Freshwater ecology: periphyton rapid assessment monitoring in streams—method 2 (RAM-2)

Version 1.0

This specification was prepared by Duncan Gray in 2013.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

This rapid assessment protocol is based on that presented by Biggs & Kilroy (2000). Percentage cover of algae is recorded at fixed points on transects across the stream reach of interest. This method is designed to obtain cover estimates and other basic information about the entire algal community and enables a general assessment of stream enrichment. The method was developed from the Stream Health Monitoring and Assessment Kit (SHMAK) (Biggs et al. 1998) and recognises 12 main types of periphyton based on colour and thickness (Fig. 1). Repeated surveys at regular intervals can create a comprehensive picture of periphyton community dynamics.

This method is the standard technique for assessing periphyton communities in New Zealand and is widely applied by regional councils for State of the Environment (SOE) monitoring and reporting. It is not suitable for estimates of percentage periphyton cover of the site because it does not standardise by a known unit of stream bed (as in RAM-1). Instead, cover estimates per sediment particle are estimated, then multiplied (i.e. weighted) by a pollution score to give a general assessment of water quality conditions (see 'Periphyton score field sheet and calculator' in '[Periphyton RAM data sheets]'—docdm-777283). Note that a relatively new method for assessing periphyton communities is being used by some regional councils but this is not expanded here (Kilroy et al. 2013).

Figure 1. Examples of periphyton types commonly associated with nutrient enrichment and stable flows in streams. Top left: medium, possibly thick, dark brown mats. Top right: medium thickness green mat. Bottom left: long brown filaments adhere to rocks adjacent to a tracer stone used to measure stream bed movement. Bottom right: medium thickness dark brown mats and short green filamentous algae. Photos: Golder Associates.

Assumptions

- Physical habitat conditions at each site are standardised as much as possible.
- Simple random sampling is applied to positioning of transects at each site.
- The sample is representative of periphyton cover in the wider stream.
- Observer accuracy is similar between areas and over time.

Advantages

- This method is cheap and easy to apply.
- The method requires no specialised resources.
- The method does not require material to be removed from the stream.
- The method is an accepted way to assess periphyton community cover and composition and an existing large number of records using this method enhances comparability between sites at different spatial and temporal scales, depending on the objectives of the study.

Disadvantages

- Provides only a crude estimate of the actual biomass of periphyton.
- Estimates of cover/length are subjective and imprecise with an unknown level of observer bias and are only capable of detecting large spatial or temporal trends.
- The method is not appropriate for detecting the effects of specific discharge or pollution events (quantitative methods would be more appropriate).

Suitability for inventory

This method is suitable for a crude inventory of periphyton types in relation to temporal or spatial trends. However, it does not provide information on specific taxa with a stream.

Suitability for monitoring

- This method is highly suitable for monitoring the effects of broadscale enrichment or temporal patterns in periphyton community composition and cover.
- It is not appropriate for monitoring the effects on composition and biomass of a specific discharge (more precise, quantitative techniques are more suitable for this application).

Skills

Field observers will require:

- Basic training in stream periphyton and habitat sampling

- Basic outdoor and river-crossing skills
- A reasonable level of fitness

Study design and sample processing are specialised processes that require input from a TSO, Science Officer or external contractor.

Resources

Periphyton sampling of New Zealand streams may be carried out by a single field operative. However, in the interests of safety it is recommended that sampling is done by teams of at least two people.

Standard equipment includes:

- Two tape measures (10 m and 20 m long)
- Four 6–10 mm diameter aluminium pegs (> 20 cm long) curved at one end to hold tapes in place (a mallet for knocking in pegs may be useful)
- Small tea strainer (approximately 8 cm in diameter)
- Field data sheet (preferably waterproof)
- Periphyton field identification chart (Figs 2 and 3 below)
- GPS and batteries
- Waterproof notebook and pencils

