Freshwater ecology: periphyton rapid assessment monitoring in streams—method 1 (RAM-1)

Version 1.0

This specification was prepared by Duncan Gray in 2013.

Contents

Synopsis 2
Assumptions 3
Advantages 3
Disadvantages 3
Suitability for inventory 3
Suitability for monitoring 3
Skills 3
Resources 4
Minimum attributes 4
Data storage 5
Analysis, interpretation and reporting 6
Case study A 6
Full details of technique and best practice 10
References and further reading 11
Appendix A 12

Department of Conservation
Te Papa Atawhai

Synopsis

This rapid assessment protocol is based on that presented by Biggs & Kilroy (2000). This protocol is designed specifically to provide a quick assessment of the cover of filamentous algae to establish compliance with periphyton guidelines for the protection of aesthetic, recreational and fishing values (see table 2 in 'Introduction to periphyton monitoring in freshwater ecosystems'—docdm-765928).

Figure 1. Top: blooms of long green filamentous algae. Bottom left: brown filamentous algae adheres to a tracer stone used to assess bed disturbance in a stream. Right: mature long green filaments amid a matrix of light brown mat-forming algae. Photos: Golder Associates.

This method involves establishing transects across a site and recording the percentage cover of filamentous algae, > 3 cm in length, for a given number of points on each transect. Percentage cover values are then averaged to obtain an estimate of the average cover of the site by filamentous green/brown algae. This method can also be used to create an approximate map of filamentous periphyton on the stream bed and if repeated over time in conjunction with physico-chemical measurements be used to suggest the basic controlling factors of periphyton proliferations. Note that another relatively new method for assessing periphyton communities is being used by some regional councils but this is not expanded here (Kilroy et al. 2013).

Assumptions

- The physical habitat conditions at each site are standardised as much as possible.
- Transects and points are positioned randomly within a transect at each site.
- The sample is representative of periphyton cover in the wider stream.

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 compliance with periphyton guidelines.

Disadvantages

- This method provides no information about the composition of periphyton communities.
- The method is only a crude estimate of the actual biomass of periphyton.
- Estimates of cover/length are subject to observer bias.
- The method is not appropriate for use in detecting the effects of specific discharge or pollution events.

Suitability for inventory

This method is only suitable for an inventory of general enrichment/occurrence of nuisance algae; it provides no information about taxa or community composition.

Suitability for monitoring

- This method is suitable for monitoring of general enrichment and nuisance algae and may be applied rapidly over numerous sites to indicate the locations of possible concern.
- The method is not suitable for monitoring specific compliance issues and provides only crude data on periphyton communities.

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:

- 2 tape measures (50 m and 20 m long).
- 4 pegs (> 20 cm long) and mallet.
- Sampling quadrat consisting of an open steel/alloy ring or square 15-20 cm in diameter (size is not critical, but try to use the same size consistently for a given stream/site).
- Glass or clear plastic bowl c. 20 cm in diameter, with a flat bottom for looking into the water. Underwater viewers are now commercially available. They are constructed from clear perspex or bought (e.g. a Nuova Rade viewer).
- Field data sheet or notebook (preferably made of waterproof paper) and pencil.

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 where possible. 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 can be collected without recourse to specialised equipment or processing in a laboratory. Basic training in the use of this habitat sheet and/or 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 within a group of field observers or within a particular project. There is considerable opportunity for user bias with this method of habitat assessment.

Data storage

During field sampling, data is conventionally recorded on a hardcopy data sheet prior to transfer to an electronic format. Hardcopy sheets will 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) is available (see 'Periphyton score field sheet and calculator' in 'Periphyton RAM data sheets'—docdm-777283). This data sheet is designed for use with the RAM-2 protocol and can record percentage cover of 12 types of periphyton. Data from RAM-1 sampling may be recorded on these sheets or into a generic list format into a field notebook in order to save paper. The periphyton score calculator would not produce meaningful results with RAM-1 data. Data should be entered into an electronic media in the same format to avoid confusion. Electronic data sheets should contain all the information required to identify each sample, and any habitat or water chemistry data that was collected simultaneously may be appended on a separate worksheet within the electronic file (usually Excel).

