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Report on the Progress of Management Plan Implementation for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in Canada for the Period 2011- 2016

Rocky Mountain Ridged Mussel

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Canada

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under Section 72 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent ministers are responsible for reporting on the implementation of the Management Plan for a species at risk, and on the progress towards meeting its goal and objectives within five years of the date when the Management Plan was placed on the Species at Risk Public Registry and in every subsequent five-year period, until its goal and objectives have been achieved or the status of the species changes to threatened or endangered under SARA.

Reporting on the progress of management plan implementation requires reporting on the collective efforts of the competent minister(s), provincial and territorial governments and all other parties involved in conducting activities that contribute to the species' conservation. Management plans set goals and objectives for maintaining sustainable population levels of one or more species that are particularly sensitive to environmental factors, but which are not in danger of becoming extinct. Some of the identified conservation measures 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 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 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 Lily Stanton with input from Fisheries and Oceans Canada, and British Columbia's Ministry of Forests, Lands and Natural Resource Operations. The Department of Fisheries and Oceans would also like to express its appreciations 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 a species of Special Concern under the *Species at Risk Act* (SARA) in 2005. The *Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in British Columbia* (DFO 2011) was finalized and published on the Species at Risk Public Registry in 2011.

The main threats identified for the Rocky Mountain Ridged Mussel include: foreshore/riparian development; historic riverbed channelization; hydrograph modification and regulation; 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 B.C.".

The management objectives for the Rocky Mountain Ridged Mussel are as follows:

1. By 2015, address knowledge gaps about 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 a 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 and;
4. As research and inventory results on the Rocky Mountain Ridged Mussel become available, incorporate into land-use planning to inform future threat mitigation and land-use protection.

This report documents the progress of Management Plan implementation for the Rocky Mountain Ridged Mussel in Canada for the period 2011-2016. It summarizes progress made towards achieving the goal and objectives set out in the Management Plan, including:

- addressing knowledge gaps about life history;
- distribution and range, focusing primarily within the Okanagan region, including: considerable inventory of potential littoral habitat, increasing the area of occupancy and the number of known sites of Rocky Mountain Ridged Mussel;
- addressing knowledge gaps on threats such as host fish availability, invasive fish species introductions, river restoration project impacts, and rototilling Eurasian Millfoil;
- increased stewardship activities through the development of interpretive signage, the production of posters, and increased public awareness of the Rocky Mountain Ridged Mussel; and,
- incorporation of known locations of Rocky Mountain Ridged Mussel into land-use planning continues to inform future threat mitigation and land-use protection.

While there has been progress towards meeting the management goal and objectives presented in the Management Plan, continued monitoring, further clarification of threats and knowledge gaps, and increased scientific understanding will be necessary.

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1. Introduction

This Progress Report outlines the progress made towards meeting the goal and objectives listed in the *Management Plan for the Rocky Mountain Ridged Mussel (*Gonidea angulata*) in British Columbia* (Management Plan, DFO 2011) from 2011 to 2016, and should be considered as one in a series of documents for this species that are linked and should be taken into consideration together; including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Assessment Summary and Status Reports (COSEWIC 2003, 2010), and the Recovery Potential Assessment (Lauzier and Stanton 2012).

Section 2 of this document reproduces or summarizes key information on the threats to the species, the management goal and objectives, approaches to meeting the objectives, and performance measures to assess and determine the progress towards meeting the goal and objectives. For more details, readers should refer to the Management Plan.

Section 3 of this document reports on the progress of activities identified in the Management Plan to support achieving the goal and objectives, and Section 4 summarizes the progress toward achieving the management goal and objectives.

2. Background

2.1 COSEWIC Assessment Summary

The listing of the Rocky Mountain Ridged Mussel in 2005, which led to the development and publication of the Management Plan in 2011, was based on the information provided in the COSEWIC Status Report (COSEWIC 2003; COSEWIC assessment information is also included in Section 1.1 of the Management Plan). In 2010, COSEWIC re-examined and changed the status of the Rocky Mountain Ridged Mussel from Special Concern to Endangered in an updated COSEWIC Status Report (COSEWIC 2010).

