Proceedings of the Canadian Freshwater Species at Risk Research Network (SAR NET) – Year 3 Symposium: November 13-14, 2019, Burlington, Ontario

Editors: Kelly A. McNichols-O'Rourke, Todd J. Morris and D. Andrew R. Drake

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ABSTRACT

McNichols-O'Rourke, K.A., Morris, T.J. and Drake, D.A.R. (Editors). 2020. Proceedings of the Canadian Freshwater Species at Risk Research Network (SAR NET) – Year 3 Symposium: November 13-14, 2019, Burlington, Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 3389: vii + 25 p.

The Canadian Freshwater Species at Risk Research Network (SAR NET), an academic research network developed with financial support from Fisheries and Oceans Canada (DFO), held its year 3 symposium at the Canada Centre for Inland Waters in Burlington, Ontario on November 13-14, 2019. The objective of the symposium was to disseminate research results from the 14 SAR NET projects, to provide an opportunity for management partners to engage with academic partners, and to explain how SAR NET results are integrated into Species at Risk management within DFO. The symposium was attended by 60 participants from four provinces (British Columbia, Alberta, Ontario, Quebec) and one U.S. state (Michigan), and included 10 academic institutions, DFO Science and Species at Risk Program teams, and members of the Ontario and British Columbia provincial governments.

RÉSUMÉ

McNichols-O'Rourke, K.A., Morris, T.J. and Drake, D.A.R. (Editors). 2020. Proceedings of the Canadian Freshwater Species at Risk Research Network (SAR NET) – Year 3 Symposium: November 13-14, 2019, Burlington, Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 3389: vii + 25 p.

Le réseau canadien de recherche sur les espèces d'eau douce en péril (SAR NET), un réseau de recherche universitaire établi grâce au soutien financier de Pêches et Océans Canada (MPO), a tenu son troisième symposium les 13 et 14 novembre 2019 au Centre canadien des eaux intérieures à Burlington, en Ontario. L'objectif du symposium était de diffuser les résultats des recherches menées dans le cadre des 14 projets du SAR NET, de donner l'occasion aux partenaires de gestion d'avoir des échanges avec des partenaires universitaires et d'expliquer l'intégration des résultats du SAR NET dans la gestion des espèces en péril au MPO. Le symposium a réuni 60 participants provenant de quatre provinces (Colombie-Britannique, Alberta, Ontario, Québec) et d'un État américain (Michigan), dont des représentants de 10 établissements universitaires, des équipes des sciences et du programme des espèces en péril du MPO ainsi que des gouvernements provinciaux de l'Ontario et de la Colombie-Britannique.

PREFACE

In 2017, Fisheries and Oceans Canada (DFO) and the University of Toronto Scarborough hosted a workshop to review progress made toward addressing scientific activities identified in Recovery Strategies and Recovery Potential Assessments as necessary to support the recovery of at-risk fishes and mussels within the Great Lakes basin. The 2017 review focused on the 43 species listed under the *Species at Risk Act* (SARA) or assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered, Threatened, or of Special Concern within the freshwaters of the Great Lakes basin and St. Lawrence River. By reviewing research accomplishments and recognizing areas where progress has been lagging, workshop participants identified key research gaps that can be addressed by targeted research within the academic community. Results of the review demonstrated that, as of 2017, substantial research progress had been made in the areas of population ecology and habitat-related research. Gaps in research progress were identified for questions related to threats (specifically, identifying threat mechanisms and their impact) and recovery (threat mitigation and species reintroductions). As a result of the 2017 workshop and a competitive funding process, DFO developed the Canadian Freshwater Species at Risk Research Network (SAR NET) through the Oceans and Freshwater Science Contribution Program in 2017. The network is a binational network that includes 10 universities within three DFO regions (Pacific, Central and Arctic, Quebec), as well as one university in Michigan, USA. The network consisted of 14 research projects focused on: (1) better understanding threats that are implicated for at-risk fishes and mussels; and (2) recovery research, including approaches for threat mitigation and research to support species reintroductions.

The Canadian Freshwater Species at Risk Network held its final (year 3) symposium on November 13-14, 2019 (McNichols-O'Rourke et al. 2020). Similar to the year 2 symposium, the meeting was hosted by DFO and held at the Canada Centre for Inland Waters in Burlington, Ontario. The symposium included 20 platform presentations over the two-day period and involved DFO Science, academic partners, and members of the DFO Species at Risk Program.

The objective of this symposium was to have the 13 principal investigators (10 academic partners) share research results completed as part of the three-year network. During the second day of the symposium, the Central and Arctic regional Species at Risk Management Team provided an update on the integration of SAR NET results into Species at Risk recovery and protection, with a key message that the "Species at Risk program needs science through collaborative efforts for effective recovery, defensibility, and strategic implementation." A business meeting involving the principal investigators and the DFO SAR NET steering committee was held to discuss the future of the network as this fiscal year represented the final year of funding through the Oceans and Freshwater Science Contribution Program.

EDITORS' COMMENTS

These proceedings contain abstracts that were presented at the 2019 SAR NET symposium. The abstracts were reviewed in a limited capacity and formatted by the editors. They were not sent for external review. Questions or comments relating to their content should be directed to the authors of each abstract and not the editors. The views and statements contained in these proceedings are those of the speakers and are neither condoned nor rejected by the editors. Any use of trade names or products does not constitute endorsement or recommendation for use.

REMARQUES DES ÉDITEURS

Le présent compte rendu contient tous les résumés ayant été présentés lors de la réunion de recherche. Les résumés ont été révisés en partie et formatés par les éditeurs. Ils n'ont pas fait l'objet d'un examen externe. Les questions ou les commentaires liés à leur contenu devraient être envoyés aux auteurs de chaque résumé et non aux éditeurs. Les points de vue et les affirmations exprimés dans ces comptes rendus sont ceux des conférenciers et n'ont été ni approuvés, ni infirmés par les éditeurs. L'utilisation d'une marque de commerce ou d'un produit ne constitue nullement une forme d'approbation ou de recommandation de son utilisation.

