Defining and Evaluating Recovery of OCN Coho Salmon Stocks:
Implications for rebuilding stocks under the Oregon Plan

Summary of a workshop organized by the Independent Multidisciplinary Science Team, August 4-5, 1999

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Purpose of the IMST Workshop

The Independent Multidisciplinary Science Team (IMST) is preparing a report on harvest impacts, escapement, and recovery of Oregon coho salmon. The report will address the technical basis for actions identified by the Oregon Plan and Amendment 13 of the Pacific Coast Salmon Plan of the Pacific Fishery Management Council.

In spite of the fact that recovery of depressed stocks is the primary goal of the Oregon Plan and a legal mandate of the Pacific Fishery Management Council, the IMST has found no explicit statement of the definition of "recovery". The only criteria for determining whether specific stocks meet the goal of rebuilding stocks are the triggers for changing harvest levels. The IMST has been unable to find either an explicit conceptual framework for recovery or a description of the technical basis for the harvest management criteria.

Because this question is central to the Oregon Plan and harvest management of depressed salmon stocks, the IMST decided to explore definitions and criteria for recovery that may be useful to state and federal managers. The IMST convened 19 regional leaders in salmon management and research in a workshop on Goals for Recovery of OCN Stocks on August 4-5, 1999. The main purposes of the workshop were to 1) define the concept of recovery and 2) to identify criteria for evaluating recovery. Although the focus of the workshop was OCN coho salmon, the definitions and criteria for recovery apply to all salmonid species and populations. The following report summarizes the conclusions and recommendations of that workshop.

Participants in the IMST workshop on Defining and Evaluating Recovery of OCN Stocks on August 4-5, 1999 are listed below. This report attempts to capture the discussion and conclusions of the workshop, but it does not necessarily reflect the views of all participants.

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Background

Populations of Oregon Coastal Natural (OCN) coho salmon historically exceeded 1.5 adult spawners. As recently as the early 197Os, populations ranged from more than 600,000 to over 1 million adults, but their numbers have declined to less than 25,000 in the late 1990s. Similar declines in coho salmon stocks have been documented from British Columbia, Washington, and California. In 1994, targeted harvests of coho salmon in commercial and sport fisheries in the ocean off the coast of Oregon were eliminated. In 1999, however, a selective fishery for hatchery coho was permitted along the Oregon Coast. Numbers of ocean recruits have remained at low levels and reached a record low in 1997, despite the fact that escapement of adult spawners (i.e., numbers that are not harvested and enter freshwater) has remained fairly constant since the early 1970s. Furthermore, ratios of adult recruits per spawner demonstrate a decline over the past 20 years and have been below replacement in recent years. All three brood years of OCN (river) coho salmon will have failed to replace themselves if the preseason prediction for the 1999 brood is accurate (IMST communication with the PMFC-SSC 1999). These trends for OCN stocks resulted in the ESA listing of the Oregon Coast and the Southern Oregon/Northern California Evolutionarily Significant Units (ESU) by NMFS as "threatened". The Endangered Species Act defines a threatened species as any species or distinct population segment which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Oregon Plan for Salmon and Watersheds

The mission of the Oregon Plan for Salmon and Watersheds is **"to restore our coastal salmon populations and fisheries to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits"** (Oregon Coastal Salmon Restoration Initiative Conservation Plan, March 1997). The Plan explicitly states that one of the strategies of the Oregon Plan will be to "establish appropriate environmental benchmarks that will represent successful achievement of OCSRI goals and identify appropriate interim indicators that will track progress toward overall goals". In spite of these laudable goals, the Oregon Plan contains no explicit definition of what trends or responses would constitute "recovery" or "restoration" of coastal salmon.