Assessment Summary - November 2003

Common name
Rocky Mountain Ridged Mussel

Scientific name
Gonidea angulata

Status
Special Concern

Reason for Designation
The distribution of this species is limited to southern British Columbia in the Okanagan and Kootenay River systems. This species has likely been impacted by the damming of the Kootenay, Columbia and Okanagan Rivers and the channelization of the Okanagan River and resulted in loss of alteration of the mussel's habitat quality and extent.

Occurrence
British Columbia

Status history
Designated Special Concern in November 2003. Assessment based on a new status report.

Assessment Summary - November 2010

Common name
Rocky Mountain Ridged Mussel

Scientific name
Gonidea angulata

Status
Endangered

Reason for Designation
This mussel, one 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 November 2003. Status re-examined and designated Endangered in November 2010.

2.2 Threats

This section summarizes the information found in Section 1.5 of the Management Plan on threats to the Rocky Mountain Ridged Mussel.

2.2.1 Threats to the Rocky Mountain Ridged Mussel

Table 1. Summary of the threats identified for the Rocky Mountain Ridged Mussel, excerpted from the Management Plan.

Threat	Level of Concern[1]	Description
Foreshore/riparian development	High	Loss of natural shoreline habitat from municipal, agricultural, forestry, and industrial land-use resulting in fragmented aquatic habitat.
Historic riverbed channelization	High	Altered river morphology and river hydraulic characteristics. Loss habitat features such as riffles, pools and eddies and 85% of riparian vegetation increases water velocities, substrate instability, and water temperatures.
Hydrograph modification and regulation	Medium	Creation of dams and weirs altered flow and water level regimes desynchronizing host/parasite interactions, increased scouring downstream of dams and risk of stranding and/or desiccation in shallow littoral habitats.
Aquatic introduced species	Medium	Non-native fish species compete with and may prey upon native host fish species. Eurasian Water Milfoil transforms habitat characteristics, changes fish distribution and its removal by rototilling may pose a direct threat. Zebra and Quagga Mussel and Asian Clam, if introduced, could have detrimental impacts to native mussels.
Host species availability	Low	Loss of potential fish hosts through harvest, competition from introduced fish and/or extirpation due to changes in habitat from hydrograph modification, channelization and development.
Watershed land-use related pollution	Low	Nutrient, sediment loading, and toxins such as ammonia and endocrine disruptors associated with agricultural and urban run-off from fertilizers, pesticides, antifouling agents, pharmaceuticals, and detergents causes reduced growth rate, respiration and metabolism, tissue deterioration and death.
Disturbance or direct harm	Low	Removal from habitat, damage or injury to individual mussels.
Climate change	Low	Change in water temperature, littoral zone vegetation and stream hydrograph patterns may impact reproductive success and timing of life history events.

2.3 Conservation

This section summarizes the management goal and objectives (found in the Management Plan) necessary for the conservation of the Rocky Mountain Ridged Mussel, and associated performance measures that define and measure progress towards their achievement.

[1] Level of Concern indicates whether managing the threat is an overall high, medium, or low level of concern for conservation of the species, taking into account the stress, extent, occurrence, frequency, casual certainty, and severity of the specific threat. The full threats classification table can be found in Section 1.5 of the Management Plan.

2.3.1 Management Goal and Objectives

Section 2 of the Management Plan identified the following management goal necessary for the conservation of the species: “to maintain viable, self-sustaining, ecologically functioning and broadly distributed populations within suitable habitats at the species’ current distribution and range in B.C.”

Section 2 of the Management Plan also identified the following management objectives:

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 increased number of stewardship activities initiated and completed for land managers and public users of habitat occupied by the Rocky Mountain Ridged Mussel.

4. As research and inventory results on the Rocky Mountain Ridged Mussel become available, incorporate into land-use planning to inform future threat mitigation and land-use protection.

2.3.2 Performance Measures

A qualitative review[2] of achievements associated with broad strategies, and the management goal and objectives for the Rocky Mountain Ridged Mussel is detailed in Section 3.2.1 of this document.