CANADIAN FRESHWATER SPECIES AT RISK RESEARCH NETWORK (SAR NET)

Principal Investigator	Affiliation	Project Title
Ackerman, Josef	University of Guelph	Determining the Effect of Multiple Stressors (suspended sediment, temperature, nutrient loading) on the Ecophysiology of SAR Mussels under Ecologically Relevant Flow Conditions
		Determining the Habitat of Juvenile SAR Unionid Mussels through the Application of Supply Side Ecology
Cooke, Steven	Carleton University	Are Captive Breeding Programs for Freshwater SAR Fish and Mussels Effective at Achieving Conservation Targets in the Wild?
Chapman, Lauren	McGill University	Hot Fish and Hypoxia: Effects of Dual Stressors on Canadian Freshwater Fishes at Risk
Cuddington, Kim	University of Waterloo	Temperature Variability and Threat Assessment for SARA-listed Species
Jackson, Donald	University of Toronto	Predicting Species at Risk: Insight Gained from Species Co-occurrences
Mandrak, Nicholas	University of Toronto Scarborough	Determining Seasonal Variation in Critical Thermal Maximum of Endangered Redside Dace at its Northern Range
Pitcher, Trevor	University of Windsor	Characterizing Population Genetics, Captive Breeding, and Thermal Tolerance of Small Fishes at Risk
Poesch, Mark	University of Alberta	Identifying the Impact of Altered Flow Regimes on Milk River Populations of Plains Sucker
Power, Michael	University of Waterloo	Thermal and Oxygen Tolerances of the Imperilled Eastern Sand Darter
Ricciardi, Anthony	McGill University	Competition between Benthic Fish Species at Risk with Trophically Overlapping Invasive Species
Rodríguez, Marco	Université du Québec à Trois-Rivières	Understanding the Response of Listed Fishes to Environmental Stressors, with an Emphasis on Turbidity, in Streams and Wetlands in the Canadian Great Lakes Basin
Rosenfeld, Jordan	University of British Columbia & BC Ministry of the Environment	To Determine the Effects of Stream Flow Temperature, and Nutrient Inputs on the Extent of Hypoxia in Salish Sucker Critical Habitat
Zanatta, David	Central Michigan University	Development of Empirically-Driven Genetic Guidelines for Captive Breeding and Propagation of SAR Freshwater Mussels

PROGRAM AGENDA: Wednesday, November 13, 2019

Time	Title	Presenter (Affiliation)
10:00	Welcome to SAR Network Research Symposium (Y3)	Andrew Drake (DFO Science)
10:20	Welcome to Fisheries and Oceans Canada	Gavin Christie (DFO Science)
Threat Mechanism Projects		
10:30	Assessing Threats with Simple River Temperature Models	Jordan Rosencranz (University of Waterloo)
10:50	Responses of Endangered Fishes to Environmental Stressors in the Canadian Great Lakes basin	Geoffrey Marselli (Université du Québec à Trois-Rivières, Trois-Rivières)
11:10	Thermal Tolerance Depends on Age, Season, and Body Condition in Endangered Redside Dace *Clinostomus elongatus*	Trevor Pitcher & Andy Turko (University of Windsor)
11:35	Characterizing Population Genetics and Captive Breeding in the Imperilled Lake Chubsucker	Ryland Corchis-Scott (University of Windsor)
11:55	**Lunch (Provided at CCIW)**	
13:00	Effects of Flow, Water Quality, and Hypoxia on the Endangered Salish Sucker	Kaitlyn Zinn (University of British Columbia)
13:20	Reconciling Potentially Divergent Effects of Hypoxia from Lab Assays, Field Experiments, and Correlative Habitat Associations: Problems with Detection and Extrapolating to Population-level Effects	Jordan Rosenfeld (B.C. Ministry of the Environment)
13:40	Save Our Suckers: Assessing the Impacts of Threats to the Survival of the Plains Sucker (*Pantosteus jordani*) in the Milk River	Taylor MacLeod (University of Alberta)
14:00	Multiple Stressor Effects on the Ecophysiology of Freshwater Mussels: Flow, Temperature, and Turbidity	Kirsten Luck (University of Guelph)
14:20	Hydrodynamic Shear Stress as a Predictor of Freshwater SAR Mussel Settlement	Julian Lum (University of Guelph)
14:40	**Break**	
15:00	Physical Modelling of the Dispersion and Settlement of Juvenile Freshwater SAR Mussels – Supply Side Ecology	Christopher Farrow (University of Guelph)

15:20	Acclimation Capacity of the Pugnose Shiner to Elevated Water Temperature and Hypoxia	Lauren Chapman (McGill University)
15:40	Phenotypic Plasticity in Juvenile Pugnose Shiner in Response to Elevated Water Temperature	Lindsay Potts (McGill University)
16:00	**Wrap-up Day 1 – Meeting Close**	
18:00	**Group Dinner, Offsite**	

PROGRAM AGENDA: Thursday, November 14, 2019

Time	Title	Presenter (Affiliation)
9:00	Arrival	
9:20	Seasonal Variation in Critical Thermal Maximum of Endangered Redside Dace at its Northern Range	Alexandra Leclair (University of Toronto Scarborough)
9:40	Thermal and Oxygen Tolerances of the Imperilled Eastern Sand Darter (*Ammocrypta pellucida*)	Britney Firth (University of Waterloo)
10:00	Assessing Risk of Competition between Invasive and Native Fishes: Eurasian Tench (*Tinca tinca*) versus Redhorses (*Moxostoma* spp.)	Christophe Benjamin (McGill University)
10:20	**Break**	
Species Reintroduction Projects		
10:40	Reintroduction of SARA-listed Fishes in Canada: Where are we now and where are we going?	Karl Lamothe (DFO Science)
11:00	Co-occurrence Modelling: A Tool for Predicting Distributions of Species at Risk	Jennifer Bontje (University of Toronto)
11:20	Development of Empirically Driven Genetic Guidelines for Captive Propagation of Imperilled Freshwater Mussels	Nichelle VanTassel (Central Michigan University)
11:40	Can Conservation Targets for Imperilled Freshwater Fishes and Mussels be Achieved by Captive Breeding and Release Programs?	Lisa Kelly (Carleton University)
12:00	**Lunch (Provided at CCIW)**	
13:00	Species at Risk Program Presentation – Integrating Research Results into SAR Recovery and Protection	Jessica Epp-Martindale, Dave Balint, Shawn Staton (DFO SAR Program)
14:00	Closing remarks	Andrew Drake
14:20	**Wrap Up Day 2 – Symposium Close**	

