List of 'First Cut' References with Abstracts

Supplement to:

A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest

By

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List of 'First Cut' References with Abstracts

The references and abstracts in this supplementary document were analyzed and reviewed for "A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest," by Peter B. Bayley, as reported to the Washington State Independent Science Panel in May, 2002. The 441 'first cut' documents listed here resulted from a search in Cambridge Scientific Abstracts (CSA). In some cases the CSA abstracts listed below were incomplete. In addition, information was not always complete for "gray" literature references. "Codes" at the end of each reference represent the classification as described in Appendix 2 of the above report. Observations and annotations by the author are marked within # … # symbols.

Alexander, G. R., and E. A. Hansen. 1983. Sand sediment in a Michigan trout stream Part 2. Effects of reducing sand bedload on a trout population. North American Journal of Fisheries Management 3: 365-372.

This is the second of a two-part sedimentation study. A sediment basin excavated in a Michigan trout stream reduced the sandy bedload sediment by 86% (from 56 ppm down to 8 ppm). Following the reduction in bedload, trout numbers increased significantly during the next 6 years. Small or young trout increased about 40% throughout the treated area. Larger and older trout increased in that part of the treated area that had an erodible sand bed. Although trout production increased 28%, growth rate of the trout changed but little. Both brown trout (Salmo trutta) and rainbow trout (Salmo gairdneri) populations responded similarly to the bedload reduction. The results suggested that in-stream sediment basins are an effective means for removing sand bedload and that even small amounts of moving-sand bedload sediments can have a major impact on a trout population.

Codes: reach quant substrate temporal

Alexander, G. R., and E. A. Hansen. 1986. Sand bed load in a brook trout stream. North American Journal of Fisheries Management 6: 9-23.

An experimental introduction of sand sediment into Hunt Creek in the northern Lower Peninsula of Michigan that increased the bed load 4-5 times resulted in a significant reduction of brook trout (Salvelinus fontinalis) numbers and habitat. The brook trout population declined to less than half of its normal abundance. The growth rate of individual fish was not affected. Population adjustment to the poorer habitat was via a decrease in brook trout survival rates, particularly in the egg to fry and/or the fry to fall fingerling stages of their life cycle. Habitat for brook trout and their food organisms became much poorer, as judged by the drastic reductions of both. Stream morphometry changed considerably, the channel becoming wider and shallower. Furthermore, sand deposition aggraded the streambed and eliminated most pools. The channel became a continuous run rather than a series of pools and riffles. Water velocities increased, as did summer water temperatures. Relatively small sand bed-load concentrations of only 80 ppm had a profound effect on brook trout and their habitat.

Codes: reach quant popdyn instream substrate temporal

Amiro, P. G. 1989. Remote surveying of juvenile Atlantic salmon stream habitat, documentation of use and erivation of pro-rated production models. Report; Conference; Summary SAF 89-05. multi reach quant instream.

A procedure to derive quantitative juvenile Atlantic salmon (Salmo salar) habitat information by using aerial photographs and orthophotographic maps together with fish density distribution curves is presented and tested. The technique allows for the near complete coverage of a river system in a systematic and quantitative computer model. Viewable water surface area, corrected to a standardized summer low width, is summarizeable on a tributary, branch or complete river system basis in a distance and stream gradient interval matrix. Photo measured area was estimated with a 15% negative bias of proximate measured area. Stream gradient was estimated with substantial positive bias.

Total parr densities estimated by electrofishing at 114 sites on the Stewiacke River and 64 sites on the St. Mary's River, Nova Scotia, Canada, were significantly distributed in a quadratic or negative exponential manner with respect to stream gradient. Optimum stream gradient was about 2% on the orthophotographic maps or about 1% proximate measured surface grade. The technique provides a basis to derive systematic estimates of habitat pro-rated production for Atlantic salmon streams for which there is photo coverage. Incorporation of an optimum production density curve would allow river-specific estimates of required spawning escapement. #summary only#.

Codes: multi reach quant instream

The rivers of Labrador. Canadian Special Publication of Fisheries and Aquatic Sciences 81: 397.

Physical and biological data are presented for 120 river systems in Labrador. Past and present developments within the watersheds are documented. Physical data presented include characteristics of each drainage system, and locations and descriptions of obstructions to fish passage. The size and location of salmonid rearing and spawning habitat are presented for 82 rivers. The distribution within Labrador of 24 freshwater, anadromous and catadromous fishes is summarized. Emphasis is placed on the production and freshwater exploitation of Atlantic salmon (Salmo salar). Production estimates, based on available rearing habitat for salmon parr, are presented for 60 rivers. Catch/effort data from the commercial fishery for Arctic char (Salvelinus alpinus) in northern Labrador are tabulated.

Codes: multi reach habitat qual spawn instream

Annoni, P., I. Saccardo, G. Gentili, and L. Guzzi. 1997. A multivariate model to relate hydrological, chemical and biological parameters to salmonid biomass in Italian Alpine rivers. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 439-452.

A multivariate statistical analysis was performed to assess the relationships between a series of river habitat parameters and the variation in salmonid biomass in 13 stations in Italian Alpine salmonid rivers. Various river data were collected and principal component analysis was used to identify the relevant parameters. The best regression model was calculated using two statistics: Mallows' Cp and R super(2) adjusted for degrees of freedom. The best model only uses six parameters and explained 89% of variation in fish biomass. Various statistical indices were calculated to evaluate model quality and robustness. A sensitivity analysis was carried out to determine how the model slope would change due to independent measurement errors in the parameters. These effects were mostly negligible. This demonstrated that it is possible to simplify habitat quality evaluation using a subset of environmental parameters which should be useful for river management.

Codes: multi reach quant instream

Anon. 1977. Comparison of coastal cutthroat trout populations in allopatry and those sympatric with coho salmon and sculpins in several small coastal streams on Vancouver Island, B.C. Report

Biomass density and growth of summer stocks of coastal cutthroat trout (Salmo clarki) populations above (allopatric) and those below barrier falls sympatric with coho salmon (Oncorhynchus kisutch) and sculpins (Cottus spp.) were compared in six small coastal streams on Vancouver Island, B.C. Range in mean fish biomass densities in allopatric trout populations was 1-6 g/m SUP-2 (GX = 2 . 2 g/m SUP-2), whereas sympatric populations of coho, trout, and sculpins combined was 2-9 g /m SUP-2 (GX = 5 . 1 g/m SUP-2), with trout contributing less than 1 g/m SUP-2 in all habitats. Biomass density of allopatric trout populations approximated that of the combined populations of sympatric trout and coho. Mean body size for grouped age classes and summer growth of age O trout were significantly less in sympatric than in allopatric trout populations. In stream simulator studies, microhabitat use and aggressive behavior were similar for both trout types when tested separately, other than that sympatric trout

defended riffle territories more vigorously, responded to the feeding cycle with greater synchrony, and used components of aggressive display hydromechanically more suited to fast water habitats, than did allopatric trout.

Codes: multi experi sppinter quant noenv

Anon. 1977. Interactions for food and space between sympatric populations of juvenile coho salmon and coastal cutthroat trout in a stream simulator during winter and spring. Report

Interactions for food and space between sympatric populations of underyearling coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) were investigated in a stream simulator during winter and spring. Temperature was the main determinant of coho and trout microhabitat use in winter. At 3 degree C, both species almost exclusively occupied pools, whether in allopatry or in sympatry. At 5 degree C, minor segregation was evident, with species relative abundance in riffles being higher for trout and in pools for coho. Factorial analyses of variance indicated temperature, size of fish, water velocity and simulated food supply were ranked (high to low) as affecting microdistribution. Coho and cutthroat trout fry communicated using the same signal set as in summer with chases, nips and lateral displays comprising more than 80% of their total aggressive activity. Non-contact behaviors were more frequently used by coho; nipping was more frequently used by trout. Both salmonids were most aggressive when food was present, irrespective of temperature. However, levels of aggressiveness differed with temperature and space: at 3 degree C, aggression was low and neither species defended riffles; at 5 degree C, aggression was higher and both species actively defended riffles during feeding. Patterns of species microhabitat use and behavioral interactions in spring were similar to, but more pronounced than those in winter at 5 degree C. Stream management strategy should take into account the importance of providing adequate winter cover appropriate to the different age-classes in sympatric populations of coho salmon and coastal cutthroat trout.

Codes: habitat qual sppinter instream wtemp

Anon. 1977. Interactions for food and space between sympatric populations of underyearling coho salmon and coastal cutthroat trout in a stream simulator during summer. Report

Interactions for food and space between sympatric populations of underyearling coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) were investigated in a stream simulator during summer. In sympatry, partitioning of space was rapid and similar to that in nature, in that coho numerically dominated pools and trout dominated riffles. In allopatry, their microhabitat use was similar, in that 60-75% of either species occupied pools. Factorial analyses of variance indicated that size of fish, simulated food supply and water velocity were ranked (high to low) as affecting microdistribution. Coho and cutthroat trout fry communicated using an array of similar body postures and movements, with chases, nips and lateral displays comprising more than 80% of their total aggressive activity. Non-contact behaviors were more frequently used by coho; nipping was more frequently used by trout. Both salmonids were most aggressive when food was present. Species levels of aggressiveness were similar in allopatry, but differed between habitat types in sympatry, coho being more inclined to defend pools and trout riffles. Stream management strategy should take into account the importance of maintaining habitat diversification in streams supporting sympatric populations of coho salmon and cutthroat trout.

Codes: habitat qual sppinter instream

Anon. 1997. Investigation of the habitat and production of sea trout (Salmo trutta L.) in tributaries to the River Laerdal (Norway). Institutt for Fiskeri og Marinbiologi [IFM RAPP.], Nov

Densities of sea trout (Salmo trutta L.) parr and alevins in 10 tributaries (small rivers and creeks) to the River Laerdal beneath the Sjurshaug waterfall in Laerdal County, Western Norway, were estimated by electrofishing in September-October 1996. This was done to investigate the importance of these tributaries to the total population of sea trout in the River Laerdal. Sea trout were found in 7 of 10 tributaries, while no fish were caught in the remaining 3 tributaries. Smolt production in the different rivers were also calculated, indicating a total smolt production of

about 5800 sea trout smolt annually. Our results indicate that only 2% of the total annual production of sea trout smolts originate in the tributaries, while 98% is produced in the main fiver. In one river, River Nivla, parr and alevins of Atlantic salmon (Salmo salar L.) were also found.

Codes: multi reach quant noenv foreign

Anon. 1997. Investigations of the habitat and production of the sea trout (Salmo trutta L.) in small rivers and creeks in Kvam county, Hordaland (Norway)

Densities of sea trout (Salmo trutta L.) parr and alevins in 25 small rivers and creeks in Kvam County, Western Norway, were estimated by electrofishing in September-October 1996. 21 of 25 rivers held sea trout, while no fish were caught in the remaining 4 rivers. Smolt production in the different rivers were also calculated, indicating a total smolt production of about 17.000 sea trout smolt annually. In 6 rivers, parr and/or alevins of Atlantic salmon (Salmo salar L.) were also found, with a total smolt production of about 3000 salmon annualy. Salmon parr found in two very small creeks are probably the offspring of escaped farmed salmon. Adult sea trout infestated with sea lice were found in 6 rivers, and 58% of all adult sea trout were injured by the lice.

Codes: multi reach quant noenv foreign

Anon. 1997. Kalispel resident fish project. Annual report, January 1, 1995--December 31, 1995.

In 1995 the Kalispel Natural Resource Department (KNRD) in conjunction with the Washington Department of Fish and Wildlife (WDFW) initiated the implementation of a habitat and population enhancement project for bull trout (Salvelinus confluentus), westslope cutthroat trout (Oncorhynchus clarki lewisi) and largemouth bass (Micropterus salmoides). Habitat and population assessments were conducted in seven tributaries of the Box Canyon reach of the Pend Oreille River. Assessments were used to determine the types and quality of habitat that were limiting to native bull trout and cutthroat trout populations. Assessments were also used to determine the effects of interspecific competition within these streams. A bull trout and brook trout (Salvelinus fontinalis) hybridization assessment was conducted to determine the degree of hybridization between these two species. Analysis of the habitat data indicated high rates of sediment and lack of wintering habitat. The factors that contribute to these conditions have the greatest impact on habitat quality for the tributaries of concern. Population data suggested that brook trout have less stringent habitat requirements; therefore, they have the potential to outcompete the native salmonids in areas of lower quality habitat. No hybrids were found among the samples, which is most likely attributable to the limited number of bull trout. Data collected from these assessments were compiled to develop recommendations for enhancement measures. Recommendations for restoration include riparian planting and fencing, instream structures, as well as, removal of non-native brook trout to reduce interspecific competition with native salmonids in an isolated reach of Cee Cee Ah Creek.

Codes: multi reach sppinter substrate quant?

Armstrong, J. D. 1997. Self-thinning in juvenile sea trout and other salmonid fishes revisited. Journal of Animal Ecology [J. Anim. Ecol.] 66: 519-526.

Self-thinning, the reduction in density (N) as a consequence of the increase in the mean weight (W) of individuals, occurs widely in populations of plants when their growth is constrained at high densities, but has only recently been reported to occur within populations of wild mobile animals. It has been suggested that a self-thinning relationship in which the gradient (Delta log (W) / Delta log (N)) approximates to -1 times 33 describes concomitant changes in W and N within cohorts of a population of anadromous brown trout (sea trout) Salmo trutta throughout their lives as juveniles in fresh water. This apparent self-thinning occurs with no evidence of density-dependent growth or mortality (as measured by key-factor analysis) after the critical period. Here, the relationship between weights and densities of trout has been examined further. A linear model incorporating log (N), year class and time of year explained 99 times 5% of the variation in log (W), giving a significantly better fit than incorporating onlylog (N)

and year class. Variation in log (N) explained 85% of the variation in log (W); the addition of year class increased this value by 6% and the addition of monitoring period increased it by a further 8 times 5%. The gradients for the relationships between log (W) and log (N) within years varied significantly with time of the year. Pooled thinning trajectories for the first winter of the life of trout differed significantly from a gradient of -1 times 33, while those for the second summer were highly variable and sometimes positive (suggesting that immigration could exceed mortality). Thinning trajectories over the first summer of life were related inversely to the densities of trout at the start of the monitoring period in that summer (N sub(s)), but this relation appeared to approach an asymptote at high values of N sub(s). The mean of the thinning trajectories for cohorts with high N sub(s) (exceeding 300 fish 60 m super (-2)) was not significantly different from -1 times 33. However, these slopes were shown to result primarily from the presence of high numbers of failed non-territorial fish early in the summer rather than true thinning throughout the summer. The apparent absence of a simple consistent thinning relationship after a critical period in the first couple of months of the lives of cohorts can be explained by three factors. First, the total availability of limiting resources, such as space and food, is not constant but changes with the mean size of the trout. Secondly, there is a winter cessation of growth. Thirdly, trout switch to use different habitats during their development. The implications for interpreting thinning relationships for salmonid fishes in general are discussed.

Codes: multi reach quant popdyn noenv temporal

Armstrong, J. D., V. A. Braithwaite, and M. Fox. 1998. The response of wild Atlantic salmon parr to acute reductions in water flow. Journal of Animal Ecology 67: 292-297.

A seasonal reduction in water flow, due both to prevailing weather conditions and anthropogenic disturbance, is a prominent feature of the habitat in many riverine systems, yet the response of many aquatic vertebrates, such as juvenile Atlantic salmon, to low flows is not well understood. However, in accordance with general fitness optimization theory, it might be predicted that salmon will emigrate from shallow areas to seek refuge in pools as water levels decrease to critically low levels (fitness approaches zero). To test this prediction, we directly measured the movement response of individual Atlantic salmon (Salmo salar L.) (74-109 mm) to drought in near-natural mesocosms. 2. In five separate trials during summer, groups of salmon were introduced into enclosed 30-m long sections of stream, each comprising a central 10-m long region of shallow riffle habitat bordered upstream and downstream by 10-m long regions of deeper water. After fish had settled into home ranges, those fish inhabiting deep areas were removed and the water flow was later decreased to zero over 2 days, so that the riffles were nearly dry. The movements of each individual fish within the enclosures were monitored remotely and continuously using a passive integrated transponder (PIT) tracking system. 3. Of the total of 33 fish with home ranges that included only riffle habitat, 14 moved into deep water at some point during drought, but only seven of these fish (0-50% between trials) established new home ranges that included deep areas. The others returned to regions of riffle during the drought. None of the eight fish that definitely had not sampled in pool habitat prior to settling on riffle emigrated during drought. 4. The optimal response of salmon parr to moderate natural drought appears not to be fixed, but for many individual fish it may be to stay in shallow riffle areas. The optimal response of salmon parr to extreme natural drought and anthropogenic dewatering will, in many cases, be to move. An increase within the population of traits that promote an ideal response to natural drought will therefore make it more vulnerable to severe drought and anthropogenic de-watering and vice versa. 5. The absence of emigration by salmon from shallow areas during acute drought can be reconciled with fitness optimization theory if, when natural drought progresses, fish become stranded in shallow areas some considerable time before the point at which they die.

Codes: experi enclos reach qual migrat instream

Armstrong, J. D., V. A. Braithwaite, and F. A. Huntingford. 1997. Spatial strategies of wild Atlantic salmon parr: exploration and settlement in unfamiliar areas. Journal of Animal Ecology 66: 203-211.

Relationships between distributions of animals and the resources they use can be expected to depend critically on the mobility of individual animals within populations. However, there is little information on the movements of individuals within populations of animals in most natural aquatic systems, so it is difficult to model accurately the processes that underlie their distributions. Aspects of the processes involved in the colonization of vacant areas by

stream-resident Atlantic salmon Salmo salar (69-114 mm length) were measured under near-natural conditions. In five separate trials over summer months, groups of salmon were introduced into enclosed 30-m long sections of stream, each comprising three distinct 10-m long regions of habitat. The subsequent movements of each individual fish within the enclosures were monitored remotely and continuously using a passive integrated transponder (PIT) tracking system. Considerable variation was observed between the activity of different individual salmon. Some of the fish (range between trials, 3-33%) settled into localized home ranges without moving between regions, 10-38% of the fish moved within two regions, and 37-87% of the salmon moved through all three regions of their enclosure. A fraction (0-20%) of some of the populations was particularly mobile and never settled but continued to move throughout all three regions of the enclosure. Within the scale of this current study, it would appear that, for territorial animals such as salmon parr, certain members of the population will settle in new territories after very little exploration of their new environment. The propensity to explore was independent of habitat type, but was directly proportional to the size of the fish. The time from release until 50% of fish in populations settled (excluding the mobile fraction) ranged from 0.3 to 2.4 days. Activity levels were particularly high and initial movements by fish were directed upstream in trial 1, early in the summer, perhaps reflecting upstream migration by salmon parr within the population of the burn at this time.

Codes: experi reach qual popdyn migrat noenv

Armstrong, J. D., J. W. A. Grant, H. L. Forsgren, K. D. Fausch, R. M. DeGraaf, I. A. Fleming, T. D. Prowse, and I. J. Schlosser. 1998. The application of science to the management of Atlantic salmon (Salmo salar): integration across scales. Canadian Journal of Fisheries and Aquatic Sciences 55: 303-311.

The need for integration across spatial and temporal scales in applying science to the management of Atlantic salmon is considered. The factors that are currently believed to affect the production of anadromous adult Atlantic salmon (synthesized from recent reviews) are arranged in a hierarchy in which any given process overrides those processes at lower levels. There is not a good correlation between levels in the process hierarchy and levels in hierarchies of scale. This demonstrates the importance of integrating across scales in identifying the optimum foci for targeting management action. It is not possible to generalize on the need for integration across scales within management plans. This is because of the complex ecology of salmon, the broad range of characteristics of the systems of which they are a part, and the fact that both local scale and broad scale management can have broad scale effects. Many uncertainties remain regarding the large-scale components of the ecology of salmon, the way that small-scale mechanisms interact with life histories, and the way that different factors interact to limit production of fish. When more is understood of these processes, it is likely that generalized rules might be developed to predict the management requirements for stream systems. In the meantime, it is essential that there is good integration among managers working at different scales and it is important that management systems operating at all spatial scales include highcalibre expertise to compensate for the present paucity of general rules.

Codes: review philosophy multi reach qual temporal lulc

Armstrong, J. D., F. A. Huntingford, and N. A. Herbert. 1999. Individual space use strategies of wild juvenile Atlantic salmon. Journal of Fish Biology [J. Fish Biol.] 55: 1201-1212.

Movements of 60 stream-dwelling wild Atlantic salmon Salmo salar (97-118 mm), each tagged with a passive integrated transponder, were monitored during four trials in an enclosed section (24 m long, 45.1 m super(2) total area) of a stream at a range of densities (four, eight, 16 and 32 fish per enclosure). Patterns of space use differed markedly between individuals, with 80% of fish establishing home ranges within 8 days of introduction to the enclosure (settlers) and the remainder continuing to move throughout the length of the enclosure (non-settlers). Although aggressive interactions were quite frequent and dominant fish were observed chasing subordinates, there was considerable overlap of home ranges of settlers at all densities; this was the case even at lower densities at which only a fraction of the enclosure was used by the fish. Thus, rather than adopting fixed territories, the salmon showed a high level of space sharing. Individual fish used the same local area in different ways, ranging from highly localized feeding on drifting food items to a wider-ranging strategy of specialising on benthic food. Among the fish that settled absolute growth rates were inversely related to body size, and at high densities fish lost weight. These

results suggest that space use in wild juvenile salmon is more complex than a mosaic of territories, that salmon demonstrate significant variability in individual space use patterns, and that large fish may suffer disproportionately when populations are at the carrying capacity of their environment.

Codes: experi enclose quant migrat habitat

Armstrong, J. D., P. E. Shackley, and R. Gardiner. 1994. Redistribution of juvenile salmonid fishes after localized catastrophic depletion. Journal of Fish Biology 45: 1027-1039.

Juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) were depleted at three sites (c. 108-380 m super(2)) of a natural stream during the summer months of 1991 and 1992. Local population changes and movements of fish marked in sections adjacent to each depleted area were monitored thereafter. There was very little movement of marked salmon parr into the central regions of the depleted areas following the immediate post-marking period. Upstream movement by young-of-the-year fish from high density sections in mid-late summer was noted for trout but not salmon. Unmarked 1-year-old salmon parr immigrated into depleted areas in June 1992, and the pattern of recolonization was consistent with migration upstream from the adjoining river. It is concluded that resident salmon were very strongly site-attached and resource tracking was of no functional significance as a compensatory mortality mechanism. The occurrence of a long distance migratory component in the population during early-mid summer indicates that this, rather than local resource tracking, constitutes a potential compensatory mechanism.

Codes: experi reach qual migrat

Bagliniere, J. L., and A. Champigneulle. 1986. Population estimates of juvenile Atlantic salmon, Salmo salar, as indices of smolt production in the R. Scorff, Brittany. Journal of Fish Biology 29: 467-482.

The numerical production of juvenile Atlantic salmon was estimated on an Armorican Massif river (Brittany), using habitat characteristics of the main stream and an annual electrofishing census from 1975 to 1983. This showed that (i) 0 + fish accounted for 79% of the production; (ii) there were larger annual variations of production in spite of some compensatory events depending on genetic and environmental factors; (iii) riffles and rapids (depth <40 cm, current velocity >40 cm s super (-1)) were the more productive habitats, providing 86.4% of the production from 28% of the water area; (iv) the middle course of the river accounted for 57.6% of production, producing more 1 + individuals in a large area of rapids. Features of this method, their limitations and the value of the results are discussed in relation to the estimation of smolt production. (DBO).

Codes: habitat quant instream temporal

Baigun, C. R., J. Sedell, and G. Reeves. 2000. Influence of water temperature in use of deep pools by summer steelhead in Steamboat Creek, Oregon (USA). Journal of Freshwater Ecology 15: 269-279.

This study examined use of deep pools (>0.8 m mean depth) based on thermal characteristics by adult summer steelhead in Steamboat Creek, Oregon. Steamboat Creek had a heterogenous thermal profile, with some segments exceeding the preferred temperature of steelhead. Deep pools were scarce (4% of the total habitat types), and 39% of them were identified as cool pools (mean bottom water temperature 19 degree C). Adult summer steelhead were found primarily in deep pools, avoiding other habitats such as glides, riffles, and even cool tributary junctions. Adult abundance in deep pools did not show significant variation between years and was inversely associated with mean bottom temperature. Use of cool pools was estimated to be 11 times the use of warm pools. However, the presence of unoccupied cool pools suggested that other ecological variables may be involved in pool selection.

