DEOXYGENATION IMPACTS OF LAKE WEED

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Dr Max Gibbs is a water quality scientist who has worked for NIWA and predecessors for 52 years. He has spent the last 44 years studying lakes and estuaries around New Zealand, and has been a member of the Bay of Plenty Regional Council Water Quality Technical Advisory Group (TAG) since it was formed in the 1980s. Max was instrumental in identifying the hydraulic coupling between Lakes Rotorua and Rotoiti in 1986, which lead to the installation of the Ohau Channel diversion wall, completed in 2008, to improve the water quality in Lake Rotoiti. Today he is talking on the deoxygenation impacts of lakeweed in Lake Rotoiti and whether decomposition of the lakeweed is slowing the recovery of the lake.

TRANSCRIPT

Kia ora and good afternoon. This talk came about from a series of questions that were asked at a TAG meeting in May 2016. These included:

1) What are the consequences of invasive weed growth?
2) What is the succession of species invasion and will it get worse?
3) What are the risks associated with these invasive weeds spreading?
4) What are native aquatic species of the littoral zone and their values?
5) What are the impacts of the associated water clarity improvements on weed?
6) What are possible control measures/options/experience/typical costs and challenges?
7) What are the current BOPRC monitoring programmes?
   (i) Lakes SPI; what does this mean? Incursion monitoring?
   (ii) How do we compare with other regions? Can we improve?
8) What are the agencies involved and their current actions?

I will really only address the first two questions.

What are the consequences of invasive weed growth? A potential consequence is the possibility that these weeds might be altering the geochemical and oxygen dynamics in Lake Rotoiti.

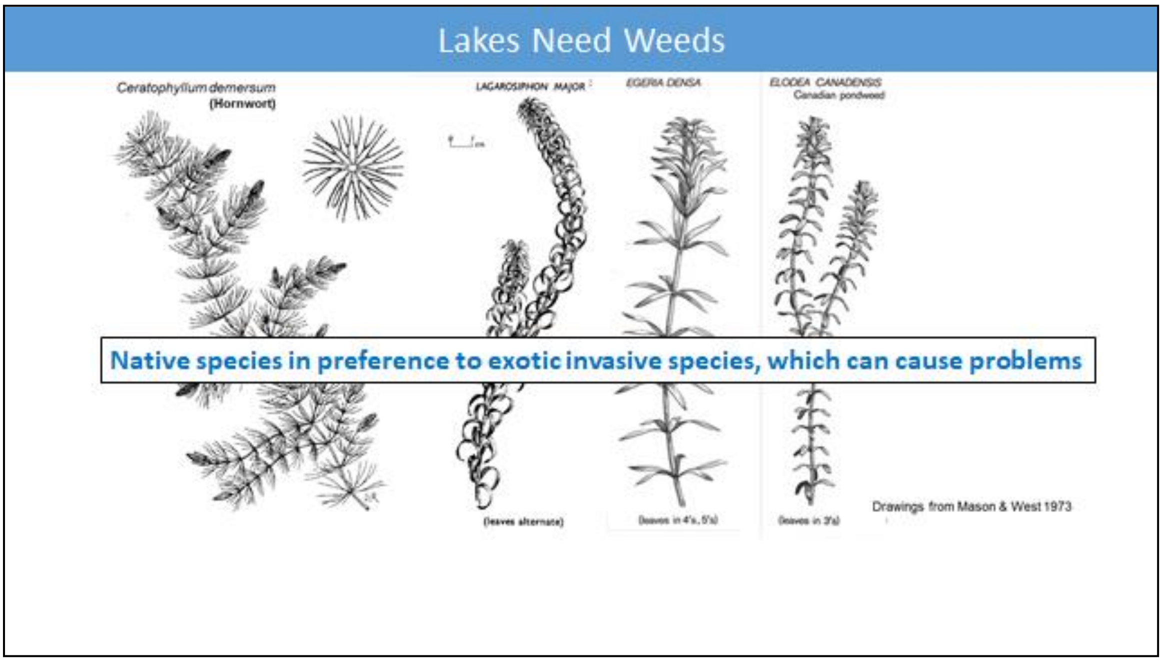
The LakesWater Quality Society asked the question, ‘Can the slow recovery of the anoxic hypolimnion be attributed to decay of the weedbeds that have established around the periphery of the lake?’

