specific responsibilities for overseeing the listing and recovery of species that are at risk nationally, and plays a role in resolving issues under the Federal Provincial Accord for Protection of Species at Risk in Canada
RNWH have been assigned a low priority for assessment by COSEWIC
RNWH were considered secure in Ontario in the CESCC 2005 report

3  Section 5.0 The Lake Ontario Ecosystem
Additional information on changes to the Lake Ontario is provided in Mills et al. (2003) and (Mills et al. 2005). Section 5.0 would be improved by including the information presented in the latter two publications.

Section 5.0 Lake Ontario Ecosystem has been expanded to include changes to the Lake Ontario ecosystem as provided by in Mills et al. (2003) and Mills et al. (2005).

Additional information on the Lake Ontario Ecosystem has been included.
An introductory statement on why a discussion of the Lake Ontario ecosystem has been included in a literature review of RNWH would be useful to provide context
i.e., understanding the Lake Ontario Ecosystem and fish community and the changes that have occurred is necessary to understand what is happening to RNWH

Range of RNWH has been added in section 2 to describe northern and southern parts of its range and Great Lakes Locations (This has been moved to Round Whitefish Distribution Section 2.0) for better readability
Comment regarding RNWH as a target harvest species is removed from sentence discussing piscivorous fish.
Extraneous information regarding OPG studies have been removed and section has been edited to allow for greater clarity.
COSEWIC comment has been added (note that this comment is also expanded in Section 6)
<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Section 5.0 The Lake Ontario Ecosystem</td>
<td>Additional discussion on the changes to the Lake Ontario fishery that was previously in Section 6.0 was also moved to Section 5.0. Changes to the Lake Ontario fishery have been moved to Section 5. However, the section is difficult to follow. The section could benefit from some reorganization that discusses the state of the Lake ecosystem and food web and the changes that have occurred as a result of Dresser mussel and followed by the state of the fish community and then the implications of these changes to fisheries management.</td>
<td>The Lake Ontario Ecosystem this point needs to be stated clearly at the outset.</td>
<td>The comments are addressed by the changes</td>
<td></td>
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<tr>
<td>3</td>
<td>Section 6.0 Trends in Round Whitefish</td>
<td>Fish listings have been modified to reflect shallow and deepwater fish communities as reported by Stewart et al. (2013), and this paragraph has been moved to Section 5.0.</td>
<td>The comments are addressed by the changes</td>
<td>The comments are addressed by the changes</td>
<td>N/A</td>
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<tr>
<td>3</td>
<td>Section 6.0 Trends in Round Whitefish</td>
<td>LOMU catch data reference has been corrected in the first paragraph of Section 6.0.</td>
<td>The comments are addressed by the changes</td>
<td>The comments are addressed by the changes</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Section 6.0 Trends in Round Whitefish/Section 3.0 Round Whitefish Life History</td>
<td>Information on OPG Studies have been summarized and included in Section 3.0.</td>
<td>The comments are addressed by the changes</td>
<td>The comments are addressed by the changes</td>
<td>N/A</td>
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<tr>
<td>3</td>
<td>Section 6.0 Trends in Round Whitefish</td>
<td>The COSEWIC Status of RNWH and CESC working group designation is included in the second paragraph of Section 6.0.</td>
<td>The statement in Section 6.0 is correct but it is incorrect in Section 3.</td>
<td>Statement in Section 3 was corrected</td>
<td>The comments are addressed by the changes</td>
</tr>
<tr>
<td>3</td>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario</td>
<td>Introductory paragraphs on Section 7.0 have been modified to illustrate that the decline of RNWH in Lake Ontario cannot be disassociated with the ecological changes that are happening in Lake Ontario ecosystem over the past several decades, including the presence of invasive species and associated impacts to food webs, competition for resources, composition of substrates, and predation pressures.</td>
<td>The comments are addressed by the changes</td>
<td>The comments are addressed by the changes</td>
<td>N/A</td>
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<tr>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Invasive Species</td>
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<td>The literature review would benefit from including a summary of the stressors affecting Lake Ontario and the response of the fish community to them as described by Mills et al. (2003, 2005). The summary of stressors and responses could then be used to draw parallels to RNWH. A summary discussing whether this is a likely factor affecting RNWH is needed. Although the absence of specific studies will likely prevent making direct linkages to RNWH explicitly, a number of implicit linkages could be made.</td>
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</table>

| Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Habitat Quality |
| Little information about habitat preferences is provided. The authors indicate that no research on the use or preference of substrates by RNWH for spawning in Lake Ontario has been conducted. While this is true, a number of studies (Lane 1996; Steinhardt et al. 2007; Stewart et al. 2007) do provide some general information on habitat suitability and life history. Information from these papers would augment the discussion of RNWH life history presented in Section 3. |

| Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Habitat Quality |
| Although an attachment to correspondence between OPG and the Canadian Nuclear Safety Commission (CNSC) (Sweetnam 2010) suggested that larval fish studies would be undertaken in 2011, the results of these studies are not reported in the literature review. Results from the DNS5 studies would help to determine if RNWH eggs surveyed through to emergence. If the larval fish studies have been complete and results are available they should be included in the literature review. |

| Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Predation |
| Establishment of Round Goby in Lake Huron likely affected the abundance of demersal fish in Lake Huron (Riley 2008). Is it likely that top down predators are affecting RNWH in Lake Ontario? A summary discussing how this factor links to RNWH is needed. |

| Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Food Availability |
| Including a figure similar to the generalized food web described by Stewart, et al. (2007) but modified, if necessary, to reflect Lake Ontario, would provide interpretation of RNWH diet and main sources of energy. The figure would also provide a starting point for subsequent discussions of food availability and possible effects on Lake Ontario RNWH populations. A generalized food web as described by Stewart, et al. (2007) has been provided in Section 7.4. |

| Responses to Additional Comments (Sep 2014) |
| The comments were addressed by the changes. |
| The comments were addressed by the changes. |
| The comments are addressed by the changes. |
| The comments are addressed by the changes. |
| The comments are addressed by the changes. |
| The comments are addressed by the changes. |
## SCHEDULE C CLASS ENVIRONMENTAL ASSESSMENT TO ADDRESS THE LIMITATIONS OF THE DUFFIN CREEK WPCP OUTFALL – PART II ORDER RESPONSE – PEER REVIEW OF ROUND WHITEFISH CONCERN - CH2M HILL REPORT AND LGL LITERATURE REVIEW - COMMENT/RESPONSE LOG

<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/ Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Food Availability</td>
<td>Additional discussion on the linkage between the decline of the Diporeia and the subsequent increase in dreissenid mussels has been linked to the demise of Lake Whitefish populations in eastern Lake Ontario, and as such, it is plausible that a similar effect is also occurring in Round Whitefish populations is provided in Section 7.4. Information from Lozano et al. (2001) describing the decline in macroinvertebrate densities, especially populations of an important food item such as Diporeia, in Lake Ontario sediment is described in further detail.</td>
<td>Page 19 Para 1:  RNWH and LKWH feeding on molluscs is not relevant to the discussion As Diporeia sp. are amphipods and not small molluscs they the sentence should be changed indicate that RNWH and LKWH also feed on amphipods to be correct</td>
<td>Responses to Additional Comments (Sep 2014) Statement changed from molluscs to amphipods</td>
<td>The comments are addressed by the changes</td>
</tr>
<tr>
<td>6</td>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Food Availability</td>
<td>The significance of food availability as a factor that might be influencing RNWH needs to be discussed.</td>
<td>The point being made is not clear.</td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Nearshore Water Temperature</td>
<td>Growth of larval LKWH in the Bay of Quinte was linked to prey abundance. Since diets of larval LKWH and RNWH are similar, is it possible that declines in the number of small copepods and cladocerans affected survival and recruitment of RNWH?</td>
<td>These points have been added to Section 7.5.</td>
<td></td>
<td>The comments were addressed</td>
</tr>
<tr>
<td>6</td>
<td>Section 7.0 Factors with Potential to Impact Round Whitefish in Lake Ontario – Nearshore Water Temperature</td>
<td>Additional discussion on increases in water temperature from climate change, as well as thermal impacts from industrial plan discharges is provided in Section 7.5</td>
<td>The comments are addressed by the changes</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Section 8.0 Conclusions</td>
<td>These points have been added to Section 8.0. to strengthen the conclusion. Patrick et al 2013 citation added.</td>
<td>These points have been added to Section 8.0. to strengthen the conclusion. Patrick et al 2013 citation added.</td>
<td>Page 20 Para 1:  Peer review scientific literature is not mentioned although it was reviewed Remaining changes address the comments</td>
<td>The comments are addressed by the changes</td>
</tr>
</tbody>
</table>
Available information on the life history of the RNWH, including diet, habitat requirements, reproduction, predation, and competition was reviewed.