Codes: habitat qual instream wtemp

Baran, P., M. Delacoste, F. Dauba, J. M. Lascaux, and A. Belaud. 1995. Effects of reduced flow on brown trout (Salmo trutta L.) populations downstream dams in French Pyrenees. Regulated Rivers: Research & Management 10: 347-361.

The effects of 16 hydroelectric power plants, in operation for 75 years, were studied in 15 non-polluted Salmonid streams in the Pyrenean mountains. The populations of brown trout (Salmo trutta L.) and the physical habitat characteristics were compared between two sections, one upstream of the dams (control section) and one below the dams with constant reduced flow (residual section). The average velocity, depth and area of cover decreased significantly below the dams. Similarly, the total abundance of brown trout calculated per linear metre of stream decreased at nine sites for biomass and eight sites for densities. The reductions of biomass and densities per unit area were less at seven sites. The abundances of the main stages of brown trout were modified differently; adults were affected more than fry by constant reduced flow. The modifications of biomass and densities of the age classes were significantly related to the instream flow below the dam, expressed as a proportion of the mean annual flow at the control section. Similarly, the differences of total, adult, juvenile and fry abundances between the control and residual section were significantly related to the differences in weighted usable area (WUA), average depth, average velocity and area of cover. A multiple linear regression model using differences of WUA and area of cover explained 84% of the difference of biomass per linear metre of stream and 68% of the difference of density. Estimating the relative capacity of a stream to support fish after a reduction in flow by measuring the variations of WUA is a promising approach for predicting the development of brown trout populations. The results are discussed in terms of modifications and the relative capacity of a stream to support a brown trout population.

Codes: multi experi reach microhab quant instream lakehydro hem

Baran, P., M. Delacoste, J. M. Lascaux, and A. Belaud. 1993. Relationships between habitat features and brown trouts populations (Salmo trutta L.) in Neste d'AureValley. Edited by J. P. Grandmottet, J. P. Masson, G. Balvay and J. Verneaux. 321-340 p.

The relationships between habitat features and biomass and density of brown trout (Salmo trutta L.) were studied in 33 sections of the Neste d'Aure stream and three of its tributaries: the Neste du Louron, the Neste du Rioumajou and the Espiaube stream in the Hautes-Pyrenees region. The Habitat Quality Index (HQI) model I (BINNS and EISERMAN, 1979), based on 10 environmental variables, was tested. The biomass predicted by the model were not linearly related with biomass of trout observed by electrofishing on the 33 sections. The best linear model was obtained after logarithmic transformations of the two variables. However, the slope of the regression line was significantly different from 1 ($t=2.53$ ($p<0.01$)). The HQI model did not appear to be a good method of assessing the biomass of brown trout in the Neste d'Aure valley. Correlations between habitat variables and brown trout biomass and density were investigated. Total biomass was significantly related to elevation (between 1350 and 600 m), cover, maximum summer temperature (between 10 and 16 degree C), conductivity, mean bottom velocity, mean depth and width/depth ratio. Total density was significantly related to the same variables, with the exception of mean depth, and in addition to water gradient and stream width. The study by age-class showed that the abundance of young-of-the-year trout is related to elevation, temperature and conductivity. Only width was the habitat feature related to abundance of young-of-the-year. No correlations were found with other physical habitat features. Abundance of one-year-old trout (1+) was related with the same variables of elevation, temperature and conductivity in addition; their density and biomass were also related to cover. Density of catchable trouts (length greater than 180 mm) was correlated with cover, depth, temperature, elevation and conductivity. The stepwise regression analyses produced combinations of variables that explained 86% of the variations in biomass (with 5 variables). This type of work can be very useful in the management of fishing and of trout populations.

Codes: multi habitat quant warning instream wtemp hem foreign

Baran, P., M. Delacoste, J. M. Lascaux, F. Dauba, and G. Segura. 1995. The interspecific competition between brown trout (Salmo trutta L.) and rainbow trout (Oncorhynchus mykiss Walbaum): Influence on habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 283-290 p.

The influence of interspecific competition on the occupation of physical habitat of the Estibere stream was studied in two rainbow trout populations (Oncorhynchus mykiss), one in allopatry and the other in sympatry with brown trout (Salmo trutta L.). The occupation of the Weighted Usable Area (WUA) was calculated by the PHABSIM model of the IFIM methodology (BOVEE, 1982). The occupation by rainbow trouts was significantly greater (t test, $p<0.05$) for the allopatric population than for the sympatric population. Surface of cover, gradient and the occupation of the physical habitat by adults of brown trout explained 77 % of the variation of the occupation of the physical habitat by rainbow trout. For the adults of brown trout, the surface of cover explained 81 % of the variation of the occupation of physical habitat. Interspecific competition may influence the occupation of physical habitat by the different species and life-stages.

Codes: microhab quant ifim sppinter instream hem foreign

Baran, P., M. Delacoste, G. Poizat, J. M. Lascaux, S. Lek, and A. Belaud. 1995. Multi-scales approach of the relationships between brown trout (Salmo trutta L.) populations and habitat features in the central Pyrenees. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 399-406 p.

The influence of spatial scales, of reach, of sequence and morphodynamic units on occupation by trout populations of the physical habitat calculatedby IFIM methodology was studied on 264 morphodynamic units of 15 streams of the Central Pyrenees (France). A variance analysis model explained respectively 51.1% and 69.8 % of the variability of the occupation of physical habitat by total density and by total biomass of trout. The results are discussed in relation to the interest of multi-scales approach for the carrying capacity concept of salmonid streams and the relation between biological processes and spatial scales.

Codes: multi microhab reach quant ifim hem foreign

Baran, P., S. Lek, M. Delacoste, and A. Belaud. 1996. Stochastic models that predict trout population density or biomass on a mesohabitat scale. Hydrobiologia 337: 1-9.

Neural networks and multiple linear regression models of the abundance of brown trout (Salmo trutta L.) on the mesohabitat scale were developed from combinations of physical habitat variables in 220 channel morphodynamic units (pools, riffles, runs, etc.) of 11 different streams in the central Pyrenean mountains. For all the 220 morphodynamic units, the determination coefficients obtained between the estimated and observed values of density or biomass were significantly higher for the neural network (r super(2) adjusted = 0.93 and r super(2) adjusted = 0.92 ($p<0.01$) for biomass and density respectively with the neural network, against r super(2) adjusted = 0.69 ($p<0.01$) and r super(2) adjusted = 0.54 ($p<0.01$) with multiple linear regression). Validation of the multivariate models and learning of the neural network developed from 165 randomly chosen channel morphodynamic units, was tested on the 55 other channel morphodynamic units. This showed that the biomass and density estimated by both methods were significantly related to the observed biomass and density. Determination coefficients were significantly higher for the neural network (r super(2) adjusted = 0.72 ($p<0.01$) and 0.81 ($p<0.01$) for biomass and density respectively) than for the multiple regression model (r super(2) adjusted = 0.59 and r super(2) adjusted = 0.37 for biomass and density respectively). The present study shows the advantages of the backpropagation procedure with neural networks over multiple linear regression analysis, at least in the field of stochastic salmonid ecology.

Codes: multi microhab quant modeling instream

Barnard, S., and R. J. Wyatt. 1995. An analysis of predictive models for stream salmonid populations. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 365-373 p.

A total of 73 multivariate (empirical) models predicting salmonid populations from biological and environmental variables were assessed. In conjunction with this, the published results of 15 tests of models are briefly commented on. The relationships between the sources of the significant variables and the performance of the models are discussed in relation to the development of HABSCORE, a management tool for salmonid fisheries which is based on empirical predictive models. An assessment of the predictive capabilities of the models implied that a combination of variables (those which relate to the large-scale features of the catch ment and those which describe the instream conditions) were more useful in predicting trout stocks than either source of variables alone. Whilst raw data gathered from relatively 'narrow' ecological ranges have been used to formulate the majority of models detailed in the literature, such models often have high predictive power only within the same ecological range, and are consequently restricted in their applicability elsewhere. In order to develop models which can be used as fisheries management tools it is desirable to base the model development on data from a wide geographical base. Although specific definitions of many parameters may differ between fishery workers, there is general agreement regarding the nature of those parameters perceived to be useful or important for model development. Given the production of a se ries of rigorous definitions for these parameters it should be possible to propose a system of habitat description that would be both widely applicable and would give rise to reproducible results.

Codes: review multi reach quant instream lulc hem

Barnard, S., R. J. Wyatt, and N. J. Milner. 1995. The development of habitat models for stream salmonids and their application to fisheries management. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 375-385 p.

The paper briefly describes the development of HABSCORE, a salmonid habitat assessment technique based on a series of empirical statistical models which relate salmonid abundance to observed habitat variables. Fisheries and habitat data for 602 notionally pristine sites throughout England and Wales were used in the development of salmonid population prediction models. These sites provided a total of 130 independent variables from which five regression models, predicting salmonid population size, were produced. These models (for 0 super (+) salmon, >0 super (+) salmon, 0 super(+) trout, >0 super(+) [<20cm] trout and >0 super(+) [>20cm] trout) explained between 28.7 % and 46.2 % of the total variance in population densities observed in the raw data. Partitioning of the variances within the raw data suggested that the models account for between 45.1 % and 86.7 % of the total spatial variation. Error associated with the measurement of the habitat variables used accounted for c1.1 % of the total variance in the five models. The quality of the models is briefly discussed. The outputs of the models, and the potential management applications of HABSCORE, are described.

Codes: multi reach quant instream lulc temporal hem

Bartholow, J. M. 1996. Sensitivity of a salmon population model to alternative formulations and initial conditions. Ecological Modelling 88: 215-236.

Salmon populations in many Pacific coast rivers are in serious decline and in danger of becoming threatened or endangered. A fish population model (SALMOD) that tracks fall chinook salmon (Orcorhynchus tshawytscha) has been developed for the Trinity River, California. The model considers the principal environmental factors influencing movement and mortality of young-of-the-year salmon from the time of spawning and egg deposition until they leave freshwater rivers as juveniles. Numbers of salmon produced by alternative managed flow regimes can be estimated using SALMOD. This paper explores the consequences of alternative model construction and formulation choices on model behavior, and the impact of the number of spawhets returning from the ocean on development of a robust flow management decision. Results show that SALMOD is responsive to the user's choice of spawner nesting behavior (superimposition), but relatively insensitive to spatial scale describing fish rearing habitat quality. The choice of a suitable managed flow regime is sensitive to the number of adult fish returning to

spawn and even more so to their distribution throughout the study area at time of spawning. It would be possible to tailor an adaptive annual flow regime based on monitoring of spawner numbers and their distribution.

Codes: modeling popdyn hydro

Barton, D. R., W. D. Taylor, and R. M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management 5: 364-378.

The relationships between riparian land use and environmental parameters that define the suitability of southern Ontario streams for trout were examined for 40 sites on 38 streams. Weekly observations of maximum and minimum temperature, coarse and fine suspended matter, and discharge were made during June, July, and August 1980. Land use was determined from aerial photographs of each stream. Fish were surveyed at each site during August by electrofishing and seining. The only environmental variable which clearly distinguished between trout and nontrout streams was weekly maximum water temperature: streams with trimean weekly maxima less than 22 C had trout; warmer streams had, at best, only marginal trout populations. Trout streams tended to have low concentrations of fine suspended solids and a more stable discharge, but so did many of the other streams. Water temperature, concentration of fine particulate matter, and variability of discharge were inversely related to the fraction of the upstream banks covered by forest. Fifty-six percent of the observed variation in weekly maximum water temperature could be explained by the fraction of bank forested within 2.5 km upstream of a site. Other land uses were not clearly related to stream variables, except that high concentrations of fine suspended solids were most often observed in reaches used as pasture. Analysis of data from sites located within buffer strips yielded a regression relating maximum weekly temperatures to buffer strip length and width. The regression accounted for 90% of the observed variation in water temperature for these sites. The model was verified further by comparisons with observed temperatures at a second set of sites located downstream from buffer strips.

Codes: multi reach quant wtemp ripar

Bates, D. J., G. G. McBain, and R. W. Newbury. 1997. Restoration of a channelized salmonid stream, Oullette Creek, British Columbia. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Oullette Creek, a second-order coastal stream, is located on the Sechelt Peninsula approximately 20 kilometers from Vancouver, British Columbia. This stream, which once supported thriving populations of anadromous salmonids, was relocated and channelized in 1978. This action resulted in major changes in stream geometry that affected fish habitat. In 1993 and 1994, detailed biophysical inventories were conducted on the lower reach of Oullette Creek. These inventories were followed by redesign and restoration of fish habitat. The primary goal of the restoration was to restore the natural pool and riffle ratio with instream rock weirs built to duplicate natural riffles and pools. The result has been the collection of spawning gravel on the upstream edge of riffles and increased areas in pools for rearing. The natural geometry of a stream of this size in this region was used to set the design width, depth, substrate size, and final pool/riffle sequencing. Basic stream characteristics of bankfull width, depth, and discharge were established by surveying a series of reaches in different tributaries in the project stream and similar drainage basins located nearby. In 1995, after the first phase of the restoration was completed, a third biophysical inventory was conducted on Oullette Creek. Preliminary results indicate that the restored areas are stabilizing, providing a significant increase in rearing habitat for both coho salmon and cutthroat trout.

Codes: experi habitat instream nofish

Baxter, C. V., C. A. Frissell, and F. R. Hauer. 1999. Geomorphology, Logging Roads, and the Distribution of Bull Trout Spawning in a Forested River Basin: Implications for Management and Conservation. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 854-867.

The Swan Basin in Montana is considered a stronghold of regional significance for the bull trout Salvelinus confluentus, a native char whose populations are fragmented and declining throughout its range. We used correlation analysis to examine spatial and temporal variation of bull trout redd count data (1982-1995) relative to geomorphic and land-use factors among nine principal spawning tributaries of the Swan River. Bull trout redd numbers were positively correlated with the extent of alluvial valley segments bounded by knickpoints and negatively correlated with the density of logging roads in spawning tributary catchments. The density of logging roads in spawning tributary catchments was not significantly correlated with geomorphic factors. Temporal trends among the principal spawning streams were variable. In four of the nine principal spawning streams, redd numbers increased significantly during the survey period, and in the remaining streams, redd numbers showed no significant change. Changes in redd numbers with time were negatively correlated with catchment road density and positively correlated with the extent of bounded alluvial valley segments. The significance of bounded alluvial valley segments to bull trout spawning habitat may be related to groundwater-surface water exchange occurring within these segments. Our results emphasize the importance of valley geomorphology to bull trout, and our results suggest that prior land use may have adversely affected bull trout populations in the Swan Basin. Protection of critical spawning tributary catchments from additional road building and associated land-use disturbance will likely be necessary for the maintenance of viable bull trout populations in the Swan Basin. Geomorphic context and land-use status of spawning tributaries are important considerations for future monitoring and management of this species.

Codes: reach spawn instream wtemp substrate lulc temporal

Baxter, C. V., and F. R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 1470-1481.

The distribution and abundance of bull trout (Salvelinus confluentus) spawning were affected by geomorphology and hyporheic groundwater - stream water exchange across multiple spatial scales in streams of the Swan River basin, northwestern Montana. Among spawning tributary streams, the abundance of bull trout redds increased with increased area of alluvial valley segments that were longitudinally confined by geomorphic knickpoints. Among all valley segment types, bull trout redds were primarily found in these bounded alluvial valley segments, which possessed complex patterns of hyporheic exchange and extensive upwelling zones. Bull trout used stream reaches for spawning that were strongly influenced by upwelling. However, within these selected reaches, bull trout redds were primarily located in transitional bedforms that possessed strong localized downwelling and high intragravel flow rates. The changing relationship of spawning habitat selection, in which bull trout selected upwelling zones at one spatial scale and downwelling zones at another spatial scale, emphasizes the importance of considering multiple spatial scales within a hierarchical geomorphic context when considering the ecology of this species or plans for bull trout conservation and restoration.

Codes: reach quant instream substrate wtemp lulc

Baxter, J. S., and J. D. McPhail. 1997. Diel microhabitat preferences of juvenile bull trout in an artificial stream channel. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 975-980.

We measured day and night microhabitat preferences of age-1 juvenile bull trout Salvelinus confluentus in an artificial stream channel in early spring, and observed a significant diel shift in both microhabitat use and preference. Microhabitat variables examined were water depth, stream bottom water velocity, overhead cover, and substrate. Fish showed a stronger preference for cover during the day than at night, and generally preferred the deeper and faster areas in the channel at night compared to the daytime. The results are of importance in determining how juvenile bull trout use cover, and they suggest that maintaining or increasing rearing capacity and

survival of juveniles is related to ensuring that adequate amounts of large, coarse rock substrate remain in streams. Our observations also suggest that daytime snorkeling counts of juvenile bull trout may provide inaccurate estimates of abundance because of the juvenile's extensive use of cover during the day.

Codes: experi enclos microhab quant warning

Baxter, J. S., and J. D. McPhail. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bulltrout (Salvelinus confluentus) from egg to alevin. Canadian Journal of Zoology/Revue Canadien de Zoologie [Can. J. Zool./Rev. Can. Zool.] 77: 1233-1239.

We measured survival of bull trout (Salvelinus confluentus) embryos to the alevin stage in areas selected and not selected by females for spawning. In this study we tested the hypotheses that (1) females are utilizing habitats influenced by discharging groundwater and that (2) there is a reproductive advantage to spawning at these selected sites. Embryo survival was assessed by placing fertilized eggs in capsules that could be retrieved once they were placed in selected and nonselected locations. The survival rate was significantly higher (88.6 vs. 76.1%) and less variable in the selected area, but alevin lengths did not differ significantly between areas. The selected areas were, on average, locations of groundwater discharge and higher water temperatures over the incubation period, while nonselected locations were in areas of surface-water recharge and lower water temperatures. The results suggest that appropriate reproductive habitats which offer the best incubation environments may be limited in bull trout systems, and that site selection by females may increase fitness and be critical for population viability.

Codes: microhab popdyn spawn hydro wtemp

Beall, E., J. Dumas, D. Claireaux, L. Barriere, and C. Marty. 1994. Dispersal patterns and survival of Atlantic salmon (Salmo salar L.) juveniles in a nursery stream. ICES Journal of Marine Science 51: 1-9.

The spatial and temporal patterns of dispersal and the survival of Atlantic salmon (Salmo salar L.) fry and parr were analysed over 1 year in a small stream of the Basque Country (south-west France). Dispersal just after emergence was studied with eight drift nets placed 10 to 800 m downstream from an artificial redd stocked with 15 000 eyed eggs. Subsequent distribution of parr was determined by electrofishing in June, October, and February in representative sections of the stream including habitats 750 m upstream and 2400 m downstream from the redd. Early dispersal following emergence lasted 12 days for the majority (95%) of the fry population. Most fry (71%) settled within the first 200 m downstream from the redd, and 91% within the first 400 m. In June, parr were found 2400 m downstream and 750 m upstream, with 68% of the population established within 900 m downstream, and only 4% upstream. In October, there was a slight downstream shift of densities. In February, 56% of the parr were found within 900 m downstream and 11% upstream. Survival from egg planting to first dispersal in March was 51.9% and 11.8% over 1 year.

Codes: reach spawn quant popdyn migrat

Beard, T. D., Jr., and R. F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society 120: 711-722.

Total densities of wild brown trout Salmo trutta ages 1 to 7 varied widely (range, 130-1,304/hectare) among 12 sample sections in Spring Creek, a 35-km-long stream in a limestone area of central Pennsylvania. During a 2-year study we determined the relative importance of spawning habitat and other habitat features on spatial variation in density. Densities of age-0 and of all age-1 and older brown trout were positively correlated with redd densities. Embryo survival was lowest in sections with low brown trout densities, but embryo survival was not as important as redd density in determining population size. Redd density appeared to be a function of availability of suitable spawning substrate. Habitat variables such as depth, pool area, cover, and substrate were not correlated with brown trout density. Spawning habitat and other habitat features were quantified with the habitat suitability index model. Scores derived from the model were poorly correlated with densities of age-0 and of age-1 and older brown trout.

We concluded that juvenile brown trout do not disperse widely from natal areas, and that local population densities are largely a function of the availability of spawning habitat.

Codes: reach quant popdyn spawn instream ifim warning hem

Beecher, H. A., T. H. Johnson, and J. P. Carleton. 1993. Predicting microdistributions of steelhead (Oncorhynchus mykiss) parr from depth and velocity preference criteria: test of an assumption of the Instream Flow Incremental Methodology. Canadian Journal of Fisheries and Aquatic Sciences 50: 2380-2387.

We tested an assumption of the Physical Habitat Simulation of the Instream Flow Incremental Methodology (IFIM) that fish select microhabitats based on the quality of one or several hydraulic conditions. We developed preference curves for juvenile steelhead (Oncorhynchus mykiss) in Morse Creek, Washington, USA, that accounted for availability of depths and velocities and their utilization by steelhead parr. To allow comparison of intervals among preference curves from different studies, we developed preference indices. We then evaluated the relationship between steelhead parr density and preference or preference indices for depth, velocity, and depth and velocity combined using an independent data set from a different year and an adjacent location in Morse Creek; these indices reflected observed densities of steelhead parr. There was a significant rank correlation between steelhead parr density and preferences or preference indices of steelhead parr for velocity alone and for depth and velocity combined, but not for depth alone. Steelhead parr strongly avoided habitat in which depth preference was 0.0, but velocity preference appeared to influence use of habitat where depth preference was not 0.0. Steelhead parr avoided cells with low preference indices and preferred cells with high preference indices. These relationships support an assumption of the IFIM.

Codes: quant microhab ifim hem

Behmer, D. J., and C. P. Hawkins. 1986. Effects of Overhead Canopy on Macroinvertebrate Production in a Utah Stream. Freshwater Biology 16: 287-300.

Fish managers often recommend removal of riparian trees and shrubs along trout streams to increase sun-light penetration and allow increased growth of algae and aquatic macrophytes within the stream. The enhanced plant growth is assumed to increase stream productivity by increasing the base of the food chain and preventing fine sediments from shifting over gravel and rubble. Macroinvertebrate abundance and production were compared between an open and shaded site of a stream in the Wasatch Mountains, Utah. Mean biomass was significantly higher at the open site for midges (Chironomidae), 4.6 times; Baetis bicaudatus, 5.7 times; Baetis tricaudatus, 2.3 times; Drunella coloradensis, 12 times and Cinygmula sp., 1.6 times. Abundance of most other macroinvertebrates (except black flies: Simuliidae) was also greater at the open site, but differences were not significant. Black fly biomass was 1.7 times greater at the shaded site. Seasonal production, estimated by the size-frequency and instantaneous growth rate methods, was greater at the open site than the shaded site for most taxa (except black flies) and reflected differences in standing crops between the sites rather than differences in rate of growth. Excluding black flies, production at the open site was twice as high as at the shaded site. The greater abundance and production of most invertebrate taxa at the open site is probably associated with either higher quality food (algae and algal detritus), or a phototactic attraction to sunlit areas. Sampling of large cobbles was an efficient method of sampling all taxa except Cinygmula sp. which was more abundant on smaller substrate particles.

Codes: experi reach nofish ripar

Bergheim, A., and T. Hesthagen. 1990. Production of juvenile Atlantic salmon, Salmo salar L., and brown trout, Salmo trutta L., within different sections of a small enriched Norwegian river. Journal of Fish Biology 36: 545-562.

Growth, density and production of juvenile Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) were studied in three different sections of the Kvassheimsaana River in south-western Norway from 1979 to 1983. Section 1, in the upper part of the river, is located above a waterfall impassable for migratory salmonids and is surrounded by grazing land. Sections 2 and 3, in the middle and lower parts of the river, are influenced by agricultural activity. The number of 0+ salmon sections 2 and 3 varied between 30 multiplied by 1 and 167 multiplied by 8 specimens 100 m super (-2), with mean values of 90 multiplied by 2 and 95 multiplied by 2 specimens 100 m super (-2), respectively; the density of 1+ salmon, with mean values of 16 multiplied by 3 and 51 multiplied by 0 specimens 100 m super (-2), was significantly correlated with the original fry density. Densities of brown trout were low in all sections (< 20 specimens 100 m super (-2)). Fry density was highest in section 3 and parr density in section 1. All age groups of sympatric brown trout grew significantly faster in sections 2 and 3 compared with allopatric brown trout in section 1.