Program Abstracts

Platform 1 - Assessing Threats with Simple River Temperature Models

Jordan Rosencranz[1], Kim Cuddington[1], Madison Brook[1], Marten Koops[2], Andrew Drake[2]

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Water temperature is one of the primary factors that determines the survival and reproduction of aquatic organisms. Unfortunately, temperature records are often incomplete or unavailable, particularly for riverine ecosystems supporting multiple Species at Risk. Modelled river temperatures are needed to assess periods of thermal stress or suitability and the resulting performance of aquatic species. Simple models can predict water temperatures from air temperature or past water temperatures. In this study, we calibrated and tested four simple river temperature models: non-linear regression, combined seasonal oscillations with regression, water temperature lag, and artificial neural networks. Models were tested on nine sites in the Grand and Speed Rivers, Ontario, and independently tested on seven sites in the Upper Thames River, Ontario. We evaluated the performance of these models using thermal criteria relevant to the fitness of a Threatened species - Black Redhorse (*Moxostoma duquesni*). The best performing air to water temperature model of thermal characteristics for mean temperatures during the spawning period in May was combined seasonal oscillations with regression (Thames *RMSE=1.66;* Grand: *Bias=0.02*). The model that best predicted maximum temperatures during July and August, when an impairment threshold could be reached, was also combined seasonal oscillations with regression (Thames: *RMSE=1.93*). However, when predicting maximum temperatures during summer, bias was lowest for non-linear regression (Thames: *Bias=-0.26).* The water temperature lag model, which requires the previous day's water temperature as an input, had the highest predictive power for both daily maximum summer water temperatures (Grand: *RMSE=0.93*) and mean spawning period temperatures (Thames: *RMSE=1.22*), and may be useful for filling in incomplete datasets. We note that seasonal evaluation criteria lead to a different definition of the best-fitting model than metrics such as lowest root mean square error and bias of the overall temperature series. The combined seasonal oscillations with regression, non-linear regression, and water temperature lag models have wide applicability, and can be used to relate water temperature to the performance of other fish and mussel species.

Platform 2 - Responses of Endangered Fishes to Environmental Stressors in the Canadian Great Lakes basin

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Anthropogenic changes in environmental stressors such as turbidity, water temperature, oxygen concentration, and water velocity are a major threat to endangered aquatic species. However, endangered species are often rare in nature, which poses special challenges when quantifying their responses to environmental stressors. Our main goal in this study was to understand the responses of endangered fishes listed under the *Species at Risk Act* to environmental stressors in lakes, streams, and wetlands in the Canadian Great Lakes basin. We combined existing DFO data on relative abundance and environmental features with literature data on species functional traits (growth, mortality, fecundity, mobility) and phylogeny into a single database. The resulting database comprised information on 115 species, including 10 listed species (Black Redhorse, Blackstripe Topminnow, Eastern Sand Darter, Grass Pickerel, Lake Chubsucker, Pugnose Minnow, Pugnose Shiner, Redside Dace, Spotted Gar, and Spotted Sucker). We used a joint species distribution model (JSDM) to simultaneously quantify all species' responses to environmental stressors and their relationship with functional traits. The JSDM incorporated phylogenetic correlations as well as features of the sampling design (spatial, temporal, and gear effects), and provided quantitative estimates of the effects of environmental stressors on species relative abundance. The hierarchical structure of the JSDM allowed for statistical "borrowing of strength", in which information from the abundant species contributes to the estimates for rarer species. Our results show that model-derived responses to environmental stressors can provide a “management-friendly” basis for species classification in terms of their tolerance to various forms of environmental change. Future work will develop model-derived metrics to assess species-specific threats.

Platform 3 - Thermal Tolerance Depends on Age, Season, and Body Condition in Endangered Redside Dace *Clinostomus elongatus*

Andy J. Turko[1], C.B. Nolan[2], S. Balshine[3], G.R. Scott[4], T.E. Pitcher[1,2]

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[4]*Department of Biology, McMaster University*

Urbanization increases water temperatures in streams and rivers and is hypothesized to be responsible for the declines of many endangered fishes. However, little is known about seasonal variation in thermal tolerance for many Species at Risk, nor do we understand the physiological factors that promote increased tolerance to thermal stress. Redside Dace (*Clinostomus elongatus*) are listed as Endangered in Canada but some healthy populations persist in the USA. Using fish from a robust Ohio population, we measured acute thermal tolerance (CT_{max}) at five time points over an annual cycle (summer, autumn, winter, spring, summer) from 2018-2019. Redside Dace CT_{max} was highly dependent on ambient water temperatures as expected. Furthermore, in spring (when stream temperature ~15°C) and summer (stream temperature ~22°C), CT_{max} was significantly higher in juveniles than adults. In winter (stream temperature ~2°C) CT_{max} was higher in adults. In adult Redside Dace, body condition (Fulton's K) was positively correlated with CT_{max} at each time point, but CT_{max} was not related to reproductive investment or energy stores. In juvenile Redside Dace, this relationship only occurred at three of five timepoints. To test whether the observed correlation between body condition and thermal tolerance was causative, we fed captive Redside Dace low- or high-ration diets for two months (which caused significant differences in body condition) and then measured CT_{max}. In adult Redside Dace, CT_{max} was significantly higher in fish fed the high- versus low-ration diet, indicating that body condition directly influences thermal tolerance. CT_{max} was similar between juveniles fed each experimental ration. We conclude that temperatures in urbanized Redside Dace habitats may approach summer CT_{max} values when pavement-warmed storm water is discharged directly to streams, so restoration strategies that mitigate these temperature spikes should be emphasized. Furthermore, our results show that fish health and body condition matter for thermal tolerance. Thus, restoration activities that improve Redside Dace habitat quality may also increase thermal tolerance.