3. Progress towards Conservation

The Management Plan divides conservation efforts into six broad strategies: 1) Protection; 2) Management; 3) Research; 4) Monitoring and Assessment; 5) Outreach and Communication; and 6) Restoration. Progress in carrying out these broad strategies is reported in Section 3.1 of this document. Section 3.2 reports on the progress towards meeting the broad strategies.

[2] The Management Plan states that specific performance measures have not been devised; however, it includes questions to guide the measurement of progress. These questions are referred to herein as “interim performance measures”.

3.1 Activities Supporting Conservation

Table 2 provides information on the activities undertaken to address the approaches[3] and broad strategies identified in the Management Plan.

Table 2. Details of activities supporting the conservation of the Rocky Mountain Ridged Mussel from 2011 to 2016.

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
Broad Strategy: Protection				
1	Apply and monitor existing legislation, guidelines and best management practises.	3	• FLNRO[4] evaluates guidelines and best management practices to ensure recovery actions by the ORRI[5] reflect and consider species at risk and that Rocky Mountain Ridged Mussel habitat is protected through the Okanagan Large Lakes Protocol. • Columbia Environmental, on behalf of the FLNRO, provided a review and analysis of Rocky Mountain Ridged Mussel relocation and the FLNRO monitored populations to assess its effectiveness (Columbia Environmental 2013, Nield pers. comm. 2016). • In 2016, the FLNRO evaluated survey methodologies completed by qualified professionals to determine if current practises are adequate for detection (Nield pers. comm. 2016). • BC MOE[6] analyzed compliance with the BC *Water Act* at foreshore development sites in the Okanagan (COSEWIC 2010).	FLNRO; MOE ; ORRI
Broad Strategy: Management				
2	Integrate Rocky Mountain Ridged Mussel into federal, provincial, regional, municipal planning documents and guidelines.	4	• Rocky Mountain Ridged Mussels have been incorporated into a number of federal, provincial, regional and municipal planning documents and guidelines including: ○ The Okanagan Fish Water Management tool (Hyatt 2004); ○ Okanagan Region Large Lakes Foreshore Protocol (MOE 2009); ○ The Okanagan Water Board's Eurasian Water Milfoil rototilling treatment plan (Dunbar 2009);	DFO[7]; FLNRO; MOE

[3] Referred to as "Actions" in the Management Plan. For consistency with other Progress Reports, they are referred to herein as "Approaches."
[4] British Columbia's Ministry of Forests, Lands, and Natural Resource Operations.
[5] Okanagan River Restoration Initiative.
[6] British Columbia's Ministry of Environment.
[7] Fisheries and Oceans Canada.

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
			○ The Rocky Mountain Ridged Mussel Stewardship Agreement with the City of Penticton (FLNRO 2015a). ○ The Rocky Mountain Ridged Mussel Stewardship Agreement with the District of Summerland (FLNRO 2015b), ○ The Rocky Mountain Ridged Mussel Stewardship Agreement with Flood Protection Staff within FLNRO for along the Okanagan River (Nield pers.comm. 2016).	
Broad Strategy: Research				
3	Draft an inventory schedule for watersheds with unconfirmed records of Rocky Mountain Ridged Mussel (Kootenay, Columbia, Similkameen and southern Vancouver Island).	1	• No additional surveys have been completed in the Kootenay, Columbia, Similkameen watersheds or Southern Vancouver Island since 2009.	None
4	Create a list of knowledge gaps, resources needed to address gaps; and partners for implementing research that fills knowledge gaps.	1	• FLNRO and the BC Rocky Mountain Ridged Mussel Working Group created a list of knowledge gaps, which is updated annually (Nield pers.comm. 2016). • Lauzier and Stanton's Recovery Potential Assessment (2012) identified knowledge gaps and a list of suggested research activities to address knowledge gaps. • Stanton et al. (2012) conducted preliminary studies into the timing of glochidial release and potential fish hosts within Okanagan Lake. • Collaborations between UBCO[8] and FLNRO facilitated research and addressed several knowledge gaps including: ○ clarification of a number of threats (host fish availability, introduced fish species, river restoration projects, Eurasian Milfoil rototilling) (Mageroy 2015a; Mageroy 2015b); ○ habitat preferences (Snook 2015); ○ juvenile recruitment (Mageroy 2015b); ○ probable primary fish hosts (Mageroy 2015b); and,	DFO; MOE; UBCO; FLNRO

