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Graduate Student Symposium on Fish Population Dynamics and Management

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Graduate Student Symposium on Fish Population Dynamics and Management

Fisheries Centre, University of British Columbia, Canada

edited by

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and
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Director's Foreword

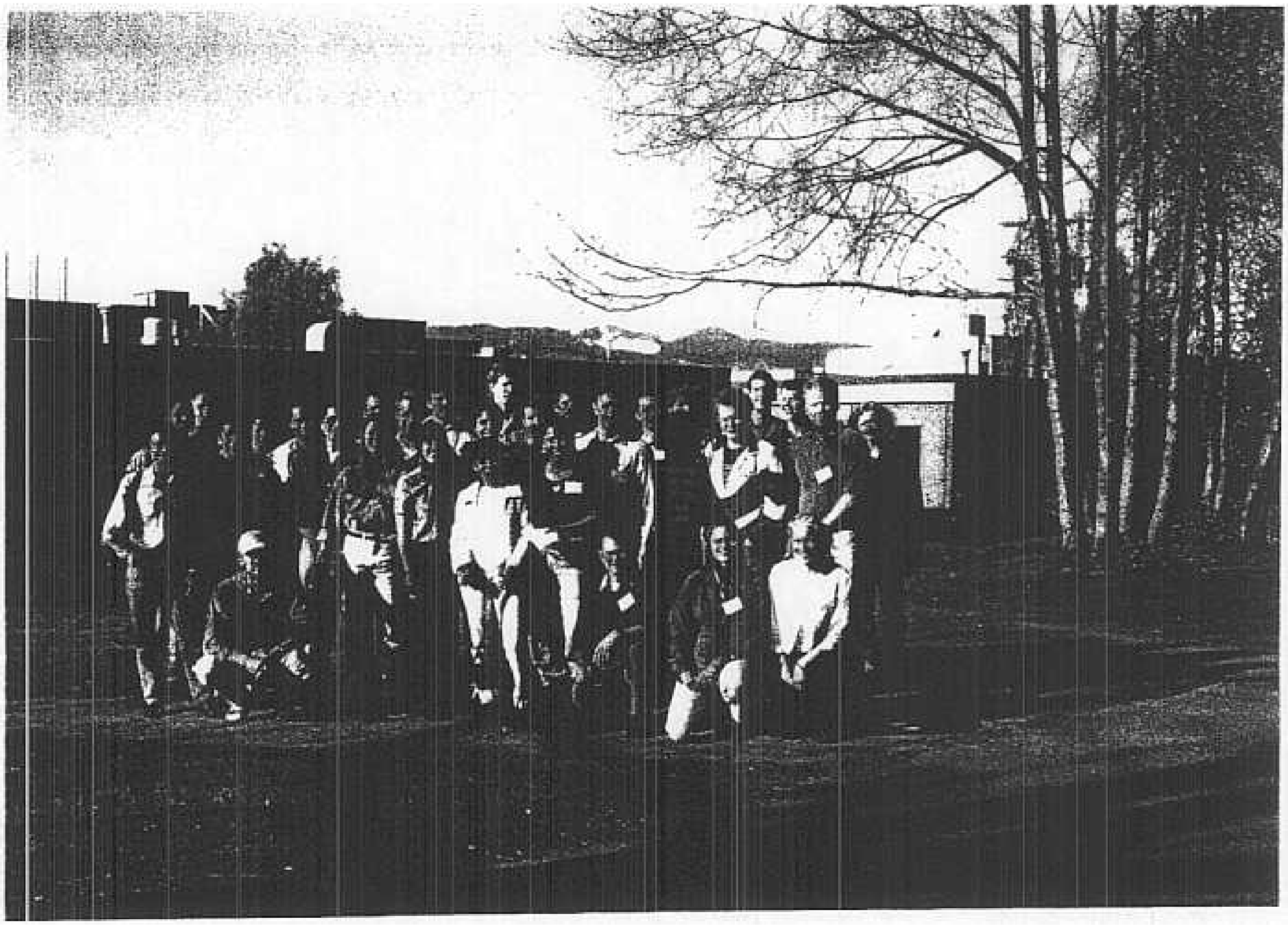
From April 22-23 1995 the UBC Fisheries Centre was delighted to host over 30 fishery graduate students from the Universities of British Columbia, Minnesota, Washington, Oregon State and Simon Fraser University who met in order to participate in the first Graduate Fisheries Symposium on Fish Population Dynamics and Management. It is hoped that this is the first of an annual series.

