Periphyton in relation to nutrients and flows in the Hurunui River

January to May 2015

Cathy Kilroy
Janine Wech
NIWA, PO Box 8602, Christchurch

Funding: Ngāi Tahu Forest Estates Ltd.
Questions that prompted the study

1. What parts of the Hurunui River are nutrient-saturated for periphyton growth?

2. How important is growth rate in determining eventual “standing crop”?

3. Is periphyton in the lower Hurunui River P-limited?

4. Can periphyton be managed by holding P at current levels, but allowing some increase in N?

5. What are prospects for controlling periphyton by managing nutrient concentrations?
Project components

AIM: Explain periphyton patterns w.r.t. nutrient concentrations and other environmental variables

In different parts of the river, over one summer season:

1. Measure dissolved N and P concentrations
2. Conduct accrual rate experiments
3. Carry out nutrient limitation assays
4. Record / measure periphyton on the river bed
5. Investigate sediment-sourced P for Phormidium
Site locations

NRWQN site + flow recorder
Periphyton site
Hydrological context

Mandamus: median flow ~41 cumecs

SH1: median flow ~50 cumecs
Hydrological context

Site visits Freshes

Daily mean flow (m$^3$/s)

Mandamus SH1

Site visits
Freshes
1. Measure dissolved N and P concentrations

Sample filtering
Dissolved reactive phosphorus (DRP) concentrations

Season mean (mg/L)

0.0011
0.0008
0.0007
0.0006

SH7 > Mandamus
Gorge > other sites
Dissolved inorganic nitrogen (DIN) concentrations

Dissolved inorganic N (DIN) (mg/L)

Season mean (mg/L)

<table>
<thead>
<tr>
<th>Season</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

All sites differed
Data from the NRWQN sites at Mandamus and SH1 (monthly data)
Summer low flows only

DRP: comparison with other years

Mandamus

SH1
DIN: comparison with other years

Data from the NRWQN sites at Mandamus and SH1 (monthly data)

Summer low flows only
2. Accrual rate experiments

Artificial growing surfaces deployed at each site

Four replicate blocks
Weekly sample collection
Timing of accrual experiments

Daily mean flow (m$^3$/s)

- Mandamus
- SH1

Site visits

Experiment 1
Experiment 2
Accrual rate experiments

Key results

- Fastest/most accrual at Gorge, both experiments: ~42 days to reach HWRRP limit
- Second most rapid accrual at SH7 in Expt 1
- Low accrual at Balmoral in Expt 1, but similar to SH7 in Expt 2
- Limited or no accrual at Mandamus
- Accrual rates at all sites suggested nutrient limited growth rates
Example: Gorge, Experiment 1, Paver 4

5 – 7 days growth between photos
Example: Balmoral, Experiment 1, Paver 1

5 – 7 days growth between photos. N.B. invertebrate grazing
3. Nutrient limitation assays

Preparing to deploy nutrient diffusing substrate (NDS) trays
Interpretation of nutrient limitation assays

Results confirmed by measuring chlorophyll $a$ in the lab.
Timing of nutrient limitation assays

Daily mean flow (m$^3$/s)

Mandamus SH1

Site visits

<table>
<thead>
<tr>
<th>Date</th>
<th>Mandamun</th>
<th>SH1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Nov-14</td>
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<tr>
<td>1-Dec-14</td>
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<td>1-Jan-15</td>
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<td>1-Feb-15</td>
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<td>1-Mar-15</td>
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<td>1-Apr-15</td>
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<td>1-May-15</td>
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<tr>
<td>1-Jun-15</td>
<td></td>
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</table>
**Summary results**

<table>
<thead>
<tr>
<th></th>
<th>6-20 Jan</th>
<th>20 Jan-4 Feb</th>
<th>24 Feb-16 Mar</th>
<th>16 Mar-1 Apr</th>
<th>1 Apr-20 Apr</th>
<th>20 Apr-5 May</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandamus</strong></td>
<td>N</td>
<td>NP</td>
<td></td>
<td></td>
<td>NP</td>
<td></td>
</tr>
<tr>
<td>N:P 4 – 16</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>SH7</strong></td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>P</td>
<td>NP</td>
</tr>
<tr>
<td>N:P 8 – 35</td>
<td></td>
<td></td>
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<tr>
<td><strong>Balmoral</strong></td>
<td>P</td>
<td>P_N**</td>
<td></td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N:P 57 – 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gorge</strong></td>
<td>P</td>
<td>P</td>
<td></td>
<td>P</td>
<td></td>
<td>NP?</td>
</tr>
<tr>
<td>N:P &gt;200</td>
<td></td>
<td></td>
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</table>


**P limitation with secondary N-limitation
4. Record / measure periphyton on the river bed

Visual estimates of % cover

Sample collection for estimates of chlorophyll $a$ per square metre
Timing of surveys and sample collections

![Graph showing daily mean flow (m³/s) with site visits marked by arrows for Mandamus and SH1.]
Periphyton cover on the river bed (visual estimates)

Mandamus

Fils_green  Fils_other  Didymo  Mats  Phormidium  Sludge  Film  No algae
Periphyton cover on the river bed (visual estimates)

- Fils_green
- Fils_other
- Didymo
- Mats
- Phormidium
- Sludge
- Film
- No algae

**Mandamus**

**SH7**
Periphyton cover on the river bed (visual estimates)

Mandamus

SH7

Balmoral
Periphyton cover on the river bed (visual estimates)

