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SCIENTIFIC AND STATISTICAL COMMITTEE (SSC) REVIEW OF WASHINGTON COASTAL AND PUGET SOUND COHO SALMON ESCAPEMENT ESTIMATION METHODOLOGIES: SUMMARY AND RECOMMENDATIONS

Introduction

The SSC Salmon Subcommittee met in Olympia, Washington on September 14-15 to review Washington coastal and Puget Sound coho escapement estimation methodologies. Committee members present were Peter Dygert, John Geibel, Han-Lin Lai, and Peter Lawson. Absent were David Hankin and Dexter Pitman. The Salmon Technical Team was represented by Pat Pattillo. Jim Seger attended for the Council. Agencies and tribes represented included Washington Department of Fisheries (WDF), Northwest Indian Fisheries Commission (NWIFC), Quinault, Quilleute, and Hoh.

This meeting was part of a process, initiated by the Council, to review coho stock size predictors used in Washington State waters. At the start of the process, in March 1988, The SSC determined that an understanding of escapement estimation methodologies was necessary background to a review of the predictive methods. At the request of the SSC, WDF and tribes prepared a set of reports describing their methods for estimating coho escapements and giving examples of specific applications. Copies of these reports are available from Morris Barker, WDF, or the PFMC.

This report summarizes the SSC's findings and recommendations for improvements to the spawning escapement methodologies.

GENERAL CONSIDERATIONS

Estimating salmon spawning escapements is a difficult management and research problem. An extensive literature has developed as biologists attempt to improve escapement estimates in a wide variety of situations (see Symons and Waldichuck 1984, and Cousens, et al. 1982). Accurate estimation of spawning escapements is expensive and time consuming, and may not even be feasible in many places. Nonetheless, current management approaches demand quantitative and timely estimates of escapements for two principal purposes: (a) post-season assessment of management success (achievement of escapement "goals"), and (b) pre-season prediction of future run sizes.

The State of Washington, in cooperation with many Indian tribes, expends considerable time and money attempting to estimate salmon spawning escapements in streams of the Washington Coast and Puget Sound. They have encountered a wide range of problems inherent in this kind of work. The problems identified in this report are not unique to this region, and the agencies involved cannot be expected to find satisfactory solutions to all of these problems. Some problems can be solved relatively easily, whereas other problems will take a considerable commitment of resources. In a

few cases, improved survey designs may result in a reduction of survey effort when compared to present levels. In this paper we report to the Council and to the various agencies involved in estimating coho salmon escapements in Washington State the specific problems that we see as most important to regional management.

Methods used to estimate coho escapements in Washington State are based on either live counts or redd counts. The development of escapement estimation methodologies is a system-specific, evolutionary process. The result depends on factors such as basin geomorphology and hydrology, stream morphology, coho life history variations, species composition, and judgments of field biologists. Due to regional differences in stream types, live counts are generally used in Puget Sound while redd counts are favored in streams along the Washington Coast and the Strait of Juan de Fuca.

PUGET SOUND

In general, escapements in Puget Sound drainages are estimated from live counts conducted weekly in index sections. Two major assumptions of the spawning ground survey method are:

1) Index sections are representative of the entire basin.

2) Spatial distribution of spawners is the same at all spawning densities and flow regimes.

Snohomish River

The Committee was presented with a specific example of the Snohomish River survey method. Therefore discussion was focused on this system, which had 41 per cent of Puget Sound spawners in 1977. The proportion of the Snohomish basin that is surveyed is quite small. Indexes account for less than three per cent of the linear distance of suitable spawning habitat (exact figure not available). The number of surveys conducted was increased from 23 index surveys (11.2 miles) to 53 (27.9 miles) in 1984 and 56 (28.5 miles) in 1988. The surveys were added to increase coverage of the basin, but have not been incorporated into the index. The SSC was asked for recommendations on how best to use these additional surveys. We recommend that the effort directed toward conducting these extra surveys be used to test major assumptions of the survey method and to expand specific knowledge of spawning habitat in the Snohomish River.

Selection of Index Areas

The representativeness of index sections cannot be determined in the Snohomish basin because the entire basin has not been surveyed and characterized with respect to available habitat.

