OREGON COASTAL NATURAL COHO REVIEW TEAM REPORT

AN ASSESSMENT OF THE STATUS OF THE OREGON COASTAL NATURAL COHO STOCK AS REQUIRED UNDER THE DEFINITION OF OVERFISHING

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This report was prepared at the request of the Pacific Fishery Management Council (Council) by a team of scientists with special knowledge and experience in salmon fishery and habitat management relationships as they relate to coho salmon. The Council expresses its deep appreciation to members of the Oregon Coastal Natural (OCN) Coho Review Team to provide this assessment of the status and management needs of the OCN coho stock. In addition, the Council wishes to thank the team members' agencies and institutions for their willing support of this effort.

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I. CHARGE AND PURPOSE

The Magnuson Fishery Conservation and Management Act states: "Conservation and management measures shall prevent overfishing while achieving, on a continuous basis, the optimum yield from each fishery for the United States fishing industry." The implementation of Amendment 10 to the Pacific Fishery Management Council's (Council) salmon fishery management plan (FMP) in 1991 provided a definition of overfishing for each stock or stock complex covered by the FMP.

The Council's definition of overfishing states:

> Overfishing is an occurrence whereby all mortality, regardless of the source, results in a failure of a salmon stock to meet its annual spawning escapement goal or management objective, as specified in Section 3.5 of the salmon FMP for three consecutive years, and for which changes in the fishery management regime offer the primary opportunity to improve stock status. While this condition is defined as overfishing in the broad sense, it is recognized that this situation may also be the result of nonfishing mortality and fishery management actions may not adequately address the situation.

Under this definition, the determination of overfishing a stock is a two step process. The process is triggered when a salmon stock fails to meet its annual spawning escapement objective for three consecutive years. The second step is a review by a Council–appointed work group to investigate the causes of the shortfall and report its conclusions and recommendations for assuring future productivity of the stock to the Council.

The Oregon coastal natural (OCN) coho stock, comprised of those naturally spawning coho stocks originating in Oregon coastal basins (streams and lakes) south of the Columbia River, has not met its annual FMP spawning escapement objective since 1986. Therefore, at its April 1991 meeting, the Council directed the formation of a work group to review the status of this stock and report its conclusions and recommendations prior to the development of the 1992 ocean salmon fishery management options. This report, developed by the OCN Coho Review Team, fulfills that Council directive.

The OCN Coho Review Team was chaired by William Pearcy, Professor of Oceanography at Oregon State University. The full group met on June 3, August 13 and November 7 of 1991. Work subgroups met on several additional occasions to draft materials for review. Section leaders who provided the initial drafting of the report sections were:

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A complete list of the members of the review team can be found in the "Acknowledgements" on the inside cover of this report.

II. ASSESSMENT OF THE PROBLEM

OVERVIEW

The technical condition that initiates stock review under the overfishing amendment to the salmon FMP is three consecutive years of spawning escapements which are below the annual goal. OCN coho have failed to meet the Council's spawning escapement goal for four consecutive years.

There are several reasons for the declining trend in OCN coho escapements and a definite determination of a primary cause is not possible, given current inadequacies in our knowledge of the OCN coho stock and its critical habitat. Except for an index used to estimate spawning escapement, all other assessments for OCN coho are based on assumptions derived from hatchery components of Oregon production index (OPI) area coho stocks. The accuracy of the spawning estimate derived by expanding the spawning index is in question and is currently being analyzed. How well the OCN stock meets the assumptions derived using other coho stocks has never been determined. Figure 1 lists and diagrams the relationship of the preseason predictions, postseason assessments and actual stock parameters.

The major factors identified by the review team as contributing to the decline in the OCN coho spawning escapements, include the following.

Fishery Management Regime

- Overestimation by the stock abundance predictor.
- Inaccurate expansion of the spawning population.
- Inadequate seeding of the freshwater habitat and disproportionate escapement of spawners among the coastal streams.
- Level of time/area stratification used to assess stock specific fishery mortality in the coho assessment modeling is not supported by the available information on OCN stock distribution.

Stock Productivity

- Widespread and significant degradation of freshwater habitat due to abusive land practices.
- A 15-year trend of poor oceanic conditions.

Since 1988, OCN coho stock abundance has been predicted using a Ricker stock/recruit relationship modified to account for interannual variation in survival, and fitted with data from 1970 to the most recent year available. During this time, the model has predicted stock sizes 35 to 50 percent larger than those estimated by postseason analysis which, despite its dependence on some unconfirmed assumptions as noted above, is the method by which fishery management performance is currently assessed. The preseason abundance prediction directly affects both fishery quotas and the spawning escapement goal each year. When the prediction is high, harvest quotas and the spawning escapement

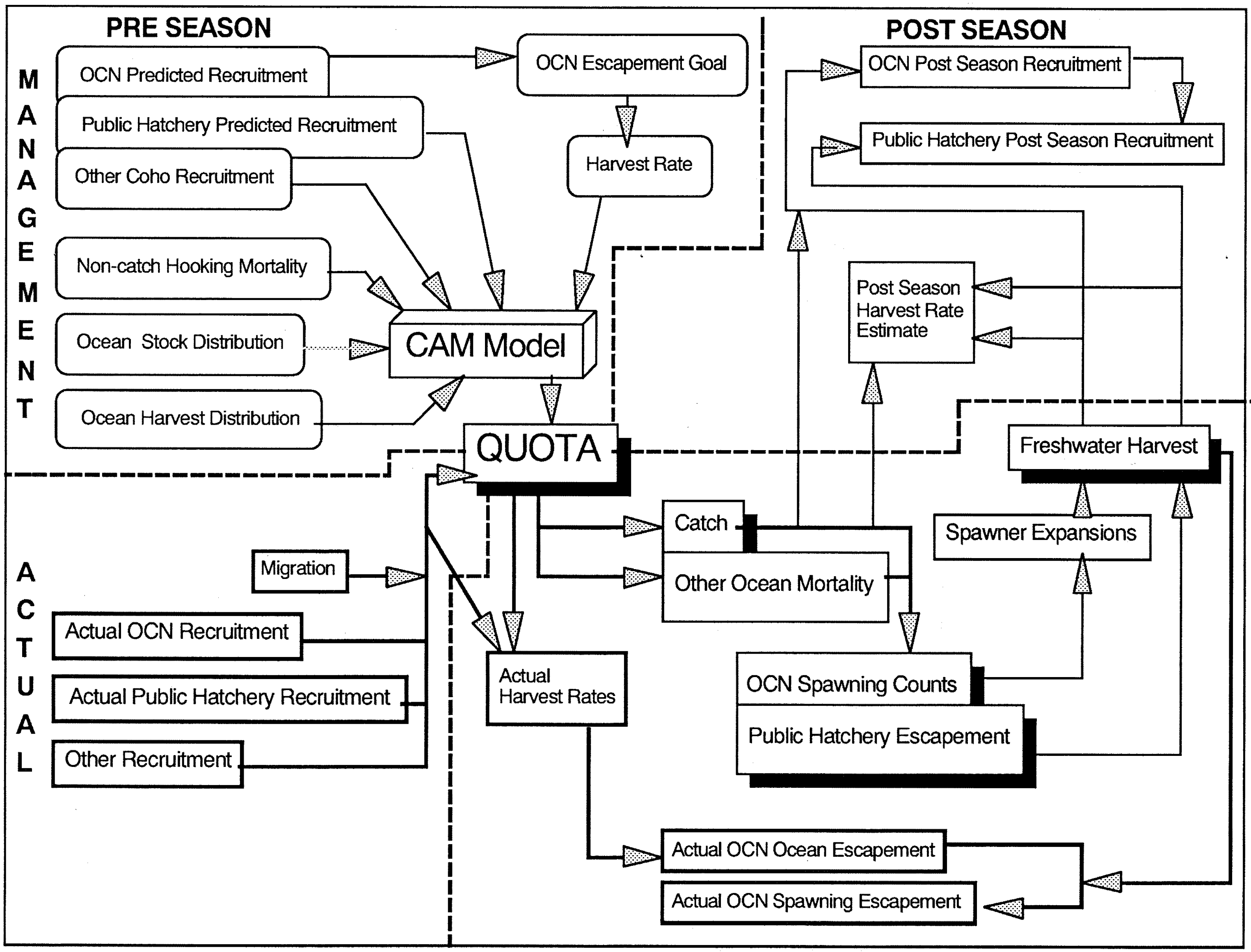

Figure 1. Flowchart of preseason and postseason management processes compared with actual stock sizes and fisheries. Management effect on stocks is through the harvest quota.

goal are set too high. As a result, target harvest rates are exceeded and spawning escapements are lower than projected. As long as the prediction is higher than the actual stock size, the spawning escapement will be lower than the goal.

Bias in the preseason abundance predictor is a strong candidate for the primary factor which resulted in review under the overfishing definition. However, it is clear that OCN coho are showing a disturbing downward trend in spawning escapements and that the other factors listed above are also having a significant but unquantifiable influence on that trend. Based on long–term monitoring in standard survey areas, the annual spawning escapement estimated to achieve maximum sustainable yield (MSY) for OCN coho has not occurred since 1971 (see Figure 2 in Section V).

CONCLUSION

Suboptimal habitat, both freshwater and marine, has reduced the OCN coho stock productivity and lowered MSY harvest rates. Many streams are "underseeded" and have low densities of juveniles (based on fish densities in summer habitat). Inventory data indicate that winter habitat may be especially degraded and could result in low smolt production even if sufficient spawners were available to fully seed the habitat. Fishing mortality may have been higher than intended by management agencies because of inadequate or inaccurate stock assessments and predictions in combination with quota harvests. Together, these factors have combined to reduce OCN coho spawning escapements to seriously low levels.

We therefore conclude that OCN coho stocks are depressed. However, inadequate stock assessment information prevents the review team from conclusively identifying overfishing as the primary cause of recent low spawning escapement levels. In the short–term, changes to the fishery management regime, especially development of an unbiased OCN coho stock abundance predictor, coupled with appropriate harvest rates, appear to offer an initial opportunity to provide adequate natural seeding. The amount of improvement from any increased seeding may be limited by adverse habitat factors unless a compreshensive integrated program is initiated to address these issues.

III. RECOMMENDATIONS

Based on the assessment of problems facing OCN coho, including the identified inadequacies in the estimates of true stock parameters, the Council should take a conservative approach for 1992 in developing an OCN coho harvest regime. Ocean and inland harvest rates should be set to assure more uniform escapement of all stocks. This should immediately help reduce underseeding of the habitat. To assure future productivity of the OCN coho stock and to minimize negative impacts on ocean fisheries from inappropriate management actions, an aggressive program to clarify stock status and to better isolate critical limiting factors for the stock should be undertaken immediately.

The OCN Coho Review Team recommends the actions listed below to address the failure of the OCN coho stock to achieve its FMP spawning escapement goal. While the actions are divided into short-term, long-term, and "other" actions, all should commence as soon as possible. "Long-term" simply means that it will take several years before results from the action can be realized or utilized for management. Additional details and documentation of the need for these recommended actions follow in Sections IV, V and VI and the report appendices.

SHORT-TERM ACTIONS

1. Develop an unbiased OCN stock recruitment predictor. This would assist in achieving annual OCN spawner escapement goals.

2. Accelerate current studies to improve OCN spawner escapement estimates. The results from these studies should:

    a. Improve the estimate of total ocean population abundance, thereby removing one source of bias which can result in higher than intended harvest rates.

    b. Provide information needed to re-evaluate the spawner escapement goal.

    c. Generally improve our knowledge of the distribution of OCN coho spawners and the availability of spawning habitat.

3. Investigate and evaluate the feasibility of alternative approaches to quota management. The development of seasonal harvest rates, which promote coastwide simultaneous fisheries on coho and chinook salmon, may reduce the likelihood of high harvest rates on OCN stocks. Other benefits include better fishery stability, simpler regulations and a reduction in management cost.

