

# Rocky Mountain Ridged Mussel (*Gonidea angulata*) Index Site Surveys in the Okanagan Basin, British Columbia, 2017-2020

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**ROCKY MOUNTAIN RIDGED MUSSEL (*Gonidea angulata*) INDEX SITE SURVEYS IN THE  
OKANAGAN BASIN, BRITISH COLUMBIA, 2017–2020**

by

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## ABSTRACT

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.

Rocky Mountain Ridged Mussel (*Gonidea angulata*) is one of only a few species of freshwater mussel in British Columbia, restricted in Canada to the Okanagan Basin. In 2005 this species was listed under the *Species at Risk Act* (SARA) as Special Concern, and in 2010 it was reassessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered. As a continuation of previous work and to inform future assessments and conservation efforts in the Okanagan Basin, nine index sites that were easily accessible and known to have *G. angulata* were selected to estimate abundance at these areas over time. Mean mussel densities across all index sites from 2017–2020 ranged from 0.06 to 1.49 mussels/m<sup>2</sup>. Estimates of total abundance ranged between 111 and 2,075 mussels. *G. angulata* are mobile animals and the extent to which they move daily or seasonally is unknown, thus population estimates are expected to fluctuate seasonally and annually to some degree. We recommend that these surveys be continued annually to provide ongoing estimates of abundance for future assessment work and to inform conservation efforts focused on the survival or recovery of this species.

## RÉSUMÉ

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.

Au Canada, la gonidée des Rocheuses (*Gonidea angulata*) est une des rares espèces de moule d'eau douce de la Colombie-Britannique, et elle est limitée au bassin de l'Okanagan. En 2005, cette espèce a été inscrite à la liste des espèces préoccupantes au titre de la *Loi sur les espèces en péril* et, en 2010, elle a été réévaluée par le Comité sur la situation des espèces en péril au Canada (COSEPAC) et inscrite en tant qu'espèce en péril. Dans la continuité des travaux entrepris et pour orienter les futures évaluations et mesures de conservation dans le bassin de l'Okanagan, des sites repères facilement accessibles et reconnus pour leur population de *G. angulata* ont été sélectionnés pour en estimer l'abondance au fil du temps. La densité moyenne de moules parmi tous les sites repères de 2017 à 2020 variait de 0,06 à 1,49 moule/m<sup>2</sup>. L'abondance totale était estimée à entre 111 et 2 075 moules. La *G. angulata* étant un animal mobile, l'étendue de ses déplacements quotidiens ou saisonniers est inconnue. Les estimations devraient donc, dans une certaine mesure, varier en fonction des saisons et des années. Nous recommandons de poursuivre ces relevés chaque année, pour pouvoir fournir en continu des estimations de l'abondance en prévision de futures évaluations et pour orienter les efforts de conservation axés sur la survie ou le rétablissement de cette espèce.

## INTRODUCTION

Rocky Mountain Ridged Mussel, *Gonidea angulata* (Lea, 1838), is a freshwater bivalve in the family Unionidae. It is morphologically and taxonomically unique as the only extant member of the genus *Gonidea* (Graf 2002). *G. angulata* is a large, trapezoidal-shaped mussel, with a shell up to 125 mm long, 65 mm high, 40 mm wide, and shell walls up to 5 mm thick (Clarke 1981). It has a sharp and prominent posterior ridge running from the umbo to the angular basal margin of each valve, hence the common name Rocky Mountain Ridged Mussel (Figure 1). The periostracum, or outer shell, is commonly yellowish brown to blackish brown with obvious concentric growth rests, and the nacre, or inner shell, is centrally white or salmon coloured but pale blue along the outer posterior margin (Clarke 1981). Its hinge teeth are irregular and poorly developed.

*G. angulata* reaches the northern limit of its global range in southern British Columbia (BC). In Canada, live *G. angulata* have only been observed within the Okanagan Basin (COSEWIC 2010; BC Conservation Data Centre 2020). Populations within the Okanagan Basin account for approximately 5% of the current global distribution (COSEWIC 2010). Throughout its North American range, this species is found within both lacustrine and riverine habitat, and within Canada, predominantly in lakes where soft substrate is present with a low slope (0–20%) (COSEWIC 2010; Snook 2018). Freshwater mussels also have a distinctive life cycle, which includes a parasitic larval stage (glochidia) that requires a fish host to complete their reproductive cycle (Neves et al. 1985). Therefore, host fish must also be available within potential suitable habitat (COSEWIC 2010; Snook 2018).

