Freshwater Research News

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About FRN

Freshwater Research News (FRN) aims to bring the results of current freshwater research to a wider audience. Using non-specialist language as far as possible, FRN summarises the background and significance of recently-published research findings, giving special attention to novel ideas, new interpretations, and interdisciplinary connections involving the freshwater environment. FRN appears four times per year.

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.

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Ultraviolet light (1).....UV as an opportunity

Several fish species are capable of ultraviolet vision and have UV body patterns that are used for social signalling. Sexually mature female sticklebacks have dark bars on the upper body that have high UV contrast with the surrounding silvery water, and UV signals influence the choice of female sticklebacks by males. In experimental trials, a mature female was separated from a male by an angled barrier containing two optical filters. One filter transmitted UV light but the other did not. Male fish spent more time viewing the female through the full-spectrum filter than through the one opaque to UV. This preference on the part of males wasn't simply a by-product of female behaviour, since females didn't show a bias toward either of the filters.

Reference: Rick, I.P. & Bakker, T.C.M. (2008). UV wavelengths make female three-spined sticklebacks (*Gasterosteus aculeatus*) more attractive for males. *Behavioral Ecology & Sociobiology* 62, 439–445.

Ultraviolet light (2) …..UV as a threat

In high latitudes, ultraviolet radiation has the potential to be very damaging to aquatic animals because waters are relatively transparent and light is continuous during summer. In addition, UV fluxes have increased due to ozone depletion, and are set to increase by a further 20-90% over the next ten years. These concerns have prompted research to assess the extent to which different species are protected from UV damage by naturally occurring pigments (typically, high latitude animal plankton are red, brown or black in colour). Analyses of twelve common crustacean species - including water fleas, copepods, fairy shrimps and tadpole shrimps - collected from tundra ponds in Canada and Alaska revealed the presence of four main types of UV protectants, namely carotenoids, melanins, scytonemin and mycosporine-like amino acids. All twelve species had protective pigments and most had multiple types. Since the various pigments have different protective properties, it seems that when they occur together, these compounds provide plankton with broadband sunscreens.

Reference: Rautio, M., Bonilla, S. & Vincent, W.F. (2009). UV photoprotectants in Arctic zooplankton. *Aquatic Biology* 7, 93–105.

Interactions between viruses and bacteria

Viruses are a major source of mortality for aquatic organisms, and their attacks on bacteria and plankton release nutrients which are recycled through the microbial and plant-based food chains. Although suspended organic and inorganic particles in rivers and lakes are known to support rich microbial communities, there have been few studies on the interactions between suspended particles, viruses and bacteria. Experiments with water taken from the Danube River showed that abundances of both viruses and bacteria were higher on organic particles (leaf litter and visible suspended aggregates) than inorganic particles (mineral sediment). They were also higher on particles that were aged in water rather than fresh, presumably because aging allowed a biofilm to develop on the particle surface. Bacterial production in the water was reduced when counts of planktonic viruses were high, but it increased when attached viruses were abundant, possibly because the adhesion of viruses to particles prevented them from infecting bacteria in the water, and/or because attacks by attached viruses released nutrients from particle cells. In summary, attached bacteria were strongly affected by particle quality, while bacteria in the plankton were more affected by viral abundance.

References:
Kernegger, L., Zweimuller, I. & Peduzzi, P. 2009. Effects of suspended matter quality and virus abundance on microbial

parameters: experimental evidence from a large European river. *Aquatic Microbial Ecology* 57, 161–173.

Weinbauer, M.G., Bettarel, Y., Cattaneo, R., Luef, B., Maier, C., Motegi, C., Peduzzi, P. & Mari, X. 2009. Viral ecology of organic and inorganic particles in aquatic systems: avenues for further research. *Aquatic Microbial Ecology* 57, 321-341.

Invasive mussels hit Great Lakes fisheries

In the Great Lakes of North America, the spread of introduced zebra mussels and quagga mussels (*Dreissena* species) since the late 1980s has led to major changes in the populations of bottom-dwelling animals. *Dreissena* compete for food with native species, and their abundant shells and waste products significantly modify the lake sediments. Populations of several major invertebrate groups declined by up to 75% between 2000 and 2003. These invertebrates included species of *Diporeia* (scuds, or amphipods). Because *Diporeia* are the main preferred food of the lake whitefish, their demise has caused whitefish to switch to less profitable prey. At the same time there have been strong declines in whitefish growth and abundance, with serious implications for commercial fisheries of the Great Lakes.

