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***NCASI's Mission***
*To serve the forest products industry as a center of excellence for providing technical information and scientific research needed to achieve the industry's environmental goals.*

## CONTENTS

## 7.3 Revisiting the Botkin Salmon Study

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### 7.3.1 *Introduction*

In 1991 the Oregon Senate funded a "scientific inquiry on the state of knowledge of the anadromous fish runs in western Oregon." With publication of the final report in 1995, the so-called "Botkin Study" virtually disappeared from salmon discussions. In this paper we resurrect the Botkin Study, providing a "condensed" version of the report and its findings. In particular, we discuss key findings and recommendations of the report, especially those related to forest management. For each of these we attempt to answer the questions--do these findings hold in terms of our current understanding; and have the recommendations of the report been acted upon?

THE BOTKIN STUDY:

Oregon Senate Bill 1125 (1991) authorized a "scientific inquiry" on anadromous fish runs in western Oregon. Specifically, project goals for the Botkin study were established to:

1) "Conduct an objective, non-ideological analysis of existing information" regarding anadromous fish populations in western Oregon;
2) "Explain what actions and policies are possible for constructive solutions to the declines of the fisheries,"
3) "Explain the implications for the environment . . . for each of the policy options,"

and

4) "Suggest ways that management may be improved . . . by improving the connection between scientific research and management."

In 1992, Dr. Daniel B. Botkin, then with the Center for the Study of the Environment (CSE), was hired to conduct this study. A "blue-ribbon panel" of experts was formed to guide the analysis of information gathered by CSE staff and subcontractors, based on a study approach previously used by Dr. Botkin for assessing flow requirements for Mono Lake, California.

SCALE OF THE STUDY:

Support from the California Department of Forestry and Fire Protection expanded the study area to include northern California. The study area covered ". . . western Oregon south of the Columbia River and west of the Cascades, continuing south to include the Klamath and Trinity watersheds in California," as well as portions of the Pacific Ocean (Figure 1).

The time frame used by Botkin included all of recorded history (generally less than 225 years for the study area, depending upon specific locations), with a concentration on the last 150 years (since European settlement). The reliance upon "credible statistics" further reduced the effective time period to less than 50 years, well within the living memory of much of his intended audience. Analysis of trends in regional salmon populations, therefore, is generally limited to the time since World War II. As a result, Botkin doesn't consider the important 1860-1940 period of settlement, commercial fisheries, industrialization, and human population growth.

INTENDED AUDIENCE:

Botkin's audience is clearly intended to be the State legislators that ordered the study and OSU scientists that managed its completion. For example, most of his final recommendations for actions described in Report 8 (Botkin et al. 1994: Vol. 2, p.219-225), begin with the phrase "*The state of Oregon should...*"

The intended audience for this paper is the private landowners and resource managers of western Oregon who operate on a county, river drainage, and sub-basin scale to manage individual salmon stocks. This problem (general policy versus local action) is addressed by Botkin as the fourth goal of the study: to "suggest ways that management may be improved…by improving the connection between scientific research and management."

## IDENTIFICATION OF COMMON BELIEFS:

The Botkin study listed six common beliefs about salmon populations and habitat that provided the basis of the debate (and the funding for his study) regarding salmon abundance and survival:

1) Prior to European settlement, there was a super-abundance of salmon;
2) Prior to European settlement, the forests of western Oregon and northern California were essentially all old growth;
3) This extensive old growth was essential to the super-abundance of salmon;
4) American Indians had little effect on the extent of old growth and the abundance of salmon;
5) There has been a great decline in salmon abundance since the time of European settlement;
6) This is directly related to a great decline in old growth extent since the time of European settlement.

The second belief has been largely disproved (Zybach 1993a, Teensma et al. 1991), a condition used by Botkin to discount the third and sixth beliefs (Botkin et al. 1994: Vol. I, pp: 75-83). However, it is still generally believed that a super-abundance of salmon existed in western Oregon prior to European settlement, and that a great decline in salmon populations has occurred since that time. The role of Indians in the prehistoric environment of western Oregon remains an issue of debate (Zybach et al.1995, Zybach 1993a).

## ASSUMPTIONS OF THE BOTKIN STUDY:

The Botkin study's goals were addressed on the basis of five stated assumptions:

1) Rational solutions are possible for complex environmental problems;
2) Preferred solutions are rationally based upon the best available scientific information;
3) It is possible to take constructive actions even when information is incomplete;
4) Research and management are integral parts of the same processes; and
5) Completely definitive answers are seldom possible.

These assumptions provide the rationale for applying the findings and recommendations of the Botkin study on an immediate and practical ("*constructive action*") basis. This paper examines to what degree such actions, based upon Botkin's research and proposed solutions, have taken place in the nearly three years since his report was completed.

### 7.3.2 *Pocket guide to the "Botkin Study"*

Nine reports were prepared as products of the "Botkin Study". These included:

- Report 1: *Rationale for a New Approach*
- Report 2: *Related Studies*
- Report 3: *Available Data on Fish Populations*
- Report 4: *Available Data on Land Use*
- Report 5: *Analysis of Fish Models*
- Report 6: *Forecasting Spring Chinook Runs*
- Report 7: *Management of the Riparian Zone for the Conservation and Protection of Salmon*
- Report 8: *Findings and Options (3 volumes)*
- Report 9: *Overview of Findings and Options*

Reports 1 through 7 represent ongoing progress during the study to identify sources of information, and provide data synthesis and analysis of key questions. Report 8 provides the reader with a comprehensive discussion and the final conclusions and observations of the study. The Botkin Study seems to have been a source of frustration for members of the study team, if we interpret correctly some of the remarks in Report 8. For example, the authors note that *"demands are made on scientists to provide scientific answers on issues for which there has never been an adequate plan or attempt to obtain measurements, as if science were alchemy, and that scientists could conjure up rationally based, scientific answers and policy out of old beliefs and folklore."* The lack of data, from statistically reliable fish counts to past management histories, frustrated cleaner evaluations, yet a number of conclusions having significance to forest management were reached.

SUBSECTIONS AND FINDINGS OF REPORT 8:

Report 9 is a succinct summary of most information contained in the three volumes of Report 8. As such, it can be used as a functional introduction and index to the entire Botkin study. Report 8 remains the more comprehensive description of findings, containing nine sections of discussion with over 50 subheadings, and covering 175 pages (Botkin et al. 1994: Vol. I, p.26-201). Brief titles and descriptions of each of the sections are given below, as a means to bridge the goals and assumptions of the Botkin Study with a listing and analysis of the recommendations that follow:

Counting Fish (Botkin et al. 1994: Vol. I, p.26-51):

This section discusses the analysis of trends, peak count data, comparisons between dam counts and peak counts, long-term trends, valid statistical monitoring methods, trends from other regions, and numbers of returning adult fish in recent years. Much of this work was completed under contract to Dr. Benjamin Stout. A thorough examination of possible correlations between salmon populations, ocean troll success, water flow levels, and logging activities in the Willamette River basin caused Stout to conclude (Stout, 1994: p. 28):

> *"The salmonid fishery would be much better served if those responsible for monitoring the several species would have a carefully designed sampling program. The effect of this would be a dataset that could use more sophisticated analyses and begin to develop cause and effect relations rather than correlations that may be spurious."*

A more complete discussion about salmon population counts is provided in Section 7.3.3, Statistically Valid Data.

Status of Salmon Stocks (Botkin et al. 1994: Vol. I, p.51-57):

This section discusses Geographic Information System (GIS) work based upon Frissel's Wilderness Society study of old growth timber and salmon population patterns. However:

> *". . . because the data are from such a wide variety of sources, and it is not clear which sources provided information about which stocks, the determinations do not meet standard statistical requirements. . . we warn the reader that we cannot guarantee the reliability or accuracy of the status of stocks."*

A more thorough examination of the limitations imposed by Botkin's reliance on the Wilderness Society GIS layers is provided by Norheim (1997). Also, see the expanded discussion in Section 7.3.3, Trends Assessments for the Rogue and Umpqua Rivers.

Use of Models to Forecast Fish Returns (Botkin et al. 1994: Vol. I, p.58-74):

This section describes traditional fish forecast models, models in use today, models used to set harvest levels, correlations between water flows and salmon status, and the role of hatcheries in increasing fish populations. See discussion in Section 7.3.3, Management Models.

Riparian Zones and Salmon Status (Botkin et al. 1994: Vol. I, p.75-111):

This section discusses current status of riparian zones within the study area, riparian habitats, forest succession, riparian habitat functions for salmon, riparian zones as a focus of management, geomorphic features, functions, shading, litter, sunlight, nutrient flows, history of "destruction," agricultural and urban uses, spatial and temporal scales, proposed setback options, the FEMAT plan, ODF proposed (c.1993) rules, and some "experimental strategies." See discussion in Section 7.3.3, Adequacy of Forest Riparian Protection in Oregon.

Watershed Conditions and Salmon Status (Botkin et al. 1994: Vol. I, p.112-138):

This portion reviews the functions and roles of watershed-based agencies, multiple and overlapping government jurisdictions, watershed level conditions affecting salmon habitat, floods, seasonal variations in flow after logging, sediment supply and migration, land use and erosion, channel morphology, cyclical impacts (Gordon Reeves' theories), gravel removal, importance of geomorphic processes for salmon habitat, estuaries, agricultural effects, stream habitat loss in urban areas, and dams.

Effects of Chemical Usage on Salmon (Botkin et al. 1994: Vol. I, p.139-145):

This section discusses uses of pesticides and fertilizers in Oregon, effects of pesticides on fish, detecting pesticides in streams and industrial pollutants.

Correlations Between 1988 Land Conditions and Salmon Stocks (Botkin et al. 1994: Vol. I, p.146-164):

This section discusses methods of regression analysis, results, comparisons of relative effects between agricultural practices and forestry practices, forestry practices and urban effects, and resolving the varying conclusions. See the discussion in Section 7.3.3, Land-Use Correlations.

Oceanic Factors Affecting Salmon Abundance (Botkin et al. 1994: Vol. I, p.165-173):

This section discusses upwellings, El Niño, salmon production, "Large-scale Environmental Change in 1976," conflicting findings about ocean effects, and climate variability (Kaczynski 1997, Section 7.13.)

Sources of Salmon Mortality (Botkin et al. 1994: vol. I, p.174-201):

This section discusses ocean fishing, legal and illegal bycatches, drift-nets, marine mammals, conflicting findings, and bird predation.

KEY FINDINGS OF REPORT 9:

Report 9 reduced the findings to 25 pages (Botkin et al. 1995: p. 20-44) and organized them into three categories:

1) general findings (those of interest to the manager, but more likely to be considered at a regional or statewide scale),

2) the populations of current stocks, and

3) the presence (as opposed to absence or extinction) of current stocks.

The latter two categories have specific application at a watershed-scale and are of most potential use to landowners and resource managers.

General Findings:

- **Salmon populations are only partially open to control or influence by people. Ocean conditions or seasonal and long-term climate changes, for example, appear to have great influence over survival rates of adult and juvenile populations.**

We believe this to be an important consideration. Salmon spend most of their adult lives at sea, where most adult mortality occurs (Figure 2). It has been recognized for some time that major declines in salmon populations have resulted from ocean conditions outside direct human influence (Van Hyning 1968). For example, Figure 3 identifies specific years (c. 1917 and c. 1925) of nonhuman-related salmon decline in Alaskan fisheries. These fisheries included significant numbers of Oregon chinook, steelhead, and chum (DeLoach 1934: p.34).

- **Models currently in use for setting harvest quotas are not adequate for this purpose, for projecting population trends, or estimating the effects of human actions on fish abundance.**

In Report 5 (Botkin et al. 1994) systematically dismantled computer models in current use and/or development for a number of stated reasons:

> *"As with most models used in the management of fisheries worldwide, the models used for the Pacific Northwest assume that the environment, both natural and influenced by humans,*

> *is constant. Of course there is no such consistency . . . Therefore, effects of environmental change on salmon populations cannot be adequately addressed with these models. . .*
>
> *Current models assume a logistic growth curve as the fundamental density-dependent relationship . . . When used as the basis to set harvests, methods based on the logistic curve have failed repeatedly for more than 50 years. . .*
>
> *Another problem, perhaps the major problem, with existing models is that they tend to require data that are not available, or are inadequately available, and may be difficult and costly to measure under any conditions. . .*
>
> *Existing models are not adequate for realistic, accurate projections of populations, trends, harvest quotas, or to estimate the effects of human activities on fish abundance. . .*
>
> *Neither an adequate nor comprehensive model exists at this time."*

A set of standards for developing new computer models is discussed, with three basic criteria established to compensate for inadequacies in the existing models: 1) predictions must be restricted to variables that can be readily measured; 2) parameters must be derivable from data that can be readily obtained; and 3) important causes of variation in fish populations must be taken into account (Botkin et al. 1994: p.13). Some of the factors recommended to be represented in new models include water quality, water temperature, gravel conditions, habitat complexity, and predation. See the discussion in Section 7.3.3, Management Models.

- **The present state of science does not allow for the precise determinations of genetic differences among Pacific salmon stocks.**

We believe that this is an important point that needs further consideration. For example, Table 1 (Weber and Fortune c.1973: p.7) demonstrates the great number of summer steelhead hatchery smolts introduced to the Siletz River in the 1950s and 1960s. Many of these fish were hybrids, or were obtained from stocks native to other rivers. Despite these documented introductions, focused efforts are currently being taken to "save" the "only native run of summer steelhead in the Oregon Coast mountain range" (Meehan 1995: p.C1).

- **Under the Endangered Species Act, there are many more management options for stocks listed as threatened rather than endangered. Therefore, for good legal and resource management reasons, it benefits both the State of Oregon and private landowners to prevent threatened stocks from becoming endangered.**

It should be noted that this finding is reflected in current statewide efforts to keep "threatened" stocks of western Oregon coho, cutthroat trout, and steelhead from becoming listed as "endangered" by the US Fish and Wildlife Service. This rationale is at the core of the Governor's Coastal Salmon Plan (Nicholson 1997).

- **The potential production of salmon in a stream changes through forest age. Following the clearing of riparian vegetation, there is a period of about one to five years when potential salmon production increases. Between six to forty years, potential production falls to a minimum. After 40 years, potential production is about the same as for a mature forest.**

We find this is a debatable, and in some cases, inaccurate, conclusion, perhaps reflecting a bias against past logging practices. Figure 4 is taken from the Botkin report and illustrates this finding. The difficulty in using information of this nature for practical management applications is that it is, as labeled, hypothetical. It is unlikely that salmon populations can be related so closely to local stand age of trees, or any other single factor, without considering the specific salmon species, the limiting channel conditions or competitive interactions, or the stream classification or ecoregion. Recommendations for using information of this type before testing and without caution is probably premature. This is especially true because current forest practices in Oregon, with few exceptions, avoid clearing of riparian vegetation. See Section 7.3.3, Adequacy of Forest Riparian Protection in Oregon.

The pattern of increased aquatic productivity immediately following riparian disturbance is not a new observation (Bisson 1996, Hall 1982). In fact, one of the ironies of forest riparian research has been increased fish productivity immediately following harvesting near streams (Hawkins 1981). Similarly, Bisson (1996) has found a period of high productivity following disturbance of streams by the eruption of Mt. St. Helens, despite elevated stream temperatures. This period of elevated productivity was followed by a decline. This pattern can be explained by the increase in primary productivity due to increased light and resulting, abundant, high quality food for salmonids in the form of increased grazing invertebrates.