Understanding the decline of RNWH in Lake Ontario cannot be uncoupled from what is happening to Lake Ontario. Multiple physical and biological stressors have caused profound changes in the Lake Ontario ecosystem (Mills et al. 2003, Mills et al 2005).

Lake Ontario has experienced significant reductions in phosphorus with a concomitant shift toward oligotrophy—a dramatic increase in water clarity resulting from both nutrient reduction and proliferation of filter-feeding Dreissena spp.

As a result of increased clarity, light penetration has increased. The response to greater light penetration is reflected in a redirection of energy productions from the pelagic to the benthic habitat. Benthic energy pathways will be favoured over pelagic energy pathways, particularly in nearshore and embayment habitats of Lake Ontario. A shift in the direction of energy flow will have dramatic ecological consequences for Lake Ontario, favouring colonization of bottom-dwelling organisms, promoting fish communities that make efficient use of the benthic habitat, and enhancing growth rate cycles of benthic algae and submersed aquatic vegetation.

No single cause for the decline of RNWH could be identified, however, it is likely that declines are in response to lake-wide changes. No evidence in the literature suggests that changes to the loss of spawning habitat are responsible for declines in RNWH. No references in the literature reviewed suggest that extensive growth of Cladophora affects RNWH spawning habitat. No references in the literature reviewed indicate that the loss of spawning habitat is responsible for declines in RNWH.
### Section 1 Introduction (Additional Comments)

The focus of attention on RNWH and assessment of effects on RNWH spawning habitat appears to have arisen from the assumption that RNWH are an accepted indicator of aquatic community health (Ecometrix 2014). RNWH were selected as a Valued Ecosystem Component (VEC) in the environmental assessment associated with the expansion of both Pickering Nuclear Generating Station (PNGS) and the Darlington Nuclear Generating Station (DNGS). Since the concept was originally introduced in the early 1980s by Gordon Beanlands and Peter Duinker (Beanlands and Duinker 1983) use of VECs has become a standard practice in environmental assessment. The purpose of VECs is to focus the assessment on a relatively small number of species that are of greater local importance and to consider these species as indicators or “sentinels” of environmental impacts (Golder and SENES 2009). RNWH were selected as VECs for the environmental assessment of the PNGS and DNGS specifically because of:
- potential thermal effects on nearshore spawning shoals
- concerns surrounding entrainment of eggs and larvae, and
- habitat loss with construction in the nearshore (DNGS).

VECs are project specific and will often vary from one project to another, as the environmental effects of each project can be different. Selection of RNWH as a VEC for the PNGS and DNGS environmental assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health. Considering, that the project as currently proposed will not involve in-water construction within the nearshore zone and will not result in an increase in phosphorus loadings, the decision not to use RNWH as a VEC is justified and consistent with accepted environmental assessment methods.

### Section 2 Summary and Conclusion / Section 3 Literature Review (Additional Comments)

There are references in the literature (Higgins, et al. 2008) that suggest that Cladophora provides habitat for a number of aquatic invertebrates, primarily Gammarus spp. and chironomids, as well as cladocerans, tricopterans, mollusks, and crayfish. As these organisms are part of the diet of many fish species, it could be argued that Cladophora has a beneficial effect on fish communities. Similarly, matts of filamentous algae such as Cladophora are highly associated with spawning habitat of Longnose Gar, Lake Chubsucker, Golden Shiner, and Greenside Dace (Lane et al. 1996), and newly hatched pike preferred cover provided by Cladophora to that provided by more structured aquatic macrophytes (Engstrom-Ost and Mattila 2008). Survival rates of pike larvae in the presence of predation threats were also higher when filamentous algae were present (Engstrom-Ost and Mattila 2008). However, it is unreasonable to imply that such benefits make accumulations of Cladophora that reach nuisance levels acceptable or beneficial to fish and fish habitat.