Reference: Nalepa, T.F., Pothoven, S.A. & Fanslow, D.L. 2009. Recent changes in benthic macroinvertebrate populations in Lake Huron and impact on the diet of lake whitefish (*Coregonus clupeaformis*). *Aquatic Ecosystem Health & Management*, 12(1), 2–10.

Stunningly efficient electrofishing

Electrofishing, where an electric current is used to stun fish so that they are easy to catch, is a standard technique for sampling freshwater fish. A common electrofishing practice is to sample a predetermined length of stream in a single pass. Several studies have examined whether single-pass electrofishing gives a good index of the size of trout and salmon populations, but few have assessed its ability to accurately represent the multispecies structure of fish communities. Canadian researchers electrofished 50 m stretches of stream near Lake Ontario and found that single- and multiple-pass sampling provided very similar estimates of the relative importance of taxonomic families, feeding guilds, reproductive guilds and disturbance-sensitive fish species. Thirty-three fish species were caught, including sunfish, trout, suckers and sculpins. On average, only 0.7 extra species per site were collected by multiple-pass sampling compared to single-pass fishing, leading the authors to conclude that in their streams, species detection was best served by single-pass sampling at several sites rather than multiple-pass sampling at fewer sites.

Reference: Reid, S.M., Yunker, G. & Jones, N.E. 2009. Evaluation of single-pass backpack electric fishing for stream fish community monitoring. *Fisheries Management and Ecology* 16, 1–9.

Endocrine disruptors increase after rain

Some chemical contaminants that enter freshwater systems are known to be endocrine disruptors - in other words, they have the capacity to interfere with the physiology of aquatic organisms by mimicking or blocking hormones. Even when concentrations of individual contaminants are too low to have a measurable impact, endocrine disruption can still result from continuous exposure to a mixture of chemicals, making it important to study the effects of several contaminants at the same time. Swiss researchers used liquid chromatography coupled with a mass spectrometer to measure the concentrations of a range of endocrine disrupting compounds in wastewater and in water taken from the Glatt River in an industrial area near Zurich. In treatment plants, removal rates for most types of endocrine disruptor were high, but in some cases, levels of endocrine disrupting compounds actually increased, presumably due to chemical transformation in the wastewater. Removal efficiency was highest in plants where activated sludge treatment was followed by sand filtration. When river flows increased as a result of heavy rainfall, flows of endocrine disruptors also increased and there was no evidence for pollutant dilution. The observed increase was probably due to the fact that when rainfall was high, treatment plants were unable to handle the extra capacity and were forced to discharge raw wastewater directly into the river.

Reference: Jonkers, N., Kohler, H-P. E., Dammshauser, A. & Giger, W. 2009. Mass flows of endocrine disruptors in the Glatt River during varying weather conditions**.** *Environmental Pollution* 157, 714–723.

Glaciers, climate warming and stream ecology

Recent reviews of the impacts of glacial change on stream hydrology and ecology note that glaciers have shown a consistent retreat over the last 20-30 years, and that continued climate warming over the next century is likely to lead to significant changes to glacier-fed streams. In response to warming trends, streamflows are predicted to rise initially, but then fall to a lower level due to glacier retreat and a reduction in the area available for snowmelt. Recent modelling for the Bridge River catchment in British Columbia predicts a long-term decline in glacier area and summer streamflows of around 30%. Other work suggests that a 10% loss in glacier cover would increase stream temperatures by 1.2 – 1.6% in summer. This is likely to be ecologically significant since, for example, a warming of 2^{o}C in water temperature is sufficient to produce a shift in the dominant species of trout by affecting the balance of competition. Increased temperatures will encourage higher levels of biological production and species diversity, but lower flows will slow the movement of nutrients downstream, reduce the availability of side channel habitats, and favour

organisms with less streamlined and flattened body shapes. As glaciers retreat they initially deliver more sediment to streams, which can alter channel morphology and water quality. However, in the longer term, sediment transport is more likely to decline as glacial erosion and runoff decrease. Non-environmental impacts will also be felt, including a reduced capacity for hydropower generation as a result of lower streamflows.

References:
Moore, R.D., Fleming, S.W., Menounos,B., Wheate, R., Fountain, A., Stahl, K., Holm, K. & Jakob, M. 2009. Glacier change in western North America: influences on hydrology, geomorphic hazards and water quality. *Hydrological Processes* 23, 42–61.