Platform 4 - Characterizing Population Genetics and Captive Breeding in the Imperilled Lake Chubsucker

Ryland Corchis-Scott[1], Daniel Heath[1], Andrew Drake[2], Nicholas Mandrak[3], Trevor Pitcher[1]

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Freshwater fishes are thought to be in decline around the world due to anthropogenic activities. When habitat remediation is insufficient, reversing the decline of at-risk freshwater fish requires the use of captive breeding and reintroduction. Reintroduction biology is a recent and rapidly evolving field with theoretical frameworks still under development. For example, it is key to ensure source population selection and reproductive skew in captive populations be accounted for in reintroduction planning. These challenges to successful reintroduction can be studied using population genetics for source population selection related hypotheses and microsatellites to assess reproductive skew among potential breeding individuals (as part of a captive breeding program). Lake Chubsucker (*Erimyzon sucetta*) is a declining federally Endangered freshwater fish with a broad, yet fragmented, North American distribution. Microsatellite markers, reproductive skew in captivity, and the genetic structure of populations were previously uncharacterized for this species. The objectives of this project are to isolate and characterize polymorphic microsatellite loci (n=20) and use these to evaluate the genetic structure of *E. sucetta* populations across its range. Additionally, this research aims to understand the practicalities of captively breeding *E. sucetta* for reintroduction and examine reproductive skew within captive populations (n=4). A better understanding of genetic diversity within and among *E. sucetta* populations will help conservationists select source populations for reintroduction while knowledge of reproductive skew will inform breeding protocols for this fish. The data gathered here will inform properly managed reintroduction efforts and add to current knowledge of the genetic challenges associated with captive rearing and reintroduction. This research could inform Lake Chubsucker recovery efforts in Canada and can be applied to reintroductions and captive breeding for other imperilled fishes.

Platform 5 - Effects of Flow, Water Quality, and Hypoxia on the Endangered Salish Sucker

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The Salish Sucker is a federally Endangered species under Canada's *Species at Risk Act*, and is restricted to 11 watersheds in British Columbia (lower Fraser River Valley) and six in Washington State. Agricultural development has been historically prominent in these areas, and hypoxia and the physical destruction of habitat have been identified as the most important threats to this species. Synergistic effects of reduced streamflow, nutrient inputs, and high temperatures is likely a large determinant of seasonal hypoxia. The effects of stream flow on temperature and dissolved oxygen in Salish Sucker critical habitat, and corresponding changes in habitat use, distribution, and growth of Salish Sucker were studied. Through various flow manipulation and enclosure experiments it was found that severely reducing flow in off-channel ponds resulted in higher temperatures and lower dissolved oxygen (< 3mg/L). Salish Sucker showed variable growth rate differences in flow and no-flow treatments, while juvenile Coho Salmon showed significant differences. It is likely that the availability of an oxygenated refuge in all treatments mitigated negative impacts of reduced water quality on Salish Sucker. This information will help inform both current habitat and land use management, as well as future management under projected climate warming and reduced stream flow.

Platform 6 - Reconciling Potentially Divergent Effects of Hypoxia from Lab Assays, Field Experiments, and Correlative Habitat Associations: Problems with Detection and Extrapolating to Population-level Effects

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In this presentation I provide an overview of the effectiveness of a hierarchy of approaches at detecting any negative impact of hypoxia on Salish Sucker. Hypoxia effects can be assessed in laboratory studies that vary dissolved oxygen in a controlled environment, with field experiments, or by analyzing habitat associations of fish in the wild**.** Ultimately, the goal is to understand how population distribution and abundance changes as a function of hypoxia. While stressor-response relationships based on laboratory assays of individual behavior, growth, or survival may be definitive, their extrapolation to the population level may be somewhat problematic. On the other hand, large-scale habitat associations capture emergent population-level effects but remain fundamentally correlative, and may generate spurious predictions of impact. For instance, species like Salish Sucker that prefer deep, slow habitats (e.g. pools and ponds) will usually be positively associated with higher temperatures and lower dissolved oxygen because their preferred slow-water habitat is the most likely area in a stream to go hypoxic.

A review (meta-analysis) of laboratory studies clearly shows a general positive relationship between dissolved oxygen and both ration and growth, indicating that aerobic metabolism associated with digestion (i.e., SDA) is limited by hypoxia. Compared to lab studies, field experiments may produce ambiguous results if difficulty creating a homogenous hypoxic treatment allows fish to exploit well-oxygenated refuges or engage in other mitigative behaviours. Analysis of the relationship between Salish Sucker presence and CPUE at the reach scale is in progress, as well as the relationship between population size and the proportion of habitat that goes hypoxic at the watershed scale, hopefully allowing an assessment of the power to detect effects based on individual vs. landscape-scale responses.

Platform 7 - Save Our Suckers: Assessing the Impacts of Threats to the Survival of the Plains Sucker (*Pantosteus jordani*) in the Milk River

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[2]*Fisheries and Oceans Canada, Winnipeg, MB, Canada*

The Plains Sucker is a newly named species of catostomid, the Milk River population of which is considered Threatened by COSEWIC. Reports by Fisheries and Oceans Canada have isolated flow augmentation and drought as the major threats to its survival, but no detailed information exists regarding the extent of these threats. Flow augmentation occurs between May and October annually via the St. Mary Canal, which transfers approximately 20m^3/s of water from the St. Mary River in Montana into the North Fork of the Milk River, a tributary of the Missouri drainage.

