Freshwater Research News

Issue 2   September 2009

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 will summarise the background and significance of recently-published research findings, giving special attention to novel ideas, new interpretations, and interdisciplinary connections involving the freshwater environment. Four issues a year are planned.

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

Many thanks to everyone who sent me positive comments following the first issue of FRN. Encouraged by the response, I'll continue in the same vein!

Please:

- ❖ forward this newsletter to other individuals or networks who may not yet know about FRN.
- ❖ contact me if you'd like to be added to, or deleted from, the mailing list.

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Natural-born contaminators

By acting as prey for riparian predators such as spiders, birds, bats, reptiles and amphibians, aquatic insects play an important role in the transfer of energy and materials from freshwater to terrestrial food webs. However, many freshwater streams have a history of pollution: for example, in the U.S. 38% of recently surveyed stream sections were listed as ''impaired'' for fish consumption, mainly due to persistent contaminants such as mercury and polychlorinated biphenyls (PCBs). Do insects therefore transfer persistent pesticides from impaired streams to the riparian zone?   A South Carolina study shows that they do. Measurements of stable isotope concentrations in fauna from a stream polluted by PCBs were used to clarify feeding pathways, by identifying the prey types taken by different riparian predators. PCB concentrations were also measured, and were found to be high in several predator species. Predators that depend heavily on aquatic insects contained the highest PCB levels. The use of chemical contaminants as tracers of stream-derived energy can help to bridge the gap between reach-scale and landscape-scale studies.

Reference: Walters, D.M., Fritz, K.M. & Otter, R.R. 2008. The dark side of subsidies: adult stream insects export organic contaminants to riparian predators. *Ecological Applications* 18(8), 1835–1841.

Conditional success

One way of studying the responses of predators to changes in the abundance of their prey is to monitor the status of both predator and prey populations over time, which is usually a costly and time-consuming operation. A simpler, albeit indirect, alternative is to assume that a predator's body condition (its weight for a given length) reflects its growth rate, feeding success and, and therefore the availability of prey. This assumption has been supported in studies of walleye (*Sander vitreus*, a perch-like fish) in Oneida Lake, New York. Analysis of data collected over 23 years revealed that the body condition of walleye was directly related to their growth rate (as deduced from scale rings) and prey fish abundance (based on trawl catches and mark-recapture experiments). However, in some other studies of fish body condition, such correlations were weak or non-existent. Therefore, before using predator condition as an indicator of prey fish abundance, preliminary work should be done to confirm that predator and prey populations in the target water body are closely coupled.

Reference: Vandervalk, A.J., Forney, J.L. & Jackson, J.R. 2008. Relationships between relative weight, prey availability, and growth of walleyes in Oneida Lake, New York. *North American Journal of Fisheries Management* 28,1868–1875.

Staying in circulation

Groynes are rigid structures that extend from a river bank into the channel, often at right angles to the stream. While they have been traditionally used by engineers to reduce bank erosion, their role in habitat improvement (e.g., by helping to increase pool-riffle diversity) has also been recognised. By affecting the amount of time that water is retained in small-scale eddies, groynes can influence ecological processes like nutrient dynamics and plankton growth. However, to date the use of groyne fields in stream rehabilitation projects has been mainly a trial-and-error affair because we haven't had a very clear idea of how groynes affect flow dynamics. Austrian researchers have gone a long way toward remedying this situation by using computational fluid dynamics to simulate 3-D water movement in groyne fields, and then checking their model against observations in the River Danube. Their findings contradicted a previous assumption that groynes delay the passage of water most when river flows are low: retention times were actually highest when flows were just high enough to submerge the groynes. The flow model is transferable to other groyne systems, and is being refined to include the effects of wind and bank vegetation.

Reference: Tritthart, M., Liedermann, M. & Habersack, H. 2009. Modelling spatio-temporal flow characteristics in groyne fields. *River Research & Applications* 25, 62–81.

Dams and biodiversity

Dam-building typically limits the natural variations in river flow and water temperature that are important to maintain aquatic biodiversity. Controlled releases of water from dams can help to offset the loss of physical variation to some extent, but they don't always improve biodiversity. Releases from Granby Reservoir on the upper Colorado River had little impact on low macroinvertebrate diversity in the area just below the dam, where water flows and temperatures were both regulated. In contrast, at a site 5 km downstream of the dam, where flows were regulated but temperatures were near-natural, macroinvertebrate communities were richer and similar in structure to those above the dam. The main message from this study is that restoring natural flows may not succeed in restoring biodiversity unless other important deficits, such as the lack of thermal variation, are also addressed.