Observations by Connolly and Hall (1994) about cutthroat trout populations in coastal Oregon forest streams shows the importance of understanding the specific mechanisms for response and not relying on stand age as a single surrogate for physical/biological riparian conditions. Connolly and Hall found that the lowest cutthroat trout populations were low in second-growth stands where conifers dominated the riparian vegetation and in-stream large woody debris (LWD). They also found the highest cutthroat trout populations in second-growth stands where hardwoods dominated the riparian vegetation and large woody debris was abundant. In some case, short and long-term management implications will need to be weighed (i.e., the benefits of conifers versus hardwoods as riparian vegetation). Again, a single factor, like stand-age, is not an adequate measure without information about the stream type, aquatic species of concern, vegetation, and other factors. The riparian forest may have dramatically different characteristics than the upslope forest, especially under the new forest practice rules. Other factors, like aquatic species of concern, tree species in the riparian zone, and the presence of large woody debris may greatly influence the productivity of the stream reach.

**Table 1** Siletz River summer steelhead stocking rates, estimated angler catch and underwater resting pool counts.

Note method for determining stock of sport catch and relation of stocking rate to subsequent (2 to 3 year) resting pool counts.

(Weber and Fortune c. 1973: p. 7)

| Year | Stocking Rate[b] | Estimated Angler Catch[c] | Underwater Resting Pool Counts |
|---|---|---|---|
| 1956 | -- | 385 | -- |
| 1957 | -- | 221 | -- |
| 1958 | -- | 298 | -- |
| 1959 | 25,000 | 358 | -- |
| 1960 | 29,500 | 596 | 443 |
| 1961 | -- | 1,057 | 515 |
| 1962 | 52,000 | 486 | 284 |
| 1963 | 58,200 | 814 | 473 |
| 1964 | 52,600 | 465 | 244 |
| 1965 | 55,400 | 1,406 | 519 |
| 1966 | 60,000 | 2,526 | 867 |
| 1967 | 59,000 | 1,136 | 634 |
| 1968 | 74,000 | 2,568 | 249 |
| 1969 | 80,100 | 2,291 | 653 |
| 1970 | 109,000[a] | 2,877 | -- |
| 1971 | 75,000 | 6,810[d] | 430 |
| 1972 | 84,000 | 4,002[d] | 354 |

[a] Includes 43,000 hybrid winter-summer steelhead

[b] Bulk of fish return to the river two years after release

[c] Derived from angler catch cards, not adjusted for bias. Statistical estimates of bias for period 1962-1971 range from -15.6% to -18.7% (Oregon Wildlife Comm., 1972). All steelhead catches for the months of May through November were assumed to be summer steelhead. This assumption is not entirely correct.

[d] Includes hybrid winter-summer steelhead.

- **The general policy of large-scale removals of large woody debris (LWD) from stream channels prior to 1980 is still limiting the quality of salmon habitat, a condition that could persist for 50-100 years following the removal of the debris.**

Again, we find this to be a debatable conclusion. Figure 5 shows the rate and volume of logging in Oregon since white settlement, with most harvest beginning after 1920 and peaking in the 1950s and 1960s. Conversely, Figure 6 shows a marked decline in chinook landings on the Columbia River between 1880 and 1920 (a 40-year period preceding most logging in Oregon), and reaching bottom in the 1950s and 1960s. To further confound this pattern, Figure 7 shows a marked increase in Columbia River chinook from the 1960s to the present, a period during which riparian large woody debris should have been at a minimum and salmon habitat (and therefore, populations) the most "limited."

One possible argument supporting the Botkin connection between large woody debris removal and salmon decline is the change in character of forest harvesting and stream treatments. While declines prior to 1920 may not correlate to the highest periods of timber harvest, these are periods when splash dams, and harvesting and yarding in stream corridors were acceptable options. Concurrent activities along major waterways associated with agriculture, urban development, and navigation removed large wood debris, channel sinuosity, and wetland connections.

Past management affects probably varied depending on channel conditions and the forest stand management. Particularly for small streams, there were concerns about the increased large woody debris loads occurring after harvesting and, in some cases, wood placed in streams as part of corduroy roads in the 1920's and 1930's can still be found today.

Despite the apparent lack of correlation between logging history and salmon decline (in addition to chinook, most other salmon species are believed to have declined dramatically in western Oregon before 1900 or 1920 as well), Botkin offers a proposed option to help compensate for this "limiting" condition (Cummins et al. 1994: p.2):

> ". . . *an inventory of the large trees capable of supplying large woody debris is carried out. The existing number of such trees is compared with the appropriate large woody debris loading required for salmon habitat found in average riparian forests. If the count is lower than this amount, then one protects a wider zone to include the required number of trees.*"

We note in this management formula an arithmetical standard (average number of trees) for an untested assumption ("appropriate" for "required" salmon habitat) based on unmeasured amounts of large woody debris found in "average riparian forests" is used to determine logging buffer zone width. In this option, whoever determines the average number of trees required to load large woody debris sufficient for salmon habitat on average riparian forests (and convinces others that this has been accomplished) influences all logging boundaries for streams and headwalls, i.e., virtually all logging boundaries in the Douglas-fir region.

. Over time, under this option, all dynamic and diverse qualities associated with riparian zones in different forests, at different elevations, in different counties, etc., would be manipulated to conform to an idealized homogenized "average." In fact, the Governor's Oregon Plan voluntary guide for managing large woody debris follows the basic concepts and methods of this formula (Bell, et al. 1997). A useful alternative is proposed by Newton et al. (1996) to use active management to accelerate the development of desired riparian forest conditions while still providing for economic returns.

Bisson et al. (1987) report that, "large woody debris enhances the quality of fish habitat in all sizes of stream." House and Crispin (1990) have even correlated fish numbers and the economic value of those fish to large woody debris in streams. Yet, when Bisson and Sedell (1982) compared streams in clearcut and old growth stands and they found more fish biomass in the streams associated with clearcuts. However, there was a shift in the proportions of species and age classes.

> "*Riffles in streams that underwent extensive debris removal were elongated and in many cases extended through former pool locations. Increases in the proportional abundance of underyearling steelhead and cutthroat trout after clearcutting is possibly explained by the preference of these fishes for riffle habitat, while the relative decline of coho and older cutthroat may have resulted from the loss of pool volume and large, stable debris for cover.*

While large woody debris is generally desirable for fish habitat, no one stream habitat conditions is best for all fish species and age classes.

- **Average mortality of chinook and coho by legal fishing for the years 1952-1991 were computed to be:**

| | | | |
|---|---|---|---|
| Ocean, commercial | 2,385 metric tons | 65% | |
| Ocean, sport | 827 metric tons | 22% | |
| Ocean, legal bycatch | 225 metric tons | 6% | (all salmon) |
| Freshwater, sport | 248 metric tons | 7% | |

By comparison, predation by birds, marine mammals and illegal fishing was assessed to be minimal (Botkin et al. 1995: p.37). See the discussion about local perspectives in Section 7.3.3.

Populations of Individual Salmon Stocks:

Has there been a change in overall salmon numbers since European settlement? According to Botkin, little information exists at this time to arrive at meaningful conclusions, even for the past 50 years (Botkin et al. 1995: p.19):

> *"One example of the lack of adequate data is that although there are counts of salmon at many locations, of the 26 major rivers that flow into the ocean within the study area, there are scientifically valid counts on only the Rogue and on the Umpqua, and only at one location each."*

Beginning in the 1940s, direct counts of returning adults that passed by a viewing window at the Gold Ray Dam on the Rogue and the Winchester Dam on the Umpqua provided the only statistically valid numbers that have been assembled for any stocks of coastal Oregon salmon south of the Columbia River. The "most striking thing" about the result of these counts is the great variation in returning adult populations from year to year. Statistical analyses confirms no consistent trend that can be applied to all species on both rivers. See the discussion in Section 7.3.3, Statistically Valid Data.

- **On the Rogue River, only fall chinook and summer steelhead show significant statistical trends. Both are upward. On the Umpqua, fall chinook and summer steelhead are also the only two stocks showing a significant trend. Both are downward** (Botkin et al. 1995: p.20). See the discussion in Section 7.3.3, Trend Assessments for the Rogue and Umpqua Rivers.
- **Based on the observations of a local commercial fisherman and intensive statistical analysis, it has been shown that 80 to 90 percent of the variation in returning spring chinook adult salmon on the Rogue can be accounted for by only four environmental variables: water flow differences, the number of smolts released by hatcheries, ocean upwellings, and ocean troll catches** (Botkin et al. 1995: p.19, 22). See the discussion in Section 7.3.3, Trend Assessments for the Rogue and Umpqua Rivers.
- **Past efforts to count fish populations in coastal rivers other than the Umpqua and the Rogue have been so poorly designed that the numbers generated by these efforts are useless for measuring change because too much bias (and too little documentation) is present in these systems. Because population numbers are unknown for coastal salmon stocks, there is no way to accurately (with statistical certainty) measure changes in those numbers.**

In summation, we believe Botkin has demonstrated that too little information exists to accurately determine whether a significant change in salmonid populations has taken place in western Oregon during the past 50 years.

Presence of Individual Salmon Stocks:

Has there been a change in geographic distribution of salmon stocks since European settlement?

Results of the distribution findings were obtained entirely from a single source, Frissel's work with the Wilderness Society (Botkin et al. 1995: p.23). GIS layers were constructed from historical ranges of eight identified stocks of six salmon species and compared with their current ranges. Colored maps were produced that graphically displayed the current status and known distributions of these stocks (ibid.: p. 30-31). Findings are that:

- **Fall chinook are extinct in 17% of their range within the study area.**
- **Spring chinook are extinct in 24% of their range in western Oregon.**
- **Chum are extinct in 34% of the study area. They are considered threatened throughout their remaining range in western Oregon.**
- **Coho are extinct in only 3.5% of the study area, but are considered threatened throughout their entire range in western Oregon.**
- **Sockeye are extinct within 99.9% of their range within the study area.**
- **Searun cutthroat are considered threatened, but not extinct, throughout their entire range within the study area.**
- **Winter steelhead are extinct in 14% of their range within the study area.**
- **Summer steelhead are extinct in 41% of their range within the study area.**
- **Clearings and grass and shrub categories of land use are statistically significantly correlated with local extinctions of chinook, sockeye and steelhead. Land use patterns, including forestry practices, seem unrelated to chum extinctions. Coho and steelhead extinctions are correlated with changing forest cover patterns** (Botkin et al. 1995:p.25-28). A discussion of these findings is provided in Section 7.3.3, Land-Use Correlations.

RECOMMENDATIONS:

There are 52 final recommendations resulting from the Botkin Study. Final recommendations are arranged under four categories (followed by the total number of original recommendations in parenthesis):

1) actions to improve salmon habitat related to forest practices (7),

2) actions to improve salmon habitat or survival not directly related to forest practices (13),

3) measurement needs related to forest practices (9), and

4) measurement needs not directly related to forest practices (23).

Most of Botkin's recommendations are directed to legislators and scientists rather than private landowners and resource managers. Many of the remaining recommendations are of little practical value because they have already been implemented for other (usually economic) reasons, or because they are redundant. The first two forest practice recommendations, for example, begin with the word "continue." Another recommended forest practice is to "maintain permanent forest roads at a level sufficient to avoid major washouts or chronic erosion." This has been a primary objective of logging road engineers since the 1930s. An example of redundancy is provided under the measurement needs category: one of the 52 recommendation is to "make quantitative measurements of environmental conditions before and after forest harvesting such as: stream temperature . . .," while a subsequent recommendation is to "monitor water temperatures before and after forest operations . . ."

The following list of 17 management recommendations was derived by sorting, filtering, and combining the final Botkin recommendations. They have been prioritized by category, based upon the Botkin Study findings and their potential usefulness to land owners and resource managers.

Forest Practices Actions to Improve Salmon Habitat (2):

Based on the discussion above, only two recommendations remain to be considered.

- **Where possible, close as many previously constructed logging roads as is feasible** (Botkin et al. 1995: p.51).

This recommendation has been adopted by the Clinton Plan for Northwest Forests and that forest industry is identifying roads that present highest risk of landsliding for remediation.

- **"Develop a management strategy for an adequate loading" of large woody debris in "areas that lack sufficient large streamside trees"** (Botkin et al. 1995: p.51).

This strategy has been adopted as a key to the Oregon Salmon Plan (Bell et al. 1997). It is also an element in the Oregon Forest Practice Rules and President's Forest Plan.

Improvement Actions Not Directly Related to Forest Practices (5):

These recommendations are intended to be adopted at a regional or national scale. Their implementation would have direct consequences for resource managers at the watershed or district level.

- **Develop watershed-based management** (Botkin et al. 1995: p.52).

This recommendation has been adopted by the State as key to the Governor's Coastal Salmon Restoration Initiative (CSRI) by encouraging the development of local watershed councils and the development of standard watershed analysis and monitoring methods (Nicholas 1997).

- **Give priority to maintaining persistent endangered stocks over attempts to restore extinct stocks** (Botkin et al. 1995: p.52).

This recommendation is also key to the CSRI, with its focus on maintaining or improving existing coho populations (Nicholas 1997).

- **Formulate adaptive policies that change with fluctuations in environmental conditions, changes in scientific information, and changes in cultural values** (Botkin et al. 1995: p.52).
- **Conduct risk assessment as part of management planning** (Botkin et al. 1995: p.52).
- **Help educate the public regarding the different policy implications of managing for biological diversity, managing for sport fishing, and managing for commercial fishing** (Botkin et al. 1995: p.52).

These three recommendations have yet to be implemented, although they may be intended as strategies within the guidelines of the CSRI (Nicholas 1997).

Measurement Needs Related to Forest Practices (3):

The following set of three types of measurements is needed to better assess changing forest and wildlife habitat conditions over time. Implementation would probably be at the national or regional level, but application would be at a watershed-scale.

- **Inventory conditions of riparian zones where salmon spawn and rear** (Botkin et al. 1995: p.52).

This recommendation is being addressed by the Oregon Plan (Nicholas 1997).

- **Make quantitative measurements of environmental conditions before and after forest harvesting, including: fish populations, stream temperature, water chemistry and other water qualities, gravel and sediment accumulations, light levels, species abundance, tree sizes, tree ages, gravel and sediment accumulations, and woody debris sizes, placement and locations** (Botkin et al. 1995: p.52-53).

These measures are currently being adopted by the CSRI (Bell et al. 1997), but that emphasis on making pre- and post-logging measurements is lacking. However, many forest companies are developing monitoring efforts to measure environmental conditions before and after forest harvesting.

- **Develop a sample design that economically considers variations in conditions and forest operations** (Botkin et al. 1995: p.53).

This recommendation does not seem to be considered in either the Clinton Plan or the CSRI at this time.

Measurement Needs Not Directly Related to Forest Practices (7):

The following recommendations can be implemented at a county scale, with most applications at a watershed scale. Most of these recommendations have several consequences so far as the management of information is concerned and might just as reasonably been recommended for timber management, ecological research, or public education purposes as salmon management.

- **Enter inventory data, along with logging and reforestation records, into a GIS format** (Botkin et al. 1995: p.53).

A model for this recommendation was developed for the Botkin study that demonstrated the capability for transforming historical data from the 1850s and earlier to useful GIS and computerized database formats (Zybach 1994).

- **Conduct research to reconstruct forest history within watersheds and make maps showing ages of stands, resettlement vegetation, and logging history** (Botkin et al. 1995: p.53-54).