4. Reduce non-retention fisheries which result in the discarding of coho. Conduct at-sea sampling to estimate coho encounter rates during these non-retention fisheries. This would improve estimates of ocean harvest mortalities. Additional at-sea studies on gear selectivity may lead to reduced coho mortalities in chinook directed fisheries.

5. Develop a fishery mortality predictive model with time/area stratification that is supported by the available OCN information. This would improve the ability of managers to predict OCN harvest mortality during the preseason process of developing allowable fisheries.

6. Conduct systematic random sampling in Oregon coastal basins during 1992 to evaluate the extent of juvenile underseeding of OCN habitat.

7. Reinstate a program to systematically collect scales from landings of coho salmon and improve scale classification methodology to help determine the proportion of OCN coho in the ocean fisheries. Ten years of scale samples from an earlier program should be reanalyzed.

LONG-TERM ACTIONS

1. Protect freshwater habitat from further degradation. State and federal land-use management and fisheries agencies should develop a comprehensive approach to habitat protection on a watershed basis such as that developed by Johnson et al. (1991).

2. Evaluate the feasibility of an OCN indicator stock program beginning in 1992. Such a program could provide reliable estimates of fishery harvest rates, and freshwater and marine survival rates and OCN harvest distribution. This program would assist in developing unbiased OCN recruitment data and thus an improved OCN stock recruitment predictor. Improved catch distribution information would assist in the preseason prediction of OCN harvest mortality when developing allowable fisheries.

3. Inventory coho populations and freshwater habitat in coastal streams in order to assess the current status of coho salmon habitat and to identify limiting factors. According to the American Fisheries Society (Nehlsen et al. 1991), 25 of 36 coho stocks from key watersheds of the Oregon coast are identified as "at risk or declining." Action is needed to:

   a. Develop a coordinated long-term program to monitor the status of juvenile coho populations, stream habitat and the effectiveness of habitat protection and restoration programs in selected streams in all major coastal basins.

   b. Expand stream habitat inventories (summer and winter) in coastal basins to assess the current status of coho salmon habitat and identify limiting habitat using the methods of Reeves et al. (1989) and Nickelson (unpublished).

OTHER ACTIONS

1. Restore habitat by addressing limiting factors. Habitat work that does not address limiting factors has been shown to be ineffective. In addition, to aid the long-term healing of the stream ecosystem, conifers should be planted in the riparian zone.

2. Evaluate the use of hatchery fish (genetically similar only; *see* Oregon Department of Fish and Wildlife, [ODFW] Wild Fish Policy) to "jump-start" populations in underseeded habitat of good quality by developing a demonstration project.

3. Develop a management strategy that is sensitive to interannual variations in stock productivity as indexed by ocean conditions. This would allow higher harvest rates during periods of high productivity, but restricted harvest rates during poor ocean conditions.

IV. OCN COHO SALMON OCEAN FISHERY MANAGEMENT METHODOLOGIES

INTRODUCTION

This section provides a critique of methodologies used to manage the ocean harvest of OCN coho. One methodology, or set of procedures, is used for preseason prediction and season setting. Another methodology is used for postseason assessment. Many of the procedures used pre and postseason are taken from sources developed for purposes other than management of ocean fisheries.

Preseason, managers estimate coho recruitment and construct ocean harvest regulations which target achievement of OCN coho spawning escapement goals. The annual escapement goal ranges from 135,000 to 200,000 adults, with the latter as the overall long–term goal (Beidler et al. 1980, Council 1986). The OCN spawner escapement goal was first defined in Oregon's Coho Management Plan (ODFW 1982).

Postseason, managers estimate OCN spawning escapement. This estimate together with estimates of total ocean and freshwater mortality, and public hatchery ocean escapements, are used to produce all other postseason stock assessments for Oregon production index (OPI) area coho. (The OPI area extends from Leadbetter Point, Washington to the U.S./Mexico border.) Postseason OCN stock assessment is used annually to measure attainment of the spawner escapement goal, and as a check for accuracy of the preseason abundance prediction. Postseason assessments then become part of the recruitment data base used in all subsequent preseason predictions. This process allows continual refinement of preseason prediction. However, any errors or biases in the postseason analysis are carried forward into future stock assessments.

Three components of coho stocks are measured directly in the OPI area where fisheries are managed specifically to achieve OCN coho spawning escapement goals (Council 1984). These three components (in number of fish) are:

- Ocean harvest mortality excluding the catch of private hatchery stocks (C)
- Public hatchery escapement (H)
- OCN ocean escapement (S)

Annual estimates of OCN recruitment, public hatchery recruitment and OPI area ocean harvest rates are generated from these three measurements as follows:

$$\textit{OCN Recruitment} = \left[C \times \frac{S}{S+H}\right] + S \qquad \text{(Equation 1)}$$

$$\textit{OPI Area Ocean Harvest Rate} = \frac{C}{S+H+C} \qquad \text{(Equation 2)}$$

$$\textit{Public Hatchery Recruitment} = H+C - \left[C \times \frac{S}{S+H}\right] \qquad \text{(Equation 3)}$$

Errors or bias in the estimation of C, H and S will affect the accuracy of all OPI area stock assessments and predictions. The assumptions in making these estimates are:

- The OPI area is a closed system – no net migration
- Unaccounted mortality is constant
- Equal harvest rates on all OPI area stocks

Appendix A contains a detailed description of the methodologies used in managing ocean fisheries harvesting OCN coho. Appendix B contains a detailed description of recommendations for improving management. Appendix C outlines the postseason procedure used in assessing hook–and–release mortality in the commercial troll fishery.

PROBLEMS WITH METHODOLOGIES

OCN Recruitment Estimates

OCN coho recruitment consists of OCN ocean and freshwater harvest mortality and OCN spawning escapement (Equation 1). The annual postseason estimate of OCN recruitment is calculated using the OCN ocean escapement and the estimated OPI area ocean harvest rate (Equation 2). A bias in either of the methodologies used to measure OCN ocean escapement or estimate OPI area harvest rate would result in a biased OCN recruitment estimate and thus OCN recruitment predictor because the predictor utilizes the range of recruitment observed in past years. Because the annual OCN spawning escapement goal is determined from the OCN recruitment prediction (Council 1986), an overestimated OCN recruitment prediction could result in the adoption of harvest quotas that are excessive for achievement of the adopted OCN spawning escapement goal.

Harvest Mortality

The vast majority of the ocean harvest of OCN coho is assumed to occur within the OPI area. OPI area coho ocean harvest mortality occurs as landed catch and mortality on hooked fish that escape (drop–offs) or are released. Only landed catch is measured directly and is based on sampling rates which usually exceed 20 percent (Schindler et al. 1991). Mortality on drop–offs, released sublegal fish or from other sources (e.g., natural mortality, net fisheries, etc.) are not estimated and thus are not addressed.

Legal–sized coho are often released in commercial troll fisheries directed toward chinook salmon. Estimates of mortality from these fisheries are approximated using historical catch rates, observed effort and regulations. Annual at–sea sampling programs to estimate hook–and–release mortality are not conducted. Non–retention mortalities have been estimated to comprise up to five percent of the annual OPI area stock recruitment.

Freshwater harvest mortality of adult OCN coho occurs as landed catch in recreational fisheries and as mortality on drop–offs and released fish. Only landed catch is measured. The OCN freshwater harvest derived from recreational punch card returns, is estimated to represent three percent of the total OCN ocean escapement over the last five years. However, if OCN spawning escapement is overestimated, then this percentage would be higher. Mortality from dropping off the hook and other sources (e.g., natural mortality, poaching, releasing fish) is not estimated and thus is not addressed.

OPI Area Ocean Harvest Rate

Another way of stating Equation 1 is that the OPI area ocean harvest rate is used to derive OCN recruitment from the OCN ocean escapement. This assumes the OPI area ocean harvest rate represents the ocean harvest rate on OCN coho. This assumption has not been verified because direct estimates of the ocean harvest rate on OCN coho are not available. Coho assessment modeling suggests that differences exist between the actual ocean harvest rate of the OCN stock aggregate and the OPI area stock composite since the early 1980s when fisheries north of Cape Falcon were reduced relative to fisheries south of Cape Falcon. It is also likely that the ocean harvest rate varies among individual OCN stocks. The magnitude of these harvest rate differences are affected by annual OPI area ocean fishery structures and regulations.

Implicit in the derivation of the OPI area ocean harvest rate is the existence of a closed system (e.g., net immigration or emigration into the OPI area does not occur). Preliminary information suggests a balance did not occur in 1991 as favorable ocean conditions in the OPI area attracted non–OPI area produced fish. Inconsistent structuring of regional fisheries and changes in the composition of smolts released from OPI area hatcheries may have also contributed to the variation of immigration and emigration of coho within the OPI area.

OCN Spawning Escapement

Annual estimates of the OCN coho spawning escapement, derived through spawning ground surveys, are the only direct measure of the abundance of this stock aggregate. Spawning ground surveys were not specifically developed for estimating total OCN spawner escapement, but rather as a relative escapement index. Starting in the 1980s, survey data were expanded to total spawners because of management needs, in spite of the recognition that the surveys were not appropriate for this use. The methods used to index spawning escapements have changed over the past 41 years. Current methods are detailed in Cooney and Jacobs (1990).

Separate escapement estimates are made for OCN populations spawning in coastal river and lake basins. The accuracy of estimates of OCN spawning escapement in coastal river basins depends upon three assumptions:

1. Estimates of spawning density in survey stream segments are unbiased.
2. Estimates of the total amount of coho salmon spawning habitat are correct.
3. Survey areas are a representative sample of the actual spawning habitat.

To date, none of these assumptions have been validated. With the availability of new data, historic estimates of the quantity of spawning habitat appear high. The spawning density observed in survey areas probably overestimates mean overall spawning density. Thus, positive biases associated with assumptions 2 and 3 probably have resulted in OCN spawning escapement estimates that have been higher than actual levels.

Estimates of OCN escapement are made for three coastal lake basins: Siltcoos, Tahkenitch and Tenmile. Over the last 5 years, spawning escapement to coastal lake basins has comprised 5.6 percent of the total estimated OCN spawning escapement. However, if OCN spawning escapement in river basins is overestimated, then this percentage would be higher.

OCN Spawning Escapement Goal

The 200,000 adult long–term spawning escapement goal is fundamentally linked to standard spawning survey expansions (42 fish per mile times 4,764 miles of spawning habitat). The surveys provided the basis for determining the goal and are used to track the success in achieving the goal. The appropriateness of the OCN escapement goal is dependent upon the degree that standard spawning survey expansions represent the actual spawning escapement of OCN coho. Thus, any biases associated with expansions of the standard survey index directly bias the magnitude of the escapement goal.

Recruitment Predictions

Annual predictions of coho recruitment are made for 24 stocks contributing to the OPI area. Five of these stocks originate from the OPI area and include OPI public hatchery and OCN stocks which are the primary components of OPI area recruitment. The methodology used to predict recruitment of these stocks is based on multiple regression models and has been in use since 1988 (Council 1988). Postseason assessments of OCN recruitment have been consistently below preseason predictions over the last four years.

Management Planning - Coho Assessment Model (CAM)

The CAM is used during the preseason planning process to develop allowable OPI area coho ocean harvest quotas that are consistent with achieving the OCN spawning escapement goal. It has been used in the management of ocean fisheries harvesting OCN coho since 1984, and is a descendant of the Washington Department of Fisheries (WDF)/National Bureau of Standards (NBS) main frame model (Hunter 1985, Scott 1988).