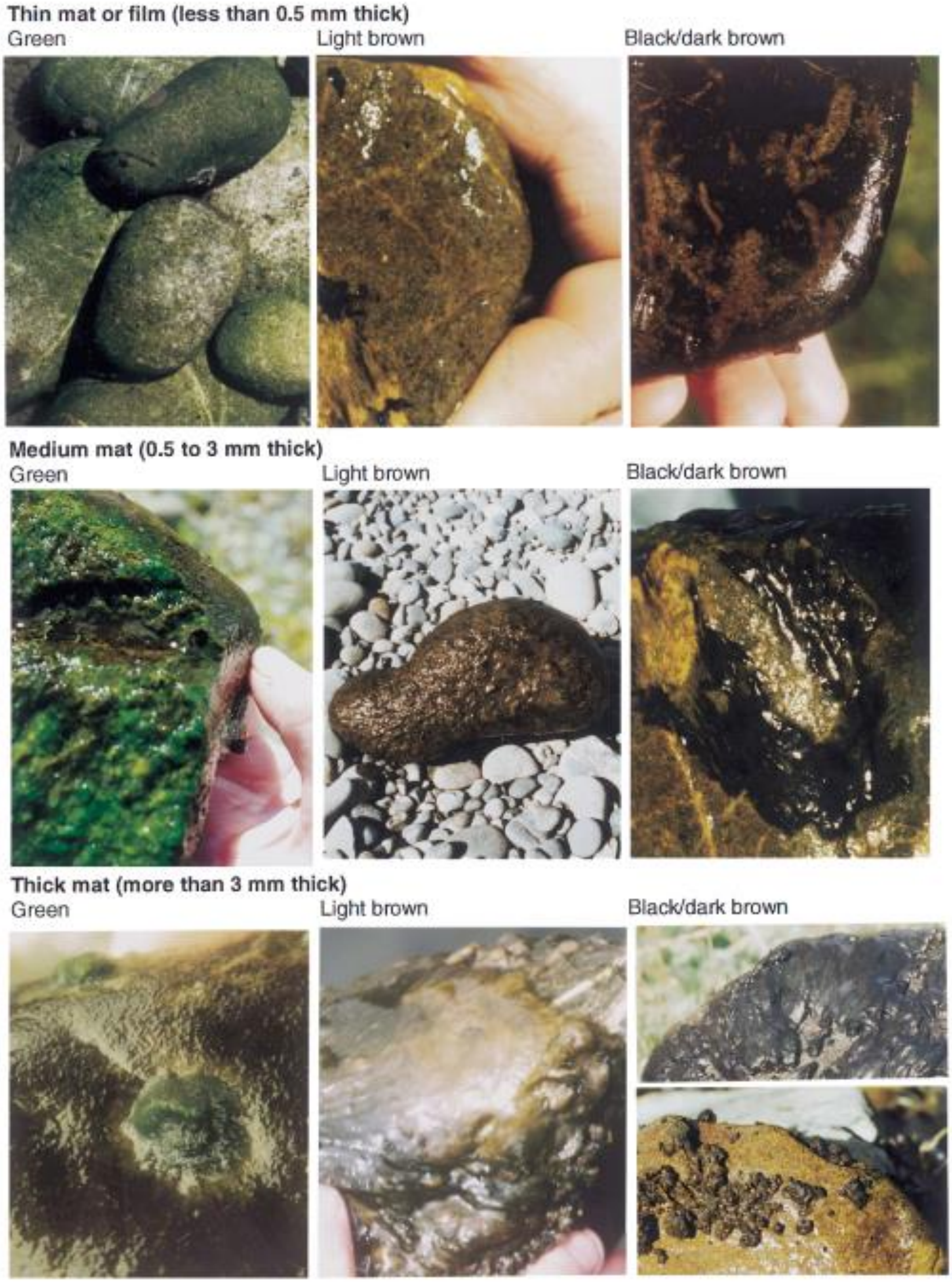

Figure 2. Periphyton field identification chart, part 1 (Biggs & Kilroy 2000).

