spawn 6-7X

Behnke

Subject: update for Bob Behnke re: TROUT coverage (703) 284-9413
Date: Thu, 28 Jun 2001 10:55:27 -0400
From: Christine Arena <carena@tu.org>
To: kgarrod@cnr.colostate.edu

phone

Hi Bob-

Thanks for your note as passed along to me by Bill Sullivan.

Please send me your Autumn column. I'll need it by July 5.

Upcoming topics for TROUT coverage include:

AUTUMN-
~~*golden trout, CA - ESA listing~~
*Housatonic River, CT - hydro relicensings
*Black Earth Creek, WI - fishing

WINTER
I've scheduled 2 stories that will discuss topics in Alaska:

1) "Are Alaska's coldwater fisheries in trouble?" This article by Jim Yuskavitch will discuss the health of Alaska's fisheries, theories on what's threatening them, and Trout Unlimited's goals and positions re: their conservation and protection. It will also describe the work of TU's new office and staff based in Anchorage.

2) Salmon ecology - A general piece about the life cycle and biology of Bristol Bay sockeye salmon. This is by Bruce Hampton, author of the upcoming Bristol Bay book, "Rivers of Life."

Other Winter stories will cover Esopus Creek, NY (water withdrawals) and Tennessee tailwaters (fishing).

That's it for now. I hope all's well.

Best,
Christine

Spring

last invoice $500
- Karen Typing

A comparative analysis of three computer stream models

Philip Harrison, Earth Sciences Department, jnoa4@aol.com
University of Northern Colorado

ABSTRACT:

Instream flow water allocations increased after the passage of the National Environmental Policy Act of 1969. At the Federal level most instream flow research centered around instream flow incremental methods developed first by the U.S. Fish and Wildlife Service and currently by the Biological Resources Division of the U.S. Geological Survey. Two contemporary models used by the Biological Resources Division are Physical HABitat SIMulation System and SALMOD. The Physical HABitat SIMulation System (PHABSIM) models the physical properties of stream habitat (hydrology and substrate) and then conceptually represents the fish habitat requirements by weighted useable area or habitats theoretically suitable for fish. The SALMOD model is a extension of the PHABSIM model. SALMOD adds and incorporates fish cohorts throughout their life cycle. These two models represent the state of the art for instream flow models used by Federal government.

Another stream model was developed by a consortium of public utilities and funded through the Electric Power Research Institute. The CompMech model was developed for monitoring the effects of a hydropower dam on the Tule river in California, The CompMech model is a individual based model (IBM) that follows each individual fish from birth to death in the population. CompMech also uses parts of the PHABSIM for its model.

This research will compare the three stream models by compiling a common dataset used as input, from the Poudre River.

RESEARCH SIGNIFICANCE

1. To compare utility of models for water planners, hydrologists, biologists, and ecologists
2. To determine trout population limiting events based on habitat (discharge)
3. To determine ultimately, how much water stream fish need and how much data are required ?

Figure 1. PHABSIM Basics

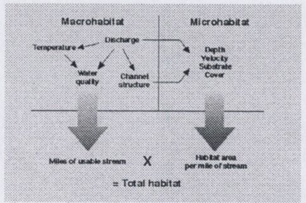
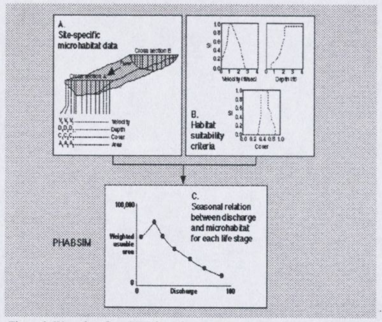


Figure 1. Was taken from URL http://www.mesc.usgs.gov images/primer1.gif

Figure 2. How PHABSIM calculates habitat values as a function of discharge. Graph A., first, depth (Di), velocity (Vi), cover conditions (Ci), and area (Ai) are measured or simulated for a given discharge. Graph B., suitability index (SI) criteria are used to weight the area of each cell for the discharge. The habitat values for all cells in the study reach are summed to obtain a single habitat value for the discharge. Graph C., the procedure is repeated through a range of discharges to get area of useable habitat.