Management of Ocean Harvest

The federally mandated Pacific Fishery Management Council (PFMC) that includes representatives from Oregon, Washington, California, the federal government, and Treaty Indian Tribes manages harvest of coastal salmon. PFMC was established by the Magnuson

Fishery Conservation and Management Act of 1976 and the Sustainable Fisheries Act of 1996. The Council is responsible for developing fishery management plans for salmon and other marine species off the coasts of Washington, Oregon and California. The state of Oregon manages most nearshore and inland fisheries but co-manage many of the fisheries in the Columbia River Basin together with the state of Washington and Treaty Indian Tribes. Recent salmon harvest management for ocean fisheries governed by the PFMC has been defined by Amendments 11, 13, and 14 to the 1984 Coastal Salmon Management Plan. Amendment 13 was adopted in 1997 as a recovery and rebuilding plan for OCN coho salmon, which "1) defines individual management criteria for four separate stock components, 2) sets overall harvest exploitation rate targets for OCN coho salmon that significantly limit the impact of fisheries on the recovery of depressed stock components, 3) promotes stock rebuilding while allowing limited harvest of other abundant salmon stocks during critical rebuilding periods, and 4) is consistent with the Oregon State recovery plan" (Draft Final Pacific Coast Salmon Plan, August 1999). The PFMC actions identify critical issues in rebuilding OCN coho salmon stocks-unique genetic composition of stocks, long-term cycles, critical periods- but published reports and plans do not explicitly define "recovery".

Though "recovery" or "restoration' are not explicitly defined in the Oregon Plan or PFMC's Coastal Salmon Management Plan, the harvest management matrix of these plans identifies criteria for some aspects of recovery (Appendix 1). This matrix numerically defines poor spawner abundance and low marine survival and sets trigger points for relaxation of harvest restrictions as these population attributes improve. Increased harvest above incidental levels is allowed when both spawning escapements and marine survival improve from low to medium or high levels. These criteria are indicators of positive responses in salmon populations and are examples of elements that could be included in a definition of recovery.

What Is "Recovery"?

Workshop participants agreed that the few existing state or federal definitions of recovery are broad but contain critical elements that should be included in more explicit definitions. The U.S. Fish & Wildlife Service defines recovery as:

> **"the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of species with the minimum necessary investment of resources" (U.S. Fish & Wildlife Service 1990).**

Workshop participants noted that most programs focused on the aspects related to reversal of declines and long-term survival, but most did not explicitly include neutralization of threats in evaluating recovery.

Workshop participants collectively identified relevant characteristics or responses of salmon that are important for defining recovery:

- Survival of populations or stocks is insured.
  - Populations are self-sustaining through long periods.
  - Risk of extinction is low.
  - Populations are adequate to cause delisting under ESA.

- Salmon are sufficiently abundant to meet cultural uses.
  - Salmon provide visual experience for the public.
  - Salmon are available to support social traditions.

- Salmon are sufficiently abundant to meet economic/consumptive uses.
  - Salmon can support sport harvest.
  - Salmon can support commercial harvest.

- Ecological requirements are met across geographic range:
  - Population size .
  - Productivity
  - Distribution
  - Diversity of life history types
  - Ecological functions of salmon in the ecosystem
  - Distribution of future habitats is suitable to sustain populations

Based on these attributes, subgroups of workshop participants developed three draft definitions for recovery:

<u>Alternative 1</u>
Recovery is the maintenance of diverse and productive freshwater habitat and sufficient natural spawners to produce self-sustaining levels of natural fish at maximum production levels over the long term. Maximum sustainable harvest or maximum sustainable production has been used to define such levels.

<u>Alternative 2</u>
A recovered population must be naturally self-sustaining over prolonged periods of poor climatic and environmental conditions at the level of basins or landscapes. The spawning and rearing habitat will be of sufficient quality and quantity to provide natural sustainability as well as substantial environmental, cultural, and economic benefits. Under all conditions, the population should be large enough and diverse enough at each life history stage such that:

- spawning escapements reflect historical, temporal and spatial distribution patterns,
- genetic diversity is maintained, with the goal of preserving as many of the historically observed phenotypes as possible,
- adult returns are adequate to fulfill necessary ecosystem functions.

