

Report on the Progress of Recovery Strategy
Implementation for the Northern Madtom (*Noturus
stigmaosus*) in Canada for the Period 2012–2016

Northern Madtom



2018

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Rapport sur les progrès de la mise en œuvre du programme de rétablissement du chat-fou du Nord (*Noturus stigmosus*) au Canada pour la période 2012-2016

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under Section 46 of the Species at Risk Act (S.C. 2002, c.29) (SARA) the competent ministers responsible for reporting on the implementation of the recovery strategy for a species at risk, and on the progress towards meeting its objectives within five years of the date when the recovery strategy was placed on the Species at Risk Public Registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible.

Reporting on the progress of recovery strategy implementation requires reporting on the collective efforts of the competent minister(s), provincial organizations and all other parties involved in conducting activities that contribute towards the species' recovery. Recovery strategies identify broad strategies and approaches that will provide the best chance of recovering species at risk. Some of the identified strategies and approaches are sequential to the progress or completion of others; not all may be undertaken or show significant progress during the time frame of a report on the progress of recovery strategy implementation (progress report).

The Minister of Fisheries and Oceans is the competent minister under SARA for the Northern Madtom and has prepared this progress report.

As stated in the preamble to SARA, success in the recovery of species at risk depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in the recovery strategy and will not be achieved by Fisheries and Oceans or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing the recovery strategy for the Northern Madtom for the benefit of the species and Canadian society as a whole.

Acknowledgements

This Progress Report was prepared by Pooi-Leng Wong (DFO), Josh Stacey (DFO) and Shawn Staton (DFO). To the extent possible, this Progress Report has been prepared with input from the province of Ontario, Ontario Ministry of Natural Resources and Forestry, Essex Region Conservation Authority, St. Clair Region Conservation Authority and the Upper Thames River Conservation Authority.

Executive summary

The Northern Madtom was listed as endangered under the Species at Risk Act in 2003. The Recovery Strategy for the Northern Madtom (*Noturus stigmosus*) in Canada was finalized and published in the Species at Risk Public Registry in 2012. The main threats identified for the Northern Madtom include siltation, turbidity, nutrient loading, physical habitat loss, toxic compounds, invasive species (formerly referred to as exotic species), and climate change.

Population and distribution objectives for the Northern Madtom are to maintain distributions of extant populations in Lake St. Clair, and the Detroit, St. Clair, and Thames rivers. During the time period reported by this progress report, the following activities have been accomplished in support of the recovery objectives as stated in the recovery strategy:

- targeted sampling for extant populations of Northern Madtom has been conducted
- environmental DNA (eDNA) surveys have been conducted in areas where Northern Madtom was historically known to occur as well as locations where the species is not known to occur but suitable habitat may be present
- a recovery potential assessment has been completed that includes population-level threat assessments and provides a much clearer understanding of recovery feasibility
- research pertaining to the habitat requirements and demographics of Northern Madtom in the St. Clair-Detroit River system has been conducted by U.S. agencies and academic institutions
- the implementation of stewardship activities and the encouragement of Best Management Practices within watersheds applicable to Northern Madtom is ongoing and funded through the federal Habitat Stewardship Program

Taken together, these ongoing and/or completed activities indicate that progress is being made toward the goal of recovering Northern Madtom populations in Canada; however, there are still a number of areas where further information is required. For example, a standardized index population and habitat monitoring program is still needed to derive data that can provide abundance estimates and inform population models.

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1. Introduction

This progress report outlines the progress made towards meeting the objectives listed in the recovery strategy for the Northern Madtom (*Noturus stigmosus*) from 2012 to 2016 and should be considered as one in a series of documents for this species that are linked and should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (2012), the Recovery Potential Assessment (RPA) of Northern Madtom (2012), and the recovery strategy (2012).

Section 2 of the progress report reproduces or summarizes key information on the threats to the species, population and distribution objectives for achieving its recovery, approaches to meeting the objectives, and performance indicators to measure the progress of recovery. For more details, readers should refer back to the Recovery Strategy for the Northern Madtom (*Noturus stigmosus*) in Canada. Section 3 reports the progress of activities identified in the recovery strategy to support achieving the population and distribution objectives. Section 4 summarizes the progress made and the outcome of the recovery effort.

2. Background

2.1 COSEWIC assessment summary

The listing of the Northern Madtom as endangered in 2003 gave rise to the development and publication of the recovery strategy for the species in June 2012 (Edwards et al. 2012). The recovery strategy was mainly based on the information provided in the COSEWIC Assessment and Status Report on the Northern Madtom (COSEWIC 2002). This information has also been included in section 1.1 of the recovery strategy.

Common Name: Northern Madtom

Scientific Name: *Noturus stigmosus*

Current COSEWIC Status & Year of Designation: Endangered (2002)

Reason for designation: This species has a very restricted Canadian range (two extant locations), which is impacted by deterioration in water quality and potential negative interactions with an exotic species, the Round Goby (*Neogobius melanostomus*). One population (Sydenham River) has been lost since 1975.

Canadian Occurrence: Ontario

COSEWIC Status History: Examined in April 1993 and placed in the data deficient category. Re-examined in April 1998 and designated special concern. Status re-examined and uplisted to endangered in November 2002. Last assessment was based on an existing status report with an addendum.