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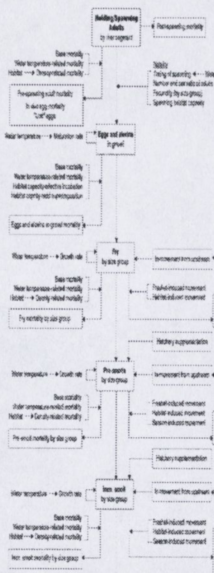


Figure 3. Was taken from URL http://www.mesc.usgs.gov/images/primer 2.gif

Figure 2. **IBM** or CompMech Model Processes

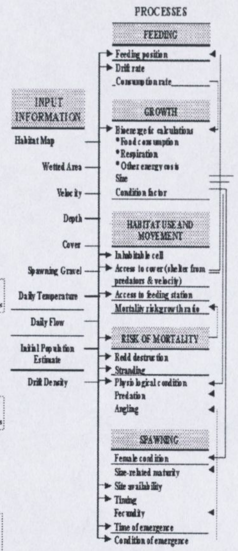


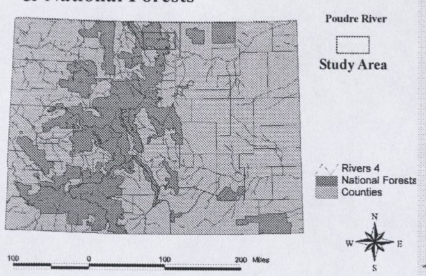
Figure 4. From URL http://www.stream.fs.fed.us

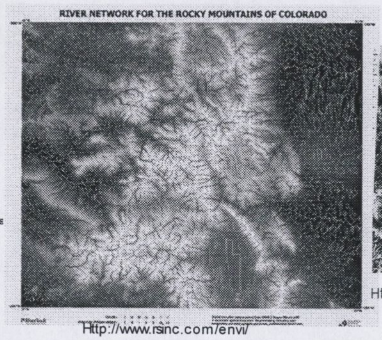
References
Bartholow, J.M, 1996, Sensitivity of a salmon population model to alternate formulations and initial conditions: Ecological Modeling, 88(1-3):215-226.

Milhous, R.T., Wegner, D.L., and Waddle, T., 1984, User's Guide to the Physical Habitat Simulation System (PHABSIM), Instream Flow Information Paper 11: USFWS, FWS/OBS-81/43 Revised, 475 p.

Winkle, W.V., Railsbback, S.E., and Baldrige, J.E., 1998, Individual- based model of Brown and Rainbow trout for instream assessment: model description and calibration: Ecological Modeling, 110(2):175- 207.

Colorado Rivers & National Forests





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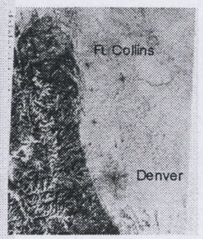

Http://rst.gsfc.nasa.gov/Sect6/

Poudre River

Study Area

Dr Behnke For your comments [ca 2000]
Sorry it took so long
File: proposal4b 10-28-00 hard drive crashes, classes...
Philip

UNIVERSITY OF NORTHERN COLORADO

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Department of Earth Sciences

A Proposal for a Master's Thesis/Graduate Research Project

A COMPARATIVE ANALYSIS OF THREE COMPUTER STREAM MODELS

Philip Harrison

Advisor ______________________
William H. Hoyt, Ph.D.

Committee ______________________
William D. Nesse, Ph.D.

____
John C. Moore, Ph.D.

College of Arts and Sciences
Department of Earth Sciences

DRAFT FOR YOUR WRITTEN COMMENTS

Abstract:

Instream flow water allocations became common after the passage of the National Environmental Policy Act of 1969. At the Federal level most instream flow research centered around instream flow incremental methods developed first by the U.S. Fish and Wildlife Service and currently by the Biological Resources Division of the U.S. Geological Survey. Two contemporary models used by the Biological Resources Division are Physical HABitat SIMulation System; and SALMOD. The Physical HABitat SIMulation System models the physical properties of stream habitat (hydrology and substrate) and then conceptually represents the fish habitat requirements by weighted useable area or habitats theoretically suitable for fish. The
SALMOD model is a refinement of the Physical HABitat SIMulation System model. SALMOD adds and incorporates fish cohorts throughout their life cycle. These two models represent the state of the art for instream flow models used by the Federal government.

Another stream model was developed by a consortium of public utilities and funded through the Electric Power Research Institute. As part of monitoring the effects of a hydropower dam on the Tule river in California, the CompMech model was developed. The CompMech model is an individual based model that follows each individual fish from birth to death in the population. CompMech also uses parts of the Physical HABitat SIMulation System for its model.

This research will compile a common dataset used as input to compare the three stream models of Physical HABitat SIMulation System, SALMOD and CompMech. Model comparison will include advantages and disadvantages, the amount of data required to run the models (input files), the model output (output files), and how difficult it is to learn and use the models. The processes used by each model will be compared. CompMech and SALMOD will be used to study two variables, discharge and trout population. Baseline comparison will be made using ten yearly hydrographs (water years) picked to represent median to average hydrographs. Population limiting events will be determined by simulating hydrographs that cause a 50 percent decline in trout population (number or biomass) over ten years or less.