[8] University of British Columbia, Okanagan Campus

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
			○ periods of encystment (Mageroy 2015b).	
5	Build relationships with academic institutions, and raise awareness regarding research opportunities.	1	• FLNRO, MOE and UBCO collaborated on a graduate research project (Snook 2015) to increase understanding of the basic biology and define distribution and habitat requirements of the Rocky Mountain Ridged Mussel. • A post-doctoral research fellow with UBCO (Mageroy 2015a; 2015b) investigated: juvenile recruitment; the impact of milfoil harvesting; potential fish hosts; the impact of limited fish host availability; the impact of introduced fish species; and the impact of river restoration initiatives.	FLNRO; MOE; UBCO; DFO
6	Build international relationships, particularly with U.S. biologists and resources professionals working on the Rocky Mountain Ridged Mussel and mollusc conservation.	1	• FLNRO presented a talk on management of Rocky Mountain Ridged Mussel remotely to an Ontario mussel research meeting in 2016 (Morris et al. 2016), and is actively involved in sharing initiatives and providing information to the Pacific Northwest Native Freshwater Mussel Workgroup (Nield pers. comm. 2016). • UBCO also presented the above paper at the Freshwater Mussel Symposium at Common Resources, Challenges, and Solutions, in Coeur d'Alene, Idaho, in 2016.	FLNRO; MOE; UBCO
Broad Strategy: Monitoring and Assessment				
7	Updating inventory guidelines for freshwater molluscs (e.g. FDIS[9] guidelines) and BC CDC[10] reporting guidelines.	1	• Guidance for Freshwater Mussels in the Okanagan (FLNRO 2017) follow 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). • FLNRO produced a draft guidance document outlining survey methodology, mitigation, relocation methods, relocation monitoring, and data collection for freshwater mussels in the Okanagan, including the Rocky Mountain Ridged Mussel (FLNRO 2017).	FLNRO; MOE; BC CDC
8	Complete Geographic Information Systems mapping exercise that	2	• Snook (2015) constructed a habitat suitability model utilizing Geographic Information Systems identifying potential relocation sites, sites of high importance, and the prospective distribution of	UBCO; FLNRO; MOE

[9] B.C.'s Field Data Information System.
[10] British Columbia Conservation Data Centre

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
	defines potential habitat for the Rocky Mountain Ridged Mussel in the Okanagan watershed.		Rocky Mountain Ridged Mussel within the Okanagan watershed.	
9	Draft an inventory and monitoring schedule for the Okanagan watershed (e.g. using bathymetric maps, aerial photos, etc.).	2	• FLNRO establishes annual priorities for monitoring and surveying of the Rocky Mountain Ridged Mussel using Snook's (2015) expanded habitat model.	FLNRO
10	Refine standardized protocol for mollusc inventory, habitat and threat information collection.	2	• Stanton et al. (2012) refined and tested protocols for qualitative and quantitative surveys for the Rocky Mountain Ridged Mussel. • Continued surveys adopt a similar approach to document presence and define the current distribution of the Rocky Mountain Ridged Mussel (Smith 2006; Mackie et al. 2008; Stanton et al. 2012; FLNRO 2017). • Stanton et al. (2012), Mageroy (2015a; 2015b), and Snook (2015) collected and documented inventory, habitat, and threat information; Mageroy's methodology could be applied at other locations.	DFO; MOE; FLNRO; UBCO
11	Implement inventory and monitoring protocols throughout the Okanagan watershed.	2	• Stanton et al. (2012) reported on inventory and initial population assessments completed between 2008 and 2011. • Stanton et al. (2012) completed quantitative surveys in 2011 examining the density and distribution at various depths along the littoral zone of Okanagan Lake at Dog Beach and Kinsmen Beach in Summerland. • DFO conducted repeated density by depth monitoring surveys at seven sites on a one-time or annual basis from 2011-2016 (MacConnachie pers. comm. 2016). • ONA[11] (2016) conducted inventory, and monitoring activities for the Rocky Mountain Ridged Mussel throughout 2014-2016. • FLNRO and MOE conducted excavation surveys in 2012 to	DFO; UBCO; GOC[12]; FLNRO; ONA; GOC