Reference: Rader, R.B., Voelz, N.J., Ward, J.V. 2008. Post-flood recovery of a macroinvertebrate community in a regulated river: resilience of an anthropogenically altered ecosystem. *Restoration Ecology* Vol. 16 (1), 24–33.

More phosphorus in groundwater than previously thought

Because phosphorus (P) is the main limiting nutrient in most freshwater ecosystems, it's essential to restrict artificial inputs of this element to help prevent environmental problems such as plankton blooms and negative impacts on food webs. Traditionally, phosphorus control has been viewed as a surface-water issue: P has a strong tendency to adsorb onto mineral particles and to form metal complexes in the soil and subsoil, and transfers of phosphorus to and from groundwater have not been considered important. This view has now been challenged following the analysis of historical water quality data from 3600 sites in the U.K. and the Irish Republic, which showed that concentrations of P in groundwater often exceeded national thresholds for nutrient enrichment. Levels of P at urban sites were significantly higher than elsewhere, and were lowest in areas of woodland and semi-natural grassland or scrub. More research is needed to better understand two-way transfers of P between groundwater and the surface, and the effects of such transfers on nutrient concentrations.

Reference: Holman, I. P., Whelan M. J,. Howden N. J. K,. Bellamy P. H,. Willby N. J,. Rivas-Casado M & McConvey P. 2008. Phosphorus in groundwater—an overlooked contributor to eutrophication? *Hydrological. Proceses* 22, 5121–5127.

Magical model passes the acid test

Over the last 150 years the fallout from industrial emissions (acid rain) has increased levels of acidity in inland waters, especially in Europe and North America, with serious consequences for ecosystem health. Efforts are underway to reverse the effects of acidification, but in order to assess their success it's important to compare present-day acid levels with original "natural" concentrations. Pre-industrial acid levels in lakes are commonly estimated using a mathematical model (MAGIC - Model of Acidification of Groundwater in Catchments). Although powerful, MAGIC requires many types of input data, on hydrology, local land use, rainfall, runoff and lake water quality, which limits its application. To address this problem, Swedish researchers have developed a much simpler model that requires data only on present-day concentrations of base cations (Ca, Mg, Na, K), sulphate and chloride. The new model was calibrated to pre-industrial reference values predicted by MAGIC for 95 Swedish lakes, and has a high level of reliability.

Reference: Erlandsson, M., Folster, J., Wilander, A. & Bishop, K. 2008. A metamodel based on MAGIC to predict the pre-industrial acidity status of surface waters. *Aquatic Sciences* 70, 238–247.

Natural clean-up of uranium

High levels of uranium in drinking water threaten human health because of the dangers associated with radiation and chemical toxicity. Environmental monitoring in the Kaminosawa Stream in central Japan revealed a sharp increase in dissolved uranium near a large K-feldspar mine. Downstream, four concrete dams capture suspended silt and sand originating from the mine. In the sediments collected by the dams, there was a strong relationship between uranium and the levels of organic and amorphous inorganic matter, indicating that uranium was being removed from the water by adsorption. The results showed that dissolved uranium was reduced to near-normal background levels by sediment capture and downstream dilution.

Reference: Manaka, M., Seki, Y., Okuzawa, K. & Watanabe, Y. 2008. Uranium sorption onto natural sediments within a small stream in central Japan. *Limnology* 9,173–183.

A fine line

Human disturbance tends to increase the amount of fine sediment entering freshwater streams. High loads of fine sediment in streams can have negative effects on the growth, reproduction and migration of fish, but there have been few attempts to define threshold sediment concentrations above which fish communities are significantly impacted. Data gathered from mountain streams in 12 western U.S. states showed that an ecological condition score based on the diversity and biology of fish and amphibians fell by 4.7% for each 10% increase in fines (defined as bottom sediment particles less than 0.06 mm in diameter). To conserve aquatic vertebrates in these mountain streams, fines should not exceed 5% of all sediment particles.

Reference: Bryce, S.A., Lomnicky, G.A., Kaufmann, P., McAllister, L.S. & Ernst, T.L. 2008. Development of biologically based sediment criteria in mountain streams of the western United States. *North American Journal of Fisheries Management* 28, 1714–1724.