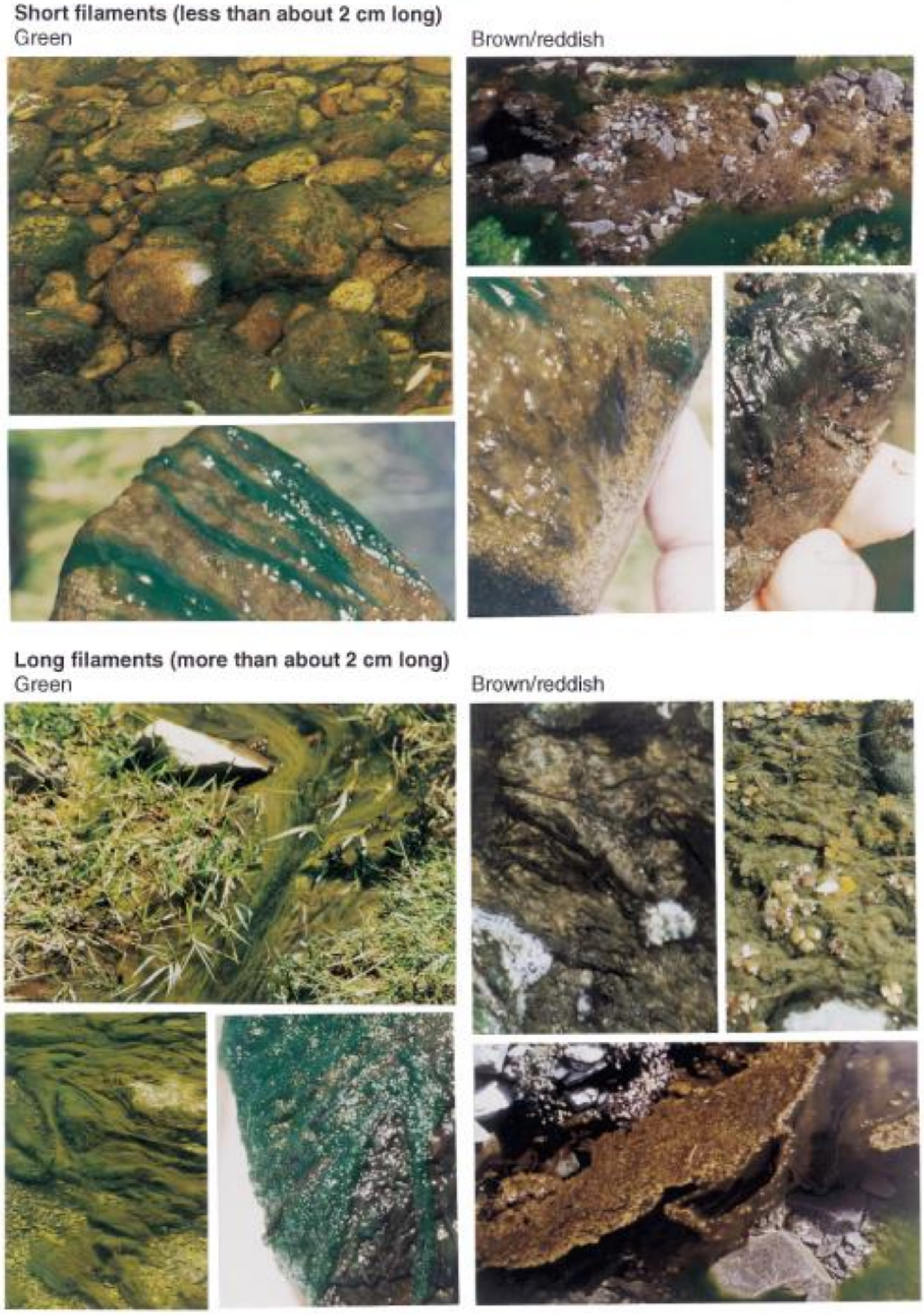

Figure 3. Periphyton field identification chart, part 2 (Biggs & Kilroy 2000).

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

The more information that is collected at each site, the more thorough and complete will be any interpretation of the biological data collected. However, some basic information should be recorded with each sample collected:

- Substrate composition
- Riparian vegetation
- Stream width
- Stream depth
- Stream velocity

It is also common to collect basic water chemistry information. Temperature (°C), electrical conductivity (µS), pH and dissolved oxygen may all be measured by handheld meters to inform biological data. Some habitat and sites notes are also worthwhile, e.g. the occurrence of stock at the site or evidence of recent flooding.

The 'Stream habitat assessment field sheet' (docdm-761873) is a good guide to the basic information that should be collected from every sampling location and does not require specialised equipment or processing in a laboratory. Basic training in the use of this habitat sheet and a thorough perusal of Harding et al. (2009) is required before use.[1] As with all visual and qualitative assessments it is important to standardise collection protocols and calibrate observations between all the different observers who will be involved in field data collection. There is considerable opportunity for user bias with this method of habitat assessment.

Data storage

Data is conventionally recorded on a hardcopy data sheet during field sampling and then transcribed to an electronic format. Hardcopy sheets should be clearly marked with the details of the project and identity/location of samples. The format of hardcopy data sheets is normally columns representing transects/samples and rows for each periphyton type group. An example data sheet and periphyton score calculator (Biggs et al. 1998) are available (see 'Periphyton score field sheet and calculator' in 'Periphyton RAM data sheets'—docdm-777283). This data sheet is designed for use with this protocol and can record percentage cover of 12 types of periphyton.

[1] http://www.cawthron.org.nz/coastal-freshwater-resources/downloads/stream-habitat-assessment-protocols.pdf

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely as soon as possible, preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Data should be entered into an electronic media in the same format as the field data sheets. This differs to DOC best practice which recommends a 'long data' format where data from each field on the data sheet (date, time, location, transect designation, sample number, algae type, score, etc.) is in columns, with each row representing a single observation. However, following the Biggs et al. (2000) format reduces confusion and allows the use of a pre-formatted calculator to derive basic statistics (mean periphyton score and standard error for each site). More complex analyses using statistical packages such as R may require you to re-format data into a standard 'long format'.

Electronic files should contain all the information required to identify each sample (observer names, dates, location, transect and sample names). Habitat or water chemistry data that was collected simultaneously should be clearly linked to periphyton data. In Excel, this is often captured as a separate worksheet within the same workbook. Habitat and water chemistry data should be entered in a comparable format to biological data. This should be done as soon as possible and by the field operative so that details are fresh. All hardcopies of habitat data and notes should be labelled and stored in a project file and retained.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

All electronic files should have a notes sheet which details relevant information for future users. Every user, beginning with the person who enters the data, should record details of any changes to the data, including when and why they were made. It is best practice to retain a single version of the data which has undergone quality control and may not be altered. All analysis is performed on copies of this master sheet.

Finally, copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.