Codes: reach experi graz ag quant

Biggs, B. J. F., M. J. Duncan, I. G. Jowett, J. M. Quinn, C. W. Hickey, R. J. Davies-Colley, and M. E. Close. 1990. Ecological characterisation, classification, and modelling of New Zealand rivers: An introduction and synthesis. New Zealand Journal of Marine and Freshwater Research 24: 277-304.

A programme of research to characterise, classify, and model New Zealand rivers according to hydrological, water quality, and biological properties is introduced. The results are detailed in the accompanying eight research papers. These studies provide the first national perspective on water quality and biology in New Zealand's rivers using a consistent methodology. They are also the first step toward providing managers with robust models for predicting the effects on aquatic biota of changes in flow regimes and catchment land use. A synthesis of the results is given in this paper together with recommendations for riverine ecoregions in New Zealand. #(See Jowet 1992)#.

Codes: multi quant datasource modeling instream lulc hydro

Bilby, R. E., and P. A. Bisson. 1987. Emigration and production of hatchery coho salmon (Oncorhynchus kisutch) stocked in streams draining an old-growth and clear-cut watershed. Canadian Journal of Fisheries and Aquatic Sciences 44: 1397-1407.

Downstream movement of coho salmon fry (Oncorhynchus kisutch) stocked in old-growth and clear-cut watersheds occurred in three phases: (1) a brief period of heavy emigration immediately after stocking, (2) relatively little movement throughout most of the summer, and (3) intermittent heavy emigration during early autumn freshets. Coho emigrated whenever a streamflow change greater than or equal to 3% multiplied by d super (-1) occurred, but movement nearly ceased at flows above a certain level. Temperature changes were less important than discharge in triggering movement. When high densities were stocked, emigrant fry were smaller than residents. Coho production therefore appeared to be most strongly influenced by trophic conditions, while volitional residency was most strongly influenced by habitat quality.

Codes: multi reach qual migrat hydro

Bilby, R. E., and B. R. Fransen. 1992. Effect of habitat enhancement and canopy removal on the fish community of a headwater stream. Northwest Science 66: 137.

The riparian trees along a 2km section of stream in western Oregon were logged in 1985, in violation of forest practice regulations. As part of the judgement against the landowner, wood was placed in the channel to improve habitat in 1988. Fish populations and habitat have been monitored since 1986 at 3 sites: the enhanced area, an non-

enhanced reach without a canopy and a non-enhanced reach with a canopy. Pool area increased 20% as a result of the wood addition at the enhanced site. Pool area during summer also increased at the site with the canopy due to beaver activity. Speckled dace (Rhinichthys osculus) have exhibited the greatest response, increasing in numbers at all 3 sites, with greatest gains in the enhanced reach. Salmonid density at all three sites also has increased since 1988. Age 0+ steelhead (Oncorhynchus mykiss) exhibit an inverse relationship between density and growth.

Codes: experi reach quant ripar instream

Bilby, R. E., B. R. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53: 164-173.

Epilithic organic matter, all aquatic macroinvertebrates except shredders, and fish were significantly enriched with N and C in streams (western Washington state, U.S.A.) where spawning coho salmon (Oncorhynchus kisutch) were present. Riparian vegetation adjacent to salmon-bearing streams and shredding macroinvertebrates were enriched with N but not C. The highest levels of enrichment of the stream biota with the heavier isotopes occurred in the early spring, shortly after carcasses had decomposed. Autotrophic uptake was not an important avenue of incorporation. The proportion of nitrogen contributed by spawning salmon varied among trophic categories, ranging from about 17% in collector-gatherers to more than 30% in juvenile coho salmon. Carbon contributed by spawning ranged from 0% in the foliage of riparian plants and shredders to 34% in juvenile coho salmon.

Codes: multi reach qual ripar trophic

Binns, N. A. 1994. Long-term responses of trout and macrohabitats to habitat management in a Wyoming headwater stream. North American Journal of Fisheries Management 14: 87-98.

After 111 habitat improvement devices and 2,150 ft of riprap were installed (1973-1977) in Beaver Creek, northeast Wyoming, the stream developed a narrower channel with deep pools that helped brook trout Salvelinus fontinalis survive low flows. After 7 years, brook trout 6 in and longer had increased 1,814%, brook trout less than 6 inches had increased 1,462%, and the total population density had reached 2,074/mi (268 lb/acre). By 1990, after extended drought during the 1980s, the brook trout population had dropped to 222/mi (41 lb/acre), but this level was 90% better than before habitat development. Over 90% of the devices remained fully functional 18 years after installation, even though some of them were esthetically displeasing due to exposure of logs and planks. Wooden plunges were comparatively easy to install and dug good pools. Deflectors worked better directing currents than digging pools. Wood bank overhangs and overpour (Hewitt) ramps provided variable results, were hard to install, were apt to be damaged by floods, and are not recommended for Wyoming streams.

Codes: experi reach habitat quant hydro temporal

Binns, N. A., and F. M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Trans. Am. Fish. Soc. 108: 215-228.

A habitat quality index (HQI) was developed to predict trout standing crop in Wyoming streams. Measurements of trout habitat were collected from 36 streams that ranged in elevation from 1,146 to 3,042 m. Average late summer stream width varied from 1.4 to 44 m, while average daily flow was between 0.6 and 1.46 mSUP-3 /second. Stream gradient ranged from 0.1% to 10%. A multiple regression analysis indicated those habitat measurements best related to trout standing crop in the study streams. Predictive models were built from these measurements. The best HQI model explained 96% of the variation in trout standing crop (multiple regression correlation coefficient R = 0.983), suggesting a close relationship between HQI predictions and measured trout stocks. The nine habitat attributes used in this model were late summer stream flows, annual stream flow variation, water velocity, trout cover, stream

width, eroding stream banks, stream substrate, nitrate nitrogen concentration, and maximum summer stream temperature.

Codes: multi habitat quant instream substrate wtemp hem

Binns, N. A., and R. Remmick. 1994. Response of Bonneville cutthroat trout and their habitat to drainage-wide habitat management at Huff Creek, Wyoming. North American Journal of Fisheries Management 14: 669-680.

Beginning in 1978, in an effort to restore Bonneville cutthroat trout Oncorhynchus clarki utah, 68 instream habitat structures and 3,760 ft of rock riprap were installed in the Huff Creek (Wyoming) drainage, and livestock was controlled through exclosures and herding. Drainage-wide cutthroat trout abundance and biomass peaked in 1984 at 456 trout/mi and 56 lb/acre. The largest population (1984; 685 trout/mi, 82 lb/acre) occurred at the site containing instream structures within an exclosure. By 1989, mean cutthroat trout numbers (170 trout/mi) were significantly higher ($P = 0.01$) than in 1978 (35 trout/mi), despite severe drought in 1987-1989 and a 75-100 year flood in 1984. Drainage-wide Habitat Quality Index scores were significantly higher and total cover was significantly greater in 1989 than in 1978, but bank stability was not significantly improved. However, banks armored with machine-placed rocks became stable; in contrast, natural healing was slow where rocks were not used. Cutthroat trout abundance was correlated to the previous year's stream discharge, the quantity of cover, and pool area. Plunge pools created by instream structures were deeper than natural pools and greatly aided fishery rejuvenation.

Codes: experi reach habitat quant graz hydro temporal

Bjornn, T., and D. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138. In The influence of forest and rangeland management on salmonids and their habitat. W. R. Meehan, editors. American Fisheries Society Special Publication 19, Bethesda, MD.

#excellent review. Good source for spawning and juvenile habitat preferences and survival at habitat scales, inc. lab work. Good summary of WUA and varibility, with dependence on pref. curves presumed (p124-5).#.

Codes: review habitat quant spawn instream watqual wtemp

Bjornn, T. C., S. C. Kirking, and W. R. Meehan. 1991. Relation of cover alterations to the summer standing crop of young salmonids in small southeast Alaska streams. Transactions of the American Fisheries Society 120: 562-570.

Summer abundance of young coho salmon Oncorhynchus kisutch, steelhead O. mykiss, and Dolly Varden Salvelinus malma was assessed in small streams on Prince of Wales Island, Alaska, in an attempt to measure the response of these fish to various types of cover alterations. The standing crop of subyearlings decreased during summer, but none of the decrease could be attributed to the changes in cover we made. Subyearling coho salmon (about 75% of the fish present) did not respond either to the removal of natural riparian vegetation or to the addition of simulated riparian canopy, large boulders, woody debris, or simulated undercut banks. Localized movements within the streams were sufficient to provide relatively rapid recolonization of the experimental habitat units. The forms of cover we evaluated were relatively unimportant in regulating abundance of young coho salmon in small streams.

Codes: experi multi habitat quant migrat ripar

Black, R. W., and T. A. Crowl. 1995. Effects of instream woody debris and complexity on the aquatic community in a high mountain, desert stream community. Edited by D. A. Hendrickson.

In order to understand the effect of changes in habitat complexity generated by instream woody debris on trout and macroinvertebrate densities and their interactions, we manipulated woody debris densities in the fall of 1991, resulting in significant changes in trout densities and physical characteristics in the summer of 1992. Trout prey electivity (Chesson's) and capture efficiency were directly related to habitat complexity. Macroinvertebrate densities did not respond as significantly to changes in habitat complexity as trout densities. The macroinvertebrates appeared to be limited by primary productivity rather than habitat complexity at the scale of complexity examined here. Habitat complexity was decreased in all of the manipulated study sections by high spring runoff in 1993 which removed most of the smallest branches. Measured responses where not as significant due to the reduction in complexity caused by high spring runoff. If stream restoration efforts are to succeed, additional work on spatial and temporal changes in habitat complexity are needed.

Codes: experi reach quant instream lwd trophic

Blackwell, B. F., G. Gries, F. Juanes, K. D. Friedland, L. W. Stolte, and J. F. McKeon. 1998. Simulating migration mortality of atlantic salmon smolts in the Merrimack River. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 18: 31-45.

Successful restoration of Atlantic salmon Salmo salar to New England rivers involves the identification and management of mortality sources at different life history stages. The purpose of this study was to examine the effects of mortality during migration on Atlantic salmon smolts exiting the Merrimack River. Our objective was to review data pertaining to smolt production, migration, passage at hydroelectric facilities, and predation in the Merrimack River and construct a simulation model of smolt migration. We constructed a migration model incorporating riverflow-based decision rules affecting migration rate, delay at dams, dam passage mortality, and migration mortality. Mean model estimates of in-river survival ranged from 0.7% to 23.5%. Estimated transit times generally increased in migration scenarios in which smolts began migration later in the season; beginning migration later in the season also resulted in lower in-river survival. The model was evaluated by comparing records of returns of two-seawinter adults to the Merrimack River to a likely range of marine survival rates. For 9 of 14 smolt years, model estimates for the number of smolts exiting the river were comparable with the range of smolt output necessary to achieve the corresponding adult returns. Model estimates of in-river survival that fell below the the lower threshold for 5 of the 14 smolt years could be explained in part by relatively high marine survival experienced by these cohorts. We argue that this model can have important applications in population assessment, river management, and salmon restoration.

Codes: modeling migrat popdyn noenv hydro

Bohlin, T. 1977. Habitat selection and intercohort competition of juvenile sea-trout Salmo trutta. Oikos 29: 112-117.

By artificially changing the population density, the habitat preference of 1+ sea-trout S. trutta with respect to different biotopes was studied by electro-fishing in a closed area of of a small stream. The trout seemed to prefer pools or rocky substrates to shallow, smooth-bottom riffles. Marking experiments supported the hypothesis of 'owner's advantage' in the competition for space between resident and introduced fish, and revealed a marked stationarity in spite of possible experimental disturbances. There were significant differences between the mean lengths of 1+ trout in the different biotopes, the deeper biotopes having the largest means. A few older trout showed a similar pattern. There were significant differences between the relative density of O+ trout in the diferent biotopes, the largest densities occurring in shallow, smooth-bottom riffles with low density of older trout. Stream tank experiments showed a tendency for competitive segregation between O+ and I+ trout, the latter being dominant and preferring pools to riffles. Field data of O+ and 1+ density showed a biennial fluctuation with alternating peaks for

O+ and 1+ for a period of five consecutive years. Intercohort interaction, favoured by drought, was a probable cause.

Codes: experi habitat enclos quant instream sppinter lab

Bourgeois, C. E., D. A. Scruton, D. E. Stansbury, and J. M. Green. 1993. Preference of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) for two types of habitat improvement structures. Edited by R. J. Gibson and R. E. Cutting. 103-108 p.

A long-term research program has been developed to evaluate transferability of habitat improvement technology, developed throughout North America, for use with freshwater fish species and endemic conditions in Newfoundland. The initial experiment in this study program in 1990 was to test preferences of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) for two types of habitat improvement structures installed in a controlled flow spawning channel. Data analysis revealed no difference in preferences between species for the test structures based on volitional residence after 5 days. Both species demonstrated a similar order in preference for the mid-channel, stream bank, and control treatments, respectively. This order of selection was constant at high and low density and low and average density but not high and averge density.

Codes: experi enclose quant habitat

Bourgeois, G., R. A. Cunjak, D. Caissie, and N. El Jabi. 1996. A spatial and temporal evaluation of PHABSIM in relation to measured density of juvenile Atlantic salmon in a small stream. North American Journal of Fisheries Management 16: 154-166.

We evaluated the relationship between weighted usable area (WUA) predicted by the physical habitat simulation (PHABSIM) model and the population density of juvenile Atlantic salmon Salmo salar in Catamaran Brook, New Brunswick, Canada. Various temporal and spatial scales of study were used to establish whether a positive linear relationship existed. The PHABSIM model was applied to 19 sites representing four habitat types, and various streamflow scenarios were used to calculate the amount of available WUA. Maximum WUA values for different habitat types and different reaches usually occurred at flows representing 85% of mean annual flow. Fish densities at the 19 sites were estimated by electrofishing in the summer and late autumn for 3 years. Few positive, significant relations were established between Atlantic salmon density and WUA; r super(2) values ranged from 0.18 to 0.95, with the best relations occurring at the scale of habitat type (5 of 16 comparisons were significant, $P < 0.05$). The WUA values calculated from the 15-d average flow before fish sampling displayed the best associations with fish density. (See Cade, B. S. & Terrell, J. W. 1997 criticism of regression forced through zero).

Codes: microhab quant ifim warning hydro hem

Bowlby, J. N., and J. G. Imhof. 1989. Alternative Approaches in Predicting Trout Populations from Habitat in Streams. Pages 317-330. In Alternatives in Regulated River Management. CRC Press, Boca Raton Florida.

Trout modeling attempts have led to the development of the Ontario Trout Habitat Classification (OTHC), which is a model developed using discriminant function analyses to relate trout habitat variables to broad categories of trout biomass density. Here two models used to predict trout biomass density, the Habitat Quality Index (HQI) developed by Binns and Eiserman and the OTHC are examined, including their problems, and improvements are proposed. In the development of OTHC, variables with some nonlinearity performed better in discriminant function models than regression models. Where trout populations are stable, higher precision in prediction might be obtained and a regression model would be preferable. Otherwise, a discriminant function model might provide as much precision as a regression model. The selected variables should represent limiting habitat factors. The variables used in HQI (late summer flow index, annual flow variation, maximum summer temperature, nitrate, benthic invertebrate diversity, eroding banks, submerged aquatic vegetation, water velocity, and stream width) and OTHC (ATP concentration of suspended solids, mean July and August maximum weekly temperature, biomass of benthos, log

shelter, undercut bank shelter, and pool area) are good candidates. However, care must be taken to avoid highly correlated, redundant variables. Different life stages of fish have different requirements. Accordingly, a simple regression or discriminant function model cannot be expected to provide a resource manager with a complete set of predictions required to manage fish habitat. An alternative approach may be to develop multistage models that are interdependent. Habitat could then be managed to optimize survival of the most critical life history stage. (See also W90-09997) (Rochester-PTT).

Codes: multi modeling warning instream wtemp trophic hem

Bowlby, J. N., and J. C. Roff. 1986. Trout biomass and habitat relationships in southern Ontario streams. Transactions of the American Fisheries Society 115: 503-514.

The authors examined relationships between the biomass of trout (species of Salvelinus and Salmo) and physical and biological habitat variables in streams to identify habitat factors that might limit trout biomass. Two habitat quality index models developed by Binns and Eiserman for Wyoming streams accounted for only 6.7 and 9.2% of the variation in trout biomass at Ontario stream sites. Different factors must limit trout biomass in Wyoming streams than in Ontario streams. Regression and discriminant function analyses indicated that trout biomass in southern Ontario is correlated with microcommunity biomass (measured as ATP of the suspended solids, and representing bacteria, fungi, and algae), percent pool area, mean maximum summer temperature, biomass of small benthic invertebrates, presence of piscivorous fish, and a variable representing pools and overhead cover.

Codes: multi reach quant instream wtemp trophic

Bozek, M. A. 1991. Generality of habitat models for Colorado River cutthroat trout fry and the influence of adults on habitat choice and behavior. Dissertation, University of Wyoming.

Because habitat choice by fish can be influenced by various abiotic and biotic factors, habitat models developed in streams can be site-specific and, thus, limited in their general application across streams. Macro- and microhabitat analyses provided complimentary information concerning the habitat use of cutthroat trout (Oncorhynchus clarki) fry. On a microhabitat scale, fry generally used slow water velocities (<0.06 m/s), water depths greater than 3 cm, and a variety of substrate types. Different geomorphological features provided suitable microhabitat among the study streams. On a macrohabitat scale, fry density was related to the abundance of spawning gravel. Adults appeared to have little influence on the habitat used by fry in either laboratory or field conditions primarily due to the abundance of slow-water in all cases. Habitat selection of fry appears to reflect innate preferences rather than adult-fry interactions. The generality of habitat suitability models among seven geomorphically different first- and second-order streams and among years at two of those sites was analyzed. Water depths, velocities and substrates that were available to and used by fry differed significantly among sites and years. No single model developed from any site was found to be satisfactory for use across all sites. However, use of either site-specific models or a composite model appeared to be satisfactory for predicting suitable habitat at each site. Knowing the degree of variability in model predictions prior to use can allow users to determine acceptable levels of error and base their management decisions accordingly. (DBO).

Codes: habitat microhab modeling instream substrate

Bozek, M. A., and F. J. Rahel. 1991. Assessing habitat requirements of young Colorado River cutthroat trout by use of macrohabitat and microhabitat analyses. Transactions of the American Fisheries Society 120: 571-581.

The authors used both microhabitat and macrohabitat analyses to better assess habitat requirements of young Colorado River cutthroat trout Oncorhynchus clarki pleuriticus. Microhabitat analyses revealed that among a range of stream types, young cutthroat trout consistently preferred slow water (<0.06 m/s) and depths over 3 cm. Suitable habitat of this type was provided by different types of pool habitat within the geomorphically diverse study streams.

Macrohabitat analysis indicated that the density of young cutthroat trout was positively correlated with the abundance of spawning gravel and negatively correlated with stream depth (adjusted R super(2) = 0.67). This relationship helped explain the absence of young cutthroat trout from some stream reaches that had suitable microhabitat but that often lacked suitable spawning habitat. The two types of habitat analysis provided complementary information concerning the habitat requirements of young Colorado River cutthroat trout in the study streams.

Codes: habitat microhab instream

Bozek, M. A., and F. J. Rahel. 1992. Generality of microhabitat suitability models for young Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) across sites and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 552-564.

The generality of microhabitat-use and preference models for young-of-year (YOY) Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) was tested across sites and years among geomorphically different streams. Depths, velocities, and substrate types used by YOY cutthroat trout often differed across both sites and years. These differences could only partially be explained as a result of differences in microhabitat availability. Microhabitat-use and preference models also varied in their ability to predict the amount of suitable microhabitat across sites. Estimates of suitable microhabitat abundance differed by up to 40% when microhabitat models were randomly used across sites. Use of a composite model resulted in estimates of suitable microhabitat abundance that differed by less than 20% of that estimated by site-specific models.

Codes: multi habitat microhab instream substrate warning

Bradford, M. J. 1994. Trends in the abundance of chinook salmon (Oncorhynchus tshawytscha) of the Nechako River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 51: 965-973.

Trends in the abundance of chinook salmon (Oncorhynchus tshawytscha) of the Nechako River, a tributary of the Fraser River, were analyzed to quantify the ecological effects of water abstraction for electricity generation. In years when the majority of returning chinook adults used the upper Nechako River for spawning, the survival of offspring for the entire river was poorer than in years when spawning was concentrated in the lower reaches. Relative to the historical discharge, the upper Nechako River has experienced the greatest degree of water abstraction, and the lower survival of chinook brooks originating from the upper river may be early emergence of fry caused by elevated fall and winter water temperatures or to higher rates of predation on juveniles and loss of rearing habitat caused by the elimination of the spring freshet.

Codes: popdyn hydro temporal noenv

Bradford, M. J., and P. S. Higgins. 2001. Habitat-, season-, and size-specific variation in diel activity patterns of juvenile chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss). Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 58: 365-374.

Juvenile salmonids that live in streams are sometimes nocturnal and may spend the day concealed in the stream substrate. The diel activity patterns of juvenile chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss) were observed in two areas of the Bridge River, British Columbia, in all four seasons. In a reach with higher flows, most fish were nocturnal year-round, and they emerged from the substrate only at dusk to forage. In the reach with lower flows, some fish were active in the water column in the day in summer, but others remained concealed in the substrate until dusk. Parr and older fish were more nocturnal in summer than fry. All fish were nocturnal in winter. Because this study design controlled for temperature and photoperiod, it was concluded that the differences in behaviour that were observed between reaches were due to habitat conditions that likely affected the trade-off between more risky daytime foraging and less efficient, but safer, nighttime foraging. Habitat-

driven variation in activity patterns will likely affect the processes that regulate these populations and could make the prediction of the effects of ecosystem manipulations such as changes in flow very difficult.

Codes: habitat qual migrat hydro

Bradford, M. J., and J. R. Irvine. 2000. Land use, fishing, climate change, and the decline of Thompson River, British Columbia, coho salmon. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 13-16.

This study investigates a recent, major decline in the abundance of a large aggregate of coho salmon (Onchorynchus kisutch) spawning in the Thompson River, British Columbia, watershed. It was found that the decline could be attributed to a declining trend in productivity related to changing ocean conditions, overfishing, and freshwater habitat alteration. Among individual watersheds, rates of decline in adult coho salmon abundance were correlated with agricultural land use, road density, and a qualitative measure of stream habitat status but not with the proportion of land recently logged. The recovery of these populations will require the prudent regulation of fishing, the restoration of salmon producing watersheds, and an improvement in ocean conditions.

Codes: basin quant instream lulc temporal

Bradford, M. J., R. A. Myers, and J. R. Irvine. 2000. Reference points for coho salmon (Oncorhynchus kisutch) harvest rates and escapement goals based on freshwater production. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 677-686.

A simple scheme is described for the management of coho salmon (Oncorhynchus kisutch) population aggregates that uses reference points derived from an empirical analysis of freshwater production data. A rectilinear "hockey stick" model is fit to 14 historical data sets of female spawner abundance and resulting smolt production and found that at low spawner abundance, the average productivity was about 85 smolts per female spawner. Variation in productivity among streams may be related to the quality of the stream habitat. It is shown here how freshwater productivity can be combined with forecasts of marine survival to provide a limit reference point harvest rate. The method used here will permit harvest rates to track changes in ocean productivity. Historical data was also used to estimate that, on average, a density of 19 female spawners times km super (-1) is required to fully seed freshwater habitats with juveniles. However, there was considerable variation among the streams that might limit the utility of this measure as a reference point. Uncertainty in the forecasts of marine survival and other parameters needs to be incorporated into this scheme before it can be considered a precautionary approach.

Codes: multi basin quant popdyn noenv

Bradford, M. J., and G. C. Taylor. 1997. Individual variation in dispersal behaviour of newly emerged chinook salmon (Oncorhynchus tshawytscha) from the upper Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 1585-1592.

Immediately after emergence from spawning gravels, fry of stream-type chinook salmon (Oncorhynchus tshawytscha) populations from tributaries of the upper Fraser River, British Columbia, distribute themselves downstream from the spawning areas, throughout the natal stream, and into the Fraser River. The hypothesis was tested that this range in dispersal distances is caused by innate differences in nocturnal migratory tendancy among individuals. Using an experimental stream channel, repeatable differences were found in downstream movement behaviour among newly emerged chinook fry. Fish that moved downstream were larger than those that held position in the channel. The incidence of downstream movement behaviours decreased over the first 2 weeks after emergence. It was proposed that the variation among individuals in observed downstream movement behaviour

leads to the dispersal of newly emerged fry throughout all available rearing habitats. Between- and within-population variation in the freshwater life history observed in these populations may be caused by small differences in the behaviour of individuals.