Additional literature references have been added to Section 3. Wording changed to remove implication that excessive accumulations of Cladophora are acceptable or beneficial to fish and fish habitat.

- The point that was being made by the comment has been removed.
- Yes there are references to suggest that Cladophora may be used by some fish species. (These were provided in the comments)
- However, the main point was that regardless of whether some Cladophora is provided habitat for some species it is unreasonable to imply that growths of Cladophora that reach nuisance levels such as those that are present along the north shore of Lake Ontario are beneficial
- Suggesting the nuisance growth of Cladophora is okay because some fish use it is inappropriate
- The paragraph added (i.e., paragraph 3 on page 2) leaves the impression that conclusions of the literature review were those of Ecometrix and not of RNWH

Responses to Additional Comments (Sep 2014)

- References to the use of Cladophora by some fish species has been removed from Sections 2 and 3.
- Paragraph 3 on page 2 has been edited to reflect the conclusions of the literature review conducted by LGL.

### Responses to Additional Comments (Sep 2014)

- The comments are addressed by the changes

<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Section 1 Introduction (Additional Comments)</td>
<td>Comments added to supplement the response to Statement 1 in Section 5 (Response to Statements in EcoMetrix Report)</td>
<td>• The comments were addressed</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Technical Memorandum: Response to Issue and Concern on Round Whitefish prepared by CH2M HILL

- The comments were addressed by the changes
<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Section 4 Response to Statements in Ajax Part II Order Report (Additional Comments) Comment 1: there is no assessment at all of the effect excessive Cladophora growth has on fish or fish habitat. The effects of the project on Cladophora growth was assessed. The assessment determined that local point sources were not major contributors to Cladophora growth and that Cladophora growth was primarily driven by factors operating on a lake-wide basis. Moreover, loadings of Phosphorous, the nutrient affecting growth of Cladophora, will not be changed by the project and will remain at the current level of 311 kg/d. As Cladophora growth appears to be result of lake wide phenomena and baseline phosphorous loading will not be changed by the implementation of the preferred alternative, no effects on Cladophora growth are expected. The assessment of effects of Cladophora on fish or fish habitat does not appear warranted.</td>
<td>Additional comments added</td>
<td>The statement could be further strengthened by providing a indicating the role of phosphorus as a limiting nutrient for Cladophora growth (with the appropriate reference) and then stating that phosphorus loadings are not going to change as a result of the project.</td>
<td>Responses to Additional Comments (Sep 2014) Statement that phosphorus is the limiting nutrient for Cladophora growth was added with an appropriate reference (Higgins et al. 2008).</td>
<td>The comments are addressed by the changes</td>
</tr>
<tr>
<td>8</td>
<td>Section 4 Response to Statements in Ajax Part II Order Report (Additional Comments) Comment 2: there is a lack of information and data on fish species, habitat and the current conditions of the lake bottom within the nearshore Fish Habitat and Lake Bottom Conditions. The preferred option for the outfall will not involve in-water construction in the nearshore zone and will not change phosphorous loadings. There will be an increase in the size of the mixing zone for unionized ammonia to 5.7 ha from 4.1 ha; however, even with the increase in size, the mixing zone occupies a small portion of the surface area of the 1800 has nearshore zone. For the purpose of visualization, 5.7 ha can be represented by a circle with a radius of about 135 m or a square of about 240 x 240 m. By contrast, 1800 ha would occupy a circle with a radius of 2.3 km or a square about 4200 m by 4200 m. It is recognized that the shape of neither the mixing zone nor the nearshore zone is a circle or a square. Taking into account the nature of the expected effects associated with the preferred alternative, the available information on the conditions of the lake bottom within the area affected is adequate for the assessment.</td>
<td>Additional comments added</td>
<td>The comments were addressed</td>
<td></td>
<td>The comments are addressed by the changes</td>
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<td>9</td>
<td>Section 4 Response to Statements in Ajax Part II Order Report (Additional Comments) Comment 3: there is no assessment of the current use of habitat by Round Whitefish, a key local species, or other species and the potential for excessive Cladophora to impact fish habitat. RNWH were selected as a VEC for the environmental impact assessment associated with the PNSG and DNGS. The use of RNWH as a VEC for the PNSG and DNGS environmental assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health or that RNWH are</td>
<td>Additional comments added</td>
<td>The comments were addressed</td>
<td>N/A</td>
<td>The comments are addressed by the changes</td>
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appropriate as VECs for all environmental assessments on the northshore of Lake Ontario