A prototype for this recommendation was developed for the Botkin study (Zybach 1993) that was summarized in a later report (Zybach 1994).

- **Establish a statistically-valid permanent plot system to monitor changes in forest conditions** (Botkin et al. 1995: p.53).
- **Establish statistically-valid monitoring of salmon abundance and conduct accurate counts of returning fish** (Botkin et al. 1995: p.54-55).
- **Map and maintain maps of the geographic status of salmon stocks** (Botkin et al. 1995: p.54).

- **Conduct historical, archeological, and anthropological studies to estimate the range of adult fish returns prior to 1950** (Botkin et al. 1995: p.54).
- **Conduct a study of present and past watershed conditions for salmon** (Botkin et al. 1995: p.54).

These latter recommendations have not been implemented and steps have not been taken (with the exceptions of measuring certain fish populations and mapping salmon stocks) to implement most of them.

### 7.3.3 *Some key findings and recommendations: how valid are they today?*

STATISTICALLY VALID DATA:

The Study concluded that, despite the long-term investment in salmon monitoring in the study area, *"Of the 26 rivers that flow into the Pacific in the study area, there are statistically valid counts of returning adult fish for only two rivers."*

Fish were directly counted passing over only two dams, Gold Ray Dam on the Rogue River from 1942 to 1992 and Winchester Dam on the Umpqua from 1946 to 1992. Even with these counts, a number of problems were identified including missing hatchery release information and changes in salmon measures (wild or hatchery). Other methods to measure returning adult fish, such as the peak count method (field count of spawning and dead salmon in a selected reach at a period considered to represent peak returning numbers), were determined by the Botkin Study to not be statistically valid. The peak count method was not designed to identify variations in the timing of returning salmon or to account for reach population variations. The sites selected for monitoring were found to not be ". . . *a statistically-valid representation of all the streams used by salmon, but rather selected by convenience or by some other statistically arbitrary method."* Further complicating regional assessments of trends, when and where counts were obtained changed over time. Finally, it was found that estimates of returning adult salmon based on direct measures at Gold Ray and Winchester and did not compare well with the results of the peak count method.

Oregon Department of Fish and Game (ODFG) representatives have expressed frustration at this assessment (Berry et al. 1995, Jacobs 1997). Problems associated with peak counts were recognized well before the Botkin Study. In 1981, the ODFG initiated the use of the "area under the curve" method to replace the peak count method for coho salmon. This involves monitoring live coho throughout the spawning period to account for variations in spawners over time. Beginning in 1990, the Oregon Department of Fish and Wildlife adopted stratified random sampling methods to estimate coho salmon populations and address the recognized problems of peak counts. While fall chinook counts continue to be estimated using the peak count method, the spawning time for fall chinook is compressed compared to coho. In evaluating the assessments by the Botkin study, Berry et al. (1995) recommended that assessments should be based on populations adjusted for ocean harvest rates.

There are also some concerns about the adult return data collected at the dams (Jacobs 1997, Becklin 1997, Berry et al. 1995). A number of changes in monitoring methods have occurred that could potentially influence the results of these "statistically valid" counts. For example, potential problems with the Gold Ray dam counts include possible errors distinguishing jack salmon from half pounders (type of steelhead), changes in monitoring protocol and counting station facilities, and difficulty counting during turbid flows. [For the first 3 years of monitoring at Gold Ray Dam, gates were closed so fish could only pass when counting occurred. Then a 40-hour subsampling approach was used and fish were not counted at night. In 1971 underwater windows improved counting, and in 1992 video cameras were installed to further improve counts]. During one period more coho salmon were being detected at the upstream Cole Creek fish hatchery than were being measured passing Gold Ray dam. Some steps have been taken to address these concerns and correct the data. Despite the noise introduced by these changes and problems, most agree that the Gold Ray Dam salmon return data is the best trend information for the study area.

TREND ASSESSMENTS FOR THE ROGUE AND UMPQUA RIVERS:

Using the data from the Gold Ray and Winchester Dams, the Study Team evaluated trends in salmon. They concluded that *"Available data in the study area for salmon returning to spawn on the Rogue and Umpqua Rivers show no consistent pattern in population trends."*

For the periods of record for various salmon runs at Gold Ray Dam, *". . . both fall chinook and summer steelhead show significant upward trends, but there is not statistically-significant trend for spring chinook, coho or winter steelhead."* For Winchester Dam, there were significant upward trends for fall chinook and summer steelhead; no significant trends for spring chinook, coho, and winter steelhead; and a significant decline for sea-run cutthroat trout. Counts since 1972 (significant because of initiation of the Oregon Forest Practices Program) showed general improvements in runs for the Rogue while the Umpqua data was mixed.

The Botkin Study authors correctly cautioned that the limited information on salmon escapement, both temporally and spatially, thwarts our ability to assess region-wide trends. For example, while coho salmon showed no statistical trends for Gold Ray and Winchester dams, ocean harvest showed a reduction from an annual mean of 8,000,000 pounds for the period 1892 to 1940 to an mean of less than 4,000,000 pounds from 1940 to the present. A comparison of the historic record of commercial salmon harvest on the Columbia (Figure 6) with the same data for the period of record for the study area (beginning 1942-1946) shows how unrecorded declines might not be detected with the limitations of the data.

Since 1992, most salmon runs on the Rogue River have continued to rebound remarkably. Becklin has prepared very useful records of salmon counts for Gold Ray Dam using a moving average to smooth for annual fluctuations (Appendix A). The 1995 fall chinook, spring chinook, and coho salmon returns were the largest or near largest ever recorded for Gold Ray Dam and the ten-year running averages are at or near the maximum for the period of record. Summer steelhead showed returns well above those observed in the 1970s and 1980s, and winter steelhead returns, although lower than the returns measured in the early 1940s, are above counts from 1950 through the mid 1980s.

MANAGEMENT MODELS:

The Study made a strong conclusion that the *"Models currently in use do not consider environmental change, either natural or human induced, so they are not adequate for accurate projections of population trends, harvest quotas, or for estimating the effects of human action on salmon."* For the Rogue, *". . . variations in water flow, hatchery releases, and ocean-troll catch account statistically for 80 to 90 percent of the variation in the number of returning adults during the past 20 years."*

This observation has important implications for predicting future salmon trends and setting limits for salmon harvest. Recent wet years should be evident by strong salmon runs, if this correlation holds. Some indirect implications about the effects of forest management on runoff are also discussed. In fact, two manuscripts by Jones and Grant describing studies of forest management impacts on peak flows (later combined into a *Water Resources Research* article, Jones and Grant 1996) are discussed extensively.

The Botkin Study found a strong correlation between adult spring chinook salmon returning to Gold Ray dam and the minimum November 1-day flow 3 to 4 years earlier. A number of fisheries biologists expressed concern about this correlation, noting that November flows occur after spawning and before emergence. While it is possible that these flows may influence egg survival, the life history of spring chinook does not seem to support this connection. Some biologists speculated that it is more likely that these November flows are covariant with ocean conditions. Higher flows in November represent ocean conditions that result in higher salmon survival.

Becklin (1996a, 1996b, 1997a, 1997b, 1997c) has done extensive qualitative analysis of individual salmon response to flows and water-quality conditions for the Rogue River. He tested flows during critical life stage periods and found apparent increases in returns for: fall chinook with increased flow during August-October; spring chinook and increased annual flow, coho with decreased flows from November through February, and summer steelhead and increased annual flow. Winter steelhead returns appeared to respond less to flow than other species, Appendix A. An important point is that conditions that favor one species may be unfavorable for another. Individual species assessments for Rogue River salmon by Becklin can be visited on the Internet at http://www.silversides.com (as of September 1997).

A number of additional factors need to be considered in estimating potential returns in addition to flow. Overholtz (1995) concluded that the 1995 chinook salmon returns, the largest on record since 1960, were influenced by the magnitude of the ocean fishing in 1993 and 1994. Low harvest rates due to restrictive fishing reasons dropped the exploitation rate to around 10-20% in these years. This action alone allowed for a run size in 1995 that was 2-3 times as large as it would have been under the normal ocean harvesting pattern of 50-70%.

LAND-USE CORRELATIONS:

The Study attempted to apply Geographic Information System (GIS) methods to estimates of salmon stock conditions to assess potential land-use correlations. Of all the Study's findings and observations, this is probably the most obviously flawed. Salmon population conditions were mapped based on Frissel (1993). Because of the variable quality of the data used by Frissel to estimate the condition of the salmon stocks, the six classifications originally used were condensed to three: present, threatened, and locally extinct. Comparing these salmon condition estimates to land-use condition for Western Oregon in 1988, the Study concluded that:

> "*Effects of forest practices vary with species and their habitats. Correlations show that: 1) the presence of winter and summer steelhead is correlated positively with some amount of forest cover greater than 33 percent of the watershed; and local extinction is most strongly correlated with non-forest land use; 2) past forest conditions are one of the factors correlated with local extinction of steelhead and coho, species that spawn and breed in smaller, upper streams in watersheds. But forest conditions are not strongly correlated with local extinction of chum, which breed in estuaries and main river stems; and 3) sea-run cutthroat trout exist where there are sufficient mixed stands of trees; however, the larger the area in clearings, grass and shrubs, the less likely sea-run cutthroat will be present.*"

Early in the study, the importance of dams was recognized and an attempted was made to document where barriers were placed to salmon. The team was frustrated by poorly documented and conflicting information about dams. This, however, does not excuse the apparent lack of assessment about the role of dams in recorded extinctions or declines.

During the Botkin Study, an Oregon Department of Water Resources (ODWR) map was used to identify 394 dam sites in the study area. The Botkin Study also reported the ODWR estimated there were 10,000 to 20,000 dams which are not included in state inventories (below minimum size but could still influence salmon).

Basins shown with extinct winter and summer steelhead populations can almost entirely be explained by Detroit, Foster/Green Peter, Cougar, Dexter, and Iron Gate Dams. Coho salmon are shown as threatened or extinct throughout the Study range but most of the extinct population can again be explained by Iron Gate Dam. See Figure 8 which compares winter steelhead status with the presense of dams.

Robison (1997) concluded that the land-use correlations had flaws even more fundamental than the absence of dams in the analysis. He concluded that not only were the fish status classifications flawed, but the basic regression model used was inappropriate and subject to spurious correlations. The regression of land-use to fish status involved a comparison between the area in the three fish-condition classifications (abundant, threatened, extinct) and area in 15 land classifications for 38 hydrologic units (based on a 0.5 mile region around streams). Robison concluded that the primary reason for the high correlations ($r^2$) was because area was being regressed against area. In his comments (page 211 of Botkin Report 8), he provides an example for the analysis of cutthroat trout.

> "*...the status of cutthroat trout is always endangered. This means that within a watershed all the land would be endangered status (100 percent), no matter which hydrological unit is evaluated. The reason the $r^2$ for the sea-run cutthroat trout is 0.85 is because as basin area of a hydrologic unit increases,* [so] *does the area in different land cover types...*"

ADEQUACY OF FOREST RIPARIAN PROTECTION IN OREGON:

The Botkin Study occurred at a time when the President's Forest Plan was being developed and revisions were being made in the Oregon Forest Practices Act rules, both of which affect forest riparian protection. The Botkin Study concluded that:

> "*It is the opinion of the panel that the proposed federal (FEMAT option 9) riparian standards and the new ODF Water Protection Rules will improve protection of salmon habitat, if enforced as specified to us. However ODF rules may not provide sufficient loading of large woody debris to the stream channel, especially in the short term in secondary forests.*"

Research on riparian standards for forests has been a high priority for the Oregon Department of Forestry (ODF) and for forest industry. ODF has recently concluded a pilot stream-temperature study (Dent and Walsh 1997) and has initiated additional research. A Ph.D Thesis by Hairston (1996) at Oregon State University found that there were significantly more trees being left for recruitment of large woody debris under the new Oregon forest practice rules when compared to the old rules (Figure 9). Additional work by NCASI and Oregon State University provides methods of assessing riparian functions before and after forest management (Adams et al. 1997) and an assessment of riparian vegetation effectiveness (NCASI in press). Monitoring and research needs for forest riparian areas are discussed more fully by Irwin and Ice (1997) in this Special Report.

OCEAN INFLUENCE AND LOCAL PERSPECTIVES:

> *"Long-term variations in ocean currents may shift conditions that are good for salmon from north (off Alaska and British Columbia) to south (off Washington, Oregon and California) and back again."*

This topic is covered in detail by Kaczynski (1997), Section 7.13. Ocean conditions and ocean fishing presence appear to be important factors in salmon returns. Mantua (1997) reports that warming and cooling of the Pacific Ocean at depths of several dozen feet causes dramatic shifts in salmon production. Periods of salmon adundance and excellent ocean conditions in Alaska are periods of poor ocean conditions for salmon in the Northwest.

Coastal Oregon residents were recently questioned about their beliefs on the causes of local salmon declines. The three factors most commonly listed were: predation by marine mammals (seals and sea lions), high seas drift net take, and ocean conditions. The pollster discounted this list as an attempt to explain declines by factors not caused by local residents. These views appeared particularly suspect with publication of *Factors of Decline* and *The Status of Review of Steelhead* by NMFS (1996a and 1996b), which trivialized these factors. However, recent information gives more credibility to these local perceptions. In addition to ocean conditions, marine mammals and off-shore fishing now appear to be more important than initially believed.

Briggs (1997) reviewed the *Final Draft Report to Congress of Information on the Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and on the Coastal Ecosystems of Washington, Oregon, and California* (Beeson et al. 1997). Previous NMFS reviews had concluded that marine mammal predation was not an important factor. A similar conclusion was made in the Botkin Study, discounting concerns raised by Palmisano et al. (1993). Briggs observes that the *Report to Congress* concluded that: "...marine mammals are truly a problem to salmonid populations that must be dealt with..., California sea lion and harbor seal populations are not in danger, and do not need federal protection to thrive..., pinipeds eat lots of salmonids sometimes..., and may be causing high levels of injury to escaping salmon..., and uncontrolled pinniped population growth impacts the economy and the ecosystem" and may be causing declines in other fish populations, including Pacific whiting and eulachon smelt.

Control of off-shore fishing appears to be an important factor in salmon returns (Overholtz 1995). While improved returns can be attributed, in part, to recent controls on the ocean take, the role of drift net take is not well understood. However, Palmisano et al. (1993) report that significant numbers of salmon are harvested away from their place of origin and mixed-stock ocean fisheries in the past have contributed to substantial reductions in salmon returns. Clearly, ocean fishing levels have a direct effect on salmon returns.

### 7.3.4 *Some specific concerns about the study*

STRENGTH OF CONNECTION TO SALMON DECLINE AND COST OF RECOVERY:

The Botkin Study was designed by the Oregon Legislature to:

1) *"assign the relative importance of forest practices"* to the perceived decline *("if that is the case")* in anadromous fish stocks in western Oregon, and

2) *"make recommendations as to how forestry practices can assist in the recovery of anadromous fish populations."*

If the "perceived decline" in salmon stocks is determined to be erroneous or (if accurate) a result of conditions unrelated to forest management practices, then changes in forest practices are unlikely to contribute to "recovery." In either instance (lack of decline or lack of culpability), recommendations for change are likely to be costly, ineffective and/or unnecessary. Botkin offers a large number of recommendations with his final report, which suggests he believes salmon stocks have declined in western Oregon and forestry is a responsible agent. A careful reading of the texts, however, demonstrates he also believes that inadequate proof of either assumption currently exists.