The primary concern about using the CAM model for the analysis of management options is whether the true OCN ocean distribution is adequately represented. The coded–wire tag (CWT) data used centered around hatchery release groups from the north and central Oregon coastal regions. Ocean distribution of OCN coho is based on relatively few observations compared to other stocks in the model. The underlying assumption is that all Oregon coastal stocks have the same migration patterns, timing and distribution. This suggests that fisheries anywhere along the coast will have an equal impact on all components of the Oregon coastal stock. It is becoming increasingly apparent that recent fishing regimes could in fact have a differential impact on north, central and southern coastal stocks that are beyond the resolution of the model (Council 1991).

CONCLUSIONS

The major methodological problem for managing fisheries impacting OCN coho is insufficient data for fine grained time/area quota management to achieve a numerical spawning escapement goal. Specific data problems include the following:

1. Probable over–expansion of spawning densities from index surveys leading to inflated spawner estimates, recruitment estimates and spawner escapement goal.

2. Unknown relationship between OCN and general OPI area ocean harvest rates.

3. Knowledge of OCN ocean distribution.

In addition, the tendency of the OCN predictor to overestimate recruitment compounds the spawner expansion problem.

Possible scenarios which would result in the failure to meet OCN spawning escapement goals given quota fisheries include:

1. Either OCN or public hatchery recruitment is overpredicted.
2. OCN spawning ground surveys are overexpanded.
3. Significant emigration from or unaccounted mortality occurs in the OPI area.
4. OCN coho ocean distribution is not adequately represented in the CAM.

RECOMMENDATIONS

The following studies, along with changes in management techniques, are suggested to assist in improving OCN fishery management.

1. Develop an OCN Indicator Stock Program to provide reliable estimates of fishery harvest rates and OCN catch distribution. This program would assist in developing long–term unbiased OCN recruitment data and thus an improved OCN stock recruitment predictor. Improved harvest distribution information would assist in the preseason prediction of OCN harvest mortality when developing allowable fisheries.

2. Adopt an unbiased OCN stock recruitment predictor. This would assist in achieving annual OCN spawner escapement goals.

3. Continue studies to improve OCN spawner escapement estimates. The results from this study may be used to remove spawner population bias from the OCN recruitment data and assist in re–evaluating the spawner escapement goal.

4. Reduce non–retention fisheries which result in the discarding of coho. Conduct at–sea sampling to estimate coho encounter rates during these non–retention fisheries. This will improve accounting of ocean harvest mortalities. Additional at–sea studies on gear selectivity may lead to reduced coho mortalities in chinook directed fisheries.

5. Develop a fishery mortality assessment model with time/area stratification that is supported by the available OCN information. This will improve the ability of managers to predict OCN harvest mortality during the preseason process of developing allowable fisheries.

6. Investigate and evaluate the feasibility of alternative approaches to quota management. The development of seasonal harvest rate structures which promote coastwide simultaneous fisheries on coho and chinook salmon may reduce the likelihood of high harvest rates on OCN stocks. Other benefits include better fishery stability, simpler regulations and a reduction in management cost.

LITERATURE CITED

Beidler, W. M., T. E. Nickelson, and A. M. McGie. 1980. Escapement goals for coho salmon in coastal Oregon streams. ODFW, Fish Div., Fish Info. Rep. 80–10. Portland, OR. 30 p.

Cooney, C. X. and S. E. Jacobs. 1990. Oregon Coastal Spawning Surveys in 1989. ODFW Annual Progress Report.

Council. 1984. Framework Amendment for Managing the Ocean Salmon Fisheries off the Coasts of Washington, Oregon, and California Commencing in 1985.

Council. 1986. Seventh Amendment to the Salmon Fishery Management Plan.

Council. 1988. Preseason Report I: Stock abundance analysis for 1988 ocean salmon fisheries.

Council. 1991. Preseason Report I: Stock abundance analysis for 1990 ocean salmon fisheries.

Hunter, M.A. 1985. The 1976–1978 brood coho model. WDF Progress Report 222.

ODFW. 1982. Comprehensive plan for production and management of Oregon's anadromous salmon and trout. Part II. Coho salmon plan.

Scott, J. B. 1988. Coho fishery management assessment model user's manual. Draft Version 3.10. Northwest Indian Fisheries Commission.

Schindler, E., L. Osis and R. J. Kaiser. 1991. The 1990 Oregon Ocean Salmon Fisheries. ODFW Annual Progress Report.

V. OCN COHO SALMON IN THE FRESHWATER ENVIRONMENT

INTRODUCTION

The typical life history pattern of OCN coho salmon is to spawn at age–3 during late fall and winter (mid–November to early February)(Moring and Lantz 1975). Spawning and rearing of juveniles generally takes place in small tributary streams, although rearing may also take place in lakes where available. Fry emerge from February to early June (Moring and Lantz 1975) and occupy backwater pools and the stream margins (Lister and Genoe 1970, Mundie 1969, Nickelson et al. 1992a). About 95 percent of coho salmon smolts migrating from Oregon streams have spent one summer and one winter in fresh water before migrating to sea (Moring and Lantz 1975). Summer rearing takes place primarily in pools whereas winter rearing occurs primarily in off–channel alcoves and in beaver ponds (Nickelson et al. 1992a). Seaward migration of smolts occurs primarily from March through May (Moring and Lantz 1975).

Over the past 30 to 60 years, 2 primary factors in fresh water have had a major influence on the production of OCN coho salmon smolts. The first factor has been the degradation of the freshwater habitat reducing the potential to produce smolts. Winter habitat in particular appears to be lacking in many streams. The second, and possibly more important factor during the last 20 years, has been a reduction in the number of adult fish spawning, such that, even in their degraded state, many habitats are no longer adequately seeded. These impacts have been serious: 25 of 36 stocks of coho salmon from key watersheds of the Oregon coast are now identified as "at risk or declining" (Nehlsen et al. 1991).

INADEQUATE SEEDING OF FRESHWATER HABITAT

Over the past decade, the failure of the OCN coho salmon spawning population to seed freshwater rearing habitats has been a problem. Beidler et al. (1980) determined that 20 female spawners (or 40 females and males combined) per mile was needed to seed coho salmon habitat in Oregon coastal streams. Generally, a total count of 40 adults per mile equals an average peak count of 20 adults/mile (McGie 1986). Average peak fish/mile counts have been below this level every year since 1971 (Figure 2). As a result of inadequate wild spawners, the summer habitat of 13 out of 15 coastal streams sampled from 1980–1985 was underseeded all 6 years (i.e., densities of juveniles in pools were less than 1 fish per square meter [Nickelson et al. 1992a]). The summer habitat of the other two streams was underseeded in five of the six years (Solazzi et al. 1990). During summers 1985–1990 only 36 out of 73 coastal streams sampled were found to be fully seeded. A major problem is that the abundance of spawners is not evenly distributed among coastal basins. For example, in 1986, the last year that the estimated spawning population approached the 200,000 goal, 9 out of 14 river basins had average spawner densities of less than 42 fish per mile, the level needed coastwide to achieve the 200,000 goal (Jacobs 1989). Low egg and fry survival could also be contributing to the underseeding problem.

The typical stock–recruitment model suggests that as spawner numbers decrease, total recruits decreases, but recruits per spawner increases (Ricker 1975). This process is a reflection of density dependent limitations of the freshwater habitat and has been demonstrated for coho salmon smolt production in Oregon coastal streams (Beidler et al. 1980). However, very low numbers of spawners

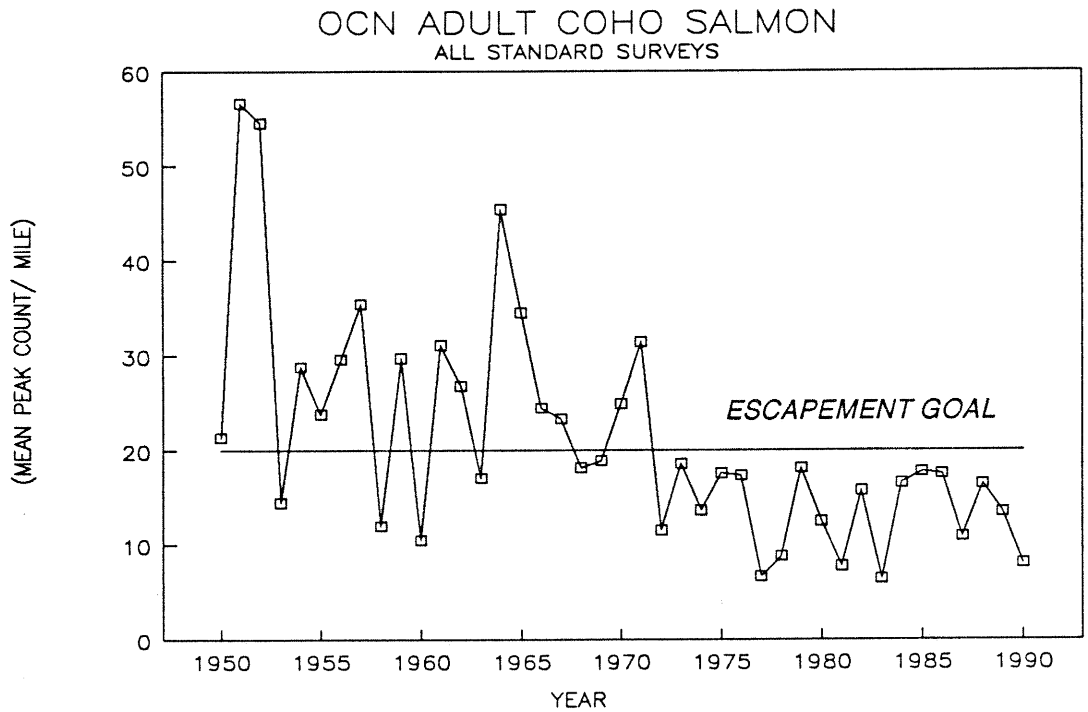

Figure 2. Peak counts of adult OCN coho salmon in standard spawning surveys, 1950–1990. Horizontal line depicts escapement goal. Counts in 1981–1990 were adjusted to remove hatchery strays.

may fall below a theoretical "point of preservation" beneath which density compensation no longer acts and recruits per spawner decreases as spawners decrease (ODFW 1982). This may be due to a loss of genetic diversity in a population and result in the population not responding to a reduction in harvest rates, as has been suggested for lower Columbia River coho salmon (ODFW 1991). Low numbers of spawners in some coastal basins may have resulted in fragmentation of the populations to the extent that they are below the point of preservation. Impacts of genetic interactions with hatchery fish may also be greater when wild spawners are in low abundance. Hatchery supplementation of these populations likely results in a drastic reduction in effective population size (Ryman and Laikre 1991) thus reducing the fitness of the wild population.

FRESHWATER HABITAT DEGRADATION

Historic Perspective

Much of the freshwater habitat of coho salmon in the OPI has been extensively affected by past and present human activities. Historically streams were complex, often containing large quantities of wood and boulders. There were extensive backwaters and overflow channels, particularly in the larger systems. Streams were cleared of obstructions and channels diked and straightened beginning with early settlers (Sedell and Froggat 1984, Benner draft manuscript). Channels in all sizes of streams were further cleared and altered for transportation of logs and other materials (Sedell and Luchessa 1982, Sedell et al. 1991). The consequences of these early actions has been the loss of habitat, particularly productive off-channel areas, and the simplification of other habitat.

This process of habitat simplification has continued into the present. A suite of factors, including agriculture, urbanization and timber harvest (Resch et al. 1988, Hicks et al. 1991) are responsible for this current decline. Intensive programs to remove wood from streams channels have also been conducted throughout the OPI in the 1960s (House and Boehne 1987). Today, few streams contain complex habitats.

Decreased habitat complexity can affect production of coho salmon. House and Boehne (1987) found that standing crops of coho salmon in pools of streams that had been cleaned was 25 percent of that in uncleaned streams. Research in areas outside of Oregon have observed similar patterns (Dolloff 1983, Bisson and Sedell 1984, and Heifetz et al. 1986).