Alternative 3

Sustainability is the most fundamental principle underlying salmon recovery. Wild fish must be sufficiently abundant, productive, diverse (in terms of life histories), and widely distributed that the resource as a whole is self-sustaining into the future. Recovered (self-sustaining) salmon populations should provide environmental, cultural, and economic benefits. However, consumptive benefits (from harvest) may limit the ability to achieve environmental/ecosystem benefits and non-consumptive cultural/economic benefits.

These definitions of recovery would most likely meet de-listing criteria of a population listed under the Federal ESA. They assume that spawning and rearing habitat will be available in sufficient quantity and quality to meet the minimum requirements for natural sustainability even under the poorest protracted climatic and environmental conditions relative to fish survival. Therefore, habitat restoration is vital for recovery. A key issue under ESA would be the status of populations and habitat over a "significant portion of the range". Even if the ESU were healthy in some parts, it would still be threatened or endangered if at risk in a significant portion of the range.

These definitions assume that even under minimum criteria for recovery there will likely be production above and beyond spawning escapement needs for consumptive uses. However, during the initiation and implementation of recovery measures, extreme caution must be exercised to avoid declines of populations to levels so low that demographic and genetic effects (e.g., depensation) create great uncertainty about the population's production response.

Opinions of the workshop participants differed about production levels that are targeted in. harvest management. Some members of the workshop felt strongly that a recovered stock should provide fisheries benefits at maximum sustainable production or some other level calculated to optimize harvest while maintaining sustainability. Other workshop members were concerned that a production optimization goal may not be the best strategy for managing salmon. In particular, maximum production is not necessarily compatible with the three bulleted criteria in Alternative 2 above. In 1977, Larkin published "An epitaph for the concept of maximum sustained yield", identifying several limitations to this approach. The scientific community remains divided on the use of maximum sustained yield in fisheries management, but the concept continues to serve as the cornerstone of management under the Magnuson Fishery Conservation and Management Act.

While recovery defined within the context of de-listing an endangered or threatened population meets minimum requirements for a self-sustaining population, it should not be construed as the definition within the context of the Oregon Plan. The Oregon Plan specifically includes goals for long-term sustainable production above and beyond spawning escapement needs. Rather than simply sustaining a recovered population at levels suitable for de-listing, Oregon Plan goals require that management measures should strive for production that insures self-sustaining populations, even in the worst environmental and climatic conditions, including protracted periods of poor conditions for fish survival.

Criteria for evaluating recovery

Major types of criteria

Stocks are characterized by their abundance, productivity, population structure, demographic independence, geographic distribution, and genetic structure. Workshop participants concluded that the most effective measures that could be related to criteria for recovery were:

- Abundance
- Productivity
- Spatial and temporal structure
- Diversity
- Ecological functions

Risk of Extinction-Models

A recent report to the PFMC assessed risks to OCN coho salmon stocks for a period of 99 years (33 generations) and provided a comparison of populations with no harvest to those subjected to recent management alternatives (ODFW-NMFS 1998). This assessment predicted that there is little difference in risk of extinction between harvest policies of either Amendment 11 or the more recent Amendment 13 under poor ocean conditions. The analysis also predicted that the risk of extinction with no harvest of any kind is 30-50% less than the risk with harvest under Amendments 11 or 13. OCN coho salmon populations from several tributaries of the north coast of Oregon exhibited much higher risks of extinction with no harvest impacts (20-35% chance of extinction within 99 yr) than mid-coast and south coast populations. The report concluded, “if poor marine survival persists for many generations, no harvest management regime alone will restore OCN coho salmon.”

Workshop participants felt that assessment of risk of extinction is an essential element of evaluation of recovery. In the context of the Endangered Species Act, recovery must be related to extinction risk. Existing models of life cycles, habitat relationships, or harvest impacts provide useful tools for quantifying risks of extinction (Allendorf et al. 1997, Nickelson and Lawson 1998, Wainwright and Waples 1998) and tracking changes in populations. At the same time, models are in early stages of development and uncertainty in projections is high. Existing models currently portray different risks of extinctions for some coastal basins and consistent trends for others. If we are going to use models to estimate risk of extinction, model relationships and assumptions must be specified. Links between observations about characteristics of healthy stocks and critical monitoring elements are necessary to increase confidence in model results. Key indicators could be used to supplement model estimates or replace models if model performance is questionable.