One survey selection criterion was "road access and proximity to other index areas." This suggests that the surveys may be clumped in space and may not represent the range of spawning habitats in the system. Another selection criterion, "adequate numbers of fish," suggests that index areas are positively biased with respect to the (unknown) true mean numbers of spawners per unit stream length or area. Spawner distributions certainly change from year to year, but the degree of variability is unknown. This is a problem, to some extent, in all spawning escapement indexes based on spawning ground surveys. The SSC is concerned that WDF work to address these problems in an attempt to improve their estimates.

Base Years

In Puget Sound, counts of fish in index sections are keyed to "base years" in which spawning ground surveys were conducted at the same time that actual escapements were estimated. Each year, live counts are used to create an "area under the curve" (AUC) index. Actual spawning escapement is assumed to vary in linear proportion with the AUC index. To arrive at the estimated spawning escapement for a given year, the base year escapement estimates are adjusted in proportion to the change in AUC.

The base year method is the weakest feature of Puget Sound spawning escapement estimates, both conceptually and in execution. The relationship between base year escapements and AUC estimates is unknown and untested. As currently used, a linear relationship passing through the origin is assumed. In practice, additional error is introduced because the base year escapements are, for many basins, gross estimates. For most basins documentation of the methods used to arrive at these estimates is lacking. In other systems, notably the Skagit and the Snohomish, tagging studies were conducted in 1977 to estimate spawning escapements. We understand that these studies are documented, but have not been provided with the reports. We also understand that mark/recapture studies are ongoing in the Skagit River.

The SSC feels strongly that the base year method for expanding AUC estimates to total spawning escapement is seriously inadequate as implemented. If this method is to continue to be used, efforts must be made to measure spawning escapements in major drainages for at least three years. In the process the relationship between AUC and spawning escapements could be investigated. Alternatively, management regimes could be adjusted to use the AUC indexes, rather than the escapement estimates, in setting seasons and quotas.

WASHINGTON COAST

Coastal escapement estimates are based primarily on redd counts. Redds are identified and marked weekly in coastal streams. Near the peak of spawning, extensive supplemental surveys are conducted to count visible redds. Supplemental surveys are conducted once in a season. These supplemental redd counts are expanded by the ratio of cumulative redds for the season to visible redds (over all index areas in a stratum) at the time of the supplemental survey. This gives an estimate of total redds for the supplemental survey. Indexes and supplemental survey sections are stratified by habitat type or spawning density. Exact methods vary between agencies and river systems.

The redd count method assumes that each redd represents the total reproductive effort of a single female. This assumption may be valid for coho at low to medium spawning densities. At high densities, redd counts are likely to underestimate total spawners due to redd superimposition.

Male spawners are estimated assuming a sex ratio; for coho, this sex ratio has been assumed to be 50:50. At the SSC's request WDF provided data on observed sex ratios at four locations. In Bingham Creek, on the coast, the mean sex ratio was, in fact, about 50:50 (range 40:60 - 55:45).

Bingham Creek

Bingham Creek was one of the study sites in a comparative study of escapement estimation techniques for coastal streams (Chitwood and Parrack 1987, Chitwood 1988). The study was a cooperative effort of WDF and Quinault Fisheries Division (QFiD) with funding from the Pacific Salmon Commission. In this study, upstream migrants were trapped and counted. These absolute counts were then compared with estimates using mark/recapture, live count, and redd count techniques. Survey coverage in the basin was greater than 90 per cent, so investigators were more familiar with spawning activity, and probably obtained a better enumeration with all techniques, than is usually the case. Live counts underestimated trap counts by 38 and 27 percent in 1986 and 1987, years of moderate escapements. Redd counts underestimated trap counts by 10 and 20 percent in the same two years. In 1988 escapements were high due to large hatchery returns. No trap count is available for 1988, but the total coho spawner estimate from redd counts was only 31 per cent of the live count estimate. This suggests that superimposition caused an underestimate of female spawners in 1988. Such high escapements are rarely observed, so this problem is not apt to occur often. Mark/recapture estimates of escapement were 103 percent and 105 percent of trap counts in 1986 and 1987 but were not available for 1988.

Survey Coverage

Survey coverage of coastal streams is generally quite high. In Grays Harbor, the largest and least intensively surveyed major drainage, surveys are coordinated between WDF and QFiD. According to figures reported to the SSC, index surveys cover about 188 miles or 10 per cent of 1834 total miles of habitat. Index plus supplemental surveys cover 538 miles or 29 per cent of the spawning habitat. This stands in marked contrast to the three per cent coverage of the Snohomish basin in Puget Sound.