Milner,A.M., Brown, L.E. & Hannah, D.M. 2009. Hydroecological response of river systems to shrinking glaciers. *Hydrological Processes.* 23, 62–77.

High densities trigger floodplain migrations

Many animals, including species of insects, mammals, fish and birds, undergo migrations from seasonal environments. Surprisingly little is known about the factors that trigger these movements, although unfavourable conditions, limited resources, predation pressures and competition have all been proposed. The Guinea tilapia (*Tilapia guineensis*) is the commonest fish species on the Gambia River floodplain. This species occurs in pools, normally at densities of around 11 fish / m^2 but at times as high as 500 fish / m^2, and rapidly colonises new habitats that become available in the rainy season. The willingness of Guinea tilapia to migrate was assessed by counting the number of fish that traversed a shallow ramp to escape from a 1 m x 1 m outdoor tank over a seven day period. The proportion of the population that migrated was significantly higher when fish were stocked at a density of 40 / m^2 than when they were at low or medium densities (10 or 25 fish / m^2), probably because of increased territorial competition at high density. In other experiments, withholding food from fish stocked at medium density had no significant effect on migration rate, although there was an increase in exploratory behavior (attempts to move onto the ramp).

Reference: Louca, V., Lindsay, S.W. & Lucas, M.C. (2009). Factors triggering floodplain fish emigration: importance of fish density and food availability. *Ecology of Freshwater Fish* 18, 60–64.

Agricultural pollution cuts out key shredders

Farming-related changes in land use have been shown to affect the structure and composition of aquatic communities and to reduce the efficiency with which organic matter is broken down and recycled in streams. To relate aquatic community structure to ecosystem function, French researchers measured sediment microbial activity and rates of leaf litter breakdown at twelve stream sites that differed in terms of surrounding land

use (forest, extensive agriculture, intensive agriculture). Results from the four-month field program showed that microbial activity was positively correlated with sediment organic content and point-source nutrient pollution from local farms, but was unrelated to broader land-use patterns. In contrast, the breakdown of beech leaf litter in coarse mesh bags was unrelated to local nutrient levels but strongly related to land use, showing a 75% decrease in intensively farmed areas compared with a forested reference site. Litter breakdown was also directly related to the abundance of shredding invertebrates collected from the litter bags. These shredders were dominated by gammarids (shrimp-like amphipods), which made up most of the invertebrates at the reference site. Gammarids are sensitive to high levels of nitrogen and phosphorus, which explains their low numbers at the impacted locations. The results suggest that the rate of litter breakdown, but not microbial activity, is a useful index of agricultural impact at the catchment level, but they also highlight the key role played by one dominant group (gammarids) as opposed to the invertebrate or shredder communities as a whole.

Reference: Piscart, C., Genoel, R., Doledec, S., Chauvet, E. & Marmonier, P. 2009. Effects of intense agricultural practices on heterotrophic processes in streams. *Environmental Pollution* 157, 1011–1018.

Biodiversity boosts ecosystem function

Although several studies have shown that the richness of invertebrate species in an ecosystem tends to have a positive effect on primary production, few researchers have examined whether larger-bodied vertebrate species can have a similar impact. In principle, increases in the richness of fish assemblages should increase primary production because the combined effects of species with different feeding strategies are beneficial – for example in reducing the abundance of grazing invertebrates, increasing the flow of nutrients from land to water by eating insects, increasing nutrient flow by foraging on drifting organic matter, and redistributing nutrients by disturbing the sediment. A study in Oklahoma used experimental channels containing zero to six local fish species selected randomly from a larger pool of twelve species. In all channels containing fish, total fish density was kept constant. Primary production over a 42 day period was measured by reference to algal growth on clay tiles placed in each artificial stream, and had a significant positive relationship with the number of fish species. These results suggest that fish assemblages composed of species with different feeding strategies tend to show more complementary or facilitating interactions than more uniform assemblages, and support the idea that ecosystem functions and services are likely to be damaged by species extinctions.

Reference: Hargrave, C.W. 2009. Effects of fish species richness and assemblage composition on stream ecosystem function. *Ecology of Freshwater Fish* 18, 24–32.