The Symposium was jointly organised by Alida Bundy from the Fisheries Centre, UBC and Elizabeth Babcock from the School of Fisheries, UW. These proceedings consist of extended abstracts of papers presented at the Symposium together with a list of participants and a summary of discussion items.

Fishery science is in a state of dynamic flux today. Old ideas are being re-visited and re-vitalised using new tools of the computing and information explosion. Graduate students are the life blood of any research institute and so we are making this record of the Symposium more widely available to communicate important discussion themes that we think are at the frontiers of fishery science.

The Graduate Student Symposium on Fish Population Dynamics and Management constitutes the 2nd in a series of meetings/workshops held at the UBC Fisheries Centre in 1995 and was partially sponsored by the Fisheries Centre. The workshop series aims to focus on broad multidisciplinary problems in fisheries management, provides a synoptic overview of the foundation and themes of current research, and attempts to identify profitable ways forward. Edited reports of the workshops are published in Fisheries Centre Research Reports and are distributed to all participants and to selected international fisheries libraries. Further copies are available on request.

Tony J Pitcher
Professor of Fisheries
Director, UBC Fisheries Centre



Standing, from left to right:
Ted Tien-hsiang Tsai, Patrick McConney, James Scandol, Jesus Jurado-Molina, Sherry Larkin, Ricardo Torres, Leonardo Huato, Chris Tuninga, Lisa Thompson, Trevor Hutton, Stacey Rassmussen, Chris Costello, Silvia Salvas, Lorraine Read, Warren Schlechte, Christina Robb, Ying Chuenpagdee, Martin Esseen, James Lady, Ramón Bonfil, Michiyo Shima, Richard Porter, Calvin Peters, Tim Liermann, Milo Adkison, Derek Ogle, Marianne Johnson.

Kneeling, from left to right:
Judson Venier, Murdoch McAllister, Beth Babcock, Alida Bundy.

Organisers' Introduction

The first of an intended annual series of Graduate Fisheries Symposia for North American West Coast Universities was held at the Fisheries Centre, UBC, 22-23 April 1995. The aims of the Symposium were to provide a venue for fisheries students to make contact with one another, for students to formally and informally discuss their work and to foster knowledge and communication links between fisheries students in different universities and departments. The Symposium was very successful, with many participants voicing interest and stimulation in papers presented and in formal and informal discussion.

Alida Bundy
Fisheries Centre
University of British Columbia

Elizabeth A Babcock
School of Fisheries
University of Washington

Summary of the Symposium

Thirty five students from the Fisheries Centre, UBC, the Department of Fisheries and Wildlife, UM (University of Minnesota), the School of Fisheries (SOF) and the Center for Qualitative Science (CQS), UW, the Department of Agriculture and Resource Economics, OSU (Oregon State University), and the School of Resource and Environmental Management (REM), SFU (Simon Fraser University) attended the meeting. 18 papers were presented. The meeting began on the Saturday morning with 'Modelling in Fisheries Assessment', followed by two shorter sessions in the afternoon, 'Decision Analysis' and 'Policy'. The two sessions on Sunday morning, 'Estimation and Survey Methods' and 'Ecosystem Management' ended the meeting. The quality and interest of all the papers was high, stimulating many questions and discussions which extended into the coffee and lunch breaks. In addition, we ended Saturday with an informal discussion session.

