Freshwater Research News

Issue 1 May 2009

Welcome to the first issue of ***Freshwater Research News*** (FRN), which aims to disseminate the results of freshwater research to the wider community. Using non-specialist language as far as possible, FRN will bring summaries of the background and significance of recent research projects to a general audience. FRN will give special attention to novel ideas, new interpretations, and interdisciplinary connections involving the freshwater environment.

You might find FRN of interest if you are:

- **involved in managing aquatic resources**, for example as a member of a government agency;
- an **educator or student** interested in aquatic environments;
- a **member of a community organization** involved in environmental protection or conservation (e.g., Landcare, catchment groups);
- an **aquatic researcher** interested in staying aware of developments outside your main specialist area.

Editor's note

I'm planning to produce at least three or four issues of FRN per year, as time permits. Although I intend to include a smorgasbord of material from across the freshwater sciences, the coverage of subjects featured in FRN will inevitably reflect my own biases, so if you think your own pet area receives less attention than it deserves, well that's life I guess…

My own research has focussed chiefly on the ecology and behaviour of fish and crustaceans, mainly at the University of Queensland. In recent years I've been involved in consultancies and educational projects involving stream biodiversity and habitat improvement, and I currently have adjunct positions with Charles Sturt University and the University of Queensland.

Please forward FRN to others who may be interested. To add your name to the **FRN email list**, contact me at K.Warburton@uq.edu.au.

Kev Warburton

Streamside tree cover: "aim for at least 50%"

Fallen leaves and bark are the main sources of energy for organisms inhabiting small forest streams. However, in Australia the historical effects of land clearing have converted large areas originally covered by *Eucalyptus* (e.g. river red gum) forest into pasture or cropland, and the removal of overstorey trees has led to a dramatic decrease in the amount of bottom detritus available to drive instream food webs. Recent measurements suggest that adequate amounts of detritus are generated only where at least 50% of the original canopy cover is retained, a finding that may be useful as a rule of thumb for restoring cleared streams.

Reference: D. J. Reid, P. S. Lake, G. P. Quinn and P. Reich. 2008. Association of reduced riparian vegetation cover in agricultural landscapes with coarse detritus dynamics in lowland streams. *Marine and Freshwater Research* 59, 998-1014.

Floodplain production

Although floodplain habitats are recognized as areas of high river productivity, there have been few direct comparisons of production in the floodplain and the main channel. In the first half of the calendar year, discharge to the Sacramento River is high because of rainfall and snowmelt, and water is diverted through the Yolo Bypass, a 240 km^2 floodplain. Simultaneous monitoring in the main channel and the bypass revealed that although the floodplain received only 3% of the total stream flow, it contributed 14-37% of the total algal biomass entering the estuary downstream. These findings support the idea that if river water can be passed through a floodplain during the flood season, inputs to aquatic food webs should increase.

An interesting finding in this study was that, while algal production was positively related to light and temperature in winter and early spring, these relationships were negative in late spring and summer - presumably because intense light levels near the surface had an inhibitory effect on algal growth.

Reference: Lehman P.W., & Sommer, T. & Rivard, L. 2008. The influence of floodplain habitat on the quantity and quality of riverine phytoplankton carbon produced during the flood season in San Francisco Estuary. *Aquatic Ecology* 42,363–378.

Animal movements between drainage basins: how random are they?

Geomorphological barriers between major freshwater systems mean that movements of stream fauna between adjacent drainage basins are impossible or very rare. Mitochondrial sequence data have been used to look for evidence of genetic exchange across the barrier that separates the Lake Eyre and Gulf of Carpentaria basins. Two species were studied: bony bream (*Nematolosa erebi*) and freshwater prawn (*Macrobrachium australiense*). While there was no evidence that prawns had dispersed across the divide in the last million years, bony bream populations seem to have crossed at least twice, around 160,000 and 350,000 years ago. These events occurred well after the Pliocene (5.5 – 3.3 million years ago), when geological activity connected and rearranged the two basins. It seems that since the Pliocene faunal dispersal has occurred only very rarely, presumably assisted by low topography and large-scale flood events. Why bony bream, but not freshwater prawns, managed to disperse, requires more explanation: was it just a random occurrence or can it be explained by biological (e.g., life history) differences between the species?

Reference: Kate D. Masci, Mark Ponniah and Jane M. Hughes. 2008. Patterns of connectivity between the Lake Eyre and Gulf drainages, Australia: a phylogeographic approach. *Marine and Freshwater Research*, 59, 751-760.