Codes: experi reach migrat

Bradford, M. J., G. C. Taylor, and J. A. Allan. 1997. Empirical review of coho salmon smolt abundance and the prediction of smolt production at the regional level. Transactions of the American Fisheries Society 126: 49-64.

Regional habitat and fisheries management planning requires estimates of the capacity of watersheds to produce salmonids. To predict the average abundance of smolts of coho salmon Oncorhynchus kisutch produced by streams and rivers, we related estimates of smolt abundance to habitat features derived from maps and discharge records. We assembled a database of 474 annual estimates of smolt abundance from 86 streams in western North America for this analysis. We found that only stream length and to a lesser extent latitude were useful in predicting mean smolt abundance. The frequency distribution of annual estimates of smolt abundance from individual streams tended towards a normal rather than the more usual lognormal distribution; the median coefficient of variation in abundance was 37%. Our results are consistent with the view that, on average, smolt abundance is limited by spatial habitat, but that there is significant annual variation in abundance probably due to variation in habitat quality caused by climate, flow, or other factors. We conclude that forecasting smolt yield from stream length and latitude is feasible at the watershed or regional level, but that the precision of a prediction for a single stream is poor. A more detailed approach will be required for local forecasting.

Codes: multi quant basin temporal warning

Bremset, G., and O. K. Berg. 1997. Density, size-at-age, and distribution of young Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) in deep river pools. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 2827-2836.

A comparison of populations of juvenile Atlantic salmon (Salmo salar) and brown trout (S. trutta) in four deep pools (maximum depths 2.0-4.0 m) and 12 shallow riffles in three rivers showed significantly higher density, size-at-age, and biomass of the pool-dwelling salmonids. There were 2.5 times more parr per unit of area in the pools compared with the riffles. The pool-dwelling trout had a larger size-at-age than riffle specimens, and the pool-dwelling salmon were larger than those found in the riffles in three of four cases. The relative biomass of salmonid parr in two of the investigated pools was 6.9 and 12.0 g/m super(2) compared with the means of 1.6 and 3.7 g/m super(2) in the riffles. There are two possible explanations that are discussed for the larger size-at-age of the fish in the deep pools: 1) movements of large, dominant parr into the pools as they grow older or 2) favorable conditions in the pools that give pool-dwelling fish an energetic advantage. In contrast with established theory, the current data show that deep pools are favorable habitats for both young Atlantic salmon and brown trout.

Codes: multi habitat quant migrat instream

Bridcut, E. E., and P. S. Giller. 1993. Movement and site fidelity in young brown trout Salmo trutta populations in a southern Irish stream. Journal of Fish Biology 43: 889-899.

Populations of brown trout Salmo trutta were monitored at a number of sites within a single stream, using an individual marking technique and recapturing uniquely marked fish repeatedly over a period of 12 months. Individual 1+ and 2+ resident brown trout in the Glenfinish River were found to consist of stationary and mobile component populations. The latter population consisted of a number of individuals observed moving mostly in an upstream direction, within a range of 0.03-2.24 km. On a large spatial scale, individuals in the stationary component population exhibited some degree of home site fidelity within the stream, over a period of 3-4 months, after which

the fish tended to move from the site. Within sites, fidelity to either riffle or pool habitats, mostly the latter, was apparent in a proportion of the population. On a smaller scale, fidelity to the exact position with respect to boulders in the stream was also evident in a number of individuals. Home range size was calculated amongst these individuals, with ranges of up to 20 m recorded.

Codes: quant migrat habitat reach instream

Brown, T. G., and G. F. Hartman. 1988. Contribution of seasonally flooded lands and minor tributaries to the production of coho salmon in Carnation Creek, British Columbia. Transactions of the American Fisheries Society 117: 546-551.

Ten percent of the juvenile coho salmon Oncorhynchus kisutch rearing in the main channel of Carnation Creek during the summer moved into intermittent tributaries and ephemeral swamps (off-channel winter habitats) during the autumn of 1983. The number of juveniles residing within specific off-channel sites during winter was governed by the magnitude of water levels associated with the first fall storms relative to the flooding levels required for adequate access to these sites ($P < 0.05$). Off-channel habitats contributed 15.3% of the watershed's coho salmon smolts in 1983 and 23.1% in 1984. A 25-year flood event (65 m^3/s) occurred in January 1984 and may have reduced the main-channel contribution for that year. The inability of coho salmon smolts to emigrate from off-channel habitats and return to the main channel in spring may have reduced the off-channel contribution in 1983. April-May water levels were 37% below the 13-year mean water level in 1983 and 55% above it in 1984.

Codes: quant offchann hydro

Brown, T. G., I. V. Williams, and A. Langston. 1987. Watershed database: Barkley Sound, Vancouver Island. Report ISSN 0706-6465. database.

Catalogue of 64 Barkley Sound streams which provides information on: location, physical characteristics, forest cover, tenure status, biogeoclimatic variants and relative abundance of salmonid species. This catalogue was designed to provide a single source of the information considered essential to initial practical study designs for future fish/forestry research.

Codes: database

Brown, T. G., I. V. Williams, and R. T. E. Pulfer. 1987. Watershed database: Clayoquot Sound, Vancouver Island. Report ISSN 0706-6465. database.

Catalogue of 34 Clayoquot Sound streams which provides information on: location, physical characteristics, forest cover, tenure status, biogeoclimatic variants and relative abundance of salmonid species. This catalogue was designed to provide a single source of the information considered essential to initial practical study designs for future fish/forestry research.

Codes: database

Brusven, M. A., W. R. Meehan, and J. F. Ward. 1986. Summer use of simulated undercut banks by juvenile chinook salmon in an artificial Idaho channel. North American Journal of Fisheries Management 6: 32-37.

The effects of introducing simulated undercut stream banks on the distribution of juvenile chinook salmon (Oncorhynchus tshawytscha) were studied in a naturally vegetated, flow-regulated channel in Idaho in 1980 and 1981. In all tests, mean fish weight was greater in covered than in open sections. Preference for the covered versus uncovered experimental sections was highly significant during July and August tests. For all tests combined, 82% of the fish by numbers and 85% by biomass were collected in covered sections. The results suggest that undercut

banks as simulated by artificial shelters, are an important summer habitat component for juvenile chinook salmon that should be carefully evaluated by the manager.

Codes: experi reach quant instream

Bryant, M. D. 1988. Gravel pit ponds as habitat enhancement for juvenile coho salmon. General Technical Report PNW-GTR-212. (USDA, Forest Service, Pacific Northwest Research Station, Portland, OR) 10p.

Gravel pits built during road construction in the early 1970's near Yakutat, Alaska, filled with water and were connected to nearby rivers to allow juvenile salmonids to enter. Seasonal changes in population size, length and weight, and length frequencies of the coho salmon (Oncorhynchus risutch) population were evaluated over a 2-year period. Numbers of coho salmon fluctuated, but two of the ponds supported high populations, 2,000 fish throughout the study. These ponds appeared to support coho salmon throughout the winter.

Codes: offchann quant

Bryant, M. D., P. E. Porter, and S. J. Paustian. 1991. Evaluation of a stream channel-type system for southeast Alaska. Report FSGTR-PNW-267.

Nine channel types within a hierarchical channel-type classification system were surveyed to determine relations between salmonid densities and species distribution, and channel type. Two other habitat classification systems and the amount of large woody debris also were compared to species distribution and salmonid densities, and to stream channel types. Although trends appeared in salmonid densities and channel types, population estimates were too variable to show a relation between density and channel types. Depth-velocity criteria that separated habitat into shallow-slow, deep-slow, shallow-fast, and deep-fast were poorly related to fish populations and channel types. Within Bisson classification system, coho salmon (Oncorhynchus kisutch) parr were positively correlated to off-channel habitat types. Large wood was more abundant in despositional channel types, and coho salmon densities were positively related to debris accumulations of 10 or more pieces and to rootwads.

Codes: multi reach quant lwd offchann instream warning

Bryant, M. D., D. N. Swanston, R. C. Wissmar, and B. E. Wright. 1998. Coho Salmon Populations in the Karst Landscape of North Prince of Wales Island, Southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 425-433.

Karst topography is a unique and distinct landscape and its geology may have important implications for salmon productivity in streams. The relationship between salmonid communities and water chemistry and the influence of habitat was examined in a set of streams on north Prince of Wales Island, southeast Alaska. Streams in karst landscapes showed higher alkalinities (1,500-2,300 mu eq/L) than streams not influenced by karst landscapes (750-770 mu eq/L). A significant, positive relationship was observed between alkalinity and density of coho salmon parr Oncorhynchus kisutch. Backwater pools supported higher densities of coho salmon than did other habitat units. Both coho salmon fry and parr tended to be larger in most karst-influenced streams than in nonkarst streams. Although past timber harvest practices in the riparian areas of several of the streams appeared to influence stream habitat and water temperature, streams flowing through karst landscapes had a distinct water chemistry. Furthermore, these streams appeared to support more fish than nonkarst streams.

Codes: multi habitat quant offchann lulc watqual

Bryant, M. D., B. E. Wright, and B. J. Davies. 1992. Application of a hierarchical habitat unit classification system: Stream habitat and salmonid distribution in Ward Creek, Southeast Alaska. Report FSRN-PNW-508.

A hierarchical classification system separating stream habitat into habitat units defined by stream morphology and hydrology was used in a pre-enhancement stream survey. The system separates habitat units into macrounits, mesounits, and microunits and includes a separate evaluation of instream cover that also uses the hierarchical scheme. The paper presents an application of the system to a pre-enhancement survey of habitat and salmonid populations. Application of the method accompanied by snorkel counts of fish allowed us to determine habitat area, salmonid densities within habitat units, and an estimate of the total salmonid population by species. The method is useful to rapidly describe and stratify stream habitat to determine salmonid distribution and abundance during stream surveys.

Codes: reach habitat quant instream

Bult, T., S. C. Riley, R. L. Haedrich, R. J. Gibson, and J. Heggenes. 1999. Density-dependent habitat selection by juvenile Atlantic salmon (Salmo salar) in experimental riverine habitats. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 56: 1298-1306.

Habitat use was investigated of Atlantic salmon (Salmo salar) parr in experimental riverine enclosures made up of pool, riffle, and run habitats over a range of densities (0.1-1.25 fish times m super(-2)) to test the implicit assumption in habitat modelling that habitat selection does not change with population density. Results indicated that habitat use changed with population density, with relatively more parr in pools and fewer in runs at higher population densities. Temperature influenced parr distribution, with relatively more parr in runs and fewer in riffles and pools at higher temperatures. Parr distribution was primarily affected by hydromorphological differences among pool, riffle, and run habitats. Effects of population density and temperature on use of pool, riffle, and run habitats were often as large as effects of hydromorphological differences among pool, riffle and run habitats on fish distributions over the range of temperatures and densities observed. Results varied considerably, despite controlled experimental conditions. It was concluded that habitat selection by juvenile Atlantic salmon parr may be density dependent and potentially quite variable.

Codes: enclos habitat quant popdyn wtemp

Bult, T. P., R. L. Haedrich, and D. C. Schneider. 1998. New technique describing spatial scaling and habitat selection in riverine habitats. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 14: 107-118.

We propose a quantitative multi-scale technique based on frequency analysis and randomisation to study habitat selection by fish in riverine habitats. The technique can be used over any range of spatial scales in an environment with irregular boundaries. We illustrate the approach using simulated distributions and field data on juvenile Atlantic salmon (Salmo salar) distributions, obtained by snorkelling in North Harbour River, Newfoundland, Canada. We suggest that current habitat models may be improved by a more explicit use of space and time scales. Multi-scale approaches to study fish-habitat relationships and multi-scale habitat models may be better at capturing how fish are associated with their environment than single-scale approaches and models. Habitat selection studies should focus on identifying scales most appropriate to management questions. From this, management of fish populations and fish habitats may be improved.

Codes: reach habitat modeling

Burgess, S. A. 1985. Some effects of stream habitat improvement on the aquatic and riparian community of a small mountain stream. Edited by J. A. Gore. 223-246 p.

The purpose of this study was to determine the effectiveness of a relatively simple habitat improvement program in increasing trout (Salvelinus fontinalis) biomass in an experimental section of a small mountain stream. The intention was to use relatively simple techniques with low cost and labor requirements.

Codes: experi reach quant instream

Burgess, S. A., and J. R. Bider. 1980. Effects of Stream Habitat Improvements on Invertebrates, Trout Populations, and Mink Activity. Journal of Wildlife Management 44: 871-880.

A section of spring-fed mountain stream near Lac Carre, Quebec, was altered to provide improved habitat for brook trout. A similar 100 meter section of stream was left unimproved as a control. Changes included adding small dams of rocks and logs, large boulders, and cover. After 2 years the trout population and biomass in the improved stream increased by 208% and 179%, respectively; crayfish, by 220%. In the improved section, water temperatures were the same as in the control; insect populations were higher. Mink were 52.5% more active near the improved stream, but preyed mostly on crayfish and small mammals. Analysis of mink scats showed that trout were not an important prey. (Cassar-FRC).

Codes: experi reach quant instream

Burns, J. W. 1972. Some effects of logging and associated road construction on northern California streams. Transactions of the American Fisheries Society 101: 1-17.

The effects of logging and associated road construction on four California trout and salmon streams were investigated from 1966 through 1969. This study included measurements of streambed sedimentation, water quality, fish food abundance, and stream nursery capacity. Logging was found to be compatible with anadromous fish production when adequate attention was given to stream protection and channel clearance. The carrying capacities for juvenile salmonids of some stream sections were increased when high temperatures, low dissolved oxygen concentrations, and adverse sedimentation did not accompany the logging. Extensive use of bulldozers on steep slopes for road building and in stream channels during debris removal caused excessive streambed sedimentation in narrow streams. Sustained logging prolonged adverse conditions in one stream and delayed stream recovery. Other aspects of logging on anadromous fish production on the Pacific Coast are discussed.

Codes: multi experi reach quant lulc instream substrate wtemp watqual

Cade, B. S., and J. W. Terrell. 1997. Comment: Cautions on forcing regression equations through the origin. North American Journal of Fisheries Management 17: 225-227.

Bourgeois et al. (1996) evaluated relationships between weighted usable habitat area (WUA) and density of juvenile Atlantic salmon Salmo salar in New Brunswick stream. They were testing one of the most criticized features of the instream flow incremental methodology: the assumption that fish standing stock is positively correlated with WUA. They estimated fish densities by electrofishing, and they calculated WUAs for day-of-sampling and averaged streamflows. Then they used regression analysis to assess how the relation y = beta sub(0) + beta sub(1)X sub(1) + epsilon between fish density (y) and WUA (X sub(1); epsilon is an error term) was affected by season (summer, autumn), year (1990-1992), and spatial scale (habitat, reach, basin). They also examined the effect of forcing each regression through the origin (y = beta sub(1)X sub(1) + epsilon) on the grounds that "no habitat equals no fish." They reported that "in most cases, forcing the intercept to 0 improved the r super(2) from a low nonsignificant relation to a highly significant relation" and documented the changes in their Table 5. One must ask how a linear regression model with only one parameter (slope) can fit data better (have a higher r super(2)) than a two-parameter

model (slope and intercept). The answer is that it cannot. The real cause of he apparent improvement was a change in the underlying null model.

Codes: ifim stats warning hem

Campbell, E. A. 1999. Influence of Streamflow and Predators on Habitat Choice by Trout

I examined the effect of flow and presence of large brown trout (potential predators) on habitat choice by juvenile rainbow trout and brook charr. Experiments were conducted in a large (8.1 m x 1.5 m) stream enclosure with a pool-riffle-pool configuration. Large brown trout, when present, were confined to the upstream pool. Juvenile trout and charr tended to leave the riffle and occupy the pools when flow was low. They also were less likely to be found in the upstream pool when large brown trout were present; juvenile fish remaining in the upstream pool avoided the deep area with cover favored by the large brown trout especially at sunset and at night at high flow. Low flow apparently caused juvenile trout and charr to inhabit pools with large brown trout that they would otherwise avoid. Observations of marked individuals indicated that juvenile fish increased their preference for shallower water of intermediate velocity when flow changed from low to high, even after adjusting for different depth and velocity availabilities. This suggests that depth and velocity preferences were flow dependent. Furthermore, velocity choice of aggressive fish increased more than for non- aggressive individuals, and velocity choice of rainbow trout increased more than for brook charr. Feeding rates of juvenile rainbow trout and brook charr declined both when flow was low and when large brown trout were present, although aggressive fish had higher overall feeding rates than non-aggressive individuals. Feeding rates were likely affected by changes in food availability related to both flow level and changes in local fish density, as well as the aggressiveness of individual fish. This result indfcates that microhabitats having water of the same velocity may not always be of the same value to drift-feeding juvenile salmonids. Overall, this study has shown that flow and predator effects on juvenile salmonid habitat choice are extremely complex. Both habitat use and feeding rate were strongly affected by flow, predator presence, diel period, and the aggressiveness level of individual fish. Interactions among these variables were common. Models used to recommend instream flows for regulated streams may not adequately evaluate stream fish habitat.

Codes: enclos reach habitat quant trophic sppinter warning

Capra, H. 1995. Improvement of habitat models for brown trout: sampling scales; utilization of habitat time series. Report; Dissertation Dissertation, Lyon-1 Univ., France Univ. Claude Bernard.

Our goals, to increase predictive power of fish / habitat relationships simulations were: (1) to develop a new biological model (in contrast with suitability curves); (2) to analyse relationships between habitat time series and fish population dynamics. Fish Habitat relationships modelling at a local scale individual to perform a vital activity. This new sampling scale, called minihabitat (Ambiance in french), is larger than the focal point (snout fish) but smaller than the morphological unit in habitat hierarchy. 1- The minihabitat sampling procedure enables to get biological data representative of population structure, and physical data representative of available habitat in a stream segment. 2- The multiple regression on variabiliy of the three physical parameters (Depth, velocity and substrate) has the best predictive power and is the most transferable model to predict minihabitat trout density. Integrating habitat temporal dynamics The main aim of this study was to found habitat bottlenecks for different trout life stages. 1- A new tool was developed to study habitat (or discharge) time series. In fact, it enables to identify Continuous Under-threshold Durations (CUT curves) (DCHL in french) during which available habitat is less than the threshold value. 2- Two life stages were sensible to habitat fluctuations. Habitat conditions during reproduction and post-emerging periods both influence the strength of the young of the year after and of the adults three years after. Habitat conditions during long low flow periods influence the strength of the adult of the same year. This study points out the need of a definition of a instream regime, more than an instream flow.

Codes: modeling microhab instream temporal foreign

Capra, H., P. Breil, and Y. Souchon. 1995. A new tool to interpret magnitude and duration of fish habitat variations. Regulated Rivers: Research & Management 10: 281-289.

The main result of habitat simulation procedures is a static relationship between an index of potential habitat, e.g. weighted usable area (WUA), versus discharge in a study reach representative of a stream. A new methodology was developed to analyse the timing and magnitude of physical habitat variations. Three options are presented: (i) the habitat time series; (ii) the habitat duration curves; and (iii) the continuous under threshold habitat duration curves. The last option is a new procedure to interpret habitat chronicles. It determines continuous durations during which the total WUA in a study reach was lower than a given threshold. The assumption according to which some durations/threshold values could represent limiting events for fish population dynamics is illustrated with surveys of two wild brown trout populations. The relationship between spawning habitat conditions and the relative density of 0+ the year after was studied. A continuous duration of more than 20 days with spawning habitat conditions lower than 80% of the optimum conditions seemed to limit the number of 0+ trout. This procedure is presented as a tool to interpret natural discharge time series for management.

Codes: microhab modeling instream ifim hydro hem

Cederholm, C. J., R. E. Bilby, P. A. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett, and J. W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 947-963.

Many fish habitats have been altered in Pacific Northwest streams and rivers over the past century by a variety of land use practices, including forestry, urbanization, agriculture, and channelization. There are research and management needs for evaluation of the effectiveness of rehabilitation projects intended to enhance stream fish habitat recovery. The response of populations of juvenile coho salmon Oncorhynchus kisutch and steelhead O. mykiss to addition of large woody debris (LWD) was tested in North Fork Porter Creek (NFPC), a small coastal tributary of the Chehalis River, Washington. The NFPC was divided into three 500-m study sections; two sections were altered with two approaches (engineered and logger's choice) to adding LWD, and the third was kept as a reference site. Immediately after LWD addition, the abundance of LWD pieces was 7.9 times greater than the pretreatment level in the engineered site and 2.7 times greater in the logger's choice site; abundance was unchanged in the reference site. Subsequent winter storms brought additional LWD into all three study sites. In the years that followed, the amount of pool surface area increased significantly in both the engineered and logger's choice sites, while it decreased slightly in the reference site. After LWD addition, winter populations of juvenile coho salmon increased significantly in the engineered and logger's choice sites, while they remained the same in the reference site. There were no significant differences in the coho salmon populations during spring and autumn within the reference, engineered, or logger's choice sites. The coho salmon smolt yield from the engineered and logger's choice sites also increased significantly after LWD addition, while it decreased slightly in the reference site. After LWD addition, the reference site and the engineered site both exhibited increases in age-0 steelhead populations; however, the population in the logger's choice site did not change. There was no difference in age-1 steelhead abundance among sites, or before and after enhancement during any season. Winter populations of juvenile coho salmon and age-0 steelhead were related inversely to maximum and mean winter discharge.

Codes: experi quant lwd hydro

Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative Effects of Logging Road Sediment on Salmonid Populations in the Clearwater River, Jefferson County, Washington. Pages 38-74 in Proceedings of a conference "Salmon spawning gravel: a renewable resource in the Pacific Northwest?" Report 39, Washington Water Resource Center, Washington State University, Pullman, WA.

In 1971 a series of massive landslides on the west coast of the Olympic Peninsula, which included both logging and road sidecast failures, prompted research on the sedimentation of salmonid spawning habitats. The sedimentation from logging road activities has caused long-term concern for fisheries resources of the Clearwater River. This

study included analyses of field situations supplemented by controlled experiments. Significant amounts (15-25 percent) of fine sediments (less than 0.85 mm diameter material) are accumulating in spawning gravels of some heavily roaded tributary basins. This accumulation is highest where the road area exceeds 2.5 percent of the basin area. Tributaries of relatively steep gradient are less likely to accumulate high levels of fines. The survival of salmonid eggs to emergence is inversely correlated with percent fines when the percentage of fines exceeds the natural level of 10 percent. The presence of 2.5 km/km-squared of gravel-surfaced roads undergoing an average distribution of road uses is found to be responsible for producing sediment at 2.6 to 4.3 times the natural rate in a drainage basin. Sixty percent of the road-related sediment production is caused by landslides, while 18-26 percent is caused by erosion on road surfaces. However, if fine sediment alone is considered, the production from road surfaces and landslides is nearly equal. (Garrison-Omniplan).

Codes: multi reach qual spawn substrate

Chapman, D. W. 1995. Efficacy of structural manipulations of instream habitat in the Columbia River basin. Rivers 5: 279-293.

Instream habitat structures designed to enhance salmon populations have been placed in many tributaries in the Columbia River basin. Examination of test data reveals little reliable evidence of benefits. Suitable protocols for study require many years and suitably paired test and reference areas; a commitment of resources not evident to date. Emphasis on instream structures reduces emphasis on problems that contribute to loss of instream habitat quality. I suggest that managers shift attention to watershed husbandry instead of relying on instream palliatives.

Codes: review multi experi instream lulc warning

Chapman, D. W., and E. Knudsen. 1980. Channelization and Livestock Impacts on Salmonid Habitat and Biomass in Western Washington. TAFS 109: 357-363.

The authors examined salmonid habitat and biomasses in 50-70-m pairs of altered and control sections of small (discharges less than 0.3 m super (3) second super (-1)) streams around Puget Sound in western Washington in 1978-1979. Altered sections had been channelized or used by livestock. Channelization significantly reduced overhead cover, sinuosity, wetted area, and woody bank cover while increasing bank grasses. Total habitat area declined in altered areas. These impacts most damaged the quality of habitat for cutthroat trout (Salmo clarki) over 70 mm in length. Biomass of coho salmon (Oncorhynchus kisutch) did not decline significantly in altered sections except in areas severely damaged.

Codes: multi experi reach quant graz ripar

Chisholm, I. M., and W. A. Hubert. 1986. Influence of stream gradient on standing stock of brook trout in the Snowy Range, Wyoming. Northwest Science 60: 137-139.

