Models Linking Habitat And Salmon Production: A Technical Workshop, September 29-30 at the NWFSC

Wednesday, September 29

10:00	Introduction Bob Bilby
10:10	Bayesian Belief Networks and Evaluation of the Interior Columbia River Basin Alternatives (ICBEMP) Bruce Rieman and Jim Peterson (U.S. Forest Service – Boise)
10:40	Development of fish models based on habitat relationships for the Umpqua River basin and the Willamette River basin Stan Gregory (Oregon State University)
11:10	Development of empirical fish models for the Willamette River basin, based on habitat characteristics at local and landscape scales. John Van Sickle (U.S. EPA – Corvallis)
11:40	A skeptic's view of habitat quality and salmon survival: If habitat quality is so important for salmon, why is it so hard to detect it in survival data? Charlie Paulsen (BPA)
12:15-1:30	Lunch
1:30	Overview of the Aquatic Habitat Components of CLAMS Gordon Reeves (U.S. Forest Service – Corvallis
2:00	'EDT - an expert system approach' Lars Mobrandt (EDT)
2:30	A habitat-based life-history model for coho salmon Pete Lawson (NMFS Newport Lab)
2:30 – 3:00	Break
3:00	The Skagit Chinook Restoration Analysis Model Eric Beamer and Bob Hayman (Skagit System Cooperative)
3:30	Freshwater Habitat and Salmon Recovery: Relating Land Use Actions to Fish Population Response Bob Bilby, George Pess, Blake Feist, Tim Beechie (NMFS-NWFSC)
4:00 – 5:30	Discussion: Commonalities and differences among these habitat-fish production models

Thursday, September 30

8:30	Introduction	
	Discussion 1 (Blake Feist)	**Discussion 2 (Michael Pollock)**
8:45 – 11:30	**Data Management and Application** - What type of data should we be collecting to support model development, management decisions and evaluate recovery? - How do we use fish data in developing habitat fish relationships? - What can we do with existing data? - How do we evaluate data quality? Metadata standards and data distribution issues, how do we ensure that data are used appropriately? - Variability and uncertainty with respect to data: how do we express these in model outputs? - Can we identify hypotheses to identify biological mechanisms for observed correlations? - What is the role of historic information? - Are there examples where data limitations were overcome?	**What would the ideal model look like?** - Can we use model output to frame hypotheses that can be tested using alternative management? - What are the assumptions and limitations? - Appropriate spatial and temporal scales? How do we scale up and scale down? - How do we express variability and uncertainty in model output? - What is the role of historic information?
11:30 – 12:00	Report Back	
12 – 1:15	Lunch	
1:30 – 3:30	Synthesis	

Data Management and Application

- What type of data should we be collecting to support model development, management decisions and evaluate recovery?

- How do we use fish data in developing habitat fish relationships?

- What can we do with existing data?

- How do we evaluate data quality? Metadata standards and data distribution issues, how do we ensure that data are used appropriately?

- Variability and uncertainty with respect to data: how do we express these in model outputs?

- Can we identify hypotheses to identify biological mechanisms for observed correlations?

- What is the role of historic information?

- Are there examples where data limitations were overcome?

- What is the role of historic information

What would the ideal model look like?

- Can we use model output to frame hypotheses that can be tested using alternative management?

- What are the assumptions and limitations?

- Appropriate spatial and temporal scales? How do we scale up and scale down?

- How do we express variability and uncertainty in model output?

- What is the role of historic information?

EDT - an expert system approach.

Lars Mobrand (larsm@mobrand.com) and Larry Lestelle (lestelle@mobrand.com)

Abstract We present preliminary results from an application of the EDT method to Yakima Basin. The EDT method is a habitat life history based approach to relating events and actions affecting watersheds to the performance of populations, species communities and ecosystems. This presentation focuses on the relationship between habitat characteristics and spring chinook performance. Performance is measured in terms of productivity, abundance potential, and life history diversity. We show how based upon a reach by reach description of 19 habitat attributes a production functions can be estimated that are consistent with observed runsizes.