The discussion concerned the interdisciplinary nature of fisheries science. It was first noted that the sessions and papers in the Symposium covered a wide number of disciplines, including biology, modelling, economics, socio-economics, law and social science. However, it was questioned how well these disciplines are integrated into fisheries management, science and teaching and how effective communication between disciplines is. This was followed by a question about how much the individual fisheries scientist should know of other disciplines. Opinion was mixed. Some expressed the view that fisheries biologists should have a reasonable knowledge of the social, economic and political aspects of fisheries to enable them to better understand fisheries problems and issues and place them in an advantaged position to advise managers. Considerable discussion ensued concerning the view that effective fisheries management depends on understanding the behaviour of fishers, but whether fisheries biologists should or could study fisher's behaviour was questioned. Many discussants considered overspecialisation and discipline isolation to be negative. However, others disagreed. They felt that biologists should stay within their own discipline, in order that biological advice to management be independent and objective. They also considered that the social aspects of fisheries should be studied by the appropriate specialists. They did not however negate the role of the other disciplines in fisheries science.

The majority considered the social and economic side of fisheries to be very important. It was generally agreed that fisheries science must be multidisciplinary and that in order for fisheries science, and therefore management of fisheries to be successful, scientists from different disciplines must have a sufficient knowledge of the other "fisheries" disciplines to enable effective communication and understanding. The lack of communication and understanding between disciplines was identified as key problem area in today's science, which seems to consist of a tripartite, but separate, structure of biology, economics and sociology. Although this is an improvement on the old unitary biological approach, effective links need to be further built and maintained.
The implications of the multidisciplinarity of fisheries science for graduate teaching programs was also discussed. Again it was generally agreed that programs need improvement, that they should include discipline options and that the connection

between disciplines should be explicitly considered.

The final event of the Saturday was a evening boat trip aboard the MW Invader, a 1930s steam yacht. It was a beautiful evening with a bit of a breeze and we cruised the Burrard Inlet and False Creek. For those from out of town it was a great chance to see Vancouver in its majestic setting, but even for those from Vancouver the boat trip was a great treat. It provided a further chance for people to get to know each other and relax in an informal atmosphere, while taking in the scenery.

The Symposium was funded by registration fees (CA$20) and a very useful contribution from the Fisheries Centre, UBC.

Next Years Symposium

It was proposed at the conclusion of the meeting that an organising committee, with a member from each of the West Coast universities, should be formed to organise next years symposium and that this committee should have an annual rolling membership. The 1996 committee are:

Elizabeth A Babcock (UW)
Christina Robb (SFU)
Silvia Salas (UBC)
Christopher J. Costello (OSU)

and the 1996 Symposium will be held at the School of Fisheries, University of Washington.

It would be very beneficial for the 1996 organising committee if attendees (and others interested) started to consider the themes they might like to see discussed at 1996 meeting. The Symposium provides a unique opportunity for graduate students involved in fisheries research to criticise (without their advisors distracting them) issues affecting their discipline. Some initial areas ripe for discussion might include:

What does graduate education in fisheries lack in 1996 ?
Are we really preparing for fisheries management for the 21st century ?
What is the best balance between qualitative and quantitative fisheries science ?
What is the best balance between social and ecological research in fisheries ?

For further information and copies of this report, please contact either Beth Babcock or Alida Bundy, or any of the 1996 committee (addresses at the end of this report).

Schedule

Fisheries Centre, Ralf Yorque Room
Saturday 22 - Sunday 23 April

Saturday

8.30 - 9.00 Registration, Coffee and Muffins

9:00-9:10 Introduction

Modelling in Fisheries Assessment

9:10 Babcock, Elizabeth. UW. A dynamic model of fisher effort allocation in a multispecies trawl fishery.
9:35 Bonfil, Ramón. UBC. Monte Carlo testing of fisheries models for sharks.
10:00 Huato, Leonardo. UBC. Optimal migratory paths for returning sockeye salmon.