Extinction risk modeling addresses several criteria for recovery but not all criteria. Extinction risk models are weakly linked to genetic risk models. Metapopulation models are available but data are scarce (direction and magnitude of exchange) and they treat all units as equal. Empirical analysis of stock performance related to extinction risk projections is needed but is currently non-existent or preliminary. In particular, we need to link'observed attributes of healthy stocks to model projections.

Several critical elements for assessing extinction risk and recovery require increased research effort and funding:

- Future trends in distribution and quality of habitats need to be projected and used in assessment of extinction risk. Most assessments are based only on current habitat conditions. Habitat changes are likely to be at least as dynamic as other environmental factors and possibly more dynamic.
- Data on freshwater survival and production are critical but scarce.
- Assumptions about trends in marine survival need to be explicit.
- Climate changes are likely to affect marine *and* freshwater conditions and survival. These relationships and assumptions should be carefully inspected.
- Application of *different* models will reveal both differences and consistencies, which may be useful in identifying critical processes, areas of major risk, and gaps in knowledge. Contrasts between population dynamics approach with habitat-based approach can reveal important patterns or factors related to population trends.

Geographic context

Three different geographic contexts for OCN coho salmon management are recognized under the Oregon Plan-evolutionarily significant units (ESU) developed by NMFS, gene conservation groups (GCG) developed by ODFW, and four aggregate stock components under Amendment 13 of the PFMC. Allendorf et al. (1997) argue for assessment at a stock or watershed basis. Workshop participants concluded that goals for recovery can be applied effectively to these three different geographic contexts for spawner escapement and stock assessment. While they differ in spatial extent, they are largely hierarchical and can be nested.

Ecological needs

Measures of populations and genetic composition often focus on numerical responses of the salmon themselves but ignore food resources and ecological processes that support the productivity of the populations and fitness of the individuals. The roles of salmon carcasses in stream productivity have been documented in recent studies (Brickell and Goering 1970, Kline et al. 1990, 1993, Bilby et al. 1996). Recovery criteria should include a margin for carcass inputs and production of food resources for juveniles.

Specific criteria for recovery

Subgroups of workshop participants discussed criteria for recovery and listed the following stock characteristics or measures of performance that could be developed in the future frameworks for recovery. The following criteria are examples:

- Greater than 1: 1 spawner-to spawner replacement for at least three brood cycles (9 years) for each brood year of OCN stocks in GCGs or management units before minimal harvest impacts are exceeded
- Sufficient population size to ensure that 75% of high quality habitat is fully seeded in each GCG or management unit
- Escapement of spawners sufficient to produce maximum smolt production (MSP) for freshwater habitats
- Minimum populations of 1 ,OOO-3,000 naturally produced spawners per basin per year or brood cycle, depending on basin size
- Minimum production of 80- 120 smolts/female spawners at or below full seeding. This provides replacement of spawners at 3% marine survival. This could be either higher or lower at different marine survival rates (Bradford, M.J., Myers, B.A., and Irvine, J.R. in press).
- Sufficient population size to ensure that 25% of lowland habitats (e.g., coastal valley floor streams, tidal streams) can sustain populations at 3% marine survival
- Sufficient population size to ensure that 75% of populations meet or exceed recovery criteria in each GCG
- Sufficient population size to ensure that natural spawners maintain viable metapopulation structure, use marginal habitats, and provide genetic exchange with populations in adjacent basins. Such populations would provide "normal" levels of connectivity among subpopulations.
- Sufficient population size to meet ecosystem functions related to energy and nutrients from salmon carcasses
- Attain desired proportional distributions of high quality habitats (defined by historical patterns and modified by attainability and social acceptance), recognizing that stream habitats and landscapes are dynamic

Although target levels of total spawners and spawners/mile of stream were discussed for ESUs and GCGs, the workshop participants developed no specific recommendations.

