

Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2017 to 2021

Rocky Mountain Ridged Mussel



2023

Recommended citation:

Fisheries and Oceans Canada. 2023. Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2017 to 2021. *Species at Risk Act* Management Plan Report Series. Fisheries and Oceans Canada, Ottawa. v + 15 pp.

For copies of the progress report, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, recovery strategies, residence descriptions, action plans, and other related recovery documents, please visit the [Species at Risk Public Registry](#).

Cover illustration: Rocky Mountain Ridged Mussel (*Gonidea angulata*) from Okanagan Lake, British Columbia (September 2020). Photograph by L. Dealy.

Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du plan de gestion de la gonidée des Rocheuses (*Gonidea angulata*) au Canada pour la période 2017 à 2021 »

© His Majesty the King in Right of Canada, represented by the Minister of Fisheries and Oceans Canada, 2023. All rights reserved.
ISBN 978-0-660-45976-9
Catalogue no. En3-5/15-1-2022E-PDF

Content (excluding the cover illustration) may be used without permission, with appropriate credit to the source.

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 the protection of species at risk throughout Canada. Under section 72 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent minister must monitor the implementation of the management plan and must assess its implementation 5 years after the plan is included in the public registry, and in every subsequent 5-year period until its objectives have been achieved.

Reporting on the progress of management plan implementation requires reporting on the collective efforts of the competent minister, provincial and territorial governments, and all other parties involved in conducting activities that contribute to the species' conservation. Management plans set conservation goals and objectives for special concern species to prevent them from becoming further at risk. Some of the identified broad strategies and approaches are sequential to the progress or completion of others and not all may be undertaken or show significant progress during the timeframe of a report on the progress of management plan implementation (progress report).

The Minister of Fisheries and Oceans (DFO) is the competent minister under SARA for the Rocky Mountain Ridged Mussel and has prepared this progress report.

As stated in the preamble to SARA, success in the conservation 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 management plan and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. The cost of recovering and conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing the management plan for the Rocky Mountain Ridged Mussel for the benefit of the species and Canadian society as a whole.

Acknowledgments

This progress report was prepared by Andrew Baylis with input from Manon Morrisette, Ahdia Hassan, Sean MacConnachie, and Mark Potyrala (Fisheries and Oceans Canada). To the extent possible, this progress report has been prepared with input from Greg Wilson and Lora Nield (British Columbia Ministry of Land, Water and Resource Stewardship) as well as James Arner (British Columbia Ministry of Forests). DFO would also like to express its appreciation to all individuals and organizations who have contributed to the conservation of the Rocky Mountain Ridged Mussel.

Executive summary

The Rocky Mountain Ridged Mussel (*Gonidea angulata*) was listed as special concern under the *Species at Risk Act* (SARA) in 2005. The “Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada” was published on the Species at Risk Public Registry in 2011 ([DFO 2011](#)). In 2010, the species was reassessed as endangered by COSEWIC ([COSEWIC 2011](#)) and the species is currently under consideration for listing as endangered under SARA.

The threats identified in the management plan for the Rocky Mountain Ridged Mussel include: foreshore, riparian and littoral zone development, historic riverbed channelization, hydrograph modification and regulation (effects of dam operation), aquatic introduced species, host species availability, watershed land-use related pollution, disturbance or direct harm, and climate change.

The management goal for the Rocky Mountain Ridged Mussel is to maintain viable, self-sustaining, ecologically functioning and broadly distributed populations within suitable habitats in its current distribution/range in British Columbia (BC).

The “Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel in Canada for the Period 2017 to 2021” reports on the progress made by Fisheries and Oceans Canada (DFO) and its partners towards implementing the management plan and achieving its objectives. During this time period, progress has been made towards:

- addressing knowledge gaps on genetic population structure, identification of host fish species, and interaction with Eurasian Water Milfoil
- collecting information required to identify important habitats that support the life cycle of the species
- expanding inventory surveys to new areas of littoral habitat within the Okanagan River watershed using standardized protocols
- continuing development of stewardship activities in the areas of public education, outreach, and habitat restoration
- incorporating information about the Rocky Mountain Ridged Mussel into stewardship agreements and other planning processes to improve conservation of the species and mitigation of threats

While progress has been made towards meeting the management goal and management objectives and interim performance measures detailed in the management plan, additional measures are necessary to ensure the long-term viability of Rocky Mountain Ridged Mussel in BC. Further work is needed to clarify threats and limiting factors, and improve coordination and communication between decision makers, stakeholders, researchers, and Indigenous groups around the interactions between the Rocky Mountain Ridged Mussel and human activities.