System and Scale The Yakima basin was partitioned into approximately 150 reaches. The full life cycle of spring chinook was included. Spatial resolution was coarse in the marine environment finer in fresh water. A monthly temporal scale was used. Th life history of spring chinook was divided into 17 distinct life stages. The scale was chosen based on experience with several applications of the EDT method. We try to capture the most obvious features of the landscape at this time space scale, from the perspective of each life stage, because it is consistent with the scale at which land use management and restoration actions can be implemented and results observed.

Data The EDT is an expert system approach that translates data that describe the landscape into population parameters. It is driven by whatever habitat data is available.

Advantages and Disadvantages The high dimensionality, many spatial, temporal, life stage strata are both its strength and weakness. The large number of parameters provide robustness. It does require attention to detail and it can at times be challenging to present results and assumptions clearly.

Data Habitat generated runsizes match independently observed fish numbers. Most important result is an expert system that can tell us how to prioritize and sequence recovery actions. It generates testable hypotheses regarding effectiveness of implemented measures.

References: Lichatowich et al, Fisheries, 1995; 20, (1) 10-18. Mobrand et al. CJFAS, 1997; 54,2964-2973.

A habitat-based life-history model for coho salmon

Pete Lawson (NMFS Newport Lab)

Abstract A habitat-based life-cycle model of Oregon coastal natural (OCN) coho salmon *Oncorhynchus kisutch* was developed. Freshwater production dynamics of individual stream reaches were estimated from habitat survey data. Within a river basin, populations in reaches were independent except for straying of returning spawners. In this sense, each reach represented a population within the basin metapopulation. In Monte Carlo simulations marine survival was varied from high (6%) to low (1%) and back to high in three periods of 10 generations. During the period of poor marine survival populations in reaches with higher-quality habitat persisted, while those in reaches with low-quality habitat tended to extinction. Abundance declined more rapidly than distribution. When marine survival improved, strays from the persistent populations gradually recolonized unpopulated reaches. Repopulation took several generations, suggesting that OCN coho abundance and distribution may adjust to changes in marine survival over periods of multiple generations. Results are sensitive to assumptions about metapopulation structure. In healthy metapopulations with adequate high-quality habitat this time lag could provide resilience against prolonged periods of poor marine survival. Distributions of spawners should be considered along with abundance in evaluating the status of stocks.

System and Scale We are modeling Oregon coastal natural coho salmon life history at the basin scale. There are 12 major basins on the Oregon coast north of Cape Blanco, with areas of about 10,000 km^2 each. Freshwater production is modeled at the "reach" scale, with a reach representing about 1.5 km of stream. Each basin contains 200-500 reaches. Marine mortality is modeled as a single annual rate. For risk assessment, a single coho salmon brood cycle is modeled over 33 generations (99 years).

Data

Habitat data Tom Nickelson (ODFW) derived estimates of overwinter carrying capacity for individual reaches from habitat data in all coastal basins. Sampling rates ranged from 16% to 64%. The method is described in Nickelson, T.E. 1998. A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams. Oreg. Dep. Fish Wild. Div. Info. Rep. 98-4.

Fish data Spawner abundances were taken from spawner survey data provided by Steve Jacobs (ODFW). Productivity data and other life history parameters were derived from a variety of studies.

Other data Cyclical variability in marine survival was derived from the Aleutian Low Pressure index as reported by Beamish, R.J. and Bouillon, D.R. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.

Data needs We are currently working with the Coastal Landscape Analysis and Modeling Study (USFWS, Corvallis) to use coastal data sets and process models they have developed as a basis for a spatially explicit version of this model.

