Cawthron Research News

September 2002

"High algal production is one explanation for the Motueka's abundant fish population"

What is driving the food chain in the Motueka River?

This article is the result of work carried out as part of the Integrated Catchment Management (ICM) program that is currently underway on the Motueka River. This program is funded by the NZ Foundation for Research Science & Technology and aims to improve understanding of how to manage a large and complex catchment from the ridge tops to the sea. Research is focusing on issues such as water allocation, effects of changes in land use, and on how people use scientific information to make decisions. The program is a collaborative effort between Landcare Research, Tasman District Council, Cawthron Institute and several other research agencies. For more information on the program check out the website at: http://icm.landcareresearch.co.nz

Freshwater ecosystems are strongly influenced by activities on the surrounding land and are the linkage between the land and the sea. Therefore a good understanding of what is controlling the food-base of these systems is required to understand how changes might affect freshwater ecosystem health and the transfer of material to the coast. In this article Cawthron Scientist Dr Roger Young reports on measurements of the food-base of the river from the headwaters to the lower reaches.

The lower reaches of the Motueka River

On a farm it's obvious that the more grass that you grow, the more sheep or cattle that you can produce. In rivers the same situation applies. The only difference is that there are two distinct sources of 'grass' that may drive the system – algae that grow within the river and terrestrial plant material that grows on the land, but eventually ends up in the river. Some types of invertebrates that live in rivers rely on algae as their main food supply, while others love eating tree leaves. Therefore the relative importance of these two sources of food has a big impact on the numbers and types of stream invertebrates, and subsequently fish, that a river will support.

Current theory on the way that undisturbed river ecosystems work is that the headwaters of forested rivers are primarily fuelled by inputs of terrestrial material. Algae are more important food sources in the mid-reaches of rivers where the channel is wider making a gap in the forest canopy and allowing more sunlight for algal photosynthesis. The lower reaches of really large rivers are often fuelled by terrestrial inputs again because little light is able to reach algae growing on the bottom of a deep and turbid river.

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The relative contribution of terrestrial and aquatic food sources for a reach of a river can be determined using measurements of ecosystem metabolism – the combination of algal production and ecosystem respiration (oxygen uptake). These measurements are made using changes in dissolved oxygen concentration over a 24 hour period. During daylight, algal photosynthesis increases the oxygen in the water, while at night oxygen concentrations decrease due to continual respiration by fish, invertebrates and microorganisms (Figure 1).

Ecosystem metabolism—the combination of algal production and ecosystem respiration

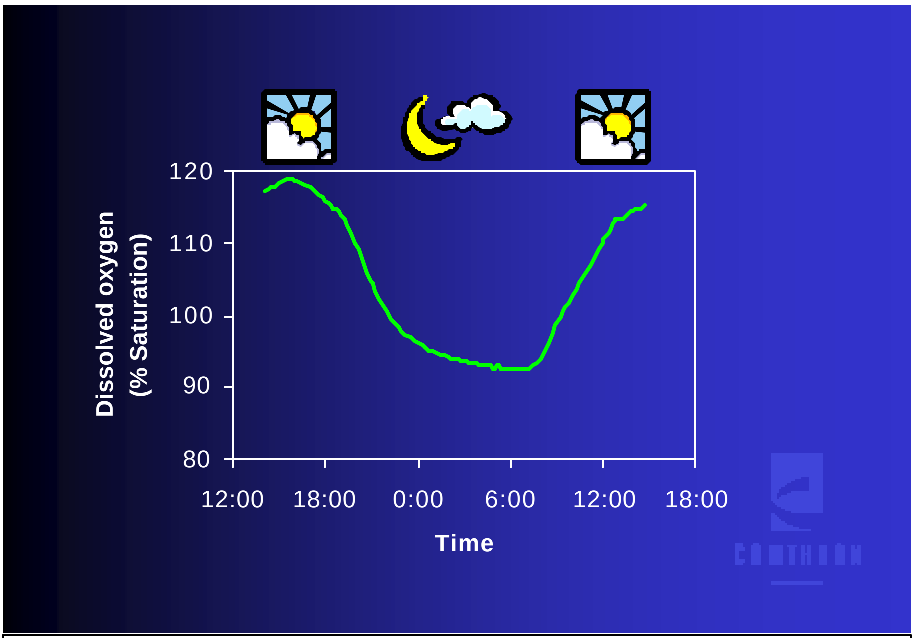

Figure 1. *Dissolved oxygen concentration over a 24 hour period in the lower reaches of the Motueka River.*

Study sites

I measured ecosystem metabolism at nine sites along the length of the Motueka River in winter (July 2001) and summer (March 2002). These sites ranged from Woodmans Bend at the lower end of the Motueka River through to headwater reaches of the Wangapeka and Motupiko (Figure 2). Water quality and light were measured at each of the sites in conjunction with the oxygen measurements.