ANTI-LOGGING BIAS:

Reports 7, 8, and 9 reveal an apparent anti-logging bias in the Botkin study (Zybach 1996: 19-22). A summary of the bias is best stated in the appendix to report 8 (Botkin et al. 1994: Vol. III, p. A3):

> *In the absence of systematic mapping of habitat conditions, and of some measure of the direction of their change, it is impossible to say more than that considerable expanses of salmonid habitat have been degraded in logged areas in recent decades, and that much of what was destroyed is far from fully recovered.*

A noticeable example of how this bias is translated to recommended action is provided in Report 7 (Cummins et al. 1994: p. 30):

> *". . . as long as information is incomplete, management should choose actions that confine error to the conservative side. . . this means that whenever there is uncertainty, more, rather than fewer trees should be left uncut in the buffer zones and the widths of these zones should be wider rather than narrower."*

The "conservative" assumption, thus, is that salmon populations will probably benefit by having more trees in a wider area than already required by the President's Forest Plan or ODF rules. In fact, the "best BCW ["bankfull channel width option"] plan maintains a landscape with 50 percent or greater in late successional or mature forest" (Cummins et al. 1994: p.3) and maintains "approximately 10 (big conifer) trees per 100 m. of stream length" (ibid.: p.30). Certainly, leaving more large commercial trees, over a greater area, for a longer period of time than legally required is a costly practice. The fact that this suggestion is intended to mitigate past effects caused by "destructive" (to salmon populations) and "degrading" (to salmon habitat conditions) logging operations must be taken into account when compared with other options for improving salmon numbers.

### 7.3.5 *Conclusions*

The "Botkin Report" provides a summary of information and current thinking on the interaction of forest management and other factors on salmon in western Oregon and northern California. The Botkin Study arrived at five primary conclusions, each in response to a specific "charge" by the Oregon Senate.

CAUSES OF SALMON DECLINES:

Agriculture, forestry, urbanization, overharvest through legal catch, dams, and naturally occurring drought are major factors in salmon declines. Potentially important factors include unregulated and illegal salmon harvest, gravel harvest, unfavorable ocean conditions, legal bycatch and non-catch mortality, hatchery fish interference, and irrigation (Botkin et al. 1995: p.45).

We believe this conclusion may contradict Botkin's findings that too little valid statistical information exists to determine if, indeed, a decline in salmon numbers can be documented. In fact, subsequent independent assessments agree with the observation by the Botkin Study about the limited amount of statistically reliable data for salmon populations. This conclusion also seems to support the idea of an anti-logging bias in the report's findings. To state that forestry is a "major cause" of salmon decline, while unfavorable ocean conditions (a documented cause of short-term population declines) is only a "potentially important factor" is unwarranted and misleading when compared to the body and other findings of the study's reports.

IMPORTANCE OF FOREST PRACTICES TO SALMON DECLINES:

A degradation of forest conditions that affect riparian and stream habitats would lower salmon potential; restoration of these habitats would increase this potential. It is in this way that forest practices are a major factor (Botkin et al. 1995: p.46).

Again, this conclusion is based entirely on hypothesis. "Salmon potential" is a human construct that may or may not equate to increased numbers of mature fish. Another paper in this Special Report documents comparable salmon returns for both watersheds with heavy management impacts and watersheds with little or no recent management impacts (Megahan et al.). Instead, it is our belief that favorable riparian and stream habitat conditions can positively influence salmon populations but only if there is sufficient escapement to seed suitable habitat.

IMPORTANCE OF STREAM HABITAT IN LIMITING SALMON POPULATIONS:

The most important habitat characteristics in streams are minimum water flow, food, obstructions to flow that create debris dams and have other effects on stream shape, and gravel necessary for spawning. Large woody debris plays a major role in the development of stream shape and form beneficial to salmon (Botkin et al. 1995: p.46-49).

We agree stream habitat is one of several factors affecting salmon populations. There is compelling evidence that there are relationships between salmon returns and environmental/management factors including runoff, hatchery releases, and off-shore fishing catch. However, the mechanisms are not yet clear and there are different relationships for different species. Conclusions about relationships between forest conditions and extinction of coho and steelhead appear to have missed the obvious impact of impassable fish barriers created with construction of dams.

HOW FOREST PRACTICES HAVE AFFECTED SALMON HABITAT:

Regression analysis does not indicate that forest practices have been a factor in the status of all species of salmon. Maps of the combined presence and local extinction of chinook and chum support the suggestion that chum spawning seems unrelated to forest practices. Steelhead and coho are very much affected by forest cover. This analysis suggests that for these two species, relatively speaking, forest cover is an important factor in past local extinction (Botkin et al. 1995: p.49).

However, a comparison of the Botkin maps shows the overwhelming importance of dams to extinction. Recommended testing of the ODF riparian protection rules have been conducted and additional assessments are underway to insure that the forest practice rules meet water-quality and habitat goals. Conclusions about forestry being a major factor in fish declines appear to be unsubstantiated but widely accepted. Trends in salmon populations since the 1972 adoption of the forest practices program reveal no overwhelming declines in salmon populations.

HOW FOREST PRACTICES LIMIT SALMON POPULATIONS:

Both the proposed FEMAT standards and the new ODF Water Protection Rules, if implemented as stated and if accompanied by adequate monitoring, will result in an improvement of the riparian zone and salmon habitat (Botkin et al. 1995: p.51).

This conclusion is supported by recent findings by Hairston (1996) and seems to contradict Botkin's assertion that additional mitigating actions should be taken.

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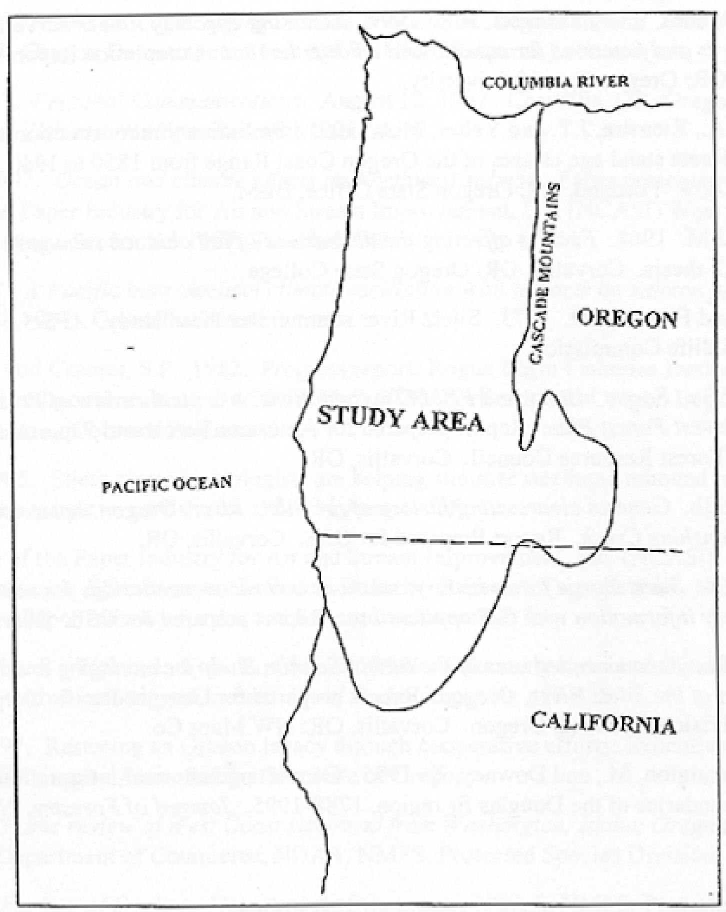



**Figure 1** Botkin Study Area

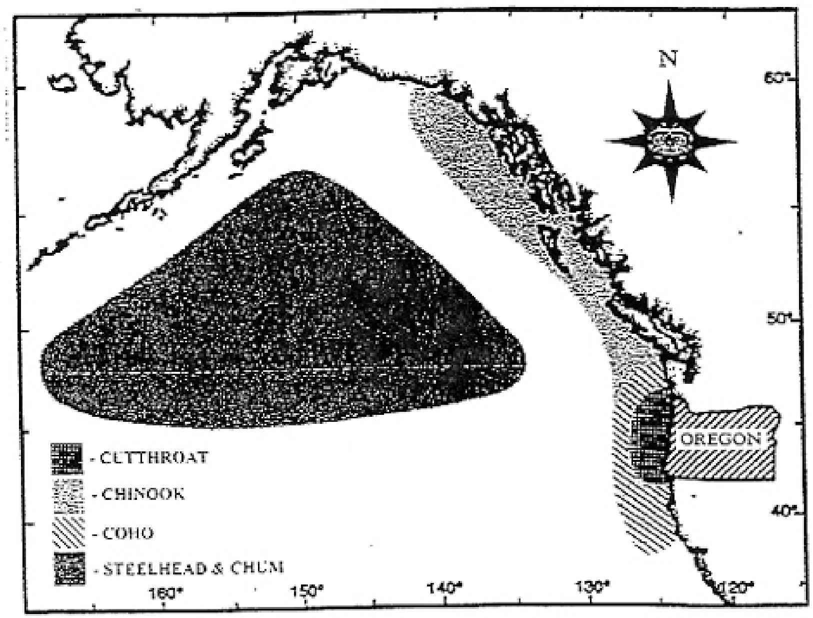
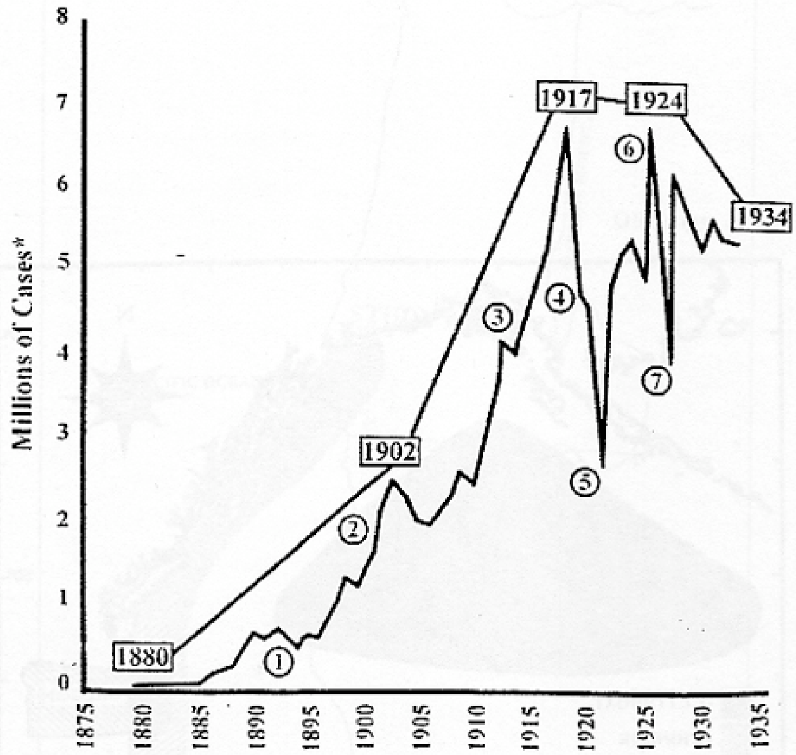



**Figure 2** Map of ocean ranges of anadromous solmonids native to Oregon (Source: ODFG). Note access to Washington, Canadian, and Alaskan fisheries.




1) Economic Depression of 1892
2) Development of Bristol Bay – Reds
3) Development of Southeastern Alaska
4) Drop in Reds in Western Alaska
5) Drop in Chums and Pinks in Southeastern Alaska
6) Rise in All Species – biological
7) Drop in all Species – biological

**Figure 3** Fluctuations in Alaska Salmon cath with factors contributing to variations (Source: DeLoach 1934).

1880– 193

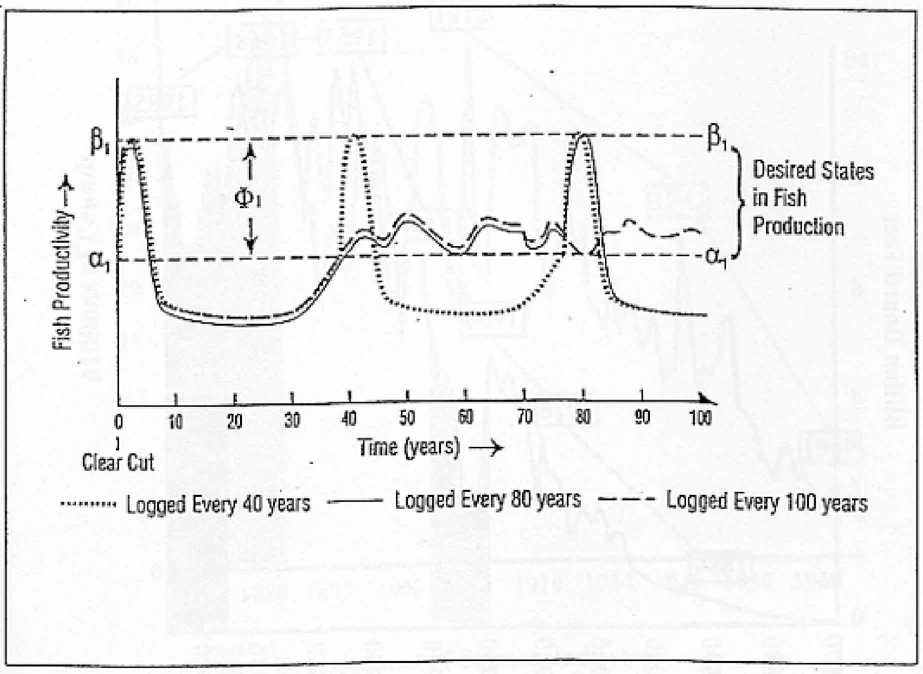



**Figure 4** Hypothetical production level of salmon over time under logging rotations of 40, 80, and 100 years. Desirable levels of fish production fall between $\alpha_1$ and $\beta_1$.

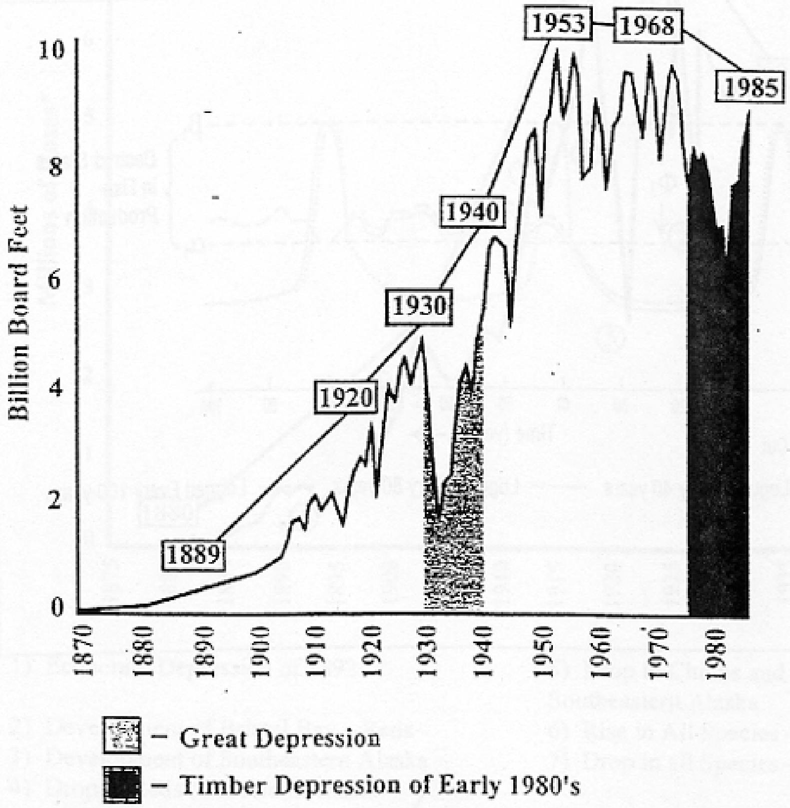



Figure 5 Oregon timber harvest, 1869-1985 (Source: Oregon Department of Forestry).