DFO remains committed to ensuring the long-term viability of the Rocky Mountain Ridged Mussel across its extant distribution in the wild. The progress made to date would not have been achieved without the contribution of partners like the Okanagan Nation Alliance, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, British Columbia Ministry of Environment and Climate Change Strategy, Invasive Species Council of British Columbia, Habitat Conservation Trust Foundation, University of British

Columbia – Okanagan Campus, and Utah State University. DFO looks forward to continued collaboration and welcomes the participation of additional partners.

Table of contents

| | |
|---|-----|
| Preface | ii |
| Acknowledgments | ii |
| Executive summary | iii |
| Table of contents | v |
| 1 Introduction | 1 |
| 2 Background | 1 |
| 2.1 COSEWIC assessment summary and threats to the species | 1 |
| 2.2 Conservation | 2 |
| 3 Progress towards conservation | 3 |
| 3.1 Activities supporting conservation | 5 |
| 3.2 Summary of progress towards conservation | 10 |
| 3.2.1 Status of interim performance measures | 10 |
| 4 Concluding statement | 12 |
| 5 References | 13 |

1 Introduction

The “Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2017 to 2021” (herein referred to as progress report) outlines the progress made towards meeting the objectives listed in the “Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada” ([DFO 2011](#); herein referred to as management plan) during the indicated time period. The progress report is part of 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) assessment and status reports ([COSEWIC 2003](#), [2011](#)), the management plan, and the “Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2011-2016” ([DFO 2017](#)).

Section 2 of the progress report summarizes key information on the threats to the species and the management goal and management objectives for achieving its conservation. For more details, readers should refer to the management plan. Section 3 reports on the progress of broad strategies identified in the management plan to support achieving the management goal and management objectives. Section 4 summarizes the progress toward achieving the management goal and management objectives.

2 Background

2.1 COSEWIC assessment summary and threats to the species

In 2003, COSEWIC assessed the Rocky Mountain Ridged Mussel as special concern (COSEWIC 2003). The species was subsequently listed as special concern under Schedule 1 of the *Species at Risk Act* (SARA) in 2005 which led to the 2011 publication of the management plan.

COSEWIC re-assessed Rocky Mountain Ridged Mussel as endangered in 2010 (COSEWIC 2011). The species is currently under consideration for listing as endangered under Schedule 1 of SARA. In 2019, the Governor in Council proposed to amend Schedule 1 of SARA to reclassify the Rocky Mountain Ridged Mussel as endangered. In response to public comments received on this proposal, relating to the need to maintain flexibility in managing European Water Milfoil (*Myriophyllum spicatum*), an aquatic invasive plant, which co-occurs with the Rocky Mountain Ridged Mussel), the Minister of Fisheries and Oceans Canada announced that a recommendation on whether to reclassify the species would be made at a future date. The Rocky Mountain Ridged Mussel remains a species of special concern under SARA and its conservation needs will be met via implementation of measures identified in the Management Plan (DFO 2011).

Assessment Summary – November 2010**Common name**

Rocky Mountain Ridged Mussel

Scientific name*Gonidea angulata***Status**

Endangered

Reason for designation

This mussel, 1 of only a few species of freshwater mussel in British Columbia, is restricted in Canada to the Okanagan basin. Historically, channelization and water regulation in the Okanagan River have affected mussel beds and caused population reduction. Additional sites have been found since the original COSEWIC assessment (2003). Currently, Zebra and Quagga (dreissenid) Mussels are the most serious potential threat to the native mussel. Dreissenid mussels have had devastating effects on native unionid communities elsewhere, such as in the Great Lakes region. A recent assessment of the sensitivity of the Okanagan basin to dreissenid mussels demonstrated that the latter could spread quickly and establish intense infestation on native mussels once introduced. Within the foreseeable future, the introduction of dreissenids into the Okanagan basin is likely because they can survive for days out of water and are known to be transported between water bodies on trailered watercrafts; dreissenid mussels have been intercepted on trailered boats heading to British Columbia in recent years. Ongoing foreshore and riparian development, and some methods of control of invasive Eurasian Watermilfoil reduces habitat and affects water quality.

Occurrence

British Columbia

Status history

Designated special concern in May 2003. Status re-examined and designated endangered in November 2010.

Section 1.5 of the management plan provides information on the threats to the conservation of the Rocky Mountain Ridged Mussel. These threats include: foreshore, riparian and littoral zone development; historic riverbed channelization; hydrograph modification and regulation (effects of dam operation); aquatic introduced species; host species availability; watershed land-use related pollution; disturbance or direct harm; and climate change.