Invasive species not entirely bad

Dense stands of invasive plants can have serious negative impacts on aquatic ecosystems – for example, they can impede water exchange, reduce nighttime oxygen concentrations and change pH levels. Nevertheless, depending on the growth form of the species concerned, they can still provide structurally suitable habitats for fish and their macroinvertebrate prey. Thus their overall impact will depend on the balance between their negative and positive features. *Lagarosiphon major* is an exotic macrophyte that commonly outcompetes and replaces native aquatic plants. In Lake Dunstan, New Zealand, it forms a dense band around the entire lake perimeter and extends to a depth of about 6 m. The biomass of a native fish species (the common bully, *Gobiomorphus cotidianus*) increases with the density of *Lagarosiphon*, and bully diets are dominated by invertebrates commonly associated with macrophytes. Although removal of the weed isn't feasible because it easily recolonises from upstream, it seems that *Lagarosiphon* can provide some ecosystem functions in disturbed habitats.

Reference: Bickel, T.O. & Closs, G.P. 2008. Fish distribution and diet in relation to theinvasive macrophyte *Lagarosiphon major* in the littoral zone of Lake Dunstan, New Zealand. *Ecology of Freshwater Fish* 17, 10–19.

Copepods and mosquito control

Gambusia (mosquitofish) are commonly used for mosquito control, but are difficult to stock in small water bodies and can have disastrous negative impacts on native freshwater fauna. In a search for other natural control agents, an Indian study has shown that copepod crustaceans (*Mesocycops aspericornis*) are efficient predators on mosquito larvae (*Anopheles stephensi*). Because these copepods often occur at high density in shallow, stagnant water bodies and have the ability to enter a dormant stage to help them survive regular periods of drying, they are promising candidates for the control of mosquito populations.

Reference: R. Kumar, P. Muhid, H.-U. Dahms, L.-C. Tseng and J.-S. Hwang. 2008. Potential of three aquatic predators to control mosquitoes in the presence of alternative prey: a comparative experimental assessment. *Marine and Freshwater Research* 59, 817-835.

Active research on activity

In principle, bioenergetic models can give good estimates of food consumption and growth rates of predators, but they rely heavily on assumptions about the levels of activity of the animals concerned. Activity can be measured from video records of animals held in enclosures, but to follow activity patterns over a full growing season, a very intensive sampling program is required. A potentially much more cost-effective approach is to measure the mean concentration of a chemical tracer (such as stable caesium, ^{133}Cs) in the bodies of sampled predators at two points in time and calculate the amount of tracer that has accumulated as a result of feeding on prey during the intervening period. However, the tracer approach assumes a direct relationship between tracer accumulation and activity, and also assumes that the concentration of tracer in the food, and its assimilation in predator bodies, remain constant, which is unlikely. Comparisons of the two approaches using Arctic char, a salmonid fish, suggest that video records are more trustworthy than tracer data when in situations where animal behaviour can be well described (e.g., as in enclosures or on coral reefs). When behaviour patterns are unknown (e.g., during migrations) the tracer approach is preferable, but its reliable application will require more accurate information on tracer concentrations and assimilation.

Reference: Guenard, G., Boisclair, D., Ugedal, O., Forseth, T. & Jonsson, B. 2008. Comparison between activity estimates obtained using bioenergetic and behavioural analyses. *Canadian Journal of Fisheries & Aquatic Sciences* 65, 1705-1720.

Swimming in the rain

Small terrestrial arthropods, such as springtails, beetles, ants and flies, that drop into streams are an important food source for fish. In a tropical (Hong Kong) study, terrestrial arthropods contributed up to 43% (by volume) of the diet of a local species of cyprinid fish (*Parazacco spilurus*).

Arthropod "rain" into forest streams was estimated at about 20 grams dry weight per square metre per year. The corresponding estimate for shrubland streams was about 25% lower (c. 15 grams). These estimates were higher than those made in previous studies on temperate streams in Japan and Oregon (9-14 grams).

Reference: Eric K. W. Chan, Yixin Zhang and David Dudgeon. 2008. Arthropod 'rain' into tropical streams: the importance of intact riparian forest and influences on fish diets. *Marine and Freshwater Research* 59, 653-660.

Understanding sediment dumping

Where the width of a stream is artificially reduced, for example by channelisation or levee construction, the flow velocity, and thus the capacity of the stream to transport sediment, are increased. However, stream narrowing can sometimes cause sediment to be unexpectedly dumped rather than removed, and there are cases where sediment has built up so much that the river is raised above the level of the floodplain, and where levees have failed in extreme floods. Mathematical modeling has shown how unexpected sediment dumping can be caused by the way that stretches of narrowed channel alternate with unconfined, wider reaches, and demonstrates the potential dangers associated with sharp variations in channel width.   The model gives a picture of how the river bed evolves through time by showing how waves of sediment erosion and deposition propagate up and down the stream from a point of narrowing.

