Moore, K. M. S., and S. V. Gregory. 1988. Response of young-of-the-year cutthroat trout to manipulation of habitat structure in a small stream. Transactions of the American Fisheries Society 117: 162-170.

In Mack Creek, a third-order stream flowing through a 450-year-old coniferous forest in Oregon's Cascade Mountains, population size of young-of-the-year cutthroat trout Salmo clarki was positively correlated with length of stream edge and area of lateral habitat. Lateral habitats included backwaters and eddies at the margin of the channel that made up 10-15% of total stream area. Lateral habitat area was reduced at higher or lower streamflow, but the length of channel perimeter formed by lateral habitats was never less than twice the length of the reach. In an experimental manipulation of lateral habitat before the emergence of young fish from the redd, an increase in lateral habitat area of 2.4 times the area observed in control reaches resulted in a 2.2-times greater density of age-0 cutthroat trout. Young-of-the-year fish were virtually eliminated from stream sections with reduced area of lateral habitat. Growth was not affected by the greater density of fish in reaches with enhanced lateral habitat.

Codes: experi habitat quant offchann

Moore, K. M. S., and S. V. Gregory. 1988. Summer habitat utilization and ecology of cutthroat trout fry (Salmo clarki) in Cascade Mountain streams. Canadian Journal of Fisheries and Aquatic Sciences 45: 1921-1930.

Emergent cutthroat trout fry (Salmo clarki) were observed in the margins, backwaters, and side channels, collectively called "lateral habitats," of three study streams with different riparian vegetation. Most fry remained in these lateral habitats until the end of their first summer. The abundance of cutthroat fry was proportional to the area of lateral habitat in each of the study streams. Average size and growth rate of fry were related to the effect of site elevation on stream temperature and the influence of riparian vegetation on the availability of invertebrate food.

Codes: multi habitat quant offchann ripar wtemp

Moscrip, A. L., and D. R. Montgomery. 1997. Urbanization, flood frequency, and salmon abundance in Puget lowland streams. Journal of the American Water Resources Association [J. Am. Water Resour. Assoc.] 33: 1289-1297.

Urbanization history and flood frequencies were determined in six low-order streams in the Puget Lowlands, Washington, for the period between the 1940/50s and the 1980/90s. Using discharge records from USGS gauging stations, each basin was separated into periods prior to and after urban expansion. Four of the study basins exhibited significant changes in urbanized area, whereas two of the study basins exhibited only limited change in urbanized area and effectively serve as control basins. Each of the basins that experienced a significant increase in urbanized area exhibited increased flood frequency; pre-urbanization 10-year recurrence interval discharges correspond to 1 to 4-year recurrence interval events in post-urbanization records. In contrast, no discernible shift in flood frequency was observed in either of the control basins. Spawner survey data available for three of the study basins reveal systematic declines in salmon abundance in two urbanizing basins and no evidence for decreases in a control basin. These data imply a link between ongoing salmon population declines and either increased flood frequency or associated changes in habitat structure.

Codes: multi experi reach spawn lulc hydro temporal

Moyle, P. B., D. M. Baltz, and N. J. Knight. 1983. Instream flow requirements of native California stream fishes. Report OWRT-B-210-CAL(1).

Summaries are presented for two years of microhabitat studies on ten species of California stream fishes: rainbow trout, brown trout, speckled dace, California roach, hardhead, Sacramento squawfish, Lahontan redside, Sacramento sucker, Tahoe sucker, riffle sculpin, Paiute sculipin and the perch. The measurements of velocity, depth and substrate associated with each species can be used to construct habitat use curves useful for small streams in the

Sacramento Valley and in the Truckee drainage. Results imply that if instream flow recommendations are based on the requirements of just one species (usually rainbow trout in California), the populations of other species may change in unpredictable ways. Instream flow recommendations made using "habitat preference curves" constructed from data collected outside the impact area may not give an accurate picture of the effects of the changed flow regime on rainbow trout or other species.

Codes: multi instream microhab sppinter ifim warning hem

Murphy, M. L., and J. D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitat in small streams of the Cascade Mountains, Oregon. Can. J. Fish. Aquat. Sci. 38: 137-145.

Assemblages of aquatic vertebrate and insect predators were inventoried in streams in old-growth and logged coniferous forests. Effects associated with logging depended on stream size, gradient, and time after harvest. Clear-cut sections where the stream was still exposed to sunlight (5-17 yr after logging) generally had greater biomass, density, and species richness of predators than old-growth (>450-yr-old) forested sections. Increases were greatest in small (first-order), high gradient (10-16%) streams, where clear-cut sites had both greater periphyton production and coarser streambed sediment than old-growth sites of similar size and gradient. Effects on predators were mixed in larger, lower gradient streams, where clear-cut sites showed accumulation of sediment and relatively small increases in periphyton production. Second-growth logged sections (12-35 yr after logging), reshaded by deciduous forest canopy, had lower biomass of trout and fewer predator taxa than old-growth sites.

Codes: multi reach quant instream substrate trophic ripar temporal

Murphy, M. L., C. P. Hawkins, and N. H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110: 469-478.

Small streams differing in sediment composition were compared in logged and forested reaches to determine effects of accumulated fine sediment on stream communities under different trophic conditions. Three stages of forest community succession were studied in the Cascade Mountains: recently clear-cut areas without forest canopy (5-10 years after logging); second-growth forest with deciduous canopy (30-40 years after logging); and old-growth coniferous forest (>450 years old). One stream with mostly coarse sediment (56-76% cobble) and one with more fine sediment (5-14% sand and 23-53% gravel) were contrasted for each successional stage. In general, streams traversing open clear-cuts had greater rates of microbial respiration, and greater densities or biomasses of aufwuchs, benthos, drift, salamanders, and trout than did the shaded, forested sites regardless of sediment composition. We conclude that for these small Cascade Range streams, changes in trophic status and increased primary productivity resulting from shade removal may mask or override effects of sedimentation.

Codes: multi experi quant? lulc instream substrate trophic

Murphy, M. L., J. Heifetz, S. W. Johnson, K. V. Koski, and J. F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. Canadian Journal of Fisheries and Aquatic Sciences 43: 1521-1533.

To assess short-term effects of logging on juvenile Oncorhynchus kisutch, Salvelinus malma, Salmo gairdneri, and Salmo clarki in southeastern Alaska, the authors compared fish density and habitat in summer and winter in 18 streams in old-growth forest and in clearcuts with and without buffer strips. Buffered reaches did not consistently differ from old-growth reaches; clear-cut reaches had more periphyton, lower channel stability, and less canopy, pool volume, large woody debris, and undercut banks than old-growth reaches. In summer, if areas had underlying limestone, clear-cut reaches and buffered reaches with open canopy had more periphyton, benthos, and coho salmon fry (age 0) than old-growth reaches. In winter, abundance of parr (age > 0) depended on amount of debris. If debris

was left in clear-cut reaches, or added in buffered reaches, coho salmon parr were abundant (10-22/100 m super(2)). If debris had been removed from clear-cut reaches, parr were scarce (< 2/100 m super(2)).

Codes: multi reach quant instream substrate trophic ripar lwd

Murphy, M. L., J. Heifetz, J. F. Thedinga, S. W. Johnson, and K. V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (Oncorhynchus) in the glacial Taku River, Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 46: 1677-1685.

Habitat utilization by juvenile Pacific salmon (Oncorhynchus) was determined in summer 1986 by sampling 54 sites of nine habitat types: main channels, backwaters, braids, channel edges, and sloughs in the river; and beaver ponds, terrace tributaries, tributary mouths, and upland sloughs on the valley floor. Physical characteristics were measured at all sites, and all habitats except main channels (current too swift for rearing salmon) were seined to determine fish density. Each species of Oncorhynchus was absent from about one-quarter of the seining sites of each habitat type. The lower Taku River provides important summer habitat for juvenile salmon, but many suitable areas were unoccupied possibly because of their distance from spawning areas and poor access for colonizing fish.

Codes: reach quant offchann instream

Murphy, M. L., K. V. Koski, J. M. Lorenz, and J. F. Thedinga. 1997. Downstream migrations of juvenile Pacific salmon (Oncorhynchus spp.) in a glacial transboundary river. 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: 2837-2846.

Migrations of juvenile Pacific salmon (Oncorhynchus spp.) in the glacial Taku River (seventh order) were studied to assess movement from upriver spawning areas (in British Columbia) into lower-river rearing areas (in Alaska). Differences between fyke-net catches in the river and seine catches in the river's estuary indicated that many downstream migrants remained in the lower river instead of migrating to sea. In particular, age-0 coho salmon (O. kisutch) and chinook salmon (O. tshawytscha) moved downriver from May to November but were not caught in the estuary. Age-0 sockeye salmon (O. nerka), coho presmolts, and other groups delayed entry into the estuary after moving downriver. Groups of juvenile coho (ages 0-2) were tagged from the fyke net with coded-wire to determine when they left the river. One-third of all tags recovered from sport and commercial fisheries occurred 2-3 years later, showing that many coho remained in fresh water for 1-2 years after moving to the lower river. Lower-river areas of large glacial rivers like the Taku River can provide essential rearing habitat for juvenile salmon spawned upriver and are important to consider in integrated whole-river management of transboundary rivers.

Codes: reach qual migrat temporal

Nakamoto, R. J. 1994. Characteristics of pools used by adult summer steelhead oversummering in the New River, California. Transactions of the American Fisheries Society 123: 757-765.

I assessed characteristics of pools used by oversummering adults of summer steelhead Oncorhynchus mykiss between July and October 1991 in the New River, northwestern California. Most fish occupied channel confluence pools and other pools of moderate size (200-1,200 m super(2)); these pools had less than 35% substrate embeddedness and mean water depths of about 1.0-1.4 m. Microhabitat occupied during daylight hours included cover provided by bedrock ledges and boulders where water velocity averaged 9.3 cm/s (range, 1-34 cm/s); steelhead densities under this cover were highest at the higher velocities. Fish also occupied areas with riparian shading and waters deeper than 1 m. I observed localized areas of cool water in some of the study pools. The availability of coolwater areas in pools did not increase adult fish use of those pools. The results of this study

indicate that the distribution of summer steelhead in the New River during July-October is more strongly controlled by physical habitat characteristics than by the availability of thermal refugia.

Codes: habitat microhab quant substrate instream wtemp ripar

Nakano, S. 1995. Individual differences in resource use, growth and emigration under the influence of a dominance hierarchy in fluvial red-spotted masu salmon in a natural habitat. Journal of Animal Ecology 64: 75-84.

The relationships between dominance status and individual differences in foraging behaviour, habitat use, growth and emigration were examined for fluvial red-spotted masu salmon, Oncorhynchus masou ishikawai, in a mountain stream. Size-structured linear dominance hierarchies were recognized among individuals inhabiting the same stream pools. Observations on space utilization and foraging behaviour revealed fish to be either territorial or nonterritorial. Within each local pool, dominant fish exclusively occupied the mid or surface layer of the pools as foraging territories, whereas subordinates adopted nonterritorial tactics, primarily utilizing the bottom layer. Of the territorial fish, more dominant individuals tended to occupy focal points nearer the pool inlet, where they had priority of access to drifting food items. These fish showed higher actual foraging rates, feeding upon larger prey than their subordinates. This foraging advantage resulted in their having larger daily growth increments. The more dominant fish in each pool exhibited a more sedentary tendency than their subordinates. Population densities in the pools did not fluctuate appreciably owing to both emigration of nonterritorial subordinates and immigration. These results support the hypothesis that unequal resource partitioning among individuals subject to a dominance hierarchy plays an important role in their density-dependent population regulation.

Codes: habitat quant popdyn sppinter trophic

Nakano, S., F. Kitano, and K. Maekawas. 1996. Potential fragmentation and loss of thermal habitats for charrs in the Japanese archipelago due to climatic warming. Freshwater Biology 36: 711-722.

The upper thermal limits of the present distributions of two charr species, Dolly Varden, Salvelinus malma, and white-spotted charr, S. leucomaenis, in streams of the Japanese archipelago were examined using groundwater temperature as an index of thermal condition. The lower limits of the altitudinal distributions of Dolly Varden and white-spotted charr were delineated, respectively, by 8 and 16 degree C groundwater isotherms. The potential impact of future climatic warming on the geographical distribution, habitat extent and population fragmentation of each species was predicted at both the full archipelago and individual catchment levels. For Dolly Varden, analysis at the full archipelago level indicated a loss of 27.6, 67.2, 79.6 and 89.6% of the current geographical range, respectively, for a 1, 2, 3 and 4 degree C increase in mean annual air temperature. The present distribution area of white-spotted charr would likewise reduce by 4.1, 20.5, 33.8 and 45.6%, respectively. Based on the analyses of three individual catchments, one for Dolly Varden and two for white-spotted charr, the lower habitat boundaries for the two charr species could be expected to rise increasingly to higher elevations in each catchment as warming proceeded. As a consequence, there would be large reductions in mean habitat area, with increasing habitat fragmentation followed by localized extinctions of the two species.

Codes: multi qual reach lulc wtemp

Nakano, S., S. Kitano, K. Nakai, and K. D. Fausch. 1998. Competitive interactions for foraging microhabitat among introduced brook trout charr, Salvelinus fontinalis, and native bull charr, S. confluentus, and westslope cutthroat trout, Oncorhynchus clarki lewisi, in a Montana stream. Environmental Biology of Fishes 52: 345-355.

Competitive interactions for foraging microhabitat among introduced brook charr, Salvelinus fontinalis, and native bull charr, S. confluentus, and westslope cutthroat trout, Oncorhynchus clarki lewisi, were studied by species removal experiments in a tributary of the Flathead Lake and River system, northwestern Montana, focusing on

brook charr influences on bull charr. When the three species were in sympatry, they interacted with each other, forming a size-structured, mixed-species dominance hierarchy in two stream pools. The influences of interference interactions were examined by measuring changes in five characteristics of foraging microhabitat and behavior, focal point height and velocity, cover use, and foraging rate and distance, after the successive removal of two species. Cutthroat trout removal resulted in increased foraging rates and distances, and decreased cover use for brook charr, but no changes for bull charr. After removal of brook charr from the two-species system, bull charr also increased foraging rates and distances and occupied more exposed positions. Moreover, total fish densities, which had initially decreased owing to the removal experiments, were partly compensated for by subsequent bull charr immigration, implying that competitive interactions with brook charr are an important factor in the mechanisms responsible for the regulation of bull charr densities, at least on a local scale.

Codes: experi microhab quant sppinter migrat

Naslund, I. 1987. Effects of habitat improvement on the brown trout (Salmo trutta L.) population of a north Swedish stream.

Habitat improvement structures have been installed in an attempt to restore the brown trout (Salmo trutta) populations in Sweden. To evaluate the effects of such structures a project was started in Laaktabaecken Creek, a tributary to the River Vindelaelven in Lapland. The fish population is dominated by resident brown trout with poor growth, early maturation and a short lifespan. Four types of habitat improvement structures were tested: stream deflectors; boulder dams; boulder groups; and a combination of stream deflectors and boulder dams. Boulder dams proved to be the most efficient structures. Brown trout densities increased by 200% and biomass by 400%.

Codes: experi quant instream

Naslund, I., E. Degerman, and F. Nordwall. 1998. Brown trout (Salmo trutta) habitat use and life history in Swedish streams: Possible effects of biotic interactions. 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: 1034-1042.

To test if habitat use and life history of stream-dwelling brown trout (Salmo trutta) differed between allopatric and sympatric situations, three streams were compared with differing fish communities and data were used from a large national database containing electrofishing results from Swedish streams. In the three-creek study, allopatric brown trout used all habitats and shifted from nursery areas in riffles to pool habitats, where adult growth and survival were higher. Mainly females shifted habitat and this was undertaken after age 1. Sympatric brown trout under intense pressure from other fish species remained in the riffles throughout their life cycle. Under moderate pressure from other species, larger brown trout used slow-flowing habitats. Early growth was more rapid in sympatry. Sympatric brown trout also had a lower adult to juvenile growth ratio and lower adult survival and matured earlier than allopatric brown trout. The data from the nationwide database showed that frequency of occurrence and abundance of brown trout were negatively associated with the number of coexisting fish species. It was also verified that the habitat shifts between riffles and pools were more common and possibly more beneficial in terms of growth and survival in allopatry. In addition the existence of differences in juvenile growth between allopatric and sympatric populations was verified.

Codes: multi reach quant popdyn sppinter instream

Nass, B. L., K. K. English, and H. R. Frith. 1996. Assessment of summer rearing habitat and juvenile coho abundance in the Kwinageese River, B.C., 1992. Report

Habitat use by juvenile coho salmon (Oncorhynchus kisutch) was examined in the Kwinageese River, British Columbia, as part of the 1992-1993 Nisga'a Interim Measures Program (IMP). Foot and snorkel surveys were carried out during Aug and Sep to quantify wetted area and juvenile coho abundance by habitat and cover type. To

determine if coho production was limited by available habitats, comparisons of observed total coho abundance and densities (by habitat type) were made with those presented in the literature. Linear densities of coho fry were the highest in small tributaries and pools with cover, followed by runs with cover. Runs and riffles with no cover had the lowest densities. Densities between habitats with cover and habitats without cover were significantly different in some comparisons. Side channels accounted for the greatest total linear habitat and the highest total abundance of juvenile coho. Pools contributed only 11.7% to total linear habitat but accounted for 16.5% of total abundance. Total estimated coho fry abundance was only 27% of the potential abundance estimated using a coho production model. Comparison of maximum density and biomass estimates for 29 B.C. streams revealed that the Kwinageese maximum for age 2 coho maximum was substantially higher than the maximum for all other streams surveyed. The average value for the 5 sites surveyed on the Kwinangeese River was only 20% of these maximum levels. Factors such as escapement or winter rearing habitat are more likely to be limiting coho production in the Kwinageese River than summer rearing habitat.

Codes: habitat quant instream

Nehlsen, W. 1997. Prioritizing watersheds in Oregon for salmon restoration. Restoration Ecology [Restor. Ecol.] 5: 25-33.

This paper describes an ecosystem approach (the Bradbury framework) to prioritizing watersheds for watershed restoration and salmon recovery, and gives an example of its application. The framework was applied at three spatial scales (in descending order) to prioritize (1) river basins within the north coast geographic area of Oregon (USA), (2) watersheds within the Tillamook Bay basin, and (3) restoration activities at the watershed level. Implementing the framework identified the Nehalem and Tillamook Bay basins as high priority for the north coast of Oregon. Within the Tillamook Bay basin, the Wilson, Kilchis, and Trask river watersheds emerged as high priority. Preliminary analysis indicated that controlling sediment sources by addressing upland road conditions and allowing floodplain and riparian ecosystems to recover are highestpriority protection and restoration activities within the Tillamook Bay basin. The sample application demonstrates that an ecosystem approach (the Bradbury framework) is particularly advantageous where data are limited, although previous identification of relatively intact areas is required. Implementing the framework is intended to lead to restoration of native species, but it may not provide immediate assistance for some species or populations of concern.

Codes: multi reach segment nofish substrate ripar philosophy

Nehring, R. B., and R. M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the physical habitat simulation system. Rivers 4: 1-19.

The authors used the Instream Flow Incremental Methodology (IFIM) and Physical Habitat Simulation system (PHABSIM) to investigate the influence of stream discharge and the concomitant variation in habitat on wild rainbow (Oncorhynchus mykiss) and brown (Salmo trutta) trout populations in Colorado streams. We identified critical salmonid habitat limitations on 10 of the 11 streams studied over a 13-year period. The 2-4-week-old fry, egg incubation, and spawning life stages were most sensitive to critical habitat "bottlenecks." Linear regression analyses revealed statistically significant correlations (P less than or equal to 0.05) between weighted usable area (WUA), an index of physical habitat quality and quantity (determined using PHABSIM), and density (n/ha) of age-1 or -2 rainbow and brown trout in 10 of 11 streams studied. Correlations between WUA (based on mean monthly flow) and density were superior in both accuracy and precision in properly identifying population-limiting events compared to correlations between mean monthly stream discharge (during the critical time period) and trout density.

Codes: multi reach quant spawn instream microhab ifim hem

Nelson, R. L., W. S. Platts, D. P. Larsen, and S. E. Jensen. 1992. Trout distribution and habitat in relation to geology and geomorphology in the North Fork Humboldt River drainage, northeastern Nevada. Transactions of the American Fisheries Society 121: 405-426.

The authors studied the existing distribution of native Lahontan cutthroat trout Oncorhynchus clarki henshawi and exotic brook trout Salvelinus fontinalis with respect to geologic and geomorphic land-classes in the upper North Fork Humboldt River drainage, Nevada. We evaluated habitat conditions in study sites to determine which measured components of habitat structure provided the best discriminators among study stream reaches in the different land-classes and among trout-supporting and unpopulated study reaches. At a finer level of resolution, we used the habitat attributes with the most discriminatory power to plot the distributions of study areas by land-class and by presence or absence of trout along coordinate axes reflecting environmental gradients defined by these attributes. Elevation, substrate embeddedness, and streamflow were the variables with the most discriminatory power among land-classes defined by parent geologic material (geologic district), but gravel abundance in the substrate was more useful than streamflow in further discriminating among land-classes at the lower-level classification defined by geomorphic character (landtype association).

Codes: multi qual lulc substrate

Newman, R. M., and T. F. Waters. 1989. Differences in brown trout (Salmo trutta) production among contiguous sections of an entire stream. Canadian Journal of Fisheries and Aquatic Sciences 46: 203-213.

Production dynamics of a wild brown trout (Salmo trutta) population were examined for 3 yr in each of eight contiguous 305-m-long sections that constituted the entire length of South Branch Creek, a limestone stream in southeastern Minnesota. Standing stock and production also differed significantly among sections, but relative differences among sections were fairly constant over the 3 yr. The most productive sections had standing stocks and production rates that were 1.5-2 times higher than the least productive sections. Year strongly influenced growth rate, with growth in 1982 almost double that in 1981, but growth rates did not differ significantly among sections. Habitat differences among sections appeared to regulate density, size, standing stock, and production. Factors that affected the entire stream influenced recruitment and growth.

Codes: reach quant popdyn instream temporal

Nickelson, T. E., and P. W. Lawson. 1998. Population viability of coho salmon, Oncorhynchus kisutch, in Oregon coastal basins: Application of a habitat-based life cycle model. 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: 2383-2392.

