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Assessing a proponent-driven process for endangered species threat mitigation: Ontario's *Endangered Species Act*, American Eel, and hydropower

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Abstract

American Eel (*Anguilla rostrata*) were used as a case study to assess whether Ontario's *Endangered Species Act* proponent-driven regulatory approach resulted in successful imperilled species management outcomes. American Eel observation databases and proponent-prepared mitigation plans and monitoring data were used to assess whether: (*i*) facilities within the distribution range were registered, (*ii*) effects monitoring protocols were adequate to evaluate adverse effects of facilities, (*iii*) proponents implemented mitigation actions that followed best management practices (BMPs), and (*iv*) effectiveness monitoring designs were adequate to evaluate effectiveness of mitigation actions. Less than half of the facilities (8 of 17) within the extant species range were registered. Few eels were observed at each facility, precluding proponents from effectively evaluating the facilities' effects. Mitigation actions following BMPs were only implemented for eel out-migration at three facilities. Half of the registered facilities implemented effectiveness monitoring, but experimental designs did not follow best practices and standards. To improve this proponent-driven approach, regulators could reduce ambiguity in regulation language and provide clearer, quantitative requirements for facility registration, effects monitoring, mitigation actions, and effectiveness monitoring. Proponents could improve monitoring efforts to establish species occurrence and generate baseline data to measure facility effects and mitigation action effectiveness.

Key words: imperilled species, species at risk, effectiveness monitoring, effects monitoring, permit-by-rule, conditional exemption

Introduction

Imperilled species are often managed using top-down strategies based on regulation and enforcement or bottom-up strategies based on voluntary action. For example, legislation at the national level can be seen within the *U.S. Endangered Species Act* (US ESA), Canada's *Species at Risk Act*, the *Biodiversity Law of Costa Rica*, and the *Endangered Species Protection Act of Australia* (Waples et al. 2013). Such top-down approaches ensure that any activities involving imperilled species are managed through governmental institutions, usually at the federal or state/provincial levels; however, such frameworks may be insufficient to reverse population declines in imperilled species (Favaro et al. 2014). There are many voluntary bottom-up approaches for mitigating anthropogenic effects on imperilled species. For example, a voluntary approach was implemented to protect Saskatchewan grasslands as essential habitat for declining Burrowing Owl (*Athene cunicularia*) populations (Warnock and Skeel 2004). This bottom-up effort demonstrated a positive effect on grassland habitat conservation; however, landowners involved in the voluntary management program had little incentive to continue with the program due to low numbers of Burrowing Owl (Warnock and Skeel 2004). Private-sector proponent-driven initiatives and self-enforcement have become more prevalent in Canada and the United States (Huque and Watton 2010).

On the regulatory spectrum, a proponent-driven regulatory approach falls between a bottom-up voluntary and a top-down hierarchical regulator driven approach, which reflects a shift in regulation towards joint efforts between government, business, and stakeholders (Lange and Gouldson 2010). In a proponent-driven regulatory approach, there are requirements outlined by a regulator that also provides auditing and oversight, but the responsibility and decision-making for developing a mitigation plan, implementing mitigation actions, monitoring, reporting, and maintenance of records lies with the proponent. Proponent-driven regulatory frameworks may empower private landowners and developers that are proactive, and their involvement in knowledge uptake and participation in conservation efforts may elicit better engagement through altruistic pro-engagement behaviours (Steg and Vlek 2009). Proponent-driven regulations rely on the ethics of the proponent, which can have significant effects on individual actions (Furger 1997), and auditing and enforcement by the regulator to ensure compliance. Their success also depends on clear guidance from the regulator such that proponents know what is expected of them.

In 2007 the Ontario government enacted the Ontario *Endangered Species Act* (2007) (Ontario ESA), the primary legislation regulating the protection of imperilled species in the province of Ontario, Canada. During the first five years, proponent activities that could affect a Threatened or Endangered species or their habitat could be authorized through permits or entering into agreements with the regulator (Environmental Commissioner of Ontario (ECO) 2017). This permit and agreement process resulted in a heavier workload for the regulator and delays for proponents to receive permits/authorizations under the Ontario ESA (ECO 2017). In addition to the permits/authorizations, a 2013 amendment to Ontario Regulation 242/08 (O.Reg.242/08) introduced a proponent-driven conditional exemption framework that authorized eligible activities, provided prescribed requirements of the regulation were met by the proponent. Exemptions applied to various activities, including natural resource development projects such as existing hydropower generating stations.

For hydropower proponents, the conditional exemption framework is a proponent-driven process whereby authorizations (i.e., conditional exemptions) to operate the facility are automatically issued to a proponent who has identified that their activity may impact a species listed as Endangered or Threatened under the Ontario ESA; registered the activity by submitting a notice indicating the affected species, among other information; and completed all prescribed conditions of the regulation including preparing and implementing a mitigation plan for the facility (**Fig. 1**). Proponents are expected to self-determine whether their facilities kill, harm, or harass a species listed as Endangered or Threatened in Ontario or impact their habitat and register them if they do (O.Reg.242/08, 2007, 23.12). However, there is no framework for how potential impacts to species or their habitat are determined. The requirements of the mitigation plan for hydropower operators are to explain the potential adverse effects the facility could have on the species or its habitat, outline reasonable steps they will take to minimize those effects, and include a plan for monitoring the facility's effects on the species and the effectiveness of mitigation actions. Proponents must develop

