ONTARIO POWER GENERATION

Report

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Pickering Nuclear Generating Stations 2021 Impingement Monitoring Report

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Table of Contents

Page

List of Tables and Figures

Page

Revision Summary

Revision Number	Date	Comments
R000	2022-06-01	Initial issue.

Executive Summary

This report documents outcomes of impingement mitigation measures and impingement monitoring for the 2021 calendar year. The report satisfies both condition 3.1 and condition 3.2.1 of the *Fisheries Act* Authorization for Pickering Nuclear Generating Station (PNGS), which was issued in January 2018.

The primary measure to avoid or mitigate fish impingement at PNGS is the Fish Diversion System (FDS). The FDS is a net comprised of 20 mesh panels that extend from the lake bottom to the water surface and encompass the intake. Connected, the FDS panels have a combined length of 610 m. Primary and secondary skirts are attached to the main net and are designed to deploy if the float line of the main net sinks or is pulled beneath the surface. The FDS was in place and functioning from May 4 to November 1, 2021.

Consistent with prior years, depth loggers, recording instantaneous depth at 15-minute intervals, were installed on the FDS to monitor the float line depth relative to the water surface. The loggers were attached to the main net, the primary skirt, and the secondary skirt. According to logger data, the secondary skirt on the East, West and South aspect was within the target 30 cm of the water surface 99.8%, 99% and 89.5% of the time, respectively.

Impingement monitoring occurred throughout the calendar year. Fish collected in bar screen and travelling screen bins during the sampling periods were identified, counted, and weighed to calculate impingement numbers, biomass and rates of biomass impinged per unit volume of intake water. In 2021, 325 bins were assessed.

A total of 36 taxa, identifiable to the species level were impinged. The combined biomass of all species and ages impinged in 2021 was 1,585.1 kg, a rate equivalent to 0.32 kg per million cubic metres of station intake volume. Alewife (507.4 kg; 32%) and Gizzard Shad (307.85 kg; 19.4% of total biomass) were most common, typical of prior years of impingement monitoring.

There were no Species at Risk Act (SARA) Schedule 1 fish species observed impinged in 2021. Fifteen American Eel, with a combined biomass of 18.2 kg, were documented during impingement monitoring. The extrapolated number is 55 individuals with an estimated combined biomass of 66.76 kg. Eleven Northern Pike were documented. The annualized estimate was 41 individuals with a combined biomass of 90.6 kg. There were no episodic fish kill events in 2021 and the biomass impinged was 1,585.07 kg. The biomass is below the threshold of two consecutive years of impingement biomass of less than 3619 kg, as 1585.07 kg was impinged in 2021, and 3,525.72 kg was impinged in 2020.

1.0 INTRODUCTION

Ontario Power Generation Inc. (OPG) is the owner and operator of the Pickering Nuclear Generating Station (PNGS). PNGS, located on the north shore of Lake Ontario, has eight CANDU pressurized heavy water reactors (Units) on the site. PNGS has six Units operating with two Units in Safe Storage state. PNGS has been operating safely and generating electric power since 1971. PNGS draws large volumes of lake water, through a surface water intake, for cooling purposes. An environmental effect of using lake water for cooling is impingement of aquatic organisms.

A *Fisheries Act* Authorization for PNGS (Authorization) was issued to OPG on January 17, 2018 (DFO, 2018). The Authorization period extends from the date of issue to December 31, 2028.

This report is being submitted to satisfy both condition 3.1 and condition 3.2.1 of the Authorization.

2.0 IMPINGEMENT AVOIDANCE AND MITIGATION MEASURES

2.1 Fish Diversion System

2.1.1 Design and Design Modifications

The FDS is the primary measure to avoid and mitigate fish impingement. The FDS design consists of a main net, which covers the entire depth of the water column, and a primary skirt and secondary skirt that self-deploy when water depths increase, or the main net is pulled subsurface.

There were no modifications made to the FDS design in 2021.

2.1.2 Installation and Removal

A complete check of the FDS system components was completed by OPG prior to installation.

Condition 2.1.1.1 of the Authorization requires installation of the main net by May 1 of each year and installation of the secondary net by June 1 of each year. OPG completed installation of the FDS main net by May 4, 2021; and the primary and secondary skirts were installed by May 19, 2021.

There was an anticipated delay in installation of the FDS main net due to poor weather in April. The DFO was notified in an April 29, 2021 email of the potential delay in the FDS installation and this was acknowledged by DFO.

Once installed, the FDS was in place and functioning until November 1, 2021. FDS removal commenced November 10, 2021 and the system was removed from the Lake in its entirety by December 7, 2021. The start of removal date complies with condition 2.1.1.2 of the Authorization which requires the FDS, in its entirety, to remain in place and functioning until November 1st of each year.

2.1.3 Operations and Maintenance

While installed, the FDS was inspected and maintained on an ongoing basis. Inspection and maintenance consisted of:

- Visual checks of net floats by Nuclear Security Officers to assess if main, primary, or secondary floats were below the surface;
- If visual checks indicated some of the floats were submerged, follow up checks were completed to determine the cause of the net sag and whether additional maintenance was necessary; and
- Multi-day per week subsurface inspection, hydraulic cleaning, and net maintenance by the Dive Operations team of OPG's Advance Inspection Maintenance (AIM) Department.

2.1.4 Functionality and Performance

The Authorization requires OPG to demonstrate the FDS is functioning as intended. During operations, functionality and performance are measured through visual checks, inspections and maintenance as described above. If the FDS is not functioning as intended, the cause is investigated and addressed.