9 Section 4 Response to Statements in Ajax Part II Order Report (Additional Comments)
Comment 4: there is a lack of current information on the reproductive success of Round Whitefish in Lake Ontario, and within the area studied by the Regions
The purpose of the environmental assessment was to assess the effects of the preferred alternative. The preferred alternative did not involve in water work in the nearshore area that would have physical effects on shoreline or littoral habitats, and Phosphorus loadings did not change from baseline conditions. Information on fish and fish habitat in the area was adequate for the purpose of the assessment. Additional information on the reproductive success of RNWH would not have changed the outcome of the assessment.
Additional comments added. • The statement about the priority assigned by COSEWIC is misleading.
• RNWH were given a low priority for assessment by COSEWIC.
• The statement implies the RNWH are a low priority species. This is not correct.
• It might be possible to imply that since RNWH has been assigned a low priority for assessment COSEWIC have determined that there are, currently, no concerns about the status of RNWH. However unless this can be confirmed it would be speculative at best.
Responses to Additional Comments (Sep 2014) • Sentence was corrected to specify that round whitefish were given low priority for assessment by COSEWIC

9 Section 4 Response to Statements in Ajax Part II Order Report (Additional Comments)
Comment 5: there is no assessment of the effect the mixing zone has or will have on important fish habitat and/or spawning areas.
Mixing zone for Phosphorus for the preferred alternative is reduced in size and the mass loading of 311/kg/d remains unchanged. Although the mixing zone for un-ionized ammonia has increased relative to existing conditions, the 5.7 ha mixing zone is still small in comparison the area of the nearshore zone within the Study Area. Data collected for the study indicate that the lake bed consists of sand and cobble with intermittent boulders. These features are neither unique nor in short supply within the area. Any effects within the mixing zone, should they occur, will be localized. The overall supply of similar habitats will not be changed substantially.
Additional comments added • The comments were addressed
Responses to Additional Comments (Sep 2014) • N/A
• The comments are addressed by the changes
### General Comment – Peer Review

<table>
<thead>
<tr>
<th>Page</th>
<th>Section 5 Response to Statements in Ecometrix Report (Additional Comments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td><strong>Statement 1: Effects of Cladophora on Fish Habitat</strong></td>
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<td>RNWH were specifically selected as a VEC for the environmental assessment of the PNGS and DNGS because of</td>
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<td>- potential thermal effects on nearshore spawning shoals</td>
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<td>- concerns surrounding entrainment of eggs and larvae and,</td>
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<td>- habitat loss with construction in the nearshore</td>
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<td>(Golder 2007, Golder and SENES 2009). VECs are project specific and will often vary from one project to another. The use of RNWH a VEC for the PNGS and DNGS environment assessments should not be taken to imply that RNWH are a generic indicator of aquatic ecosystem health or that RNWH are appropriate as VECs for all environmental assessments on the northshore of Lake Ontario. Nuisance growths of Cladophora are a lake wide problem and appear to be driven by changes in substratum, water clarity, and P availability associated with the establishment of dense dreissenid mussels (Higgins, et al. 2008). Contributions of phosphorus from local point sources have a small influence on conditions supporting Cladophora growth (Leon, et al. 2009). The preferred alternative will not change phosphorous loadings, which remain at the current level of 311 kg/d. As Cladophora growth appears to be the result of lake wide phenomena, and phosphorous loading will not be changed, the preferred alternative is not expected to affect Cladophora growth. The assessment of effects of Cladophora on fish or fish habitat does not appear warranted.</td>
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<td><strong>Reasons for selecting round whitefish as VECs for the PNGS and DNGS was revised in the text.</strong></td>
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<td></td>
<td>Text regarding lake-wide Cladophora problem was added to response to Comment 1 in Section 4 (Response to Statements in Ajax Part II Order Report) and Statements 10 and 17 in Section 5 (Response to Statements in EcolMetrix Report).</td>
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<td><strong>Reasons for selecting round whitefish as VECs for the PNGS and DNGS was revised in the text.</strong></td>
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<td>The comments were addressed by the changes.</td>
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| 10   | **Statement 5: Lack of Information on Fish Species, Fish Habitat Data and Substrates within the Study Area - Section 5.1 (Page 5-1) - Fish habitat utilization was not appropriately assessed for the offshore zone of the study area.** |
|      | The purpose of the environmental assessment was to assess the effects of the preferred alternative. The preferred alternative did not involve in water work in the offshore and consequently will not have physical effects on lake bottom habitats. Phosphorus loadings did not change and the mixing zone for un-ionized ammonia will remain small. Taking into account the nature of the expected effects associated with the preferred alternative, the additional information on utilization of offshore fish habitats would not change the assessment. |
|      | **Additional comment added** |
|      | The comments were addressed |
|      | N/A |

