Hanson, D. L., and T. F. Waters. 1974. Recovery of standing crop and production rate of a brook trout population in a flood-damaged stream. Transactions of the American Fisheries Society 103: 431-439.

The brook trout (Salvelinus fontinalis Mitchill) population in Valley Creek, Minnesota, recovered from heavy flood damage in 1965-66 in terms of standing crop, growth, and production rates over a period of 4 to 5 years. Standing crops of brook trout increased numerically by 20-fold from a low of 498/ha in 1966 to 10,882/ha in 1969, and in biomass by 6-fold from 25 kg/ha in 1966 to a maximum of 148 kg/ha in 1970. Growth rate early in the recovery period was high due to the low density of trout but decreased in successive years as fish density increased. Annual production was about 50 kg/ha during the flood years but increased during the recovery years to a maximum of 167 kg/ha in 1969. Cohort production for the 1965 year class, the one most seriously affected by the floods, was about 15 kg/ha, whereas cohort production for the 1968 year class, the last one that could be completely followed in this study, was about 190 kg/ha. After the floods, rainbow trout (Salmo gairdneri Richardson) immigrated into the study section from downstream; although variable in year class strength, the rainbow contributed substantially to total salmonid standing crop and annual production in some years. It has apparently become permanently established, even after total recovery of the brook trout population.

Codes: experi reach quant popdyn sppinter migrat hydro temporal

Hartman, G. F., and T. G. Brown. 1987. Use of small, temporary, floodplain tributaries by juvenile salmonids in a west coast rain-forest drainage basin, Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 44: 262-270.

Seasonal movement of trout (Salmo clarki and S. gairdneri) into and out of three tributaries which drain areas ranging from 15 to 100 ha within the lower Carnation Creek catchment basin were monitored periodically from 1972 to 1985. The number of trout entering the three tributaries relative to total trout was as high as the number of coho salmon (Oncorhynchus kisutch) entering these tributaries relative to total coho. The percentage of the salmonid population represented by trout was highest in the two largest tributaries and lowest in the smallest. Trout were most clearly associated with nonvegetated sand and gravel bottom portions of the three tributaries. Coho were associated with this habitat too, but they also frequented portions of the tributaries that were vegetated and had a mud substrate. The paper considers some of the implications of use of small drainages by trout to habitat managers.

Codes: quant reach offchann migrat substrate temporal

Hartman, G. F., J. C. Scrivener, and M. J. Miles. 1996. Impacts of logging in Carnation Creek, a high-energy coastal stream in British Columbia, and their implication for restoring fish habitat. Canadian Journal of Fisheries and Aquatic Sciences 53: 237-251.

The land form, surficial geology, and hydrometeorology of the west coast of British Columbia cause streams in the region to be highly variable in flow and vulnerable to land-use disturbance. Carnation Creek, a small drainage in this region, was studied intensively for >20 yr to examine the impacts of forest harvesting. Landslides and debris torrents modified steep slope tributaries and the mainstem of the creek. Bank erosion also altered the stream channel on the alluvial flood plain. These effects were additive in the system and reduced the quality of spawning and rearing habitat for juvenile salmonids. In streams like Carnation Creek, it is necessary to restore some stability to the hill slopes and gullies before attempting fish habitat improvements in the main channel. Salmonid production was limited by combinations of processes and conditions that were different for each species and life-history stage. Knowledge of the processes that limit fish production must be applied in habitat improvement work or the projects risk failure. Programs intended to restore natural function to systems or to improve habitat for fish must be planned, evaluated, and reported methodically if they are to succeed and provide information of use to future programs.

Codes: reach quant ripar lulc temporal warning

Hartzler, J. R. 1983. The effects of half-log covers on angler harvest and standing crop of brown trout in McMichales Creek, Pennsylvania. North American Journal of Fisheries Management 3: 228-238.

Approximately 40 m super(2) of supplemental shelter provided by 68 half-log cover devices were added to 700 m (0.52 hectare) of McMichaels Creek, a relatively infertile stream in eastern Pennsylvania. A control area of similar size was left undeveloped. Angling data and yearly electrofishing inventories were used to measure changes in the standing crops of brown trout (Salmo trutta)) greater than or equal to 200 mm (catchable-size) and 100-199 mm long (subcatchable). Anglers creeled 10% more trout in treated sections after cover installation, wherease the brown trout harvest declined by 11% in the untreated sections. Numbers and biomass of brown trout greater than or equal to 200 mm in control sections declined in postdevelopment years. Standing crops of smaller trout increased significantly in both cover and control sections, with the greatest changes occurring in control areas. The poor response of "catchable-size" brown trout to cover enhancement in McMichaels Creek was attributed to the presence of abundant natural cover. Environmental factors other than shelter apparently determined the density of subcatchable trout.

Codes: experi reach quant instream lwd

Harvey, B. C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. North American Journal of Fisheries Management 6: 401-409.

I examined the impact of small suction dredges (hose diameter, <16 cm) on fish and invertebrates in two California streams (North Fork of the American River and Butte Creek) in a 2-year study. I studied both the effect of one dredge (1980) and the effects of an average of six dredges in a 2-km section of stream (1981). Ten replicate Surber samples per station were taken monthly to compare macroinvertebrate abundances at control and dredged stations before, during and after dredging in both years. Dredging significantly affected some insect taxa when substrate was altered. A recolonization experiment showed that numerical recovery of insects at dredged sites was rapid. Mask-and-snorkel censuses and observations of tagged fish indicated that major changes in available habitat caused local decreases in fish density. Dredging affected riffle sculpins (Cottus gulosus) more severely than rainbow trout (Salmo gairdneri), probably because of differences in microhabitat requirements. Local turbidity increases below active dredging probably did not affect invertebrates and fish.

Codes: multi experi habitat quant substrate

Harvey, B. C. 1998. Influence of large woody debris on retention, immigration, and growth of coastal cutthroat trout (Oncorhynchus clarki clarki) in stream 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.] 55: 1902-1908.

Over 4 months and about 1 year coastal cutthroat trout (Oncorhynchus clarki clarki) greater than or equal to age-1 in Little Jones Ceek, California, remained at similar rates in pools with and without large woody debris. This result was based on attempts in July and November 1995 to collect and tag all fish in 22 pools and three collections of fish from the same pools in November 1995, May 1996, and August 1996. Retention of fish appeared to be greater in pools with large woody debris in May 1996. The presence of large woody debris in pools did not influence immigration or growth of cutthroat trout. Both immigration and growth increased downstream over the 3850-m study reach. Low retention and substantial immigration of cutthroat trout into experimental pools indicate that movement is important in the dynamics of this population. First- and second-order channels appear to be important sources of fish for the third-order study reach, while the study reach may export significant numbers of fish to downstream reaches accessible to anadromous fish.

Codes: experi habitat reach quant migrat lwd

Harvey, B. C., and R. J. Nakamoto. 1996. Effects of steelhead density on growth of coho salmon in a small coastal California stream. Transactions of the American Fisheries Society 125: 237-243.

Weight change in age-0 coho salmon Oncorhynchus kisutch at about natural density was negatively related to the density of juvenile steelhead (anadromous rainbow trout O. mykiss) in a 6-week experiment conducted in July-August 1993 in the north and south forks of Caspar Creek, California. The experiment used 12 enclosed stream sections, each containing a pool and a portion of upstream riffle, with two replicates of three steelhead densities-zero, natural density (1x), and twice the natural density (2x)-on both the north and south forks. The natural density of coho salmon was about one-sixth the density of steelhead. Coho salmon survival was high (87% overall) and not related to treatments. In the north fork, coho salmon weight change was positive in zero density steelhead treatments, zero in 1x treatments, and negative in 2x treatments. Coho salmon weight change in the south fork was less favorable than in the north fork but was also negatively related to the density of steelhead. These results indicate that under some conditions resource partitioning by salmonid species does not eliminate negative interspecific interactions.

Codes: experi enclos reach quant sppinter popdyn

Harvey, B. C., and R. J. Nakamoto. 1997. Habitat-dependent interactions between two size-classes of juvenile steelhead in a small stream. Canadian Journal of Fisheries and Aquatic Sciences 54: 27-31.

The presence of small steelhead (Oncorhynchus mykiss; averaging 55 mm fork length) influenced the growth of larger juvenile steelhead (90 mm fork length) during a 6-week experiment conducted in North Fork Caspar Creek, California, in summer 1994. In fenced replicate deep stream sections in this small stream, growth of the larger steelhead was greater in treatments in which small steelhead constituted half of the total biomass of fish than in treatments with an equal biomass comprised entirely of larger fish. In shallow habitats, growth of larger fish was lower in the presence of small fish. The growth of small fish was unaffected by the presence of larger juveniles and also was independent of habitat. Survival of both size-classes was high (70-90%) and unrelated to habitat or the presence of the other size-class. The advantage of large body size in intraspecific interactions among steelhead does not exist in all types of habitat, and interactions between the two size-classes may contribute to lower abundance of large juveniles in streams where aggradation reduces water depth.

Codes: experi enclos reach quant sppinter popdyn instream

Haury, J., and J. L. Bagliniere. 1996. Macrophytes as structuring component for fish habitat in a salmonid river. A study of fish microrepartition in a macrophyte site in the River Scorff (southern Brittany). Cybium. Paris 20: 111-127.

A review of the ecological functions of the macrophytes in the Armorican rivers is presented along with unpublished data, within a multi-compartment framework. Macrophytes have a fair cover (>80% of the river bed) in salmonid rivers of the Armorican Massif. At the river network scale, macrophytes show a longitudinal zonation, and they can be used as physical bio-indicators. At a local scale, macrophytes present patches into the river bed, belts on, or close to, the banks, and a multi-layer composition involving various eco-morphological types. The seasonal variability of macrophyte cover is important, from 9 to 95% of river bed. In summer, the mean biomass of macrophytes is about 160g of dry matter per m2. The main hydrodynamical effects of macrophytes are modifications of current velocity and trapping of fine particles. General interactions with fish are presented comparing plant and fish cycles, and showed the prominence of indirect effects on fish community. A study of fish microdistribution within a heavily covered stretch of the River Scorff is presented. In late June and close September, the vegetation maps showed the spatial and seasonal variability of macrophytes. In June, one of the seven physically homogeneous habitats had a 100% cover by Ranunculus penicillatus and mainly had scarce Planer's lampreys (Lampreta planeri). Young salmons (Salmo salar) avoided macrophytes and other shelters: they standed in open current areas. Trouts (Salmo trutta), specially the oldest ones, were located closer to shelters due either to macrophytes or shaded banks. Eels (Anguilla anguilla) and pikes (Esox lucius) used the same biotopes, with slow waters and bank shelters. Lampreys (Lampetra planeri) stayed in plant shelters, specially close to banks where fine

sediments were deposited. Minnows (Phoxinus phoxinus) were caught in open water, not far from shelters. Stone-loaches (Nemacheilus barbatula) and bullheads (Cottus gobio) were found in coarse bed substratum. This study concluded to negative effects of large macrophyte cover upon the distribution and density in most fish species.

Codes: multi qual microhab instream

Haury, J., J. L. Bagliniere, A. I. Cassou, and G. Maisse. 1995. Analysis of spatial and temporal organization in a salmonid brook in relation to physical factors and macrophytic vegetation. HYDROBIOLOGIA

Codes: reach quant? instream

Hawkins, C. P., M. L. Murphy, N. H. Anderson, and M. A. Wilzbach. 1983. Density of fish and salamanders in relation to riparian canopy and physical habitat in streams of the northwestern United States. Canadian Journal of Fisheries and Aquatic Sciences 40: 1173-1185.

Relationships between density of fish and salamanders, riparian canopy, and physical habitat were investigated by studying 10 pairs of streams. Among vertebrate taxa, salmonids and sculpins were more abundant in streams without riparian shading than in shaded streams. Abundance of salamanders was not affected by canopy type. Densities of both salamanders and sculpins were correlated with substrate composition, whereas salmonid abundance was not or only weakly so. Salamanders were found only at high-gradient sites with coarse substrates, and sculpins were most abundant at lower-gradient sites with finer-sized sediments. An interaction was observed between the influence of canopy and that of physical setting on density of both invertebrate prey and total vertebrates.

Codes: multi reach quant ripar substrate instream

Hayes, J. W. 1995. Spatial and temporal variation in the relative density and size of juvenile brown trout in the Kakanui River, North Otago, New Zealand. New Zealand Journal of Marine and Freshwater Research 29: 393-407.

Spatial and temporal variation in relative density of 0+ and 1+ brown trout (Salmo trutta) was examined over three summers in the Kakanui River, North Otago, New Zealand. Both 0+ and 1+ trout were distributed throughout the river. Spatial variation in relative density was much higher than annual variation. Within years, relative density of 0+ brown trout varied by 5 to 92 times between sites (mean coefficient of variation, CV = 1.08) and of 1+ trout by 18 to 84 times between sites (CV = 1.13). Mean relative density of 0+ brown trout varied by 1.5 to 2.0 times between years (CV = 0.35) and of 1+ trout by 3.6 to 23.2 times between years (CV = 0.96). The pattern of 0+ trout spatial distribution was not closely related to the distribution of redds (which also were distributed throughout the river) and not related to the distribution of benthic invertebrate food. By their second summer, most trout occupied the middle and lower reaches of the river. Mean length of both 0+ and 1+ trout increased with distance downstream. Floods greater than 290 m super(3) s super(-1), and with a return period of 4 years, during the late incubation and early fry stages (August-November) were associated with impaired recruitment, yet a large flood (816 m super(3) s super(-1)) in March 1994 had no apparent effect on the survival of 0+ trout 80-100 mm in length.

Codes: reach quant hydro trophic temporal noenv

Hearn, W. E., and B. E. Kynard. 1986. Habitat utilization and behavioral interaction of juvenile Atlantic salmon (Salmo salar) and rainbow trout (S. gairdneri) in tributaries of the White River of Vermont. Canadian Journal of Fisheries and Aquatic Sciences 43: 1988-1998.

Competition for space between stocked juvenile Atlantic salmon, Salmo salar, and wild juvenile rainbow trout, S. gairdneri, was examined in stream channel experiments, a field experiment, and in field habitat surveys. In stream

channels providing riffle and pool habitats, species differed in their distribution both as underyearlings (0+) and as yearlings (1+). Yearling salmon occurred more often in stream channel riffles during trials with 1+ rainbow trout than during trials testing only salmon. In a field experiment conducted to determine if the stocking of 0+ Atlantic salmon causes the displacement of resident 0+ rainbow trout, salmon fry were stocked at a density of 85 per 100 m super(2). The authors found no evidence of competition between cohorts of underyearlings; however, the niche shift by 1+ salmon in the stream channels suggested that, at times, juveniles of these species will compete for space.

Codes: experi reach habitat quant sppinter

Heggenes, J. 1988. Effect of experimentally increased intraspecific competition on sedentary adult brown trout (Salmo trutta) movement and stream habitat choice. Canadian Journal of Fisheries and Aquatic Sciences 45: 1163-1172.

Movements and habitat choice of 19 brown trout (Salmo trutta) resident in a stream was monitored during one season, while in the next season the population was increased by introducing 130 wild brown trout captured further downstream. No differences in the movement patterns of resident trout at the two population densities, or of residents compared with nonresidents, were found. Median movement distance was 0 m. Sixty-six percent of the movements were less than plus or minus 50 m, 11% were between 50 and 100 m, and 23% were greater than plus or minus 100 m. Introduced nonresident trout occupied habitats different from those occupied by residents. Nonresidents were more often observed in shallower areas with less cover and finer substrate, i.e. less preferred habitats.

Codes: habitat migrat instream

Heggenes, J. 1988. Physical Habitat Selection by Brown Trout (Salmo trutta) in Riverine Systems. Nordic Journal of Freshwater Research 64: 74-90.

Knowledge about habitat requirements of brown trout (Salmo trutta) is important for stream management and impact assessment. The method of observation may influence the habitat suitability results obtained. The best approach may be to adopt a combination of direct underwater observation and electrofishing, if a variety of habitat conditions are studied. A distinction should be made between physical habitat variables affecting in situ habitat choice and habitat variables affecting carrying capacity, such as, boundary conditions, because their spatio-temporal dimensions are different. Water depth, water velocity, streambed substrate and cover seem to be the most important physical stream characteristics influencing in situ habitat choice by brown trout. Preferred habitat is positively correlated with fish size. Smaller brown trout occupy shallow riffle areas with cobble substrate, while the larger fish prefer deeper stream areas with cobble/boulder substrate and abundant cover. All sizes of fish seek out low water velocity micro-niches to minimize energy expenditure. Different studies emphasize the importance of different habitat variables. This is probably a reflection of the diverse factors modifying habitat selection. Total available habitat should be quantified in all habitat analysis studies, because availability can modify habitat choice strongly. Different habitat characteristics may be the limiting factors in different streams and true habitat preferences cannot therefore be constructed from habitat use data alone. Furthermore, habitat selection may be modified by biological factors such as fish population density and composition, food supply and presence of other species. In addition greater attention should be given to the possible interactions between physical habitat variables. (Author 's abstract).

Codes: review habitat microhab substrate instream

Heggenes, J. 1996. Habitat selection by brown trout (Salmo trutta) and young Atlantic salmon (S. salar) in streams: static and dynamic hydraulic modelling. Regulated Rivers Research & Management 12: 155-169.

Brown trout (Salmo trutta) and young Atlantic salmon (S. salar) in streams are selective in their habitat use, which is partially determined by hydro-physical conditions. Habitat selection may be quantified in models and combined with hydraulic models to evaluate instream habitat suitability. Fish occupancy of habitat depends on the fish species

and size. Brown trout prefer deep stream areas with moderate to low water velocities and rocky substrates, whereas young Atlantic salmon chose more fast flowing and often shallower areas. Habitat selection has been quantified in static selection models which should be based on measures of habitat usage and availability (preferences) and combined with data on hydro-physical conditions to build predictive habitat models. Such models assess habitat availability and capacity rather than discharge-biomass relationships. Limitations of static models in fish habitat studies are (1) the relevant hydrophysical variables are not included, (2) the interaction terms are difficult to quantify and not incorporated, (3) the hydraulic models may not operate on a spatial scale that is relevant to fish, (4) the models include spatial but only to a limited extent temporal heterogeneity in habitat conditions and (5) biotic factors are not included. Streams may be extremely heterogeneous ecosystems, both spatially and temporally, which may influence habitat selection and modelling. In response to varying habitat availabilities (stream size and structure, water flows) habitat selection in brown trout and young Atlantic salmon is dynamic and relatively flexible. Furthermore, changes in temperature may result in seasonal and daily niche shifts. Therefore unless the dynamic aspects of habitat selection are incorporated into the habitat models, long-term predictive power in habitat-hydraulic modelling is unlikely. However, habitat-hydraulic modelling is useful tool in a 'no net loss of habitat' management strategy regardless of these shortcomings.