To assess extinction risk for Oregon coastal coho salmon, Oncorhynchus kisutch, a life cycle model was developed based on habitat quality of individual stream reaches estimated from survey data. Reach-specific smolt output was a function of spawner abundance, demographic stochasticity, genetic effects, and density- and habitat-driven survival rates. After natural mortality and ocean harvest, spawners returned to their natal reaches. Populations in reaches with poor habitat became extinct during periods of low marine survival. With favorable marine survival, high productivity reaches served as sources for recolonization of lower quality reaches through straying of spawners. Consequently, both population size and distribution expanded and contracted through time. Within a reach, populations lost resilience at low numbers when demographic risk factors became more important than density-dependent compensation. Population viability was modeled for three coastal basins having good and moderate habitat and constant habitat conditions, extinction risk in 99 years was negligible in basins with good and moderate habitat and 5-10% in the basin with poor habitat. Reductions in habitat quality up to 60% in 99 years resulted in reduced coho salmon populations in all basins and significantly increased extinction risk in the basin with poor habitat.

Codes: multi modeling risk reach quant popdyn instream

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 783-789.

Habitat use by juvenile coho salmon (Oncorhynchus kisutch) during spring, summer, and winter was examined in Oregon coastal streams. Coho salmon fry were most abundant in backwater pools during spring. During summer, juvenile coho salmon were more abundant in pools of all types then they were in glides or riffles. During winter, juvenile coho salmon were most abundant in alcoves and beaver ponds. Because of the apparent strong preference for alcove and beaver pond habitat during winter and rarity of that habitat in coastal streams, we concluded that if spawning escapement is adequate, the production of wild coho salmon smolts in most coho salmon spawning streams on the Oregon Coast is probably limited by the availability of adequate winter habitat.

Codes: multi experi quant habitat instream offchann

Nickelson, T. E., M. F. Solazzi, S. L. Johnson, and J. D. Rodgers. 1992. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 790-794.

We examined the use of constructed pools by juvenile coho salmon (Oncorhynchus kisutch) during summer and winter. Log, gabion, and rock structures placed across the full stream width provided good summer habitat but poor winter habitat for juvenile coho salmon. Rearing densities in constructed habitats during summer and winter were generally similar to those in natural habitats of the same type, except that constructed dammed pools supported lower densities during winter than natural dammed pools. The addition of brush bundles to pools created by full-stream-width structures increased the density to juvenile coho salmon in dammed pools during winter, but not in plunge pools. We concluded that the development of off-channel habitat has the greatest potential to increase production of wild coho salmon smolts in Oregon coastal streams.

Codes: multi experi quant habitat lwd instream offchann

Niemelä, E., M. Julkunen, and J. Erkinaro. 1999. Revealing trends in densities of juvenile Atlantic salmon, Salmo salar L., in the subarctic River Teno using cluster analysis on long-term sampling data. Fisheries Management and Ecology [Fish. Manage. Ecol.] 6: 207-220.

The density of juvenile Atlantic salmon, Salmo salar L., was monitored at 57 sites representing different habitats in the River Teno and two of its major tributaries from 1979 to 1995. Cluster analyses were used to combine sites with similar densities and to study trends in densities within clusters. It was found that management measures have played an important role in maintaining salmon stocks and there was some evidence of increasing juvenile salmon densities. Parr densities decreased significantly in one cluster containing 45% of the sites studied in the River Utsjoki, whereas densities increased significantly in one cluster in the River Teno and in one cluster in the River Inarijoki containing 38% of the sites in these rivers. Fry densities increased significantly in two clusters containing 16% of all the sites studied in the three rivers. In general, the mean densities in successive years in the clusters were independent. The results demonstrate the value of long-term monitoring in ecological investigations.

Codes: multi reach basin quant temporal noenv

Nislow, K. 1998. The Relationship Between Habitat and Performance of Age-0 Atlantic Salmon.

In this study, I examined the interactive effects of prey and physical habitat on foraging, habitat selection, growth, and survival of age-0 Atlantic salmon, Salmo salar. I combined field observations of salmon behavior, surveys of habitat and prey availability, laboratory and field experiments, and computer modeling to test whether differences in

prey and habitat affect performance parameters of age-0 salmon. Understanding these effects is critical for the restoration of Atlantic salmon to their historic range, and provides a test of basic ecological theory concerning early life history energetics of fish populations. Differences in prey and habitat were strongly associated with salmon performance. Salmon foraging rates were higher in a high-invertebrate abundance vs. a low-abundance stream. However, foraging rates were uncorrelated with invertebrate abundance in individual territory locations within streams, and individuals did not preferentially establish territories in locations with the highest prey abundance. Instead, salmon preferred microhabitat locations where both prey abundance, and the ability to detect and capture prey, were relatively high. Small, early season fish (May-June) preferred low-current speed microhabitats, while larger, late season fish (July- August) preferred high-current speeds. Loss rates (=loss of fish due to mortality and emigration) of age-0 salmon were significantly lower in streams with a greater percentage of preferred early season habitat, but were uncorrelated with availability of late season habitat. Habitat manipulation via the introduction of large woody debris and boulder structures increased preferred early season habitat, and had a neutral effect on invertebrate prey, suggesting a net positive impact on age-0 salmon. Bioenergetics modeling confirmed that differences in habitat and prey translated into major predicted differences in growth rate potential between streams and seasons, and reinforced the importance of early season habitat in influencing the potential for streams to successfully rear salmon through their first summer. This study demonstrates that early life history energetics can explain differences in the growth and survival of stream fish populations. Effects on early life history habitat conditions are therefore likely to be critical for Atlantic salmon management and restoration efforts.

Codes: experi microhab quant popdun lwd instream trophic

Nislow, K. H., C. Folt, and M. Seandel. 1998. Food and foraging behaviour in relation to microhabitat use and survival of age-0 Atlantic salmon. CJFAS 55: 116-127.

Using underwater snorkeling observations and field experiments, the influence was examined of food availability on foraging behavior, habitat use, and survival of age-0 Atlantic salmon (Salmo salar) during the critical first-summer growth period. While most feeding attempts were directed at drifting invertebrate prey, a higher rate was found of benthic feeding forays than previously reported for salmon. Greater food abundance was associated with higher feeding foray rates, more time allocated to foraging, occupancy of higher microhabitat velocities, and greater first-year survival between two study streams. Experimental drift reduction reduced drift foray rates and triggered a change in behavior to increased benthic feeding. In contrast, within a single stream, greater predicted invertebrate drift in high-velocity microhabitats was unrelated to either microhabitat occupancy or drift foray rates of age-0 salmon. It is suggested that in some situations, salmonid foraging is related more directly to overall prey density than to the availability of high-velocity, high drift rate microhabitats. Differences in resource tracking (increased foraging, growth, or survival with increased food abundance) at different scales, along with the use of alternative predation models, underscore the importance of considering behavior when linking food resources to growth and survival of stream salmonids.

Codes: experi microhab qual trophic

Nislow, K. H., C. L. Folt, and D. L. Parrish. 1999. Favorable foraging locations for young Atlantic salmon: application to habitat and population restoration. Ecological Applications 9: 1085-1099.

Declines in the populations of salmonid fishes have generated major interest in conservation and restoration of wild populations and river habitats. We used a foraging-based model, combined with field observations and surveys, to predict individual habitat use, and to assess the effects of stream habitat conditions and management practices on the potential for reestablishing Atlantic salmon, Salmo salar. Using a model based on a simple trade-off between increasing prey encounter rate and decreasing salmon capture success with increasing stream current velocity, we predicted favorable foraging locations for salmon in their first (age-0) spring and summer. We tested, in six streams, whether (1) salmon preferred locations (=microhabitats) that were predicted to yield high consumption rates, (2) salmon growth and survival was greater in streams with a greater proportion of preferred, profitable, microhabitats, and (3) stream habitat remediation (introduction of large in-stream structures such as large woody debris) increased the availability of microhabitats found to be preferred by salmon, and energetically profitable. Salmon early in their

first season (May-June) were predicted to obtain the highest consumption rates (within 10% of maximum) in microhabitats with a narrow range of relatively slow current velocities (0.08-0.18 m/s). In contrast, later in the season (July-August) fish were predicted to obtain highest consumption rates over a wide range of fast current velocities (0.21-0.57 m/s). Salmon in both the early and late seasons showed strong preferences (use in proportion to availability) for microhabitat in velocity categories predicted to provide high consumption. Streams with the greatest proportion of preferred early-season, but not late-season, microhabitats retained a higher proportion of salmon as measured at the end of the first summer. Stream habitat remediation increased the amount of preferred early-season microhabitat and did not negatively affect invertebrate prey abundance, or the amount of preferred late-season microhabitats. Thus, the availability of favorable foraging areas for juveniles significantly improves the retention of salmon during the critical first summer, and stream remediation provides better foraging habitat during this important period. Our results are encouraging for broader application to identify sites that show promise for salmon reintroduction, and to help guide restoration of particular sites to provide suitable habitat.

Codes: modeling microhab quant trophic lwd

O'Grady, M. F. 1993. Initial observations on the effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish waters. Aquaculture and fisheries management 24: 563-573.

The effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish rivers were investigated. In summertime, when marginal vegetation limited the extent of incident light reaching the river bed, a marked decline in both juvenile salmon, Salmo salar, and juvenile and adult trout, Salmo trutta, numbers were observed relative to stocks in adjacent areas with a less dense canopy. This appears to be a countrywide phenomenon in all available salmonid habitats. In the case of both juvenile salmon and all trout numbers a correlation is evident between the extent of shade, as measured in terms of the reduction in aquatic vegetation, and fish numbers, which fall as shade levels increase. Data also suggest that the length of tunnelled channel, upstream of tunnelled sites electrofished, seems to influence the standing crop of juvenile salmon with numbers of these fish falling with increasing tunnel length. This relationship is not evident in relation to trout numbers.

Codes: experi multi reach quant ripar

Paulsen, C. M., and T. R. Fisher. 2001. Statistical Relationship Between Parr-to-Smolt Survival of Snake River Spring-Summer Chinook Salmon and Indices of Land Use. TAFS 130: 347-358.

We used simple regression models to demonstrate an association between land use and parr survival of chinook salmon Oncorhynchus tshawytscha from overwintering areas in the Snake River drainage of Idaho and Oregon to the first main-stem dam encountered during emigration to the Pacific Ocean. We used data on tagged (passive integrated transponder tags) releases of naturally produced Snake River spring-summer chinook parr and subsequent tag detections, as well as indices of land use, vegetation, and road density. We spot-checked the land-use and vegetation indices in a field survey of spawning and rearing areas in the summer of 1999, and we believe that they are reliable indicators of land-use patterns. The models also employed month of release, length of parr at release, and a drought index as independent variables. The models were developed and tested using parr tagged from 1992 through 1998. Age-0 parr that reared in wilderness areas (a land-use category; not necessarily federally designated Wilderness Areas) had the highest survival during their last 6-9 months of freshwater residence. In contrast, parr that reared in young, dry forests (typically, intensively managed timber lands) had the lowest survival. Similarly, parr that reared in areas of low road density had substantially higher survival than those in areas of high road density. We concluded that in the area studied there is a close association between land-use indices and survival of chinook salmon parr during their last 6-9 months of freshwater residence. This analysis suggests that road-building and associated land-use activities in the region may have a detrimental effect on the survival of juvenile chinook salmon and that mitigative changes in these activities could be warranted because Snake River spring-summer chinook salmon are listed as threatened under the Endangered Species Act.

Codes: multi basin popdyn quant lulc hydro

Pert, E. J., and D. C. Erman. 1994. Habitat use by adult rainbow trout under moderate artificial fluctuations in flow. Transactions of the American Fisheries Society 123: 913-923.

Adult rainbow trout Oncorhynchus mykiss were observed in a 20-m reach of river to determine habitat use (at four flow levels) and preference (at two flow levels) under daily fluctuations in discharge from a hydropower peaking operation. Maximum increase in discharge was threefold (from 1.6 to 5.1 m super(3)/s), which is small compared with that of some hydropower peaking operations. Available habitat (based on velocity and depth) was different under low and high flows. At the low discharge level, nearly twice as much of the lowest velocity-class (0.00-0.15 m/s) and eight times more of the shallowest depth-class (0.0-0.02 m) were available. Distributions of adult habitat use revealed that fish focal point and water column velocities increased with increasing discharge. At the highest discharge levels, more fish were found in the deepest water, and the fish assumed positions closer to the streambed, than at the three lower discharges. Fish were usually associated with boulders at all discharges. Habitat preference shifted to deeper and faster water as discharge increased. Two types of individuals were identified on the basis of habitat use under various discharge levels. Pattern-1 individuals displayed strong site fidelity and used higher focal point velocities at higher discharges. Pattern-2 individuals were generally more mobile than pattern-1 individuals and showed no relationship between discharge and focal point velocity. Repeated observations made on individually marked fish indicated that description of habitat use and preference in terms of microhabitat may yield a false interpretation of optimal habitat for the populations as a whole. It is likely that few individuals in a population of territorial fish occupy the optimal habitat. Interpreting the most frequently used microhabitat as optimal habitat for a population is probably incorrect and could result in erroneous predictions of available habitat based on instream flow assessment models.

Codes: qual habitat microhab hydro instream warning hem

Petrosky, C. E., and T. B. Holubetz. 1986. Idaho Habitat Evaluation for Off-Site Mitigation Record: Annual Report 1985.

The Idaho Department of Fish and Game (IDFG) conducted an evaluation of existing and proposed habitat improvement projects for anadromous fish in the Clearwater River and Salmon River drainages during 1984 and 1985. Projects included in the evaluation are funded by or proposed for funding by the Bonneville Power Administration under the Northwest Power Planning Act. The Clearwater River and Salmon River drainages account for virtually all of Idaho 's wild and natural production of summer steelhead and spring and summer chinook salmon, as well as a remnant run of sockeye salmon. Although a majority of the habitat still available to steelhead and salmon is high quality, man 's activity in Idaho has degraded many streams. Sedimentation has increased with widespread logging, road building, and associated activities. Intensive livestock grazing near streams has removed riparian vegetation, changed stream morphology, and accelerated soil erosion. Mining has had profound effects in parts of the drainages through stream channel alterations, discharge of toxic effluents, and increased sedimentation. Irrigation withdrawals have reduced flows and increased water temperatures, often to critical levels for steelhead and salmon during summer. Primary objectives of this evaluation project are to: (1) document physical changes that result from habitat enhancement; (2) measure changes in steelhead and chinook parr/smolt production attributable to all habitat enhancement projects; (3) determine project effectiveness to guide future enhancement activity, and (4) determine benefits in terms of increased smolt and adult production resulting from each habitat enhancement project. General level studies on each project will provide a large database that can be used to predict response of increased or decreased fish production from a physical change in anadromous fish habitat. This data should assist sponsors of future habitat enhancement projects in more accurately estimating fishery benefits of their proposed projects. This database will also assist in defining limiting habitat factors for the various types of streams in Idaho. (Lantz-PTT).

Codes: reach multi substrate hydro wtemp quant? Datasource

Platts, W. 1991. Livestock grazing. Pages 389-423. 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 instream graz temporal economic

Platts, W. S., and R. L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8: 333-345.

The authors describe the magnitude of fluctuations in trout populations in several widely separated streams in the intermountain region of the western US, and consider their potential effect on land-management planning. Trout populations included native and exotic species, self-reproducing and hatchery-maintained populations, and assemblages that ranged from monospecific to diverse. Annual fluctuations in population statistics were generally large, and were related to geographic setting and trout species. Except in cases of irregular occurrence, populations of brook trout Salvelinus fontinalis, particularly in Rocky Mountain study areas, were numerically the most stable; those of allopatric cutthroat trout Salmo clarki (= Oncorhynchus) in the Great Basin were the least stable numerically. Total salmonid community tended to fluctuate less than individual populations, except when fry of anadromous chinook salmon Oncorhynchus tshawytscha were present. Inherent trout population fluctuations must be considered within the framework of land-use planning if fishery goals are to be achieved. Habitat-based models to evaluate the effects of land uses and habitat enhancement efforts frequently fail to incorporate these fluctuations. Such models often have little utility in predicting sizes or biomass of salmonid populations in the intermountain west.

Codes: quant lulc sppinter temporal warning hem

Platts, W. S., and R. L. Nelson. 1989. Stream canopy and its relationship to salmonid biomass in the Intermountain West. North American Journal of Fisheries Management 9: 446-457.

To assess prevailing stream canopy (riparian overstory) conditions on representative streams in the northern Rocky Mountains and the Great Basin of the western USA, we measured several riparian habitat components, including canopy density, light intensity, unobstructed sun arc, and average potential daily thermal input in grazed and ungrazed (rested) portions of each stream. We also determined to what extent, if any, these habitat components were correlated with salmonid biomass and whether either they or salmonid biomass differed significantly between geogrpahic regions or between grazed or rested pastures. Unobstructed sun arc was significantly and positively correlated with thermal input ($P < 0.01$), and it was the best overall predictor of salmonid biomass per unit volume (r super(2) = 0.58). Thermal input was a better predictor of salmonid biomass per unit volume in the Great Basin (r super(2) = 0.92) than in the Rocky Mountains (r super(2) = 0.50). #(foregoing abstract from CSA incomplete, Author's abstract from another source follows)#

To assess prevailing stream canopy (riparian overstory) conditions on representative streams in the northern Rocky Mountains, and the Great Basin of the western USA, several riparian habitats, including canopy density, light intensity, unobstructed sun arc, and average potential daily thermal input were measured in grazed and ungrazed (rested) portions of each stream. It was also determined to what extent, if any, these habitat components were correlated with salmonid biomass and whether either they or salmonids differed significantly between geographic regions or between grazed or rested pastures. Unobstructed sun arc was significantly and positively correlated with thermal input, and it was the best overall predictor of salmonid biomass per unit volume. Thermal input was a better predictor of salmonid biomass per unit volume in the Great Basin than in the Rocky Mountains, where the thermal regime may exert more influence on fish populations. Mean estimates of fish biomass per unit volume differed significantly between the Great Basin (55.9 g/cum) and Rocky Mountain (13.1 g/cum) study areas and were better related to stream canopy attributes than biomass estimates based on stream surface area; in the Great Basin study areas, the two types of biomass estimates were only weakly correlated with each other. In the Rocky Mountains, ungrazed sites generally had more canopy cover than grazed sites. In the Great Basin study areas, however,

differences in canopy were unimportant and were probably related to local management practices in several cases. (Author 's abstract).

Codes: reach multi experi graz ripar quant

Poff, N. L., and A. D. Huryn. 1998. Multi-scale determinants of secondary production in Atlantic salmon (Salmo salar) streams. Canadian Journal of Fisheries and Aquatic Sciences 55: 201-217.

Understanding variation in the freshwater production of Atlantic salmon across its range is a critical aspect of the species' conservation, restoration, and management. We focus on how environmental factors operate at four hierarchical scales (region, watershed, reach, local habitat) to influence the production and survivorship of juvenile salmon and the production of their invertebrate food base. Using published, quantitative information about invertebrate production in small, cold streams characteristic of Atlantic salmon nursery steams, we estimate expected maximum salmon production will be ca. 9 (range 6-22) g wet mass times m super(-2) times year super(-1), which compares favorably with reported literature values of <1 to 17 g times m super(-2). We highlight some empirically based, shortcut approaches to estimating invertebrate production that may be particularly useful for evaluating salmonid production across a range of scales. We also consider how availability of invertebrate prey may influence salmon production. As a synthesis, we integrate existing information into a multi-scale framework by making qualitative predictions (hypotheses) about expected patterns of invertebrate and salmon production at different habitat scales. We then develop quantitative, heuristic scenarios that predict (hypothesize) how salmon and invertebrate production will change in response to selected physicochemical and non-trophic habitat limitations operating at the watershed (geology, land use) and reach (channel form, canopy) scales. Predicted values, which fall within the range of observed values for Atlantic salmon streams, demonstrate that a multi-scale habitat perspective can provide important insights into local to regional variation in the production of Atlantic salmon across its range and thus contribute to Atlantic salmon conservation, restoration, and management.

Codes: modeling reach basin quant trophic ripar lulc

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52: 703-709.

#Has same limitations as any multiple c-m-c approach - e.g., closed population, catchability independent of age and habitat, assumption of animals behaving independently and identically. It also needs uniquely identifiable tags with a sufficiently high probability of recapture over extended time periods in order to estimate recruitment and/or survival.#

Codes: quant modeling

Quinn, T. P., and N. P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (Oncorhynchus kisutch) in Big Leaf Creek, Washington. CJFAS 53: 1555-1564.

Wild juvenile coho salmon (Oncorhynchus kisutch) were individually marked in October 1990 and 1991 to evaluate the effects of habitat complexity and fish size on over-winter survival in Big Beef Creek, Washington. Habitat complexity was quantified for the habitat unit where the fish were collected and, in 1991, also for the 500-m reach downstream from the collection site. Survival, estimated from recovery of marked smolts at the stream's mouth, differed between years (25.4 and 46.2%) and also varied among habitat units and reaches within years. Survival was at most weakly correlated with complexity of the habitat units but was strongly correlated with the quantity of woody debris and density of habitat units in the 500-m reach, and distance from the estuary. Because distance covaried with habitat complexity, it was not possible to ascertain which factor had the primary influence on survival. Larger fish generally survived at a higher rate than smaller individuals. Fish tagged above William Symington Lake were smaller in the fall but larger as smolts and had higher survival rates than those tagged below

the lake. Results reveal complex relationships between size, habitat, and growth that may affect over-winter survival and subsequent life history events.

Codes: reach quant popdyn lwd instream

Reeves, G., J. D. Hall, T. Roelofs, T. Hickman, and C. Baker. 1991. Rehabilitatiing and modifying stream habitats. Pages 519-557. 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 habitat basin hydro warning

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1991. Responses of anadromous salmonids to habitat modification: How do we measure them? Edited by J. Colt and R. J. White. AFS, BETHESDA, MD 62-67 p.