Floodplain habitat fragmentation

In arid and sub-arid environments, floodwaters trigger strong pulses in productivity by creating temporary aquatic habitats on the river floodplain and delivering nutrients to stimulate the food web. After a flood event, water bodies on the floodplain gradually dry out and become more fragmented. In principle, the resulting mosaic of conditions should lead to wide contrasts between water bodies in terms of the densities of different species. Support for this prediction has come from a study of a floodplain – wetland complex in the Narran River in south-east Australia. During a nine-month period following a flood in February 2004, total zooplankton densities at different sites on the floodplain diverged strongly and eventually varied over a wide range (< 30 to >4000 animals / litre). At some sites plankton communities became distinct within a couple of weeks of the flood event, probably due partly to variations in the emergence of resting stages from the sediment. While site differences explained most of the variation in the abundance of some plankton groups (water fleas, seed shrimps), the time since flooding was a more important factor for other groups, such as copepods. Densities of water fleas were highest at the only site with aquatic vegetation, possibly because it helped to protect them from predators. These findings help to show how the timing of flood events and small-scale floodplain habitat mosaics interact to affect river production.

Reference: James, C.S.., Thoms, M.C. & Quinn, G.P. 2008. Zooplankton dynamics from inundation to drying in a complex ephemeral floodplain-wetland. *Aquatic Sciences*. 70, 259 – 271.

Infochemicals inhibited by UV

Kairomones are “infochemicals” that escape from predators and stimulate prey species to develop improved anti-predator defence systems. For example, predatory phantom midges (*Chaoborus* sp.) release a kairomone that is detected by hairs on the antennae of juvenile water fleas (*Daphnia* sp.), which are common prey of midges. As a result, the water fleas develop toothed keels on their heads, which help to protect them against midge predation.

It's well known that ultraviolet radiation (UV) can have adverse effects on aquatic organisms, and that it alters and degrades organic substances. It seems that this impact extends to infochemicals, because water fleas placed in water containing UV-treated kairomone extract developed keels that were less than half the normal size. These results show that UV has the potential to affect predator-prey interactions in aquatic systems. Plankton such as waterfleas show strong vertical migration, and avoid the upper water layers by day. Vertical migration can therefore help to protect prey species by ensuring that they are in contact with active kairomones, but away from the harmful effects of direct UV radiation.

Reference: Sterr, B. & Sommaruga, R. 2008. Does ultraviolet radiation alter kairomones? An experimental test with *Chaoborus obscuripes* and *Daphnia pulex. Journal of Plankton Research* 30 (12), 1343-1350.

How to get a sleeker body in four weeks

Some animals respond to different environmental conditions by changing their body form. Compared to control fish raised in still water, juvenile montezumae swordtails (*Xiphophorus montezumae*) raised in flowing water for 32 days developed more streamlined bodies by increasing their length : depth ratio. In faster-swimming fish species such as salmonids, forced exercise is known to increase food intake, which provides the energy needed for swimming. In contrast, the swordtails in these experiments didn't show a similar change in appetite. These results point to the possibility that fast- and slow-swimming species may respond differently to high flow conditions, and that species with changeable body form can reduce their energy needs through better streamlining.

Reference: Alcaraz, G. & Urrutia, V. 2008. Growth in response to sustained swimming in young montezumae swordtails, *Xiphophorus montezumae. Marine and Freshwater Behaviour and Physiology* 41(1), 65–72.

Weedy competitors

Although the competitive success of coexisting plant species depends on above-ground and below-ground effects, the ways that these types of competition operate together aren't well understood. In aquatic plants the issue is especially complex because, while the shoots of aquatic species compete for light and the roots compete for nutrients (as in land plants), the shoots also compete for dissolved carbon and nutrients taken up from the water. *Hydrilla verticillata* and *Myriophyllum spicatum* are both invasive aquatic weeds that readily displace native plants. In mixed-species experiments *Hydrilla* grew faster, branched more and shaded out *Myriophyllum*, while at the same time reducing the root growth of the other species. Therefore, in this case both above-ground and below-ground interactions were positive for *Hydrilla* . However, *Hydrilla* was limited by shoot competition with other plants of its own species. In dense weedbeds, water pH increases and this restricts the source of inorganic carbon to bicarbonate. It's therefore likely that the invasive ability of some aquatic plants (such as *Hydrilla*) is partly due to their ability to adapt to low light levels and high levels of bicarbonate.

Reference: Wang, J-W.., Yu, D., Xiong, W. & Han, Y-Q. 2008. Above- and belowground competition between two submersed macrophytes. *Hydrobiologia* 607,113–122.