2.2 Conservation

This section summarizes the information, found in the management plan, on the management goal and management objectives that are necessary for the conservation of the Rocky Mountain Ridged Mussel and on interim performance measures that provide a way to define and measure progress toward achieving the management goal and management objectives.

Management goal

The management goal for the Rocky Mountain Ridged Mussel is to maintain viable, self-sustaining, ecologically functioning and broadly distributed populations within suitable habitats at the species' current distribution and range in British Columbia (BC).

With respect to this goal, the current range of the Rocky Mountain Ridged Mussel includes the Okanagan River watershed, from the northernmost record of a shell found in Vernon to the southernmost record of a shell found in the Osoyoos area. The range extent will be expanded if occurrences are found in other areas.

Management objectives

The management objectives¹ for Rocky Mountain Ridged Mussel are to:

- 1) by 2015, address knowledge gaps about the life history, provincial range and threats to the Rocky Mountain Ridged Mussel
- 2) by 2015 inventory 75% of potential littoral habitat within the Okanagan River watershed, with standardized protocol for habitat and threat information collected at each site searched
- 3) by 2015, demonstrate an increased number of stewardship activities initiated and completed for land managers and public users of habitats occupied by the Rocky Mountain Ridged Mussel
- 4) as research and inventory results on Rocky Mountain Ridged Mussel become available, incorporate into land-use planning to inform future threat mitigation and land use protection

The management plan did not include performance measures. In line with the previous progress report, the management objectives will be used as interim performance measures, to measure the progress made towards the conservation of the Rocky Mountain Ridged Mussel.

3 Progress towards conservation

The management plan divides the conservation effort into 6 broad strategies and 20 associated conservation actions:

Broad strategy: protection

- apply and monitor existing legislation, guidelines and best management practices

Broad strategy: management

- integrate Rocky Mountain Ridged Mussel into federal, provincial, regional, municipal planning documents and guidelines as we learn more about the species

Broad strategy: research

- draft an inventory schedule for watersheds with unconfirmed records of Rocky Mountain Ridged Mussel (Kootenay, Columbia, Similkameen and southern Vancouver Island)

¹ Management objectives are time bound in the management plan but still apply beyond 2015.

- create a list of knowledge gaps, resources needed to address gaps; approaches to filling knowledge gaps; and partners for implementing research that fills knowledge gaps
- build relationships with academic institutions, and raise awareness regarding research opportunities
- build international relationships, particularly with United States (US) biologists and resources professionals working on the Rocky Mountain Ridged Mussel and mollusc conservation

Broad strategy: monitoring and assessment

- continue to use and improve upon the inventory guidelines established for freshwater molluscs and BC Conservation Data Centre reporting guidelines
- complete geographic information systems mapping exercise that defines potential habitat for the Rocky Mountain Ridged Mussel in the Okanagan watershed
- draft an inventory and monitoring schedule for the Okanagan watershed (for example, using bathymetric maps, aerial photos, etc.)
- refine standardized protocol for mollusc inventory, habitat and threat information collection
- implement inventory and monitoring protocols throughout the Okanagan watershed

Broad strategy: outreach and communication

- continue to distribute information to dive shops, marinas, government (all levels), and resource professionals
- extend communication and distribution of the Large Lakes Protocol to public
- develop and distribute educational materials for the Rocky Mountain Ridged Mussel, highlighting the importance and ecological function of freshwater molluscs, as indicators of water health
- modify and make accessible habitat best management practices to include Rocky Mountain Ridged Mussel habitats adjacent to private lakeshore residences and businesses
- provide training or information materials to resource professionals working in or near Rocky Mountain Ridged Mussel habitats
- develop and initiate a comprehensive reporting system for sightings in conjunction with fishing licenses and recreational sport fishery programs in the Okanagan River watershed
- work with local stewardship groups to contact landowners with property on lakeshores adjacent to optimal Rocky Mountain Ridged Mussel habitat that is both occupied (mussels present) and unoccupied (potential restoration habitat)
- work with local stewardship groups to develop infrastructure, best management practices, guidelines and explore other approaches that limit agricultural and private property wastewater runoff. These initiatives could be completed in conjunction with actions for other species at risk

Broad strategy: restoration

- consider Rocky Mountain Ridged Mussels in watershed scale restoration projects

Progress in carrying out these broad strategies is reported in section 3.1 of this report. Section 3.2 reports on the progress toward meeting the interim performance measures.

3.1 Activities supporting conservation

Table 1 provides information on the implementation of activities undertaken to address the broad strategies identified in the management plan. A number of activities were implemented prior to 2017 which have been documented in the “Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2011- 2016” (DFO 2017).