Gradient and other instream habitat variables were assessed for their influence on brook trout (Salvelinus fontinalis) abundance in small streams where brook trout were the only fish species present. Brook trout occurred throughout the gradient-range studied (0.4-9.2 percent), but increased gradient had a negative influence on abundance. Gradient, width to depth ratio, mean depth, and mean width accounted for 68.8% of the variation in brook trout abundance among the 24 study reaches.

Codes: multi reach quant instream

Clark, M. E., and K. A. Rose. 1997. Factors affecting competitive dominance of rainbow trout over brook trout in southern Appalachian streams: Implications of an individual-based model. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 126: 1-20.

We used an individual-based model to examine possible explanations for the dominance of rainbow trout Oncorhynchus mykiss over brook trout Salvelinus fontinalis in southern Appalachian streams. Model simulations were used to quantify the effects on interspecific competition of (1) competitive advantage for feeding sites by rainbow trout, (2) latitudinal differences in stream temperatures, flows, and daylight, (3) year-class failures, (4) lower fecundity of brook trout, and (5) reductions in spawning habitat. The model tracks the daily spawning, growth, and survival of individuals of both species throughout their lifetime in a series of connected stream habitat units (pools, runs, or riffles). Average densities of each species based on 100-year simulations were compared for several levels of each of the five factors and for sympatric and allopatric conditions. Based on model results and empirical information, we conclude that more frequent year-class failures and the lower fecundity of brook trout are both possible and likely explanations for rainbow trout dominance, that warmer temperatures due to latitude and limited spawning habitat are possible but unlikely explanations, and that competitive advantage for feeding sites by rainbow trout is an unlikely explanation. Additional field work should focus on comparative studies of the reproductive success and the early life stage mortalities of brook and rainbow trout among Appalachian streams with varying rainbow trout dominance.

Codes: habitat modeling popdyn sppinter instream wtemp temporal

Clark, M. E., K. A. Rose, D. A. Levine, and W. W. Hargrove. 2001. Predicting climate change effects on Appalachian trout: Combining GIS and individual-based modeling. Ecological Applications 11: 161-178.

We coupled an individual-based model of brook trout (Salvelinus fontinalis) and rainbow trout (Oncorhynchus mykiss) with a geographic information system (GIS) database to predict climate change effects on southern Appalachian stream populations. The model tracked individuals of both species through the daily processes of spawning, growth, feeding, mortality, and movement for 30 years in a stream reach consisting of connected pools, runs, and riffles. The southern Appalachian Plateau was divided into 101 watershed elevation band zones. Model simulations were performed for a representative stream reach of each stream order in each zone. Trout abundance was estimated by multiplying predicted trout densities (measured in number of trout per meter) by the total length of streams of each order in each watershed elevation zone. Three climate change scenarios were analyzed: temperature only (1.5-2.5[degree]C warmer stream temperatures); temperature and flow (warmer stream temperatures and lower baseline flows with threefold higher peak flows); and temperature, flow, and mortality episodes (warmer stream temperatures, changed flows, and flow-related scouring of redds). Increased temperature alone resulted in increased abundances of brook and rainbow trout. The temperature-and-flow scenario resulted in a complex mosaic of positive and negative changes in abundances in zones, but little change in total abundance. Addition of episodic mortality in the form of floods that scour redds and kill eggs and fry caused a net loss of rainbow trout. Predicted changes in habitat (based on simulation results and temperature alone) were, at best, weakly correlated with predicted changes in abundance. The coupling of individual-based models to GIS databases, in order to scale up environmental effects on individuals to regional population responses, offers a promising approach for regional assessments.

Codes: multi reach modeling popdyn sppinter instream wtemp temporal lulc

Clarke, K. D., and D. A. Scruton. 1999. Brook trout production dynamics in the streams of a low fertility Newfoundland watershed. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 1222-1229.

Production of brook trout Salvelinus fontinalis ranged from 99 to 651 g times 100 m super (-2) times year super(-1) among headwater streams of the Copper Lake watershed in insular Newfoundland. Ratios of annual production to mean annual biomass (P/B) ranged from 0.9 to 1.5 among the same streams. Empirical models developed from stream salmonid populations in the United States successfully predicted modal production based on water alkalinity

and P/B ratios based on age-class structure of the populations. Differences in production among streams were consistent with previous work in low-fertility headwater systems, which suggests habitat attributes of the stream define salmonid production within the range dictated by the water fertility. The most important of these attributes in this study was food abundance. Substrate composition and habitat complexity may have played secondary roles in determining production in the most productive stream.

Codes: multi reach quant instream trophic

Clarkson, R. W., and J. R. Wilson. 1995. Trout biomass and stream habitat relationships in the White Mountains area, east-central Arizona. Transactions of the American Fisheries Society 124: 599-612.

We surveyed stream habitats and fish populations at 243 stations among 21 high-elevation trout streams in the Apache-Sitgreaves National Forest and White Mountain Apache Reservation in the White Mountains area, east-central Arizona, from 1986 to 1990. The White Mountains area makes up most of the historic habitat for Apache trout Oncorhynchus apache, listed by the U.S. federal government as a threatened species. A generalized linear model relating trout biomass and stream, riparian, and geomorphic habitat variables was developed (R super(2) = 0.68). Among the significant variables in the systematic components of the model, bank damage by ungulates was the only variable solely influenced by land management practices. We attribute the bulk of the bank damage to domestic cattle grazing and conclude that better cattle management is necessary for improvement of trout habitats. Another significant variable, channel width, was partly dictated by geomorphology but was also correlated with bank damage by ungulates. Three significant variables in the model were completely geomorphic (station elevation, channel type, riparian area width) and thus not useful for management purposes. The model coefficient of determination was relatively low in comparison with some other trout-habitat models developed in the western USA. This result may indicate that trouts in our study area are limited less by physical habitat than by climatic events or predation and competition influences.

Codes: reach multi graz ripar quant

Conder, A. L., and T. C. Annear. 1987. Test of Weighted Usable Area Estimates Derived from a PHABSIM Model for Instream Flow Studies on Trout Streams. North American Journal of Fisheries Management 7: 339-350.

An assessment was made of the biological validity of weighted usable area (WUA) from the physical habitat simulation (PHABSIM) model based on standing crops of trout (Salvelinus and Salmo spp.) measured in Wyoming streams and standing crops predicted by the habitat quality index (HQI). Tests were made in trout streams for (1) validity of the HQI, (2) relationships between WUA and measured standing crops in different streams, and (3) relationships between WUA and the HQI within streams. Significant correlation ($r=0.934$; $P<0.05$) was found between HQI scores and trout standing crop during the low-flow period. No significant correlation was found for WUA and the measured standing crop among different streams; correlation coefficients for all tests were either near zero or moderately negative. Significant positive correlation ($P<0.05$) did exist for 7 of the 60 within-stream analyses of WUA vs. HQI; 19 other positive correlations were strong ($r>0.90$), but statistical significance was limited by the number of data points at each site. Although positive correlations were expected for all 60 cases, 18 tests showed a negative correlation, 3 of which were significant. Analyses indicated that trout species, stream size, and stream gradient influence the validity of the within-stream relationship between WUA and the trout standing crop predicted by the HQI. Among test streams with steeper gradients and where velocity exerted the greatest influence on the HQI score, apositive correlation was observed in all cases, regardless of stream size or dominant species. When an attribute other than velocity has the greatest influence on trout density with change in discharge, WUA estimates may be invalid. This observation indicates that a relationship between WUA and trout standing crop may exist, but the nature of the relationship is likely to be unique for each stream. (Author 's abstract).

Codes: multi reach quant instream ifim warning hem

Connolly, P. J. 1997. Influence of stream characteristics and age-class interactions on populations of coastal cutthroat trout. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Resident cutthroat trout are often the only salmonid species, and sometimes the only fish species, occupying first- and second-order streams in the central Oregon Coast Range. As cutthroat trout grow, the habitat they utilize changes. Age-0 cutthroat trout are often associated with the lateral margins of a stream, whereas age-1 and older cutthroat trout are largely associated with pools. Bisson et al. observed that cutthroat trout of all ages generally preferred cover provided by woody debris in both pool and riffle habitats. In this paper, I show that complex age-class and habitat interactions may regulate recruitment success of cutthroat trout. I argue that this possibility should be considered in evaluating the health of populations and the effects of stream restoration projects.

Codes: multi reach qual popdyn lwd instream warning

Connolly, P. J., and J. D. Hall. 1999. Biomass of coastal cutthroat trout in unlogged and previously clear-cut basins in the central Coast Range of Oregon. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 128: 890-899.

Populations of coastal cutthroat trout Oncorhynchus clarki clarki were sampled in 16 Oregon headwater streams during 1991-1993. These streams were above upstream migration barriers and distributed among basins that had been logged 20-30 and 40-60 years ago and basins that had not been logged but had burned 125-150 years ago. The objective of our study was to characterize the populations and habitats of age-1 or older cutthroat trout within these three forest management types. Streams within unlogged basins had relatively low levels and a small range of trout biomass (g/m super(2)). Streams in basins logged 40-60 years ago supported low levels but an intermediate range of trout biomass. Streams in basins logged 20-30 years ago supported the widest range of biomass, including the lowest and highest biomasses among all streams sampled. The variable that best explained the variation of trout biomass among all 16 streams was the amount of large woody debris (LWD). All streams were heavily shaded during at least part of the year by mostly closed tree canopies. Deciduous trees were more prominent in canopies over streams in logged basins, while conifers were more prominent in the stream canopies of unlogged basins. Our results suggest that trout production in basins extensively clear-cut 20-60 years ago may generally decrease or remain low over the next 50 or more years because of decreasing loads of remnant LWD, persistent low recruitment potential for new LWD, and persistent heavy shading by conifers. These logged basins are not likely to show an increase in trout biomass over the next 50 years unless reset by favorable natural disturbances or by habitat restoration efforts.

Codes: multi habitat quant ripar lwd lulc

Contor, C. R., E. Hoverson, P. Kissner, and J. Volkman. 1996. Umatilla Basin natural production monitoring and evaluation. Annual progress report, 1994--1995. Report

This report summarizes the activities of the Umatilla Basin Natural Production Monitoring and Evaluation Project (UBNPME) from September 30, 1994 to September 29, 1995. This program was funded by Bonneville Power Administration and was managed under the Fisheries Program, Department of Natural Resources, Confederated Tribes of the Umatilla Indian Reservation. An estimated 36.7 km (22.6 miles) of stream habitat were inventoried on the Umatilla River, Moonshine, Mission, Cottonwood and Coonskin Creeks. A total of 384 of 3,652 (10.5%) habitat units were electrofished. The number of juvenile fish captured follows: 2,953 natural summer steelhead (including resident rainbow trout; Oncorhynchus mykiss), one hatchery steelhead, 341 natural chinook salmon (O. tshawytscha), 163 natural coho salmon (O. kisutch), five bull trout (Salvelinus confluentus), 185 mountain whitefish (Prosopium williamsoni), and six northern squawfish (Ptychoicheilus oregonensis). The expanded population estimate for the areas surveyed was 73,716 salmonids with a mean density of 0.38 fish /m(sup 2). Relative salmonid abundance, seasonal distribution and habitat utilization were monitored at index sites throughout the basin. During index site monitoring, the following species were collected in addition to those listed above: american shad (Alosa sapidissima), smallmouth bass (Micropterus dolomieu), carp (Cyprinus carpio) and chiselmouth (Acrocheilus

alutaceus). Thirty-nine sites were electrofished during the spring and summer seasons, while 36 sites were sampled in the fall season. A study of the migration movements and homing requirements of adult salmonids in the Umatilla River was conducted during the 1994-95 return years. Radio telemetry was used to evaluate the movements of adult salmonids past diversion dams in the lower Umatilla River and to determine migrational movements of salmonids following upstream transport.

Codes: multi quant migrat instream database

Contor, C. R., and W. S. Platts. 1991. Assessment of COWFISH for predicting trout populations in grazed watersheds of the intermountain west. Report FSGTR/INT-278. reach multi graz quant modeling warning.

COWFISH (Lloyd 1986) is a model designed to estimate livestock impacts on stream-riparian features and to estimate impacts on fish abundance and fisheries economic values. The EPA (1987) reports that COWFISH was designed for conditions in Montana, but that it is usable, with alterations, throughout the Western United States. A study applied the COWFISH model to a variety of streams in the intermountain West to determine its capability to estimate fish populations in grazed watersheds. Testing on 14 streams in Idaho, Nevada, and Utah revealed that the model had little value for predicting numbers of trout in watersheds grazed by livestock. The model holds promise for estimating the health of stream channels and riparian complexes.

Codes: reach multi graz quant modeling warning

Coutant, C. C. 1996. Comment: effects of instream brush on juvenile coho salmon. Transactions of the American Fisheries Society 125: 150-151.

Spalding et al. (1995) concluded that four configurations of brush (Christmas trees) suspended in an artificial stream channel at differing branch densities had no discernible effects on rearing of first-year coho salmon Oncorhynchus kisutch. The focus of their experiments was on brush as cover-as an attractant, as protection from predators, as a shield from aggression between individuals, and as an aid to foraging efficiency. Although the experiment seems well designed for its objectives, it did not capture some of the potentially important benefits of brushy debris for young salmon. Thus, it could mislead those who attempt to rehabilitate rearing habitats for coho salmon and other salmon species. An alternative or additional hypothesis for their study could have focused on the role of submerged brush as a substrate for production of invertebrate food.

Codes: experi quant habitat lwd warning

Crisp, D. T. 1993. Population densities of juvenile trout (Salmo trutta) in five upland streams and their effects upon growth, survival and dispersal. Journal of Applied Ecology 30: 759-771.

Survival, growth and downstream dispersal of trout (especially 0 group) and the relationships of these variables to initial stocking density were studied in north Pennine streams. Two methods were used.First, electrofishing censuses were made in a marked reach of each of four streams over a period of about 20 years. Second, downstream moving trout were trapped in two streams over a 10-year period. Each stream upstream of the trap was experimentally stocked with "swim-up" trout fry, using a different population density each year. Before 1970 the four census reaches showed very large year-upon-year variations in August trout parr densities, with local failures of recruitment in some years. Survival (including the effects of losses by dispersal) from swim-up to early August, for starting population densities of 0-10 fry/m super(2), was about 10% regardless of initial density. Estimates of survival from August to early October were 30-50% for the census reaches and 55-65% for the areas upstream of the traps. However, for August 0 group densities of 0-0.9/m super(2), estimated instantaneous loss rate from August of the first year of life up to age 40-65 months showed a positive curvilinear relationship to population density in the first year of life. Loss rate was, therefore, density-dependent during this period. At starting densities around 4-5 fish/m super(2) dispersal was negligible. As initial density rose above 4-5 fish/m super(2) and towards 10 fish/m super(2) the percentage of loss attributable to dispersal rose towards 30%. As initial densities decreased from 4 to

1.4 fish/m super(2), the percentage rose to around 20%. Below a starting density of 1.4 fish/m super(2) the percentage decreased.

Codes: multi reach quant popdyn migrat temporal

Culp, J. M. 1986. Experimental evidence that stream macroinvertebrate community structure is unaffected by different densities of coho salmon fry. Journal of the North American Benthological Society 5: 140-149.

Manipulative field enclosure/exclosure experiments were carried out in Carnation Creek, British Columbia to determine if patch-restricted coho fry (Onchorhynchus kisutch) affected the distribution and abundance of macroinvertebrates in the drift or benthos. Density, biomass, and size distribution of macroinvertebrates in the drift were not significantly affected by fish density treatment. Additionally, with the exception of large swimming larvae of Ameletus sp. and Baetis tricaudatus, macroinvertebrate density, size distribution, and biomass in the benthos were also not significantly affected by fish density treatments. Thus, despite fish densities being increased from two to four times above ambient patch levels, patch-restricted coho fry had little measurable effect on macroinvertebrate distribution and abundance in Carnation Creek during the low discharge period of August to September.

Codes: experi enclos habitat quant trophic

Culp, J. M., G. J. Scrimgeour, and G. D. Townsend. 1996. Simulated fine woody debris accumulations in a stream increase rainbow trout fry abundance. Transactions of the American Fisheries Society 125: 472-479.

Habitat for young-of-the-year rainbow trout Oncorhynchus mykiss was enhanced in a fourth-order stream during August-October 1991 by the addition of wooden structures that simulated accumulations of fine woody debris (FWD). The experiment represented a two-factorial design with the presence or absence of FWD bundles and time since debris introduction as factors. Immediately after FWD placement, fry density, individual biomass, fry condition factor, and total fry biomass were similar in treated and untreated sites. As the experiment progressed, density and total fry biomass significantly increased at treated but not at untreated sites. Individual biomass and condition factor did not differ between treated and untreated areas, and they were affected only by time since FWD placement. Because individuals at treated and untreated sites were the same size, added FWD did not affect an individual's net rate of energy gain. Rather, we hypothesize that the FWD provided structurally complex habitat that acted as a refuge from predators and as sites from which foraging forays were staged. Adding FWD to a stream can increase carrying capacity for trout fry, and adult population density may increase as a result.

Codes: experi habitat quant lwd

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. CAJFS 53: 267-282.

This paper reviews the habitat characteristics and the behaviour of selected stream fishes during winter in temperate-boreal ecosystems. Emphasis is placed on the salmonid fishes upon which most winter research has been directed. As space is the primary factor regulating stream fish populations in winter, aspects of winter habitat are considered at various spatial scales from microhabitat to stream reach to river basin. Choice of winter habitat is governed by the need to minimize energy expenditure, with the main criterion being protection from adverse physicochemical conditions. The distance moved to wintering habitats, and the continued activity by many fishes during the winter, need to be considered when making management decisions regarding fish habitat. How habitat is affected by land-use activity in stream catchments is discussed with reference to impacts from water withdrawal, varying discharge regimes, and erosion or sedimentation. Even stream enhancement practices can deleteriously affect stream habitat if project managers are unaware of winter habitat requirements and stream conditions.

Maintenance of habitat complexity, at least at the scale of stream sub-basin, is recommended to ensure the diversity of winter habitats for fish communities.

Codes: review habitat migrat qual substrate instream lulc

Cunjak, R. A., T. D. Prowse, and D. L. Parrish. 1998. Atlantic salmon (Salmo salar) in winter: 'The season of parr discontent?'. Canadian Journal of Fisheries and Aquatic Sciences 55: 161-180.

Effects of the winter regime on northern streams and rivers is extremely variable and characterized by dramatic alterations in physical habitat to which Atlantic salmon (Salmo salar) must acclimate and adapt to survive. This paper synthesizes recent advances in the biological and hydrologic/geomorphic disciplines, with specific reference to Atlantic salmon overwintering in the freshwater portions of those running waters subject to freezing water temperatures. The specific requirements and adaptations for surviving winter at the three distinct life-stages in freshwater (egg, parr, kelt) are identified in relation to the characteristics of three biophysical phases: early winter, midwinter, and the break-up/warming phase. In a case study of Catamaran Brook (New Brunswick), a hydro-ecological analysis was used to explain interannual variability in juvenile abundance, especially for young-of-the-year salmon. A strong relation was found between winter discharge and interstage survival in 5 of 6 years. That is, juvenile salmon abundance in summer was highest following winters with high streamflow, presumably a function of habitat availability, especially beneath ice cover. The lowest measured egg-0+ survival (9.2%) was related to an atypical midwinter, dynamic ice break-up triggered by a rain-on-snow event that resulted in severe scouring of the stream-bed and redds. Interannual variability in Atlantic salmon parr abundance from 1990 to 1996 was largely explained by density-independent (environmental) constraints to winter survival. The complexity of stream processes during winter underscores the need for interdisciplinary research to quantify biological change.

Codes: reach quant popdyn hydro temporal noenv

Cunjak, R. A., and J. Therrien. 1998. Inter-stage survival of wild juvenile Atlantic salmon, Salmo salar L. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 209-223.

A biological model was developed to calculate annual survival between life stages of juvenile Atlantic salmon, Salmo salar L., in Catamaran Brook, a small stream basin (52 km super(2)) in the Miramichi River catchment in New Brunswick, Canada. Seven years' data (1990-1996) were used in the model. Input variables included: daily fish counts and measurements of parr (3-4 age classes), smolts, and adult salmon at a fish-countingfence near the stream mouth; biennial quantification of all habitat types along the watercourse; fish density estimated by electric fishing at 30 sites; and estimates of young-of-the-year emigration via stream drift. Continuous recording of stream discharge provided data to assist in interpretation of survival estimates. Annual survival for juvenile salmon in their first 3 years of life in the stream averaged between 31% and 34%. The greatest annual variation (CV = 0.699) occurred at the egg to 0+ (summer) stage with a low of 9.2% survival recorded for a winter with an atypical midwinter flood event; parr and pre-smolt survival were similarly affected. Survival from egg deposition (after correction for losses caused by predation and retention/non-fertilization) to smolt emigration was between 0.16% and 0.52%, which is low relative to estimates from many other studies. Survival of smolts to returning 1-sea-winter adults (grilse) averaged 8.5%. Potential errors in the computation of the model are discussed, e.g. inaccurate counts of spawning adults during high autumn stream flow. A possible explanation for the low egg to smolt survival was the environmental conditions experienced during various winters. Mean egg survival was 1.3 times higher (39.3%) and egg to smolt survival increased to 1.03% when the two winters characterized by extremely low discharge or midwinter freshets were excluded from the calculation. Density-dependent factors related to a beaver dam, which limited spawning distribution, may also have contributed to poor survival and increased fry emigration in one year. Environmental factors, particularly winter conditions, in streams such as Catamaran Brook may act as bottlenecks to natural production of Atlantic salmon.

Codes: reach quant popdyn instream hydro temporal

Dahl, J. 1998. Effects of a benthivorous and a drift-feeding fish on a benthic stream assemblage. Oecologia 116: 426-432.

I assessed the impact of both drift-feeding (Salmo trutta, brown trout) and benthic-feeding (Cottus gobio, bullhead) fish on a benthic assemblage during a 1-month-long field experiment. I used enclosures containing cobble/gravel substrata with 6-mm mesh net that allowed invertebrates to drift freely in and out of enclosures. Four treatments, arranged in a factorial design, were tested: a predator-free control, bullheads only (2.67 bullheads/m super(2), two per enclosure), brown trout only (2.67 brown trout/m super(2), two per enclosure), and bullheads and brown trout together (2.67 fish/m super(2), one of each). Bullheads reduced the densities of seven invertebrate taxa (Gammarus pulex amphipods, Baetis rhodani mayfly nymphs, Leuctra spp. stonefly nymphs, Polycentropus spp. caddis larvae, Pacifastacus leniusculus signal crayfishes, Simuliidae, blackfly larvae, and Limnephilidae, caddis larvae) whereas brown trout only affected one taxon (B. rhodani). The weaker effect of brown trout on benthic prey was probably related to its heavy reliance on terrestrial prey. Dietary analyses showed that more than 80% of prey consumed by brown trout were terrestrial animals, whereas bullhead only consumed benthic prey. Neither bullhead nor brown trout affected the absolute number of immigrating or emigrating invertebrates in enclosures, but bullhead affected the per capita emigration rates of G. pulex. Direct predation by bullhead was more important than avoidance behavior (drift) in determining densities of six of the seven taxa; only G. pulex densities were equally affected by avoidance behaviour and direct predation. Direct predation by brown trout was also more important in determining densities of B. rhodani. The presence of bullhead raised periphyton biomass, presumably mediated via their consumption of grazers. Brown trout had no effect on periphyton biomass and these results indicate that the presence of alternative prey, in this case terrestrial animals, may have repercussions for fish-benthic macroinvertebrate-periphyton interactions and may potentially explain some of the variable impacts of fish on benthic macroinvertebrates that have been reported in the literature.

Codes: habitat enclos sppinter quant

Dauble, D. D., and D. R. Geist. 2000. Comparison of mainstem spawning habitats for two populations of fall chinook salmon in the Columbia River basin. Regulated Rivers Research & Management 16: 345-361.