In 2012, COSEWIC re-examined and confirmed the status of the Northern Madtom as endangered (COSEWIC 2012).

Common Name: Northern Madtom
Scientific Name: *Noturus stigmosus*
Current COSEWIC Status & Year of Designation: Endangered (2012)
Reason for Designation: This species is one of the rarest freshwater fish in Ontario, being found at only four locations in river systems in southwestern Ontario. Substantial and ongoing threats in these rivers include siltation, turbidity, exotic species and toxic compounds, which have all been assessed as high levels of concern. Although there may be some localized improvement in habitat, overall there is an inferred continuing decline in habitat quality and substantial ongoing threats throughout its range.
Canadian Occurrence: Ontario
COSEWIC Status History: Species considered in April 1993 and placed in the data deficient category. Re-examined in April 1998 and designated special concern. Status re-examined and designated endangered in November 2002 and May 2012.

2.2 Distribution

Since 2011, Northern Madtom has been detected in several new locations throughout its Canadian range within the Detroit, St. Clair, and Thames rivers (Figure 1).

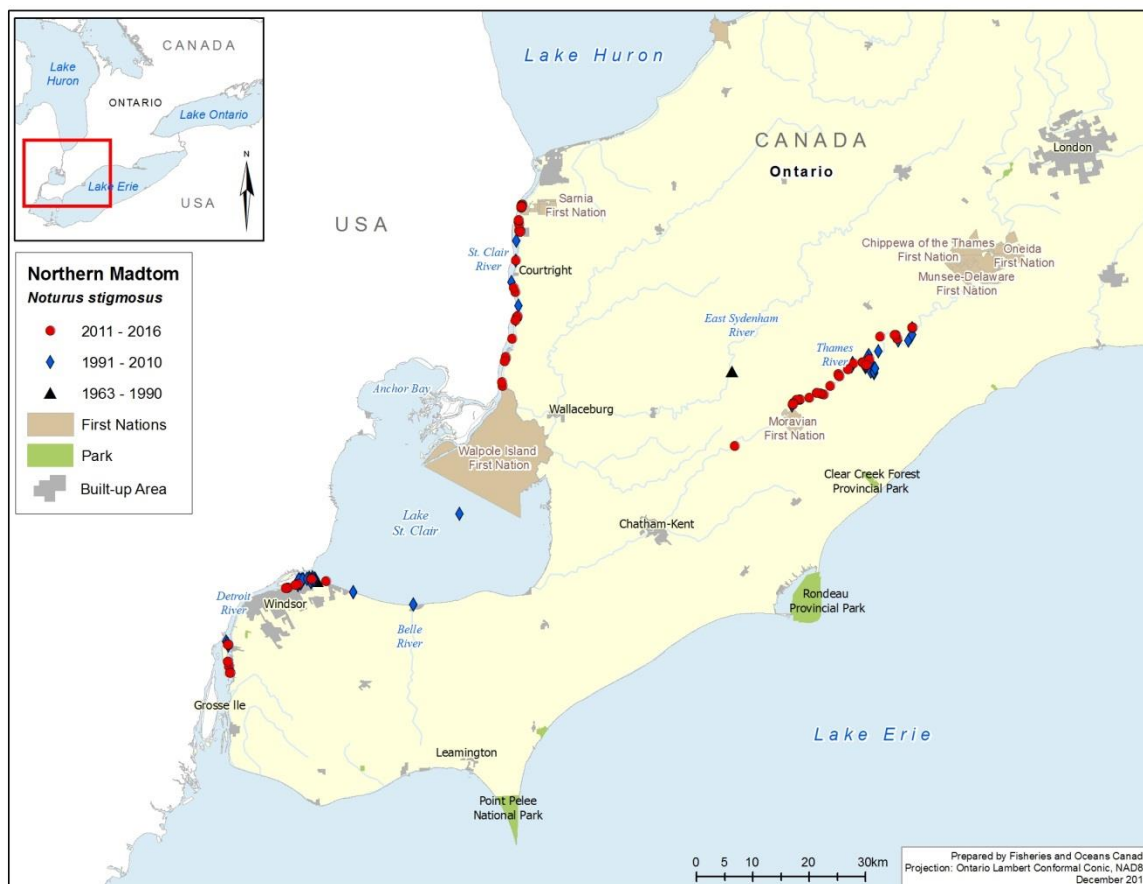


Figure 1. Historical distribution and recent detections of Northern Madtom in southwestern Ontario.

2.3 Threats

This section summarizes the most recent information on threats to survival and recovery of Northern Madtom and threats to its critical habitat.

2.3.1 Threats to the Northern Madtom

Potential threats were initially identified in the recovery strategy. However, since the publication of the strategy, an RPA (Fisheries and Oceans Canada [DFO] 2012) has been published that identifies population-level threats for Northern Madtom, ranked by priority (Table 1). Threat status was ranked in terms of the threat likelihood and threat impact on a population-by-population basis (see McCulloch and Mandrak 2012 for details). The threat likelihood and threat impact for each population were combined in a threat status matrix resulting in the final threat status for each population reported in the table below.