The performance of the net was assessed using loggers which record atmospheric pressure and convert pressure to depth based on the difference between the FDS logger and an onshore reference logger. The loggers are attached to the FDS while the main net and both skirts are installed. The loggers are removed, and data is downloaded, after the FDS is removed in November. A total of twenty-one depth loggers were installed on the FDS in 2021 to monitor the depth of the main net, primary skirt, and secondary skirt float lines relative to the water surface. There are four loggers attached to each aspect of the secondary skirt, two loggers to each aspect of the primary skirt and one logger on each aspect of the main net. All 21 loggers were retrieved, however the South-Main logger malfunctioned during the season and the East-Main data logger malfunctioned between September 22 and October 31; and this data was therefore excluded from analyses.

For monitoring purposes, FDS performance is deemed acceptable when the loggers on the secondary skirt are at the surface or submerged to depths not exceeding 30 cm. The pressure data obtained from each logger, and a common reference logger is used to calculate the depth of the float line at the specified attachment point on the FDS and to validate visual or field observations.

If the FDS fails in any capacity, repairs are expedited, and visual inspections are increased until functionality is restored.

Based on the combined visual checks, inspections, maintenance, and logger data evaluation, 2021 FDS performance was very good. Factors that may have affected the FDS during 2021, as reported by visual checks and field observations, are as follows:

- From May 10 to May 14, prior to the full installation of the primary and secondary skirts, the main and installed primary skirt was degraded, primarily along the East aspect. The planned installation of the east primary and secondary skirt was completed on May 17 and the gap was eliminated. This circumstance serves as an example illustrating the function and benefits of the primary and secondary skirts. No other degraded conditions were observed during the period the FDS was installed.

- On September 14 OPG divers repaired a small gap near the bottom where the main net and groyne had detached.

Table 1 provides a weekly summary of the percentage of time that floats on the secondary skirt were between the surface and 30 cm depth, for each aspect of the FDS, for the period the FDS was in service, and loggers were attached to main, primary, or secondary skirts. As a benchmark, a 3% reduction n equates to five hours of submergence below 30 cm.

Table 1: Fraction of week that each aspect of the FDS secondary skirt was at the surface or not greater than 30 cm below the surface from May 25 to October 31, 2021.

Week		Aspect		
Start	End	East	South	West
25-May-21	29-May-21	100.00%	97.76%	99.64%
30-May-21	05-Jun-21	100.00%	87.87%	97.99%
06-Jun-21	12-Jun-21	100.00%	95.76%	99.85%
13-Jun-21	19-Jun-21	100.00%	88.54%	96.65%
20-Jun-21	26-Jun-21	100.00%	87.54%	94.64%
27-Jun-21	03-Jul-21	100.00%	99.00%	99.55%
04-Jul-21	10-Jul-21	100.00%	99.37%	100.00%
11-Jul-21	17-Jul-21	100.00%	94.57%	99.89%
18-Jul-21	24-Jul-21	100.00%	90.44%	100.00%
25-Jul-21	31-Jul-21	100.00%	96.21%	99.85%
01-Aug-21	07-Aug-21	100.00%	95.87%	99.78%
08-Aug-21	14-Aug-21	100.00%	87.83%	92.60%
15-Aug-21	21-Aug-21	99.93%	41.33%	99.26%
22-Aug-21	28-Aug-21	100.00%	89.32%	100.00%
29-Aug-21	04-Sep-21	99.37%	66.56%	99.52%
05-Sep-21	11-Sep-21	99.96%	86.87%	99.26%
12-Sep-21	18-Sep-21	100.00%	98.77%	99.93%
19-Sep-21	25-Sep-21	99.96%	99.55%	100.00%
26-Sep-21	02-Oct-21	100.00%	100.00%	100.00%
03-Oct-21	09-Oct-21	100.00%	99.85%	100.00%
10-Oct-21	16-Oct-21	99.93%	96.39%	100.00%
17-Oct-21	23-Oct-21	99.96%	81.40%	100.00%
24-Oct-21	30-Oct-21	95.76%	79.65%	100.00%

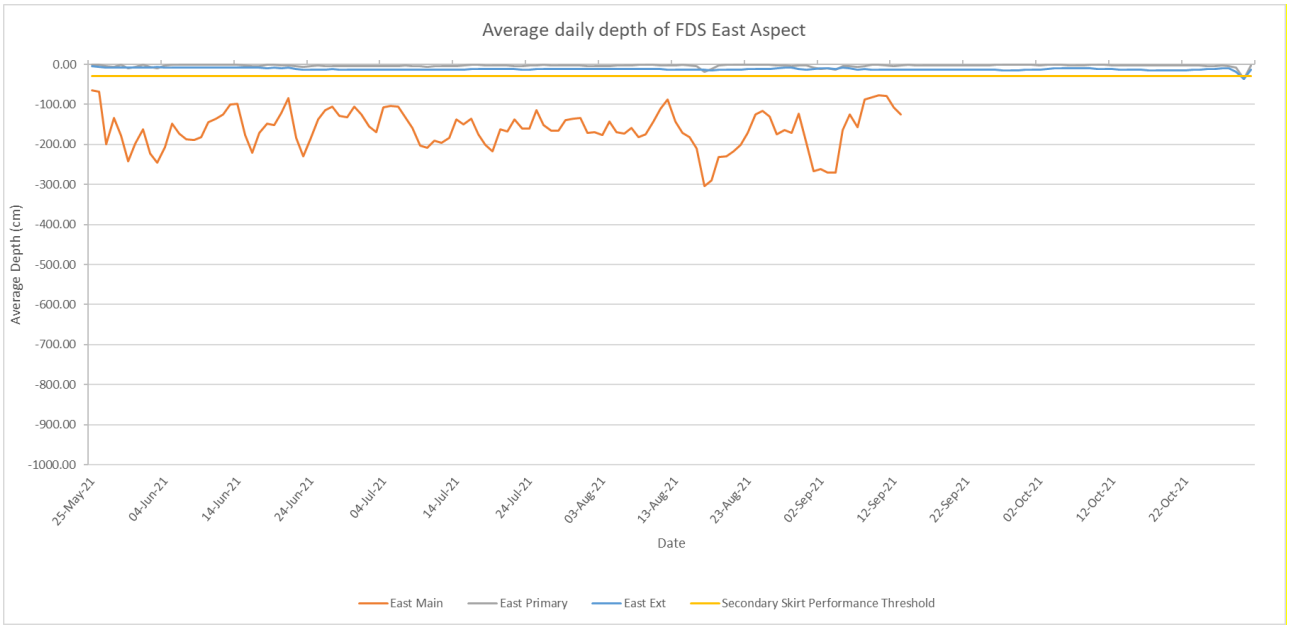
Week		Aspect		
Start	End	East	South	West
31-Oct-21	31-Oct-21	100.00%	75.00%	100.00%