Major strengths and weaknesses of the approach? The strength of this approach is it models population dynamics at a low level. This permits exploration of effects such as demographic stochasticity that are not easily modeled with more general production models. Questions about the fine structure of populations (metapopulation structure, migration and straying, local habitat effects) can also be explored. The disadvantage is the high data requirement. We are currently exploring ways to estimate productivity parameters from GIS data sets so the model can be used where detailed habitat data are not available.

Model Results: Please see abstract.

Applications Results have been used in assessing risks associated with Amendment 13 to the Salmon Fishery Management Plan of the Pacific Fisheries Management Council. We anticipate that the model will be used in development of rebuilding criteria, risk assessment of habitat and harvest activities, and research to improve understanding of coho salmon life history dynamics.

Publications, references or web-site resources

Nickelson, T.E. and Lawson, P.W. 1998. Population viability of coho salmon, *Oncorhynchus kisutch*, In Oregon coastal basins: application of a habitat-based life cycle model. Can. J. Fish. Aquat Sci. 55:2383-2392.

http://research.nwfsc.noaa.gov/fram.sat.research.htm

The Skagit Chinook Restoration Analysis Model

Eric Beamer and Bob Hayman, Skagit System Cooperative

Skagit System Cooperative is the fisheries management agency of the Swinomish Tribal Community, Upper Skagit Indian Tribe, and the Sauk-Suiattle Indian Tribe. Other agencies involved with at least some portion of this model include the USGS Western Fisheries Research Center Biological Resource Division, NMFS Northwest Fisheries Science Center and Washington Department of Fish and Wildlife. Research to develop inputs to this model has been funded by Pacific Salmon Treaty Implementation Funds, and by Seattle City Light under the Skagit Fisheries Settlement Agreement.

Abstract Started in 1995, the Skagit Chinook Restoration Model is a work in progress to be provisionally complete in 2001, using fish input data through one complete brood year (BY94), and modified as additional data become available. The intent is to model the production of Skagit River origin chinook according to discrete chinook life-stages and habitat preferences, so that: 1) the likely effects of different proposed restoration actions can be evaluated; and 2) our assumptions about chinook limiting factors can be tested. Juvenile and adult life history patterns are identified from patterns observed on chinook otoliths that are collected in various habitat types or zones within the Skagit River basin or estuary. Fish use and habitat parameters are inventoried throughout the river basin and estuary to estimate capacity and survival during the following lifestages: spawning, freshwater rearing and estuary rearing. Adult recruitment rates are estimated by using coded wire tag data from Skagit River origin indicator stocks.

System and Scale We intend to model chinook production from the Skagit River and its estuary (drainage area is approximately 8,544 km^2). The habitat scale used in the model is reach level, approximately 10^2-10^4 meters linear scale depending on aquatic habitat types. We chose the Skagit because of our management interest and current chinook stock status. The habitat scale was chosen so that model results would be sensitive to habitat projects.

Data

Habitat data

1. Spawning habitat: basin-wide inventory using aerial photography and field based confirmation of channel types. Estimate of current habitat conditions completed 1999.

2. Freshwater rearing habitat: basin wide inventory of mainstem, tributary, and off-channel habitat using aerial photography and measured field-based sub-sample. Hydromodified banks 100% field inventoried. Estimate of current habitat conditions completed 1996, refined in 1999. Estimate of historical conditions expected in 1999.

3. Estuary rearing habitat: Delta wide inventory of open channels, blind channels, and tidally influenced wetlands using aerial photography, old maps and survey notes, and measured field-based sub-sample. Estimate of current habitat conditions completed 1996, refined in 1999. Estimate of historical conditions expected in 1999.