To address the impacts of flow augmentation the slip speed of several populations of Plains Sucker was measured using a swim tunnel respirometer and compared between water bodies in southern Alberta and Saskatchewan that experience augmentation and those that do not. Critical thermal maximum (CT_{max}) tests were conducted on the same populations to inform the impacts of droughts and warming waters, which are likely to be exacerbated under current climate change projections. I present some results collected during the 2019 field season on these two experiments.

In addition to specific information on swimming ability and thermal tolerance for modelling habitat suitability, I will have the opportunity to collect more general information about the Plains Sucker. The literature is currently limited to information about the Mountain Sucker, *Catostomus platyrhynchus*, a classification which was recently separated into 4 species: *P. jordani*, *P. platyrhynchus*, *P. lahontan* and *P. bondi*. Information about the Mountain Sucker is comprised of studies in the United States, sometimes beyond the range identified for the Plains Sucker. Data on age, growth, and fecundity may not be representative of the Plains Sucker, especially in Canada, where it exists on the northern edge of its range.

Platform 8 - Multiple Stressor Effects on the Ecophysiology of Freshwater Mussels: Flow, Temperature, and Turbidity

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Freshwater mussel habitats are exposed to habitat degradation, sedimentation, and erosion as a result of land-use changes, which can impact mussel feeding and respiration. Of particular concern, flow, temperature and total suspended solid (TSS) concentration play key roles in mussel ecophysiology and likely interact as multiple stressors. The goal of this research is to examine how flow, temperature and TSS affect the clearance rates (*CR*; volume of water cleared of suspended particles by a mussel per unit time) and oxygen consumption (OC) of freshwater mussels. *Lampsilis siliquoidea* (n = 50; shell length = 11.00 ± 0.21 [mean ± SEM] cm) were acclimated to three holding temperatures (12.5, 20 and 27.5 ˚C) and are currently being tested at three levels of water velocity (0, 15 and 25 cm s^{-1}) and TSS concentration (0, 10 and 20 mg L^{-1}) in a split-split-plot design. In addition, treatments acclimated to 12.5 and 27.5 ˚C are being tested at 20˚C in a 2 × 3 design with five replicates, with three levels of TSS flux: 1) 0 mg m^{-2} s^{-1}; 2) 150 mg m^{-2} s^{-1}; and 3) 500 mg m^{-2} s^{-1}. Flow rate, temperature, chlorophyll α fluorescence and turbidity are being measured in a recirculating flow chamber over the course of one hour, with each trial involving a no-mussel control and five replicates. Oxygen (O_2) concentration is being measured using the InEx method described by Yahel et al. (2005), where the O_2 concentration of the water is measured at the aperture of the excurrent siphon of the mussel as well as ambient water. The results obtained from this study will provide insight into the interactions among these stressors and their effects on mussel ecophysiology. Ultimately, this information will enhance unionid conservation efforts and the formulation of protection guidelines, regulations and recovery plans.

Platform 9 - Hydrodynamic Shear Stress as a Predictor of Freshwater SAR Mussel Settlement

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Species At Risk freshwater mussel habitats are thought to be affected by hydrodynamics, which facilitate juvenile settlement to the streambed, and substrates, which provide physical support. The purpose of this study is to identify how hydrodynamic forces (e.g., bed shear stress) at the reach and local scale affect settlement and presence of juvenile mussels in the riverbed. We took high resolution riverbed elevation measurements to estimate reach-level shear stress via the depth slope product and identify possible locations where juvenile mussels exist. Local bed shear stress was measured using the law of the wall and excavated to find juvenile mussels via an airlift system. Throughout the 2018 and 2019 field seasons, 136 locations were excavated within the Sydenham River (Southern Ontario) near Florence, Ontario. 26 juvenile unionids were recovered at 23 locations with relatively low measured local shear stress (i.e. ≤ 0.93 Pa) and higher quantities of smaller sediment size classes (i.e. ≤ 2 mm). Logistic regression produced a predictive model for finding where juvenile mussels could be found in the stream bed. Similar analysis is underway to ascertain other habitat indicators. These results are consistent with laboratory predictions that critical shear stress causes the incipient motion of juvenile mussels. These results help identify the habitats of juvenile unionid mussels and will aid in the recovery of these imperilled organisms.

Platform 10 - Physical Modelling of the Dispersion and Settlement of Juvenile Freshwater SAR Mussels – Supply Side Ecology

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Juvenile unionid Species at Risk (SAR) mussels settle out of the water column from their host vertebrate (mostly fish) into viable habitat on the riverbed. The hydrodynamic conditions that disperse juvenile mussels downstream and mediate settlement are likely important determinants of recruitment rates in their populations. Particle release experiments using physical models (alginate microbeads) of juvenile mussels are underway. These physical models are similar in size and density to juvenile mussels while being biodegradable, non-toxic, and readily detectable. The current microbeads are made from a calcium alginate shell and their density is manipulated with glycerol/water solutions. We have successfully encapsulated two dye compounds (riboflavin, blueberry extract) into the microbeads. The dyes are detectable via fluorescence and pH manipulation, respectively. Acute exposures (72 h) of the dyed and undyed microbeads provided to Quagga Mussels (*Dreissena bugensis*) indicated that the microbeads are not acutely toxic and present a low risk to SAR mussels/habitat. A biodegradation study at a local river is currently underway. A field study involving the release and recapture of microbeads is underway at a site where high resolution riverbed elevation survey data have been collected. Microbead releases are followed by captures in drift nets and specially designed sedimentation traps to reveal patterns of transport and entry into the riverbed. Results from this study will present information on the downstream dispersion of juvenile mussels as well as their entry into riverbed habitat.