A good question and I hope that I can answer it. Lakes need weeds and Tracey Burton has shown you the sort of aquatic weeds that we have in the lake. We require native species in preference to exotic invasive species because they cause problems.

The littoral zone, the band of vegetation around the edge of the lake is very important. What is it that aquatic weeds are doing that native species are not? It can be summarised as:

1) Nuisance value to recreation, (boating, swimming, access, aesthetics)
2) Altering geochemical and oxygen dynamics (unquantified)
3) Effects on mahinga kai (unquantified)
4) Reduced native biodiversity
5) A range of other things too

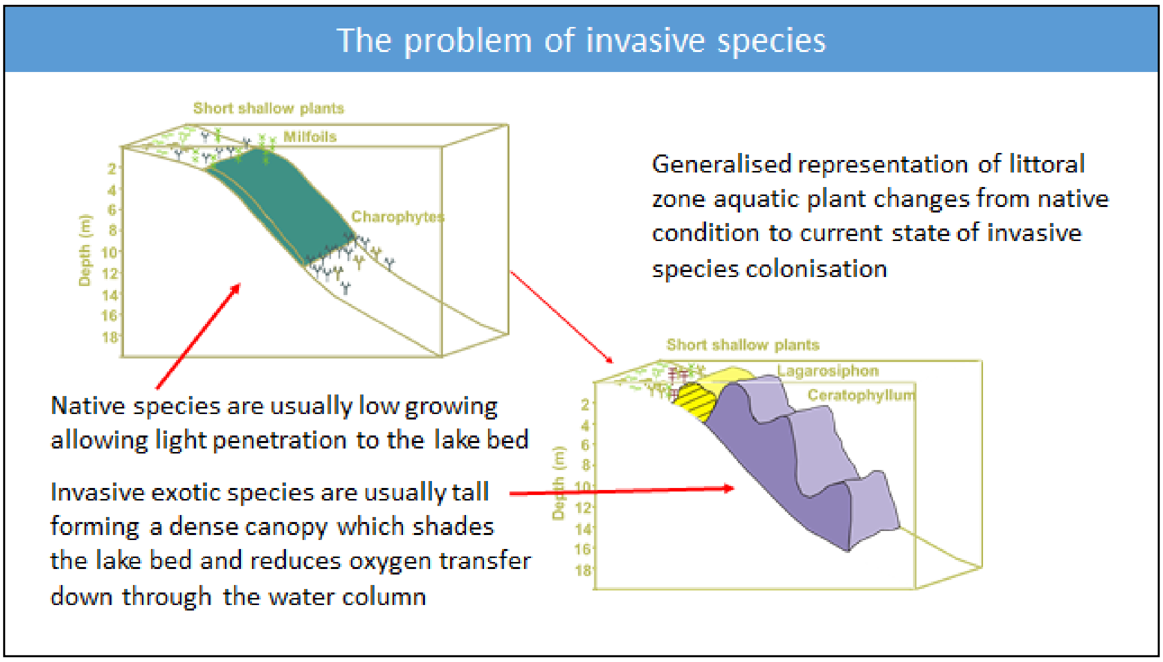
What is the succession of species invasion and will it get worse? Lake Rotoiti would always have had a valuable littoral zone of aquatic plants and in places such as Okawa Bay there would have been high density and biomass of these, probably more than wanted. In general the biomass of aquatic plants in Lake Rotoiti has increased as a result



of a succession of invading species such as elodea, lagarosiphon, ceratophyllum (hornwort) and egeria. The littoral zone plays a very important role in the lake ecosystem health.

Even in large deep lakes such as Lake Rotoiti where the littoral zone itself may be less than 10% of the lake area it plays a very important role. High environmental variability in the littoral zone means high biodiversity and complex ecosystem structures which is what we want.

We want a range of habitat, native and exotic species, which can support the other biota within the lake. In the littoral zone they form the interface between the land and lake with nutrient sediment attenuation. They provide food for herbivores and bottom feeding scavengers and filter-feeding animals. They form a substrate for other plants (epiphytes) and animals. They form a breeding substrate and shelter for vertebrates and fish. They provide a rich feeding ground for fish-eating and plant-eating birds and they have the capacity to settle out fine settlement from the water column and sediment groom and maintain the clarity of the lake. They also impact on lake oxygen and the biogeochemical cycles.