Figure 1 to 3 provide the time series of average daily depth of the East, South and West aspects of the FDS, respectively. Table 2 provides a summary of the depth data as a frequency distribution during the monitoring period. On the East aspect, the secondary skirt was located within 30 cm of the water surface 99.77% of the time and was within 50 cm of the surface approximately 99.85% of the time. The secondary skirt on the West aspect was within 30 cm of the surface 99.05% of the time and within 50 cm of the surface 99.82% of the time. For the South aspect, the secondary skirt was within 30 cm of the water surface 89.48% of the time and within 50 cm of the surface 99.97 of the time. The primary skirt was located within 30 cm of the water surface, 98.97%and 59.12% of the time for the East and, West aspects, respectively.

Although the South and West extended skirts both dipped below the 30 cm threshold on several occasions during the season, they remained within 50 cm of the surface. The low fish impingement numbers during the period the FDS was installed (discussed in *Section 4.0 Fish Impingement*) indicate that it was effective in mitigating fish impingement.

The net sagging experienced, particularly by West and South aspects of the FDS was likely caused by algae build-up, often in combination with strong winds and waves, as evidenced by the visual inspection reports. In late May and June, large amounts of algae were reported in the vicinity of the FDS, which required significant maintenance efforts. Based on operational experience, the West and South aspect are more prone to algae build-up and being impacted by strong winds and waves than the East aspect.

Figure 1: Daily average depth of FDS float lines on the East facing aspect.



*Main-East logger malfunctioned commencing September 21 and subsequent data was excluded from analysis.

Figure 2: Daily average depth of FDS float lines on the South facing aspect.

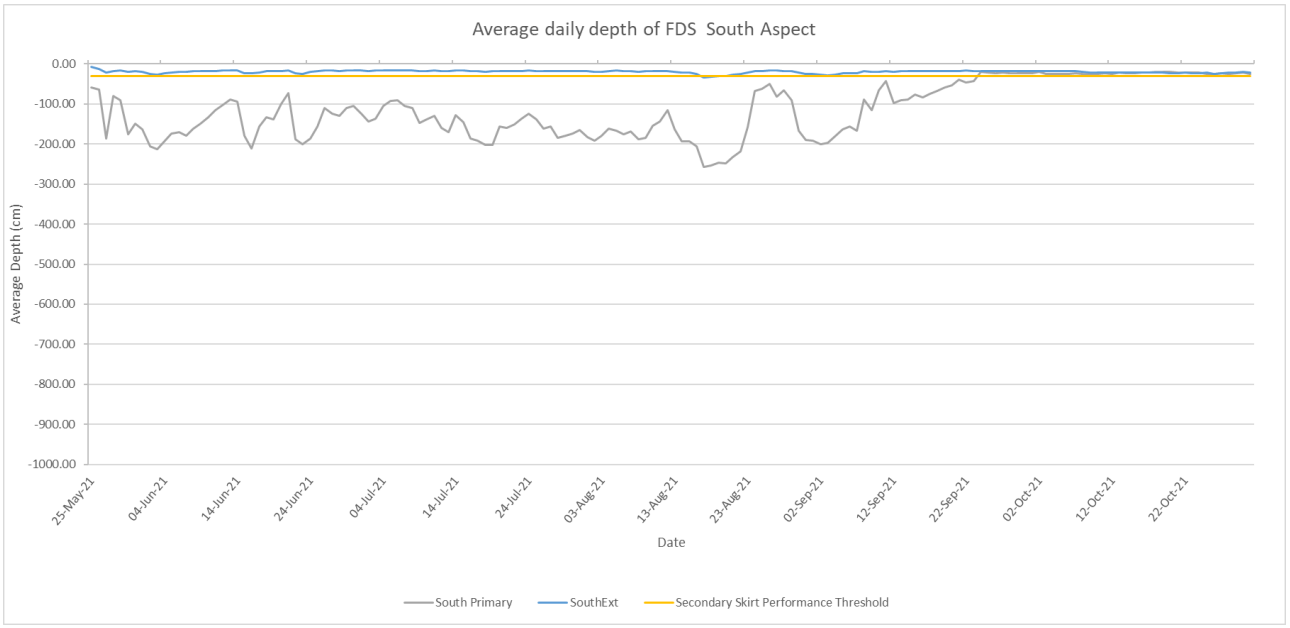


Figure 3: Daily average depth of FDS float lines on the West facing aspect.