The data derived from RAM-2 sampling is an estimate of the community composition of periphyton communities and provides more analytical options than RAM-1. Biggs et al. (1998) provide a site water quality indicator (mean Periphyton Score), and the proportional percentage cover of the different algal types on the stream bed can also be compared. Samples collected at multiple sites on an environmental gradient or on multiple occasions through time can be analysed using correlation or regression analysis to compare algal cover/composition to physico-chemical data. Alternatively, this data may be used to compare between groups or 'treatments' pre-defined by an experimental manipulation or land-use type using an approach such as ANOVA.

Case study A

Case study A: assessment of flow regime change on periphyton communities

Synopsis

River impoundment may have a significant effect on the flow regime downstream of a dam which results in commensurate changes in the periphyton community. The primary effect on the flow regime is to alter the occurrence and magnitude of high flows. High flows, which have adequate energy to mobilise substrates and slough periphyton growths, are termed as "flushing flows". In this case study a long term data set of periphyton observations, before and after the construction of a dam, is analysed. Although the occurrence of nuisance growths of filamentous algae changed little post construction, the cover of algal mats did increase. Nutrient levels showed no consistent trend and therefore the change in algal mat cover could be attributed to the change in flow regime. There was no consistent relationship between accrual period (the number of days since the previous flushing flow) and periphyton cover, however using a published relationship between accrual and nutrient concentrations it was possible to predict the biomass increase of periphyton before and after dam construction. This case study illustrates a long term application of the rapid periphyton assessment to examine the effects of flow regime change, but would be applicable to shifts in nutrient loading to streams or the removal of riparian shade.

Objectives

- To determine whether periphyton growths in the (fictional) Derwent River changed over time in relation to impoundment (creation of a dam upstream from the sampling location).

Sampling design and methods

Data was collected by the (fictional) National Institute of Rivers and Pond Research (NIRP) using a protocol designed prior to the publication of Biggs & Kilroy (2000). Observations were taken from one sampling transect. A GPS reference and steel warratah on the upper stream bank was used to confirm the origin. Percentage cover of the two categories were recorded for 10 sample stones, collected at regular intervals along the transect laid across the river from the origin to the opposite bank.

This method is similar to that described in this protocol, but focused solely on potential nuisance-forming periphyton communities, rather than recording all 12 periphyton communities in the current method specification. Observations were carried out monthly between January 1989 and March

2011 at the SH1 Bridge site on the Derwent River, Canterbury. In 1998 a dam was constructed on the Derwent River which drastically altered the flow regime and periphyton communities in the river.

Results

From 242 sampling occasions, 96 found an average percentage cover of long filamentous algae of close to zero and average long filamentous algae cover exceeded nuisance levels (30% cover) on 14 occasions (Fig. 4). Algal mats were absent on 83 occasions and nuisance levels (60%) were exceeded 23 times (Fig. 5).