Statement of Problem:

A variety of computer models of stream physical habitat have been used to study the effects of discharge on fish habitat and population (Bartholow and Waddle, 1994). This research will compare advantages and disadvantages of three contemporary stream models by using a common dataset.

Significance of Research:

A recent salmonid habitat literature review cites the importance of water as habitat, but fails to quantify discharge or flow regimes needed (Marcus and others, 1990, p. 26). This lack of unquantified discharge in the review and many other habitat related publications underscores the need for stream models. Historically stream models have been used for water allocation and planning. In the 1970's the U.S. Fish and Wildlife Service instream flow research group started using stream models as part of its instream flow incremental method (IFIM). In the 1990's the instream flow group was transferred to the U.S. Geological Survey, Biological Resources Division, which currently supports the Physical HABitat SIMulation System, and SALMOD models. As part of monitoring the effects of a hydropower dam on the Tule river in California, the CompMech model was developed. The CompMech model is an individual based model (IBM) that follows each individual from birth to death in the population.

This proposal will compare three contemporary stream models: Physical HABitat SIMulation System (PHABSIM), SALMOD, and CompMech. Currently there are two lines of thought in stream modeling those favoring: IBM models like CompMech and those favoring IFIM models such as PHABSIM and SALMOD. This research will compare the models using a common dataset. The proposed research will benefit water planners, hydrologists, biologists, and ecologists.

Stream modeling allows the comparison of various alternatives ("what if" predictions) with out the time and expense of conventional field studies. Modeling is a good way to see how well a stream ecosystem is understood, and where there are data gaps and additional research is needed.

Literature Review of Models

Excerpted and Edited from URL: http://www.mesc.usgs.gov

IFIM in a Nutshell

Instream flow methods have been developed by biologists and hydrologists working for regulatory water development agencies and wildlife agencies. Efforts over the last three decades provided the impetus for ecological studies leading to a growth in the understanding of the relations between stream flow and aquatic ecology. Currently, most of the evidence gathered has focused on fish and macro-invertebrate habitat requirements. Water management problem solving has evolved from setting fixed minimum flows with no specific aquatic habitat benefit to incremental methods in which aquatic habitats are quantified as a function of discharge (Stalnaker and others, 1995).

Research in the form of correlating the well-being of fish populations with physical and chemical attributes of the flow regime. A habitat variables set was shown to contribute significantly to the variation in fish production (cite WY). These were water velocity minimal water depths and instream objects such as: cover, bottom substrate materials, water temperature, dissolved oxygen, total alkalinity, turbidity, and light penetration through the water column. These elements were blended into methodologies for analyzing proposed water withdrawal or storage-release activities and were applied to Federal water projects.

Starting in the late 1970's small hydropower development began. Hydropower sites came under examination by state and Federal fishery management interests. Whilst transitioning from evaluating large Federal reservoirs to evaluating small hydropower, the Instream Flow Incremental Methodology (IFIM) was developed under the guidance of the U.S. Fish and Wildlife Service. This new methodology integrated the planning concepts of water supply, analytical models from hydraulic and water quality engineering, and empirically derived habitat versus flow functions. The result was simulations of the quantity and quality of "potential habitat" resulting from proposed water development. Such efforts were refined and enhanced during the next 10 years, driven by relicensing applications submitted to the Federal Energy Regulatory Commission. (Bovee, 1998, p. 4).

IFIM matured against the backdrop of minimum flow standards, quantitative impact analyses, water budgets, and interdisciplinary analyses. IFIM by necessity was developed by an interdisciplinary team and was founded on a basic understanding and description of the water supply and habitats within stream reaches of concern.

Looking at streamflow over time facillitates comparasions of the frequency and duration of wet and dry periods, to examine the difference between snow-melt and rain-driven systems, and finally to determine the intensity and duration of short-term events such as cloud bursts and peaking cycles. To change operating decisions within large-scale water development settings, a tool was needed that illuminated conflicts and complementary water uses, considered and evaluated each user's needs. Additionally a tool that was understandable, acceptable, and easy to use by a broad clientele. Such decisions involve a diversity of disciplines, including engineers, hydrologists, biologists, recreation planners, lawyers, and political scientists.