Responses of anadromous fish populations to habitat manipulations are seldom measured. The primary reasons given for this neglect are inadequate funds, personnel, and time. This paper examines ways in which biological responses to habitat manipulation can be evaluated at different stages in the life history of anadromous salmonids. Responses that can be measured are changes in numbers of adult fish, changes in numbers of juvenile fish, and changes in numbers of smolts leaving a stream or stream system. The authors assess the merits of each approach and conclude that changes in smolt numbers are the best way to evaluate the effect of habitat manipulation projects on anadromous salmonid populations. Evaluation programs should be developed on a basin or subbasin scale because reach or site scales provide an inadequate context for evaluating change. Evaluations should also consider the response of the entire salmonid community to changes in habitat rather than the response of a single or target species.

Codes: philosophy method instream basin

Reeves, G. H., F. H. Everest, J. R. Sedell, and D. B. Hohler. 1990. Influence of habitat modifications on habitat composition and anadromous salmonid populations in Fish Creek, Oregon, 1983-88. Annual report, 1988. Report DOE/BP/16726-5.

Modification of degraded habitats to increase populations of anadromous salmonids is a major focus of management agencies throughout the Pacific Northwest. Inherent in implementing habitat improvements is the need for quantitative evaluation of the biological and physical effects of such work. While it is not economically possible to thoroughly evaluate every habitat project, it is essential that intensive evaluations be done on selected representative projects. One such evaluation program has been underway since 1982 on Fish Creek, a tributary of the Clackamas River near Estacada, OR. Habitat modification has been done by the USDA Forest Service, Estacada Ranger District, Mt. Hood National Forest with funding provided in part by the Bonneville Power Administration (BPA). The USDA Forest Service, Anadromous Fish Habitat Research Unit, Pacific Northwest Research Station (PNW), Corvallis, OR is charged with: evaluating the biological and physical responses to habitat modifications on a basin scale; and developing a cost-benefit analysis of the program. The objectives of this paper are to: report 1988 observations of biological and physical changes in habitat, salmonid populations, and smolt production in Fish Creek, and examine preliminary trends in fish habitat and populations related to habitat improvement over the period 1983-1988. The authors have prefaced the trends in the latter objective as preliminary because we believe it could take a minimum of 10 years before the full biological and physical responses to habitat work are realized.

Codes: reach quant temporal instream

Reeves, G. H., J. D. Hall, and S. V. Gregory. 1997. The impact of land-management activities on coastal cutthroat trout and their freshwater habitats. Sea Run Cutthroat Trout: Biology, Management, And Future Conservation., American Fisheries Society, Oregon Chapter, Corvallis, Oregon 138-145.

Relatively few studies of the impact of land-management activities on anadromous salmonids and their freshwater habitats have considered coastal cutthroat trout. Those that included cutthroat trout have generally found that they are susceptible to the effects of land-management activities. Numbers of cutthroat trout juveniles and smolts have declined following such activities as timber harvest. Their numbers may remain depressed for extended periods following such disturbances, for reasons that are not clear. We offer an explanation: changes in pool depth and complexity may reduce habitat suitability, which may in turn reduce the carrying capacity of the stream or reduce survival by forcing juveniles to compete with other species. Coastal cutthroat trout may be the "canary in the coal mine" with respect to the integrity of aquatic ecosystems throughout their range. Management policies must be directed at arresting the decline in quality and quantity of freshwater habitat if coastal cutthroat trout populations are to persist.

Codes: review philosophy instream ripar sppinter

Reeves, G. H., D. B. Hohler, B. E. Hansen, F. H. Everest, J. R. Sedell, T. L. Hickman, and D. Shively. 1997. Fish habitat restoration in the Pacific Northwest: Fish Creek of Oregon. Watershed Restoration: Principles and Practices., American Fisheries Society 5410: 20814-2199.

The decline of anadromous salmonids in the Pacific Northwest of the United States is attributable to a suite of factors that includes overexploitation in sport and commercial fisheries, habitat alteration, migration barriers, variable ocean conditions, and influence of hatchery practices. A combination of these factors is generally associated with the depressed status of almost every population. The factor most associated with the decline of individual populations is habitat alteration, which includes a decline in the quantity and quality of freshwater habitat. Habitat in streams used by anadromous salmonids in the Pacific Northwest has been simplified as a consequence of many human activities. Simplification includes the loss of habitat, quality, diversity, and complexity. Such changes have occurred as a result of past as well as more recent activities and are common throughout much of the range of anadromous salmonids in western North America.

Codes: philosophy instream ripar

Reid, L. M. 2001. The epidemiology of monitoring. Journal of the American Water Resources Association 37: 815-820.

#only monitoring studies that had failed were considered #

Codes: review method design philosophy warnings

Reinhardt, U. G., and M. C. Healey. 1998. Predation risk as an opportunity for compensatory growth in juvenile coho salmon?

The present study explores the reasons for the apparent higher susceptibility of small individuals to predation. Field and laboratory observations were made of size-dependent foraging strategies in age-0 coho salmon (Oncorhynchus kisutch) under predation risk. In laboratory stream tanks groups of juvenile coho salmon were given a choice of a safe habitat and a habitat offering the same amount of food but associated with simulated predation risk from a model predator. Fish that made use of a risky pool were smaller and fewer in numbers than their counterparts in the safe pool. Overall growth rates were depressed and the difference in growth rates between small and large individuals was reduced when compared with control experiments without simulated predation. This suggests that large fish behaved in a risk-averse manner compared to small individuals, the latter making use of enhanced feeding opportunities indirectlyprovided by the presence of the predation threat. Speculation is that in a natural

environment, the presence of predators may serve to depress growth rates in a population through risk-avoidance behaviour, but may allow for growth compensation among size classes within a cohort. Befor removal of predators as paart of an enhancement scheme for salmonids, managers may consider the potential effect not only on mortality rates but also on growth patterns in a population of fish. (D.B.O.).

Codes: experi microhab lab popdyn

Richards, C., P. J. Cernera, M. P. Ramey, and D. W. Reiser. 1992. Development of off-channel habitats for use by juvenile chinook salmon. North American Journal of Fisheries Management 12: 721-727.

Fisheries habitat improvement frequently requires the exploitation of existing or artificial features of stream channels and associated floodplains. Along the Yankee Fork of the Salmon River, four series of off-channel mining dredge ponds were connected to the river by excavating channels; surface-water control structures were installed to regulate flow through each series of ponds. The project was created to increase rearing habitat for juvenile chinook salmon Oncorhynchus tshawytscha. Highest fish densities (5.2/m squared) in the newly constructed pond series were in connecting channel habitats. These densities were higher than those reported in other streams and may have been related to the hatchery origin of the stocked fish. Densities observed in the ponds were similar to those reported in natural habitats. Addition of habitats through incorporation of dredge ponds increases management options for rebuilding chinook salmon populations in the stream.

Codes: quant offchann habitat

Rieman, B. E., D. C. Lee, and R. F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1111-1125.

We summarized existing knowledge regarding the distribution and status of bull trout Salvelinus confluentus across 4,462 subwatersheds of the interior Columbia River basin in Oregon, Washington, Idaho, Montana, and Nevada and of the Klamath River basin in Oregon, a region that represents about 20% of the species' global range. We used classification trees and the patterns of association between known distributions and landscape characteristics to predict the likely distribution of bull trout in unsampled subwatersheds. Bull trout are more likely to occur and the populations are more likely to be strong in colder, higher-elevation, low- to mid-order watersheds with lower road densities. Our results show that bull trout remain widely distributed and occur in most of the subbasins representing the potential range. Some strong and relatively secure populations exist. In general, bull trout are better represented in the region as a whole than many other native species. Important declines in distribution and status are evident, although the extent of change is clouded by uncertainties in the historical distribution. Despite the broad distribution, much of the current range is poorly represented by strong or protected populations. The southern margins of the range are a particular concern and could be an important priority for conservation management. Continued habitat loss associated with disruptive land use practices threatens remaining bull trout populations. Even with no further habitat loss, existing fragmentation could contribute to continuing local extinctions aggravated by the expansion of introduced species and the effects of climate change.

Codes: multi qual lulc

Rieman, B. E., and J. D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124: 285-296.

Bull trout Salvelinus confluentus and other salmonids in the Pacific Northwest are believed at risk of local and regional extinctions because of ongoing habitat loss and fragmentation. Biologists have focused on defining and protecting critical stream channel characteristics, but there is little information regarding the scale or spatial geometry of habitat that may be necessary for the species' long-term persistence. We investigated the influence of habitat patch size on the occurrence of bull trout by determining the presence or absence of fish in naturally

fragmented watersheds of the Boise River basin in Idaho. We defined patches of potential habitat for bull trout as watersheds above 1,600 m elevation, a criterion based on the presumed restriction of local populations by stream temperature. We used logistic regression to investigate the possible influence of patch size as well as stream width and gradient on the occurrence of bull trout at reach, stream, and patch scales of analysis. Both stream width and patch size were significant in the models, but individual effects could not be clearly resolved because of collinearity. The predicted probability of occurrence based on patch size alone was less than 0.10 for patches smaller than about 1,000 ha and more than 0.50 for patches larger than about 2,500 ha. Our results support the hypothesis that area of available habitat influences the distribution of disjunct populations of bull trout. An area effect is consistent with the predictions of island biogeography and metapopulation theory, and our work suggests that larger-scale spatial processes may be important to the persistence of species like bull trout.

Codes: multi qual reach segment basin instream

Rieman, B. E., and J. D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16: 132-141.

We analyzed redd counts of bull trout Salvelinus confluentus in northern Idaho and northwestern Montana and found evidence of stronger correlation in the number and year-to-year change in number of redds between streams that were closer together than between streams that were far apart. The pattern was weak, however, indicating that spatial heterogeneity in habitat, in population demographics, or in life history at a local scale is important to stability of regional populations. The weak correlations also indicate that monitoring only a few index populations may not clearly represent the dynamics of larger regional populations. If synchrony is weak and not masked by sampling error, conservation management should favor the maintenance of high-quality habitats and strong local populations in proximity to each other to facilitate dispersal and demographic support. Common declining trends among all streams within a single lake basin show that even well-dispersed regional populations face important risks. Conservation management of species like bull trout must maintain populations at both local and regional scales.

Codes: multi basin segment spawn qual temporal

Riley, S. C., and K. D. Fausch. 1995. Trout population response to habitat enhancement in six northern Colorado streams. Canadian Journal of Fisheries and Aquatic Sciences 52: 34-53.

The effects were examined of log drop structures on trout populations in six small, remote Rocky Mountain streams. Angling pressure was low on all streams, and most anglers killed no fish. Log drop structures were installed in 250-m treatment sections in summer 1988, and results were compared with adjacent 250-m control sections during 1987-1990. The structures caused marked changes in habitat, including greatly increased pool volume, decreased current velocity, and increased depth and cover. After the structures were installed, abundance and biomass of age-2 and older trout (and often age-1 trout) increased in all six streams, but there was no evidence that trout were in better condition or grew to larger sizes in most streams. Recaptures of tagged trout in two streams showed that the logs did not result in increased growth or survival of resident trout, although recaptures of fin-clipped trout inother streams suggested that apparent survival may have increased temporarily in treatment sections.

Codes: multi experi reach quant migrat popdyn instream fishing

Rimmer, D. M. 1985. Effects of Reduced Discharge on Production and Distribution of Age-0 Rainbow Trout in Seminatural Channels. Transactions of the American Fisheries Society 114: 388-396.

The effects of reduced discharge on emigration, abundance, growth, production, and distribution of underyearling rainbow trout, Salmo gairdneri, were studied in small, seminatural experimental streams in New Zealand. Three stream channels had constant discharges of 0.125 cu m/s from mid-November (spring in southern hemisphere) to mid-February. Discharge was then reduced in two channels, but remained unchanged in the third. Reduction of discharge by 32% (to 0.085 cu m/s) and by 60% (to 0.050 cu m/s) caused no increase in downstream emigration, the emigration rate immediately before reduction being 0.1-0.7 fish/d and that for 5 months after reduction being 0.0-

0.3 fish/d. However, the results may have been influenced by unequal population sizes in the channels before the discharges were altered. Presumably, these differences were caused by unequal hatching success of eggs planted in the channel substrates. Population density was greatest (41/100 sq m) in the channel selected for control discharge. Following discharge alteration, this pattern continued (lowest discharge: 21/100 sq m; control: 7/100 sq m). Fish size differences between channels at the end of the experiment (7 July) were in direct relation to channel discharges and in inverse relation to population density (largest fish in the control and smallest fish in the low discharge channel). Reductions in instantaneous growth rates were attributable to reduced discharge, but occurred about 2 months after discharge reduction. Reduced discharge depressed production after about 1.5 months and by the end of the experiment there had developed a direct relationship between discharge and production; production was 1.4 g/100 sq m at 0.125 cu m/s and -3.8 g/100 sq m at 0.050 cu m/s. There were no significant differences among the channels in the distribution of fish among riffle, pool, and run habitat types. Before discharge reduction, fish in all channels occurred mostly in the riffles and, after reduction, fish in control and treated channels became progressively more evident in the pools. Discharge reduction had no effect on this distribution. (Author 's abstract).

Codes: experi reach quant popdyn migrat hydro

Rimmer, D. M., U. Paim, and R. L. Saunders. 1983. Autumnal habitat shift of juvenile Atlantic salmon (Salmo salar) in a small river. Canadian Journal of Fisheries and Aquatic Sciences 40: 671-680.

Autumnal changes in behavior and distribution of three age-classes of juvenile Atlantic salmon (Salmo salar) were determined during 3 yr in the Little Sevogle River of northeastern New Brunswick. In summer, salmon were always observed above the streambed, each holding a station over a single, unshaded stone. About 84% of the entire population occurred in the run habitat-type, 12% in riffles and 5% in pools. Underwater visual censuses showed the salmon to be continuously numerous in summer, but, as soon as water temperature fell to or below 10 degree C in autumn, they disappeared from their stations and their visible population decreased by 92-98%. Thereafter, the salmon were found almost exclusively in sheltered substrate chambers beneath surface streambed stones. However, salmon distribution among runs, riffles, and pools (77, 18, and 5%, respectively) did not differ significantly from that in summer. Trapping, marking, and absolute population estimates indicated neither dwindling nor egress of the resident population.

Codes: microhab habitat quant substrate temporal wtemp

Ringstad, N. R. 1974. Food competition between freshwater sculpins (genus Cottus) and juvenile coho salmon (Oncorhynchus kisutch): an experimental and ecological study in a British Columbia coastal stream. Report

A system of experimental troughs was designed to examine food competition between sculpins and juvenile coho. Manipulation of sculpin densities showed that sculpins at higher than stream densities were able to crop down the benthos sufficiently to significantly reduce drift densities and thus coho growth. At close to natural stream densities sculpins did not limit coho growth. A detailed study of the autecology of the 2 sculpins C. asper and C. aleuticus occurring in Carnation Creek did not alter this conclusion. Juveniles of both sculpin spp are found in the estuary. These results from either estuarine spawning or upstream spawning combined with downstream movement from March to July to the estuary, and subsequent metamorphosis of larvae. Upstream migration of young cottids takes place a year later from Aug to Dec. In the lower 1500 m of the stream C. asper tends to occupy areas with good cover and low current velocity, whereas C. leuticus is restricted to the peripheral areas of C. asper habitat and riffles. In the lowest reaches of the stream the ratio of C. aleuticus to C. asper is 4:1. Above 1500 m, in the absence of C. asper, C. aleuticus occupies all available habitat. C. aleuticus is smaller per age group than C. asper and the life span of both spp is up to 7 yr. Both spp are primarily bottom foragers feeding on aquatic insect larvae. Feeding increases throughout the night with maximal activity at or just before dawn. Some sexually mature adults of both spp undertake a downstream spawning migration in the spring. Most C. asper spawn in the estuary while C. aleuticus may undergo only local migrations and spawns primarily in freshwater.

Codes: experi reach qual sppinter trophic

Rinne, J. H. 1994. The effects of fire and its management on southwestern (USA) fishes and aquatic habitats. Lake and Reservoir Management 9: 108.

Based on case histories from 5 headwater streams on two National Forests in Arizona and New Mexico, the effects of naturally-caused wildfire on aquatic habitats, fishes and their food supply may be marked and long-lasting. Hydrologic events following recent (1989-1990) wildfires in Arizona and New Mexico effectively extirpated two population of brook trout (Salvelinus fontinalis), one of rainbow trout (Oncorhynchus mykiss) and one of Gila trout (O. gila). Aquatic macroinvertebrates densities effectively declined to zero within a month after the Dude Fire, and diversities 25 to 70% a year later. Trout re-introduced one year after the fire declined 85 to 97% in a two-year period. Suppression of fire in forests of the Southwest has resulted in increased fuel loading on watersheds and more large, hot, crowing wildfires. Removal of 60% of more of forest vegetation, extensive exposure of bare soil, and large accumulations of ash, followed by annual summer monsoon storms (July-September), result in flow events that have a high probability of totally removing a stream fish population and/or dramatically altering a potential food source, aquatic macroinvertebrates. #Abstract only.#.

Codes: multi experi reach quant lulc temporal ripar trophic

Rinne, J. N. 1982. Movement, home range, and growth of a rare southwestern trout in improved and unimproved habitats. North American Journal of Fisheries Management 2: 150-157.

Data collected on 129 recaptured Gila trout (Salmo gilae) in three streams on the Gila National Forest, New Mexico, indicated that this endangered trout tended to stay near "home" (mean movement < 0.1 km) and grew less, both in streams containing larger fish populations and streams containing log improvement structures, than in other streams. Those fish that moved went greater distances downstream. Few fish (< 2%) moved upstream over habitat-improvement structures, and such movement was limited by structures greater than or equal to 0.5 m high. In one intermittent stream, these fish oriented to permanent-water reaches. Future introductions of this rare trout should be in headwater areas, and habitat improvement should be done with a conservative number of low (0.5 m) structures.

Codes: multi reach quant migrat instream ripar

Rinne, J. N. 1988. Grazing effects on stream habitat and fishes: Research design considerations. North American Journal of Fisheries Management 8: 240-247.

A 4-year study of a montane stream from which cattle grazing had been excluded for 10 years indicated that stream bank vegetation and stability were markedly improved and that stream substrate fines were somewhat reduced, but it indicated that fish populations were unaffected. Shortcomings of this case history study are common to past similarly designed studies of grazing effects on fishes and their habitats. Three major deficiencies in research design are (1) lack of pretreatment data, (2) improper consideration of fishery management principles, and (3) linear positioning of treatments along a stream. Future research on riparian grazing effects must address these factors in addition to designs of long-term (10+ years) ecosystem (watershed) studies.

Codes: reach graz quant design

Rinne, J. N., and A. L. Medina. 1988. Factors influencing salmonid populations in six headwater streams, central Arizona, USA. Polskie Archiwum Hydrobiologii/Polish Archives of Hydrobiology 35: 515-535.

Comparison of abiotic and biotic variables that could influence trout populations in six headwater streams, central Arizona (USA) suggests that physical habitat strongly influences salmonid density and standing crop. Stepwise regression analysis indicated that stream depth explained most of the variation in density and biomass of trout (66 and 77%, respectively). Stream substrate explained 11 and 9% of the variation in trout density and biomass,

respectively. Livestock grazing is suggested as a significant contributor to increased substrate fines (< 0.25) and reduced fish populations in several of these streams.

Codes: reach multi instream graz quant

Rodriguez, M. A. 1995. Habitat-specific estimates of competition in stream salmonids: A field test of the isodar model of habitat selection. Evolutionary Ecology 9: 169-184.

The population densities of sympatric Atlantic salmon, Salmo salar and brook charr, Salvelinus fontinalis, were measured in riffle and pool stream habitats to test whether non-linear isodars, a multispecific model of habitat selection based on ideal distribution assumptions, could (1) predict the distribution of densities between habitats and (2) reproduce the processes postulated to underlie spatial segregation and species interactions in previous laboratory and field studies. The model provided a good fit to observed density patterns and indicated that habitat suitability declined non-linearly with increased heterospecific competitor densities. Competitive effects in riffles appeared to be due to exploitative resource use, with salmon always emerging as the superior competitor. No evidence was found for interference competition in riffles. In contrast, interspecific competition in pools seemed to occur through exploitation and interference. The specific identity of the superior competitor in pools depended on the density of both species; pools provided the charr with refuge from competition with the salmon, presumably through the adoption by the charr of density-dependent behaviours, such as schooling and group foraging, that mitigated the negative impact of the salmon. Charr were displaced from the riffles toward the pools as the total salmon density increased. The isodar analysis, based on limited density data, successfully reproduced the processes suggested to underlie spatial segregation in previous field and laboratory studies and provided new insights into how changes in competitor densities modify habitat suitability in this system.

Codes: modeling habitat quant sppinter

Roni, P. 2001. Responses of fishes and salamanders to instream restoration efforts in western Oregon and Washington. Project Completion Report to Bureau of Land Management, Oregon State Office, 1515 S.W. 5th St. Portland OR 97208 and Environmental Conservation Division, Northwest Fisheries Science Center, NMFS, 2725 Montlake Blvd. E., Seattle WA 98112. , 132 p. January 2001.

#This report is really a comparative study in that he measures the density of organisms among structures in treated streams in comparison to densities in streams which have not been treated. He blocks his study design by essentially, gradient, bankfull width, channel type,confinement, and species composition. Essentially, the argument is that the experiment is done and he is merely collecting the results of the experiment (much like our study with Boone). The number of paired streams of treatment and reference reaches was 30. Each reach was about 100m long. The problem is like ours'. His measurements are snap-shot of densities, albiet once in summer and another during the winter. The dynamic aspects of population change are not covered. Mind you, this is a good study, but does not meet our strict criterion of following population change and yes putting large wood in streams appears to help juvenile salmonids.# (See Roni and Quinn (2001)).

Codes: multi experi reach quant instream lwd

Roni, P., T. J. Beechie, R. E. Bilby, F. E. Leonetti, M. M. Pollock, and G. R. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. NAJFM 22: 1-20.