Break: 10:25-10:50

10:50 Lady, James. UW. Mark-recapture models for estimating stream life of spawning salmon.
11:15 Schlechte, Warren. UW. Investigations into the dynamics of the Pacific razor clam along the Washington coast.
11:40 Scandol, James. UBC Application Strategies for Biophysical Models of Salmon Migration and Production in the Northeast Pacific.

Lunch 12:05-1:15

Decision Analysis

1:15 Larkin, Sherry. OSU. Social welfare impacts of alternative recruitment specifications: implications for Pacific whiting management using bioeconomic analysis.
1:40 Peters, Calvin. SFU. An analysis of stocking and research programs in two British Columbia lakes using a quantitative decision- support model.
2:05 Robb, Christina. SFU. A method for determining when to declare a surplus in the Nass River sockeye salmon fishery.

Break 2:30-2.50

Policy

2:50 Hutton, Trevor. UBC. Fisheries management policy and practice in South Africa: the present and the future.
3:15 McConney, Patrick, UBC. Social networks and tropical small-scale fisheries management and planning.
3:40 Porter, Richard. UBC. Exploring liability in the context of pollution and the fishery

4:05 - 5:00 Open Discussion

6.00 - 10.30 - Boat Trip
Leave here at 5.30pm, to board at 6.00pm. We depart at 6.30, returning to port at 10.30pm. There will be a buffet dinner aboard, but unfortunately we could not run to drinks as well, so you are going to have to buy your own, Sorry!

Sunday

Estimation and Survey Methods

9:30 McAllister, Murdoch K. UW. Evaluating the bias and variance from fish migration in trawl estimates of abundance

10:20. Tsai, Ted Tien-hsiang. UW. Standardization of fishing effort and abundance trends of the major groundfish resources in the southern part of the East China Sea.

10.45 - 11.05 Break

Ecosystem Management

11:05 Bundy, Alida. Fisheries Assessment and Management in a data sparse, multispecies, multigear fishery

11:30 Shima, Michiyo. UW. Marine mammal- fishery interactions in the Gulf of Alaska and comparisons to other ecosystems.

11:55 Thompson, Lisa. UBC. Effects of nutrient additions to Kootenay Lake, B. C., on zooplankton and kokanee salmon (*O. nerka*) biomass and productivity.

Lunch 12:20 pm⇒

One Page Summaries

A dynamic model of effort allocation in the West Coast groundfish trawl fishery

Elizabeth A Babcock,
SOF, UW.

For fisheries management to be effective, it is necessary to understand the behavior of fishermen, particularly how they choose a target species, gear or fishing grounds. This problem can be addressed using dynamic programming models, assuming that fishermen make the decision that will maximize net profit over a trip.

The U. S. West Coast shore-based trawl fishery is a multispecies fishery in which vessels generally target more than one species during a trip. The targeted species groups have been categorized into five "strategies" -- midwater trawling for widow rockfish, deepwater Dover sole trawling, bottom rockfish trawling, nearshore mixed species trawling and shrimp trawling. The fishery is managed with trip limits, which are quotas on the amount of each species that can be landed by an individual vessel, per trip or per week. Vessels can change their fishing strategy in response to changes in trip limits and other regulations, market conditions or fish distribution.

A stochastic dynamic model was developed to simulate a fishing trip for an individual vessel, and predict the strategy choices the vessel would make. The input parameters for the model were calculated using an observer database developed by Pikitch et al. (e.g. Pikitch et. al. 1990, Fisheries Research Institute Publication FRI-UW-9019). The model requires information on the cost of fishing each strategy, probability of some random event such as weather or gear damage in each strategy, the probability distribution of catches in each strategy, and the trip limits on each species. The vessel skipper is assumed to know the costs and probability distributions without error.

During each hour of the modeled trip, the vessel chooses the activity that will maximize the expected increase in net profit between the current time and the end of the trip. A trip is modelled backward in time to calculate the optimal choice for every possible vessel state. The optimal choices are then used to model a trip forward in time, and calculate the probability that the vessel is fishing each strategy at each time.