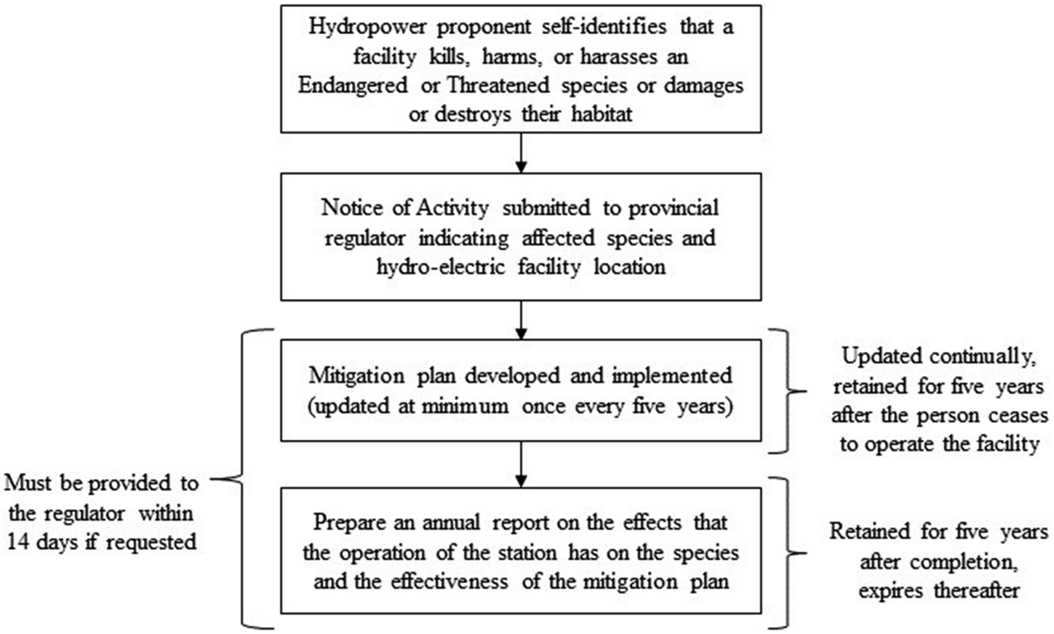

Fig. 1. Proponent-driven framework for hydropower operators under O.Reg.242/08, 2007, 23.12 of the Ontario *Endangered Species Act* (2007). Hydropower operators are granted an automatic conditional exemption to operate their facility if these requirements are met.

mitigation plans that are updated at minimum once every five years and prepare an annual report on the monitoring components. Monitoring reports must be retained for five years, and the regulator can request and audit these documents to ensure that the requirements of the Ontario ESA (O.Reg.242/08, 2007, 23.12) were met. The intent of the conditional exemption regulatory framework was to strike a balance between being overly prescriptive with regulatory requirements and allowing flexibility for proponents to develop their own plans (K. Corrigal, Ontario Ministry of Environment, Conservation and Parks (MECP), personal communication, 2020; ECO 2017). It was designed to streamline approvals in circumstances where there are predictable effects and common approaches for minimizing adverse effects (K. Corrigal, MECP, personal communication, 2020). It assumes that proponents know their case-specific sites best and, therefore, the most appropriate and efficient way(s) to minimize adverse effects. Streamlining authorizations via conditional exemptions is beneficial to the provincial regulator and proponents through efficient resource use (time, money, personnel; K. Corrigal, MECP, personal communication, 2020), and could be beneficial to imperilled species if quicker decision-making and implementation of mitigation actions are undertaken (Dee Boersma et al. 2001; Martin et al. 2012). In general, this depends on whether proponents interpret regulations and implement mitigation efforts in a manner that achieves or deviates from the original goals of the regulation (Clare and Krogman 2013; McSpirit et al. 2005). Thus, there is also a need for regulators to set rigorous guidelines for management and application of proponent-driven conditional exemption regulatory regimes to ensure their success (Black 2001).

Mitigation plans that outline mitigation actions, monitoring plans, and effectiveness monitoring are essential planning components for attaining successful species recovery outcomes (DFO 2012; Smokorowski et al. 2015). Mitigation actions are intended to reduce, minimize, or eliminate over time the adverse effects of a project (Lewis et al. 2013; DFO 2019). Effectiveness monitoring, a rigorous science-based approach that includes a standardized and transferable monitoring design (Noon et al. 1999; DFO 2012), is a longer-term process that quantifies the effects of mitigation and monitoring

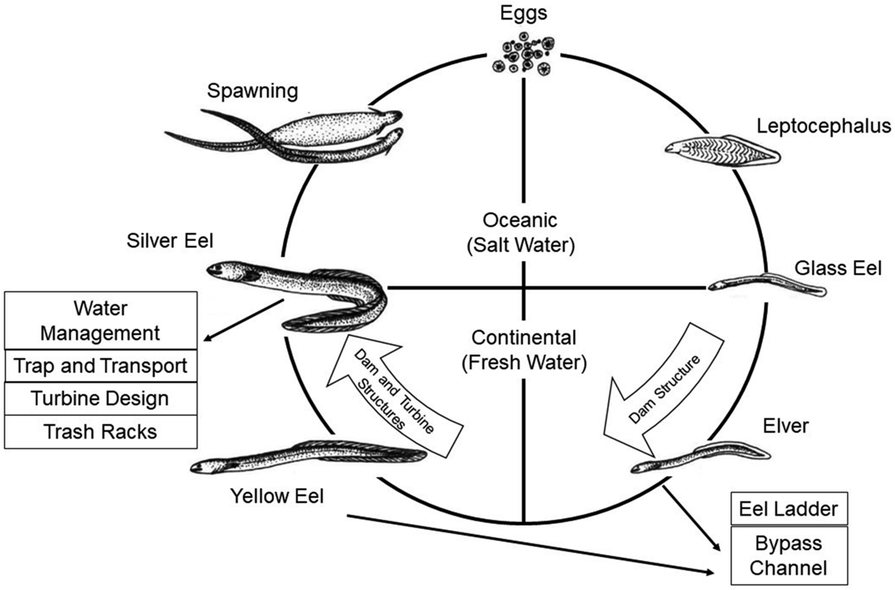

Fig. 2. American Eel life cycle and hydropower effects in oceanic and freshwater environments. The left side of the figure represents eels during downstream migration and the right side represents upstream migration. Arrows within the circle denote hydropower effects on different life stages. Mitigation efforts for each freshwater life stage are noted in exterior boxes. Effects and mitigation actions are adapted from OWA (2010); American Eel life stages are adapted from OMNR (2007).

actions. Effectiveness monitoring requires a comparison to reference data, ideally employing a Before-After-Control-Impact (BACI) design (Conquest 2000), though other alternative comparators can also be appropriate (Lewis et al. 2013; Smokorowski et al. 2015). To remain consistent with the language used in the Ontario ESA, in the present study "effectiveness monitoring" refers to monitoring the effectiveness of mitigation actions, whereas "effects monitoring" refers to monitoring the effects that a hydropower facility has on a species.