Table 1. Threat status for all Northern Madtom populations in Canada, resulting from an analysis of both the threat likelihood and threat impact. The number in brackets refers to the level of certainty assigned to each threat level, which reflects the lowest level of certainty associated with either initial parameter (threat likelihood, or threat impact). Certainty has been classified as: 1=causative studies; 2=correlative studies; and 3=expert opinion (adapted from DFO 2012).

Threats	Lake Erie Drainage	Lake St. Clair Drainage			
	Detroit River	Thames River	St. Clair River	Lake St. Clair	Sydenham River
Invasive species	High (3)	High (3)	High (3)	High (3)	High (3)
Climate change	Unknown (3)	High (2)	Unknown (3)	High (2)	High (2)
Siltation	Low (3)	High (3)	Low (3)	Medium (3)	High (3)
Turbidity	Low (3)	Medium (3)	Low (3)	Low (3)	Medium (3)
Nutrient loading	Medium (3)	Medium (3)	Low (3)	Medium (3)	Medium (3)
Physical habitat loss	Medium (3)	Low (3)	Medium (3)	Medium (3)	Low (3)
Contaminants and toxic substances	Low (3)	Low (3)	High (3)	Low (3)	Low (3)

Since the publication of the recovery strategy and the RPA, research has been conducted that further investigates the potential effects of invasive species on Northern Madtom. For example, Burkett and Jude (2015) examined interspecific competition between Round Goby (*Neogobius melanostomus*) and Northern Madtom and found that they use different resources where they overlap, resulting from behavioural differences in feeding habits. This may prevent significant dietary overlap from occurring, suggesting that competition for food may not be a significant threat; however, Round Goby may still affect Northern Madtom by preying on its eggs and juveniles, competing for food, habitat, and nests (French and Jude 2001; Janssen and Jude 2001) as discussed in the recovery strategy.

2.3.2 Threats to critical habitat

Critical habitat for Northern Madtom has been identified, to the extent possible, in section 2.7 of the recovery strategy. Examples of activities that are likely to result in destruction to critical habitat (i.e., threats to critical habitat) are listed below:

Physical habitat loss:

- Dredging
- Grading
- Excavation
- Structure removals (e.g., log salvage, moving of rocks in navigational channels)
- Placement of material or structures in water (e.g., groynes, piers, infilling, partial infills, jetties)
- Shoreline hardening

Physical habitat loss or modification:

- Construction of dams and/or barriers
- Water-level management or water extraction activities

Toxic compounds:

- Over-application or misuse of herbicides and pesticides
- Release of urban and industrial pollution into habitat

Nutrient loadings:

- Over-application of fertilizer and improper nutrient management (e.g., organic debris management, wastewater management, animal waste, septic systems and municipal sewage)

Siltation and turbidity:

- Work in or around water with improper sediment and erosion control (e.g., overland runoff from ploughed fields, use of industrial equipment, cleaning or maintenance of bridges or other structures); removal of riparian zones
- Unfettered livestock access to waterbodies

The list of activities provided above is neither exhaustive nor exclusive, and their inclusion has been guided by the relevant threats to habitat described in the recovery strategy. For more details on the activities likely to result in the destruction of critical habitat, consult Table 12 in the recovery strategy.

2.4 Recovery

This section summarizes the information found in the recovery strategy on the population and distribution objectives necessary for the recovery of the Northern Madtom. This section also describes the performance indicators that provide a way to define and measure progress toward achieving the population and distribution objectives.

2.4.1 Population and distribution objectives

Section 2 of the recovery strategy identified the following goals and objectives necessary for the recovery of the species.

Recovery goal

The long-term recovery goal (greater than 20 years) is to sustain and enhance the viability of existing populations of Northern Madtom in the Erie-Huron corridor, the Thames River from Littlejohn Rd. upstream to vicinity of Tate Corners, and the Sydenham River if the species is still present in the system.

Population and distribution objectives

Population and distribution objectives for the Northern Madtom over the next five years are to maintain distributions of extant populations in Lake St. Clair, the Detroit River, the St. Clair

River, and the Thames River. Quantifiable objectives relating to individual populations are not currently possible; these will be developed once necessary surveys and studies have been completed. Knowledge gaps will be addressed by recovery actions given 'urgent' priority included in the recovery planning approaches (refer to Table 4 of the recovery strategy).

Recovery objectives

Short-term objectives (5-10 years) have been established to assist with meeting the long-term recovery goal and are listed in Table 2.

2.4.2 Performance measures

Section 2.6 of the recovery strategy includes the following performance indicators to define and measure progress toward achieving the population and distribution objectives. These indicators are outlined in Table 2.

Table 2. Performance indicators for evaluating the achievement of recovery objectives (adapted from Edwards et al. 2012).