Fish data

1. Spawning escapement: ongoing stream reach estimates based on field and aerial surveys.
2. Spawning habitat preference: ongoing monitoring of redd density by tributary channel type in a sub-sample of each channel type.
3. Fecundity: ongoing fecundity samples from wild Skagit chinook through indicator stock projects. Started in 1995.
4. Juvenile rearing in freshwater mainstem habitat: boat electrofishing in mainstem habitat. (pilot level 1993, full data collection completed in 1995 and 1996).
5. Juvenile outmigration population estimate: ongoing estimate based on scoop and screw trapping data operated in the mainstem Skagit River near Burlington.
6. Juvenile rearing in estuary habitat: ongoing collections using fyke trap and beach seine methods at 9 and 25 sites respectively, starting in 1992.
7. Juvenile composition estimate in Skagit Bay: ongoing beach seine collections starting in 1995.
8. Adult terminal area composition estimate: ongoing based on in-river test fishery started in 1995.

Life History data

1. Baseline collections of sagittal otoliths from juvenile chinook were collected throughout the Skagit River basin, estuary, and Skagit Bay in 1995 to identify the spatial extend of three naturally induced otolith marks (developmental, estuarine, and bay). Juvenile life history types are estimated according to the presence or absence of these marks and the time period individual fish spend in the habitats associated with these marks.
2. The Skagit chinook outmigration by life history type was estimated from ongoing collections of otoliths from juveniles captured in Skagit Bay.
3. The Skagit chinook adult return by juvenile life history type was estimated from ongoing collections of otoliths from adult chinook taken in the in-river test fishery or on the spawning grounds.

Strengths and Weaknesses

Strengths:

-Using real fish density, life history, and habitat data collected from the Skagit specifically for building this model.

-Model framework is based on isolated lifestages and testable hypotheses, which can be revised over time as validation monitoring information warrants. The entire model does not need to undergo revision if one part is improved.

Weaknesses:

-Model does not include detail for nearshore habitat, which may be impacting production.

-Validation monitoring will require a long time period and the model's confidence may not be in the same scale as the estimated benefits of specific restoration actions.

-Likely low confidence in population estimates of juvenile chinook at specific sites within the Skagit estuary based on the expansion means from each habitat type. Predicted changes in some habitat quality parameters are difficult to quantify.

Model Results

To date, the project has identified:

1. detail in ocean type life histories patterns used by Skagit Chinook
2. four types of developmental otolith checks, and tentative identification of the sections of the river from which they originate.
3. preference of channel type for spawning (tributary level)
4. a starting point for quantifying of the effects of peak flow on egg to fry survival
5. rearing preferences of juvenile chinook in mainstem edge habitat
6. support for hypotheses regarding an overall estuary habitat rearing constraint
7. large picture understanding of habitat loss or change, and sensitivity to various land uses throughout the Skagit River basin, mainly related to a change in capacity.

Applications

1. Habitat restoration planning and monitoring
2. Fisheries planning and monitoring, including changes to fish culture programs.

Publications, references or web-site resources

Beamer, E. 1998. Skagit River Flow and Scour Study Progress Report #1. Skagit System Cooperative, La Conner, Washington. 10 pages.

Beamer, E and G. Pess. 1999. Effects of Peak Flows on Chinook Spawning success in two Puget Sound River Basins. Extended Abstract for Amercian Water Resources Association National Conference, December 1999 in Seattle, Washington.

Beamer, E. and R. Henderson. 1998. Juvenile Salmonid Use of Natural and Hydromodified Stream Bank Habitat in the Mainstem Skagit River, Northwest Washington. Skagit System Cooperative, La Conner, Washington. 51 pages.

Beamer, E., J. Sartori, and K. Larsen. 1997. The Skagit River Chinook Life History Study Plan. Skagit System Cooperative and Western Fisheries Research Center. 14 pages.

Collins, B. 1998. Preliminary Assessment of Historic Conditions of the Skagit River in the Fir Island Area: Implications for Salmonid Habitat Restoration. Report to Skagit System Cooperative, La Conner Washington. 66 pages.

Hayman, R. A., C. Baranski, D. Seiler, and R. Henderson. 1995. FY 1995 Skagit summer chinook indicator stock study. Skagit System Cooperative Chinook Indicator Stock Progress Rept. No. 1. NWIFC Contract #3310 for FY95. Skagit System Cooperative, La Conner, WA.