The American Eel (*Anguilla rostrata*) is a semelparous, catadromous, panmictic species that reproduces in the Sargasso Sea, and is the only *Anguillidae* species that occurs in North America. Once highly abundant in Ontario waters throughout the upper St. Lawrence River and Lake Ontario watershed (USLR-LO), American Eel recruitment in the USLR-LO has declined by 99% since the 1980s (MacGregor et al. 2009). Hydropower facilities and dams are the main threat to the USLR-LO portion of the American Eel population, directly contributing to the decline of the species by preventing juvenile upstream migration and causing mortality of downstream migrating adults during passage through turbines (**Fig. 2**; OMNR 2007; MacGregor et al. 2013). The conservation status of American Eel varies by jurisdiction. American Eel is listed as Endangered under the Ontario ESA but is not listed in the other regions of Canada. Federally, the American Eel is assessed as Threatened under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) but does not receive protections under the *Species at Risk Act* (SARA). In the United States, American Eel is not listed with any state governments or federally under the US ESA. American Eel is listed as Endangered on the International Union for the Conservation of Nature (IUCN) Red List; however, this has no regulatory implications in Canada or the United States.

The American Eel serves as an effective case study to assess actions and outcomes under the Ontario ESA proponent-driven process because scientifically sound best management practices (BMPs) were developed by the industry association representing hydropower producers in Ontario (Ontario Waterpower Association (OWA) 2010; Chaput et al. 2014). Similar proponent-driven regulatory regimes or processes have been enacted for air quality environmental regulation in Ontario (ECO 2017), in Alberta for watercourse construction projects (Alberta Environment and Parks 2019), and at the federal level for projects subject to the Canadian Fisheries Act 2012 (repealed 2019) (Rice et al. 2015), but to our knowledge the proponent-driven process in Ontario ESA O.Reg.242/08 is a novel approach for imperilled species management. Although our case study is focused on a single species in Canada, the findings are relevant to other jurisdictions that have, or are considering implementing, proponent-driven processes for imperilled species management. We are unaware of any other syntheses or reflective papers on the effectiveness of this emerging management paradigm.

Here we used a novel approach that combines an observation database with proponent- and regulator-driven mitigation plans to assess the Ontario ESA proponent-driven process. Our goal for this paper was to examine if the Ontario ESA proponent-driven process resulted in successful outcomes for an imperilled species, using American Eel as a case study. Specifically, we assessed whether the proponent-driven process under O.Reg.242/08 was successfully mitigating adverse effects of hydropower facilities for this species. We used an American Eel observation database and regulator- and proponent-provided mitigation plans and monitoring data to assess whether: (*i*) hydropower facilities where eel were expected to be present were registered, (*ii*) effects monitoring protocols were adequate to evaluate the effects of the operation of the station on the species, (*iii*) proponents selected mitigation actions that followed BMP and implemented these actions as proposed, and (*iv*) effectiveness monitoring designs were adequate to evaluate the effectiveness of mitigation actions. This was used to generate generic guidance on proponent-driven conservation initiatives.

Methods

To determine the current American Eel distribution in relation to Ontario hydropower facilities, we developed an objective criterion based on observation data obtained from the Natural Heritage Information Center (NHIC) in July 2019. The NHIC data included observations submitted by industry, government, nongovernmental organizations, and individuals, both voluntarily and as a reporting requirement under collection permits (NHIC 2019). This database was filtered to only include American Eel observations with associated geographical coordinates or descriptions that allowed for manual determination of a geographical position and observations extending from 1 January 1999 to 22 July 2019. The 20-year duration was chosen to accurately reflect the present-day eel distribution because eel distribution significantly contracted from 1980 to 2000 (MacGregor et al. 2013). Other studies that have used historical and current observation data to determine endangered species distribution used similar temporal criteria (e.g., Teresa et al. 2014). Eel observations from proponent monitoring reports were added to the NHIC data. Observations were plotted in ArcGIS (version 10.6) with the Government of Canada National Hydro Network and National Hydro Network Hydrographic Linear Feature Dataset used as a base map (Natural Resources Canada 2019). Hydropower facilities were plotted using the Ontario Hydro Network Hydrographic Point shapefile (Ontario Ministry of Natural Resources and Forestry 2011) and the Ontario Dam Inventory shapefile (Ontario Ministry of Natural Resources and Forestry 2019). Google Earth (version 7.3.2.5776) and internet sources (e.g., Google searches, proponent websites) were used to validate whether a structure was a hydropower facility or other type of barrier.

Hydropower facilities that may impact American Eel were identified by delineating the area from the most upstream reliable American Eel observations to the next upstream barrier impassable by American Eel. We interpreted adverse effects to include prevention of upstream migration and turbine mortality during out-migration. Therefore, we expected all facilities downstream of reliable eel observations to be registered, along with all facilities upstream of reliable eel observations, provided there were no other (i.e., natural or nonhydropower) impassable barriers in between. Observations were considered reliable if: they resulted from fish sampling, a photo was submitted along with an observation, they were submitted by the regulator, or if multiple observations (i.e., five or more) were submitted by individuals. Facilities at the base of natural barriers with American Eel downstream were not expected to be registered because these facilities do not have adverse effects on upstream migration. Facilities in the Niagara River and Twelve Mile Creek (connecting to the Welland Canal) were not expected to be registered because American Eel are not native to Lake Erie and face an ecological trap out-migrating through Niagara Falls if they pass upstream. The list of facilities expected to be registered with the province was compared to the list of registered facilities obtained through the *Freedom of Information and Privacy Protection Act* (FIPPA) or shared voluntarily.

To assess mitigation, monitoring, and registration of hydropower facilities, a freedom of information request was submitted in February 2019, under FIPPA, to obtain all American Eel documentation related to O.Reg.242/08 that the Ontario Ministry of Natural Resources and Forestry (OMNRF) received from hydropower proponents (see **Table S1 in Supplementary Material** for documents requested). Owing to changes in administrative responsibilities, a subsequent FIPPA request was submitted to the MECP in January 2020 for additional documentation. Under O.Reg.242/08 23.12, proponents are only required to submit mitigation plans and monitoring reports to the provincial government when requested (within 14 days). Therefore, these documents were only obtainable through FIPPA if they had been previously requested by the regulator. To obtain additional or updated documents, hydropower proponents were asked to provide them voluntarily. Document-screening and data-extraction processes were adapted from a systematic review process outlined by Rytwinski et al. (2017). Additional FIPPA document screening and data extraction details are available in the **Supplementary Material**.