The model was used to predict the strategy choice of a vessel a vessel with various trip limits. For example, the model was run for a vessel choosing between the Bottom Rockfish and Deepwater Dover strategies, with varying trip limits on yellowtail rockfish (*Sebastes flavidus*), an important component of the Bottom Rockfish strategy. The model predicted that without a yelllowtail trip limit, the vessel would always fish BRF; with a trip limit of zero, the vessel would always fish DWD; with an intermediate trip limit, the vessel would fish BRF until the limit is reached, then switch to DWD. These results are qualitatively consistent with observed fisher behavior. The model will also be used to predict strategy choice with more complex trip limits, and with various gear regulations.

Dynamic programming seems to be effective in predicting fisher strategy choice with respect to trip limits. The approach has the potential to be useful both as a means of studying fisher behavior theoretical and as a management tool.

Monte Carlo testing of fisheries models for sharks.

Ramón Bonfil,
Fisheries Centre, UBC

Surplus production models have been disregarded for assessing elasmobranch fisheries due to perceived model misspecification The more sophisticated age-structured models might not be an alternative solution due to present poor understanding of elasmobranch biology and ecology and the level of precision in the data required by such models. Recent studies on fisheries modelling suggest that many of the problems with catch/abundance models lie in the data rather than model inadequacy.

In the present study, the Schaefer and the Fox dynamic surplus production models and the delay-difference model of Deriso-Schnute are compared through Monte Carlo simulation to test their performance in estimating assessment and management parameters. A full age-structured stochastic simulation model of a shark population is built and a fisheries submodel generates 100 yearly replicates of artificial catch and CPUE data from this population. Six different operating models are considered, including all possible combinations of the Ricker and the Beverton-Holt stock-recruitment models and spatial distribution as characterised by hyperstability, hyperdepletion or proportionality between CPUE and biomass. Each model being tested is fitted to these data using the Total Least Squares fitting procedure, which takes account of observation as well as process errors in order to find parameter estimates.

Preliminary results indicate that assuming multiplicative observation errors in the estimating models improves the performance of all models as opposed to assuming additive observation errors. For simulations under the Beverton-Holt recruitment model and proportionality in the CPUE-biomass relationship, there is a particularly bad performance by the Fox models for optimal effort estimation, and by the Deriso model for both management parameters and for expected discrepancy. The estimates from the Schaefer model, if not particularly good, are at least within acceptable limits as compared to similar studies. When the Ricker recruitment model is considered most models cannot estimate properly or reliably the optimal effort, and the Deriso model keeps failing at estimating optimal catch and has high expected discrepancies.

The further assumption that the system was at equilibrium when the fishery started (B_o=K assumption) did not seem to benefit the estimating procedures. This strategy helped improve optimal effort estimates ins some cases, but at the cost of a deterioration on stock biomass estimates. When the hyperdepletion and hyperstability operating models are considered, all three fishery models show dismal performance in parameter estimation. Hyperdepletion situations seem to be particularly difficult for estimation.

Further research will focus on improving values of parameters that are fixed constant for the Deriso-Schnute model, as errors in this area might account for the bad performance of the model. This however only highlights the probably impossible level of accuracy and precision needed in real situations to make this type of model useful for practical purposes. The robustness of the models will be tested by carrying out more simulations under a different effort regime (with less contrast in the data) and using a less productive population.

Fisheries assessment and management in a data sparse, multispecies, multigear fishery

Alida Bundy,
Fisheries Centre, UBC.

San Miguel Bay in the Philippines has been heavily fished for 2 to 3 decades and exhibits classic over fishing symptoms such as decreasing catch-per-unit-effort, increasing effort and diversity of effort, changes in species composition and reduced profits. The multispecies, multigear fishery catches some 108+ species and is comprised of 18+ small scale gears and 4 trawling sectors and has a history of conflict, typical of many fisheries where large and small-scale sectors co-exist. Fisheries management and monitoring are minimal and consequently, fisheries data are sparse. There are only two well documented periods in time, 1980-1981 and 1992-1993 when comprehensive surveys took place. No time series of catch and effort or other fisheries related data exists thus rendering standard fisheries assessment methods inoperable.