Hayman R., E. Beamer, R. McClure. 1996. FY 1995 Skagit River Chinook Research. Skagit System Cooperative Chinook Restoration Research Progress Report #1, NWIFC Contract #3311 for FY95. Skagit System Cooperative, La Conner, WA.

Hayman, R. A. and R. Henderson. 1997. FY 1996 Skagit summer chinook indicator stock study. Skagit System Cooperative Chinook Indicator Stock Progress Rept. No. 2-Revised. NWIFC Contract #3605 for FY96. Skagit System Cooperative, La Conner, WA.

Hayman, R. A. and R. Henderson. 1998. FY 1997 Skagit summer chinook indicator stock study. Skagit System Cooperative Chinook Indicator Stock Progress Rept. No. 3. NWIFC Contract #3702 for FY97. Skagit System Cooperative, La Conner, WA.

Seiler,D., L.Kishimoto, and S.Neuhauser. 1998. 1997 Skagit River wild 0+ Chinook production evaluation. Washington Department of Fish and Wildlife, Olympia, WA. 57 pp.

Skagit System Cooperative. 1996. FY96 Skagit River Chinook Restoration Research Annual Narrative Report. Skagit System Cooperative, LaConner WA. 14 pages.

Skagit System Cooperative and Western Fisheries Research Center. 1998. Skagit Chinook Life History Study Progress Report Number 1. Skagit System Cooperative, La Conner WA. 8 pages.

Skagit System Cooperative and Western Fisheries Research Center. 1999. Skagit Chinook Life History Study Progress Report Number 2. Skagit System Cooperative, La Conner WA. 14 pages.

Evaluation of the Potential Effects of Land Management Alternatives in the Interior Columbia River Basin

Bruce Rieman and Jim Peterson, U.S. Forest Service Rocky Mountain Research Station, Boise Idaho.

Abstract Analysis of the potential effects of ICBEMP land-management alternatives on aquatic ecosystems are complicated by the sheer size and diversity of the Interior Columbia Basin, uncertainty concerning ecological processes, and integration of multiple and sometimes conflicting management objectives. Past efforts have been frustrated by the lack of an efficient framework to organize the large body of available information, consider multiple and complex interactions, acknowledge uncertainty, and examine assumptions as inputs change. In an attempt to address these issues, we used Bayesian Belief Networks as an analytical framework. To consider trends in the status of six salmonid fishes in more than 6,000 subwatersheds across the Basin, we represented linkages among management activities, watershed and biological conditions with a series of conditional probability tables based on empirical information and professional judgement. Our results may be used to consider the relative differences in trends expected among alternatives and regions within the Basin.

System and Scale Interior Columbia River Basin within the United States. The interior basin is that area upstream of the Cascade crest. The scale was the result of an agency response to issues associated with East Side? Forest Health

Data Both real data and subjective information are used in the analysis. The linkages in the networks are based largely on expert opinion because there is little empirical information describing physical or biological processes at this scale. Existing characterizations of the biophysical conditions for landscapes (Jensen et al. 1997), fish assemblages (Lee et al. 1997), and an interpretation of planned management activities based on the alternatives outlined in the draft EIS (Hann et al., in prep.) represent the primary information available for our analysis. The biophysical coverages and their summaries to subwatersheds were obtained from the Interior Columbia Basin Ecosystem Management Project (Quigley and Arblebide 1997). Predictions of the land management activities (Hann et al. in prep.) included estimates of road density, mechanical ground disturbance, livestock grazing, and the probability of large wildfire for current (baseline) current conditions and at 10 and 100 years from current. In addition, we developed rule-sets to assign a level of mitigation (e.g. high, moderate, low) in each subwatershed based on the conservation strategies and management standards outlined in the SEIS alternatives. All inputs for the networks were summarized from equivalent (species status and distribution) or finer resolution (landscape data derived at 1 km pixel) information. Variables represented by the nodes in our network are viewed as conditions representative of entire subwatersheds. Our summaries are based on trends in or counts of subwatersheds expected to be in a particular state.