Platform 11 - Capacity of the Pugnose Shiner to Elevated Water Temperature and Hypoxia

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For freshwater fishes, elevated water temperatures associated with climate warming and hypoxia (low dissolved oxygen, DO) are two stressors than can co-occur and are likely to interact because both stressors affect oxidative metabolism – fish metabolism and oxygen demand increase with water temperature, while hypoxia limits oxygen supply. Exposure to both stressors may have negative effects, but it is also possible that exposure to either high temperatures or hypoxia could improve tolerance to the alternative stressor (referred to as cross-tolerance). Here, we report the results of two acclimation studies. The first explored effects of elevated water temperature on thermal tolerance and metabolic rate of the Endangered Pugnose Shiner (*Notropis anogenus*). The second tested whether acclimation to hypoxia affects thermal tolerance. Pugnose Shiner adults were collected from SUNY Cobleskill, NY in October 2017 (Experiment 1) and May 2019 (Experiment 2) and brought to McGill University, QC. In the first experiment, Pugnose Shiner were exposed to a 2-week acclimation to six different ecologically relevant temperatures. Response variables included critical thermal maximum (CT_{max}), agitation temperature (T_{ag}), thermal stress window, and standard metabolic rate (SMR). Fish acclimated to warmer waters were able to increase their CT_{max}; however, they exhibited avoidance behavior (T_{ag}) well before reaching CT_{max}. SMR increased sharply with acclimation to elevated water temperature, suggesting that acclimation did not induce thermal compensation. In a second experiment, we asked whether acclimation to hypoxia improves thermal tolerance. Fish were acclimated to three different DO treatments (normoxia: >95% saturation medium-hypoxia: ~56% saturation; low-hypoxia: ~40% saturation) for 2 weeks, and thermal tolerance metrics (CT_{max}, T_{ag}), and the thermal stress window were quantified under two different test DO levels (high DO; >95% and low DO; ~40%). Normoxia-acclimated fish exhibited a lower CT_{max} when tested under low-hypoxia (~40% saturation) than when tested under normoxia. However, fish acclimated to both medium-hypoxia and low-hypoxia maintained CT_{max} at the same level when tested under low DO (~40% saturation) as when tested under high DO (>95% air saturation). This suggests that physiological and behavioral plasticity in response to hypoxia-exposure may help this species to cope with the elevated water temperature.

Platform 12 - Phenotypic Plasticity in Juvenile Pugnose Shiner in Response to Elevated Water Temperature

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Climate change has emerged as an increasingly important threat to freshwater systems. To cope with rapidly changing thermal regimes, freshwater fishes must either relocate or adjust through genetic adaptation and/or phenotypic plasticity. Understanding phenotypic responses to warming waters may be vital for effective conservation strategies, especially for already imperilled species because these taxa tend to be more sensitive to changes in their environment and are already contending with other, and potentially interactive, threats. However, few studies have examined the thermal biology of Canadian freshwater fish Species at Risk. Furthermore, laboratory experiments examining the effects of temperature often rely on short-term exposures and do not consider interactive effects. This study investigated the effect of rearing temperature on critical thermal maximum (CT_{max}), standard metabolic rate (SMR), and gill size in the threatened Pugnose Shiner (*Notropis anogenus*) and effects of acute hypoxia exposure on CT_{max} of Pugnose Shiner from different rearing temperatures. Juvenile Pugnose Shiner were reared for 4 months in one of five different ecologically relevant temperatures. CT_{max} was measured under normoxia and acute exposure to hypoxia to test for oxygen sensitivity of upper thermal limits in this species. CT_{max} increased with elevated water temperature. Agitation temperature (temperature at which fish show behavioural signs of thermal stress) also increased with rearing temperature and occurred, on average, 7.63°C below the CT_{max}. CT_{max} was lower when fish were acutely exposed to hypoxia and showed no increase between 19°C and 25°C. Surprisingly, CT_{max} under acute hypoxia increased sharply at the highest temperature. SMR increased between 16°C and 25°C, and then declined significantly at 28°C, indicating that their ability to reverse thermodynamic effects on SMR is limited, and there was no evidence of long-term thermal compensation. Gill size (e.g. total gill filament length, hemibranch area) increased with long-term exposure to high temperature, which may increase oxygen uptake capacity and fuel increased metabolic demands. Identifying source populations with greater thermal tolerance or implementing captive breeding under higher temperature regimes may improve the success of introduction efforts and promote population persistence with climate change, but fitness trade-offs in thermal tolerance should be examined.

Platform 13 - Seasonal Variation in Critical Thermal Maximum of Endangered Redside Dace at its Northern Range

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Understanding the thermal performance of fishes is necessary to identify optimal thermal habitat, which can provide insight into how species productivity may shift under climate change. Using an experimental thermal chamber, we investigated seasonal variation in the Critical Thermal Maximum (CT_{max}) and the thermal response window (TRW) of wild-caught Redside Dace (n = 169) in Two Tree River, Ontario. Streamside CT_{max} trials were used to identify the maximum temperature at which Redside Dace maintain equilibrium, providing a powerful tool for understanding how thermal stress affects individual performance. The TRW was calculated as the difference between CT_{max} and acclimation temperature, defined as the ambient temperature of the stream. By conducting monthly streamside trials June-October 2018, May 2019 and October 2019, we assessed whether CT_{max} and TRW varied based on acclimation temperature, body size and dissolved oxygen concentration. Mean CT_{max} varied between 27.59°C and 33.63°C and TRW varied between 7.12°C and 24.09°C based on minimum and maximum acclimation temperatures of 3.59°C and 24.39°C, respectively. Based on mixed effects models, preliminary results indicated a positive linear relationship between CT_{max} and acclimation temperature, and a negative linear relationship between TRW and acclimation temperature. Significant differences were observed for monthly mean ambient stream temperatures, CT_{max} and TRW in most cases, without a significant effect of body size or dissolved oxygen concentration. Results provide insight into the thermal performance of Redside Dace, which to-date has been difficult to assess due to the species rarity and lack of suitable streamside protocols.