Table 1. Details of activities supporting the conservation of the Rocky Mountain Ridged Mussel from 2017 to 2021.

| # | Broad strategy | Activity descriptions and results | Participants ² |
|---|----------------|---|--|
| 1 | Protection | <p>Existing legislation, guidelines, and best management practices continued to be applied and monitored, including:</p> <ul style="list-style-type: none"> the Rocky Mountain Ridged Mussel continues to be protected under the <i>Fisheries Act</i>. Any works, undertakings, or activities taking place in or near water that may impact fish³ and fish habitat are subject to regulatory review to avoid and mitigate project impacts. Any death of fish or the harmful alteration, disruption, or destruction of fish habitat, requires a <i>Fisheries Act</i> authorization to promote conservation of Rocky Mountain Ridged Mussel, the Province of British Columbia (BC) continues to monitor relocations⁴, evaluate survey methodologies, and ensure compliance with the BC <i>Water Sustainability Act</i> the BC <i>Riparian Areas Protection Regulation</i> (RAPR) protects riparian areas from new development, which limits sediment entry into stream habitat | Province of British Columbia, Fisheries and Oceans Canada (DFO) |
| 2 | Management | <p>Guidelines and best management practices for freshwater mussel surveys and relocations were developed (British Columbia Ministry of Forests, Lands and Natural Resource Operations [BC FLNRO] 2017) and training on the application of these guidelines is provided to environmental consultants (qualified environmental professionals) in the Okanagan Region.</p> <p>Rocky Mountain Ridged Mussels were recognized in a number of provincial, regional and municipal planning documents and guidelines (summarized in DFO 2011). During the current reporting period, Rocky Mountain Ridged Mussels were incorporated into the Okanagan Region Large Lakes Foreshore Protocol (British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development [BC FLNRORD] 2018b).</p> | BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BC FLNRORD), |

² Participants are ordered based on order of mention in the respective activity cell.

³ Fish includes (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

⁴ Relocation involves deliberately moving mussels from one location to another to mitigate threats from development.

| # | Broad strategy | Activity descriptions and results | Participants ² |
|---|----------------|---|------------------------------------|
| 3 | Research | <p>BC FLNRORD and the BC Rocky Mountain Ridged Mussel Working Group developed a list of knowledge gaps in 2016 that is updated annually (Nield pers. comm. 2022).</p> <p>BC FLNRORD and BC Ministry of Environment and Climate Change Strategy (BC ENV) gave a presentation on guidance for freshwater mussel surveys and relocations in the Thompson-Okanagan area at the 2017 Canadian Freshwater Mollusc Research Meeting.</p> <p>Collaborations between DFO, BC ENV, BC FLNRORD, University of British Columbia – Okanagan Campus (UBCO), and Utah State University (USU) facilitated research and addressed several knowledge gaps. Specifically, the following studies have been completed:</p> <ul style="list-style-type: none"> • Mock et al. (2020) described patterns of genetic variation in Rocky Mountain Ridged Mussel across its global range. Overall results indicated genetic diversity decreased upstream and showed differences in allele frequencies above and below Okanagan Falls, suggesting the falls may be an upstream velocity barrier preventing gene flow. The northern Okanagan Lake population results showed lower genetic diversity with evidence of low-level inbreeding, indicating it is a small, spatially isolated population that may have been established by a long-distance dispersal event • through experimental study and field surveys, researchers from UBCO found that rototilling (or rotoation; a control method used for aquatic invasive Eurasian Water Milfoil) has a negative effect on Rocky Mountain Ridged Mussel (Mageroy et al. 2017). In 2020, Wade et al. delineated known mussel beds and potential overlap with Eurasian Water Milfoil to inform management decisions related to species at risk conservation and aquatic invasive species control. The authors of this study recommend detailed site evaluations prior to the application of milfoil control methods to mitigate effects on Rocky Mountain Ridged Mussel. The study addresses concerns presented by a water management board in opposition to the potential reclassification of the Rocky Mountain Ridged Mussel from special concern to endangered • Snook et al. (2018) used snorkel survey data, habitat data, and 2 complementary classification methods to develop habitat suitability models for the species. The study’s findings suggest that factors affecting distribution of Rocky Mountain Ridged Mussel are comparable between rivers and lakes. Through these models, the authors prioritized sites for conservation based on predictor variables that indicated favorable habitat characteristics for the species. This study aims to support the identification of critical habitat⁵, should the species be re-classified as endangered under Schedule 1 of SARA • surveys in 2017 (Brownlee et al. 2017) found encysted Rocky Mountain Ridged Mussel glochidia exclusively on Prickly Sculpin, which provides further support for previous studies (Mageroy 2013, | BC ENV, BC FLNRORD, DFO, UBCO, USU |