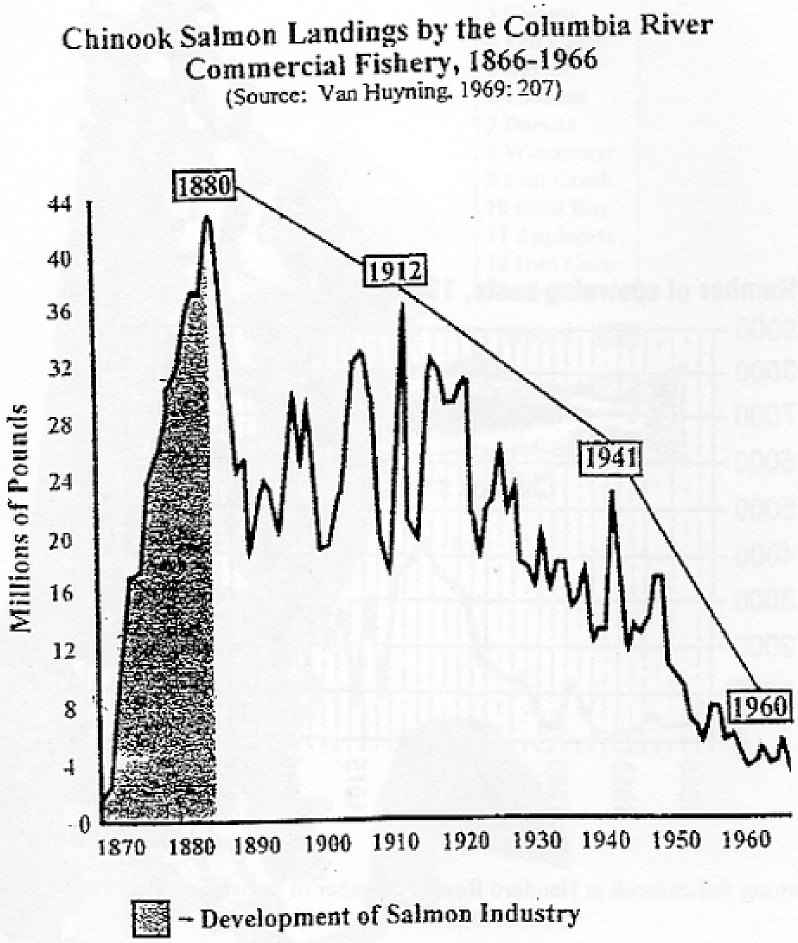





Figure 6 Chinook salmon landings by the Columbia River Commercial Fishery, 1866-1966 (Source: Van Huyning, 1969:207).

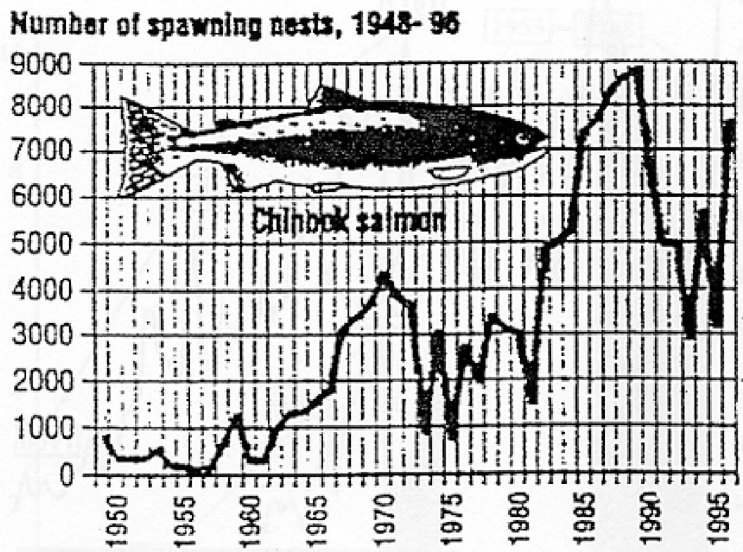



**Figure 7** Spawning fall chinook at Handord Reach. Number of spawning nests, 1948-1996 (Source: Bittner and Swisher 1997).

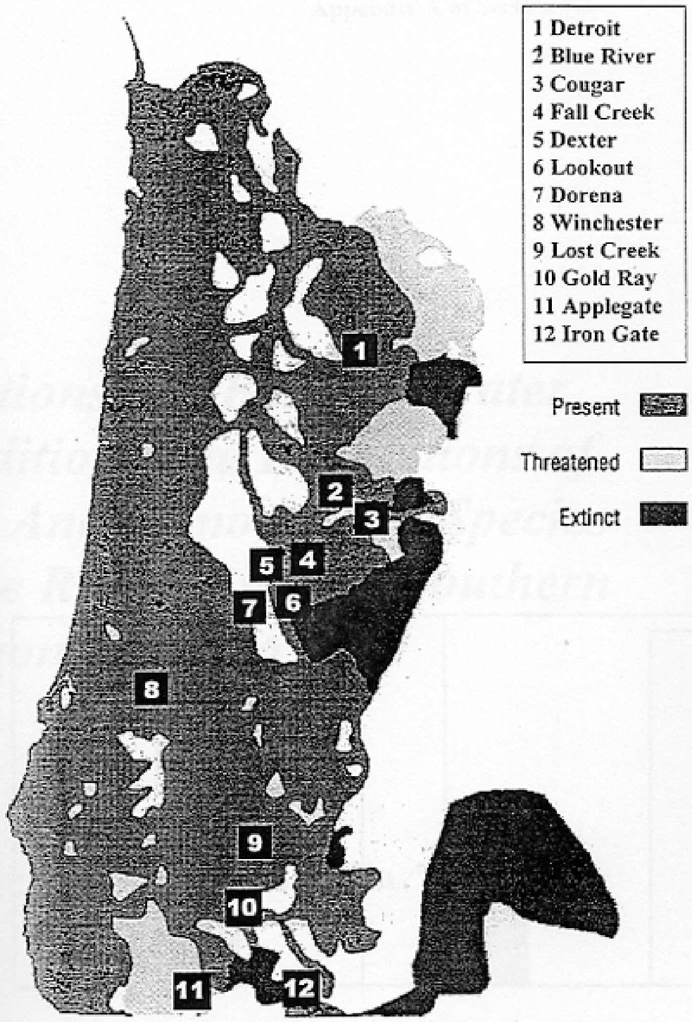



**Figure 8** Winter steelhead present, threatened, and extinct in W. Oregon and the Presence of selected dams (Botkin et al. 1995).

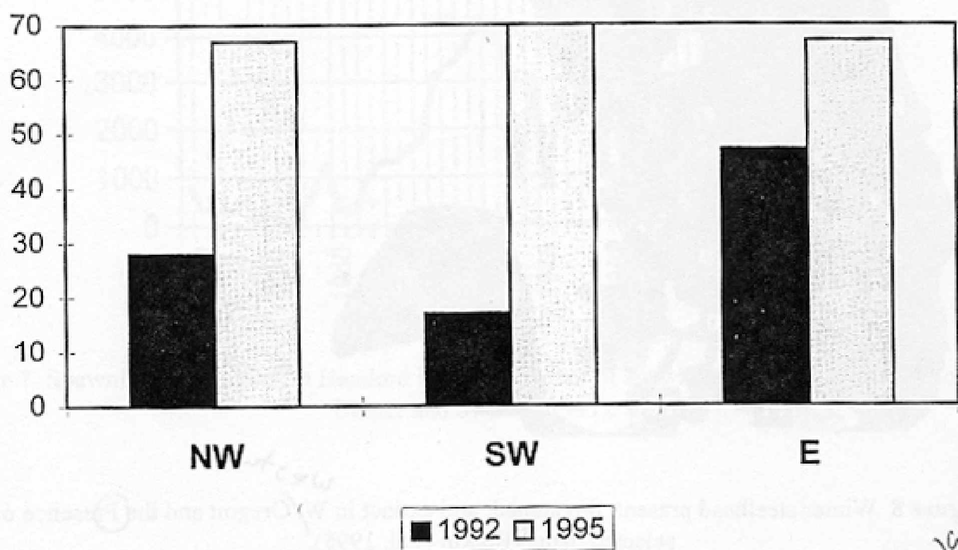



**Figure 9** Comparison of percent of conifer basal area retained after harvest in RMA (from Hairston 1996)

**Appendix A of Section 7.3**

# *Relationships Between Water Conditions and Populations of Five Anadromous Fish Species in the Rogue River in Southern Oregon - 1940 to 1996*

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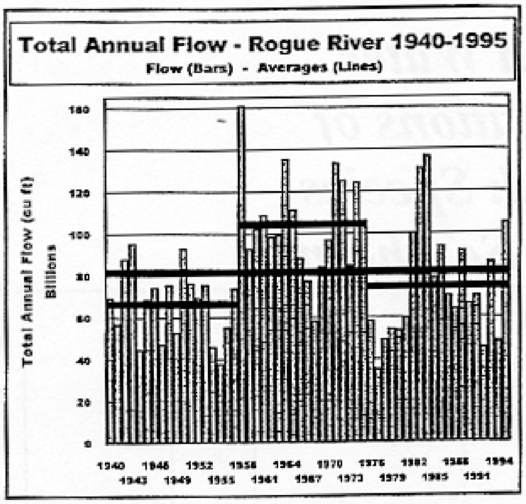
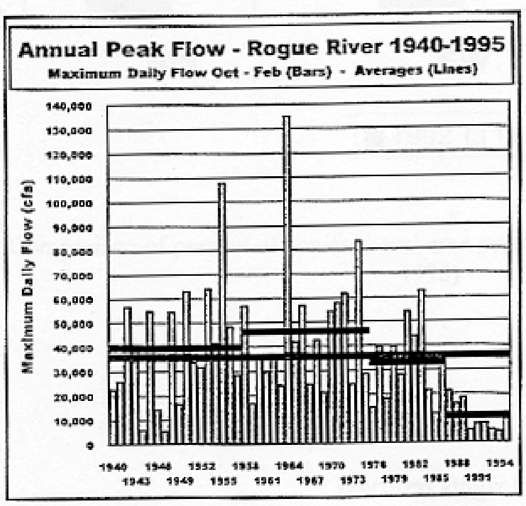
## Rogue River Flow and Temperature

Rogue River flow dynamics are primary determinants of annual and long-term salmon and steelhead escapement. Long-term precipitation patterns and their related long-term flow patterns, typically twenty years in length, cause long-term variations in escapement. Incremental events, primarily flood surges, cause incremental variations in escapement of individual species based on the characteristics of the event and the spawning cycle of each species. The nature of the flow-dynamics-to-escapement relationship varies by species, therefore, a generalized conclusion about river conditions cannot be uniformly applied to all five species of salmon and steelhead in the river. Population trends for the Rogue River Basin cannot be understood or predicted without examining the dynamic impacts that flow and temperature have on each of these species. Additionally, since Rogue River salmon and steelhead escapement averages just 1.5% of smolt production, Pacific Ocean rearing conditions are also primary determinants of escapement. However, wild juvenile production and hatchery supplementation underpin future population sizes.




Top: Total annual flow is shown in billions of cubic feet each year from 1940-1995. The 55-year average is 82 billion cubic feet. Period averages vary with weather.
Bottom: The maximum rate of flow is shown for each year from 1940-95. Major flood surges are clear. Average peak flows are shown for individual periods.




In addition to the importance of total annual flow in the river, seasonal flow is important, too, and has an influence on water temperatures. During long-term periods of drought, mountain snowpacks are reduced, resulting in reduced water flows during the summer and fall seasons of the year. During periods of higher river temperatures, mortality rates of adult Fall Chinook, Coho Salmon and Summer Steelhead are elevated.

Fortunately, year-to-year seasonal water temperatures demonstrate plateaus of improvement since 1940, but most notably since 1973. Weather related phenomena in the Rogue River watershed are partly responsible for this improvement. However, improved Summer and Fall river flow since 1977 is largely attributable to managed outflows from Lost Creek Reservoir, built in 1973 and located upstream from Gold Ray Dam and Cole M. Rivers Fish Hatchery.

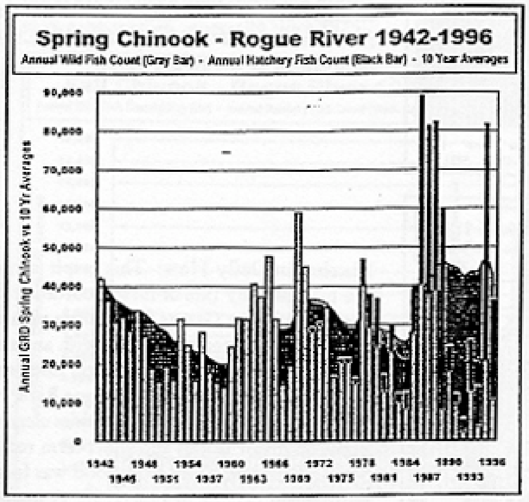
The annual average rate of flow of the Rogue River at Grants Pass, Oregon, has had substantial year-to-year variations during the period of 1940 thru 1995. These variations in average annual flow rate are affected by flood surges in some years, but they are also affected by reduced flow rates during periods of drought.

Annual, average rates of flow become more meaningful when analyzed through the application of rolling averages. The long-term drought of 1940-57 is clearly demonstrated by reduced average river flows. Long-term cooler/wetter weather from 1958-75 is also clear. A period of moderate drought and reduced precipitation resulted in generally moderate river flows from 1976-94, but ended with three years of alternately dry, then wet, weather with variations in river flow.

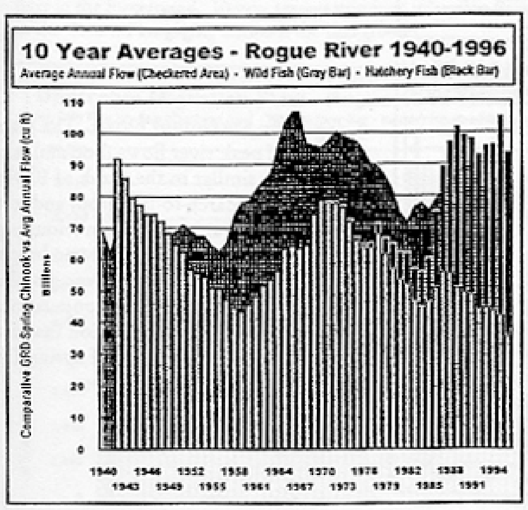
Following 1994, the Northwest began a predictable 20-year period of wetter and colder weather than the past period of relatively moderate drought. This long-term weather change appears related to periodic, long-term changes in North Pacific Ocean conditions rather than to events surrounding El Ninos.