Platform 14 - Thermal and Oxygen Tolerances of the imperilled Eastern Sand Darter (*Ammocrypta pellucida*)

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Anthropogenic stressors are predicted to increase water temperature and reduce dissolved oxygen (DO), which is expected to impact Species as Risk. Species at Risk are vulnerable to changing water temperatures and DO levels as they often have unique physiological tolerances compared to species within their family and genus. In this study, we assess the critical thermal maximum (CT_{max}) and the critical oxygen tolerance (P_{crit}) of Eastern Sand Darter (ESD; *Ammocrypta pellucida*), a small benthic fish listed as Threatened under the *Species at Risk Act*. To determine CT_{max} and P_{crit} of ESD, field-based trials were conducted across seasons from May-November to obtain a range of acclimation temperatures (10-25°C). CT_{max} was assessed using critical thermal maximum experiments where temperature was increased using standardized methods of 0.3°C per minute until thermal stress endpoints of agitation and loss of equilibrium occurred. P_{crit} was assessed using closed respirometry with oxygen being depleted by fish respiration until the endpoint of loss of equilibrium. This research will determine the seasonal responses of ESD to common aquatic habitat stressors (thermal and oxygen impairment). Preliminary results show CT_{max} and P_{crit} having phenotypic plasticity across seasons. Furthermore, preliminary results show that ESD is oxyconforming, they decrease their oxygen consumption with decreasing levels of available environmental oxygen. These objectives have implications for the conservation of the species under SARA by directly informing abiotic habitat suitability, thereby contributing to the definition of critical habitat for the species.

Platform 15 - Assessing Risk of Competition between Invasive and Native Fishes: Eurasian Tench (*Tinca tinca*) versus Redhorses (*Moxostoma spp.*)

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A globally invasive Eurasian cyprinid fish, the Tench (*Tinca tinca*), is increasing in abundance exponentially in the St. Lawrence River and will likely become established in the Great Lakes in the near future. Tench is a generalist benthivore with a broad tolerance to environmental conditions, including temperature. It occurs in calm, shallow waters of lakes and large rivers, and feeds primarily on benthic macroinvertebrates. It overlaps in diet and habitat with several functionally-similar native species, including a group of catostomid fishes, redhorses (*Moxostoma spp.*), which contain Species at Risk in Canada. To experimentally assess the potential for resource competition, we designed an array of 30 outdoor mesocosms containing Tench and Shorthead Redhorse (*Moxostoma macrolepidotum*). We will compare growth rates and glycogen levels of Shorthead Redhorse and Tench in conspecific and heterospecific treatments. In a pilot experiment conducted last summer, abnormally high mesocosm water temperatures (>35°C) revealed a drastic difference in the survival rates of Silver Redhorse (*Moxostoma anisurum*) and Tench under natural thermal stress. All Silver Redhorse died during the episodic event, whereas no mortality or long-term loss of growth was observed for Tench. These results suggest a competitive advantage under climate warming that must be considered when interpreting the implications of resource competition between Tench and redhorses. Higher summer maximum temperatures might drive redhorses away from habitat tolerable to Tench.

Platform 16 - Reintroduction of SARA-listed Fishes in Canada: Where Are We Now and Where Are We Going?

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There are over 70 species, subspecies, and/or designatable units (DUs) of fishes presently listed for protection under Schedule 1 of the Canadian *Species at Risk Act* (SARA). For extirpated species or species threatened by extirpation, reintroduction has been identified in several federal recovery documents as a strategy that could aid in the recovery of SARA-listed fish species. Specifically, reintroduction has been identified to support recovery for Atlantic Salmon (*Salmo salar*), Atlantic Whitefish (*Coregonus huntsmani*), Channel Darter (*Percina copelandi*), Copper Redhorse (*Moxostoma hubbsi*), Eastern Sand Darter (*Ammocrypta pellucida*), Gravel Chub (*Erimystax x-punctatus*), Lake Chubsucker (*Erimyzon sucetta*), Northern Madtom (*Noturus stigmosus*), Pugnose Shiner (*Notropis anogenus*), Redside Dace (*Clinostomus elongatus*), Spring Cisco (*Coregonus sp*.), Striped Bass (*Morone saxatilis*), Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), and White Sturgeon (*Acipenser transmontanus*). However, reintroduction for the purposes of conservation has only occurred for five of these SARA-listed species. Momentum to facilitate conservation-based reintroduction projects for SARA-listed fishes is increasing but there is considerable uncertainty around what makes reintroduction successful. We will discuss the current state of SARA-listed fish reintroductions in Canada, uncertainties that delay such efforts, and elaborate on research questions that, if answered, will increase the likelihood of successful future reintroduction efforts in the future.

Platform 17 - Co-occurrence Modelling: A Tool for Predicting Distributions of Species at Risk

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Species distribution models (SDMs) can be an effective way to analyze complex species and community data, potentially leading to strong inferences about habitat requirements and community structure. Species at Risk (SAR) present a unique challenge when modelling distribution, because their sample sizes are small and data are limited. In addition to these challenges, most SDMs focus on abiotic factors and omit biotic factors. Co-occurrence modelling can use both abiotic and biotic factors to give a more complete picture of a species distribution. The addition of biotic elements can lead to insights into possible positive or negative interactions between species and their effect on distribution. Here, we use a novel method to predict the distribution of an Endangered warm water fish that inhabits the coastal wetlands of the lower Great Lakes, Lake Chubsucker (*Erimyzon sucetta*). We also evaluate whether the inclusion of biotic factors can increase the predictive validity of SDMs at multiple scales, focusing on whether this methodology can lead to new hypotheses about threats and limiting factors of SAR fishes in Ontario. Preliminary results indicate that dominant aquatic vegetation, Grass Pickerel (*Esox americanus vermiculatus*), and water temperature are key variables in predicting the presence of Lake Chubsucker.