Harvest management

Harvest management units in the ocean encompass broader coastal areas that contain mixed stocks with different proportions of stocks. Amendment 13 has provisions for allowing stepwise increases in allowable harvest rates for specific OCN components if they begin to rebuild faster than others. However, in mixed stock fisheries where data are not available to allow for harvest of OCN stock components at different rates, management actions will be constrained by the status of the weakest component stock. The PMFC's Salmon Technical Team emphasized this problem with Amendment 13 since the FRAM model does not evaluate impacts on each of the OCN components; hence there is no assurance that exploitation rates will be constrained within allowable levels for each component.

The current policy of increasing harvest impacts at 50% of full seeding of the best available habitat was a policy decision that was based on the expectation of a 50% increase in spawners in each subsequent generation, assuming a 3% marine survival rate. This technical basis, whether valid or not, is not documented by either PFMC or ODFW. Other conceptual frameworks, such as the habitat-based life cycle model (Nickelson and Lawson 1998), were not used to develop Amendment 13. In part, use of models was not possible because the Amendment 13 and the life cycle model were developed concurrently. The basis for the current policy is related generally to a precautionary approach that NOAA developed for managing fisheries (Restrepo et al. 1998). The rebuilding plan identified in this NOAA report calls for explicit identification of 1) stock size at maximum sustained yield, 2) a rebuilding period, 3) desired rebuilding trajectory, and 4) a transition from rebuilding regulations to more optimal management. Workshop participants agreed that assumptions for rebuilding and links between harvest levels or triggers for shifting harvest regimes need to be identified explicitly. The participants also agreed that the "Precautionary Principle" needs to be defined for Pacific Salmon stocks, and that using the term without a relevant definition was not appropriate.

Management decision points under Amendment 13 are presently based upon estimates of parental and grandparental spawning escapements and smolt to jack marine survival. Concerns were expressed that these criteria do not span sufficient time to indicate real population trends. Alternative requirements could be an absolute minimum criterion for recovery of OCN coho stocks of greater than 1: 1 spawner-to-spawner replacement for each brood year over at least three brood cycles and a recovery to a minimum population size before harvest impacts can exceed 10- 13%. Another alternative would be at least two consecutive generations of recovery (spawning recruits/parental adult of >1.5) until seeding above 50% of high quality habitat is achieved. Workshop participants agreed that the timeframe for population responses is a critical aspect of measuring recovery of salmon stocks and requires careful evaluation.

In spite of significant improvements, aspects of current management policies may not be precautionary or conservative. At the fishery exploitation rates of Amendment 13, what conditions should prevent directed harvest and maintain low mortality rates of ≤10-13%? At higher spawner abundances, what conditions would indicate that harvest rates could be increased? Workshop participants concluded that managers could:

- Make exploitation rate continuous rather than stepped
- Set most conservative exploitation rate at greater than 50% of full seeding
- Maintain minimum harvest impacts for several years when populations are recovering
- Manage harvest impacts for each stock component separately

Monitoring

At some point in the near future, the State will be required to evaluate the status and trend of coastal salmon and the success of the Oregon Plan. Development of an explicit definition of recovery and related criteria are essential for the development and rigor of the Oregon monitoring program. The process and criteria that will be used in that evaluation should be identified as soon as possible. The monitoring program should then be enhanced to provide the necessary information for the future assessment that will be required. Planned evaluation of status and trends should explicitly identify the statistical power to detect trends within reasonable time frames as part of the development of monitoring actions.

The Oregon Plan currently includes a monitoring plan, with annual reporting requirements, that addresses many of the elements that could define recovery (e.g., adult returns, juvenile out-migrants, smolt-to-adult survival rates, habitat assessments). The current monitoring approach was developed to assess many of the important attributes of OCN coho salmon stocks. Though not comprehensive or systematic, these measurements could be implemented rapidly and are likely to be key elements of a framework for recovery. As an interim tool, the current monitoring-plan is rigorous and has identified several new approaches (e.g., life cycle monitoring sites).