Citations:
Lee, D. C.; Sedell, J. R.; Rieman, B. E.; Thurow, R. F.; Williams, J. E. and others. 1997. Broadscale assessment of aquatic species and habitats. Chapter 4 *in* Quigley, Thomas M. and Arbelbide, Sylvia J. An assessment of ecosystem components in the Interior Columbia Basin. Portland. OR: USDA Forest Service, Pacific Northwest Research Station.
Jensen, M. and others. 1997. Biophysical environments of the basin. Chapter 2 *in* Quigley, Thomas M. and Arbelbide, Sylvia J. An assessment of ecosystem components in the Interior Columbia Basin. Portland. OR: USDA Forest Service, Pacific Northwest Research Station.

Strengths and Weaknesses The approach is an attempt to replace 'expert panels' with a formal model the has the potential to organize huge volumes of spatially explicit information. Strengths include an ability to incorporate both empirical and subjective information; explicit incorporation of uncertainty; flexibility of model based approaches that allow evaluation of assumptions, changing inputs etc.; quantifiable results; and an ability to implement with spatial detail. The weaknesses are the virtual lack of data characterizing whole watershed/population responses that would be most useful in generating the conditional probabilities for many of the relationships.... i.e. a heavy reliance on 'expert opinion'; and a reliance on other complex process-based models for predictions of landscape and land management activities and effects.

Model Results Our analysis indicated that all of the alternatives could be expected to produce positive changes in the condition of aquatic habitats and salmonid population status in the long-term. In the short-term, differences among alternatives were small. However, predictions for one alternative indicated declining trends in habitat capacity and population status, primarily due to the greater risks associated with implementation. Model projections also indicated that trends were greater for habitat capacity than salmonid population status, both because of uncertainty and attenuation in the model and because salmonid population status was affected by both aquatic habitat and external biological factors. Among the salmonids, trends were greater for residents than the anadromous forms, principally because of the additional influence of the migratory corridor assumed for the latter. Across the Basin, differences among the alternatives were relatively small, but larger differences were observed with spatial stratification in the summaries. The nature and effectiveness of implementation could accentuate those differences. The networks should be used only for considering relative differences and trends among the alternatives and not for predictions of the actual number or condition of habitats and extant populations.

Applications The results are intended to provide supporting information for the selection or modification of a preferred alternative for implementation under Columbia River Basin Ecosystem Management Plan.

References A manuscript is in progress. The summary reports are to be released on the project web site, but we don't know when that will be.

Development of empirical fish models for the Willamette River basin, based on watershed physiography and land use/land cover.

John Van Sickle

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Abstract Multiple regression models are under development for estimating fish assemblage characteristics in 2-4 order streams throughout the Basin. Model response variables include an Index of Biotic Integrity, native taxa richness, and presence/absence of key taxa (eg, salmonids). Explanatory variables include Land Use/Land Cover (LULC) proportions in watersheds and riparian zones, as well as physiographic features such as streamflow, stream gradient and size, and network distance to a larger river.

System and Scale Models will be used as a component of the Willamette Basin Alternative Futures Analysis, an EPA-sponsored program in which Univ. Oregon, Oregon State Univ. and EPA scientists are projecting the ecological effects of alternative scenarios of future human development throughout the Basin. Because all model explanatory variables can be estimated from GIS coverages, estimates of stream ecological condition can be made for all 2-4 order reaches in the Basin.

Data Fish assemblage data (single-pass backpack electroshocking) and local physical habitat data collected at ~120 sites using uniform EPA EMAP protocols. LULC was estimated from classified thematic mapper imagery, enhanced by overlays of urban boundaries, roads, etc. Physiographic features were estimated from river network, DEM and annual precipitation coverages.