*G. angulata* was designated Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2003 (COSEWIC 2003). It was subsequently listed under the *Species at Risk Act* (SARA) in 2005. The status of *G. angulata* was re-assessed by COSEWIC as Endangered in 2010 largely due to the potential threat of introduced Zebra (*Dreissenia polymorpha*) and Quagga (*D. bugensis*) mussels, ongoing foreshore and riparian development, and the potential impact of some Eurasian Watermilfoil (*Myriophyllum spicatum*) control methods (COSEWIC 2010). The tendency of freshwater mussels to occupy shallow water may also make them susceptible to emersion (exposure to air) when water levels decline, thermal stress, and increased risk of predation (Vaugh and Taylor 1999; Burlakova and Karatayev 2007).

Very little quantitative information is available for population assessments for *G. angulata*. Stanton et al. (2012) documents much of the efforts undertaken up until 2011 to develop and apply qualitative and quantitative surveys to characterize the presence of *G. angulata* in BC and to estimate density and local abundances in the Okanagan watershed. As a continuation of 2011–2016 work (MacConnachie et al. 2021), index sites known to have measurable densities of *G. angulata* were visited from 2017 to 2020. Surveys at index site are intended to provide a relative index of abundance and trends over time, and not a population estimate for *G. angulata* in Canada. This document summarizes the findings of surveys undertaken over four years in the



Okanagan watershed with the goal of providing mean density and abundance estimates by site.

## METHODS

### INDEX SITES

Aggregations of *G. angulata* have been previously documented in Okanagan Lake, Okanagan River, Skaha Lake, Vaseux Lake, and Osoyoos Lake within the Okanagan Basin (COSEWIC 2010). For this study, sites known to have *G. angulata* present with easily accessible shorelines were selected as index sites including Dog Beach, Kinsmen Park, Three Mile Beach, Vaseux Lake, and Vernon (Figure 2; Table 1). A brief qualitative description of each site was provided in MacConnachie et al. (2021).

### SURVEY DESIGN

Surveys involved a two-person snorkel team to place transect lines and count mussels. An additional observer was located on shore to record data. First a baseline (surveyor's tape) was stretched out along the shoreline at the waters' edge, which ranged from 27 to 75 m depending on the index site. The start and end point of each baseline were recorded with a GPS. Transects perpendicular to the baseline were placed systematically every three metres along the baseline starting at 0 m. Transects varied in length but averaged approximately 30 m and were typically terminated when the substrates were no longer appropriate for surveying (e.g. a sudden drop off in depth, plant material obstructed the view, or an old dock or other large object limited access). Along each transect, a 1-metre ruler was used as a guide to measure width and constrain search effort, and running tallies of observed *G. angulata* were recorded using a hand held tally counter. When counting mussels, sediment sifting did not occur and individuals were not disturbed or removed from the substrate in order to limit physiological stress.

The survey design follows similar methods as MacConnachie et al. (2021) except depth measurements were not collected. Because of the high frequency of zero counts by quadrat, a total count of mussels along the transect was documented. This approach allowed for a similar population estimate to be calculated while decreasing the amount of time in the field.

Surveys were conducted during daylight hours (0900–1600) in late August from 2017 to 2019 and in mid-September in 2020 (Table 1).

## DATA ANALYSIS

As all transects were one metre wide, the total area of all transects combined determined the Area Surveyed at each index site for each year (Table 2). The Sample Area for each survey was estimated to be three times the area surveyed, as transects were placed systematically every three metres along the baseline (Table 2). Estimates of the Sample Area therefore represent the total potential area which could have been surveyed. Mean density was determined by averaging all transect densities (mussels per m<sup>2</sup>) in a site. Mean density and abundance estimates were computed using Data Analysis Tools in Microsoft Excel.

## RESULTS

The geographic positions of the index sites and the year(s) they were surveyed between 2017 and 2020 are provided in Table 1. Note that the reported GPS coordinates in Table 1 are approximations as the baseline shifted spatially each year due to fluctuating lake water levels.

For each index site, a summary of *G. angulata* count data, mean density, and abundance estimates by sample area are provided in Table 2.

Mean densities ranged from 0.06 ±0.05 mussels/m<sup>2</sup> at Dog Beach (index site DOG-1) in 2017 to 1.49 ±0.91 mussels/m<sup>2</sup> at Kinsmen Beach (index site KIN-2) in 2020 (Table 2). Abundance estimates for index sites ranged from 111 ±86 individuals at Dog Beach (index site DOG-1) in 2017 to 2,075 ±1,100 mussels at Three Mile Beach (index site TMB) in 2020 (Table 2).