Extensive hydroelectric development in the Columbia River system has eliminated most mainstem riverine habitat available for spawning by fall chinook salmon (Oncorhynchus tshawytscha). The two remaining populations, Hanford Reach, Columbia River and Hells Canyon Reach, Snake River, are separated geographically and their status is markedly different. Annual escapements to Hanford Reach have averaged approximately 80000 adults, while the Snake River run size has declined to < 1500 adults over the past 10 years. We compared their spawning habitat characteristics over a range of measurement scales, as a means to identify strategies for rebuilding the weak Snake River population. Physical habitat characteristics of redds were similar for both study areas. Redd locations were correlated with channel characteristics, such as braiding and sinuosity. Several differences between the two spawning areas were identified at the watershed scale: the Hells Canyon Reach had a much steeper longitudinal gradient, was largely confined by bedrock, and had a more variable flow regime. These features are controlling variables that operate at the reach-scale to limit the availability and size of substrate and other conditions that influence egg deposition and incubation survival. Geomorphological characteristics of the two study sites are sufficiently different to indicate that the production potential of the Hells Canyon Reach population is markedly lower than that of the Hanford Reach population.

Codes: basin spawn qual instream substrate temporal

Davies, P. E., and M. Nelson. 1994. Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. Aust. J. Mar. Freshwat. Res. 45: 1289-1305.

Impacts from the logging of Eucalyptus forest on stream habitat, macroinvertebrate abundance and diversity, and fish abundance were surveyed in Tasmania, Australia. Forty-five pairs of sites from 34 streams of greater than or equal to 2.5 km super(2) catchment area were each sampled once during summer in the period 1990-92. Each site

pair consisted of an 'impacted' site downstream of a logging treatment and an upstream or closely matched 'paired control' site. Site pair treatments encompassed two logging methods (cable and conventional) with a range of riparian buffer strip widths (0-50 m) and included unlogged controls. Differences between site pair variables were used as test statistics for the detection of logging impacts. Logging significantly increased riffle sediment, length of open stream, periphytic algal cover, water temperature and snag volume. Logging also significantly decreased riffle macroinvertebrate abundance, particularly of stoneflies and leptophlebiid mayflies, and brown trout abundance. All effects of logging were dependent on buffer strip width and were not significantly affected by coupe slope, soil erodibility or time (over one to five years) since logging. All impacts of logging were significant only at buffer widths of <30 m. Minimum buffer widths for eliminating logging impacts on stream habitats and biota are discussed.

Codes: experi multi reach quant ripar substrate wtemp trophic

Debowski, P., and E. Beall. 1995. Influence of dewatering on movements and distribution of salmon parr (Salmo salar L.) in relation to habitat characteristics in an experimental stream. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 267-275 p.

The response of Atlantic salmon parr to major decreases in water ievels, typical summer low flows, is not well documented. Three experiments were conducted in an artificial stream designed with sequences of riffle, flat, and pool habitat, each habitat in a section 10 m long by 3 m wide. In deeper water, parr did not respond to water level or flow decrease. In shallow water, they reduced activity, particularly feeding, and in critical conditions a portion of the population moved into deeper water. The remainder of the parr buried themselves into the gravel. After flow increase, some of the downstream moving parr returned to the riffle habitat.

Codes: enclos reach habitat quant migrat hydro

Debowski, P., and G. Radtke. 1998. Density and growth of young brown trout (Salmo trutta L.) in streams of northern Poland versus habitat attributes. Polskie Archiwum Hydrobiologii 45: 77-89.

Codes: multi habitat quant instream

Decker, A. S., J. M. Bratty, S. C. Riley, and J. Korman. 1999. Estimating standing stock of juvenile coho salmon (Oncorhynchus kisutch) and cutthroat trout (O. clarki) in a small stream: a comparison of sampling designs. method design quant.

We estimated standing stocks of juvenile coho salmon (Onchorynchus kisutch) and cutthroat trout (O. clarki) in a small stream during the fall, and used observed and simulated standing stock estimates to compare the precision and cost effectiveness of alternate sampling designs. Overall, a whole-stream mark-recapture approach produced the most precise coho standing stock estimate, but results were probably biased and the method would not be cost effective in most typical streams. Among removal methods, a stratified random sampling design (stratified by habitat type and reach) produced the most precise and cost effective estimates of coho standing stock. The most precise estimates of cutthroat standing stock, however, were produced by a proportional sampling design because cutthroat were distributed more evenly among habitat types. Simulations suggest that sampling approximately 7 percent of the habitat units in the stream was sufficient to provide a precise (CV = 0.1) estimate of coho standing stock using a stratified random sampling design. This result is specific to the study stream and further research is necessary to determine if it applies to other streams. The use of a calibrated one-pass sampling design (single pass capture totals were calibrated with 3-pass removal estimates) with stratified random sampling was marginally more cost-effective than a stratified random design where three-pass removal population estimation was carried out at all sites. Our results show that calibrated one-pass sampling with block nets can provide a reasonable index of coho abundance. However, one-pass estimates made without block nets may be biased, and installing blocknets may make this design relatively less cost-effective. If quantitative population data are required for juvenile soho stock

assessment in British Coumbia, we recommend a stratified random sampling design in place of the current representative index site program.

Codes: method design quant

Deegan, L. A., B. J. Peterson, H. Golden, C. C. McIvor, and M. C. Miller. 1997. Effects of fish density and river fertilization on algal standing stocks, invertebrate communities, and fish production in an arctic river. Canadian Journal of Fisheries and Aquatic Sciences 54: 269-283.

This study examines the relative importance of bottom-up and top-down controls of an arctic stream food web by simultaneous manipulation of the top predator and nutrient availability. A two-step trophic system (algal to insects) was created by removal of the top predator (Arctic grayling, Thymallus arcticus) in fertilized and control stream reaches. Fish abundance was also increased 10 times to examine the effect of high fish density on stream ecosystem dynamics and fish. The response was measured of epilithic algae, benthic and drifting insects, and fish to nutrient enrichment and to changes in fish density. Insect grazers had little effect on algae and fish had little effect on insects. In both the control and fertilized reaches, fish growth, energy storage, and reproductive response of females declined with increased fish density. Fish growth and energy storage were more closely correlated with per capita insect availability than with per capita algal standing stock.

Codes: reach enclos trophic quant

Delacoste, M., P. Baran, F. Dauba, and A. Belaud. 1993. A study of brown trout (Salmo trutta L.) spawning macrohabitat in a French mountain stream. Evaluation of a physical habitat potential for spawning. Bulletin francais de la peche et de la pisciculture 331: 341-356.

Macrohabitat used by brown trout (Salmo trutta L.) for spawning was studied in the Neste du Louron river, in 61 morphodynamic units (pool, riffle,...) distributed in 8 reaches. These units have been characterized by physical variables (surface and bottom current velocity, depth, substrat size, water gradient, discharge) and by biological variables (trout density and biomass, trout redds density). Results showed that, at a morphodynamic unit scale, there are no correlation between redds density and trout density and biomass in this morphodynamic unit, depth variables, width of unit. There are high correlations between redds density and the percentage of bottom area with gravel suitable for spawning (0.2-5 cm), substrat size, current velocity variables, flow/width variable, water gradient. At a reach scale, there are significant correlations between redds density and trout density and biomass. A statistical relation has been assessed from multiparametric regression, and from a sample of 41 morphodynamic units randomly chosen. It uses 4 variables and explains 87% of the redds density. This relation has then been validated on another sample of 20 morphodynamic units. Some applications from these relations are briefly discussed.

Codes: reach habitat spawn quant instream foreign

Delacoste, M., P. Baran, S. Lek, and J. M. Lascaux. 1995. Classification and key for the identification of moutain stream morphodynamic units. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 149-156 p.

The hydromorphodynamic diversity of 294 units from 15 Pyrenean mountain streams was studied. 6 main groups and 18 secondary groups could be distinguished according to a multivariate analysis. A key for the determination of morphodynamic units in mountain streams is proposed. Five successive quantitative or qualitative discrimination levels aliow the determination of 18 types of units. The variability of the biological characteristics of these 18 groups has been tested for trout and redd abundance. These 18 groups explain 45.6 % of the total trout biomass variability, and 18.8 % of the young-of-the-year trout biomass variability.

Codes: multi reach quant instream foreign

Delacoste, M., S. Lek, P. Baran, I. Dimopoulos, and J. L. Giraudel. 1996. [Neuronal model versus multiple regression that predicts trout spawning grounds]. Edited by J. Ferraris, D. Pelletier and M. J. Rochet. ORSTOM, PARIS (FRANCE), 151-156 p.

Models of habitat (deterministic or stochastic) putting in relation variables of the environment and characteristics of freshwater fish (abundance, reproduction...) are good tools for decision help. 95 models of this kind are numbered. Most of them are built by means of regression analysis. In this work, the authors compare the predictive capacity of the multiple regression and of the neuronal network (known for its capacity to deal with nonlinear relations). The values predicted by models will be compared to observed values of biological data: prevision of the density of common trouts spawning grounds (Salmo trutta L.) from 10 variables of habitat, in 6 Pyrenean rivers (SW of France).

Codes: multi reach spawn modeling instream foreign

Detenbeck, N. E., P. W. DeVore, G. J. Niemi, and A. Lima. 1992. Recovery of temperate-stream fish communities from disturbance: A review of case studies and synthesis of theory. EM 16: 33-53.

To evaluate the relative effect of autecologic factors, site-specific factors, disturbance characteristics, and community structure on the recovery of temperate-stream fish communities, we reviewed case histories for 49 sites and recorded data on 411 recovery end points. Most data were derived from studies of low-gradient third- or fourth-order temperate streams located in forested or agricultural watersheds. Species composition, species richness, and total density all recovered within one year for over 70% of systems studied. Lotic fish communities were not relient to press disturbances (e.g., mining, logging, channelization) in the absence of mitigation efforts (recovery time > 5 to > 52 yr) and in these cases recovery was limited by habitat quality.

abstract from CSA: Data on recovery rates of aquatic communities from natural and anthropogenic disturbances are necessary for establishing exceedance criteria for water quality standards and for testing current ecological theory. To evaluate the relative effect of autecologic factors, site-specific factors, disturbance characteristics, and community structure on the recovery of temperate-stream fish communities, the case histories of 49 sites and recorded data on 411 recovery end points were studied. Most data were derived from studies of low-gradient third-order and fourth-order temperate streams located in forested or agricultural watersheds. Species composition, species richness, and total density all recovered within one year for over 70% of systems studied. Lotic fish communities were not resilient to press disturbances in the absence of mitigation efforts and in these cases recovery was limited by habitat quality. Following pulse disturbances, autecological factors, site-specific factors, and disturbance-specific factors all affected rates of recovery. Centrarchids and minnows were most resilient to disturbance, whereas salmonid populations were least resilient of all families considered. Species within rock-substrate/nest-spawning guilds required significantly longer time periods to either recolonize or reestablish predisturbance population densities than did species within other reproductive guilds. Recovery was enhanced by the presence of refugia but was delayed by barriers to migration, especially when source populations for recolonization were relatively distant. Median population recovery times for systems in which disturbance occurred during or immediately prior to spawning were significantly less than median recovery times for systems in which disturbances occurred immediately after spawning. There was little evidence for the influence of biotic interactions on recovery rates. (Mertz-PTT) 35 054227003.

Codes: review multi quant noenv temporal

Dewberry, C., P. Burns, and L. Hood. 1998. After the Flood. The Effects of the Storms of 1996 on a Creek Restoration Project in Oregon. Restoration & Management Notes [Restor. Manage. Notes] 16: 174-182.

Floods can have a major effect on Pacific salmon populations in a watershed. Major storms create debris-torrents (land-slides of soil, gravel, logs, trees, and boulders) that move down tributary stream channels where they under-cut and fell riparian trees; create, destroy, and move log jams; carve new stream channels on the valley floor; and

both destroy and create valley habitat for aquatic organisms. In healthy watersheds, the immediate effects of floods on Pacific salmon may be minimal or short-lived, and in the long term have positive effects. In degraded watersheds, the effects can be devastating on Pacific salmon populations in both the short and long term. The effects of floods should be a major concern for any restoration project in the Pacific Northwest.

Codes: reach qual hydro ripar

Dolloff, C. A. 1986. Effects of Stream Cleaning on Juvenile Coho Salmon and Dolly Varden in Southeast Alaska. TAFS 115: 743-755.

The effects are described of selective removal of woody debris on populations of juvenile coho salmon Oncorhynchus kisutch and Dolly Varden Salvelinus malma in two small streams on Prince of Wales Island, Alaska, during the summers of 1979-1981. These streams contained debris left when surrounding forests were clear-cut in the late 1960s. Debris smaller than 60 mm in diameter and larger debris not embedded in the stream channel were manually removed from half of the study reach on each stream in 1979 by state-of-the-art techniques. Immigration and emigration of fish from the study sections and intrastream movements were very limited after an initial period of population adjustment in the spring regardless of treatment. Population densities and production of both species were typically higher in sections where debris accumulations had not been removed. Production of age-0+ and age-1+ coho salmon and age-1+ and age-2+ Dolly Varden during the June-September period ranged from 0.70 to 2.22 g/sq m in the cleaned sections and from 0.84 to 2.10 g/sq m in the uncleaned sections. Carrying capacities for both species were lower in cleaned sections despite the use of selective techniques for removing woody debris. (Author 's abstract).

Codes: multi experi reach quant lwd

Dolloff, C. A. 1987. Seasonal population characteristics and habitat use by juvenile coho salmon in a small southeast Alaska stream. Transactions of the American Fisheries Society 116: 829-838.

The density, growth, production, and movements of juvenile coho salmon Oncorhynchus kisutch from a wild population were evaluated after the fish were transplanted into five types of habitat (clear-cut, forest, meadow, slough tributary, forest tributary) in a small southeastern Alaska stream. Instantaneous growth ranged from 0.0066 in the clear-cut habitat to 0.0055 in the slough tributary. Daily increase in fork length was about 0.10 mm/d system-wide. Annual production of coho salmon in each habitat type was: meadow, 3.32 g/m super(2); slough tributary, 2.47 g/m super(2); clear-cut, 1.75 g/m super(2); forest, 1.59 g/m super(2); and forest tributary, 1.34 g/m super(2). During all sampling periods, most fish were recaptured at the site where they were released; those fish that moved neither selected nor avoided specific habitat types.

Codes: experi reach quant ripar

Dunham, J. B., and G. L. Vinyard. 1997. Incorporating stream level variability into analyses of site level fish habitat relationships: some cautionary examples. Transactions of the American Fisheries Society 126: 323-329.

Codes: multi reach segment instream warning

Dunham, J. B., and G. L. Vinyard. 1997. Relationships between body-mass, population density, and the self-thinning rule in stream-living salmonids. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 54: 1025-1030.

Codes: multi reach quant popdyn noenv temporal

Eaglin, G. S., and W. A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13: 844-846.

We examined the influence of logging and road construction on substrate and standing stocks of trout (Salvelinus and Salmo) in 28 stream reaches in the Medicine Bow National Forest, Wyoming. The extent to which roads crossed watercourses (culvert density) within a drainage and the proportion of the drainage that was logged were positively correlated to both the amount of fine substrate and embeddedness. Trout standing stocks had a negative relation with the density of culverts. Erosion of soil from road surfaces, ditches, and disturbed areas adjacent to roads that subsequently is deposited in stream channels seems to be an important mechanism by which logging has affected stream habitat.

Codes: multi reach quant lulc substrate

Ebel, W. J. 1985. Review of Effects of Environmental Degradation on the Freshwater Stages of Anadromous Fish. Pages 62-69. Habitat Modification and Freshwater Fisheries. Proceedings of a Symposium of the European Inland Fisheries Advisory Commission. May 23-25. Aarhus, Sweden. Butterworths, London, England.

Early research efforts begun in the 1950s and continued to the present to address the problems of environmental degradation on anadromous fish were centered mainly on fish behavioral work designed to provide solutions to fish passage problems. Information leading to solutions to passage problems for both adult and juvenile salmonids caused by dams and impoundments in the Columbia River was the highest priority of this research. Research on various fisheries enhancement measures was also begun in the late 1960s to increase production of Columbia River salmon. Some conclusions drawn from the study are: (1) Velocities in adult fish passage facilities should fall within the range of 2.4-4.0 m/s for optimum passage of salmonids; (2) Use of electrical guidance systems to divert fish from turbines or into bypass flumes or traps in rivers was effective under controlled conditions, but was impractical for operational field applications; (3) Use of water and air jets, sound, and lights to guide juvenile migrants were effective only under limited and controlled environmental conditions; (4) Travelling screens, suspended at an angle to the stream flow, were effective in flumes or irrigation canals for guiding juvenile migrants, but costs and engineering problems preclude their use at dams or large streams; (5) Adult passage of anadromous salmonids through both large and small reservoirs was not a serious problem in reservoirs studied on the Columbia River, except during periods of high water temperature; (6) Juvenile migrants were adversely affected by the impoundments on the Columbia River, which caused substantial delays in migration. These delays, coupled with changed environmental conditions in the river, caused substantial mortality to juvenile migrants which was as high as 95% in the Columbia River during low flow periods; and (7) Studies of the effect of water temperatures and supersaturation of atmospheric gas on salmonids led to the establishment of water temperature and atmospheric gas standards for the Columbia River. Any increase in temperature above 17-20 C or increase in atmospheric gas above 110% of the air-saturation value was considered detrimental to fish in the Columbia River. (See also W87-09036) (Lantz-PTT).

Codes: review qual migrat instream lakehydro

Ebersole, J. L., W. J. Liss, and C. A. Frissell. 2001. Relationship between stream temperature, thermal refugia and rainbow trout Oncorhynchus mykiss abundance in arid-land streams in the northwestern United States. Ecology of Freshwater Fish 10: 1-10.

Warm stream temperatures may effectively limit the distribution and abundance of Pacific salmon Oncorhynchus spp. in streams. The role of cold thermal refugia created by upwelling groundwater in mediating this effect has been hypothesized but not quantitatively described. Between June 21 and September 15, 1994, rainbow trout O. mykiss abundance within 12 northeast Oregon (USA) stream reaches was inversely correlated with mean ambient maximum stream temperatures ($r=-0.7$, $P<0.05$). Some rainbow trout used thermal refugia (1-10 m2 surface area) that were on average 3-8[degree]C colder than ambient stream temperatures. Within the warmest reaches, high

ambient stream temperatures (>22[degree]C) persisted from mid-June through August, and on average 10-40% of rainbow trout were observed within thermal refugia during periods of midday maximum stream temperatures. Frequency of cold-water patches within reaches was not significantly associated with rainbow trout density after accounting for the influence of ambient stream temperature (P=0.06; extra sum of squares F-test). Given prolonged high ambient stream temperatures in some reaches, the thermal refugia available in the streams we examined may be too small and too infrequent to sustain high densities of rainbow trout. However, these refugia could allow some rainbow trout to persist, although at low densities, in warm stream reaches.

Codes: multi reach quant wtemp

Edwards, E. D., and A. D. Huryn. 1996. Effect of riparian land use on contributions of terrestrial invertebrates to streams. Hydrobiologia 337: 151-159.

Since terrestrial invertebrates are often consumed by stream fishes, land-use practices that influence the input of terrestrial invertebrates to streams are predicted to have consequences for fish production. We studied the effect of riparian land-use regime on terrestrial invertebrate inputs by estimating the biomass, abundance and taxonomic richness of terrestrial invertebrate drift from 15 streams draining catchments with three different riparian land-use regimes and vegetation types: intensive grazing - exotic pasture grasses (4 streams), extensive grazing - native tussock grasses (6 streams), reserve - native forest (5 streams). Terrestrial invertebrate drift was sampled from replicated stream reaches enclosed by two 1 mm mesh drift nets that spanned the entire channel. The mean biomass of terrestrial invertebrates that entered tussock grassland (12 mg ash-free dry mass/m super(2)/d) and forest streams (6 mg AFDM/m super(2)/d) was not significantly different ($p > 0.05$). However, biomass estimated for tussock grassland and forest streams was significantly higher than biomass that entered pasture streams (1 mg AFDM/m super(2)/d). Mean abundance and richness of drifting terrestrial invertebrates was not significantly different among land-use types. Winged insects contributed more biomass than wingless invertebrates to both pasture and tussock grassland streams. Winged and wingless invertebrates contributed equally to biomass entering forest streams. Land use was a useful variable explaining landscape-level patterns of terrestrial invertebrate input for New Zealand streams. Evidence from this study suggests that riparian land-use regime will have important influences on the availability of terrestrial invertebrates to stream fishes. Codes: reach multi graz ripar trophic nofishEifert, W. H. 1982. The Selection of Fishery Parameters for Inclusion in the Stream Reach Inventory and Channel Stability Index. An ocular watershed evaluation methodology, entitled Stream Reach Inventory and Channel Stability Index (SRICSI), was designed primarily to assess the physical aspects of channel and streambank stability. The SRICSI 's value as an aquatic habitat evaluation technique was basically unknown. During the spring and summer of 1981, seventeen representative study sites on two second-order montane streams were evaluated through application of the SRICSI procedure and three aquatic habitat assessment methodologies. Salmonid population estimates were also obtained for each site. Results indicate that a significant relationship exists between SRICSI scores and both trout population estimates, and to two of the three habitat evaluation procedures. All observed correlations were negative, suggesting that as SRICSI scores increase, trout standing crops and habitat condition decreases. Of 63 habitat-related independent variables, 40 also display significant correlation to trout standing crop data. Fifteen variables were selected for possible inclusion in the SRICSI. Inclusion of those variables found compatible with the SRICSI procedure should increase its biological sensitivity, thereby broadening its use in aquatic habitat studies. (Moore-SRC).

Codes: method multi reach quant instream

Eifert, W. H., and T. A. Wesche. 1982. Evaluation of the Stream Reach Inventory and Channel Stability Index for instream habitat analysis. Report SER-82.

In 1975, the Northern Region of the U.S. Forest Service developed an ocular watershed evaluation methodology entitled "Stream Reach Inventory and Channel Stability Index" (SRICSI). Designed to assess the physical aspects of channel and streambank stability, the SRICSI's value as an aquatic habitat evaluation technique was basically unknown. During the spring and summer of 1981, 17 representative study sites on two 2nd order montane streams were evaluated through application of the SRICSI procedure and three aquatic habitat assessment methodologies.

Salmonid population estimates were also obtained for each site. Trout standing crop estimates were statistically compared to study site SRICSI scores, the results obtained from the habitat evaluation procedures, and to data collected on 63 habitat-related independent variables. Results indicate a significant relationship exists between SRICSI scores and both trout population estimates and to two of the three habitat evaluation procedures.

Codes: method multi reach quant instream

Ekloev, A. G. 1996. Effects of habitat size and species richness on anadromous brown trout, Salmo trutta L., populations. Fisheries Management and Ecology 3: 97-101.

During the last century, vegetation cover associated with stream margins has been reduced in many streams because of channelisation vegetation (Wolf 1960). There are plans to restore many of these streams. However, it is important to identify what types of streams to restore and how to best accomplish this before implementing these plans. Consequently a study was initiated to identify which factors were related to trout density in non-channelised streams. In this study, the density of migratory brown trout (Salmo trutta) populations in riffle and run habitats was measured over 2 years, in 10 streams in 1992 and in 18 streams in 1993. Seven of the sites from 1992 were also sampled in 1993. The streams were located in 10 catchment areas, within a restricted geographic and climatic region along the western and southern coast of Scania, southern Sweden, and serve as nursery areas for migratory brown trout.

Codes: multi habitat quant instream ripar

Ekloev, A. G., and L. A. Greenberg. 1998. Effects of artificial instream cover on the density of 0 + brown trout. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 45-53.

The effect of instream cover on the density of juvenile sea trout, Salmo trutta L., in two streams in southern Sweden was studied. One of the streams, Vallkaerrabaecken, was narrow (2-3 m) and had few sympatric species, whereas the other stream, Braaan, was wider (6-8 m) and had many sympatric species. Three treatments were used: (1) addition of artificial vegetation; (2) an undisturbed control; and (3) removal of natural vegetation. Only the first two treatments were tested in Braaan, whereas all three treatments were tested in Vallkaerrabaecken. The 0 + trout density was higher in sections containing artificial vegetation than in control sections, which in turn had higher densities than sections where natural vegetation was removed. Moreover, the effect of adding artificial vegetation on trout density was most pronounced at the end of the summer. The results indicate that instream cover from submerged macrophytes may be important for maintaining high 0 + trout densities in small and medium-sized streams where other types of instream cover are in short supply.

Codes: experi reach quant instream

Ekloev, A. G., L. A. Greenberg, C. Broenmark, P. Larsson, and O. Berglund. 1998. Response of stream fish to improved water quality: a comparison between the 1960s and 1990s. Freshwater Biology 40: 771-782.