Winter habitat suitability and availability may also be affected by habitat alteration. Coho salmon are closely associated with large wood during winter. Loss of complex pools can result in increased susceptibility to predation or displacement during high water (Hicks et al. 1991). Rodgers (1986) found that winter habitat for coho salmon in an Oregon stream that had been cleared of wood was restricted to a few pools. Estimated over-winter survival was 9 percent. Two pools which had accumulations of wood and accounted for less than 0.5 percent of the total available habitat produced 40 percent of the smolts. In Alaska, numbers of coho salmon smolts was lower in reaches where wood was removed relative to uncleared controls (Murphy et al. 1986). Similar observations were made in British Columbia (Bustard and Narver 1975, Tschaplinski and Hartman 1983).

There are other implications of decreased habitat complexity that influence production of coho salmon in fresh water. There is reduced storage of gravel and organic matter, which is an important energy source for prey items (Hicks et al. 1991). Early rearing habitat, especially along stream margins, is reduced (Moore and Gregory 1988). In addition, gravel present is more mobile and less suitable for spawning. For example, in the Clearwater Basin, Washington, survival to emergence of coho salmon has been reduced by 50 percent as a result of sedimentation (Cederholm and Reid 1987) and winter peak flows appear to be a major factor influencing smolt production.

Changes in water quality may also influence freshwater production. Reeves et al. (1987) observed that interspecific competition between redside shiners (*Richardsonius balteatus*) and juvenile steelhead trout (*Oncorhynchus mykiss*) was influenced by water temperature. Trout dominated at temperatures below 20°C and shiners at above 20°C. Similar results may occur with coho salmon and non-salmonids. In Carnation Creek, British Columbia, increased water temperatures resulted in accelerated growth of juvenile coho salmon (Holtby 1988). Timing of smolts migration occurred earlier than before temperature elevation. The consequence of this is unknown exactly. However, Holtby (1988) using a model of adult survival and timing of smolt release predicted that adult survival would decrease.

Current Status

As a result of the loss of diversity of habitat in coastal streams, the habitat needed for coho salmon rearing during winter appears to be rare in many streams. Stream habitat inventory data show that prime winter habitat composes less than 2 percent of the total winter area of 14 coast range streams surveyed (Nickelson et al. 1992a). If this data is typical of coastal streams in general, it would suggest that smolt production is low even when the habitat is seeded.

Other than winter habitat, OCN coho salmon smolt production could be affected by other freshwater habitat factors. Some examples of these are:

1. Spawning and rearing habitat has been lost because culverts, tide gates and sluice–outs have blocked adult passage.

2. Reduced gravel quantity or quality may result in reduced egg survival. Loss of gravel may particularly be a problem in streams that have been splash–dammed.

3. Summer habitat has been lost because of increased water temperature usually in the lower reaches of streams, particularly in agricultural areas.

However, much more inventory data is needed to get a clearer picture of the current condition of coho salmon habitat and the freshwater habitat factors limiting production in individual streams.

Over the past decade, state and federal management agencies have implemented programs to restore freshwater habitat of anadromous salmonids throughout the OPI. The thrust of most efforts has been the introduction of structural elements, such as large trees and gabions (heavy wire baskets that are filled with rocks and placed on the stream bottom), in order to increase complexity. Unfortunately, the vast majority of these efforts have not been effective in creating suitable winter habitat (Nickelson et al. 1992b), and evaluations of smolt production resulting from these actions are woefully lacking (Reeves et al. 1991).

In addition, most habitat restoration efforts have been conducted on a relatively small spatial scale and thus have only addressed a small fraction of the total amount of degraded habitat. Because of the extensive amount of degraded habitat, it is unlikely that such efforts will be able to make anything more than token improvements in the quality and quantity of freshwater habitat, and coastal streams are not likely to heal themselves soon because many riparian zones lack large conifers to provide the large wood often associated with winter habitat. For example, in the Salem District of the Bureau of Land Management (BLM), the riparian zones of about 75 percent of the miles of coho salmon habitat have few or no large trees present (BLM 1991). For these streams, "full recovery is not expected for 200 years" (BLM 1991).

Watershed level programs that link aquatic habitat with other parts of the ecosystem will be necessary to maintain high quality freshwater habitats and restore presently degraded habitats. Such an approach has been developed by Johnson et al. (1991) to deal with the problems of spotted owls, old-growth forest ecosystems and stocks of anadromous salmonids that are in need of special management consideration because of declining populations. Under this plan, 45 watersheds on federal lands in the OPI are designated as special areas for management of anadromous salmonid habitat. These watersheds are core reserves for the different stocks and it is hoped that they will be seed sources for other areas as habitat improves. Commodity production in these watersheds would be greatly curtailed. In addition, streams outside these areas would be subjected to wider riparian management areas than are currently in place. In addition, there is the call for massive watershed restoration programs to restore degraded habitat.

This is the first time that such an integrated conservation and recovery program at the ecosystem level has been proposed. It is our belief that the Council should examine this plan more closely and encourage inclusion of the watershed and fish component in any legislation passed by Congress or programs developed by the responsible management agencies. It is only with such programs that currently productive freshwater habitat of coho salmon and other anadromous salmonids can be maintained and degraded habitats restored.

OTHER POSSIBLE FACTORS INFLUENCING PRODUCTION

We also considered a number of other factors that likely influence OCN smolt production but to a lesser or unknown extent. These factors are listed below.

1. The use of herbicides may have resulted in reduced smolt production through lethal and sublethal effects.

2. Degradation of estuarine habitats may have resulted in reduced survival of wild smolts during migration.

3. Competition from and genetic interactions with hatchery fish may have resulted in reduced production of wild coho salmon.

RECOMMENDATIONS

1. Protect freshwater habitat from further degradation. State and federal land-use management and fisheries agencies should develop a comprehensive approach to habitat protection on a watershed basis such as that developed by Johnson et al. (1991).

2. Inventory coho populations and freshwater habitat in coastal streams in order to assess the current status of coho salmon habitat and to identify limiting factors. Specifically,

   a. Develop a coordinated long-term program to monitor the status of coho populations, stream habitat and the effectiveness of habitat protection and restoration programs at in selected streams in all major coastal basins.

   b. Expand stream habitat inventories (summer and winter) in coastal basins to assess the current status of coho salmon habitat and to identify limiting habitat using the methods of Reeves et al. (1989) and Nickelson (unpublished).

3. Restore habitat by addressing limiting factors. Habitat work that does not address limiting factors has been shown to be ineffective. In addition, to aid the long-term healing of the stream ecosystem, conifers should be planted in the riparian zone.

4. Evaluate the use of hatchery fish (genetically similar only; *see* ODFW Wild Fish Policy) to "jump-start" populations in underseeded habitat of good quality by developing a demonstration project.

LITERATURE CITED

Beidler, W. M., T. E. Nickelson, and A. M. McGie. 1980. Escapement goals for coho salmon in coastal Oregon streams. ODFW Fish Div., Fish Info. Rep. 80-10. Portland, OR. 30 p.

Benner, P. draft. Historical reconstruction of the Coquille River and surrounding landscape. Report to Oregon Dept. of Environ. Qual., Portland.

Bisson, P. A., and J. R. Sedell. 1984. Salmonid populations in streams in clearcut vs. old-growth forests of western Washington. p. 121-129. *In* W. R. Meehan, T. R. Merrell, Jr., and T. A. Hanley [ed.] Fish and wildlife relationships in old-growth forests; proceedings of a symposium held April 1982, Juneau, AK. Am. Inst. Fish. Res. Biol., Juneau AK.

BLM. 1991. Prototype resource management plan/Environmental impact statement: Chapter 3 - Fish. Draft manuscript.

Bustard, D. R., and D. W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 32:667-680.

Cederholm, C. J., and L. M. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: A project summary. p. 373-397. *In* Streamside management forestry and fishery interactions. Contribution No. 57, Univ. Wash., Inst. For. Res., Seattle, WA.

Dolloff, C. A. 1983. The relationships of woody debris to juvenile salmonid production and microhabitat selection in small southeast Alaska streams. Doctoral Dissertation. Montana State University, Bozeman, MT.

Heifetz, J., M. L. Murphy, and K. V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. N. Am. J. Fish. Manage. 6:52–58.

Hicks, B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat changes. Am. Fish. Soc. Special Pub. 19:483–518.

Holtby, L. B.. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on coho salmon (*Oncorhynchus kisutch*). Can J. Fish. Aquat. Sci. 45:502–515.

House, R. A., and P. L. Boehne. 1987. The effect of stream cleaning on salmonid habitat and populations in a coastal Oregon drainage. West. Jl. Appl. For. 2:84–87.

Jacobs, S. E. 1989. Oregon coastal salmon spawning surveys, 1986–1988. ODFW Fish Div., Three-year Update Prog. Rep. Portland, OR. 115 p.

Johnson, K. N., J. F. Franklin, J. W. Thomas, and J. Gordon. 1991. Alternatives for management of late-successional forests of the Pacific Northwest. A report to the Agriculture and the Merchant Marine and Fisheries Committees of the U.S. House of Representatives. Washington D.C. 59 p.

Lister, D. B., and H. S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. J. Fish. Res. Board Can. 27:1215–1224.

McGie, A.M. 1986. Management goals and objectives for coho salmon in Oregon coastal rivers. ODFW Informational Report 86-4.

Moore, K. M. S., and S. V. Gregory. 1988. Response of young-of-the-year cutthroat trout to manipulation of habitat structure in a small stream. Trans. Am. Fish. Soc. 117:162–170.

Moring, J. R., and R. L. Lantz. 1975. The Alsea watershed study: Effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part I – Biological studies. ODFW Fish Res. Rep. No. 9. 66 p.

Mundie, J. H. 1969. Ecological implications of the diet of juvenile coho in streams. p. 135–152. *In* T. G. Northcote [ed.] Symposium on salmon and trout in streams. H. R. MacMillan Lectures in Fisheries. Univ. of British Columbia, Vancouver, B.C. 388 p.

Murphy, M. L., J. Heifetz, S. W. Johnson, K. V. Koski, and J. F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaska. Can. J. Fish. Aquat. Sci. 43:1521–1533.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16(2):4–21.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992a. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49 (In press).

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992b. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49 (In Press).

ODFW. 1982. Comprehensive plan for production and management of Oregon's anadromous salmon and trout Part II–Coho salmon plan. ODFW Fish Div., Portland, OR. 188 p.

ODFW. 1991. Lower Columbia River coho salmon: Evaluation of stock status, causes of decline, and critical habitat – part 2. ODFW Fish Div., Portland, OR. 119 p.

Reeves, G. H., F. H. Everest, and J. D. Hall. 1987. Interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdneri*) in western Oregon: the influence of water temperature. Can. J. Fish. Aq. Sci. 44:1603–1613.

Reeves, G. H., F. H. Everest, and T. E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. USDA Forest Service, Gen. Tech. Rep. PNW–GTR–245, Portland, OR. 18 p.

Reeves, G. H., J. D. Hall, T. D. Roelofs, T. L. Hickman, and C. O. Baker. 1991. Rehabilitating and modifying stream habitats. Am. Fish. Soc. Special Pub. 19:519–557.

Resch, V. H., A. V. Brown, A. P. Covich, M. E. Gurtz, H. W. Li, G. W. Minshall, S. R. Reice, A. L. Sheldon, J. B. Wallace, and R. Wissmar. 1988. The role of disturbance in stream ecology. J. North Amer. Bentho. Soc. 7:433–455.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada, No. 191. 382 p.

Rodgers, J. D. 1986. The winter distribution, movement, and smolt transformation of juvenile coho salmon in an Oregon coastal stream. M.S. Thesis. Oregon State University, Corvallis, OR.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Cons. Biol. 5:325–329.