The Oregon Plan and the Coastal Salmon Plan of the PFMC are complex management approaches that require extensive information on populations at various life stages, habitat conditions, ocean survival, and harvest impacts; Workshop participants agreed that explicit links between development of harvest practices and 1) scientific database, 2) model projections, and 3) review of monitoring results are essential.

Major elements of monitoring systems for OCN coho salmon include the same five elements identified as criteria for evaluating recovery- abundance, productivity, spatial and temporal structure, diversity, and ecological functions.

Abundance

Abundances of both juveniles, out migrants, and adults are important measures of population status at the levels of watersheds, Gene Conservation Groups, ESU, and harvest aggregates. Measurement at all of these levels is extremely difficult and costly. The existing spawner survey of ODFW is one of the best long-term records of coho salmon abundance in the region, but it only provides data for one life history phase. Small populations are likely to respond differently to human and environmental stressors than large populations. Potential for interactions at low numbers may lead to unexpected outcomes. Monitoring systems should attempt to represent these distinct characteristics of stocks in their long-term assessment approach.

Monitoring of abundance can be too imprecise to detect numerical changes in escapement trends (Pella and Myren 1974). Abundances at different life history stages can respond differently to changes in freshwater habitat. Assessment of changes in freshwater survival based on numbers of spawners is difficult if marine survival and harvest rates are changing during the monitoring period (Hilbom and Walters 1992; Kormen and Higgins 1997). Integration of monitoring of abundances of specific life stages and habitat conditions in life cycle monitoring sites can improve the ability to interpret trends in coastal salmon. Further integration of data from these sites with life cycle models and'harvest data will provide an important monitoring component.

Productivity

Characteristics of healthy stocks need to be identified so that characteristics of coastal salmon stocks can be compared with model or trend projections. Measures of productivity, such as number of smolts produced per female, provide important indications of trends in , freshwater habitat conditions. Other measures, such as numbers of returning adults per smolt, may identify shifts in ocean regimes and potential harvest impacts. These measures require estimates of abundance at several life history stages. Such measurements require major sampling facilities, large staff and field crews, and analysis. As a result, the potential to gather such information at many sites across the range of coastal basins is extremely limited.

Currently this information is being collected at life cycle monitoring sites, however additional sites are desirable to represent a broader spectrum of OCN coho salmon populations. Monitoring efforts must be carefully designed to be representative, efficient, and effective. These innovative monitoring sites need to be coordinated with local habitat measurements, basin habitat assessments, remote sensing and long-term land use monitoring, use of hatcheries to provide marked fish to measure ocean survival, and experimental tagging of wild fish. Current staffing and funding levels are inadequate to provide these critical measures.

Spatial and temporal structure

The geographic distribution of salmon and conditions of their habitats are important measures of performance and potential for recovery. Monitoring the distribution of juvenile and adult OCN and habitat condition across the landscape is part of the existing monitoring plan. Distribution of spawners may reveal the degree to which available habitat is used and serve as an important measure of the status of stocks. Workshop participants suggested that benchmarks, such as 75% of available habitat occupied, could serve as useful measures of recovery of OCN coho salmon. In these applications, definitions and measurement of "available habitat" and "high quality habitat" is essential. Along with these measures of the distribution of salmon in different watersheds, the condition of freshwater habitat-current, historical, and future-across the landscape is an important and readily monitored measure of recovery. Workshop participants stressed the need for more dynamic and spatially descriptive measures of habitat in all aspects of monitoring, modeling, and policy. Trends in relative abundances of different quality habitats are essential for determining the potential threats to stocks and the potential for recovery during favorable climatic conditions. Development of both historical reconstructions and future projections of habitat conditions is essential for determining trends in OCN coho salmon and assessing their risk of extinction through models. Workshop participants noted that recent development of satellite remote sensing technology makes monitoring of land use and land cover both effective and affordable. Increased spatial resolution is increasing the accuracy of such habitat-related assessments.