Codes: review modeling microhab habitat hydro ifim warning hem

Heggenes, J., J. L. Bagliniere, and R. A. Cunjak. 1999. Spatial niche variability for young Atlantic salmon (Salmo salar) and brown trout (S. trutta) in heterogeneous streams. Ecology of Freshwater Fish [Ecol. Freshwat. Fish] 8: 1-21.

Habitat is important in determining stream carrying capacity and population density in young Atlantic salmon and brown trout. We review stream habitat selection studies and relate results to variable and interacting abiotic and biotic factors. The importance of spatial and temporal scales are often overlooked. Different physical variables may influence fish position choice at different spatial scales. Temporally variable water flows and temperatures are pervasive environmental factors in streams that affect behavior and habitat selection. The more frequently measured abiotic variables are water depth, water velocity (or stream gradient), substrate particle size, and cover. Summer daytime, feeding habitats of Atlantic salmon are size structured. Larger parr (>7 cm) have a wider spatial niche than small parr. Selected snout water velocities are consistently low (3-25 cm times s super(-1)). Mean (or surface) water velocities are in the preferred range of 30-50 cm times s super(-1), and usually in combination with coarse substratum (16-256 mm). However, salmon parr demonstrate flexibility with respect to preferred water velocity, depending on fish size, intra- and interspecific competition, and predation risk. Water depth is less important, except in small streams. Summer daytime, feeding habitat of brown trout is also characterized by a narrow selection of low snout water velocities. Habitat use is size-structured, which appears to be mainly a result of intraspecific competition. Water depth is considered the most important habitat variable for brown trout. Spatial niche overlap is considerable where the two species are sympatric. Habitat use by salmon is restricted through interspecific competition with the more aggressive brown trout (interactive segregation). However, subtle innate differences in behavior at an early stage also indicate selective segregation. Seasonal changes in habitat use related to water temperatures occur in both species. While active at night, the fish move to more exposed holding positions primarily on but also above the substrate. Diurnal changes in habitat use take place also in summer.

Codes: review microhab habitat qual sppinter wtemp hydro

Heggenes, J., T. G. Northcote, and A. Peter. 1991. Spatial stability of cutthroat trout (Oncorhynchus clarki) in a small, coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 48: 757-762.

Spatial stability and local movement of a cutthroat trout (Oncorhynchus clarki) population were studied from winter to late summer in a small, coastal stream. The majority of the population was static and resided within a home range < 22 m super(2), while a small fraction of the fish apparently was more mobile. Local movement was very restricted; 32.4% of the individually marked cutthroat were recaptured within 1 m of their original capture and marking site, and 48% remained within 3 m of that site. Only 17.9% of the fish moved more than 50 m. This behaviour was stable during winter, spring, and summer and may be of adaptive significance. Fish occupying pool

areas moved considerably less than fish occupying shallow habitats, indicating that pool dwellers were dominant fish.

Codes: reach migrat qual instream

Heggenes, J., and S. J. Saltveit. 1990. Seasonal and spatial microhabitat selection and segregation in young Atlantic salmon, Salmo salar L., and brown trout, Salmo trutta L., in a Norwegian river. Journal of Fish Biology 36: 707-720.

Seasonal microhabitat selection by sympatric young Atlantic salmon and brown trout was studied by diving. Both species, especially Atlantic salmon, showed seasonal variation with respect to surface and mean water velocities and depth. This variation is partly attributed to varying water flows and water temperatures. In winter the fish sought shelter in the substratum. A spatial variation in habitat use along the river due to different habitat availabilities was observed. Both species occupied habitats within the ranges of the microhabitat variables, rather than selecting narrow optima. It is hypothesized that the genetic basis allows a certain range to the behavioural response. Microhabitat segregation between the two species was pronounced, with brown trout inhabiting the more slow-flowing and partly more shallow stream areas. Atlantic salmon tolerated a wider range of water velocities and depths. Habitat suitability curves were produced from both species. It is suggested that habitat suitability curves that are based on observations of fish occupancy of habitat at median or base flow may not be suitable in habitat simulation models, where available habitat is projected at substantially greater water flows.

Codes: microhab qual sppinter instream ifim warning hem

Heifetz, J., M. L. Murphy, and K. V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North American Journal of Fisheries Management 6: 52-58.

Effects of logging on preferred winter habitats of juvenile salmonids in southeastern Alaskan streams were assessed by comparing the area of preferred winter habitat in 54 reaches of 18 streams. Three types of streams were sampled at each of six locations: a stream in a mature, undisturbed forest; a stream in a clear-cut area but logged on at least one bank; and a stream in a clear-cut area with strips of forest (buffer strips) along the stream bank. To identify preferred winter habitats, we classified stream areas in 12 of 18 streams into discrete habitat types and compared the density of salmonids within these habitat types with average density of the entire reach. Most wintering coho salmon (Oncorhynchus kisutch), Dolly Varden (Salvelinus malma), and steelhead (Salmo gairdneri) occupied deep pools with cover (i.e., upturned tree roots, accumulations of logs, and cobble substrate). Riffles, glides, and pools without cover were not used. Seventy-three percent of all pools were formed by large organic debris. Reaches in clear-cut areas without buffer strips had significantly less area of pool habitat than old-growth reaches. Buffer strips protected winter habitat of juvenile salmonids by maintaining pool area and cover within pools. In some cases blowdown from buffer strips added large organic debris to the stream and increased the cover within pools.

Codes: multi habitat reach qual? instream lwd substrate ripar

Herger, L. G., W. A. Hubert, and M. K. Young. 1996. Comparison of habitat composition and cutthroat trout abundance at two flows in small mountain streams. North American Journal of Fisheries Management 16: 294-301.

We assessed habitat features measured in the recently developed basinwide habitat inventory for their relations to abundance of native cutthroat trout Oncorhynchus clarki in small streams of the Rocky Mountains. We also evaluated the manner in which habitat and fish abundance changed as streamflow declined during the summer sampling season. Our observations corroborated the assumption that the basinwide habitat inventory is a valid technique for identifying channel unit types with differing levels of use by cutthroat trout. We found higher biomass of cutthroat trout in pools than in glides or riffles. Plunge pools and higher biomass than dammed pools. Biomass was greater in low-gradient riffles than in rapids, and no fish were found in cascades. We observed an increase in

the abundance of channel unit types, changes in the physical dimensions of channel unit types, and a decrease in overall stream length with declines in flow. We concluded that the basinwide habitat inventory does identify habitat features affecting the abundance of cutthroat trout, but variation in flow during summer changes the relative abundance and physical features of habitat units. Comparisons of basinwide inventories among years within a specific watershed may be affected by differences in discharge, so inventories should be conducted at similar discharges to enable meaningful assessment of possible changes in habitat.

Codes: multi habitat quant instream hydro

Hesthagen, T., J. Heggenes, B. M. Larsen, H. M. Berger, and T. Forseth. 1999. Effects of water chemistry and habitat on the density of young brown trout Salmo trutta in acidic streams. Water, Air, & Soil Pollution [Water, Air, Soil Pollut.] 112: 85-106.

We examined the relationship between young brown trout (Salmo trutta) density in lake tributaries, and water chemistry and habitat variables. The study was carried out during the autumn in three acidic, softwater river systems in western and southwestern Norway; Gaular and Vikedal (1987-1993) and Bjerkreim (1988-1993). The streams had mean calcium concentrations of 0.35 mg L super(-1) (Gaular), 0.52 mg L super(-1) (Vikedal) and 0.84 mg L super(-1) (Bjerkreim). The concentration of inorganic Al was generally low, with mean values of 8.40 (Gaular), 22.22 (Vikedal) and 43.36 mu g L super(-1) (Bjerkreim). In multiple regressions that involved different water chemistry variables, brown trout density correlated best with calcium concentration and with a combination of calcium and pH; the Ca super(2+):H super(+) ratio. In Vikedal and Gaular, calcium explained 51 and 57%, respectively, of the variability in brown trout densities. Althoug alkalinity exhibited the best correlation with brown trout density in Bjerkreim (r super(2)=0.33), it was similar to that of the model that included all major ions plus pH. The Ca super(2+):H super(+) ratio had a larger effect for variability in brown trout density in Gaular (r super(2)=0.66) than calcium alone. In Vikedal and Bjerkreim, the Ca super(2+):H super(+) ratio also correlated with brown trout density, but considerably less than in Gaular. The predictive power of habitat variables was much lower than that of water chemistry; the single most important factors were altitude in Gaular (r super(2)=0.22), mean water temperature in Vikedal (r super(2)=0.11) and depth SD (index of heterogeneity) in Bjerkreim (r super(2)=0.07). Models that included both habitat and water chemistry variables showed that the density of young brown trout was predicted primarily by calcium concentrations in Gaular (r super(2)=0.75) and Vikedal (r super(2)=0.54), as opposed to pH in Bjerkreim (r super(2)=0.25). Habitat had low effect in all three river systems (r super(2)=0.01-0.04). The final model explained 86, 68 and 32%, respectively, of the variability in brown trout density in the three catchments. Thus, water chemistry variables seem to be factors that limit the density of young brown trout in acidic softwater streams.

Codes: multi reach quant watqual instream warning wtemp

Hetrick, N. J., M. A. Brusven, T. C. Bjornn, R. M. Keith, and W. R. Meehan. 1998. Effects of canopy removal on invertebrates and diet of juvenile coho salmon in a small stream in southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 876-888.

We assessed changes in availability and consumption of invertebrates by juvenile coho salmon Oncorhynchus kisutch in a small stream in southeast Alaska where patches of dense second-growth riparian vegetation bordering the stream had been removed. Benthic invertebrate populations were assessed during summer 1988 and 1989 with a Hess sampler. Aerial invertebrates were sampled during summer 1989 with wire-mesh sticky traps hung just above the water surface and with floating clear-plastic pan traps. Invertebrate drift was assessed during summer 1989 with nets placed at the downstream end of closed- and open-canopy stream sections. Diets of age-0 and age-1 coho salmon were sampled by flushing stomach contents of fish collected from closed- and open-canopy stream sections. Abundance and biomass of benthic invertebrates were larger in open- than in closed-canopy stream sections and were primarily dipterans, ephemeropterans, and plecopterans. More insects were caught on sticky traps in open than

in closed sections on two of four dates sampled, and composition of the catch was primarily dipterans (74% in both closed- and open-canopy sections).

Codes: experi reach qual ripar trophic

Hetrick, N. J., M. A. Brusven, W. R. Meehan, and T. C. Bjornn. 1998. Changes in Solar Input, Water Temperature, Periphyton Accumulation, and Allochthonous Input and Storage after Canopy Removal along Two Small Salmon Streams in Southeast Alaska. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 859-875.

Changes in solar radiation, water temperature, periphyton accumulation, and allochthonous inputs and storage were measured after we removed patches of deciduous, second-growth riparian vegetation bordering two small streams in southeast Alaska that produce coho salmon Oncorhynchus kisutch. Solar radiation and leaf litter input were measured at the water surface at random locations dispersed through six alternating closed- and open-canopy stream sections. Water temperature, periphyton, and stored organic samples were collected near the downstream end of each section. Solar radiation intensity was measured with digital daylight integrators and pyronometers, periphyton biomass and chlorophyll a were measured on red clay tile substrates, allochthonous input was measured with leaf litter baskets, and benthic organic matter was measured with a Hess sampler. Average intensity of solar radiation that reached the water surface of open-canopy sections was significantly higher than in closed-canopy sections of two streams measured during daylight hours in summer 1988 and of one stream measured day and night in summer 1989.

Codes: experi multi nofish ripar wtemp trophic

Hicks, B. J. 1990. The influence of geology and timber harvest on channel morphology and salmonid populations in Oregon Coast Range streams. Dissertation Dissertation, Oregon State University.

Geology influences mainstem channel morphology in streams of about 1500 ha basin area in the Oregon Coast Range. Habitat availability and salmonid populations were surveyed in 3 km of main channel in each of five streams in basalt and five streams in sandstone. Differences in channel morphology were related to channel gradient (measured from topographic maps). Streams in basalt had a mean gradient of 2.5 plus or minus 0.6% (mean plus or minus 95% confidence limits), compared to 1.2 plus or minus 0.5% for streams in sandstone with the same basin area. The streams in sandstone had greater mean frequency of pools (28 pools per kilometer) than the streams in basalt (18 pools per kilometer, Mann-Whitney U test, $p = 0.016$). Mean frequency of glides (17 and 19 glides per kilometer) and riffles (26 and 23 riffles per kilometer) in streams in basalt and sandstone was not different (Mann-Whitney U test, $p > 0.15$). However, riffles were almost twice as long in streams in basalt (14.6 m, geometric mean length) as in sandstone (7.7 m), and this difference in length was significant (Mann-Whitney U test, $p = 0.008$). Salmonid populations in streams in different rock types reflected the relative habitat availability. Streams in basalt were dominated by steelhead (Oncorhynchus mykiss), and cutthroat trout (Oncorhynchus clarki). In contrast, streams in sandstone were dominated by coho salmon (Oncorhynchus kisatch). Age 0 coho salmon, and age 1 and older steelhead, resident rainbow trout, and cutthroat trout occupied pools more than glides or riffles. Age 0 steelhead and trout occupied pools, glides, and riffles about equally, except that pools in sandstone and riffles in basalt were slightly avoided. Mean densities of salmonids in streams in sandstone were greater than those in basalt. Salmonid biomass in basalt and in sandstone, however, was similar because fish of the same species and age class were larger in streams in basalt than in sandstone, and there were also more age 1 and older fish in streams in basalt. Timber harvest did not influence channel morphology significantly, except that the number of pools associated with large woody debris declined with increasing timber harvest. Streamflows in summer were generally much greater in basalt than in sandstone, though differences in rainfall influenced these streamflow differences. Coastal streams generally had higher flows than those further inland, but a stream in basalt had a higher base flow than streams in sandstone with similar summer climates. Timber harvest appeared to influence low flows in streams in sandstone.

Apparent survival of age 0 trout was related to summer low flows in streams in sandstone, and these flows were inversely related to amount of timber harvest. (DBO).

Codes: multi reach quant instream ripar lulc

Hicks, B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat changes. Pages 484-518. 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.

Codes: review multi reach quant lulc instream temporal

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. Summer and winter habitat selection by juvenile chinook salmon ina highly sedimented Idaho stream. Transactions of the American Fisheries Society 16: 185-195.

Summer and winter habitat utilized by age-0 spring chinook salmon Oncorhynchus tshawytscha was assessed in the Red River, an Idaho stream heavily embedded with fine sediment. During summer 1985, chinook salmon used habitats with water velocities less than 20 cm/s, depths of 20-80 cm, and close associations with cover (undercut banks). Densities were greater than 60 fish/100 m super(2). As the fish became larger they selected faster, deeper water. Eighty percent of the chinook salmon emigrated from the study sites in October when stream temperatures were 4-8 degree C, apparently because suitable winter habitat was not available.

Codes: habitat quant instream

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (Oncorhynchus kisutch). CJFAS 45: 502-515.

#cited in Hicks et al. 1991, p.501-2 regarding high survival in floodplains. #

Codes: quant popdyn basin wtemp lulc offchann temporal

Holtby, L. B., and J. C. Scrivener. 1989. Observed and simulated effects of climatic variability, clear-cut logging and fishing on the numbers of chum salmon (Oncorhynchus keta) and coho salmon (O. kisutch) returning to Carnation Creek, British Columbia. Edited by C. D. Levings, L. B. Holtby and M. A. Henderson, 62-81 p.

The population dynamics of coho and chum salmon have been studied at Carnation Creek since 1970 as part of a multi-disciplinary study of the effects of logging on a small salmon stream in a coastal rainforest. The authors have developed models that predict the numbers of chum and coho salmon from correlative relationships between survival and growth at various life stages and (1) climatic, hydrologic and physical variables, (2) indices of those features of the stream habitat that were affected by logging and, (3) exploitation rates in the fishery. The authors suggest that overall variability in the salmon abundance will tend to increase in the wake of land-use activities, particularly when accompanied by high levels of exploitation and adverse environmental conditions.

Codes: modeling reach quant hydro ripar lulc temporal

Horan, D. L., J. L. Kershner, C. P. Hawkins, and T. A. Crowl. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta Mountain streams. Transactions of the American Fisheries Society 129: 1250-1263.

Habitat degradation has reduced the complexity and connectivity of streams on the north slope of the Uinta Mountains in northeastern Utah. These changes have diminished the historical range of Colorado River cutthroat trout Oncorhynchus clarki pleuriticus, isolated the populations of this subspecies, and perhaps increased its risk of extinction. We assessed the effects of fragment area and habitat complexity on Colorado River cutthroat trout density. We studied 88 reaches in 4 isolated stream fragments. At the fragment scale, both the density of adults and habitat complexity increased significantly as fragment size increased. In the smaller fragments, the density of adults was lower while that of juveniles was higher. Habitat differed substantially among fragments. At the reach scale, the density of adults was positively related to elevation, the percentage of undercut banks, and mean substrate particle size and negatively related to residual pool depth and the extent of large woody debris. The density of juveniles was positively related to the extent of large woody debris and negatively related to residual pool depth and stream width. The habitat complexity index was weakly related to adult density at the reach scale. We were not able to distinguish the influence of habitat area or complexity on the density of adults, but a population living in an isolated stream fragment with low habitat complexity probably requires more area to persist than a population of the same size living in a highly complex habitat.

Codes: multi reach segment quant instream lwd substrate

House, R. 1995. Temporal variation in abundance of an isolated population of cutthroat trout in western Oregon, 1981-1991. North American Journal of Fisheries Management 15: 33-41.

The magnitude of variation in an isolated population of wild coastal cutthroat trout Oncorhynchus clarki clarki is described for an 11-year study period during which conditions in a Cascade Mountain drainage in western Oregon were relatively stable. Dead Horse Canyon Creek watershed, which drains 1,376 ha in the upper Molalla River, experienced no storm events or disturbances of riparian habitat that caused major changes in channel configuration. Cutthroat trout populations in Dead Horse Canyon Creek varied from year to year, while habitat conditions remained constant, which thereby complicated any analyses of the independent effects of land management activities on the population. The cutthroat trout population fluctuated substantially fish the least. Because most of the habitat models used to predict changes in trout populations do not incorporate natural variations in populations under similar habitat conditions, measuring the impact of land management activities by short-term studies may result in erroneous conclusions. Based on Dead Horse Canyon Creek monitoring, models that obtain data by separating habitat types and that consider only older age-classes of trout may be the most accurate in predicting changes in population levels.

Codes: reach quant ripar instream temporal warning

House, R. 1996. An evaluation of stream restoration structures in coastal Oregon stream, 1981-1993. North American Journal of Fisheries Management 16: 272-281.