# Rogue River Spring Chinook

Overview: Spring Chinook Salmon arrive in the early spring and spawn in the fall. Approximately 50% are wild fish and 50% of hatchery origin. Long-term variations in escapement link directly to long-term variations in total annual river flow. As long-term river flows increase, more Spring Chinook return as adults. As long-term river flows subside, fewer Spring Chinook return as adults. Incremental flood events have only moderate impact on this mainstem spawning species, especially since 1975.




Top: Annual returns of wild and hatchery Spring Chinook adults as recorded at Gold Ray Dam. 10-year averages of wild and hatchery adults are shown in the background.
Bottom: 10-year averages of wild and hatchery adult returns shown as bars in the foreground. 10-year average total annual river flow at the Grants Pass gaging station is the background.




Life Cycle: Spring Chinook Salmon (ie: stream type chinook) begin to return to the Rogue River in March and migrate by July primarily to the upper river. They linger in upper river holding areas for a few months until spawning in the late fall. Approximately 40% return to Cole Rivers Hatchery to be processed. Redds are established in the mainstem river, and fry emerge in the early spring. Survival of fertile eggs in the redds and the fry emergence rate is moderately affected by flood surges and winter river conditions during incubation. After emerging, wild fry disburse throughout the river. Fingerling Spring Chinook move into mainstem and estuarine rearing areas, and most smolts migrate to saltwater their first year. After surviving winter river flows, other wild yearling smolts enter saltwater in their second spring. Hatchery smolts are released in August and September and quickly migrate to the Pacific Ocean. Adults return to the river after 2 to 3 years in saltwater. The average return rate of hatchery Spring Chinook to Gold Ray Dam is 1.39% of released smolts.

Population Variations: Escapement of Rogue Spring Chinook experienced significant declines during the 1940-57 period of drought. The return of adults then showed substantial improvement from 1960 thru 1973, though low annual counts occurred in the 1967-68 period. From 1974-84, escapement again was generally lower as average river flows declined, though hatchery supplementation began to result in significantly increased returns. Massive returns of adult fish in the 1985-89 period were followed by sharply reduced escapement from 1990-94 as river flows again declined during this period of moderate drought. A return to a period of generally higher precipitation and increased river flows beginning in 1995, combined with Pacific Ocean harvest restrictions, resulted in large 1995-96 returns, though runs were heavily of hatchery origin.

Primary Escapement Determinant: Total annual river flow is the primary cause of river-based changes in Spring Chinook escapement. Long-term variations in the population size of this species track remarkably with long-term variations in river flow. Peak river events do not appear to be a primary cause of long-term escapement changes, though redd destruction and yearling losses during major flood events are identifiable as causes of short-term reductions in population size. Controlled reservoir releases result in lower summer & fall water temperatures, but Spring Chinook typically migrate to cooler upriver sections of the Rogue awaiting their fall period of spawning before natural overheating of the lower river, which occurred before 1975.

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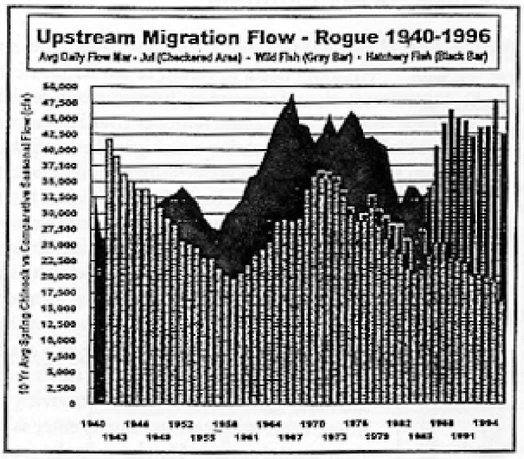
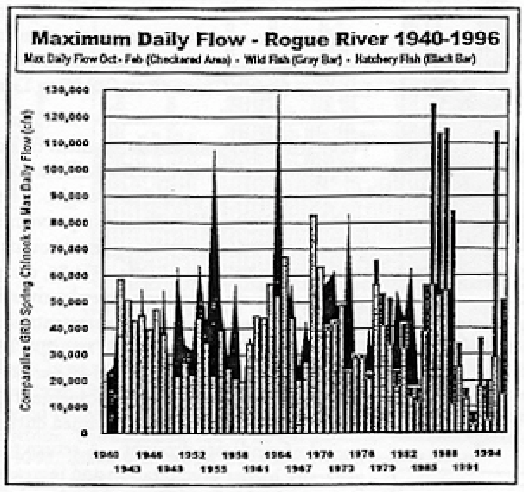
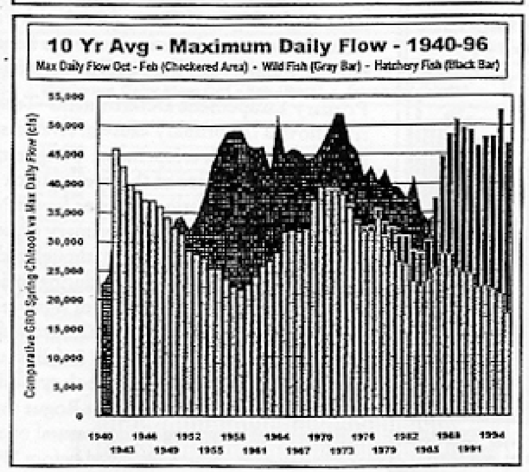



Upstream Migration Flow: The graph of 10-year average flows (top) during the March-to-July upstream migration of Spring Chinook is remarkably similar to the shape and conclusion offered by the graph of 10-year average annual flow (previous page). The high degree of correlation between river flows during upstream migration to population trends strongly supports the conclusion that mainstem river flow is a direct determinant of Spring Chinook escapement in the Rogue River.




Maximum Daily Flow: This graph (center) depicts the highest daily rate-of-flow recorded at the USGS gaging station at Grants Pass during each calendar year and compares peak flows with annual Spring Chinook escapement. This graph discloses flood events capable of scrubbing Rogue River mainstem Spring Chinook redds and provides clear correlation between major floods and short-term reductions in Spring Chinook. The 1955 flood was followed by escapement decline in 1957-1959. A major flood in 1964 was followed by steep reductions in 1967 and 1968. Periods of moderate peak flows are followed by higher escapement such as the 1956-63 peak flows which were followed by strong 1960-65 returns.

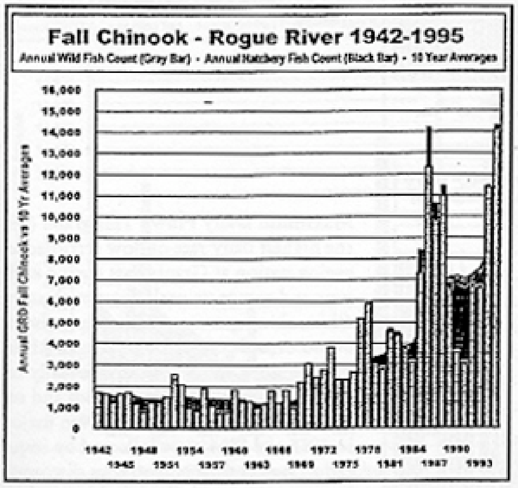



Long-Term Maximum Flow: The graph of 10-year averages of peak river flows (bottom) is also remarkably similar to the graph of 10-year average flows during March-to-July (top) and to the graph of 10-year average annual flow (previous page). The high degree of correlation between long-term averages of peak flows and long-term averages of upstream migration flows to long-term population trends strongly supports the conclusion that mainstem river flow is a direct determinant of Spring Chinook escapement in the Rogue River.

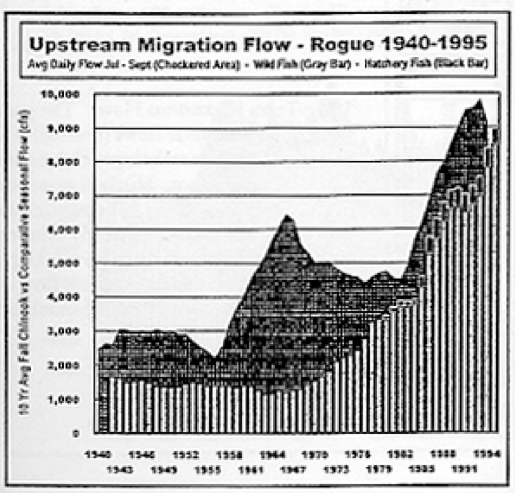
3

# Rogue River Fall Chinook

**Overview:** Fall Chinook Salmon arrive in mid-summer and spawn in the fall. Approximately 99% are wild fish. Substantially increased escapement since the mid-1970's links directly to US Corps of Engineers controlled increases in summer river flows. Since the completion of Lost Creek Reservoir, substantially more Fall Chinook have returned to the upper river as adults. Incremental flood events have only moderate impact on this mainstem spawning species, especially since 1975.



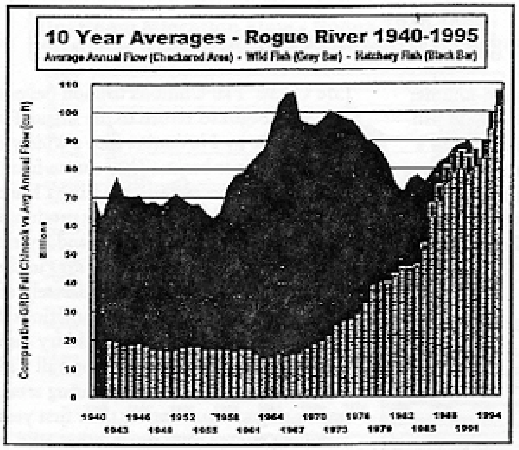

Top: Annual returns of wild and hatchery Fall Chinook adults as recorded at Gold Ray Dam. 10-year averages of wild and hatchery adults are shown in the background.
Bottom: 10-yr avg of wild and hatchery adult returns shown as bars in the foreground. 10-year average upstream migration flow at the Grants Pass gaging station is the background.



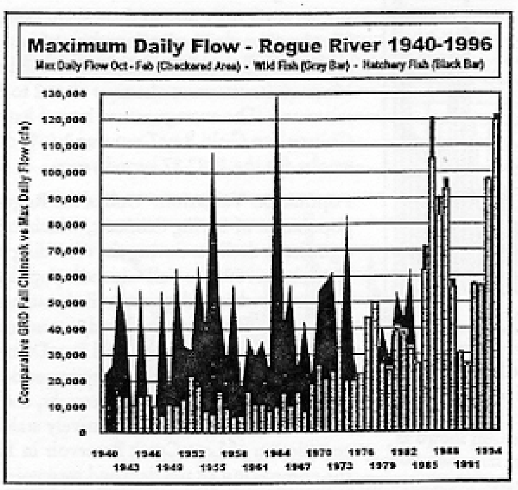

**Life Cycle:** Fall Chinook Salmon (ie: ocean type chinook) begin to return to the Rogue River in July and migrate by November into a widely distributed area of the river basin. They spawn from October to January. Few return to Cole Rivers Hatchery, where no Fall Chinook smolt are now produced. Redds are established in mainstem rivers, and fry emerge in the early spring. Survival of fertile eggs in the redds and the rate of fry emergence is moderately affected by flood surges and winter river conditions during incubation. After emerging, wild fry disburse throughout the river. Fingerling Fall Chinook move into mainstem and estuarine rearing areas, and most smolts migrate to saltwater their first year. After surviving winter river flows, other wild yearling smolts enter saltwater in their second spring. Hatchery smolts were released in August and September and quickly migrated to the Pacific Ocean. Most adults return to the river after 2 to 3 years in saltwater. The average return rate of hatchery Fall Chinook to Gold Ray Dam was 2.46% of released smolts for the 1982-87 brood years.

**Population Variation:** Unlike the Rogue's population of Spring Chinook, which experienced significant declines during the recording period of 1942 thru 1959, the Fall Chinook population remained stable and quite small throughout 1942-1968. During that period, annual quantities of Fall Chinook counted at Gold Ray Dam averaged approximately 1,500 fish. Despite periods of high precipitation and periods of drought, the population of Fall Chinook remained relatively stable until the completion of Lost Creek Reservoir in 1973. With the completion of the dam and reservoir, Fall Chinook escapement has increased with uniform regularity and with dramatic returns of wild adults throughout the river basin. Typical mid-1990's returns averaged 8-10 times the 1942-1968 annual average.

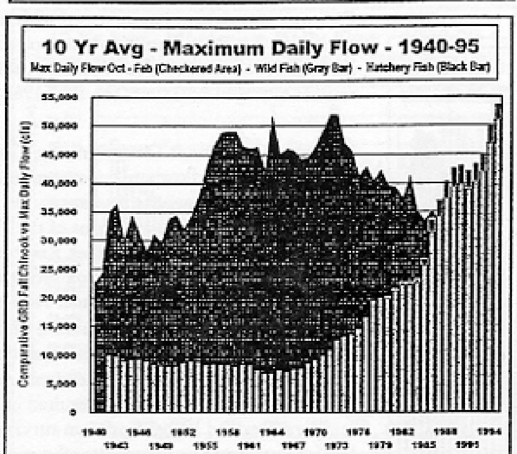
**Primary Escapement Determinant:** The rate of summer/fall river flow and concurrent spikes in water temperature are the primary causes of river-based escapement variations of the Fall Chinook. Since 1973, Lost Creek Reservoir has been especially helpful to Fall Chinook returns because of controlled increases in late-summer rates-of-flow and the reduced late-summer temperature of the Rogue River. As controlled summer/fall reservoir releases have been increased to supplement natural upper river flows, higher river flows resulted in lower water temperatures and higher upstream survival similar to, but improved compared to natural summer/fall flow increases during the 1958-74 long-term period of increased precipitation in the basin.




Average Annual Flow: The graph of 10-year average annual flows (top) is remarkably similar to the shape and conclusions offered by the graph of 10-year average peak flows (bottom). Minimal correlation between total annual river flows to population trends of the Fall Chinook presents a clearly different conclusion than similar comparisons of flow with populations of Spring Chinook. Average annual flow is not the primary determinant of Fall Chinook escapement or long-term population trends.




Maximum Daily Flow: This graph (center) depicts the highest daily rate-of-flow recorded at the USGS gaging station at Grants Pass during each calendar year and compares peak flows with annual Fall Chinook escapement. This graph discloses flood events capable of scrubbing Rogue River mainstem Fall Chinook redds but provides only modest correlation between major floods and subsequent reductions in Fall Chinook. Even major peak flows in 1955 and 1964 were followed by imperceptible reductions in escapement, thus discounting the importance of peak flow to the population of Fall Chinook.

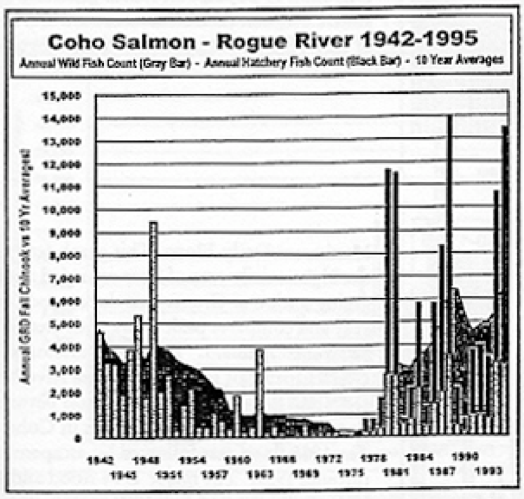



Long-Term Maximum Flow: The graph of 10-year averages of peak river flows (bottom) is also remarkably non-correlating with long-term Fall Chinook escapement. Minimal correlation between average peak river flows to population trends of the Fall Chinook reinforces a clearly different conclusion than similar comparisons of flow with populations of Spring Chinook. Average annual flow is not the primary determinant of Fall Chinook escapement.