The effect of improved water quality on fish assemblages in streams in southern Sweden was assessed by comparing species composition at 161 sites and water quality at twenty-nine sites in the 1960s and the 1990s. Water quality had improved and there was an increase in the number of sites or catchments with brown trout (Salmo trutta), stone loach (Barbatula barbatula) and eel (Anguilla anguilla). The response was greatest for brown trout and was best explained by increased oxygen concentrations. The number of sites with nine-spined stickleback (Pungitius pungitius), ide (Leuciscus idus) and brook lamprey (Lampetra planeri) decreased between the 1960s and 1990s.The decrease was greatest for nine-spined stickleback and was related to the increase in sites with trout, suggesting that nine-spined stickleback may be sensitive to predation or competition. Improved water quality has led to recolonization by brown trout, probably enabling biotic interactions to play a larger role in structuring fish

assemblages. Improving water quality was an effective method for rehabilitating fish populations in streams where natural colonization was possible.

Codes: multi habitat quant watqual noenv temporal

Ekloev, A. G., L. A. Greenberg, C. Bronmark, P. Larsson, and O. Berglund. 1999. Influence of water quality, habitat and species richness on brown trout populations. Journal of Fish Biology 54: 33-43.

The influence of water quality, physical habitat and species richness on the occurrence, density and size of brown trout at 216 stream sites in southern Sweden was studied. Discriminant analysis showed that the occurrence of trout at a locality was largely determined by oxygen conditions and medium-sized substrata. At localities where trout occurred, the density of 0+ trout was highest in narrow streams with high oxygen concentrations. For older trout, >0+ in age, stream size and temperature were negatively related to density. Biotic factors also appeared to affect trout density, as trout density was inversely related to abundance of predators and coexisting species. Even intraspecific competition appeared to be important as length of 0+ trout was inversely related to trout density. It is suggested that improvements of water quality may be an effective way to restore sea trout populations in southern Sweden, especially in narrow streams where smolt production has the highest potential.

Codes: multi reach quant sppinter watqual substrate instream

Elliott, J. M., and M. A. Hurley. 1998. Population regulation in adult, but not juvenile, resident trout (Salmo trutta) in a Lake District stream. Journal of Animal Ecology 67: 280-286.

Unlike a neighbouring sea-trout population that showed strong density-dependent survival, a resident trout population (Salmo trutta L.) showed simple proportionate survival in the early life-stages. However, this persistent population fluctuated within narrow limits. Mature adults, especially during spawning, were the only possible life-stage left in which regulation might occur. 2. An October census, just prior to spawning, was made at five sites (total area 300 m super(2)) from 1965 to 1983. Gravel nests (redds) associated with females of known size were excavated outside these sites to obtain a power-function relationship between egg density per redd and female length (range 181-280 mm, n = 26). This relationship and the census data for females (range 186-284 mm) were used to estimate egg densities in each year-class. 3. The census data for the early life-stages (0+, 1+, 2+ trout) confirmed proportionate survival with no evidence for density-dependent regulation. In contrast, the number of spawning females produced in each year-class was strongly density dependent on the initial number of females that laid eggs at the start of the year-class. Similarly, total egg production in each year-class was density dependent on initial egg density. 4 Both relationships were well described by the Ricker and Beverton-Holt stock-recruitment models ($P < 0.001$) and the goodness-of-fit was similar for both models. This study is probably the first to provide clear evidence for fish population regulation in the adult, rather than the juvenile, stage.

Codes: quant popdyn spawn noenv temporal

Elliott, S. T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. Transactions of the American Fisheries Society 115: 392-400.

Logging debris resident for five or more years in small streams of southeastern Alaska is frequently removed to improve salmonid habitat. This practice was evaluated for its effects on juvenile anadromous Dolly Varden Salvelinus malma and macrobenthos populations in a small spring-fed stream during 1973-1981. Debris, consisting of limbs, needles, and fragmented logs, was removed by hand from the entire stream in July 1976. The surface area, number, and size of pools was reduced thereafter, and the water velocity increased. Macrobenthos density and invertebrate drift decreased 60-90% immediately after debris removal but returned to pretreatment levels in 1977. The Dolly Varden pouplation decreased from 900 to less than 100 fish by 1978 and then fluctuated sharply between late 1978 and 1981. Removal of old logging debris does not improve habitat and can result in smaller rearing

populations. Old debris should not be removed unless a block to migrating adult spawners or impairment of water quality can be demonstrated.

Codes: experi reach quant lwd temporal

Elso, J. I., and P. S. Giller. 2001. Physical characteristics influencing the utilization of pools by brown trout in an afforested catchment in Southern Ireland. Journal of Fish Biology [J. Fish Biol.] 58: 201-221.

Seasonal and spatial variation in brown trout Salmo trutta L. abundance, density and biomass were studied in 29 pools of varying size in an afforested catchment together with the physical characteristics of those pools. A movement of 0+ trout towards the pools as the year progresses was detected. Water volume of the pool accounted for a significant amount of the variation in metrics across all seasons. Cover provided by overhanging vegetation also explained a significant amount of variation, especially during the summer. Water velocity, percentage of undercut bank and substrate composition had little explanatory power in the distribution of trout in the pools. In all seasons significant relationships between both fish biomass (g m super(-2)) and fish number and water volume in the pool were found. However, in summer and autumn there was also a significant correlation between both fish density (fish m super(-2)) and biomass and water volume in the pool described by a power function with a coefficient >1. These relationships were consistent across the subset of pools studied over a 2-year period. Thus there was a proportionally greater number of fish in deeper pools than in the shallower ones in summer and autumn, suggesting that trout use the available habitat (i.e. the pool) as a three dimensional space in which an increase in the third dimension (depth) leads to a proportionally greater number of fish per unit area.

Codes: multi habitat quant migrat instream

Emlen, J. M. 1995. Population viability of the Snake River chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 52: 1442-1448.

In the presence of historical data, population viability models of intermediate complexity can be parameterized and utilized to project the consequences of various management actions for endangered species. A general stochastic population dynamics model with density feedback, age structure, and autocorrelated environmental fluctuations was constructed and parameterized for best fit over 36 years of spring chinook salmon (Oncorhynchus tshawytscha) redd count data in five Idaho index streams. Simulations indicate that persistence of the Snake River spring chinook salmon population depends primarily on density-independent mortality. Improvement of rearing habitat, predator control, reduced fishing pressure, and improved dam passage all would alleviate density-independent mortality.

Codes: multi modeling spawn popdyn temporal

Erman, D. C., and D. Mahoney. 1983. Recovery After Logging in Streams With and Without Bufferstrips in Northern California.

The impact of logging on aquatic resources involves a reduction in nearstream vegetation and disturbance of the land surface. This frequently leads to elevated sediment loads, increased water temperature, disruption of aquatic food webs, and decreased habitat diverstiy. In some cases logging has resulted in greater diversity and biomass of young salmonids. Six logged sites, six narrow-buffered sites, and 17 controlled sites were sampled from 25 streams grouped into nine blocks in northern California. The samples were taken 6-10 years after logging and 5 or 6 years after an initial postlogging study in order to evaluate recovery rates. Unbuffered streams showed considerable but incomplete recovery based on a diversity index of macroinvertebrates. Compared to the mean of control streams, the mean diversity of logged streams was 9.1% lower in 1980-81 versus 25.2% lower in 1975. Narrow-buffered streams, by contrast, changed little since the last survey. The mean diversity was 12.5% lower than controls in 1980, compared to 12.4% in 1975. The six streams showed a positive association between buffer width and diversity index. By employing a measure of transportable sediment stored in the stream bed, it was found that the logged and

narrow-buffered streams still contained significantly more fine sediment than comparable control streams. Narrow buffers were not effective in promoting a more complete or rapid rate of recovery than streams without buffers. A few taxa had higher density in stations with more fine sediment, and, as a result, the diversity index was lower in those stations. (Garrison-Omniplan).

Codes: multi experi qual nofish? reach ripar

Everest, F. H., and W. R. Meehan. 1981. Forest Management and Anadromous Fish Habitat Productivity.

The anadromous fishery resources of western North American are produced largely within forested watersheds. Forest and rangeland management activities that can influence the quality of anadromous fish habitat include timber harvest, road construction, and livestock grazing. Organic debris from forested watersheds of the Pacific Northwest and Alaska enters streams through direct litterfall, landslides, debris torrents, timber felling, and streambank erosion, plus blowdown of trees and branches. Large woody debris can create habitat for rearing salmonids, but may cause sedimentation in spawning areas. Large, naturally occurring debris can promote streambank stability and reduce streambed scour. Large accumulations of fine organic debris can adversely affect habitat by reducing dissolved oxygen and producing toxic leachates. Total removal of debris can result in a completely open channel, promoting streambed sour, steambank instability, and loss of fish habitat productivity. Debris torrents, a common mass erosion event in the Pacific Northwest, have a negative impact on habitat and production of anadromous salmonids in small streams immediately downstream from the torrent egress. Studies within a 1-mile reach of Knowles Creek, however, indicate that the total effect of debris torrents in that sediment-poor watershed tends to be positive. Preliminary results of a livestock grazing study do not show profound effects on fish populations among various grazing systems or between one to three years of season-long grazing and ungrazed controls. (Moore-SRC).

Codes: reach instream substrate lwd quant?

Everest, F. H., J. R. Sedell, G. H. Reeves, and M. D. Bryant. 1991. Planning and evaluating habitat projects for anadromous salmonids. Edited by J. Colt and R. J. Whilte. AFS, BETHESDA, MD. 68-77 p.

To improve habitat in a stream system, planning, implementing, and evaluating improvements must address the appropriate spatial and temporal scales, including (1) subbasin inventory information for all seasons of the year--a departure from the usual site or reach inventory normally done during summer, (2) a thorough analysis of factors limiting fish production in the subbasin during all seasons of the year, (3) identification of improvement techniques that address limiting factors, and (4) selection of sites for habitat projects in the basin. Items (1) and (2) are usually done by fishery biologists; items (3) and (4) are more interdisciplinary, thereby requiring skills of both biologists and hydraulic engineers. The evaluation of habitat projects encompasses physical, biological, and economic aspects that must be placed in an appropriate spatial and temporal context. This paper proposes a sequential process for planning and evaluating habitat improvement projects, and discusses examples from northwest Oregon and southeast Alaska.

Codes: experi design reach quant

Everest, F. H., J. R. Sedell, G. H. Reeves, and J. Wolfe. 1985. Fisheries enhancement in the Fish Creek Basin: An evaluation of in-channel and off-channel projects, 1984. Annual report 1984. Report DOE/BP/16726-1.

Construction and evaluation of salmonid habitat improvements on Fish Creek, a tributary of the upper Clakamas River, was continued in fiscal year 1984. Habitat improvement work in the basin is designed to increase the annual number of chinook, coho, and steelhead smolt outmigrants from the basin. The primary objectives include: (1) evaluation and quantification of changes in salmonid spawning and rearing habitat resulting from a variety of habitat improvements; (2) evaluation and quantification of changes in fish populations and biomass resulting from

habitat improvements; and (3) evaluation of the cost-effectiveness of habitat improvements developed with BPA and KV funds on Fish Creek. (DBO).

Codes: experi design reach quant

Fausch, K. D., C. Gowan, A. D. Richmond, and S. C. Riley. 1995. The role of dispersal in trout population response to habitat formed by large woody debris in Colorado mountain streams. Bulletin francais de la peche et de la pisciculture 337-339: 179-190.

Fishery managers commonly use logs to create pool habitat for salmonids in mountain streams throughout the world, often to compensate for a lack of natural large woody debris (LWD) due to deforestation or other disturbances in riparian forests. Measurements of LWD in 11 Colorado mountain streams that drain patches of old-growth spruce-fir (Picea-Abies) forest indicated that most pools were formed by LWD. These pool-forming pieces were, on average, larger than pieces that did not form pools. The majority spanned the channel perpendicular to flow and formed plunge and dammed pools. Fishery managers that use perpendicular logs to form pools generally assume that the added habitat will increase survival of resident salmonids during critical periods such as winter. Results of a long-term experiment to test this hypothesis in six Colorado mountain streams showed that resident trout populations increased rapidly and significantly in 250-m treatment sections versus adjacent controls. However, recaptures of marked trout and direct trapping to measure dispersal indicated that the pool-forming logs increased adult trout populations primarily by inducing fish that were moving to remain in the treatment sections, rather than by increasing in situ overwinter survival as reported by others. Research and management of resident stream salmonids has been guided by the restricted movement paradigm, which states that most adult fish are relatively sedentary. However, analysis of previous movement studies revealed that most investigators focused only on fish recaptured in the reaches where they were released, a critical design flaw that causes a bias against detecting movement. Substantial fish movement has important implications for habitat enhancement and restoration, and calls for a watershed management approach.

Codes: experi multi reach quant migrat instream lwd warning

Fausch, K. D., C. L. Hawkes, and M. G. Parsons. 1988. Models that predict standing crop of stream fish from habitat variables: 1950-85. General Technical Report PNW-GTR-213. United States Department of Agriculture Forest Service.

Codes: review reach habitat quant instream ripar lulc warning

Fausch, K. D., and R. J. White. 1981. Competition between brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta) for positions in a Michigan stream. CJFAS 38: 1220-1227.

Competition between brook trout (Salvelinus bontinalis) and brown trout (Salmo trutta) was studied by measuring characteristics of daytime positions held by brook trout before and after studied by measuring characteristics of daytime positions held by brook trout before and after removalof the brown trout from 1800 m of a stream. After brown trout removal, brook trout larger than 15 cm chose resting positions with more favorable water velocity characteristics and more often in shade. The position shift was greatest for the largest brook trout, those of 20-30 cm. Feeding positions of brook trout changed little upon brown trout removal according to our criteria. The shift in resting positions of brook trout after release from competition with brown trout indicates that brown trout excluded brook trout from preferred resting positions, a critical and scarce resource. The combined effects of such interspecific competition, differential susceptibility to angling, differential response to environmental factors, and predation of brown trout on juvenile brook trout may account for declines of brook trout populations while brown trout populations expand in many streams of the northeastern United States where the two species are sympatric.

Codes: qual reach microhab sppinter instream

Fjellheim, A., and G. G. Raddum. 1996. Weir building in a regulated west Norwegian river: Long-term dynamics of invertebrates and fish. Edited by J. E. Brittain, I. Brinkman and C. Nilsson. 501-508 p.

In the period 1975-1990 long-term studies of succession and dynamics of invertebrates and fish were conducted in a weir basin area in the strongly regulated River Ekso. During the years of the study, the invertebrate community in the basin was subjected to great changes. In the first years after weir building, biomass was greatest in the riffles due to a higher abundance of lotic species like the mayfly, Baetis, blackflies and many stonefly larvae. The biomass of oligochaetes and chironomids was similar both in the riffles and in the deeper and more lentic weir basin. In the following years the biomass of lentic chironomid species increased dramatically in the basin. In 1984 the fauna was dominated by Stictochironomus pictulus. In 1988 another species, Chironomus melanotus, also became very abundant. At this time net benthic animal production in the basin had increased 10-fold compared with 1975-1976. A high flow situation during the summer of 1989 altered the weir basin community dramatically. The mean autumnal biomass decreased 4.5 times compared with 1988, dominant lentic species disappeared and lotic/semi-lotic species like the stoneflies Amphinemura sulcicollis, Leuctra fusca and Capnia pygmaea increased in density. Prior to regulation the density of brown trout in the riffle, which later constituted the weir basin area, was 2.5 individuals 100 m super(-2). During the first years after regulation and weir building, fish density increased to 11.1. In 1983 a density of 23.0 trout 100 m super(-2) was achieved. The trout were stunted and showed marked tendencies towards food depletion. During 1984-1985 most of the brown trout population of the basin were removed and used as stock material in the reservoirs of the hydropower station. This resulted in a higher growth rate in the remaining weir basin population. The strong reduction in trout density was followed by major immigration of small (2+ and 3+) trout from the surrounding riffles to the basin. The trout population was now harvested, while a small population of adult spawners was retained. Weir basins increase the area of pool habitats in strongly regulated rivers, and are of major benefit for trout populations, especially by segregating size classes and increasing winter survival. The presence of intermittent riffle sections is also very important, both as spawning and nursery areas and for fish food production.

Codes: experi quant trophic temporal

Ford, J. E., and D. G. Lonzarich. 2000. Over-winter Survival and Habitat Use by Juvenile Coho Salmon (Oncorhynchus kisutch) in Two Lake Superior Tributaries. Journal of Great Lakes Research [J. Great Lakes Res.] 26: 94-101.

Dramatic declines in commercial and recreational fisheries for coho salmon (Oncorhynchus kisutch) in Lake Superior have raised questions about the natural factors that limit their productivity. Snorkelingsurveys were conducted during the winters of 1995-96 and 1996-97 to estimate over-winter mortality and determine winter habitat use by juvenile coho salmon in two spring-fed tributaries of Chequamagon Bay, Lake Superior. Results indicated high densities of juvenile coho salmon in pool habitats of the two streams (x = 0.85 fish/m super(2)) and high over-winter survival (> 45%). Regression analyses revealed no significant relationships between fish distribution and physical habitat variables (large woody debris, overhead cover, and pool size). No shift in habitat use over the winter was found. These results contrast sharply with findings from the Pacific Northwest where juvenile coho salmon generally occupy complex pool habitats during the winter. Although streams of the Great Lakes region are similar in many respects to Pacific streams, differences, particularly in stream flow regimes, indicate that the early life history of coho salmon populations in these two regions differ dramatically. These observations may have important implications on the management of stream habitats in the Great Lakes.

Codes: multi habitat quant instream lwd warning

Fraidenburg, M. E., and R. H. Lincoln. 1985. Wild chinook salmon management: an international conservation challenge. North American Journal of Fisheries Management 5: 311-329.

The complexity of managing wild chinook salmon (Oncorhynchus tshawytscha) stocks arises primarily from marine migrations across political boundaries, the currently seriously overfished condition of stocks along the North

American Pacific Coast, and detrimental impacts from activities of competing users of the freshwater habitat. Despite the fact that data and analytical capabilities are adequate, many chinook salmon stocks continue to decline. This is happening because consistent management standards are lacking or not applied by decision-making bodies in favor of various unquantified socio-political alternatives. Yielding to socio-political pressures occurs even at the biological staff level, resulting in compromised biological recommendations that further undermine the fundamental management goal of long-term stock health and viability. We describe three chinook salmon case histories as paradigms of the problem: (1) the Georgia Strait stock where managers have failed to apply management standards aimed at increasing spawning escapements; (2) the Klamath River stock where managers have applied situational management standards which continuously compromise or ignore spawning escapement objectives; and (3) the upper Columbia River "bright"stock where conditional standards are being applied by numerous regulatory entities placing spawning escapement needs at a lower priority than other considerations.

Codes: philosphy

Friesen, T. A., and D. L. Ward. 1996. Status and condition of fish assemblages in streams of the Tualatin River Basin, Oregon. Northwest Science 70: 120-131.

We conducted fish inventories at 38 sites on fifteen streams of the lower Tualatin River Basin as part of a study to document fish species and assess the impacts of urbanization on native fish assemblages. We used three-pass electrofishing techniques to survey each site in spring, summer, autumn, and winter. We collected 25 species of fish from ten families; twelve species from five families (6.3% of the total catch) were exotic to Oregon. Reticulate sculpin Cottus perplexus, a native fish tolerant of habitat degradation, comprised 68.4% of the catch. Number of species per stream ranged from 5 to 15; number of native species ranged from 4 to 10. Sites in the upper sections of streams contained the largest number of trout, native minnows, and sculpins, whereas lower sites contained more diverse species assemblages and a larger number of introduced fish. We found a significant difference in the number of native species among sites of different stream order, but no significant difference when all species were considered. Our catch also varied seasonally, likely due to species motility, gear selection, and variation in life history stages. Native species intolerant to habitat disturbances (torrent sculpin Cottus rhotheus and Oncorhynchus spp.) comprised only 1.7% of the total catch, and 2.0% of the total catch exhibited parasites or physical anomalies. The relatively low number of intolerant species, high proportion of fish with parasites or anomalies at some sites, introduction of exotic species, and reported habitat deficiencies suggest that native fish assemblages in the basin are at least moderately unhealthy.

Codes: multi reach quant instream

Garcia de Jalon, D., M. Mayo, and M. C. Molles. 1996. Characterization of Spanish Pyrenean stream habitat: relationships between fish communities and their habitat. Regulated Rivers Research & Management 12: 305-316.

Spanish Pyrenean streams are characterized by extreme summer drought and torrential flows during spring snowmelt and their fish communities are dominated by trout at high altitudes and by barbel in the lower reaches. The Instream Flow Incremental Methodology (IFIM) was adapted to analyse the fisheries habitat of Spanish streams. Parameters were developed that measure the particular characteristics of these streams, taking into account the habitat needs of the main developmental stages (adults, juveniles, fry and spawning) in different seasons. For this analysis 'potential habitat' was defined as that determined by hydraulics and geomorphological features. 'Real habitat used' was defined by the fish population characteristics (densities, biomass, age-structure and population dynamics). Habitat complexity was calculated as the diversity of habitats of different developmental stages and different species. Habitat conditions during summer-drought were analysed by the simulation of low flow conditions as measured by gauging stations. Habitat parameters were measured in several stream reaches and compared with the characteristics of the fish populations they supported by multivariate analysis. The results show that fish abundance increases downstream along the river continuum, indicating that the habitat carrying capacity increases downstream. The depth and rock surfaces are the main factors limiting the capacity of the stream to provide refuges. Trout populations are also influenced by submerged macrophytes. This IFIM evaluation of stream

habitat was not correlated with fisheries features because factors other than hydraulics appear to limit trout population in the Pyrenean study streams. Hydraulic factors may limit the fish populations during brief periods, but population recovery from these disturbances may take longer than the time available between disturbances events.

Codes: multi reach quant microhab instream ifim warning hem

Giannico, G. R. 2000. Habitat selection by juvenile coho salmon in response to food and woody debris manipulations in suburban and rural stream sections. CJFAS 57: 1804-1813.

This study explored the effects of food and woody debris manipulations on the summer distribution of juvenile coho salmon (Oncorhynchus kisutch) in small suburban streams. To examine fish responses to these factors, three different experiments were carried out in modified sections of two streams. The results showed that the distribution of juvenile coho salmon in a stream section was primarily controlled by the availability and distribution of food among pools and by the presence and density of woody debris. Food, however, played a dominant role because the foraging quality of a pool not only affected the density of fish in it but also the response of those fish towards instream debris. In food-rich stream sections, low proportions of juvenile coho salmon occupied pools with dense woody debris in the spring, which changed towards late summer. In contrast, in food-poor reaches, high proportions of fish were found in pools with abundant debris in the spring. Pools that combined abundant food with sparse woody debris were the most favoured by the fish. It is important that salmonid habitat enhancement projects consider that open foraging areas interspersed with woody debris characterize the typeof summer habitat that juvenile coho salmon prefer.

Codes: experi habitat quant lwd trophic

Giannico, G. R., and M. C. Healey. 1999. Ideal free distribution theory as a tool to examine juvenile coho salmon (Oncorhynchus kisutch) habitat choice under different conditions of food abundance and cover. Canadian Journal of Fisheries and Aquatic Sciences 56: 2362-2373.

We investigated the mechanisms affecting habitat choice by juvenile coho salmon (Oncorhynchus kisutch) in relation to the patchy distribution of food and cover. We tested the following hypotheses: (i) the distribution of juvenile coho, both between patches in a pool and between separate pools in a channel, corresponds numerically to the food input rate of those habitat patches as predicted by the "input-matching rule" of ideal free distribution (IFD) and (ii) the addition of instream cover, by increasing visual isolation among competitors, promotes input matching both within and between pools. We conducted our experimental work in artificial channels and we used two different types of cover, instream and overhead. In the absence of cover and with either no differences or relatively small differences in food abundance between patches, the spatial distribution of juvenile coho responded numerically to the input rate of food as predicted by the IFD. However, when differences in food abundance between patches were relatively large or cover was present, fish distributions consistently undermatched food input rate in the rich patch. Coho foraged in open patches away from cover within single pools but preferred pools with cover when choosing between separate pools. Several IFD models were used to examine the observed dispersion patterns.

Codes: experi enclos habitat quant trophic ripar instream

Gibson, R. J. 1988. Mechanisms regulating species composition, population structure, and production of stream salmonids; A review. Polskie Archiwum Hydrobiologii/Polish Archives of Hydrobiology 35: 469-495.