A 1.7-km reach of East Fork Lobster Creek, an Oregon coastal tributary of the Alsea River, was treated with mostly full-spanning, rock-filled gabions in 1981 and boulder structures in 1987. East Fork Lobster Creek (EFLC) supports runs of coho salmon Oncorhynchus kisutch and fall chinook salmon O. tshawytscha winter steelhead O. mykiss, and sea-run and resident cutthroat trout O. clarki. The main objective of treatment was to improve spawning and summer rearing habitat for coho salmon, habitat determined to be lacking during 1980 surveys. Freshets in the winter of 1981-1982 filled all gabion structures with large gravel; the surface area of pool and low-gradient riffle habitat increased but area of high-gradient riffle habitat decrease. From 1985 through 1993, the average number of coho salmon spawners in EFLC increased 2.5 times compared with returns during 1981-1984. In EFLC, treated areas supported significantly more juvenile coho salmon and cutthroat trout and had higher overall salmonid biomass than control areas, whereas age-0 trout (cutthroat trout plus steelhead) and juvenile steelhead showed no increases. For the entire 1.7-km reach receiving treatment, the number of coho salmon juveniles was higher after

than before treatment, whereas numbers of steelhead and cutthroat trout fry and juveniles remained constant. Between 1981 and 1992, over 50% of the coho salmon and steelhead spawned on newly deposited, higher-quality gravels associated with 15 gabion structures that fully spanned the bank-full channel width. Quality of gravels impounded by gabions equaled or exceeded the quality of gravels in unmodified areas of the creek. Habitats, primarily pools, created by gabion structures lasted 10 years; however, disintegration of wire mesh tops starting in 1989 caused a slow reduction in pool habitat and gravel riffles at treated sites. All boulder structures remained functional in 1992. Results of this study provide some evidence that interim instream restoration to improve degraded streams and increase salmonid stocks at risk of extinction can be used until long-term watershed restoration strategies have been implemented.

Codes: experi reach instream substrate temporal

House, R. A., and P. L. Boehne. 1985. Evaluation of instream enhancement structures for salmonid spawning and rearing in a coastal Oregon stream. North American Journal of Fisheries Management 5: 283-295.

East Fork Lobster Creek, Oregon is an example of a stream that lost much of its productivity as an anadromous salmonid stream following logging activities, intensive stream cleaning, and flooding. The stream in the study area was almost devoid of instream structures, resulting in a nearly total lack of spawning gravel and rearing habitat. Stream enhancement structures installed in East Fork Lobster Creek were successful and functional after two winters with usual freshets. The structures dramatically increased the diversity of the stream bed, trapped gravel, and created shallow gravel bars and deep, covered pools. Also, the number, size, and quality of the pools increased in areas with structures. Coho salmon (Oncorhynchus kisutch) and steelhead (Salmo gairdneri) spawning increased substantially, as well as the numbers of rearing coho, steelhead fry, and steelhead and cutthroat trout (Salmo clarki) parr. this study shows that similar degraded streams can be rehabilitated by properly designed enhancement programs. Such programs are effective and are needed to help ensure the protection of naturally spawning and rearing wild salmonid stocks and the survival of their young.

Codes: experi reach qual? instream substrate

House, R. A., and P. L. Boehne. 1986. Effects of instream structures on salmonid habitat and populations in Tobe Creek, Oregon. North American Journal of Fisheries Management 6: 38-46.

Tobe Creek, Oregon, was studied in 1982 and 1983 to compare physical and biological differences between a young-alder stream section logged and cleaned of large debris 20 years ago and a mature mixed-conifer section unlogged and containing large amounts of large woody debris. Stream enhancement techniques were used in 1982 to simulate large woody debris in the logged alder section to try to increase salmonid use. Large woody debris in the channel caused the development of secondary channels, meanders, pools, and undercut banks in the unlogged, mature-conifers, stream section. These elements were noticeably missing in the young-alder section. The mature-conifer section had more than twice as many pools and 10 times the amount of spawning gravel compared to the young-alder section. Salmonid biomass was significantly greater in the mature-conifer than the young-alder section prior to stream enhancement; after enhancement, no significant difference was found. Prior to enhancement, three times as many coho salmon (Oncorhynchus kisutch) and trout fry (cutthroat trout and steelhead) were living in the mature-conifer stream section. There was a positive correlation between coho salmon numbers and the presence of large woody debris. The study revealed that structure is most likely a more important factor than shade in governing a stream's capacity for producing salmonids.

Codes: experi reach quant ripar lwd instream

Howard-Williams, C., and S. Pickmere. 1999. Nutrient and vegetation changes in a retired pasture stream. Recent monitoring in the context of a long-term dataset. Science for Conservation [Sci. Conserv.] 5-34.

This report records water quality and vegetation changes in the Whangamata Stream, Lake Taupo catchment from 1995 to 1998. The data represent the latest three years of a 24-year study on changes to this pasture stream since riparian strips were established in 1976, to retire the margins of the stream from pastoral farming. This data set is unique in New Zealand for its continuity and allows a quantitative assessment of the extent and time scales of change in rehabilitation programmes of this nature. The process of rehabilitation of the stream was assisted by some plantings of native species among the pasture-grassed banks. During this three-year study period, the number of vascular plant species recorded in the stream and along the banks has increased from 119 to 148. Native plants made up 41% of the total. Woody species are invading the flax-dominated stream banks. The reaches of the stream which had the original plantings (c. 1976) have the highest number of species. The old pasture has proved very resistant to invasion and in many areas where assisted plantings have not occurred, extensive areas of rank grass comprising the original pasture species are still intact. The ability of the stream bank and channel flora to remove nutrients from the stream has been reduced over this three-year monitoring period, with nitrate and dissolved reactive phosphorus uptake in mid-summer now less than 15% of the mass flow of these nutrients. This compares with c. 90% removal in the mid-1980s. Total suspended solids show a strongly seasonal pattern with values increasing in winter and decreasing to low values (<5 g m super(-3)) in summer. A similar pattern was recorded in the late 1970s and early 1980s. The winter maximum TSS concentration in 1996 was very high (c. 70 g m super(-3)) coinciding with the Ruapehu eruption which blanketed much of the catchment in ash. The stream channel was essentially clear of the plant blockages which were a feature of the 1980s and early 1990s. The water flowed unimpeded below a dense cover of flax and toetoe, allowing easy access for spawning trout to the upper reaches of the stream. Fernbird, fantails, bellbird, pukeko were observed. The stream is now an increasingly important wildlife area. The role of the protected riparian strips has therefore changed over the years from a sediment and nutrient trapping mechanism to sediment control, with greatly enhanced wildlife values.

Codes: experi reach temporal nofish ripar graz substrate

Hubert, W. A., and S. J. Kozel. 1989. Testing of Habitat Assessment Models for Small Trout Streams in the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 9: 458-464.

The applicability of four habitat assessment models to small trout streams in the Medicine Bow National Forest were tested. All models yielded predictions of trout standing stocks or ratings of trout cover that were correlated with measured trout standing stocks; however, the predicted and measured standing stocks were not directly proportional, and not all model variables appeared to contribute to the predictions or ratings derived from the models. Among the habitat variables included in the four models, those most highly correlated with trout standing stocks were width-to-depth ratio, abundance of overhead bank cover, average stream width, and level of late-summer streamflow. It is hypothesized that much of the variation in measured habitat and model predictions among the study reaches was due to natural variation in habitat features associated with stream size and reach gradient. (Sand-PTT).

Codes: modeling reach habitat quant instream ifim warning hem

Hubert, W. A., R. P. Lanka, T. A. Wesche, F. Stabler, R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Grazing management influences on two brook trout streams in Wyoming. Pages 290-294. In Riparian ecosystems and their management : reconciling conflicting uses. R. R. Johnson, editors. USDA Forest Service general technical report RM, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Dept. of Agriculture, Fort Collins, CO.

Brook trout (Salvelinus fontinalis) abundance and instream habitat characteristics were evaluated in two rangeland streams. Heavily grazed and lightly grazed reaches of two streams with different grazing management were

compared. Relationships between stream morphology, riparian zone characteristics, and trout abundance were observed.

Codes: reach experi multi graz ripar instream quant

Hubert, W. A., T. D. Marwitz, K. G. Gerow, N. A. Binns, and R. W. Wiley. 1996. Estimation of potential maximum biomass of trout in Wyoming streams to assist management decisions. North American Journal of Fisheries Management 16: 821-829.

Fishery managers can benefit from knowledge of the potential maximum biomass (PMB) of trout in streams when making decisions on the allocation of resources to improve fisheries. Resources are most likely to be expended on streams with high PMB and with large differences between PMB and currently measured biomass. We developed and tested a model that uses four easily measured habitat variables to estimate PMB (upper 90th percentile of predicted mean biomass) of trout (Oncorhynchus spp., Salmo trutta, and Salvelinus fontinalis) in Wyoming streams. The habitat variables were proportion of cover, elevation, wetted width, and channel gradient. The PMB model was constructed from data on 166 stream reaches throughout Wyoming and validated on an independent data set of 50 stream reaches. Prediction of PMB in combination with estimation of current biomass and information on habitat quality can provide managers with insight into the extent to which management actions may enhance trout biomass.

Codes: multi reach quant instream

Hughes, N. F. 1998. A model of habitat selection by drift-feeding stream salmonids at different scales. Ecology 79: 281-294.

Whole-stream size gradients of drift-feeding stream salmonids have received practically no attention, perhaps because the smaller-fish-upstream pattern that is thought to prevail is consistent with knowledge of habitat selection by other stream fish at the local scale. However, a rather counterintuitive larger-fish-upstream pattern has recently been documented for Arctic grayling (Thymallus arcticus) in Alaska and brown trout (Salmo trutta) in New Zealand, and habitat selection theory cannot explain these observations. My goal in this paper is to improve this situation by developing a model that predicts the distribution of a population of fish both within single pools and over the length of the entire river, as well as the behavioral mechanism responsible. The model uses information on invertebrate drift density and water temperature to predict the growth rate of different sizes of fish at the positions available in the stream. Fish then distribute themselves so that each individual occupies the most profitable position it can defend, with the largest fish winning any disputes. The model suggests that streams can be classified into categories based on the way temperature and drift density vary with the passage downstream. Each of these categories favors a different combination of size gradient and behavioral mechanism. A larger-fish-upstream pattern due to size-dependent habitat preference is predicted for streams with cool temperatures and low drift densities, conditions found in Arctic grayling streams. A larger-fish-upstream pattern due to competition between fish of different size is predicted in warm streams, irrespective of drift density, conditions found in many New Zealand trout streams. A smaller-fish-upstream pattern due to competition between fish of different size is expected in cool streams with high drift abundance; currently no data are available to test this prediction.

Codes: modeling basin reach migrat popdyn quant trophic wtemp

Hughes, N. F. 1998. Use of whole-stream patterns of age segregation to infer the interannual movements of stream salmonids: a demonstration with Arctic grayling in an interior Alaskan stream. Transactions of the American Fisheries Society 127: 1067-1071.

I show how patterns of whole-stream age segregation can be used to infer interannual movements of stream salmonids. First, estimates of recruitment and mortality rates for the population as a whole are calculated using data from fish sampled along the entire length of the river. These rates are used to simulate the age structure of an idealized population. Next, each age-class is divided among lower, middle, and upstream reaches, according to the

proportions observed in the real population. Finally, the amount of interannual movement is estimated from the pattern of age segregation that would exist after 1 year if recruitment and mortality were allowed to act on the simulated population but no fish moved between reaches. Application of this technique to the "older-fish-upstream" distribution pattern of Arctic grayling Thymallus arcticus in an Alaskan river showed that substantial movements are required to maintain the observed pattern of age segregation. Annual emigration was estimated at 24%, 11%, and 0% for downstream, midriver, and upstream reaches respectively, estimated immigration was 2%, 30%, and 51%.

Codes: modeling basin reach migrat popdyn quant noenv

Hughes, N. F. 1999. Population processes responsible for larger-fish-upstream distribution patterns of Arctic grayling (Thymallus arcticus) in interior Alaskan runoff rivers. Canadian Journal of Fisheries and Aquatic Sciences 56: 2292-2299.

During the summer months, Arctic grayling (Thymallus arcticus) in Alaskan streams adopt a larger-older-fish-upstream distribution pattern. In this paper, data is analysed from two large interior Alaskan rivers to determine how population processes maintain this size and age gradient. These analyses support the hypothesis that age-phases recruitment and growth-dependent movement are primarily responsible for this distribution pattern. Age-phased recruitment describes the way that the mean age of fish recruiting to a reach increases upstream, from ages 0-1 in the lower river to ages 3-7 in the headwaters. This process begins with the concentration of spawning fish, and the resultant fry, in the lower reaches of the river. Downstream movement during the first year of life further concentrates young fish in the lower river. Over time, the distribution of this cohort broadens steadily as individuals move further upstream, so that fish recruiting to headwater reaches are 3-7 years old. This process contributes to both size and age gradients. Growth-dependent movement magnifies the size gradient by sorting fast-growing fish into the upper river and slow-growing fish into the lower river. This sorting results from the fact that individuals making long-distance upstream movements tend to have grown particularly rapidly that year, while individuals making long-distance downstream movements tend to have grown especially slowly that year. The hypothesis that age and size gradients are the result of whole-stream gradients in growth or mortality acting on a sedentary population was rejected. However, there was some evidence that fish did grow more slowly in the lowest 40 km of one river, although this made only a minor contribution to the size gradient, and growth rates were remarkably constant for the next 120 km. There was no suggestion that spatial variation in mortality rate contributed towards the size or age gradient, but natural and sampling variability could have obscurred small but significant differences between reaches.

Codes: modeling basin reach migrat popdyn quant noenv

Hunt, R. L. 1976. A long-term evaluation of trout habitat development and its relation to improving management-related research. TAFS 105: 361-364.

Responses of a wild brook trout (Salvelinus fontinalis) population to instream habitat development in a 0.7 km reach of Lawrence Creek were monitored for 7 years and compared to population data for the 3-year period prior to development. Mean annual biomass of trout, mean annual number of trout over 15 cm (legal size), and annual production increased significantly during the 3 years following development, but more impressive responses were observed during the second 3 years. Maximum number and biomass and number of legal trout did not occur until 5 years after completion of development. The peak number of brook trout over 20 cm was reached the sixth year after development. Where long-term studies of aquatic systems are needed to evaluate effects of environmental perturbations, it may be desirable to deliberately delay collection of posttreatment data. Such a start-pause-finish sequence of research would provide more valid and less costly evaluations and utilize the time of researchers more efficiently.

Codes: experi reach quant instream temporal

Hunt, R. L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Technical Bulletin 162. Department of Natural Resources, Madison, Wisconsin. 80p.

Codes: review habitat reach quant instream

Hunt, R. L. 1992. Evaluation of Trout Habitat Improvement Structures in Three High-Gradient Streams in Wisconsin. Technical Bulletin 179. Department of Natural Resources, Madison, WI.

Eight types of in-channel trout habitat improvement structures were installed in 3 treatment zones (TZs) on portions of 3 Wisconsin trout streams having TZ gradient of approximately 1% (53-72 ft/mi). Structures were installed in the TZs at densities of 142/mi in Camp Creek, 100/mi in Devils Creek, and 208/mi in Twenty Mile Creek. Most of the wood and rock used to build the structures were gathered on site. Approximately 63% of the 72 test structures provided good or excellent trout habitat 4 yrs after installation. Two structure types, the channel constrictor and the cross-channel log/bank revetment, provided consistently good habitat for adult trout. Durability and functional performance of structures were much better in the 2 smaller TZs, on Camp Creek and Twenty Mile Creek, than in the largest TZ on Devils Creek. Only the channel constrictor and some bank cover logs functioned effectively in the Devils Creek TZ. Average cost per structure was $230 for the 2 smaller TZs on Camp and Twenty Mile creeks. Project cost per mile was approximately $38,000 (165 structures/mi). Wages for the professional crew accounted for 65% of the total cost. Abundance and biomass of wild brown trout (Salmo trutta) in April increased significantly in the Camp Creek TZ (1984 vs 1985-89 average), despite unfavorable below-normal streamflow regimes during the last 2-3 yrs of the post-installation period. Density of legal sized trout peaked at 457 trout/mi; biomass peaked at 344 lb/mi. Spring and fall densities of legal sized brown trout and total biomass in the spring and fall declined in the reference zone (RZ) during the post-installation period. At Devils Creek, densities of wild brook trout (Salvelinus fontinalis) and domestic brown trout in September were sparse in both the TZ and the RZ throughout the evaluation, due to lack of natural recruitment. At Twenty Mile Creek, legal sized wild brook trout (>/= 6 in) increased an average of 118% (to 185 trout/mi) in the TZ (1983-85 vs. 1986-89) and peaked at 392 trout/mi in September 1986. In the adjacent RZ, no change occurred in average density (189 trout/mi) of legal sized brook trout. Fisheries management recommendations include use of 7 of the 8 test structures to improve trout habitat in other small high gradient streams in Wisconsin and greater use of volunteer labor to reduce project costs. (Lantz-PTT).

Codes: experi multi reach quant instream economic temporal

Huusko, A., and T. Yrjaenae. 1997. Effects of instream enhancement structures on brown trout, Salmo trutta L., habitat availability in a channelized boreal river: A PHABSIM approach. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 453-466.

Stream channel morphology and hydraulic conditions were measured before and after channel modification and boulder structure placements in a channelized boreal river to determine whether more favourable rearing habitat for brown trout, Salmo trutta L., was created. The assessment was performed using physical habitat simulation (PHABSIM) procedures based on summer and winter habitat preferences of brown trout for depth, velocity and substrate. The results showed that the availability of potential physical trout habitat can be increased in the study river at simulated low and moderate flow conditions by reconstruction of the river bed and placing instream boulder structures. The resulting diversity of depth and velocity conditions created a spatially more complex microhabitat structure. Improved habitat conditions were able to sustain a larger trout population. Hydraulic habitat models, like the PHABSIM framework, seem to be a suitable procedure to evaluate the benefits of physical habitat enhancement.

Codes: microhab qual? instream ifim hem

Irvine, J. R. 1987. Effects of Varying Flows in Man-Made Streams on Rainbow Trout (Salmo gairdneri Richardson) Fry. Pages 83-97. Regulated Streams: Advances in Ecology. Plenum Press, New York.

The construction in 1980 of the lower Waitaki River replicate stream channels in New Zealand allowed the possibility of studying regulated stream flow with controls in space and time. The purpose of this paper is to present

results from two experiments in which the effects of flow changes, simulating conditions below a hydroelectric peaking plant, on rainbow trout fry emigration, growth and condition, production and habitat preferences were examined. Up to five-fold flow changes occurring twice daily, five days per week, had remarkably little effect on rainbow trout fry, illustrating how well-adapted fry are to varying discharge. Downstream emigration was not affected. However, in separate experiments at the replicate streams, downstream emigration of chinook or quinnat salmon fry was increased by fluctuating discharge. Varying flows resulted in significant weight gain for rainbow trout in the low density stream. Invertebrate drift densities sometimes increased during flow changes. Trout habitat preferences were similar in constant flowing and fluctuating streams. (See also W89-01736) (Lantz-PTT).