Diversity

Beyond simple abundances, measures of the numbers of ljfe history types and their representation across the landscape are important elements of an analysis of long-term stock dynamics (Healey and Prince 1995). Workshop participants noted that life history diversity is strongly linked to genetic diversity, leading to the old admonition to make sure you keep all the pieces (Leopold 1966). Such measures could include phenotypic/life history diversity, run time, age structure, body size, juvenile out migration, and ocean migration patterns. Distributions and abundance of major ecological types (e.g., populations in clear water versus glacial systems) and their abundances may demonstrate trends and help identify causal factors.

The participants felt that additional focused funding and staffing support are required for monitoring of fish abundance at all stages, habitat measurements at reach levels and basin levels, ocean survival, and application of existing models of habitat, production, harvest impacts, and risk of extinction. Workshop participants strongly endorsed expansion of the life cycle monitoring sites currently being developed by ODFW. These sites provide important data on all life history stages for selected sites along the coast. These sites will directly measure smolt-to-adult survival so that ocean survival as well as harvest impacts can be differentiated in assessment of population trends. Coordination with hatcheries to provide marked fish for these areas would provide an alternative measure of ocean survival. Limitation of specific funding for this critical monitoring approach is a major concern.

Hatchery practices and hatchery fish can strongly affect behavior, fitness, migration timing, and genetics of coastal salmon. Understanding the percent of populations of natural and hatchery origin is critical. Current mass marking programs allow the percentage of hatchery fish spawning with wild fish to be estimated during spawning surveys.. While spawning surveys provide information on numbers and proportions of marked and unmarked spawners, they do not provide measures of the consequences of spawning between hatchery and wild fish. The relative reproductive success and mixing of natural and hatchery fish is an important factor in stock status, but research is extremely scarce. Recent development of genetic markers to identify progeny makes such studies possible and would be an important addition to the proposed life cycle monitoring sites.

Ecological functions

The ecological role of adult salmon, particularly as a nutrient source for freshwater communities and young salmon, traditionally has been ignored in salmon monitoring. Recent studies of the role of carcasses in nutrient cycling demonstrate the need for production well above minimum viable populations to support ecologically healthy and robust stocks. Though carcass distribution programs are being initiated in several Oregon coastal drainages, currently there are no scientifically sound experimental measures of the effects of salmon carcasses in coastal streams for OCN coho salmon. However, studies conducted in other areas suggest that OCN coho populations may benefit from such programs. Workshop participants recommend explicit attention to functional aspects of salmon populations in addition to measures of abundance.

Major Conclusions:

The Oregon Plan was created because of clear declines in coastal salmon populations. The State is faced with serious questions about risk of extinction of populations, major factors contributing to declines, goals for resource decisions, guidance for public and private actions, and design of monitoring. Assessment and future projections of the status of salmon stocks are a central requirement in each phase of the Oregon Plan.

Participants in the workshop arrived at the following conclusions:

1. **Explicit definition of recovery of depressed stocks and criteria for evaluating population status and trends is essential for successful implementation of the Oregon Plan for Salmon and Watersheds and the PFMC's Coastal Salmon Management Plan. These should be developed as soon as possible.**

2. **Recovery should encompass the three major elements identified in the U.S. Fish and Wildlife Service .definition-reversal of declines, neutralization of threats, and insured long-term survival.**

3. **During periods of environmental stress or poor ocean survival, salmon populations must be protected and habitat quality must be restored to prevent extinctions and to permit future rebuilding of salmon stocks.** ,

4. **Criteria for stock performance and habitat conditions should be established to provide guidance for rebuilding salmon stocks under varying ocean and freshwater conditions over the long term.**

   4 a. An increase in numbers of salmon alone does not constitute recovery, even if abundance exceeds minimum viable populations or harvest production targets.

   4 b. Widespread distribution of salmon populations in watersheds and appropriate habitat conditions must be achieved during periods of good survival to provide a buffer against subsequent periods of poor survival.

   4 c. Adequate and appropriate genetic variability must be represented in the populations.