Strengths and Weaknesses

Strengths:
- Ability to spatially extrapolate to all small streams.
- Ability to estimate effects of large-scale land use change. - Focus on data-based predictive modeling.
-Some quantitative uncertainty estimates are possible.

Weaknesses:
- High uncertainty at scale of individual reaches or watersheds. - Extrapolation to future conditions questionable, if LULC correlation structure changes.
- Extrapolation from site to reach scale is speculative.

Results Preliminary models suggest that physiographic features explain most variation in fish response variables, and LULC variables provide additional significant, but weak, explanatory value.

Applications See 'system and scale' above. Model projections will be made for 3 Future scenarios: a) Continuation of Current development trends, b) Development alternative, c) Conservation alternative.

Publications, references or web-site resources
Modeling is still underway, no publications yet.

Pacific Northwest Ecosystem Research Consortium homepage:
http://osu.orst.edu/Dept/pnw-erc/

Classification of TM image:
http://www.fsl.orst.edu/larse/wrb/wrb.htm

Freshwater Habitat and Salmon Recovery: Relating Land Use Actions to Fish Population Response

Bob Bilby, George Pess, Blake Feist, Tim Beechie (NMFS-NWFSC)

Abstract The relationship between freshwater habitat condition and productivity of fish populations has traditionally been examined at very fine spatial scales (individual habitat units or short stream reaches) over short periods of time (one to five years). Much of this research has attempted to associate an environmental condition to a life-stage specific response by the fish, such as the effect of fine sediment on incubation survival. This type of research is important to understand the mechanisms by which various factors affect salmon populations and provides a basis for evaluating the potential impacts of land-use actions. However, it generally has not been possible to use these site-specific, life-history specific relationships to estimate productivity of salmon populations at larger spatial scales (i.e., watershed or regional). This difficulty stems from the high degree of reach-to-reach variation in salmon production and the lack of comprehensive, reach-specific population information. In addition, reach level habitat relationships usually do not address the spatial and temporal heterogeneity in conditions that occurs naturally in streams and rivers and promotes overall system productivity. Integrating the cumulative effect of multiple risk factors on survival and productivity of a population throughout its freshwater residency requires an examination of the habitat-population relationship at large spatial and long temporal scales. Our approach uses descriptors of habitat condition (natural and human-impacted) that reflect the availability and condition of the full range of specific habitat types a species requires to complete the freshwater phase of its life history. Defining habitat in this way addresses seasonal or life-history variations in habitat requirements. These definitions of habitat condition are derived by examining the spatial distribution of fish abundance in a watershed, segregating the sites into classes based on relative abundance of fish and identifying the habitat characteristics common to each productivity class

System and Scale

Watershed scale. Salmon stocks are usually defined at the scale of a watershed. Thus, modeling at this scale enables evaluation of habitat conditions and population response at the level of entire stocks or populations.

Data

Habitat data	Existing GIS based coverages and remotely sensed data bases (Land Sat, aerial photographs)
Fish data	Spawner escapement data
Data needs	More comprehensive and consistent spawner inventories. Records of juvenile abundance with better geographical distribution and over longer time periods.

Strengths and Weaknesses Provides a mechanism for evaluating population response to habitat alterations. Uses watershed-specific data to develop the fish-habitat relationships. The quality and quantity of available data on fish populations and habitat limit accuracy of the method.

Model Results

Provides an indication of the coarse-level habitat attributes that are associated with different levels of productive potential. Indication of the relative sensitivity of locations to different land use actions.

Applications

Not yet determined.

Publications, references or web-site resources

See Workshop handout.

A skeptic's view of habitat quality and salmon survival: If habitat quality is so important for salmon, why is it so hard to detect it in survival data?