Codes: experi enclos habitat quant migrat lakehydro

Irvine, J. R., I. G. Jowett, and D. Scott. 1987. A test of the instream flow incremental methodology for underyearling rainbow trout, Salmo gairdnerii, in experimental New Zealand streams. New Zealand Journal of Marine and Freshwater Research 21: 35-40.

The instream flow incremental methodology predicts the potential amount of habitat in a stream, rather than fish biomass or numbers. The authors introduced rainbow trout (Salmo gairdneri) into stream channels next to the Waitaki River, South Island, New Zealand, and subsequently maintained a constant flow in these streams. The biomass of rainbow trout in individual riffles and pools of the streams was determined and related to the amount of usable area in these habitats calculated using the incremental methodology. Regardless of fish stocking density, rainbow trout biomass in late summer and early winter was not correlated with the amount of usable habitat.

Codes: experi habitat quant ifim warning hem

Isaak, D. J., and W. A. Hubert. 2000. Are trout populations affected by reach-scale stream slope? 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: 468-477.

Reach-scale slope and the structure of associated physical habitats are thought to affect trout populations, yet previous studies confound the effect of stream slope with other factors that influence trout populations. The effect of stream slope on trout populations was isolated by sampling reaches immediately upstream and downstream of 23 marked changes in stream slope on 18 streams across Wyoming and Idaho. No effect of stream slope on areal trout density was observed, but when trout density was expressed volumetrically to control for differences in channel cross sections among reaches in different slope classes, the highest densities of trout occurred in medium-slope reaches, intermediate densities occurred in high-slope reaches, and the lowest densities occurred in low-slope reaches. The relative abundance of large trout was reciprocal to the pattern in volumetric trout density. Trout biomass and species composition were not affected by stream slope. Our results suggest that an assumption made by many fish-habitat models, that populations are affected by the structure of physical habitats, is at times untenable for trout populations in Rocky Mountain streams and is contingent upon the spatial scale of investigation and the population metric(s) used to describe populations.

Codes: multi experi reach quant instream warning

Jakober, M. J., T. E. McMahon, R. F. Thurow, and C. G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 223-235.

We used radiotelemetry and underwater observation to assess fall and winter movements and habitat use by bull trout Salvelinus confluentus and westslope cutthroat trout Oncorhynchus clarki lewisi in two headwater streams in the Bitterroot River drainage, Montana, that varied markedly in habitat availability and stream ice conditions. Bull trout and cutthroat trout made extensive (>1 km) downstream overwintering movements with declining temperature in the fall. Most fish remained stationary for the remainder of the study (until late February), but some fish made

additional downstream movements (1.1-1.7 km) in winter during a low-temperature (less than or equal to 1 degree C) period marked by anchor ice formation. Winter movement was more extensive in the mid-elevation stream where frequent freezing and thawing led to variable surface ice cover and frequent supercooling (<0 degree C). Habitat use of both species varied with availability; beaver ponds and pools with large woody debris were preferred in one stream, and pools with boulders were preferred in the other. Trout overwintered in beaver ponds in large (N = 80-120), mixed aggregations. In both streams, both species decreased use of submerged cover following the formation of surface ice. Our results indicate that (1) continued activity by trout during winter is common in streams with dynamic ice conditions and (2) complex mixes of habitat are needed to provide suitable fall and winter habitat for these species.

Codes: multi reach qual migrat wtemp instream

Jenkins, T. M., Jr., S. Diehl, K. W. Kratz, and S. D. Cooper. 1999. Effects of population density on individual growth of brown trout in streams. Ecology 80: 941-956.

Some studies suggest that lotic populations of brown trout (Salmo trutta) are regulated through density-dependent mortality and emigration to the extent that mean growth rates of resident survivors are unrelated to trout densities. To test this, we studied the relationship between density and growth, mortality, and emigration of brown trout in two alpine streams and a set of stream channels in eastern California. We sampled trout at the scale of "segments" (5-31 m long riffles, runs, and pools) and "sections" (340-500 m in length) of Convict Creek over a 3-yr period. Trout were also sampled during 6 yr in seven 90-m sections of Mammoth Creek. For 2 yr, we manipulated trout densities in Convict Creek by removing trout from two sections and adding trout to two other sections. We also manipulated densities in seven 50-m stream channels, using a natural size distribution of trout in one year and underyearlings only in a second year. In both streams, average size (body length or mass) of underyearlings in fall was negatively related to trout density and was furthermore affected by sampling location and year. The strong, negative relationship between individual mass and density of trout could be detected at the spatial scale of whole sections, but not at the scale of individual segments. #(abstract incomplete)#

Codes: experi reach segment popdyn quant temporal noenv

Johnson, S. W., and J. Heifetz. 1985. Methods for assessing effects of timber harvest on small streams. Report NOAA-TM-NMFS-F/NWC73.

The methods used by the Northwest and Alaska Fisheries Center's Auke Bay Laboratory in assessing the effects of clear-cut logging on salmonid habitat and the effectiveness of buffer strips in protecting fish habitat during and after logging are described in detail. The methods have been used by the laboratory since 1982 to study fish populations and habitat in three different categories of streams in southeastern Alaska. The methods described include measurements of fish, periphyton, benthos, preferred fish habitats, and stream physical characteristics, such as discharge gradient, substrate, and water quality.

Codes: methods design ripar

Jones, K. K., and K. M. S. Moore. 2000. Habitat assessment in coastal basins in Oregon: Implications for coho salmon production and habitat restoration. Edited by E. E. Knudson, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser. CRC Press LLC, 2000 Corporate Blvd., NW Boca Raton FL 33431 USA

Quantitative habitat surveys have been conducted in western Oregon streams since 1990. Over 950 streams, a total of 6,000 kilometers, have been surveyed in coastal basins with the results organized into over 3,100 reaches characterized by land use, channel morphology, and valley form. The data have been compiled into a comprehensive database that describes key attributes of instream habitat, riparian structure, and channel morphology. The information was used to describe current status of habitat throughout the coastal basins and the potential to support coho salmon Oncorhynchus kisutch populations. Example maps and evaluations were

developed for the Yaquina River watershed to describe and compare coho salmon habitat. The datasets will support sustainability because they can be used to estimate potential survival and production of juvenile coho salmon in coastal basins, to identify core habitats, for designing and evaluating monitoring programs, and for developing restoration strategies.

Codes: multi habitat reach segment nofish ripar instream datasource

Jowett, I. G., and M. J. Duncan. 1990. Flow variability in New Zealand rivers and its relationship to in-stream habitat and biota. New Zealand Journal of Marine and Freshwater Research 24: 305-317.

Flow variability indices were determined for 130 sites on New Zealand rivers and the sites were divided into groups based on these indices. Univariate and discriminant analyses were used to identify the catchment characteristics which contributed to flow variability. Accounted for a broad regional distribution of groups. Relationships were found between flow variability, and morphological and hydraulic characteristics. There were strong associations with periphyton communities and trout distribution and abundance and a weak association with benthic invertebrate communities. Water velocity was the most important hydraulic variable; it could be linked to changes in water temperature, benthic invertebrate and periphyton community structure, and trout distribution and abundance.

Codes: multi reach qual? instream trophic wtemp hydro

Jowett, J. G. 1990. Factors related to the distribution and abundance of brown and rainbow trout in New Zealand clear-water rivers. New Zealand Journal of Marine and Freshwater Research 24: 429-440.

Brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) populations at 157 riverine sites throughout New Zealand were divided into groups based on species, size, and abundance. The groups were examined to determine significant differences in hydrological, water quality, water temperature, biological, in-stream habitat, and catchment variables between groups. A discriminant model was developed with nine environmental factors which correctly classified 72% of a subset of 65 sites. Fish species distribution was related to climatic (water temperature), geographical, and hydrological factors, whereas fish abundance was determined by factors relating to flow variability, river gradient, in-stream habitat, and the presence of lakes in the catchment.

Codes: multi reach quant? instream wtemp watqual lulc hydro lakehydro

Jowett, J. G. 1992. Models of the abundance of large brown trout in New Zealand rivers. North American Journal of Fisheries Management 12: 417-432.

Multiple-regression models of the abundance of brown trout Salmo trutta larger than 200 mm total length were developed from combinations of hydrological, catchment, physical, water quality, and benthic invertebrate biomass variables in New Zealand rivers. Three hydrological and catchment variables explained 44.4% of the variation in trout abundance, and benthic invertebrate biomass alone explained almost 45%. Together, invertebrate biomass and weighted usable area (WUA) for adult brown trout drift-feeding habitat explained 64.4% of the variation in trout abundance. The model best suited to the application of the instream flow incremental methodology (IFIM) explained 87.7% of the variation in brown trout abundance at 59 sites. Two variables were calculated with flow data: WUA for food production at median flow and WUA for adult brown trout drift-feeding habitat at mean annual low flow. Other variable within the model either did not vary with flow or varied little. This study demonstrates that WUA is an important determinant of adult brown trout abundance, refuting one of the major criticisms of IFIM.

Codes: multi reach quant instream wtemp watqual lulc trophic hydro ifim hem

Jutila, E., A. Ahvonen, and M. Laamanen. 1999. Influence of environmental factors on the density and biomass of stocked brown trout, Salmo trutta L., parr in brooks affected by intensive forestry. Fisheries Management and Ecology [Fish. Manage. Ecol.] 6: 195-205.

The influence of environmental factors on the density and biomass of stocked brown trout, Salmo trutta L., parr was studied in brooks subjected to intensive forestry in the Isojoki river basin, western Finland. Multivariate regression analysis showed that 69% of the variation in the population density of parr was determined by five variables: (1) mean water depth; (2) the abundance of pools; (3) stony bottom substrates with stones sized between 2 and < 10 cm in diameter; (4) undercut banks; and (5) the percentage of shading by trees. Correspondingly, 57% of the variation in the biomass of parr was determined by three variables: (1) mean water depth; (2) the abundance of pools; and (3) benthic vegetation. Dredging of the brooks and forest ditching had the most harmful consequences for the nursery habitats of brown trout parr. Measures for the rehabilitation of brown trout production in these brooks are discussed.

Codes: multi reach quant instream substrate ripar

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinnook salmon in the Columbia River Basin. Science 290: 977-979.

Construction of four dams on the lower Snake River (in northwestern United States) between 1961 and 1975 altered salmon spawning habitat, elevated smolt and adult migration mortality, and contributed to severe declines of Snake River salmon populations. By applying a matrix model to long-term population data, we found that (i) dam passage improvements have dramatically mitigated direct mortality associated with dams; (ii) even if main stem survival were elevated to 100%, Snake River spring/summer chinook salmon (Oncorhynchus tshawytscha) would probably continue to decline toward extinction; and (iii) modest reductions in first-year mortality or estuarine mortality would reverse current population declines.

Codes: modeling popdyn quant hydro noenv

Keeley, E. R. 2000. A experimental analysis of territory size in juvenile steelhead trout. Animal Behaviour 59: 477-490.

I experimentally manipulated levels of food abundance and density of competitors to determine how these factors influence the territory size of juvenile steelhead trout, Oncorhynchus mykiss. Steelhead trout were held in artificial stream channels and I followed cohorts that were fed at one of three levels of food abundance and stocked at one of three levels of fish density. By measuring territory size over a 2-month period, while the fish were growing, I was also able to assess the effects of body size in determining the size of a territory. Defended and foraging areas were similar in absolute size, but the frequency of space use was different for defence than for foraging. As predicted, territory size decreased with increasing levels of food abundance and increased with decreasing levels of fish density. In addition, territory size increased with increasing body size even after controlling the effects of food abundance and competitor density. In comparison to previous studies, territory size of steelhead trout changed more dramatically in response to changing levels of food and competitors. For territorial animals with indeterminate growth, territory size is not only adjusted as a trade-off between the costs and benefits of defence, but also with respect to body size due to increasing metabolic demands as individuals grow.

Codes: experi microhab quant trophic

Keeley, E. R., P. A. Slaney, and D. Zaldokas. 1996. Estimates Of Production Benefits For Salmonid Fishes From Stream Restoration Initiatives. Watershed Restoration Management Report No. 4. Watershed Restoration Program. Ministry of Environment, Lands and Parks and Ministry of Forests, British Columbia

#Takes published data as is, without noting methods of population density estimation or scale of estimates (e.g. length of stream sampled and its order). Uses data dominated by summer samples, but does not consider seasonal

effects or attraction effects of retsored reaches, which would compromise extrapolations to whole stream or adult returns. Looks at species separately. Analyses by paired-t across studies without investigating interactions (which is not possible if each study is reduced to a pair opf mean values). Given the foregoing, finds significant increases in local densities due to habitat restoration, and taken at that unspecified local scale, the results are convincing and encouraging.#

Codes: review exper quant reach offchann

Keith, R. M., T. C. Bjornn, W. R. Meehan, N. J. Hetrick, and M. A. Brusven. 1998. Response of Juvenile Salmonids to Riparian and Instream Cover Modifications in Small Streams Flowing through Second-Growth Forests of Southeast Alaska. Transactions of the American Fisheries Society 127: 889-907.

We manipulated the canopy of second-growth red alder Alnus rubra and instream cover to assess the effects on abundance of juvenile salmonids in small streams of Prince of Wales Island, southeast Alaska, in 1988 and 1989. Sections of red alder canopy were removed to compare responses of salmonids to open- and closed-canopy sections. At the start of the study, all potential instream cover was removed from the study pools. Alder brush bundles were then placed in half the pools to test the response of juvenile salmonids to the addition of instream cover. Abundance of age-0 coho salmon Oncorhynchus kisutch decreased in both open- and closed-canopy sections during both summers, but abundance decreased at a higher rate in closed-canopy sections. More age-0 Dolly Varden Salvelinus malma were found in open-canopy sections than in closed-canopy during both summers. Numbers of age-1 and older coho salmon and Dolly Varden were relatively constant during both summers, and there was no significant difference in abundance detected between open- and closed-canopy sections. Abundance of age-0 coho salmon decreased in pools with and without additional instream cover during both summers. Abundance of age-1 and older coho salmon and age-0 Dolly Varden did not differ significantly in pools with or without added cover during either summer. Abundance of age-1 and older Dolly Varden was higher in pools with added instream cover than in pools without cover during both summers. Age-0 coho salmon decreased in abundance throughout the summer in both years. Emigration was measured in 1989 and accounted for most of the decrease in abundance. Age-0 coho salmon emigrants were significantly smaller than age-0 coho salmon that remained in the stream.

Codes: multi experi reach quant migrat ripar lwd

Keller, C. R., and K. P. Burnham. 1982. Riparian Fencing, Grazing, and Trout Habitat Preference on Summit Creek, Idaho. North American Journal of Fisheries Management 2: 53-59.

In 1975, 3.2 km of Summit Creek, Idaho were fenced by the Bureau of Land Management to exclude livestock from the riparian area. Six stream sections were electrofished in 1979 to determine differences in trout abundance, size, and growth between grazed and ungrazed stream sections. Electrofishing station were paired by habitat type. There were more trout in ungrazed sections than in grazed sections in all three habitat types sampled. With one exception, there were more catachablesized (200 mm long or longer) rainbow trout (Salmo gairdneri) and brook trout (Salvelinus fontinalis) in the ungrazed area than in the grazed area. There was also evidence that the average size of the fish was less in grazed sections. Fish population data were not collected prior to fencing; therefore it cannot be firmly concluded that the trout population increased within the livestock enclosure as a result of fencing the riparian area. However, the combined results of previous trout habitat improvements documented for Summit Creek, as a result of the fencing, and this study support the conclusion that trout prefer stream areas in ungrazed habitat over grazed habitat.

Codes: reach experi graz quant

Kelly-Quinn, M., D. Tierney, W. Roche, and J. J. Bracken. 1996. Distribution and abundance of trout populations in moorland and afforested upland nursery streams in County Wicklow. Biology and Environment 96B: 127-139.

Codes: multi reach quant ripar

Kennedy, G. J. A. 1988. Stock enhancement of Atlantic salmon (Salmo salar L.). Edited by D. Mills and D. Piggins. , 345-372 p.

The efficacy of different enhancement techniques for Atlantic salmon (Salmo salar) is evaluated. Stocking techniques. The relative merits and drawbacks of stocking with green and eyed ova, unfed and fed fry, parr and smolts is discussed, along with an assessment of appropriate stocking densities. Recommendations for further research are made in a number of areas. Alternative enhancement techniques are discussed under the headings of stream remedial measures, adult transfers and lake rearing. It is concluded that more research is required into problems associated with the latter before definitive recommendations can be produced. Successes with adult transfers in Canada suggest that there is scope for investigation of the applicability of this technique elsewhere.

Codes: review quant reach noenv

Kennedy, G. J. A., and C. D. Strange. 1980. Population changes after two years of salmon (Salmo salar L.) stocking in upland trout (Salmo trutta L.) streams. J. Fish. Biol. 17: 577-586.

The survival of salmon stocked in upland trout streams in the presence of salmon parr was found to be only about half the value recorded when trout alone made up the resident stock. Changes in the trout population were also recorded following the 2 yr of salmon stocking, and these suggested that the presence of salmon parr may also influence trout fry survival. The findings are discussed in the context of habitat competition and total stream holding capacity.

Codes: multi experi reach quant sppinter noenv

Kershner, J. L., C. M. Bischoff, and D. L. Horan. 1996. Comparison of population, habitat, and genetic characteristics of Colorado River cutthroat trout in wilderness vs. non-wilderness streams in the Uinta mountains. Annual Meeting of the Western Division of the American Fisheries Society, 14-18 Jul 1996. Eugene, OR (USA). American Fisheries Society, Oregon Chapter, PO Box 722, Corvallis, OR 97339, Contact individual authors directly.

Codes: experi multi reach qual

Kjelson, M. A., and P. L. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin rivers, California. Edited by C. D. Levings, L. B. Holtby and M. A. Henderson. 100-115 p.

Mark-recapture studies of smolt survival in the Sacramento-San Joaquin Delta of California provides empirical data on the effects of water development on fall-run chinook salmon (Oncorhynchus tshawytscha). Recoveries of coded-wire tagged hatchery fish from the ocean troll fishery and estuarine trawling yielded two survival measures that were positively correlated (r = 0.90). Smolt survival from both measures were highly correlated to river flow, temperature, and percent diversion. Survival of fish exposed to diversion was about 50% less than those not exposed. Study designs to quantify the independent effects of temperature on survival and the survival of wild smolts are presented.

Codes: basin popdyn hydro wtemp

Klassen, H. D., and T. G. Northcote. 1986. Stream Bed Configuration and Stability Following Gabion Weir Placement to Enhance Salmonid Production in a Logged Watershed Subject to Debris Torrents. Canadian Journal of Forest Research 16: 197-203.