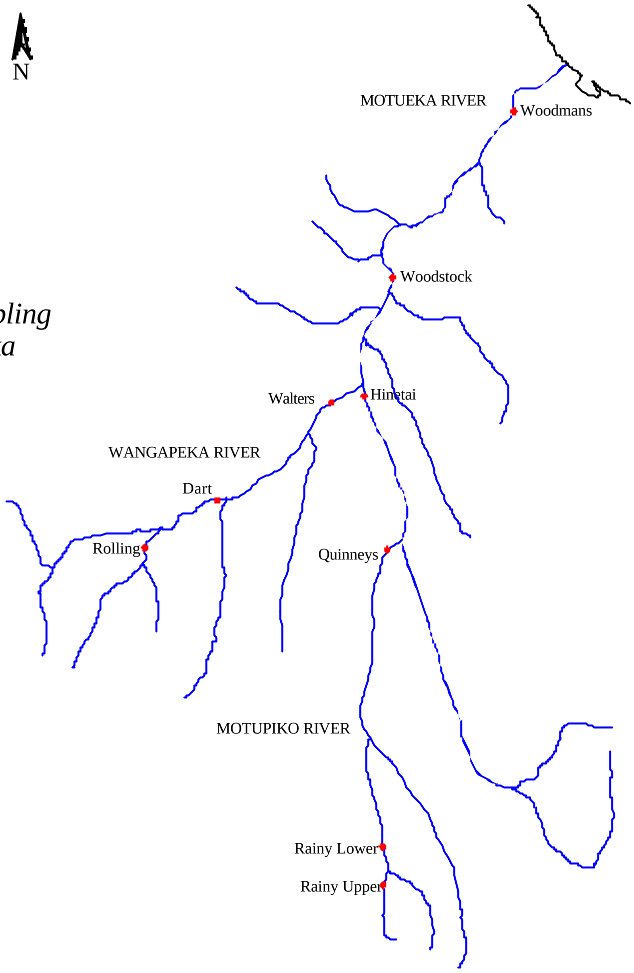

Figure 2. *Location of sampling sites throughout the Motueka River catchment.*

Results

Algal production (GPP) ranged from 0.3 – 13 $gO_2/m^2/day$ in the winter and from 2.4 – 10.9 $gO_2/m^2/day$ in the summer (Figure 3). Community respiration (CR) ranged from 1.6 – 24.8 $gO_2/m^2/day$ in the winter and from 3.5 – 15.6 $gO_2/m^2/day$ in the summer (Figure 3). Algal production was highest in the lower reaches of the river during winter and summer, and community respiration also showed a downstream increase in winter (Figure 3). No longitudinal pattern in community respiration was observed during the summer.

The balance between terrestrial and aquatic food sources is assessed using either the ratio of algal production to community respiration (P/R) or the difference between algal production and community respiration (P-R or Net ecosystem metabolism, NEM). When P/R is >1 (or NEM >0) then more organic matter is being produced than is being consumed in that reach of the river and algal biomass will build up. However, if P/R <1 (or NEM <0) more organic matter is being respired than is being produced in that reach of the river. This suggests that additional sources of organic matter, either from upstream or from surrounding land, are fuelling at least some of the ecosystem.

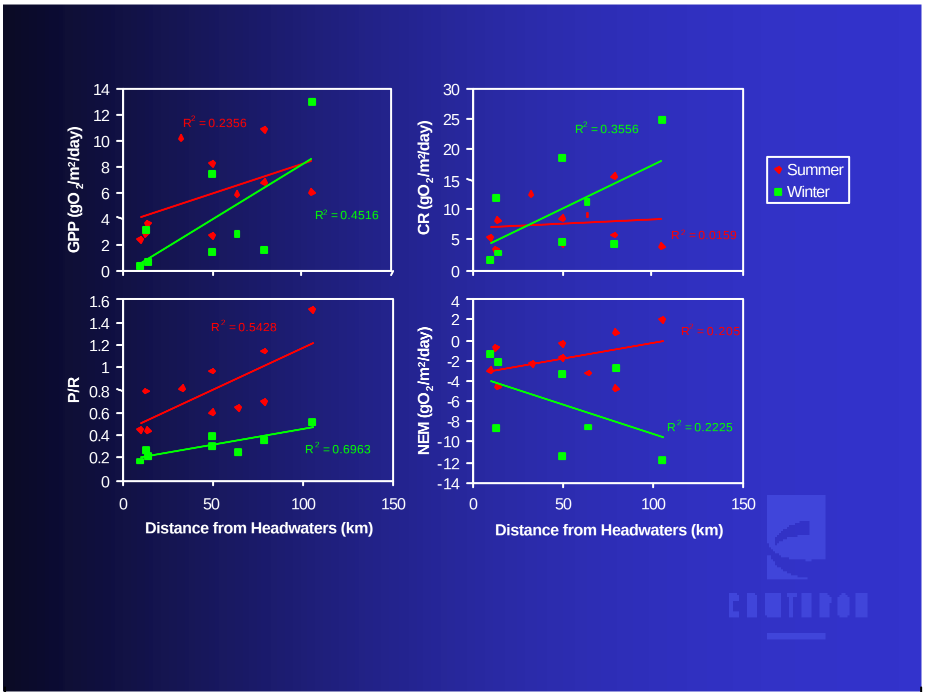

Figure 3. *Longitudinal patterns in algal production (GPP) and community respiration (CR) along the Motueka River. The balance between these measurements (P/R and NEM) is also shown.*

The food chain within the Motueka River appears to rely on terrestrial sources of organic matter during winter, particularly in the headwaters (Figure 3). This is also the case in the headwaters of the river during summer. However, during summer the lower reaches of the river were highly productive (P/R >1) and algal biomass is expected to accumulate and/or be exported downstream and thus contribute to the functioning of the coastal ecosystem (Figure 3). This algal material would potentially provide a very high quality food source for shellfish (cockles, scallops, oysters, mussels) living within the plume extending from the river mouth.