We analyzed proponent monitoring and mitigation actions according to the requirements of O.Reg.242/08 paragraph 23.12(6) and assessed these actions from a scientific perspective. Based on the requirement to monitor the adverse effects of the facility on target species, we reviewed whether hydropower proponents quantified the number or proportion of eels prevented from moving upstream and the proportion of eels killed during downstream passage. Effects monitoring designs were assessed against published scientific standards (e.g., paired comparisons between sites upstream and downstream of a facility; Lewis et al. 2013). Based on the requirement to minimize the adverse effects of the facility on target species, we reviewed whether proponents included mitigation actions that were expected to avoid or reduce harm to American Eel, and whether the mitigation actions followed BMPs and criteria outlined in OWA (2010). Actions aside from directly monitoring and mitigating adverse effects were also reviewed. These pro forma actions included providing contact information, a map, a species list, and notifying and training employees and contractors on the presence of the species and steps they must take if encountered. Based on the requirement to monitor the effectiveness of mitigation actions, we expected proponents to quantify the effectiveness of their mitigation actions (e.g., controlled-release trials to assess successful passage rate). If effects monitoring actions also involved mitigation (e.g., netting or electrofishing coupled with trap and transport around the facility), these were considered both effects monitoring and mitigation actions. Ad hoc actions or observations from mitigation or monitoring efforts that were not outlined in the mitigation plan were not included in the analysis of mitigation actions and effects monitoring.

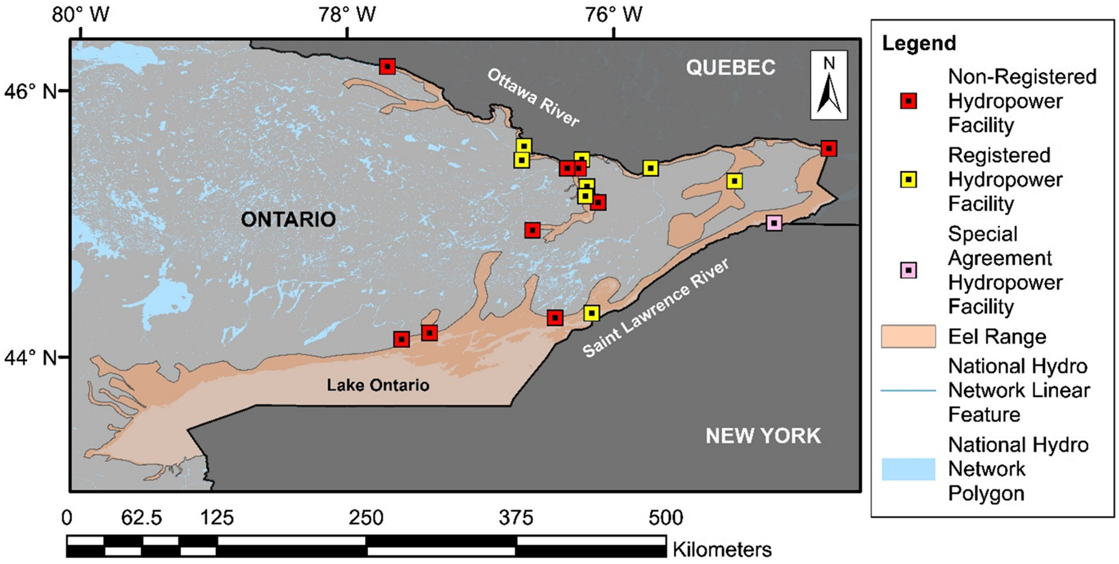

Fig. 3. American Eel range from Natural Heritage Information Center and proponent observations from 1 January 1999 to 22 July 2019 extending to the next impassable barrier. The base map was produced using the Government of Canada National Hydro Network and National Hydro Network Hydrographic Linear Feature Dataset (Natural Resources Canada 2019) and the hydropower facilities were plotted using the Ontario Hydro Network Hydrographic Point shapefile (Ontario Ministry of Natural Resources and Forestry 2011) and the Ontario Dam Inventory shapefile (Ontario Ministry of Natural Resources and Forestry 2019). See Table 1 for a breakdown of facilities by waterbody. Data provided by Ontario Ministry of Natural Resources, copyright Queen's Printer for Ontario 2019. The use of these data in this figure does not constitute an endorsement by the Ministry of this figure.

Results

Facility registration

The American Eel range, as defined based on 2479 observations, was determined to extend to Des Joachims Generating Station on the Ottawa River and to multiple tributaries of Lake Ontario and the Ottawa River (Fig. 3). There were 23 hydropower facilities directly upstream or downstream of reliable observed eels (Table 1). The five facilities on the Niagara River and Twelve Mile Creek were not expected to register. The Saunders Generating Station on the St. Lawrence River produced 113 513 observations from eel ladder counts, but this facility is managed by a separate imperilled species management agreement between the province and Ontario Power Generation (OPG; the proponent) and was thus not considered hereafter beyond determining eel distribution range. Of the 17 remaining hydropower facilities deemed to be in the present eel range and expected to register, only eight appear to be registered (47%) based on the FIPPA request and proponent-provided documents (Table 1, Fig. 3).

Facility mitigation and monitoring

A total of 12 mitigation plans and 32 monitoring-related reports were reviewed, which encompassed eight hydropower facilities. The number of years covered by monitoring-related reports varied among hydropower facilities from two to six years. The number of mitigation plans was greater than the number of registered facilities because multiple iterative mitigation plans covering different time periods were provided for some facilities.

Table 1. The river systems, number of facilities, and number of registered facilities determined to be within the American Eel distribution range.

River system	No. of facilities (no. registered)
Bonnechere	1 (1)
Cataraqui	1 (0)
Gananoque	1 (1)
Madawaska	1 (0)
Mississippi	5 (2)
Moira	1 (0)
Niagara	2 (0[a])
Ottawa	5 (3)
St. Lawrence	1 (0[a])
South Nation	1 (1)
Trent	1 (0)
Twelve Mile Creek	3 (0[a])

[a] Facilities that were not expected to be registered.