Millions of dollars are spent annually on watershed restoration and stream habitat improvement in the U.S. Pacific Northwest in an effort to increase fish populations. It is generally accepted that watershed restoration should focus on restoring natural processes that create and maintain habitat rather than manipulating instream habitats. However, most process-based restoration is site-specific, that is, conducted on a short stream reach. To synthesize site-specific techniques into a process-based watershed restoration strategy, we reviewed the effectiveness of various restoration

techniques at improving fish habitat and developed a hierarchical strategy for prioritizing them. The hierarchical strategy we present is based on three elements: (1) principles of watershed processes, (2) protecting existing high-quality habitats, and (3) current knowledge of the effectiveness of specific techniques. Initially, efforts should focus on protecting areas with intact processes and high-quality habitat. Following a watershed assessment, we recommend that restoration focus on reconnecting isolated high-quality fish habitats, such as instream or off-channel habitats made inaccessible by culverts or other artificial obstructions. Once the connectivity of habitats within a basin has been restored, efforts should focus on restoring hydrologic, geologic (sediment delivery and routing), and riparian processes through road decommissioning and maintenance, exclusion of livestock, and restoration of riparian areas. Instream habitat enhancement (e.g., additions of wood, boulders, or nutrients) should be employed after restoring natural processes or where short-term improvements in habitat are needed (e.g., habitat for endangered species). Finally, existing research and monitoring is inadequate for all the techniques we reviewed, and additional, comprehensive physical and biological evaluations of most watershed restoration methods are needed.

Codes: review multi basin reach offchann warnings

Roni, P., and T. P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques. Ottawa ON [Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.] 58: 282-292.

Thirty streams in western Oregon and Washington were sampled to determine the responses of juvenile salmonid populations to artificial large woody debris (LWD) placement. Total pool area, pool number, LWD loading and LWD forming pools were higher in treatment (LWD) placement. Total pool area, pool number, LWD loading, and LWD forming pools were higher in treatment (LWD placement) than paired reference reaches during summer or winter. Juvenile coho salmon (Oncorhynchus kisutch) densities were 1.8 and 3.2 times higher in treated reaches compared with reference reaches during summer and winter, respectively. The response (treatment minus reference) of coho density to LWD placement was correlated with the number of pieces of LWD forming pools during summer and total pool area during winter. Densities of Ag-+1 cutthroat trout (Oncorhynchus clarkii) and steelhead trout (Oncorhynchus mykiss) did not differ between treatment and reference reaches during summer but were 1.7 times higher in treatment reaches during winter. Age-1+ steelhead density response to treatment during summer was negatively correlated with increases in pool area. Trout fry densities did not differ between reaches, but the response of trout fry to treatment was negatively correlated with pool area during winter. Research indicates that LWD placement can lead to higher densities of juvenile coho during summer and winter and cutthroat and steelhead during winter.

Codes: multi experi reach quant instream lwd

Roper, B. B., D. L. Scarnecchia, and T. J. La Marr. 1994. Summer distribution of and habitat use by chinook salmon and steelhead within a major basin of the South Umpqua River, Oregon. Transactions of the American Fisheries Society 123: 298-308.

Snorkeling and established stream habitat assessment methods were used to determine basinwide summer habitat use by juvenile chinook salmon Oncorhynchus tshawytscha and juvenile steelhead O. mykiss in 1989 in eight reaches along 39 km of Jackson Creek, a fifth-order tributary to the South Umpqua River, Oregon. Juvenile steelhead (ages 0-3) were widely distributed throughout the entire stream but age-1 and older fish were found in higher densities in the middle reaches whereas age-0 fish were found in higher densities in the upper reaches. Juvenile chinook salmon were found in the highest densities in the middle reaches. Juvenile steelhead used mostly riffles in the downstream reaches but mostly pools in the upstream reaches. Age-0 chinook salmon were strongly associated with pools in all reaches. Several factors are suggested that may have influenced distribution and abundance of both species; these include high stream temperatures in the lower reaches, habitat preferences of each species, and the interaction and resultant habitat segregation between the two species. Densities of steelhead varied by nearly 5-fold over the reaches studied and densities of chinook salmon varied by more than 10-fold. Thus,

habitat studies on streams with variable habitat and patchy fish distributions should be conducted over a larger area of the basin than has typically been the case in previous studies.

Codes: reach quant instream

Rosenfeld, J. 2000. Effects of fish predation in erosional and depositional habitats in a temperate stream. Canadian Journal of Fisheries and Aquatic Sciences/Journal Canadien des Sciences Halieutiques et Aquatiques. Ottawa 57: 1369-1379.

Combined effects of predation by benthic and drift-foraging fish (prickly sculpin (Cottus asper) and coho salmon (Onchorhynchus kisutch parr) on benthic invertebrate community and trophic structure were evaluated in Mayfly Creek, a previously fishless stream in the Coast Range Mountains of British Columbia. The role of microhabitat in mediating predation effects was assessed by comparing invertebrate community structure on unglazed ceramic tiles and gravel baskets nested within enclosures. The role of macrohabitat was evaluated by placing enclosures in pool and riffle habitats. Effects of fish predation were most pronounced on tile substrate and in riffle habitat and least pronounced on gravel substrate in pool habitat. The presence of fish caused a decrease in abundance of larger bodied herbivores (primarily the mayflies Ameletus and Baetis) and had positive indirect effects on algae and smaller invertebrates (primarily Orthocladiinae chironomids and nemourid stoneflies), probably through competitive release. In contrast with herbivores, detritivorous invertebrates were less influenced by fish predation and more highly correlated with the abundance of organic detritus. The distribution and abundance of detritivores in Mayfly Creek appear to be primarily influenced by bottom-up forces, while grazers in algal-based food chains are more strongly influenced by top-down effects (fish predation).

Codes: reach sppinter trophic qual

Rosenfeld, J., M. Porter, and E. Parkinson. 2000. Habitat factors affecting the abundance and distribution of juvenile cutthroat trout (Oncorhynchus clarki) and coho salmon (Oncorhynchus kisutch). 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: 766-774.

The distribution, abundance, and habitat associations of juvenile anadromous coastal cutthroat trout (Oncorhynchus clarki) and coho salmon (Oncorhynchus kisutch) were evaluated using survey data from 119 sites in coastal British Columbia. Both cutthroat and coho occurred at their highest densities in very small streams (<5 m channel width), and bankfull channel width was the single best predictor of cutthroat presence ($p = 0.0001$) and density (R super(2) = 0.55). Within a channel, densities of coho and larger (yearling and older) cutthroat parr were highest in pools, while densities of young-of-the-year cutthroat were significantly lower in pools and highest in shallower habitats. Abundance of larger cutthroat parr and pool habitat were positively correlated with large woody debris (LWD) within a subset of intermediate-gradient gravel-cobble streams, where pools appear to be limiting to larger cutthroat parr abundance. More than 50% of pools were formed by scour associated with LWD in streams ranging from 1.2 to 11 m channel width, and pools formed by LWD scour were on average 10% deeper than pools formed by other mechanisms. Disproportionate use of small streams by cutthroat indicates that protection of small stream habitat is important for long-term conservation of sea-run populations.

Codes: multi reach quant instream lwd substrate

Roussel, J. M., and A. Bardonnet. 1999. Ontogeny of diel pattern of stream-margin habitat use by emerging brown trout, Salmo trutta, in experimental channels: influence of food and predator presence. Environmental Biology of Fishes 56: 253-262.

Age-0 brown trout, Salmo trutta, inhabit shallow and slow-flowing habitats where they can easily maintain stationary swimming positions. However, recent results have shown that they use deeper and faster habitats during daylight than at night, suggesting the occurrence of a nocturnal movement toward stream-margin habitats.

Experiments were conducted to describe precisely when this diel pattern of habitat use appears during ontogeny. In two indoor channels, free-embryo brown trout were deposited under the gravel. When emerging, alevins were free to choose between margin (2 cm deep, 0-2 cm s super(-1)) or deep habitat (12 cm, 2-4 cm s super(-1)), or to leave the channel (upstream or downstream). During the week of emergence, upstream and downstream catches, fish habitat use (deep habitat or margin), and fish behavior (resting or swimming) were measured by direct observations and trap counts. Three treatments were performed: (1) fish artifically fed on drifting invertebrates, (2) fish exposed to predators (bullhead, Cottus gobio), and (3) control channels (no food, no predator). In control and food channels, a diel pattern of habitat use was observed 1-2 days after the emergence started. Most fish rested in the margin at night, whereas they moved towards the deep habitat during daylight to hold stationary swimming positions. In the presence of bullhead, most trout were cryptic, and visible fish stood in the margin during both daylight and at night. The importance of predation risk and foraging behavior on the ontogeny of the diel pattern of habitat use is discussed. Results support the direct development without larva from free-embryo via alevin in brown trout.

Codes: experi habitat qual trophic

Roussel, J. M., A. Bardonnet, J. Haury, J. L. Bagliniere, and E. Prevost. 1998. Aquatic plants and fish assemblage: a macrophyte removal experiment in stream riffle habitats in a lowland salmonid river (Brittany, France). Edited by P. Prunet, J. L. Bagliniere, B. Breton, O. Kah, F. Pakdel and P. Saglio. Conseil Superieur de la Peche, Boves (France)

The effect of aquatic weed development on fish habitat preferences was studied during a two-year in situ experiment in lotic habitats of the Scorff river (Brittany, France). In the two riffles studied (800 and 600 M super(2) macrophytes (essentially Ranunculus penicillatus) covered more than 70% of the total surface area during the growing season in spring. In May, macrophytes were removed from one stream bank to the center of the riverbed (in each riffle) in order to create habitat without aquatic vegetation. The main effect of macrophyte removal on the physical habitat variables was an increase in water velocity (60% on average). One month later, electrofishing surveys showed greater fish biomass and higher densities in vegetated habitats. The same species were present in both habitat types but density in Atlantic salmon parr (Salmo salar L.) was higher in habitats without macrophytes (30 ind times 100 m super(-2) on average) than in vegetated habitats (15 ind times 100 m super(-2) on average). Conversely, stone loach (Barbatula barbatula L.) and European minnow (Phoxinus phoxinus L.) densities were 47 ind times 100 m super(-2) on average in vegetated habitats, i.e. two to four times greater than in habitats without vegetation. The results point out that macrophytes can change drastically habitat conditions and suggest a decrease in the carrying capacity of riffles for age-0 salmon parr.

Codes: experi habitat quant instream

Sabaton, C., L. Siegler, V. Gouraud, J. L. Bagliniere, and S. Manne. 1997. Presentation and first applications of a dynamic population model for brown trout, Salmo trutta L.: Aid to river management. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 425-438.

A mathematical model representing the long-term change in a trout population under different river management scenarios is presented. It describes the structure of a population broken down into age classes based on the Leslie matrix; if the population structure for any given month is known, the model should be able to estimate that of the following month. The passage from one month to the next takes into account various relevant factors: survival rate of individuals in the different age classes; fertility rate of females; linear and weighted growth rates; displacement linked to habitat fluctuations using weighted usable area (WUA) values. The model was applied to two French rivers. Regular monitoring of trout populations on the River Kernec enabled comparison of the response of the model with no displacement, with actual variations in fish stocks on the first river. In addition, the knowledge of WUA chronologies on the River Echez made it possible to carry out initial simulations of the response of a fish population to different river management scenarios at the second site.

Codes: modeling popdyn habitat ifim temporal hem

Saffel, P. D., and D. L. Scarnecchia. 1995. Habitat use by juvenile bull trout in belt-series geology watersheds of northern Idaho. Northwest Science 69: 304-317.

Bull trout (Salvelinus confluentus), a native char of the Pacific Northwest, has declined in abundance and distribution in recent years. Little is known about the habitat use by salmonids in streams with substrate characterized by Belt-Series geology. Such information could be used by managers to evaluate potential effects of land use practices on the species, or to enhance or protect existing habitat. A total of 28 pools, 60 riffles, and 46 runs was sampled in 14 reaches of four streams to determine habitat use of age 0 and age greater than or equal to 1 juvenile bull trout in three habitat types (pools, runs, and riffles) and in channel margins and main channels. Age 0 bull trout used habitat types in equal proportion to availability, whereas age greater than or equal to 1 juvenile bull trout selected pools and avoided riffles. Lateral position within the stream channel differed with age class: 88% of the age 0 fish were in the channel margins, whereas 91% of the age greater than or equal to 1 fish were in the main channel. In addition to the habitat use study, 18 reaches in six streams were studied to determine habitat characteristics that influence abundance and distribution of juvenile bull trout. Reaches with high densities (3.9 to 11.2 fish/100 m super(2)) of bull trout had maximum summer temperatures ranging from 7.8 to 13.9 degree C, whereas most reaches with low densities (<1.0 fish/100 m super(2)) had higher maximum summer temperatures (18.3 to 23.3 degree C). Density of juveniles in reaches increased with the number of pocket pools/100 m. The combination of number of pocket pools and maximum summer temperature explained nearly two-thirds of the variation in density of juvenile bull trout.

Codes: multi reach habitat quant instream wtemp

Sale, M. J., J. M. Loar, G. F. Cada, and P. Kanciruk. 1983. Applicability of the instream flow incremental methodology (IFIM) for predicting trout biomass and abundance. EOS, Transactions, American Geophysical Union 64: 702.

An evaluation of the IFIM physical habitat model (U.S. Fish and Wildlife Service) is being carried out in trout streams in the southern Appalachian mountains. This study will provide guidance for regulators and developers on the assessment for instream flow needs at hydroelectric projects. Eight sites with naturally reproducing populations of brown trout (Salmo trutta) and/or rainbow trout (S. gairdneri) and with minimal disturbances from water pollution, stocking, and excessive fishing pressure were selected for study in Tennessee and North Carolina. Weighted usable area (a measure of physical habitat condition), water quality, benthic invertebrate biomass, fish standing crop, and fish production were estimated at each site over an eighteen-month period. A multivariate statistical approach was used to determine the best predictors or fish biomass and abundance.

Codes: multi reach quant instream watqual ifim hem

Sankovich, P., R. W. Carmichael, and M. L. Keefe. 1998. Fish research project - Oregon: Smolt migration characteristics and mainstem Snake and Columbia River detection rates of PIT-tagged Grande Ronde and Imnaha River naturally-produced spring chinook salmon. Annual report 1996.

This is the fifth year of a multi-year study to assess smolt migration characteristics and cumulative detection rates of naturally-produced chinook salmon (Oncorhynchus tshawytscha), from northeast Oregon streams. The goal of this project is to develop an understanding of interpopulation and interannual variation in several early life history characteristics of naturally-produced chinook salmon from the Grande Ronde and Imnaha River subbasins. This project provides information useful in the recovery of listed Snake River spring/summer chinook salmon. Specific populations included in the study are (1) Catherine Creek, (2) upper Grande Ronde River, (3) Lostine River, (4) Imnaha River, (5) Wenaha River, and (6) Minam River. In this document, we present findings from research completed in 1996. Naturally-produced chinook salmon populations in the Grande Ronde and Imnaha River subbasins have declined drastically in recent years due in part to habitat alterations and hydropower development. Declines have continued despite extensive mitigation efforts, including fish passage improvements, artificial production, supplementation, and habitat modification (BPA Division of Fish and Wildlife 1990). Snake River

spring/summer chinook salmon (hereafter referred to as chinook salmon), which include naturally-produced chinook salmon in the Grande Ronde and Imnaha River subbasins, have been listed under the Endangered Species Act of 1973 as threatened or endangered since 1992.

Codes: multi reach basin migrat instream temporal

Scarnecchia, D. L., and E. P. Bergersen. 1986. Production and habitat of threatened greenback and Colorado River cutthroat trouts in Rocky Mountain headwater streams. Transactions of the American Fisheries Society 115: 382-391.

Field studies conducted in 1979 and 1980 to assess the production and habitat of cutthroat trouts Salmo clarki in three headwater tributaries in north-central Colorado yielded the following estimates of production (g/m2): greenback cutthroat trout S. c. stomias in Roaring Creek, 3.3 in 1959 and 2.3 in 1980; greenback cutthroat trout in the Right Hand Fork of Roaring Creek, 3.6 in 1979 and 1.5 in 1980; Colorado River cutthroat trout S. c. pleuriticus in Little Green Creek, 2.2 in 1979 and 3.6 in 1980. Biomass and production in Roaring Creek and Right Hand Fork of Roaring Creek were dominated by old („3 years) slow-growing fish. Little Green Creek was the warmest and slowest moving of the creeks studied and had a low diversity of substrates dominated by fine and coarse gravel--it also had the highest biomass and production of young of the year. Right Hand Fork Roaring Creek had faster flows and more extensive undercut banks--it also had the most large fish („152 mm long). Biomass and production of cutthroat trout within the three streams depended mainly on stream-specific physical characteristics. In addition, year-class strength appeared to be mainly affected by the time of emergence and growth rates of juveniles prior to their first winter and by the abundance of large resident fish.

Codes: multi reach quant popdyn instream substrate

Scarnecchia, D. L., and E. P. Bergersen. 1987. Trout Production and Standing Crop in Colorado 's Small Streams, as Related to Environmental Features. North American Journal of Fisheries Management 7: 315-330.

Annual production of trout (Salvelinus and Salmo spp.) in 10 small northern Colorado streams ranged from 1.5 to 18.4 g/sq m in 1979 and 1980. Midsummer biomass ranged from 3.9 to 28.2 g/sq m. Ratios of production to biomass ranged from 0.23 to 0.95. Fish production and biomass were related inversely to elevation and directly to substrate diversity, conductivity, alkalinity, and water hardness. Combinations of the various factors explained much of the variation in production: elevation and width:depth ratio, 60%; elevation and substrate diversity, 54%; elevation, substrate diversity, and percentage of zero-water-velocity stations, 79%; and elevation, width:depth ratio, and alkalinity, 77%. Similar relationships were developed for midsummer biomass. There was a strong correlation between midsummer biomass and annual production as well as between annual production and the density of fish of desirable size (152 mm long or longer) in each stream. Several relationships are proposed from these data sets that can be used to predict trout production in small, high-elevation streams. Estimated habitat quality indices for the 11 sections were significantly related to midsummer biomass of trout in 1979 but not in 1980. (Author 's abstract).

Codes: multi reach quant instream watqual substrate

Scarnecchia, D. L., and B. B. Roper. 2000. Large-scale, differential summer habitat use of three anadromous salmonids in a large river basin in Oregon, USA. Fisheries Management and Ecology 7: 197-209.

Codes: multi reach quant? instream

Scherer, E., R. E. McNicol, and E. J. Murkin. 1984. Observations on habitat selection and partitioning by brook charr, Salvelinus fontinalis (Mitchill), in the South Duck River, a Manitoba woodland stream. Report ISSN 0706-6473.

The South Duck River is a spring-fed woodland stream in west-central Manitoba, containing a population of brook charr, S. fontinalis, but no other salmonid species. This report presents results of a preliminary survey on habitat selection and partitioning by this species within a 168 m long stream section, in relation to current velocity, substrate, and depth. A distinct separation of habitats for young-of-the-year and older year-classes was apparent. Young-of-the-year preferred shallow (approximately equals 10-20 cm deep), moderately fast-flowing (10-20 cm multiplied by s super(-1)), gravel and rubble covered areas, while older year-classes were found in deeper areas (20-85 cm deep), with a wider range of current velocities and substrates, including areas covered with sand and silt.

Codes: habitat qual? instream substrate

Schneider, J. 1998. Habitat choice in juvenile Atlantic salmon (Salmo salar Linne, 1758) at selected releasing spots in the Rhineland-Palatinate. Zeitschrift Fuer Fischkunde 5: 77-100.

The daytime habitat choice of 355 juvenile (0+ and 1+) Atlantic salmon (Salmo salar) parr was examined in second and third order streams in the Rhineland-Palatinate state (Germany) by electrofishing using the point abundance method. The study is part of the "Salmon 2000" program intended to reintroduce Atlantic salmon to the river Rhine where they were extirpated in the middle of the century. The stream locations salmon parrs inhabited were classified as riffle-pool, deep pool, low current and standing water habitats. Association to cover by salmon parr was determined by measuring different cover structures such as submerse vegetation /roots, overhanging structures and rocks at the micro-scale of salmon position (focal point). Furthermore individual substrate choice was recorded. Finally, physical factors such as water depth, water velocity, broken water surface, shade and distance from the shore were also assessed at the focal point of salmon. Competition was studied by recording the number of salmonids (salmon and brown trout (Salmo trutta) captured at the same location. Results were analysed separately for (1) young-of-the-year (age 0+) < 100 mm standard length (n1 = 200) and (2) 1+ parrs (n2= 155) measuring > 100 mm SL. Large salmon parrs preferred deeper locations (e.g. deep pools), low velocities and a low percentage of gravel. Small salmon inhabited mainly riffles with variable velocities and avoided deep pools. The results will help to determine habitat suitability for successful re-introduction of the species.

Codes: multi microhab qual instream foreign

Scott, J. B., C. R. Steward, and Q. J. Stober. 1986. Effects of urban development of fish population dynamics in Kelsey Creek, Washington. Transactions of the American Fisheries Society 115: 555-567.

A 30-mo study of the comparative dynamics of the fish populations inhabiting Kelsey Creek, located in the City of Bellevue, Washington, and a nearby pristine control stream suggest that urban development has resulted in a restructuring of the fish community. Environmental perturbations, including habitat alteration, increased nutrient loading, and degradation of the intragravel environment appeared to have a greater impact on coho salmon Oncorhynchus kisutch and nonsalmonid fish species than on cutthroat trout Salmo clarki. Although the total biomass (g/m super(2)) of fish in each stream was similar, its composition differed markedly. Ages 0 and I cutthroat trout were the majority of the fish community inhabiting Kelsey Creek, whereas the control stream supported a diverse assemblage of salmonids of various ages and numerous non-salmonids.

Codes: experi reach quant instream watqual substrate

Scrivener, J. C., and B. C. Andersen. 1984. Logging impacts and some mechanisms that determine the size of spring and summer populations of coho salmon fry (Oncorhynchus kisutch) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 41: 1097-1105.

Natural patterns in emergence times, seaward movements, instream distributions, densities, and growth of coho salmon fry (Oncorhynchus kisutch) between March and September are contrasted with patterns observed during and fate logging in the Carnation Creek watershed. After streamside logging in 1976-77, fry emerged up to 6 wk earlier and moved seaward more quickly than during years before logging. These observations are attributed to higher water temperatures during the winter and to emergence during a period of more frequent freshets. Increased fry movement from the stream could result in habitat being underutilized. In sections affected by intense streamside logging, the deposition of "fine" logging debris led to increased fry densities during the summers of 1977 and 1978.

Codes: experi reach quant migrat ripar wtemp

Scruton, D. 1996. Evaluation of the construction of artificial fluvial salmonid habitat in a habitat compensation project, Newfoundland, Canada. Regulated Rivers Research & Management 12: 171-183.