There are 2 main issues to be addressed in SMB: multispecies management and management to mitigate conflict, both in the face of large uncertainty. A simplified adaptive management approach is developed here as a means to address both these necessities in the fishery. This paper describes the first step of this multistage process where hypotheses about the multispecies resource are developed.

Ecopath 2 (Christensen and Pauly 1992), a steady-state ecosystem model was used to investigate the resource dynamics. The model is based on a series of balanced linear equations which are solved by matrix algebra where,

Production by (i) - all predation on (i) - non-predation losses of (i) - export of (i) = 0, for all (i). That is,

$$B_iPB_i - \Sigma_j B_j * QB_j * DC_{ji} - PB_i * B_i(1-EE_i) - EX_i = 0$$

where,
B_i = biomass of (i),
P/B_i = Production/Biomass ratio of (i),
Q/B_i = Consumption/Biomass ratio of (i),
DCji = Proportion of (i) in the diet of (j),
$(1-EE_i)$ = other mortality of (i),
EX_i = Export of (i).
The 3 parameters B, P/B, Q/B where estimated from the trawl survey data and diet was taken mainly from the representative data on the literature.

From the results of the model and an analysis of the fishery data, the following hypotheses were made:

1. Competitive and predatory interactions influence the impact of fishing on the resource. most competition occurs at trophic level 3 and predation at higher levels.

2. San Miguel Bay acts as a nursery area, continually re-stocked from outside. Significant import and export appear to exist

3. Large flow to detritus has a positive impact on the resource.

The ensuing problems and ideas for modelling these hypotheses were briefly discussed.

References

Christensen, V. and D. Pauly (1992) A Guide to the ECOPATH II program (version 2.1). ICLARM Software 6, International Centre for Living Aquatic Resources Management, 72 pp.

Optimal migratory paths for returning sockeye salmon

Leonardo Huato
and
Carl J. Walters,
Fisheries Centre, UBC

Research on salmon migration has focused on the mechanisms salmon may use for navigation and orientation, and the effect of the oceanographic conditions on arrival time and condition of the fish. In this paper we hypothesize that salmon should choose returning trajectories that minimize ocean travel costs in order to maximize reproductive output at their home stream. We then investigate how such trajectories are related to salmon distribution prior to migration, time to arrival and costs of migration.

We develop a spatially explicit optimality model to calculate cost-effective travel trajectories for returning Fraser sockeye salmon, *Oncorhynchus nerka,* over a grid of starting points covering the Northeast Pacific Ocean. Because we were interested in the oceanic part of the returning migration, we made the migration goal the mouth of the Fraser river.

Travel costs, expressed as total metabolism, are calculated from a bioenergetics model. We used sea surface temperature data taken from the COADS data set to calculate optimal swimming speed and metabolic cost at that speed, and surface current estimates from the OSCURS model to calculate ground speed of salmon and swimming time to next gridpoint. Optimal trajectories were then calculated over the entire grid with a dynamic programming algorithm. Total metabolic cost was set as the state variable to minimize, and compass bearing was the decision variable.

Modeled trajectories show that optimal paths are position-dependent, and suggest that salmon should use currents as an aid to migration. Bioenergetics shows that currents are the main factor in the selection of the trajectories since the cost of swimming outweigh the effect of temperature in the metabolism of the fish. Nonetheless, as salmon get closer to home, environmental factors are less likely to affect the trajectory due to the fixed nature of their goal. Trajectory patterns show that complexities in coast line configuration can also affect trajectory choice, as happen when salmon reach the northern tip of Vancouver Island, where only two trajectories are possible.