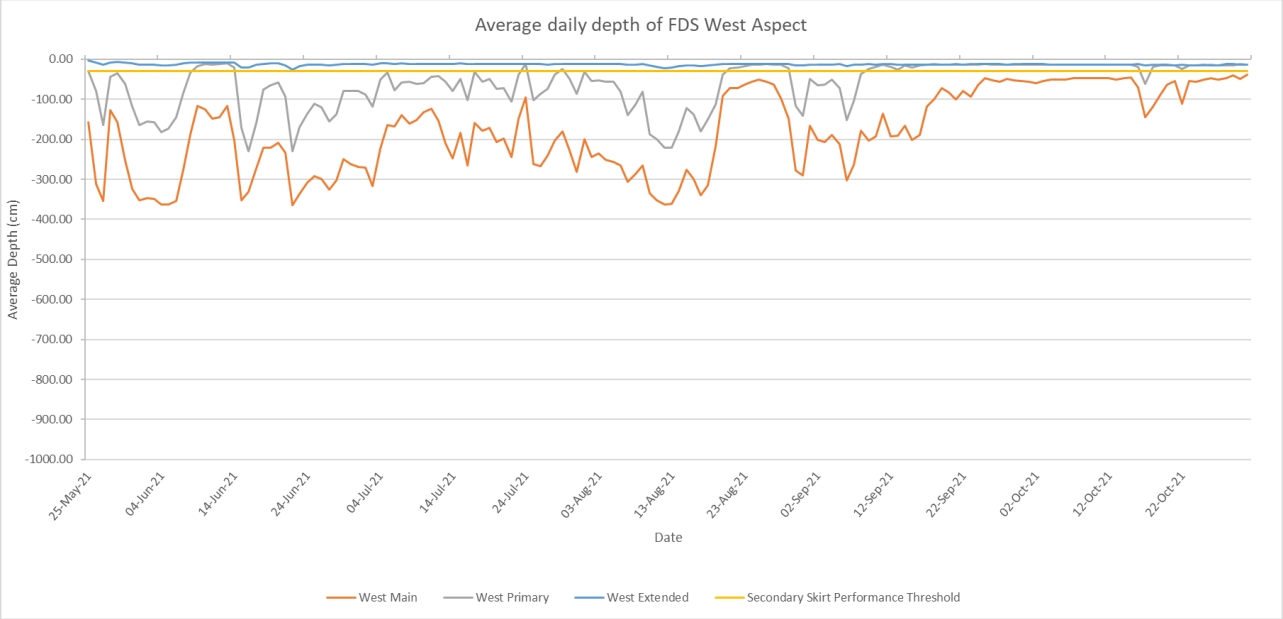


Table 2: Time frequency that primary and secondary float lines were in individual depth ranges based on depth logger data.

Depth below surface (cm)	Aspect and Net								
	East			South			West		
	Ext	Main	Primary	Ext	Main[1]	Primary	Ext	Main	Primary
0-30	99.8 %	0.5%	99.0%	89.5 %	-	35.1%	99.1 %	0.6%	59.1%
30-50	0.1%	0.8%	0.6%	10.5 %	-	5.4%	0.8%	11.3%	5.0%
50-100	0.1%	20.5 %	0.3%	0.0%	-	10.1%	0.2%	22.2%	11.0%
100-200	0.1%	49.9 %	0.1%	0.0%	-	23.2%	0.0%	22.1%	15.8%
200-300	0.0%	27.0 %	0.0%	0.0%	-	26.2%	0.0%	23.4%	9.1%
> 300	0.0%	1.4%	0.0%	-	-	-	0.0%	20.4%	0.0%

Notes:

1. The South-Main logger malfunctioned during the season and the East-Main data logger malfunctioned between September 22 and October 31.

3.0 IMPINGEMENT MONITORING

3.1 Monitoring Effort

Fish collected in bins during the sampling periods are identified, counted, and weighed to calculate impingement numbers, biomass and rate of biomass impinged per unit volume of intake water. Table 3 displays the sampling effort in 2021 and compares it with the previous years. Results indicate that the fraction of time sampled in 2021 is comparable to that of the FDS compliance verification period, as intended.

Table 3: Comparison of yearly impingement monitoring effort during different monitoring periods.

Period	Year	# Bins Sampled	Total In-Service Bin Hours sampled	% of time sampled [3]
Pre-FDS	2003 - 2004	574	32,236	46%
	2006 [1]	234	25,420	36%
FDS Performance Evaluation	2010	1,505	37,904	54%
	2011	1,456	38,541	55%
	2012	1,181	29,415	42%
FDS Compliance Verification [2]	2013	400	14,711	21%
	2014	353	12,178	17%
	2015	281	9,516	14%
	2016	338	12,012	17%
	2017	327	11,808	17%
Fisheries Act Authorization Monitoring [2]	2018	354	11,495	16%
	2019	353	12,439	18%
	2020 [4]	334	10,374	15%
	2021 [4]	325	12,388	18%

Notes:

1. Monitoring in 2006 encompassed spring, summer and fall only.
2. In addition to the weekly routine impingement sampling, OPG has committed to undertake event-based sampling if a fish run occurred between the regularly scheduled sampling events.
3. Based on full year of service for the 8 bin locations.
4. For 2020 and 2021 totals exclude bins out of service. Surrogate data from adjacent bins of the same type was used to estimate impingement in these bins during the out-of-service period.

3.2 Unit Operating Status and Intake Volume

Table 4 provides the number of days that condenser cooling water (CCW) pumps were not operating at a specific Unit in 2021. Total CCW intake volume in 2021 was 5.02 billion cubic

metres. PNGS Unit 2 and Unit 3 are in a safe storage state and the CCW pumps are not used, as these Units are not generating power. When operating, each Unit normally has two CCW pumps running. CCW pumps are normally out of service only during planned unit outages, but on occasion are shut down during an unplanned outage.