In 1987, the provincial transportation agency in Newfoundland, Canada requested approval from the Canadian Department of Fisheries and Oceans (DFO) to destroy a 162 m section of fluvial salmonid habitat to accommodate highway construction. The DFO's Policy for the Management of Fish Habitat required the proponent to compensate for this habitat loss through the construction of a replacement section of stream. The results are presented from a research programme to evaluate the success of this project focusing on: (1) considerations in the design and construction of the replacement habitat; (2) a comparison of key habitat attributes between the destroyed stream section and the compensatory habitat; and (3) the utilization of the compensatory habitat by resident fish. The results of the study indicate an increase in habitat area of 125 m super(2) (23%) over the 162 m section of stream habitat lost due to construction, primarily related to the increase in thalweig length (20% increase) resulting from designed sinuosity in the compensatory habitat. Habitat design increased the amount and proportion of pool habitat to benefit the primary resident species, brook trout (Salvelinus fontinalis) and resulted in a 134% increase in pool quantity (increase of 98 m super(2)), a 281% increase in pool volume (31.06 m super(3)), a 223% increase in the pool to riffle ratio and a 29% increase in the mean depth. Fish biomass, after an initial decrease after construction (1991), increased to the highest level during the study (93.5 g per 100 m super(2) unit) in 1993, a 2.1-fold increase over the average pre-construction biomass. A corresponding decrease in salmonid densities was evident, primarily reflecting a shift in use from young of the year (YOY or 0+) Atlantic salmon (Salmo salar) to larger, older brook trout in response to desired habitat features. Using biomass as an indicator of 'productive capacity' and considering the increase in habitat quantity, there was a 2.58-fold increase in productive capacity over the stream lost due to highway construction and, in the context of DFO's habitat policy, compensation has resulted in a 'net gain' in habitat.

Codes: experi reach quant instream

Scruton, D. A., K. D. Clarke, T. C. Anderson, A. S. Hoddinott, M. C. Van Zyll De Jong, and K. A. Houston. 1997. Evaluation of habitat improvement and restoration initiatives for salmonids in Newfoundland, Canada. Canadian manuscript report of fisheries and aquatic sciences/Rapport manuscrit canadien des sciences halieutiques et aquatiques. Imprint varies [CAN. MANUSCR. REP. FISH. AQUAT. SCI./RAPP. MANUSCR. CAN. SCI. HALIEUT. AQUAT.], Mar 40:

Declining Atlantic salmon Salmo salar stocks, which forced the closure of the commercial salmon fishery in Newfoundland in 1992, coupled with the increasing economic importance of the recreational salmonid fishery, has resulted in two major federal-provincial agreements over the past decade aimed at rebuilding the salmonid stocks. These agreements included habitat improvement and restoration as a major strategy and supported 142 projects. It was recognized that a proportion of these projects should undergo scientific evaluation to provide information on the effectiveness and transferability of techniques and to assist in developing region-specific criteria to guide publicly sponsored habitat initiatives. This report provides an overview of these evaluations, as selected case

studies, including projects involving restoration of habitat degraded by historic forest harvesting, removal of a natural migration barrier, and the addition of spawning gravel to increase juvenile production. Results of a series of experimnents in a controlled flow channel to investigate the effect of several habitat alterations on salmonid populations under Newfoundlan conditions are discussed. Generally, the projects evaluated have been successful in increasing salmonid abundance and/or production. Results highlight the importance of hydrological and biological considerations to habitat improvement and restoration initiatives.

Codes: review experi enclos reach quant

Scruton, D. A., and L. J. Ledrew. 1997. A retrospective assessment of the flow regulation of the West Salmon River, Newfoundland, Canada. Fisheries Management and Ecology [Fish. Manage. Ecol.] 4: 467-480.

The Upper Salmon Hydroelectric Project in central Newfoundland, Canada, constructed in the early 1980s, affected the hydrology of the West Salmon River, a major spawning and juvenile rearing river for landlocked Atlantic salmon, Salmo salar L., and brook trout, Salvelinus fontinalis (Mitchill). A controlled flow release strategy, based on Tennant's Montana method, was developed to protect this habitat and prescribed a release of 40% of the mean annual flow (MAF) (2.6 m super(3) s super(-1)) between 1 June and 30 November and 20% of the MAF (1.3 m super(3) s super(-1)) from 1 December to 31 May. Studies were conducted to assess the impact of river regulation including: (1) a post-impoundment evaluation of the anticipated geomorphic and sedimentary characteristics; (2) monitoring of juvenile fish populations under regulation; and (3) a retrospective IFIM (instream flow incremental methodology) assessment. Studies provided evidence of the initial stages of river aggradation. Biological monitoring found no apparent effects of sediment deposition on spawning and egg incubation. However, densities of older age classes (parr, 1+ and greater) declined under regulation, possibly related to poor overwintering conditions under the lower winter flow. IFIM study results supported these observations and indicated that the prescribed flow regimen provided habitat conditions that would benefit salmon fry more than older age classes. This retrospective assessment suggested that future proposals for flow regulation in Newfoundland should consider the need for more dynamic flow management as well as to provide overwintering habitat for resident fish. Habitat-hydraulic models are preferred to standard setting approaches owing to more detailed analysis of habitat trade-offs as related to flow regulation.

Codes: reach quant spawn lakehydro instream substrate ifim hem temporal

Shepard, B. B. 1989. Evaluation of the U.S. Forest Service ' COWFISH ' Model for Assessing Livestock Impacts on Fisheries in the Beaverhead National Forest, Montana. Pages 23-33. Practical Approaches to Riparian Resource Management: An Educational Workshop. American Fisheries Society, Bethesda MD.

The COWFISH fish habitat model developed by the U.S. Forest Service was evaluated during 1986 and 1987 at 43 stream sites within the Beaverhead National Forest, Montana to determine the ability of the model to assess effects of livestock grazing on trout fisheries. The COWFISH model uses a field survey of five variables (percentage of streambank with overhanging vegetation, percentage embeddedness, percentage of the streambank undercut, percentage of the streambank in an altered condition, and width:depth ratio) in association with channel gradient and the presence or absence of granitic parent material within the drainage to predict optimum and existing numbers of catchable (152 mm total length and longer) trout. The model predicted reasonable estimates of catchable cutthroat trout Oncorhynchus clarki, rainbow trout O. mykiss, and hybrids of these species at 19 sites where one or more of these forms occurred; however, predicted numbers of catchable brook trout Salvelinum fontinalis were imprecise at the 26 sites containing brook trout. Habitat suitability index results for field data collected by different observers did not appear to be significantly different, and results for sites that deviated from model site criteria were not significantly different from sites that met site criteria. Minor modifications in the model appeared to slightly improve model performance. Use of the COWFISH model by range professionals and livestock permittees did increase their awareness of the effects of livestock grazing on aquatic resources. (See also W90-05491) (Author 's abstract).

Codes: reach multi graz instream quant hsi modeling hem

Shepherd, B. G., J. E. Hillaby, and R. J. Hutton. 1986. Studies on Pacific salmon (Oncorhynchus spp.) in Phase 1 of the Salmon Enhancement Program. Volume 2: Data appendices. Report ISSN 0706-6457. database.

From 1977 to 1984 the New Projects Unit initiated 38 field studies on wild salmon stocks throughout British Columbia, in order to develop biological design criteria for proposed enhancement projects. The purpose of this report is to make the data from these studies more easily available to other users. Data are presented on migration timing, distribution and abundance of adults and juveniles; spawner characteristics; and length, weight and condition factors of juveniles. Physical characteristics of stream habitat important for spawning and rearing of wild salmon are also reviewed. These data are tabulated by stream and stock in Volume II; Volume I overviews the information by species and region, and provides perspective on factors which may have affected the findings.

Codes: database

Shepherd, B. G., J. E. Hillaby, and R. J. Hutton. 1986. Studies on Pacific salmon (Oncorhynchus spp.) in Phase 1 of the Salmonid Enhancement Program. Volume 1: Summary. Report ISSN 0706-6457. database.

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Codes: database

Sheppard, J. D., and J. H. Johnson. 1985. Probability-of-use for depth, velocity, and substrate by subyearling coho salmon and steelhead in Lake Ontario tributary streams. North American Journal of Fisheries Management 5: 277-282.

Probability-of-use information for depth, velocity, and substrate by subyearling coho salmon (Ohcorhynchus kisutch) and steelhead (Salmo gairdneri) in three New York tributaries of Lake Ontario was obtained during June and October in 1980. In June, coho salmon occurred predominantly in areas with mean velocities of 0.30-0.70 ft/second and at depths of 2.00-2.40 ft, whereas steelhead occupied habitats with mean velocities of 0.40-0.80 ft/second and depths of 0.30-0.50 ft. In October, subyearling coho salmon were found in areas with mean velocities of 0.00-0.30 ft/second and at depths of 1.50-2.80 ft while steelhead occurred at depths of 0.60-1.20 ft where mean velocities were 0.10-0.80 ft/second. Subyearling coho salmon occurred over gravel-cobble substrates during both seasons, whereas steelhead were found in areas with substrate material of larger sizes in the autumn. Observed seasonal differences in the habitat and flow preferences of both species were completely masked when the data were pooled to yield a single estimate for depth and mean velocity. Variations in the probability-of-use for these habitat parameters may be related to seasonal differences in fish size and the physical characteristics of the streams.

Codes: multi qual microhab habitat instream

Shirvell, C. S. 1989. Ability of PHABSIM to predict chinook salmon spawning habitat. Regulated Rivers: Research & Management 3: 277-289.

PHABSIM (Physical HABitat SIMulation), part of the Instream Flow Incremental Methodology, was used to predict the spawning habitat used by chinook salmon (Oncorhynchus tshawytscha) in a 600 m long section of the

Nechako River, British Columbia, Canada. Predictions of the model were compared to the location and amount of habitat actually used by adult chinook salmon. About 70% of the spawning area actually used by the population was predicted as unusable by the "best" prediction, while 87% of the area predicted as usable has never had recorded use. PHABSIM predicted 210% to 660% more spawning habitat was available than historically had ever been used. Chinook salmon in the Nechako River spawn mainly on the upstream face of dunes, therefore, the assumption in PHABSIM that conditions predicted at the transects remain unchanged upstream and downstream part way to the adjacent transects was false. About two-thirds of the correct predictions being made for the wrong reason. The accuracy of PHABSIM's predictions for spawning might be improved by incorporating an index of river bottom topography or velocity gradient into the model.

Codes: qual hydro microhab instream ifim warning hem

Shirvell, C. S. 1994. Effect of changes in streamflow on the microhabitat use and movements of sympatric juvenile coho salmon (Oncorhynchus kisutch) and chinook salmon (O. tshawytscha) in a natural stream. Canadian Journal of Fisheries and Aquatic Sciences 51: 1644-1652.

Changes in river discharge (referred to as "streamflow" herein) associated with flow regulation can have negative effects on fish and wildlife resources. The microhabitats at positions selected by juvenile coho (Oncorhynchus kisutch) and chinook salmon (O. tshawytscha) following a change in streamflow differed from microhabitats occupied at normal streamflows. At drought streamflow (37% mean seasonal streamflow (MSF)), juvenile coho salmon selected slower, darker, and higher sites above the streambed ($P < 0.05$) than sites selected at normal (75% MSF) or flood (159% MSF) flows. Juvenile chinook salmon microhabitat use changed similarly with changes in streamflow, but the difference were not significant. Up to one fifth of the fish chose positions with faster water velocities than those available either 30 cm above or 30 cm lateral to them. These fish chose positions inconsistent with the hypothesis of optimal position selection based on maximizing net energy gain. On average, fish moved 6.8 m following a change in streamflow. Juvenile coho salmon generally moved upstream in response to decreasing streamflows and downstream in response to increasing streamflows. Juvenile chinook salmon tended to move offshore and downstream in response to all streamflow changes.

Codes: qual hydro microhab instream

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

This study's objective was to quantify the water depth, water velocity, and substrate used by adult brown trout Salmo trutta for feeding and spawning in rivers. Brown trout (mean fork length 42 cm) preferred a mean depth of 65.0 cm and a mean velocity of 26.7 cm multiplied by second super(-1) at the position occupied by the fish for feeding, but for spawning they preferred a mean depth of 31.7 cm, a mean velocity of 39.4 cm multiplied by second super(-1), and a mean substrate size of 14.0 mm. Analysis of variance showed brown trout preferred the same velocity for the same activity in all rivers and years regardless of whether they were from allopatric or sympatric populations, but microhabitats used for feeding and spawning were significantly different. Velocity appeared to be the most important factor determining position choice but ranking of factors may vary with the type of activity. Brown trout chose positions with optimum combinations of depth and velocity instead of positions with more preferred values of either factor alone. Population size may be limited by the amount of the least abundant activity-specific microhabitat.

Codes: qual spawn microhab instream substrate

Shuler, S. W., and R. B. Nehring. 1993. Using the physical habitat simulation model toevaluate a stream habitat enhancement project. Rivers 4: 175-193.

Adult and juvenile brown trout (Salmo trutta) habitat suitability criteria (HSC) curves developed in the Rio Grande and South Platte rivers, Colorado, were used in the Physical Habitat Simulation (PHABSIM) model to evaluate habitat (weighted usable area; WUA) created by enhancement structures in the Rio Grande River. Although HSC curves for the two rivers produced slightly different estimates of WUA at a single study site and flow, WUA relations among study sites were similar over a wide range of flows. For both HSC curve sets, adult trout WUA and density were positively correlated across 10 study sections in each of 3 years (1989 through 1991). Beyond age-3, the significance level increased with age. Correlations of juvenile brown trout density and WUA were not significant. Composite suitability indexes (water depth, velocity, and cover) for individual cells were stratified into optimal, acceptable, and unsuitable habitat ranges. Observation by snorkeling and angling revealed that adult and juvenile trout preferred optimal and acceptable habitat zones and avoided unsuitable habitat during day and night across a range of flows. Habitat quality and quantity differed among structures over a range of flows. In riffle areas, greater levels of habitat enhancement increased preferred habitat availability according to the PHABSIM model. Moreover, densities of trout greater than or equal to 35 cm increased significantly after the placement of habitat enhancement structures.

Codes: qual instream microhab ifim hem

Simondet, J. A. 1997. Seasonal and diel response to habitat complexity by an allopatric population of coastal cutthroat trout. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

In contrast to salmonids in other systems, density of cutthroat trout in Little Jones Creek, a tributary of the Middle Fork Smith River, California, is not significantly related to the presence of large woody debris. The cutthroat trout is the only fish species in Little Jones Creek. In this study, I tested the relationship between cutthroat trout density and habitat complexity in a field experiment that used pools as experimental units. By adding a variety of structures, I enhanced the complexity of 6 of 12 pools that initially contained no large substrate elements and few microhabitats that provided cover for fish. I then removed pool inhabitants from each experimental unit, and added fish from elsewhere in the study reach to approximately double natural fish densities. I observed fish over 6 weeks in summer and 4 weeks in winter, during day and night. Cutthroat trout did not respond to differences in habitat complexity. In both summer and winter, fish densities rapidly returned to natural levels in both enhanced and control pools. During summer, approximately equal numbers of fish were observed during day and night, but during winter approximately 2.5 times more fish were observed at night than in the day. In Little Jones Creek, in the absence of competition from other fishes, simple and complex pools appear similarly valuable to cutthroat trout.

Codes: experi habitat quant instream lwd

Simpkins, D. G., W. A. Hubert, and T. A. Wesche. 2000. Effects of Fall-to-Winter Changes in Habitat and Frazil Ice on the Movements and Habitat Use of Juvenile Rainbow Trout in a Wyoming Tailwater. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 129: 101-118.

Overwinter declines in the abundance of small rainbow trout Oncorhynchus mykiss have been observed in a section of the Big Horn River that lies downstream from Boysen Reservoir, where reservoir releases prevent surface ice formation. To provide insight into the possible causes of these declines in abundance, radiotelemetry was used to determine movement and microhabitat use of juvenile (20-25 cm total length) rainbow trout during the fall and winter of 1995-1996. Throughout the fall and winter, both stocked (hatchery) and naturallyspawned (wild) fish were generally found in main-channel pools with cover that reduced current velocities to less than 2 cm/s near the bottom and with nearby (<2 m) water velocities that were greater than 15 cm/s. These locations provided refuges from the current, with adjacent flowing water that could deliver drifting aquatic invertebrates. The fish were generally associated with cover that was formed by aquatic vegetation early in the fall, but they shifted to cobble and boulder cover (in deeper water) as the aquatic vegetation decomposed and as winter progressed. Episodes of frazil ice in

January and early February were associated with movements of wild fish in the upstream portion of the study area--from normal activity areas to refuges at the bottom of deep pools or under shelf ice in shallow water near shore. Frazil-ice episodes often initiated long-term movements among fish. Our results suggest that changing habitat features from fall to winter and frazil-ice episodes can cause juvenile rainbow trout to move and to modify their habitat use, depending on their location in a tailwater.

Codes: migrat qual microhab instream substrate hydro

Slaney, T. L., K. D. Hyatt, T. G. Northcote, and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21: 20-32.

Using fisheries agency databases and files, we assembled a summary database on the status of anadromous salmon stocks (genus Oncorhynchus) from British Columbia and Yukon streams. We then collected supplementary information by circulating the database among fisheries professionals and interest groups throughout British Columbia and thus identified 9,662 anadromous salmon stocks. These stocks included 866 chinook, 1,625 chum, 2,594 coho, 2,169 pink, 917 sockeye, 867 steelhead and 612 sea-run cutthroat trout stocks. We assessed the status of anadromous stocks by employing a classification scheme similar to that of Nehlsen et al. (1991). Assessments were possible for 5,487 (57%) of all stocks and included all large, commercially important stocks. The assessments found 624 stocks were at high risk, 78 were at moderate risk, 230 were of special concern, and 142 were extirpated in this century. We were unable to classify 4,172 (43%) of the stocks because of an absence of reliable data. Due to their small size, these stocks are not of great commercial importance, although they are important to the maintenance of salmonid diversity. We also identified many potential threats to anadromous salmon stocks. The absence of systematic, high-quality assessments at the biological stock level precluded reliable assignment of the specific causes for many of the stocks apparently at risk. Nevertheless, habitat degradation associated with logging, urbanization, and hydropower development contributed to most of the 142 documented stock extinctions. Furthermore, there is little doubt that overutilization by commercial and recreational fisheries has in many cases resulted in severe stock depressions that, when added to other factors, has put many stocks at risk.

Codes: review basin lulc ripar hydro warning

Smith, H. A., S. P. Blachut, and B. Bengeyfield. 1987. Study Design for Fisheries and Hydrology Assessment in a Glacial Watershed in British Columbia. In Regulated Streams: Advances in Ecology. Plenum Press, New York.

In Canada those rivers with glaciated catchments and salmonids primarily include major rivers which transect the Coast Mountains, of which the Homathko River is an example. These river basins are characterized by very rugged topography, steep gradients, high precipitation and heavy glaciation. The rivers are utilized by significant runs of wild stocks of anadromous and resident salmonids. This combination of important fisheries stocks utilizing complex mountainous glacial rivers in remote locations presents numerous problems beyond a typical instream flow assessment, including a study design, logistics and lack of historical data. These glacial river systems present a very dynamic physical environment. As a result, the fish populations are adapted to such variability. Study methodologies require considerable assessment and modification to the specific river under investigation. ' Off-the-shelf ' models will not necessarily address all the significant parameters identified by hydrology-fisheries linkage studies. The importance of understanding the habitat-population linkages must not be underestimated, as the ultimate result of an impact assessment should be in terms of number of fish, area of habitat. (See also W89-01736) (Lantz-PTT).

Codes: multi design hydro warning

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and J. D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. CJFAS 57: 906-914.

A BACI (before-after-control-impact) experimental design was used to examine the effects of increasing winter habitat on the abundance of downstream migrant salmonids. Two reference streams and two treatment streams were selected in the Alsea and Nestucca basins of Oregon. Population parameters for juvenile coho salmon (Oncorhynchus kisutch), age-0 trout (Oncorhynchus spp.), steelhead (Oncorhynchus mykiss), and coastal cutthroat trout (Oncorhynchus clarki) were estimated each year for 8 years in each stream. Stream habitat was modified to increase the quality and quantity of winter habitat during the summers of 1990 (Nestucca Basin) and 1991 (Alsea Basin). Complex habitat was constructed by adding large woody debris to newly created alcoves and dammed pools. Numbers of coho salmon summer juveniles and smolts increased in the treatment streams relative to the control streams during the posttreatment period. Overwinter survival of juvenile coho salmon also increased significantly in both treatment streams posttreatment. Summer trout populations in the treatment streams did not change, but downstream migrant numbers the following spring did increase. These increases suggest that winter habitat was limiting abundance of all three species.

Codes: experi multi reach quant lwd offchann

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and S. Van de Wetering. 1997. Juvenile sea-run cutthroat trout: Habitat utilization, smolt production, and response to habitat modification. Edited by J. D. Hall, P. A. Bisson and R. E. Gresswell. American Fisheries Society, Oregon Chapter, Corvallis, Oregon (USA)

Increased focus on the status of anadromous salmonid populations and habitat in the Pacific Northwest has led to the idea that instream habitat modification projects may be a useful tool to help aid in the recovery of declining populations. To evaluate how effective these projects are at increasing salmonid populations, we need to have a general understanding of the specific habitats used by these fish during each season. With this information we can better determine the type and amount of habitat that is in shortest supply to the fish. Once these have been identified, the habitat modification project can be designed to help fill the need for a specific type of habitat. The purpose of this paper is to briefly describe the habitat-specific population data on juvenile cutthroat trout that we have collected from Oregon coastal streams and to describe the results from two habitat modification projects undertaken by the Bureau of Land Management in an effort to increase anadromous salmonid smolt production. This information should be helpful in designing more effective habitat modification projects. This paper presents only the cutthroat trout portion of our results. We have collected similar information on coho salmon and steelhead.

Codes: design instream experi

Spalding, S., N. P. Peterson, and T. P. Quinn. 1995. Summer distribution, survival, and growth of juvenile coho salmon under varying experimental conditions of brushy instream cover. Transactions of the American Fisheries Society 124: 124-130.