Effects monitoring and other eel sampling

Effects monitoring actions included trash rack inspections, intake canal inspections, tailrace surveys, and tailwater surveys. Effects monitoring actions followed presence/absence or impact-only designs where proponents counted injuries and mortalities. Monitoring frequency and duration also varied among years (Table 2). The most common effects monitoring actions for out-migration mortality were trash rack inspections, which were undertaken at five facilities and resulted in no observations. Tailrace surveys and intake canal inspections were also undertaken at the same five facilities that resulted in one and five observations, respectively, all of which were mortalities at the same facility. The degree to which upstream passage was prevented was not monitored; portable eel ladder traps were deployed, but the purpose of doing so was either described as upstream passage mitigation or not described at all. Effects monitoring designs tended to not follow scientific standards for measuring the magnitude of impacts and did not produce estimates of either the number or proportion of eels harmed.

Eels were sampled using trap netting, boat electrofishing, backpack electrofishing, and eel ladder traps, and movements tracked using acoustic telemetry and passive integrated transponder (PIT) tags, but the proponents did not specify what effects these sampling and tracking efforts were meant to monitor. For two facilities, the purpose of electrofishing and trap netting was stated as assessing eel presence and abundance in the vicinity of the facilities. Forty-one American Eel were sampled through these methods (Table 2).

Mitigation and associated actions

One upstream migration mitigation action and four downstream out-migration actions were implemented by hydropower proponents across four facilities. Four of these five actions followed BMPs (Table 2). Trash rack spacing adjustment and fish bypasses were implemented at the same facility. Night-time shutdowns were implemented at one facility. Transporting captured eels >800 mm was planned at two facilities; however, eels >800 mm were not transported as directed by the regulator.

Table 2. Proponent mitigation, effectiveness monitoring, and effects monitoring actions among hydropower facilities.

Action (migration direction, no. eels observed)	Description/design	No. Facility	Monitoring frequency
Effects monitoring (46)			
Trash rack inspection (D, 0)	Visually inspect trash racks for impinged eels and carcasses.	5	Weekly, monthly
Intake canal inspection (D, 5)	Intake canal dewatered and visually inspected for eels or mortalities.	5	During trash rack inspections
Tailrace survey (D, 1)	Netting installed in the tailrace to capture eels and mortalities.	6	Weekly
Trap netting (D/U, 2)	Night-time trap net (24 h sets).	2	Monthly
Electrofishing; boat (D/U, 37)	Night-time boat electrofishing. 20 min transects, 1.1 to 1.9 km/h boat speed.	2	Weekly
Electrofishing; pack (D/U, 0)	Backpack electrofishing	1	Yearly, 1 week per year
Tailwater survey (D, 1)	Boat survey, visually searching for injured or dead eels downstream of GS.	3	Weekly
Telemetry array (D/U)	Acoustic receivers at facility to detect any acoustic tagged eels.	1	Ongoing
Passive integrated transponder (PIT) tag (D/U)	Implant captured eel with PIT tags to track movement.	2	Ongoing
Mitigation (2)			
Portable eel ladder and trap (U, 0)	A removable ladder, holding tank, and water supply, monitored by visual inspection or by camera. Coupled with trap and transport.	4	Daily, 3 times per week
Water management[a] (D)	Night-time shutdown during eel migration (May–October).	1	Daily, 3 times per week
Eel bypass[a] (D, 2)	Series of pipes that bypass the turbines and releases into the tailrace, monitored by camera.	1	Ongoing
Trap and transport[a] (D, 0)	Any captured eel that is > 800 mm will be transported downstream	2	Ongoing
Trash rack spacing[a] (D, 0)	Changing trash rack spacing to prevent passage into turbine intakes.	1	Ongoing
Effectiveness monitoring			
Discuss eel observations with expert	Discuss mitigation and monitoring with an expert and adjust actions accordingly.	8	Yearly
Cameras	Monitor eel passage at bypass and portable eel ladder traps.	4	Ongoing (bypass), while ladder trap installed

Note: The migration direction (U = upstream, D = downstream) and number of live eels or mortalities observed is indicated in parentheses where appropriate. The frequency of actions that were conducted among facilities are indicated. Daily = once per day, weekly = once per week, monthly = once per month unless otherwise specified.

[a] Actions outlined as a best management practice by OWA (2010) or followed commonly accepted scientific standards (e.g., Lewis et al. 2013).

Portable eel ladder traps were installed at four facilities, and mitigation plans indicated that any captured juveniles would be transported upstream of the facility, making this the only upstream mitigation action, though not one identified as a BMP (Table 2). For four of the eight facilities, no upstream nor downstream mitigation actions were identified.

All eight registered facilities included components in their mitigation plan whereby contact information, a map, and a list of imperilled species that may be encountered at the facility were provided. The mitigation plans also indicated that personnel and contractors were to be trained on identifying, handling, and reporting imperilled species that were present and affected by the facilities.

Effectiveness monitoring and effectiveness of mitigation actions

Two effectiveness monitoring actions were implemented at hydropower facilities (Table 2). Four facilities used cameras to monitor for juvenile American Eel using portable ladder traps and one facility used cameras to monitor for downstream eel passage through a bypass. No eels were reported as observed or captured in the portable ladder traps. Two out-migrating adult eels were observed using the bypass, but the number of eels that out-migrated through other turbines at this facility was not assessed. This monitoring approach did not follow effectiveness monitoring standards (e.g., no "before" data were collected and there was no control).

Discussion

The conditional exemption proponent-driven regulatory approach reviewed here has led to few documented demonstrably positive outcomes for American Eel. Our analysis indicated that fewer than half of the hydropower facilities likely to adversely affect the species were registered with the provincial regulator. Of those registered, only half implemented mitigation actions that could reduce adverse effects of the facility on the species. Effectiveness monitoring revealed evidence of only two eels saved from turbine mortality since 2013, though recent monitoring reports were not obtained for all facilities.

Registration

The list of registered facilities differed markedly from the list generated through our analysis of observation data. Hydropower proponents may obtain an authorization within the Ontario ESA that exempts eligible facility-related activities that kill, harm, or harass species at risk; however, no details are provided on how this should be determined. Because this is a proponent-driven process, the regulator does not provide case-specific notifications of which facilities must seek an authorization under the Ontario ESA. Instead, the regulator can review or provide guidance on a facility-by-facility basis if requested by the proponent (K. Corrigal, MECP, personal communication, 2020). Before the Ontario ESA shifted to the proponent-driven process in 2013, hydropower proponents received direction (i.e., notification letters) from the regulator at the time (OMNRF) on whether a facility required an agreement (D. Stanley, OPG, personal communication, 2020). When the onus shifted to proponent self-identification in 2013, the understanding of responsibilities between proponents and the regulator may have been unclear and may have contributed to why the list of registered facilities differed from our expectations. Indeed, confusion about expectations of the regulator is a key issue that underpins many of the problems identified in this study.