It is important that habitat and water chemistry data are entered in a comparable format to biological data, i.e. columns as sites, and this should be done as soon as possible 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.

All electronic files should have a notes sheet which details any relevant information for future users. In particular, each user, beginning with the field operative who enters the data, should record details of any changes to the data, including when and why they were made. It is also recommended 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.

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, also as soon as possible, and 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.

Summarise the results in a spreadsheet or equivalent. Arrange data as 'column variables'—i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen,

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

identity, etc.) in columns, with each row representing the occasion on which a given survey plot was sampled.

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.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. 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-1 sampling is an estimate of the percentage cover of long filamentous algae only and provides for only limited analytical options. Essentially, the mean cover of long filamentous algae should be calculated for each site and compared to the appropriate guideline threshold (see 'Introduction to periphyton monitoring in freshwater ecosystems'—docdm-765928). If samples are collected at multiple sites along an environmental gradient or on multiple occasions at the same location it will be possible to use correlation or regression analysis to compare algal cover to physico-chemical environmental data.

Case study A

Case study A: assessing periphyton cover before and after dam construction using RAM-1

Synopsis

Filamentous algae are considered to have reached nuisance levels at 30% coverage of the stream bed (Biggs & Kilroy 2000). This is a common occurrence when either nutrient levels increase or flushing flow occurrence decreases, particularly below an impoundment. In this generic example we explore a comparison between a dammed and un-dammed stream by comparing periphyton communities before and after construction of the dam. There were some changes in the physico-chemical environment; stream temperature increased and nitrogen concentration decreased. However, there was a highly significant increase in the cover of filamentous algae, as measured by the RAM-1 method, which occurred after construction of the dam. Additional flow data would have provided more assurance about the result but the overall conclusion is sound.

Objectives

- To assess the effects on filamentous periphyton cover of the construction of a dam on a generic foothills river.

Sampling design and methods

The North and South branches of the Ouse River rise in hill country before converging and flowing out to the sea. The North Branch is in national park whilst the South Branch flows through private farmland. A dam for the generation of hydroelectricity was constructed on the North Branch in December of 2006. The cover of filamentous algae was observed on the bed of the Ouse River North and South branches for 1 year before and after the construction of the dam. This Before–After Control Impact (BACI) design allowed for a comparison of the effect of impoundment on periphyton in the North Branch. The use of a control site also allowed any external broadscale influences to be discounted. Sampling was conducted on 26 occasions in each year but only after a 1-month period of stable flows. Substrate, temperature and nutrient data was collected on each sampling occasion. Sampling was undertaken using the RAM-1 method which estimates the percentage cover of long filamentous algae at a site (Biggs & Kilroy 2000).

Results

Environmental data from the impacted North Branch of the Ouse River was compared to qualify any conclusion made based on the periphyton data (Fig. 2). Substrate in the North Branch did not differ in mean width between 2006 and 2007, ANOVA $p = 0.06$. However, temperature was significantly higher in 2006 after construction of the dam, ANOVA $p < 0.005$. Both the concentration of nitrogen and phosphorus showed a decline after construction of the dam; however, this was significant for nitrogen, ANOVA $p = 0.014$, but not dissolved reactive phosphorous, ANOVA $p = 0.069$.