Woody debris is an important feature of streams, and its presence and abundance have been correlated with the abundance, growth, and survival of juvenile salmonids. To investigate the proximatemechanisms linking brushy woody debris to salmonid fishes, we determined, over a 1-month period in summer, the spatial distribution of juvenile coho salmon Oncorhynchus kisutch introduced into an outdoor experimental stream containing riffle-pool units that had one of four different levels of instream brushy-debris complexity. We then equalized the fish density in each unit and monitored fish growth and survival over a 15-week period. Coho salmon distribution, growth, and survival varied greatly but were not consistently related to the complexity of brushy debris.

Codes: experi quant habitat lwd

Stalnaker, C. B., K. D. Bovee, and T. J. Waddle. 1996. Importance of the temporal aspects of habitat hydraulics to fish population studies. Regulated Rivers Research & Management 12: 145-153.

The direct and indirect influences of hydrology and hydraulics on the usability of stream habitats by stream fish are discussed. Most habitat-hydraulic models in use today emphasize the spatial aspects of habitat quality and quantity. It is our contention that the temporal dynamics of habitat quantity are a major influence, determining fish population responses in riverine environments. This may manifest through dramatic shifts in the velocity and temperature distributions over seasons and years as influenced by climatic conditions as well as reservoir operations. Time series simulations of usable habitat available to various life stages of brown and rainbow trout and smallmouth bass populations demonstrate that the usable space and its stability during the early life history is directly translated into year-class-strength for these fish populations. Riverine ecosystems are temporally dynamic due to the stochastic nature of precipitation events. Therefore an understanding of the temporal aspects of streamflow and habitat is essential to designing water management schemes intended to protect, enhance or restore riverine fish populations.

Codes: ifim hydro temporal hem

Steingrimsson, S. O., and J. W. A. Grant. 1999. Allometry of territory size and metabolic rate as predictors of self-thinning in young-of-the-year Atlantic salmon. Journal of Animal Ecology 68: 17-26.

Self-thinning is a progressive decline in population density caused by competitively induced losses in a cohort of growing individuals and can be depicted as: log sub(10) (density) = c - beta log sub(10) (body mass). 2. In mobile animals, two mechanisms for self-thinning have been proposed: (i) the space hypothesis predicts that maximum population density for a given body size is the inverse of territory size, and hence, the self-thinning slope is the negative of the slope of the allometric territory-size relationship; (ii) the energetic equivalence hypothesis predicts that the self-thinning slope is the negative of the slope of the allometric metabolic rate relationship, assuming a constant supply of energy for the cohort. 3. Both hypotheses were tested by monitoring body size, population density, food availability and habitat for young-of-the-year Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick. The results were consistent with the predictions of the space hypothesis. Observed densities did not exceed the maximum densities predicted and the observed self-thinning slope of -1 times 16 was not significantly different from the slope of -1 times 12, predicted by the allometry of territory size for the population under study. 4. The observed self-thinning slope was significantly steeper than -0 times 87, predicted by the allometry of metabolic rate, perhaps because of a gradual decline in food abundance over the study period. The decline in density was more rapid in very shallow sites and may have been partly caused by a seasonal change in water depth and an ontogenetic habitat shift rather than solely by competition for food or space. 5. The allometry of territory size may be a useful predictor of self-thinning in populations of mobile animals competing for food and space.

Codes: reach quant popdyn instream trophic

Steward, C., and T. C. Bjornn. 1990. Fill'er up: Stream carrying capacity. Focus Renewable Resour. 15: 16-17.

How many fish can a stream support? What factors are responsible for variations in fish abundance? To answer these questions, three years of study on the distribution, abundance, and behavior of juvenile steelhead trout (Oncorhynchus mykiss) and chinook salmon (O. tshawytscha) in relation to several key habitat features were completed: streamflow, pool morphology, cover, and water temperature. Habitat quality and quantity, along with food availability, are important factors governing in the production of seaward migrating juvenile salmon and trout in Idaho's streams. The general hypothesis was that because these juvenile fish are habitat specialists and thus sensitive to their surroundings, the physical characteristics of a stream should dictate its "carrying capacity", that is, the upper limit on the number of fish it can support.

Codes: quant instream trophic

Stoneman, C. L., and M. L. Jones. 2000. The influence of habitat features on the biomass and distribution of three species of southern Ontario stream salmonines. Transactions of the American Fisheries Society [Trans. Am. Fish. Soc.] 129: 639-657.

We developed models to predict habitat use and productive capacity of brook trout Salvelinus fontinalis, brown trout Salmo trutta, and rainbow trout Oncorhynchus mykiss in southern Ontario streams using readily measured habitat variables. We collected habitat and fish biomass data from 118 streams distributed throughout southern Ontario. Our habitat variables included those for morphology and substrate, water quality, instream physical habitat types, and bank vegetation. We used trout biomass, estimated from a single-pass electrofishing technique, as our indicator of site productive capacity. A discriminant function model showed modest separation among sites with low, moderate, high, and very high total trout biomass, based on differences in water temperature, percent pools, substrate, and cover. The discriminant function correctly classified sites in 80 of 118 cases. A regression tree model indicated that water temperature was by far the most important habitat variable at distinguishing sites with differing total trout biomass. A second, species-level discriminant analysis showed better separation among sites (65 of 82 cases correctly classified) where trout biomass was dominated by rainbow, brook, or brown trout; this was based on differences in water temperatures, percent pools, substrate size, average competitor biomass, and cover. A classification tree model yielded similar results. Our results are consistent with an earlier modeling effort to predict trout biomass from habitat in southern Ontario streams. Our findings add to those by (1) increasing the geographic breadth of the data used to fit the models, (2) providing a model for which all the requisite data for a site can be collected in a single day, and (3) showing that species-level models are better at linking habitat to fish biomass than are total trout biomass models.

Codes: multi reach quant instream wtemp substrate wtaqual modeling

Stoneman, C. L., M. L. Jones, and L. Stanfield. 1996. Habitat suitability assessment models for southern Ontario trout streams. Model development and evaluation. Report multi reach quant instream wtemp substrate wtaqual ifim warning hem.

The Canadian government's 1986 Policy for the Management of Fish Habitat, and in particular its "No Net Loss" guiding principle, has heightened our awareness of the need for better tools to evaluate the impacts of human activity on the productive capacity of fish habitat. Using trout biomass as a measure of productive capacity, we collected biomass and habitat data from 118 sites across southern Ontario to test the models. Data collected in 1992 showed that the existing rainbow Oncorhynchus mykiss, brown Salmo trutta and brook Salvelinus fontinalis trout HSI models are poor predictors of biomass. We developed new, modified, HSI-type models, and these provide substantially better predictions than the original models. When we tested the new models using data collected in 1993, they performed equally well. Deviations from the expected biomass at individual sites were frequently attributable to probable biotic interactions with other salmonid species.

Codes: multi reach quant instream wtemp substrate wtaqual ifim warning hem

Strange, R. J., and J. W. Habera. 1998. No net loss of brook trout distribution in areas of sympatry with rainbow trout in Tennessee streams. Transactions of the American Fisheries Society 127: 434-440.

Lowest distributional elevations for brook trout Salvelinus fontinalis in 25 streams in east Tennessee were determined during 1991-1995 to evaluate changes related to encroachment and possible replacement by rainbow trout Oncorhynchus mykiss since surveys conducted during 1978-1984. No efforts to remove rainbow trout or enhance brook trout populations were made in these streams during the 7-16-year intervals between surveys. Compared with the earlier surveys, brook trout distributions receded (lower elevation increased) in nine streams (36%), advanced (lower elevation decreased) in eight streams (32%), and did not change in eight streams (32%). The average total change in stream length occupied by brook trout was a 109-m downstream increase (SE = 82) with a mean annual increase of 8 m (SE = 6). Neither average total change nor annual change was significant ($P > 0.19$). Additionally, the highest elevations at which rainbow trout were present (determined in 10 streams) increased in four streams but decreased in six. The average total change in stream length occupied by rainbow trout was a

158-m decrease in elevation (SE = 151) with a mean annual change of -14 m (SE = 13). Neither average total change nor mean annual change was significant (P > 0.30). We concluded that rainbow trout were not affecting the downstream limit of most brook trout populations where the two species occurred sympatrically in Tennessee. Further, after examining published data from Great Smoky Mountains National Park, we found no evidence that the downstream limits of brook trout distribution in most streams were affected by the presence of rainbow trout between the 1950s and 1970s. These data support an emerging theory that the distributional limits of brook trout and rainbow trout in sympatry in the southern Appalachian Mountains will ebb and flow upstream and downstream over time.

Codes: multi reach quant sppinter temporal noenv

Stuber, R. J., R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Trout habitat, abundance, and fishing opportunities in fenced vs unfenced riparian habitat along Sheep Creek, Colorado. Report; Conference RM-120.

Fencing was used to protect 40 hectares of riparian stream habitat along 2.5 km of Sheep Creek, Colorado, from adverse impacts due to heavy streamside recreation use and cattle grazing. Fish habitat within the fenced area was narrower, deeper, had less streambank alteration, and better streamside vegetation than comparable unfenced sections. Estimated trout standing crop was twice as great, and proportional stock density (PSD) was higher than in unfenced sections. There was a higher proportion of nongame fish present in unfenced sections. Projected fishing opportunities within the fenced sections were double those estimated for a comparable length of unfenced habitat along the same stream.

Codes: reach experi graz ripar instream quant

Swales, S. 1982. A ' Before and After ' Study of the Effects of Land Drainage Works on Fish Stocks in the Upper Reaches of a Lowland River. Fisheries Management 13: 105-114.

Fish populations were markedly changed in the upstream reaches of the River Soar, Leicestershire, after river channel works improved land drainage. The study site was a 100 m slow-flowing reach 1 m deep, with shallow riffles at its upstream and downstream limits and abundant bankside trees and vegetation. The drainage scheme consisted of river dredging and widening and vegetation clearance, designed to reduce floodingon 360 ha of agricultural land. Although water quality parameters, flow conditions, add bottom substrate before (5/5/77) and after (3/15/79) channel works were not different, there was a marked decrease in instream cover. Mean densities of fish > 10 cm long were 0.160 per sq m before and 0.048 per sq m after the project. The mean standing crop of fish was 39.0 g per sq m before and 9.6 g per sq m after the project. Reductions in standing crop were: brown trout, 100%; chub, 81%; dace, 72%; and roach, 15%. (Cassar-FRC).

Codes: experi quant instream ripar

Swales, S. 1988. Utilization of off-channel habitats by juvenile coho salmon (Oncorhynchus kisutch) in interior and coastal streams in British Columbia. Edited by V. Sladecek. VERH. INT. VER. THEOR. ANGEW. LIMNOL./PROC. INT. ASSOC. THEOR. APPL. LIMNOL./TRAV. ASSOC. INT. LIMNOL. THEOR. APPL. vol. 23, no. 3

In streams and rivers throughout British Columbia, Canada, juvenile coho salmon (Oncorhynchus kisutch) show a strong preference for still or slow-flowing habitats with abundant cover. During the summer rearing period, juvenile coho are generally most abundant in main channel pools, they find cover among submerged root wads, logs, branches and other organic debris common in streams in the Pacific Northwest. As water temperatures decrease during autumn and early winter, coho show large-scale migrations away from summer rearing areas to tributaries, back-channels, sloughs, ponds and lakes in which they overwinter. Studies were carried out to evaluate the use of small ponds, lakes and other off-channel habitats as overwintering and rearing areas for juvenile coho in the

Coldwater R., a second-order tributary of the Fraser R. in interior B.C., and the Keogh R., a small coastal river in north-eastern Vancouver Island. Small ponds and side-channels were the preferred overwintering areas for juvenile coho in the Coldwater R., with densities of up to 4,000 coho overwintering in a small (1 ha) pond in the upper reaches of the river.

Codes: quant? habitat offchann

Swales, S., R. B. Lauzier, and C. D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. CJZ 64: 1506-1514.

The winter distribution and abundance of juvenile salmonids was investigated in various main channel and off-channel habitats in the Coldwater and Nicola rivers in the southern interior of British Columbia. Catches were generally low in all main channel habitats, with coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri) being most abundant and chinook salmon and Dolly Varden char being present in smaller numbers. Coho salmon and steelhead trout catches were generally highest in pools with abundant instream and riparian cover. Steelhead trout was the main species in riprap bank protected areas, although catches were generally low. Highest overall catches were recorded in side channels and off-channel ponds, where water temperatures were usually several degrees higher than in the main river. The authors conclude that juvenile salmonids in the rivers investigated showed considerable habitat segregation during the winter. As in coastal rivers, juvenile coho salmon made extensive use of off-channel ponds, while rainbow trout and chinook salmon were generally most abundant in riprap and deep pools containing log debris, respectively.

Codes: multi habitat quant ripar offchann wtemp instream lwd

Swales, S., and C. D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (Oncorhynchus kisutch) and other juvenile salmonids in the Coldwater River, British Columbia. CJFAS 46: 232-242.

Off-channel ponds in the upper reaches of the Coldwater River, British Columbia, were major rearing areas for juvenile coho salmon (Oncorhynchus kisutch). Chinook salmon (Oncorhynchus tshawytscha), steelhead trout (Salmo gairdneri), and Dolly Varden char (Salvelinus malma) were generally scarce in the ponds, although they were numerous in the main river. Coho salmon were predominant at "natural" river sites while steelhead trout was the main species at sites with "rip-rap" bank stabilization. Catches of juvenile coho were much lower in the main river than in the ponds where they were the main species, and were more variable in the river.

Codes: quant reach offchann instream

Symons, P. E. K., and M. Heland. 1978. Stream habitats and behavioral interactions of underyearling and yearling Atlantic salmon (Salmo salar). J. Fish. Res. Board Can. 35: 175-183.

From an examination of over 20 yr of data from the Northwest Miramichi River and some additional data from small tributaries to the Nashwaak River, highest densities of 100 underyearling and 80 yearling or older Atlantic salmon (Salmo salar) per 100 m SUP-2 were found at sites where water velocities averaged 50-65 cm/s. At sites with lower or higher water velocities maximum observed densities decreased. Experiments in laboratory streams demonstrated that underyearling Atlantic salmon <7 cm (total length) occurred in shallow (10-15 cm) pebbly (1 . 6-6 . 4 cm diam) riffles of natural streams by choice. As they grew they began to prefer deeper (>30 cm) riffles with boulders (>25.6 cm diam). Yearlings >10 cm reduced the numbers of underyearlings <6 cm in these deeper habitats by chasing them, and occasionally by catching and eating them. Social interactions, such as displays used in territorial defence, did not occur between yearlings and underyearlings until the latter exceeded 6.5 cm, the size at which they began to move to deeper riffles. Planting densities for hatchery-reared salmon recommended in the literature were refined, taking the space and habitat requirements of different-sized juvenile salmon into account.

Codes: microhab lab quant instream

Tait, C. K., J. L. Li, G. A. Lamberti, T. N. Pearsons, and H. W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13: 45-56.

The authors study reaches on 3rd-order tributaries of the John Day River in eastern Oregon included riparian areas ranging from denuded, heavily grazed streambanks to intact forest. Average summer solar inputs to these sites varied from 165 to 2230 megajoules/m super(e), and stream temperatures were influenced by the density and extent of canopy. Densities of steelhead trout (Oncorhynchus mykiss) and sculpin (Cottus spp.) decreased significantly with greater incident radiation and higher stream temperatures. Periphyton standing crops closely tracked solar inputs and was, in turn, strongly positively correlated with biomasses of total invertebrates and of grazers. The large-bodied caddisfly Dicosmoecus accounted for the higher total invertebrate biomass observed in exposed sites. These insects composed 55-96% of the total biomass in open reaches.

Codes: reach multi graz ripar wtemp trophic quant

Taugboel, T., and R. Andersen. 1986. Effect of habitat change on the density of brown trout Salmo trutta in a small stream. Fauna (Blindern) 39: 98-102.

The authors estimated number and density of parr (> 0 +) and resident trout, Salmo trutta, in the small stream, Austadbekken, in 1982, 1983 and 1985. In 1984 the lower part of the stream was canalised, reducing the habitat heterogeneity drastically. In 1982/83 the habitat was heterogeneous with numerous hiding places, whereas the habitat was more homogenous after the canalisation. In the upper part of the stream there were no significant difference in fish density between the three years. In the lower part there were no significant difference in density between 1982 and 1983. In 1985, however, the density was reduced by 90% compared to 1982 and 1983. The reduced density in the lower part in 1985 was probably due to the dramatic habitat change. Trout individuals are territorial, and homogeneous habitats with few hiding places therefore support less fish compared to more heterogeneous habitats.

Codes: experi quant instream

Taylor, E. B. 1991. Behavioural interaction and habitat use in juvenile chinook, Oncorhynchus tshawytscha, and coho, O. kisutch, salmon. Animal Behaviour 42: 729-744.

Young anadromous chinook salmon and coho salmon reside sympatrically in many streams and rivers tributary to the North Pacific Ocean. This study tested the hypothesis that behavioural domination by coho salmon, which reside in freshwater for at least 1 year before seaward migration, promotes variability in habitat use and in the duration of freshwater residence by chinook salmon, which migrate seaward in their first year of life ("ocean-type") or after a year or more in freshwater ("stream-type" chinook). In laboratory stream channels coho behaviourally dominated chinook; they spent more time attacking chinook than vice versa and numerically dominated upstream sections of the channels where food was introduced. Principal components analysis was used to study habitat used by coho and chinook in four natural streams. In two streams where they were sympatric, coho and chinook used different habitats: coho used slow water, deep "pool" areas while chinook used faster water, shallow "riffle" areas. In two streams where chinook were allopatric, however, they made greater used of pool habitats than when in sympatry.

Codes: experi enclos qual microhab sppinter

Theurer, F. D., I. Lines, and T. Nelson. 1985. Interaction Between Riparian Vegetation, Water Temperature, and Salmonid Habitat in the Tucannon River. Water Resources Bulletin 21: 53-64.

The Tucannon River watershed is located in southeastern Washington. The upper third of the watershed is on public land and has enough riparian vegetation and clean substrate to serve as satisfactory salmonid spawning and rearing habitat. The lower two-thirds is on privately owned land; here the river has lost most of its vegetation and is not satisfactory for either rearing or spawning habitat. Physical-process, ecological, and economic models are used to: analyze the instream water temperatures with respect to existing and proposed riparian vegetation under natural conditions; use these water temperatures to determine salmon and steelhead fish populations that were based upon actual field count and known temperature preference data; and determine the economic worth based upon the estimated carrying capacity of the river, the estimated number of return spawners, and the economic value of commercially caught and sport-caught salmon and steelhead. The analysis demonstrates the efficacy of multidisciplinary modeling efforts to relate riparian vegetation, water temperature, and salmonid habitat. The economic results clearly indicate the value and feasibility of restoring riparian vegetation on the Tucannon River. The total cost for restoring the entire thermal regime would be less than 1.5 million dollars, as contrasted to the present worth of 6.9 million dollars. (Moore-IVI).

Codes: reach quant modeling wtemp ripar economic

Thompson, W. L., and D. C. Lee. 2000. Modeling relationships between landscape-level attributes and snorkel counts of chinook salmon and steelhead parr in Idaho. 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: 1834-1842.

Knowledge of environmental factors impacting anadromous salmonids in their freshwater habitats, particularly at large spatial scales, may be important for restoring them to previously recorded levels in the northwestern United States. Consequently, existing data sets were used and an information-theoretic approach to model landscape-level attributes and snorkel count categories of spring-summer chinook salmon (Oncorhynchus tshawytscha) and steelhead (Onorhynchus mykiss) parr within index areas in Idaho. Count categories of chinook salmon parr were negatively related to geometric mean road density and positively related to mean annual precipitation, whereas those for steelhead parr were negatively related to percent unconsolidated lithology. These models predicted that chinook salmon parr would be in low count categories within subwatersheds with >1 km times km super(-2) geometric mean road densities and (or),700 mm mean annual precipitation. Similarly, steelhead parr were predicted to be in low count categories in subwatersheds with .30% unconsolidated lithology. These results provide a starting point for fish biologists and managers attempting to map approximate status and quality of rearing habitats for chinook salmon and steelhead at large spatial scales.

Codes: multi reach basin qual lulc modeling

Thurow, R. F., D. C. Lee, and B. E. Rieman. 1997. Distribution and status of seven native salmonids in the interior Columbia River basin and portions of the Klamath River and Great basins. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 17: 1094-1110.

We summarized presence, absence, current status, and potential historical distribution of seven native salmonid taxa - bull trout Salvelinus confluentus, Yellowstone cutthroat trout Oncorhynchus clarki bouvieri, westslope cutthroat trout O. c. lewisi, redband trout and steelhead O. mykiss gairdneri, stream type (age-1 migrant) chinook salmon O. tshawytscha, and ocean type (age-0 migrant) chinook salmon - in the interior Columbia River basin and portions of the Klamath River and Great basins. Potential historical range was defined as the likely distribution in the study area prior to European settlement. Data were compiled from existing sources and surveys completed by more than 150 biologists. Within the potential range of potamodromous salmonids, status was unknown in 38-69% of the area, and the distribution of anadromous salmonids was unknown in 12-15%. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management, and used the models to predict the presence of taxa in unsampled areas. The composition, distribution, and status of fishes within

the study area is very different than it was historically. Although several of the salmonid taxa are distributed throughout most of their potential range, declines in abundance and distribution and fragmentation into smaller patches are apparent for all forms. None of the salmonid taxa have known or predicted strong populations in more than 22% of their potential ranges, with the exception of Yellowstone cutthroat trout. Both forms of chinook salmon are absent from more than 70% and steelhead from more than 50% of their potential ranges, and all are approaching extirpation in portions of their remaining ranges. If current distributions of the taxa are useful indicators, many aquatic systems are remnants of what were larger and more complex, diverse, and connected systems. Because much of the ecosystem has been altered, areas supporting strong populations or multiple species will be critical for conservation management. Moreover, restoration of a broader matrix of productive habitats also will be necessary to allow fuller expression of phenotypic and genotypic diversity in native salmonids.