Population and distribution objective	Performance indicators
i. Refine population and distribution objectives.	Completion of background surveys required to fully describe all extant populations by 2015.
ii. Ensure the protection of critical habitat.	Completion of activities outlined in the Schedule of Studies for the complete determination of critical habitat within the proposed timelines.
iii. Determine long-term population and habitat trends.	Population and habitat monitoring program established by 2014 (within regions currently identified as critical habitat).
iv. Evaluate and mitigate threats to the species and its habitat.	Report results of research on the impacts/effects of competition by Round Goby by 2014. Report results of additional research that assists with the evaluation of impacts/effects of threats to the Northern Madtom by 2016. Quantification of Best Management Practices (BMPs) (e.g., number of Nutrient Management Plans [NMPs] or Environmental Farm Plans [EFPs] established) implemented to address threats by 2014.
v. Examine the feasibility of relocations and captive rearing.	Report on the feasibility (and need) for relocations and captive rearing of Northern Madtom.
vi. Ensure efficient use of resources (human and fiscal) during recovery planning efforts.	Collaboration with all ecosystem recovery teams and other stakeholders.
vii. Improve awareness of Northern Madtom and engage the public in the conservation of the species.	Document any changes in public perceptions and support for identified recovery actions through guidance identified in the communications strategy (by 2015).

3. Progress towards recovery

The recovery strategy for the Northern Madtom divides the recovery effort into five broad strategies: 1) survey and monitoring; 2) research; 3) management and coordination; 4) communication and outreach; and, 5) stewardship. Progress in carrying out these broad strategies is reported in section 3.1. Section 3.2 reports on the activities identified in the schedule of studies to identify critical habitat. Section 3.3 reports on the progress on meeting the performance indicators and other commitments (e.g., action plan and Critical Habitat Order) identified in the recovery strategy and information obtained through its implementation.

3.1 Activities supporting recovery

Table 3. Activities conducted or ongoing since the completion of the Northern Madtom recovery strategy.

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
Broad Strategy 1: survey and monitoring				
Approach: population assessment				
(1-1) ² Conduct targeted sampling in areas of occupied habitat as well as historically occupied habitat (e.g., Sydenham River). Use sampling techniques proven to detect Northern Madtom (e.g., night/day seining and trawling).	Targeted surveys have been conducted for Northern Madtom in Lake St. Clair, and the St. Clair, Thames, and Detroit rivers. Environmental DNA (eDNA) sampling has led to positive detections in the North and East Sydenham rivers (Balasingham 2016); however, further sampling with traditional methods is required to confirm these results within the Sydenham River watershed.	i	Met, ongoing	DFO, University of Windsor, OMNRF
(1-2) Conduct targeted sampling in areas lacking Northern Madtom records but possessing potentially suitable habitat. Sampling should be done during both the day and night using sampling techniques proven to detect Northern Madtom.	No conventional targeted sampling has been conducted in areas lacking Northern Madtom records but possessing potentially suitable habitat. eDNA surveys, a more recent monitoring tool, have led to a positive detection for Northern Madtom in the Grand River (Balasingham 2016); however, further sampling and analysis is required to confirm the species' presence in this watershed.	i	Met, ongoing	DFO, University of Windsor, OMNRF
(1-3) Establish a sampling protocol for Northern Madtom informed by the results of background surveys. Establish and implement a standardized index population and habitat monitoring program using the sampling protocol for	A long-term sampling protocol has not been fully developed at this time; however, progress has been made in terms of investigations into the optimal gear type, sampling effort required, and detection probabilities (Dextrase et al. 2014). Applicable findings include: a) trawls (Missouri and Siamese) appear to be the effective	i, iii	Not met, underway	DFO, OMNRF

¹ Participant full names: Fisheries and Oceans Canada (DFO), Environment and Climate Change Canada (ECCC), Ontario Ministry of Natural Resources and Forestry (OMNRF), St. Clair Region Conservation Authority (SCRCA); Essex region Conservation Authority (ERCA); and, Lower Thames Valley Conservation Authority (LTVCA).

² Numbering of activities relate back to the numbering found in Tables 4, 5 and 6 from the recovery strategy. For example, reporting on the first activity from Table 4 in the strategy is referred to here as 1-1; reporting on the first activity from Table 5 in the strategy is referred to here as 2-1.

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
Northern Madtom.	gear to detect Northern Madtom; b) detection probabilities were generally low; c) most covariates, including habitat variables, were not supported; d) detection probability increased with the size of sample sites, as well as the number of sample sites within a given reach; and, e) the results of this analysis were incomparable between locations.			
Broad strategy 2: research				
Approach: habitat and life-history requirements				
(1-4) Determine the seasonal habitat needs, including home range and species movement, of all life stages of Northern Madtom.	<p>DFO has conducted sampling surveys within the Thames River to investigate habitat use by Northern Madtom. Furthermore, several studies have been conducted in Michigan waters of the Detroit River that have quantified the species abundance, movements, age and habitat use (Manny et al. 2014). The results of this study indicated: sand and cobble substrates as preferred substrates for Northern Madtom (but note that it was also found among mud and bedrock dominated sites); the species appeared to use deeper water habitats during the daylight hours and disperse into shallower waters during lowlight or night conditions; and Northern Madtom will likely use artificially created spawning reefs (which may have positive implications for future habitat improvement and/or mitigation projects).</p> <p>Another research project conducted in Michigan waters of the St. Clair-Detroit River system (Conard 2015) has led to the development of a habitat supply model based off of surface velocity and water depth. This model demonstrates a strong correlation between these variables and the abundance and occurrence of Northern Madtom. This author also observed a strong correlation between Northern Madtom abundance and rocky substrates including areas of bedrock.</p>	ii	Not met, underway	University of Michigan, U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, OMNRF