Table 4: CCW pump operating status in 2021.

Unit Operating Status	
Unit	Days without operating CCW pumps at unit
1	0
2	365
3	365
4	0
5	44
6	0
7	89
8	136

3.3 Data Quality Management

OPG undertakes data quality management of the fish impingement monitoring program at various steps during the program design, data collection, data entry, data analysis and results reporting process. Impingement monitoring followed OPG approved procedures, standards, guides, and manuals.

Fish were identified and enumerated by staff that are trained in identification of Ontario fish species. Photos of impinged fish that are measured and weighed were taken and archived to assist in subsequent species verification, if an identification was uncertain. If captured, identification of species listed in Schedule 1 of the Species at Risk Act (SARA) are verified by the Royal Ontario Museum (ROM) or other qualified third party; however, none were captured in 2021. In some cases, uncommon species or species that are particularly difficult to key to species level are also verified by ROM staff. In 2021, one species identified in the field as a Spoonhead Sculpin was sent to ROM for verification and was determined to be a Slimy Sculpin.

Field results were entered into an impingement database and independently verified. The total number of routine monitoring samples and monitoring hours for each month at each bin monitoring location was reviewed. In 2021, Unit 012 trash screens (012TS) were out-of-service during 43 sampling occasions, Unit 034 trash screens (034TS) were out-of-service during 14 sampling occasions, the Unit 078 trash screen (078TS) was out of service during five sampling occasions and the Unit 078 bar screen was out of service during one sampling occasion. Since either the CCW pumps were operational, or service water supply to the

station was still being obtained, impingement for these sampling periods was estimated using sample data obtained from the neighbour unit, for the same screen type. Bin sampling and fish data were assumed to be equal, while intake volumes referenced unit specific volumes (i.e., the original intake volumes for the out-of-service unit and screen type were still applied to the impingement calculations).

3.3.1 Atypical Impingement Volumes that were Potential Data Outliers

Once all entered data was validated, queries in the database that are designed to calculate impinged numbers and biomass for each bin sampled during routine monitoring were run. Except for bins using surrogate data, the total count and total biomass in each bin for each monitoring event was reviewed and compared against historic (2010-2018) rates, standardized to a 24-hour collection period, to flag potential outliers. Unlike some previous years, there were no outliers above the bin specific threshold flagged in the 2021 data.

3.4 Impingement Estimate

The formulas used to calculate monthly impingement and extrapolate it over the year are provided in Appendix A.

4.0 2021 FISH IMPINGEMENT

4.1 All Species and Life Stages

Figure 4 and Table 5 provide the biomass of fish impinged in 2021. The quantity of fish impinged is provided in Table 6, and the rate of biomass impinged per unit volume of intake water used by the CCW pumps is provided in Table 7. All estimates are for all species and life stages of fish recorded impinged. Consistent with prior impingement reports for the Authorization period, Figure 4 and Table 5 exclude the 2017 impingement event. The Authorization value is based on Age-1 equivalent impingement and entrainment estimates for 23 modelled species only, not the all-species, all-age impingement biomass estimate provided in this report. Any of the 23 species that were impinged in 2021 that will be included in the Age-1 equivalent modeling are denoted with an asterisk (*) beside the species name in Table 5 and Table 6.

Figure 4 illustrates cumulative monthly biomass of impinged fish of all species and ages. The combined biomass of all species and ages impinged in 2021 was 1,585.07 kg, a rate equivalent to 0.32 kg per million cubic metres of station intake volume. In 2021, the biomass impinged was below the two consecutive year threshold of 3619 kg. In 2020, the annual total of 3,525.72 kg was reported impinged.

Figure 4: Annual cumulative biomass (kg) of fish of all species and ages impinged from 2016-2021