Sedell, J. R., and J. L. Froggatt. 1984. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal. Internationale Vereinigung für theoretische und angewandte Limnologie Verhandlungen 22:1828–1834.

Sedell, J. R., F. N. Leone, and W. S. Duval. 1991. Water transportation and storage of logs. Am. Fish. Soc. Special Pub. 19:325–368.

Sedell, J. R., and K. J. Luchessa. 1982. Using the historical record as an aid to salmonid habitat enhancement, p. 210–223. *In* N. B. Armantrout [ed.] Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Bethesda, MD. 376 p.

Solazzi, M. F., T. E. Nickelson, and S. L. Johnson. 1990. An evaluation of the use of coho salmon presmolts to supplement wild production in Oregon coastal streams. ODFW Fish Res. Rep. No. 10. 22 p.

Tschaplinski, P. J., and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Can. J. Fish. Aq. Sci. 40:452–461.

VI. MARINE HABITAT

Survival and growth of OCN coho are dependent on ocean environmental conditions. Studies from Carnation Creek, British Columbia showed that 50 percent of the interannual variability in coho recruitment was determined in the ocean (Holtby et al. 1990). Nickelson (1983, 1986) found that survival of OPI area public hatchery smolts was highly correlated with coastal upwelling and Lawson (unpublished data) found that upwelling alone explained 64 percent of the variability in OCN coho ocean recruits since 1970. Although, there is little specific understanding of the marine phase of OCN coho life history, it is clear that marine conditions affect stock productivity, sustainable harvest rates, migration patterns and availability to fisheries.

BASIS FOR MANAGEMENT

Management goals and expectations for OCN coho salmon, including expected yield, harvest rates and escapement goals, are set forth in the Oregon Coho Salmon Management Plan (ODFW 1982). These expectations and goals were based on the results of a stock–recruitment analysis of production from the 1950–1977 brood years (see Appendix 2 in ODFW [1982]). These broods experienced highly variable ocean conditions, including 10 years of strong upwelling, which is positively correlated to ocean survival of public hatchery coho originating predominantly from the Columbia River (Nickelson 1986) and to recruitment of OCN coho. However, 1991 is the first year that upwelling has been strong since 1975. Weak upwelling has been the predominant pattern, occurring about 75 percent of the time. OCN coho broods whose smolts entered the ocean in years of strong upwelling have produced significantly ($p=0.003$) more recruits than broods whose smolts entered the ocean in years of weak upwelling (Nickelson, personal communication). Therefore, the stock/recruitment model based on earlier years of strong upwelling is not appropriate for the weak upwelling years since 1976.

Nickelson (1983) warned that managers and harvesters should lower their expectations as to the number of hatchery coho to expect given the prevailing ocean conditions. One way to view expectations for OCN coho production under weak upwelling conditions is to apply a stock–recruitment relationship to only those broods since 1950 that were influenced by weak upwelling. As can be seen from Table 1, the maximum sustained yield (MSY) under this recruitment

TABLE 1. Comparison of stock–recruitment parameters for broods influenced by weak upwelling 1950–1987 and the same parameters based on the 1950–1978 broods as presented in Appendix 2 of the Oregon Coho Salmon Management Plan (ODFW 1982).

Parameter	Coho Plan	Weak Upwelling Years 1950–1987
Parameter a	1.92	1.58
Maximum Recruitment	767,000	572,000
Spawners Needed for Maximum Recruitment	281,000	320,000
MSY	528,000	320,000
Spawners Needed for MSY	197,000	198,000
Recruits at MSY	725,000	518,000
Exploitation Rate at MSY	0.728	0.618

relationship is 200,000 fish less than that for the relationship presented in the Coho Plan (ODFW 1982), whereas spawners needed for MSY remains the same. Essentially, the effect of weak upwelling appears to be a reduction in recruits for a given level of spawners (Figure 3). When the stock is less productive, the optimal harvest rates are also lower, suggesting that harvest rates should be lowered during periods of poor upwelling. This area of research needs continuing attention. Of particular concern are long-term (decadal) changes in the suitability of ocean conditions for coho salmon.

MARINE LIFE HISTORY

OCN coho cannot be readily identified in the ocean. As a result, there is no way to collect information on ocean distribution, migratory patterns, interactions with hatchery stocks and correlations with ocean environmental conditions. There are estimates of spawners and indirect estimates of ocean adults, but no counts of smolts entering the ocean. This makes it difficult to separate marine factors affecting growth and survival from freshwater production factors.

The only direct estimates of ocean catches of wild fish come from scale studies. These suggest that the percentage of wild fish in the sport and troll catches from Astoria to Brookings ranged from 8 to 25 percent between 1978–1987 (L. Borgerson, unpublished data). No trend for a decreasing proportion of wild fish in the catch was evident in these data. The mean percentage of wild fish calculated from scales was 18 percent, compared with 24 percent from landings and escapement data. No correlation exists (r^2=0.085) between these two independent estimates of wild fish contribution in the ocean fisheries, indicating problems in one or both estimation techniques. Resumption of scale collections and refinement of the interpretation of scale patterns should receive a high priority as the least expensive means of obtaining estimates of wild fish contribution rates in ocean fisheries independent of catch and escapement data.

Oregon coastal hatcheries using native brood stocks may produce coho runs with ocean life histories similar to OCN coho. However, the few pertinent investigations suggest that wild and hatchery coho may have different distributions at sea. Research in the early 1980s showed that OPI hatchery fish do not undertake extensive migrations north of Washington during their first summer in the ocean (Pearcy and Fisher 1988). On the other hand, Hartt and Dell (1986) tagged juvenile coho in the Gulf of Alaska and recovered some as adults in Oregon waters. The possibility that wild and hatchery fish have different ocean migration patterns needs to be considered when using hatchery CWT groups to track OCN coho life history patterns.

GENERAL RECOMMENDATIONS

Realizing that marine conditions affect stock productivity, sustainable harvest rates, migration patterns, and availability to fisheries, we should improve our knowledge of OCN coho stocks so their health can be monitored and they can be more effectively managed. To do this we need:

- Methods to identify OCN stocks at sea and in the laboratory.
- Long-term studies to monitor ocean distribution, migration patterns and ocean survival of OCN stocks.

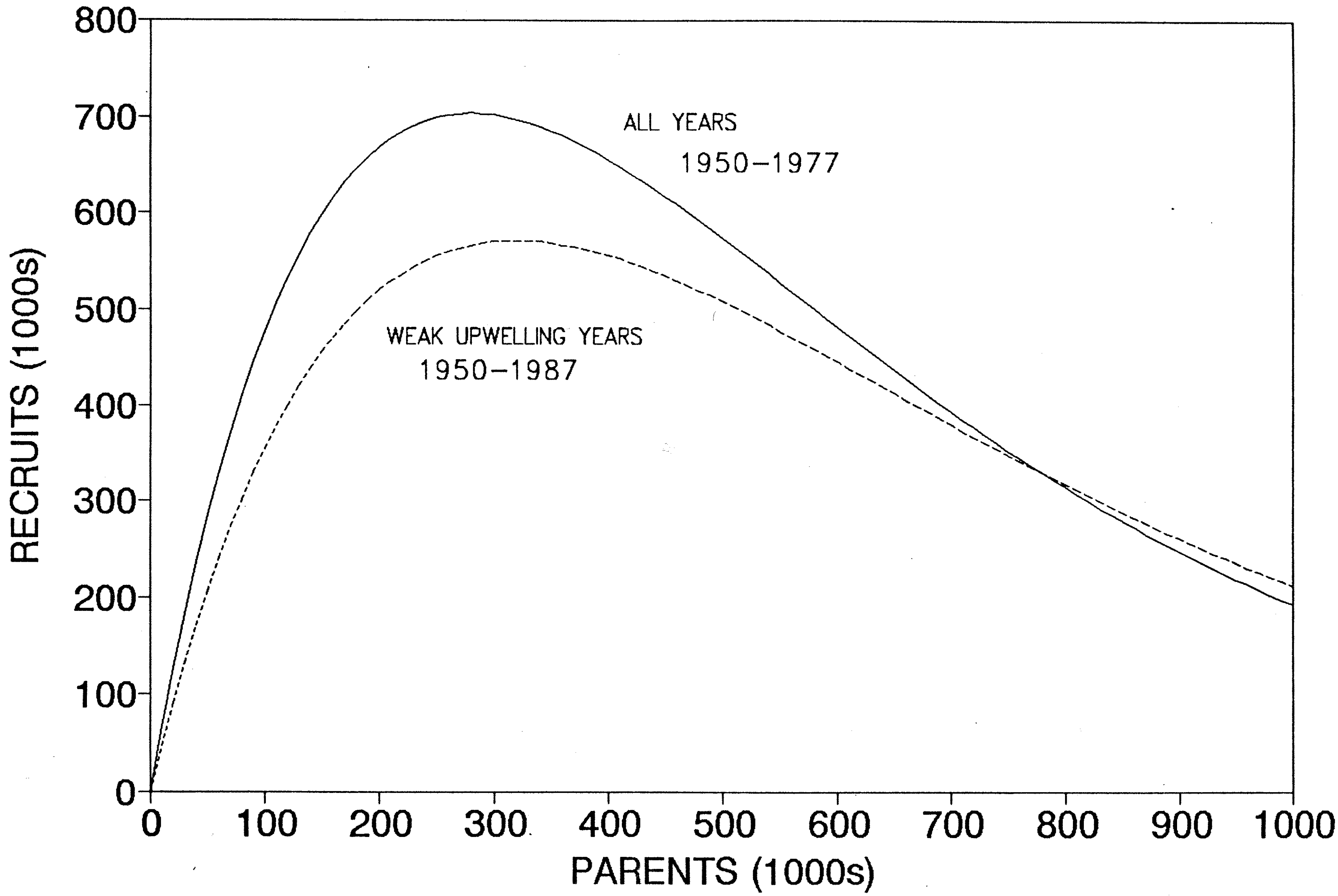

Figure 3. Stock–recruitment relationships for OCN coho salmon.

SPECIFIC RECOMMENDATIONS

1. Develop a management strategy that is sensitive to interannual variations in stock productivity as indexed by ocean conditions. This would allow higher harvest rates during periods of high productivity, but restricted harvest rates during poor ocean conditions.

2. Reinstate a program to systematically collect scales from landings of coho salmon. This may require reexamining the techniques used to discriminate among stocks based on scales.

3. Summarize the results of the 10 years when scales were sampled and identified; compare these results with other estimates of wild stock composition in the ocean; evaluate new methods (such as the chemical composition of the freshwater portion of the scales) in an attempt to corroborate the scale discriminations.

4. Initiate an intensive study of the population dynamics of one or more indicator stocks of OCN coho, to include estimates of both freshwater and marine survival. Such research should be coordinated with similar efforts in Washington and British Columbia to enable us to make regional comparisons.

5. Develop methods to recognize OCN coho. This could include marking all hatchery fish with external (fin clips, injections, brands) or internal (otolith, CWT) marks. Wild fish could also be identified more directly through scale analysis, elemental analysis of otoliths or scales, or, possibly, genetic stock identification.

LITERATURE CITED

Hartt, A.C., and M.B. Dell. 1986. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. Int. North Pac. Fish. Comm. Bull. 46:1–105.

Holtby, L.B., B.C. Anderson, and R.K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (Oncorhynchus kisutch). Can. J. Fish. Aquat. Sci. 47:2181–2194.

Nickelson, T. E. 1983. Influence of ocean conditions on abundance of coho salmon (Oncorhynchus kisutch) in the Oregon Production Area. ODFW Fish Div., Fish Info. Rep. 83–6. Portland, OR. 23 p.