Streams supporting salmonids are characterized by riffles and pools, with the success of a species depending on the availability of suitable habitat for the ecological needs of the different life stages of the species. Juveniles of one species may be primarily riffle dwellers, which may be anadromous, such as the Atlantic salmon, and a second species may primarily occupy the slower water and pools, such as brown trout or American brook trout. Social

behavior is affected by a number of factors, including water velocity, availability of food, and temperature, so that levels of aggression can change, affecting production.

Codes: review microhab habitat sppinter instream wtemp

Gibson, R. J. 1993. The Atlantic salmon in fresh water: Spawning, rearing and production. Reviews in Fish Biology and Fisheries 3: 39-73.

Fluvial salmonids have evolved to use the diversity of habitats in natural streams for different life history stages and at different seasons. Required freshwater habitat of Atlantic salmon (Salmo salar) can be classified generally as that suitable (i) for spawning, (ii) for feeding during the major growing period, and (iii) for overwintering. Spawning habitat of salmon is usually in rapid water at the tail of pools on the upstream edge of a gravel bar, ideally with depths about 25 cm, in mean water velocities of about 30-45 cm/s, with maximum velocities about 2 body lengths/s, and with a substrate of irregularly shaped stones of cobble, pebble, and gravel. Underyearling salmon (< 7 cm TL) are most common in shallow (< 15 cm) pebbly riffles, whereas older and larger parr (> 7 cm TL) are usually in riffles deeper than 20 cm with a coarse substrate. Depth preference increases with size. Multiple linear regression models quantifying parr habitat have identified substrate as an important variable, with a positive relationship to an index of coarseness. Negative relationships were found with mean stream width, range of discharge, and overhanging cover. Water chemistry, especially alkalinity, nitrates, and phosphates, are important regulators of production. Although similar variables had importance, coefficients among rivers differed. Interactions occur among variables. Further studies are required to quantify productive capacity of habitat for parr. Results suggest that useful models can be derived and if a river system is mapped, and stratified by habitat, then smolt yield could be predicted and the required egg deposition could be estimated. In winter, young salmon shelter among coarse substrate or move to pools, but continue feeding, with larger parr being more active.

Codes: review multi quant habitat instream substrate

Gil, J., and M. C. Healey. 1999. Ideal free distribution theory as a tool to examine juvenile coho salmon (Onchorynchus kisutch) habitat choice under different conditions of food abundance and cover. CJFAS 56: 2362-2373.

This study investigates the mechanisms affecting habitat choice by juvenile coho salmon (Onchorynchus kisutch) in relation to the patchy distribution of food and cover. The following hypotheses were tested: 1) the distribution of juvenile coho, both between patches in a pool and between separate pools in a channel, corresponds numerically to the food input rate of those habitat patches as predicted by the "input-matching rule" of ideal free distribution (IFD) and 2) the addition of instream cover, by increasing visual isolation among competitors promotes input matching both within and between pools. Experimental work was conducted in artificial channels and two different types of cover, instream and overhead were used. In the absence of cover and with either no differences or relatively small differences in food abundance between patches, the spatial distribution of juvenile coho responded numerically to the input rate of food as predicted by the IFD. However, when differences in food abundance between patches were relatively large or cover was present, fish distributions consistently undermatched food input rate in the rich patch. Coho foraged in open patches away from cover within single pools but preferred pools with cover when choosing between separate pools. Several IFD models were used to examine the observed dispersion patterns.

Codes: experi enclos habitat quant instream ripar trophic

Gislason, G. M., J. S. Olafsson, and H. Adalsteinsson. 1998. Animal communities in Icelandic rivers in relation to catchment characteristics and water chemistry. Preliminary results. Nordic Hydrology [Nordic Hydrol.] 29: 129-148.

Catchment areas of Icelandic rivers are mostly barren or with little vegetation cover in the highlands, but with heathland and mire vegetation in the lowlands. Chemical composition and nutrient availability in Icelandic rivers

are influenced by geology, topography and vegetation cover in the river basins. This seems to determine the density and diversity of benthic invertebrates, species composition of anadromous fish and catch of salmon in Icelandic rivers. Species composition of benthic communities is determined by particulate organic matter drifting downstream from river head-waters. Filter feeding blackfly larvae dominate lake outlets, while algal grazing chironomid larvae dominate rivers not influenced by lakes. In well vegetated catchment basins, lake-fed rivers have higher catches of salmon than non-lake fed rivers. Only a few of the rivers flowing from poorly vegetated areas sustain salmon. Glacial rivers have the lowest density and diversity of benthic invertebrates of all river groups and do not sustain fish populations.

Codes: reach multi ripar lakehydro qual

Glova, G. J. 1986. Interaction for food and space between experimental populations of juvenile coho salmon (Oncorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) in a laboratory stream. Hydrobiologia 131: 155-168.

Populations of juvenile coho salmon (Onoorhynchus kisutch) and coastal cutthroat trout (Salmo clarki) frequently cohabit small coastal streams in western North America. When tested separately at 13 degree C, their habitat demands were similar and approximately 60-75% of either species occurred in pools. When tested together they segregated, with approximately 75% of coho in pools and up to 63% of cutthroat trout in riffles. In winter, at 3 degree C, both species preferred pools and overhead cover, whether tested separately or together. At 5 degree C, they partially segregated in a pattern similar to, but far less pronounced than, that in summer. Both species used similar forms of aggressive behaviour, although aggressive displays were more frequently used by coho, while nipping was more frequently used by cutthroat trout. Both salmonids were most aggressive when food was presented, irrespective of season, although coho responded with greater rapidity and intensity to feeding than did cutthroat trout.

Codes: experi habitat qual sppinter ripar

Glova, G. J. 1987. Comparison of allopatric cutthroat trout stocks with those sympatric with coho salmon and sculpins in small streams. biology of fishes. The Hague 20: 275-284.

Juvenile stocks of allopatric (upstream of barrier falls) cutthroat trout Salmo clarki and those sympatric (downstream of barrier falls) with coho salmon Oncorhynchus kisutch and sculpins Cottus spp., were sampled during the late summer period of low flows in six small coastal streams in British Columbia. The objective was to obtain and compare information on pattern of habitat use and fish size distribution of these two trout types. In most instances, density (n m super(-2); g m super(-2)) of cutthroat trout was considerably greater in pools and glides in the allopatric than in the sympatric stocks. The results of this study provide insight of potential impact of coho salmon juvenile transplants into stream segments supporting allopatric cutthroat trout.

Codes: multi habitat quant sppinter instream

Gortz, P. 1998. Effects of stream restoration on the macroinvertebrate community in the River Esrom, Denmark. Aquatic Conservation: Marine and Freshwater Ecosystems [Aquat. Conserv.: Mar. Freshwat. Ecosyst.] 8: 115-130.

The macroinvertebrate fauna of three restored and two reference sections in the River Esrom was compared 4 years after completion of a restoration project using gravel, boulders and stream concentrators on a 3.2-km reach in order to enhance the physical structure and natural trout spawning. Sampling was performed by standard methods (stone-, core- and kick-sampling). The faunal communities were compared by Bray-Curtis similarity, diversity (H), saprobic index (SI) and Danish fauna index (DFI) methods. Restoration with stream concentrators resulted in a deeper and narrower stream with a higher flow velocity near the bottom and a coarser substrate compared with the reference section. The fauna showed higher similarity to the fauna found on the stony bottom sections due to immigration of

taxa preferring stony substrate (e.g. Lepidostoma hirtum, Theodoxus fluviatilis) and SI and DFI generally improved from II to/towards I-II. Clean-water species such as Agapetus ochripes and Limnius volckmari, were found in significantly higher numbers in the restored sections compared with the reference section. Five times as many trout spawning redds occurred in the restored sections than in the non-restored. However, electro-fishing revealed few young-of-the-year trout and did not reflect spawning success. It was concluded that attempts to improve the physical structure and spawning environment altered invertebrate composition, but did not enhance trout production.

Codes: experi qual spawn trophic

Gosse, J. C. 1985. Brown trout (Salmo trutta) responses to stream channel alterations, their microhabitat requirements, and a method for determining microhabitat in lotic systems. Dissertation.

Stream channel alterations are alleged to have detrimental effects on the stream fauna, particularly the sport fishery. Four study sites were chosen to evaluate the quantitative effects of channel alterations on a brown trout (Salmo trutta) population: (1) an unaltered control; (2) an area dredged twice during the course of the study; (3) an area bulldozed 4 years prior to study, half of which was bulldozed again during the study; (4) an area bulldozed 4 years prior to study, 400 meters of which has remained channelized and 100 meters of which has reverted to natural meandering. Population estimates were made approximately bi-monthly for at least a year in each site. Analysis of variance was used to compare among sites for average total density and biomass, and total production per interval. Dredging had less effect on the population than did bulldozing. Populations in the bulldozed sites were most severely effected in those areas that had retained the greatest degree of artificial configuration. The youngest and oldest age groups were most severely effected by stream alterations. Growth was not affected by channel alterations. A technique was developed for quantitatively defining the precise microhabitat of a stream dwelling species in situ. Scuba equipment was modified to allow observations of fish in high velocity streams and at low temperatures. An air-exhaust system prevented bubbles from disturbing the fish. A sonic transmitter-receiver allowed the diver to communicate with the surface personnel who monitored the instruments and recorded data. Brown trout microhabitat was measured by life stage (age 0, juvenile, and adult) and physical activity from summer through winter for a wide variety of stream habitats in two different river systems. Water velocity at fish location, water depth, fish depth, substrate, and overhead light appear to be the most important of the physical parameters monitored in defining brown trout microhabitat. Physical activity and life stage of the fish were vital subdivisions in defining microhabitat requirements. Trout selected specific microhabitat areas from the range of habitat available in each stream. The adverse effects observed for channel alterations can be explained in terms of microhabitat requirements (DBO).

Codes: experi reach quant microhab instream method

Gowan, C., and K. D. Fausch. 1996. Long-term demographic responses of trout populations to habitat manipulation in six Colorado streams. Ecological Applications 6: 931-946.

Fish communities in high-elevation, Rocky Mountain streams consist of only one or a few trout species, so these streams are ideal for quantifying how physical habitat manipulation influences population biology. Managers often alter habitat structure in hopes of increasing the number or size of fish in a population, but this practice has not been rigorously evaluated, and the mechanisms involved are not well understood. We measured fish abundance and habitat conditions in each half of 500-m study reaches in six streams for 2 yr before and 6 yr after installing 10 low log weirs in a randomly designated half (treatment section). Mean depth, pool volume, total cover, and the proportion of fine substrate particles in the stream bed increased in treatment sections within 1 to 2 years, whereas habitat in adjacent controls remained unchanged. Abundance and biomass of adult fish, but not juveniles, increased in treatments relative to controls in all streams. Recaptures of trout that were individually tagged and others that were batch marked revealed that immigration was primarily responsible for increased adult abundance and biomass, whereas no biologically significant differences occurred for recruitment, survival, or growth. Few (<5%) immigrants to treatment sections came from adjacent controls, indicating that the increased adult abundance did not result simply from fish redistributing within the study reach, but was caused instead by immigration from beyond the reach boundaries. Immigration to control sections was frequent as well, leading us to conclude that fish

movement was common, contrary to most literature on stream trout. We also detected a high degree of concordance in fish abundance fluctuations within and among streams, suggesting that regional factors influenced fish populations over large spatial scales. Our research shows that log weirs increase trout abundance, but only if other management activities assure that fish dispersal remains unimpeded within the drainage.

Codes: multi experi reach basin quant migrat instream substrate warning

Gowan, C., and K. D. Fausch. 1996. Mobile brook trout in two high-elevation Colorado streams: re-evaluating the concept of restricted movement. Canadian Journal of Fisheries and Aquatic Sciences 53: 1370-1381.

Movements of brook trout (Salvelinus fontinalis) were studied in two high-elevation (>2700 m) Colorado streams by marking (n = 4005) and recapturing fish using weirs and electrofishing at locations spaced up to 4500 m apart. Movement was most common in the upstream direction during summer, and about equal upstream and downstream between summers. Highest rates of movement occurred during and just after runoff, and before spawning, but substantial numbers of fish moved throughout the summer. Fish captured moving through weirs tended to be longer but in poorer condition than fish captured during electrofishing in 500-m reaches between weirs (i.e., the general population). On the basis of capture histories for individual fish, 59 and 66% in the two streams moved at least 50 m (up to 3380 m), even though most could be tracked only for several months. Thus, significant proportions of fish in electrofishing samples spaced throughout the stream bore marks from locations up to 2000 m away, indicating that long-range movements were relatively common. This conclusion is contrary to most literature on resident stream salmonids. We show how methods commonly used to study movement may be seriously biased, and suggest that movement may be more widespread than currently recognized.

Codes: multi segment migrat noenv

Grant, J. W. A., J. Englert, and B. F. Bietz. 1986. Application of a method for assessing the impact of watershed practices: effects of logging on salmonid standing crops. North American Journal of Fisheries Management 6: 24-31.

Preliminary studies on three control streams (unaffected by logging) indicated that there were no significant intrastream differences in the total biomass of Atlantic salmon (Salmo salar), brown trout (Salmo trutta), and brook trout (Salvelinus fontinalis) between discrete areas of similar habitat. Therefore, total salmonid biomass should be a good indicator of stream habitat quality for salmonids and useful in assessing the impacts of watershed practices. Total salmonid biomass was used to assess the effect of logging disturbances, including stream crossings, clearcuts, and bank modification, on the salmonid populations of 10 streams in New Brunswick and Nova Scotia. This biomass was measured at pairs of logging-disturbed and upstream control areas of the 10 streams. Salmonid biomass decreased significantly downstream of two stream crossings, probably because of increased siltation, while seven clear-cuts and one bank modification along the other eight streams had no significant effect on salmonid biomass. Removal of the canopy cover was associated with increases in the fork length or weight at age, or both, of juvenile Atlantic salmon but had no consistent effect on the size at age of brook trout.

Codes: multi experi reach quant substrate ripar

Grant, J. W. A., and D. L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47: 1724-1737.

We examined the old, but untested hypothesis that territory size limits the maximum population density of salmonids in streams. Growth and mortality trajectories of salmonid cohorts from eight experimental studies were compared to the maximum-density regression, the inverse of the territory-size regression. In shallow habitats, such as riffles and raceways, the cohort trajectories followed the maximum density regression quite closely and were consistent with the territory-size hypothesis. Our results suggest that the territory-size regression has practical value

for predicting the maximum densities of stream-dwelling salmonids in shallow habitats and the occurrence of density-dependent population responses.

Codes: experi enclos habitat microhab quant popdyn

Grant, J. W. A., S. O. Steingrimsson, E. R. Keeley, and R. A. Cunjak. 1998. Implications of territory size for the measurement and prediction of salmonid abundance in streams. Canadian Journal of Fisheries and Aquatic Sciences 55: 181-190.

Information about territory size is useful for both the measurement and prediction of salmonid abundance. Percent habitat saturation (PHS), the percentage of the stream area occupied by the territories of salmonid fishes, is a better measure of abundance than population density because the former integrates the effects of (a) several age-classes or species in a stream, and (b) variation in growth rate or sampling date. "Effective density" or "effective PHS," calculated by weighting crude density (no. times m super(-2)) or PHS by the number of organisms in the sampling unit, more accurately reflects density from the organism's point of view than does crude density or PHS. Effective density and PHS of Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick, increased by 0.4 fish per m super(2) and 4%, respectively, for each order of magnitude decrease in the area of the sampling unit. Literature data suggested that territory size is inversely related to food abundance and can be used to predict changes in salmonid abundance that accompany changes in food abundance. The allometry of territory size was a better predictor of the decline in density of a cohort of Atlantic salmon in Catamaran Brook than the allometry of metabolic requirements.

Codes: habitat quant popdyn noenv temporal

Greenberg, L. A., E. Bergman, and A. G. Eklov. 1997. Effects of predation and intraspecific interactions on habitat use and foraging by brown trout in artificial streams. Ecology of Freshwater Fish 6: 16-26.

We studied habitat use, foraging rates and behavior of 10 cm and 12 cm long brown trout, Salmo trutta, at two densities, 1.5 and 3.0 fish/m super(2), in artificial streams that contained either the amphipod, Gammarus pulex, alone or G. pulex together with the piscivore, northern pike, Esox lucius. Gammarus were stocked in and largely restricted to the pools at a density of 128 Gammarus/m super(2)/pool. Large trout (12 cm) used pools more and riffles less when small trout (10 cm) were present than when small trout were absent. Small trout consumed fewer Gammarus when together with large trout than when alone, but showed no difference in habitat use in the presence and absence of large trout. Habitat use and number of Gammarus consumed per trout were not affected by trout density for either size-class when alone. For both size-classes of trout, use of pools and foraging rates were higher in the absence than in the presence of pike, and pike primarily resided in the pools. The number of aggressive interactions by both size-classes of trout decreased when pike was present. Our results indicate that for habitats that differ in food resources and predation risk, size structure may affect habitat use and foraging by brown trout.

Codes: enclos experi reach quant sppinter trophic

Greenberg, L. A., and J. Dahl. 1998. Effect of habitat type on growth and diet of brown trout, Salmo trutta L., in stream enclosures. Fisheries Management and Ecology [Fish. Manage. Ecol.] 5: 331-348.

The effect of habitat on the growth and diet of brown trout, Salmo trutta L., stocked at the same densities in nine stream enclosures, comprising three habitat types of different quality, were tested. The habitats, which were created based on microhabitat preference data, were a shallow water habitat lacking cobbles (habitat 1), a deeper, mixed cobble-bottomed (128-384 mm diameter) habitat (habitat 2) and a large cobble-bottomed (256-384 mm) habitat of intermediate depth (habitat 3). Brown trout were found to have greater increases in total biomass in habitats 2 and 3 than in habitat 1. The pattern for length did not follow that of biomass as trout had greater increases in total length in habitat 2 than in the other two habitats. Biomass of food in trout diets reflected habitat-specific fish biomass changes, with a greater total biomass of prey as well a greater biomass of the leech, Erpobdella, in habitats 2 and 3 than in habitat 1. There were no habitat-specific differences in the biomass of benthic or drifting invertebrates in the

enclosures, with the exception of a tendency for an effect of habitat on the biomass of Erpobdella. Although there may have been habitat-specific differences in food resources that were not detected, it is believed that the higher biomass growth in habitats 2 and 3 may have reflected differences in cover afforded by the deeper water and coarser substrates and/or improved foraging opportunities facilitated by the larger volumes of water in the deeper habitats in which the trout could search for prey.

Codes: enclos experi habitat quant trophic

Gries, G., K. G. Whalen, F. Juanes, and D. L. Parrish. 1997. Nocturnal activity of juvenile Atlantic salmon (Salmo salar) in late summer: Evidence of diel activity partitioning. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 54: 1408-1413.

Paired day-night underwater counts of juvenile Atlantic salmon (Salmo salar) were completed on tributaries of the West River, Vermont, USA, between 28 August and 10 September 1995. At water temperatures ranging from 13 to 23 degree C, the relative count of juvenile salmon was greater at night. Nocturnal counts differed for young-of-the-year and post-young-of-the-year (PYOY) salmon, with PYOY exhibiting almost exclusively nocturnal activity. Nocturnal activity in late summer may enable salmon to maintain population densities when space and suitable feeding areas may be limited. Nocturnal activity of juvenile salmon should be considered in studies of habitat use, competition, time budgets, and associated bioenergetic processes.

Codes: experi quant habitat noenv

Griffith, J. S., and R. W. Smith. 1995. Failure of submersed macrophytes to provide cover for rainbow trout throughout their first winter in the Henrys Fork of the Snake River, Idaho. North American Journal of Fisheries Management 15: 42-48.

Submersed aquatic plants that are abundant in some stream reaches have a potential to provide winter concealment cover for juvenile salmonids. We monitored an index of macrophyte abundance in a portion of the Henrys Fork of the Snake River during two winters that differed in severity and assessed the densities of age-0 rainbow trout Oncorhynchus mykiss associated with the macrophytes. The macrophyte index averaged 84-87% in November 1989 and 1992, and an average of 10-13 fish/100 m super(2) were concealed there. In 1990, macrophyte cover declined to 59% in January and 46% in every February; fish density declined by about one-third by January and dropped to nearly zero in February. In 1992-1993, the macrophyte index declined to an average of 39% following anchor ice formation in December and to 32% in January. Fish density in December was reduced to about half of the November density and to about 1 fish/100 m super(2) in January. Movement of marked fish in 1989-1990 was predominantly from macrophytes into cobble and boulder cover along the bank. During these 2 years, cover provided by submersed macrophytes in the study area was not adequate to hold age-0 rainbow trout the winter. During winter of 1992-1993 no natural bank habitat was available because of low water flows, and we believe that none of the 1992 cohort of rainbow trout survived in the study area.

Codes: reach quant instream temporal

Guay, J. C., D. Boisclair, D. Rioux, C. Leclerc, M. Lapointe, and P. Legendre. 2000. Development and validation of numerical habitat models for juveniles of Atlantic salmon (Salmo salar). Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 57: 2065-2075.

The ability of numerical habitat models (NHM) to predict the distribution of juveniles of Atlantic salmon (Salmo salar) in a riverwere evaluated. NHMs comprise a hydrodynamic model (to predict water depth and current speed for any given flow) and a biological model (to predict habitat quality for fish using water depth, current speed, and substrate composition). NHMs were implemented with a biological model based on 1) preference curves defined by

the ratio of the use to the availability of physical conditions and 2) a multivariate logistic regression that distinguished between the physical conditions used and avoided by fish. Preference curves provided a habitat suitability index (HSI) ranging from 0 to 1, and the logistic regression produced a habitat probabilistic index (HPI) representing the probability of observing a parr under given physical conditions. Pearson's correlation coefficients between HSI and local densities of parr ranged from 0.39 to 0.63 depending on flow. Corresponding values for HPI ranged from 0.81 to 0.98. It was concluded that HPI may be a more powerful biological model than HSI for predicting local variations in fish density, forecasting fish distribution patterns, and performing summer habitat modelling for Atlantic salmon juveniles.

Codes: habitat quant instream ifim warning hem

Hall, J. D., and N. J. Knight. 1981. Natural variation in abundance of salmonid populations in streams and its implications for design of impact studies. EPA-600/S3-81-021. United States Environmental Protection Agency report, Corvallis, OR. July 1981.

Salmonids are the principal fish species of economic importance affected by pollution in the Western United States. Assessment of damage to these fish populations cannot be undertaken without some understanding of the natural variation in abundance within and between populations. An extensive literature review relating to stock size and production of salmonid populations in streams was carried out to bring together data on the magnitude of natural variation in population size and to relate this variability to environmental conditions whenever possible. Temporal and spatial variation may be as high as several orders of magnitude, and are sufficient to mask significant perturbations caused by nonpoint source (NPS) pollutants. Environmental variables most closely associated with spatial variation are those relating to the quality of salmonid habitat, particularly physical characteristics such as cover. Streamflow and food abundance have been associated with both temporal and spatial variation. Considerable emphasis should be placed upon systems of rating habitat quality in attempts to minimize the effects of natural variation when evaluating the impact of NPS pollutants. As a means of more clearly separating natural variation from damage caused by NPS pollutants, more emphasis should be placed upon the study of basic processes in stream ecosystems and more extensive use should be made of paired comparisons in the design of impact studies. (Moore-SRC).

Codes: review multi quant reach temporal instream

Ham, K., and T. Pearsons. 2000. Can reduced salmonid population abundance be detected in time to limit management impacts? CJFAS 57: 17-24.

Eight populations of native salmonids (Oncorhynchus mykiss, Oncorhynchus tsawytscha, Salvelinus confluentus, Oncorhynchus clarki Prosopium williamsoni) were evaluated to determine if rapid, sensitive detection of a reduction in abundance is possible in the Yakima River basin, Washington, where a large-scale test of hatchery supplementation is being conducted. Prospective power to detect impacts to abundance was estimated from 3-16 annual baseline surveys conducted by electrofishing, trapping, or snorkeling. High interannual variation in abundance estimates (CV = 26-94%) prevented detection of small impacts for most taxa. For three taxa, models of environmental and biological influences accounted for between 42 and 49% of temporal variation, increasing our ability to detect impacts of other influences. Detectable impacts for a t test with alpha = 0.1 and beta = 0.1 were >18% for all eight taxa and >54% for four ofeight taxa. It is suggested that population abundance monitoring may not provide feedback sufficiently sensitive or rapid enough to implement corrective actions that prevent impacts from causing harm or exceeding an acceptable level, especially for rare or highly valued taxa with small acceptable impacts.

Codes: multi reach quant risk modeling warning