⁵ Under the *Species at Risk Act* (SARA), critical habitat is the habitat that is necessary for the survival or recovery of listed extirpated, endangered, or threatened species, and that is identified as critical habitat in a recovery strategy or action plan.

| # | Broad strategy | Activity descriptions and results | Participants ² |
|---|---------------------------|---|---|
| | | <p>2016) that have suggested that sculpin is the most important host fish species for Rocky Mountain Ridged Mussel</p> | |
| 4 | Monitoring and Assessment | <p>Guidance: Guidance was developed in 2018 to provide advice to qualified environmental professionals undertaking freshwater mussel surveys and relocations within the Thompson-Okanagan area (BC FLNRORD 2018a). The “Guidance for Freshwater Mussels in the Okanagan” follows a modified version of the protocol for detection of freshwater mussel species at risk developed for the Ontario-Great Lakes Area (Mackie et al. 2008) and provides information and advice in the following areas:</p> <ul style="list-style-type: none"> • project requirements based on presence of Rocky Mountain Ridged Mussel; survey methodology (including timing and techniques) • impact mitigation • relocation methodology • data collection • monitoring following relocation • reporting <p>Threat monitoring (aquatic introduced species): The Invasive Species Council of British Columbia (ISCBC) conducted a literature review to assess the impacts of invasive species on species at risk in BC, including interactions between Eurasian Water Milfoil and Rocky Mountain Ridged Mussel (Tamburello and Litt 2021).</p> <p>The Invasive Mussel Monitoring Fund administers support for early detection lake monitoring in the Okanagan Valley and other areas of BC to mitigate impacts of Zebra and Quagga Mussels (HCTF 2020).</p> <p>Studies to support critical habitat identification: Following the COSEWIC (2011) reassessment of Rocky Mountain Ridged Mussel as endangered, work was undertaken to support the identification of potential critical habitat for Rocky Mountain Ridged Mussel in light of a potential <i>Species at Risk Act</i> Schedule 1 status change. Specifically, Snook (2018) modelled habitat suitability using foreshore inventory and mapping data to provide information required to support the identification of critical habitat for Rocky Mountain Ridged Mussel in Okanagan Lake.</p> <p>Surveys: During this reporting period, studies have been completed to monitor the presence of Rocky Mountain Ridged Mussel in known areas, as well as to detect their presence at new sites:</p> | <p>BC FLNRORD, DFO, Habitat Conservation Trust Foundation (HCTF), ORRI, Okanagan Nations Alliance (ONA), BC ENV</p> |

| # | Broad strategy | Activity descriptions and results | Participants ² |
|---|----------------------------|---|---------------------------|
| | | <ul style="list-style-type: none"> • in 2019, BC FLNRORD conducted surveys at 4 sites where Rocky Mountain Ridged Mussel are known to co-occur with Eurasian Water Milfoil control activities (Arner pers. comm. 2022) • DFO conducted annual index site surveys at 9 locations in the Okanagan Basin from 2017 to 2020 (MacConnachie et al. 2021) • DFO conducted shore-based exploratory surveys to confirm Rocky Mountain Ridged Mussel presence at 6 accessible sites in 2018; no mussels were found (Dealy et al. 2021) • in 2020, DFO surveyed 83.6 km of shoreline at the southern end of Okanagan Lake by boat; Rocky Mountain Ridged Mussels were observed in new areas outside of known index sites, but there were no observations that could be defined as high density mussel beds (Dealy et al. 2021; MacConnachie pers. comm. 2022) • the Okanagan River Restoration Initiative (ORRI; refer to table 1 row 6) conducted pre-restoration monitoring surveys in 2019 and observed Rocky Mountain Ridged Mussels at Okanagan Falls (Rivard-Sirois 2020) | |
| 5 | Outreach and Communication | <p>An educational and behaviour change program, the Invasive-Wise Tourism program, was developed and materials were presented to 16 partners across southern BC to help prevent the introduction of invasive species, propose potential mitigative actions, and promote awareness of Rocky Mountain Ridged Mussel (and other species at risk) among tourists and visitors (ISCBC 2021).</p> <p>In several online meetings, the ISCBC worked with the Indigenous Invasive Species Network (IISN) and Indigenous partners to seek information and advice on intersects between species at risk, invasive species, and cultural values (ISCBC 2021). Meetings included discussion of potential future impacts to Rocky Mountain Ridged Mussel by invasive Zebra and Quagga (dreissenid) mussels.</p> | ISCBC, IISN |
| 6 | Restoration | <p>ORRI⁶ is a partnership between First Nations, governments, and local stakeholders with the aim to return sections of the channelized Okanagan River to more natural, complex, and diverse conditions (Rivard-Sirois 2020).</p> <p>In 2017, BC FLNRORD developed habitat restoration guidance with information and advice pertaining to Rocky Mountain Ridged Mussel life cycle, host fish, habitat requirements, and restoration needs. ORRI has since incorporated this guidance into restoration design planning (Arner pers. comm. 2022).</p> <p>ORRI continues to benefit local riparian and aquatic species (including the Rocky Mountain Ridged Mussel and their host fish) by:</p> | ORRI, BC FLNRORD |