Charlie Paulsen

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Abstract The Program for Analyzing and Testing Hypotheses (PATH) has focused most of it's attention on hydrosystem actions for Snake River chinook. However, they have also developed a number of simple models to describe how various spawning/rearing habitat quality indices affect spawner-recruit and parr-smolt survival for Snake spring/summer chinook. Literature reviews done in 1996-97 found almost no studies relating measured chinook spawner-recruit survival to land use or habitat quality.

In work done in 1995-97, I and others looked at relationships between times series of land use information (percentage of watersheds logged, grazed, or burned per year) and time series of spawner-adult recruit survival (see BPA PATH Web Page). As is common in this type of work, the models assumed that intensified land use would reduce the low-density "a" parameter in Ricker stock-recruit models. The results from these analyses were essentially inconclusive: they showed no consistent relationships between land use and spring/summer chinook survival for approximately 16 stocks above Bonneville Dam.

Work by William Thompson and Danny Lee, USDA Forest Service (in review) using the same stock-recruit data series sheds some light these counter-intuitive results: after testing a wide variety of stock-recruit models, they concluded that the most plausible model, by a wide margin, was one which used the same Ricker "a" for all stocks. This strongly suggests that models which attempt to relate low-density survival to land use are doomed to failure, at least for the stocks noted.

Work that I and Tim Fisher (Beak Consultants, Portland) have done within the past two years is, perhaps, more promising (in review, AFS Transactions). Using information on Snake spring/summer chinook tagged as parr in rearing areas well above Lower Granite dam, we have constructed a time series of Cormack-Jolly-Seber survivals (to Lower Granite) for approximately 20 stocks for tagging years 1992-98. The fish are tagged in the late summer and early fall, and migrate downstream through the Snake the following spring. The results suggest a strong, intuitively appealing relationship between overwinter survival and land use indices (vegetation cover/land management and road density, both from the IBCEMP).

Data

Fish Fish release data (PIT tag ID's, release location, date of release, and size at release) for wild spring/summer chinook are extracted from PTAGIS. We use releases in the late summer and fall, for fish having tagger-assigned migration for the following year. At least by assumption, these are parr or pre-smolts. Detection records for the same fish at mainstem Snake and Columbia dams are derived from the same source.

Habitat Habitat data were prepared by Danny Lee (USDA Forest Service, Sacramento) for related work in PATH. We use two different indices of land use: geometric mean road density (KM/KM^2) in watersheds where the parr are thought to over-winter, and a "cluster" variable that describes land use/vegetation cover in the same, subbasin-size areas.

We also employ the Palmer Drought Index for each climate region (four in the study area) in the year of tagging.

Strengths and weaknesses The major strength of the approach is that it is the only application we are aware of for chinook that relates directly estimable survival to objective measures of land use. Two weaknesses are obvious: first, cross-sectional approaches such as this one cannot directly answer questions about how survival may change as land use or habitat quality changes. Second, there is very little information on where the parr and pre-smolts over-winter: over-wintering areas were assign by regional biologists, but one cannot know for certain where the fish spend the 5-8 months between tagging and detection at mainstem dams.

Results Models are weighted so that they give less emphasis to sites/years with less precise survival estimates. Linear models relating median survival to an intercept term, habitat cluster, length at tagging, and the drought index have R-squares of approximately 0.67 (i.e., they explain two-thirds of the variation in survival across tagging sites and years). Larger fish are much more likely to survive, and years with higher precipitation have higher survival. Wilderness areas have the highest survival, while recently logged areas have the lowest. Similar models using road density have R-squares of 0.60 – 0.64, with areas of low road density having higher survival. Nonlinear (logistic or Poisson) models yield similar results. Similar models, but without the habitat indices, have R-Squares of approximately 0.56. In addition, the cluster variables and road density explain about 40% of the variation in length at tagging, suggesting that they may have a double whammy in their effects on survival. Slightly more complex models can be constructed that explain about 80% of the variance in survival.

Applications I'm hoping workshop participants will have some ideas on this.

Publications

A revised version of the AFS submission will be available the week of Oct. 15. Contact me if you wish to receive a copy.