Reference: Siviglia, A., Repetto, R., Zolezzi, G. & Tubino, M. 2008. River bed evolution due to channel expansion: general behaviour and application to a case study (Kugart River, Kyrgyz Republic). *River Research & Applications* 24, 1271–1287.

More than meets the eye

Although it's a commonplace that surface runoff is an important source of sediment in freshwater streams, the relative importance of sediment that enters via subsurface (drainage) pathways is much harder to gauge. Researchers in the U.K. simultaneously measured surface and subsurface sediment flows in a small agricultural catchment and found that subsurface sources dominated the sediment supply. Although rainfall, and hence soil saturation and surface runoff, were low during the monitoring period, the study highlighted the need for comparative data from other catchments to help clarify how subsurface pathways deliver sediment and pollutants to streams. For example, do subsurface inputs derive mainly from sediment originally eroded at the surface, or from sediment mobilized below the surface? Subsurface passage is likely to be most important in soils such as artificially-drained cracking clays, where macropore networks are well-defined.

Reference: Deasy, C., Brazier, R.E., Heathwaite, A.L. & Hodgkinson, R. 2009. Pathways of runoff and sediment transfer in small agricultural catchments. *Hydrological Processes* 23, 1349–1358.

Development, hydrology and ecosystems

How does the development of water resources affect the functioning of river ecosystems? In particular, what are the impacts of water extraction and flow regulation? Comparisons of north Australian rivers with those in the Murray-Darling basin, which can be used as reference systems to assess post-development change, suggest that there are three main hydrological drivers of ecological function. These are the regularity and permanence of flows, the variability and absence of flows, and the extent of wet-dry seasonality. The findings emphasize the need for water resource development to be carried out in an ecologically-sensitive fashion.

Reference: Leigh, C. & Sheldon, F. 2008 Hydrological changes and ecological impacts associated with water resource development in large floodplain rivers in the Australian tropics. *River Research & Applications* 24: 1251–1270.

Safer at night

Stocks of Atlantic salmon are declining in the face of a variety of threats, including competition with exotic fish species. Invasive rainbow trout are aggressive toward Atlantic salmon and force them to leave their refuges, making them more vulnerable to day-active predators. However, at twilight and at night, trout have no significant effect on salmon behaviour, apparently because aggression is reduced at low light levels.

Reference: Blanchet, S., Loot, G., Bernatchez, L. & Dodson, J.J. 2008. The effects of abiotic factors and intraspecific versus interspecific competition on the diel activity patterns of Atlantic salmon (*Salmo salar*) fry. *Canadian Journal of Fisheries & Aquatic Sciences* 65, 545-1553.

Dust storms can create algal blooms

Following a severe dust storm in October 2002, levels of plant plankton in coastal waters off Queensland increased to up to twice the long term average. Dust storms deliver nutrients such as iron, which encourages the growth of blooms of nitrogen-fixing cyanobacteria (blue-green algae). The fertilizing influence of dust storms is likely to be greatest in the dry season, when the supply of riverborne nutrients is low, and this effect is set to become more common as a result of extended droughts predicted under climate change.

Since iron has been shown to limit phytoplankton growth in lakes, dust storms are no doubt capable of fertilizing freshwater as well as marine systems.

References:

Emily C. Shaw, Albert J. Gabric and Grant H. McTainsh. 2008. Impacts of aeolian dust deposition on phytoplankton dynamics in Queensland coastal waters. *Marine and Freshwater Research* 59, 951-962.

Vrede, T. & Tranvik, L. J. 2006. Iron Constraints on Planktonic Primary Production in Oligotrophic Lakes. *Ecosystems* 9, 1094-1105.

Gutless diet analysis

Working out the range of foods consumed by an animal population helps to clarify how it is supported by particular types of prey. A standard way to collect dietary information is to examine the contents of predator guts, but because the feeding patterns of individuals are often quite flexible, many guts must normally be examined to obtain a reliable picture for the population as a whole. A promising alternative approach, trialled through a study of the diets of perch and roach in a Finnish lake, is to use the fact that a predator's body composition mirrors that of its prey. In particular, variations in stable carbon and nitrogen isotopes across individuals should give an indication of the diet width for the whole population. Unlike conventional diet analysis, this technique reflects the feeding history, rather than just the last meal, of each predator, so that accurate population-level information can be achieved with smaller sample sizes. The researchers found that after mass removal of fish from the lake, isotope variances increased, presumably because the food spectrum expanded in response to the lower availability of fish prey. The isotope variance of perch later contracted sharply, at a time that coincided with increased fish prey in the form of young-of-the-year perch and roach.

Reference: Syvaranta, J. & Jones, R. 2008. Changes in feeding niche widths of perch and roach following biomanipulation, revealed by stable isotope analysis. *Freshwater Biology* 53, 425–434.