⁶ ORRI partners include ONA, BC FLNRORD, DFO, Confederated Colville Tribes, Osoyoos Indian Band, Penticton Indian Band, Regional District of Okanagan-Similkameen, South Okanagan Similkameen Conservation Program, Nature Trust of BC, Ducks Unlimited Canada, Canadian Wildlife Service (Environment and Climate Change Canada) as well as contractors Mariposa Consulting, Newbury Hydraulics, and HR Hydraulics.

| # | Broad strategy | Activity descriptions and results | Participants ² |
|---|----------------|---|---------------------------|
| | | <ul style="list-style-type: none"> • restoring habitat and increasing fish passage through the removal of vertical drop structures • conducting pre-restoration monitoring surveys • beginning to reconnect the K'əmçənítkw floodplain / Okanagan River (Lukey 2021) | |

3.2 Summary of progress towards conservation

3.2.1 Status of interim performance measures

Table 2 provides a summary of the progress made toward meeting the interim performance measures outlined in section 2.2 of this progress report. Each interim performance measure has been assigned 1 of 4 statuses:

- 1) not met: the interim performance measure has not been met, and little to no progress has been made
- 2) partially met, underway: moderate to significant progress has been made toward meeting 1 or more elements of the interim performance measure, and further work is ongoing or planned
- 3) met: the interim performance measure has been met and no further action is required
- 4) met, ongoing: the interim performance measure has been met, but efforts will continue as needed to achieve the objectives outlined in the species' management plan

Table 2. Summary of progress made toward meeting the interim performance measures outlined in the first progress report for the Rocky Mountain Ridged Mussel from 2017 to 2021.

| Interim performance measure | Status | Details |
|--|-------------------------|--|
| Have knowledge gaps about life history, provincial range, and threats to the Rocky Mountain Ridged Mussels been addressed? | Partially met, underway | Progress was made in addressing knowledge gaps related to genetic population structure, host fish confirmation, interaction with Eurasian Water Milfoil, and information required to identify important habitats that support the life cycle of the species. Refer to table 1, row 2 for further detail regarding research conducted in the 2017 to 2021 reporting period. |
| Was 75% of potential littoral habitat within the Okanagan River Watershed inventoried, with standardized protocols for habitat and threat information collected at each site searched? | Partially met, underway | <p>Since 2017, further progress was made towards inventorying potential littoral habitat within the Okanagan River Watershed using standardized protocols. Though it is difficult to determine what percentage of littoral habitat has been surveyed, it is likely that the goal of surveying 75% of littoral habitat has not yet been reached. Okanagan Lake has a shoreline length of approximately 270 km (Eyles et al. 1990). Survey efforts prior to 2011 searched approximately 30 to 60 km of the shoreline in the watershed. Snook (2015) surveyed over 16% of Okanagan Lake. Other efforts prior to 2017 are described in the previous progress report (DFO 2017).</p> <p>In 2018, Fisheries and Oceans Canada (DFO) researchers conducted exploratory surveys at 6 publicly accessible sites along the shoreline of Okanagan Lake. In 2020, DFO conducted boat-based surveys over a total of 83.6 linear km of shoreline (refer to row #4 of table 1).</p> |

| Interim performance measure | Status | Details |
|---|--------------------------------|---|
| <p>Have an increased number of stewardship activities been initiated and completed for land managers and public users of habitats occupied by the Rocky Mountain Ridged Mussel?</p> | <p>Partially met, underway</p> | <p>In the reporting period 2017 to 2021, progress was made in the area of stewardship:</p> <p>In 2020 and 2021, the Invasive Species Council of British Columbia developed the Invasive-Wise Tourism program and held a series of meetings with Indigenous Invasive Species Network and Indigenous partners to seek information and advice on intersects between species at risk (including Rocky Mountain Ridged Mussel), invasive species, and cultural values (refer to row #5 of table 1).</p> <p>Okanagan River Restoration Initiative and Okanagan Nations Alliance have continued ongoing restoration projects that benefit Rocky Mountain Ridged Mussel by restoring habitat and increasing fish passage.</p> |
| <p>Have research and inventory results on Rocky Mountain Ridged Mussel been incorporated into land-use planning to inform future threat mitigation and land-use protection?</p> | <p>Partially met, underway</p> | <p>In the reporting period 2017 to 2021, progress was made towards the consideration of Rocky Mountain Ridged Mussel in land-use planning processes. Information to promote conservation of the species continued to be incorporated into various planning processes (refer to row #2 of table 1).</p> |