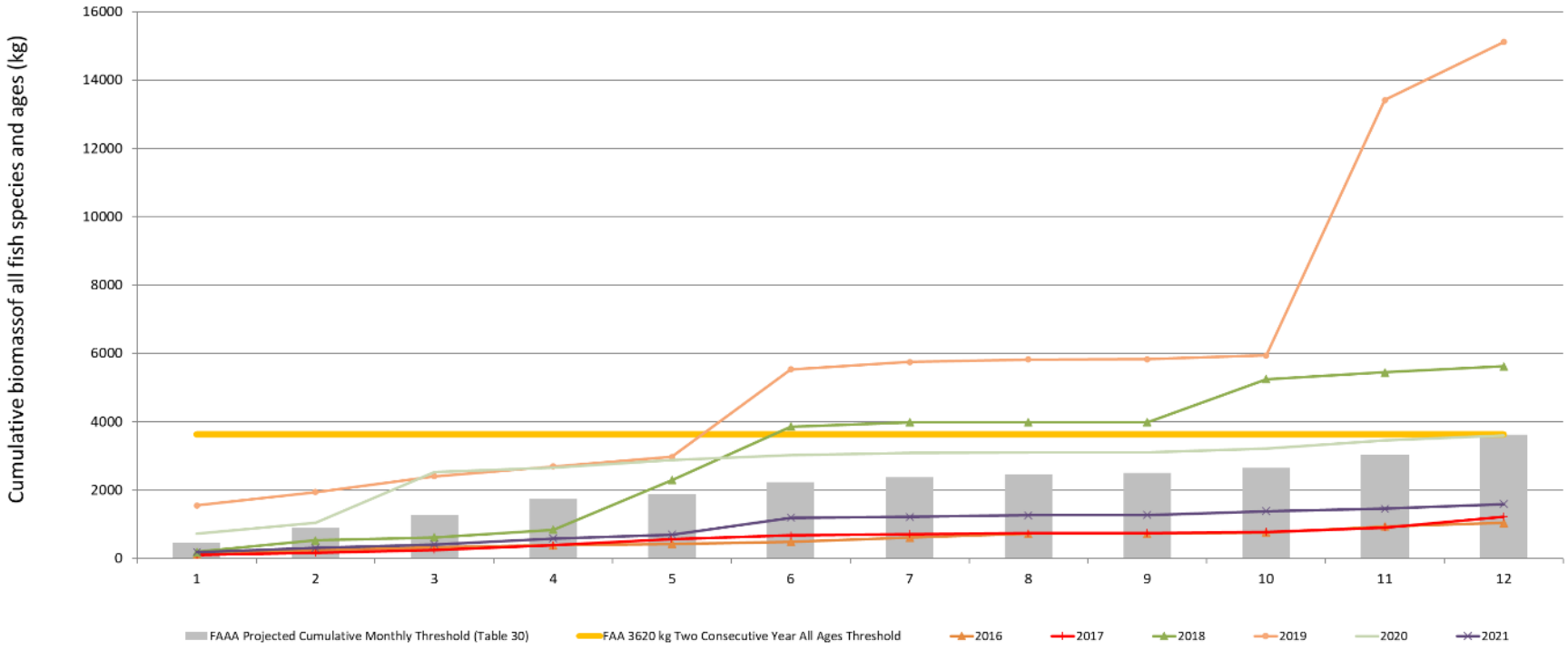


Table 5: Monthly biomass and annual fish impinged (kg) at Pickering Nuclear Generating Station in 2021

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Alewife*			0.00	15.95	17.22	337.57	13.23	13.70	0.10	109.02	0.59		507.40
American Eel	31.15	3.40										32.20	66.76
Atlantic Salmon*			0.03	5.21	0.07	0.30							5.61
Black Bullhead*		0.72		0.37							0.05		1.14
Black Crappie												0.69	0.69
Bluegill*	0.65		0.04	0.23	0.34		0.57	1.45	0.67			0.47	4.42
Bowfin	4.07			2.58			7.87						14.52
Brown Bullhead*	3.60							0.51					4.12
Brown Trout											0.02		0.02
Channel Catfish	0.45		0.07	0.09				1.20					1.81
Chinook Salmon*	0.13	0.11									17.16	17.60	34.99
Common Carp*		17.33					0.06		0.90		0.06		18.35
Common Shiner											0.02		0.02
Emerald Shiner*	50.78	0.20											50.98
Gizzard Shad*	68.97	72.89	73.16	54.86					0.09		3.74	34.15	307.85
Gold Fish								0.18					0.18
Lake Trout*		10.23									11.45		21.68
Lake Whitefish											3.10	1.65	4.75
Logperch				0.03	0.08		0.89	0.31			0.01		1.32
Longnose Gar		1.66	0.60										2.26
Northern Pike*	13.21		7.68	5.13	6.74						16.02	41.80	90.58
Pumpkinseed											0.12		0.12
Rainbow Smelt*	0.89	1.22	10.08	25.11	12.25	2.61	0.05		0.07	0.95	0.24		53.46
Rainbow Trout*				23.08							9.66		32.74
Rock Bass			0.50		0.74	0.39						0.04	1.67
Round Goby	0.96	2.59	7.17	18.09	64.33	151.66	8.08	29.70	3.07	1.49	9.35	1.45	297.95

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (kg)
Round Whitefish*											1.67		1.67
Sea Lamprey			3.82										3.82
Shorthead			0.10										0.10
Slimy Sculpin				0.06									0.06
Smallmouth Bass*				3.73				0.36			0.22		4.32
Three-spine Stickleback*	5.45	0.12	1.89	2.73	1.81	0.06	0.02	0.24			0.28		12.60
Unid	3.52												3.52
Unid - Salmonids													0.00
Unid- Catfishes													0.00
White Bass*											0.02		0.02
White Perch*											0.22	0.06	0.29
White Sucker*		3.92	0.06	17.01	3.75				0.26				25.00
Yellow Perch*			2.05	4.69	0.16						0.36	1.01	8.27
Total (kg)	**183.83**	**114.37**	**107.25**	**178.96**	**107.48**	**492.60**	**30.78**	**47.67**	**5.16**	**111.47**	**74.39**	**131.12**	**1,585.07**

Table 6: Number of fish impinged at Pickering Nuclear Generating Station in 2021

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (#)
Alewife*			3	989	4,491	83,536	2,990	2,662	30	25,411	108		120,222
American Eel	26	3										25	55
Atlantic Salmon*			3	9	25	8							44
Black Bullhead*		10		5							3		18
Black Crappie												3	3
Bluegill*	15		6	4	6		29	97	36			24	217
Bowfin	4			10			8						21
Brown Bullhead*	30							12					42
Brown Trout											3		3
Channel Catfish	8		3	9				7					26
Chinook Salmon*	19	7									3	3	32
Common Carp*		3					40		28		3	4	79
Common Shiner											3		3
Emerald Shiner*	22,492	145											22,637
Gizzard Shad*	76	77	90	53		7			28		28	43	402
Gold Fish								14					14
Lake Trout*		3									3		7
Lake Whitefish											3	4	7
Logperch				4	19		95	70			3		191
Longnose Gar		3	3										7
Northern Pike*	8		3	4	6						7	14	41
Pumpkinseed											3		3
Rainbow Smelt*	103	89	955	2,424	1,639	563	20		39	1,736	59		7,628
Rainbow Trout*				13							3		17
Rock Bass			6		6	8						14	34
Round Goby	115	105	404	6,232	6,381	18,121	1,290	3,774	243	259	1,417	178	38,518