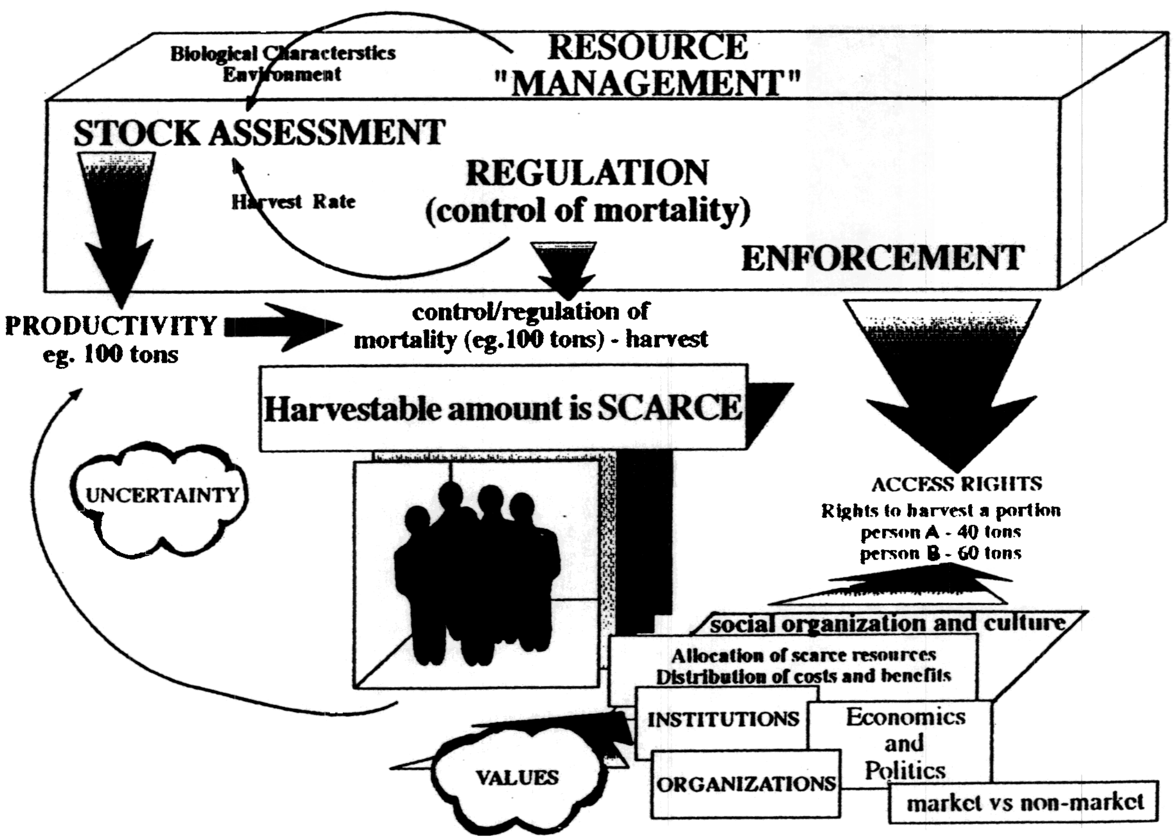
Modeled trajectories also shown that under the oceanographic conditions of the Alaskan Gyre, a 2 kilogram sockeye salmon can cover the area from 155□ W up to the river (122□ W) in less than three months, requiring 300-500 grams of body mass (depending on the starting point) in energy units to cover such distance. This sets an outer boundary to where salmon can be at the onset of the migration in order to arrive to the Fraser river in the required time.

Fisheries Management Policy and Practice in South Africa: the Present and the Future.

Trevor Hutton,
Fisheries Centre, UBC.