This interdisciplinary effort concluded that an analytical methodology capabilities include a variety of instream flow problems, from simple diversions to complex storage and release schemes involving hydropeaking schedules. For evaluating alternatives, the method had to identify, evaluate, and compare potential solutions, allow tailoring to a specific stream reach, and most importantly be expandable such that reach information could be applied throughout a river basin. IFIM has developed over a period of 15 years to met most these needs via a river network analysis that incorporates fish habitat, recreational opportunity, and woody vegetation response to alternative water management schemes. Results are presented as a time series of flow and habitat at selected points within a river system.

1. Physical HABitat SIMulation System (PHABSIM) studies

Excerpted and Edited from URL: http://www.mesc.usgs.gov

This part consists of several sequential activities: data collection, model calibration, predictive simulation, and synthesis of results. Proper implementation of the study is critical and can bring credibility to the decision process but will not, by itself, result in good decisions.

During implementation, sampling locations are selected for collecting data used in predictive models. Data collected can include temperature, pH, dissolved oxygen, biological parameters, and measures of flow such as velocity, depth, and cover. These variables are used in describing the relation between stream flow and stream habitat utility. IFIM relies heavily on models because they can be used to evaluate new projects or new operations of existing projects. Model calibration and quality assurance are keys during this phase and, when performed. carefully, lead to reliable estimates of the total habitat within the study area during simulation of the alternative flow regimes (Milhous, 1999). Total habitat is synthesized by integrating large-scale macrohabitat variables with small-scale microhabitat variable. An important intermediate product from this phase is the baseline habitat time series. This analysis determines how much habitat in total would be available for each life stage of each species over time. The baseline habitat time series provides the base from which rational judgments can be made about proposed alternative management schemes.

Some site-specific measurements of temperature, water quality, depths, and velocities are routinely used to calibrate physical and chemical models, samples of the aquatic organisms and their habitat use must be used to 'calibrate' the habitat simulations used in IFIM alternatives analyses.

Baseline analysis results in estimates of the relation between flow and total habitat, as well as measures of the amount of habitat available under the chosen baseline conditions and the various with-project alternatives. This habitat quantification leads naturally into the next phase that will compare and evaluate the alternatives. Before discussing the next phase, however, it would be best to make specific mention of PHABSIM.

Many people confuse IFIM with the Physical HABitat SIMulation System (PHABSIM). Where IFIM is a general problem solving approach employing systems analysis techniques, PHABSIM is a specific model designed to calculate an index to the amount of microhabitat available for different life stages at different flow levels. PHABSIM has two major analytical components: stream hydraulics and life stage-specific habitat requirements.

Figure 1. How PHABSIM calculates habitat values as a function of discharge. (A) First, depth (Di), velocity (Vi), cover conditions (Ci), and area (Ai) are measured or simulated for a given

discharge. (B) Suitability index (SI) criteria are used to weight the area of each cell for the discharge. The habitat values for all cells in the study reach are summed to obtain a single habitat value for the discharge. The procedure is repeated through a range of discharges to obtain the graph (C).