Platform 18 - Development of Empirically Driven Genetic Guidelines for Captive Propagation of Imperilled Freshwater Mussels

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It has been more than a decade since the publication of two review papers (Jones et al. 2006, Hoftyzer et al. 2008) outlining genetic considerations for captive propagation of imperilled freshwater mussels. While our knowledge of genetic diversity and structure of wild stocks of numerous unionid species has advanced extensively, there has not been the same advancement in our understanding of genetic diversity of captive bred mussels in comparison to wild populations. This study will provide empirical data critical for effective, responsible propagation efforts. Our null hypothesis was that wild and captive-bred mussel populations have equivalent genetic diversity. Genetic data were obtained using genotyping of 8 microsatellite loci for *Lampsilis fasciola* (Wavy-rayed Lampmussel, Special Concern in Canada) and 9 microsatellite loci for *Ptychobranchus fasciolaris* (Kidneyshell, Endangered in Canada). Mantle tissue biopsies or foot swabs were collected from adult mussels from each species from the Grand and Sydenham rivers in Ontario, Canada. Captively propagated juveniles of each species were grown to harvestable size in the White Lake Fish Culture Station in Ontario. No significant differences were detected between wild and propagated *L. fasciola* based on genetic diversity metrics (allelic richness, rarefacted allelic richness, observed heterozygosity, expected heterozygosity, and inbreeding coefficient) using Kruskal-Wallis tests. Pairwise F_{ST} values among wild caught specimens, hatchery raised juveniles, and across different time periods (2008 to 2018) were significant ($P<0.0001$), but low (0.014-0.026). Pairwise D_{est} values were significant and somewhat higher (0.027-0.140) suggesting some fixation of alleles and limited differentiation. STRUCTURE analysis corroborated these findings with strong support for a single genetic population ($K=1$). Based on the data from *L. fasciola*, there is no evidence of reduced genetic diversity between wild and propagated individuals. We hypothesize that with at least 10 females contributing to brood stock, the contribution of multiple males to each glochidial brood help maintain the genetic diversity reflecting the natal population. Research is ongoing with the *P. fasciolaris* genotypes being analyzed and a new hatchery study on *L. fasciola* is underway with genotypes from source females and propagated juveniles grown out separately to assess genetic variation within broods from single females.

Platform 19 - Can Conservation Targets for Imperilled Freshwater Fishes and Mussels be Achieved by Captive Breeding and Release Programs?

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Captive breeding programs are one of the many tools used by conservation practitioners as a means of conserving, supporting, and supplementing populations of imperilled species. Captive breeding programs exist around the globe for freshwater mussels and fishes, but the state of knowledge on this topic is yet to be evaluated by systematic mapping procedures. We are conducting a systematic map to provide an overview of the existing literature based on the effectiveness of captive-breeding programs, for the purpose of achieving conservation targets for imperilled freshwater fishes and mussels in the wild. To identify relevant studies for inclusion, we searched five bibliographic databases, two search engines, 19 specialist websites and solicited grey literature through relevant sources. We screened articles at title and abstract, then by full-text using predefined inclusion criteria. Included studies were coded for key variables of interest. To date, 973 datasets (e.g., different species, programs, and/or outcomes) from 397 articles have been included in the systematic map database. These studies will be used to quantify and describe the available evidence, providing insights into, for example: (1) the geographical distribution of the evidence base; (2) the types of study designs used to evaluate programs; (3) the frequency and types of imperilled freshwater fishes and mussels studied; (4) the frequency of program objectives (i.e., propagation, re-introduction, supplementation, experimental); (5) within each program objective, the frequency of the different stages studied (i.e., broodstock selection, rearing and release methods, monitoring in the wild); and (6) the frequency and types of outcomes measured. Visual heat maps of the links between program objectives/stages and outcomes will be generated for the fish and mussel groups and used to address questions such as: (1) What types of outcomes are measured for a given program objective and stage?; (2) Where are the knowledge gaps?; (3) Where are the evidence clusters?; and, (4) Are there any biases or limitations in the current evidence base? The outputs from this systematic map (i.e., the report, map database and heatmaps) will provide a first step toward improving our understanding of the effectiveness of captive-breeding programs for their ability to achieve conservation targets in the wild.

Platform 20 - Integrating Research Results into SAR Recovery and Protection

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In 2002, the *Species at Risk Act* (SARA) was proclaimed with the goals of preventing wildlife species declines, recovery of species that are at risk (Extirpated, Endangered, Threatened), and to manage species that are of Special Concern. Once a species is listed under the *Act*, the Species at Risk Program (SARP) is responsible for recovery planning, implementation, and monitoring, which includes development of Recovery Strategies, Management Plans, and Progress Reports. SARP works closely with Fisheries and Oceans Canada (DFO) Science and other partners to acquire science advice on threats and mitigation approaches when dealing with a Species at Risk (SAR).

The Canadian Freshwater Species at Risk Research Network (SAR NET) has provided valuable information that is pertinent to understanding and protecting freshwater SAR mussels and fishes as it relates to specific threats and threat mechanisms, habitat evaluation, modelling, breeding, and reintroduction programs. These projects have filled in some knowledge gaps identified in recovery documents. For example, SAR NET experiments that focused on fish thermal tolerance (e.g., response to elevated water temperature, hypoxic conditions, oxygen tolerances) provide an understanding of the required thermal regime for a given species, guide thresholds of water quality parameters, as well an understanding of how climate change may affect certain species. Modelling projects help inform management by identifying potential new locations of target species, estimations or projections of future impacts of various threats, as well as refining critical habitat. Those projects that focused on breeding programs or reintroductions will provide a foundation for science advice, including genetic guidelines, for future implementation.

More scientific information is needed to determine threat thresholds, identify and/or refine critical habitat – including habitat required by all life stages – as well as the feasibility of augmentation and/or reintroduction. However, the current SAR NET projects have provided SARP with information that not only improves the effectiveness of recovery, but that is also scientifically defendable. SARP supports and encourages the continuation of SAR NET as it helps improve recovery of freshwater species that are currently listed under SARA, as well as those that will be listed in the future.

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REFERENCES

McNichols-O'Rourke, K.A., Morris, T.J., and Drake, D.A.R. (Editors). 2020. Proceedings of the Canadian Freshwater Species at Risk Research Network (SAR NET) – Year 2 Symposium: November 13-14, 2018, Burlington, Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 3365: vii + 17 p.