

REPORT

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Prepared For: Technical Committee

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Subject: **Genetic analysis of *Lindavia intermedia*, the diatom that causes lake snow**

1. Précis

Landcare Research was commissioned by Otago Regional Council (ORC) to undertake genetic analyses to determine whether the diatom responsible for forming lake snow, *Lindavia intermedia*, is a recent arrival in New Zealand. These analyses compared samples from overseas lakes to samples collected from a number of New Zealand lakes using advanced genetic techniques. Samples from New Zealand lakes included material from Lakes Coleridge, Hawea, Wakatipu and Wanaka while samples were obtained from two lakes in North America: Lake Youngs in Washington State and Cultus Lake in British Columbia, and one lake in Europe – Lac Lemán on the border of Switzerland, France and Italy. Attempts to secure material from other localities were unsuccessful.

The genetic analysis involved the Landcare team identifying areas of high genetic variability in the chloroplast and nuclear material of *L. intermedia* and developing genetic primers¹ specifically to compare the genetic similarity between the different localities.

The key finding was that specimens from Lake Youngs (USA) and all New Zealand lakes were genetically and morphologically identical. This strongly suggests that *Lindavia intermedia* is not a New Zealand native species and that its most likely origin is North America.

If *Lindavia* was native to New Zealand, it would be expected to exhibit some genetic variability from lake to lake, due to genetic isolation and evolution of the populations in each of the lakes. For example, samples from Cultus Lake and Lake Youngs, both of which are in North America, exhibited some genetic differences in this analysis. If *Lindavia* was native to New Zealand, it would also be expected to be genetically distinct from Northern Hemisphere populations due to the long physical distance between these populations and the (presumably) restricted exchange of material between these populations that would prevent genetic divergence (separation) over time. It is also worth noting that there are no known populations of *Lindavia intermedia* in other Southern Hemisphere lakes.

¹ A primer is a short strand of RNA or DNA (generally about 18-22 bases) that serves as a starting point for DNA synthesis.

Taken together with the results of sediment coring in New Zealand lakes, the results of the genetic analyses undertaken by Landcare Research represent a strong circumstantial case for transfer of *Lindavia intermedia* to New Zealand from the Northern Hemisphere, particularly North America.

2. Where to from here?

During the workshop with experts late in 2016, a research plan was developed, prioritising research needed to inform and support management of lake snow. This plan has previously been presented to Council (2017/0705, 15 March 2017; Report number 2017/0802, 14 June 2017) and is attached to this report (Appendix A). The development of the plan occurred alongside an understanding that *Lindavia intermedia* was, in all likelihood, not a New Zealand native species. The research plan priorities are still relevant in light of the findings of the Landcare Research genetics work commissioned by ORC.

The Science team of ORC are working with Otago University and Landcare Research to progress scoping and delivery of the key research components (Components 1 ii); 1 iii); 2A i); 2B i); and 5) identified in Appendix A in line with the 2017/18 ORC Annual Plan. The Annual Plan makes financial provision for these key research components².

The identification of appropriate ways of managing lake snow in the Southern alpine lakes will require ORC to work collaboratively with Ministry of Primary Industries, Environment Canterbury and Environment Southland. That collaboration commenced with their participation in the experts' workshop convened by ORC in 2016. Arrangements are being made to start the next phase of that collaboration.

3. Recommendations

1. The report "*Lindavia intermedia*, the causative organism of New Zealand lake snow: relationships between New Zealand, North American and European populations according to molecular and morphological data" is received and noted.
2. The actions being taken by Otago Regional Council in response to the findings in that report are noted.
3. That Council will continue to work collaboratively with stakeholders and interested parties to develop feasible methods of managing the effects of lake snow on water quality

Gavin Palmer
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² The 2017/18 Annual Plan includes the target "*Continue to lead research into feasible methods of managing the effects of lake snow on water quality*".

Appendix A

Table 1. Research priority work streams, priority ranking, associated costs and justification. *The table below complements the summary table provided in the proceedings of the 20 December 2016 experts' workshop.*

Priority Ranking	Code
High - Immediate	High - Immediate
High - Medium term	High - Medium term
Medium - Medium term	Medium - Medium term