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
No measures were prescribed within the recovery strategy that involve the collection of demographic information; however, several studies have been completed since the publication of the recovery strategy that provide this sort of information.	A growth curve (von Bertalanffy) has been generated using Northern Madtom length-at-age data from specimens collected in Michigan waters of the St. Clair-Detroit River system (Conard 2015). This work may help inform demographic studies within Canadian waters of the same system.	iii	n/a	University of Michigan
Approach: threat assessment				
(1-5) Investigate the impacts of Round Goby and Zebra Mussel (<i>Dreissena polymorpha</i>) on Northern Madtom. Studies to include impacts on Northern Madtom spawning success.	DFO has conducted surveys within the Thames River to determine co-occurrence patterns of Northern Madtom with Round Goby. In addition, a study conducted by the University of Michigan (Burkett and Jude 2015) examined interspecific competition between Round Goby and Northern Madtom in the St. Clair River and found: a) the relative abundance of Northern Madtom decreased between May 1994 and May 2011; b) Northern Madtom had significant dietary overlap with Round Goby in 1994; however, this trend was not repeated in 2011; c) Northern Madtom tended to consume a wider variety of prey items compared to Round Goby, while larger individuals of the latter group tended to have diets strongly comprised of Zebra Mussel; and, d) these results suggest that resource partitioning may have prevented significant dietary overlap from occurring. Another study conducted in the Detroit River (Manny et al. 2014) led to the observation that Northern Madtom is sensitive to sunlight penetration within the water column and avoid light by inhabiting deeper water during daylight hours. This finding suggests that Northern Madtom may be particularly sensitive to dreissenid invasions when increased sunlight penetration within the water column results.	iv	Not met, underway	University of Michigan, US Environmental Protection Agency
(1-6) Investigate the impacts of physical habitat changes on the Northern	Since the recovery strategy was posted in 2012, an RPA (DFO 2012) has been published that includes an evaluation of threat levels for each population within	iv	Not met, ongoing	DFO, Michigan Department of

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
Madtom.	Ontario, including physical habitat loss. Recent research by the Michigan Department of Natural Resources regarding the projected effects of climate change have identified Northern Madtom as extremely vulnerable within the Great Lakes (Hoving et al. 2013).			Resources, University of Michigan
(1-7) Monitor the spread of Zebra Mussel in watersheds occupied by Northern Madtom.	No sampling has been conducted that specifically targets dreissenid mussels within the known extent of Northern Madtom; however, DFO Species at Risk mussel sampling occurs at several sites within the Thames River where Northern Madtom is known to occur, which involves monitoring the presence or absence of Zebra Mussel. Furthermore, the OMNRF, in cooperation with the Ontario Federation of Anglers and Hunters (OFAH), have established the <u>EDDSMAPs</u> reporting tool, which provides a central location for members of the public, as well as researchers from partner organizations, to upload coordinates and relevant information pertaining to invasive species detections in Ontario.	iv	Met, ongoing	DFO, OMNRF, OFAH
(1-9) Investigate the impacts (lethal/sub-lethal) of pollutants in the Huron-Erie corridor, and nutrient loading in the Sydenham and Thames rivers, on Northern Madtom.	DFO is currently conducting research regarding the effects of Bayluscide (a lampricide) on Northern Madtom; however, the results are not yet available. Similarly, another study conducted by the U.S. Geological Survey (Boogaard et al. 2016) examined the potential impacts of Bayluscide on the Tadpole Madtom (<i>N. gyrinus</i>), a surrogate for the Northern Madtom. The authors concluded that Northern Madtom should be able to effectively detect the presence of this lampricide and avoid it.	iv	Not met, ongoing	DFO, U.S. Geological Survey
Approach: assessment of population genetics				
(1-8) Examine genetic relationships between populations as well as the amount of genetic variation within populations. Compare genetics of Canadian populations of Northern Madtom to populations in the U.S.	Samples have been collected from population genetics surveys conducted in the St. Clair, Thames and Detroit rivers and analysis is currently underway.	v	Not met, underway	University of Windsor

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
Approach: artificial propagation				
(1-10) If the need for population supplementation is determined, develop relocation and captive rearing techniques and incorporate into population-specific action plans as required. Conduct population genetics research prior to captive rearing and relocation.	Not completed.	v	Not met	
Broad strategy 3: management and coordination				
Approach: coordination of recovery implementation				
(2-1) Work with relevant organizations (e.g., USFWS, OMNRF, conservation authorities, First Nations) and ecosystem- and single species recovery teams to share knowledge, implement recovery actions and to obtain incidental sightings	Essex-Erie Fish Species at Risk Recovery Program has been ongoing, involving collaboration between DFO, ERCA and LTVCA to implement habitat improvement and restoration activities within tributaries of Lake St. Clair and the Detroit River. The OMNRF has prioritized a number of recovery actions, including inter-organizational coordination efforts, within their Government Response Statement that align with recovery measures prescribed in the federal recovery strategy for the Northern Madtom.	vi	Met, ongoing	ERCA, LTVCA, OMNRF
(2-2) Encourage municipalities to protect habitats that are important to Northern Madtom in their Official Plans.	DFO species at risk guidance was provided to Ontario municipalities that have aquatic (fish/mussel) species at risk within their areas to be used for Municipal Official Plan updates. Species at risk guidance was updated in 2015 and additional contact/outreach to these and all other Ontario municipalities with species at risk in their areas was completed in 2016-17. To date, the municipality of Chatham-Kent and the City of London have incorporated this guidance into their planning process.	vi, vii	Met, ongoing	City of London, Regional Municipality of Chatham, OMNRF