Tandem V-shaped gabion weirs for improving spawning habitat for salmon were installed to replace large organic debris at three sites below the terminus of a debris torrent in Sachs Creek, Queen Charlotte Islands. Stream conditions were compared between gabion and nearby control sites. The stability of added and entrapped gravel at all gabion sites was poor over the first winter and excessive scour threatened the integrity of the upstream steeper (3%) slope gabion site. However, the two gabion sites at lower (1%) slope successfully stabilized spawning gravel in the second year after installation, probably through a reduction in the local slope gradient and self-armouring of the high flow channels. Higher summer densities of juvenile coho slamon and steelhead trout were recorded at the gabion sites compared with the control sites. Underyearling coho fry were also significantly larger at gabion sites than at control sites. Improved rearing habitat was created for coho juveniles by the gabions, a result of increased pool area and cover. (Author 's abstract).

Codes: experi quant? instream substrate

Knapp, R. A., and K. R. Matthews. 1996. Livestock grazing, golden trout, and streams in the Golden Trout Wilderness, California: impacts and management implications. North American Journal of Fisheries Management 16: 805-820.

Impacts of livestock grazing on California golden trout Oncorhynchus mykiss aguabonita and their habitat were studied inside and outside of livestock exclosures in the Golden Trout Wilderness, California. In two consecutive years, the majority of stream physical characteristics showed large differences between grazed and ungrazed areas, and the directions of these differences were consistent with the recovery of exclosed streams and riparian areas from impacts caused by livestock grazing. Ungrazed areas consistently had greater canopy shading, stream depths, and bank-full heights and smaller stream widths than grazed areas. California golden trout were very abundant in the study sites; their densities and biomasses were among the highest ever recorded for stream-dwelling trout in the western United States. California golden trout density and biomass per unit area were significantly higher in ungrazed than in grazed areas in three of four comparisons. Differences between grazed and ungrazed areas were less consistent when density and biomass were calculated on the basis of stream length. Our results suggest that current levels of livestock grazing are degrading the stream and riparian components of the study meadows to the detriment of golden trout populations.

Codes: reach experi graz ripar quant

Knapp, R. A., and H. K. Preisler. 1999. Is it possible to predict habitat use by spawning salmonids? A test using California golden trout (Oncorhynchus mykiss aguabonita). 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: 1576-1584.

In this study, nonparametric logistic regression was used to determine what habitat features were associated with the locations chosen by spawning California golden trout (Oncorhynchus mykiss aguabonita). From this nonparametric model, a parametric model was developed that incorporated the habitat features most strongly associated with spawning sites and this model was used to calculate the probability of use by spawning golden trout for specific stream locations. The overall nonparametric model was highly significant and explained 62% of the variation in spawning location. Four of the eight habitat variables, substrate size, water depth, water velocity, and stream width, had highly significant effects and alone explained 59% of the variation in spawning location. Results of a cross-validation procedure indicated that the parametric model generally provided a good fit to the data. Results indicate that location-specific probabilities of use were predictable based on easily measured habitat characteristics and that nonparametric regression, an approach still rarely used in ecological studies, may have considerable utility in the

development of fish-habitat models. Given the escalating pace at which fish habitats are being altered, such models are increasingly important in predicting the effects of these alterationson populations.

Codes: reach spawn qual instream substrate modeling

Knapp, R. A., V. T. Vredenburg, and K. R. Matthews. 1998. Effects of stream channel morphology on golden trout spawning habitat and recruitment. Ecological Applications [Ecol. Appl.] 8: 1104-1117.

Populations of stream-dwelling salmonids (e.g., salmon and trout) are generally believed to be regulated by strong density-dependent mortality acting on the age-0 life stage, which produces a dome-shaped stock-recruitment curve. Although this paradigm is based largely on data from anadromous species, it has been widely applied to stream-resident salmonids despite the fact that the processes limiting or regulating stream-resident populations remain poorly understood. The purpose of the present study was to determine whether stream channel morphology affects the availability of spawning habitat for California golden trout, and whether spawning habitat availability influences the production of age-0 trout and recruitment into the adult population. Wide stream reaches contained significantly more spawning habitat and a higher density of nests and age-0 trout than did narrow reaches. In contrast to the idea that salmonid populations are regulated by density-dependent mortality of age-0 fish, we found that the mortality of age-0 trout was largely density independent. In addition, over most of the range of observed fish densities, the density of a particular cohort was positively correlated between years for age-0, age-1, and age-2 trout. Therefore, our golden trout study population was limited by spawning habitat, with spawning habitat availability influencing the production of age-0 trout as well as recruitment into the adult population. Grazing by cattle has widened the study streams, and our current findings help to explain why stream sections subject to grazing had more spawning habitat and higher golden trout densities than ungrazed sections. Individual growth rates of golden trout are apparently negatively density dependent, and these grazing-related increases in trout density have likely resulted in decreased growth rates. Our study demonstrates that it is only by gaining an understanding of how processes operate that we will be able to predict the effects of habitat alteration on populations.

Codes: experi reach graz quant spawn popdyn

Knudsen, E. E., and S. J. Dilley. 1987. Effects of riprap bank reinforcement on juvenile salmonids in four western Washington streams. North American Journal of Fisheries Management 7: 351-356.

Summer and fall juvenile salmonid populations in five pairs of stream sections were estimated shortly before and after construction of flood and erosion control projects. All five projects included bank reinforcement with rock riprap and three included streambed alterations. Juvenile coho salmon Oncorhynchus kisutch, juvenile steelhead Salmo gairdneri, and cutthroat trout Salmo clarki were apparently adversely affected by construction in the three smaller, and most severely altered, stream sections. Negative short-term effects of construction appeared to increase with severity of habitat alteration, to decrease with increase in stream size, and to decrease with increasing fish size.

Codes: experi multi reach quant substrate instream

Kocik, J. F., and C. P. Ferreri. 1998. Juvenile production variation in salmonids: population dynamics, habitat, and the role of spatial relationships. Canadian Journal of Fisheries and Aquatic Sciences 55: 191-200.

Anadromous Atlantic salmon (Salmo salar) exhibit a complex life history that requires the use of haitats that span several different temporal and spatial scales. While fisheries scientists have investigated the various elements of habitat and how they affect Atlantic salmon growth and survival, these studies typically focus on requisite requirements for a single life history stage. Current advances in the understanding of salmonid populations in lotic systems indicates that ignoring the spatial positioning of different habitats and dispersal capabilities of fish between them may affect estimates of habitat quality and production of juvenile Atlantic salmon. Using the concepts of juxtaposition and interspersion, it is hypothesized that discrete functional habitat units (FHU) occur within river

systems and that the spatial structure of FHU affects fish production. Utilizing a simulation model, it is illustrated how modeling FHU structure of spawning and rearing habitat in a river system can improve understanding of juvenile Atlantic salmon production dynamics. The FHU concept allows a flexible approach to more comprehensive analyses of the impacts of habitat alterations, seasonal habitat shifts, and spatial ecology of salmonids at various scales.

Codes: philosophy habitat reach migrat modeling temporal

Kocik, J. F., and W. W. Taylor. 1996. Effect of juvenile steelhead on juvenile brown trout habitat use in a low-gradient Great Lakes tributary. Transactions of the American Fisheries Society 125: 244-252.

We investigated habitat use of wild brown trout Salmo trutta in Gilchrist Creek, Michigan, with and without a parallel cohort of introduced steelhead Oncorhynchus mykiss. This stream is typical of the region, having a low-gradient, stable discharge and a high sand bedload. By snorkeling, we evaluated seasonal habitat use in two stream reaches before and after steelhead introduction to one of the reaches. Age-0 brown trout occupied stream margins soon after emergence, using cover provided by aquatic vegetation growing on sand and silt substrates. By summer and fall, brown trout moved into deeper water and used more diverse cover types. From summer to fall, the smaller age-0 steelhead used lower current velocities than did age-0 brown trout. Similar water depth, substrate, and cover were used by the two species. At the densities studied, age-0 brown trout habitat use did not change in response to the presence of age-0 steelhead. We believe that three factors minimized the effect of steelhead: (1) the larger size of the brown trout, which gave them a competitive advantage; (2) vertical habitat segregation with steelhead suspended in the water column and brown trout near or at the bottom; and (3) temporal differences in habitat ontogeny with shifts of older, larger fish to deeper, faster water. These factors may permit these two species to coexist in low-gradient rivers.

Codes: experi reach quant sppinter instream substrate

Kondolf, G. M. 1994. Livestock grazing and habitat for a threatened species: land-use decisions under scientific uncertainty in the White Mountains, California, USA. Environmental Management 18: 501-509.

The North Fork of Cottonwood Creek, in the White Mountains, Inyo National Forest, California, is a critically important refuge for the Paiute cutthroat trout (Oncorhynchus clarki seleniris), a federally listed threatened species. Habitat for these fish appears to be limited by excessive levels of fine sediment in the channel, and livestock grazing of riparian meadows has been implicated in delivery of sediment to the channel. However, the relationships between land use and sediment yield have not been conclusively determined, in large part because there are no historically ungrazed sites to serve as long-term controls. Accordingly, land-use decisions must be made under scientific uncertainty. To reduce erosion and sedimentation in the stream, the Forest Service spent approximately US$260,000 from 1981 to 1991 to repair watershed damage from livestock grazing, prevent livestock from traversing steep banks, and limit livestock access to the channel. Throughout this period, livestock grazing has continued on these lands, yielding less than $12,000 in grazing fees. In revising its Allotment Management Plan for the basin, the Forest Service rejected the "no-grazing" alternative because it was inconsistent with its Land and Resource Management Plan, which specifies there is to be no net reduction of grazing.

Codes: substrate graz qual economic

Korman, J., and P. S. Higgins. 1997. Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. Canadian Journal of Fisheries and Aquatic Sciences 54: 2058-2067.

We provide a quantitative examination of the utility of escapement data for monitoring changes in salmonid populations caused by habitat alterations. We used Monte Carlo simulations to determine the precision, duration of monitoring, and the effect size required to achieve acceptable statistical inferences based on before-after (BA) and before-after-control-impact (BACI) comparisons. There was generally less than a 50% chance of detecting a

population response unless the population change was large (more than a twofold increase) or the post-treatment monitoring period long (>10 years). Statistical power was improved by increasing the precision of escapement estimates, but the extent of improvement was dependent on the magnitude of population response to treatment, the duration of monitoring, and the extent of natural variability in abundance. BACI comparisons generally had a 10-15% lower probability of detecting a population change than BA comparisons unless the degree of covariation in survival rates between control and treatment stocks was very strong. Autocorrelation in error, simulating patterns of high and low survival rates over time, generally reduced power by 5-15%. Our results identify the conditions where escapement information can be used to make reliable inferences on salmonid population changes and provides a means for evaluating alternative monitoring designs.

Codes: modeling design risk

Kozel, S. J., and W. A. Hubert. 1989. Factors influencing the abundance of brook trout (Salvelinus fontinalis) in forested mountain streams. Journal of freshwater ecology. La Crosse, WI 5: 113-122.

Physical and biological factors that appear to influence standing stocks (kg/ha) of brook trout (Salvelinus fontinalis) were identified in the Medicine Bow National Forest, Wyoming, for 32 forested reaches of mountain streams in drainages unaltered by human activity. Brook trout abundance declined as stream size increased. This decline appeared to be related to at least two factors--decline in habitat quality with increasing stream size and interaction with brown trout (Salmo trutta) at lower elevations. The greatest variation in brook trout abundance (R super(2) = 0.77) was accounted for by drainage basin area and elevation of the stream reach. (DBO).

Codes: multi reach quant instream substrate lulc

Kozel, S. J., and W. A. Hubert. 1989. Testing of habitat assessment models for small trout streams in the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 9: 458-464.

We tested the applicability of four habitat assessment models to small trout streams in the Medicine Bow National Forest. All models yielded predictions of trout standing stocks or ratings of trout cover that were correlated with measured trout standing stocks; however, the predicted and measured standing stocks were not directly proportional, and not all model variables appeared to contribute to the predictions or ratings derived from the models. Among the habitat variables included in the four models, those most highly correlated with trout standing stocks were width-to-depth ratio, abundance of overhead bank cover, average stream width, and level of late-summer streamflow. We hypothesize that much of the variation in measured habitat and model predictions among our study reaches was due to natural variation in habitat features associated with stream size and reach gradient. Our results identify the habitat features that appear to drive the habitat models when applied to small trout streams that have been minimally altered by man in the central Rocky Mountains.

Codes: multi reach quant instream ifim warning method hem

Kozel, S. J., W. A. Hubert, and M. G. Parsons. 1989. Habitat features and trout abundance relative to gradient in some Wyoming streams. Northwest Science 63: 175-182.

Channel gradient has been shown to have a negative relation to trout standing stocks indicating that separation of stream channels into gradient classes may provide a better understanding of the relationships between habitat and trout abundance. Our major objective was to determine if there are significant differences in habitat features and standing stocks of trout > 100 mm between two classes of channel gradient, low (0.1-1.4% channel slope) and moderate (1.5-4.0%). We also determined statistical relations between habitat features and trout standing stocks in each class of channel for unaltered streams on the Medicine Bow National Forest, Wyoming. Low-gradient reaches were found to have deeper nearshore water depths, more undercut banks, and more trench pools than moderate-gradient reaches, while moderate-gradient reaches had more cobble substrate, dammed pools formed by woody debris, and plunge pools. The mean standing stock was 267 kg/ha in low-gradient reaches and 102 kg/ha in

moderate-gradient reaches. Habitat features correlated with trout standing stocks differed between the two gradient classes.

Codes: multi reach quant instream substrate

Kruse, C. G., W. A. Hubert, and F. J. Rahel. 1997. Geomorphic influences on the distribution of Yellowstone cutthroat trout in the Absaroka Mountains, Wyoming. TAFS 126: 418-427.

Influences of large-scale abiotic, geomorphic characteristics on distributions of Yellowstone cutthroat trout Oncorhynchus clarki bouvieri are poorly understood. We sampled 151 sites on 56 perennial streams in the Greybull-Wood river drainage in northwestern Wyoming to determine the effects of geomorphic variables on Yellowstone cutthroat trout distributions. Channel slope, elevation, stream size, and barriers to upstream movement significantly influenced the presence and absence of Yellowstone cutthroat trout. Wild populations of Yellowstone cutthroat trout were not found upstream of barriers to fish migration, at sites with channel slopes of 10% or greater, or at elevations above 3,182 m. Based on channel slope alone, logistic regression models correctly classified presence or absence of Yellowstone cutthroat trout in 83% of study sites. The addition of elevation and stream size in the models increased classification to 87%. Logistic models tested on an independent data set had agreement rates as high as 91% between actual and predicted fish presence. Large-scale geomorphic variables influence Yellowstone cutthroat trout distributions, and logistic functions can predict these distributions with a high degree of accuracy.

Codes: multi reach qual instream lulc

Kucera, P. A., and D. B. Johnson. 1986. Biological and Physical Inventory of the Streams within the Nez Perce Reservation: Juvenile Steelhead Survey and Factors that Affect Abundance in Selected Streams in the Lower Clearwater River Basin, Idaho. DE87-009919. DOE Report No. DOE/BP/10068--T1. National Technical Information Service, Springfield VA. 22161.

A biological and physical inventory of selected tributaries in the lower Clearwater River basin was conducted by the Nez Perce Tribe Department of Fisheries Management during 1983 and 1984. The purpose of the juvenile steelhead study was to collect information for the development of alternatives and recommendations for the enhancement of the anadromous fish resources in streams on the Nez Perce Reservation. Five streams within the Reservation were selected for study: Bedrock and Cottonwood Creeks were investigated over a two years period (1983-1984) and Big Canyon, Jacks and Mission Creeks were studied for one year (1983). Biological information was collected and analyzed on the density, biomass, production and outmigration of juvenile summer steelhead trout. Physical habitat information was collected on available instream cover, stream discharge, stream velocity, water temperature, bottom substrate, embeddedness and stream width and depth. The present report focuses on the relationships between physical stream habitat and juvenile steelhead trout abundance. The downstream outmigration of juvenile steelhead principally occurred during the spring and fall periods. Fall pulses in downstream movement were generally reflected in short term increases in yearling fish densities at lower stream sampling stations. Abundance of yearling steelhead in the spring of 1984 (May-June) actually increased as the smolt outmigration was completed The redistribution of non-smolt age I+ fish into the sample station locations, apparently accounts for the increase. Genetic stock assessment of four Reservation stream steelhead populations indicated that two of the streams may have been affected by Dworshak Hatchery steelhead. The remaining two populations were more similar to steelhead from the grande Ronde, Imnaha and Salmon River systems. (Lantz-PTT).

Codes: multi quant migrat instream wtemp substrate

Kwak, T. J., and T. Waters. 1997. Trout production dynamics and water quality in Minnesota streams. TAFS 126: 35-48.

We sampled fish assemblages and quantified production dynamics of brook trout Salvelinus fontinalis, brown trout Salmo trutta, and rainbow trout Oncorhynchus mykiss in 13 southeastern Minnesota streams during 1988-1990 to examine the influence of water quality on fish populations in fertile trout streams. Fish assemblages in 15 stream reaches were abundant, but low in diversity; 13 species were collected. Parameter means (ranges) over the reaches were species richness, 4.1 (1-8); density, 29,490 (1,247-110,602) fish/ha; and biomass, 253.5 (49.6-568.6) kg/ha. Means (ranges) for salmonids were annual mean density, 2,279 (343-8,096) fish/ha; annual mean biomass, 162.0 (32.5-355.5) kg/ha; and annual production, 155.6 (36.7-279.6) kg /ha. Salmonid production and mean biomass were greater during the spring-fall interval than during fall-spring; young cohorts (ages 0-1) contributed the greatest proportion to population biomass and production. Salmonid annual production-to-mean-biomass ratio (P/B) averaged 1.06 (0.64-1.42), and means were significantly different among species (1.03 for brown trout, 1.54 for brook trout, and 1.92 for rainbow trout). A significant linear model was developed that describes P/B as an inverse function of population age structure and may be used to improve accuracy in approximations of annual production from mean biomass. Fish density, biomass, or production were not correlated with eight water quality variables describing ionic and nutrient content in these streams, but when data from other United States streams with a wide range in alkalinity were incorporated, salmonid production was strongly, positively correlated with alkalinity. The wide range in fish population and production statistics and their lack of correlation with water quality suggest that no uniform fish carrying capacity exists among these streams and that factors other than water fertility limit fish density, biomass, and productivity at this spatial scale, but the overall maximum production rate in the region may be governed by water quality.

Codes: multi reach popdyn quant watqual noenv

L'Abee-Lund, J. H., and T. G. Heggberget. 1995. Density of juvenile brown trout and Atlantic salmon in natural and man-made riverine habitats. Ecology of Freshwater Fish 4: 138-140.

The density of juvenile brown trout (Salmo trutta L.) and Atlantic salmon (Salmo salar L.) was significantly higher along river bank areas protected against erosion than along natural river banks in the River Gaula, Central Norway. A habitat shift appeared in Atlantic salmon, and a behavioural shift was demonstrated by brown trout from August to October. The effect of habitat on densities of juvenile salmonids should be taken into account as mitigation measures on eroded river banks and when assessing fish production in rivers.