Estimation Methods

A variety of estimation methods is used, sometimes within the same drainage. For example, both WDF and QFiD survey parts of the Queets River. The two escapement estimate are combined, and differences reconciled for a total Queets estimate. WDF stratifies by stream type, with the idea that redd longevity is related to geomorphology (i.e., the ratio of cumulative / visible redds is affected by redd longevity). QFiD stratifies by observed spawning density. The WDF method is more suitable for expansion to unsurveyed stream sections. The QFiD method probably gives better estimates of total redds in the surveyed sections, but makes extrapolation to unsurveyed sections dependent on the subjective judgement of the surveyors and biologists.

Stream Catalog

On the Washington Coast, survey data are expanded to obtain total escapement estimates using data from the "stream catalog." This is a gazetteer of streams in Washington with estimates of linear miles in each system. Estimates of stream miles were originally derived from maps, resulting in incomplete cataloging of the low order headwater tributaries where coho usually spawn. The committee was told that linear miles were underestimated by 5-15 per cent and spawning and rearing areas by 50-100 per cent. Total escapements estimated from survey counts expanded using mileages from the stream catalog are therefore apt to be low. Biologists from the coast were concerned with this problem. They continually revise the stream catalog as their specific knowledge of each basin increases.

COMMITTEE OBSERVATIONS, COMMENTS, AND RECOMMENDATIONS

The SSC recognizes that resources available for escapement surveys are limited. We feel that the following suggestions will help improve the quality of the escapement estimations within the framework of the existing programs. We recommend that the

escapement estimation programs be evaluated with respect to the following comments.

In no case do the escapement "estimation" methodologies permit estimation of sampling variance. For example, in Puget Sound the use of fixed index areas requires that one invoke untestable assumptions regarding the constancy of spawner distributions and the relationship between AUC and total escapement. In the absence of estimates of sampling variance it is impossible to assess the likely accuracy of escapement estimates. Future collection of data should be based on statistically valid randomized sampling designs from which valid estimates of uncertainty could be calculated. These designs could be implemented as supplemental studies designed to complement existing work and verify critical assumptions. Knowledge gained would then be applied to current sampling programs to make them more robust. The increased survey effort in the Snohomish River could be redirected into this type of study.

Most base year escapement estimates in Puget Sound are undocumented and of unknown value. Effort should be directed to obtaining base year data in those systems without good estimates. Priority should be given to systems with large escapements (eg. Stillaguamish), and systems of importance to the ocean fisheries.

The relationship between AUC escapement estimates and total escapements needs to be defined. This is most important for the Skagit and Snohomish basins and the Hood Canal. The SSC understands that such a study is underway in the Skagit River. The results of this study may address many of the concerns expressed in this report.

On the coast, survey coverage is high with 25-60 percent or more of each basin being surveyed. While these intensive coverages would appear to give good escapement estimates, we are aware of only one case where the results of these surveys have been validated. Mark/recapture estimates, weir counts, or other independent estimation techniques should be used to verify the redd count estimates.

Use of the stream catalog for expansion on the coast produces underestimates. Through the efforts of biologists on the coast, this problem is gradually being remedied as the catalog is updated based on new surveys.

Mark/recapture escapement estimates allow calculation of sampling variance while live counts and redd counts do not. Mark/recapture studies are generally more expensive than the survey methods, and therefore may not be a cost-effective management tool for annual escapement estimation. However, this technique is valuable for validation of the results from standard surveys. If mark/recapture studies or other independent

estimation techniques were used in addition to the standard surveys on a few systems each year, confidence in the escapement estimation results would increase rapidly.

The weakest part of the escapement estimation procedure on both the Washington Coast and Puget Sound is the expansion from survey estimates to absolute escapements. Many of the comments in this report pertain to the problems with this extrapolation. Current management regimes demand that these estimates be made, then set regulations which depend on the accuracy of very approximate numbers. Managers are encouraged to rely more on the escapement indexes (i.e., AUC estimates, redd counts) and to deemphasize the importance of absolute escapement estimates.

The SSC thanks the State and Tribal biologists who have participated in this review. Their efforts continue to contribute to our knowledge of coho spawning biology. We hope our comments are taken as constructive criticisms to be used as a guide for setting priorities in designing new projects and reexamining old ones.

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