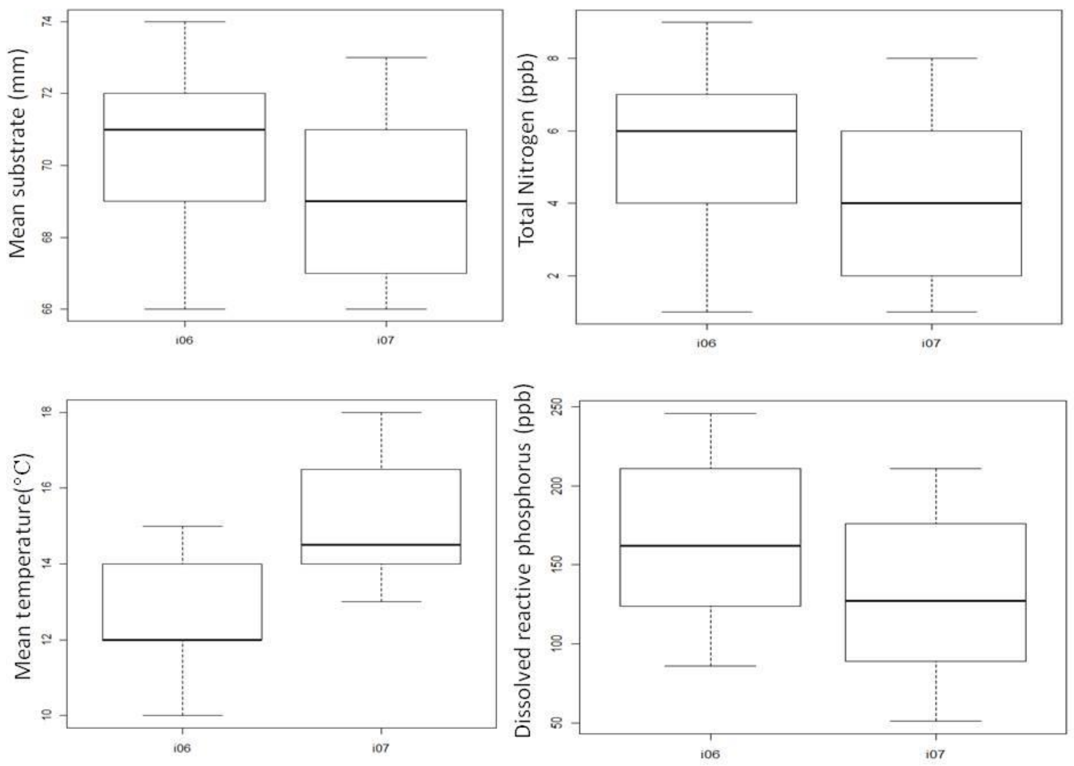

Figure 2. Comparisons of environmental conditions in the North Branch of the Ouse River before (I06) and after (I07) dam construction. Top left: mean substrate width. Bottom left: mean temperature. Top right: total nitrogen. Bottom right: dissolved reactive phosphorus.

Periphyton data from both the North and South branches of the Ouse River clearly show that while the occurrence of long filaments does not change between years in the South Branch control, there is a significant increase after construction of the dam on the North Branch (Fig. 3). Nested ANOVA was highly significant d.f. 3, $F = 22.082$, $p < 0.005$. Tukey's Honestly Significant Difference (HSD) *post hoc* test indicated that I07 was significantly different to the other three groups but that there were no other significant differences.

