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Dear Jonny,
Following our meeting and site visit to potential trout spawning tributaries, in the Bruce Creek Catchment of Lake Brunner, under Envirolink advice grant WCRC28, this letter provides a summary of the issues that we discussed on site and some suggestions for future actions.

Recent increases in agricultural landuse intensity, particularly in association with conversion to dairy farming, have been accompanied by a perception, among anglers, that the quality of recreational trout fisheries has declined in affected lowland streams. The impacts of increased fine sediment loads in streams affected by agriculture are of particular concern.

Fish & Game's regular monitoring of the Lake Brunner trout fishery has shown large fluctuations in the size and abundance of trout in the lake. This trout population supports a significant recreational fishery, with many anglers attracted from outside the district.

To be most effective, monitoring programmes for trout and other fish need to be underpinned by a limiting factor analysis which considers the sensitivity of the various life history stages to the range of potential effects. Many physical and biological features influence the abundance of salmonid populations and it is crucial to identify the factors that limit production (Reeves et al. 1991; Hartman et al. 1996). There may be specific daily or seasonal periods when food, cover, water quality, or predation act to control the size of a specific population. An informal limiting factor analysis undertaken by Fish & Game suggested that spawning and recruitment success were the factors most likely to be limiting the trout population in Lake Brunner. Potential impacts of recent dairy farm conversions in the catchment on the quality and quantity of spawning habitat were identified as a possible issue.

Brown trout typically spawn in the autumn to early winter, laying their eggs in nests (or redds) that the female excavates in the streambed gravels. The female then digs more gravel from immediately upstream to cover the eggs, which incubate in the gravel over winter before hatching in the spring. The young trout (alevins) remain in the gravels of the redd until they have absorbed the remaining contents of their yolk-sacks, and subsequently emerge as fry. The incubation period is temperature dependent and may take 2–3 or more months in the Westland.

Good quality trout spawning habitat requires sufficient intra-gravel flow to provide the incubating eggs with dissolved oxygen, and remove metabolic waste products. The substrate also needs to be of suitable quality. Small enough that it can be moved by the female trout as she digs her redd, and free of excessive amounts of fine sediment that reduce the permeability of the gravel. Shivell & Dungey (1983) found that brown trout in New Zealand preferred a mean substrate size of 14 mm for spawning. However, they are capable of moving larger substrate. Kondolf (2000) suggested that the maximum movable size of substrate for spawning salmonids is gravel with a median diameter up to about 10% of their body length. So for a 60 cm trout the median substrate size should not be above 60 mm. Raleigh et al. (1986) stated that brown trout prefer gravel with a diameter of about 10 to 70 mm for spawning substrate, but utilise gravel from 30 to 100 mm.

However, salmonids are particularly sensitive to the direct effects of sedimentation (by silt and sand) of their spawning habitat and to indirect effects through sediment smothering their benthic invertebrate food resources (Waters 1995). Sedimentation can also reduce the habitat quality for juvenile and adult fish, by clogging interstitial spaces that are often used as cover, and by infilling pools (Bjornn & Reiser 1991).

Another consideration is the stability of the substrate in relation to the tractive forces generated by floods during the spawning season. If floods cause the gravels in which the eggs are incubating to move, significant mortality is likely to result. For this reason the relative stability of flow in spring fed streams makes for good trout spawning habitat, as long as they have suitable substrate.

Fry and fingerling rearing habitat adjacent to spawning areas is a requirement for the successful development of young trout. Fry/fingerlings require cover where they can take refuge from predators and from disturbances, such as floods. In small spring fed streams they often use undercut banks, over hanging vegetation, or macrophytes as cover.

During our site visit we visually inspected short sections of a number of tributaries running through predominantly dairy farming land. Most tributaries appeared to be unfenced, or fenced on one side only, allowing free stock access to the steam banks and bed. Much of the potential trout spawning habitat in these streams appeared to be degraded, with large quantities of fine sediment being a particular issue, although the prolific macrophyte beds (mainly watercress) would be expected to provide good juvenile trout habitat – at least in places where part of the channel remains open and flowing. The two tributaries we visited (School Creek and an unnamed tributary of Bruce Creek) that were fenced to prevent stock access on both banks had large amounts of suitable looking spawning gravels, with much lower concentrations of fine sediment. This suggests that land use practices, particularly allowing stock free access to the banks and streambeds, have led to spawning habitat degradation.