Codes: experi reach quant instream ripar

La Voie, W. J. I., and W. A. Hubert. 1997. Late summer and fall use of stream margins of young-of year brown trout in a high-elevation stream. Journal of Freshwater Ecology [J. Freshwat. Ecol.] 12: 291-302.

The authors determined the relative abundance of young-of-year (YOY) brown trout (Salmo trutta) from late summer to fall during day and night in stream margin habitats of Douglas Creek, Wyoming. No significant differences in relative abundance were observed from August 14 through October 26. Few YOY brown trout were observed during the day over the entire sampling period, but significantly greater numbers were seen at night. Within stream margins, YOY brown trout of 36-75 mm total length primarily resided in concealment cover among interstices of cobble during the day and emerged at night. Because no significant change in relative abundance was observed throughout the study period, it is concluded that a shift to winter habitat did not occur up until three days prior to ice formation when the diurnal range in water temperature was 2.5-7.5 degree C.

Codes: experi habitat qual? instream substrate

Lee, D. C., and B. E. Rieman. 1997. Population viability assessment of salmonids by using probabilistic networks. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1144-1157.

Public agencies are being asked to quantitatively assess the impact of land management activities on sensitive populations of salmonids. To aid in these assessments, we developed a Bayesian viability assessment procedure (BayVAM) to help characterize land use risks to salmonids in the Pacific Northwest. This procedure incorporates a hybrid approach to viability analysis that blends qualitative, professional judgment with a quantitative model to provide a generalized assessment of risk and uncertainty. The BayVAM procedure relies on three main components: (1) an assessment survey in which users judge the relative condition of the habitat and estimate survival and reproductive rates for the population in question; (2) a stochastic simulation model that provides a mathematical representation of important demographic and environmental processes; and (3) a probabilistic network that uses the results of the survey to define likely parameter ranges, mimics the stochastic behavior of the simulation model, and produces probability histograms for average population size, minimum population size, and time to extinction. The structure of the probabilistic networks allows partitioning of uncertainty due to ignorance of population parameters from that due to unavoidable environmental variation. Although based on frequency distributions of a formal stochastic model, the probability histograms also can be interpreted as Bayesian probabilities (i.e., the degree of belief about a future event). We argue that the Bayesian interpretation provides a rational framework for approaching viability assessment from a management perspective. The BayVAM procedure offers a promising step toward tools that can be used to generate quantitative risk estimates in a consistent fashion from a mixture of information.

Codes: modeling risk philosophy popdyn

Leidholt-Bruner, K., D. E. Hibbs, and W. C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho salmon fry in two coastal Oregon streams. Northwest Science 66: 218-223.

Beaver (Castor canadensis) dams and coho salmon (Oncorhynchus kisutch) fry were examined for their relationships in two coastal Oregon streams in 1987. Our initial spring survey of 19 km of stream found only one dam still complete after winter. By autumn, the number of dams had increased to 1.1 and 1.2 per km on the two streams. Beaver dams increased summer pool habitat 7 to 14% over unmodified conditions. Although density of coho (per m super(2) and m super(3)) was similar among pool types, beaver ponds were larger and contained more coho fry than non-beaver pools; thus, beaver increased rearing habitat for coho during the late summer low flow. Beaver represent a low-cost tool deserving more consideration for stream rehabilitation projects.

Codes: multi reach quant instream

Leiner, S. 1995. Growth, mortality and production of brown and rainbow trout in New Mexico streams. Ribarstvo. Zagreb 53: 51-62.

Thirty-two representative trout sites in 15 high elevation New Mexico streams (1,661 - 2560 m above sea level) were sampled in 1988 and 1989. Fish (Salmo trutta, m. fario and Oncorhynchus mykiss) was captured by consecutive removal via electrofishing in net-blocked segments from 65 to 160 m long. Maximum estimated trout length (L sub(max)) was related inversely to yield. Instantaneous rate of mortality was also marginally related to yield. The production index ranged from 1.38 to 32.02 g/m super(2)/year. Variation in production was highly correlated to trout biomass. Trout growth and production were best defined by the relationships where: cover, stream width, water temperature, yield by anglers, L sub(max), and nitrate-nitrogen concentration were included.

Codes: multi quant popdyn instream watqual fishing

Leiner, S. 1996. The habitat quality index applied to New Mexico streams. Hydrobiologia 319: 237-249.

The accuracy of two trout biomass (standing stock) prediction models, developed for Wyoming streams by Binns & Eiserman (1979), was evaluated for New Mexico streams inhabited by brown trout, Salmo trutta L. and rainbow trout, Oncorhynchus mykiss Walbaum. Thirty-two representative sites in 15 different streams were sampled under summer low-flow conditions in 1988 and 1989. The 11 physical, chemical, and biological variables used in original models were used as independent variables for simple and multiple regression analysis designed to predict total trout biomass. Model I of Binns and Eiserman proved to be of limited utility; it explained 53% of the variation in total trout biomass at each of the New Mexico sites (kg/ha = 8.916 + 0.830/Model I/). Only 9.5% of the biomass variations was explained by Model II. Statistical analysis showed that trout biomass was significantly correlated with nitrate-nitrogen concentration and macroinvertebrate diversity in Model I. Because both variates are time consuming to estimate, Model I may not be any more cost-effective than sampling trout directly. The low predictive power of Model II probably indicates that it is limited to the geographical area of field measurement origin.

Codes: multi habitat quant instream warning watqual trophic

Leiner, S., and R. A. Cole. 1995. Habitat related models that predict rainbow and brown trout biomass in New Mexico streams. Ichthyos. Ljubljana 12: 13-41.

In contrast with other statistical models developed to predict trout biomass for management purposes, models developed during this study include fishing intensity and stocking variables, both of which are important management attributes that influence the relative contributions of other variables to management models. Thirty two sites on 15 high elevation streams were chosen to represent trout streams throughout state of New Mexico. Combined, brown (Salmo trutta) and rainbow (Oncorhynchus mykiss) trout biomass was simply correlated with nitrate-nitrogen concentration (r super(2) = 0.205; P = 0.009), zoobenthic biomass (r super(2) = 0.259; P = 0.003), and zoobenthic diversity (r super(2) = 0.472; P less than or equal to 0.001). Brown trout biomass was positively correlated with cover (r super(2) = 0.191; P = 0.012) and negatively correlated with fishing intensity (r super(2) = 0.152; P = 0.027). Rainbow trout biomass was positively correlated with zoobenthic biomass (r super(2) = 0.202; P = 0.010), zoobenthic diversity (r super(2) =0.588; P degree 0.001), nitrate-nitrogenconcentration (r super(2) = 0.135; P = 0.039) and nutrient (total nitrogen or total phosphorus) concentration (r super(2) = 0.125; P = 0.047). The model that explains the most variation (adjusted R super(2) = 0.831) of combined trout biomass included five physical, two chemical, one biological, and one angler-oriented attributes. More useful management models, which excluded the expensive biological variables, explained between 67 and 74 percent of trout biomass variation. The brown trout model that explained the greatest variation in biomass (R super(2) sub(a) = 0.779) included zoobenthos diversityand five other variables. More management efficient models excluded all biological variables and explained between 66 and 71 percent of brown trout biomass variation. The most explanatory model for rainbow trout biomass (R super(2) = 0.880) relied heavily on biological variables and no suitable management alternatives were found that did not include at least one biological variable.

Codes: multi reach quant instream wtaqual trophic fishing

Lek, S., A. Belaud, P. Baran, I. Dimopoulos, and M. Delacoste. 1996. Role of some environmental variables in trout abundance models using neural networks. Aquatic living resources/Ressources vivantes aquatiques. Nantes 9: 23-29.

Neural networks provide a "black box" model for explaining and predicting trout abundance with 8 environmental variables. This work investigates the specific effect of each variable, by inputting fictitious configurations of explanatory variables and by checking the responses of the model. The comparison between this response of the model to environmental variables on one hand, and results from field observations on the other hand, shows similarities and indicates neural network modelling can be trusted. The elevation appears to be the major explanatory factor. The influence of shelters, bottom velocity and Froude number also play an important role. When considered separately, depth does not have a notable influence on the density of trout. Such confirmations of field observations suggest that these models can be used to obtain a clear identification and hierarchization of the factors

influencing the abundance of trout and the mode of action of the factors. This approach can be extended to other applications in quantitative ecology in which non-linear relationships are usually observed.

Codes: modeling habitat quant instream

Levings, C. D., and R. B. Lauzier. 1991. Extensive use of the Fraser River basin as winter habitat by juvenile chinook salmon (Oncorhynchus tshawytscha). Can. J. Zool./J. Can. Zool. 69: 1759-1767.

Habitat in the low-water channel of the mainstem Fraser River and larger tributaries during winter may be an unappreciated factor influencing production of stream-type chinook salmon (Oncorhynchus tshawytscha) in this system. Data from electrofishing surveys showed that shorelines were used by juvenile chinook from river km 110 to km 770. Almost the entire mainstem was therefore probably winter habitat, and major tributaries such as the Thompson, Quesnel, and Nechako rivers were also used. Estimated chinook density on the mainstem Fraser increased with distance upstream (maximum 0.30 m super(-2) at km 750 (Prince George)), but the highest density (0.99 m super(-2)) in the surveys was observed on the Thompson River at Spences Bridge. The mean size of juvenile chinook decreased with distance upstream on the Fraser, ranging from 97 mm at km 110 to 65 mm at km 770. Chinook juveniles were feeding on Diptera, Trichoptera, and Plecoptera in winter. Some apparent growth was observed in the lower Fraser in early winter.

Codes: reach quant instream

Levings, C. D., and D. J. H. Nishimura. 1997. Created and restored marshes in the Lower Fraser River, British Columbia: Summary of their functioning as fish habitat.

Ecological comparisons of transplanted, natural (reference) and disrupted(unvegetated) marsh sites on the Fraser River estuary, British Columbia, were conducted between 1991 and 1994. The study examined vegetative biomass and cover, invertebrate abundance, fish abundance, fish residency, fish food, and submergence time for the three habitats. Standing crop biomass at 3 transplanted sites were within the range of values for reference sites but was much lower at an unstable site where sediment slumping had occurred. In all study reaches, abundance of invertebrates at transplant and reference sites was significantly higher than at disrupted sites. No significant difference was observed among marsh sites when chum salmon (Oncorhynchus keta) and chinook salmon (O. tschawytscha) fry abundance were compared. However, chinook and sockeyesalmon (O. nerka) smolt catches were significantly different among marsh sites and were usually higher at disrupted sites. The study shows that numerous factors need to be examined in determining if restored marshes will function as natural habitats. The development of a standardized set of reference criteria would assist in invaluating whether or not transplanted marshes are functioning as designed.

Codes: experi reach offchann trophic instream

Li, H. W., G. A. Lamberti, T. N. Pearsons, C. K. Tait, J. L. Li, and J. C. Buckhouse. 1994. Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. TAFS 123: 627-640.

In a study of cumulative effects of riparian disturbance by grazing on the trophic structure of high desert trout streams, watersheds with greater riparian canopy had higher standing crops of rainbow trout Oncorhynchus mykiss, lower daily maximum temperatures (range, 16-23 degree C compared with 26-31 degree C), and perennial flow. Watershed aspect influenced the response of trophic structure to grazing influences. Standing corps of rainbow trout were negatively correlated with solar radiation and maximum temperature in watersheds flowing northward. A different relationship was observed for a set of watersheds with a southern aspect, perhaps due to the presence of spring seeps and stream desiccation in the heavily grazed stream. Trout biomass was negatively correlated with solar radiation, whereas positive relationships were found for discharge and depth. Algal biomass was positively correlated with solar insolation ($r = 0.91$), total invertebrate biomass ($r = 0.77$), and herbivorous invertebrate biomass ($r = 0.79$) in all watersheds. Invertebrate biomass was not significantly correlated with rainbow trout

standing crop. High irradiance apparently resulted in increased algal biomass and invertebrate abundance. However, temperature elevations to levels close to lethal may impose high metabolic costs on rainbow trout, which may offset higher food availability and affect the availability of prey.

Codes: reach multi graz ripar wtemp trophic quant

Li, H. W., C. B. Schreck, C. E. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202. In Community and evolutionary ecology of North American stream fishes. W. J. Matthews and D. C. Heins, editors. University of Oklahoma Press, Norman, OK.

Recent structural alterations to watersheds of the Pacific Northwest have changed the ecological setting for fish assemblages. Dams have acted as physical zoogeographic barriers and may have increased the importance of fish diseases both of zoogeographic barriers and as mechanisms structuring fish assemblages. The impoundments favor the establishment of exotic, temperate mesotherms and eurytherms from the Midwest. Forestry, grazing, and bank-stabilization practices have changed the morphology of watersheds and diminished the role of large woody debris and riparian vegetation. Fishing has depleted juvenile Oncorhynchus tshawystscha, and certain other species no longer support commercial fisheries. Harvesting of salmonids has led to a significant reduction of nutrient input to nutrient-poor stream complexes. Stock depletion has given rise to hatcheries that now produce fish that are different genetically from the ancestral populations.

Codes: multi reach qual graz ripar

Lim, P., G. Segura, A. Belaud, and C. Sabaton. 1993. Study of the habitat of brown trout (Salmo trutta fario). Role of artificial and natural covers on trout populations. Edited by J. P. Grandmottet, J. P. Masson, G. Balvay and J. Verneaux. 373-396 p.

The aim of this study was to quantify the role of various cover types and examine their selection by brown trout. The study was developed on two river course sections in the Pyrenees: the river PIQUE (altitude 920 m NGF) and the river GER (altitude 390 m NGF), situated in the department of the Haute-Garonne (31). For the natural cover, we have experimented on three sets which have been transitionally blocked by wire netting; rocky river bank, undercut bank and woody debris. This has been performed on the river GER. Initially, the sector, for all these types of covers, had an average density of 2469 ind/ha for a biomass of 278 kg/ha. When the access to the covers is protected, the density stabilises to 1000 ind/ha, being a decrease in the order of 55% in density and biomass. According to the type of cover, the recolonisation, after 21 days of reopening of the covers, is estimated between 28 and 72% for the biomass and between 42 and 62% for the density. For the artificial covers, six types of building materials (brick, tile ...) have been experimented on the river PIQUE section (all natural covers having been removed). By type of covers and their location, the trout density varied from 3 to 23 ind/m super(2) of cover, and from 0.09 to 0.2 ind/m super(2) outside cover. Among the material used, we observed a clear preference for brick and, depending on the dispositions tested, the best results have been obtained with the covers placed near the banks, or being in the totality of the bed. The experiment has shown the major role the natural and artificial covers have on trout populations.

Codes: experi microhab quant instream

Linlokken, A. 1997. Effects of instream habitat enhancement on fish populations of a small Norwegian stream.

Weirs and pools were created by using an excavator on a 200 m long experimental section in a small tributary (mean discharge 0.95 m super(3)/s) of the River Glomma in southeastern Norway. The experimental section was once dredged to facilitate timber floating. The most abundant fish species in the stream were brown trout (Salmo trutta), bullheads (Cottus poecilopus) and minnows (Phoxinus phoxinus). Four weirs, placed in two pairs, were constructed to create 10 m wide, 15 m long and approximately 1.5 m deep pools. Small pools, 2-3 m wide and 0.7 m

deep, were distributed in the stream bed between the two pairs of weirs. The density of brown trout was annually estimated by means of the mark-recapture method for the first two years (1986-87) and by successive removal the last year before enhancement (1988) and annually during six years after the enhancement (1989-96, except in 1993-94). A reference section was sampled simultaneously, except in 1989. The mean density of brown trout on the experimental section was 18.3 per 100 m prior to enhancement, and increased by 200% after the construction of weirs. The increase was due to increased number of specimens > 10 cm, whereas number of specimens <10 cm (agegroups less than or equal to 1+) decreased. In 1996 the density was reduced close to the conditions before enhancement, and this was probably caused by a heavy flood in 1995, deteriorating the weirs followed by a cold winter with thin snow layer and a thick ice cover. Age group 2+ dominated in the pooled sample, and low representation of agegroups less than or equal to 1 + indicated that the brown trout stock on this section must be recruited by immigration from sections upstream.

Codes: experi quant migrat instream temporal

Lisle, T. E. 1986. Effects of woody debris on anadromous salmonid habitat, Prince of Wales Island, southeast Alaska. North American Journal of Fisheries Management 6: 538-550.

The effects of woody debris on anadromous salmonid habitat in eight streams on Prince of Wales Island, southeast Alaska, were investigated by comparing low-gradient (1-9%) first- or second-order streams flowing through either spruce-hemlock forests or 6-10 year-old clear-cuts, and by observing changes after debris was selectively removed from clear-cut reaches. Woody debris decreased the rate of shallowing as discharge decreased, thus helping to preserve living space for fish during critical low-flow periods. Debris dams were more frequent in clear-cut streams (14.9/100 m), which contained more debris, than in forested streams (4.2/100 m). As a result, total residual pool length (length when pools are filled with water but there is no flow) and length of channel with residual depth greater than 14 cm--the depth range occupied by 84% of coho salmon (Oncorhynchus kisutch)--were greater in clear-cut streams than in forested streams. Greater volumes of woody debris in clear-cut streams produced greater storage of fine sediment (<4-mm diameter) unless the stream gradient was sufficiently high to flush sediment from storage. One-half of the debris dams broke up or were newly formed over a 3-year period, which suggests that they usually released sediment and woody debris before the pools they formed were filled with sediment. Woody debris removal decreased debris-covered area, debris dam frequency, and hydraulic friction in some cases but, in others, these variables were unaffected or recovered within 2 years after erosion and adjustment of the streambed. No consistent differences in pool dimensions were found between treated and untreated clear-cut reaches. Comparisons of habitat in forested and clear-cut streams suggested that removing debris from clear-cut streams reduced salmonid carrying capacity. Retention and natural reformation of debris dams in cleared reaches prevented the expected deterioration of habitat. However, the removal and destabilization of existing woody debris may cause depletion of debris before riparian trees can regrow and furnish new material to the clear-cut streams.

Codes: multi nofish ripar instream substrate lwd

Loar, J. M. 1985. Application of habitat evaluation models in southern Appalachian trout streams. Final project report. Report ORNL/TM-9323.

Habitat evaluation models are being widely used to identify instream flow requirements for aquatic biota at hydroelectric projects and other water resource developments. A study was conducted to evaluate the validity of physical habitat indices for predicting the response of trout (Salmo gairdneri) populations to changes in stream-flow. Because the use of habitat indices is based on the assumption that fish abundance or biomass is positively correlated with the value of the habitat index, the study focused on an analysis of fish-to-habitat relationships. Eight study sites on cold water streams with naturally reproducing populations of brown and rainbow trout were selected. Fish biomass, abundance, and production were estimated, using electrofishing and Petersen mark-recapture techniques. Physical habitat was quantified, using the IFIM's Physical Habitat Simulation (PHABSIM) system at

each site. Habitat condition alone was not sufficient to explain differences in rainbow trout abundance. (Environ. Sci. Div. No. 2383.).