We developed impartial criteria to identify which facilities might impact American Eel based on observation data. Though we have confidence in our criteria, our data-quality thresholds were subjective and alternate decisions made by proponents could drive the discrepancy between the number of expected versus observed registered facilities. It is unclear whether proponents reviewed observation data held by the regulator or other proponents on the same system, or relied on direct sampling when deciding whether to register facilities. Clarity from the regulator on the number, type, quality, and recency of observations, along with the sampling effort necessary to reasonably detect a species if it is present, would assist proponents in registering the correct facilities. However, the onus is ultimately on the proponent to identify if they will impact American Eel and register under the relevant conditional exemptions.

The self-identification and facility registration rates in the present study are consistent with results from other assessments of similar proponent-driven environmental legislative regimes. A proponent-driven process required for wetland disturbance in other jurisdictions in North America, whereby proponents self-identify that their actions require permitting, found a registration rate of less than 50%. A study by Clare and Creed (2014) found that 82 percent of wetland destruction in Alberta, Canada, from 1999 to 2009 was undertaken without obtaining necessary permits. A similar study by Clare et al. (2011) found that 50% of wetlands in Massachusetts, United States, were filled without a permit. These studies, combined with our assessment results, suggest that proponent-driven processes may only be partially effective, and regulators should audit registration compliance in regimes requiring proponent self-identification.

Effects monitoring

The effects monitoring actions undertaken through the reports reviewed in this study did not quantify the number or proportion of imperilled species individuals affected by any facility. Such information is necessary for estimating the cumulative effects of hydropower facilities on target species and for establishing baselines to evaluate the effectiveness of mitigation actions. The language of O.Reg.242/08, s. 23.12(1) does not specify that effects must be quantified, but simply that they must be monitored. As such, effects monitoring efforts by hydropower proponents may have met Ontario ESA regulatory requirements, but experimental designs did not follow commonly accepted best practices and scientific standards. Proponents did not identify specific monitoring objectives (though this is not explicitly required), and it is unclear what purposes drove their monitoring protocol designs. Specifying monitoring objectives, such as monitoring upstream and out-migrating eel passage to identify changes in abundance, density, and (or) distribution, provides direction to monitoring efforts and promotes openness and transparency. Observing eel mortalities associated with a particular infrastructure component or operational modification only shows that a facility has an adverse effect but does not quantify the effect. For meaningful out-migration effects monitoring, the total number of eels passing through the facility or the proportion of mortalities observed through a given sampling strategy must first be estimated, but this process was not described or cited in any mitigation plan. Ultimately, effects monitoring data appeared to serve little purpose beyond identifying the presence/absence of live or dead eels, which may have satisfied the regulatory requirements but is of limited value to the management of the species.

Effects monitoring designs reviewed here were not suitable for generating animal density or abundance estimates needed to determine the effects of the facility on the species. Though trapping and electrofishing were conducted at facilities in this study with stated objectives of estimating species presence/absence and abundance, the techniques as described only confirmed presence/absence. Boat electrofishing was conducted downstream of each facility, but rarely upstream, and catch-per-unit-effort (CPUE) was not reported. The CPUE was reported for trap netting and backpack electrofishing, but these were only conducted either downstream or upstream of a facility. Monitoring efforts inadequately assessing adverse effects are a common outcome in imperilled species management (Campbell et al. 2002; Auditor General of Ontario 2021). Effects monitoring is hindered by low abundance of imperilled species (Van der Burg et al. 2011), which was the case for the facilities in the present study. Effects monitoring challenges are further amplified for American Eel because they are long-lived with a complex life history and are difficult to sample. Control or reference conditions/sites (i.e., "before" data) are often problematic to define with low species abundances, but relative comparisons could be made for effects monitoring purposes (Block et al. 2001). For example, effects monitoring could be conducted to determine current turbine mortality rates. Power analyses could be conducted to develop effects monitoring experimental designs (*a priori*) or test the rigour and strength of inferences of a design (*a posteriori*) for imperilled species (Peterman 1990). However, power analyses should be used as a cursory guide to aide decision-making because significance in effects can be problematic for imperilled species; power is typically low and results are subject to stochasticity. Therefore, basing decisions on statistical significance can be controversial.

Research on turbine mortality rates for American Eel may be suitable for modelling the adverse effects of facilities in Ontario; however, the regulation appears to require site-specific monitoring. The European Eel (*Anguilla anguilla*) has a similar biology and is also negatively affected by hydropower (McCarthy et al. 2008; Pedersen et al. 2012), so studies of this congener may also be useful. Eel turbine injury/mortality and other adverse effects have been modelled for many facilities (Electrical Power Research Institute (EPRI) 2001), including at facilities located within the same region as those in the present study (Great Lakes Fishery Commission (GLFC) 2005; Heisey et al. 2019). Standard modelling of injury and mortality estimates could be pooled for several facilities and grouped by factors such as generation flow (e.g., >100 $m^3{\cdot}s^{-1}$) or for certain infrastructure types (e.g., turbine type or size). It is less clear whether or how these injury and mortality rates vary on a site-specific basis, given the differences in size, infrastructure, and environmental conditions present at each facility. It is also unclear whether modelled effects would be accepted in lieu of field effects monitoring under the regulation. Some field sampling may be required to validate models or create facility-specific models; however, direct quantification of turbine mortality at every facility may not be a wise use of species at risk management resources. For example, eels purchased from legal commercial fisheries in other jurisdictions could be used for turbine mortality studies and (if they survived passage) tracked downstream through multiple stations. The empirical data could then be compared against modelled data to confirm the validity of modelled data as a substitute for ongoing field monitoring. The regulator and proponents do not appear to be pursuing a coordinated approach to pool resources through these mitigation plans; however, this is occurring through a parallel initiative. The Eel Passage Research Center (EPRC), hosted by EPRI, is engaging in such collaborative efforts (Jacobson 2017), and OPG is contributing to this initiative through the separate management agreement for the Saunders Generating Station (Pratt et al. 2021).