South Africa has an array of highly integrated fisheries including commercial, recreational and subsistence fisheries. Commercial catches are dominated by hake and anchovy. There are also fisheries for rock lobster, abalone and various linefish. In the last few decades the central government has played an ever-increasing role in management, administering its regulatory policy through the Sea Fishery Act. Most of the fisheries have developed in a way that is typical world-wide, from open access to restricted open access fisheries to restricted and regulated access. The main tools used by the state to restrict and regulate access include technical conservation measures (mesh restrictions) and effort or catch control which are expressed in the regulations as limited licences and permits.

The move towards regulated access in the major commercial fisheries occurred before the current political changes in the country. Presently, one of the most contentious issues being considered is access rights; past practices have been questioned and re-distribution has been called for. A review of the fisheries, the current management structure, the policy and various laws, and the key issues that are being debated were presented. The issue is complicated because of the very nature of fishing: resource management and the allocation of scarce resources are linked in a very complex way. A conceptual model of the components and the linkages was presented (see figure below). The aim was to consider the factors which play a role in management. Controlling the harvest of the productivity is inextricably linked to the principle objectives of management, that is, an efficient allocation of the resource and equitable distribution of the result. Understanding these linkages is crucial to determining the possible consequences of major changes in the current policy. The form of the access rights and how they are defined is of critical importance in determining whether the objectives mentioned above will be met.



Mark-Recapture models for estimating stream life of spawning salmon

James Lady,
CQS, UW.

One widely used method for measuring escapement for populations of Pacific Salmon is the area-under-the-curve (AUC) method, by which the estimate of total escapement is calculated by dividing an estimate of total fish-days by an estimate of the average stream residence time, or stream life. In order to estimate escapement accurately using the AUC method, an accurate estimate of stream life must first be obtained. The goal of my research is to develop mark-recapture models to estimate stream life. I am using computer simulation studies to study the statistical properties of stream life estimates based on these mark-recapture models.

A mark-recapture model that uses counts of live individuals can be used to estimate the conditional survival probabilities from one sampling occasion to the next. An estimate of stream life can then be obtained from these conditional survival probabilities. I propose to develop more precise estimates of stream life in two ways: By using the Weibull distribution to model the stream survival process, and by incorporating counts of dead individuals as well as live individuals into the mark-recapture model.

One motivation for incorporating the Weibull distribution is that it decreases the number of parameters that must be estimated in order to estimate stream life. In a mark-recapture model that does not incorporate the Weibull distribution, the conditional survival probabilities from one sampling occasion to the next are separate parameters that must be estimated. However, if the stream survival process is assumed to follow the Weibull distribution, only the two parameters of the distribution need to be estimated in order to describe the entire stream survival process, and subsequently to estimate the stream life. The need to estimate fewer parameters should increase the precision of the estimate of stream life.

One possible disadvantage of incorporating the Weibull distribution is that the actual distribution may not follow the Weibull distribution. Therefore, the robustness of Weibull-based estimates to deviations from the Weibull must be explored.

Preliminary simulations have been performed to compare two separate estimates of stream life: A nonparametric estimate based on the estimates of the conditional survival probabilities, and an estimate obtained by incorporating the Weibull distribution. Both estimates are based on models which incorporate the detection of live individuals. The results show that the nonparametric estimate consistently has a lower sample variance than the Weibull estimate, and the Weibull model did not perform well with "little information" (low probabilities of detection, small initial release size, and small number of sampling occasions). However, the mean squared error (MSE) for the Weibull estimate is often less than the MSE for the nonparametric estimate, suggesting that the Weibull estimate is less biased. Also, the Weibull estimate seems fairly robust to deviations from the Weibull distribution, provided there are high probabilities of detection, a large enough release size, and a sufficiently large number of sampling occasions.

Future research will involve the incorporation of counts of dead individuals as well as counts of live individuals into the mark-recapture model. This provides more information on the survival process that should increase the precision of the estimate of stream life, but it also increases the number of parameters that must be estimated (e.g., probability of carcass detection, probability of the retention of a carcass from one sampling occasion to the next). I am interested in looking at the trade-off between these two factors, and determining whether incorporating counts of dead individuals can be used to increase the precision of the estimate of stream life.