Codes: reach quant microhab instream ifim warning hem

Lobon-Cervia, J. 1996. Response of a stream fish assemblage to a severe spate in northern Spain. Transactions of the American Fisheries Society 125: 913-919.

I assessed the effects of a devastating spate upon the populations of brown trout Salmo trutta, Atlantic salmon S. salar, and European eel Anguilla anguilla of the Esva River basin in northern Spain. Numbers and lengths were determined for fish sampled with electrofishing techniques at nine sites along three streams before and after the spate. In addition, brown trout and Atlantic salmon that had been marked in two streams prior to the spate permitted a direct evaluation of the immediate effects. Because the spate occurred at the spawning time and destroyed reproductive habitats, I also determined its effects upon the recruitment of that year-class of brown trout. There was no evidence of negative effects of the spate upon the variables examined. The persistence of the site-specific populations after the spate was independent of site characteristics and the corresponding numbers and sizes of fish. The recruitment of brown trout was successful and similar to that of previous years. I hypothesize that mechanical responses related to microhabitat use permit brown trout and Atlantic salmon to withstand spates.

Codes: experi reach quant hydro noenv

Lonzarich, D. 1992. Patterns of community structure and microhabitat use by stream fishes in three Washington streams. Northwest Science 66: 137.

Studies on the ecology of streams in the Pacific Northwest focus almost exclusively upon salmonids and have consequently biased our views of how these systems function and respond to land-use disturbances. An approach is advanced here that integrates information on the biology of other stream fishes with knowledge of salmonids to better evaluate the impacts of stream disturbance. Comparisons are made of fish assemblages in different streams examining relationships with habitat structure and flow regime. Further, potential inter-relationships among species are examined through studies of habitat and microhabitat use. Seasonal electro-shocking and snorkeling surveys were conducted three Washington streams from summer 1990 to the present.

Codes: multi reach quant sppinter instream hydro

Lorenz, J. M., and J. H. Eiler. 1989. Spawning habitat and redd characteristics of sockeye salmon in the Glacial Taku River, British Columbia and Alaska. Transactions of the American Fisheries Society 118: 495-502.

Spawning habitats of sockeye salmon Oncorhynchus nerka in the Taku River and its tributaries in British Columbia and Alaska were studied to determine habitat use and redd characteristics in a glacial river system. We used radiotelemetry to track adult sockeye salmon to 26 spawning reaches, and 63 spawning sites were sampled for habitat characteristics. Over 40% of the sockeye salmon in the sampling area had a freshwater age of zero, and most of these spawned in main channels or off-channel areas. The availability of upwelling groundwater influenced habitat use in the main stem of the river; upwelling groundwater was detected in nearly 60% of the sites sampled in main-stem areas. Spawning sites with upwelling groundwater had lower water velocities and more variable substrate compositions than sites without upwelling groundwater.

Codes: multi reach qual spawn migrat instream hydro

Maeki-Petaeys, A., T. Muotka, and A. Huusko. 1999. Densities of juvenile brown trout (Salmo trutta) in two subarctic rivers: Assessing the predictive capability of habitat preference indices. 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: 1420-1427.

The applicability was examined of habitat preference indices for predicting density variations of age-0 brown trout (Salmo trutta) in two rivers in northern Finland. Trout densities in these rivers were monitored for 7 or 8 years. Habitat suitability for trout fry was assessed using summer and winter preference curves for water velocity, depth, and substrate. Substrate suitability indices based on summer preference curves explained 21-74% of the among-site variation in trout densities. The negative effect of high discharge on trout abundance was best predicted by the composite depth x substrate index. Sites with the highest apparent survival (density of age-1 trout in year t versus density of age-0 trout in year t - 1) produced high indices when winter substrate curves for age-0 trout were used, indicating high immigration rates to these sites. This study shows that when preference indices are used for predictive purposes, the mechanisms underlying habitat bottlenecks must be known. In boreal areas, winter presents a bottleneck period forjuvenile salmonids, and the importance is stressed of using winter habitat curves when habitat hydraulic models are applied to areas with severe winter conditions.

Codes: multi reach microhab quant popdyn instream substrate warning hem

Manske, M., and C. J. Schwarz. 2000. Estimates of stream residence time and escapement based on capture-recapture data. Canadian Journal of Fisheries and Aquatic Sciences 57: 241-246.

The area-under-the-curve method is a widely used method for estimating salmon escapement. The method depends on obtaining an accurate estimate of stream residence time, or stream life. This paper develops an estimator of stream residence time based oncapture-recapture data. If the capture-recapture experiment is performed on the entire population, the escapement can also be estimated using the area-under-the-curve method. Simulations showed that the stream residence estimator and the area-under-the-curve estimator provide precise estimates of stream residence and escapement, respectively. These methods were used to estimate the stream residence times and escapements of coho salmon (Oncorhynchus kisutch) in a small river on Vancouver Island in 1989 and 1990.

Codes: method quant migrat

Marchand, F., and D. Boisclair. 1998. Influence of fish density on the energy allocation pattern of juvenile brook trout (Salvelinus fontinalis). CJFAS 55: 796-805.

The objectives of this study were 1) to assess the influence of fish density on the energy allocation pattern of juvenile brook trout (Salvelinus fontinalis) and 2) to define the mechanism by which this influence occurs. Growth, consumption, and activity rates were estimated of brook trout held in 8-m super(3) enclosures characterized by two different densities (four or eight fish per enclosure; D4 and D8 enclosures, respectively). Eight experiments designed to estimate these variables were performed during a 27-day period. Fish from D4 enclosures grew twice as much as those from D8 enclosures. For any given experiment, consumption rates were not significantly different between the two fish densities (0.434-1.09 g dry - 100 g wet super(-1) times day super(-1)). Fish stocked in D8 enclosures displayed more agressive behavior, executed 5.5 times more movements, and swam at speeds 13% faster than fish in D4 enclosures. These differences resulted in activity rates fourfold higher in D8 enclosures than in D4 enclosures. Empirical analyses combining results with published values of growth, consumption, and activity rates supported the hypothesis that competition can have a negative effect on growth through a decrease in consumption rates and an increase in activity costs.

Codes: experi enclos quant popdyn trophic

Marschall, E. A., and L. B. Crowder. 1996. Assessing population responses to multiple anthropogenic effects: a case study with brook trout. Ecological Applications 6: 152-167.

Population declines are often caused by multiple factors, including anthropogenic ones that can be mitigated or reversed to enhance population recovery. We used a size-classified matrix population model to examine multiple anthropogenic effects on a population and determine which factors are most (or least) important to population dynamics. We modeled brook trout (Salvelinus fontinalis) in southern Appalachian mountain streams responding to multiple anthropogenic effects including the introduction of an exotic salmonid species (rainbow trout, Oncorhynchus mykiss), a decrease in pH (through acidic deposition), an increase in siltation (from roadbuilding and logging), and an increase in fishing pressure. Potential brook trout responses to rainbow trout include a decrease in survival rate of small fish, a change in density dependence in survival of small fish, and a decrease in growth rates of all sizes. When we included these responses in the population model, we found that population size tended to decrease with an increase in small-fish growth rate (producing a population with fewer, but larger, fish). In addition, changes in patterns of density-dependent survival also had a strong impact on both population size and size structure. Brook trout respond to decreases in pH with decreased growth rate in all size classes, decreased survival rates of small fish, and decreased egg-to-larva survival rates. This combination of effects, at magnitudes documented in laboratory experiments, had severe negative impacts on the modeled population. If siltation effects were severe, the extreme increase in egg-to-larva mortality could have strong negative effects on the population. However, even very strong increases in large fish mortality associated with sport harvesting were not likely to cause a local extinction. In all of these cases, the interaction of drastic changes in population size structure with randomly occurring floods or droughts may lead to even stronger negative impacts than those predicted from the deterministic model. Because these fish can reproduce at a small size, negative impacts on survival of the largest fish were not detrimental to the persistence of the population. Because survival of small juveniles is density dependent, even moderate decreases in survival in this stage had little effect on the ultimate population size. In general, a brook trout population will respond most negatively to factors that decrease survival of large juveniles and small adults, and growth rates of small juveniles.

Codes: modeling popdyn substrate

Marshall, D. E., and E. W. Britton. 1990. Carrying capacity of coho salmon streams. CAN. MANUSCR. REP. FISH. AQUAT. SCI. 2058: 38.

The carrying capacity of coho (Oncorhynchus kisutch) salmon streams was analyzed by comparing coho smolt yields (expressed as numbers and biomass) with rearing space (expressed as length and area of stream accessible to spawners). The two smolt yield variables and the two rearing space variables were analyzed for a linear relationship using the equation y = a + bx, and for a curvilinear relationship using the equation y = ax super(b). The goodness of fit (r) of data points to the two regression types was then compared. The data were obtained from the literature and unpublished sources, and included one or more years of smolt output data, and data on length and/or area for 21 streams, 2 ponds and 2 side channels.

Codes: multi reach quant spawn noenv

Martin, D. J., L. J. Wasserman, and V. H. Dale. 1986. Influence of riparian vegetation on posteruption survival of coho salmon fingerlings on the west-side streams of Mount St. Helens, Washington. North American Journal of Fisheries Management 6: 1-8.

The 1980 eruption of Mount St. Helens impacted salmon streams on the west side of the mountain primarily by debris and mud deposits; depositions of ash and large wood were relatively minor disturbances. We examined factors related to juvenile coho salmon (Oncorhynchus kisutch) disappearance during the summer and winter months of 1981 and 1982. Correlations exist between the survival of anadromous fish, instream vegetative debris cover, and water temperature. Summer mortality was related to high stream temperatures and winter mortality to the lack of large organic debris. Recovery of riparian vegetation would reduce stream temperatures and cause debris to be retained. Tree growth data suggest trees will be tall enough to effectively shade the third- and fourth-order

streams in 5-20 years, and that it will be 50-75 years before the trees are large enough to create organic debris structures when they fall into a stream. These results imply that management activities that promote large organic debris will enhance fish survival.

Codes: experi multi reach qual ripar substrate

Martin, D. J., L. J. Wasserman, R. P. Jones, and E. O. Salo. 1984. Effects of Mount St. Helens eruption on salmon populations and habitat in the Toutle River. Report FRI-UW-8412. experi reach popdyn instream lwd substrate.

The eruption of Mount St. Helens on May 18, 1980 caused massive devastation of fishery resources in the Toutle River watershed. Catastrophic changes caused by the debris avalanche, pyroclastic flows and mudflows destroyed fish populations and 218 km (77 percent) of the 280 km of anadromous fish habitat formerly utilized by salmonids. Adult salmon spawned in unstable volcanic substrates with average concentrations of fine particles ranging from 11.2 percent to 36.0 percent in 1981 and from 11.2 percent to 33.5 percent in 1982. Survival of eggs to hatching stage in volcanic substrate ranged from 50 percent to 95 percent. Any success was attributed to groundwater upwelling. Juvenile coho mortality ranged from 0 percent to 83 percent during the summer period and was closely associated with high water temperature. Mortality during winter ranged from 62-83 percent in unaffected streams and 82-100 percent in affected streams and was associated with channel stability, suspended sediment, and the amount of cover provided by large organic debris.

Codes: experi reach popdyn instream lwd substrate

Mather, M. E. 1998. The role of context-specific predation in understanding patterns exhibited by anadromous salmon. Canadian Journal of Fisheries and Aquatic Sciences 55: 232-246.

Predation is frequently studied in aquatic systems that contain salmon. Because these systems are difficult to manipulate and replicate, rigorous across-system comparisons are essential. Herein I review the literature on factors that may influence predation across systems. Specifically, I evaluated how often predation on salmonids was important across prey taxa, life stage, habitat, predator taxa, methodology, and spatial scale. Further, I examined what factors were influential in systems where predation was important. In nine journals from 1959-1996, 45 field studies explicitly tested the importance of direct effects of predation on anadromous salmonid prey. Authors of 36 (80%) studies concluded that predation was important. More studies in which predation was deemed important focused on smolts subjected to fish predation in the transitional river and estuary habitats. Furthermore, field surveys at larger spatial scales were most often used. Finally, most studies reported little information on confounding factors that complicate predation. If we are to learn from these complex systems, we need to collect, analyze, and report similar types of information that are collected across systems and years using rigorous and systematic methods.

Codes: review habitat reach sppinter warning

Matthews, K. R., N. H. Berg, D. L. Azuma, and T. R. Lambert. 1994. Cool water formation and trout habitat use in a deep pool in the Sierra Nevada, California. Transactions of the American Fisheries Society 123: 549-564.

The authors documented temperature stratification in a deep bedrock pool in the North Fork of the American River, described the diel movement of rainbow trout Oncorhynchus mykiss and brown trout Salmo trutta, and determined whether these trout used cooler portions of the pool. From July 30 to October 10, 1992, the main study pool and an adjacent pool were stratified (temperature differences between surface and bottom were as great as 4.5 degree C) on all but two days. Six rainbow and one brown trout equipped with temperature-sensitive radio transmitters used water with temperatures ranging from 12 to 19.3 degree C. During the late afternoon, when the widest range of water temperature was available, trout were found in temperatures up to 19.3 degree C even though cooler (14.5

degree C) water was available. Radio tracking indicated that fish were significantly more active and had significantly larger home ranges at night; fish were least active during the day. Because we found no evidence of subsurface seepage into the pool and water flowing into the pool was warmer than the pool's maximum temperature, we concluded that the geometry and depth of deep pools may moderate elevated summer water temperatures that can stress trout populations.

Codes: habitat microhab qual instream wtemp

May, C. W., E. B. Welch, R. R. Horner, J. R. Karr, and B. W. Mar. 1997. Quality Indices for Urbanization Effects in Puget Sound Lowland Streams.

The Puget Sound lowland (PSL) ecoregion contains an abundance of complex and historically productive salmonid habitat in the form of small streams as well as their riparian forests and wetlands. These watersheds are under intense pressure due primarily to the cumulative effects of urban development. Instream habitat characteristics, riparian conditions, physio- chemical water-quality, and biological attributes of 22 PSL streams (120 survey reaches) were studied over a gradient of development levels to determine relationships between urbanization and stream quality and suggest target conditions for management/protection. Urbanization of PSL watersheds has resulted in an increase in the fraction of total impervious area (% TIA) and a decrease in forested area, including a significant loss of natural riparian forests and wetlands. The cumulative effects of a modified hydrologic (distrubance) regime, the loss of instream structural complexity, and the alteration of channel morphological characteristics accompanying urbanization have resulted in substantial degradation of instream habitat during the initial phases of the development process.

Codes: multi reach nofish ripar instream

McMahon, T. E., and L. B. Holtby. 1992. Behaviour, habitat use, and movements of coho salmon (Oncorhynchus kisutch) smolts during seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 49: 1478-1485.

Coho salmon (Oncorhynchus kisutch) smolts formed aggregations in pools with large woody debris during their migration downstream and into the Carnation Creek estuary, British Columbia. Smolts utilized the estuary throughout the smolt run, with periods of high outmigration coinciding with spring tides which brought warmer, more saline water into the estuary. Smolt abundance in the stream and estuary was positively related to debris volume, and 82% of the 1260 smolts observed during underwater counts occurred within 1 m of debris. Debris volume and smolt density were significantly lower in clearcut than in buffered stream sections. Our observations support the need to retain and manage large woody debris for smolt habitat in streams and estuaries.

Codes: reach quant migrat lwd ripar

McMenemy, J. R. 1995. Survival of Atlantic salmon fry stocked at low density in the West River, Vermont. North Am. J. Fish. Manage. 15: 366-374.

Fry of Atlantic salmon Salmo salar stocked at low density (32/100 m super(2); plus or minus 0.7, SE) in the West River, Vermont, produced underyearling and yearling parr densities of 13.5 plus or minus 0.8/100 m super(2) and 5.9 plus or minus 0.5/100 m super(2), respectively. Survival of fry stocked at low density to underyearling and yearling parr was 42 plus or minus 2.5% and 19 plus or minus 1.3%, respectively. Density of underyearling parr produced from fry stocked at low density was not significantly different from the 10.6 plus or minus 1.5 parr produced from fry stocking at high density (mean, 117 plus or minus 16.5/100 m super(2)). However, the 4.0 plus or minus 0.8 yearling parr/100 m super(2) produced was significantly lower at high stocking density. Survival to underyearling and yearling parr at high stocking density was 11.6 plus or minus 2.0% and 4.6 plus or minus 1.0%, respectively, both significantly lower than survival rates at low stocking density. Thus, low-density stocking produced equal or greater densities of parr with much higher survival rates. Estimated smolt production from low-

density fry stocking (with the assumption of a parr-to-smolt overwinter survival rate of 65%) was about 4.0 smolts/100 m super(2); this is equivalent to a fry-to-smolt survival rate of 13%. Results from stocking fed and unfed fry were similar, except fed fry were more likely to produce yearling smolts. Managers of restoration and enhancement programs with limited broodstock, eggs, or incubation space should be able to produce more smolts by stocking fry at lower densities over wider areas without affecting per-unit-area smolt production.

Codes: experi reach quant popdyn noenv

McMichael, G. A., and T. N. Pearsons. 1998. Effects of wild juvenile spring chinook salmon on growth and abundance of wild rainbow trout. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 127: 261-274.

We investigated some of the ecological impacts to rainbow trout Oncorhynchus mykiss that could occur by supplementing spring chinook salmon O. tshawytscha in the upper Yakima River basin, Washington. Controlled field experiments conducted in three different streams indicated that presence of wild juvenile spring chinook salmon did not adversely affect growth of wild rainbow trout in high-elevation tributaries. Experiments at two spatial scales, habitat subunit and stream reach scales, were used to detect impacts. Insmall-enclosure experiments conducted in two tributaries to the Yakima River in 1993 and 1994, specific growth rates (SGRs) of wild rainbow trout paired with wild juvenile spring chinook salmon were not significantly lower than SGRs of their unpaired counterparts (1993: P = 0.360; 1994: P = 0.190). Stream reach experiments in another Yakima River tributary in 1995 also indicated that introductions of wild juvenile spring chinook salmon into 100-m-long enclosures, at a numerical density equal to the preexisting wild rainbow trout, did not adversely affect rainbow trout growth or abundance. The mean fork length (FL) and instantaneous growth rate (IGR) of age-O wild rainbow trout in stream reach enclosures were unaffected by introduced spring chinook salmon after 7 (FL: P = 0.318) and 14 weeks (FL: P = 0.387, IGR: P = 0.265) in sympatry. Mean fork lengths and IGRs of age-1 rainbow trout were also unaffected by the addition of the spring chinook salmon after 7 weeks (FL: P = 0.553, IGR: P = 0.124) and 14 weeks (FL: P = 0.850, IGR: P = 0.084) of cohabitation. Furthermore, the stream reach experiment showed that spring chinook salmon introduction did not affect rainbow trout abundance (P = 0.298) or biomass (P = 0.538). Site elevation in the stream reach tests appeared to influence rainbow trout size more than the addition of juvenile spring chinook salmon. Site elevation was negatively correlated with length of wild age-O (P < 0.001) and age-1 (P < 0.001) rainbow trout in October 1995. It appears that rainbow trout and spring chinook salmon partitioned the resources so that impacts were not detected. Our work suggests that rainbow trout have a refuge from interactions with juvenile spring chinook salmon in high-elevation portions of tributaries (e.g., over 700 m).