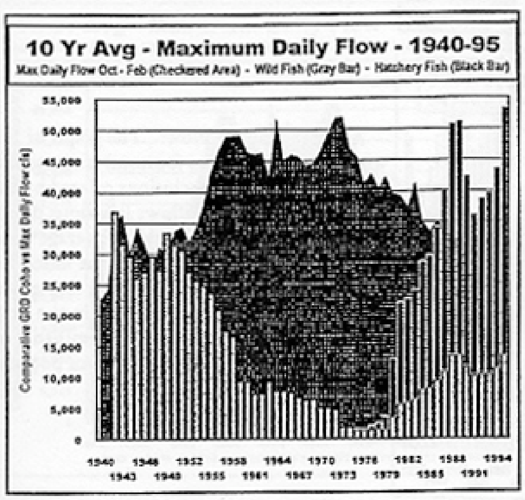
5

# Rogue River Coho Salmon

Overview: Coho Salmon arrive in late summer and spawn in early winter. Approx. 30% are wild fish and 70% of hatchery origin, though 65% of the 607 miles of Coho habitat is downriver from the Gold Ray Dam counting station. Drought and incremental flood events adversely impact this tributary spawning species. Cycles of increased river flow and flood surges coincide with reduced wild Coho runs. Moderate flows and the absence of flood events maximize wild Coho escapement.

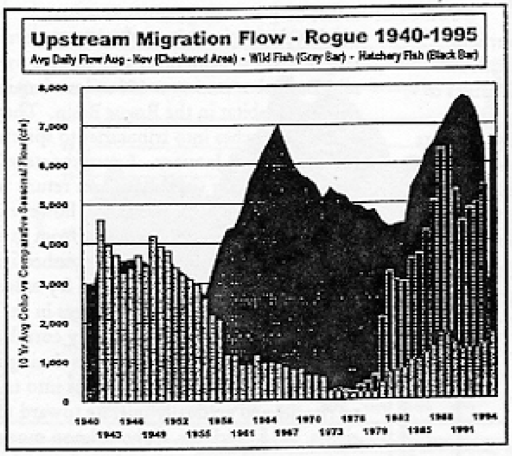



Top: Annual returns of wild and hatchery Coho Salmon adults as recorded at Gold Ray Dam. 10-year averages of wild and hatchery adults are shown in the background.
Bottom: 10-year averages of wild and hatchery adult returns shown as bars in the foreground. 10-year average maximum daily flow at the Grants Pass gaging station is the background.

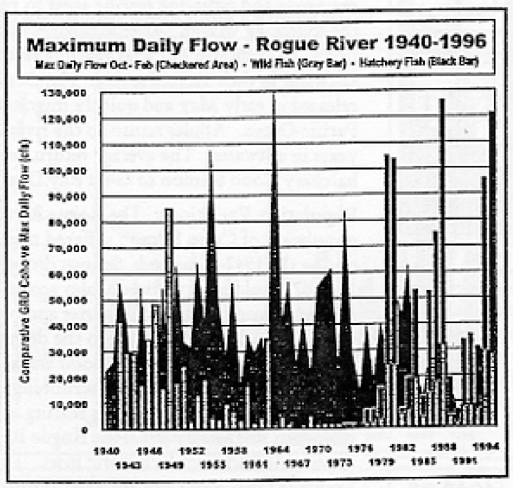



Life Cycle: Coho Salmon begin to return to the Rogue River in September and migrate by mid-December into over 600 miles of mainstem and tributary habitat in the Rogue Basin. They make quick approaches into tributaries to spawn from November thru January. Approximately 70% of Cohos counted at Gold Ray Dam return to Cole Rivers Hatchery to be processed, however, two thirds of Coho habitat lies downstream from this counting station. Redds are primarily established in smaller streams and tributary waters, and fry emerge in the early spring. Survival of fertile eggs in the redds and the rate of fry emergence is closely correlated to flood surges and winter river conditions during incubation. After emergence, wild fry disburse into tributary territories and gradually migrate toward mainstem rivers. As fingerlings, Coho Salmon move into mainstem and estuarine rearing areas to reside thru the following winter. After surviving winter river flows, 14-15 month old wild yearling smolts enter saltwater in their second spring. Hatchery smolts are released in early May and quickly migrate to the Pacific Ocean. Adults return to the river after 1 to 2 years in saltwater. The average return rate of hatchery Coho Salmon to Gold Ray Dam is 1.4%.

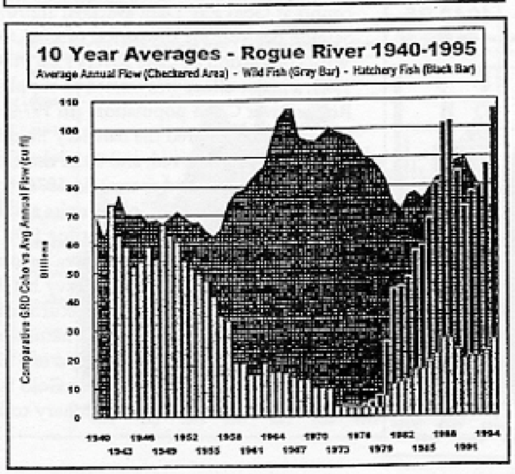
Population Variations: The Rogue River population of Coho Salmon suffered major declines during the 1942-64 period. Serious drought during 1940-57 would have reduced Coho access to spawning habitat in many smaller tributaries and reduced the survival rate of Coho fry due to the dewatering of rearing areas. Then dramatic flood washes in the 1958-74 period caused massive scrubbing destruction of redds and losses of yearlings rearing in the mainstem Rogue. By 1967, the Rogue River's Coho population had reached historic lows. Typical fish counts at Gold Ray Dam averaged approx. 200 Coho Salmon per year for the period of 1964 thru 1976. With completion of Cole Rivers Fish Hatchery in 1973, a major effort was started to supplement the Rogue River Coho population. In 1974, 117 adult Coho Salmon entered the hatchery holding pools. In 1975, 102 adults arrived, and 60 of these fish were processed for eggs and sperm. In 1976, the hatchery released its first 20,122 Coho smolts and by 1979 released 197,644 smolts. Except for 1978 and 1981, approx. 200,000 Coho smolts have been released each year into the Rogue. Despite heavy hatchery supplementation and increased returns of hatchery Cohos, wild Cohos also began a natural recovery in the mid-1970's. During the period of 1991-1994, 20,753 Cohos were counted over Gold Ray Dam, but only 12,736 returned to the hatchery to be processed.




**Upstream Migration Flow:** The graph of 10-year average flows (top) during the August-to-November upstream migration of Coho Salmon is quite similar to the shape and conclusion offered by the graph of 10-year average annual flow (bottom). Moderate correlation between river flows during upstream migration to population trends generally supports the conclusion that mainstem river flow is a determinant of Coho Salmon escapement in the Rogue River.



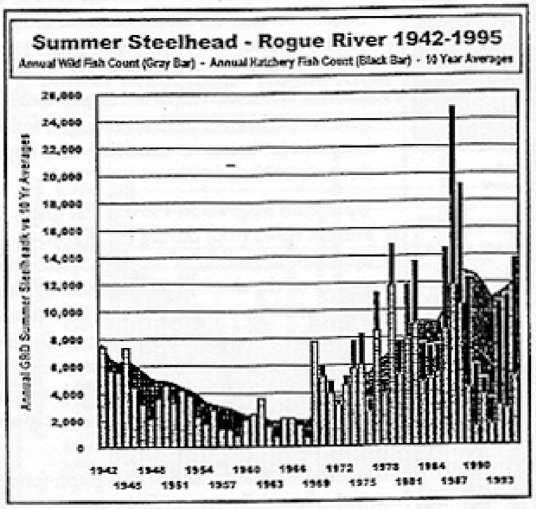

**Maximum Daily Flow:** This graph (center) depicts the highest daily rate-of-flow recorded at the USGS gaging station at Grants Pass during each calendar year and compares peak flows with annual Coho Salmon escapement. This graph discloses flood events capable of scrubbing Rogue River tributary redds and provides clear correlation between major floods and subsequent reductions in Coho Salmon. The 1955 flood was followed by escapement decline through 1959. The major 1964 flood and generally high peak flows through 1974 were followed by extremely depressed Coho returns through 1979. By comparison, periods of moderate peak flows are followed by higher escapement such as the 1976-78 peak flows which were followed by increased 1979-81 Coho escapement.



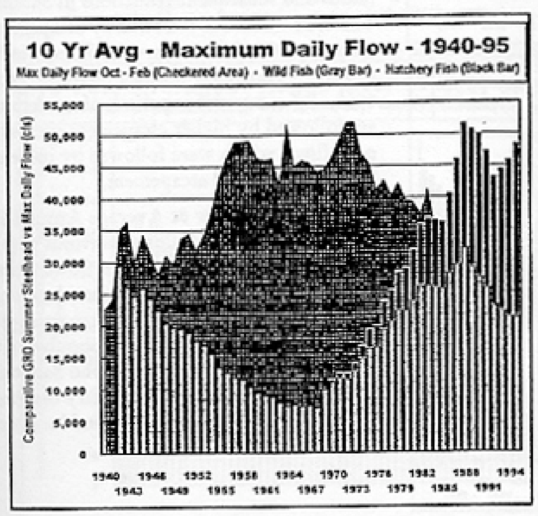

**Average Annual Flow:** The graph of 10-year average annual flows (bottom) is remarkably similar to the shape and conclusions offered by the graph of 10-year average peak flows (previous page). A high degree of correlation between average annual river flows to population trends of the Coho Salmon offers clear support for the conclusion that elevated flows and drought related dewatering in the Rogue River watershed are the primary determinants of Coho Salmon escapement and long-term population trends.

# Rogue River Summer Steelhead

Overview: Summer Steelhead arrive in mid-summer and spawn in the fall, predominately in the upper river. Approx. 85% are wild fish and 15% of hatchery origin counted at Gold Ray Dam. Like Coho Salmon, periods of drought and incremental flood events adversely impact this species. Cycles of increased river flow and flood surges coincide with reduced wild Summer Steelhead runs. Moderate flows and the absence of flood events maximize the escapement of Summer Steelhead.

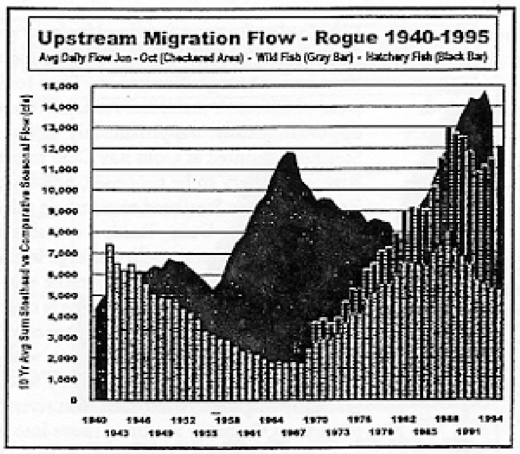


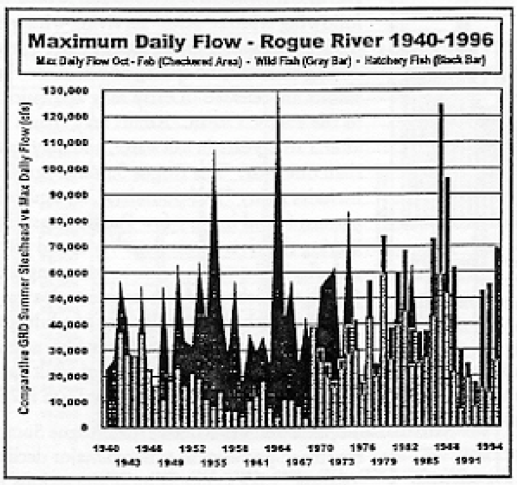

Top: Annual returns of wild and hatchery Summer Steelhead adults as recorded at Gold Ray Dam. 10-year averages of wild and hatchery adults are shown in the background.
Bottom: 10-year averages of wild and hatchery adult returns shown as bars in the foreground. 10-year average maximum daily flow at the Grants Pass gaging station is the background.

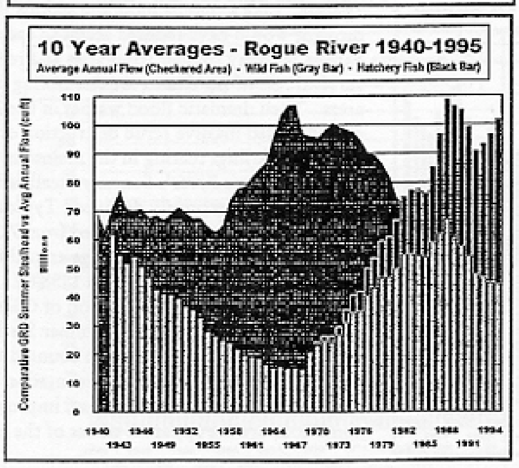



Life Cycle: Summer Steelhead begin to return to the Rogue River in June and migrate into most of the river basin through November. They feed heavily in areas of Chinook mainstem redds and spawn opportunistically. Approximately 40% of Summer Steelhead counted at Gold Ray Dam return to Cole Rivers Hatchery to be processed, however, 70% of all Rogue Summer Steelhead may remain uncounted below Gold Ray Dam. Redds are established in rivers and tributary waters, and fry emerge in the spring. Like Coho Salmon, survival of fertile eggs in the redds and the rate of fry emergence is closely correlated to flood surges and winter river conditions during incubation. After emergence, wild fry competitively disburse into tributary waters and gradually migrate toward mainstem rivers. As fingerlings, Summer Steelhead move into mainstem and estuarine rearing areas to reside thru the following winter. After surviving winter flows, 14 month old wild yearling smolts enter saltwater during their second spring or summer. Hatchery smolts are released in early May and quickly migrate to the Pacific Ocean. Adults may return to the river after 1 to 2 years in saltwater, and may spawn more than one year. The Rogue Summer Steelhead run includes many "half-pounders", an unusual migratory pattern found in very few Pacific Coast rivers. After leaving the river as smolts, they spend just a few months in the ocean prior to returning as immature, 12-18 inch fish. Though unable to spawn, they enter the river with the summer run of adult spawners, and primarily stay within the lower fifty miles of the river. The average return rate of adult hatchery Summer Steelhead to Gold Ray Dam is 2.94%.

Population Variations: The Rogue Summer Steelhead population suffered major decline during 1942-68. Like Coho Salmon, the serious 1940-57 drought would have reduced access to spawning habitat in many smaller tributaries and reduced the survival rate of fry due to the dewatering of rearing areas. Then dramatic flood washes in the 1958-74 period caused massive scrub destruction of redds and losses of yearlings rearing in the mainstem Rogue. By 1968, the Rogue River's Summer Steelhead population had seriously declined. Typical fish counts at Gold Ray Dam declined from 7,387 in 1940 to just 693 in 1968 despite average annual hatchery supplementation of 40,352 from 1958-68. In 1969, four years prior to the completion of Cole Rivers Hatchery, the population of Summer Steelhead began to rebound with 7,768 adult fish counted at Gold Ray Dam. Average hatchery supplementation of 145,788 smolts each year from 1969-73 and improved river conditions are the apparent causes of the increased




Summer Steelhead counts during 1969-75, with an average of 6,250 fish counted during this period. 1973 completion of Cole Rivers Fish Hatchery allowed an expanded effort to supplement Rogue River Summer Steelhead with hatchery smolts. In 1974, 270 adult Summer Steelhead entered the hatchery, and 268 fish were processed for eggs and sperm. In 1975, 198 adults arrived, and 2,389 returned in 1977. 18,322 smolts were released in 1974, and 186,353 in 1976. 1976-91 releases averaged 160,000 and the 1991-95 average was 263,000 smolts. Dramatic increases of both wild and hatchery returns were recorded in the 1969-85 period of moderate flows and reduced flood wash intensity. Returns then suffered as the Rogue watershed entered another period of moderate drought, followed by intermittent increases associated with improved river flows in 1993 and 1995.