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
(2-3) Ensure planning and management agencies are aware of habitats that are important to Northern Madtom.	Species at risk screening maps have been provided annually to conservation authorities (through Conservation Ontario) that indicate where Northern Madtom critical habitat is located within a given jurisdiction or municipality to inform planning and permitting decisions.	ii	Met, ongoing	DFO, Conservation Ontario, ERCA, LTVCA, SCRCA, OMNRF
Approach: threat management				
(2-4) In cooperation with relevant ecosystem-based recovery teams and organizations, evaluate watershed-scale stressors to populations and their habitats.	DFO has updated watershed-scale analysis of stressors for the Sydenham River watershed within the Sydenham River Action Plan (DFO 2016). In addition, watershed report cards were published in 2012 by the respective conservation authorities that manage them. Within Essex Region, phosphorus levels exceeded the provincial water quality objectives in Turkey, Pike and Duck creeks, as well as the Little, Puce, and Belle rivers. These water quality objectives were also exceeded in the Thames and East Sydenham rivers.	vi, vii	Met, ongoing	ECCC, ERCA, SCRCA, UTRCA
(2-5) Develop a management plan addressing potential risks and proposed actions in response to existing invasive species and to the arrival or establishment of new invasive species.	No such management plan has been developed in the last five years; however, an action plan to address the potential arrival/establishment of high priority aquatic invasive species (AIS) will be developed by DFO's AIS Program. The focus of this program is to prevent the introduction of AIS, respond rapidly to the detection of new species, and manage the spread of already established AIS (e.g., Round Goby).	iv	Not met	DFO
Broad strategy 4: communication and outreach				
(3-2) Promote stewardship among landowners abutting aquatic habitats of Northern Madtom as well as other local residents and First Nations.	The Carolinian Canada Coalition has provided outreach materials to First Nation groups concerning stewardship practices and ecological restoration activities. Although Northern Madtom was not a species included in their	vi, vii	Met, ongoing	CCC, SCRCA, OFA, OMNRF

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
	<p>information package, it will benefit from the stewardship and habitat improvement activities that this project has promoted. Specifically, these outreach materials were communicated to Delaware Nation (Moravian of the Thames), Walpole Island First Nation, and Chippewas of the Thames First Nation all of whom have lands that are within the distribution of Northern Madtom.</p> <p>As part of an ongoing watershed-based, species at risk recovery program, the St. Clair Region Conservation Authority have: a) delivered presentations centred on species at risk and BMPs to various groups at community events; b) maintained a species at risk information website; c) sent approximately 1900 letters to landowners with property abutting reaches of the Sydenham River watershed to encourage the use of BMPs; and, d) distributed news letters that inform the public of imperilled species within the Sydenham River watershed as well as potential habitat improvement activities that could be undertaken by such landowners.</p> <p>The Ontario Federation of Agriculture has delivered information packages encouraging and instructing the application of BMPs throughout the Lake Erie Lowlands, which includes Essex Region.</p>			
(3-4) Develop and implement a strategy for communicating with target land users/stakeholders with respect to recovery activities as required	Cancelled – the ongoing communications to stakeholders associated with activities 3-2 and 3-3 largely achieves this objective.	vii	Not met	
(3-7) Increase public awareness of the impacts of invasive species on the natural ecosystem and encourage the use of existing invasive species reporting systems. Anglers should be discouraged from emptying the contents of their bait-buckets in waterbodies	AIS information has been disseminated through the Watercraft Inspection Program and educational outreach material distributed by DFO (public postings and direct engagement). Furthermore, licensed commercial baitfish harvesters in Ontario have completed Hazard Analysis and Critical Control Point training, which focuses on impacts and prevention of the spread of AIS. Publicized	iv, vii	Met, ongoing	DFO, OMNRF

Activity	Descriptions and results	Recovery objectives	Progress	Participants ¹
where the bait was not captured.	research funded by DFO (Drake and Mandrak 2014a; 2014b) has quantified the risk of invasive species introductions throughout the province.			
Broad Strategy 5: stewardship				
Approach: habitat improvement/restoration				
(3-3) Work with landowners and other interest groups to implement BMPs in areas that will provide the most benefit. Encourage the completion and implementation of EFPs and NMPs.	BMPs and habitat improvement activities have been conducted in the Sydenham and Thames rivers, as well as Essex Region (tributaries to Lake St. Clair and the Detroit River). With all three locations combined, a total of 169 ha of vegetation planting was completed, 48 ha of riparian habitat has been restored, and 408 ha of other habitat improvement activities have been conducted. Within the Thames River, 152 landowners participated in the development of land management plans (e.g., EFP and NMP).	iv, vi, vii	Met, ongoing	LTVCA, UTRCA, SCRCA, ERCA
(3-5) Facilitate access to funding sources for land owner and local community groups and First Nations engaged in stewardship activities.	The Habitat Stewardship Program (HSP) provides support for local stewardship initiatives led by conservation authorities and ENGOS. Access to HSP funding has resulted in a number of habitat improvement projects within the Sydenham River, Thames River and Essex region watersheds. Matching funds for some of these activities were provided through the Species at Risk Stewardship Fund (funded by OMNRF). For more details quantifying the habitat improvement activities achieved through access to these funds, refer to 3-3 above.	vii	Met, ongoing	DFO, ECCC, SCRCA, UTVCA, LTVCA, ERCA, OMNRF
(3-6) Provide clear communications addressing funding opportunities and landowner concerns and responsibilities under SARA and the provincial Endangered Species Act, 2007 (ESA).	The St. Clair Region Conservation Authority has developed and issued postcards that inform applicable landowners of grants and funding for BMP projects.	vii	Met, ongoing	SCRCA