What drives lake food webs?

Because of their landlocked status, lakes have often been assumed to support relatively closed ecosystems, with food webs that are driven mostly by internal production - i.e., photosynthesis by aquatic plants within the lake itself - rather than by inputs of carbon from the surrounding land. This belief has been challenged by recent studies in which lake waters have been labelled with inorganic carbon (^{13}C) to track transfers of carbon through the food web. In Peter Lake, a small lake in Wisconsin, estimates of the amount of fish growth supported by externally-sourced carbon were high (51-80%). Although this contribution fell to 25-55% when nutrients were added to the lake, presumably because they stimulated internal production, the results showed that lake food webs can be heavily subsidized by terrestrial carbon. This conclusion seems to hold regardless of lake size. In Lake Crompton, Wisconsin, a relatively large lake with a maximum depth of 18.5 m, around half of the growth of fishes (bluegill and yellow perch) was fuelled by external carbon sources. Bottom-dwelling invertebrates were more important food sources for fish than midwater prey, even though the production of invertebrates was much higher in midwater than on the bottom. Although somewhat paradoxical, this finding was probably due to the fact that midwater invertebrates tend to be relatively small, and therefore less attractive as prey.

References:

Carpenter, S., Cole,J. Pace,M., Van de Bogert, M., Bade, D., Bastviken, D., Gille, C., Hodgson, J., Kitchell, J. & Kritzberg, E. 2005. Ecosystem subsidies: terrestrial support of aquatic food webs from ^{13}C addition to contrasting lakes. *Ecology* 86, 2737 –2750.

Weidel, B., Carpenter, S., Cole, J., Hodgson, J., Kitchell, J., Pace, M. & Solomon, C. 2008. Carbon sources supporting fish growth in a north temperate lake. *Aquatic Sciences* 70, 446 – 458.

Selectively targeting toads

The cane toad (*Bufo marinus*), a native of Central & South America, has been introduced to over thirty countries around the world to control insect pests. However it has turned into a serious environmental problem itself, mainly because it is highly toxic and poisons native predators. Managing the cane toad threat is a major challenge, but help may be at hand in the form of pheromone-based control agents. As with other species of toads and frogs, cane toad tadpoles communicate using chemical cues, and lab tests showed that they fled when extracts from the bodies of tadpoles of the same species were added to their water. The same chemicals also reduce tadpole survival rate. Crucially, chemical communication seems to be species-specific because tadpoles of fifteen native Australian species of frogs did not respond to the cane toad extract, which raises the possibility of developing a biological control agent that selectively targets invasive toads.

References:

Hagman M. & Shine R. 2008. Australian tadpoles do not avoid chemical cues from invasive cane toads (*Bufo marinus*). *Wildlife Research* 35A, 59–64.

Hagman M. & Shine R. 2009. Species-specific communication systems in an introduced toad compared with native frogs in Australia. *Aquatic Conservation: Marine & Freshwater Ecosystems* 19, 724–728.

Freshwater conservation and agriculture

Agricultural activities threaten freshwater biodiversity by causing habitat loss, pollution from chemicals and nutrients, and sedimentation as a result of soil erosion. Governments now offer financial incentives to farmers and land managers to adopt environmentally-sensitive practices, but there have been few attempts to assess how well these measures protect aquatic species. Since freshwater biodiversity and agriculture tend to be inversely related, it's possible to model the conservation impacts of returning agricultural land to semi-natural habitats such as forest, woodland, grassland and wetland. Researchers in an English study that involved the collection of data on 361 species of freshwater plants and macroinvertebrates concluded that it was possible to protect aquatic biodiversity, at a much higher level and at no extra cost, by creating areas of semi-natural habitat around targeted high-biodiversity water bodies. This type of reserve design would extend effective protection to up to 90% of the species surveyed, including most of the rare ones. Costs were measured in terms of available remuneration for the creation of buffer strips under the English Environmental Stewardship scheme. The study was notable in that reserve design incorporated information on both species richness and the presence of rare species, and drew on data from a wide range of habitat types (lakes, ponds, ditches, rivers and streams). Ponds were the most useful reserve elements because of their high richness and rarity value and their low costs of inclusion.

Reference: Davies, B., Biggs, J., Williams, P. & Thompson, S. 2009. Making agricultural landscapes more sustainable for freshwater biodiversity: a case study from southern England. *Aquatic Conservation: Marine & Freshwater Ecosystems* 19, 439–447.