However, it is not clear that simply excluding stock from the streams would be sufficient to restore the spawning habitat in these streams. As part of the land development process some of tributaries appear to have had their channels widened, and in some places straightened, presumably in an attempt to increase their capacity to convey flood flows. However, this has resulted in wider slower flowing streams, with reduced ability to flush out accumulated fine sediment (i.e. reduced stream power). It may take more than simple riparian fencing to remedy this. Some efforts at revegetation with bank stabilising plants such as flax and low shrubby plants may be required, with the aim of narrowing and deepening the channel using a stream's own hydraulic power. Resulting shading may also help to reduce excessive growth of water cress – thereby reducing sedimentation and flow restriction. It may also be necessary to restore some sinuosity in streams that have been straightened, in order to increase habitat diversity within the stream.

In the longer term it would be good to assess the effects of installing riparian fencing to exclude stock from already degraded spawning habitat, to see if that intervention alone would be sufficient to bring about an improvement. The Bruce Creek Catchment lends itself to a comparative study of changes in habitat condition over time in newly fenced sections of stream, versus streams where stock access remains unrestricted.

Monitoring in the meantime should focus on whether landuse practices in the catchment are continuing the degradation of trout spawning habitat. Consideration should be given to installing a continuous turbidity meter in Bruce Creek to capture episodic turbidity events in the monitoring record. Continuous turbidity/water clarity data would also allow effects to be interpreted with respect to frequency and duration (not just magnitude). Pulses of suspended solids will be accompanied by siltation of the stream bed. Frequent or continuous monitoring of water clarity or turbidity ought to pick this up, but infrequent monitoring may not. Pulses of turbidity, and entrained sediment, from frequent or irregular cow crossings, or bank grazing may be missed by infrequent monitoring, but over time do substantial damage through siltation of the stream bed. Continuous turbidity data could be used in combination with NIWA's suspended sediment data, from their ongoing study in the catchment, to estimate annual sediment loads.

WCRC's monitoring programme would also benefit by including an assessment of the distribution of spawning habitat within the catchment and an assessment of stream-bed sedimentation. Heavy siltation is obvious even to the casual observer. Often it can be seen blanketing the stream bottom and filling in the spaces between cobbles and gravel. Where surface blanketing is less obvious (e.g. in riffles), plumes of sediment will be released when the bottom is disturbed with the foot. However, the challenge is to quantify what is otherwise a subjective visual assessment.

Quantitatively determining the quality of salmonid spawning habitat can be a difficult and time consuming undertaking. It usually involves taking gravel samples from redds and estimating either the percentage of fines (silt and sand fractions) or geometric mean particle diameter and its variance. These measures can then be used to estimate embryo incubation mortality based on published correlative studies (Shirazi & Seim 1979, 1981). Incubation mortality can also be directly estimated by digging up a sample of redds near the end of the incubation period and calculating the proportion of eggs that are dead (Hobbs 1937, 1940). A combination of the two approaches allows one to determine whether there is a problem and whether it is related to infiltration of spawning gravels with fine sediment (Hay 2005). As well as sedimentation, trout eggs incubating in the gravel are also susceptible to damage through trampling by stock, if they have access to the stream.

LandCare Research has made progress with developing a relatively rapid fine sediment assessment technique. They recently reviewed methods for characterising riverbed substrates and settled upon a quick visual assessment of dominant substrate size and proportion of fine sediment at points along cross-sections in runs as being appropriate for catchment wide assessment and monitoring of fine sediment deposition (Phillips & Basher 2005).

NIWA has also contributed to this subject with the 'quorer' – colloquially termed the 'Irish rubbish tin' (Quinn et al. 1997; http://www.niwascience.co.nz/ncwr/tools/quorer/). This is a cost-effective, quantitative option for regional councils to assess fine sediment levels and the results are directly relevant for interpreting benthic macroinvertebrate samples and trout spawning habitat. With the 'quorer' method, a 24 cm diameter x 32 cm PVC pipe is placed on the stream bed and the top 5–10 cm of substrate disturbed to suspend fine sediment. Water samples are then taken of the 'slurry' and analysed for suspended sediment concentration. The mean suspended sediment concentration within the pipe is subtracted from the ambient concentration in the stream to give the contribution from the stream bed.