Codes: experi multi habitat enclos reach quant popdyn sppinter

MDFG. 0. The effect of cattle grazing on brown trout in Rock Creek, Montana. Montana Department of Fish and Game Special Report

Studies of a natural, free-flowing stream section with densely vegetated banks showed better fish population structure than a contiguous section flowing through a heavily grazed area. The natural area supported 4,645 brown trout per hectare at 238.8 kilograms per hectare compared to 1,732 browns at 71.0 kg/ha n the overgrazed area. Thus, the biomass of brown trout was 3.4 times greater in the natural area. Species other than brown trout were 20% more numerous in the grazed area. Large numbers of juvenile mountain whitefish accounted for the difference. The natural area possessed fewer numbers of other fish, but they exceeded the biomass of the grazed area by 87%. The ungrazed section had 82% more cover per hectare of stream than the grazed section. Marked differences in floristic composition and density of herbaceous vegetation was evident between the two areas. Overgrazing and subsequent stream course alteration had essentially eliminated tall and low shrub strata. The combination of too many cattle, reduced vegetation and poor soils led to 80% more stream channel alteration in the grazed area. In addition, the stream channel was wider, shallower and continually migrated within the grazed area.

Codes: reach experi graz quant

Mesick, C. F. 1995. Response of brown trout to streamflow, temperature, and habitat restoration in a degraded stream. Rivers 5: 75-95.

In Rush Creek, California, historical dewatering, flooding, grazing, and gravel operations reduced the quantity of gravel, woody debris, and pool habitat; widened and incised the channel in the downstream reaches; and restricted the riparian vegetation to a narrow band along the stream margin. This study monitored the self-reproducing brown trout (Salmo trutta) population in degraded and undisturbed reaches from 1985 to 1993, primarily to determine the response to streamflow and restoration work. High streamflow in conjunction with fluctuating temperatures during winter reduced survival of juvenile trout and growth rates of all ages. Maximum summer water temperatures were also negatively correlated with growth and survival rates. Moderate summer streamflows reduced temperature fluctuations, particularly in the downstream segments, thereby improving growth and survival; however high summer flows reduced growth rates and eliminated large prey. The availability of large prey resulted in high growth and survival in spite of high summer temperatures. Survival and growth were positively correlated with the amount of pool habitat, water depth, and streambed complexity, particularly when winter flows and summer water temperatures were high. Gravel availability and young-of-the-year production increased with high flows prior to spawning. However, moderate flows mobilized instream gravel without providing gravel recruitment. Gravel added to the stream as part of restoration work increased young-of-the-year densities, particularly in the reaches where gravel was placed. Large pools excavated in the main channel that had root wads and clusters of boulders added for cover increased growth rates but did not increase survival when winter flows were high. Rewatered side channels, some with excavated pools, were utilized by few trout but increased survival and growth when winter flows were high.

Codes: reach exper graz ripar instream hydro quant popdyn

Metcalfe, N. B., N. H. C. Fraser, and M. D. Burns. 1999. Food availability and the nocturnal vs. diurnal foraging trade-off in juvenile salmon. Journal of Animal Ecology 68: 371-381.

Much attention has been devoted to explaining the spatial distribution of foraging animals, but rather little to their temporal distribution (i.e. whether they are diurnal, nocturnal or crepuscular). Many animals face predictable diel cycles of food availability or predation risk, and so the approach of measuring the relative ratio of mortality risk to food gained (the `minimize mu /f rule) can be applied equally as well to different time periods of the day as to alternative food patches or habitats. 2. This method is used here to investigate the diel activity patterns of juvenile Atlantic salmon, which have previously been shown to become increasingly biased towards nocturnal activity in winter, hiding for much of the day in streambed refuges. Calculations based on published data show that nocturnal foraging in winter is far safer per unit of food obtained than is diurnal, despite greatly reduced food capture efficiency at night-time light levels. 3. Using an automated activity monitoring system based on passive integrated transponder (PIT) tags, this study shows that winter diel activity patterns in salmon are dependent on food availability. A change in food density led to a parallel change in time spent in the refuge, but (as predicted by the mu /f rule) the effect was greatest at the time of day with the least favourable ratio of predation cost to feeding benefit. Thus an experimental increase in food availability led to a 16% reduction in time spent in nocturnal foraging but a 98% reduction in time spent foraging by day, with fish spending only 0 times 6% of the daylight hours out of the refuge at the highest food density. 4. However, brief daytime foraging bouts had a major impact on growth rates (presumably because feeding efficiency was much greater in daylight), especially when food was scarce. Daytime feeding was thus profitable in terms of rapid food acquisition but normally suboptimal in terms of risk of predation. 5. Daily activity patterns are therefore suggested to be the result of a complex tradeoff between growth and survival, which takes account of diel fluctuations in food availability, food capture efficiency and predation risk; individual variation in the extent of diurnal feeding in salmon may result from state-dependent differences in the benefits of rapid feeding and growth.

Codes: experi habitat quant popdyn trophic instream

Meyer, K. A., and J. S. Griffith. 1997. Effects of cobble-boulder substrate configuration on winter residency of juvenile rainbow trout. North American Journal of Fisheries Management 17: 77-84.

We assessed first winter habitat use by placing wild rainbow trout Oncorhynchus mykiss (52-155 mm total length) in wire-mesh enclosures with different cover treatments and at varying fish densities. Cobble-boulder substrates (20-40 cm diameter) were arranged in four different configurations: (1) no cobble-boulders, (2) cobble-boulders present but not touching, (3) cobble-boulders touching in a single layer, and (4) cobble-boulders touching and stacked in two layers. As the configuration of rock substrate was changed to create more concealment cover, the number of fish remaining in the enclosures after 96 h increased significantly, even though the quantity of rock substrate did not change. The initial stocking density of fish had no overall significant effect on the number of fish remaining in enclosures after 96 h. However, analysis of each cover x density treatment showed that when the substrate arrangement created little concealment cover, the number of fish remaining in the enclosures did not increase with an increase in initial fish density, but when the substrate arrangement created relatively more concealment cover, more fish remained in the enclosures when the initial fish density was increased. In trials with rock cover present, fish emigrating from the enclosures were larger than those remaining in the enclosures. Our results demonstrate the importance of the configuration of cobble-boulder substrate in determining its suitability as winter cover for rainbow trout.

Codes: experi enclose habitat quant substrate

Milner, A. M., E. E. Knudsen, C. Soiseth, A. L. Robertson, D. Schell, I. T. Phillips, and K. Magnusson. 2000. Colonization and development of stream communities across a 200-year gradient in Glacier Bay National Park, Alaska, U.S.A. CJFAS 57: 2319-2335.

In May 1997, physical and biological variables were studied in 16 streams of different ages and contrasting stages of development following glacial recession in Glacier Bay National Park, southeast Alaska. The number of microcrustacean and macroinvertebate taxa and juvenile fish abundance and diversity were significantly greater in older streams. Microcrustacean diversity was related to the amount of instream wood and percent pool habitat, while the number of macroinvertebrate taxa was related to bed stability, amount of instream wood, and percent pool habitat. The percent contribution of Ephemeroptera to stream benthic communities increased significantly with stream age and the amount of coarse benthic organic matter. Juvenile Dolly Varden (Salvelinus malma) were dominant in the younger streams, but juvenile coho salmon (Oncorhynchus kisutch) abundance was greater in older streams associated with increased pool habitat. Upstream lakes significantly influenced channel stability, percent Chironomidae, total macroinvertebrate and meiofaunal abundance, and percent fish cover. Stable isotope analyses indicated nitrogen enrichment from marine sources in macroinvertebrates and juvenile fish in older streams with established salmon runs. The findings are encapsulated in a conceptual summary of stream development that proposes stream assemblages to be determined by direct interactions with the terrestrial, marine, and lake ecosystems.

Codes: multi reach temporal qual lakehydro trophic instream lwd

Milner, N. J., R. J. Hemsworth, and B. E. Jones. 1985. Habitat evaluation as a fisheries management tool. Journal of Fish Biology 27 (suppl. A): 85-108.

The application, rationale and process of habitat evaluation methods are discussed in the context of present day fisheries management. The need to consider habitat features at site and catchment level is stressed. Development of habitat evaluation techniques for assessing brown trout (Salmo trutta) habitat in Welsh streams is reported, and examples of these approaches are given: qualitative (visual assessment), semi-quantitative (a combination of subjective and quantitative measurements) and quantitative measurements on transect system). Habitat attribute-fish population models were based on functional linear regressions and multiple regression (for the quantitative method). The problems associated with soft-water sites are discussed in terms of factors affecting site carrying capacity.

Codes: philosophy qual quant microhab instream hem

Milner, N. J., R. J. Wyatt, S. Barnard, and M. D. Scott. 1995. Variance structuring in stream salmonid populations, effects of geographical scale and implications for habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 387-398 p.

Trout (Salmo trutta, L.) and salmon (Salmo salar, L.) populations in streams exhibit temporal and spatial variation. However, the ability of habitat models (empirical models relating fish abundance to spatial features) to explain overall variance in abundance is restricted just to the spatial component. It is therefore important to be able to quantify the contribution from the spatial component to total variance. This allows assessment of both the potential maximum performance of models as well as their actual performance in relation to the maximum. Furthermore, such variance partitioning offers insight into the relative roles of spatial and temporal (synchronous) factors in influencing population abundance and how these vary according to the geographical scale of sampling. Habitat models (HABSCORE), recently developed for Welsh streams, were used to explain variance in a ten year data set for which temporal and spatial variance could be estimated. Spatial factors explained between 46 and 62 % of overall variance within the Conwy system. This identifies the maximum limits for the performance of such models working at this scale. With the exception of poor performance for salmon parr, the habitat models accounted for 60-95 % of the spatial component, corresponding to 38-46 % of overall variance. In addition, variance structure was compared at four different levels of analysis: within tributaries on the Conwy, within nine different large separate river systems, within three areas and within the region of Wales. Spatial variance increased from 22-42 % (means) at within-tributary level to 42-65 % at regional level. In contrast, temporal variance (a measure of synchrony in population variability) decreased from 24-39 % within tributaries to 0.7 - 9.0 % at regional level. At within-rivers and larger scale the temporal variance displayed in 0 super(+) abundance was consistently lower than that for >0 super(+) fish. Some of the factors influencing variability at the different geographical scales are briefly discussed.

Codes: multi reach quant instream lulc temporal hem

Milner, N. J., R. J. Wyatt, and K. Broad. 1998. HABSCORE--applications and future developments of related habitat models. Aquatic Conservation: Marine and Freshwater Ecosystems 8: 633-644.

The role of habitat evaluation methods (HEM) is briefly reviewed in the context of contemporary fisheries management. Management requirements of HEMs for fisheries purposes include setting spawning targets, and assessing compliance against these targets, environmental impact assessment, habitat protection and restoration, survey design, classification and reporting of fish and habitat resources. Currently available or emerging HEMs are compared against these management applications. 2. HABSCORE is a system of salmonid stream habitat measurement and evaluation based on empirical models of fish density against combinations of site and catchment features. An outline is provided of the derivation, performance and applications of HABSCORE. 3. The effectiveness of HABSCORE and other HEMs depends on their ability to explain the spatial component of variance seen in fish population data. Variance analysis of HABSCORE performance shows how the relative importance of spatial and temporal variance alters at different geographical scales, the latter (indicative of synchronous variation) being much more important within small tributaries. HEMs based only on catchment features explain significant proportions of spatial variance, demonstrating their potential in catchment-scale evaluation. 4. Other contemporary HEMs considered include PHABSIM, procedures to transport spawning targets between rivers, fisheries classification, and habitat evaluation for restoration purposes. All of these have limitations in the management of habitat at catchment scale. Future fisheries applications, such as setting spawning targets or integrated catchment management planning, will probably require some combination of GIS-based, extensive classification and site-based field observations of habitat quality. This approach is being developed through the Fisheries River Habitat Inventory which links HABSCORE to a national fisheries classification system.

Codes: review philosophy microhab instream ifim hem warning

Mitchell, J., R. S. McKinley, G. Power, and D. A. Scruton. 1998. Evaluation of Atlantic salmon parr responses to habitat improvement structures in an experimental channel in Newfoundland, Canada. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 14: 25-39.

Distributional patterns and microhabitat selection of Atlantic salmon (Salmo salar) parr were investigated in relation to habitat improvement structures in a controlled flow experiment channel at Noel Paul's Brook, Newfoundland. The channel consisted of six replicates, each containing three randomly arranged treatments. Each replicate included a control treatment with no habitat modification, a mid-channel treatment with a boulder cluster and low-head barrier dam, and a stream bank treatment with undercut banks and wing deflectors. The influence of size class, density, discharge and diurnal/nocturnal differences on microhabitat selection were evaluated. Results showed that the mid-channel treatment did not serve its purpose at lower discharges (0.032-0.063 m super(3) s super(-1)), and as a result was not the treatment of choice. However, as the discharge increased (0.13 m super(3) s super(-1)), more salmon took up residence in this treatment. In all experiments, greater depths were selected in the stream bank treatment, and salmon parr in the mid-channel treatment consistently selected positions closer to cover. Larger parr preferred greater depths and were found closer to the improvement structures. Benthic and drifting food availability were also estimated, and results showed that 'funnelling effects' of the drift were created near the structures. This study indicates that these structures have the potential to create favourable feeding sites, and provide the necessary physical characteristics required by salmon parr.

Codes: experi microhab qual instream hydro

Mitro, M. G. 2000. Sampling and Analysis Techniques and Their Application for Estimating Recruitment of Juvenile Rainbow Trout in the Henrys Fork of the Snake River, Idaho. Dissertation

Juvenile rainbow trout were sampled to quantify production and recruitment processes in the Henrys Fork, to identify factors limiting the trout population, and to propose management actions to improve natural recruitment. The study area was a 25-km river reach that varied in width from 50 to 150 m. I used distance sampling to identify spawning areas in the Henrys Fork and to quantify spawning activity therein. I developed and evaluated mark-recapture and removal techniques to address the inherent difficulties in the sampling and analysis of large abundances of age-0 salmonids over a large spatial scale. Mark- recapture data were collected from 100-m long sample areas. I found the Chao Mt estimator for mark-recapture data to have minimal bias and interval coverage close to the nominal level in simulations with mean capture probabilities (0.02-0.106) and rates of emigration (0-10%) based on actual Henrys Fork data sets. Three-pass removal data were collected along the banks in 15-m units. I developed and rigorously evaluated simple linear regression and mean capture probability models to predict abundance from the first-pass catch. These models worked particularly well for estimating abundance over a large spatial scale, allowing effort to be reallocated from intensively sampling few areas to sampling many areas with reduced effort, resulting in gains in estimate precision. These techniques were used to provide a comprehensive analysis of age- 0 rainbow trout recruitment in the Henrys Fork. There was suitable habitat throughout the study area to support the yearly production of 150,000 to 250,000 age-0 trout through summer and autumn. Recruitment to the fishery was limited by poor survival during their first winter. I identified a flow- survival relation for age-0 trout in a river section with complex bank habitat. The number of age-0 trout that survived their first winter was related to higher discharge during the latter half of winter. The higher discharge during the latter half of winter created more available habitat in the section with complex bank habitat and coincided with the loss of age- 0 trout from non-bank areas. Movement of age-0 trout was detected from river sections with simple bank habitat to sections with complex bank habitat. I recommended that winter discharge be managed to increase the availability of complex bank habitat, thereby improving recruitment of age-0 rainbow trout.

Codes: method quant popdyn spawn migrat instream hydro

Mobrand, L. E., J. A. Lichatowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance `through the eyes of 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.] 54: 2964-2973.

The intent of this paper is to show that discussion of watershed health and salmon (Oncorhynchus sp.) performance can incorporate a much greater degree of complexity without the loss of clarity. More temporal-spatial detail can and should be included, more life history complexity, and more watershed-specific information. The framework and performance measures used in watershed and management generally, and salmon management specifically, are inadequate. The bottleneck metaphor is cited all too frequently as a basis for discussion. The bottleneck analogy is useful in understanding capacity, but capacity alone cannot explain observed responses of salmon populations to environmental change. An argument can be made that where protection and enhancement of weak stocks is the priority, productivity is a more critical variable. A framework built only around productivity and capacity is also not sufficient. It neglects the need for connectivity of habitats that salmon must pass through to complete their life histories. Adding life history diversity as the third component of performance provides the time and space structure needed to deal with connectivity while also allowing for integration of populations where they mingle.

Codes: philosophy basin lulc temporal warnings

Modde, T., and T. B. Hardy. 1992. Influence of different microhabitat criteria on salmonid habitat simulation. Rivers 3: 37-44.

This paper explores differences in predicted habitat using the Physical Habitat Simulation (PHABSIM) system given Suitability Index (SI) curves developed from data collected in three classes of macrohabitat (i.e., runs, riffles [including rapids], and eddies) versus composite curves using all available data. Rainbow trout, Oncorhynchus mykiss, and cutthroat trout, O. clarki, from the same populations used different microhabitats. The construction of focal velocity SI curves from pooled data on macrohabitat types produced a curve that did not represent actual fish use except at the margins of the curve. Individual habitat cells were classified during field collection of hydraulic transect data and used to compute useable habitat based on the macrohabitat-specific and composite SI curves. A comparison of weighted useable area (WUA) generated from macrohabitat-specific versus aggregate SI curves showed a 36% difference. (DBO).

Codes: reach quant microhab habitat instream ifim warning hem

Montgomery, D. R., E. M. Beamer, G. R. Pess, and T. P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Sciences 56: 377-387.

Analysis suggests that salmonid spawning patterns in mountain drainage basins of the Pacific Northwest are adapted to, among other things, the timing and depth of channel bed mobility. It is hypothesized that because the bed of pool-riffle and plane-bed reaches scours to a variable fraction of the thickness of alluvium, survival to emergence is favored by either burying eggs below the annual scour depth or avoiding egg burial during times of likely bed mobility. Conversely, annual mobility of all available spawning gravel in steeper step-pool and cascade channels favors either adaptations that avoid egg burial during times of likely bed mobility or selection of protected microhabitats. Consistent with these expectations, it was found that salmonid spawning distributions track channel slope distributions in several west-slope Pacific Northwest watersheds, implying that spatial differences in channel processes influence community structure in these rainfall-dominated drainage basins. More detailed field surveys confirm that different channel types host differential use by spawning salmonids and reveal finer-scale influences of pool spacing on salmonid abundance.

Codes: spawn qual habitat instream substrate hydro