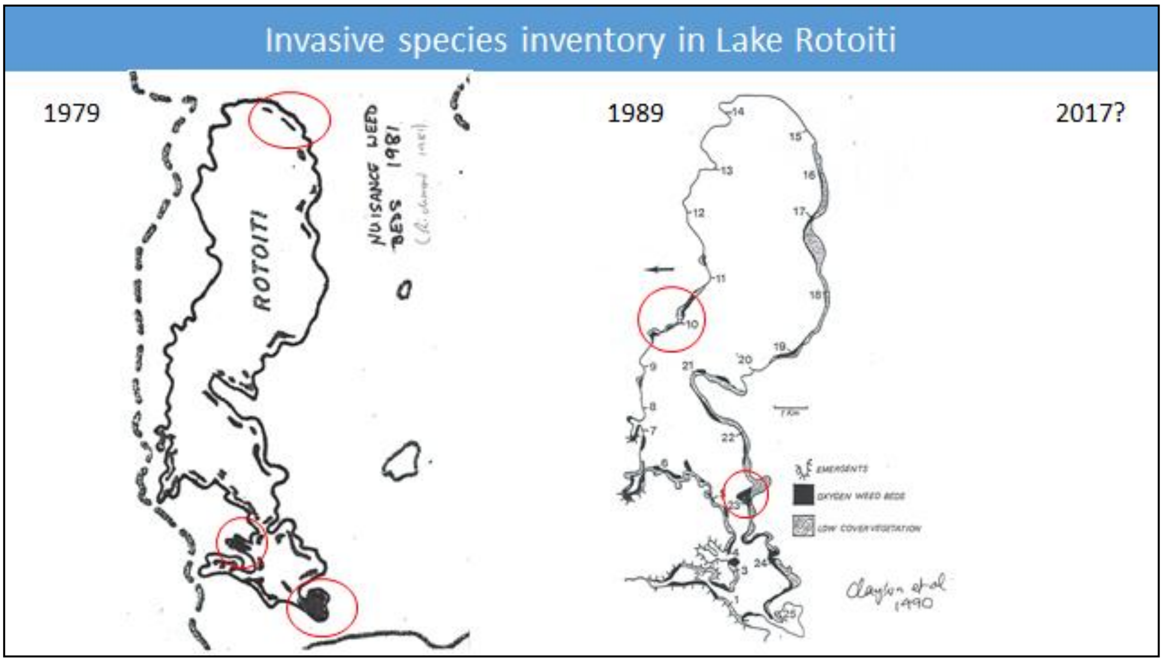
This is a generalisation for the littoral zone aquatic plant changes, from a native condition to an invasive condition. The native species are usually low growing allowing light to penetrate. Invasive exotic species are usually tall and form dense canopies that shade out the lake bed and reduce oxygen transfer down through the water column.

Comparisons between native and exotic invasive species show that:-

- Native weedbeds are generally low growing and may extend further down the littoral profile than invasive species, to deeper water, depending on water clarity
- Native weedbeds have a lower biomass than weedbeds of exotic invasive species which grow up to the surface and form dense canopies that shade out the native species

- The density of the exotic weedbeds reduces water movement through the beds and reduces oxygen transfer into these weedbeds allowing hypoxic zones to develop
- These hypoxic zones coupled with their higher biomass, means that when exotic weedbeds collapse they have the potential to affect the oxygen concentration in the lake as that biomass decomposes

Surveys of Lake Rotoiti in 1979 show various areas where they first found the invasive oxygen weed beds. The circles in 1979 indicate areas of oxygen weed and the elodea in Okawa Bay features prominently. The survey in 1989 shows other areas where oxygen weed was found and in 2017 there is not much change. What is noticeable is that the weed beds extend in a very thin border around the edge of the lake.