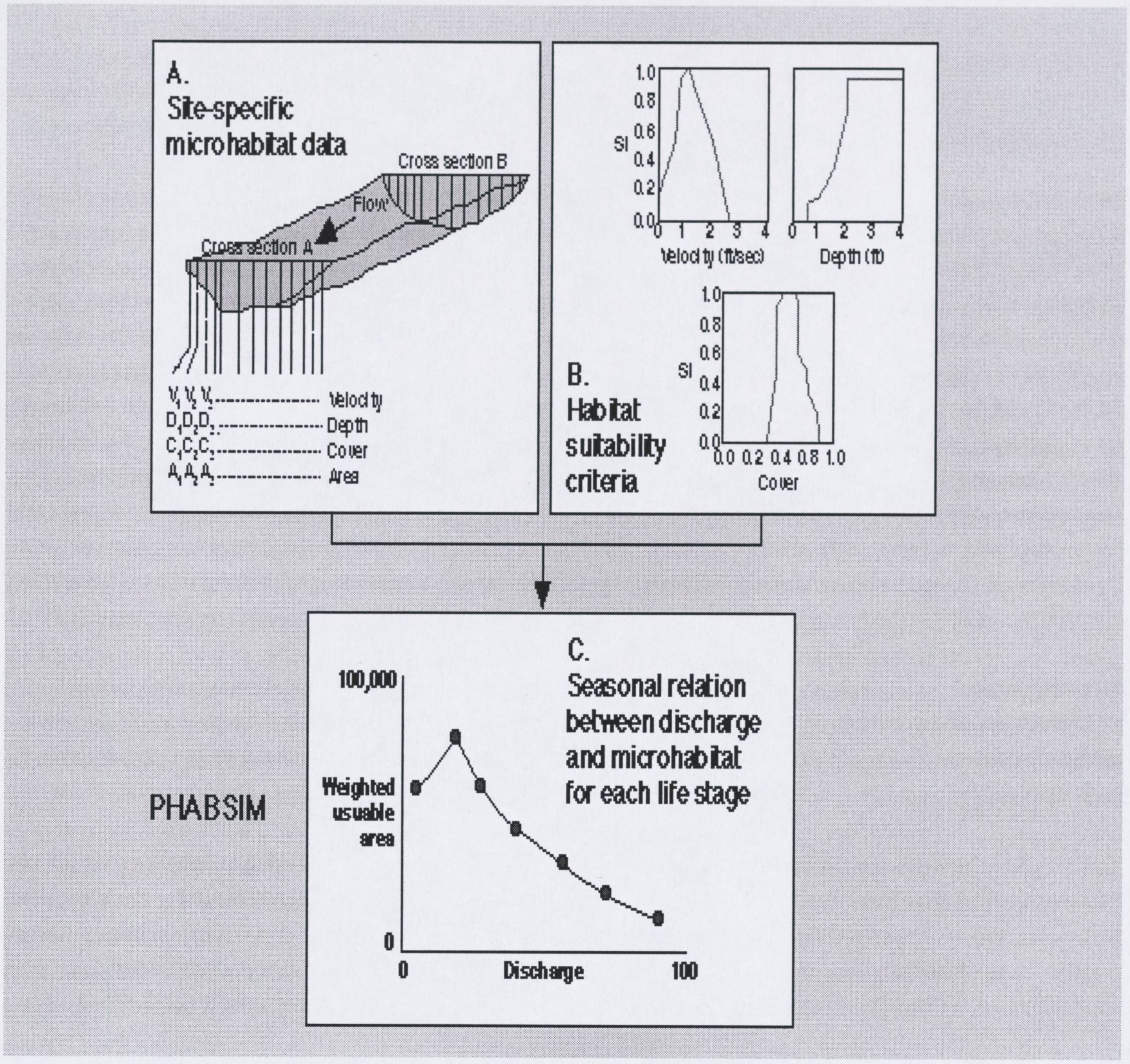

Figure 1. Was taken from URL http://www.mesc.usgs.gov

The stream hydraulic component predicts depths and water velocities at specific locations on a cross section of a stream. Field measurements of depth, velocity, substrate material, and cover at specific sampling points on a cross section are taken at different flows. Hydraulic measurements, such as water surface elevations, are also collected during the field inventory.

These data are used to calibrate the hydraulic models and then predict depths and velocities at flows different from those measured.

The hydraulic models have two major steps. The first is to calculate the water surface elevation for a specified flow, thus predicting the depth. The second is to simulate the velocities across the cross section. Each of these two steps can use techniques based on theory or on empirical regression techniques, depending on the circumstances. The empirical techniques require much supporting data; the theoretical techniques much less. Most applications involve a mix of hydraulic sub-models to characterize a variety of hydraulic conditions at various simulated flows.

The habitat component weights each stream cell using indices that assign a relative value between 0 and 1 for each habitat attribute indicating how suitable that attribute is for the life stage under consideration. These attribute indices are usually termed habitat suitability indices and are developed using direct observations of the attributes used most often by a life stage, by expert opinion about what the life requisites are, or by a combination. Various approaches are taken to factor assorted biases out of this suitability data, but they remain indices that are used as weights of suitability. In the last step of the habitat component, the hydraulic estimates of depth and velocity at different flow levels are combined with the suitability values for those attributes to weight the area of each cell at the simulated flows. The weighted values for all cells are summed (Milhous and others, 1984, p. V-3) thus the term weighted usable area (WUA).

There are many variations on the basic approach outlined above, with specific analyses tailored for different water management phenomena, or for special habitat needs. However, the fundamentals of hydraulic and habitat modeling remain the same, resulting in a WUA versus discharge function. This function should be combined with water availability to develop an idea of what life stages are impacted by a loss or gain of available habitat at what time of the year. Time series analysis plays this role, and also factors in any physical and institutional constraints on water management so that alternatives can be evaluated.

Several things must be remembered about PHABSIM. First, it provides an index to the microhabitat availability; it is not a measure of the habitat actually used by aquatic organisms. It can only be used if the species under consideration exhibit documented preferences for depth, velocity, substrate material/cover, or other predictable microhabitat attributes in a specific environment of competition and predation. The typical application of PHABSIM assumes relatively steady flow conditions such that depths and velocities are comparably stable for the chosen time step. PHABSIM does not predict the effects of flow on channel change. Finally, the field data and computer analysis requirements can be relatively large.