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (#)
Round Whitefish*											3		3
Sea Lamprey			10										10
Shorthead Redhorse			6	10									16
Slimy Sculpin				7									7
Smallmouth Bass*				5				14			16		35
Three-spine Stickleback*	19,954	77	1,102	1,356	1,089	35	10	146			207		23,976
Unid	38		3									19	60
Unid - Salmonids	8											4	11
Unid- Catfishes	8	10											18
White Bass*											7		7
White Perch*											29	7	37
White Sucker*		7	3	27	6				22				65
Yellow Perch*			50	62	12						13	14	150
Total (#)	**42,903**	**540**	**2,652**	**11,221**	**13,680**	**102,278**	**4,483**	**6,795**	**427**	**27,406**	**1,927**	**355**	**214,666**

Table 7: Impinged biomass, intake volume and impingement rate by volume

Year	Annual Biomass (kg)	Annual Station Flow (Billion m^3)	Annual Rate (kg/million m^3)
2003/2004	18,214	4.19	4.35
2010	4,617	4.88	0.95
2011	4,012	4.77	0.84
2012	1,706	4.94	0.35
2013	2,926	4.86	0.60
2014	3,953	4.82	0.82
2015[1]	8,553	5.07	1.69
2016	1,035	4.70	0.22
2017	1,217	5.05	0.24
2018	5,616	4.88	1.15
2019	15,114	5.27	2.87
2020	3,525	4.91	0.72
2021	1,585	5.02	0.32

Note: [1] 6,000 kg of impingement in 2015 was attributable to a single event in May 2015 caused by an opening in the net seam. Excluding this event, the impingement rate in 2015 was 2,553 kg or 0.50 kg/million m^3 of station intake volume.

4.2 Species Impinged in 2021 to be Included in Age-1 Equivalency Estimates

The Authorization value is based on the modeled Age-1 equivalent biomass for 23 species which were used in the Fisheries Act Application for Authorization (FAAA)(OPG, 2017) modeling. In 2021, 20 of the 23 species were impinged. Freshwater Drum, Largemouth Bass and Walleye were not observed in impingement monitoring in 2021. The combined biomass impinged for the 20 species was 1005 kg, representing 29% of the total biomass impinged.

4.3 Regulated and Other Aquatic Invasive Fish and Mussel Species

One regulated invasive species, Round Goby (297.95 kg extrapolated value) was impinged in 2021. Round Goby is an invasive species listed in Part 2 of SOR/2015-121 Aquatic Invasive Species Regulations and is a Species Subject to Prohibitions and Controls. In Ontario, the Aquatic Invasive Species Regulations also applies to Grass Carp, Bighead Carp, Silver Carp, Black Carp, Zebra Mussel, Quagga Mussel, any species of the Snakehead family, Ruffe, Rudd, and Tubenose Goby. Zebra Mussel and Quagga Mussel are impinged consistently, but like Round Goby these species are not included in estimates of serious harm to fish due to impingement.

Though Round Goby is included in impingement estimates for all species and age classes, DFO agreed in their review of the FAAA and the Authorization that they are not included in estimates of Age-1 equivalent losses.

4.4 Species at Risk Act Schedule 1 Fish Species

There were no SARA Schedule 1 fish species observed impinged in 2021.

4.5 Endangered Species Act Species at Risk in Ontario List fish species

American Eel is a species listed as Endangered in the Species at Risk in Ontario (SARO) List of the Endangered Species Act (ESA). During 2021, fifteen (15) American Eel, with a combined biomass of 18.2 kg, were documented during impingement counts in 2021. One was impinged in February and the remainder were impinged in January or December. The extrapolated number of American Eel impinged in 2021 was 55 individuals with an estimated combined biomass of 66.76 kg.

4.6 Northern Pike

In 2021, OPG documented 11 Northern Pike with a combined mass of 25.14 kg during impingement monitoring. All were captured outside of the period the FDS was installed. The annualized estimate of impingement in 2021 was 41 individuals with a combined biomass of 90.58 kg. Table 8 summarizes the extrapolated annual number and extrapolated annual biomass of Northern Pike impingement since 2010.

Table 8: Number and biomass in Northern Pike impinged in 2010-2021.

Year	Annual Number	Annual Biomass (kg)
2010	50	51
2011	46	120
2012	46	133
2013	58	188
2014	36	112
2015	27	70
2016	12	31
2017	33	21
2018	67	106
2019	92	143
2020	49	99
2021	41	91

4.7 Episodic Fish Kill Events

There were no episodic fish kill events in 2021.

5.0 IMPINGEMENT TRENDS

5.1 Comparison with Authorization and FAAA Impingement Predictions

OPG's FAAA estimates were used to define an annual all ages impingement threshold of 3,619 kg in each of two consecutive years of impingement monitoring during the Authorization period. Condition 3.2.1.1 of the Authorization states that if this threshold is exceeded, communications with DFO should be held to discuss the root causes, with the potential need for subsequent adaptive management. This commitment was included as a condition of the Authorization.

The impingement estimates for both 2020 and 2021 are below 3,619 kg. Therefore, impingement is below the two-year threshold.

5.2 Trends

The 2021 impingement rate was 0.32 kg/million cubic metres of CCW intake volume compared to the rolling (2017-2021) five-year mean of 1.06 kg/million cubic metres of CCW intake volume, and ten-year mean of 0.9 kg/million cubic metres of CCW intake volume.