Nickelson, T. E. 1986. Influences of upwelling, ocean temperature, and smolt abundance on marine survival of coho salmon (Oncorhynchus kisutch) in the Oregon Production Area. Can. J. Fish. Aquat. Sci. 43:527–535.

ODFW. 1982. Comprehensive plan for production and management of Oregon's anadromous salmon and trout Part II–Coho salmon plan. ODFW Fish Div., Portland, OR. 188 p.

Pearcy, W.G., and J.P. Fisher. 1988. Migrations of coho salmon, *Oncorhynchus kisutch*, during their first summer in the ocean. Fishery Bulletin 86:173–195.

APPENDIX A - DETAILED DESCRIPTION OF METHODOLOGIES

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APPENDIX A – DETAILED DESCRIPTION OF METHODOLOGIES

This appendix replicates much of the information provided in Section IV of the report, but provides additional technical detail. It has been included to provide a complete and ready reference to the fishery management methodologies relevant to OCN coho management for those interested in such details.

Methodologies used to manage the ocean harvest of OCN coho are illustrated in Figure A–1. Annually during the preseason process of adopting ocean fisheries, the OPI area stock recruitments are predicted and fishery options are modeled to determine the allowable harvest quotas which will achieve OCN spawning escapement goals. Each year, postseason estimates are made of ocean harvest, and ocean escapement of OCN and public hatchery stocks. From this postseason information, OPI area ocean harvest rates are estimated, stock recruitments are reconstructed and annual OCN and public hatchery predictors are refined. A detailed description of these methodologies follows.

POSTSEASON METHODOLOGIES

OCN Recruitment

The components of OCN recruitment consist of OCN ocean and freshwater harvest mortality and OCN spawning escapement. The annual postseason estimate of OCN recruitment (Equation 1 – see page 7) is calculated using the measured OCN ocean escapement and the estimated OPI area ocean harvest rate (Equation 2 – see page 7). Postseason estimates of annual OCN recruitments since 1970 together make up the OCN recruitment data base from which the OCN recruitment predictor is based. This is the period used for all OPI area coho recruitment data bases. The quality of the OPI area catch and escapement information before 1970 is considerably poorer because of inconsistent sampling.

The OCN recruitment data base directly influences: (1) annual predictions of OCN stock recruitment and (2) the annual determination of the OCN spawner escapement goal. The annual OCN spawner escapement goal is determined by the OCN recruitment prediction for that year as specified in the seventh amendment to the salmon FMP (Council 1986).

The accuracy of the annual OCN recruitment predicted is influenced by the precision of the recruitment data base, since the predictor utilizes the range of recruitment observed in past years. For example, if the recruitment data base is biased with consistent overestimation, then it is likely the annual prediction will also be overestimated. An overestimated OCN recruitment could result in the adoption of harvest quotas that are excessive for the achievement of the adopted OCN spawning escapement goal. The OCN recruitment predictor was reviewed and adopted by the Council in 1988.

Harvest Mortality

Harvest mortality of OCN coho occurs as landed catch and mortality on hooked fish that escape (drop–offs) or are released. They occur in ocean and freshwater fisheries. Only landed catch is measured directly, based on sampling rates which usually exceed 20 percent (Schindler et al. 1991).

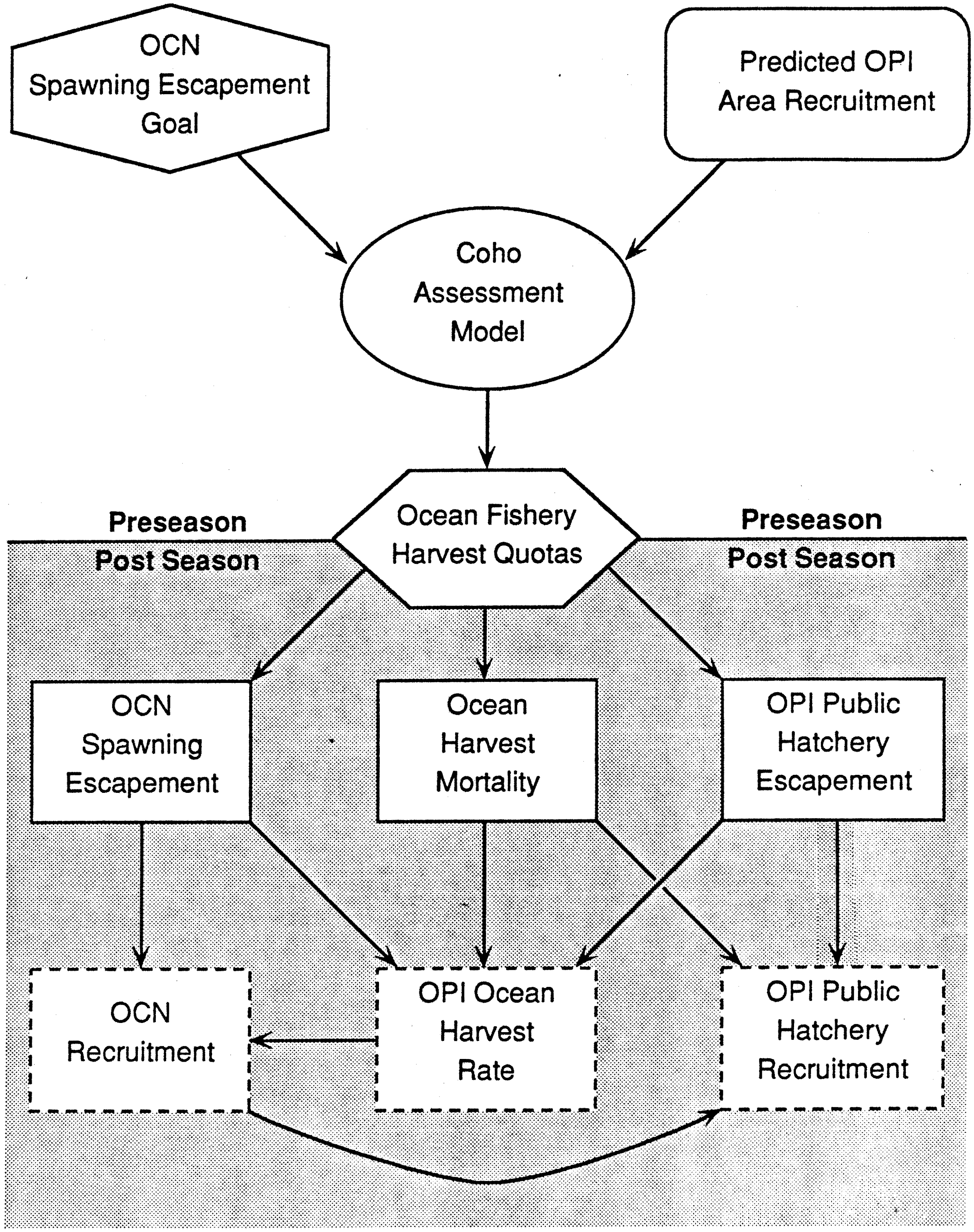

Figure A–1. Methodology used to manage the ocean harvest of OCN coho salmon. Postseason methodology components consist of both direct estimates (solid boxes) and indirect estimates (broken boxes).

Ocean mortality of legal sized fish that were released in the commercial troll fishery are approximated and included in the recruitment data base. Estimates are based on historical catch rates and observed effort (see Appendix C). The magnitude of mortality from other sources (e.g., natural mortality, net fisheries, fish released in the recreational fishery) are not estimated and thus not addressed.

Ocean Harvest Mortality

The vast majority of the ocean harvest of OCN coho is assumed to occur within the OPI area. The postseason estimated ocean harvest mortality of OCN coho is back–calculated from the OCN ocean escapement estimate of spawners and freshwater harvest. The methodology uses the estimated OPI area ocean harvest rate and is calculated using the following equation:

Ocean harvest mortality of OCN coho = $[S/(1-R)] - S$ (Equation 4)

where

S = OCN ocean escapement (freshwater harvest and spawner escapement)

R = OPI area ocean harvest rate

Since 1970, the estimated annual ocean harvest mortality of OCN coho has ranged from 77,500 to 1,139,700 coho.

Ocean Harvest Rate – The above methodology used to estimate the ocean harvest mortality of OCN coho assumes that the OPI area ocean harvest rate represents the ocean harvest rate on OCN coho. Whether the general OPI area ocean harvest rate represents the ocean harvest rate on OCN coho has not been demonstrated, because a direct estimate of the ocean harvest rate on OCN coho is not available. Coho assessment modeling suggests that differences exist between the actual harvest rate on the OCN stock aggregate and the OPI area stock composite since the early 1980s when fisheries north of Cape Falcon were reduced relative to fisheries south of Cape Falcon. It is also likely that the ocean harvest rate varies between OCN substocks (Nehalem to Coquille rivers). The magnitude of these harvest rate differences are affected by annual OPI area fishery structures and regulations.

The accuracy of OPI area ocean harvest rate estimates (Equation 2 – see page 7) relies on the accurate accounting of ocean harvest mortalities (landings and non–retention mortality) and OPI area ocean escapements.

Closed System – Implicit in the derivation of the OPI area ocean harvest rate is the existence of a closed system. This is the assumption that immigration of other stocks into OPI fisheries balance with the catch of OPI origin coho north of Leadbetter Point (emigration). Preliminary information suggests a balance did not occur in 1991 as favorable ocean conditions in the OPI area attracted non–OPI area produced coho. Annual ocean distribution depends in unknown ways on ocean environmental conditions.

Annual fishery regulations that differ substantially among coastal regions probably invalidates the closed system assumption. The degree of fishery restriction often varies between the regional areas located north and south of Cape Falcon.

Substantial changes in the stock mix produced by OPI area hatcheries also influences this assumption (Council 1991). Columbia River hatcheries are currently releasing about 50 percent north migrating (Cowlitz River) smolts and 50 percent south migrating (Toutle River) smolts. In the 1970s, this was about 20 percent Cowlitz River and 80 percent Toutle River. A significant portion of north–migrating stocks tend to be caught outside the OPI area. Fishery management in the 1980's has generally reduced ocean harvest off Washington relative to Oregon.

Two concerns arise from this combination of factors. First, many Cowlitz River coho are landed outside the catch accounting area. Therefore, a portion of the catch of OPI stocks may not be included in our catch statistics. Second, with fewer hatchery fish migrating south, the proportion of wild stocks in the OPI area catch may be higher than it was in the 1970s. With fisheries more concentrated off Oregon, this could be elevating the ocean harvest rates on OCN coho above the OPI area stock composite ocean harvest rate.

Freshwater Harvest Mortality

Adult OCN coho freshwater harvest mortality occurs as landed catch in recreational fisheries, and as mortality on hooked fish that escape (drop–offs) or are released. Only landed catch is measured. Mortalities from dropping off the hook and from other sources (e.g., natural mortality, poaching, releasing fish) are not estimated and thus are not addressed.

The freshwater harvest of OCN coho is derived from recreational punch card returns. Since 1970, the annual estimate of OCN coho adults in the freshwater harvest ranges from 1,500 to 13,500 adults. The freshwater harvest is estimated to represent three percent of the total OCN ocean escapement over the last five years. However, if OCN spawning escapement is overestimated then this percentage would be higher.

Approximately 20 percent of all punch cards are returned from which an estimated catch of combined hatchery and natural produced (OCN) coho is calculated. The estimated harvest of OCN fish is calculated using the catch timing pattern observed on non–hatchery influenced river systems. The method assumes that hatchery fish do not contribute to the fisheries after October. Historically, peak spawning at most coastal hatcheries has occurred in October. The freshwater harvest of OCN coho adults is estimated as follows:

$$\text{Freshwater Harvest of OCN Coho Adults} = A/B \qquad \text{(Equation 5)}$$

where

A = statewide November through January freshwater coho catch in coastal river systems (excluding the Columbia River)

B = the average percent of the total season freshwater coho harvest that occurred from November through January on non–hatchery influenced coastal river systems (excluding the Columbia River)

Because there is a one year lag in the availability of punch card estimates, a temporary estimate of freshwater harvest is made postseason. This estimate is usually based on the average harvest during the previous three years.