4 Concluding statement

Within this reporting period (2017 to 2021), through the implementation of the activities identified in the “Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada”, some progress has been made in conserving the Rocky Mountain Ridged Mussel including:

- addressing knowledge gaps on genetic population structure, host fish confirmation, and interaction with Eurasian Water Milfoil
- collecting information required to identify important habitats that support the life cycle of the species
- expanding inventory surveys to new areas of littoral habitat within the Okanagan River watershed using standardized protocols
- continuing development of stewardship activities in the areas of public education, outreach, and habitat restoration
- incorporating information about the Rocky Mountain Ridged Mussel into stewardship agreements and other planning processes in order to improve conservation of the species and mitigation of threats

The overall management goal for Rocky Mountain Ridged Mussel is to maintain viable, self-sustaining, ecologically functioning and broadly distributed populations within suitable habitats in its current distribution/range in BC. While there is a lack of current population abundance and trend data, Rocky Mountain Ridged Mussel are monitored through periodic studies and continue to be encountered throughout their known range.

Further work is needed in the following areas:

- clarifying threats and limiting factors
- developing an inventory schedule for areas of potential Rocky Mountain Ridged Mussel occupancy to expand on previous exploratory surveys
- expanding upon existing stewardship activities and creating new initiatives related to public education and habitat restoration for Rocky Mountain Ridged Mussel
- improving coordination and communication between decisionmakers, stakeholders, researchers, and Indigenous groups around the interactions between the Rocky Mountain Ridged Mussel and human activities

DFO remains committed to the conservation of the Rocky Mountain Ridged Mussel. The work started and completed to date has built a strong foundation for continued research and management of this species over the next reporting period. The progress made to date would not have been achieved without the contribution of partners like the Okanagan Nation Alliance, British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, British Columbia Ministry of Environment and Climate Change Strategy, Invasive Species Council of British Columbia, Habitat Conservation Trust Foundation, University of British Columbia – Okanagan Campus, and Utah State University. DFO looks forward to continued collaboration and welcomes the participation of additional partners.

5 References

- Arner, J. pers. comm. 2022. Email correspondence with A. Baylis. June 2022. British Columbia Ministry of Forests.
- BC FLNRO (British Columbia Ministry of Forests, Lands and Natural Resource Operations). 2017. Guidance for Okanagan River Restoration Initiative for the Protection and Conservation of Rocky Mountain Ridged Mussel (*Gonidea angulata*). Ministry of Forests, Lands and Natural Resource Operations, Resource Management, Ecosystems Section, Penticton, BC. [unpublished]
- BC FLNRORD (British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development). 2018a. Guidance for Freshwater Mussels in the Okanagan. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Resource Management, Ecosystems Section, Penticton, B.C.
- BC FLNRORD. 2018b. Okanagan Large Lakes Foreshore Protocol. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Resource Management, Ecosystems Section, Penticton, B.C.
- Brownlee, S., Mageroy, J., and Walker, I. R. 2017. Rocky Mountain Ridged Mussel (*Gonidea angulata* Lea) in the Okanagan Valley, British Columbia: Host fish field sampling and mussel surveys in 2017.
- COSEWIC. 2003. COSEWIC assessment and status report on the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 29 pp.
- COSEWIC. 2011. COSEWIC assessment and status report on the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 56 pp.
- Dealy, L., MacConnachie, S., Wade, J., and Grant, P. 2021. Exploratory Surveys of Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Okanagan Lake, British Columbia, in 2018 and 2020. Can. Data Rep. Fish. Aquat. Sci. 1333: vi + 9 p.
- DFO. 2011. Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in British Columbia. Fisheries and Oceans Canada, Vancouver. iv + 52 pp.
- DFO. 2017. Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the period 2011 – 2016 *Species at Risk Act* Management Plan Report Series. Fisheries and Oceans Canada, Ottawa. iii + 18 pp
- Eyles, N., Mullins, H. T., and Hine, A. C. 1990. Thick and fast: sedimentation in a Pleistocene fiord lake of British Columbia, Canada. *Geology* 18(11): 1153-1157.
- HCTF (Habitat Conservation Trust Foundation). 2020. Invasive Mussel Lake Monitoring Fund – 2019 Project Performance Report. Canada Nature Fund for Species at Risk – Final Report. 2019NFPAC033. [unpublished]