## DISCUSSION

Rocky Mountain Ridged Mussel (*G. angulata*) which has been assessed as Endangered, is one of only a few species of freshwater mussel in BC, and is restricted to the Okanagan Basin in Canada. In this watershed *G. angulata* has been impacted by historical loss and degradation of habitat (COSEWIC 2010) and the survival or recovery of this species may continue to be jeopardized by current threats ranging from the potential impacts of Zebra (*Dreissenia polymorpha*) and Quagga (*D. bugensis*) mussels, ongoing foreshore and riparian development, and the potential impact of some Eurasian Watermilfoil control methods (DFO 2010). Although freshwater mussels play an important role in aquatic ecosystems as filter feeders, affecting nutrient dynamics and water chemistry, as components of food webs, and as indicators of freshwater ecosystem health (Grabarkiewicz and Davis 2008), a large number of knowledge gaps remain for *G. angulata* and other freshwater mussel species. Despite the risk of extinction *G. angulata* faces, very little quantitative information is available for population assessments. Therefore, it is imperative that surveys are conducted to

characterize the presence of *G. angulata* in BC, to estimate density at index sites in the Okanagan watershed and other investigations continue to elucidate its role in the ecosystem and the continued impacts of threats on this population (DFO 2010).

Abundance estimates of *G. angulata* across all index sites from 2017–2020 reflect a minimum number of mussels per index site. In this study only visible individuals were enumerated in order to limit physiological stress associated with sediment sifting or removing individuals from the substrate. *G. angulata* are mobile animals (COSEWIC 2010), and the extent to which they move daily or seasonally is unknown. The influence of variables, such as water temperature, substrate size and mussel size on mobility are also not fully understood. Therefore, estimates at sites are expected to fluctuate seasonally and annually to some degree. Regardless, estimates of density for 2017–2020 appeared to remain fairly stable at sites over time, with the exception of 2020, which appeared to have noticeable increases in abundance across all sites.

Estimates of mean density and abundance of *G. angulata* at each site for 2017–2020 appear lower than those reported in a similar study at the same sites for 2011–2016 (MacConnachie et al. 2021). Differences may not reflect population level changes, but may reflect a change in enumeration (i.e., in 2011–2016 quadrats were used and counts were conducted within each quadrat (MacConnachie et al. 2021), where as in 2017–2020, individuals were enumerated across the entire length of each transect).

#### Future Research Recommendations:

- Refining habitat requirements, linking distribution and survival to substrate type and availability.
- Further study to understand the spatial overlap and potential impact of some Eurasian Watermilfoil control methods.
- Further study related to comparing different methods for enumerating *G. angulata*.

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**Table 1. Geographic positions of index sites surveyed for *Gonidea angulata* in the Okanagan Basin, British Columbia, and survey dates from 2017 to 2020.**