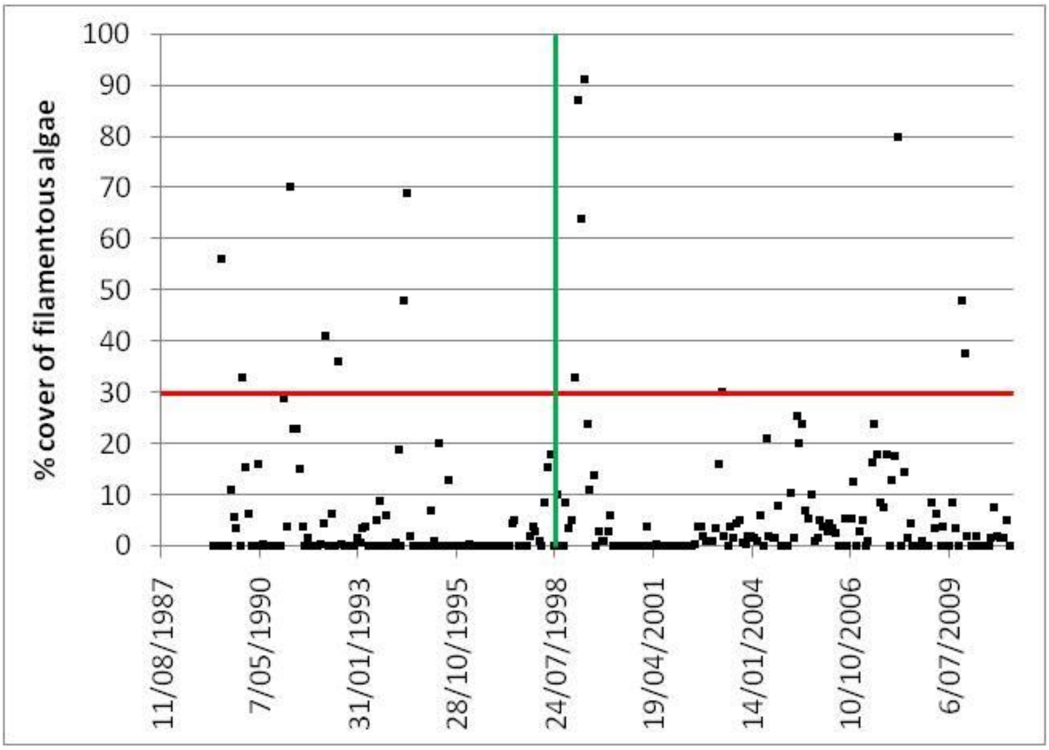

Figure 4. Percentage cover of filamentous algae on the bed of the Derwent River at the SH1 Bridge. The red line denotes the nuisance algae guideline threshold for filamentous algae (Biggs & Kilroy 2000). The green line denotes construction of the dam.

The occurrence of nuisance filamentous algae showed no broad trend over the sampling duration; however, observations of algal mats increased dramatically after the year 1998 when dam construction began to alter river flow. Thus, mean cover with thick mats increased from 5.8% in the 11 years prior to 1998 to 25% in the 13 years since dam construction in 1998.

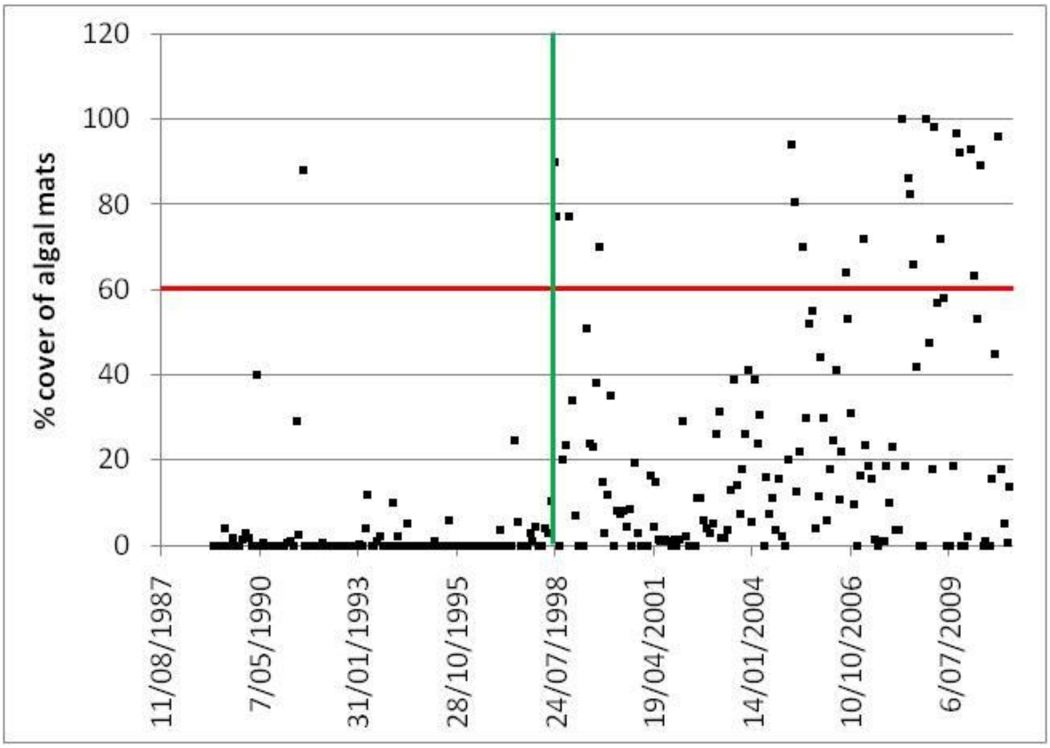

Figure 5. Percentage cover of algal mats on the bed of the Derwent River at the SH1 Bridge. The red line denotes the nuisance algae guideline threshold for mats (Biggs & Kilroy 2000). The green line denotes construction of the dam.

The results presented in Figs 4 and 5 provide little information about reasons for observed changes in the periphyton community. Alterations in the periphyton community are often associated with changes in the available nutrient concentrations in the water (which encourage growth).

However, dam construction did not appear to alter available nutrient concentration: recorded levels of total nitrogen and dissolved reactive phosphorous over the sampling period did not show a trend in relation to damming, like that observed in the percentage cover of periphyton mats (Figs 6 and 7). Although reactive phosphorus concentration increased in the first year or so after dam construction, it then returned to levels similar to the initial state. Researchers therefore considered that the increase in periphyton mats observed in the Derwent River was attributable to a change in the discharge regime after damming.