3.2 Activities supporting the identification of critical habitat

Table 4 provides information on the implementation of the studies outlined in the schedule of studies to identify critical habitat from the recovery strategy. Each study has been assigned one of four statuses:

- 1) Completed: the study has been carried out and concluded
- 2) In progress: the planned activity is underway and has not concluded
- 3) Not started: the activity has been planned but has yet to start
- 4) Cancelled: the planned activity will not be started or completed

Table 4. Status and details of the implementation of the schedule of studies outlined in the recovery strategy.

Study	Timeline	Status	Descriptions and results	Participants
Conduct studies to determine the habitat requirements for each life stage of the Northern Madtom.	2012-2014	In progress	DFO has conducted surveys within the Thames to characterize habitat use by the Northern Madtom. In addition, a number of life-history characteristics, including habitat needs, have been investigated by U.S. researchers (Table 5, measure 2-4).	DFO, University of Michigan, U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, OMNRF
Survey and map habitat quality and quantity within historical and current sites, as well as sites adjacent to currently occupied habitat.	2011-2014	Not started	DFO has not undertaken such studies since the publication of the recovery strategy; however, potential Northern Madtom habitat has been identified within the St. Clair-Detroit River system using a habitat suitability index model developed by U.S. researchers (Table 5, measure 2-4).	University of Michigan
Conduct additional Northern Madtom surveys to fill in distribution gaps, and to aid in determining population connectivity and home ranges/territories.	2011-2014	In progress	Targeted surveys for Northern Madtom have been focused in areas where the species is known to occur. At this stage, targeted sampling within novel areas has only been conducted within Lake St. Clair. To adequately address this measure, further sampling might be conducted in: <ul style="list-style-type: none"> • the lower Detroit River • the area within the Detroit River 	DFO, OMNRF

Study	Timeline	Status	Descriptions and results	Participants
			between Fighting Island and Belle Island; the habitat suitability index model developed by Conard et al. (2015) indicates that this area would be highly suitable based on depth and surface velocity <ul style="list-style-type: none"> • the lower Thames River, the Grand River, and the Sydenham River (North and East branches) to confirm recent, positive eDNA detections 	
Create a population-habitat supply model for each life stage.	2014-2016	Not started		DFO
Based on information gathered, review population and distribution goals. Determine amount and configuration of critical habitat required to achieve goal if adequate information exists. Validate population-habitat supply model and refine critical habitat descriptions as necessary.	2014-2016	Not started		DFO

3.3 Summary of progress towards recovery

3.3.1 Status of performance indicators

Table 5 provides a summary of the progress made toward meeting the performance indicators outlined in Table 2. Each indicator has been assigned one of four statuses:

- 1) Not met: the performance indicator has not been met, and little to no progress has been made
- 2) Not met, underway: the performance indicator has not been met, but there has been moderate to significant progress made
- 3) Met: the performance indicator has been met and no further action is required
- 4) Met, ongoing: the performance indicator has been met, but efforts will continue until such time the population is considered to be recovered (i.e., the indicator will be reported against in the next five-year progress report)

Table 5. Summary of progress made toward meeting the performance indicators.

Performance indicator	Status	Details
Completion of background surveys required to fully describe all extant populations by 2015.	Met, ongoing	Targeted surveys have been conducted in areas where populations are known to be extant (Table 3); however, these populations have yet to be fully described. For example, abundance estimates are lacking, and sampling has not been conducted to fill in distributional gaps (a scheduled study to identify critical habitat [Table 4]).
Completion of activities outlined in the Schedule of Studies for the complete determination of critical habitat within the proposed timelines.	Not met, underway	This performance indicator has been partially met; two of the scheduled studies are currently in progress (Table 4).
Population and habitat monitoring program established by 2014 (within regions currently identified as critical habitat).	Not met, underway	Occupancy models were developed to determine detection probabilities for Northern Madtom and provide guidance on sampling effort (Dextrase et al. 2014). The results suggest that trawls appear to be the most suitable gear for this species; however, the development of a standardized index population and habitat monitoring program has not yet occurred.
Report results of research on the impacts/effects of competition by Round Goby by 2014.	Not met, underway	DFO has conducted surveys within the Thames River to determine the level of co-occurrence between Northern Madtom and Round Goby. Additional progress has been made through academic research at the University of Michigan.