- **Mandamus**
- **Balmoral**
- **SH7**
- **Gorge**

Legend:
- Fils_green
- Fils_other
- Didymo
- Mats
- Phormidium
- Sludge
- Film
- No algae
Periphyton composition (by cell counts)

- **Mandamus**
  - Green filaments
  - Diatoms
  - Cyano-bacteria

- **SH7**
  - Green filaments
  - Diatoms
  - Cyano-bacteria

- **Balmoral**
  - Green filaments
  - Diatoms
  - Cyano-bacteria

- **Gorge**
  - Green filaments
  - Diatoms
  - Cyano-bacteria

**Upstream** to **Downstream**
Periphyton composition (by biovolume)

- Mandamus: Green filaments 80%, Diatoms 20%
- SH7: Green filaments 60%, Diatoms 40%
- Balmoral: Green filaments 40%, Diatoms 60%
- Gorge: Green filaments 20%, Diatoms 80%
Periphyton biomass (chlorophyll $a$)

- Mandamus
- SH7
- Balmoral
- Gorge

HWRRP threshold
Effect of high flows on chlorophyll $\alpha$ at different sites

- Steepest slope at Gorge = most effective removal by high flows ($\textit{Phormidium}$)
- Flatter slope at SH7 = flows less effective (didymo)
- Growth at Mandamus too low for flows to make much difference
- N.B. Flood events in study period were small ($< 2 \times$ median)
**Studies 1 to 4: Summary**

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean DIN (mg/L)</th>
<th>Mean DRP (mg/L)</th>
<th>Accrual rate (RANK, fastest = 1)</th>
<th>Nutrient limitation</th>
<th>95th % chlorophyll a (mg/m²)</th>
<th>Dominant cover</th>
<th>High flow effects (RANK, most = 1)</th>
<th>Taxonomic composition</th>
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</thead>
<tbody>
<tr>
<td>SH1</td>
<td>0.005</td>
<td>0.0006</td>
<td>4</td>
<td>N or NP</td>
<td>18</td>
<td>Sludge, didimo, GF</td>
<td>4</td>
<td>Strong downstream turnover in species composition</td>
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<tr>
<td>SH7</td>
<td>0.015</td>
<td>0.0008</td>
<td>2</td>
<td>NP</td>
<td>101</td>
<td>Didimo, GF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balmoral</td>
<td>0.050</td>
<td>0.0007</td>
<td>3</td>
<td>P</td>
<td>84</td>
<td>Sludge, Phorm.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Gorge</td>
<td>0.375</td>
<td>0.0011</td>
<td>1</td>
<td>P</td>
<td>234</td>
<td>Phorm., sludge, mats</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Key Points**

- **Mandamus**
- **Balmoral**
- **Gorge**
- **SH1**

- **Flow recorder**
- **Periphyton site**
5. Investigate sediment-sourced P for *Phormidium*

Sediment traps deployed at each site
Measured weight and P content of trapped fine sediment
Timing of sediment trap study (low/receding flow)

- Daily mean flow (m$^3$/s)
- Mandamus
- SH1

Sediment trap deployment (6 days)

Site visits

Sediment trap study: summary results

### P in sediment:
- **Loosely bound**
- **Redox-sensitive**
- **Metallic oxide-bound/organic**

#### Yield (mg P / square metre / day)

<table>
<thead>
<tr>
<th>Sediment size fraction (μm)</th>
<th>Mandamus</th>
<th>SH7</th>
<th>Balmoral</th>
<th>Gorge</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;63</td>
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<tr>
<td>63 &lt;125</td>
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<td></td>
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<tr>
<td>125&lt;250</td>
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<tr>
<td>&lt;63</td>
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Increasingly tightly bound P
What does all this mean in relation to the original questions and to drivers of periphyton along the river?
Questions that prompted the study

1. What parts of the Hurunui River are nutrient-saturated for periphyton growth?

   In summer 2015, according to NDS, all four sites were nutrient-limited:
   - Upper catchment (SH7 & upstream) N or co-limited;
   - Lower catchment (Balmoral & downstream P-limited;
   - N not limiting in lower river at levels of DRP in 2015;
   - Didymo thrives in N+P co-limited environment (SH7).
Questions that prompted the study

2. How important is growth rate in determining eventual “standing crop”?

Accrual rate and standing crop generally corresponded.

In Jan – Feb, lower accrual and standing crop at Balmoral than SH7 despite higher N.

Accrual at Gorge led to exceedance of HWRRP threshold within 40 days after a high flow.

Accrual rates at all sites suggested nutrient-limited growth rates.
Questions that prompted the study

3. Is periphyton in the lower Hurunui River P-limited?

According to NDS, yes.

But chlorophyll $a$ still exceeded HWRRP threshold (Gorge).

Sediment could be an additional P source driving growth of *Phormidium*.

Note: *Phormidium* has higher chlorophyll $a$ content per unit area than some other algae.
Questions that prompted the study

4. Can periphyton be managed by holding P at current levels, but allowing some increase in N?

Depends on baseline levels:

- DRP very low during this study (very low flows)
- Patterns in N & P limitation similar to those in earlier NDS assays.

NDS showed that increasing N would increase biomass at SH7 and Balmoral, if DRP also increased (e.g., to levels seen in previous years) [also changed species composition]
Questions that prompted the study

5. What are prospects for controlling periphyton by managing nutrient concentrations?

Difficult to predict: multiple factors affect standing crop;

Changing DIN & DRP concentrations affect species composition as well as accrual rates;

In the Hurunui main stem, strong downriver gradients of DIN and possibly DRP (including sediment P sources) drives gradients in periphyton species and standing crop.
Questions?