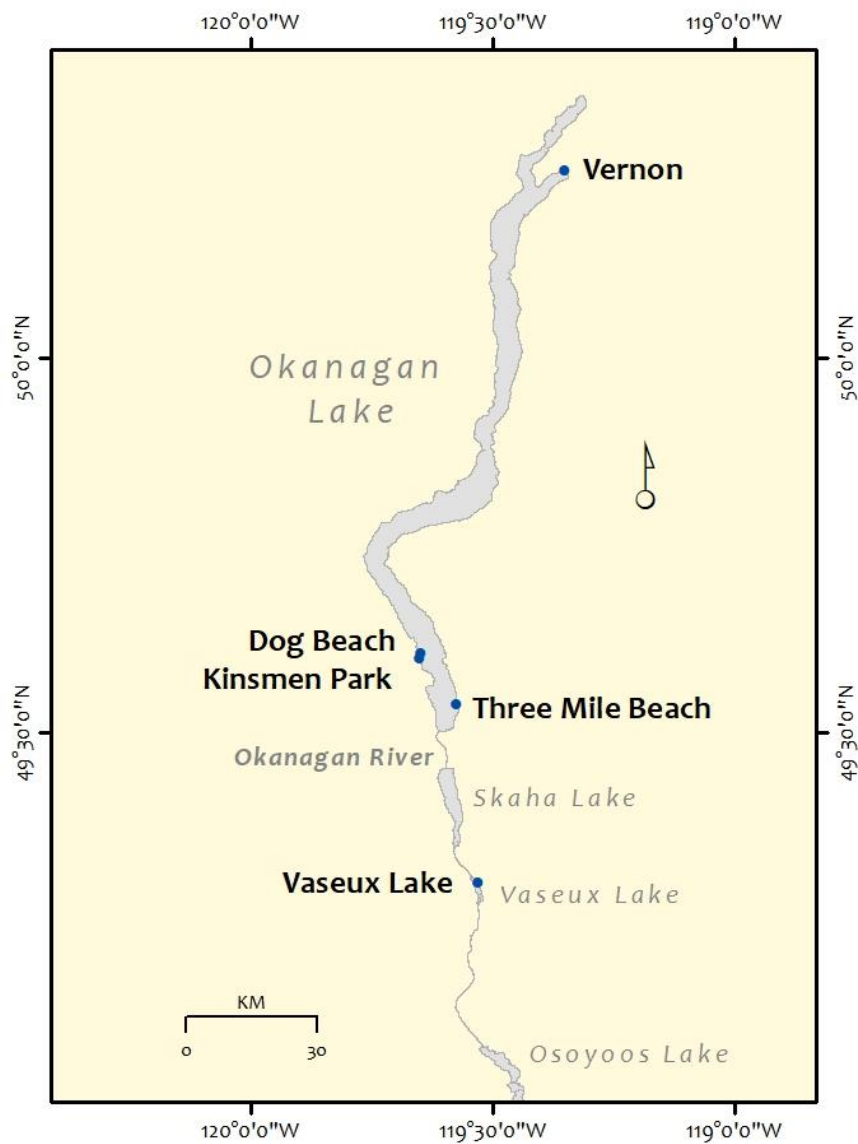
Site	Index Site	Start Latitude	Start Longitude	Survey Dates			
				August 28–31, 2017	August 21–23, 2018	August 11–16, 2019	September 12–15, 2020
Dog Beach	DOG-1	49.60709	-119.64971	X	X	X	X
	DOG-2	49.60758	-119.65009	X	X	X	X
Kinsmen Park	KIN-1	49.59900	-119.65080	X	X	X	X
	KIN-2	49.59945	-119.65099	X	X	X	X
Three Mile Beach	TMB	49.53777	-119.57670		X	X	X
	TMB-1	49.53754	-119.57650	X			
	TMB-2	49.53777	-119.57670	X			
Vaseux Lake	VAS	49.29765	-119.53076	X			
Vernon	VER	50.24958	-119.35226		X		

**Table 2. Summary of *Gonidea angulata* count data, mean density, and abundance estimates per sample for the year(s) that each index site was surveyed between 2017 and 2020.**

Index Site	Year	# Transects	Area Surveyed (m <sup>2</sup> )	Total Mussel Count	Mean Density		Sample Area (m <sup>2</sup> )	Abundance Estimate	
					Mussels/m2	SD		# Mussels	SD
DOG-1	2017	16	585	35	0.06	0.05	1,755	111	86
	2018	16	662	100	0.16	0.09	1,986	320	179
	2019	21	849	115	0.14	0.07	2,547	360	190
	2020	16	585	196	0.34	0.16	1,755	604	281
DOG-2	2017	16	660	55	0.08	0.06	1,980	165	116
	2018	17	553	52	0.09	0.06	1,659	156	98
	2019	18	595	50	0.08	0.07	1,785	149	127
	2020	18	665	175	0.26	0.30	1,995	528	597
KIN-1	2017	15	293	135	0.40	0.38	879	356	332
	2018	16	371	167	0.40	0.44	1,113	446	488
	2019	16	378	213	0.51	0.44	1,134	578	499
	2020	14	310	285	0.90	0.54	930	841	498
KIN-2	2017	10	220	277	1.28	0.63	660	842	418
	2018	15	350	292	0.84	0.66	1,050	881	690
	2019	18	401	167	0.45	0.50	1,203	540	602
	2020	14	387	556	1.49	0.91	1,161	1,728	1,061
TMB-1	2017	18	444	368	0.82	0.80	1,332	1,092	1,069
TMB-2	2017	9	378	76	0.20	0.13	1,134	231	152
TMB	2018	18	509	227	0.45	0.23	1,527	685	358
	2019	25	783	399	0.58	0.47	2,349	1,370	1,103
	2020	21	637	655	1.09	0.58	1,911	2,075	1,100
VAS	2017	16	500	41	0.08	0.12	1,500	121	184
VER	2018	16	320	92	0.29	0.40	960	276	381



**Figure 1. Image of an adult Rocky Mountain Ridged Mussel (*Gonidea angulata*) from Okanagan Lake observed in July 2009 at Dog Beach, Summerland, British Columbia. Photograph by L. Stanton.**



**Figure 2. Sites selected for yearly surveys of Rocky Mountain Ridged Mussels (*Gonidea angulata*) in the Okanagan Basin, British Columbia (2017–2020).**