Codes: multi modeling basin qual lulc

Thurow, R. F., D. C. Lee, and B. E. Rieman. 2000. Status and distribution of chinook salmon and steelhead in the interior Columbia River basin and portions of the Klamath River basin. 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

This chapter summarizes information on presence, absence, current status, and probable historical distribution of steelhead Oncorhynchus mykiss and stream-type (age-1 migrant) and ocean type (age-0 migrant) chinook salmon O. tshawytscha in the interior Columbia River basin and portions of the Klamath River basin. Data were compiled from existing sources and via surveys completed by more than 150 biologists working in the region. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management. Biophysical setting was an important determinant of species distributions and habitat suitability. We applied model results to predict fish presence in unsampled areas and mapped expecteddistributions in more than 3,700 subwatersheds. Chinook salmon and steelhead are extirpated from more than 50% of their potential historical ranges. Most remaining populations are severely depressed; less than 2% of the watersheds in the current range were classified as supporting strong populations of steelhead or stream-type chinook salmon. Wild, indigenous fish are rare; 22% of remaining steelhead stocks and less than 17% of chinook salmon stocks were judged to be genetically unaltered by hatchery-reared fish. Much of the historical production has been eliminated. However, a core for maintaining and rebuilding functional areas remains. Protection of core areas critical to stock persistence and restoration of a broader matrix of productive habitats will be necessary for productive and sustainable fisheries. This effort will require conservation and restoration of sufficient habitats to ensure the full expression of phenotypic and genotypic diversity in chinook salmon and steelhead.

Codes: multi modeling qual basin lulc

Tripp, D. B., and V. A. Poulin. 1992. Effects of logging and mass wasting on juvenile salmonid populations in streams on the Queen Charlotte Islands. Report 0-7718-9258-6.

The effects of logging and mass wasting on juvenile coho salmon and Dolly Varden char were assessed in streams on the Queen Charlotte Islands. Fish densities and habitat characteristics of 27-33 stream reaches were measured during summer and fall. Reach samples included undisturbed, unlogged oldgrowth forest, logged streams not directly affected by recent mass wasting (logged), and logged streams directly affected by recent debris torrents and slides (mass wasted). Overwinter survivals and smolt yields in three mass wasted and three non-mass wasted streams (all logged) were also estimated in a downstream spring fish trapping program, after determining the number of fish present in each stream the previous fall.

Codes: multi reach quant popdyn ripar

Tschaplinski, P. J. 2000. The effects of forest harvesting, fishing, climate variation, and ocean conditions on salmonid populations of Carnation Creek, Vancouver Island, British Columbia. Pages 297-328. In Sustainable Fisheries Management: Pacific Salmon. E. E. Knudson, C. R. Steward, D. D. MacDonald, J. E. Williams and D. W. Reiser, editors. CRC Press LLC, 2000 Corporate Blvd., NW Boca Raton FL 33431 USA.

The Carnation Creek Fisheries-Forestry Interaction Project, initiated in 1970, is the longest, continuous study of the effects of forestry practices on biological and physical watershed processes in North America. This case study was initially designed to investigate the effects of different streamside forest-harvest treatments on stream channels, aquatic habitats, and fish. The salmonid populations of Carnation Creek have been monitored through 5 pre-logging, 6 during-logging, and 14 post-logging years as one component of this multidisciplinary study. Forest harvesting has had complex and often variable effects upon Carnation Creek fish species and life stages. Chum salmon Oncorhynchus keta have shown the sharpest decline. After logging, numbers of adults returning to the stream fell to about one third of the pre-logging average. This decline is due partly to reductions in egg-to-fry survival resulting from decreased quality of spawning and egg-incubation habitats in the lowermost stream reach. Reductions in summer rearing habitat appear to explain the roughly 50% post-logging decline in abundance of coho salmon O. kisutch fry inhabiting the stream. However, the fewer coho fry have produced >1.5-times more smolts after logging due to improved overwinter survival, which is in turn correlated with increased winter water temperatures and summer growth. Increased smolt abundance has not caused more adults to return. Coho returning to the system have declined after logging by 31%, due at least partly to both depressed marine survivals resulting from earlier timing of spring smolt migrations and ocean climate shifts. The production of salmonids from coastal streams clearly depends upon processes occurring both within watersheds and the marine environment. We cannot control natural shifts in marine ecosystems and climate. Therefore, to sustain our salmonid resources, we must always apply our best forest-harvest practices to ensure that adverse effects of natural variations are not compounded with those of inappropriate land use.

Codes: experi reach basin quant ripar lulc temporal

Tschaplinski, P. J., and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Sciences 40: 452-461.

Numbers of juvenile coho salmon (O. kisutch) in streams are reduced subtantially in winter compared to those that occur in summer. Most of this reduction occurs early in autumn with the onset of the first seasonal freshets. Stream sections containing adequate winter habitat in the form of deep pools, log jams and undercut banks with tree roots and debris lost fewer fish during freshets and maintained higher numbers of coho in winter than sections without these characteristics. These features provide shelter and reduce stream velocities. Microhabitats occupied by coho juveniles in winter after logging were unchanged from those described before logging -- all microhabitats were characterized by low water velocities (less than or equal to 0.3 m/s). Up to 48% of the coho population inhabiting stream sections with adequate shelter remained there by midwinter (Jan. 3). The apparent survival rate during and after logging was 67.4%, essentially unchanged from the prelogging value. Logging has neither reduced the numbers of coho juveniles that enter such sites in autumn to overwinter, nor reduced the numbers leaving these sites to reenter Carnation Creek in spring.

Codes: experi reach quant ripar instream lwd temporal

Unwin, M. J. 1997. Survival of chinook salmon, Oncorhynchus tshawytscha, from a spawning tributary of the Rakaia River, New Zealand, in relation to spring and summer mainstem flows. Fishery Bulletin [Fish. Bull.] 95: 812-825.

To characterize the impact of spring floods on the survival of juvenile chinook salmon (O. tshawytscha) in the unstable, braided rivers on the east coast of New Zealand's South Island, I examined correlations between spring and summer flows in the mainstem of the Rakaia River and fry-to-adult survival for chinook salmon spawning in a headwater tributary. Flow parameters that were investigated included mean flow, maximum flow, and the ratio of

mean to median flow (an index of flow variability), calculated during peak downriver migration of ocean-type juveniles (August to January). Survival was uncorrelated with mean or maximum flow but was positively correlated with the ratio of mean to median flow during spring (October and November). The correlation suggests that pulses of freshwater entering the ocean during floods may buffer the transition of fingerlings from fresh to saline waters and thus partly compensate for the lack of an estuary on the Rakaia River. A positive correlation between spring flow variability and the proportion of ocean-type chinook in relation to stream-type chinook is also consistent with this hypothesis. All correlations were relatively weak, reinforcing earlier results that production is primarily controlled by marine influences. These findings further demonstrate the considerable ability of chinook salmon to adapt to new habitats.

Codes: reach basin popdyn hydro noenv

Urabe, H., and S. Nakano. 1999. Linking microhabitat availability and local density of rainbow trout in low-gradient Japanese streams. Ecological Research [Ecol. Res.] 14: 341-349.

Quantification of reach-based microhabitat availability for rainbow trout (Oncorhynchus mykiss), considering their microhabitat requirements in two low-gradient streams, northern Japan, was attempted to test for habitat space limitation of local trout density. Underwater observations revealed that fish selected microhabitats of moderate current velocity, relatively greater depth and shorter distance to overhead cover in both streams, although habitat features used and available differed slightly between the streams. Habitat space for fish potentially available in the channel environment was evaluated using principal component analysis (PCA) of both available and used microhabitat. A close relationship was evident in both streams between reach-based microhabitat availability and fish density, which was assessed by a three-pass removal method. Direct estimates of fish microhabitat availability using PCA can contribute to accurate predictions of local fish density and provide insight into the mechanisms responsible for fish-habitat relationships in streams.

Codes: multi reach microhab quant instream

Usio, N., and S. Nakano. 1998. Influences of microhabitat use and foraging mode similarities on intra- and interspecific aggressive interactions in a size-structured stream fish assemblage. Ichthyological Research [Ichthyol. Res.] 45: 19-28.

Aggressive interactions, foraging behaviour and microhabitat use were observed among four sympatric stream fishes inhabiting the water column: ayu (Plecoglossus altivelis), white-spotted charr (Salvelinus leucomaenis), masu salmon (Oncorhynchus masou) and Japanese dace (Tribolodon hakonensis), each species being categorised into five body-size classes (species-size groups; SSG's). Aggressive interactions were observed between most pairs of SSG's, an almost linear dominance order being apparent throughout the three-month study period. Ayu were relatively subordinate in June, but became the second most dominant in July and the most dominant in August, as a consequence of a reversal in dominance order with salmon. In contrast, smaller-sized dace, which continually suffered from intra- and interspecific aggression, occupied the most subordinate ranks throughout the study period. Intensive aggression was observed among various SSG's, exhibiting same microhabitat propensity throughout the three months. The direction and frequency of aggressive interactions varied month by month due to a reversal in dominance order between ayu and masu salmon, and/or changes in density, body size and resource use of the component members. Opponent selectivity was higher within SSG's, where resource use was assumed to be highly overlapping, rather than among SSG's throughout the study period. Correlation analysis indicated that opponent selectivity in aggressive interactions among SSG's was positively correlated with similarity in microhabitat selectivity in June, but not in other months or with that in foraging habits, suggesting that intensive aggressive behaviour reflected overlapping habitat use among assemblage members during a certain period.

Codes: microhab sppinter qual

Usio, N., and N. Shigeru. 1998. Temporal variation in foraging group structure of a size-structured stream fish community.

Temporal variation in foraging group structure of s fish assemblage was examined in a flood-prone stream in southern Hokkaido, japan. Foraging behaviour was observed underwater for four species which inhabit the water column: ayu, Plecoglossus altivelis, white-spotted char, Salvelinus leucomaenis, masu salmon, Oncorhynchus masou, and Japanese dace, Tribolodon hakonensis, with each species being categorized into five size classes (species-size group; SSG). based on foraging behaviour, each SSG of the fish assemblage was classified into one of four foraging groups: algae grazers, drift foragers, benthos-drift foragers, and omnivores, defined as SSG exhibiting similar foraging behaviour. All size classes of ayu, and of charr and salmon were categorized as algae grazers and drift foragers, respectively, throughout the study period. In contrast, size classes of dace were categorized as drift foragers, benthos-drift foragers, or omnivores with the same size classes often assigned to different foraging groups from month to month. Digestive tract contents of the fishes in the four foraging groups reflected their observed foraging behaviour, and foraging groups were therefore regarded as representing trophic groups. Abundance and membership of each foraging group varied in accordance with changes in abundance of SSG due to their growth, immigration, emigration, and/or mortality. Moreover, due to numerical dominance within the assemblage, plasticity in foraging behaviour of small- and medium-sized dace also played a key role in determining variability in the foraging group structure. Relative frequencies of two types of foraging behaviour, algae nipping and benthos foraging, of the small-sized dace were significantly correlated with the level of each resource, whereas no significant relationship was detected between foraging frequencies of the medium-sized dace and either resource. Fluctuations in foraging group structure within this assemblage occurred through niche shifts of some component members and by changes in SSG composition.

Codes: habitat quant migrat sppinter trophic

Van Winkle, W., H. I. Jager, S. F. Railsback, B. D. Holcomb, T. K. Studley, and J. E. Baldrige. 1998. Individual-based model of sympatric populations of brown and rainbow trout for instream flow assessment: model description and calibration. Ecological Modelling [Ecol. Model.] 110: 175-207.

This paper describes an individual-based model of sympatric populations of brown (Salmo trutta) and rainbow trout (Oncorhynchus mykiss in a stream habitat. The model provides a tool for projecting flow and temperature effects on trout populations by linking the hydraulic component of the instream flow incremental methodology/physical habitat simulation system (IFIM/PHABSIM) to an individual-based population model. PHABSIM simulates the spatial distribution of depth and velocity at different flows, and indirectly, the availability of spawning habitat, cover and feeding station. The individual-based model simulates reproduction, growth and mortality of individual trout as a function of flow and temperature. Population dynamics arise from the survival and reproduction of individual trout. The spatially explicit nature of the model permits evaluation of behavioral responses used by fish to changes in physical habitat. The model has been calibrated to a stream segment in the North Fork Middle Fork Tule River, California. Selected parameters were adjusted to calibrate the model for length and abundance (including production of a new year class) at the end of 1-year simulations for each of 9 years. Predicted and observed lengths were in good agreement, although neither varied appreciably among years. Predicted and observed abundances were not in as good agreement, and differed considerably for some years. These differences reflect a combination of uncertainties in the field data and uncertainties in the model structure and parameter values. Fifty-year simulations indicated that model projections of length and abundance were stationary, although abundance values fluctuated considerably. Seven advantages for using simulation models of this type are emphasized. How to most effectively interpret results from such simulation models as part of instream flow environmental assessments remains a challenge. Variability and uncertainty in both field data and replicate model simulations are realities that have implications for scientists, resource managers. and regulators in projecting growth and abundance responses of fish populations to alternative flow or temperature regimes.

Codes: modeling habitat instream popdyn ifim warning hem

Van Zyll de Jong, M. C., I. G. Cowx, and D. A. Scruton. 1997. An evaluation of instream habitat restoration techniques on salmonid populations in a Newfoundland stream. Regulated Rivers: Research & Management [Regul. Rivers: Res. Manage.] 13: 603-614.

The effect of three types of habitat improvement structures were evaluated in Joe Farrell's Brook, a small second order salmonid stream in Newfoundland, Canada which had been adversely affected by forest harvesting activities. Fish populations and key habitat attributes were monitored prior to and, in two subsequent years after, boulder clusters, V-dams and half-log covers were placed at selected sites in channellised reaches. Boulder clusters proved to be the most effective structure, increasing densities of 0+, 1+, and 3+ juvenile Atlantic salmon (Salmo salar L.) after placement of instream devices. V-dams proved to be effective in increasing both the density of brook trout (Salvelinus fontinalis Mitchel) and Atlantic salmon through the creation of more diverse pool habitat. Half-log covers increased the number of juvenile salmon age 0+ through an increase in instream cover. These increases in salmonid abundance, however, were considered not to be solely attributed to an improvement in physical habitat. Other factors may influence or modify productivity of the stream reaches treated. For example, relative abundance, size distribution, biomass, and production are controlled by physical and chemical habitat variables and are modified through inter- and intra-specific competition. The general conclusion was that the restoration techniques increased habitat heterogeneity and the degree of habitat complexity in channellised sections; therefore, reducing competition and increasing production.

Codes: experi quant instream

Virbickas, T. 1996. Fish production in Lithuania rivers of different types. Ekologija/Ehkologiya/Ecology 4: 37-47.

Investigations of fish production in Lithuania rivers were carried out in 1993-1995. It was established that production of various fish species in Lithuanian rivers changes depending on the river type: the mean production of stenothermal rheophilic benthophagous and ichthyophagous fish species (Cottus poecilopus, Salmo trutta) is the highest in coldwater streams and coldwater middle-size rivers, that of eurithermal rheophilic benthophagous species (Alburnus alburnus, Gobio gobio) in warmwater streams, eurithermal rheophilic euriphagous species (Leuciscus cephalus) in warmwater middle-size rivers, eurithermal rheo-limnophilic euriphagous species (Rutilus rutilus) in heavily eutrophicated middle-size rivers. The mean fish community production in Lithuanian rivers of various types changes depending on the river size, thermal regime and eutrophication level. Mean fish community production is the lowest in the channelized coldwater streams (P 3.74 kg/ha/yr) and the highest in the heavily eutrophicated rivers (P 28.2 kg/ha/yr). In general, fish production in coldwater rivers (range 3.74-9.67 kg/ha/yr) is much lower than in warmwater ones (range 21.6-28.2 kg/ha/yr). When compared with rivers of other European countries, ichthyocoenosis production in Lithuanian rivers is medium or low. The P/B ratio of various fish species in rivers of different type varies greatly, the lowest P/B ratios being in hardly eutrophicated rivers. Mean fish community P/B ratio is the highest in natural coldwater streams and coldwater middle-size rivers (1.02 and 0.96 respectively) and the lowest in the channelized coldwater streams and hardly eutrophicated rivers (0.55 and 0.57, respectively). Relative production of differently feeding fish species changes together with the increase of the river size, eutrophication level and changes in the thermal regime: relative production of euriphagous and planktonphagous fish species increases (0%-86.9% and 0%-4.7%, respectively), while that of benthophagous and ichthyophagous ones decreases (58.8%-2.9% and 63.5%-2.2%, respectively).

Codes: multi quant popdyn watqual noenv

Vondracek, B., and D. R. Longanecker. 1993. Habitat selection by rainbow trout, Oncorhynchus mykiss, in a California stream: Implications for the instream flow incremental methodology. Ecology of Freshwater Fish 2: 173-186.

We quantified microhabitat selection of rainbow trout (Oncorhynchus mykiss) at 2 flows (low=1.13 m super(3)/s and high=4.95 m super(3)/s) in the Pit River, California. Flows were controlled by an upstream dam and habitat availability was similar during 4 sampling periods at low flow and 2 periods at high flow. A principal components

analysis reduced 6 microhabitat variables to 3 new variables that explained 80% of the observed variance. The 3 components loaded heavily on velocity variables, depth variables and substrate. Microhabitat selection generally differed among macrohabitats (i.e., pools, runs, and riffles). Rainbow trout selected different microhabitats at high flow relative to low flow in response to the availability of deeper, faster water. At low flow, depth and velocity selection were positively correlated with seasonal temperature change for adults but not juveniles. Rainbow trout apparently sought shelter in interstitial spaces in the substrate of runs and riffles during the day in early winter. Generally, large rainbow trout were observed in pools, intermediate-sized fish in runs, and small trout in riffles. The largest fish occurred in slow, deep areas of pools, where they moved slowly without orientation to flow and were not observed feeding, whereas small fish generally faced upstream and fed in all habitat types. Foraging forays were directed up in the water column at velocities similar to the mean water column velocities at holding positions. Rainbow trout were the most abundant species in 76% of the population survey stations. Other species that might have influenced microhabitat selection by rainbow trout were uncommon.

Codes: microhab qual hydro instream wtemp

Walters, C. J., J. S. Collie, and T. Webb. 1989. Experimental designs for estimating transient responses to habitat alteration: Is it practical to control for environmental interactions? Edited by C. D. Levings, L. B. Holtby and M. A. Henderson. 13-20 p.

Survival trends for hatchery salmon stocks cannot be simply compared to survival trends in wild stocks, since the hatchery stocks may be more susceptible to changes in environmental factors such as ocean temperature. To control for such time-treatment interactions, the authors suggest a "staircase" experimental design in which treatment is initiated at different times on the treated units. The transient response and interaction parameters can be computed using general linear models, while correcting for temporal trends and inherent differences among units. The performance of such a staircase design is illustrated with data on the abundance of spring chinook salmon (Oncorhynchus tshawytscha) in the Salmon River basin.

Codes: design quant

Wankowski, J. W. J., and J. E. Thorpe. 1979. Spatial distribution and feeding in Atlantic salmon, Salmo salar L. juveniles. J. Fish Biol 14: 239-247.

The distribution, social behaviour, and feeding behaviour of juvenile Atlantic salmon were studied in a selection of stream and river habitats in northern Scotland using Scuba diving techniques. the results are discussed with respect to food acquisition and choice of feeding site. It is concluded that juvenile salmon feed predominantly on drifting material and that their daytime distribution reflects the current velocity related abundance of drift.

Codes: multi microhab qual trophic instream

Wasson, J. G., R. Bonnard, and L. Maridet. 1995. Global influence of physical habitat parameters on benthic invertebrates in trout streams: towards an integration in fish-habitat models. Edited by P. Gaudin, Y. Souchon, D. J. Orth and E. Vigneux. CONSEIL SUPERIEUR DE LA PECHE, PARIS (FRANCE), 291-299 p.

The influence of physical habitat parameters on macroinvertebrate densities and biomass was tested to further develop global suitability curves, in order to integrate food-producing zones in fish/habitat models. The database contains 371 samples taken from 28 trout stream reference sites in France. Substrate diameter and structure significantly influenced densities and biomass. Values were lower on cobbles than on boulders, but sandy substrates did not differ from both. Velocity and depth significantly influenced density. Densities increased with velocity, but

a minimum value occurred at 60-70 cm/s. Densities decreased with depth. Differences between observed patterns and existing curves are discussed.

Codes: multi habitat nofish substrate trophic foreign

Waters, T. F. 1983. Replacement of brook trout by brown trout over 15 years in a Minnesota stream: production and abundance. Transactions of the American Fisheries Society 112: 137-146.

The trout population in Valley Creek, Minnesota, changed over 15 years from virtually 100% brook trout Salvelinus fontinalis in 1965 to predominantly brown trout Salmo trutta, with some brook trout and rainbow trout Salmo gairdneri remaining. Trout densities were 6,618*hectare^-1 in spring 1965 (all brook trout), and 3,430*hectare^-1 in spring 1980 (70% brown, 15% brook, and 15% rainbow trout). Initial standing stock in spring 1965 was 184 kg*hectare^-1 (wet weight) of brook trout; in spring 1980, brown trout standing stock was 123 kg*hectare^-1 (75%), brook trout 22 kg*hectare^-1 (13%), and rainbow 19 kg*hectare^-1 (12%), for a total of 164 kg*hectare^-1. Annual production in 1965 was 61 kg*hectare^-1 by brook trout (low owing to floods in 1965); annual production in 1979 (spring 1979 to spring 1980) was 132 kg*hectare^-1 (70%) by brown, 25 kg*hectare^-1 (13%) by brook, and 33 kg*hectare^-1 (17%) by rainbow trout, for a total of 190 kg*hectare^-1. Mean annual precipitation, greater fluctuation in annual precipitation, notable single-day rainfall events, and occurrences of floods, erosion, and siltation all increased in 1965-1979 relative to the previous 10 years. These changes apparently were the cause of observed weak year classes of trout, decreases in invertebrate food production, and loss of cover for small trout. It is postulated that innate factors in the behavior of brook and brown trout, in interaction with the habitat perturbations, may have resulted in the replacement of brook by brown trout.

Codes: reach quant popdyn sppinter substrate hydro temporal

Watson, G., and T. W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: an investigation at hierarchical scales. North American Journal of Fisheries Management 17: 237-252.