[11] Okanagan Nation Alliance.
[12] Government of Canada via Habitat Stewardship Program and/or Aboriginal Funds for Species at Risk Program.

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
			determine Rocky Mountain Ridged Mussel depth in substrate (Nield pers. comm. 2016). • Snook (2015) and Mageroy (2015a) conducted inventory surveys in the Okanagan watershed, including Okanagan Lake, Skaha Lake, Vaseux Lake, Osyoos Lake and Okanagan River from 2012-2015.	
Broad Strategy: Outreach and Communication				
12	Continue to distribute information to dive shops, marinas, government (all levels) and resource professionals.	3	• Mageroy and Snook (2015) developed interpretive signage describing the status, basic biology, management needs, and distribution of the Rocky Mountain Ridged Mussel now erected at six locations within the Okanagan Valley as well as produced 1,000 interpretive posters distributed to schools and dive shops. • FLNRO produced and distributed waterproof identification cards for divers and fisheries staff (Nield pers. comm. 2016).	GOC; FLNRO; UBCO; DFO
13	Extend communication and distribution of the Large Lakes Protocol to public.	3	• The Okanagan Region Large Lakes Foreshore Protocol (2009). continues to assist federal, provincial, regional agencies, and the public during the planning of development activities and provides guidelines and a framework for management. • FLNRO provided field and GPS training in 2013 for qualified professionals undertaking mussel surveys in 2014 (Nield pers. comm. 2016). • Inventories and known distribution of species at risk, including the Rocky Mountain Ridged Mussel, are continuously updated and are reviewed annually by FLNRO.	FLNRO; MOE
14	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.	3	• Refer to Row 12 of Table 2.	Refer to Row 12 of Table 2
15	Modify and make	3	• The 2015-2019 Rocky Mountain Ridged Mussel Stewardship	FLNRO;

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
	accessible habitat best management practices to include Rocky Mountain Ridged Mussel habitats adjacent to private lakeshore residences and businesses.		Agreement (FLNRO 2015) aims to provide protection, effective planning, and stewardship activities to mitigate and remove potential threats to the species within the District of Summerland. • FLNRO actively uses the draft Guidance for Freshwater Mussels in the Okanagan (FLNRO 2016) together with the Okanagan Large Lakes Foreshore Protocol (2009) to guide habitat best management practices in the region (Nield pers. comm. 2016).	District of Summerland; MOE
16	Provide training or information materials to resource professionals working in or near Rocky Mountain Ridged Mussel habitats.	3	• FLNRO, in partnership with members from the BC CDC and MOE, created two fact sheets focusing on the Rocky Mountain Ridged Mussel and “Getting the Eye for Detection” of this species in BC (MOE 2016a; 2016b), including information on their range, life history, habitat, anatomy, identification tips, best times for surveying and general conservation guidance. • FLNRO provided information and identification training as well as a field training course in 2013 to contract biologists studying Rocky Mountain Ridged Mussels (Nield pers. comm. 2016).	FLNRO; MOE; BC CDC
17	Develop and initiate a comprehensive reporting system for sightings in conjunction with fishing licenses and recreational sport fishery programs in the Okanagan River watershed.	3	• A comprehensive reporting system for sightings of Rocky Mountain Ridged Mussels has not been completed; however pertinent sighting information is communicated among FLNRO staff on an annual basis (Nield pers. comm. 2016). • Okanagan Basin Water Board operators report freshwater mussel sightings to the Senior Ecosystems Biologist with the FLNRO.	FLNRO
18	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	3	• To date, this work has not been completed.	None