Applications

PHABSIM has been applied to a variety of trout and salmon streams primarily, in the western United States. Other uses are for smallmouth bass in the Little Wabash River, Illinois.

1. PHABSIM Model Summary

Life Stages

Adult
Spawning
Fry
Juvenile

Temporal Resolution

Weekly or Monthly Time Step
Simulated for one year
Weekly temperature
Microhabitat flow transects (PHABSIM transects)

Spatial Resolution

Microhabitat

A Cell (generally larger than one cubic meter)
A stream reach generally less than one mile

Site Specific Input Data Sets

Weekly discharge

Hardware Requirements

A NT Workstation with a Pentium CPU

2. SALMOD Model

Excerpted and Edited from URL: http://www.mesc.usgs.gov

SALMOD is a computer model that simulates freshwater salmonid populations, both anadromous and resident (Bartholow and others, 1997, p. 1). The model's premise is that egg and fish mortality are directly related to spatially and temporally variable micro- and macrohabitat limitations (Bartholow and others, 1993) which themselves are related to the timing and amount of streamflow (Bartholow and Waddle, 1995). Habitat quality and capacity are characterized by the hydraulic and thermal properties of individual mesohabitats, which we use as spatial "computation units" in the model. The model tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of local water temperature. Individual cohorts either remain in the computational unit in which they emerged or move, in whole or in part, to nearby units. Model processes include spawning (with redd superimposition), growth (including egg maturation), mortality, and movement (freshet-induced, habitat-induced, and seasonal). Model processes are implemented such that the user (modeler) has the ability to more-or-less "tweak" the model on the fly to create the dynamics thought to animate the population.

SALMOD is best explained by describing its fundamental structure in terms of temporal, spatial, and biological resolution. SALMOD employs a weekly time step for one or more biological years. Biological years typically (but not always) start with the first week of spawning. All rate parameters (e.g., growth, mortality) and physical state variables (e.g., streamflow, water temperature) are represented by mean weekly values. Spatial resolution is consistent with the mesohabitat inventory approach, in which the study area is classified and mapped as discrete mesohabitat types, intermediate between micro- and macrohabitat, that tend to behave similarly in response to discharge fluctuations. The biological resolution is fairly standard in the sense that we employ a typical categorization of fish life history related to morphology and reproductive potential. Fish in the simulated population are tracked by cohorts within computational units. Each cohort is classified by life stages, and class within life stages. The various rate parameters (e.g., growth, mortality) can depend on life stage and class.

SALMOD Model Processes

SALMOD represents the freshwater population dynamics of two life history variants: (1) an anadromous fish species/salmon that returns to the stream as an adult to spawn or (2) a resident population of salmonids/rainbow trout. The focus is on biological processes that affect the early lifestages of the species. The model simulates: (1) spawning, (2) egg development and growth, (3) movement, induced by freshets, time of year, or living space constraints, and (4) various types of mortality. In the anadromous variant, adults die after spawning and smolts do not graduate to the adult stage; they exit the study area. Thus the population is re-initialized each biological year (Bartholow, 1996). Life history patterns where the anadromous juveniles spend more than one year in freshwater have not yet been attempted with SALMOD.

In the resident variant, adults do not die after spawning and a juvenile lifestage (e.g., yearlings) may mature to adults capable of spawning. Each computational process is applied sequentially to each individual cohort for all spatial computational units for a single time step.

The simulation processes and how they function are defined by the model, but the user has a great deal of flexibility over those processes including the order of execution, specification of control parameters, and simulation options such that a range of applications and hypothesis testing may be flexibly incorporated.

Applications

SALMOD has been applied to a fall chinook population in a portion of the Trinity River, California (Williamson, 1993). We are in the process of collecting data sufficient to begin an application on the Klamath River, California. A resident trout trial with rainbow and brown trout on the Poudre River, Colorado, was completed (Hickey, 1998, p. 83). Among the uses are (1) determination of the population consequences of alternative flow and temperature regimes, (2) understanding of the relative magnitude of mortality in determining the timing and degree of habitat "bottlenecks", and (3) designing flow regimes to mitigate those bottlenecks.

Model Implementation

The SALMOD computer program is implemented in Fortran 90 with some extensions for the Intel microcomputer environment. The model is almost 100% data-driven, giving the user thorough control over the definition of the life history descriptors and the linking of the life history to the model processes. Data input has been designed to be very flexible, facilitating data import from a wide variety of data base management and spreadsheet software. Data output consists of a variety of graphs and tables that are created through post-processors. Like the input data formats, output data are arranged to expedite and encourage transfer to other postprocessing software for subsequent analysis or display.