Pinning down connectivity

The concept of connectivity is increasingly used to help explain a wide range of hydrological, geomorphological and ecological patterns and processes. However, the term connectivity is used in a number of different ways depending on the scientific discipline. For example, connectivity can refer to physical connections between hillslopes, floodplains and river channels within a catchment; the degree of coupling between surface water and subsurface aquifers; the transfer of sediment and other material between locations; or the efficiency with which runoff, animals or plant propagules can move through a stream network. This variation in use has prompted calls for a common definition of connectivity which can help workers in different disciplines to compare hydrological responses across a range of studies. In a recent review, two U.K. researchers advocate the use of a connectivity index that addresses this need. The index provides the probability that any two points are connected, and thus enables mapping of the points and their likelihood of being connected to a specific location. This approach should make it easier to focus on underlying hydrological processes rather than local complexities, and to link measurements made at different scales in space and time.

Reference: Michaelides, K. & Chappell, A. 2009. Connectivity as a concept for characterising hydrological behavior. *Hydrological Processes* 23, 517–522.

Genetic erosion due to pollution

Because most laboratory experiments on the ecological effects of chemical pollutants on aquatic species have focussed on single-generation impacts, the longer term consequences of contamination are much less well understood. German researchers reared four populations of midges (*Chironomus riparius*) in the lab over 12 generations. Two populations of midge larvae were exposed to sediment contaminated with the pesticide tributyltin, while the other two populations were experimental controls. In each generation, a range of life history parameters, including larval mortality and egg hatchability, were measured, and genetic diversity was assessed using microsatellite markers (variable repeating sequences of DNA). Relative to the controls, the pollutant-exposed midges had lower reproductive output, delayed larval development, higher larval mortality and lower genetic diversity. There were no time trends in any of the life history traits, which suggested that there had been no selection for stress-tolerant midges. However, the lower rates of survival and fertility in the exposed groups reduced the effective population size, the number of individuals contributing

to the next generation, and thus genetic variation. The results have conservation implications because they suggest that small, isolated populations are particularly vulnerable to the rapid erosion of genetic diversity as a result of chemical exposure.

Reference: Nowak, C., Vogt, C., Pfenninger, M., Schwenk, K., Oehlmann, J., Streit, B. & Oetken, M. 2009. Rapid genetic erosion in pollutant-exposed experimental chironomid populations. *Environmental Pollution* 157, 881–886.

Measuring flows using streambed temperature

How best to study the exchange of water between surface flows and subsurface aquifers? Although a number of methods are available, most have drawbacks in terms of the effort involved, the variable quality of the data obtained, or the potentially adverse impacts of environmental intervention. A relatively easy and effective monitoring solution relies on changes in streambed temperature to track flows between surface water and groundwater. Research on a perennial stream in Mississippi, carried out as part of a study to assess fate of agricultural contaminants, shows that long duration data collected during extreme high-flow events (in this case, Hurricane Katrina and Hurricane Rita in 2005) can give reliable indications of the direction and rate of vertical exchange. At the study site the stream normally received water from the aquifer, which was higher than the streambed, but during strong rain events the levels of stream and aquifer reversed and water recharged the aquifer. At such times the amount of water moving down through the streambed was about 1% of the total discharge.

Reference: Barlow, J.R.B. & Coupe, R.H. 2009. Use of heat to estimate streambed fluxes during extreme hydrologic events. *Water Resources Research* 45, W01403, doi:10.1029/2007WR006121.

Out (of range) for the count

Although mobile acoustic surveys are widely used to estimate fish stocks in both marine and freshwater environments, little is known about the reactions of fish to survey vessels operating in the relatively shallow waters of rivers and lakes. Canadian researchers used a side-scanning sonar system on the bank of the Fraser River to investigate the responses of migrating adult salmon to a 6.7 m motor boat. They found that fish within 4 m of the vessel's propeller swam off to one side, away from the downward-pointing sonar system towed by the boat. These observations help to explain why, in recent studies in the same river, mobile sonar recorded only 36% of nearshore fish passages that were simultaneously monitored by shore-based sonar, and show that avoidance responses can lead to serious underestimates of fish abundance in shallow water.

Reference: Xie, Y., Michielsens, C.G.J., Gray, A.P., Martens, F.J. & Boffey, J.L. 2008. Observations of avoidance reactions of migrating salmon to a mobile survey vessel in a riverine environment. *Canadian Journal of Fisheries and Aquatic Sciences*. 65, 2178-2190.