Spawning Escapement

Annual estimates of the OCN coho spawning escapement are the only direct measure of the abundance of this stock aggregate. Spawning ground surveys were not specifically developed for estimating total OCN spawner escapement, but rather as a relative escapement index. Starting in the 1980s, survey data were expanded to total spawners because of management needs and in spite of the recognition that the surveys were not appropriate for this use. The methods used to index spawning escapements have changed over the past 41 years. Current methods are detailed in Cooney and Jacobs (1990). A general description of past and present methodologies follows.

Annual estimates of OCN spawning escapement since 1970 range from 67,800 to 324,000 adults. Separate escapement estimates are made for OCN populations spawning in coastal river and lake basins. For coastal river basins, the basic approach in estimating OCN escapement is to extrapolate estimates of spawning density from survey index areas. The spawning density is expanded for the total estimate of spawning habitat to provide estimates of escapement in the area of interest. During the 1950–1984 period, estimates were made by expanding the overall coastwide average spawning density to the coastwide total number of miles of spawning habitat. Since 1985, estimates have been made by expanding the spawning density in individual river basins and summing all basins. This change was made as an attempt to (1) improve the accuracy of estimates by adjusting for disproportionate survey effort among individual basins and (2) account for different escapement patterns between basins.

Spawning density is estimated through spawning fish surveys. These surveys consist of walking and visually counting spawning coho in standard stream segments. Spawning fish surveys for coho have been conducted in standard stream segments in coastal river basins since 1950. During this 41 year interval, the miles of stream segments surveyed for coho have varied, ranging from about 21 to 114. In 1989, estimates of OCN coho spawning escapement to coastal river basins were based on surveys conducted in 66.1 miles of survey stream segments (1.4 percent of the estimated available spawning habitat). Before 1981, spawning density was estimated from peak counts on spawning surveys. A relationship was developed between peak counts and total escapement (McGie 1986). Since 1981, spawning surveys have been conducted to obtain area–under–the–curve (AUC) estimates of spawning density.

The accuracy of estimates of OCN spawning escapement in coastal river basins depends upon three assumptions:

1. Estimates of spawning density in survey stream segments are unbiased.

2. Estimates of the total amount of coho salmon spawning habitat are correct for the area of interest.

3. Spawning density in survey areas is a representative sample of the actual spawning density in the area of interest.

To date, none of these assumptions has been validated. Regarding Assumption 1, several factors associated with visual counts and AUC methodology could lead to biases. Factors that have been identified include: (1) life of spawning fish in survey segments, (2) counting of non–spawning fish and (3) the efficiency of visual counting fish in survey segments. Solazzi (1984) found that surveyors observe on average 75 percent of adult coho salmon in survey streams. Although these results suggest that current methods may underestimate spawning density, ODFW managers have not used these results to adjust spawning density estimates because of probable compensating biases associated with Assumptions 2 and 3. With the availability of new data, historical estimates of the quantity of spawning habitat appear high. The spawning density observed in survey areas probably overestimates mean overall spawning density. Thus, positive biases associated with Assumptions 2 and 3 probably have resulted in OCN spawning escapement estimates that have been higher than actual levels.

Estimates of OCN escapement are made for three coastal lake basins: Siltcoos, Tahkenitch and Tenmile. For the Siltcoos and Tahkenitch basins, OCN spawning escapement is estimated by expanding AUC estimates of spawning population size in standard sets of survey stream segments. These population estimates are expanded by the ratio of the quantity of spawning gravel in each basin to that in each respective survey set. For the Tenmile Lakes basin, OCN spawning escapement is estimated from a relationship between peak counts in standard index areas and mark–recapture population estimates. Over the last 5 years, spawning escapement to coastal lake basins has comprised 5.6 percent of total estimated OCN spawning escapement. However, if OCN spawning escapement in river basins is overestimated than this percentage would be higher.

OPI Public Hatchery Recruitment

The annual postseason estimate of coho recruitment from public hatcheries located in the OPI area is based on the addition of public hatchery ocean escapement plus OPI area ocean harvest mortality minus ocean harvest mortality from OCN and private hatchery stocks (Equation 3 – see methodology introduction). Another way to state Equation 3 is that the OPI area ocean harvest rate is used to derive OPI hatchery recruitment from the OPI hatchery ocean escapement.

PRESEASON METHODOLOGIES

OCN Spawning Escapement Goal

OCN coho salmon are managed to attain an annual spawning escapement of between 135,000 to 200,000 adults, with the later as the overall long–term goal. This escapement goal applies to the aggregate of all stocks inhabiting coastal streams south of the Columbia River basin to the Oregon–California border. The 135,000 to 200,000 adult spawner goal was adopted in 1986 (Council Seventh Amendment). The derivation of the long–term goal of 200,000 adults and its rational are provided in Beidler et al. (1980) and McGie (1986). The basic intent of the 200,000 adult goal is to achieve natural spawning densities in coastal river and lake basins that will, on the average, maximize the yield of these stocks to fisheries. Escapement goals of less than 200,000 adults are based on social and economic considerations.

The long–term OCN spawning escapement goal is fundamentally linked to standard spawning surveys (42 fish per mile times 4,764 miles of spawning survey habitat). The surveys provided the basis for determining the goal and are used to track the success in achieving the goal. The appropriateness of the OCN escapement goal is dependent upon the degree to which standard spawning survey expansions represent the actual spawning escapement of OCN coho. Thus, biases associated with the standard survey index directly bias the magnitude of escapement goal. Managers assume that the standard survey index in some way represents actual OCN spawning escapement. Because of the methodology currently used to estimate OCN spawning escapement, biases may result in an improperly calibrated escapement goal (e.g., how the goal is scaled to actual total stock abundance). Potential errors in calibration of the OCN spawning escapement goal will be addressed when results of the OCN methodology study are available, and as part of the Oregon coastal coho plan review slated for 1992–1993.

Other, perhaps more important, questions exist concerning the OCN spawning escapement goal. These relate to its appropriateness considering the current state of freshwater and marine habitat, and the structure of ocean fishery harvest. As described above, the OCN escapement goal is fundamentally linked to spawning densities of coho in standard spawning surveys. The present goal equates to an average of 42 adults spawning per mile in standard index stream segments. Data sets used to derive the present goal spanned the 1950–1970 brood years. If significant changes in coho habitat have occurred since that period, this goal may no longer be appropriate.

Recruitment Predictions

Annual predictions of recruitment are made for 24 stocks contributing to the OPI area. Five of these stocks originate from the OPI area and include OPI public hatchery and OCN stocks which are the primary components of OPI area recruitment. The methodology used to predict recruitment of these stocks is based on multiple regression models and has been in use since 1988 (Council 1988). The prediction for production from the OPI area is the sum of stock size estimates from public hatcheries, OCN, private hatcheries and the Salmon Trout Enhancement Program (STEP). Postseason assessments of OCN recruitment have been consistently below preseason predictions over the last four years.

There are two implicit assumptions of the prediction methodology. The first is that the harvest of any OPI origin coho north of Leadbetter Point is balanced by the harvesting of other stocks in OPI area fisheries (see Closed System). The second assumption is that the estimated harvest and ocean escapement accounts for all OPI area production.

Management Planning – Coho Assessment Model (CAM)

The CAM is used during the preseason planning process to evaluate the effects of various management options on the harvest mortality, escapement and allocation of coho stocks in the Council area. It has been used in the management of ocean fisheries harvesting OCN coho since 1984. The CAM model is a descendant of the WDF/NBS main frame model (Johnson 1975, 1978; Hunter 1985, 1986). A simplified version of the model was developed in a Lotus spreadsheet format to facilitate option analysis (Morishima and Cooney 1985; Scott 1988).

<u>Structure</u>

The model accounts for the distribution and catch of 37 stocks in 54 time/area fisheries during a 13 month period. The model accounts for fishery mortality, incidental losses and maturation. Users of the model can modify initial recruitment for each stock and input mortality or scale exploitation rates for each fishery. The base year data used in developing the model is from CWT recoveries during the 1979–1981 fishing years.

Excluding production from private aquaculture facilities, Oregon coastal production from the Columbia River mouth to the Rogue River was aggregated as a single stock. The CWT data used to represent all Oregon coastal production stocks centered around hatchery release groups from the north and central geographic regions. Oregon coastal coho populations to the south are predominantly natural fish but no additional base year tag data were available. The Oregon coastal stock is divided into natural (OCN) and hatchery components based on separate forecasts.

The primary concern about using the CAM model for the analysis of management options is the uncertainty about whether the true ocean distribution of OCN coho is adequately represented. The factors that contribute most to the uncertainty about the distribution estimates include the limited number of tag recoveries during the base years, scant number of base years, narrow geographical representation of the available codes, and use of hatchery fish to represent natural populations.

Assumptions about the distribution of the stock are based on limited recoveries of tags which were expanded for sample fraction and unmarked production into a production factor. The production factor for the Oregon coastal stock averaged approximately 100 for the three base years (Hunter 1985). This was substantially higher than for most other stocks in the model, indicating that the distribution of the Oregon coastal stock is based on relatively few observations compared to other stocks in the model.

The limited geographical scope of the base year codes is a problem. The underlying assumption is that all Oregon coastal stocks have the same migration patterns, timing, and distribution, and that these do not vary between years. The effect of this in the modeling analysis is that placement of fisheries anywhere along the coast will have an equal impact on all components of the Oregon coastal stock. It is becoming increasingly apparent that recent fishing regimes could in fact have a differential impact on north, central and southern coastal stocks that are beyond the resolution of the model (Council 1991).

The use of hatchery fish to represent the natural populations may result in inaccurate assumptions on ocean distribution patterns. Hatchery coho are known to enter the ocean as smolts earlier than natural populations. They are also thought to leave the ocean as adults earlier than natural fish due to their time of spawning. The peak time observed for coastal hatchery stocks to spawn is October through November, while the peak for natural coho occurs from November through January.

Inputs

Preseason assessments of ocean fishery options require users to input the initial recruitment of all stocks. In addition, expected mortality or exploitation rates are entered for each fishery by month and area. For each fishery option, model iterations occur until management objectives are met. These objectives include escapement goals, allocation schedules and port equity concerns.

Estimates of OPI area ocean coho harvest mortality (harvest and hook-and-release mortality) by month and area are calculated in two ways. The first method scales expected effort against observed base period levels (1979–1981 average). The second method calculates mortality outside of the model, which the user then inputs into the model. Effort scaling is usually used for commercial troll fisheries operating without landing restrictions. Effort scaling for south of Cape Falcon commercial troll fisheries uses expected levels derived through Klamath River chinook impact modeling. Independent estimates of mortality are made for most other OPI area fisheries.

An independent estimate of expected commercial troll harvest mortality is required for fisheries with hook–and–release mortality due to landing restrictions. The independent estimates of harvest and release mortality are based on historical catch rates, expected effort and regulations. To account for the variety of regulations, harvest mortality assessments are calculated on a week and area basis. Coho interception rates are estimated by adjusting the base period catch per day by the expected change in the OPI area recruitment (e.g., catch per day times [predicted recruitment] divided by [average base period recruitment]). Estimates of chinook catch rates are necessary in evaluating coho mortalities in ratio fisheries. Chinook catch rates are estimated by adjusting the catch per day from the previous year by the average of expected changes in the Rogue and Klamath rivers and central valley index stock abundances. For a description of the factors used in calculating non–landed coho mortality see Appendix C.