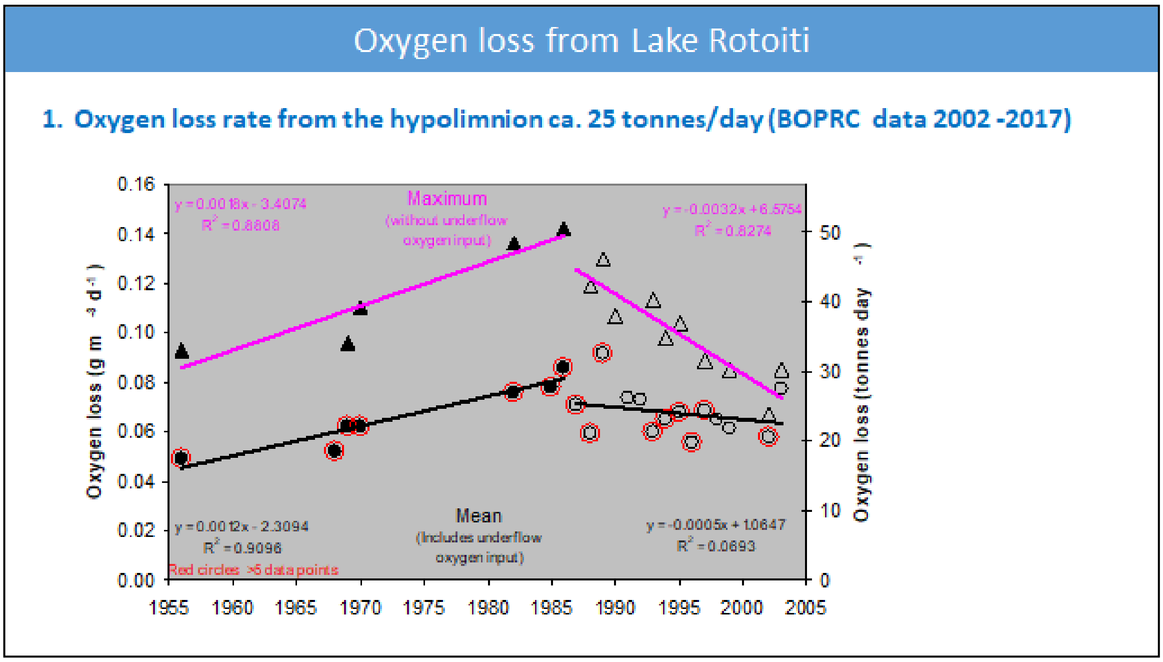


There was little change in the distribution of invasive weeds between the 1970's and 1980's suggesting that their habitat maximum had been reached. Exotic weeds such as lagarosiphon and egeria are not able to colonise water deeper than about 6 metres.

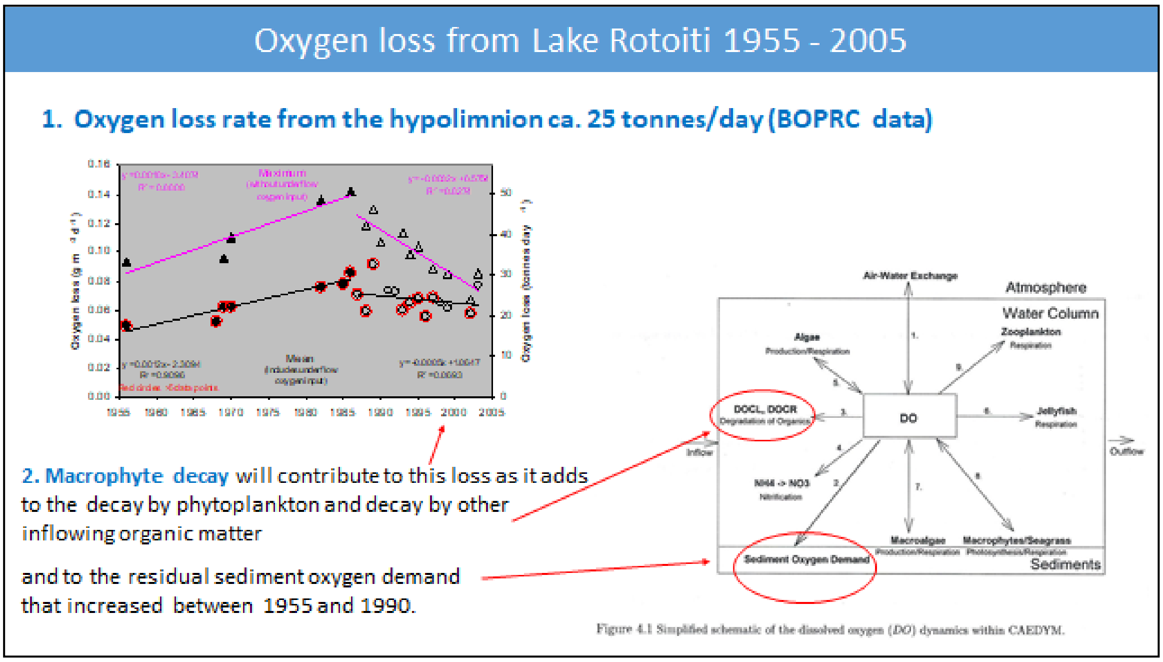
Elodea can grow down to 11 metres. Clive Howard-Williams put forward a hypothesis that there is very little additional space for new weedbed development in Rotoiti, but there is a caveat to that. As the lake gets clearer light penetrates further and weeds can move further down, but there is still a limit to how far they can go.