#	Approaches	Management Objective(s) Addressed	Description and Results	Participants
	habitat).			
19	Work with local stewardship groups to develop infrastructure, best management practises guidelines and explore other approaches that limit agricultural and private property wastewater runoff.	3	• To date, this work has not been completed.	None.
Broad Strategy: Restoration				
20	Consider Rocky Mountain Ridged Mussels in watershed scale restoration projects.	1,3	• ORRI, focusing on restoring salmon habitat by naturalizing channelized sections of the river, has the potential to benefit local riparian and aquatic species including the Rocky Mountain Ridged Mussel and their fish hosts. • Work completed by Mageroy (2015a) on the impact of river restoration projects in the Okanagan River, has been communicated to fisheries staff and FLNRO are now actively involved, providing input towards future restoration initiatives to include the Rocky Mountain Ridged Mussel (Nield pers.comm. 2016).	ORRI; ONA; DFO; FLNRO; HCTF[13]

[13] Habitat Conservation Trust Fund.

3.2 Summary of Progress towards Conservation

3.2.1 Status of Performance Measures

As the Management Plan did not indicate performance measures, the following is a qualitative review of the progress made towards the management objectives for the Rocky Mountain Ridged Mussel, including descriptions of remaining work required.

Objective 1. Have knowledge gaps about life history, provincial range, and threats to the Rocky Mountain Ridged Mussels been addressed?

Progress has been made towards addressing some knowledge gaps in life history, provincial range, and threats to the Rocky Mountain Ridged Mussel. Stanton et al. (2012) conducted preliminary life history studies documenting the timing of glochidial (larval) release, seasonal mussel movement, and correlative information on potential fish hosts. Mageroy (2015b) completed further life history studies by documenting juvenile recruitment and additional host fish field sampling, including prevalence (% of fish with glochidial) and intensity (# of glochidial per fish), in addition to further clarify the period of glochidial release and encystment (attachment to the fish host). Sculpin have been observed, potentially among several other fish, as hosts of the Rocky Mountain Ridged Mussel; however, the required abundance and other host fish species necessary remain unknown (Mageroy 2015b, DFO In prep.). DFO (In prep.) outlines remaining knowledge gaps on Rocky Mountain Ridged Mussel life history and its ecological interactions, including: length of brooding period; habitat ranges or limitations associated with sedimentation and interstitial oxygen requirements; water flow requirements; juvenile recruitment associated with host species; and, the role of riparian habitat and habitat preferences.

Extensive surveys and collaborative effort contributed to a greater understanding of provincial range, particularly within the Okanagan Basin. DFO, MOE, and FLNRO conducted exploratory surveys from 2008-2011 (Stanton et al. 2012). Snook (2015) completed surveys throughout the Okanagan Basin in conjunction with habitat modelling of Rocky Mountain Ridged Mussels in Okanagan Lake. Surveys conducted in Okanagan Lake, Skaha Lake, Vaseux Lake, Osoyoos Lake, Park Rill Creek, and Okanagan River throughout 2012-2015 also contributed to establishing the current provincial range of this species within the Okanagan (Mageroy 2015a, 2015b, Mageroy and Snook 2015, Snook 2015).

Several studies evaluated threats and provided preliminary information on the impacts to the Rocky Mountain Ridged Mussel. A density at depth survey completed in 2011, determined the proportion of Rocky Mountain Ridged Mussels in the shallow littoral zone of Okanagan Lake that may be at increased risk of mortality from physiological disturbances, such as desiccation (Stanton et al. 2012). Mageroy also investigated potential threats from limited fish host availability, introduced fish species, and river restoration projects in 2015.

A large number of threats identified in the Management Plan still require further clarification (MacConnachie pers. comm. 2016). The impact of foreshore, riparian and littoral zone development, historic riverbed channelization, hydrograph modification and regulation, aquatic introduced species, land-use related pollution in the watershed, disturbance or direct harm, and climate change all warrant more detailed research into their current and historic effects on Rocky Mountain Ridged Mussel populations. Additional knowledge gaps on basic biology and

life history characteristics include: growth and reproductive capability; food requirements and preferences; identification and effects of parasites; and, clarification of threats and limiting factors.