2. SALMOD Model Summary

Life Stages

Adult
Spawning
Incubation
Fry
Juvenile

Temporal Resolution

Weekly or monthly time step
Simulated for one or more biological years

Spatial Resolution
Microhabitat to mesohabitat

A Cell (generally larger than one cubic meter)
A stream reach generally less than one mile

Site Specific Input Data Sets

4 Stream Files:

Weekly discharge
Weekly temperature
Habitat mapping or type
Weighed usable area (WUA) discharge functions (from PHABSIM study)

4 Biological Files:

Movement, mortality, and growth
Spawning data
Species lifestage and class data
Initial population data

Hardware Requirements

A NT Workstation with a Pentium CPU

3. CompMech Model

Excerpted and Edited from URL: http://www.ornl.gov

The Electric Power Research Institute (EPRI) program on compensatory mechanisms in fish populations or CompMech has the objective of improving predictions of fish population response to increased mortality, loss of habitat/water, and release of toxicants. The program initiated in 1987, was based on a decade of prior planning by EPRI, member utilities, and academic and agency scientists. The program's longevity and productivity, and the extensive involvement of utilities as well as government resource and regulatory agencies, attest to the accomplishments of CompMech model developed by Oak Ridge National Laboratory and others.

The CompMech approach over the past decade has been to represent in simulation models the processes underlying the growth, reproduction, and survival of individual fish and then to aggregate over individuals to the population level (Winkle and others, 1996, p. 1-2).

Models have been developed and applied to key species representing a cross-section of life-history strategies/speculations. These particular species are known to experience mortalities and habitat alterations because of the operation of steam and hydroelectric generation facilities. Models for additional species are developed by modifying modules from these existing models. Life history theory provides a framework for predicting how environmental impacts might affect different fish species.

The models can be used to make short-term predictions of survival, growth, habitat utilization, and consumption for critical life stages. For the long term, the models can be used to project population abundance through time to assess the risk that the abundance will fall below some threshold requiring mitigation. If mitigation is required, alternative measures can be evaluated using the model. For both short-and long-term predictions, the models are used to compare the consequences and economics of alternative operational scenarios. To provide a perspective on the incremental effects attributable to plant operation as compared to natural mortality and other impacts such as fishing.

Compensation or compensatory mortality(Krebs p345, 1985) can be defined as the capacity of a population to self-mitigate decreased growth, reproduction, and survival of some individuals in the population by increased growth, reproduction, and survival of the remaining individuals up to a point. Compensation in the field is an emergent property of what happens to the individuals in a population. Individual-based models (IBM) represent the daily growth and probability of survival of individuals and then aggregate over [-individuals to characterize the population (Winkle and others, 1998). The CompMech approach provides a means for mechanistically bounding the potential for compensation, which is likely to vary among species with different life history strategies (Winkle and others, 1993).

The CompMech approach is designed to use as much or as little site-specific data as is available. The need for site-specific data is determined primarily by the assessment issues and the costs of regulatory alternatives (i.e., more costly decisions might possibly warrant more-extensive site-specific data collection). The abiotic environment is characterized spatially and temporally in terms of the dominant physical and chemical variables thought to influence the dynamics of the populations of concern (the habitat limiting factors). The types of fisheries information typically collected during monitoring programs, such as density, size, and age composition, are used to characterize the fish populations. Data on prey availability and predation intensity can be useful but are non-essential. Data on fecundity, bioenergetic parameters relating to consumption and respiration, and acute and chronic responses to toxicants are usually obtained from the literature (armchair biololgy). At least five basic site specific data sets are required to run the model, three physical habitat (daily temperature and discharge, and PHABSIM stream data and transects) and two biological data sets.

Applications

The CompMech approach has been applied by utilities and resource management agencies in assessments involving: (1) direct mortality due to entrainment, impingement, or fishing; (2) instream flow; (3) habitat alteration (e.g., dewatering, thermal discharges, water-level fluctuations, water diversions, exotic species); and (4) ecotoxicity.

Brown and Rainbow Trout: As part of the Response of Fish Populations to Altered Flows Project, jointly funded by EPRI, Pacific Gas & Electric Company, Southern California Edison Company and your utility bill, an individual-based instream flow model for coexisting populations of brown and rainbow trout was developed. This model was used to evaluate alternative instream flow and temperature scenarios on the Tule River in California (Pacific Gas and Electric Company, 1995). Model predictions were compared with field observations before and after experimental increases in instream flow. The model was adapted to larger rivers and stream systems in 1997 (Winkle and others, 1997, p. 1-1). The next step by the two utilities is to demonstrate its use in identifying instream flows that protect hydropower production with less impact on fisheries.