- ISCBC (Invasive Species Council of BC). 2021. Protecting Species at Risk from Threats of Invasive Species. Canada Nature Fund for Species at Risk – Final Report. 2019NFPAC049. [unpublished]
- Lukey, N. k'əmçnitkw Floodplain Re-engagement – Final Construction Report. 2021. Prepared by Okanagan Nation Alliance Fisheries Department for the k'əmçnitkw Floodplain Re-engagement Steering Committee. Westbank, BC. [unpublished]
- MacConnachie, S., Dealy, L., Wade, J., and Grant, P. 2021. Rocky Mountain Ridged Mussel (*Gonidea angulata*) Index Site Surveys in the Okanagan Basin, British Columbia, 2017–2020. Can. Manuscr. Rep. Fish. Aquat. Sci. 3211: v + 9 p.
- MacConnachie, S., pers. comm. 2022. Email correspondence with A. Baylis. June 2022. Fisheries and Oceans Canada.
- Mackie, G., Morris, T. J., Ming, D., and Department of Fisheries and Oceans, Burlington, ON (Canada). 2008. [Protocol for the detection and relocation of freshwater mussel species at risk in Ontario-Great Lakes Area \(OGLA\) \(No. 2790\)](#). DFO, Burlington, ON (Canada).
- Mageroy, J. 2013. Rocky Mountain ridged mussel (*Gonidea angulata*) in the Okanagan Valley, B.C.: [Final report on juvenile recruitment, host fish field sampling, and the impact of rototilling against Eurasian watermilfoil \(*Myriophyllum spicatum*\)](#). Report. University of British Columbia – Okanagan, Kelowna, BC.
- Mageroy, J. 2016. Rocky Mountain ridged mussel (*Gonidea angulata*) in the Okanagan Valley, B.C.: Final report on potential threats from limited fish host availability, introduced fish species, and river restoration, and mitigation of direct damage from the public. Report. University of British Columbia – Okanagan, Kelowna, BC. [unpublished]
- Mageroy, J. H., Snook, R. M., Nield, L. M., and Walker, I. R. 2017. Impact of Control Methods for Eurasian Watermilfoil (*Myriophyllum spicatum*, L.) on Western Ridged Mussel (*Gonidea angulata*, Lea): Does Rotovation Harm the Mussel? Northwest Science 91(2): 186-197.
- Mock, K. E., Walton, J. A., Brownlee, S. F., Mageroy, J. H., Wilson, G., and Walker, I. R. 2020. [Genetic variation at the species and population levels in the Rocky Mountain ridged mussel \(*Gonidea anqulata*\)](#). *bioRxiv*. 11.16.385195. doi: 10.1101/2020.11.16.385195
- Nield, L. pers. comm. 2022. Email correspondence with A. Baylis. June 2022. British Columbia Ministry of Land, Water and Resource Stewardship.
- Rivard-Sirois, C. 2020. 2019 Pre-treatment Aquatic Monitoring of the Okanagan River Restoration Initiative (ORRI) VDS Section in Okanagan Falls. Prepared by Okanagan Nation Alliance Fisheries Department. Westbank, BC. [unpublished]
- Rivard-Sirois, C. 2021. Year 2: Planning of the Okanagan River Restoration Initiative (ORRI) VDS Section in Okanagan Falls. Prepared by Okanagan Nation Alliance Fisheries Department. Westbank, BC. [unpublished]

- Snook, R. M. 2015. Modeling habitat suitability for the Rocky Mountain ridged mussel (*Gonidea angulata*), in Okanagan Lake, British Columbia, Canada (Doctoral dissertation, University of British Columbia).
- Snook, R. M. 2018. Information in support of the identification of critical habitat for the Rocky Mountain Ridged Mussel (*Gonidea angulata*). DFO Can. Sci. Advis. Sec. Res. Doc. 2018/040. viii + 56 p.
- Tamburello, N. and Litt, A. 2021. [A Systematic Assessment of Invasive Species Impacts to Species at Risk in British Columbia](#). Report prepared for the Invasive Species Council of BC (ISCBC). 25 pp + Appendices.
- Wade, J., Stephen, C., and Robertson, C. 2020. Mapping Rocky Mountain ridged mussel beds with preliminary identification of overlapping Eurasian watermilfoil within the Canadian range. *Nature Conservation* 42: 19-31.