Lake fertility (1): effects of latitude

When nutrient inputs are high, dense growths of plant plankton and periphyton (small surface-attached algae and bacteria) can shade out higher plants (macrophytes) in lakes. However, in principle macrophytes should do better in warmer climates because higher temperatures, greater light intensities and longer growing seasons will allow them to colonise deeper water and increase their surface cover. Higher rates of evaporation in warm conditions should have the effect of reducing water levels, increasing light intensities at the bottom of lakes and assisting macrophyte growth. Macrophytes also benefit by harbouring grazing animals that help to limit algal populations.

In mesososm (enclosed environment) experiments in a number of shallow European lakes, when nutrients were added the biomass of periphyton increased and the biomass of higher plants declined. However, plants managed to survive better towards the lower end of a north-south gradient (Spain) than towards the northern end (Finland). It seemed that macrophyte growth was helped by higher light intensities and evaporation-driven drops in water level in the southern lakes. In a year when the temperature gradient was less clear, the effect of latititude disappeared.

Reference: Becares, E. et al. 2008. Effects of nutrients and fish on periphyton and plant biomass across a European latitudinal gradient. *Aquatic Ecology*, 42,561–574.

Lake fertility (2): effects of nutrient pulses

How does the timing of nutrient inputs, as opposed to the total nutrient input over a given period, affect the make-up of freshwater communities? U.S. scientists ran an experiment in which 24 wetland mesocosms containing topsoil and well water were first inoculated with phytoplankton, periphyton, macrophytes, zooplankton, benthic invertebrates and associated microbes, and then fertilized with different nutrient regimes. As the nutrient load was increased, the biomass of filamentous algae rose but the biomass of macrophytes fell. However, these responses were strongest when nutrients were added at regular intervals, rather than all at one time. It seems possible that when supplies of dissolved nutrients are more continuous, algae in the water column are better placed to exploit them than the roots of macrophytes below the sediment surface.

Reference: Butzler, J. & Chase, J. 2008. The effects of variable nutrient additions on a pond mesocosm community. *Hydrobiologia*, 617, 65-73.

Survival of endangered salmon

The sockeye salmon of Snake River, Idaho, are notable because they have the most southerly distribution of all sockeye populations. They also travel the largest distance from the ocean (1450 km) and ascend higher (2000 m) than other sockeye on their spawning migration. However, Snake River sockeye suffer a high mortality rate on their long migration, and the population is presently poised on the brink of extinction. Until recently, almost nothing was known about the factors that affect migration mortality, but a telemetry study has revealed that survival is related to fish condition (which is in turn affected by the burden of parasites and injuries), the exposure to temperatures above 21^{o}C (which increases metabolic costs and the prevalence of disease), and the timing and difficulty of migration. Late-season migrants have a lower survival, and warming as a result of climate change is likely to further select against later migrants and increase the importance of cool-water habitat refuges.

Reference: Keefer, M. L.; Peery, C. A. & Heinrich, M. J. 2008. Temperature-mediated *en route* migration mortality and travel rates of endangered Snake River sockeye salmon. *Ecology of Freshwater Fish*, 17, 136-145.

Habitat area or habitat structure?

A basic tenet of ecological theory is that numbers of species tend to increase with the area of available habitat. However, numbers of macroinvertebrate species and individuals living in a lake-fed river in Finland were unrelated to the area of the stones on which they occur. Habitat complexity seemed to be more important than habitat area because species richness and numbers of individuals were closely correlated with the cover of bryophytes (mosses and liverworts), which provide significant opportunities for refuge and feeding.

Reference: Heino, J. & Korsu, K. 2008. Testing species–stone area and species–bryophyte cover relationships in riverine macroinvertebrates at small scales. *Freshwater Biology* 53, 558–568.

Spotlight on meiofauna

Meiofauna are aquatic invertebrates less than 1 mm in size. Although they may account for over 80% of the total number of species in freshwater streams, their ecological role is unclear, partly because the sieves used for the routine collection of benthic invertebrates have a mesh size of 0.5 mm, and don't retain small meiofauna. Because of its influence on the availability of oxygen and food, and the removal of waste products, substrate particle size probably has an important influence on the density and distribution of meiofauna. In a study of Arkansas headwater streams, substrate size successfully predicted the densities of most of the main meiofauna taxa. Copepods and nematodes were associated with silt and fine sand. Rotifers occurred in fine sand but avoided coarse sand. Hydrachnids avoided silt. The study showed that meiofauna can be abundant and diverse in headwater streams, and that meiofaunal communities are likely to be affected by accumulations of fine particles typically associated with human disturbance.

Reference: Radwell, A.J. & Brown, A.V. 2008. Benthic meiofauna assemblage structure of headwater streams: density and distribution of taxa relative to substrate size. *Aquatic Ecology* 42, 405–414.