Responses to Additional Comments (Sep 2014): The comments are addressed by the changes.
<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Section 5 Response to Statements in Ecometrix Report (Additional Comments)</td>
<td>Comments on selection VECs were added</td>
<td>• The statement “This Outfall Class EA process has considered all members of the fish community, habitat, and SAR fish as VECs in the study so that impacts to fisheries as a whole can be assessed, rather than those specifically chosen by OPG as VECs.” does not really add anything. • Consider deleting it and reiterating the reasons that OPG selected RNWH and that the preferred alternative did not expect to have similar effect making selection of RNWH as a VEC unnecessary.</td>
<td>Responses to Additional Comments (Sep 2014) The statement has been deleted. Reasons why OPG selected round whitefish as a VEC and how the effects of the preferred alternative in this Outfall Class EA are different was reiterated.</td>
<td>• The comments are addressed by the changes</td>
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<td>10</td>
<td>Section 5 Response to Statements in Ecometrix Report (Additional Comments)</td>
<td>Comments on round whitefish reproductive success were added</td>
<td>• The comments were addressed</td>
<td>• N/A</td>
<td>• The comments are addressed by the changes</td>
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<td>10</td>
<td>Section 5 Response to Statements in Ecometrix Report (Additional Comments)</td>
<td>Additional comments added</td>
<td>• The comments were addressed</td>
<td>• N/A</td>
<td>• The comments are addressed by the changes</td>
</tr>
<tr>
<td>Page</td>
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<td>Responses</td>
<td>Comments</td>
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<td>Disposition/Sign-Off</td>
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| 10   | **Statement 10: Additional Comments on the ESR - Section 5.4 - comment on Page 2-6, Section 2.2.3 of the ESR:** Phosphorous and unionized ammonia are identified as the most sensitive parameters with potential impacts to algal blooms and fish toxicity, yet there is no assessment in the ESR or supporting documents of the potential for excessive Cladophora growth to impact fish or fish habitat. Although Cladophora provides habitat to many benthic invertebrates and is used as spawning and nursery habitats, it is unreasonable to imply that such benefits make accumulations of Cladophora that reach nuisance levels acceptable or beneficial to fish and fish habitat. Adverse effects of Cladophora on RNWH habitat or habitat of other species have not been documented in the literature. However, the literature indicates that nuisance growths of Cladophora are a result of changes in substratum, water clarity, and P availability associated with the establishment of dense dreisseniid mussels (Higgins, et al. 2008), and local point sources have a small influence on conditions that support Cladophora growth (Leon, et al. 2009). Since phosphorous loading will not be changed by implementation of the preferred alternative, assessment of the effects of Cladophora growth on fish and fish habitat would not change the outcome of the assessment. | Removed text implying that excessive accumulations of Cladophora are acceptable or beneficial to fish and fish habitat. Additional comments added | • The comments were addressed  
• Similar changes should be made in other sections where benefits of Cladophora are discussed | • The comments are addressed by the changes |
<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
</table>
| 10   | Section 5 Response to Statements in Ecometrix Report (Additional Comments) | Additional comments added | • Attributing the statement that gathering data on the physical features present at the site and evaluating them in terms of their suitability for use species likely to be present is an accepted means of habitat assessment to the peer reviewer does not strengthen the discussion one way or the other and could move the discussion in an unintended direction.  
• The statement will be on the peer review record as it is already in the Technical Memorandum.  
• The phrase: "According to the independent peer reviewer" should be deleted | • Text removed | • The comments are addressed by the changes |