Mitigation actions

Steps to minimize the adverse effects of the station on upstream passage and downstream out-migration were implemented at half of the registered facilities; however, only out-migration mitigation actions followed the industry association's BMPs. Mitigation actions for imperilled species may be effective and meet regulatory requirements regardless of whether an action is considered a BMP. For example, half of the facilities in the present study used portable eel ladder traps to attempt to capture eels for transport. Relative to eel ladders, portable ladder traps are much smaller and have a notable difference in attraction flow and the maximum capacity in passing eels over a dam (USFWS 2017). Though portable ladder traps were not a recognized BMP for upstream passage (OWA 2010), they are commonly used and deemed effective for passing eel upstream in other jurisdictions (Solomon and Beach 2004; USFWS 2017). In the reports reviewed here, no eels were reported as captured by portable ladder traps.

The proponent-driven process was designed for circumstances where mitigation actions for minimizing effects are common and evident. In the case of American Eel, upstream passage can be remedied in a relatively (compared to out-migration mortality mitigation) effective and frugal manner by installing eel ladders (OWA 2010). In contrast, effective downstream mitigation actions for American Eel are difficult to implement, especially on large rivers. Unfortunately, the least expensive potential options, such as behavioural guidance devices to repel eels away from hazardous areas or attract to collection devices and safe passage routes, remain experimental and unproven (OWA 2010). Collaborative research is being undertaken on further developing and testing the efficacy of light, sound, and electricity for eel behavioural guidance (EPRC 2018; Pratt et al. 2021). Trap and transport of out-migrating adults can be effective (Mathers and Pratt 2011) and implemented at most sites. Water-management options are the only mitigation actions that provide absolute protection (Rickhus 2005). Voluntarily spilling water is a straightforward passage option to implement but can be economically costly to hydropower proponents because of foregone generation output (Coutant et al. 2006; OWA 2010) and can still result in fish mortality and injury rates (Coutant et al. 2006; Algera et al. 2020). Given the existing challenges surrounding effective and frugal downstream mitigation measures, implementation of mitigation actions does not appear to be simple and straightforward as would be ideal under this proponent-driven regulatory framework.

Effectiveness monitoring

Effectiveness monitoring is required by a proponent that registers for the Ontario ESA conditional exemption and is essential to confirm that mitigation actions are leading to favourable outcomes for imperilled species (Dee Boersma et al. 2001). Campbell et al. (2002) examined monitoring efforts on imperilled species recovery plans and found that effectiveness monitoring contributed to increased recovery of species listed under the US ESA. In the present study, effectiveness monitoring efforts by hydropower proponents may have met Ontario ESA regulatory requirements, but did not follow widely accepted best practices and standards for experimental designs from a scientific perspective. The shortcomings of hydropower proponents' effectiveness monitoring designs mirror challenges noted for most habitat restoration initiatives, for which evidence linking imperilled species outcomes to specific restoration actions is generally lacking (Roni et al. 2018; Hale et al. 2019; Auditor General of Ontario 2021). A proper effectiveness monitoring design would answer questions such as "what proportion of eels were transported?", "what was their post-release fate?", and "to what extent did this action reduce harm?", and would assess quantitative predictions and permit learning (Lewis et al. 2013; Geist 2015; Canessa et al. 2016). Ideally, effectiveness monitoring would follow a BACI design (DFO 2012; Lewis et al. 2013; Smokorowski et al. 2015), but this may not be applicable or possible given data constraints. Often, "before" data are lacking for imperilled species, and low species abundance makes effectiveness monitoring very challenging, which is the case in the present study. Passage efficiency, defined as the percentage of fish that are able to pass a fishway, is commonly quantified at hydropower facilities for several species (Roscoe and Hinch 2010), and proponents can draw on these designs. Natural baselines (i.e., control data) may not be known, but proper effects monitoring should measure the current percentage of fish passage. Post-intervention passage rates could then be measured and compared to evaluate effectiveness. Telemetry technologies, though also challenging and expensive, can provide quantitative estimates if experiments are designed to test specific performance-related hypotheses (Lapointe et al. 2013).

We recognize that proper facility- and action-specific effectiveness monitoring would be costly and difficult given the rarity of American Eel in the USLR-LO, and coordinated approaches may be advantageous. By pooling resources among facilities to assesses the effectiveness of mitigation actions in an adaptive management framework (Clark and Brunner 1996; McCarthy and Possingham 2007), sufficient sampling effort and replication may be more feasible, and results would be more conclusive. Pooled resource allocation tools have been designed for threatened species management (Di Fonzo et al. 2017), and the EPRC is one forum through which this could be accomplished. None of the effectiveness monitoring efforts reviewed here appear to have been undertaken in a coordinated manner. Models based on results of coordinated effectiveness monitoring results could be used to infer the effectiveness of actions at facilities that are not directly monitored. As written, the Ontario ESA conditional exemption does not appear to support this approach because facility-specific effectiveness monitoring is required; however, a path forward could be identified through collaboration with the regulator and other stakeholders and rightsholders.

Mitigation plan compliance and other actions taken

In half of the mitigation plans reviewed, no documented steps were taken to directly minimize the adverse effects of facilities on American Eel. In 2014 and 2017, the regulator reviewed a subset of registrations for compliance with the regulation (K. Corrigal, MECP, personal communication, 2020). The focus of these reviews was to assess whether the proponent met the regulatory requirements and not necessarily the effectiveness of their actions. At the completion of the first review in 2014, the regulator did reach out to proponents to provide additional guidance on complying with the regulations. It is believed that proponents improved their understanding of the requirements through these discussions (K. Corrigal, MECP, personal communication, 2020). It is unclear why failure to include any mitigation actions in some of the plans was not addressed. We are not aware of any enforcement actions addressing deficiencies in American Eel mitigation plans. Implementation of low-cost, pro forma actions was common for registered facilities; however, these actions do not directly benefit imperilled species.

Policy implications and conclusion

Mitigating hydropower effects is outlined as an immediate-term goal in Ontario's American Eel recovery strategy (MacGregor et al. 2013), but progress has been very limited and, overall, this goal is not being achieved. Owing to limited effort and experimental design deficiencies, proponent-driven monitoring efforts did not advance knowledge of the effects of the facilities or the effectiveness of mitigation actions. The Ontario ESA proponent-driven framework appears to be successful at streamlining the permitting process; however, any efficiencies gained through quicker opportunities for actions by proponents do not appear to have resulted in documented benefits to American Eel. More than a decade ago, Allen (2008, p. 2) described the greatest barrier to eel conservation as "intransigence, spin and lack of co-ordination within the corporate and government world". Based on our analysis of proponent documentation, the Ontario ESA proponent-driven process for managing hydropower's effects on American Eel does not appear to have improved this situation to date.