Independent estimates of expected recreational fishery harvest mortality are based on framework allocation schedules. These schedules reflect the allowable mortalities based on the predicted stock recruitments, fishery patterns assessed and achievement of spawner goals. Recreational fishery harvest mortality is distributed by time and area in a pattern that reflects harvest in recent years with similar seasons.

Usage

Most of the ocean harvest mortality on OCN coho is assumed to occur in OPI area fisheries. The CAM model includes 17 ocean troll and recreational time/area fisheries in the OPI area. Harvest mortality occurs during the May through September period. During the preseason management planning process, option analysis involves moving coho harvest mortality between areas and months in the troll fishery for a variety of management objectives related to spawning escapement goals, port equity concerns and chinook salmon harvest constraints. The model structure results in each time/area cell having a different estimated exploitation rate on each stock. Because of these differential rates, the model can be used to shape fisheries. The natural tendency is to search for where the impacts on stocks of concern are less. The problem is that assumptions about the structure of the OCN stock are over simplistic and the data used to estimate the distribution is rather limited (as is the situation with other stocks with high production factors). If model assumptions do not adequately describe the distribution of the stock, then the modeling analysis of fishery options will likely lead to inappropriate conclusions.

LITERATURE CITED

Cooney, C.X. and S.E. Jacobs 1990. Oregon Coastal Spawning Surveys in 1989. ODFW Annual Progress Report.

Council. 1984. Framework Amendment for Managing the Ocean Salmon Fisheries off the Coasts of Washington, Oregon, and California Commencing in 1985.

Council. 1986. Seventh Amendment to the Salmon Fishery Management Plan.

Council. 1988. Preseason Report I: Stock abundance analysis for 1988 ocean salmon fisheries.

Council. 1991. Preseason Report I: Stock abundance analysis for 1991 ocean salmon fisheries.

Hunter, M. A. 1985. The 1976–1978 brood coho model. WDF Progress Report 222.

Hunter, M. A. 1986. Modifications to the 1976–1978 brood coho model. WDF Progress Report 241.

Johnson, P.C. 1975. A model for salmon fishery regulation analysis. Second Interim Report. NBS #75745.

Johnson, P.C. 1978. A model for salmon fishery regulation analysis II. Center for Applied Mathematics, NBS.

McGie, A.M. 1986. Management goals and objectives for coho salmon in Oregon Coastal Rivers. ODFW Informational Report 86–4.

Morishima, G.S. and T.D. Cooney. 1985. Coho model documentation, Quinalt Management Center.

ODFW. 1982. Comprehensive plan for production and management of Oregon's anadromous salmon and trout. Part II. Coho salmon plan.

Oregon State University. Department of Statistics.

Schindler, E., L. Osis and R.J. Kaiser. 1991. The 1990 Oregon Ocean Salmon Fisheries. ODFW Annual Report.

Scott, J.B. 1988. Coho fishery management assessment model user's manual. Draft Version 3.10. Northwest Indian Fisheries Commission.

Solazzi, M.F. 1984. Relationships between visual counts of coho, chinook and chum salmon from spawning fish surveys and the actual number of fish present. ODFW Informational Report 84–7.

APPENDIX B – DETAILED DESCRIPTION OF METHODOLOGY RECOMMENDATIONS

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APPENDIX B – DETAILED DESCRIPTION OF METHODOLOGY RECOMMENDATIONS

Knowledge from which to manage ocean fishery harvests of OCN coho is based on OCN spawning ground surveys, ocean and freshwater harvest statistics, and ocean escapement of public hatchery stocks. OCN recruitment, ocean harvest rates and marine distribution information is estimated making critical and non–validated assumptions. Specifically, these are assumptions that OPI area ocean harvest rates are the same as ocean harvest rates on OCN coho, the OPI is a closed system (accurate estimates of OPI area ocean harvest rate and recruitment of OPI stocks), OCN spawner expansions are unbiased, and the ocean distribution of Oregon coastal hatchery coho is the same for OCN coho. Managers need unbiased estimates of OCN and OPI area public hatchery recruitment, unbiased OCN and OPI area public hatchery recruitment predictors, observations of actual ocean harvest rates on OCN coho, and better OCN ocean distribution information.

The following studies, along with changes in management techniques, are recommended to assist in improving OCN management.

LONG–TERM IMPROVEMENTS

Improvements in the methodologies used to manage the ocean harvest of OCN coho will take many years.

OCN Indicator Stock(s)

OCN indicator stocks are needed to provide information on actual ocean harvest rates and distribution. An indicator stock program for OCN coho would involve intensive monitoring of representative subunits of this group of stocks to provide estimates of critical population parameters. Ideally, such a program would consist of long–term sampling programs in several freshwater locations to provide reliable estimates of freshwater harvest, spawning escapement and smolt production. Additionally, these programs would mark smolts to estimate ocean fishery harvest rates and ocean catch distribution.

Although an OCN indicator stock program is obviously justifiable and appealing, many unanswered questions surround the feasibility of such a program. Some of the questions needing answers include:

1. How many indicator stocks are needed to adequately represent the range of life histories and population dynamics associated with the aggregate of stocks that comprise OCN coho?

2. Could indicator stocks provide estimates of population parameters with the necessary level of precision needed for management purposes?

3. Could an indicator stock program be conducted without jeopardizing the biological health of OCN populations?

As the first step in establishing an OCN indicator stock program, The OCN Coho Review Team recommends that a feasibility study be conducted to address the above questions. Similar programs are being conducted in the Northwest for chinook salmon. They are part of the Pacific Salmon Treaty monitoring and management of Klamath River fall chinook. Other programs exist for Washington and British Columbia coho stocks. Experience from these programs can provide answers for some of the above questions. Also, the applicability of recent developments in adult and smolt trapping should be explored. However, it should be recognized that the practicality of an indicator stock program may not be determined without direct field testing. Therefore, part of the feasibility study should include experimental development of methods in Oregon coastal streams.

Fishery Mortality Assessment Model

Concern exists over CAM's ability to adequately assess ocean harvest mortality of OCN coho. Improving harvest mortality assessments could be accomplished through the gathering of additional OCN coho ocean distribution information. Additional information is needed to support the present stratification level in CAM (number of time/area cells). This would entail increasing the CWT releases to adequately represent the stock. In addition, the team suggests the use of natural and hatchery stocks with coastwide representation.

Another approach to improving OCN harvest mortality assessment is the revision of the present model or development of a new model with time/area stratification supported by the available data. This implies that management of ocean fisheries be simplified. Also, realizing that coho non–retention fisheries will continue at some level, the integration of coho hook–and–release mortality assessment into the model is recommended.

SHORT–TERM IMPROVEMENTS

Improvements to some methodologies could be implemented in the short term.

OCN Recruitment Predictor

The OCN coho predictor adopted for use in 1988 was a Ricker stock–recruitment function modified to include an adjustment for interannual variability in ocean survival. This predictor has shown a consistent tendency to predict higher recruitments than actually occur. Given the quota management system, if the preseason predictor for OCN coho is too high, then the spawning escapement will be below the goal. Many factors could contribute to these overpredictions: (1) the ocean survival adjustment (public hatchery smolt survival) may not be appropriate for OCN coho, (2) the Ricker function may not be a major factor in determining annual abundance, (3) spawning ground survey densities may not be a good estimate of total spawners, (4) ocean survival conditions during the 1970s were better than average, and (5) other unidentified factors may be influencing recruitment.

Predictors are dependent on the quality of estimation of the dependent variable; in this case, OCN ocean recruitment. Expected bias in the spawning ground survey expansion factor leads to overestimation of total OCN recruitment. Using OPI area ocean harvest rates to represent ocean harvest rates on OCN coho may be incorrect.

The team recommends that the Council:

1. Adopt an unbiased OCN coho predictor.
2. Continue to improve the predictor as better information becomes available.

OCN Spawning Escapement Estimate

Present methods for estimating OCN spawning escapement have questionable accuracy and precision. Fundamental flaws associated with present methodologies can lead to overfishing these stocks through over estimating their abundance and thus allowing inappropriate ocean harvest. Standard spawning survey counts used to derive the current escapement goal for OCN coho have never been calibrated to determine how they relate to actual spawner abundance. These flaws were recognized in ODFW's Coho Salmon Plan, which recognized the need to improve OCN coho escapement methodology.

The completion of a study initiated in 1990 by ODFW is needed to develop a means of improving OCN coho spawning escapement estimates. This research followed a review by the Oregon State University Department of Statistics. They recommended incorporating a stratified random survey program (SRS) to estimate OCN spawning escapement. The present research project was designed to meet the following objectives:

1. Develop methods needed to implement a SRS approach to making OCN spawning escapement estimates.

2. Determine the precision of OCN spawning escapement estimates produced through a SRS survey program.

3. Determine the relationship between the spawning density of coho estimated from the current and the SRS survey programs.

4. Revise estimates of the total miles of coho spawning habitat in coastal river basins.

This research is planned to include four field seasons, during which standard and random spawning surveys will be conducted. These results will then be used to assess the accuracy of past escapement estimates and to improve predictors and stock status evaluations.

Hook–and–Release Encounter Rates

The current procedure which determines hook–and–release mortality is inadequate. Insufficient information exists for accurate assessments of coho interception rates. Further at–sea studies are recommended to determine the encounter rate of coho during various (1) abundance levels and (2) months. Additional study is recommended on gear selectivity paralleling the four–spreads per wire study conducted recently by ODFW and the troll industry.

Harvest Rate Management

Investigate and evaluate the feasibility of alternative approaches to quota management. The development of seasonal harvest rate structures which promote coastwide simultaneous fisheries on coho and chinook salmon may reduce the likelihood of high harvest rates on OCN stocks. Current management which depends on block time/area openings and closures is probably forcing disproportionate harvest rates on some OCN stocks compared to other OCN stocks (Council 1991). Other benefits with harvest rate management include better fishery stability, simpler regulations and a reduction in management cost.

This style of management would use block fishery openings over wide areas of the coast, in combination with effort and/or landing limitation, to achieve a target harvest rate. Actual harvest would vary dependent on stock size. The assumption is that catch per unit of effort during unrestricted fishing is a function of coho abundance. The degree which this is true will dictate the feasibility of this management system.

The reduction or elimination of non–retention fisheries is also recommended. Management lacks sufficient information to accurately assess these impacts. Simultaneous coastwide fishery structuring involving landing and effort controls in both the recreational and the troll industry would assist in achieving this.

Identifying the appropriate harvest rate for the OCN stock aggregate under this management process would be critical. The status of freshwater habitat and productivity of the various OCN substocks would need to be considered.

APPENDIX C
POSTSEASON METHODOLOGY FOR CALCULATING NON-RETENTION COHO MORTALITIES

The following is an outline of the methodology used to calculate hook-and-release mortality of legal sized coho in south of Cape Falcon ocean fisheries.

Hook-and-release Mortality - Overview

1. The estimated OPI area hook-and-release mortality since 1984 has ranged from 25,000 to over 100,000 coho per year.

2. The methodology assumes proportional impacts among OPI area stocks.

Hook-and-release Mortality - Methodology

1. For fisheries occurring before June 15:

   - Utilizes logbook coho/chinook data.
   - Incorporates a June gear type factor (1990 gear selectivity study).
   - Uses a release mortality factor (30 percent barbed hooks, 26 percent barbless hooks).

2. For June 15 through September 15 fisheries:

   - Based on observed effort by week by area.
   - Uses historical coho catch per day (CPD) by week by area which is adjusted by observed CPD.
   - Incorporates a 75 percent selectivity factor for targeting on chinook stocks (e.g., only 75 percent of the estimated CPD).
   - Incorporates a June gear type factor (1990 gear selectivity study).
   - Uses a release mortality factor (30 percent barbed hooks, 26 percent barbless hooks).

3. For fisheries after September 15:

   - Hook-and-release mortality is treated as natural mortality.