The reported declines of many stocks of bull trout Salvelinus confluentus in the Pacific Northwest has generated much interest in developing conservation and management plans to protect and rebuild populations. These plans require knowledge of the specific requirements of bull trout throughout their range. We describe the relationships between distribution and abundance of bull trout and physical and biotic factors across a large portion of their historical range. We surveyed 1,057 randomly selected sites from 93 streams within 18 major drainages throughout Washington, Idaho, and Montana for the presence of bull trout. We used logistic regression to assess the relationship between the occurrence of bull trout and several physical and biotic factors at site and habitat scales of analysis. Robust regression assessed relationships between densities of bull trout and physical parameters at site, stream, and basin scales of analysis. Bull trout occurred significantly more often in sites within alluviated lowlands and valleys and in sites with undercut banks, large substrates, pools, and where trees and shrubs were the dominant riparian vegetation. Bull trout occurrence at the site scale was inversely related to the percentage of canopy cover and vegetation overhang and the presence of brook trout S. fontinalis and rainbow trout Oncorhynchus mykiss. At the habitat scale, bull trout most often used large, deep pools that lacked extensive canopy cover. They rarely used fast-water habitats with fine sediments, extensive canopy cover, and brook trout. Bull trout densities correlated positively with pool depth, undercut banks, and diverse gradients, and indirectly with fine sediments at both the stream and site scales of analysis. In addition, high densities of bull trout with less vegetation overhang and greater, but variable, percentages of wood and boulder cover at the site scale. The combinations of variables that correlated significantly with bull trout densities varied considerably among different basins. Additionally, the amount of variation in bull trout densities explained by significant variables decreased at finer scales of analysis. These results indicate a hierarchical relationship between the distribution and density of bull trout and physical variables. Thus, land management for bull trout enhancement or protection should be site-specific and tailored within a similar hierarchical framework.

Codes: multi habitat reach segment quant ripar instream substrate

Weiss, S., and S. Schmutz. 1999. Performance of hatchery-reared brown trout and their effects on wild fish in two small Austrian streams. Transactions of the American Fisheries Society 128: 302-316.

Two small streams of contrasting physicochemical character, one crystalline and one limestone, were experimentally stocked with brown trout Salmo trutta. The study design involved doubling (three sites) or tripling (three sites) the number of large-sized resident fish (>179 or >199 mm total length, dependant on the stream) with an equal mixture of two hatchery strains; three additional sites were left unstocked as controls. In the limestone stream, short-term survival (3 months) of hatchery fish (both strains) was 80%, compared with 90% for wild fish. In the crystalline stream, survival of hatchery fish was 48% and 62% (dependant on strain), compared with 49% for wild fish. After 12 months, the survival of hatchery strains declined precipitously (range: 1-19%), compared with wild fish (range: 13-52%), dependant on stream and strain. After 3 months, about half of the recaptured hatchery fish were caught outside the 200-m-long sites in which they were stocked. Percent movement of wild fish was affected by stocking density in the limestone stream (control, 5%; doubled treatment, 14%; tripled treatment, 20%) but was unrelated to stocking density in the crystalline stream (control 32%; doubled, 20%; tripled, 28%). Stocked strains, on average, lost weight (7-11%) over the first 3 months in the limestone stream but gained weight (5-25%) over the same period in the crystalline stream. Growth of wild brown trout was negatively affected by stocking in the crystalline stream but was unaffected in the limestone stream. Despite the recorded movements, there was no significant change in the population size or biomass of wild brown trout populations due to stocking in either stream.

Codes: multi quant migrat lulc

Wesche, T. A., C. M. Goertler, and C. B. Frye. 1987. Contribution of riparian vegetation to trout cover in small streams. North American Journal of Fisheries Management 7: 151-153.

Cover is an important trout habitat component resulting from the geomorphologic characteristics of a stream channel, the stream-bank interface with the riparian community, and the stream flow. By means of regression analysis, this study quantitatively describes the relative importance of three cover parameters (overhead bank cover, rubble-boulder-aquatic vegetation areas, and deepwater areas) and two cover models as indicators of trout standing stock (Salmo trutta, S. gairdneri, Salvelinus fontinalis) in eight small streams in southeast Wyoming. Results indicated that overhead bank cover, provided primarily by riparian vegetation, is the cover parameter that explains the greatest amount of variation in trout population size.

Codes: multi reach quant ripar instream

Wesche, T. A., C. M. Goertler, C. B. Frye, R. R. Johnson, C. D. Ziebell, D. R. Paton, P. F. Ffolliott, and R. H. Hamre. 1985. Importance and evaluation of instream and riparian cover in smaller trout streams. Report; Conference RM-120.

Cover is an important trout habitat component resulting from the geomorphological characteristics of a stream channel, the streambank interface with the riparian community, and the streamflow. This paper quantitatively describes the significance of the riparian contribution to overall stream cover as related to brown trout (Salmo trutta) population size.

Codes: multi reach quant ripar instream

Wesche, T. A., C. M. Goertler, and W. A. Hubert. 1987. Modified habitat suitability index model for brown trout in southeastern Wyoming. North American Journal of Fisheries Management 7: 232-237.

The habitat suitability index (HSI) model for brown trout Salmo trutta in stream systems, developed by the U.S. Fish and Wildlife Service, was tested with data from 30 reaches on nine streams in southeastern Wyoming. The HSI was not significantly correlated ($P > 0.05$) with brown trout standing stock.

Codes: multi reach quant ifim warning hem

Whalen, K. G. 1998. Smolt Production and Overwinter Mortality of Atlantic Salmon (Salmo salar) Stocked As Fry. Dissertation.

Research was completed to determine factors affecting smolt production and overwinter mortality of Atlantic salmon (Salmo salar) stocked as fry in Vermont tributaries of the Connecticut River. Specific focuses included: (1) timing of smolt migration relative to environmental and physiological factors; (2) effect of ice formation on habitats selected and winter distribution of parr; (3) effect of maturation on parr growth and smolt recruitment; and (4) smolt production dynamics and recruitment modeling. Smolt migration timing and recruitment was determined using net weirs and counting fences and mark-recapture and winter habitat studies were completed by night snorkeling. Tributaries differed in the timing of smolt migration with the tributary warming earliest in the spring generally experiencing earlier smolt migration. Initiation and cessation of smolt migratory activity appeared to be linked to smolt physiological development. Peaks in river discharge increased smolt migratory activity after water temperature thresholds were surpassed, yet only while smolts maintained elevated gill Na +, K +-ATPase activity. Ice formation caused significant changes in the physical stream environment, including a reduction in the abundance of habitats often selected by parr. Changes in the distribution of parr over the winter generally corresponded to changes in the distribution of high velocity habitats they rarely selected and low velocity habitats they often selected. Mature parr were abundant across and within tributaries. Percent mature in October/November was positively correlated with mean size the preceding June. Studies on individually marked parr showed that mature parr exhibited poorer June to October growth than immature parr resulting in large differences in fall size. Mature parr were recruited to smolt at a reduced frequency relative to immature parr and modeling analysis indicated that this difference resulted primarily from a one-third probability of smolting for mature parr rather than differences in fall to spring survival. Simulation modeling revealed that losses in potential smolt production attributable to parr maturation may be as high as 35% when maturation percentages reach the maximum of 45% observed in this study. It is concluded that smolt physiology, winter habitat, and parr maturation are primary factors affecting smolt production and overwinter mortality of Atlantic salmon stocked as fry.

Codes: multi quant popdyn migrat hydro wtemp

Whalen, K. G., D. L. Parrish, and M. E. Mather. 1999. Effect of ice formation on selection of habitats and winter distribution of post-young-of-the-year Atlantic salmon parr. 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: 87-96.

How ice effects determine selection of habitats and distribution of post-young-of-the-year Atlantic salmon (Salmo salar) parr during the winter, was examined. Night snorkeling surveys were completed between November and April to evaluate parr habitat use and movements. Systematic measurements of water depth and velocity were recorded during ice-free and less than or equal to 55% iced conditions to quantify habitat availability. Ice formation altered the distribution and reduced the abundance of habitats commonly used by parr; differences between parr habitat use and habitat availability were greatest when ice was present. Edge ice formation resulted in the concentration of flows, and areas of high flow were formed in midchannel; few parr were observed in midchannel after ice had formed. Through the winter, most parr were found lateral to high flows on the ice edge boundary or in the post-ice period lateral to the stream midchannel. The correspondence of parr movements during winter to

changes in the physical habitat associated with ice formation indicates that movements and redistributions may be important for survival affected by ice.

Codes: qual microhab instream hydro

White, R. G., A. E. Bingham, J. H. Milligan, M. A. Brusven, and C. A. Corraino. 1985. Effects of reduced stream discharge on fish and aquatic macroinvertebrate populations. Phase 2. Report OWRT-B-053-IDA(1).

Two man-made test channels were used to investigate the effect of reduction of stream discharge on juvenile rainbow-steelhead trout and invertebrate populations. Wild juvenile rainbow-steelhead trout (Oncorhynchus mykiss) responded to seasonal 95% reductions in discharge by emigrating from the test channel. An intermediate (50%) reduction in discharge during 1980 tests resulted in little change in number or biomass. Most emigration occurred during the first night following the 95% flow reduction and was predominantly upstream. Since aquatic insects drifted catastrophically during the 24 hours following flow reduction, habitat changes, rather than food limitation, are indicated as the causative factor. A poor relationship was observed between facing velocity and the corresponding 0.6 depth velocity utilized in several predictive models. The 95% flow reduction resulted in no decrease in benthic insect density except during spring. However, numbers of Baetis tricaudatus were reduced in all experiments. (See also PB82-243478. Prepared in cooperation with Idaho Water Resources Research Inst., Moscow, (USA).) (DBO).

Codes: experi reach quant migrat hydro trophic

White, R. G., J. H. Milligan, A. E. Bingham, R. A. Ruediger, and T. S. Vogel. 1981. Effects of Reduced Stream Discharge on Fish and Aquatic Macroinvertebrate Populations.

A study was made of the responses of aquatic insects and juvenile rainbow-steelhead trout to flow-related changes in habitat, and of the predictive capability of three hydraulic simulation models that are currently used to make instream flow recommendations. Tests were conducted in the spring, summer, and fall in two large near-natural artificial stream channels having run-riffle channel configurations: one channel was maintained at constant discharge; flow in the second channel was reduced incrementally. Flow reduction produced increased behavioral/catastrophic insect drift which increased at night and varied with season, degree of flow reduction, and type and developmental stage of aquatic insects. Flow reduction also resulted in decreased trout numbers with large test fish more affected than small fish. It appeared that larger trout responded primarily to physical habitat parameters than to a decrease in food availability. No single hydraulic parameter studied (velocity, depth, surface area, wetted perimeter), consistently correlated with test fish response. Flow-related changes in cover, however, appeared to influence juvenile trout habitat utilization. The hydraulic simulation models tested generally predicted the parameters they were designed for accurately, but the models varied in ease of calibration, application, and useful extrapolation range. It was found that transect placements for hydraulic simulation data collection in run-riffle channels were more important than the number of transects used. (Zielinski-MAXIMA).

Codes: quant enclos flow hydro instream hem

Williams, J. G. 1999. Stock dynamics and adaptive management of habitat: an evaluation based on simulations. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 19: 329-341.

Simulations based on the Ricker and Beverton-Holt stock-recruitment models illustrate the difficulties with developing information about the effectiveness of habitat restoration efforts from the relation between measurements of habitat and populations of anadromous fishes. The relation between the two is confounded by density-dependent mortality and variable density-independent mortality and is masked by measurement errors. The simulations are considered in terms of populations of fall-run (ocean-type) chinook salmon Oncorhynchus tshawytscha from the Sacramento-San Joaquin river system of central California, where major federal and state efforts are underway to restore anadromous fish populations, as well as brackish and freshwater ecosystems. The

simulations show that to implement effective adaptive management of salmon habitat, these efforts must move beyond a trial and error approach in which efforts to restore salmon habitat will be evaluated by population responses. A more promising alternative is evaluating restoration efforts by identifying and testing hypotheses about the mechanisms or processes that relate the restoration actions to populations.

Codes: modeling popdyn experi instream philosophy warning

Wilzbach, M. A. 1985. Prey availability overrides cover in determining growth and abundance of stream-dwelling cutthroat trout. Dissertation

The abundance and biomass of cutthroat trout (Salmo clarki) have been found to be greater in logged than in forested streams of the Oregon Cascades. Although certain prey taxa increase in abundance following logging, habitat stability generally decreases and cover structures are removed. Research was conducted to examine the manner in which habitat features interact with the prey base to result in greater abundance of the trout in logged streams. Cutthroat trout were more effective in foraging on experimentally introduced prey (Culex spp. larvae) in a logged section of Grasshopper Creek (Lane Co., Oregon) than in a forested section. The differences in efficiency were related to prey size and to the amount of overhead shading and substrate crevices. Mean percentages of prey captured by trout were greater in logged control pools and crevice-covered pools of both sections than in forested control pools. Artificial shading of logged pools reduced capture success by the trout to levels found for trout in forested pools. Relative growth rates of cutthroat trout experimentally confined in pools were also greater in the logged than in the forested reach. Differences in growth rates were primarily due to differences between the reaches in invertebrate drift density. Higher drift density in the logged section probably reflected a greater habitat instability that increases the probability that benthic fauna will occur in the water column where they are more available as prey (DBO).

Codes: experi reach quant trophic instream ripar

Wilzbach, M. A. 1985. Relative roles of food abundance and cover in determining the habitat distribution of stream-dwelling cutthroat trout (Salmo clarki). Canadian Journal of Fisheries and Aquatic Sciences 42: 1668-1672.

Emigration of wild cutthroat trout (Salmo clarki) from laboratory channels over 1-wk trial periods was greater under conditions of low than high food abundance (5 vs. 15% of total trout biomass daily), irrespective of the amount of cover (simulated cover structures added vs. removed). When food abundance was high, emigration of trout was slightly greater under conditions of low than high cover. Cover had no effect on emigration rate when food abundance was low. These experiments suggest that at summer temperatures, food abundance overrides cover in determining the abundance and microhabitat distribution of adult cutthroat trout within a stream.

Codes: experi microhab lab migrat trophic instream

Wilzbach, M. A., K. W. Cummins, and J. D. Hall. 1986. Influence of habitat manipulations on interactions between cutthroat trout and invertebrate drift. Ecology 67: 898-911.

The objectives of this study were to examine the interactions of the riparian setting (logged vs. forested) and prey availability on the prey capture efficiency and growth of cutthroat trout (Salmo clarki) and to determine if the riparian setting influences the impact of trout predation on drift composition. Short-term relative growth rates of cutthroat trout, experimentally confined in stream pools, were greater in a logged than in a forested section of stream. Differences in growth rates were attributed to differences among pools in invertebrate drift density, and to differences in trout foraging efficiency that were related to differences between the sections in the amount of overhead shading and substrate crevices. Mean percentages of introduced prey captured by trout were greater in

logged control pools and pools of both sections whose bottoms were covered with fiberglass screening to eliminate substrate crevices than in forested control pools and logged pools that were artificially shaded.

Codes: experi habitat qual popdyn ripar trophic

Wilzbach, M. A., and J. D. Hall. 1984. Prey availability and foraging behavior of cutthroat in an open and forested section of stream. 2516-2522 p.

Past research has established that population abundance of cutthroat trout (Salmo clarki) in small streams of the Pacific Northwest (U.S.A.) differs among sites differing in riparian setting. Standing crops and productivity of the fish is greater in streams with open canopies than in streams bordered by deciduous or coniferous vegetation. The explanation appears to be food-related, as abundance of benthic and drifting invertebrates is also greater in open sites. Results suggest that effect of food abundance overrides that of habitat structure in determining trout growth and abundance patterns, and that interactions between habitat and the prey base occur that regulate how much of the prey base is actually available to the trout for consumption.

Codes: multi reach quant ripar trophic review

Wipfli, M. S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: Contrasting old-growth and young-growth riparian forests in southeastern Alaska, U.S.A. CJFAS 54: 1259-1269.

Terrestrial-derived invertebrate (TI) inputs into streams and predation on them by salmonids (40-180 mm fork length) were measured in six coastal Alaska Stream reaches from April through October 1993-1994; riparian habitat of three stream reaches contained conifer-dominated old-growth (no timber harvesting) and three were alder-dominated young-growth (31 years postclearcutting). Data from pan-traps placed on stream surfaces showed that TI biomass and nitrogen inputs averaged up to 66 and 6 mg.m super(-2).day super(-1), respectively, with no significant difference between habitats. Stomach contents from coho salmon (Oncorhynchus kisutch), cutthroat trout (O. clarki), and Dolly Varden (Salvelinus malma) revealed that TI and aquatic-derived invertebrates(A1) were equally important prey. Additionally, salmonids from young-growth systems ingested a greater TI proportion than those from old-growth systems. There were trends but no significant differences between habitats of TI and AI biomass ingested; but, statistical power was <0.30. Results showed that TI were important juvenile salmonid prey and that a riparian overstory with more alder and denser shrub understory may increase their abundance. Riparian vegetation management will likely have important consequences on trophic levels supporting predators, including but not limited to fishes.

Codes: multi reach qual trophic ripar

Wohl, N. E., and R. F. Carline. 1996. Relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three central Pennsylvania streams. Canadian Journal of Fisheries and Aquatic Sciences 53: 260-266.

We assessed relations among riparian grazing, sediment loads, macroinvertebrates, and fishes in three streams in adjacent catchments in central Pennsylvania. The catchments consisted mostly of agricultural and forest lands. Lengths of streams subjected to riparian grazing were 2.5 km along Cedar Run and 4.1 km along Slab Cabin Run; there was no riparian grazing along Spring Creek. Median daily discharge and temperatures during summer and winter were significantly different among streams. Annual sediment yields were 113, 255, and 273 t in Spring Creek, Cedar Run, and Slab Cabin Run, respectively. Substrate permeability of potential spawning sites for brown trout (Salmo trutta), and densities of benthic macroinvertebrates were significantly higher in Spring Creek than in the other streams. Densities of wild brown trout were 5-23 times higher in Spring Creek than in Cedar Run and Slab

Cabin Run. Although there were marked differences among streams with and without riparian grazing, other watershed attributes could have had some influence on these streams.

Codes: reach multi graz wtemp substrate quant

Wydoski, R. S., and W. T. Helm. 1980. Effects of Alterations to Low Gradient Reaches of Utah Streams. Fish and Wildlife Service, Biological Services Program Report FWS/OBS-80/14, April, 1980. 178 p.

Stream channels in the semi-arid intermountain west have been modified for many years by agricultural interests, primarily to provide flood protection. Of special concern is the relationship between stream channel modification and the high value fishery resource. This report describes an investigation of the effects of stream channelization on fish and macroinvertebrates in low gradient reaches of Blacksmith Fork River and the Logan River in the floodplain of Cache Valley in northern Utah. Dredged, recently bulldozed, and old bulldozed sites, plus two control areas, were selected for study. Erosion and deposition of streambed gravel were directly correlated with the percentage of stream reach that was altered. High stream flows in spring appeared to be required to maintain the depth and frequency of pools. Channelization adversely affected both fish and macroinvertebrate populations and biomass, with the severity of impact directly related to the amount and duration of disturbance of the physical habitat. In all bulldozed sites the trout populations were not self-sustaining. Dredging had less effect than bulldozing on survival of age 0 fish, but dredging may reduce spawning in the future. Water temperature, water chemistry, sampling information, a macroinvertebrate list, and length and weight information on invertebrates is provided in microfiche appendices. (Moore-SRC).

Codes: multi experi reach quant instream

Wydoski, R. S., and W. T. Helm. 1980. Effects of Alterations to Low Gradient Reaches of Utah Streams: Summary. Fish and Wildlife Service, Biological Services Program Report FWS/OBS-80/13, April, 1980. 17p.

Stream channels in the semi-arid intermountain west have been modified for many years by agricultural interests, primarily to provide flood protection. Of special concern is the relationship between stream channel modification and the high value fishery resource. This report summarizes an investigation of the effects of stream channelization on fish and macroinvertebrates in low gradient reaches of Blacksmith Fork River and the Logan River in the floodplain of Cache Valley in northern Utah. Erosion and deposition of streambed materials were directly correlated with the length of stream that was altered and the type of alteration. Channelization adversely affected both fish and macroinvertebrate populations and biomass, with the severity of impact directly related to the amount and duration of disturbance of the physical habitat. Populations, biomass and production of brown trout and mountain whitefish appeared to be directly related to the proportion of the stream reach that contained pools. (Moore-SRC).

Codes: multi experi reach quant instream

Young, K. A., S. G. Hinch, and T. G. Northcote. 1999. Status of resident coastal cutthroat trout and their habitat twenty-five years after riparian logging. North American Journal of Fisheries Management [N. Am. J. Fish. Manage.] 19: 901-911.

In 1973 two sections of a small headwater stream containing allopatric nonanadromous coastal cutthroat trout Oncorhynchus clarki were subjected to two types of streamside logging: (1) clear-cut to the streambank with all existing wood and logging debris left in the channel and on adjacent hill slopes (section B; 4.2% gradient), and (2) clear-cut to the streambank with all logging debris and existing instream wood removed from the channel and adjacent hill slopes (section A; 0.8% gradient; termed scarified). A third upstream reference section was undisturbed (section C; 4.8% gradient). The hill slopes of both treatment sections were burned in 1974. Instream habitat (large woody debris and pool percentage), water temperature, and fish populations were assessed intermittently during the following 25 years. Instream habitat, water temperature, and trout density in section B were in all years similar to the upstream reference section, C. In section A, summer maximum stream temperatures reached 30 degree C

immediately after logging but had moderated by 1975 and were similar to the reference section by 1983; the proportion of wetted area that was in pools was 14% in 1975, 33% in 1985, and 49% in 1997; trout density was low (0.05 fish/m super(2)) after logging but had returned to the reference level (0.21 fish/m super(2)) by 1983 and was double (0.49 fish/m super(2)) the reference level in 1997. The recent increase in fish density in section A may have been influenced by instream habitat enhancement and riparian thinning conducted in 1985. Trout density in section A is presently similar to that found in a nearby low-gradient stream with an undisturbed riparian zone. Our results suggest that large pieces of wood that are left in and over small streams after logging, although a contravention of current logging regulations in British Columbia, may help protect resident trout populations following riparian logging.

Codes: experi reach quant ripar wtemp lwd temporal