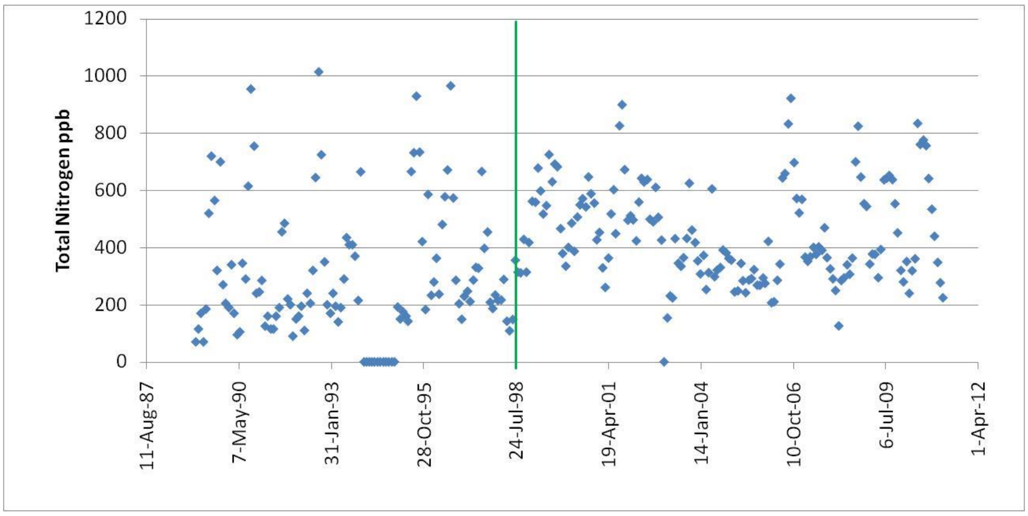

Figure 6. Total nitrogen (ppb) concentration in the Derwent River over the duration of the sampling period. The green line denotes construction of the dam.

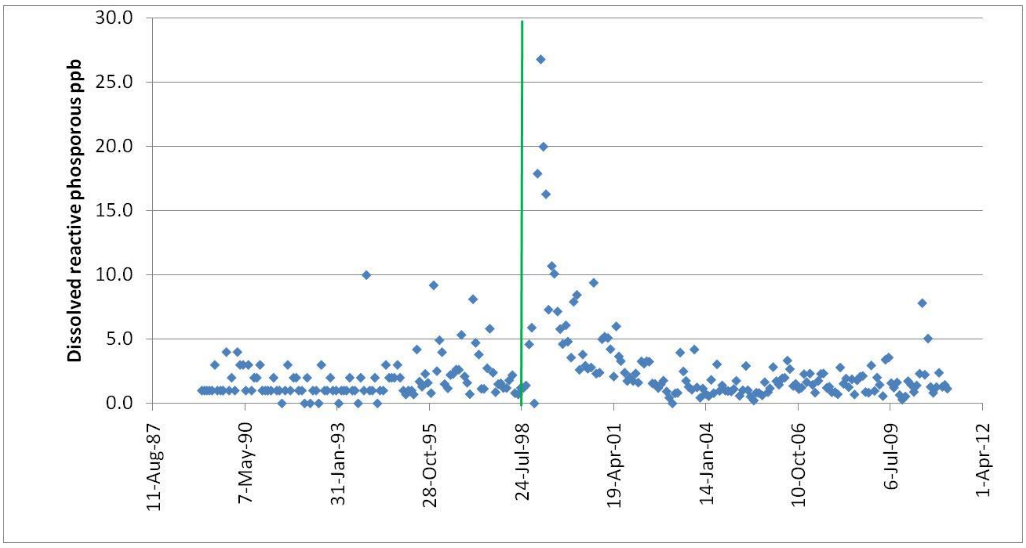

Figure 7. Dissolved reactive phosphorous (ppb) in the Derwent River over the duration of the sampling period. The green line denotes construction of the dam.

Prior to the dam's construction, mean accrual length (days of accrual since a three-times median flow event) was 15 days, compared to a mean of 75 days after dam completion. A scatter-plot of the total cover of periphyton (mats and filamentous algae) versus accrual length showed a lot of variation between the two variables but no consistent trend.