Four main opportunities for improvement in the Ontario ESA proponent-driven conditional exemption regulatory regime were identified during our objective review. First, greater clarity could be provided on registration requirements. Detailed, species-specific guidelines for determining presence based on review of collection records and field sampling requirements, for example, would improve clarity. Though it is widely accepted that the presence of diadromous species such as American Eel upstream of a hydropower facility implies harm, and therefore a requirement to seek an Ontario ESA authorization and mitigate adverse effects, the downstream presence is more ambiguous. We interpreted that any facilities upstream of eel populations and within their historic range block or impede upstream migration; however, clarity from the regulator is warranted. Following this interpretation, several unregistered facilities including the Galetta Hydroelectric Facility, Carillon Generating Station, and Kingston Mills Generating Station are downstream of registered facilities and thus should also be registered.

Second, the language of the Ontario ESA conditional exemption regulation can be vague and convey unclear expectations for hydropower proponents. There is no definition offered by the regulator of what constitutes "reasonable steps" to minimize adverse effects, nor is there a generally agreed upon scientific definition of "reasonable steps". The interpretation of normative terms, such as "reasonable steps" in O.Reg.242/08, depends on value-based judgements that affect interpretation. For example, several court challenges forced clarifications of the phrase "significant portion of its range" (Wilhere 2017), which is used in the US ESA to determine if species should be listed as Endangered or Threatened (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2014). To avoid ambiguity and clearly outline expectations for proponent actions, the regulator should define vague terms such as "reasonable steps".

Third, no quantitative performance targets have been identified. The American Eel recovery strategy calls for the restoration of upstream passage to 10% of upstream habitat every five years (MacGregor et al. 2013), which has not been achieved; however, Ontario recovery strategies are considered science-based advice and are not binding. The government response statement for American Eel remains in draft form (Auditor General of Ontario 2021), despite being legally required under the Ontario ESA within nine months of completing the recovery strategy, which was finalized in 2014. This draft statement does not contain quantitative performance targets to guide proponents. Targets, such as the proportion of eels approaching the facility that should pass upstream, or the proportion of out-migrating eels that should survive passage uninjured, would establish clear requirements that proponents are responsible for meeting and ensuring benefits for imperilled species. Specifying targets would also allow proponents to identify and implement innovative, cost-effective, efficient, and facility-specific solutions for meeting the targets, which is a major intent of proponent-driven processes.

Fourth, there was a lack of clear regulatory requirements, policies, and guidance on monitoring design and quality, and no opportunity for pooling resources across facilities in an adaptive management framework, nor for the use of modelling to estimate effects or effectiveness. Guidance on monitoring design, including replication, duration, and indicators to use as response variables could help to improve the standardization and quality of monitoring data (Braun et al. 2019). This could ensure that data are comparable among facilities and sufficiently inform American Eel recovery efforts. The regulator could amend or interpret the regulatory language to enable pooling resources by a single proponent or among multiple proponents, should they choose to do so, which would be beneficial given several proponents operate facilities on the same watercourses. Clarity could also be provided on when modelling can be used to estimate effects or effectiveness. In line with guiding principles for adaptive management of hydropower facilities (Wieringa and Morton 1996) we propose that: scientifically valid, peer-reviewed monitoring programs should be designed in direct response to imperilled species management objectives; monitoring results should be communicated among hydropower and regulatory stakeholders to develop consensus on responses to changes in hydropower processes (e.g., changes in operational conditions and (or) infrastructure components) and imperilled species trends (e.g., mortality rates, population trends); and transparency and openness in the decision-making process should be promoted and implemented among proponents. More transparent communication of regulator expectations with proponents would address many of the issues identified here.

Despite having an industry- and species-specific BMP guide, the American Eel profile is a particularly difficult case because it has a complex life cycle (panmictic, long generation time, catadromous) and is geographically multijurisdictional, thus involving several regulatory and management authorities. Furthermore, Ontario is an “island” in terms of American Eel being listed as Endangered and some facilities are situated across multiple jurisdictions. For example, Carillon Generating Station is situated entirely in Quebec with the exception of portions of the spillway. Given that the Carillon facility is the first generating station on the Ottawa River, American Eel recovery is highly unlikely in the remainder of the Ottawa River watershed unless the effects of this facility are addressed. American Eel conservation is also difficult from an industry perspective because downstream passage is much harder to address relative to upstream passage (Katopodis and Williams 2012), especially on large rivers. Combined, these factors make American Eel recovery in Ontario a particularly wicked conservation problem (Redford et al. 2013), and it is not surprising that hydropower proponents have struggled to address issues on a facility-by-facility basis.

Ontario’s proponent-driven framework needs greater specificity and quantitative targets, supporting policies and guidance communicated in a clear and consistent manner, and flexibility in requiring site-specific monitoring to achieve intended benefits. A detailed audit of the quality and value or validity of mitigation plan components and enforcement efforts is also needed to ensure both compliance and meaningful action.

The lessons shared here should be relevant to other scenarios where regulators are considering the adoption of proponent-driven processes for addressing the management and conservation of imperilled species. Choosing to implement a proponent-driven framework without adequate resources devoted to ensuring compliance will likely lead to some instances of loss of individuals or populations. Regulatory agencies must therefore choose to either build a lack of compliance into the assumptions of their regulations (e.g., by setting targets such that an anticipated failure rate does not compromise an agency's overall conservation goal), or by devoting sufficient resources to ensuring compliance. More broadly, this suggests a careful evaluation of the long-term efficiency of proponent-driven frameworks, and their effectiveness in achieving conservation objectives.

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Author contributions

DAA, JRB, SJC, and NWRL conceived and designed the study. DAA, KLN, KK, AEIA, and DMG performed the experiments/collected the data. DAA, KLN, KK, AEIA, and DMG analyzed and interpreted the data. DAA, KLN, KK, AEIA, DMG, JRB, SJC, and NWRL drafted or revised the manuscript.

Competing interests

Steven Cooke is an editorial board member for FACETS.

Data availability statement

All relevant data are within the paper and in the Supplementary Material.

Supplementary material

The following Supplementary Material is available with the article through the journal website at doi:10.1139/facets-2021-0058.

Supplementary Material 1

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