Objective 2. 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?

Progress has been made towards surveying potential littoral habitat within the Okanagan River Watershed using refined protocols; however, the goal of surveying 75% of littoral habitat has not yet been achieved. It is difficult to determine what percentage of littoral habitat has actually been surveyed. Prior to 2011, approximately 30-60 km of the shoreline or linear distance of the Okanagan River Watershed had been searched. Since 2011, a large number of additional sites have been surveyed throughout the Okanagan. Snook (2015) surveyed over 16% of Okanagan Lake in conjunction with developing a habitat suitability model for the Rocky Mountain Ridged Mussel. Snook (2014) also surveyed additional sites in the Okanagan River, Skaha Lake, Vaseux Lake, and Osoyoos Lake in 2013. Mageroy (2015a) completed a considerable amount of search effort from 2013-2015, focusing primarily on the Okanagan River and its tributaries. Although not considered littoral habitat, the ONA (2016) completed deep water surveys in Okanagan Lake in 2011 and 2014, and in Skaha Lake in 2014, finding Rocky Mountain Ridged Mussels distributed to ~5 m depth.

While no standardized protocols have been developed to gather habitat and threat information at surveyed sites, the FLNRO (2016) established draft guidance for freshwater mussels in the Okanagan. This document, currently in use by FLNRO, provides detailed protocols outlining appropriate survey, mitigation, and relocation methods, instructions for data collation, and relocation monitoring (Nield pers. comm. 2016).

Objective 3. 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?

Stewardship activities for public users of habitat occupied by the Rocky Mountain Ridged Mussel have increased. Specifically, Snook and Mageroy (2015a) produced and developed interpretive signage highlighting the biology and conservation needs of the Rocky Mountain Ridged Mussel. Signs are located in six high density Rocky Mountain Ridged Mussel sites to inform public users and mitigate negative impacts to the mussels. In addition, Mageroy (2015a) distributed 1,000 interpretive posters to local dive shops, schools, and marinas and conducted an interview based survey to evaluate the impact interpretive signage had on public perception and knowledge of the Rocky Mountain Ridged Mussel in the area.

The ONA's ORRI restored channelized sections of the Okanagan River to a more natural state for enhancing salmon habitat, with potential to impact aquatic species including the Rocky Mountain Ridged Mussel. The FLNRO, factoring in work completed by Mageroy (2015a), is working with the ORRI restoration teams towards including the Rocky Mountain Ridged Mussel in future restorations initiatives.

Currently, no stewardship activities have specifically targeted land managers. Once finalized and made available to the public and qualified professionals undertaking Rocky Mountain Ridged Mussel surveys, a document on guidance for freshwater mussels in the Okanagan (FLNRO 2016) should aid in mitigating the effects of riparian and littoral development. Further,

since COSEWIC (2010) reported low compliance at development sites on Okanagan Lake and Skaha Lake, increasing development pressures underscore the need for continued compliance promotion and enforcement of existing legislation in order to alleviate threats to Rocky Mountain Ridged Mussel habitat (Lauzier and Stanton 2012).

Objective 4. 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?

In order to avoid reducing water levels to an extent which would affect Rocky Mountain Ridged Mussels occupying the shallow littoral zone within Okanagan Lake, water managers now consider density surveys as per the Fish and Water Management Tool (MacConnachie pers. comm. 2016). All Rocky Mountain Ridged Mussel research and inventory results including new areas of occupancy identified by Mageroy (2015a) and Snook (2015) are incorporated into the Okanagan Large Lakes Foreshore Protocol (2009) which is updated annually to improve upon management and assist land-use planning for development activities.

The Okanagan Water Board's Eurasian Water Milfoil rototilling treatment plan incorporates known mussel locations to specifically avoid rototilling in those areas (Dunbar 2009). In addition, The Rocky Mountain Ridged Mussel Stewardship Agreement between the FLNRO and the District of Summerland, once officially approved, will address threats, provide protection and avoid impacts to Rocky Mountain Ridged Mussel habitat along lakeshore properties in Summerland (FLNRO 2015). This is of particular importance as a significantly large proportion of Rocky Mountain Ridged Mussels populations inhabit the littoral zone within Summerland.