5. **Definition of recovery under the Oregon Plan should emphasize the long-term viability of salmon populations. However, recovery is not complete until production is adequate to provide social, cultural, and economic benefits.**

6. **The long-term nature of recovery requires assessments based on dynamic climate, habitats, and environmental conditions. Assessments and model evaluations should incorporate the historic range of habitat conditions across the landscape and, more importantly, future alternative habitat patterns across the landscape.**

7. **Criteria for evaluating recovery of depressed stocks should be developed. They should include measures of salmon abundance, productivity, spatial and temporal structure, diversity, and critical ecological functions of salmon.**

8. **The process and criteria that will be used to evaluate the status and trend of coastal salmon and the success of the Oregon Plan must be identified as soon as possible. The monitoring program should then be modified where necessary to provide the required information for future assessment.**

9. **Current funding and staffing for monitoring and modeling of coastal salmon trends are inadequate and fragmented. Additional funding and staffing support are required for monitoring of fish abundances at alllife-history stages, habitat at reach and basin levels, ocean survival, and application of existing models of habitat, production, harvest impacts, and risk of extinction.**

10. **The state should develop specific actions that explicitly represent application of the-Precautionary Principle under the Oregon Plan. The Precautionary Principle needs to be applied to wild salmonids and to be integrated with the best available science into the management of OCN coho salmon by the Pacific Fishery Management Council and ODFW.**

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Appendix

Harvest matrix from Amendment 13 to the Pacific Coast Salmon Plan

4.1 Council-Adopted Alternative

The Council recommends implementation of Alternative 1 with minor modifications to Table 6 as presented below in Table 12. The modifications include edits to Footnote b and the addition of Footnote c which incorporates some of the criteria formerly listed within the "Low" Parent Spawner Status cell of Table 6 (additions to the language in Alternative 1 are in bold type).

TABLE 12. Council-adopted, allowable harvest impact rate criteria for OCN coho stock components.

	SMOLT TO ADULT MARINE SURVIVAL[a]		
	Low	Medium	High
PARENT SPAWNER STATUS[b]	ALLOWABLE TOTAL FISHERY IMPACT		
High Parent spawners achieved Level #2 rebuilding criteria; grandparent spawners achieved Level #1	≤ 15%	≤ 30%	≤ 35%
Medium Parent spawners achieved Level #1 or greater rebuilding criteria	≤ 15%	≤ 20%	≤ 25%
Low Parent spawners less than Level #1 rebuilding criteria	≤ 15% ≤ 10-13%[c]	≤ 15%	≤ 15%

Stock Component Rebuilding Criteria:	**Level #1** (50%)	**Level #2** (75%)
Northern	10,900	16,400
North-Central	27,500	41,300
South-Central	25,000	37,500
Southern	2,700	4,100
Total	66,100	99,300

a/ See the discussion of marine survival under Section 2.2.1.3.

b/ In the event that a spawner criteria is achieved, but a **major** basin within the stock component is less **than ten percent of the full seeding level,** the next tier of additional harvest would not be allowed in mixed-stock fisheries for that component, nor additional impacts within that particular basin (see

Table A-3 in Appendix A for a list of ***major*** basins within stock components ***and Table A-2 in Appendix A for the spawners needed for full seeding at three percent marine survival).***

c1 This exploitation rate criteria applies when parent spawners are less than 38% of the Level #l rebuilding criteria, ***or when marine survival conditions are at an extreme low as in 1994-1996 (<0.06% hatcher-y smolt to jack survival).***

The provisions in Footnote b were designed to protect weak portions of a stock component when there are serious disparities in the coho abundance levels of various major river basins within the component. Under Alternative 1, Footnote b Aid not contain a clear definition of what constituted "a severe conservation problem" or a "basin". The modifications to foot note b provide (1) a specific standard at which harvest impact increases for a stock component are prohibited-" less than 10% of full seeding in any major river basin", and (2) a reference in Appendix A to identify the full seeding level for each major basin.

Footnote c contains the triggering criteria of Alternative 1 (38% or less of full seeding) to limit the allowable harvest impact rate to 10- 13% or less. In addition, Footnote c specifies that this harvest limitation also applies when marine survival conditions are at an extreme low as in 1994-1996.