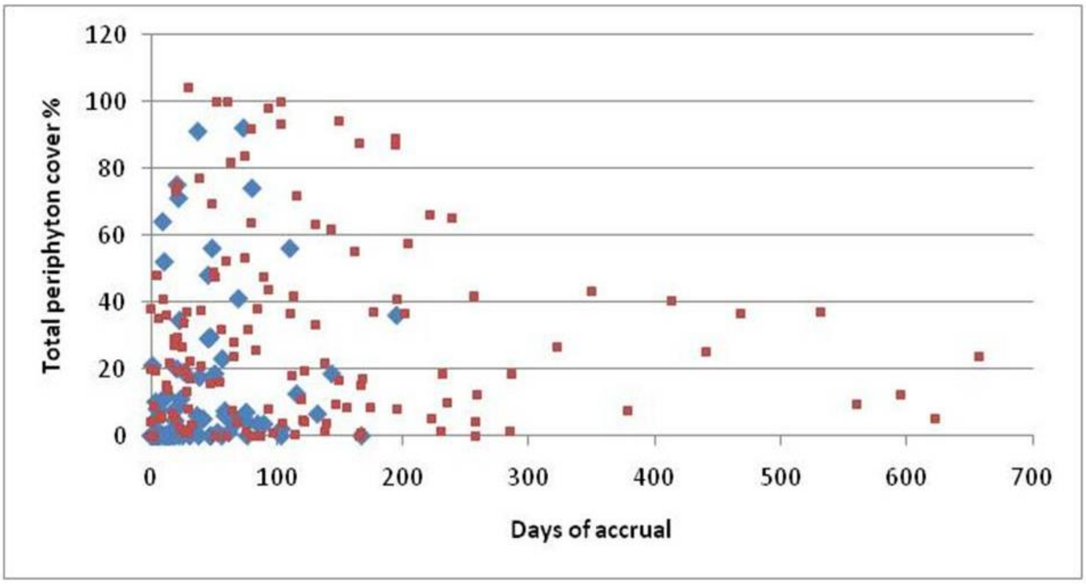

Figure 8. Total cover of periphyton in relation to days of accrual since a 3× median flow event. Blue dots represent sampling occasions prior to dam construction and red dots are post-dam construction.

Although it is interesting to monitor the effect of impoundment on stream communities, it may be more useful to predict potential impacts prior to them occurring. Using the empirical relationship provided by Biggs (2000) it is possible to predict the trophic status or occurrence of nuisance growths in the Derwent River before and after construction of the dam based on nutrient concentrations and predicted impacts on accrual length (Fig. 9). The predictions use the concentration of chlorophyll *a* as an estimate of periphyton biomass. The oligotrophic-mesotrophic boundary is set at 50 mg/m^3, which equates to the periphyton guideline limit for protection of benthic biodiversity, while the mesotrophic-eutrophic boundary is set at 200 mg/m^3, which equates to the periphyton guideline limit for protection of aesthetics, recreation and trout angling/habitat (Biggs 2000).

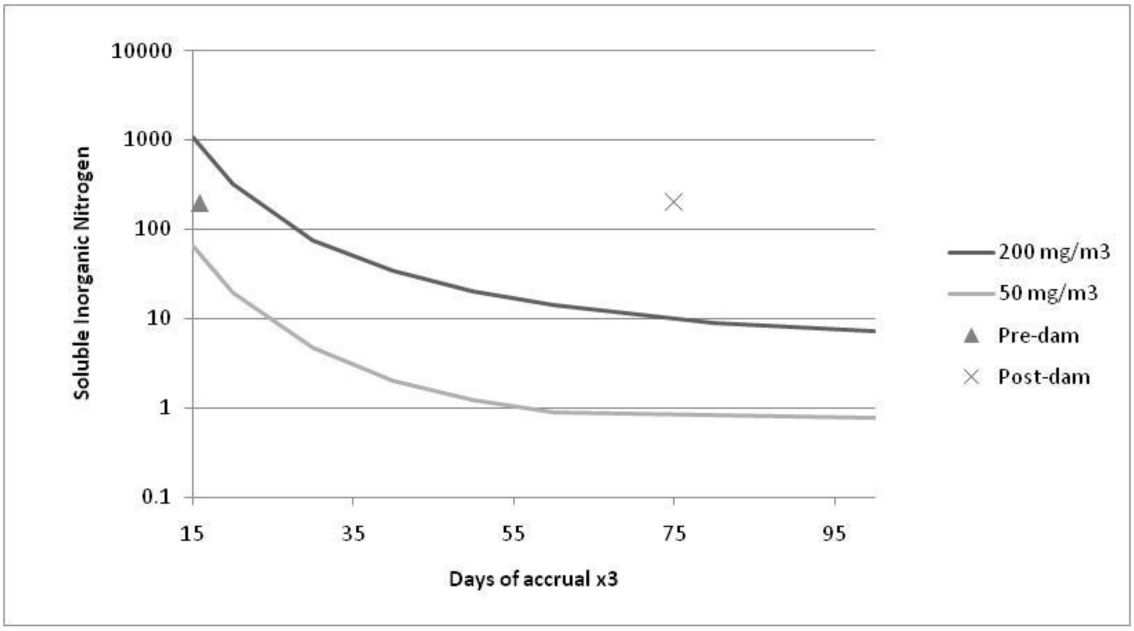

Figure 9. Predicted trophic status and biomass of periphyton in the Derwent River as a function of accrual period and nitrogen concentration before and after dam construction.

The average total nitrogen concentration did not change as a result of dam construction. However, the effect of the predicted large increase in average accrual period on the periphyton biomass resulted in a shift from a mesotrophic system (accrual period of 15 days) to a eutrophic situation (accrual period of 75 days). Before impoundment, periphyton growths may have caused some impairment of benthic biodiversity due mostly to the relatively high nutrient levels, and following impoundment, the cessation of flushing flows and increased accrual periods allowed predicted periphyton biomass to increase significantly.