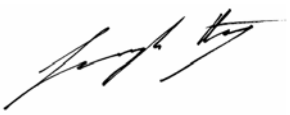
If this approach was adopted by WCRC as part of its monitoring programme, it would ultimately provide a quantitative basis for comparison of fine sediment content of the streambed over time, and could be used as a basis for measuring the efficacy of any changes landuse management. It could also be used to provide a comparison between sediment content of the streambed in existing fenced versus unfenced sections of stream (perhaps based in School Creek).

It would also be worthwhile to attempt to assess whether the remaining trout spawning habitat is sufficient to saturate the available juvenile rearing habitat. This could be done with electric fishing surveys in the early summer, to compare existing fry densities with theoretical maximum densities. Grant & Kramer (1990) provide a regression equation to predict the maximum density of juvenile salmonids based on their length:

$(\log_{10} \text{density} = -2.61 \log_{10} \text{fork length} + 2.83)$.

We hope that you find these suggestions useful.

Regards,



Joe Hay

and

John Hayes

Reference:

Bjornn TC, Reiser DW 1991. Habitat requirements of salmonids in streams. In: Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats, edited by W.R. Meehan. American Fisheries Society, Bethesda, Md. p. 83-138.

Grant WA, Kramer DL 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Freshwater and Aquatic Sciences 47: 1724-1737.

Hartman GF, Scrivener JC, Miles MJ 1996. Impacts of logging in Carnation Creek, a high-energy coastal stream in British Columbia, and their implications for restoring fish habitat. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1): 237–251.

Hay J 2005. Survival of trout eggs in relation to sediment composition of redds in Waikakahi Stream. Prepared for Fish and Game New Zealand. Cawthron Report No. 965.

Hobbs DF 1937. Natural reproduction of quinnat salmon, brown and rainbow trout in certain New Zealand waters. New Zealand Marine Department, Fisheries Bulletin No. 6. Government Printer, Wellington.

Hobbs DF 1940. Natural reproduction of trout in New Zealand and its relation to density of populations. New Zealand Marine Department, Fisheries Bulletin No. 8. Government Printer, Wellington.

Kondolf GM 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society 129: 262-281.

Phillips C, Basher L 2005. Catchment channel characteristics and riverbed substrate assessment – a review and trial of a method of fine sediment assessment in the Motueka River. Motueka Integrated Catchment Management Programme Report Series, LandCare ICM Report No. 2004-05/01

Quinn JM, Cooper AB, Davies-Colley RJ, Rutherford JC, Williamson RB 1997. Land use effects on habitat, water quality, periphyton, and benthic invertebrates in Waikato, New Zealand, hill-country streams. New Zealand Journal of Marine and Freshwater Research 31: 579–597.

Raleigh RF, Zuckerman LD, Nelson PC 1986. Habitat suitability models and instream flow suitability curves: brown trout. U.S. Fish & Wildlife Service Biological Services Program FWS/OBS/-82/10.71.

Reeves GH, Hall JD, Roelofs TD, Hickman HL, Baker CO 1991. Rehabilitating and modifying stream habitats. In Influences of forest and rangeland management on salmonid fishes and their habitats. Edited by W.R. Meehan. American Fisheries Society Special Publication 19: 519–557.

Shirazi MA, Seim WK 1979. A Stream Systems Evaluation: An emphasis on spawning habitat for salmonids. U.S. Environmental Protection Agency, Corvallis, Oregon. 36p.

Shirazi MA, Seim WK 1981. Stream system evaluation with emphasis on habitat for salmonids. Water Resources Research 17:592-594.

Shirvell CS, Dungey RG 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. Transactions of the American Fisheries Society 112: 355-367.

Waters TF 1995. Sediment in streams: sources, biological effects and control. Bethesda, Md., American Fisheries Society.