Work stream	Sub-program	Priority Ranking	Associated costs	Justification	Lead agency
1) Is <i>Lindavia intermedia</i> a native or non-native species? <i>Top priority area. Will influence the direction of other work streams</i>	i) Investigation of cell genetics (microsatellite analysis) of NZ and overseas <i>L. intermedia</i> populations	High - Immediate	<i>Currently funded by ORC. To be delivered by end of Jun 17.</i>	This work will indicate if <i>L. intermedia</i> has recently arrived in NZ and should be considered an invasive species.	ORC
	ii) Comprehensive examination of NZ diatom samples, collections, reports	High - Immediate	\$11K for detailed assessment of 3 separate catalogued collections Delivery 3 to 6 months.	To determine if previous ' <i>Cyclotella</i> ' identifications are in fact <i>Lindavia</i> . To help isolate the length of time the diatom has been present in NZ.	ORC
	iii) Historical dynamics of <i>L. intermedia</i> in NZ lakes from which it has been reported using paleolimnological diatom analysis of dated sediment cores.	High - Immediate	4 priority lakes in Otago \$56K. (\$14K per lake). Delivery 6 to 9 months for Otago's 4 priority lakes.	This work will allow a precise estimate of the time that <i>L. intermedia</i> has been present in NZ and will complement the microsatellite work currently being undertaken in (i) above.	ORC

			Estimated 10 lakes needed to be cored across Otago, Southland, Canterbury and Hawke's Bay		
2) What are the drivers of: (A) <i>L. intermedia</i> dominance in lakes and	2A i) Literature review of shifts in lake phytoplankton to increased dominance by (<i>Lindavia</i> -like) centric diatoms (e.g., climate connection)	High - Immediate	\$3K – if aligned with 2B i).	This would increase our understanding of shifts and drivers of phytoplankton community structure to one dominated by centric diatoms and provide extremely valuable information to the NZ context.	ORC
	2A ii) Are historical <i>L. intermedia</i> dynamics correlated to environmental drivers in our lakes?	Medium - Medium term	\$219K Delivery 3 years [Note: This work is covered in the University of Otago MBIE bid.]	As with 2B ii) this work-stream is extensive and likely best delivered through a University and a number of postgraduate and post-doctoral research programs.	Catchments Otago / Uni. Of Otago / CRIs / support from RC's
	2A iii) Are proliferations of <i>Didymo</i> and <i>L. intermedia</i> in South Island waters related to	Medium - Medium term	\$19K minimum Delivery difficult to estimate	If the timing and spread of these two incursions are coherent, then that would provide evidence	Catchments Otago / Uni. Of Otago / CRIs / support from RC's

	a common driver or species incursion?			of a common incursion (both place and time) and support management of future incursions and responses.	
2) What are the drivers of: (B) polysaccharide overproduction by <i>L. intermedia</i>?	2B i) Comprehensive literature review on diatom polysaccharide overproduction from similar situations overseas	High - Immediate	\$10K Delivery 3 to 6 months	Seen as a top priority and would increase our current understanding of TEP production and the lake snow phenomenon. A straightforward exercise that hasn't been undertaken to date.	ORC
	2c) Study of the relationships between diatom polysaccharide overproduction and (1) nutrient availability, (2) climate warming, and (3) grazing pressure.	High - Medium term	Year 1: \$204K Year 2: \$211K Year 3: \$198K Delivery 3 years [Note: This work is covered in the University of Otago MBIE bid.]	As with 2A ii) this work-stream is extensive and likely best delivered through a University and a number of postgraduate and post-doctoral research programs.	Catchments Otago / Uni. Of Otago / CRIs / support from RC's
3) Can we develop technologies for effective sampling and monitoring of	i) The development of new sensor technology to monitor in situ polysaccharide concentrations in	High - Medium term	\$300K per year for three years - Part of an MBIE Smart Ideas bid – decision on	Capacity to monitor the abundance and spatial variability of lake snow is critical to	Landcare Research / Uni. Of Otago / Support from ORC

<i>L. intermedia</i> and lake snow?	lakes.		success due Sept 2017.	understanding the environmental drivers that lead to lake snow production. At present these techniques do not exist.	
	ii) The development of cost-effective and efficient methods for quantitatively sampling lake snow in lakes (at different depths).	High - Medium term			Landcare Research / Uni. Of Otago / Support from ORC
	iii) Can DNA methods be developed for the sensitive detection of <i>L. intermedia</i> in lakes?	Medium - Medium term			Landcare Research / Cawthron / support from RC's
4) How might the spread of <i>L. intermedia</i> between lakes be stopped or slowed?	i) Are the BNZ Didymo sanitation methods adequate for the disinfection of <i>L. intermedia</i> ?	High - Immediate	Currently contracted by MPI who have engaged NIWA to review the effectiveness of Check – Clean – Dry on <i>Lindavia</i>	MPI are reviewing their Check/Clean/Dry campaign and how effective it is for other pest species.	MPI / NIWA
5) Supporting citizen science		High - Medium term	\$10K	Links to 3.	ORC