<p>|      | Statement 11: Additional Comments on the ESR - Section 5.4 – comment on Page 2-4, point 3 of the ESR – states that mixing zones should not impinge on important fish spawning areas – yet there was no assessment of fish distribution or habitat use within the nearshore area of the LSA (i.e., the mixing zone) and Round Whitefish and their spawning habitat has been documented in this area (Golder 2007; EcoMetrix, 2009). | Study area clarification was added as a footnote | | | |
|      | Gathering data on the physical features present at the site and evaluating them in terms of their suitability for use species likely to be present is an accepted means of habitat assessment. Depth cover and substrate are variables that are commonly used in the assessment. Habitat surveys determined that the lake bottom within the area of the mixing zone consisted of sand and cobble with intermittent boulders. This type of habitat was ubiquitous throughout the study area. None of the species that spawn at depths ranging from 5 to 15 m show high associations with sand and cobble substrates (Lane et al. 1996). | | | | |
|      | The study area consists of a Local Study Area (LSA) and a Regional Study Area (RSA) that are described in the Environmental Study Report (CH2M HILL 2014). The RSA was established to include the area within which there was potential for cumulative biophysical effects and extended to Frenchman's Bay in the west and to Paradise Beach in the east. The location of known RNWH spawning habitat is outside of the area considered to be affected by the preferred alternative. | | | | |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>General Comment – Peer Review</th>
<th>Responses</th>
<th>Comments</th>
<th>Responses to Additional Comments (Sep 2014)</th>
<th>Disposition/Sign-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Section 5 Response to Statements in Ecometrix Report (Additional Comments) Statement 17: Additional Comments on the ESR - Section 5.4 – comment on Page 13-1, Section 13.1.2 of the ESR – the report states that the operation of the preferred alternative will have no to negligible effects on the aquatic environment but the potential for excessive Cladophora growth to impact fish and fish habitat was not assessed See previous responses related to effects of Cladophora growth and effect on fish and fish habitat (e.g., response to Statement 1 and Statement 10.</td>
<td>Additional comments on the effects of Cladophora growth and effect on fish and fish habitat added.</td>
<td>• The comments were addressed  • The argument could be further strengthened by indicating the role of phosphorus as a limiting nutrient for Cladophora growth (and including the appropriate reference) and then stating that phosphorus loadings are not going to change as a result of the project</td>
<td>Responses to Additional Comments (Sep 2014)  • Phosphorus is stated as a limiting nutrient for Cladophora growth with reference to Higgins et al. 2008</td>
<td>• The comments are addressed by the changes</td>
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<td>11</td>
<td>Summary The review of current scientific literature on RNWH included most, if not all, of the available scientific literature on RNWH. The findings of the review should clearly state that: 1. RNWH are declining in Lake Ontario 2. Round whitefish is one of the least studied coregonine species 3. Understanding the decline of RNWH in Lake Ontario cannot be uncoupled from ecological changes that are occurring in Lake Ontario 4. The shift in energy pathways from pelagic to benthic brought about by the establishment and proliferation of dreissenid mussels appear to be a major driver for the ecological changes that are occurring 5. No single cause for the decline of RNWH could be identified, however, it is likely that declines are in response to lake-wide changes 6. No references in the literature reviewed suggests that extensive growth of Cladophora affects RNWH spawning habitat 7. No references in the literature reviewed indicate that the loss of spawning habitat is responsible for declines in RNWH</td>
<td>Additional comments added to Section 3</td>
<td>• The comments were addressed</td>
<td>N/A</td>
<td>• The comments are addressed by the changes</td>
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