Performance indicator	Status	Details
Report results of additional research that assists with the evaluation of impacts/effects of threats to Northern Madtom by 2016.	Not met, ongoing	Much of the threat-related research discussed in Table 3 was conducted by U.S. researchers; therefore, it is not representative of progress achieved by DFO and its partners. However, an RPA (DFO 2012) for this species has been completed and includes population level threat assessments undertaken by species experts, which is a step towards meeting this objective. In addition, DFO is currently conducting research regarding the effects of Bayluscide (a lampricide) on Northern Madtom (refer to Table 3, activity 1-9).
Quantification of BMPs (e.g., number of NMPs or EFPs established) implemented to address threats by 2014.	Met, ongoing	Habitat improvement projects such as riparian restoration, vegetation planting etc., which were funded through HSP and are applicable for Northern Madtom populations, have been quantified for watersheds within the Sydenham River, Thames River, and Essex region (refer to Table 3, activity 3-3).
Report on the feasibility (and need) for relocations and captive rearing of Northern Madtom.	Not met	Currently on hold; background work to support this has been proposed (for multiple species) within the Sydenham River Action Plan (DFO 2016).
Collaboration with all ecosystem recovery teams and other stakeholders.	Met, ongoing	Collaboration has been ongoing with members of the Essex-Erie and Sydenham River recovery programs (e.g., ERCA, LTVCA, SCRCA and UTVCA and the OMNRF) (refer to Table 3, activities 2-1 and 2-4).
Document any changes in public perceptions and support for identified recovery actions through guidance identified in the communications strategy (by 2015).	Not met	The communications strategy has been cancelled in light of ongoing communications to stakeholders implemented at the watershed level (refer to Table 3, activity 3-4).

3.3.2 Completion of action plans

The ecosystem-based Sydenham River action plan (DFO 2016) includes recovery activities that will benefit Northern Madtom (e.g., stewardship actions to address threats within the East Sydenham River).

3.3.3 Critical habitat identification and protection

Using the best available information, critical habitat has been identified for Northern Madtom populations in the following areas (Edwards et al. 2012):

1. Lower Thames River
2. Detroit River (Peche Island)
3. Detroit River (Fighting Island)

In addition, the Sydenham River was historically occupied by Northern Madtom and recent records have been found throughout the St. Clair River; areas within these locations may be considered for identification as critical habitat at a later date. Targeted surveys for Northern Madtom in the Sydenham River are prescribed in Table 4 of the recovery strategy.

In 2016, a Critical Habitat Order made under subsections 58(4) and (5) of SARA was published in the Canada Gazette, Part 2. The order is intended to satisfy the obligation to legally protect critical habitat by triggering the prohibition in subsection 58(1) of SARA against the destruction of any part of the species' critical habitat in the lower Thames and Detroit rivers, as identified in the recovery strategy.

3.3.4 Recovery feasibility

Currently, there is no need to review the recovery feasibility for this species considering no new information has been gathered that would suggest that Northern Madtom populations within Canadian waters no longer meet the feasibility criteria laid out in the recovery strategy. For example, there are still enough reproducing individuals and suitable habitat to support recovery objectives, and threats to the species can be or have been addressed through restoration efforts and the promotion of BMPs.

4. Concluding statement

There has been a substantial amount of progress regarding the implementation of the recovery activities prescribed in the recovery strategy. Targeted sampling has been conducted in and adjacent to areas where the species is known to be extant, confirming its continued presence and providing additional records beyond areas known to be occupied when the recovery strategy was prepared. The publication of an RPA for Northern Madtom has led to population level threat assessments, which provides a much clearer understanding of recovery feasibility.

Considerable progress has also been made with regard to stewardship and outreach related activities. Media broadcasts, targeted outreach and general public outreach related to species at risk awareness and the use of BMPs, have been delivered to a broad audience encompassing multiple jurisdictions within the range of Northern Madtom. In addition, stewardship training has been delivered to landowners with property that abuts occupied watersheds. Similarly,

stewardship activities including riparian restoration, vegetation planting, invasive vegetation removal, and other habitat improvement activities have been conducted in several applicable watersheds, and land management plans have been developed for specific properties.

The recent environmental DNA (eDNA) detections of Northern Madtom within the Sydenham and Grand rivers warrants follow-up sampling to confirm the species presence within these watersheds. Conventional sampling should be conducted within the North and East Sydenham rivers in adequate proximity to locations where eDNA detections were made to effectively confirm the species presence. Further, eDNA sampling is also prescribed as the next step towards validating or ruling out the presence of Northern Madtom within the Grand River watershed.

Despite the aforementioned progress, there still remain a number of recovery activities yet to be implemented. These include, but are not limited to: more conclusive research to inform the development of a sampling protocol and a standardized index population and habitat monitoring program; additional research centred on the habitat needs of each life stage of Northern Madtom (particularly at locations such as Lake St. Clair and the Thames River); investigations into competitive interactions between Northern Madtom and Round Goby, specifically related to nest establishment and spawning success; and, threat assessments of pollutants and contaminants that are prevalent in the Huron-Erie corridor. For further details on priority activities yet to be completed, please refer to tables 4 (status of schedule of studies) and 5 (status of performance indicators).

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