Chinook Salmon: Experience gained from the trout application described above led to development of an individual-based model of chinook salmon smolt production. This model links instream flow to small production by simulating the influences of riverine habitat on spawning, growth, survival, and the effect of these factors on outmigration of chinook salmon. The model is being used as part of the Environmental Impact Statement for a FERC proceeding to consider the minimum stream flows necessary to assure the continuation and maintenance of the anadromous fishery in the lower Tuolumne River, California.

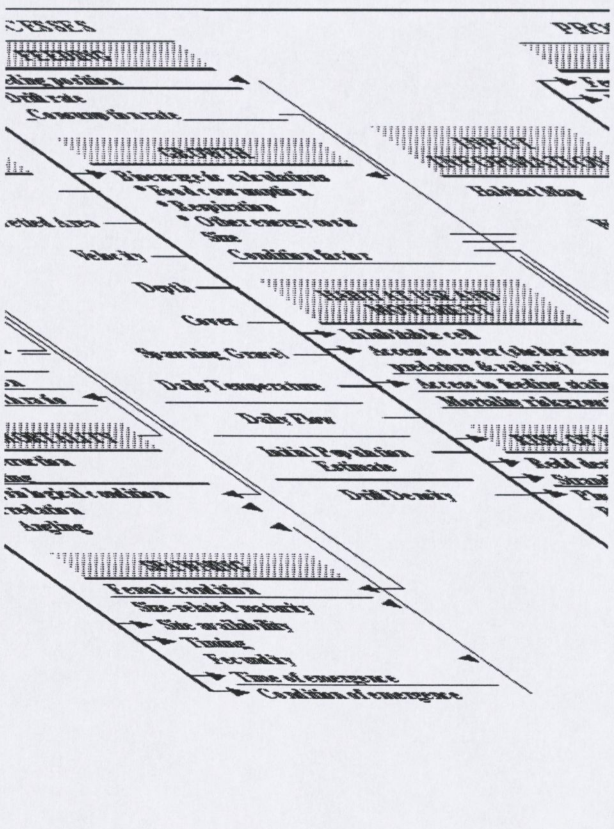

Figure 2, was taken from URL www.stream.fs.fed.us/

3. CompMech Model Summary

Life Stages

Adult
Spawning
Incubation
Fry
Juvenile

Temporal Resolution

Weekly or daily time step
Simulated for one or more biological years

Spatial Resolution
Microhabitat

A Cell (generally larger than one cubic meter)
A stream reach generally less than one mile

Site Specific Input Data Sets

3 Stream Files:

Daily discharge
Daily temperature
Habitat mapping data
Habitat (PHABSIM transect data)

1 Biological File:

Initial population data (from quarterly electroshocking)

Hardware Requirements

A NT Workstation with a Pentium CPU

Plan of Study:

This proposal will compare three contemporary stream models: PHABSIM, SALMOD, and CompMech. This research will compare advantages and disadvantages of three stream models by using a common dataset complied from existing studies of the Poudre River. The models will be compared by the amount of data required to run the models (input files), the model output (output files), and how difficult it is to learn and use the models. The processes used by each model will be compared. All models will be rated for how user friendly the models are for water planners, hydrologists, biologist and ecologists. A standardized dataset for input variables common to each model will be compiled from existing studies for the Poudre River above Ft. Collins, Colorado. This research will not require any field work other than an optional visit to photograph stream reaches used in the models.

CompMech and SALMOD will be used to study two variables, discharge and trout population. All other model variables will remain the same. Baseline comparison will be made using ten yearly hydrographs (water years) picked to represent median to average hydrographs. Population limiting events will be determined by simulating hydrographs that cause a 50 percent decline in trout population (number or biomass) over ten years or less.

Time-line

Summer 2000–Finish the proposal.
Fall 2000–Install the three models software on an windows NT workstation computer and dry run the models. Compile the standardized dataset for the Poudre River.

Spring 2001–Run the standardized dataset for the Poudre River on the three models. Run baseline and simulated hydrographs to determine trout populations for the CompMech and SALMOD models.

Summer 2001– Write up the results and finish Thesis.

Budget

A minimum budget to complete the study is $4575.

NT Workstation Computer	$3000
Travel to Ft. Collins 8 times and Poudre River 1 time (500 miles @ $.25/mi)	$125
USGS--Biological Resources Division Model Training Courses	
IF250 Theory and Concepts of Instream Flow Incremental Methodology–IFIM	$150

IF305 IFIM Stream Habitat Sampling Techniques	$650
IF310 Using the Computer-based Physical Habitat Simulation	$650
	Total: $4575

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