Updated management guidelines for the Rocky Mountain Ridged Mussel taking into consideration all results from the projects funded by the Government of Canada's Habitat Stewardship Program and conducted by Mageroy (2015a, 2015b) have been developed, and are currently being used by FLNRO (FLNRO 2016, Nield pers. comm. 2016). Guidance for Freshwater Mussels in the Okanagan (FLNRO 2017) is anticipated to provide further threat mitigation and land-use protection for the Rocky Mountain Ridged Mussel and its habitat.

Overall Goal. Has Rocky Mountain Ridged Mussel maintained viable, self-sustaining, ecologically functioning and broadly distributed populations within suitable habitats at the species' current distribution and range in B.C?

Further work will be required to fully achieve the Rocky Mountain Ridged Mussel management goal. Continued monitoring of populations within Okanagan Lake indicates the species appear to be stable or possibly declining; however, within other lakes within the Okanagan Basin, they appear to be in significant decline or could be considered remnant populations (MacConnachie pers.com. 2016). However, Mageroy (2015a; 2015b) and Snook's (2015) investigations have increased the area of known occupancy to include sections of the Okanagan River, and juvenile recruitment studies indicate that recruitment is sufficient to maintain populations numbers in certain areas, although not in all areas where Rocky Mountain Ridged Mussels are found.

COSEWIC's (2010) re-assessment of the Rocky Mountain Ridged Mussel as an Endangered species states that historic channelization together with water regulation in the Okanagan River has caused population reduction. It further states that the potential introduction of Zebra and Quagga (dreissenid) mussel into the region poses the most serious threat to the species. Additionally, COSEWIC (2010) cited ongoing foreshore and riparian development as reducing habitat and affecting water quality. In order to achieve the species management goal, research

addressing these and other threats require formal clarification, and specific mitigation measures addressing the potential threat of aquatic invasive species are required.

4. Concluding Statement

Through the implementation of conservation actions, progress has been made towards achieving the management goal and objectives outlined in the Management Plan for the Rocky Mountain Ridged Mussel. Several knowledge gaps regarding life history, provincial range, and threats have been examined and have increased our general knowledge and understanding of the biological needs, distribution and habitat requirements of the Rocky Mountain Ridged Mussel within the Okanagan Basin. Lessons learned from these studies have been incorporated into interpretive signage and stewardship activities. Significant progress has been achieved in incorporating inventory results of the Rocky Mountain Ridged Mussel into land-use planning to inform future threat mitigation and land-use protection. Habitat suitability models created for the Rocky Mountain Ridged Mussels enable biologists and managers to develop priority areas for surveying, preferred areas for mussel relocation, and aid in mitigating threats of developmental activities within suitable Rocky Mountain Ridged Mussel habitat.

Several tasks set out in the Management Plan objectives remain to be fully implemented within the Okanagan watershed, such as the Rocky Mountain Ridged Mussel Stewardship Agreement with the District of Summerland, and the Guidance for Freshwater Mussels in the Okanagan (FLNRO 2017). Standardized survey and handling protocols have yet to be refined. All information on relevant non-native species has yet to be collated. Guidance and compliance promotion materials are being finalized and will be distributed in the near future.

Despite progress towards meeting the management objectives identified in the Management Plan, the 2010 COSEWIC re-assessment of the Rocky Mountain Ridged Mussel resulted in it being reclassified as Endangered. However, the reclassification is primarily due to the potential severe impacts on the species from the serious and plausible threat of dreissenid mussels being introduced in the Okanagan basin. This new COSEWIC status suggests that further efforts will be necessary to meet the management goal of maintaining viable, self-sustaining, ecologically-functioning and broadly-distributed populations of Rocky Mountain Ridged Mussel in British Columbia. These efforts will build on the progress achieved to date and take into account an increased level of potential threat from dreissenid mussels, which may increase the scope of conservation activities.

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