The species with the largest all ages biomass impinged were Alewife (5.7.4 kg; 32%) and Gizzard Shad (307.85 kg; 19.4% of total biomass). Except for 2014, Gizzard Shad and Alewife have been the top two species impinged since 2013. In 2014, Gizzard Shad were most abundant, followed by Common Carp, then Alewife. However, using the definition of an event approved by DFO, the January 2014 circumstance in which many Common Carp were impinged would now be categorized as an event. This anomaly was assessed as part of the Fisheries Act application for Authorization and was deemed attributable to a cold snap associated with a polar vortex.

6.0 UNCERTAINTY

The following are the primary factors that contribute to uncertainty in the impingement estimates:

- There is uncertainty associated with the performance of the FDS. Depth loggers are used to assess the performance of the FDS over the installation period.
- There is uncertainty associated with numbers and species of fish that may be present in the forebay prior to FDS installation, and the number of additional fish that may enter the forebay if performance is affected by natural causes, tears, or small holes.

- There is a lag effect between the period that fish enter the forebay and the time they may be impinged. Some large fish with strong swimming capabilities may never be impinged and could leave the forebay after the FDS is removed. The lag effect and

how this affects monthly impingement numbers and biomass varies between species and life stages.

- There is uncertainty associated with the identification of fish sampled from the bins (physical counting, length/weight measurements, subsamples, and identification), largely due to the physical condition of the fish after being impinged. To mitigate the physical condition of the fish, bins are exchanged prior to weekly monitoring. To mitigate misidentification, sampling practices have been proceduralized and monitoring is undertaken by qualified individuals that have completed the Royal Ontario Museum (ROM) fish identification course. Photos are taken of collected fishes which aid in validation. Misidentification may result in small errors associated with the individual species data reported in Tables 6 and 7.

- There is uncertainty associated with missing or incomplete data from field forms. This has been minimized by self checks, peer checks and follow up communications. If necessary, missing values for certain parameters (e.g., fish length, weight) can be estimated using descriptive statistics calculated or interpreted from available data, as described in Section 3.4

- There is uncertainty in extrapolating data for periods that bins are out-of-service and non-sampled time periods. Surrogate data was used to conservatively estimate impingement for out-of-service periods. There is also high natural variability from season to season. This uncertainty has been reduced by extrapolating data within each month, and appropriate flagging, verification, and treatment of outliers in the database and associated number and biomass calculations.

- There is high natural variability from day to day, which is largely influenced by environmental factors and movement of fishes through the zone affected by the PNGS intake. The variability associated with this is real and cannot be reduced through increased sampling effort. Typically, impingement rates are more stable when the FDS is installed as the FDS deters migration of many species and life stages into the intake forebay. However, Monte Carlo simulations on the 2011 data indicated that reducing the sampling frequency from five samples to one sample per week would have minimal impact on the 95% confidence intervals.

7.0 CONCLUSION

This report documents outcomes of impingement mitigation measures and impingement estimates for the 2021 calendar year and is submitted to satisfy both condition 3.1 and condition 3.2.1 of the Authorization.

The primary measure to avoid or mitigate fish impingement at PNGS is the FDS. The start of installation was delayed to May 4 and the rationale was reported to and acknowledged by DFO. The notification and completion dates for installation of the combined FDS including secondary skirt complies with condition 2.1.1.1. The removal commenced on November 1, which complies with condition 2.1.1.2 of the Authorization.

Impingement monitoring was conducted throughout the calendar year. Fish collected in bins during the sampling periods were identified, counted, and weighed to calculate impingement numbers, biomass, and rates. Over 2021, 325 bins were assessed during routine impingement monitoring in Units 1, 4, 5, 6, 7 and 8 combined.

All ages impingement in 2021 was 1,585.07 kg or 0.32 kg/million cubic meters of CCW intake volume. A total of 36 taxa, identifiable to the species level and an estimated 214,666 fish were impinged in 2021.

8.0 REFERENCES

DFO 2018. Letter, D. Nicholson to R. Lockwood. Paragraph 35(2)(b) *Fisheries Act* Authorization for the OPG Pickering Nuclear Generating Station. January 17, 2018. P-CORR-00539.4-00003.

OPG 2013. Letter, G. Jager to M. Santini. Long-Term Fish Impingement and Entrainment Monitoring Program, Action Notice 4 of Action item 2012-48-3489, June 13, 2013. P-CORR-00531-04216.

OPG. 2017. Letter, R. Lockwood to C. Boros, DFO. Submission of an Application for Authorization under Paragraph 35(2)(b) of the *Fisheries Act*, Pickering Nuclear Generating Station. December 20, 2017P-CORR-00539.4-00002

Appendix A: Estimation of Annual Impingement

The following formulas were used calculate monthly impinged biomass for each species:

$$\text{Monthly annualized biomass impinged for species x} = \sum_{Locn=1\ to\ 8} \left[\left(\sum_{Bin=1}^{j} \sum_{Fish=1}^{i} Measured\ Fish\ Weight \right) * \frac{Total\ Flow}{SampledFlow} \right]$$

Where:

Fish = Record of individual fish in bin_j

i = Total number of fish of species x in bin_j

Bin = Record of bin sampled at a specific bin location

j = Number of bins sampled at single bin location in one month

Locn = one of 8 screenhouse bin locations

Total Flow = Total monthly condenser cooling water and reactor building service water flow at the bin location

$= \sum_{\text{Day}=1}^{\#\ \text{Days in Month}} \text{Hourly Flow}_{\text{day,locn}} * 24\ \text{hr}$

Sampled Flow = Total flow at the bin location for the sampled time periods

$= \sum_{\text{bin}=1\text{j}} \text{Hourly Flow}_{\text{day,locn}} * \#\ \text{Hours bin j was in Service}_{\text{day,locn}}$