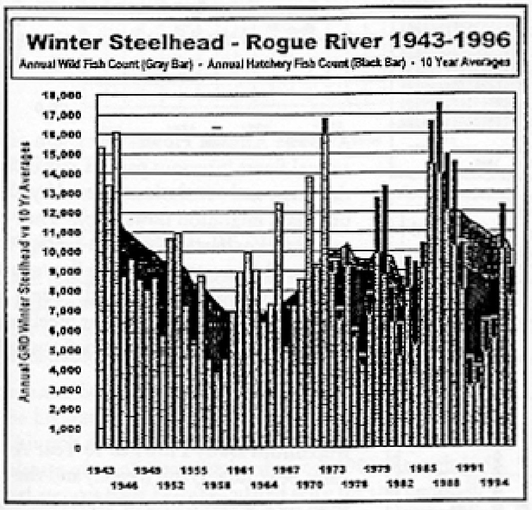
Upstream Migration Flow: The graph of 10-year average flows (top) during the June-to-October upstream migration of Summer Steelhead is modestly similar to the shape and conclusion offered by the graph of 10-year average annual flow (bottom). Moderate correlation between river flows during upstream migration to population trends generally supports the conclusion that mainstem river flow is a determinant of Summer Steelhead escapement in the Rogue River.

Maximum Daily Flow: This graph (center) depicts the highest daily rate-of-flow recorded at the USGS gaging station at Grants Pass during each calendar year and compares peak flows with annual Summer Steelhead escapement. This graph discloses flood events capable of scrubbing Rogue River tributary redds and provides clear correlation between major floods and subsequent reductions in Summer Steelhead. The 1955 flood was followed by escapement decline through 1959. The major 1964 flood was followed by extremely depressed Summer Steelhead returns through 1968. By comparison, periods of moderate peak flows are followed by higher escapement such as the 1965-70 peak flows which were followed by increased 1969-74 Summer Steelhead escapement.

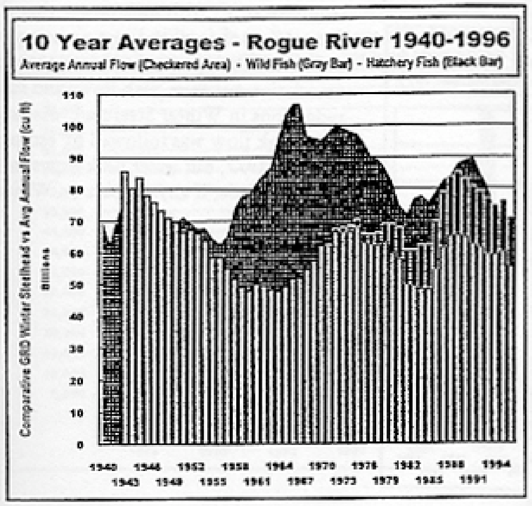
Average Peak Flow & Average Annual Flow: The graph of average peak flows (previous page) and the graph of 10-year average annual flows (bottom) offer remarkably similar shapes and conclusions. There is a high degree of correlation between average annual river flows and peak flood events to population trends of the Summer Steelhead. Like the Coho Salmon, these river flow characteristics are the primary determinants of Summer Steelhead escapement and long-term population trends.

# Rogue River Winter Steelhead

Overview: Winter Steelhead arrive in December and spawn till spring throughout hundreds of miles of streams and rivers in the Rogue Basin. Approx. 90% are wild fish, and 10% of hatchery origin counted at Gold Ray Dam. The 55 year data set of Winter Steelhead returns shows that escapement remains relatively constant despite cycles of long-term increased river flow with flood surges and long-term periods of moderate drought. The Winter Steelhead is

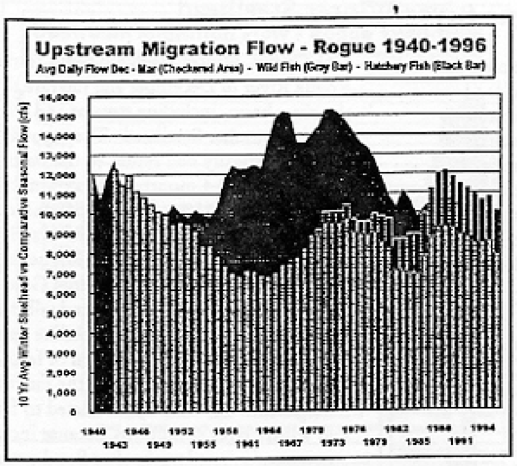


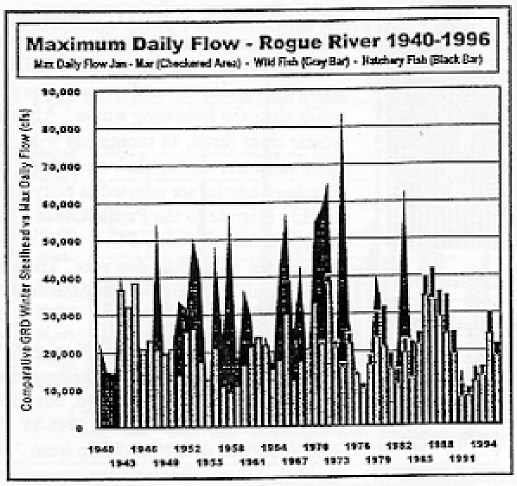

Top: Annual returns of wild and hatchery Winter Steelhead adults as recorded at Gold Ray Dam. 10-year averages of wild and hatchery adults are shown in the background.
Bottom: 10-year averages of wild and hatchery adult returns shown as bars in the foreground. 10-year average total annual river flow at the Grants Pass gaging station is the background.

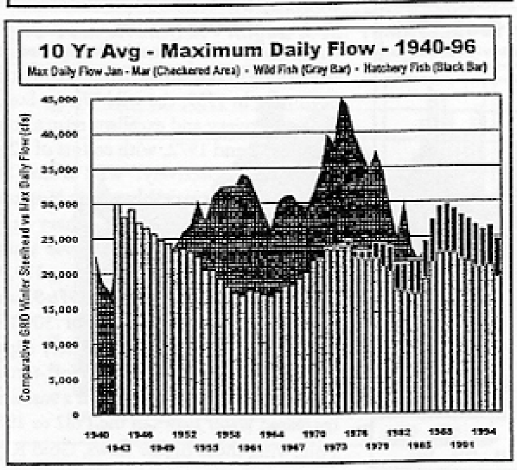



Life Cycle: Winter Steelhead begin to return to the Rogue River in December and migrate throughout the river basin, including streams and tributaries not used by Summer Steelhead. They spawn opportunistically and return to the Pacific Ocean after less than 3-4 months in fresh water. Approximately 15% of Winter Steelhead counted at Gold Ray Dam return to Cole Rivers Hatchery to be processed, however, 70% of all Rogue Basin Winter Steelhead remain uncounted below Gold Ray Dam. Redds are established in rivers and tributary waters, and fry emerge in the spring. Unlike Summer Steelhead and Coho, the survival of fertile Winter Steelhead eggs in the redds and the rate of fry emergence is not directly correlated to flood surges and winter river conditions, because incubation and emergence occurs largely after flood events subside. After emergence, wild fry competitively disburse into tributary waters and gradually migrate toward mainstem rivers. As fingerlings, Winter Steelhead move into mainstem and estuarine rearing areas to reside thru the following winter. After surviving winter river flows, 14 month old wild yearling smolts enter saltwater during their second spring or summer. Hatchery smolts are released in early May and quickly migrate to the Pacific Ocean. Adults may return to the river after 1 to 2 years in saltwater, and may spawn more than one year. The average return rate of adult hatchery Winter Steelhead to Gold Ray Dam is 1.21%.

Population Variations: The Rogue River population of adult Winter Steelhead declined dramatically from 1943 to 1946, but then experienced only moderate decline during 1946-58. By 1958, the wild adult fish count had fallen from 7,387 to 3,855 at Gold Ray Dam. Except for surges of returns in 1952-53, declining population occurred simultaneous with the 1940-57 period of drought related flow reductions in the Rogue River and its tributaries. Beginning in 1959, the wild Winter Steelhead made a steady recovery and excellent returns occurred in 1966, 1970 and 1972, with counts of 12,463, 13,789 and 16,826 respectively. Wild Winter Steelhead maintained a remarkably steady long-term population during 1965-95. Sustained hatchery supplementation since 1976 has added approx. 2,000 adult hatchery fish to annual Gold Ray Dam counts. 119,908 hatchery smolts were released in 1976, 1976-95 annual releases averaged 190,000, with a high of 309,193 released in 1982. Despite continuing hatchery support for the Winter Steelhead since 1976, short-term increases in this species did not occur until a sustained period of increased water flows in the 1982 to 1985 period. Following those higher flows, Gold Ray Dam fish



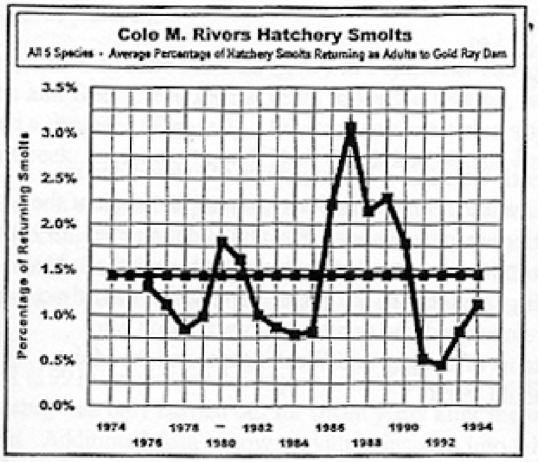




counts for 1986-91 averaged approximately 15,000 fish annually. Following that 5-year increase, 1991-92 Winter Steelhead returns in the Rogue River dropped to the lowest count in 15 years. Since then, Winter Steelhead returns have again begun to rally. Gold Ray Dam fish counts of 4,547 and 4,134 in 1991 and 1992 increased to 6,479 and 6,581 in 1993 and 1994. Upper river Winter Steelhead also spawn in waters between Gold Ray Dam and Savage Rapids Dam, five miles upstream from Grants Pass, and it is estimated that 9,345 upper river fish passed Savage Rapids Dam during the 1994-95 run, and over 20,000 Winter Steelhead may have entered the Rogue Basin that year.

Average Annual Flow: The graph of 10-year average annual flows (previous page) is remarkably similar to the shape and conclusions offered by the graph of upstream migration flows (top). They demonstrate moderate correlation between average annual river flows and upstream migration flows to the population trends of the Winter Steelhead. These studies support the conclusion that the Winter Steelhead is only modestly affected by flow variations in the river.

Maximum Daily Flows & 10-Year Averages: The daily peak flow graph (center) and the 10-year average peak flow graph (bottom) depict the highest daily and average rates-of-flow recorded at the USGS gaging station at Grants Pass during January-to-March of each calendar year, and they compare peak flows with annual Winter Steelhead escapement. These graphs disclose that few peak flow events are capable of scrubbing Rogue River Winter Steelhead mainstem and tributary redds with such power that they result in destruction of fertilized eggs or emerging fry. The daily peak flow graph provides only moderate correlation between peak flows and subsequent reductions in Winter Steelhead. As an example, the 1974 peak flow was followed by escapement decline through 1977, but lesser peak flows in 1958, 1966 and 1983 had little, if any, impact on Winter Steelhead escapement.




## Average Hatchery Smolt Escapement

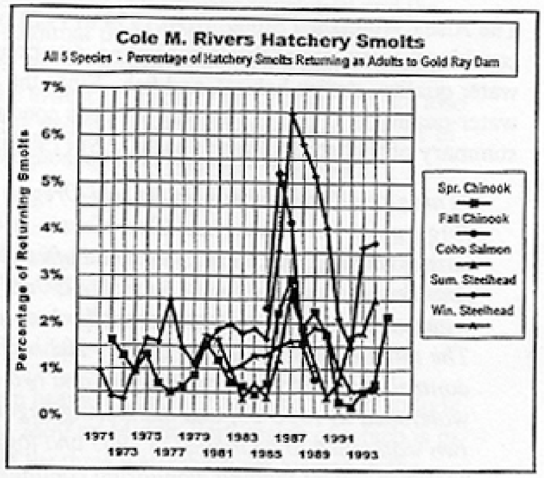
The combined rate of return of Cole M. Rivers Hatchery produced smolts has varied significantly during the 1974-94 period. During 1974-94, the total average rate of return of CMR Hatchery produced smolts was 1.43% for the 5 species of Rogue River anadromous fish. The highest average yearly rate of return of 3.07% was recorded in 1987, and the lowest of 0.44% was recorded in 1992.

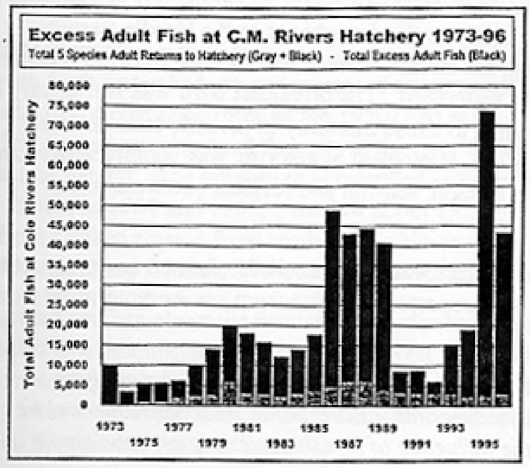
Return rates for hatchery supplemented salmon and steelhead smolts are indicative of escapement rates for wild juvenile salmonids that have matured to smolt size and successfully enter Pacific Ocean saltwater.

## Smolt Escapement by Species

Each species of anadromous fish in the Rogue River shows a unique average smolt return percentage. Despite year-to-year variations, long-term return rates are predictable for each anadromous species.

Summer Steelhead return of hatchery produced smolts is the highest at 2.94% for the 1974-94 period. The Fall Chinook average return rate is 2.46%, though hatchery releases of smolts occurred only from 1982 through 1987, and returns have been calculated only for the period of 1984 thru 1990. The average Coho Salmon return rate is 1.40%. The average Spring Chinook return rate is 1.39%. The average Winter Steelhead return rate is the lowest at 1.21%.




## Wasted Anadromous Fish at Hatchery

During the period of 1973 thru 1995, Cole M. Rivers Hatchery received substantially more adult anadromous fish than were required for its production of smolts.

The average utilization of returning adults for the 1974-1995 period was approximately 16% of total returns. During that period, approximately 84% of all of the adult fish that returned to spawn in the hatchery were discarded, sold or gifted. During years of low returns, the percentage may drop to 50%, but in high return years it approaches 90% of total returning fish.

The hatchery has received over 400,000 excess adult salmon and steelhead since opening in 1973.

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