Results collected from monitoring were used in combination with a previously established relationship which predicted the likely effects of the dam on observed periphyton biomass and the increased occurrence of nuisance growths.

Limitations and points to consider

This case study is a clear cut example of the potential effects of impoundment on the periphyton communities within a stream. The study presents a long-term data set which represents a considerable investment of resources. This degree of variation between accrual and periphyton is not unusual in a large periphyton data set. Observations have been taken over a 20-year period by numerous field parties under a variety of flow conditions. The influence of shifting seasonal patterns, substrate, micro-habitat velocity and temperature may also have played a role in creating 'noise' around the discharge–periphyton relationship. A more rigorous way to assess the change in periphyton communities would have employed a quantitative measure of biomass, rather than cover, which controls for substrate and microhabitat velocity variation. Of course such a study design would come with a higher price tag.

References for case study A

Biggs, B.J.F.; Kilroy, C. 2000: Stream periphyton monitoring manual. Prepared for the New Zealand Ministry for the Environment. National Institute of Water and Atmospheric Research, Christchurch.

Full details of technique and best practice

This procedural description is taken directly from Biggs & Kilroy (2000) but may be altered to suit the purposes of a specific study.

- Select a reference point at the downstream end of your site and on one bank drive a peg into the ground.
- Attach the tape measure to the peg and lay it out taut for a distance of 10 metres (or 5× the stream width, whichever is smaller). Attach the upstream end of the tape to a second peg.
- Divide the distance along the tape into thirds and mark the tape (i.e. 3.3 m intervals for a 10 m site distance).
- Attach the 20 m tape measure to a third peg at the location of the reference peg and unwind the tape across the stream at right angles to the main tape. Anchor the tape on the far bank with the fourth peg.
- Divide the width of the stream (water's edge to water's edge) into 5 equally spaced points.
- Working from the downstream end of the site, move out to the first point across the first transect to be sampled (this will be near the water's edge on one side of the stream). Bend down to lightly touch the sediments of the stream bed without looking at what is there. Ideally, pick up the first stone that you touch. Because the stones need to be a reasonable size to provide useful information, sometimes you will have to disregard the initial piece of sediment that you touch if it is very small (e.g. gravel or sand) and pick up a stone no more than 10 cm away which is bigger than about 4 cm across.
- If the stream bottom is gravel, sand or silt, take a scooped sample at the sampling point with the tea strainer.
- Examine each stone carefully and identify the categories of periphyton present according to their colour and thickness using the periphyton field identification chart (Figs 3 and 4). Thickness estimates are aided by running a fingertip through periphyton mats to expose a depth profile. Estimate the percentage cover of the stone in each category and enter this on the field sheet.
- Complete the transect, then move the tape upstream for the second transect at one-third interval and repeat recordings.
- When complete, calculate the mean percentage cover of sampling points for each category of periphyton and the periphyton score. Both calculations are performed for you in the field sheet (see 'Periphyton score field sheet and calculator' in 'Periphyton RAM data sheets'—docdm-777283).

Notes:

- In this procedure Biggs & Kilroy (2000) recommend the use of 4 transects per site with 5 points/stones being examined per transect giving a total of 20 assessments/replicates per site. This allows a good level of precision for activities such as SOE monitoring or detailed regional water quality assessments.

References and further reading

Biggs, B.J.F. 2000: New Zealand periphyton guideline: detecting, monitoring and managing enrichment in streams. Prepared for the Ministry for the Environment. National Institute of Water and Atmospheric Research, Christchurch.

Biggs, B.J.F.; Kilroy, C. 2000: Stream periphyton monitoring manual. Prepared for the New Zealand Ministry for the Environment. National Institute of Water and Atmospheric Research, Christchurch.

Biggs, B.J.F.; Kilroy, C.; Mulcock, C.M. 1998: New Zealand stream monitoring and assessment kit. Stream monitoring manual. Version 1. *NIWA Technical Report 40*. 150 p.

Harding, J.S.; Clapcott, J.; Quinn, J.; Hayes, J.; Joy, M.; Storey, R.; Greig, H.; Hay, J.; James, T.; Beech, M.; Ozane, R.; Meredith, A.; Boothroyd, I. 2009: Stream habitat assessment protocols for wadeable rivers and streams of New Zealand. University of Canterbury, Christchurch. http://www.cawthron.org.nz/coastal-freshwater-resources/downloads/stream-habitat-assessment-protocols.pdf

Kilroy, C.; Booker, D.J.; Drummond, L.; Wech, J.A.; Snelder, T.H. 2013: Estimating periphyton standing crop in streams: a comparison of chlorophyll a sampling and visual assessments. *New Zealand Journal of Marine and Freshwater Research.* DOI:10.1080/00288330.2013.772526

Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-765928	Introduction to periphyton monitoring in freshwater ecosystems
docdm-777283	Periphyton RAM data sheets
docdm-146272	Standard inventory and monitoring project plan
docdm-761873	Stream habitat assessment field sheet