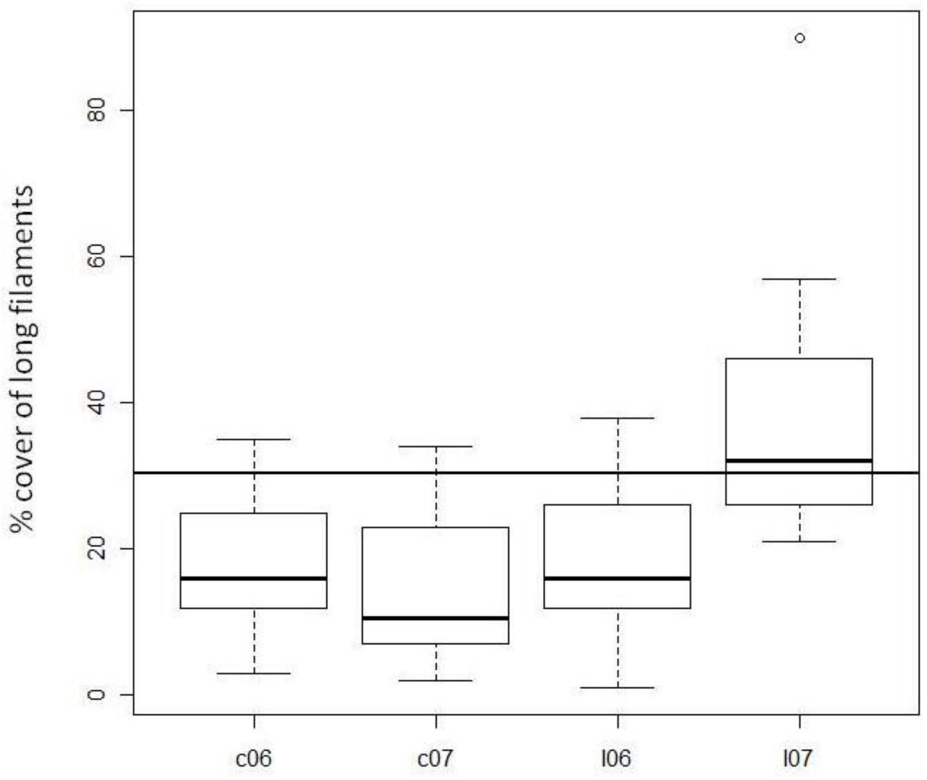

Figure 3. Box plots of the percentage cover of filamentous algae in the South Branch of the Ouse (c—control) and the North Branch (I—impact) prior to dam construction (2006) and after (2007). The horizontal line at 30% cover indicates the nuisance threshold for filamentous algal cover.

This result is highly suggestive of the fact that damming the Ouse North Branch has caused an increase in the occurrence of nuisance algae. This increase occurred despite the decline in the concentration of nutrients in the river.

Limitations and points to consider

The results of this study are quite conclusive in implicating impoundment in the proliferation of periphyton. A very useful additional data set would have been a flow record for both sites. A precise flow record allows accrual periods to be calculated and compared to nutrient levels (Biggs & Kilroy 2000). This would allow river managers to examine the patterns of periphyton growth and make alterations to the release of water from the dam to flush filamentous growth prior to reaching nuisance levels.

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 50 m tape measure to the peg and lay it out taut for its full distance (or 5× the stream width, whichever is the smaller). Attach the upstream end of the tape to a second peg.
- Calculate 10 equally spaced intervals along the tape measure (e.g. 5 m intervals for a 50 m distance.
- Attach the end of the 20 m tape measure to a third peg at the location of the reference peg and unwind the tape at right angles to the main tape. Anchor the far end with the fourth peg on the far bank.
- Divide the width of the stream (water's edge to water's edge) into 10 equally spaced points.
- Place the sampling quadrat on the stream bed centred on the first point.
- Hold the glass bowl or stream bed viewer to obtain a clear view of the streambed (this may not be necessary in small streams with laminar flow).
- Estimate the percentage cover within the quadrat of filamentous green/brown algae which have filaments > 3 cm long. Record these on your field sheet, then move across to the next point.
- Complete the transect, then move the transect for the pre-selected interval and repeat recordings.

Notes

- If the cover of the site is clearly very homogeneous (e.g. broad mats just along the periphery of the channel) then it is acceptable to reduce the number of points across each transect from 10 to 5.
- If the stream is so narrow that the area of the quadrat from one sampling interval overlaps with adjacent points then it is also acceptable to reduce the number of points across each transect or to employ a smaller quadrat.
- If the stream is > 20 m wide or too deep to wade safely, then sub-divide your site in a stream-wise fashion. This involves setting the limits of your transects out into the river based on a fixed depth or distance from shore. Using depth contours is most preferred. You then need to express your results in terms of percentage cover of filamentous algae for, say, the < 0.6 m deep section of the reach.
- There may be some difficulty in determining what constitutes a green/brown filamentous algal community with filaments > 3 cm long. In such cases, familiarise yourself with the communities at the sites before commencing the survey by picking up stones from the stream bed and examining them carefully just below the surface of the water (so that the filaments stream in the current), then lift them above the water for closer inspection.

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