So changes in the weed beds will be related to changing proportions between lagarosiphon, elodea, egeria and ceratophyllum, rather than changes in the total area around the lake. This means that the plant biomass is likely to be relatively static between years and that is important for doing the calculation that we want to do.

Going back to the LakesWater Quality Society question - 'Can the slow recovery of the anoxic hypolimnion be attributed to decay of the weedbeds that have established around the periphery of the lake?' The next slide calculates what is happening with the oxygen loss from Lake Rotoiti. From work I have done since 1980 it would suggest that we have a loss of oxygen of 25 tonnes per day and if we look at the Bay of Plenty Regional Council data from 2002 to 2017 that value has not changed.



The Dyresm/Caedym model below on the bottom right corner includes a component for decomposition degradation of organic material. The macrophyte decay, or the weed decay, will contribute to this loss as it adds to the decay by phytoplankton and other inflowing organic matter and to the residual sediment oxygen demand that increased between 1955 and 1990. The steams carry organic matter down the sides, coming into the bottom of the lake, the lake turns over nutrients growing algae which precipitate to the bed of the lake and that consumes oxygen from the hypolimnion. The weed beds collapse, they roll down to the bottom of the lake and decompose and consume oxygen.



What is the actual amount? An initial estimate of the contribution of weed decay in Lake Rotoiti oxygen consumption is:-

- Lake area 3435 ha; Dense (exotic?) weed bed area 225 ha (6% of total lake area); Lake weedbed biomass 2250 tonnes (@ 1kg (dry mass)/m^2) or 10 tonnes/ha)
- Production/Biomass ratio 1.2/1 (*Howard-Williams* 1986 for *Potamogeton pectinatus* *see also Vollenweider 1974*)
- Therefore, annual amount of weed that can be decayed = 2700 tonnes
- Total oxygen consumption over decay period for submerged macrophytes ca. 400mg O_2/g (dry wt) decayed (400 kg O_2/tonne dry wt) (*Bianchini et al. 2016*)
- Total oxygen consumption for the whole lake weedbeds annual production is
  2250 t x 400kg = 900 t O_2 or **2.4 t/day**.

The total oxygen consumption for the whole of the lake weed beds annual production comes down to an equation that says we end up with a bottom story of 2.4 tonnes of oxygen per day. That is what the weed beds contribute to the deoxygenation rate in the bottom of the lake.

In answer to the LakesWater Quality Society question, 'Can the slow recovery of anoxic hypolimnion be attributed to decay of weed beds that have established around the periphery of the lake?' The short answer is, 'No,' which should be reassuring because we do not want that to be a major component, otherwise we are sunk.

Assuming the total biomass of the weedbeds end up in the hypolimnion, which is not likely, oxygen consumption due to decay processes, may contribute about 10% to the total oxygen loss from the lakes' hypolimnion. Based on the course figures that I have been using this is an overestimate and a static calculation.

Oxygen consumption is a dynamic process and depends on climate variabilities. In warm years there is more consumption than cold years. This calculation would be better modelled using the Dyresm/Caedym model of David Hamilton's team.

In conclusion, I would like to acknowledge that the material in this talk was drawn from a number of sources, research on Lake Rotoiti in the 1950s (Hilary Jolly), mid-1970s (Geoff Fish), my own research from 1980 on, the NIWA aquatic plant team surveys, and research and monitoring by colleagues from BOPRC and University of Waikato

I would like to thank the Bay of Plenty Regional Council for providing the oxygen profile time-series data and co-funding studies with NIWA that have enabled this lake research through the Ministry of Business, Innovation and Employment research programme. I would like to thank MBI for their contract funding as well, thank you.