The Motueka River mouth showing the extent of the fresh-water plume into Tasman Bay during a flood.

How important is sunlight?

The amount of sunlight that reaches the bed of a river is often the key factor that controls algal productivity. However, other factors such as nutrient supply may also be limiting rates of photosynthesis. By relating instantaneous measurements of algal production against light intensity it is possible to assess whether light or other factors are controlling photosynthesis. If algal production continues to increase with increasing light intensity then this indicates that light is the limiting factor (Figure 4). However, if algal production levels off at high light intensities then conditions are light saturated and some other factor must be limiting photosynthesis (Figure 4).

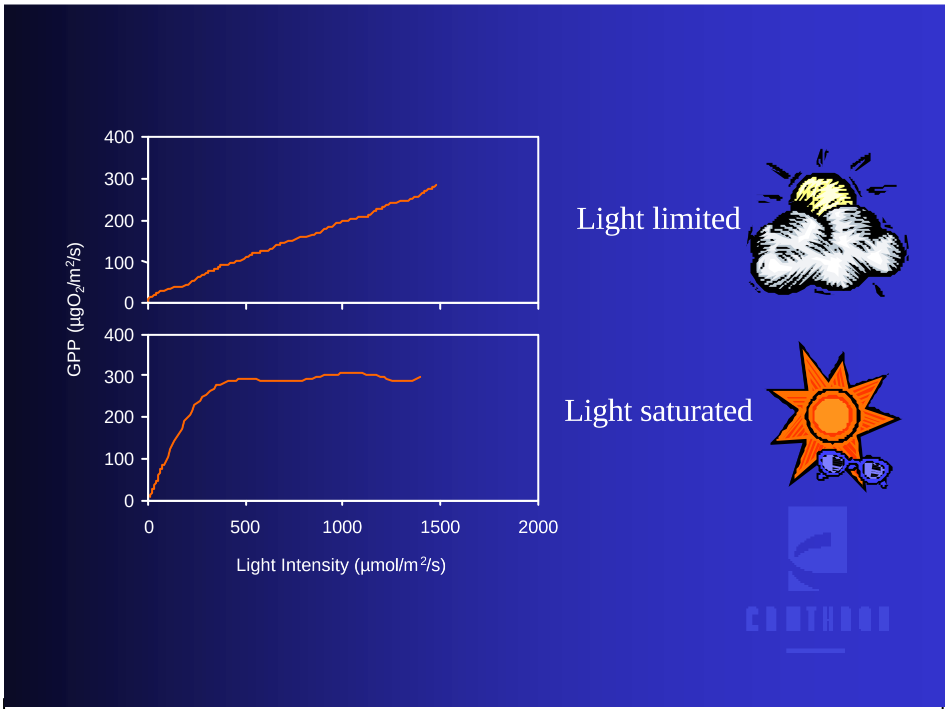

Figure 4. *Characteristic relationships between light intensity and algal production, indicating either light limitation or light saturation of photosynthesis.*

In the Motueka River all the sites that were sampled appeared to be light saturated in both winter and summer. This was surprising considering the relatively thick canopy cover in the headwater sites and suggests that the supply of nutrients (probably nitrogen) is the primary factor controlling algal productivity in the Motueka River. The downstream increase in nitrogen concentration that occurs in the Motueka River is probably responsible for the downstream increase in algal production.

Therefore, any changes in land use that lead to increased levels of nitrogen being leached into river water will result in increased algal productivity. Initially this may be a beneficial effect leading to increased densities of some invertebrates. However, really high levels of algal production may result in algal biomass reaching nuisance levels during long periods of stable flow and thus degrading water quality and physical habitat. Such a large change to the food-base of the ecosystem would result in major changes in abundance and diversity of invertebrates and fish.

How does the Motueka compare with other rivers?

Patterns of algal production and community respiration down the length of the Motueka River are similar to what is predicted by current river ecosystem theory with the upper reaches of the river being primarily fuelled by terrestrial material. On an international scale the Motueka River is relatively small and the lower reaches are still sufficiently shallow and clear to enable light to reach the riverbed, allowing relatively high rates of algal photosynthesis. Algal production in the lower Motueka is high enough to result in abundant high-quality food for grazing invertebrates, but does not appear to be too high and nuisance blooms of algae are uncommon. Grazing invertebrates make up the majority of the diet of trout and other freshwater fish in New Zealand rivers and their abundance is one explanation for the abundant fish populations in this reach of the Motueka River.

More information?

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